Uganda Journal of Agricultural Sciences, 2014, 15 (1): 27 - 39 ISSN 1026-0919

Can protected areas work in artisanal fisheries of Uganda? The case of Lakes Edward-George and Kazinga Channel

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Abstract

The Ecosystem Approach to Fisheries Management agitates for provision of Marine Protected Areas (MPAs) which seem to be effective in developed countries. However, efforts to control artisanal fisheries through protection have not been adequately assessed. The Uganda portion of Lake Edward, Kazinga channel and half of Lake George are located in Queen Elizabeth National Park, controlled and managed by the Uganda Wild Life Authority (UWA). Three of the seven recognised landing sites on Lake George occur outside the park, and by proxy are unprotected. The objective of this study was to compare fishing efforts, gears and fishery yield of the protected and unprotected lake areas and landing sites of Uganda during 2011 and 2013. Fishing effort data sets were generated through periodic census of fishing inputs, in addition to the yield. Of the total annual fish production (9,200 metric tonnes) from the Edward-George system on the Uganda portion, protected areas contributed 87% and were markedly higher than the unprotected area (13%). The number of illegal gillnets in the protected area increased by 88% relative to 12% in the unprotected area, over the same period. The principle of MPAs in conservation in artisanal fisheries may not be effective and achievable in these regions.

Key words: Kazinga channel, landing sites, Marine Protected Areas

Introduction

Lake Edward which is shared between Uganda (29%) and the Democratic Republic of Congo (71%) is located in the western Great Rift Valley at an elevation of 920 m above sea level, with its northern shores a few kilometers south of the Equator ($0^0$20'S $29^0$36'E). Lake Edward is 77 km long and 40 km wide at its maximum points and covers an area of 2,325 km^2 with an average depth of 17 m and maximum depth of 112 m which is about 3.5 km from the western (Congo) shore (Kamanyi and Mwene, 1990; NaFIRRI, 2008). The lake's major inflows are from the Nyamugasani River which drains the southwestern end of the Rwenzori Mountains, and the Ishasha, Rutshuru and the Bwindi rivers which drain the Kigezi and Rwanda highlands and Virunga volcanoes in the south.

A unique feature of the water shed of Lake Edward is its connection to Lake George, a shallow basin attached to Lake Edward through the 36 km Kazinga

Channel. Flow through Kazinga Channel is barely measurable, because the two lakes are at nearly the same elevation, although net transport is towards Lake Edward (Kamanyi and Mwene 1990, NaFIRRI 2008). Lake Edward is presently open, draining to Lake Albert to the north via Semliki River, but water loss by evaporation currently exceeds surface outflow by about 20% (Kamanyi and Mwene, 1990; NaFIRRI, 2008). Lake Edward is also an important reservoir for tropical precipitation in the Upper Nile Watershed (UNW), the equatorial headwaters of the main River Nile (Kamanyi and Mwene, 1990; NaFIRRI, 2008). Most of the lake is bordered by Queen Elizabeth National Park (QENP) in Uganda and Virunga National Park in Congo and the nearest town is Kasese and has 5 gazzeted landing sites (Fig. 1).

Lake George is a shallow lake with a mean depth of 2.5 m, a maximum depth of 4 m and an area of 250 km^2. It is situated astride the equator in the western arm of the East African rift valley at an altitude of 914 m. Most of the lake is bordered by savannah vegetation but the north-eastern sections are bordered by wetlands. It has four major effluents rivers. Three of them, Rivers Simbwe, Nsongwe and Mobuku originate from Ruwenzori Mountains. The fourth River Mpanga is a westward flowing tributary of River Katonga (Ogutu-ohwayo *et al*., 1997). Lake George is shared by Rubirizi, Kasese and Kamwenge districts and three quarters is located in the national park (Fig. 1). The fisheries are an important source of food, livelihood and income to residents in the landing sites and to urban dwellers in western and central Uganda. The fish

