GROWTH AND MORTALITY OF MOUTH BROODING TILAPIINES OF THE KAFUE FLOODPLAIN FISHERY

By

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A dissertation submitted in partial fulfilment of the requirements for the degree of Master of Science in Tropical ecology and biodiversity

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DECLARATION

I, **Makeche Mauris C**. hereby declare that this dissertation represents my own work and that it has not been previously submitted for a degree at this or any other university.

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Signature

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Date

APPROVAL

This dissertation of MAKECHE MAURIS C is approved as fulfilling part of the requirements for the award of the degree of Master of Science in Tropical Ecology and Biodiversity of the University of Zambia.

Name and Signature of Examiners

Name Examiner 1..Signature......................... Date..........................

Name Examiner 2..Signature......................... Date..........................

Name Examiner 3..Signature..........................Date..........................

DEDICATION

To my Aunties, Mrs. Juliet Samuvanga Chinyama and Mrs. Beatrice Banda Chinyama and Uncles, Mr. James Chinyama and His Lordship Mr. Justice Jones Chinyama.

ABSTRACT

Growth and mortality of *Oreochromis andersonii*, *Oreochromis macrochir* and *Oreochromis niloticus* of the Kafue Floodplain fishery were investigated between September, 2015 and November, 2015. This study was aimed at investigating the growth and mortality of mouth brooding tilapiines of the Kafue Floodplain fishery. Three stations that represent the major ecological habitats of the Kafue Floodplain fishery were selected. These were: Kafue Road Bridge (swamp), Namalyo (lagoon) and Kakuzu (riverine).

Fish specimens were collected using gillnets that were set in the evening and hauled the next morning. Length measurements were taken from each fish specimen using a fish measuring board. Weight was measured using a kitchen balance to the nearest one gramme. One-way Analysis of Variance was performed on all quantitative data using Statistix 9.0 software.

Oreochromis niloticus, an exotic mouth brooding tilapiine showed the largest growth coefficient (k) of 0.22 while *Oreochromis macrochir* had the smallest growth coefficient of 0.10. *Oreochromis andersonii* had a growth coefficient of 0.11.The large growth coefficient in *Oreochromis niloticus* relative to the other mouth brooding tilapiines of the Kafue Floodplain fishery shows that *Oreochromis niloticus* attains asymptotic length the fastest.

Oreochromis macrochir had the largest fishing mortality coefficient (F) of 1.24 while *Oreochromis andersonii* showed the smallest fishing mortality coefficient of 0.21. *Oreochromis niloticus* had a fishing mortality coefficient of 0.45. Exploitation ratios in the Kafue Floodplain fishery were found to be below the optimum value (0.5) except for *Oreochromis macrochir* (0.7). *Oreochromis andersonii* had an exploitation ratio of 0.3 while *Oreochromis niloticus* had an exploitation ratio of 0.4. This implies that the decrease in fish catches in the Kafue Floodplain fishery cannot be attributed to over-fishing but may be due to natural mortality.

KEY WORDS: Exploitation, growth, Kafue Floodplain fishery, mortality, tilapiines.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page

LIST OF APPENDICES

Page

LIST OF SYMBOLS

$^{\circ}C$	degree centigrade (degree celcius)
L_t	predicted length at different ages
$L\infty$	asymptotic length
$t-t_0$	change in time
l_m	mean length of catch sample
l_c	some length for which all fish of that length and above are vulnerable to the fishing gear
S_i	scale radius at the time of formation
$S_1=S_a$	first annulus (age one)
$S_2=S_b$	second annuli (age two)
$N^{th}=S_n$	age n

LIST OF ABBREVIATIONS

ANOVA Analysis of Variance

e exponential (antilogarithm)

E exploitation

F fishing mortality

FAO Food and Agriculture Organisation of the United Nations

In natural logarithm

K growth coefficient

Log logarithm

LSD Least Significant Difference

M natural mortality

OA *Oreochromis andersonii*

OM *Oreochromis macrochir*

ON *Oreochromis niloticus*

SASSCAL Southern African Science Service Centre for Climate Change and Adaptive Land Management

T temperature

TL total length

Z total mortality

CHAPTER 1: INTRODUCTION

1.1 Background

The Kafue Floodplain is an important fishery in Zambia ranking fourth after Lake Tanganyika, Lake Bangweulu and Lake Kariba in terms of fish output and it is also located close to most of the major urban settlements in Zambia making it exposed to several anthropogenic activities. The Kafue Floodplain fishery (figure 1.1) is located in the Kafue Floodplains on the Kafue River between the Itezhi-tezhi dam and the Kafue Gorge dam, covering an area of 6,500km^2 (Welcome, 1979). The Kafue Gorge dam is located at the downstream while the Itezhi-tezhi dam is located at the upstream. These two dams were completed in 1972 and 1977 respectively and they were constructed for hydroelectric power generation purposes (Balasubrahamanyam and Abou-Zeid, 1983). The Kafue Flats stretch from longitude 26˚E to 28˚E and latitude 15˚S to 16˚S; an approximate distance of 400km from Itezhi-tezhi to Kafue District (Welcome, 1979).

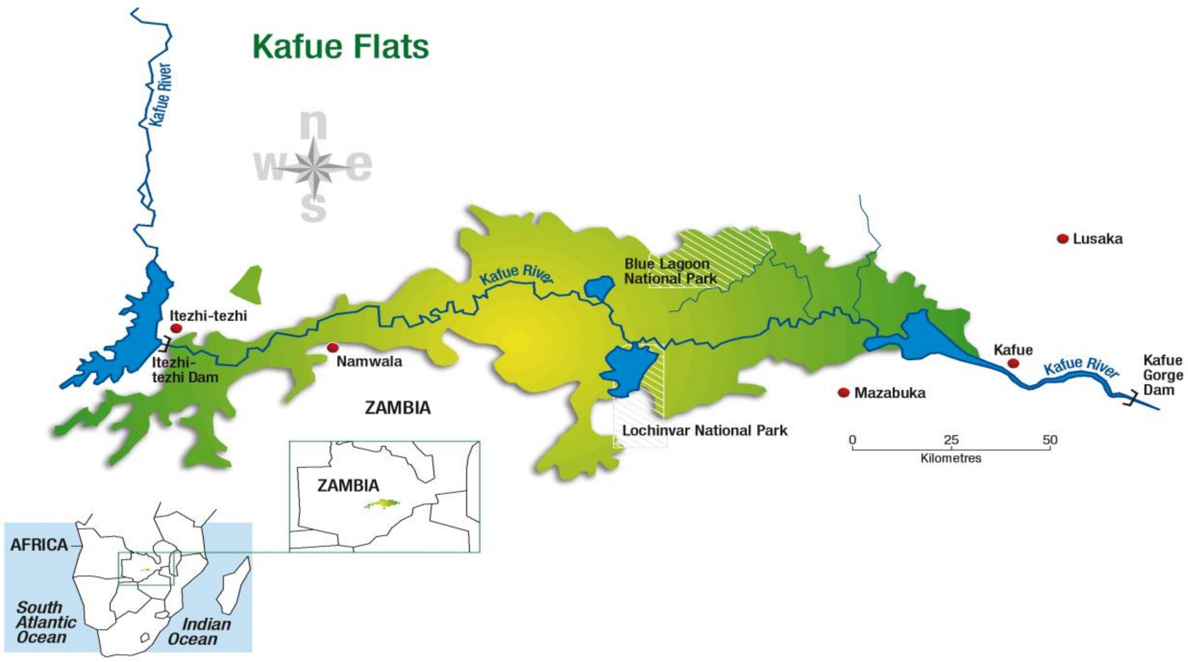

Figure 1.1: Map of the Kafue Floodplain fishery

The altitude of the Kafue Floodplains, which is the catchment area for the Kafue Floodplain fishery, is 1,021 metres above sea level at its upstream end and 976.6 metres at full Supply at its downstream (Turner, 1984). The maximum surface area of the Kafue Floodplains during the wet season is 4, 340 km^2 and from 600–1, 600 km^2 in the dry season. During the wet season, the mean depth of the Kafue flats is 2 metres (Langler, *et al*, 1971). The mean annual fluctuation in water level in the Kafue Floodplains is 3.3 metres (Welcome, 1979). Surface temperature varies between 17˚C and 33˚C (with a mean value of 24˚C) (Carey, 1971). The water of the Kafue Floodplain fishery has a concentration of 68mg/l to 220mg/l of dissolved solids. The main dissolved solids in the water include sodium ions, calcium ions, phosphates and magnesium (Smardon, 2009).

There are several environmental concerns affecting the development and management of the Kafue Floodplain fishery. The waters of the Kafue Floodplain are exposed to pollution from industrial and agricultural activities taking place in the catchment areas. The introduction of exotic fish species such as *Oreochromis niloticus* and Cray fish is also another concern to local biodiversity in the Kafue Floodplain fishery (Schelle and Pittock, 2005).

1.2 Tilapiines of the Kafue Floodplain fishery

There are fifty-five known fish species in the Kafue Floodplain fishery, of which twenty-three are of commercial importance. Cichlids account for eighty percent of all economically important fishes in the Kafue Floodplain fishery (Department of fisheries, 1993).

The tilapiines belong to the family Cichlidae and the family Cichlidae contains two lineages, the tilapiines, which are chiefly plant or sediment feeders, and Haplochromines, which are predators (Skelton, 2001).

Between these two lineages, the tilapiines are considered more important than haplochromines because they are important in artisanal fishing (Appendix 9). Tilapiines are high prolific breeders hence they can easily be farmed (Skelton, 2001). Tilapiines, commonly called breams are intelligent and very adaptable fishes. Parent tilapiines take care of the eggs and young, and coupled to the fact that they lay few eggs per spawning season, their survival rate is high compared to substrate and pelagic spawners (Jackson, 1961).

Tilapiines are identified by a dark eye-spot at the base of the soft dorsal fin, called the "*Tilapia* spot'' in juveniles and some adult fishes (Skelton, 2001). The *Tilapia* mark is a black lunule or blotch on the posterior part of the soft dorsal fin. Tilapiines are broad-headed, deep-bodied mouth brooding Cichlids. *Tilapia* scales are always cycloid and possess microscopic rings that represent annual growth (Jackson, 1961). They have fine teeth in several rows on the jaws, fine pharyngeal teeth, a high number of gill rankers, and long intestines. These features are particularly suited for grazing on phytoplanktons, diatoms, algae and detritus. Adult haplochromines have a series of yellow spots or ocelli ("egg spots'' or "egg dummies") on the anal fin. Haplochromines are carnivorous fish that feed on snails, freshwater mussels and crustaceans. They are characterised by robust pharyngeal bones with rounded, molar-like teeth (Skelton, 2001).

Among the tilapiines, the following are important to the Kafue Floodplain fishery: *Tilapia rendalli, Tilapia sparrmanii, Oreochromis niloticus, Oreochromis andersonii* and *Oreochromis macrochir*. But among these fishes, mouth brooding tilapiines which include *Oreochromis andersonii, Oreochromis macrochir* and *Oreochromis niloticus* are the most important tilapiines to the Kafue Floodplain fishery because they are the most abundant fish species in this habitat and they are also preferred by the local markets (Zambia Department of Fisheries, 2008).

The mouth brooding tilapiines of the Kafue Floodplain fishery which were studied included: *Oreochromis andersonii, Oreochromis macrochir* and *Oreochromis niloticus*. These are the only mouth brooding tilapiines of the Kafue Floodplain fishery (Department of fisheries, 1993). There is on introduced tilapiine fish species in the Kafue Floodplain fishery called *Oreochromis niloticus* (Schwank, 1994).

1.2.1 *Oreochromis andersonii*

Oreochromis andersonii (Castelnau, 1861) commonly called 'Three spotted bream' is identified by the presence of three dark spots on the trunk. Adults are generally blue-grey with light scale borders (Figure 1.2). Its fins have light spots on soft dorsal and anal margins. The outer dorsal and caudal fins are intense red. Breeding males are blue-black with a maroon flush on top of head. It prefers slow-flowing or standing water bodies such as pools, backwaters and lagoons. A mature *Oreochromis andersonii* attains about 500 millimetre total length and weighs about 3.2 kilograms (Skelton, 2001). A picture of *Oreochromis andersonii* is given in Figure 1.2.

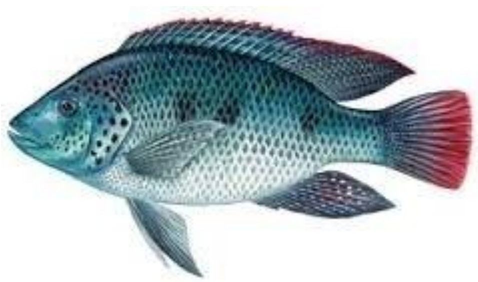

Figure 1.2: *Oreochromis andersonii*

(source: http://eol.org/pages/225655/details. Retrieved on 21st May, 2014).

Oreochromis andersonii has a dorsal formula of D XVI-XVIII,11-14 and an anal formula of AIII,11-13 (Skelton, 2001).

1.2.2 *Oreochromis macrochir*

Oreochromis macrochir (Boulenger, 1912) commonly called the 'Green-headed bream' is distinguished by its green head. Adults are generally olive to bright green with greyish flanks and fins, the head and upper abdomen has black spots while the dorsal fin and caudal fin have yellow margins. The head profile of *Oreochromis macrochir* is steep and rounded. Males are generally larger than females. Breeding males are bright green on the head and upper body. *Oreochromis macrochir* has a prominent white, tassel-like genital papilla (Skelton, 2001). A mature *Oreochromis macrochir* attains about 400 millimetres total length and weighs 2.6 kilograms. It lives in still water along river margins and back waters, in floodplains and impoundments (Jackson, 1961). A picture of *Oreochromis macrochir* is given in Figure 1.3.

Figure 1.3: *Oreochromis macrochir*

Oreochromis macrochir has a dorsal formula of D XV-XVII,11-14 and an anal formula of A III, 9-12 (Skelton, 2001).

1.2.3 *Oreochromis niloticus*

Oreochromis niloticus (Linnaeus, 1758) is identified by a caudal fin that is distinctly striped with whitish grey vertical lines. It has a well defined black tilapiine spot on the base of the dorsal fin. Breeding males have a red flush from the head to the lower body. It has a round steep head profile with long and sharp dorsal fins. The eyes are black with a white ring. An Adult *Oreochromis niloticus* attain a maximum total length of 500 millimetres and weighs about 4 kilograms (Skelton, 2001). A picture of *Oreochromis niloticus* is given in Figure 1.4.

Figure 1.4: *Oreochromis niloticus*

(source: http://org/pages/225655/details. Retrieved on 21st May, 2014).

Oreochromis niloticus has a dorsal formula of D XVI-XVIII, 12-14 and an anal formula of A III, 9-11 (Skelton, 2001).

1.3 Artisanal fishing in the Kafue Floodplain fishery

Since the 1950s the Kafue Floodplain fishery has remained primarily artisanal. Fishers still use mostly dugout canoes or fibreglass “banana boats’’ and multifilament gillnets. Although illegal, large hand-drawn seine nets, of more than 100metres in length and mesh sizes less than 1mm, are also common. Other types of fishing gear used in the Kafue Floodplain fishery include: Long lines (to catch *Hepsetus odoe* and *Clarias* in floodplains), Spears (to catch Barbels in lagoons), Traps and weirs (used in drainages to catch *Tilapia sparrmanii*) and Dip nets (used at Kafue Gorge to catch *Petrocephalus*) (Everett, 1974). Fishing is also commonly associated with beating of water to drive fish into gillnets, a method locally called *kutumpula* (Chipungu, 1981).

It remains unknown whether these types of fishing gear are the ones which have led to the observed decrease in fish catches or the average increase in water levels in the Kafue Floodplains has reduced fish catches because the traditional fishing gear are not effective at catching fish in this fishery (Department of Fisheries, 1993). The construction of the Kafue Gorge dam and the Itezhi-tezhi dam has changed the ecology of the Kafue Floodplain fishery by increasing water levels in the Kafue Floodplain fishery. The extent of flooding has reduced and the degree to which the water levels reduce during the dry season has also reduced (Balasubrahamanyam and Abou-Zeid, 1983).

1.4 Statement of the problem

There are two contradicting views regarding fish stock sizes and exploitation of fish stocks of the Kafue Floodplain fishery.

Two predictions regarding fish catches were made before the constructions of the Kafue gorge dam and Itezhi-tezhi dam. Carey and Bell-Cross (1967), postulated that artificial water levels in the Kafue Floodplains would affect seasonal fish spawning and result in poor recruitment and lead to low fish catches due to decrease in total fish biomass as a result of recruitment failures. Langler, *et al*., (1971) predicted that after the construction of the Itezhi-tezhi dam, the mean high water level in the Kafue Floodplains would increase because of increase in water retained in the area hence there would be an increase in fish production.

Total fish catches from the Kafue Floodplain fishery have been reducing gradually and the fishery seems not to be recovering from decreasing fish catches (Figure1.5 and Appendix 10). For instance, in 1966 the Kafue Floodplain fishery produced a total catch of 10,709 metric tonnes but in 1980 this fishery recorded a total catch of only 7,741 metric tonnes (FAO-Fisheries report, 2010).

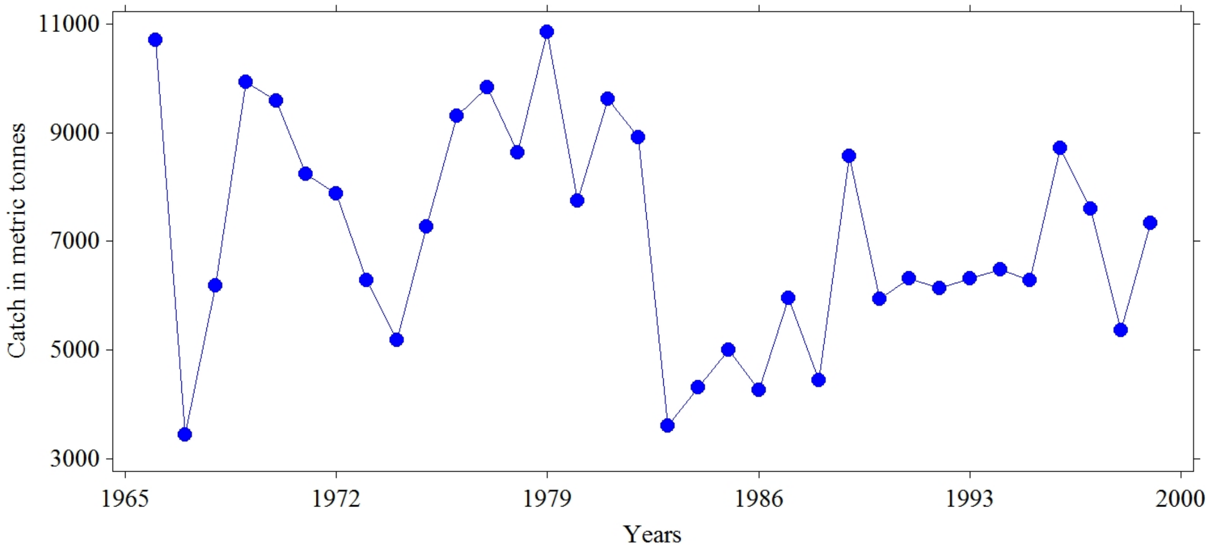

Figure 1.5: Fish catches from the Kafue Floodplain fishery from 1965 to 2000 (source: FAO Fisheries report, 2010).

