ISSN: 2347-5129
IJFAS 2014; 2(2): 283-287

www.fisheriesjournal.com
Received: 20-08-2014
Accepted: 08-09-2014

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Fishing Impacts in protected and unprotected areas of lake Victoria, Tanzania

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Abstract
Population size structure, abundance and biomass for *Oreochromis niloticus* and *Lates niloticus* from protected area of Rubondo Island National Park (RINP) and unprotected area of Kome Island (KI) in Lake Victoria were compared from July 2007 to July 2009 using fish length, number of species and their weights. Length distributions for *O. niloticus* in RINP were 1.85 and 2.04 times longer than in KI for total and standard length respectively. Total and standard lengths were significantly different between RINP and KI areas. While, those for *L. niloticus* in RINP were 1.87 and 1.91 times longer than in KI for total and standard length respectively and both were significantly different. Families of Alestidae, Bagridae, Claridae, Cichlidae, Cyprinidae, Mormyridae, Latidae and Potamonautidae were sampled. *O. niloticus* in RINP was more abundant than the conspecific species in KI and was significantly different. *L. niloticus* in KI was more abundant than the conspecific species in RINP and was significantly different. Biomass for *O. niloticus* in RINP was 6 times heavier than in KI and the biomass for *L. niloticus* in RINP was 17 times heavier than in KI. Biomass for *O. niloticus* and *L. niloticus* were both significantly different between the RINP and KI areas. Introduction of protected areas in Lake Victoria has been recommended since fish species in protected area indicated better performances in terms of size, abundance and weight.

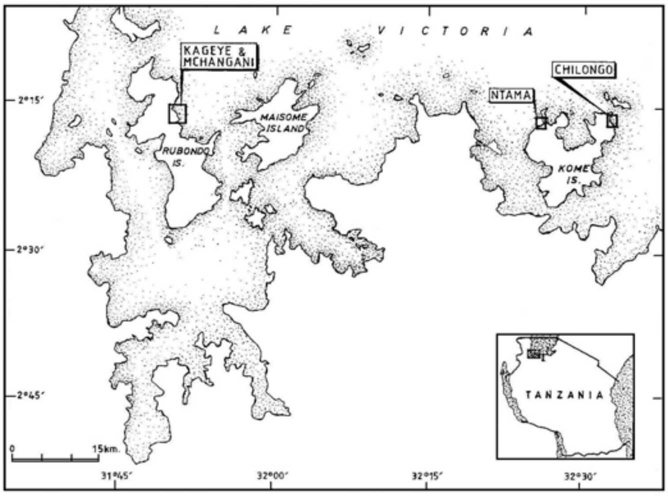
Keywords: Fishing, Lake Victoria, Protected area, Unprotected area, Biomass, Length distributions.

1. Introduction
Fishing has a major impact on fish population size structures whereby, selective cropping of commercially important and mature fish results in reduced mean fish length [1]. Main indicators for fishing impact to fish populations include total mortality rates, exploitation rate, average lengths, abundance, diversity, and condition factor [2]. Fish diversity and abundance are indicators of fish population basing on fish's composition [2]. Under normal circumstances fishers target for bigger and gravid individuals and as a result, density and size structure decline [3, 4, 5]. Fishing eliminates not only predators but also prey resulting in total change of community structure [6]. Fishing gear used may affect fish populations by destroying breeding micro habitats of substrate spawners making them unable to breed and therefore, failure in recruitment [6].

Indicators for fishing impacts of fish species in Lake Victoria basin have been reported by several investigators such as [7, 8, 9, 10]. Most of the above investigators did not compare fishing impact indicators (fish length, abundance and biomass) in protected and unprotected areas. Therefore, the current assessment of Nile tilapia, *O. niloticus* and Nile perch, *L. niloticus* in Lake Victoria was carried out to document the fishing impact indicators in relation to increased fishing pressure in the lake and proposed strategies to protect the fisheries of *O. niloticus* and *L. niloticus* which are the mainstay of fisheries of Lake Victoria. The main objective of this study was to compare fish length, fish diversity, abundance and biomass for *O. niloticus* and *L. niloticus* in protected area of Rubondo Island National Park (RINP) and unprotected area of Kome Island (KI) in Lake Victoria in Tanzania.

