TECHNICAL REPORT OF FRAME AND CATCH ASSESSMENT SURVEYS OF LAKES EDWARD AND GEORGE; AND THE KAZINGA CHANNEL CONDUCTED IN JANUARY AND JULY 2011- 2013.

(Technical document ONE-*Tech/1/2015*)

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June 2015

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Executive Summary

Capture fisheries is one of the major fisheries in the world in addition to aquaculture. The fishery is a renewable resource that needs to be monitored its magnitude, distribution and trends of fishing effort and fish catches. Some of the monitoring tools utilized by research is the regular Catch Assessment Surveys (CASs) in these water bodies to ensure generating information for the management of the fisheries of Lake Edward and George and Kazinga channel and biannual frame surveys on the same water bodies.
The National Agriculture Research Organization (NARO) funded this program under the **ATAAS** Project 5: Monitoring changes in fish stocks and development of appropriate harvesting technologies for the major commercial fish species in the five major water bodies of Uganda (Victoria, Albert, Kyoga, Edward and George). This work was done based on the statistical design laid down in Standard Operating Procedures (SOPs) agreed by the three partner states of the East African Community sharing the Lake Victoria under the emblem of Lake Victoria Fisheries Organisation. CAS was carried out in five landing sites on Lake Edward, three on Lake George and two on Kazinga channel in June 2011. Then it was later done in June 2012 and 2013 on three landings on Edward and three on Lake George and two on Kazinga channel The National Fisheries Resources Research Institute (NaFIRRI) did work in collaboration with the Department of Fisheries under Ministry of Agriculture Animal Industry and Fisheries (MAAIF) with the Beach Management Units (BMUs) and the Fisheries officers of the riparian districts. The districts covered on the Edward-George systems were Kasese, Rukungiri, Rubirizi and Kamwenge. And in addition to that frame surveys were carried on all the landing sites of the water system. This report presents findings of the CAS and Frame surveys conducted in the Edward-George systems in June 2011, 2012 and 2013 respectively. The report also presents total annual catch estimates for the three water bodies focuses on mainly the Uganda part especially the Lake Edward that is shared by the DRC Congo. Annual estimates indicated that in 2011, Kazinga channel 154.4±45.6 tonnes, Lake Edward 1,385.7±458.9 tonnes, Lake George 2,508.03±562.9 tonnes and in 2012 Kazinga channel was 203.7±40.7 tonnes, Lake Edward 1,711.2±641.8 tonnes and Lake George 2,256.7±323.0. In 2013 Kazinga channel was 755±2.48 tonnes, Lake Edward 3,192±22.21 tonnes and George 5,354±26.58 tonnes. The frame survey revealed that in 2011 Kazinga channel had 58 boats with 100 fishers, Lake Edward 300 boats 684 fishers, Lake George 552 boats with 1,103 fishers. In 2013 Kazinga channel had 99 boats 198 fishers, Lake Edward 469 boats 953 fishers and Lake George 729 boats with 1,576 fishers. This entails you that the open access policy in Uganda has always cause changes in the captures fisheries leading to changes in the fish stock levels. It is anticipated that through the CAS monitoring and Frame surveys should able to give a true picture of the fish production in these water bodies that can be utilized for management purposes. Thanks to the National Agricultural Organization that funded these studies and we look forward supporting research activities in the fisheries.

Chapter One: 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 920m 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 17m 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.