Fish catches from the Kafue Floodplain fishery have been decreasing gradually especially after 1979 when two dams were constructed along the course of the Kafue River (Figure 1.5). In the 1970s fish catches from the Kafue Floodplain fishery were averaging around 8,000 metric tonnes but total yields from the Kafue Floodplain fishery plummeted to a mean of about 6,000 metric tonnes in the 1990s (FAO Fisheries report, 2010).

Reasons for the decline in fish harvests have not been properly understood and investigated but two hypotheses can be put forward regarding the exploitation and fishery potential of the Kafue Floodplain fishery. The popular opinion regarding the state of this fishery is that the fish stocks along the Kafue Floodplains are being over-exploited and consequently fish stocks have decreased. Such opinion is supported by the studies of Williams (1960), Muncy (1976), Mbewe (2006) and Nyimbili (2006) which are based on analysis of the catch and effort data. Williams (1960) and Muncy (1976) presented evidence that the Kafue Floodplain fishery is being exploited beyond the Maximum Sustainable yield. Mbewe (2006) and Nyimbili (2006) also found that the Kafue Floodplain fishery is being over-exploited. On the contrary, Langler, *et al*., 1971; and Chapman, *et al*., 1971 have presented evidence that the Kafue

Floodplain fishery is being under-exploited. It is considered that gill nets that fishers are using are not effective at harvesting fish from the Kafue Floodplain fishery since mean water levels of the Kafue Floodplains have increased (Mung'omba, 1992).

The possible explanation to the decrease in fish catches from the Kafue Floodplain fishery is that the average water levels in the Kafue Floodplains have increased due to the construction of dams at Kafue and Itezhi-tezhi. Increase in water levels could have rendered the fishing gear being used in the Kafue Floodplain fishery not effective at exploiting fish stocks in this fishery. The other explanation to the decrease in fish yields from the Kafue Floodplain fishery can be attributed to the increase in fishing pressure. The increase in fishing pressure coupled to low rainfall in the early 1970s reduced fish yields from the Kafue Floodplain fishery as shown in Figure 1.5 (Department of fisheries, 1993).

1.5 Study objectives

1.5.1 General objective

The general objective of this study was to investigate the growth and mortality of mouth brooding tilapiines of the Kafue Floodplain fishery.

1.5.2 Specific objectives

The objectives of this research were:

(i) To investigate growth rates of mouth brooding tilapiines of the Kafue Floodplain fishery.

(ii) To estimate mortality variables of mouth brooding tilapiines of the Kafue Floodplain fishery.

(iii) To determine the exploitation ratios of mouth brooding tilapiines of the Kafue Floodplain fishery.

1.6 Hypotheses of the study

This study tested the hypotheses that:

(i) There are no significant differences in growth rates of mouth brooding tilapiines of the Kafue Floodplain fishery.

(ii) There are no significant differences in mortality variables among mouth brooding tilapiines of the Kafue Floodplain fishery.

(iii) There are no significant differences in the exploitation ratios of mouth brooding tilapiines of the Kafue Floodplain fishery.

1.7 Significance of the study

The Kafue Floodplain fishery is a very important fishery in Zambia owing to the fact that it offers many values to the ecosystem. Some values of the Kafue Floodplains are: ground water recharge, ground water discharge, flood control, removal of toxic substances from the surface, nutrient retention and food chain support and tourism (Backstrom and Jonsson, 1997). All these roles that are played by the Kafue Floodplains maintain the ecosystem of the Kafue River basin and surrounding areas in good state and provide a good habitat for the many living organisms that the ecosystem supports (Chabwela, 2010).

As a major wetland, the Kafue Floodplain fishery has many functions ranging from wetland resources such as water, fodder, timber and forage; and the high aesthetic values of a natural Floodplain. The high aesthetic values of the Kafue Floodplains that range from Lagoons, natural vegetation, beautiful beaches and presence of some endemic species of birds and the Kafue Lechwe, all promote tourism (Appelvan and Meerendonk, 1980).

The Kafue Floodplain fishery also offers many products such as fish and game. The Kafue Floodplain fishery is rich in fish biodiversity (Ellenbroek, 1987). The Kafue Floodplain fishery is the fourth largest fishery in Zambia. This fishery produces an average catch of about 8,000 metric tonnes of fish annually which is approximately 14% of the total annual catch for the whole country (FAO-Fisheries Department, 2010).

A total of Fifty-five fish species have been recorded in this ecosystem. Of these about Twenty-three fish species are commercially important (Mortimer, 1965). Some notable fishes of this fishery include *Oreochromis andersonii, Oreochromis macrochir, Oreochromis niloticus, Tilapia rendalii, Clarias gariepinus, Clarias ngamensis, Serranochromis angusticeps, Synodontis macrostoma, Macusenius macrolepidotus and Mormyrus larceda* (Appendix 9). People utilize the fish resources on a subsistence and commercial basis (Department of Fisheries, 1993).

The Kafue Floodplain fishery provide many different types of resources to different types of people, more so to the more than Two Thousand Six Hundred Batwa locals and other seasonal migrants from different parts of Zambia (Muyanga and Chipungu, 1978). Non-residents of the Kafue Floodplains also frequent the flats in search of fish (Appelvan and Meerendonk, 1980). Some resources provided by the Kafue Floodplains are: natural vegetation and by-products from trees and animals, wildlife resources, Agriculture resources (Ellenbroek, 1987), water resources, grazing and fodder, and fisheries resources (Appelvan and Meerendonk, 1980).

The Kafue Floodplain fishery is also of great importance owing to its proximity to urban centres such as Lusaka, Monze, Mazabuka and Kafue town. Urban centres provide a readily available market for fish and other wetland resources provided by the Kafue Floodplains (Appelvan and Meerendonk, 1980). However, nearness to urban centres makes the Kafue Floodplain resources vulnerable to overexploitation and other anthropogenic effects (FAO Fisheries Department, 2010). Mouth brooding tilapiines of the Kafue Floodplain fishery are especially susceptible to over-exploitation because they are of high market value and they can be easily cultured (Mbewe, 2006).

The study will help to know whether or not there is over-exploitation of mouth brooding tilapiines in the Kafue Floodplain fishery, and give recommendations that may help address the problem of over-exploitation, if any.

CHAPTER 2: LITERATURE REVIEW

2.1 Hydrology of the Kafue Floodplain fishery

The hydrology of the Kafue Floodplain in relation to the fishery has been investigated by some researchers including Muyanga and Chipungu (1978) who indicated that the Kafue Gorge dam and the Itezhi-tezhi Dam are critical to the hydrology of the Kafue Floodplain fishery as they have changed the ecology of the Kafue Floodplains. They indicated that the construction of the two dams along the course of the Kafue River has led to the emergence of floodplain flora and fauna while promoting the elimination of non-floodplain species. Grasses such as *Vossia* and *Phragmites* that are typical floodplain flora have become more abundant while shrubs and trees such as *Acacia* and *Brachystergia* have been completely eliminated from some sections of the Kafue Floodplains. Some fauna that has become prominent in the Kafue Floodplain fishery include crocodiles, hippos and Floodplain fish species such as cichlides (Ellenbroek, 1987).

The Food and Agriculture Organisation (FAO) of the United Nations survey in conjunction with Zambia Fisheries Department (2010) in the Kafue Floodplain fishery found that the regulation of the Kafue River, above (Itezhi-tezhi dam) and below (Kafue Gorge dam) the Floodplains, alters the natural flooding regime by decreasing and regularizing the maximum area flooded, decreasing the flood duration, delaying the flood, increasing the area that is permanently flooded during the dry season and reducing the amplitude of water level fluctuation by raising the minimum level of water in the Kafue Floodplain fishery. The raised new water level of the Kafue Floodplain could be a contributing factor to the decrease in fish catches from the Kafue Floodplain fishery (Mbewe, 2006).

Balasubrahamanyam and Abou-Zeid (1983) concluded that water levels along the course of the Kafue River have increased due to the construction of the Kafue gorge dam and Itezhi-tezhi dam along the Kafue River. They stated that the extent of water recession has reduced resulting in large areas that are permanently flooded. Increase in flooded areas stimulates tilapiines to spawn. These flooded habitats, unfortunately, are not ideal *Tilapia* habitats because they are not well-sheltered littoral zones. This increases natural mortality of fishes and contribute to the low fish yields from the Kafue Floodplain fishery (Department of fisheries, 1993).

Turner (1984), also investigated the hydrology of the Kafue Floodplains and found that the high energy of the water that is released from the Itezhi-tezhi Gorge Dam disturbs the habitat by removing sand, silt, zooplanktons, phytoplanktons and leafy debris. This reduces on food availability in the Kafue Floodplain fishery thereby reducing on fish growth and increases fish mortality due to increased susceptibility to predators.

Studies by Welcome (1979) on effects of damming a river on fish growth and mortality in the Qiantang river of China revealed that forty percent (40%) of fish spawning grounds are lost due to damming. Additionally, the suppression of flood regime downstream from an impoundment by means of flow regulation can also reduce on food supply for fish in the affected habitat. This reduces the productivity of the affected fishery. The FAO-Fisheries report (2010) on the hydrology of dammed rivers in Niger, Senegal and East Africa among others, concluded that the cumulative effect of diminished peak discharges, controlled water levels, reduced water velocities and increased water temperatures pose detrimental effects on fish growth and increase fish mortality.

2.2 Growth of cichlids

Growth rates of mouth brooding tilapiines vary due to both intrinsic factors and external factors such as age, sex, diet and seasonality (Skelton, 2001).

Growth patterns of fishes in the Kafue Floodplain fishery were studied by Carey (1967) and Muncy (1976) who both found that mouth brooding tilapiines are seasonal growers owing to seasonal patterns of precipitation and temperature variations that they are exposed to, which dictate the availability of habitats and food resources. Both researchers established that relative food scarcity frequently occurs during the dry seasons (April to mid-November) in the Kafue Floodplains resulting in fishes concentrating themselves in river channels and floodplain pools. However, Muncy (1976) established that, since detritus and algae (especially periphyton) are available throughout the year, food might not be a limiting factor to the growth of cichlides especially mouth brooding tilapiines that also feed on macrophytes, zooplanktons and aquatic insects.

Chapman, *et al*., (1971) demonstrated that individual growth of tilapiines in the Kafue Floodplain fishery is affected by food availability, temperature, sex, fish reproductive status, fish density and variable allocation to growth, among other factors. Food availability promotes fish growth while food scarcity, especially in the dry season months of April to November, retards fish growth. Juveniles that hatch at the beginning of the rainy season when food is available grow faster than juveniles that hatch at the end of the rainy season (Zambia Department of fisheries, 2008). Chapman, *et al*., (1971) found that sex affects fish growth because male fish grow faster than female fish. A fish that is in its ripe state of reproduction grows slower than a fish that is in immature reproductive stage (Chapman, *et al*., 1971).

Muyanga and Chipungu (1978) also demonstrated that wet season flooding in the Kafue Floodplains stimulates greater primary and secondary production thereby promoting growth among cichlides in this fishery. The fast growth of aquatic flora in the Kafue Floodplains in the rainy season creates good habitats for cichlides in the Kafue Floodplain fishery. Ellenbroek (1987) found that increase in rainfall during the rainy season promotes the growth of algae, phytoplanktons, zooplanktons and diatoms that provide food resources to mouth brooding tilapiines of the Kafue floodplain fishery.

2.3 Mortality of tilapiines

Both biotic and abiotic factors contribute to mortality among tilapiines of the Kafue Floodplain fishery. Biotic factors include competition, predation and age. Some abiotic factors that contribute to mortality among tilapiines of the Kafue Floodplain fishery are food shortages and environmental changes (FAO- Fisheries report, 2010).

Competition is both intraspecific and interspecific among fishes of the Kafue Floodplain fishery. Competition among tilapiine fish species (intraspecific competition) and interspecific competition (competition between different species) is most common during the dry season when food resources are scarce (Appelvan and Meerendonk, 1980). The onset of the dry season (April to November) is closely associated with a decrease in plankton concentration which reduces food resources for tilapiines in the Kafue Floodplain fishery. Decrease in rainfall activities also promotes competition for nesting sites because tilapiines, most especially cichlides are adapted to living in well-sheltered habitats (Schwank, 1994).

Environmental instability is another major cause of mortality among tilapiines of the Kafue Floodplain fishery. The change in the habitat in the Kafue Floodplain fishery is largely attributed to the construction of dams along the course of the Kafue River. Agricultural activities in the Kafue Floodplains also contribute to abiotic factors that increase natural mortality among tilapiines of the Kafue Floodplain fishery. Irrigation farms in the Kafue Floodplains offload effluent along the Kafue River which also make the habitat unfit for tilapiines (Schwank, 1994).

The Kafue Gorge Dam and the Itezhi-tezhi Gorge dam have altered the original aquatic conditions of the Kafue Floodplain fishery. The impoundments at these stations have changed the water quality, quantity and breeding grounds of tilapiines and other fishes of the Kafue Floodplain fishery. When the Itezhi-tezhi Gorge dam is opened in the dry season, the aquatic flora and fauna, fish inclusive, are negatively affected thereby causing high mortalities (Balasubrahamanyam and Abou-Zeid, 1983). The high energy of the sudden floods disturbs the habitat by removing sand, silt, zooplanktons, phytoplanktons and leafy debris. The habitat becomes less desirable for most fishes, most especially the tilapiines that require a well-sheltered littoral zone. Thus damming of the Kafue River has probably increased the natural mortality of tilapiines of the Kafue Floodplain fishery (Schwank, 1994).

CHAPTER 3: MATERIALS AND METHODS

3.1 Research study area

This research was conducted in the Kafue Floodplain fishery (Figure 3.1) which is located about 50 Kilometres south from Lusaka, the capital city of Zambia. Three stations that represent the study area, were selected; these were: Kafue Road Bridge (station I), Namalyo (station II) and Kakuzu (station III). These stations represent the different ecological habitats in the Kafue Floodplain fishery.

Station I, Kafue Road Bridge, in Kafue district, is the lower part of the Kafue River at a grid reference of 15˚50ˈ218"S and 28˚14ˈ110"E. It had still water and many hydrophytes ranging from submerged, floating and emergent types (Cowardin, *et al*., 1979).

Station II was located at Namalyo in Lochinvar National park in Monze district. It had a grid reference of 15˚50ˈ185"S and 28˚14ˈ126"E. This station is representative of a lagoon. It was characterized by low gradient and low water velocity. The substrate consisted mainly of sand and mud. It was a typical Floodplain with high deposition of debris (Cowardin, *et al*., 1979).

Station III, Kakuzu in Namwala district, was within latitude 15˚50ˈ166"S and longitude 28˚14ˈ149"E. It is the upper part of the Kafue River. Kakuzu was characterized by relatively fast running water. The substrate consisted of rock, cobbles, or gravel with occasional patches of sand (Cowardin, *et al*., 1979).

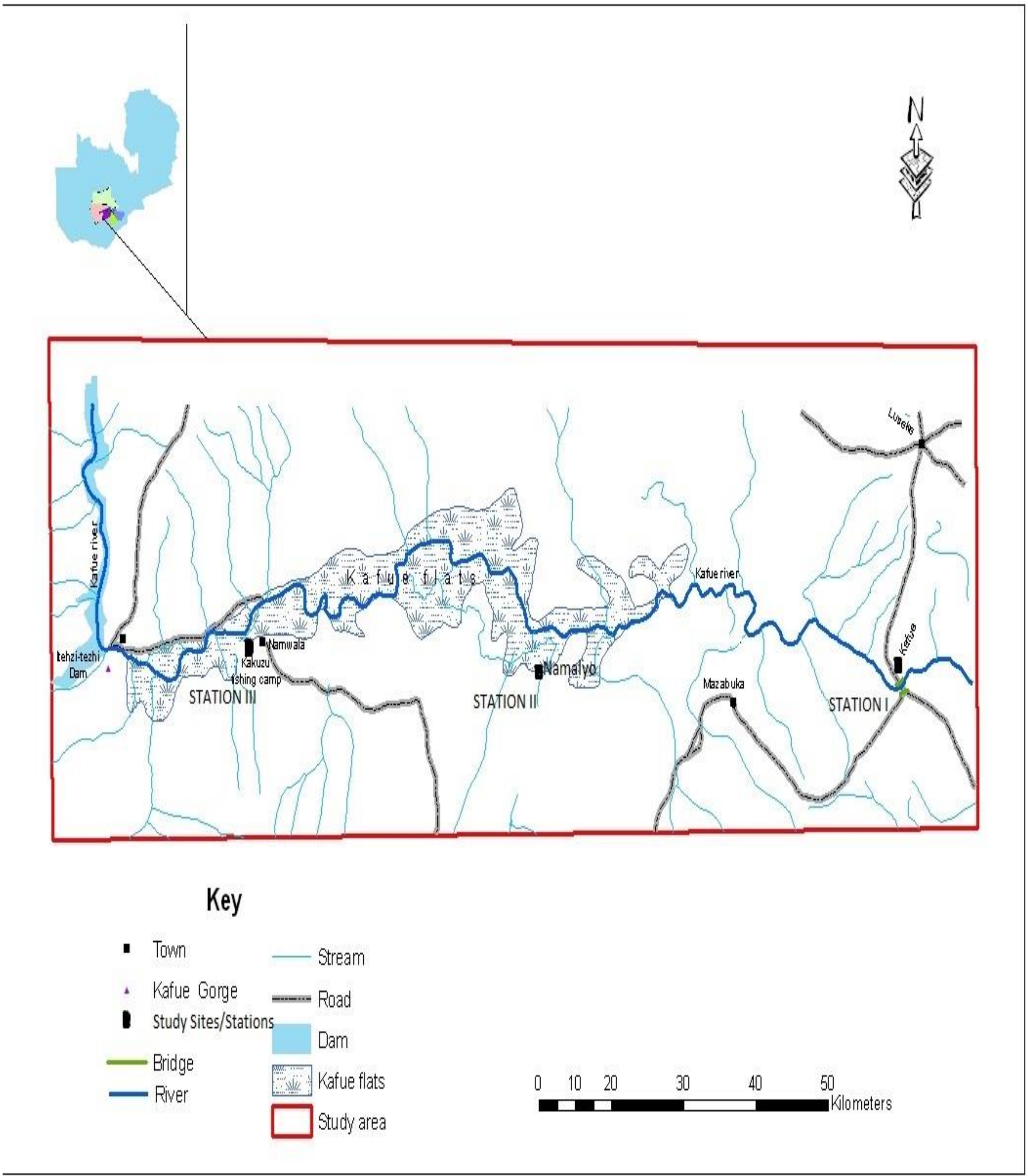

Figure 3.1: Location of the study sites (Kafue Road Bridge, Namalyo and Kakuzu) within the Kafue Floodplain fishery.

3.2 Sample collection

Fish samples were collected from Kafue Road Bridge, Namalyo and Kakuzu (Figure 3.1). Sampling was conducted for two consecutive days at each study site in October and November, 2015. Sampling during this period coincides with observed periods of rapid growth and reproductive activities of fish in the Kafue Floodplain fishery (Chapman, *et al*., 1971).

Fish samples were collected from the selected sampling study sites using a fleet of gillnets of the mesh sizes ranging from 25mm to 190mm (Table 3.1) according to methods described in the Gillnet survey Manual (Zambia Department of Fisheries, 2008). Gillnets of different mesh sizes were intended to catch fish specimens of different sizes.

