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Assessing the Abundance and Distribution of Tilapia Species in Lake Kariba

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Abstract

Tilapia species are among the major group of fish species commonly traded for consumption in Zambia. They have a wide market acceptance throughout the country. As such, they are extensively fished in all the country's major water bodies. In recent years, population growth has led to the increase in fishing pressure on the major lakes and rivers to the extent where some of them are being overexploited. A study was carried out in 2015 to assess the abundance and distribution of Tilapia species in Lake Kariba based on Catch Assessment survey (CAS) and Gillnet survey (GNS) conducted on the lake from 2012 to 2014 using relative abundance. Lake Kariba is divided into four strata (I, II, III and IV) based on the geographic and ecological characteristics, limnological structure and other given information of the lake. The results of the study showed no significant differences ($P>0.05$) in catch percentage of Tilapia species for the years considered. However, the study showed a significant decline ($P<0.05$) in catch percentage of Tilapia species on an individual stratum over the years. Among the four strata of Lake Kariba, stratum IV showed the highest rate of decline in catch percentage of Tilapia species. The study further showed that Tilapia species were more abundant and distributed in stratum IV compared to the other three strata.

Key words: Tilapia species, Catch Assessment Survey, Gillnet Survey, Relative abundance, Stratum

1.0 INTRODUCTION

Water bodies are extremely useful ecological resources that serve many human needs as well as enhancing our lives by providing a lot of opportunities. As such, a large proportion of human population live near lakes, rivers, streams, swamps, reservoirs and coastal lagoons (Adeyemi *et al.*, 2010). Many people largely depend on the resources of such water bodies such as fish as their main source of animal protein and family income (Haruna *et al.,* 2006). Fisheries are very important in the national economy and contribute significantly to employment, food production and the Gross Domestic Product (GDP). The ability to accurately estimate fish species abundance in a water body is fundamental for the effective and efficient management of fisheries (Karnauskas and Babcock, 2010).

In Zambia, the natural fishery areas in recent years have been fully and in most cases overexploited making it difficult to significantly increase fish production to meet local demand estimated at 100,000 tonnes annually and for export (Mudenda *et al.,* 2005). Substantial decline in water quality and biodiversity of most fisheries in the country have been observed in recent past. Lake Kariba was created in 1958 and since then, the lake has experienced considerable changes in its fishery and fish communities leading to inconsistencies in fish catches as observed by fishers and other studies (Kolding *et al.*, 2004). Although Lake Kariba is likely among the most studied lakes in Africa, its fishery exploitation levels are still generally unknown (Anon, 1992; Kolding, 1994; Karenge and Kolding, 1995). Fish stock assessment is key to understanding fish population dynamics which respond over time due to management regulations, species interactions, and other extrinsic influences. Trends in relative abundance are important indicators of fish community health and contribute to an understanding of fish community changes (Schneeberger *et al.,* 1998). This study was aimed at assessing the abundance and distribution of Tilapia species in Lake Kariba. Tilapia species are among the species of economic importance in Zambia and are the most preferred on the market throughout the country.

2.0 RESEARCH METHODOLOGY

2.1 Location of Study Area

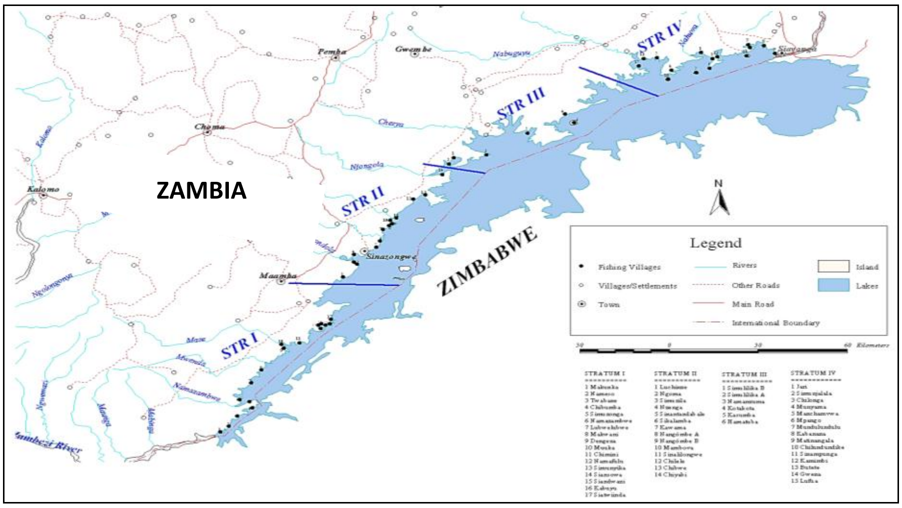

Figure 1: Map of Lake Kariba showing its Strata.
Source: Lake Kariba Fisheries Research Unit, 2013.