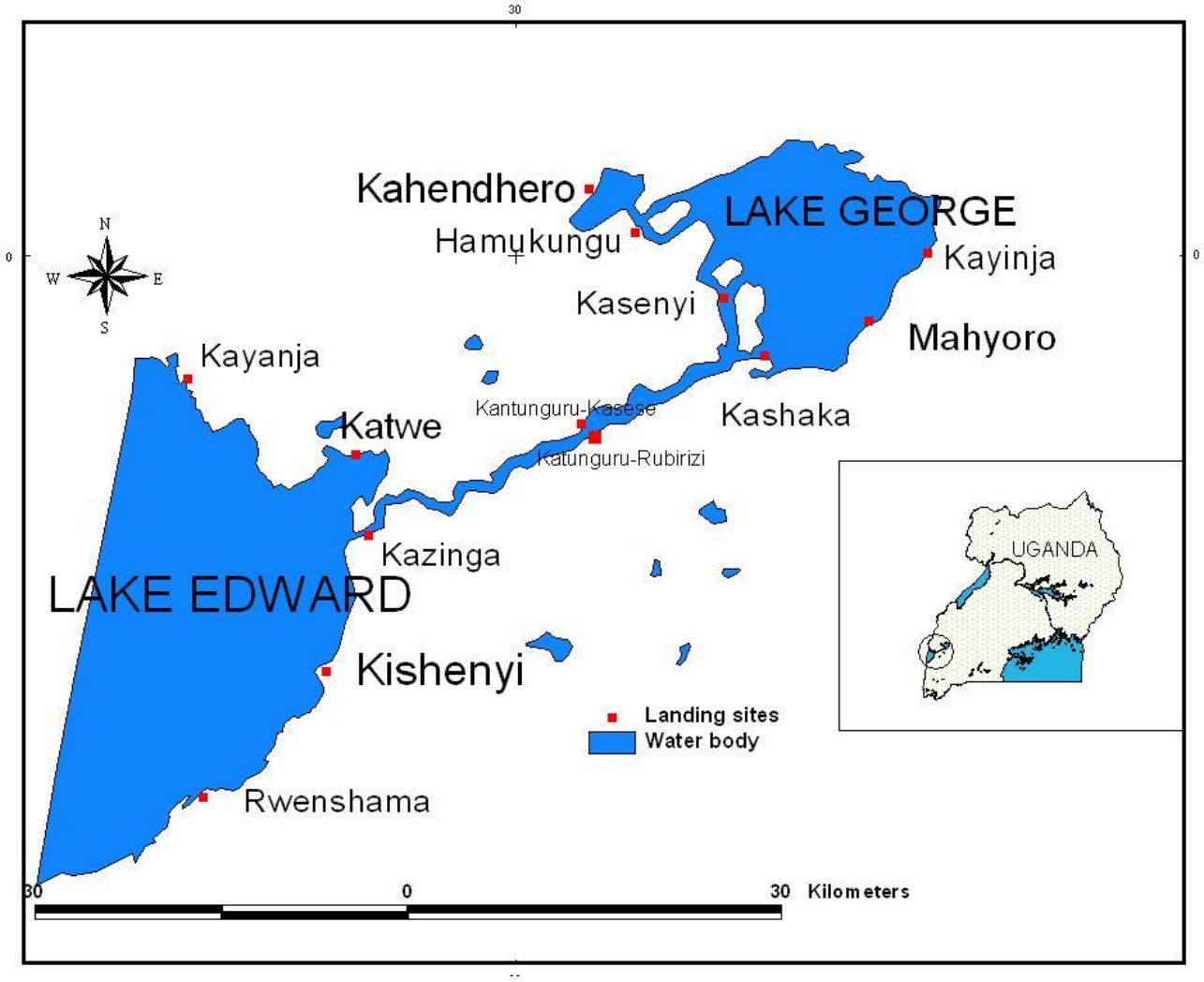

Figure 1.The location of the fish landing sites of Lake Edward-George system where frame surveys were carried out in years 2011 and 2013.

A unique feature of the watershed of Lake Edward is its connection to the shallow Lake George, 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; Crespi and Ardizzone 1995, 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 the Democratic Republic of Congo, and there are five gazzeted landing sites (Figure 1) and the nearest town is Kasese.

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 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 inflowing 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 of the lake is located in the QENP (Figure 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 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 (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 docmak* (Catfish also known locally as "Semutundu"), and *Protopterus aethiopicus* (Lungfish) and *Clarias gariepinus* (Mudfish). The other fish species include over 50 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 Lake George area is home to many perennial and migratory bird species. The 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 aimed at evaluating the production levels in terms of catch estimates of the artisanal fisheries of the Edward-George system in addition to providing information on the facilities and services at landing sites and the composition, magnitude and distribution of fishing effort to guide development and management of the fisheries resources of the Edward and George lakes and Kazinga channel.