Table 3.1: Mesh sizes of gillnets used in sampling

Mesh size (mm)	25	37	50	63	76	89	102	114	127	140	152	165	178	190
Mesh size (inches)	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5

3.3 Data collection

Data for this research was collected from both the field and in the laboratory. Field techniques were used to collect length (cm) and weight (grammes) variables from each fish species while laboratory techniques were used to age (in years) each fish species. The variables that were collected from each fish specimen were used to estimate: growth, mortality and exploitation levels.

3.3.1 Field techniques

In the field, total length and standard length of a fish sample were measured to an accuracy of one millimetre using fish measuring boards (Figure 3.2).

Figure 3.2: Length measurements using fish measuring boards

The Total length (TL) of each mouth brooding tilapiine fish species was measured from the tip of the anterior part of the mouth to the posterior end of the caudal fin. Standard length was measured from the tip of the anterior part of the mouth to the mid-base of the caudal fin. A total of 687 mouth brooding tilapiine fish species were sampled using gillnets shown in Figure 3.3.

Figure 3.3: Removing fish from gillnets after hauling them

Body weight of individual tilapiine fish species was determined to the nearest 1.0 gramme using a kitchen balance (Figure 3.4).

Figure 3.4: Measuring weight using a kitchen balance

Using strong forceps, six (06) scales were removed from each fish; all from just above the lateral line three from each side of the trunk. Scales above the lateral line of a fish are the first scales formed and they persist throughout the life of a fish (Skelton, 2001). The extracted scales were put in paper envelopes. The envelopes were then labelled by each fish species unique code, location and date of extraction. The species codes that were used were: OA for *Oreochromis andersonii*, OM for *Oreochromis macrochir* and ON for *Oreochromis niloticus*.

Total Length measurements were used to determine asymptotic lengths ($L\infty$) and growth coefficients (k) of the mouth brooding tilapiines.

3.3.2 Laboratory techniques

In the laboratory at the University of Zambia, the scales were cleaned by soaking them in warm distilled water (at 25˚c) for about ten minutes to soften them. The scales were then soaked in 10% hydrochloric acid in order to remove flesh attached to them. The scales were then made razor thin by rubbing them with a fine sand paper before embedding them between two glass slides and sealed with sellotape to avoid curling (Dahl, 1909).

The scales were then examined under a light microscope at low power (x10 magnification) to determine the age (in years) of each fish species by counting the number of annuli. The annuli were determined from the face of the centrum. The number of annual rings in each scale indicated the age of the fish species in years (Skelton, 2001).

These scale readings were used to determine growth rates of the mouth brooding tilapiines. The ages of fish species studied were also used to determine total mortalities of the mouth brooding tilapiines using the linearised catch curves (Pauly, 1983).

3.3.3 Age determination using scales

The age of each fish species was determined by back-calculations based upon linear regression model (Lee, 1920) which assumes that fish length (Total length) is directly proportional to scale radius (Dahl, 1909). Scale radii at time of annulus formation (S_i) then followed:

First annulus (age one): $S_1=S_a$

Second annuli (age two): $S_2=S_a+S_b$

n^{th} annuli (age n): $Sn=S_a+S_b+...S_n$

The number of annual rings which a tropical fish species deposits on its scales corresponds to its age (Skelton, 2001 and Jackson, 1961). The ages were used to determine the growth coefficients (k) using the Ford (1933) and Walford (1946) method which is a linear regression of age and length at each age.

3.3.4 Growth rates

Fish growth rate was assumed to follow the von Bertalanffy (1938) growth curve, which is expressed as: $L_t = L_\infty (1-e^{-k(t-to)})$; where L_t is the predicted length at different ages, L_∞ is asymptotic length, $t-t_0$ is the change in time and k is the growth coefficient. Different fish lengths were calculated at various ages using the von Bertalanffy growth equation.

3.3.5 Mortality variables

Total mortality coefficients of the *Oreochromis* fish species that were studied were determined using two methods; linearised catch curves; and Beverton and Holt equation (1957).

3.3.5.1 Using linearised catch curves

The linear regression curves were obtained using the ages of fish against natural logarithm of the number of fish at each age, using Microsoft Excel, 2007. The gradients of regression analysis denoted total mortality coefficients of the *Oreochromis* fish species (Pauly, 1980). This was done for each sampling station and for the accumulated data from all the stations.

3.3.5.2 Beverton and Holt equation method

The Beverton and Holt equation (1957) is based on the mean lengths of a fish species and it is given below:

$$Z = \frac{k(L\infty - Lm)}{Lm - Lc}$$

Where:

k is the growth coefficient.

L_∞ is the asymptotic length (length which a fish can attain if it lived upto an infinity number of years).

L_m is the mean length of the catch samples.

L_c is the length for which all fish of that age and longer are under full exploitation. L_c is the smallest length among the measured total lengths of the fish specimens.

Z is the total mortality.

The growth coefficients (k) were obtained by linear regression of number of fish against total length. Asymptotic length (L_∞) was determined using the equation by Pauly (1979) which is:

$$L_\infty = \frac{Lmax}{0.95}$$

Where Lmax is the largest length among the measured total lengths of the fish species. The asymptotic length (L_∞) determines the maximum length a fish can attain if it lived upto infinity.

Total mortality (Z) is made up of two components: F which is mortality attributed to fishing and M, the natural mortality coefficient (Gulland, 1982) and it is expressed as follows:

$$Z = M + F.$$

The fishing mortality, F, was found by rearranging the equation above.

The natural mortality coefficient, M was estimated using Pauly (1983) equation expressed as follows:

$$M = 0.8 \exp(-0.0152 - 0.279 \text{ In } L_\infty + 0.6543 \text{ In } K + 0.4634 \text{ In } T)$$

Where L_∞ is the asymptotic length, k is the growth coefficient and T is the mean water temperature of the water body where fish is found. Average temperatures of the water at the three sampling stations were measured using laboratory thermometers (Figure 3.5).

Figure 3.5: Measuring temperature using a laboratory thermometer at Kafue Road Bridge

3.3.6: Levels of exploitation

Total mortality coefficients were used to determine the levels of exploitation of the mouth brooding tilapiines of the Kafue Floodplain fishery. Using the estimated values of total mortality (from Beverton and Holt equation of 1957) and natural mortality (from Pauly equation of 1983) above, the exploitation ratio (E) was then determined from the formula of Gulland (1982) as given below:

$$E = \frac{Z - M}{Z}$$

Where Z is the total mortality coefficient and M is the natural mortality coefficient.

Values of exploitation ratios were used to determine whether or not the fish stocks in the Kafue Floodplain fishery are over-exploited. An exploitation value of 0.5 denotes optimal exploitation; an exploitation value above 0.5 denotes over-exploitation while an exploitation value below 0.5 signifies under-exploitation.

3.4 Data analyses

The data that was obtained using the various methods explained above were analysed to determine significant differences, if any. Analyses were done using One-way Analysis of Variance (p=0.05) using Statistix 9.0 software (Analytical software, 2009). One-way Analysis of Variance was used when more than two values were obtained from each mouth brooding tilapiine fish species; but whenever only one datum was obtained from each mouth brooding tilapiine fish species, the means of the values obtained were compared.

3.4.1 Age determination

The ages of each mouth brooding tilapiine fish species were analysed using One-way Analysis of Variance (p=0.05), in Statistix 9 software (Analytical Software, 2009). This analysis was done for accumulated results of each mouth brooding tilapiine fish species that was studied in the Kafue Floodplain fishery and at each study site.

3.4.2 Growth rates

The growth rates of each mouth brooding tilapiine fish species were analysed using One-way Analysis of Variance(p=0.05), in Statistix 9 software (Analytical Software, 2009). Growth curves of age against total length were plotted to show a relationship of growth among the three mouth brooding tilapiines. Linear regression of length and age was used to determine regression equations of the growth rate of each mouth brooding tilapiine fish species. Gradients were used to determine the fastest growing mouth brooding tilapiine. A fish species with the largest gradient was the fastest growing mouth brooding tilapiine. These analyses were done for accumulated results of each mouth brooding tilapiine fish species in the Kafue Floodplain fishery and at each study site.

3.4.3 Mortality variables

Mortality variables of the mouth brooding tilapiines of the Kafue Floodplain fishery were compared to determine significant differences, if any. Mean mortality variables of sampled mouth brooding tilapiines at each study site were also compared to determine any significant difference.

3.4.4 Levels of exploitation

Exploitation ratios of the mouth brooding tilapiine fish species of the Kafue Floodplain fishery were compared to determine significant differences, if any. Mean exploitation ratios of sampled mouth brooding tilapiines at each study site were also compared to determine any significant difference.

CHAPTER 4: RESULTS

4.1 Growth coefficients of fish

The growth coefficients of mouth brooding tilapiines of the Kafue Floodplain fishery are given in Table 4.1.

Table 4.1: Growth coefficients of mouth brooding tilapiines of the Kafue Floodplain fishery

species	Growth variable	
	Asymptotic length ($L\infty$)	Growth coefficient (k)
Oreochromis andersonii	357	0.11
Oreochromis macrochir	344	0.10
Oreochromis niloticus	447	0.22

There was no significant difference between the growth coefficient (k) of *Oreochromis andersonii* (k=0.11) and *Oreochromis macrochir* (k=0.10), the growth coefficient of the exotic *Oreochromis niloticus* (k=0.22) was different from the growth coefficients of *Oreochromis andersonii* and *Oreochromis macrochir*. *Oreochromis macrochir* had the smallest asymptotic length ($L\infty$=344mm) and the smallest growth coefficient (k=0.10).

4.2 Growth rates of fish in the Kafue Floodplain fishery

The growth rates of accumulated fish catches in the Kafue Floodplain fishery that were obtained using the von Bertalanffy growth equation are given in Table 4.2.

Table 4.2: Growth rates of mouth brooding tilapiines of the Kafue Floodplain fishery

Oreochromis andersonii		*Oreochromis macrochir*		*Oreochromis niloticus*	
Age (years)	Total length (mm)	Age (years)	Total length (mm)	Age (years)	Total length (mm)
1	37	1	33	1	88
2	71	2	62	2	159
3	100	3	89	3	216
4	127	4	113	4	262
5	151	5	135	5	298

The total lengths of mouth brooding tilapiines at different ages show that *Oreochromis niloticus* was the fastest growing mouth brooding tilapiine in the Kafue Floodplain fishery. Between age one and two (in years), *Oreochromis niloticus* grew by 71 millimetres (from 88mm at age one to 159mm at age two) while *Oreochromis andersonii* and *Oreochromis macrochir* grew by 34 millimetres and 29 millimetres between age one and two. Overall growth in *Oreochromis niloticus* was 210 millimetres (from 88mm at age one to 298mm at age five) but overall growth in *Oreochromis andersonii* was 114 millimetres (from 37mm at age one to 151mm at age five). *Oreochromis macrochir* had the least overall growth of 102 millimetres (from 33mm at age one to 135mm at age five).

There was a significant difference (p=0.0153) in the growth rates of the mouth brooding tilapiines of the Kafue Floodplain fishery. This means that the growth rates of mouth brooding tilapiines are statistically different. The data that were used for One-way Analysis of Variance using Statistix 9 software (Analytical software, 2009) is given in Appendix 2. The ANOVA table (Table 4.3) is given below.

Table 4.3: ANOVA results on growth rates of mouth brooding tilapiines of the Kafue Floodplain fishery

One-Way AOV for: OA OM ON

Source	DF	SS	MS	F	P
Between	2	42704.4	21352.2	6.04	0.0153
Within	12	42447.2	3537.3		
Total	14	85151.6			

The least significant difference (LSD) conducted on the growth rates to find the mean growth rate which is different from the others gave the results in Table 4.4.

Table 4.4: LSD results on growth rates of mouth brooding tilapiines of the Kafue Floodplain fishery.

LSD All-Pairwise Comparisons Test

Variable	Mean	Homogeneous Groups
ON	204.60	A
OA	97.200	B
OM	86.400	B

Alpha 0.05 Standard Error for Comparison 37.615

Critical T Value 2.179 Critical Value for Comparison 81.957

The results of the least significant difference comparisons show that the mean growth rate of *Oreochromis niloticus* was significantly different (P=0.0153) from the mean growth rates of *Oreochromis andersonii* and *Oreochromis macrochir*. The mean growth rates of *Oreochromis andersonii* and *Oreochromis macrochir* were statistically similar. The mean growth rate of *Oreochromis niloticus* was the largest (204.6mm) implying that it was the fastest growing mouth brooding tilapiine in the Kafue Floodplain fishery. The mean growth rate of *Oreochromis macrochir* was the smallest (86.4mm). The small mean growth rate of *Oreochromis macrochir* means that *Oreochromis macrochir* was the least growing mouth brooding tilapiine in the Kafue Floodplain fishery.

Linear regression of ages and total lengths of the mouth brooding tilapiines in Table 4.2 showed that the relationship between age and total length of *Oreochromis andersonii* and *Oreochromis macrochir* were similar. The linear equation that represents the relationship between age and total length in *Oreochromis niloticus* is: total length= 48+52age. The linear equation for *Oreochromis andersonii* is: total length=12+28age. The relationship between age (years) and total length (mm) in *Oreochromis macrochir* has a linear equation of total length=80+26age. The linear equations show that the gradients of *Oreochromis andersonii*, *Oreochromis macrochir* and *Oreochromis niloticus* are: 28, 26 and 52, respectively.

The total lengths obtained using the von Bertalanffy growth equation that are given in Table 4.2 were used to plot the von Bertalanffy growth curves shown in Figure 4.1.

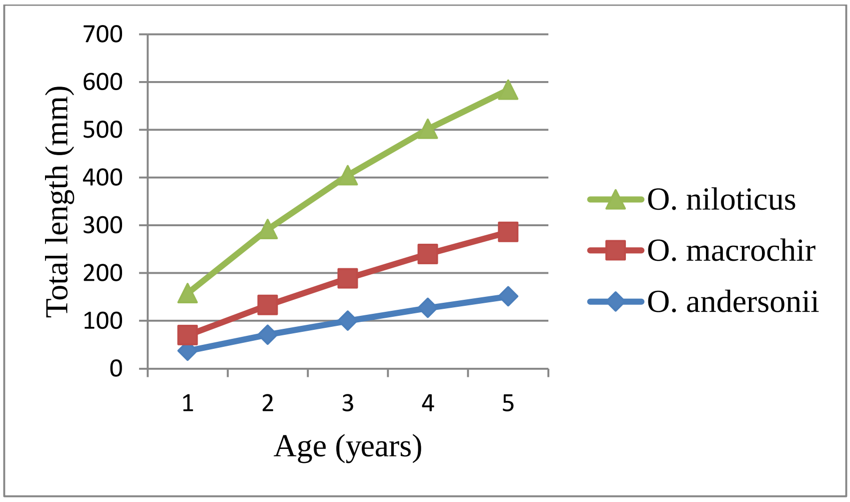

Figure 4.1: Growth curves of mouth brooding tilapiines of the Kafue Floodplain fishery

The graphs in figure 4.1 show that the growth curves of *Oreochromis andersonii* and *Oreochromis macrochir* are similar but less steep than the growth curve of *Oreochromis niloticus*. This is because the growth coefficients of *Oreochromis andersonii* (k=0.11) and *Oreochromis macrochir* (k=0.10) are similar.

4.3 Growth coefficients of fish at study sites

The growth coefficients and asymptotic lengths of the three mouth brooding tilapiines at the study sites are given in Table 4.5.

Table 4.5: Asymptotic lengths and growth coefficients of mouth brooding tilapiines at the Study sites.

Species	Asymptotic length in millimetres (L∞)			Growth coefficient (k)		
	Kafue Road bridge	Namalyo	Kakuzu	Kafue Road bridge	Namalyo	Kakuzu
Oreochromis andersonii	414	358	314	0.25	0.16	0.10
Oreochromis macrochir	402	344	304	0.24	0.12	0.08
Oreochromis niloticus	612	383	355	0.48	0.30	0.12

The asymptotic lengths of mouth brooding tilapiines at the study sites were different amongst themselves. Kafue Road Bridge tilapiines had a mean asymptotic length of 476 millimetres while Kakuzu had a mean asymptotic length of 324 millimetres. Namalyo had a mean asymptotic length of 362 millimetres. *Oreochromis macrochir* showed the smallest asymptotic length (304mm) at Kakuzu among all the three species at the three study sites while *Oreochromis niloticus* had the largest asymptotic length (612mm) at Kafue Road Bridge. *Oreochromis andersonii* had a peak asymptotic length of 414 millimetres at Kafue

Road Bridge. *Oreochromis macrochir* had the smallest average asymptotic length (350mm) because it is the smallest mouth brooding tilapiine in the Kafue Floodplain fishery. *Oreochromis niloticus* had a mean asymptotic length of 450 millimetres while *Oreochromis andersonii* had an average asymptotic length of 362 millimetres. *Oreochromis macrochir* had a mean asymptotic length of 350 millimetres.

There was no significant difference (p=0.397) among the mean asymptotic lengths of the mouth brooding tilapiines at the three study sites. The data that were used for this analysis is given in Appendix 7.3. The ANOVA table for this analysis is given in Table 4.6.

Table 4.6: ANOVA results of asymptotic lengths of mouth brooding tilapiines at the Study sites.

One-Way AOV for: OA OM ON

Source	DF	SS	MS	F	P
Between	2	17888.0	8944.00	1.08	0.3972
Within	6	49638.0	8273.00		
Total	8	67526.0			

Growth coefficients of mouth brooding tilapiines at the three study sites were similar, especially between the two indigenous mouth brooding tilapiines. *Oreochromis niloticus* had the largest growth coefficient at all three stations (k=0.48) while *Oreochromis macrochir* had the smallest growth coefficient (k=0.08).

There was no significant difference (p=0.32) among the growth coefficients of the three mouth brooding tilapiines (Table 4.7) at the three study sites. The data that were used for One-way Analysis of Variance using Statistix 9 software is given in Appendix 4. The ANOVA table for this analysis is given in Table 4.7.

Table 4.7: ANOVA results of growth coefficients of mouth brooding tilapiines at the Study sites

One-Way AOV for: OA OM ON

Source	DF	SS	MS	F	P
Between	2	0.04096	0.02048	1.36	0.3248
Within	6	0.09007	0.01501		
Total	8	0.13102			

There was no significant difference (P=0.32) among the growth coefficients of mouth brooding tilapiines at the study sites. *Oreochromis niloticus* had the largest mean growth coefficient while *Oreochromis macrochir* had the smallest mean growth coefficient. The mean growth coefficients of *Oreochromis andersonii*, *Oreochromis macrochir* and *Oreochromis niloticus* were 0.17, 0.15 and 0.3.

4.3.1 Fish growth rates at Kafue Road Bridge

The growth rates of the three mouth brooding tilapiines that were obtained using the von Bertalanffy growth equation at Kafue Road Bridge are given in Table 4.8. The values in the table show that *Oreochromis niloticus* has the largest growth rate among the three mouth brooding tilapiines at Kafue Road Bridge.

Table 4.8: Growth rates of mouth brooding tilapiines at Kafue Road Bridge

Oreochromis andersonii		*Oreochromis macrochir*		*Oreochromis niloticus*	
Age (years)	Total length (mm)	Age (years)	Total length (mm)	Age (years)	Total length (mm)
1	92	1	86	1	233
2	163	2	153	2	378
3	218	3	206	3	467
4	262	4	248	4	522

The growth rates of the mouth brooding tilapiines show that *Oreochromis macrochir* was the slowest grower among the three tilapiines, with a length increment of 67 millimetres between age one and age two (from 86mm at age one to 153mm at age two). In the same period, *Oreochromis niloticus* grew by 145 millimetres (from 233 at age one to 378mm at age two). *Oreochromis andersonii* grew by 71 millimetres (from 92mm at age one to 163mm at age two). Overall growth in *Oreochromis niloticus* during the four-year period was the highest at 323 millimetres (from 233mm at age one to 522mm at age four) followed by *Oreochromis andersonii* with an overall growth of 170 millimetres (from 92mm at age one to 262mm at age four) during the four-year period. *Oreochromis macrochir* recorded an overall growth of 162 millimetres (from 86mm at age one to 248mm at age four) during the four-year period.