2. Materials and Methods
2.1 Study area
Lake Victoria is situated close to the Equator between latitudes 0º 20′ N to 3º 0′ S, and longitudes 31º 39′ E to 34º 53′ E at an altitude of 1,134 m above the sea level [11]. The lake is shared with three riparian states of Kenya, Uganda and Tanzania at proportions of 6, 43

and 51 percent of the surface area of the lake respectively [12]. Islands of Lake Victoria form good fishing grounds and many of the small Islands are inhabited by nomadic fishers and are unprotected from fishing activities. This study was conducted at RINP and KI (Fig. 1). RINP is protected from fishing activities and KI is among areas unprotected from fishing activities in Lake Victoria



2.2 Fish collection
Fishing was conducted by deploying a beach seine net measuring 146 m long, 5 m high and 10 mm stretched mesh size of the net bag. Non motorized boat/ canoe was used. Starting from the beach leaving one end of the pulling ropes at the shore held by one person, other crews roared off shore and set the net. Hauling of the net was done by three crews on each side after the boat landed on the shore on another point. When the net was finally brought ashore and the catch was sorted into species, their number and weight recorded. The beach seine net was set offshore to depth of 4 to 6 meters parallel to the shore to assume a rectangle shape of the fished area [13, 14, 15]. Average length for the pulling ropes was 150 m long, making the sampled area at each of the four sites to be 21,900 square meters. Fish samples were identified using a Field guide book to the freshwater fishes of Tanzania [16]. Weight measurements for each fish were taken after blotting fish by cotton cloth for the total wet weight (TW) using a top loading balance to the nearest 0.1 g. Total length (TL) and standard length (SL) were measured using a tape measure from the tip of the mouth to the end of the longest part of caudal fin and the caudal peduncle for the total length and the standard length respectively, to the nearest 0.1 cm. Sexes and reproductive status of the specimens were determined macroscopically after dissecting specimens and maturity stages were assigned using a generalized classification of stages in fishes (having gonad stage I immature; stage II developing or resting; stage III maturing; stage IV spawns and stage V spent) adopted and modified after [17]. Paired gonad weights (W_G) were measured to the nearest 0.01 g using a sensitive top loading weighing balance.

2.3 Fish length frequency and population size structure
Fish length frequencies were presented in graphical form for *O. niloticus* and *L. niloticus* both for protected and unprotected areas using excel statistical program by plotting frequency versus class intervals to establish fish population size structure.

2.4 Fish diversity, evenness, abundance and biomass
Fish diversity was determined using Shannon diversity index using the formula $H' = -\sum pi(\ln pi)$ and *pi*= n/N .Where n is the number of individuals of a species, N is the total number of individuals in a sample and Pi is the proportion of each species in a sample [18, 19]. Evenness index of the sampled species was determined by using the formula E= (Evenness index) = -∑(Pi (lnpi)/LnS. Where S is the total species sampled; N is the total number of specimens; Ni is the number of specimens of a species. Abundance of each species from sampling sites was calculated from the catch of fish expressed as number of fish's per100 m^{-2} [20, 21]. The number of fish were obtained from the catch based on the swept area of 21,900 m^2. Fish biomass was determined from the average weight of the total catch for each species and expressed as g wet weight 100 m^{-2} [22].

2.5 Data analysis
Fish length for *O. niloticus* and *L. niloticus* in RINP and KI were compared using chi- square test and T- test. The Paleontological statistics (Past) version 2.14 [23] was used in statistical tests. Biomass for *O. niloticus* and *L. niloticus* in RINP and KI areas were compared for significance different using Mann-Whitney test U at $p < 0.05$.

3. Results
3.1 Length frequency distributions
Length distributions for *O. niloticus* and *L. niloticus* from RINP and KI are presented in Figures. 2 (a)-(b).