2.2 Research Design

Like most fisheries in Zambia, Lake Kariba is divided into strata for sampling purposes according to geographic and ecological characteristics, limnological structure and other information within a given fishery. The whole lake was divided into four strata: Stratum I, II, III and IV (See figure 1). Each stratum consisted of a number of fishing villages. Part of CAS and GNS data was obtained from the Sinazongwe Fisheries Training Institute – Department of fisheries where Stock Assessment Surveys for Lake Kariba were conducted every year. The main activities done during the survey included: Gillnet Survey (GNS) and Catch Assessment Survey (CAS). These activities therefore provided the required information on relative species abundance and distribution. Presently, 50 different fish species indigenous to the upper and middle Zambezi river basin had been documented on Lake Kariba (Malasha, 2008). However, only 18 species were considered to be of commercial importance. In this research however, the main interest was to assess Tilapia species abundance and distribution. The information obtained on Tilapia species was compared to that of other species in the same Lake as obtained from CAS and GNS of the same years.

The study looked at all the four strata of Lake Kariba by considering the villages that were covered during CAS (2012-2014) and GNS (2010-2015).

2.3 Data Collection and Analysis

The data collected on CAS and GNS was mainly obtained from the Sinazongwe Fisheries Training Institute and Department of Fisheries headquarters at Chilanga, Zambia. Additional information used was obtained from related published sources. The catches from CAS and GNS were analyzed within and between strata to see the trends in Tilapia species catches and of other species to see the relationship in changes for the years considered. Data collected was analyzed using Statistical Package for Social Scientists (SPSS) alongside excel in order to prepare charts and graphs.

3.0 RESULTS

Figure 2 shows summary of catch % contribution of each species/family to total fish production (2012-2014) from CAS.

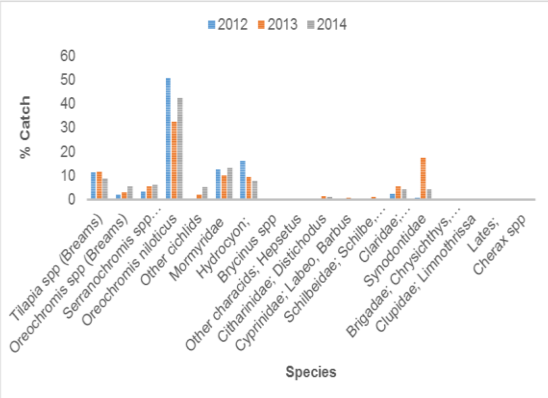

Figure 2: Overall catch % of each species towards total fish production (2012-2014).

Figure 3 gives a summary of annual fish production in metric tonnes CAS (2011-2014).

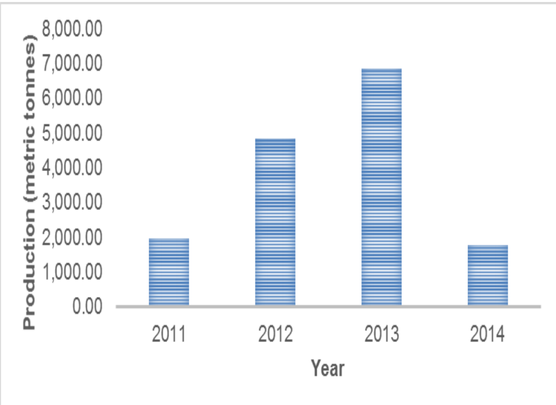

Figure 3: Summary of total production in metric tonnes (2011-2014).

Figure 4 shows % contribution of each species/family to the annual production from Stratum I to IV in 2012.

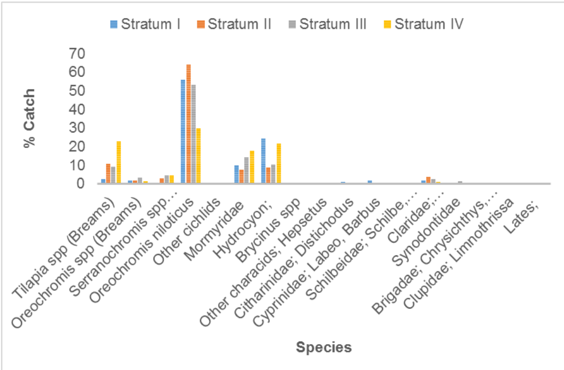

Figure 4: Catch % of each species in the four strata of L. Kariba in 2012

Figure 5 shows a summary of catch % fish species in L. Kariba from the four strata.