Specifically, the study was expected to come up with the following outputs:-

a) Information on the number of fish landing sites on the basin lakes;
b) Information on the facilities available at the fish landing sites to service the fisheries sector ;
c) Information on the number of fishers;
d) Information on the number and types of fishing crafts;
e) Information on the modes of propulsion of the fishing crafts;
f) Information on the number types and sizes of fishing gears including the number of illegal fishing gears in the fishery; and
g) Recommendations on development and management of the fisheries of the Edward and George lakes and Kazinga channel.
h) Beach values in terms of annual catches and annual revenue from the water bodies.

Chapter Two: 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 (Figure 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

The sampling methods were based on the Lake Victoria Fisheries Organization (LVFO) harmonised Standard Operating Procedure (SOPS) for collection of effort (LVFO, 2007a) and catch (LVFO, 2007b) 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. 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 fish species landed in the commercial fisheries were also taken.

The Frame Survey captured all the important characteristics of the fisheries and facilities supporting the fisheries making it a strong baseline for future reference of management interventions in fisheries. The survey covered all the landings in the three water bodies. A total of 14 landings were covered; 2 on Kazinga channel, 5 on Lake Edward and 7 on Lake George (Figure 1); however, in the March 2012 a second ungazzeted landing site known as Kanyabikere on L. George in Kamwenge district was added. Information from both Frame and Catch Assessment Surveys was used to determine yield for both the protected and unprotected areas.

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 vessel gear 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.

Calculation of beach value of catch

Beach values of the catch landed expressed as the gross income (Ug Sh) 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 (Ug shillings) were determined for each of the three water bodies. Production (yield) for the Edward –George system areas was also calculated.

Chapter Three: Frame survey results

The findings of the Frame Survey of the Edward and George lakes and Kazinga channel in January and July 2011 and March 2013 are summarized in Table 1 and 2

Landing Sites

A total of 15 landing sites were recorded in the lakes Edward, George and the Kazinga channel, (5 were on Edward, 8 were on George, 2 were on Kazinga channel).

Facilities at the Fish Landings

In 2011 the facilities observed were: landing shades (*bandas)*, cold rooms, pontoons/ jetties, fish stores, potable water, toilet facilities, boat and net repair facilities, access to the fish landing site by all-weather roads and electricity supply.
Lake Edward had 5(35.7%) of the landing sites had 4 fish shades (bandas) and 2 (20%) landings with electricity. All landings on Lake Edward had accessible roads (100%) but lucked the following systems; jetty, cold rooms and fish stores. 4(36.3%) landing sites had public toilets, 3(42.8%) had portable (safe) water; 2(28.6%) had resident fisheries, 5 (100%) with BMU office. Details of the landing site facilities are given in Table 1.

On Lake George, none of the landing sites had a cold room, jetty, permanent fish store, electricity and a facility for net repair. In addition none of the landings had electricity and resident fisheries staff; however, four landing sites (36% had public toilets; all landing sites were accessible by all weather roads; 2(28.6%) had portable (safe) water.
On Kazinga channel, there were only 2 landings but only 1 had a fishing store; both landing sites were accessible by road, had portable (safe) water, bandas; though electricity facilities were in less that 1km. (Table 1).

In 2013 the landing shades (*bandas)*, cold rooms, pontoons/ jetties, fish stores, potable water, toilet facilities, boat and net repair facilities, access to the fish landing site by all-weather roads and electricity supply were examined. The facilities at the landing sites were quite inadequate.

Lake Edward with 5(35.7%) of the landing sites had 4 fish landing shades (bandas) and 2 (20%) landings with electricity. All landings on Lake Edward had accessible roads (100%) and 5 (100%) with BMU offices but some sites lacked the following systems; jetty, cold rooms and fish stores. 4(36.3%) landing sites had public toilets, 3(42.8%) had portable (safe) water; 2(28.6%) had resident fisheries, Details of the landing site facilities are given in Table 1 and 2.