One-way Analysis of Variance showed a significant difference (p=0.0121) among the growth rates of the three mouth brooding tilapiines at Kafue Road Bridge (Table 4.9). The data that were used for this analysis is given in Appendix 5.

Table 4.9: ANOVA results of fish growth at Kafue Road Bridge

One-Way AOV for: OA OM ON

Source	DF	SS	MS	F	P
Between	2	131053	65526.6	7.51	0.0121
Within	9	78574	8730.4		
Total	11	209627			

The Least Significant Difference (LSD) test results are given in table 4.10.

Table 4.10: LSD results of fish growth at Kafue Road Bridge

LSD All-Pairwise Comparisons Test

Variable	Mean	Homogeneous Groups
ON	400.00	A
OA	183.75	B
OM	173.25	B

Alpha 0.05 Standard Error for Comparison 66.070

Critical T Value 2.262 Critical Value for Comparison 149.46

These results show that the mean growth rate of *Oreochromis niloticus* (group A) was statistically different from the mean growth rate of *Oreochromis andersonii* (group B) and *Oreochromis macrochir* (group B). The mean group rate of *Oreochromis andersonii* and the mean growth rate of *Oreochromis macrochir* are statistically similar because they are in the same group. The Least Significant Difference test also showed that *Oreochromis niloticus* had the largest mean growth rate (400mm) while *Oreochromis macrochir* had the least growth rate (173.25mm). *Oreochromis andersonii* had a mean growth rate of 183.75 millimetres.

Linear regression of ages and total lengths of the mouth brooding tilapiines in table 4.8 showed that the relationship between age and total length of *Oreochromis andersonii* and *Oreochromis macrochir* were similar. The linear equation that represents the relationship between age and total length in *Oreochromis niloticus* is: total length= 161+96age. The linear equation for *Oreochromis andersonii* is: total length =43+57age. The relationship between age (years) and total length (mm) in *Oreochromis macrochir* has a linear equation of total length=39+54age. The linear equations show that the gradients of *Oreochromis andersonii*, *Oreochromis macrochir* and *Oreochromis niloticus* are: 57, 54 and 96, respectively.

The growth rates in Table 4.8 above were used to plot the von Bertalanffy growth curves shown in Figure 4.2.

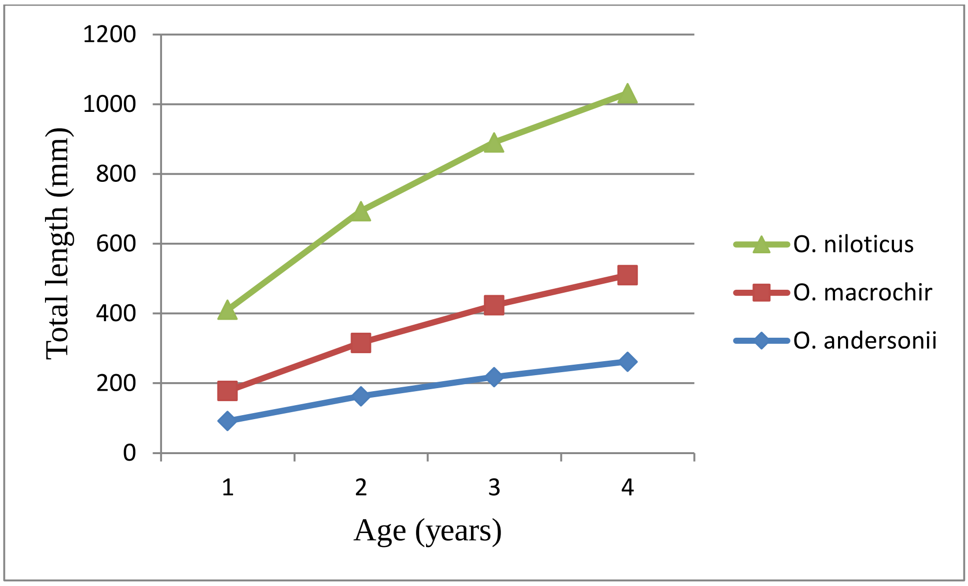

Figure: 4.2: Growth curves of mouth brooding tilapiines at Kafue Road Bridge.

The growth curves of *Oreochromis andersonii* and *Oreochromis macrochir* shown in Figure 4.2 above are similar but less steep than the growth curve of *Oreochromis niloticus*. The growth curves in Figure 4.3 also show that growth in the three mouth brooding tilapiines is fastest between ages one to three and slowest between age three to four.

4.3.2 Fish growth rates at Namalyo

The growth rates of mouth brooding tilapiines that were obtained using the von Bertalanffy growth equation at Namalyo are given in Table 4.11.

Table 4.11: Growth rates of mouth brooding tilapiines at Namalyo

Oreochromis andersonii		*Oreochromis macrochir*		*Oreochromis niloticus*	
Age (years)	Total length (mm)	Age (years)	Total length (mm)	Age (years)	Total length (mm)
1	53	1	39	1	99
2	98	2	73	2	173
3	136	3	104	3	227
4	169	4	131	4	268
5	197	5	155	5	298

Oreochromis niloticus was the fastest growing mouth brooding tilapiine at Namalyo, attaining a mean total length of 298 millimetres by age five, compared to *Oreochromis andersonii* that had a mean total length of 197 millimetres by age five. *Oreochromis macrochir* had the smallest total length of 155 millimetres by age five. *Oreochromis niloticus* grew by 74 millimetres from age one to age two (from 99mm at age one to 173mm at age two) while *Oreochromis macrochir* grew by 34 millimetres from age one to age two (from 39mm at age one to 73mm at age two). *Oreochromis andersonii* grew by 45 millimetres from age one to age two (from 53mm at age one to 98mm at age two). The overall growth in *Oreochromis niloticus* was 199 millimetres (from 99mm at age one to 298mm at age five). The overall growth in *Oreochromis macrochir* was 116 millimetres (from 39mm at age one to 155mm at age five). *Oreochromis andersonii* had an overall growth of 144 millimetres (from 53mm at age one to 197mm at age five).

There was a significant difference (Table 4.12) among the growth rates of mouth brooding tilapiines at Namalyo (P=0.0372). The data that were used for One-way Analysis of Variance using Statistix 9 software is given in Appendix 6.

Table 4.12: ANOVA results of fish growth at Namalyo

One-Way AOV for: OA OM ON

Source	DF	SS	MS	F	P
Between	2	33967.6	16983.8	4.38	0.0372
Within	12	46490.4	3874.2		
Total	14	80458.0			

The Least Significant Difference (LSD) conducted on the means of growth rates of the mouth brooding tilapiines at Namalyo using Statistix 9 software (Table 4.13) showed that the mean total length of *Oreochromis andersonii* (group AB) was statistically similar to the mean total length of *Oreochromis macrochir* (group B) and *Oreochromis niloticus* (group A). The mean total length of *Oreochromis macrochir* (100.4mm) was statistically different from the mean total length of *Oreochromis niloticus* (213mm).

Table 4.13: LSD results of fish growth at Namalyo

LSD All-Pairwise Comparisons Test

Variable	Mean	Homogeneous Groups
ON	213.00	A
OA	130.60	AB
OM	100.40	B

Alpha 0.05 Standard Error for Comparison 39.366

Critical T Value 2.179   Critical Value for Comparison 85.771

The linear equation that represents the relationship between age (Table 4.11) and total length in *Oreochromis niloticus* is: total length= 65+49age. The linear equation for *Oreochromis andersonii* is: total length =23+36age. The relationship between age (years) and total length (mm) in *Oreochromis macrochir* has a linear equation of total length=13+29age. The linear equations show that the gradients of *Oreochromis andersonii*, *Oreochromis macrochir* and *Oreochromis niloticus* are: 36, 29 and 49, respectively.

The total lengths in Table 4.11 were used to generate the von Bertalanffy growth curves shown in Figure 4.3.

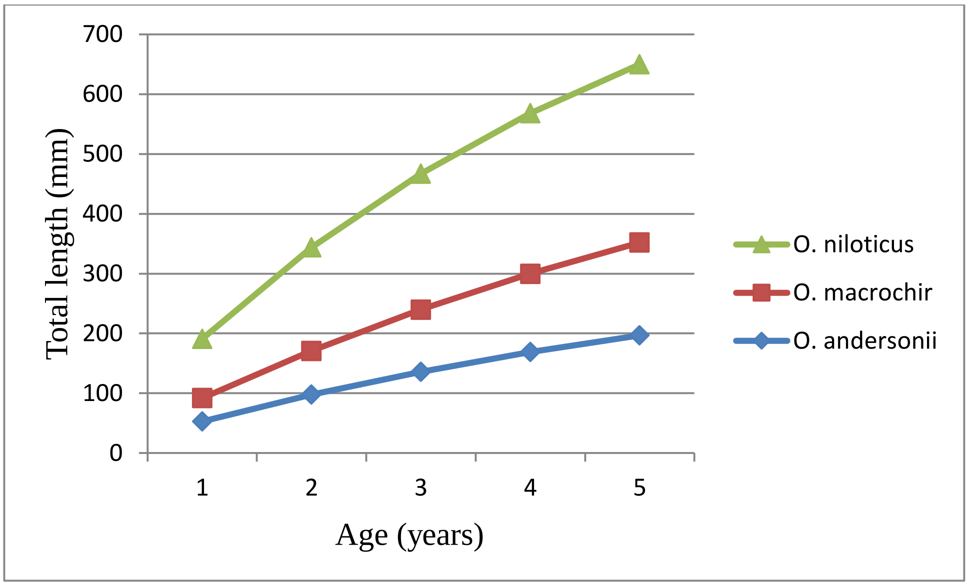

Figure 4.3: Growth curves of mouth brooding tilapiines at Namalyo.

The growth curves of *Oreochromis andersonii* and *Oreochromis macrochir* shown in Figure 4.3 are similar but less steep than the growth curve of *Oreochromis niloticus*.

4.3.3 Fish growth rates of fish at Kakuzu

The growth rates of mouth brooding tilapiines that were obtained using the von Bertalanffy growth equation at Kakuzu are given in Table 4.14.

Table 4.14: Growth rates of mouth brooding tilapiines at Kakuzu.

Oreochromis andersonii		*Oreochromis macrochir*		*Oreochromis niloticus*	
Age (years)	Total length (mm)	Age (years)	Total length (mm)	Age (years)	Total length (mm)
1	30	1	23	1	40
2	57	2	45	2	76
3	81	3	65	3	107
4	104	4	83	4	135
5	124	5	100	5	160

Total lengths of mouth brooding tilapiines at Kakuzu showed that *Oreochromis niloticus* attained the longest length (160mm total length at age five). *Oreochromis macrochir* grew to a maximum of 100 millimetres total length. *Oreochromis niloticus* grew by 36 millimetres between age one and age two (from 40mm at age one to 76mm at age two). *Oreochromis macrochir* grew by 22 millimetres between age one and age two (from 23mm at age one to 45mm at age two). *Oreochromis andersonii* grew by 27 millimetres between age one and age two (from 30mm at age one to 57mm at age two). Overall growth in *Oreochromis niloticus* in five years was 120 millimetres (from 40mm at age one to 160mm at age five). *Oreochromis andersonii* had an overall growth of 94 millimetres in five years (from 30mm at age one to 124mm at age five) while *Oreochromis macrochir* grew by 77 millimetres in five years (from 23mm at age one to 100mm at age five).

There was no significant difference (P=0.29) among the growth rates of mouth brooding tilapiines at Kakuzu. This means that the total lengths of the three mouth brooding tilapiines at different ages (in years) are statistically similar. The data that were used for One-way Analysis of Variance (Table 4.15) are given in Appendix 7.

Table 4.15: ANOVA results of fish growth at Kakuzu.

One-Way AOV for: OA OM ON

Source	DF	SS	MS	F	P
Between	2	4139.2	2069.60	1.36	0.2928
Within	12	18220.8	1518.40		
Total	14	22360.0			

The linear equation that represents the relationship between age and total length (Table 4.14) in *Oreochromis niloticus* is: total length= 14+30age. The linear equation for *Oreochromis andersonii* is: total length =9+24age. The relationship between age (years) and total length (mm) in *Oreochromis macrochir* has a linear equation of total length=6+19age. The linear equations show that the gradients of *Oreochromis andersonii*, *Oreochromis macrochir* and *Oreochromis niloticus* are: 24, 19 and 30, respectively.

The total lengths in Table 4.14 were used to generate the von Bertalanffy growth curves shown in Figure 4.4.

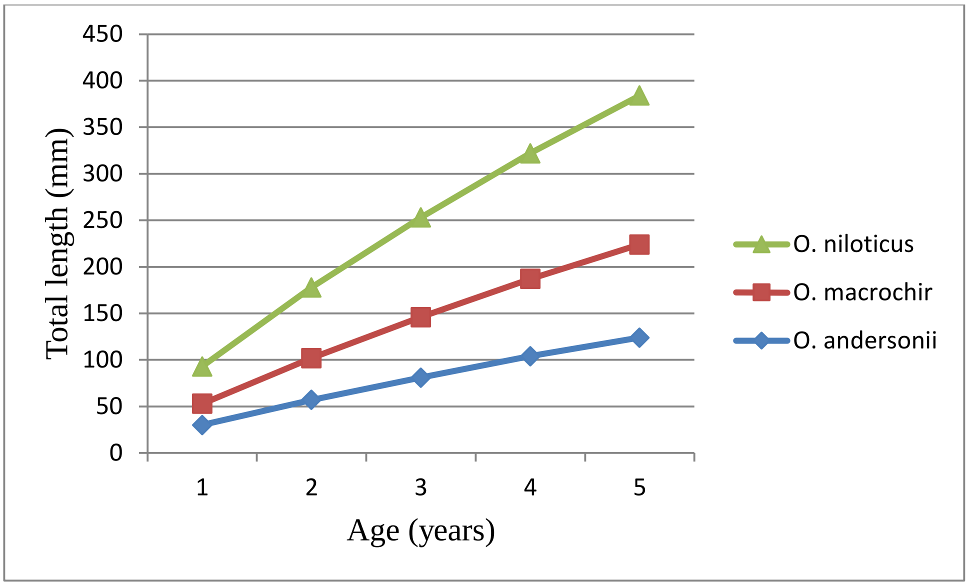

Figure 4.4: Growth curves of mouth brooding tilapiines at Kakuzu.

The growth curves of *Oreochromis andersonii* and *Oreochromis macrochir* are similar but less steeper than the growth curve of *Oreochromis niloticus*.

4.4 Fish mortality variables of the Kafue Floodplain fishery

Mortality variables that were obtained using the Beverton-Holt method were very similar to total mortality values that were obtained using linearised catch curves (Table 4.16). Natural mortality values were generally smaller than fishing mortality values.

Table 4.16: Mortality variables of mouth brooding tilapiines of the Kafue Floodplain fishery

Species	Natural Mortality (M)	Fishing Mortality (F)	Total mortality (Z)	
			Beverton-Holt	Linearised Catch curve
Oreochromis andersonii	0.49	0.21	0.7	0.64
Oreochromis macrochir	0.53	1.24	1.77	1.52
Oreochromis niloticus	0.68	0.45	1.13	0.82

Similar natural mortality variables were observed among the mouth brooding tilapiines. The least natural mortality coefficient was for *Oreochromis andersonii* (0.49). *Oreochromis niloticus* had the largest natural mortality coefficient (0.68), while *Oreochromis macrochir* had a natural mortality coefficient of 0.53 (Table 4.16). Fishing mortality values ranged from 0.21 for *Oreochromis andersonii* to 1.24 for *Oreochromis macrochir* (Table 4.16). Fishing mortality was largest in the small-sized *Oreochromis macrochir* (1.24). Total mortality parameters ranged from 0.7 in *Oreochromis andersonii* to 1.77 in *Oreochromis macrochir*.

4.4.1. Fish mortality variables at Kafue Road Bridge

The mouth brooding tilapiines showed similar fishing mortality variables at Kafue Road Bridge (Table 4.17).

Table 4.17: Mortality variables of mouth brooding tilapiines at Kafue Road Bridge.

Species	Natural Mortality (M)	Fishing Mortality (F)	Total mortality (Z)	
			Beverton-Holt	Linearised catch curve
Oreochromis andersonii	1.56	0.67	2.23	1.83
Oreochromis macrochir	0.41	0.73	1.14	0.86
Oreochromis niloticus	2.12	0.909	3.03	2.67

Fishing mortality values at Kafue Road Bridge ranged from 0.67 to 0.909. Fishing mortality was largest in *Oreochromis niloticus.* Fishing mortality values were similar in *Oreochromis andersonii* (0.67) and *Oreochromis macrochir* (0.73). Natural mortality variables ranged from 0.41 in *Oreochromis macrochir* to 2.12 in *Oreochromis niloticus*.

Linearised catch curves method gave lower values of total mortality parameters than the Beverton-Holt method at Kafue Road Bridge. The largest total mortality value obtained using the Beverton-Holt method was 3.03 in *Oreochromis niloticus* but the linearised catch method gave a peak value of 2.67 in *Oreochromis niloticus*. The least total mortality coefficient was 0.86 in *Oreochromis macrochir* using the linearised catch curve method but the Beverton-Holt method gave a least total mortality coefficient of 1.14 in *Oreochromis macrochir*.

4.4.2 Fish Mortality variables at Namalyo

The mortality variables of mouth brooding tilapiines at Namalyo are given in Table 4.18.

Table 4.18: Mortality variables of mouth brooding tilapiines at Namalyo

Species	Natural Mortality (Z)	Fishing Mortality (F)	Total mortality (Z)	
			Beverton-Holt	Linearised Catch curve
Oreochromis andersonii	0.398	0.265	0.663	0.57
Oreochromis macrochir	0.37	0.87	1.24	0.86
Oreochromis niloticus	0.5	0.8	1.3	0.9

Natural mortality variables varied from a low of 0.37 in *Oreochromis macrochir* to 0.5 in *Oreochromis niloticus* at Namalyo. Fishing mortality was largest in *Oreochromis macrochir* (0.87) and smallest in *Oreochromis andersonii* (0.27). The natural mortality was similar between *Oreochromis andersonii* (0.398) and *Oreochromis macrochir* (0.37).

4.4.3 Fish mortality variables at Kakuzu

The mortality variables of mouth brooding tilapiines at Kakuzu are given in Table 4.19.

Table 4.19: Mortality variables of mouth brooding tilapiines at Kakuzu.

Species	Natural mortality (M)	Fishing mortality (F)	Total mortality (Z)	
			Beverton-Holt	Linearised Catch curve
Oreochromis andersonii	0.89	0.38	1.27	0.786
Oreochromis macrochir	0.212	0.638	0.85	0.76
Oreochromis niloticus	0.787	0.523	1.31	0.69

Natural mortality variables were similar in *Oreochromis andersonii* (0.32) and *Oreochromis macrochir* (0.212) but different from *Oreochromis niloticus* (0.787). Fishing mortality was largest in *Oreochromis macrochir* (0.638) but smallest in *Oreochromis andersonii* (0.38).