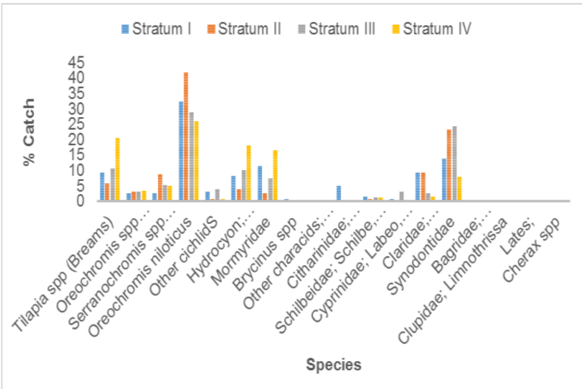

Figure 5: Catch % of each species in the four strata of L. Kariba in 2013

Figure 6 shows a summary of catch % of each species from the four strata in the year 2014 in L. Kariba.

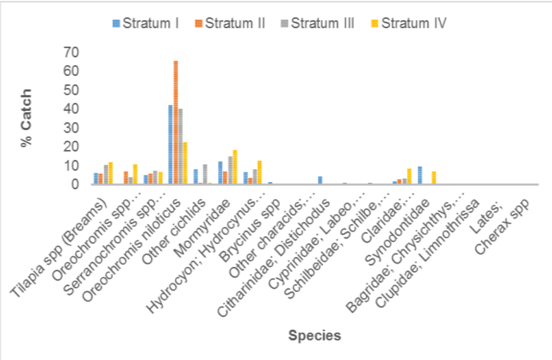

Figure 6: Summary of catch % of each species/family in the four strata of L. Kariba in 2014

Figure 7 gives a summary of catch % of Tilapia species in all the four strata of L. Kariba.

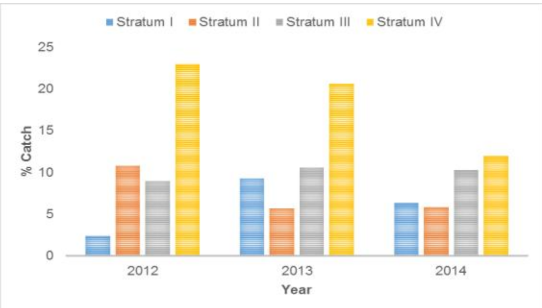

Figure 7: Catch % summary of Tilapia species in all the four strata of L. Kariba (2012-2014)

Figure 8 gives a summary of CPUE for each stratum of L. Kariba based on CAS.

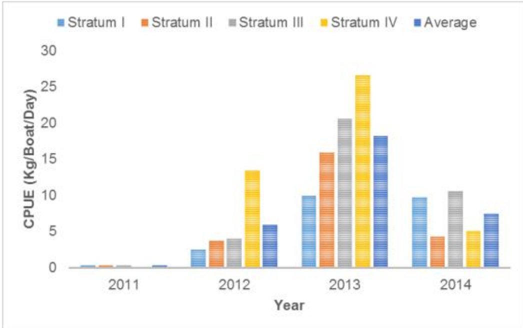

Figure 8: Summary of CPUE for each stratum according to CAS conducted for L. Kariba (2011-2014)

Figure 9 give a summary of the activity (AR) rates and the average in each stratum of L. Kariba.

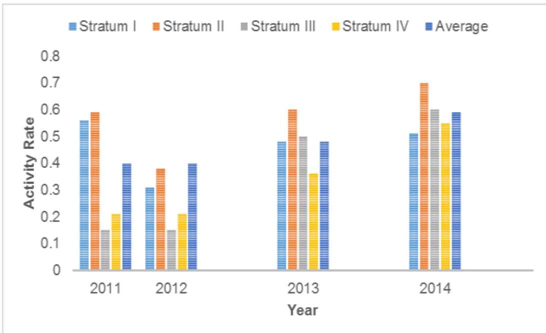

Figure 9: Summary of AR in each stratum of L. Kariba, CAS (2011-2014).