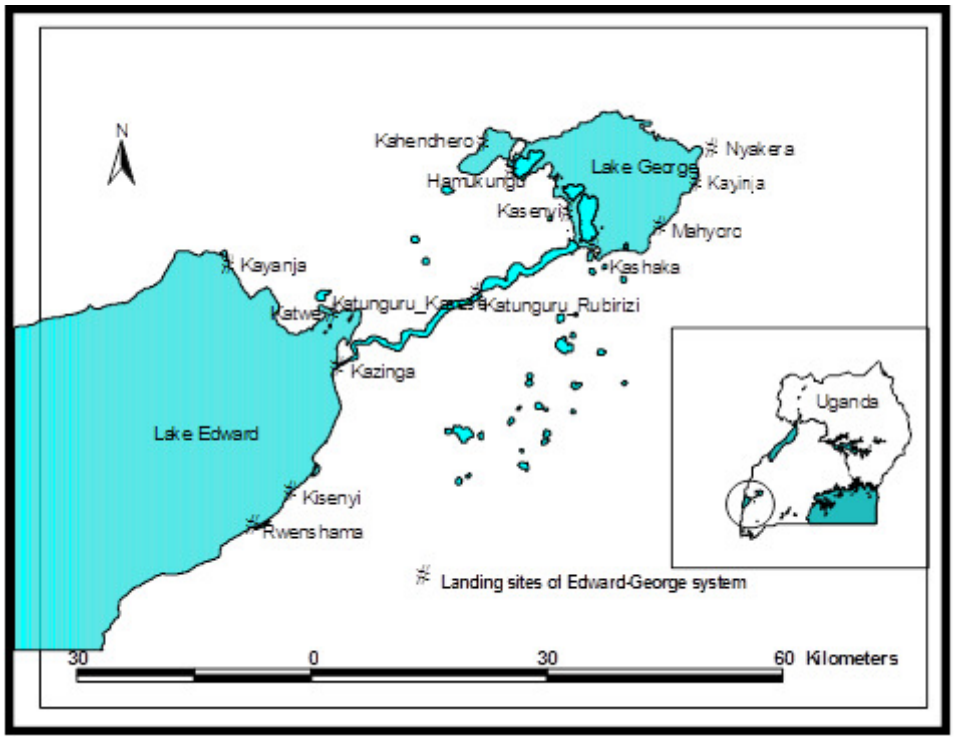

Figure 1. Landing sites for Lake Edward and George and Kazinga channel where Frame and CAS were conducted in the period of 2011, 2012 and 2013.

fauna of the lakes Edward and George is as diverse as its geological history (NaFIRRI, 2008). The lake shares some fish species with Lake Albert and others with lakes Victoria and Kivu. Geological evidence suggests that Lake Edward has had a connection with Lake Victoria up to probably the early Pleistocene period, approximately one million years ago (NaFIRRI, 2008; Ruseel, 1999). Thus most of the cichlid fishes in the lakes Edward and George are similar to those of Lakes Victoria and Kivu suggesting a common ancestry. Lakes Edward, George and Kazinga channel are home to many fish species with the commercial fisheries dominated by the Nile Tilapia (*Oreochromis niloticus*), *Bagrus docmac* (Cat fish also known locally as Semutundu), and *Protopterus aethiopicus* (Lungfish) and *Clarias gariepinus* (Mudfish). The other fish species include over 50 species of the unexploited haplochromine (Nkejje) that dominate the lakes' fish biomass (NaFIRRI, 2008). Other fauna living in the vicinity of the lake include the chimpanzees, elephants, Hippos, crocodiles and lions which are protected by the national parks.

The area is also home to many perennial and migratory bird species. This water system is therefore considered a vital conservation area and an asset to livelihoods of the riparian communities and provides a source of water for both domestic use and wild life. Three of the 14 fish landing sites on the Edward-George-Kazinga channel system fall outside the park (protected area). This study was therefore aimed at evaluating the effectiveness of Marine Protected Areas (MPAs) as an Ecosystem Approach tool to Fisheries Management in the artisanal fisheries of the Edward-George system.

Materials and methods

Study areas

The study was undertaken on Lake George, the Kazinga channel and the Uganda portion of Lake Edward. Commercial fisheries data was obtained at selected fish landing sites on the three water bodies; Edward (five), George (three) and Kazinga channel (two) between 2011 and 2013, through Catch Assessment surveys (Fig. 1). Information on fishing effort was generated through Frame Surveys on the Uganda portion of the three water systems.

The Catch Assessment and Frame survey design

Landing sites formed the primary sampling units (PSUs) and the vessel-gear (VG), categories at each landing site, formed the secondary sampling units (SSUs). At each landing site, fishing boats with fishing gears were selected for sampling. A random sample of active fishing boats was selected for each of the gear type in use encountered at the landing site. Information recorded for each sampled boat included the sampling date , type of boat, number of days the boat fished in the last one week, time of fishing (day or night, mode of propulsion of boat (paddle or motor), number of crew, gear type, gear number and size, the number and weight of each fish species landed. Individual lengths of the main target commercial species were also recorded.