On Lake George, none of the landing sites had a cold room, jetty, permanent fish store, electricity and a facility designated for net repair. In addition to that none of the landings had electricity facility and resident fisheries staff; though (4) (36.3%) had public toilets; all were accessible by all weather roads; 2(28.6%) had portable (safe) water. Kazinga channel, we had only 2 landings but only 1 had a fishing store, though both them were accessible by roads, had portable (safe) water, bandas; though electricity facilities were in less that 1km. (Table 1 and 2).

Fishing crafts and Fishers

The total number of fishing crafts operating on the Edward and George basin lakes and Kazinga channel was 932 in 2011 distributed as follows: Lake Edward,330 (35%); George, 552 (58%) and Kazinga channel,58 (5%) as compared to 2013 a total of 1,297 crafts distributed as follows, 469 (36% on L.Edward, 729 (56%) L.George and 99(8%) on Kazinga channel. All the boats on Lake Edward were Sesse flat at one end meanwhile the George lake and Kazinga had parachute type only (Table 1and 2).

In 2011 the total number of fishers operating on the two lakes plus Kazinga channel was 1,887 distributed as follows: Lake Edward, 684 (36%); Lake George 1,103 (59%) and Kazinga channel 100 (5%) as compared to 2013 with a total of 3,730 fishers distributed as follows, 953 (35%) on L.Edward, 1,579 (58%) L.George and 198(7%) on Kazinga channel.

The distribution of fishing craft types is influenced by craft stability manoeuvrability and the capacity to carry the right quantities of fishing gears for the fishing operations in the different waters bodies. The Sesse boats are the most stable and can be constructed to the size required for particular fishing operations.

This explains the large proportion of these boats in Lake Edward that is shared by both Uganda and DRC. This lake has a larger open water area compared to Lake George and Kazinga channel. On the other hand, the small unstable Parachute boats that are easy to manoeuvre in the shallow waters, are a common feature of Lake George and Kazinga channel. The three systems did not have dugout canoes as observed during all the frame surveys carried out in both years (Table 1 and 2).

Fishing Gears

During the Frame survey gillnets, long line hooks, cast nets, hand lines and traps were recorded.

Gill nets

There was an increase in the number of gillnets in 2013 with 59,356 as compared to 49,085 gillnets in 2011 on the Edward-George system and this was distributed as follows: 28,047(47%) in Lake George, 27,390(46%) in Lake Edward and 3,919(7%) Kazinga channel. In terms of gear size Kazinga channel registered 59% (4.5”) and 41% (4.0”) gill net size; mean while Lake Edward had 3% (>5”) with highest dominance of 97% (<5”). Lake George system had gillnets had 10% (>5%) meanwhile 90% (<5”).

Hooks

Hooks were one of the important gear in the Edward-George systems in addition to the gillnets. In 2011 out of 166,050 hooks, 121,100 (72.9%) were in Lake George, 16,705 (34.0%) in Lake Edward and 10,600 (6.4%) in Kazinga channel. Then in 2013 out of 365,200 hooks, 215,320 (59%) were from Lake George, 100,600 (27.5%) in Lake Edward and 49,300 (13.5%) Kazinga channel. In all the sampled lakes hooks targeted either *Protopterus* or Clarias species.

Table 1.Summary of the results on lakes Edward and George Frame Surveys (January & July 2011); LS = Landing site; GN= Gill net, SS= Small seines, CN = Cast nets, MF= Monofilament gillnets; BS= Boat seines, TR= Traps; HL = Hand line; LL = Long line.