4.5 Exploitation levels

4.5.1 Exploitation ratios of fish of the Kafue Floodplain fishery

Exploitation ratios of the three mouth brooding tilapiines in the Kafue Floodplain fishery are given in Table 4.20.

Table 4.20: Exploitation ratios of mouth brooding tilapiines of the Kafue Floodplain fishery

Species	Exploitation ratio (E)
Oreochromis andersonii	0.3
Oreochromis macrochir	0.7
Oreochromis niloticus	0.4

The exploitation ratios ranged from 0.3 to 0.7. Both *Oreochromis andersonii* (Exploitation ratio=0.3) and *Oreochromis niloticus* (Exploitation ratio=0.4) were known to be under-exploited but *Oreochromis macrochir* (Exploitation ratio=0.7) was over-exploited.

4.5.2 Fish exploitation ratios at the study sites

Exploitation ratios of the three mouth brooding tilapiines at all three study sites are given in Table 4.21.

Table 4.21: Exploitation ratios of mouth brooding tilapiines at the study sites

Species	Exploitation ratio (E)		
	Kafue road bridge	Namalyo	Kakuzu
Oreochromis andersonii	0.3	0.4	0.3
Oreochromis macrochir	0.64	0.7	0.75
Oreochromis niloticus	0.3	0.6	0.4

The exploitation ratios range from 0.3 in *Oreochromis andersonii* and *Oreochromis niloticus* at Kakuzu and Kafue Road Bridge to 0.75 at Kakuzu in *Oreochromis macrochir*. Average exploitation ratios at Kafue Road Bridge, Namalyo and Kakuzu were 0.413, 0.567 and 0.583 respectively.

Average exploitation ratios among the three mouth brooding tilapiines were similar, but *Oreochromis andersonii* gave a smaller mean exploitation ratio of 0.33 while *Oreochromis macrochir* had an above-optimum exploitation ratios of 0.7.

There was a significant difference (Table 4.22) among the exploitation ratios of mouth brooding tilapiines at the study sites (P=0.0148). The data that were used for One-way Analysis of Variance is given in Appendix 8.

Table 4.22: ANOVA results of exploitation ratios of mouth brooding tilapiines at the study sites

One-Way AOV for: OA OM ON

Source	DF	SS	MS	F	P
Between	2	0.18269	0.09134	9.23	0.0148
Within	6	0.05940	0.00990		
Total	8	0.24209			

The Least Significant Difference (LSD) test conducted on the means of exploitation ratios of the mouth brooding tilapiines at the study sites are given in Table 4.23.

Table 4.23: LSD results of exploitation ratios of mouth brooding tilapiines at the study sites

LSD All-Pairwise Comparisons Test

Variable	Mean	Homogeneous Groups
OM	0.6967	A
ON	0.4333	B
OA	0.3667	B

Alpha 0.05 Standard Error for Comparison 0.0812

Critical T Value 2.447 Critical Value for Comparison 0.1988

The LSD results showed that the mean exploitation ratio of *Oreochromis andersonii* (group B) was statistically similar to the mean exploitation ratio of *Oreochromis niloticus* (group B). The mean exploitation ratios of *Oreochromis andersonii* and *Oreochromis niloticus* were 0.4333 and 0.3667. The mean exploitation ratio of *Oreochromis macrochir* (0.6967) was statistically different from the mean exploitation ratios of *Oreochromis andersonii* and *Oreochromis niloticus*.

CHAPTER 5: DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Growth

This study found that *Oreochromis niloticus* is the fastest grower among the mouth brooding tilapiines of the Kafue Floodplain fishery. These results are in conformity with the studies of Peterson, *et al*., (2002), Zambia Department of Fisheries report (2008) and Chikopela, *et al*., (2011) which revealed that *Oreochromis niloticus* grows very fast and attains adulthood quickly. The results of this study on the fast growth of *Oreochromis niloticus* relative to local tilapiines is also consistent with international studies carried out by the Food and Agriculture Organisation (2010) in major African lakes of East Africa and West Africa.

The fast growth of *Oreochromis niloticus* relative to other mouth brooding tilapiines of the Kafue Floodplain fishery is attributed to the fact that *Oreochromis niloticus* is very adaptive, hardy and it is able to colonise a wide range of habitats (Schwank, 1994). The adaptation was seen in the large growth coefficient of *Oreochromis niloticus* compared to the indigenous mouth brooding tilapiines of the Kafue Floodplain fishery. *Oreochromis niloticus* had a higher growth coefficient than the indigenous mouth brooding tilapiines due to its adaptive nature.

The growth coefficients and asymptotic lengths of mouth brooding tilapiines that were found in this research were slightly lower than those that were found by Chikopela, *et al*., (2011) and Schwank (1994) owing to the time in which the study was conducted. The results of Chikopela, *et al*., (2011) were obtained during the rainy season while Schwank (1994) conducted the research throughout the year. Chikopela, *et al*., (2011) and Schwank (1994) obtained growth coefficients of 0.3 and 0.4 in *Oreochromis niloticus*. The reduction in fish growth in the Kafue Floodplain fishery was also observed by Schelle and Pittock (2005) who attributed the reduction in fish growth to the reduction in flood duration and extent of flooding in the Kafue Floodplain fishery. Schelle and Pittock (2005) observed that the reduction flood duration and extent of flooding in the Kafue Floodplain fishery reduces food resources for fish and consequently leads to reduction in fish growth.

5.1.2 Mortality

Natural mortality variables that were found in this research were slightly higher than those obtained by Schwank (1994). This could be attributed to the general increase in surface temperature which is making the habitat loosely unbearable for mouth brooding tilapiines of the Kafue Floodplain fishery. The mean surface temperature of the Kafue Floodplain fishery has increased from a mean of 24˚C (Carey, 1971) to a mean of 27˚C (Smardon, 2009). Studies by Pauly (1980) on One Hundred and Seventy Five fish stocks in the Caribbean also showed a correlation between increase in surface temperature and increase in natural mortality.

Natural mortality coefficients obtained were generally larger than fishing mortalities. The larger contribution of natural mortality can be attributed to the changed habitat in the Kafue Floodplain fishery because dam construction promotes growth of weeds such as *Eichhornia crassipes* and *Salvinia molesta* at the lower end which is permanently denudated while the upper end of the Kafue Floodplain fishery that is dry has less nesting grounds for fish Ellenbroek (1987). The high natural mortality results relative to fishing mortality results confirm the pre-dam prediction by Carey and Bell-Cross (1967) which stated that dam construction along the course of the Kafue River would cause a natural mortality of 92% compared to a fishing mortality of about 8%. Carey and Bell-Cross (1967) predicted reduced flooding after dam construction which could make the Kafue Floodplain fishery less favourable for fish especially mouth brooding tilapiines that require a well-sheltered littoral zone. Nyimbili (2006) also found higher natural mortality coefficients relative to fishing mortality coefficients and concluded that the reduction in surface area of the Kafue Floodplain fishery due to drying up of about 1, 500km^2 is the main contributing factor to the larger natural mortality relative to fishing mortality. Nyimbili (2006) observed that during the artificial flooding in the Kafue Floodplain which occurs around April when the Itezhi-tezhi dam is opened, fish is concentrated in pools making them vulnerable to predatory fish and birds hence the large natural mortality relative to fishing mortality. Other environmental factors such as chemical modification of the water in the Kafue Floodplain fishery could also explain the high natural mortality relative to fishing mortality. Smardon (2009) observed that industrial activities and agricultural activities in the Kafue Floodplain catchment area is responsible for a water concentration of 68mg/l to 220mg/l of dissolved solids in the Kafue Floodplain fishery which increase natural mortality of fishes in the Kafue Floodplain fishery.

The fishing mortality variables of mouth brooding tilapiines were however, larger than those obtained by Schwank (1994) because the number of fishers has increased over the years. The fishing mortality coefficients obtained in this study are larger than those determined by Mortimer (1965) because of strict regulations at present. Legislation was not so rigid at the time of Mortimer's study so fishers were using many types of fishing gear throughout the year leading to high fishing mortality.

Total mortality variables obtained in this study agree with those obtained by Mbewe (2006). Both studies have shown that total mortality variables of mouth brooding tilapiines of the Kafue Floodplain fishery are generally above 0.5. The results of these two studies however, differ in that Mbewe (2006) established that the main contribution to total mortality was fishing while this study has found that natural mortality contributes more than fishing mortality. This difference in results could be attributed to differences in techniques used in the study. Mbewe (2006) used the catch-per-unit effort method while this study used length-based fish stock assessment methods.

5.1.3 Exploitation

The research established that *Oreochromis macrochir* is over-exploited in the Kafue Floodplain fishery. Over-exploitation is consistent with studies done by William (1960), Muncy (1976) and Mbewe (2006). The Department of fisheries report (1993) on the Kafue Floodplain fishery, and Food and Agriculture Organisation Fisheries report (2010) on thirteen medium-sized fisheries in Africa, Kafue Floodplain fishery inclusive, showed that most fishes of the Kafue Floodplain fishery are being over-exploited. The under-exploitation of *Oreochromis niloticus* in the Kafue Floodplain fishery can be attributed to the fast growth of this mouth brooding tilapiine which makes it less vulnerable to the legally-recommended fishing gear. The Food and Agriculture Organisation fisheries report (2010) also established that invasive species are normally under-exploited in most African countries. Exploitation ratios of *Oreochromis macrochir* at all study sites were all above the optimum value (0.5). Over-exploitation of *Oreochromis macrochir* is consistent with the results of Haller and Marten (2008) who correlated increase in exploitation to change in the ecology of the Kafue Floodplain fishery.

5. 2 Conclusions

1. Growth rates of important mouth brooding tilapiines of the Kafue Floodplain fishery were determined. It was found that *Oreochromis niloticus* grows the fastest among the three mouth brooding tilapiines of the Kafue Floodplain fishery. Between the indigenous mouth brooding tilapiines, *Oreochromis andersonii* grows faster than *Oreochromis macrochir*.
2. Mortality variables of mouth brooding tilapiines of the Kafue Floodplain fishery were established. *Oreochromis macrochir* had the largest fishing mortality and total mortality while *Oreochromis andersonii* had the smallest fishing mortality and total mortality. *Oreochromis niloticus*, had the second largest fishing mortality and total mortality.

3. Exploitation ratios of mouth brooding tilapiines of the Kafue Floodplain fishery were determined. It is concluded that the observed decrease in fish catches from the Kafue Floodplain fishery is not due to over-exploitation but may be due to inefficient fishing gear or changed habitat that has increased natural mortality.

This research yielded information regarding the most vulnerable tilapiine fish species in the Kafue Floodplain fishery, based on mortality values.

5.3 Recommendations

The following are the recommendations based on the results of the study:

- Fast growing fish species like *Oreochromis niloticus* should be promoted in order to increase the productivity of the Kafue Floodplain fishery.

- Since exploitation is higher in the indigenous mouth brooding tilapiines than in the exotic *Oreochromis niloticus*, harvesting of indigenous mouth brooding tilapiines must be discouraged in order to prevent them from getting extinct.

- Future studies on growth of mouth brooding tilapiines of the Kafue Floodplain fishery should be conducted over a long period of time in order to study growth of mouth brooding tilapiines in different seasons and age groups.

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APPENDICES

Appendix 1: Research study results

Fishery area: Kafue Floodplain fishery. Fish sampling method: gill netting

Average temperature: 22.3˚c

No.	Date	STN	Species	Mesh	Length (mm)		Wt	Age
				size	Std	Tot	(g)	
1	26.09.15	I	*Oreochromis andersonii*	4"	237	289	535	3
2	26.09.15	I	*Oreochromis andersonii*	4"	378	223	938	4
3	26.09.15	I	*Oreochromis andersonii*	4"	221	279	461	3
4	26.09.15	I	*Oreochromis andersonii*	4"	260	300	620	4
5	26.09.15	I	*Oreochromis andersonii*	4"	227	279	426	3
6	26.09.15	I	*Oreochromis andersonii*	4"	232	287	371	2
7	26.09.15	I	*Oreochromis andersonii*	4"	249	305	456	3
8	26.09.15	I	*Oreochromis andersonii*	4"	210	268	319	2
9	26.09.15	I	*Oreochromis andersonii*	4"	267	312	639	4
10	26.09.15	I	*Oreochromis andersonii*	4"	232	282	526	4
11	26.09.15	I	*Oreochromis andersonii*	4"	237	270	480	3
12	26.09.15	I	*Oreochromis andersonii*	4"	231	278	495	3
13	26.09.15	I	*Oreochromis andersonii*	4"	357	393	850	4
14	26.09.15	I	*Oreochromis andersonii*	4"	282	327	775	4
15	26.09.15	I	*Oreochromis andersonii*	4"	231	277	382	2
16	26.09.15	I	*Oreochromis andersonii*	4"	236	280	562	3
17	26.09.15	I	*Oreochromis andersonii*	4"	229	278	443	2
18	26.09.15	I	*Oreochromis andersonii*	4"	235	281	392	2
19	26.09.15	I	*Oreochromis andersonii*	4"	326	381	762	4
20	26.09.15	I	*Oreochromis andersonii*	4"	334	390	847	4
21	26.09.15	I	*Oreochromis andersonii*	4"	326	389	826	4
22	26.09.15	I	*Oreochromis andersonii*	4"	238	299	647	3
23	26.09.15	I	*Oreochromis andersonii*	4"	229	270	492	2
24	26.09.15	I	*Oreochromis andersonii*	4"	210	262	420	2
25	26.09.15	I	*Oreochromis andersonii*	4"	224	259	362	2
26	26.09.15	I	*Oreochromis andersonii*	4"	180	224	295	2
27	26.09.15	I	*Oreochromis andersonii*	4"	220	276	563	3
28	26.09.15	I	*Oreochromis andersonii*	4"	232	278	676	3
29	26.09.15	I	*Oreochromis andersonii*	4"	247	289	697	2
30	26.09.15	I	*Oreochromis andersonii*	4"	240	271	348	2
31	26.09.15	I	*Oreochromis andersonii*	4"	230	278	467	3
32	26.09.15	I	*Oreochromis andersonii*	4"	240	289	645	3

33	26.09.15	I	*Oreochromis andersonii*	4"	232	278	479	2
34	26.09.15	I	*Oreochromis andersonii*	4"	250	302	821	4
35	26.09.15	I	*Oreochromis andersonii*	4"	217	268	396	2
36	26.09.15	I	*Oreochromis andersonii*	4"	229	261	347	2
37	26.09.15	I	*Oreochromis andersonii*	4"	230	267	389	2
38	26.09.15	I	*Oreochromis andersonii*	4"	250	291	765	4
39	26.09.15	I	*Oreochromis andersonii*	4"	368	322	921	4
40	26.09.15	I	*Oreochromis andersonii*	4"	229	278	562	3
41	26.09.15	I	*Oreochromis andersonii*	4"	249	280	595	3
42	26.09.15	I	*Oreochromis andersonii*	4"	220	269	492	2
43	26.09.15	I	*Oreochromis andersonii*	4"	320	389	827	4
44	25.10.15	I	*Oreochromis andersonii*	4"	367	323	925	4
45	25.10.15	I	*Oreochromis andersonii*	4"	321	391	825	4
46	25.10.15	I	*Oreochromis andersonii*	4"	236	282	395	3
47	25.10.15	I	*Oreochromis andersonii*	4"	240	272	352	3
48	25.10.15	I	*Oreochromis andersonii*	4"	378	325	941	4
49	25.10.15	I	*Oreochromis andersonii*	4"	267	315	652	3
50	25.10.15	I	*Oreochromis andersonii*	4"	282	334	778	3
51	25.10.15	I	*Oreochromis andersonii*	4"	249	302	463	3
52	25.10.15	I	*Oreochromis andersonii*	4"	173	218	282	2
53	25.10.15	I	*Oreochromis andersonii*	4"	236	286	537	3
54	25.10.15	I	*Oreochromis andersonii*	4"	211	267	321	3
55	25.10.15	I	*Oreochromis andersonii*	4"	231	272	496	3
56	25.10.15	I	*Oreochromis andersonii*	4"	352	307	852	4
57	25.10.15	I	*Oreochromis andersonii*	4"	180	223	296	2
58	25.10.15	I	*Oreochromis andersonii*	4"	240	269	351	3
59	25.10.15	I	*Oreochromis andersonii*	4"	221	276	558	3
60	25.10.15	I	*Oreochromis andersonii*	4"	282	327	775	3
61	25.10.15	I	*Oreochromis andersonii*	4"	232	278	528	3
62	25.10.15	I	*Oreochromis andersonii*	4"	175	215	196	2
63	25.10.15	I	*Oreochromis andersonii*	4"	368	322	924	4
64	25.10.15	I	*Oreochromis andersonii*	4"	218	265	398	3
65	25.10.15	I	*Oreochromis andersonii*	Tremmel	229	275	564	3
66	25.10.15	I	*Oreochromis andersonii*	Tremmel	221	268	493	3
67	25.10.15	I	*Oreochromis andersonii*	Tremmel	227	269	428	3
68	29.11.15	I	*Oreochromis andersonii*	Tremmel	231	276	495	3
69	29.11.15	I	*Oreochromis andersonii*	Tremmel	235	281	393	3
70	29.11.15	I	*Oreochromis andersonii*	Tremmel	249	304	456	3
71	29.11.15	I	*Oreochromis andersonii*	4"	247	298	665	3
72	29.11.15	I	*Oreochromis andersonii*	4"	228	282	390	2
73	29.11.15	I	*Oreochromis andersonii*	4"	176	219	181	2
74	29.11.15	I	*Oreochromis andersonii*	4"	196	243	261	2

75	29.11.15	I	*Oreochromis andersonii*	4"	191	238	242	2
76	29.11.15	I	*Oreochromis andersonii*	4"	191	236	204	2
77	29.11.15	I	*Oreochromis andersonii*	4"	169	212	161	2
78	29.11.15	I	*Oreochromis andersonii*	4"	166	216	177	3
79	29.11.15	I	*Oreochromis andersonii*	4"	187	239	223	4
80	29.11.15	I	*Oreochromis andersonii*	4"	221	279	352	6
81	29.11.15	I	*Oreochromis andersonii*	4"	221	279	352	6
82	29.11.15	I	*Oreochromis andersonii*	4"	176	219	184	2
83	29.11.15	I	*Oreochromis andersonii*	4"	185	236	231	3
84	29.11.15	I	*Oreochromis andersonii*	4"	202	238	245	3
85	29.11.15	I	*Oreochromis andersonii*	4"	228	282	390	4
86	29.11.15	I	*Oreochromis andersonii*	4"	188	232	218	3
87	29.11.15	I	*Oreochromis andersonii*	4"	181	229	177	3
88	29.11.15	I	*Oreochromis andersonii*	4"	178	217	182	2
89	29.11.15	I	*Oreochromis andersonii*	4"	170	214	172	2
90	29.11.15	I	*Oreochromis andersonii*	4"	168	211	166	2
91	29.11.15	I	*Oreochromis andersonii*	4"	181	228	190	3
92	29.11.15	I	*Oreochromis andersonii*	4"	193	246	265	3
93	29.11.15	I	*Oreochromis andersonii*	4"	166	208	143	2
94	29.11.15	I	*Oreochromis andersonii*	4"	182	229	192	3
95	30.10.15	II	*Oreochromis andersonii*	4"	191	237	260	3
96	30.10.15	II	*Oreochromis andersonii*	4"	176	220	197	3
97	30.10.15	II	*Oreochromis andersonii*	4"	159	198	145	2
98	30.10.15	II	*Oreochromis andersonii*	4"	214	268	322	4
99	30.10.15	II	*Oreochromis andersonii*	4"	161	218	145	3
100	30.10.15	II	*Oreochromis andersonii*	4"	184	234	232	3
101	30.10.15	II	*Oreochromis andersonii*	4"	188	230	189	3
102	30.10.15	II	*Oreochromis andersonii*	4"	146	185	116	2
103	30.10.15	II	*Oreochromis andersonii*	4"	157	186	245	1
104	30.10.15	II	*Oreochromis andersonii*	4"	168	192	263	3
105	30.10.15	II	*Oreochromis andersonii*	4"	129	151	141	1
106	30.10.15	II	*Oreochromis andersonii*	4"	132	175	196	2
107	30.10.15	II	*Oreochromis andersonii*	4"	135	178	199	2
108	30.10.15	II	*Oreochromis andersonii*	4"	158	195	271	3
109	30.10.15	II	*Oreochromis andersonii*	4"	172	201	320	3
110	30.10.15	II	*Oreochromis andersonii*	4"	123	165	152	2
111	30.10.15	II	*Oreochromis andersonii*	4"	147	172	195	3
112	30.10.15	II	*Oreochromis andersonii*	4"	157	193	263	3
113	30.10.15	II	*Oreochromis andersonii*	4"	181	225	251	3
114	31.10.15	II	*Oreochromis andersonii*	4"	156	193	149	3
115	31.10.15	II	*Oreochromis andersonii*	4"	175	213	196	3
116	31.10.15	II	*Oreochromis andersonii*	4"	168	202	153	3