Figure 10 shows catch frequency of Tilapia species in L. Kariba, GNS (2010 - 2015)

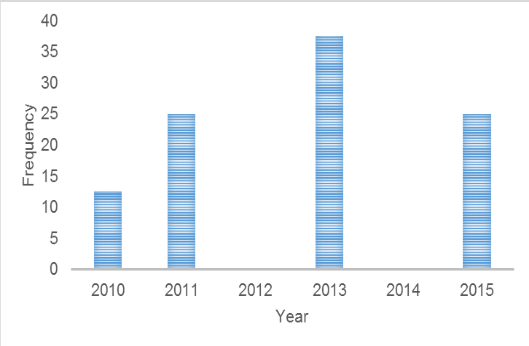

Figure 10: Catch % frequency of Tilapia species during Gillnet Survey in L. Kariba (2010 – 2015)

Figure 11, shows the average length - weight of Tilapia species in L. Kariba, GNS (2010-2015).

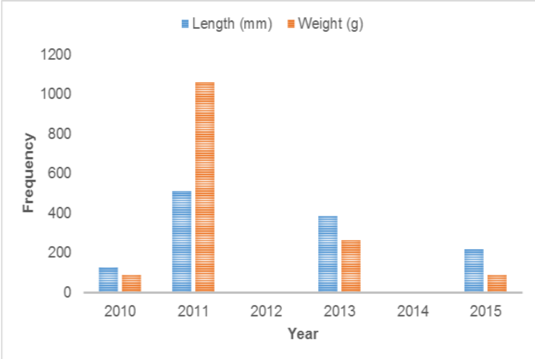

Figure 11: Average weight - length of Tilapia species in L. Kariba (2010-2015)

4.0 DISCUSSION

4.1 Catch Assessment Survey

The current study observed that when the catch percentage of the species were assessed on a yearly basis, there were no significant differences among the years under consideration. This was supported by the P-value of 0.78 ($P>0.05$) obtained from one way Analysis of Variance. On average, the catch percentages of all the eighteen species of economic importance were almost similar from 2012 through to 2014. Although 2012 recorded the highest overall catch percent contribution of the species on average, there were inconsistencies in catch percentages among the years for some species. The high variations observed in 2012 were probably because only one round of Catch Assessment Survey was conducted and at different time intervals (seasons). However, the ideal situation was to conduct surveys at the same time in all the four strata of the fishery. But due to untimely release of financial resources, surveys were conducted at different intervals. For example, surveys in stratum I, II and IV were conducted between 22nd and 31st August, while in Stratum III it was done between 9th and 18th November 2012.

Most of the species showed high variability in catch percentages and the most notable ones were *Hydrocyons, Mormyrids, Clarids, Schilbes* and most cichlids such as, *Oreochromis, Serrachromis* and others (Figure 2). Generally, the results showed a decline in catch percentage of the species and more variations appeared between 2013 and 2014 for most species. However, most species recorded higher catch percentages in 2014 compared to 2013, with a few exceptions of higher fish species in the latter year.

The annual production in metric tonnes however, showed a steady increase from 2011 to 2013, although a drastic decline was noted in 2014 (Figure 3). According to the Engineering Institution of Zambia (EIZ) Technical report (2015), the water level received for Lake Kariba in 2012 was approximately 485.8mm, in 2013 it dropped to 485.2mm, and finally in 2014 it further dropped to 485.00mm. Therefore, the minimal differences observed among the years in terms of annual production may be due to the differences in water level received in the lake during those years. The lowest water level received in 2014 compared to the other years may have led to the sudden decline observed in the annual production in metric tonnes. The results were in agreement with the findings of Sanyanga *et al.* (1994), who reported that fish catches in a given fishery go down considerably during periods of droughts. As such, a reduction in water received leads to low fish production. While an increase in water received leads to higher fish production because more food is made available for fish. The other reason was attributed to inadequate data collected on the Lake in 2014 due to the untimely and insufficient funds released by the government to conduct stock assessment for the lake which led to only one round Catch Assessment Survey being conducted on the Lake instead of the recommended three each year.

The lowest Catch per Unit Effort was observed in 2011 followed by 2012 which was slightly higher than 2014 while the highest was observed in 2013. A direct relationship was observed between Catch per unit effort and fish production in that the higher the catch per unit effort the higher the annual production in metric tons and vice versa (Compare figure 3 and 8). However, in line with the findings of Wallace and Fletcher (2005), no relationship was observed between fish production and Activity Rate of the fishery for any particular year (Compare Figure 3 and 9). Therefore, as Maunder *et al.* (2006) observed, environmental factors may also have had an influence on fish catchability.