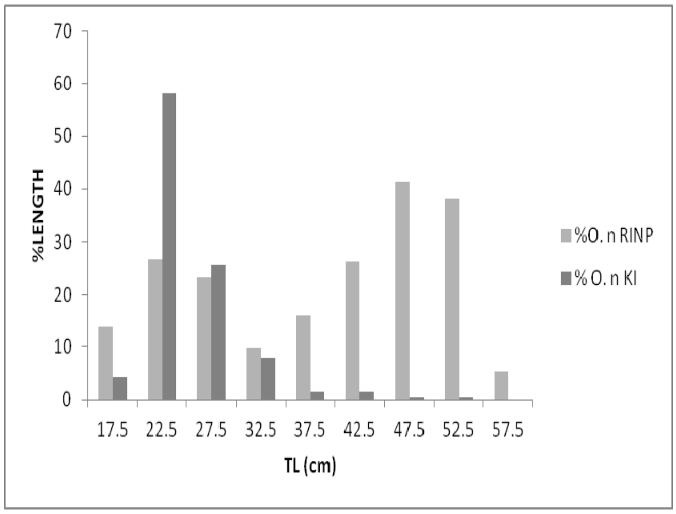


Fig 2(a): Length distributions for *O. niloticus* from RINP and KI

Males of *O. niloticus* in RINP were longer than females and significantly different at $t = -8.4$, $df = 495$ and $p < 0.0001$. Similarly, males from KI were longer than females but not significantly different at $t = 1.1$, $df = 275$ and $p > 0.27$. Comparisons between males for *O. niloticus* in RINP and KI indicated that males from RINP were longer than males from KI and were significantly different for total length at $t= -7.51$, $df = 772$, $p < 0.0001$. Length distributions for *O. niloticus* in RINP showed two modal lengths at 22.5 cm and 47.5 cm. (Fig. 2 (a)). Length distributions for *O. niloticus* from KI were skewed to the left with more specimens at 22.5 cm TL (Fig. 2 (a).

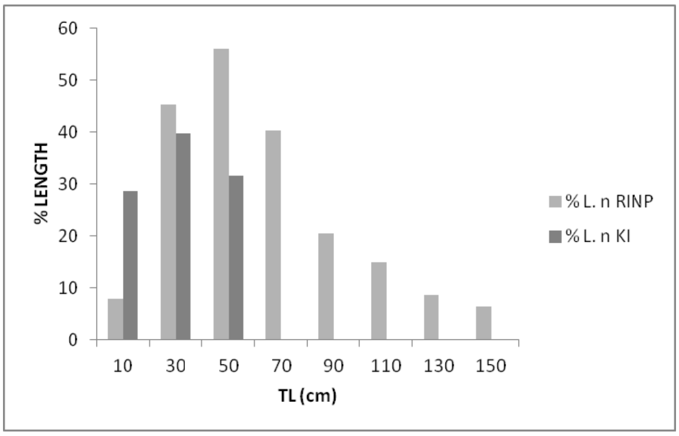


Fig 2(b): Length distributions for *L. niloticus* from RINP and KI

Length distributions for female *L. niloticus* were longer than males in RINP and KI and significantly different t= 5.87, df = 127, p<0.0001. Length distributions of *L. niloticus* from RINP were skewed to the right with decreasing occurrences as the length increased (Fig. 2 (b)).