Records of the price per kilogramme weight of each species landed in the commercial fisheries were also taken. Information from both Frame and Catch

Assessment Surveys was used to determine yield for both the protected and unprotected areas. The sampling methods were based on the Lake Victoria Fisheries Organization (LVFO) harmonised Standard Operating Procedure (SOPS) for collection of effort (LVFO, 2007b) and catch (LVFO, 2007c) data. The geo-reference points for each fish landing sites were recorded and plotted on digital map of the three water bodies using Arc Map 10.1.

Data processing and analysis

Estimation of catch rates and yield

Fishing crafts were first segregated into effort groups (vessel-gear combinations) and CAS indicators were derived for each effort group as observed. Data captured were stored and analysed in Microsoft Excel spread sheet. The mean catch rates (kg boat^{-1} day^{-1}), were estimated for each gear-vessel combination (effort group). The total fish catches (yield) were estimated using the mean catch rates, the total fishing effort from the 2012 and 2013 Frame Surveys (FS) and the boat activity coefficient (B), a measure of the probability that a fishing boat of each gear type would be active on any day during the month, derived from the mean number of days fished in the last one week. The total catch of each effort group was then estimated.

Beach values of the catch landed expressed as the gross income to fishers was estimated by raising the estimated total catch in each effort group by the unit price per kilogramme weight of each species in the commercial catch. Annual production (metric tonnes) and value (US dollars)) were determined for each of the three water bodies. Production (yield) for both the protected and unprotected areas was also calculated. Analysis of variance (ANOVA) was used to compare production from the protected and unprotected areas of the lakes Edward-George system (Flower and Cohen, 1990).

Results

Fishing effort

There was a drastic increase in terms of the landings and the fishers from 2006 to 2013 (Table 1). The trends in the fishing effort, facilities and the fisher tend to depict the extent to which Edward-George fishery is being exploited. The number of fishers on the waters of Edward-George system have been increasing concurrently with the number of boats and landing site facilities on whole system (Tables 1 and 2), most especially on the Lake George system that held close to 1,000 fishers in 2013 compared to 700 fishers in 2011 in the protected; compared with 400 *verses* 500 fishers in the unprotected area in the respective years (Table 1).The increase in the fishers moved concurrently with increase in the number of fishing boats in all areas.

In terms of effort, Edward system registered a drop from 6% in 2006 to 2% in 2013, of nets below 4 inch. On the other hand, it reduced from 90 to 80% on George system, 2011 to 2013. Hook and line fishery had a drastic increase of 237% from 2006 to 2013 on Lake Edward; while on Lake George and Kazinga, the rise was 178 and 465% from 2011 to 2013, respectively. The majority of the gillnets used on the entire Edward-George system was less than 4.5", thus affecting the exploitation of the fishery (Table 2). For the unprotected and protected areas, it was observed that the protected areas the highest size of gillnets utilised was the 4.5" mesh size compared to 4.0" mesh that

Table 1. Distribution of fishing crafts and fishers in the riparian districts of Lake George, Kazinga Channel and the Uganda part of Lake Edward (NaFIRRI-Frame Survey, 2006, 2011 and 2013)

	Water body	Protected areas		Unprotected areas	
		No. of crafts	No. of fishers	No. of crafts	No. of fishers
2006	Lake Edward Lake George Kazinga Channel	290	689		
2011	Lake Edward	330	684	-	-
	Lake George	355	709	197	394
	Kazinga Channel	58	100	-	-
2013	Lake Edward	469	953	-	-
	Lake George	558	1111	171	465
	Kazinga Channel	99	198	-	-

NB: In 2006 FS was collected on Lake Edward only

dominated the unprotected; hence the 5.0" mesh is rarely used in these waters.

Fish species composition and abundance

A total of 8 fish species were observed in the Edward-George system, namely *Oreochromis niloticus* (Linnaeus, 1758), *Protopterus aethiopicus* (Heckel, 1851), *Bagrus docmac* (Forsskål, 1775), *Clarias gariepinus* (Burchell, 1822), *Mormyrus kannume* (Forsskål, 1775) species and *Barbus altianalis* (Boulenger, 1903) *Oreochromis leucostictus* (Trewavas, 1933) and haplochromine species. On the Edward-George system the fishery has been undergoing drastic changes based on the types of fishing gears most, especially the increase in the illegal gillnets on all the water bodies. The most dominant fishing gears were the hook and line, and gillnet compared to others. Drastic increase of these gillnets and hook and line fishing gears led to high exploitation of the fishes on the Edward-George system. In Lake Edward waters, the catch rates of *Oreochromis niloticus* increased from 8.9 to 14.63 kg boat^{-1} day$^{-1,}$ thus registering 82%, *Bagrus docmac* 3.9 to 18.3 kg boat^{-1} day^{-1}and *Protopterus aethiopicus* 1.18 to 5.12 kg boat^{-1} day^{-1} then *Clarias gariepinus* 1.4 to 7.95 kg boat^{-1} day^{-1} and others 0.16 to 3.61 kg boat^{-1} day^{-1} in 2011 to 2013, respectively.