Districts	**Kamwenge**		**Kasese**			**Rubirizi**		**Rukungiri**	**Grand Total**
Water body	**George**	**Edward**	**George**	**Kazinga channel**	**Edward**	**George**	**Kazinga channel**	**Edward**	
No. of crafts	202	150	314	33	98	51	25	89	962
Derelict Crafts	17	52	82	3	25	6	5	10	200
Transport crafts (Non fishing)	2	1	2	-	6	1	-	1	13
Fishing crafts with outboard engine	-	6	-	-	6	-	1	-	13
Fishing crafts using paddles	201	143	312	33	86	50	24	88	937
Fishing crafts using Sails	-	-	-	-	-	-	-	-	-
Banda/Fish shed	-	1	3	1	2	1	1	1	10
Cold room	-	-	-	-	-	-	-	-	-
Jetty	-	-	-	-	-	-	-	-	-
Fish store	-	-	-	-	-	-	1	-	1
Electricity supply	-	1	-	-	1	-	-	-	2
Electricity <1km	-	-	-	-	-	-	-	-	-
Electricity 1-5 km	-	-	-	1	-	-	-	-	1
Electricity 6-10 km	-	-	-	-	-	-	-	-	-
Electricity >10 km	-	-	-	-	-	-	-	-	-
Public toilets	1	-	1	-	-	-	-	-	2
Portable water	1	1	3	1	2	1	1	1	11
All weather roads	-	1	2	1	1	-	1	1	7
All weather <1 km	2	1	3	1	2	1	1	-	11
All weather 1-5 km	-	-	-	-	-	-	-	-	-
All weather 6-10 km	-	-	-	-	-	-	-	-	-
All weather > 10 km	-	-	-	-	-	-	-	-	-
Net repair facility	-	1	3	1	-	1	1	-	7
Boat repair facility	2	1	3	-	-	1	1	-	8
Residence of Fisheries staff	1	1	-	-	-	-	1	1	4
Residence of BMU	2	1	1	1	1	1	1	1	9
Fish landed at LS<5 months a year	-	-	-	-	-	-	-	-	-
Fish landed at LS>5 months a year	1	-	-	-	-	-	-	-	1
Fish landed at LS all year round	-	1	2	1	-	1	-	-	5
No. OF CRAFTS BY TYPE	-	-	-	-	2	1	1	1	5
Parachute	197	-	305	33	-	-	-	-	535
Ssese flat at one end	-	149	-	-	92	50	17	89	397
PROPULSION									
Outboard	-	12	-	-	2	-	-	3	17
Paddles	197	137	305	33	90	50	17	86	915
GRAND TOTAL	**197**	**149**	**305**	**33**	**92**	**50**	**17**	**89**	**932**
No. of gillnets by mesh size	-								
GN < 2½"	-	-	-	-	-	-	-	-	-
GN2½"	3	-	15	-	-	-	-	-	18
GN 3"	4,036	-	475	-	-	-	-	-	4,511
GN3½"	4,520	-	742	-	-	-	-	-	5,262
GN 4"	6,099	-	11,126	-	-	622	-	20	17,867
GN 4½"	650	4,840	730	1,434	7,090	1,180	459	4,595	20,978
GN< 5"	**15,308**	**4,840**	**13,088**	**1,434**	**7,090**	**1,802**	**459**	**4,615**	**48,636**
GN 5"	170	-	97	-	-	-	-	-	267
GN 6"	-	20	-	-	-	-	-	-	20
GN 6½"	-	45	-	-	-	-	-	-	45
GN 7"	-	95	-	-	-	-	-	-	95
Total number of gillnets	**30,786**	**9,840**	**26,273**	**2,868**	**14,180**	**3,604**	**918**	**9,230**	**49,063**
Total No. of TR	-	-	10	-	-	-	-	9	19
Total No. of HL (no. of hooks)	100	-	-	-	-	100	-	-	200
Total No. of LL (no. of hooks)	31,000	25,450	80,200	8,100	4,400	9,900	2,500	4,500	166,050
Crafts using each main gear type									
GN	170	115	230	22	87	37	12	73	746
LL	28	37	74	11	5	13	5	14	187
HL	1	-	-	-	-	1	-	-	2
TR	-	-	1	-	-	-	-	2	3
SNAILS	-	22	-	-	-	-	-	-	22

Table 2.Summary of the results on lakes Edward and George Frame Surveys (March 2013); LS = Landing site; GN= Gill net, SS= Small seines, CN = Cast nets, MF= Monofilament gillnets; BS= Boat seines, TR= Traps; HL = Hand line; LL = Long line.