At Stratum Level

The results revealed high variations in catch percentage for Tilapia species at stratum level (Figure 7). This was supported by the results obtained from one way analysis of variance where a P-value of 0.01 obtained was compared to the P-value at 0.05 indicating a significant decline in catch percentages of Tilapia species. Of all the species considered, *Oreochromis niloticus* showed the highest catch percentage contribution to the annual production in all the strata (Figure 2). The 'invasive species' dominance was very extraordinary when compared with other species. The extraordinarily high catch percentage of *Oreochromis niloticus* compared to the other species was attributed to several reasons which include its ability to tolerate a wide range of environmental variations (Trewevas, 1983) as well as its ability to grow into adulthood at a faster rate (Peterson *et al*., 2002). Moreover, the initial introduction of Oreochromis niloticus is believed to have been done on stratum IV of Lake Kariba. Being an invasive species, the success of *Oreochromis niloticus* therefore, suggests that there are few, if any, successful competitors in the ecological systems where it has been introduced.

The year 2014 showed the highest catch percentage variation and lowest amount of fish caught. On average, stratum IV showed the highest while stratum I had the lowest catch percentage of Tilapia species compared to other strata. The results further revealed that Tilapia species were declining at a higher rate in stratum IV compared to the other three strata. However, despite the highest rate of decline in catch percentages, stratum IV still had the highest catch percentage on average compared to all the other strata. Stratum III rather showed the lowest rate of species decline for Tilapia species (Figure 7). The reason for high fish production in stratum IV was probably due to the fact that stratum IV of Lake Kariba fishery was rapidly expanding in terms of cage fish farming as well as the upgrading of electricity generation facilities. Moreover, Stratum IV is the deepest of all the strata because of the Kariba dam wall. These introduced economic activities in Siavonga (stratum IV), might have had a bearing in terms of fishing activity rate by offering alternative livelihood in form of employment to fishers either on permanent or temporal basis. The areas near cages provides safe havens for most species because they are unsuitable for inshore fishing activities and therefore the spawning grounds are rarely affected due to fishing activities.

4.2 Gillnet Survey

The results obtained from Gillnet Survey showed a decline in average length and weight of individual Tilapia species over the years considered. The results further revealed that, except for 2011, the length and weight decline of Tilapia species in Lake Kariba were directly proportional (Figure 11). These results were in line with the findings of Maunder *et al.* (2006) who reported that as fish are removed from a population that population will decrease in abundance and size of individual species. The difference observed in 2011 was attributed to differences in environmental conditions such as temperature, food availability etc. However, from 2011 to 2015, there was a constant decline in both weight and length of an individual species. The decline in abundance and size of the species was attributed to increased fishing pressure on the lake due to the increasing number of fishers joining the fishery due to high unemployment levels among youths.

5. CONCLUSION AND RECOMMENDATION

Based on the results of this study, the abundance of Tilapia species in Lake Kariba were significantly declining over the years at stratum level. On the contrary, changes in abundance over the years for the whole lake were not significant. Of all the strata of Lake Kariba, Tilapia species were more abundant and distributed in Stratum IV despite the highest rate of decline in species abundance in the same stratum. Besides fishing pressure and other factors, fish species abundance and distribution in Lake Kariba were also affected by water levels received during a particular rainy season. Lake Kariba was constantly receiving a large number of fishers on a yearly basis since it was perceived to be among few promising fisheries in terms of fish production in Zambia. The influx of fishers had contributed to a decline in the catches of fish species over the years. Therefore, the current rate of increase in the number of fishers on Lake Kariba was likely to further decrease fish species abundance in the near future. Future studies may focus on assessing fish species abundance especially those of economic importance in other fisheries in the country in order to minimize on the movement of fishers from one fishery to another which tend to increase fishing pressure on a particular fishery with more prospects.

6. ACKNOWLEDGEMENTS

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Appendix 1: Anova: Single Factor for the strata

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Stratum I	3	17.98	5.993333333	11.98253333
Stratum II	3	22.32	7.44	8.4708
Stratum III	3	29.85	9.95	0.7009
Stratum IV	3	55.45	18.48333333	33.38223333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	281.1159333	3	93.70531111	6.872855309	0.013234896	4.066180551
Within Groups	109.0729333	8	13.63411667			
Total	390.1888667	11				

Appendix 2: Anova: Single Factor for the years

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
2012	4	45.1	11.275	73.3761
2013	4	46.14	11.535	40.61876667
2014	4	34.36	8.59	8.979266667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	21.26646667	2	10.63323333	0.259401706	0.77708886	4.256494729
Within Groups	368.9224	9	40.99137778			
Total	390.1888667	11				