Lake George combined with Kazinga channel registered 9.99 to 87.55 kg boat^{-1} day^{-1} for *Oreochromis niloticus,* indicating 90% increase from 2011 to 2013. Then *Bagrus docmac* increased from 7.49 to 19.21 kg boat^{-1} day^{-1} *Protopterus aethiopicus* 5.17 to 135.07 kg boat^{-1} day^{-1} and *Clarias gariepinus* increased from 2.8 to 28.75 kg boat^{-1} day^{-1}, then other species combined contributed 51.49 to 2.61 kg boat^{-1} day^{-1}. Increase in the catch rates of the major fish species is an indicator on the high exploitation of the fishery on the water bodies of the Edward-George system.

Table 2. Distribution of fishing gears in the riparian districts of Lake George, Kazinga channel and the Uganda part of Lake Edward (NaFIRRI-Frame Survey, 2006, 2011 and 2013)

Water body	Kazinga Channel		Lake Edward			Lake George	
Year	2011	2013	2006	2011	2013	2011	2013
Gillnets							
< 2½"							9
2½"						18	203
3"						4,511	1,254
3½"						4,562	6,168
4"		2,317	924	20	375	17,847	16,603
Total no. of GN <4½"	0	2,317	924	20	375	26,938	24,237
% composition	-	59.12	6.92	0.12	1.37	90.44	86.42
4½"	1,893	1,602	12,348	16,525	26,020	2,560	3,275
5"			75		40	273	523
5½"					10		
6"				20	290	16	12
6½"					15		
7"				45	640		
7½"							
8"				95			
9"							
10"							
>10"							
Total no. of GN >4½"	1,893	1,602	12,423	16,685	27,015	2,849	3,810
% composition	100	41	93	100	99	10	14
Overall Total of GN	1,893	3,919	13,347	16,705	27,390	29,787	28,047
Other types of Gears							
Long Lines	10,600	49,300	42,500	34,350	100,800	121,100	215,320
Hand Lines						200	60
Traps			20	9	100	10	163
Monofilament nets							28
Other fishing Gears							10

A study on the three important commercial fisheries on the Edward – George system on the total length frequency in centimeters from various species sampled in the catch assessment survey in period of 2011-2013, indicated that of the *Protopterus aethiopicus* harvested from gillnets 76% and 92% from longline were all above 50% maturity. For *Oreochromis niloticus,* 92% from gillnet and 34% in longline were registered to be 50% mature. *Bagrus docmac* indicated 62% from gillnet and 73% in the longline observed under the 50% maturity (Figs. 4 and 5) (Kamanyi *et al.,* 2001).

Annual fish catches

Annual estimates and monetary value for 2011-2012 and 2014 for Kazinga channel, Lake Edward and Lake George, for the protected and unprotected areas are presented in Tables 3 and 4. In 2013, fish exploitation in the protected area by 2013 was 8 times compared to the unprotected ($p<0.05$).