117	31.10.15	II	*Oreochromis andersonii*	4"	147	185	138	2
118	31.10.15	II	*Oreochromis andersonii*	4"	169	209	156	3
119	31.10.15	II	*Oreochromis andersonii*	4"	158	193	142	2
120	31.10.15	II	*Oreochromis andersonii*	4"	185	225	258	4
121	31.10.15	II	*Oreochromis andersonii*	4"	146	185	88	3
122	31.10.15	II	*Oreochromis andersonii*	4"	162	199	148	3
123	27.11.15	II	*Oreochromis andersonii*	4"	138	176	81	3
124	27.11.15	II	*Oreochromis andersonii*	4"	178	220	170	3
125	27.11.15	II	*Oreochromis andersonii*	4"	247	340	501	5
126	27.11.15	II	*Oreochromis andersonii*	4"	191	236	261	3
127	27.11.15	II	*Oreochromis andersonii*	4"	215	270	325	4
128	27.11.15	II	*Oreochromis andersonii*	4"	178	237	201	3
129	27.11.15	II	*Oreochromis andersonii*	4"	201	273	323	4
130	27.11.15	II	*Oreochromis andersonii*	4"	192	236	262	4
131	27.11.15	II	*Oreochromis andersonii*	4"	120	147	53	2
132	27.11.15	II	*Oreochromis andersonii*	4"	147	185	118	2
133	27.11.15	II	*Oreochromis andersonii*	4"	184	233	233	3
134	28.11.15	II	*Oreochromis andersonii*	4"	163	201	151	3
135	28.11.15	II	*Oreochromis andersonii*	4"	169	210	158	3
136	28.11.15	II	*Oreochromis andersonii*	4"	158	194	145	2
137	28.11.15	II	*Oreochromis andersonii*	4"	172	198	197	3
138	28.11.15	II	*Oreochromis andersonii*	4"	187	228	187	3
139	28.11.15	II	*Oreochromis andersonii*	4"	165	224	154	3
140	28.11.15	II	*Oreochromis andersonii*	4"	176	213	198	3
141	28.11.15	II	*Oreochromis andersonii*	4"	147	185	90	3
142	28.11.15	II	*Oreochromis andersonii*	4"	186	237	235	4
143	28.11.15	II	*Oreochromis andersonii*	4"	159	193	145	2
144	28.11.15	II	*Oreochromis andersonii*	Tremmel	186	225	260	4
145	28.11.15	II	*Oreochromis andersonii*	Tremmel	147	185	89	2
146	28.11.15	II	*Oreochromis andersonii*	Tremmel	175	213	200	3
147	28.11.15	II	*Oreochromis andersonii*	Tremmel	202	241	319	4
148	28.11.15	II	*Oreochromis andersonii*	Tremmel	192	238	262	4
149	28.11.15	II	*Oreochromis andersonii*	Tremmel	160	198	151	3
150	28.11.15	II	*Oreochromis andersonii*	Tremmel	186	216	246	3
151	28.11.15	II	*Oreochromis andersonii*	Tremmel	152	181	142	2
152	28.10.15	III	*Oreochromis andersonii*	4"	184	224	190	4
153	28.10.15	III	*Oreochromis andersonii*	4"	161	280	152	3
154	28.10.15	III	*Oreochromis andersonii*	4"	170	209	167	3
155	28.10.15	III	*Oreochromis andersonii*	4"	178	226	177	4
156	28.10.15	III	*Oreochromis andersonii*	4"	168	209	158	3
157	28.10.15	III	*Oreochromis andersonii*	4"	169	211	156	3

158	28.10.15	III	*Oreochromis andersonii*	4"	170	216	158	3
159	28.10.15	III	*Oreochromis andersonii*	4"	173	217	158	3
160	28.10.15	III	*Oreochromis andersonii*	4"	178	225	179	4
161	28.10.15	III	*Oreochromis andersonii*	4"	191	241	232	4
162	28.10.15	III	*Oreochromis andersonii*	4"	194	246	243	4
163	28.10.15	III	*Oreochromis andersonii*	4"	181	226	189	4
164	29.10.15	III	*Oreochromis andersonii*	4"	228	282	390	4
165	29.10.15	III	*Oreochromis andersonii*	4"	176	219	181	4
166	29.10.15	III	*Oreochromis andersonii*	4"	196	243	261	4
167	29.10.15	III	*Oreochromis andersonii*	4"	191	238	242	4
168	29.10.15	III	*Oreochromis andersonii*	4"	191	236	204	4
169	29.10.15	III	*Oreochromis andersonii*	4"	169	212	161	3
170	29.10.15	III	*Oreochromis andersonii*	4"	166	216	177	3
171	29.10.15	III	*Oreochromis andersonii*	4"	187	239	223	4
172	29.10.15	III	*Oreochromis andersonii*	4"	221	279	352	6
173	29.10.15	III	*Oreochromis andersonii*	4"	221	279	352	6
174	29.10.15	III	*Oreochromis andersonii*	4"	176	219	184	3
175	29.10.15	III	*Oreochromis andersonii*	4"	185	236	231	4
176	29.10.15	III	*Oreochromis andersonii*	4"	202	238	245	4
177	29.10.15	III	*Oreochromis andersonii*	4"	228	282	390	6
178	29.10.15	III	*Oreochromis andersonii*	4"	188	232	218	4
179	29.10.15	III	*Oreochromis andersonii*	4"	181	229	177	3
180	29.10.15	III	*Oreochromis andersonii*	4"	178	217	182	3
181	29.10.15	III	*Oreochromis andersonii*	4"	170	214	172	3
182	29.10.15	III	*Oreochromis andersonii*	4"	168	211	166	3
183	29.10.15	III	*Oreochromis andersonii*	4"	181	228	190	4
184	29.10.15	III	*Oreochromis andersonii*	4"	193	246	265	5
185	29.10.15	III	*Oreochromis andersonii*	4"	166	208	143	3
186	29.10.15	III	*Oreochromis andersonii*	4"	182	229	192	3
187	26.11.15	III	*Oreochromis andersonii*	4"	192	239	231	4
188	26.11.15	III	*Oreochromis andersonii*	4"	175	214	162	3
189	26.11.15	III	*Oreochromis andersonii*	4"	210	266	272	4
190	26.11.15	III	*Oreochromis andersonii*	4"	196	238	242	4
191	26.11.15	III	*Oreochromis andersonii*	4"	231	287	306	6
192	26.11.15	III	*Oreochromis andersonii*	4"	186	228	224	4
193	26.11.15	III	*Oreochromis andersonii*	4"	195	236	237	4
194	26.11.15	III	*Oreochromis andersonii*	4"	215	263	280	5
195	26.11.15	III	*Oreochromis andersonii*	4"	187	234	224	3
196	26.11.15	III	*Oreochromis andersonii*	4"	178	220	168	3
197	26.11.15	III	*Oreochromis andersonii*	4"	183	221	219	3
198	26.11.15	III	*Oreochromis andersonii*	4"	198	249	241	4

199	26.11.15	III	*Oreochromis andersonii*	4"	215	268	279	5
200	26.11.15	III	*Oreochromis andersonii*	4"	203	244	331	4
201	26.11.15	III	*Oreochromis andersonii*	4"	175	203	286	3
202	26.11.15	III	*Oreochromis andersonii*	4"	198	236	240	4
203	26.11.15	III	*Oreochromis andersonii*	4"	176	216	166	3
204	26.11.15	III	*Oreochromis andersonii*	4"	169	204	158	3
205	26.11.15	III	*Oreochromis andersonii*	4"	231	298	305	4
206	26.11.15	III	*Oreochromis andersonii*	Tremmel	197	201	242	4
207	26.11.15	III	*Oreochromis andersonii*	Tremmel	173	298	165	3
208	26.11.15	III	*Oreochromis andersonii*	Tremmel	165	200	154	3
209	26.11.15	III	*Oreochromis andersonii*	Tremmel	171	209	163	3
210	26.11.15	III	*Oreochromis andersonii*	Tremmel	182	224	221	4
211	26.11.15	III	*Oreochromis andersonii*	Tremmel	204	255	274	4
212	26.11.15	III	*Oreochromis andersonii*	Tremmel	167	204	156	3
213	26.11.15	III	*Oreochromis andersonii*	Tremmel	163	209	154	3
214	26.11.15	III	*Oreochromis andersonii*	Tremmel	178	229	172	3
215	27.09.15	I	*Oreochromis macrochir*	4"	98	119	31	2
216	27.09.15	I	*Oreochromis macrochir*	4"	88	114	26	1
217	27.09.15	I	*Oreochromis macrochir*	4"	104	128	40	3
218	27.09.15	I	*Oreochromis macrochir*	4"	90	114	28	2
219	27.09.15	I	*Oreochromis macrochir*	4"	113	146	60	3
220	27.09.15	I	*Oreochromis macrochir*	4"	97	121	32	3
221	27.09.15	I	*Oreochromis macrochir*	4"	78	101	17	1
222	27.09.15	I	*Oreochromis macrochir*	4"	92	116	26	1
223	27.09.15	I	*Oreochromis macrochir*	4"	126	151	74	3
224	27.09.15	I	*Oreochromis macrochir*	4"	96	121	32	2
225	27.09.15	I	*Oreochromis macrochir*	4"	111	136	34	3
226	27.09.15	I	*Oreochromis macrochir*	4"	96	119	34	2
227	27.09.15	I	*Oreochromis macrochir*	4"	96	124	40	2
228	27.09.15	I	*Oreochromis macrochir*	4"	111	137	35	3
229	27.09.15	I	*Oreochromis macrochir*	4"	97	119	31	2
230	27.09.15	I	*Oreochromis macrochir*	4"	92	112	27	1
231	27.09.15	I	*Oreochromis macrochir*	4"	127	152	61	3
232	27.09.15	I	*Oreochromis macrochir*	4"	84	102	20	1
233	27.09.15	I	*Oreochromis macrochir*	4"	92	117	25	2
234	27.09.15	I	*Oreochromis macrochir*	4"	84	114	26	2
235	27.09.15	I	*Oreochromis macrochir*	4"	97	120	31	2
236	27.09.15	I	*Oreochromis macrochir*	4"	72	96	14	1
237	27.09.15	I	*Oreochromis macrochir*	4"	91	117	27	2
238	27.09.15	I	*Oreochromis macrochir*	4"	107	134	32	3
239	27.09.15	I	*Oreochromis macrochir*	4"	87	112	31	1

240	27.09.15	I	*Oreochromis macrochir*	4"	78	99	15	1
241	27.09.15	I	*Oreochromis macrochir*	4"	103	129	38	3
242	27.09.15	I	*Oreochromis macrochir*	4"	101	126	26	2
243	27.09.15	I	*Oreochromis macrochir*	4"	102	126	40	2
244	27.09.15	I	*Oreochromis macrochir*	4"	92	114	34	2
245	27.09.15	I	*Oreochromis macrochir*	4"	87	114	27	1
246	27.09.15	I	*Oreochromis macrochir*	4"	102	123	39	2
247	27.09.15	I	*Oreochromis macrochir*	4"	84	102	21	1
248	27.09.15	I	*Oreochromis macrochir*	4"	107	136	45	3
249	27.09.15	I	*Oreochromis macrochir*	4"	108	138	44	3
250	27.09.15	I	*Oreochromis macrochir*	4"	112	138	49	3
251	27.09.15	I	*Oreochromis macrochir*	4"	97	119	33	1
252	27.09.15	I	*Oreochromis macrochir*	4"	108	135	42	3
253	27.09.15	I	*Oreochromis macrochir*	4"	103	132	40	3
254	27.09.15	I	*Oreochromis macrochir*	4"	102	128	37	2
255	27.09.15	I	*Oreochromis macrochir*	4"	99	127	33	2
256	27.09.15	I	*Oreochromis macrochir*	4"	123	158	62	3
257	27.09.15	I	*Oreochromis macrochir*	4"	348	382	74	4
258	27.09.15	I	*Oreochromis macrochir*	4"	139	167	93	4
259	27.09.15	I	*Oreochromis macrochir*	4"	111	144	55	3
260	27.09.15	I	*Oreochromis macrochir*	4"	101	129	43	3
261	27.09.15	I	*Oreochromis macrochir*	4"	101	125	38	2
262	27.09.15	I	*Oreochromis macrochir*	4"	109	138	55	3
263	27.09.15	I	*Oreochromis macrochir*	4"	111	136	47	3
264	27.09.15	I	*Oreochromis macrochir*	4"	113	146	61	3
265	27.09.15	I	*Oreochromis macrochir*	4"	123	156	70	3
266	27.09.15	I	*Oreochromis macrochir*	4"	111	139	51	3
267	27.09.15	I	*Oreochromis macrochir*	4"	105	134	45	3
268	27.09.15	I	*Oreochromis macrochir*	4"	147	160	72	4
269	27.09.15	I	*Oreochromis macrochir*	4"	106	146	57	4
270	27.09.15	I	*Oreochromis macrochir*	4"	102	137	48	3
271	27.09.15	I	*Oreochromis macrochir*	4"	127	168	86	4
272	27.09.15	I	*Oreochromis macrochir*	4"	89	121	32	2
273	27.09.15	I	*Oreochromis macrochir*	4"	102	136	45	3
274	27.09.15	I	*Oreochromis macrochir*	4"	128	170	96	4
275	27.09.15	I	*Oreochromis macrochir*	4"	116	141	51	3
276	27.09.15	I	*Oreochromis macrochir*	4"	111	162	78	4
277	27.09.15	I	*Oreochromis macrochir*	4"	123	163	72	4
278	27.09.15	I	*Oreochromis macrochir*	4"	97	132	46	3
279	27.09.15	I	*Oreochromis macrochir*	4"	214	258	259	4
280	25.10.15	I	*Oreochromis macrochir*	4"	192	239	241	3

281	25.10.15	I	*Oreochromis macrochir*	4"	171	216	174	3
282	25.10.15	I	*Oreochromis macrochir*	4"	171	219	186	4
283	25.10.15	I	*Oreochromis macrochir*	4"	168	210	156	3
284	25.10.15	I	*Oreochromis macrochir*	4"	169	214	175	3
285	25.10.15	I	*Oreochromis macrochir*	4"	184	222	199	4
286	25.10.15	I	*Oreochromis macrochir*	4"	164	206	169	3
287	25.10.15	I	*Oreochromis macrochir*	4"	189	228	204	4
288	25.10.15	I	*Oreochromis macrochir*	4"	183	231	224	4
289	25.10.15	I	*Oreochromis macrochir*	4"	177	220	192	3
290	25.10.15	I	*Oreochromis macrochir*	4"	171	212	184	3
291	25.10.15	I	*Oreochromis macrochir*	4"	164	208	156	3
292	25.10.15	I	*Oreochromis macrochir*	4"	179	221	183	4
293	25.10.15	I	*Oreochromis macrochir*	4"	186	230	221	4
294	25.10.15	I	*Oreochromis macrochir*	4"	169	215	171	3
295	25.10.15	I	*Oreochromis macrochir*	4"	166	212	148	3
296	25.10.15	I	*Oreochromis macrochir*	4"	174	222	196	4
297	25.10.15	I	*Oreochromis macrochir*	4"	171	216	189	4
298	25.10.15	I	*Oreochromis macrochir*	4"	146	191	130	3
299	25.10.15	I	*Oreochromis macrochir*	4"	166	213	170	3
300	25.10.15	I	*Oreochromis macrochir*	4"	230	280	421	4
301	25.10.15	I	*Oreochromis macrochir*	4"	246	289	435	4
302	29.11.15	I	*Oreochromis macrochir*	4"	99	119	31	2
303	29.11.15	I	*Oreochromis macrochir*	4"	104	128	40	3
304	29.11.15	I	*Oreochromis macrochir*	4"	113	146	60	4
305	29.11.15	I	*Oreochromis macrochir*	4"	84	101	21	2
306	29.11.15	I	*Oreochromis macrochir*	4"	102	124	40	3
307	29.11.15	I	*Oreochromis macrochir*	4"	127	152	52	4
308	29.11.15	I	*Oreochromis macrochir*	4"	91	117	28	2
309	29.11.15	I	*Oreochromis macrochir*	4"	103	129	39	3
310	29.11.15	I	*Oreochromis macrochir*	4"	92	117	26	2
311	29.11.15	I	*Oreochromis macrochir*	4"	111	137	35	3
312	29.11.15	I	*Oreochromis macrochir*	4"	96	124	40	3
313	29.11.15	I	*Oreochromis macrochir*	4"	97	119	35	2
314	29.11.15	I	*Oreochromis macrochir*	4"	97	121	32	3
315	29.11.15	I	*Oreochromis macrochir*	4"	123	163	74	4
316	29.11.15	I	*Oreochromis macrochir*	4"	99	128	34	3
317	29.11.15	I	*Oreochromis macrochir*	Tremmel	108	138	45	3
318	29.11.15	I	*Oreochromis macrochir*	Tremmel	116	141	52	3
319	29.11.15	I	*Oreochromis macrochir*	Tremmel	147	160	74	4
320	29.11.15	I	*Oreochromis macrochir*	Tremmel	89	121	33	2
321	29.11.15	I	*Oreochromis macrochir*	Tremmel	72	97	15	1