3.2 Combined mean length distributions

Combined Mean (SD) length for males and females for *O. niloticus* and *L. niloticus* in RINP were higher than in KI. Mean total length of males, females and combined lengths for *O. niloticus* in RINP was 43.6±11.2, 34.7±11.1 and 40.1±12.While those from KI was 21.3±4.6, 21.9±4.8 and 21.6±4.6. Males of *O.niloticus* in RINP were 2.11 times longer than males in KI, while females in the RINP were 1.38 times longer than females in KI and the combined length in RINP was 2.53 times longer than the combined length for *O. niloticus* in KI for the total length. Mean total length did not differ between RINP and KI areas by chi -square test at chi square = 0.47, df =2 and p> 0.78 for total length. Mean total length of males, females and combined length for *L. niloticus* in RINP were 53.6±22.2, 81.3±32.2 and 56.5±32.5. The KI mean total length for males, females and combined lengths were 33.06±5.6, 37.6±5.4 and 30.2±6.9. Males, females and combined length for *L. niloticus* in RINP were 1.96 times longer than males in KI, females were 2.59 times longer than females in KI and combined length was 2.38 times longer than the combined length in KI for total length. Comparisons of mean total length between RINP and KI areas using chi-square did not differ between RINP and KI at χ^2= 0.95, df = 1 and p>0.62

3.3 Species composition, diversity and evenness

Species composition consisted of nine species collected during the study (Table 1).

Table 1: Shannon diversity index and evenness index of fish species from RINP and KI

Species	ni	Pi= ni/N	Lnpi	Pi(lnpi)	E
Bagrus docmac	2	0.0004	-7.8212	-0.0031	-0.47961
Clarius gariepinus	8	0.0016	-6.4349	-0.0013	
Brycinus jacksonii	11	0.0022	-6.1164	-0.0135	
Potamonautes spp	275	0.0551	-2.8976	-0.1598	
Haplochromis spp	3209	0.6436	-0.4406	-0.2838	
Lates niloticus	667	0.1337	-2.0116	-0.2691	
Mormyrus kanumme	4	0.0008	-7.1281	-0.0057	
Oreochromis niloticus	797	0.1598	-1.8335	-0.2931	
Rastrionebola argentea	13	0.0026	-5.9494	-0.0155	
Total	4986		H= -1.05381		

Nine species were collected from the RINP sampling sites and six species were collected from the KI sites. The species include: *Bagrus docmac*, *Brycynus jacksonii, Clarias gariepinus*, Haplochromine fishes, *L. niloticus*, *O. niloticus*, *Potamonautes* spp, *Mormyrus kanumme* and *R. argentea*. *Bagrus docmac*. *B. jacksonii* and *Potamonautes* spp were absent in KI. Diversity of fish species in the studied areas of Lake Victoria was higher in RINP area than in KI. The Shannon diversity index H' for the studied species in the RINP was 1.2 while in the KI was 0.83 and was significantly different between the areas at χ^2 = 0.069, df =1 and p < 0.05. The combined Shannon diversity index for the two areas was 1.05 (Table 1). The evenness index indicated that species in the RINP were evenly distributed than in KI, the evenness indices were 0.55, 0.47 and 0.48 for RINP, KI and combined areas respectively.

3.4 Fish abundance and biomass

Haplochromis species were more abundant in both RINP (8.85 /100 m^2 and KI areas (5.79/100 m^2). The abundance for *O. niloticus* in RINP was higher (2.35 N/100 m^2) than in KI (1.44 N/100 m^2). The abundance for *L. niloticus* in the KI was higher (2.25 N/100 m^2) than in the RINP (1.08 N/100 $m^{2)}$. Differences in abundance of *O. niloticus* during dry and wet season in RINP and KI areas were not significantly different by Mann-Whitney test at U = 68.5, Z = -1.03 and p = 0.305 and U= 65.5, Z= - 0.653 and p = 0.51 for RINP and KI areas respectively. Differences in abundance during dry and wet seasons for *L. niloticus* were significantly different in RINP at U = 27.5, Z = - 2.376 and p = 0.017 and in KI were not significantly different at U = 61, Z =-0.7227 and p = 0.78. Biomass for *O. niloticus* in RINP was 6 times higher (6.83 g/100 $m^{2)}$ than in KI are (1.16 g/100 m^2). Biomass for *L. niloticus* in RINP was 17 times higher (20.05 g/100 m^2) than in **KI** area (1.19 g/100m^2). The biomass of fish species in the RINP were significantly different from the KI by Mann-Whitney at U = 5.45, Z = -19.13 and p < 0.0001 for *O. niloticus* and U = 23.47, Z = -8.16 and p < 0.0001 for *L. niloticus* respectively.