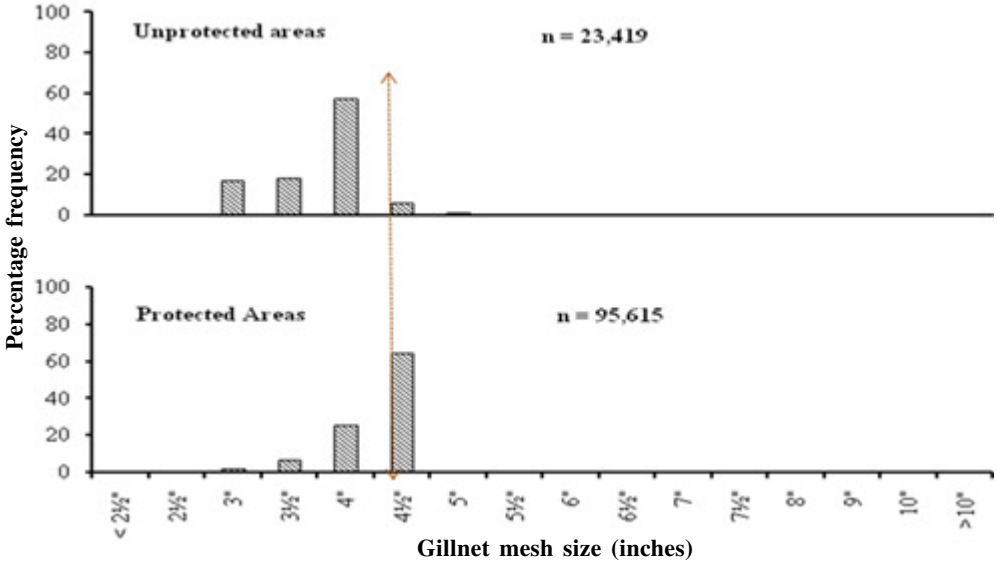

Figure 2. Showing the gillnet sizes utilised in both the unprotected and protected regions of Lake Edward-George.

Table 3. Annual catches (tonnes) and beach values in Uganda million shillings from Lakes Edward, George and the Kazinga Channel for the period 2011 to 2013

Period	2011		2012		2013	
Water body	Catch (metric t)	Value (US dollars (000)	Catch (t)	Value (US dollars (000)	Catch (t)	Value (US dollars (000)
Edward	1,386	488	1,711	2,297	3,192	4,757
George	2,509	1,023	2,254	18,763	5,354	6,030
Kazinga Channel	155	11	203	255	755	3,656
Total	4,050	1,522	4,168	21,315	9,301	14,443

Discussion

The fishing effort and fish species composition the Lake Edward- George system.

Species diversity have been changing overtime, recently 8 fish species on the Edward-George system were identified as compared to 32 that were observed in the early 1970's in just on Lake George alone and out of these 10 used to be widely distributed in the lake (Gwahaba, 1973**).** Besides that Edward- George system is observed to have undergone drastic change in the landings right from 2006 on Lake Edward survey had 290 boats that increased 3 fold by 2013 in conjunction with the fishing gears on the water body (Table 1). This trend in the increase of landing site facilities has also been observed on Lake George and Kazinga channel in the years of 2011 and 2013 frame survey; an indication of intensive exploitation of the fisheries in both fish