322	30.10.15	II	*Oreochromis macrochir*	4"	152	195	132	3
323	30.10.15	II	*Oreochromis macrochir*	4"	196	249	255	4
324	30.10.15	II	*Oreochromis macrochir*	4"	161	207	146	4
325	30.10.15	II	*Oreochromis macrochir*	4"	156	197	135	2
326	30.10.15	II	*Oreochromis macrochir*	4"	181	226	246	4
327	30.10.15	II	*Oreochromis macrochir*	4"	197	233	256	4
328	30.10.15	II	*Oreochromis macrochir*	4"	145	195	127	2
329	30.10.15	II	*Oreochromis macrochir*	4"	123	141	108	2
330	30.10.15	II	*Oreochromis macrochir*	4"	176	214	153	4
331	30.10.15	II	*Oreochromis macrochir*	4"	195	231	254	4
332	30.10.15	II	*Oreochromis macrochir*	4"	161	196	145	2
333	30.10.15	II	*Oreochromis macrochir*	4"	145	185	128	3
334	30.10.15	II	*Oreochromis macrochir*	4"	178	201	155	4
335	30.10.15	II	*Oreochromis macrochir*	4"	198	232	261	4
336	30.10.15	II	*Oreochromis macrochir*	4"	201	239	273	4
337	30.10.15	II	*Oreochromis macrochir*	4"	162	198	146	3
338	30.10.15	II	*Oreochromis macrochir*	4"	158	184	148	3
339	30.10.15	II	*Oreochromis macrochir*	4"	195	231	256	4
340	30.10.15	II	*Oreochromis macrochir*	4"	146	183	129	3
341	30.10.15	II	*Oreochromis macrochir*	4"	176	202	154	3
342	30.10.15	II	*Oreochromis macrochir*	4"	181	221	157	4
343	30.10.15	II	*Oreochromis macrochir*	4"	285	327	246	4
344	30.10.15	II	*Oreochromis macrochir*	4"	205	243	261	4
345	27.11.15	II	*Oreochromis macrochir*	4"	124	159	69	2
346	27.11.15	II	*Oreochromis macrochir*	4"	152	195	132	3
347	27.11.15	II	*Oreochromis macrochir*	4"	198	250	260	4
348	27.11.15	II	*Oreochromis macrochir*	4"	161	198	136	2
349	27.11.15	II	*Oreochromis macrochir*	4"	183	227	248	4
350	27.11.15	II	*Oreochromis macrochir*	4"	142	189	125	2
351	27.11.15	II	*Oreochromis macrochir*	4"	120	138	97	2
352	27.11.15	II	*Oreochromis macrochir*	4"	172	201	143	3
353	27.11.15	II	*Oreochromis macrochir*	4"	195	231	254	4
354	27.11.15	II	*Oreochromis macrochir*	4"	178	202	156	4
355	27.11.15	II	*Oreochromis macrochir*	4"	163	199	149	3
356	27.11.15	II	*Oreochromis macrochir*	4"	195	231	258	4
357	28.11.15	II	*Oreochromis macrochir*	4"	178	202	156	4
358	28.11.15	II	*Oreochromis macrochir*	4"	180	221	160	4
359	28.11.15	II	*Oreochromis macrochir*	4"	206	243	265	4
360	28.11.15	II	*Oreochromis macrochir*	4"	193	228	248	4
361	28.11.15	II	*Oreochromis macrochir*	4"	145	181	129	2
362	28.11.15	II	*Oreochromis macrochir*	4"	172	197	152	3

363	28.11.15	II	*Oreochromis macrochir*	Tremmel	183	223	162	4
364	28.11.15	II	*Oreochromis macrochir*	Tremmel	201	237	263	4
365	28.11.15	II	*Oreochromis macrochir*	Tremmel	158	195	147	3
366	28.11.15	II	*Oreochromis macrochir*	Tremmel	175	196	154	3
367	28.11.15	II	*Oreochromis macrochir*	Tremmel	196	231	251	4
368	28.11.15	II	*Oreochromis macrochir*	Tremmel	169	206	146	3
369	28.11.15	II	*Oreochromis macrochir*	Tremmel	181	220	158	4
370	28.11.15	II	*Oreochromis macrochir*	Tremmel	113	146	60	4
371	28.11.15	II	*Oreochromis macrochir*	Tremmel	84	101	21	2
372	28.11.15	II	*Oreochromis macrochir*	Tremmel	102	124	40	3
373	28.11.15	II	*Oreochromis macrochir*	Tremmel	214	258	259	4
374	28.11.15	III	*Oreochromis macrochir*	4"	151	196	136	3
375	28.11.15	III	*Oreochromis macrochir*	4"	173	219	162	3
376	28.11.15	III	*Oreochromis macrochir*	4"	172	225	178	4
377	28.11.15	III	*Oreochromis macrochir*	4"	190	240	223	4
378	29.10.15	III	*Oreochromis macrochir*	4"	214	258	259	4
379	29.10.15	III	*Oreochromis macrochir*	4"	192	239	241	3
380	29.10.15	III	*Oreochromis macrochir*	4"	171	216	174	3
381	29.10.15	III	*Oreochromis macrochir*	4"	171	219	186	4
382	29.10.15	III	*Oreochromis macrochir*	4"	168	210	156	3
383	29.10.15	III	*Oreochromis macrochir*	4"	169	214	175	3
384	29.10.15	III	*Oreochromis macrochir*	4"	184	222	199	5
385	29.10.15	III	*Oreochromis macrochir*	4"	164	206	169	3
386	29.10.15	III	*Oreochromis macrochir*	4"	189	228	204	4
387	29.10.15	III	*Oreochromis macrochir*	4"	253	289	224	4
388	29.10.15	III	*Oreochromis macrochir*	4"	177	220	192	3
389	29.10.15	III	*Oreochromis macrochir*	4"	171	212	184	3
390	29.10.15	III	*Oreochromis macrochir*	4"	164	208	156	3
391	29.10.15	III	*Oreochromis macrochir*	4"	179	221	183	4
392	29.10.15	III	*Oreochromis macrochir*	4"	186	230	221	4
393	29.10.15	III	*Oreochromis macrochir*	4"	169	215	171	3
394	29.10.15	III	*Oreochromis macrochir*	4"	166	212	148	3
395	29.10.15	III	*Oreochromis macrochir*	4"	174	222	196	4
396	29.10.15	III	*Oreochromis macrochir*	4"	171	216	189	4
397	29.10.15	III	*Oreochromis macrochir*	4"	146	191	130	3
398	29.10.15	III	*Oreochromis macrochir*	4"	166	213	170	3
399	26.11.15	III	*Oreochromis macrochir*	4"	182	222	241	4
400	26.11.15	III	*Oreochromis macrochir*	4"	207	255	260	5
401	26.11.15	III	*Oreochromis macrochir*	4"	194	237	195	4
402	26.11.15	III	*Oreochromis macrochir*	4"	178	203	186	3
403	26.11.15	III	*Oreochromis macrochir*	4"	181	214	192	4

404	26.11.15	III	*Oreochromis macrochir*	4"	215	267	265	5
405	26.11.15	III	*Oreochromis macrochir*	4"	223	274	284	5
406	26.11.15	III	*Oreochromis macrochir*	4"	195	241	195	4
407	26.11.15	III	*Oreochromis macrochir*	4"	184	222	190	5
408	26.11.15	III	*Oreochromis macrochir*	4"	185	224	244	5
409	26.11.15	III	*Oreochromis macrochir*	4"	221	271	285	5
410	26.11.15	III	*Oreochromis macrochir*	4"	186	221	245	4
411	26.11.15	III	*Oreochromis macrochir*	4"	178	210	186	3
412	26.11.15	III	*Oreochromis macrochir*	4"	183	221	242	3
413	26.11.15	III	*Oreochromis macrochir*	4"	212	262	265	5
414	26.11.15	III	*Oreochromis macrochir*	4"	176	201	185	3
415	26.11.15	III	*Oreochromis macrochir*	4"	198	240	197	4
416	26.11.15	III	*Oreochromis macrochir*	4"	186	222	224	4
417	26.11.15	III	*Oreochromis macrochir*	Tremmel	174	227	183	4
418	26.11.15	III	*Oreochromis macrochir*	Tremmel	201	249	254	5
419	26.11.15	III	*Oreochromis macrochir*	Tremmel	178	215	187	3
420	26.11.15	III	*Oreochromis macrochir*	Tremmel	216	278	282	5
421	26.11.15	III	*Oreochromis macrochir*	Tremmel	182	225	221	4
422	26.11.15	III	*Oreochromis macrochir*	Tremmel	193	231	194	4
423	26.11.15	III	*Oreochromis macrochir*	Tremmel	168	206	179	2
424	26.11.15	III	*Oreochromis macrochir*	Tremmel	196	237	201	4
425	26.11.15	III	*Oreochromis macrochir*	Tremmel	208	255	261	4
426	26.11.15	III	*Oreochromis macrochir*	Tremmel	215	277	281	4
427	26.11.15	III	*Oreochromis macrochir*	Tremmel	196	242	195	4
428	26.09.15	I	*Oreochromis niloticus*	4"	*170*	200	*195*	1
429	26.09.15	I	*Oreochromis niloticus*	4"	190	220	245	2
430	26.09.15	I	*Oreochromis niloticus*	4"	180	215	218	2
431	26.09.15	I	*Oreochromis niloticus*	4"	245	240	526	3
432	26.09.15	I	*Oreochromis niloticus*	4"	260	305	699	4
433	26.09.15	I	*Oreochromis niloticus*	4"	240	290	465	3
434	26.09.15	I	*Oreochromis niloticus*	4"	220	260	352	2
435	26.09.15	I	*Oreochromis niloticus*	4"	240	289	477	2
436	26.09.15	I	*Oreochromis niloticus*	4"	225	270	394	2
437	26.09.15	I	*Oreochromis niloticus*	4"	210	245	349	2
438	26.09.15	I	*Oreochromis niloticus*	4"	240	285	455	3
439	26.09.15	I	*Oreochromis niloticus*	4"	179	213	179	1
440	26.09.15	I	*Oreochromis niloticus*	4"	185	235	237	2
441	26.09.15	I	*Oreochromis niloticus*	4"	190	225	189	2
442	26.09.15	I	*Oreochromis niloticus*	4"	196	247	276	2
443	26.09.15	I	*Oreochromis niloticus*	4"	220	218	407	2
444	26.09.15	I	*Oreochromis niloticus*	4"	240	279	447	3

445	26.09.15	I	*Oreochromis niloticus*	4"	247	297	455	2
446	26.09.15	I	*Oreochromis niloticus*	4"	279	301	641	3
447	26.09.15	I	*Oreochromis niloticus*	4"	247	296	480	2
448	26.09.15	I	*Oreochromis niloticus*	4"	538	581	445	4
449	26.09.15	I	*Oreochromis niloticus*	4"	189	240	192	1
450	26.09.15	I	*Oreochromis niloticus*	4"	195	250	358	1
451	26.09.15	I	*Oreochromis niloticus*	4"	182	207	247	1
452	26.09.15	I	*Oreochromis niloticus*	4"	173	198	253	1
453	26.09.15	I	*Oreochromis niloticus*	4"	217	240	322	1
454	26.09.15	I	*Oreochromis niloticus*	4"	240	278	460	2
455	26.09.15	I	*Oreochromis niloticus*	4"	231	287	576	3
456	26.09.15	I	*Oreochromis niloticus*	4"	160	192	185	1
457	26.09.15	I	*Oreochromis niloticus*	4"	269	308	682	3
458	26.09.15	I	*Oreochromis niloticus*	4"	251	299	650	4
459	26.09.15	I	*Oreochromis niloticus*	4"	168	193	295	1
460	26.09.15	I	*Oreochromis niloticus*	4"	180	214	362	1
461	26.09.15	I	*Oreochromis niloticus*	4"	212	247	494	2
462	26.09.15	I	*Oreochromis niloticus*	4"	197	228	381	2
463	26.09.15	I	*Oreochromis niloticus*	4"	286	310	683	4
464	26.09.15	I	*Oreochromis niloticus*	4"	240	272	592	3
465	26.09.15	I	*Oreochromis niloticus*	4"	228	267	578	3
466	26.09.15	I	*Oreochromis niloticus*	4"	265	300	620	4
467	26.09.15	I	*Oreochromis niloticus*	4"	219	250	427	3
468	26.09.15	I	*Oreochromis niloticus*	4"	190	221	347	2
469	26.09.15	I	*Oreochromis niloticus*	4"	209	238	391	2
470	26.09.15	I	*Oreochromis niloticus*	4"	217	243	467	2
471	26.09.15	I	*Oreochromis niloticus*	4"	169	187	292	1
472	26.09.15	I	*Oreochromis niloticus*	4"	218	240	395	2
473	26.09.15	I	*Oreochromis niloticus*	4"	210	248	376	2
474	26.09.15	I	*Oreochromis niloticus*	4"	147	182	285	1
475	26.09.15	I	*Oreochromis niloticus*	4"	280	320	690	4
476	26.09.15	I	*Oreochromis niloticus*	4"	268	313	624	4
477	26.09.15	I	*Oreochromis niloticus*	4"	180	218	342	2
478	26.09.15	I	*Oreochromis niloticus*	4"	162	194	281	2
479	26.09.15	I	*Oreochromis niloticus*	4"	159	193	295	1
480	26.09.15	I	*Oreochromis niloticus*	4"	194	236	476	2
481	26.09.15	I	*Oreochromis niloticus*	4"	210	258	557	3
482	26.09.15	I	*Oreochromis niloticus*	4"	212	241	482	3
483	26.09.15	I	*Oreochromis niloticus*	4"	275	320	632	4
484	26.09.15	I	*Oreochromis niloticus*	4"	270	318	653	3
485	26.09.15	I	*Oreochromis niloticus*	4"	162	190	186	1

486	26.09.15	I	*Oreochromis niloticus*	4"	310	340	701	4
487	26.09.15	I	*Oreochromis niloticus*	4"	200	237	457	2
488	26.09.15	I	*Oreochromis niloticus*	4"	182	231	366	2
489	26.09.15	I	*Oreochromis niloticus*	4"	220	269	528	3
490	25.10.15	I	*Oreochromis niloticus*	4"	245	290	525	3
491	25.10.15	I	*Oreochromis niloticus*	4"	225	270	394	3
492	25.10.15	I	*Oreochromis niloticus*	4"	179	213	179	3
493	25.10.15	I	*Oreochromis niloticus*	4"	240	289	477	3
494	25.10.15	I	*Oreochromis niloticus*	4"	260	305	699	4
495	25.10.15	I	*Oreochromis niloticus*	4"	160	192	185	2
496	25.10.15	I	*Oreochromis niloticus*	4"	185	235	237	3
497	25.10.15	I	*Oreochromis niloticus*	4"	269	308	682	4
498	25.10.15	I	*Oreochromis niloticus*	4"	180	215	218	3
499	25.10.15	I	*Oreochromis niloticus*	4"	170	200	195	2
500	25.10.15	I	*Oreochromis niloticus*	4"	190	220	245	3
501	25.10.15	I	*Oreochromis niloticus*	4"	180	215	218	3
502	25.10.15	I	*Oreochromis niloticus*	4"	245	290	525	4
503	25.10.15	I	*Oreochromis niloticus*	4"	231	287	576	4
504	25.10.15	I	*Oreochromis niloticus*	4"	245	290	527	4
505	25.10.15	I	*Oreochromis niloticus*	4"	196	222	247	3
506	25.10.15	I	*Oreochromis niloticus*	4"	217	241	324	3
507	25.10.15	I	*Oreochromis niloticus*	4"	225	270	396	3
508	25.10.15	I	*Oreochromis niloticus*	4"	179	213	182	2
509	25.10.15	I	*Oreochromis niloticus*	4"	193	226	237	3
510	25.10.15	I	*Oreochromis niloticus*	4"	240	268	448	4
511	25.10.15	I	*Oreochromis niloticus*	4"	161	189	187	1
512	25.10.15	I	*Oreochromis niloticus*	4"	251	295	652	4
513	25.10.15	I	*Oreochromis niloticus*	4"	212	246	351	3
514	25.10.15	I	*Oreochromis niloticus*	4"	190	225	192	3
515	25.10.15	I	*Oreochromis niloticus*	4"	180	214	219	2
516	29.11.15	I	*Oreochromis niloticus*	4"	170	200	196	2
517	29.11.15	I	*Oreochromis niloticus*	4"	185	235	238	3
518	29.11.15	I	*Oreochromis niloticus*	4"	190	225	191	3
519	29.11.15	I	*Oreochromis niloticus*	4"	279	302	642	4
520	29.11.15	I	*Oreochromis niloticus*	4"	176	227	222	2
521	29.11.15	I	*Oreochromis niloticus*	Tremmel	174	218	195	2
522	29.11.15	I	*Oreochromis niloticus*	Tremmel	168	215	172	1
523	29.11.15	I	*Oreochromis niloticus*	Tremmel	182	223	201	3
524	29.11.15	I	*Oreochromis niloticus*	Tremmel	179	228	221	3
525	29.11.15	I	*Oreochromis niloticus*	Tremmel	178	226	206	3
526	29.11.15	I	*Oreochromis niloticus*	Tremmel	172	218	191	2

527	29.11.15	I	*Oreochromis niloticus*	Tremmel	169	216	200	2
528	29.11.15	I	*Oreochromis niloticus*	Tremmel	173	221	197	2
529	29.11.15	I	*Oreochromis niloticus*	Tremmel	181	233	206	3
530	29.11.15	I	*Oreochromis niloticus*	Tremmel	168	209	186	1
531	29.11.15	I	*Oreochromis niloticus*	Tremmel	156	194	149	1
532	29.11.15	I	*Oreochromis niloticus*	Tremmel	181	218	195	3
533	29.11.15	I	*Oreochromis niloticus*	Tremmel	186	231	238	3
534	29.11.15	I	*Oreochromis niloticus*	Tremmel	174	214	185	2
535	29.11.15	I	*Oreochromis niloticus*	Tremmel	183	213	225	2
536	29.11.15	I	*Oreochromis niloticus*	Tremmel	161	203	166	1
537	29.11.15	I	*Oreochromis niloticus*	Tremmel	192	246	296	3
538	30.10.15	II	*Oreochromis niloticus*	4"	156	193	148	3
539	30.10.15	II	*Oreochromis niloticus*	4"	184	230	212	4
540	30.10.15	II	*Oreochromis niloticus*	4"	184	228	211	4
541	30.10.15	II	*Oreochromis niloticus*	4"	176	223	214	4
542	30.10.15	II	*Oreochromis niloticus*	4"	126	164	76	3
543	30.10.15	II	*Oreochromis niloticus*	4"	137	175	83	2
544	30.10.15	II	*Oreochromis niloticus*	4"	119	149	53	2
545	30.10.15	II	*Oreochromis niloticus*	4"	122	157	68	2
546	30.10.15	II	*Oreochromis niloticus*	4"	125	160	68	2
547	30.10.15	II	*Oreochromis niloticus*	4"	114	149	50	2
548	30.10.15	II	*Oreochromis niloticus*	4"	117	152	69	2
549	30.10.15	II	*Oreochromis niloticus*	4"	159	192	148	2
550	30.10.15	II	*Oreochromis niloticus*	4"	115	150	69	2
551	30.10.15	II	*Oreochromis niloticus*	4"	126	162	76	2
552	30.10.15	II	*Oreochromis niloticus*	4"	160	195	148	3
553	30.10.15	II	*Oreochromis niloticus*	4"	185	220	213	4
554	30.10.15	II	*Oreochromis niloticus*	4"	325	364	221	4
555	30.10.15	II	*Oreochromis niloticus*	4"	256	297	149	3
556	30.10.15	II	*Oreochromis niloticus*	4"	261	298	150	3
557	30.10.15	II	*Oreochromis niloticus*	4"	126	161	81	2
558	30.10.15	II	*Oreochromis niloticus*	4"	142	180	134	3
559	30.10.15	II	*Oreochromis niloticus*	4"	156	196	149	3
560	31.10.15	II	*Oreochromis niloticus*	4"	167	195	156	3
561	31.10.15	II	*Oreochromis niloticus*	4"	124	158	75	2
562	31.10.15	II	*Oreochromis niloticus*	4"	182	200	221	3
563	31.10.15	II	*Oreochromis niloticus*	4"	212	249	305	4
564	31.10.15	II	*Oreochromis niloticus*	4"	197	237	236	4
565	31.10.15	II	*Oreochromis niloticus*	4"	163	199	158	4
566	31.10.15	II	*Oreochromis niloticus*	4"	126	164	76	3
567	31.10.15	II	*Oreochromis niloticus*	4"	185	221	222	3