Districts	*Kamwenge*		*Kasese*			*Rubirizi*		*Rukungiri*	*Grand Total*
Water body	**George**	**Edward**	**George**	**Kazinga channel**	**Edward**	**George**	**Kazinga channel**	**Edward**	
No. of crafts	171	222	492	59	125	66	40	122	1297
Derelict Crafts	28	30	90		28		2	10	188
Transport crafts (Non fishing)	2	9	1	1	5		1	1	20
Fishing crafts with outboard engine		36			3				39
Fishing crafts using paddles	171	186	492	59	122	66	40	122	1258
Fishing crafts using Sails									0
Banda/Fish shed		1	3	1	2	1	1	1	10
Cold room									0
Jetty							1		1
Fish store									0
Electricity supply		1							1
Electricity <1km									0
Electricity 1-5 km									0
Electricity 6-10 km				1					1
Electricity >10 km	1		1						2
Public toilets		1	2	1	1				5
Portable water		1	3	1	2	1	1		9
All weather roads							1	1	2
All weather <1 km	1							2	3
All weather 1-5 km									0
All weather 6-10 km									0
All weather > 10 km									0
Net repair facility		1	3	1	1	1	1		8
Boat repair facility	2	1	3			1	1		8
Residence of Fisheries staff	1	1		1			1	1	5
Residence of BMU	2	1	1	1	1	1	1	1	9
Fish landed at LS<5 months a year									
Fish landed at LS>5 months a year	1					1	1		3
Fish landed at LS all year round		1	2		2	1	1	1	8
No. OF CRAFTS BY TYPE									0
Parachute	171		492	59		66	40		828
Ssese flat at one end		222			125			122	469
PROPULSION									0
Outboard		222		59			40		321
Paddles	171		492		125	66		122	976
GRAND TOTAL	**171**	**222**	**492**	**59**	**125**	**66**	**40**	**122**	**1297**
No. of gillnets by mesh size									0
GN < 2½"			9						9
GN2½"			203						203
GN 3"	90		1164						1254
GN3½"	574		5594						6168
GN 4"	7526	75	6167	1197	80	2910	1120	220	19295
GN 4½"	735	14205	2200	462	8800	340	1140	3015	30897
GN< 5"	**8925**	**14280**	**15337**	**1659**	**8880**	**3250**	**2260**	**3235**	**57826**
GN 5"	100	40	423						563
GN 5½"		10							
GN 6"	6	290	6						302
GN 6½"		15							15
GN 7"		640							640
Total number of gillnets	**9031**	**15275**	**15766**	**1659**	**8880**	**3250**	**2260**	**3235**	**59356**
Total No. of TR			163					100	263
Total No. of HL (no. of hooks)			60						60
Total No. of MF	1		27						
Total No. of LL (no. of hooks)	14500	38600	189120	31600	23200	11700	17700	39000	365420
Crafts using each main gear type									0
GN	132	148	330		104			105	819
LL	39	47	138		21			17	262
HL			8						8
MF			9						9
TR			5						5
SNAILS		17							17
OTHERS			2						2

Other gears
During the 2011 frame survey on the Edward-George system only Basket traps, 10 were on Lake George and 9 on Lake Edward and Kazinga channel had nothing. But changes happened in 2013 Lake George registered Hook and line 60, cast nets 163 and basket traps 28, Edward George had 100 basket traps on the system.

Comparison of 2011 and 2013 Frame Surveys results with previous surveys
Information that is available on the Edward –George system form the frame surveys right from 1991 to 2013 (Table 2) is a bit scanty most especially the Lake Edward system. The number of landings on the three systems has not changed since 1997 to date since most of the parts on this system are under the game reserve. There has been and increase on the fishing effort from 203 fishing boats in 1991 to 552 in 2011 later in 2013 it was 729 on Lake George. On Lake Edward the boats have remained stable in the range of 398 to 330 from 1991 to 2011 later increased to 469 in 2013. The Kazinga channel indicated an increase of boats from 2011 to 2013 from 58 to 99 respectively.