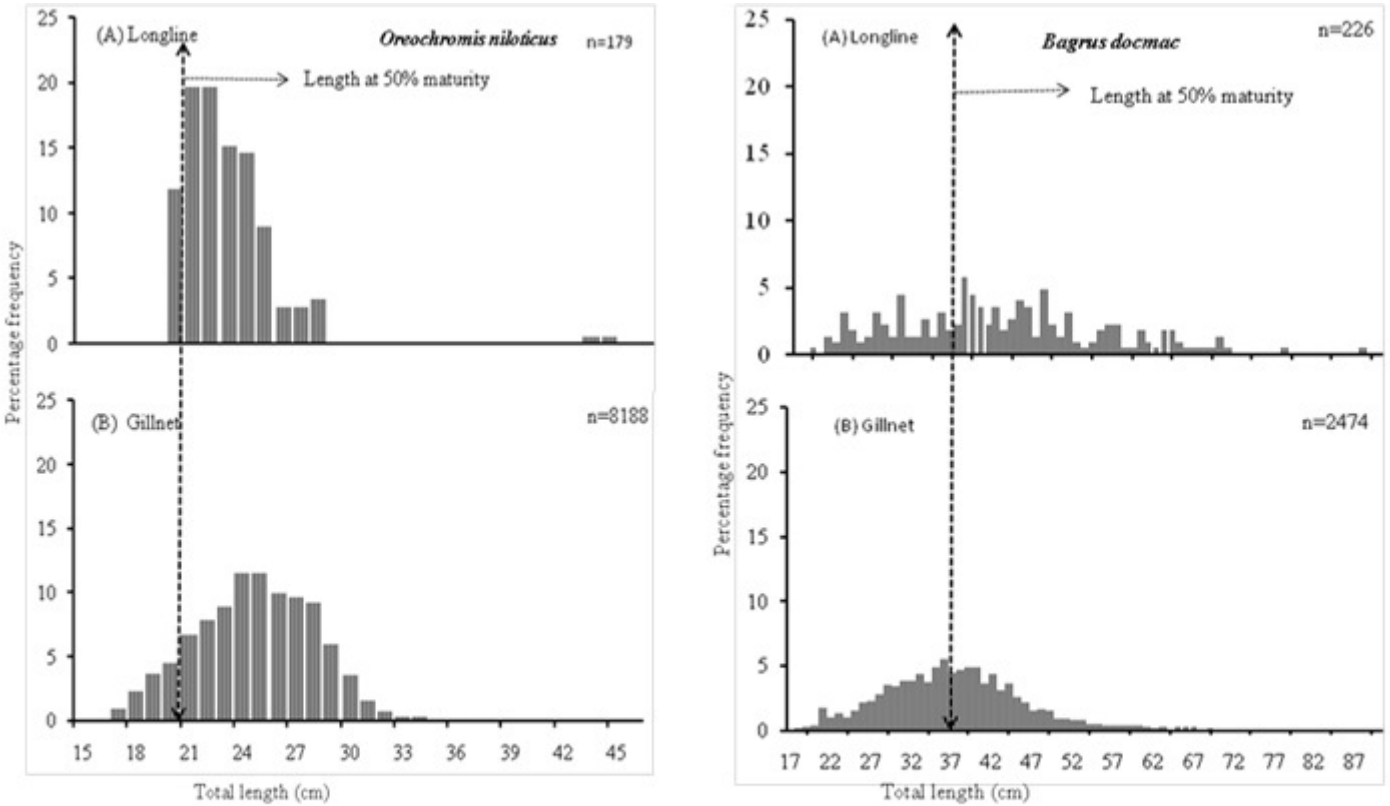

Figure 3. Shows the length at 50% maturity of *O. niloticus* and *B.docmac* from longline and gillnet for the period of 2011 to 2013 from the Edward – George system.