3.5 Seasonal biomass

Seasonal biomass for *O.niloticus* in the RINP was significantly different between dry and wet seasons at U= 14.34, Z = -7.23 and p < 0.0001. While the seasonal biomass for *O. niloticus* in

KI was not significantly different between the dry and wet season at U = 1.49, Z = -1523 and p > 0.1. There was a significant difference in seasonal biomass between dry and wet seasons for *L. niloticus* in RINP and KI during the study at U =2013, Z = -3751 and p < 0.0003 and U= 34.35 and p < 0.0015 for RINP and KI areas respectively.

4. Discussion

4.1 Fish population size structure

Mean total length for *O. niloticus* and *L. niloticus* from RINP were higher than in KI due to lower fishing pressure in RINP as compared to KI. This finding is in agreement with the findings of [24, 25, 26] whereby the length of fish in protected areas was higher than in fished areas. Specimens for *O. niloticus* and *L. niloticus* in RINP were longer than in KI. This finding indicates that current fishes fished from RINP are longer than those reported by [27] which were fished from unprotected areas of Kenyan waters whereby the longest female *O. niloticus* was 52.5 cm TL. [28] reported on his observation of the longest female specimen whose length was 56 cm TL and also, he noted on a female specimen whose length was 57 cm TL which was reported by [29]. Length of *L. niloticus* observed during this study suggest that the current sizes are less than those in the eighties, reported by [30] whereby specimens of 173 cm TL and 136 cm for female and males respectively were fished in unprotected areas. However, the longest male *L. niloticus* in the current study from RINP was longer than that reported by [30].

4.2 Species composition, diversity and abundance

The number of species in the current study was lower than what was reported by other researchers for example, [31] reported fourteen species in the Kenyan waters; [8] reported fifty species in non- trawl able areas of Lake Victoria in Tanzanian waters; [32] recorded thirteen species in Lake Victoria. The lowest number of species recorded in the current study could have been caused by the habitats sampled in the current study, sampling sites were mainly sandy beaches whereas the sites of the reported studies included river mouths, muddy areas and the sampling gear could have resulted in the low species recorded. Abundance of *O. niloticus* in RINP was higher than in the KI. This finding is in agreement with other researchers elsewhere on abundance of fish in protected areas [33, 34]. *L. niloticus* was more abundant in KI than in RINP, this could have been influenced by the general features of sampling sites and the behavior for *L. niloticus* whereby juvenile fishes are found in inshore areas of the lake and as they grow they move to the offshore areas [35].

4.3 Fish biomass

Biomass for fish species in RINP was higher than in KI due to the reason that fish species in protected areas live longer and attain bigger length and weights than in unprotected areas [36, 37, 38, 39]. Biomass for the currently studied fish species was lower than what was reported by [31] whereby *O. niloticus* and *L. niloticus* biomass was 4.5 Kg/hectare and 61.5 kg/hectare as compared to 0.7 kg/hectare and 2.005 kg/hectare for *O. niloticus* and *L. niloticus* respectively in the current study. Among the reasons for the lower biomass in the current estimation is the high fishing pressure and use of illegal fishing gears in the Lake. Different fishing methods used to estimate biomass of fishes in the lake could be another reason. The current method used beach seine net whereby [31] used bottom trawl net.

5. Conclusion

Comparisons for length, weight and species diversity between RINP and KI indicate that fish species in RINP were better than in KI. Therefore, it is recommended to introduce more protected areas from fishing activities in Lake Victoria for sustainable fishing and profitable fishing of Lake Victoria fisheries.

6. Acknowledgements

The author wishes to thank the European Union for implementing a Fisheries Management Project in Lake Victoria and the Lake Victoria Fisheries Organization as an Implementing Agency for financing this study. The author extends thanks to Mr John Kagosi a Field Assistant who assisted in collecting the fish data and lastly but not least the author thanks everyone in one way or another who made this work to be completed.

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