568	31.10.15	II	*Oreochromis niloticus*	4"	142	180	84	2
569	31.10.15	II	*Oreochromis niloticus*	4"	127	167	76	2
570	31.10.15	II	*Oreochromis niloticus*	4"	186	221	223	4
571	31.10.15	II	*Oreochromis niloticus*	4"	137	175	91	2
572	31.10.15	II	*Oreochromis niloticus*	4"	156	194	150	3
573	31.10.15	II	*Oreochromis niloticus*	4"	181	219	233	4
574	31.10.15	II	*Oreochromis niloticus*	4"	147	183	132	3
575	31.10.15	II	*Oreochromis niloticus*	4"	192	232	232	4
576	31.10.15	II	*Oreochromis niloticus*	4"	187	225	223	4
577	31.10.15	II	*Oreochromis niloticus*	4"	174	229	201	4
578	31.10.15	II	*Oreochromis niloticus*	4"	127	163	78	3
579	31.10.15	II	*Oreochromis niloticus*	4"	156	191	151	3
580	27.11.15	II	*Oreochromis niloticus*	4"	139	176	85	3
581	27.11.15	II	*Oreochromis niloticus*	4"	107	139	43	4
582	27.11.15	II	*Oreochromis niloticus*	4"	185	230	214	4
583	27.11.15	II	*Oreochromis niloticus*	4"	125	161	70	2
584	27.11.15	II	*Oreochromis niloticus*	4"	158	198	151	3
585	27.11.15	II	*Oreochromis niloticus*	4"	126	163	75	2
586	27.11.15	II	*Oreochromis niloticus*	4"	187	219	224	4
587	27.11.15	II	*Oreochromis niloticus*	4"	192	230	233	4
588	28.11.15	II	*Oreochromis niloticus*	4"	127	162	83	2
589	28.11.15	II	*Oreochromis niloticus*	4"	118	152	68	1
590	28.11.15	II	*Oreochromis niloticus*	4"	186	221	215	4
591	28.11.15	II	*Oreochromis niloticus*	4"	157	298	151	3
592	28.11.15	II	*Oreochromis niloticus*	4"	185	231	214	4
593	28.11.15	II	*Oreochromis niloticus*	4"	127	165	78	2
594	28.11.15	II	*Oreochromis niloticus*	4"	114	150	53	2
595	28.11.15	II	*Oreochromis niloticus*	4"	163	198	147	3
596	28.11.15	II	*Oreochromis niloticus*	4"	184	220	215	4
597	28.11.15	II	*Oreochromis niloticus*	4"	156	189	152	3
598	28.11.15	II	*Oreochromis niloticus*	4"	148	182	135	2
599	28.11.15	II	*Oreochromis niloticus*	4"	165	193	154	3
600	28.11.15	II	*Oreochromis niloticus*	4"	136	174	93	2
601	28.11.15	II	*Oreochromis niloticus*	4"	187	226	223	4
602	28.11.15	II	*Oreochromis niloticus*	4"	175	231	204	4
603	28.11.15	II	*Oreochromis niloticus*	4"	198	238	239	4
604	28.11.15	II	*Oreochromis niloticus*	4"	192	234	237	4
605	28.11.15	II	*Oreochromis niloticus*	4"	124	156	77	2
606	28.11.15	II	*Oreochromis niloticus*	4"	213	251	307	4
607	28.11.15	II	*Oreochromis niloticus*	4"	125	164	81	2
608	28.11.15	II	*Oreochromis niloticus*	Tremmel	175	213	199	3

609	28.11.15	II	*Oreochromis niloticus*	Tremmel	192	232	235	4
610	28.11.15	II	*Oreochromis niloticus*	Tremmel	160	191	151	3
611	28.11.15	II	*Oreochromis niloticus*	Tremmel	121	148	88	2
612	28.11.15	II	*Oreochromis niloticus*	Tremmel	186	220	214	4
613	28.11.15	II	*Oreochromis niloticus*	Tremmel	143	181	135	2
614	28.11.15	II	*Oreochromis niloticus*	Tremmel	176	222	215	4
615	28.11.15	II	*Oreochromis niloticus*	Tremmel	122	157	70	2
616	28.11.15	II	*Oreochromis niloticus*	Tremmel	127	164	79	2
617	28.11.15	II	*Oreochromis niloticus*	Tremmel	192	230	228	4
618	28.10.15	III	*Oreochromis niloticus*	4"	242	298	425	4
619	28.10.15	III	*Oreochromis niloticus*	4"	165	193	167	2
620	28.10.15	III	*Oreochromis niloticus*	4"	172	214	201	3
621	28.10.15	III	*Oreochromis niloticus*	4"	147	182	152	2
622	28.10.15	III	*Oreochromis niloticus*	4"	254	283	453	4
623	28.10.15	III	*Oreochromis niloticus*	4"	183	218	239	3
624	28.10.15	III	*Oreochromis niloticus*	4"	201	241	305	4
625	28.10.15	III	*Oreochromis niloticus*	4"	165	198	168	3
626	28.10.15	III	*Oreochromis niloticus*	4"	174	213	204	3
627	28.10.15	III	*Oreochromis niloticus*	4"	193	228	256	4
628	28.10.15	III	*Oreochromis niloticus*	4"	182	222	240	4
629	28.10.15	III	*Oreochromis niloticus*	4"	167	203	166	3
630	28.10.15	III	*Oreochromis niloticus*	4"	231	268	445	4
631	28.10.15	III	*Oreochromis niloticus*	4"	175	213	211	3
632	28.10.15	III	*Oreochromis niloticus*	4"	223	263	415	4
633	29.10.15	III	*Oreochromis niloticus*	4"	176	227	222	4
634	29.10.15	III	*Oreochromis niloticus*	4"	174	218	195	4
635	29.10.15	III	*Oreochromis niloticus*	4"	168	215	172	4
636	29.10.15	III	*Oreochromis niloticus*	4"	182	223	201	4
637	29.10.15	III	*Oreochromis niloticus*	4"	179	228	221	4
638	29.10.15	III	*Oreochromis niloticus*	4"	178	226	206	4
639	29.10.15	III	*Oreochromis niloticus*	4"	172	218	191	4
640	29.10.15	III	*Oreochromis niloticus*	4"	169	216	200	4
641	29.10.15	III	*Oreochromis niloticus*	4"	173	221	197	4
642	29.10.15	III	*Oreochromis niloticus*	4"	181	233	206	4
643	29.10.15	III	*Oreochromis niloticus*	4"	168	209	186	3
644	29.10.15	III	*Oreochromis niloticus*	4"	156	194	149	3
645	29.10.15	III	*Oreochromis niloticus*	4"	181	218	195	4
646	29.10.15	III	*Oreochromis niloticus*	4"	186	231	238	4
647	29.10.15	III	*Oreochromis niloticus*	4"	174	214	185	3
648	29.10.15	III	*Oreochromis niloticus*	4"	183	213	225	3
649	29.10.15	III	*Oreochromis niloticus*	4"	161	203	166	3

650	29.10.15	III	*Oreochromis niloticus*	4"	192	246	296	4
651	29.10.15	III	*Oreochromis niloticus*	4"	173	220	202	3
652	26.11.15	III	*Oreochromis niloticus*	4"	250	286	580	4
653	26.11.15	III	*Oreochromis niloticus*	4"	208	243	470	4
654	26.11.15	III	*Oreochromis niloticus*	4"	180	218	305	4
655	26.11.15	III	*Oreochromis niloticus*	4"	299	337	595	4
656	26.11.15	III	*Oreochromis niloticus*	4"	190	227	315	3
657	26.11.15	III	*Oreochromis niloticus*	4"	275	310	590	4
658	26.11.15	III	*Oreochromis niloticus*	4"	185	220	310	3
659	26.11.15	III	*Oreochromis niloticus*	4"	196	238	320	3
660	26.11.15	III	*Oreochromis niloticus*	4"	198	241	331	4
661	26.11.15	III	*Oreochromis niloticus*	4"	179	215	291	3
662	26.11.15	III	*Oreochromis niloticus*	4"	295	335	602	4
663	26.11.15	III	*Oreochromis niloticus*	4"	197	233	328	3
664	26.11.15	III	*Oreochromis niloticus*	4"	187	219	312	3
665	26.11.15	III	*Oreochromis niloticus*	4"	268	310	585	4
666	26.11.15	III	*Oreochromis niloticus*	4"	301	337	610	4
667	26.11.15	III	*Oreochromis niloticus*	4"	196	228	321	4
668	26.11.15	III	*Oreochromis niloticus*	4"	267	304	582	3
669	26.11.15	III	*Oreochromis niloticus*	4"	185	226	310	4
670	26.11.15	III	*Oreochromis niloticus*	4"	296	333	602	4
671	26.11.15	III	*Oreochromis niloticus*	Tremmel	282	315	594	4
672	26.11.15	III	*Oreochromis niloticus*	Tremmel	242	281	486	4
673	26.11.15	III	*Oreochromis niloticus*	Tremmel	169	200	278	2
674	26.11.15	III	*Oreochromis niloticus*	Tremmel	276	303	591	4
675	26.11.15	III	*Oreochromis niloticus*	Tremmel	189	221	312	4
676	26.11.15	III	*Oreochromis niloticus*	Tremmel	256	301	492	4
677	26.11.15	III	*Oreochromis niloticus*	Tremmel	207	249	351	4
678	26.11.15	III	*Oreochromis niloticus*	Tremmel	195	227	319	4
679	26.11.15	III	*Oreochromis niloticus*	Tremmel	196	247	323	3
680	26.11.15	III	*Oreochromis niloticus*	Tremmel	187	222	311	4
681	26.11.15	III	*Oreochromis niloticus*	Tremmel	245	293	488	4
682	26.11.15	III	*Oreochromis niloticus*	Tremmel	208	259	342	4
683	26.11.15	III	*Oreochromis niloticus*	Tremmel	242	295	427	4
684	26.11.15	III	*Oreochromis niloticus*	Tremmel	188	240	223	3
685	26.11.15	III	*Oreochromis niloticus*	Tremmel	178	211	290	3
686	26.11.15	III	*Oreochromis niloticus*	Tremmel	143	178	160	2
687	26.11.15	III	*Oreochromis niloticus*	Tremmel	214	260	297	4

Appendix 2: Data used for One-way analysis of variance of fish growth rates in the Kafue Floodplain fishery

OA	OM	ON
37	33	88
71	62	159
100	89	216
127	113	262
151	135	298

Appendix 3: Data used for One-way Analysis of Variance of fish asymptotic lengths at The study sites

OA	OM	ON
414	402	612
358	344	383
314	383	355

Appendix 4: Data used for One-way Analysis of Variance of fish growth coefficients at The study sites

OA	OM	ON
0.25	0.24	0.48
0.16	0.12	0.3
0.1	0.08	0.12

Appendix 5: Data used for One-way Analysis of Variance of fish growth rates at Kafue Road Bridge

OA	OM	ON
92	86	233
163	153	378
218	206	467
262	248	522

Appendix 6: Data used for One-way Analysis of Variance of fish growth rates at Namalyo

OA	OM	ON
53	39	99
98	73	173
136	104	227
169	131	268
197	155	298

Appendix 7: Data used for One-way Analysis of Variance of fish growth rates at Kakuzu

OA	OM	ON
30	23	40
57	45	76
81	65	107
104	83	135
124	100	160

Appendix 8: Data used for One-way Analysis of Variance of exploitation ratios at the Study sites

OA	OM	ON
0.3	0.64	0.3
0.4	0.7	0.6
0.4	0.75	0.4

Appendix 9: Fish of the Kafue Floodplain fishery (source: Mortimer, 1965; * commercially important fish)

Scientific name	English name	Family
Scientific name	**English name**	**Family**
***Mormyrus larceda**	Bottlenose	Mormyridae
**Gnathonemus macrolepidotus*	Bull-dog	Mormyridae
**Petrocephalus catastoma*	Churchill	Mormyridae
Marcusenius castelnaui	Catelnaus Stone-basher	Mormyridae
Kneria auriculata	Small scaled Minnow	Kneridae
**Hepsetus odoe*	Pike	Characidae
Petersinius rhodesiensis	Silverfish	Characidae
Micralestes acustidens	Silver Robber	Characidae
**Brycinus lateralis*	Stripe tailed Robber	Characidae
Nannochararax multifasciatus	Multi banded Citharinid	Citharinidae
Nannochararax sp	Banded Citharinid	Citharinidae
Labeo annectens	Striped mudsucker	Cyprinidae
**Labeo cylindricus*	Mudsucker	Cyprinidae
**Barbus marequensis*	Yellowfish	Cyprinidae
Barbus afrovernaya	Spot-tail Barb	Cyprinidae
Barbus barotseensis	Many spotted barb	Cyprinidae
Barbus eutaenia	Thick striped Barb	Cyprinidae
Barbus fasciolatus	Red banded Barb	Cyprinidae
Barbus haasianus	Sickle fin Barb	Cyprinidae
Barbus labialis	Plain Barb	Cyprinidae
Barbus lineomaculatus	Spotted Barb	Cyprinidae
Barbus multilineatus	Multi striped Barb	Cyprinidae
Barbus paludinosus	Serrated spine Barb	Cyprinidae
Barbus poechii	Smooth spine spot Barb	Cyprinidae
Barbus puellus	Dot tailed Barb	Cyprinidae
Barbus tangandensis	Thin striped Barb	Cyprinidae
Barbus viviparus	Twin striped Barb	Cyprinidae
Barbus (Beirababus) aurantiacus *Barbus manicensis*	Red eyed Barb Yellow Barb	Cyprinidae Cyprinidae
Barbus radiatus	Beira Barb	Cyprinidae
Coptostomabarbus wittei	Square jawed Barb	Cyprinidae
**Schilbe mystus*	Silver Barbel	Schilbeidae

**Clarias mossambicus*	Sharp toothed Barbel	Clariidae
**Clarias mellandi*	Blunt toothed Barbel	Clariidae
Clarias theodorae	Snake Barbel	Clariidae
Clarias stappersii	Blotched Barbel	Clariidae
**Claria gariepinus*	Sharptooth Catfish	Clariidae
**Clarias ngamensis*	Blunt tooth Catfish	Clariidae
Chiloglanis neumanni	Sucker-mouth Catlet	Mochokidae
**Synodontis macrostigma*	Squeaker	Mochokidae
Leptoglanis rotundiceps	Spotted catlet	Mochokidae
Nothobranchius taeniopygus	Zambia Top Minnow	Cyprinodontidae
Aplocheilichthys johnstoni	Common Top Minnow	Cyprinodontidae
Aplocheilichthys katangae	Striped Top Minnow	Cyprinodontidae
**Oreochromis andersonii*	Three-spot Bream	Cichlidae
**Oreochromis macrochir*	Green headed Bream	Cichlidae
**Oreochromis niloticus*	Nile Tilapia	Cichlidae
**Tilapia melanopleura*	Red-breasted Bream	Cichlidae
**Tilapia Sparrmanii*	Banded Bream	Cichlidae
**Serranochromis macrocephalus*	Purple-faced Bream	Cichlidae
**Serranochromis angusticeps*	Thin-faced Bream	Cichlidae
**Serranochromis robustus*	Yellow-belly Bream	Cichlidae
**Serranochromis thumbergi*	Brown-spot Bream	Cichlidae
**Sargochromis codringtoni*	Green Bream	Cichlidae
**Haplochromis giardi*	Pink Bream	Cichlidae
**Haplochromis carlottae*	Charlottes Bream	Cichlidae
**Haplochromis frederici*	Frederics Bream	Cichlidae
Haplochromis philander	Dwarf Bream	Cichlidae
Ctenopoma multispinis	Climbing Fish	Anabantidae
Ctenopoma ctenotis *Mastacemblalus mellandi*	Spiny Eel	Anabantidae Mastacembelidae

Appendix 10: Annual fish production for major fisheries in Zambia from 1966 to1999

(metric tonnes) Source: FAO Fisheries Department (2010).

YEARS	BANGW	M/LUA	M/WAN	TANG	KAFUE	KARI	LUKA	U/ZAM	LUSI	L/ZAM	TOTAL
1966	12408	9479	1672	6500	10709	1436	658	1000	0	0	43862
1967	12394	7543	2865	11968	3441	980	955	1000	0	0	41146
1968	11430	7617	3704	10104	6183	1410	1602	1000	0	0	43050
1969	11894	7717	4125	7066	9938	1345	1366	1000	0	0	51139
1970	12375	7326	4216	10835	9582	2581	1724	2500	0	0	46841
1971	11728	8342	3825	6988	8247	2311	1900	3500	0	0	49894
1972	13034	9068	5812	6281	7874	1955	2370	3500	0	0	50352
1973	14032	8031	8113	5488	6289	3098	1801	3500	0	0	46929
1974	15715	8135	5992	4522	5177	2181	1707	3500	0	0	57464
1975	9881	8483	16765	7440	7266	0	1802	5827	0	0	54267
1976	7598	10680	13330	6501	9307	0	856	5995	0	0	54267
1977	9496	9534	12513	7866	9830	0	1005	3490	0	0	53734
1978	8942	7629	10352	6474	8634	0	786	4475	277	0	47569
1979	11648	9438	7878	3119	10851	0	763	5559	255	0	49511
1980	10367	7663	9094	8256	7741	407	549	6572	339	0	50988
1981	9343	2744	5734	1983	9619	875	669	6694	0	0	37661
1982	11006	7907	10979	8010	8907	2601	776	5200	423	0	55809
1983	14467	7624	8765	8522	3605	6227	926	3301	430	308	54175
1984	14715	11050	9676	11783	4317	6769	1204	4309	600	199	64622
1985	12533	10758	9220	14900	5008	9092	1120	3864	999	238	67732
1986	8125	6284	7000	12978	4262	9657	794	5235	943	157	55437
1987	11993	7707	9497	12452	5955	8666	1572	4491	936	296	63565
1988	10059	6996	8249	10629	4440	8661	1183	9200	547	620	60584
1989	9019	7190	7039	14386	8569	10409	1401	8358	218	141	66730
1990	14569	8978	3082	15418	5946	9185	1509	6578	2135	605	68005
1991	14962	8566	3147	14113	6311	9258	1623	6614	2176	558	67328
1992	13734	8964	3018	13829	6137	8658	1554	6992	2106	602	65594
1993	15419	8920	2950	14233	6316	9722	0	6785	2173	543	67061
1994	15732	7815	3474	15927	6479	8910	1691	6064	2248	528	68868
1995	16383	7925	3138	15967	6293	8674	2508	5763	1537	470	68658
1996	8725	6426	3405	13437	8724	7593	3318	9243	1029	333	62233
1997	10629	6398	8939	12719	7601	7813	0	9605	1143	623	65470
1998	11639	6987	7220	14041	5362	9822	1870	8403	523	490	66357
1999	9101	7522	8490	12709	7335	8955	2613	4213	403	201	61542
TOTAL	**405095**	**273446**	**233278**	**347444**	**242255**	**169251**	**46175**	**173330**	**21440**	**6912**	**1918628**