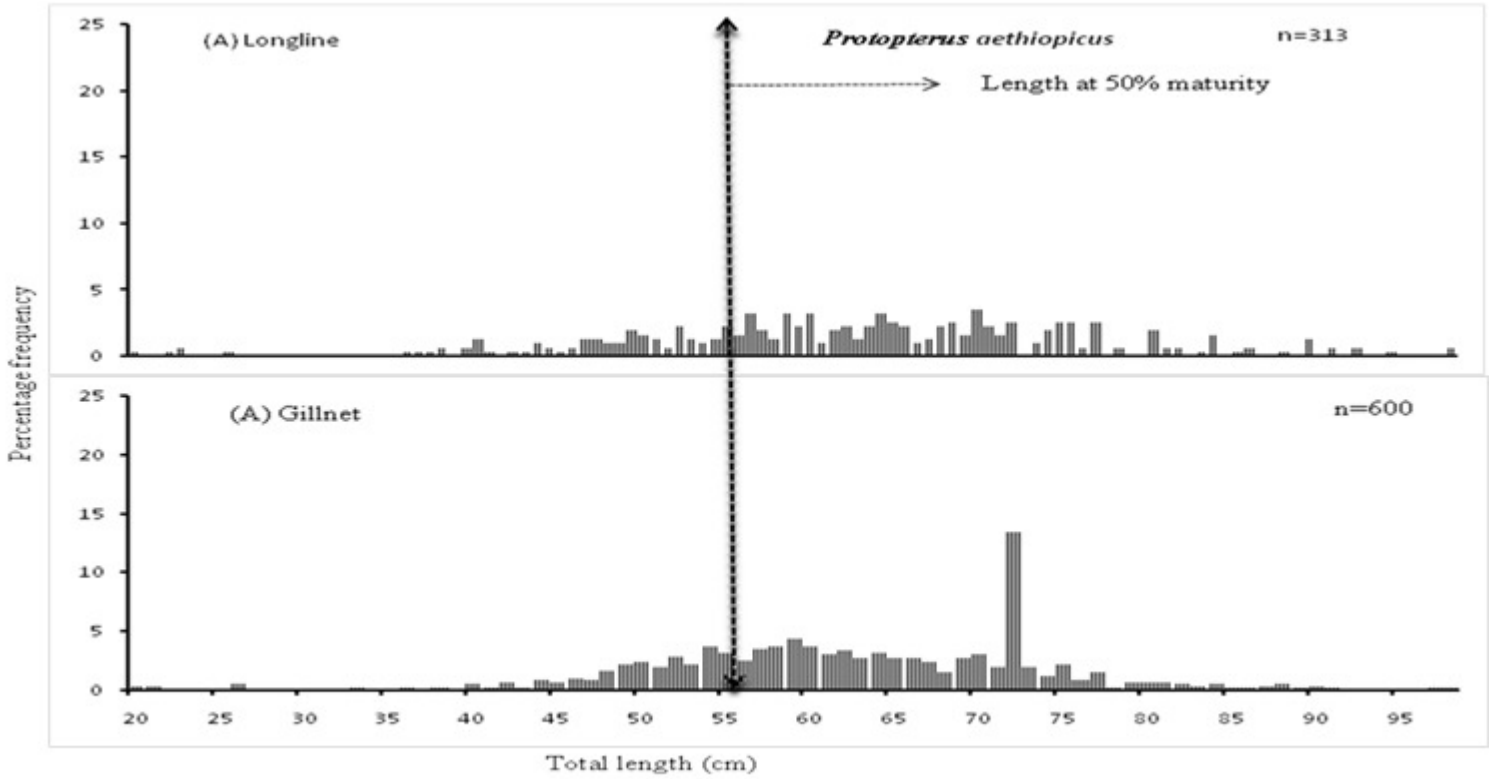

Figure 4. Shows the length at 50% maturity of *P. eithiopicus* from longline and gillnet for the period of 2011 to 2013 from the Edward – George system.

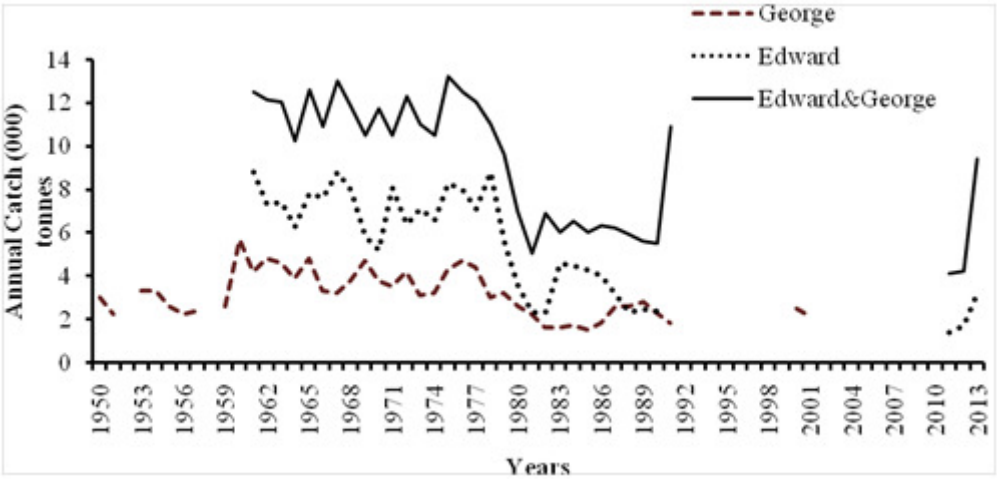

Figure 5. Trends of annual catches (metric tonnes (000) in Lakes Edward - George system, Uganda since 1960s to 2013.

Table 4. Annual catches (tonnes) from protected and unprotected areas of Lakes Edward, George and the Kazinga Channel system from 2011 to 2013

Years	Protected	Unprotected
2011	1,974.9±614.8	895.2±200.9
2012	18,767.0±805.4	805.4±115.3
2013	8,048.9±1,256.3	1,256.3±6.2

quantity and species diversity of this water systems. It is most likely that this has also led to some of the fish species reduction in the water body. Besides that the fishers on Edward system use the Ssese boats, and the two other systems that is George and Kazinga at most prefer parachute boats in addition to gillnets of 4" and below in addition to longlines below the recommend size of number 9 and basket traps, this has intensified the exploitation of the fishery thus leading to low production levels, harvesting most fishes below 50% mature from the entire water body (Table 2 and Figs. 2, 3 and 4). On Lake George system they have a special method of gillnets known as Mukira (a method of passive and active gillnetting using two joined to make the nets deeper) this system of fishing sets back in 1960's (Kamanyi and Mwene, 1990; Kamanyi *et al.,* 2001). This type of fishing is very destructive to the George system whose depth level is very low in most parts of the areas hence swiping up to the bottom of the lake. This kind of fishing led to harvesting a lot the juvenile fishes in addition to other aquatic organisms captured at the bathymetry of the lake. The effect was depicted in the changes in the catch rates of the important commercial fisheries on the lake Edward-George system; like the *Oreochromis niloticus, Bagrus docmac and Protopterus aethiopicus* registered 82% on Lake Edward and 90% on Lake George and Kazinga channel and yet the majority of the catches harvested by gillnet meshes of below 5" (Fig. 2). This is a big danger to the ecosystem and the biodiversity in general.

The population structure of the commercial fish species on the Lake Edward-George system

On the Lake Edward-George system the three commercial fisheries harvested from the two main fishing gears, the gillnets and long lines that is, *P. aethiopicus, B. docmac,* indicated that most them 50% were harvested had reached 50% maturity though for *O. niloticus* the less than 50% were below the maturation size (Figs. 3 and 4). The study indicates that most of these fishes were harvested in the gillnet mesh sizes of 4 and 4.5 inches meshes that are illegal in accordance to the Ugandan law. High fishing effort that has intensified on the Edward-George system is believed that some fish species like the *Oreochromis niloticus* and other commercial fish species to have undergone a shift in which maturation occurs and is in indication of dwarfism in the fish species. In this case the fisheries tend to mature very early , resulting to in higher natural mortality and shorter life span and the end result is negative impact on the population growth rate and also the rate of recovery (Burgis *et al.*, 1973; Gwahaba 1973; Faroese and Binohlan 1999; Kamanyi *et al.,* 2001; Hutchings 2005; Brown-Peterson *et al.,* 2011).Yet these fishes are of the most commercial species on the Edward- George waters and very much important as both as food and source of income for livelihood for the indigenous people. This explains that if one of the condition factors like the removal of illegal gears and low gill net mesh sizes below 5 inch in this water system could rejuvenate this fishery to what used to be before.

Has the Marine Protected Area Conservation measures made a change in the fisheries yield of the Edward-George System?

Trends in the Edward –George system indicate that in 1960s the fisheries were almost at 14,000 metric tonnes and today the whole water body the yield is at 10,000 tonnes (Tables 3 and 4). The fisheries resources have been declining overtime (Fig. 5) despite the fact that there are some observed gaps in the historical data (Gwahaba, 1973; Okaranon and Kamanyi, 1989; Ogutu-Ohwayo *et al.,* 1997) in the fisheries of Lake Edward - George system (Fig. 5). This paper tend to show trends in the yield from both the protected and unprotected from 2011 to 2013 as has fluctuated much (Table 4). The protected areas on Edward-George system took the biggest area as indicated (Table 4), thus harvesting 8,000 (79%) metric tonnes as compared to 1,200 (21%) tonnes in unprotected in 2013 indicating a significant difference of ($F=4.098$; $p<0.05$). A change in the gross income of the fisheries was low in 2013 as compared to the 2012 despite the fact that the fishery yield was high (Table 3), this was indication that most of the fish caught that year were juvenile that could not fetch high value. This is an area that needs to be focused by the fisheries managers. This gives a chance for the MPAs to be able to control the entire system of the water body despite the fact that has not been effective more especially when 88% of the fishing gears like the gillnets are below 5 inch mesh in the protected areas alone.

Conclusion

This study reveals that the annual fish production from the entire George-Edward-Kazinga channel system stands at close to 10,000 metric tonnes

representing 3% of annual capture fisheries production in Uganda. In the early 1970's Lake George alone could contribute 5000t the fishery (Burgis *et al*., 1973), this is not the case todate most especially with the increasing effort on the lake. In the protected areas of Lake Edward, Kazinga Channel and part of Lake George in Kasese and Rubirizi districts contributed 8,000 t (79%) compared to unprotected part with value of 1,200 t (21%). This production is low and this as a result of an intensive use of 4.0" and 4.5" mesh sizes in these water bodies as compared to 5.0" that is observed by law; and though the majority of the fishes caught indicate to be 50% mature this could attribute to legalise the 4.5" mesh particularly to the Lake Edward- George by the fisheries managers until changes in the fisheries is realised for upward adjustment. Regardless of that the Conservation measures imposed by the Park seem not to be effective on fisheries and therefore use of "FPAs" in artisanal fisheries and may not be achievable. Therefore for the success of the biodiversity conservation, the Fisheries integrated system based on the Community approach (BMUs) in conjunction with the Marine protected team and the fisheries managers could be the best tool on the management of the fisheries resources on the Edward-George system.

Acknowledgement

This study was supported by funds from the National Agricultural Research Organization. We appreciate the efforts of the colleagues at the NaFIRRI, Directorate of Fisheries Resources, the Beach management units and the Marine unit at the Queen Elizabeth National park.

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