There has been changes in the fishing gear usage, in this case boats using gillnets on Lake George decreased from 476 in 1991 to 188 in 2000 though a slight increase to 275 was observed in 2011 frame survey. The fishing boats using were 71 in 1991 then 112 in 2000 but dropped to 56 according to 2011 frame survey. On the basket traps 9 and 12 beach boats respectively in 1991 in 2011 it was only 1 basket trap observed and none as far as beach seines on Lake George. A change was observed in 2013 in the fishing gears on Lake George boats using multifilament gillnets were 553(70%), longline 192 (26%), hook and line 8(1%), basket traps 5(0.7%) and those using monofilament nets 9(1%) and others 2(0.3%). On Lake Edward boats using multi gillnets were 513 (70%), longline 85(18%) and a new development of boats used to harvest snails on the lake were 17 contributing 4% in the fishery sector. Kazinga channel system 55 boats were for multi gillnets contributing 56% and longline 44 (44%) (Table 4) (Taabu et al. 2011).

Fishing effort
There was a drastic increase in terms of the landings and the fishers from 2006 to 2013 (Table 3). 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. 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 1,2&3).

Table 3.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, 2013).

Water body	Districts	No. fishing crafts &fishers in bracket(2006)	No. fishing crafts& fishers in bracket(2011)	No. fishing crafts& fishers in bracket(2013)
L.Edward	Kasese	120	149	222
	Rubirizi	107	92	125
	Rukungiri	63	89	122
	Kamwenge	0	0	0
	Total no. of crafts	**290 (689)**	**330(684)**	**469(953)**
L.George	Kasese	-	305	492
	Rubirizi	-	50	66
	Rukungiri	-	0	0
	Kamwenge	-	197	171
	Total no. of crafts	-	**552(1,103)**	**729(1,579)**
Kazinga channel	Kasese	-	33	59
	Rubirizi	-	17	40
	Total no. of crafts	-	**50(100)**	**99(198)**

Table 4. A summary on the distribution of fishing gears on Lake George, Kazinga channel and the Uganda part of Lake Edward (NaFIRRI-Frame Survey, 2006, 2011, 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"		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			
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

” = inches

Table 5.Comparison of 1991, 1997, 2000, 2011, 2013 with 2001 in bracket is Frame survey data for lakes Edward and George and Kazinga channel (source Ogutu *et al.* 1997 and Kamanyi *et al.* 2001).

Parameter measured	**1991**		**1997**		**2000**			**2011**			**2013**		
	Edward	George	Edward	George	Edward	George	Kazinga Channel	Edward	George	Kazinga Channel	Edward	George	Kazinga Channel
Number of landing sites	5	7	5	7		7	2	5	7(7)	2(2)	5	8	**2**
Total number of fishing crafts	398	203		547		339	49	330	559(370)	50(56)	469	629	99
Number crafts using gillnets (GN)				476		188		437	275	34	253	437	42
Number of crafts using hook and line (HL)						9	10	2				8	
Number of crafts using Longline hooks (LL)				71		112		115	56	16	53	115	16
Number of crafts using Basket Traps (TR)						9		2	1		2		
Number of crafts using Boat seine						21							

Chapter four: Catch Assessment results

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}, and 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.

A study on the three important commercial fisheries on the Edward –George system on the total length frequency in centimetres 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 (Figure 2 and 3) (Kamanyi *et al.*, 2001).

Annual fish catches

Annual estimates indicated that in 2011, Kazinga channel 154.4±45.6 tonnes and value of 237 million shillings, Lake Edward 1,385.7±458.9 tonnes and value of 1,132m, Lake George 2,508.03±562.9 tonnes with the value of 2,375m shillings. In 2012 Kazinga channel was 203.7±40.7 t and the value of 2,240m, Lake Edward 1,711.2±641.8 t and the value was 5,707 m and Lake George 2,256.7±323.0 t with the value of 7,180 m shillings, then in 2013 Kazinga was 756.4±2.48 tonnes the value was 634m, Lake Edward 3,193±22.21 t the value was 12,810 m and Lake George 5,355.9±26.58 t with the value of 16,240m shillings (Table 6).

Table 6. Annual fish 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 (t)**	**Value (Ug.shs)**	**Catch (t)**	**Value (Ug.shs)**	**Catch (t)**	**Value (Ug.shs)**
Edward	1,386	1,133	1,711	5,707	3,192	12,809
George	2,509	2,375	2,254	46,627	5,354	16,236
Kazinga Channel	155	236	203	633	755	9,846
Total	**4,050**	**3,744**	**4,168**	**52,967**	**9,301**	**38,891**

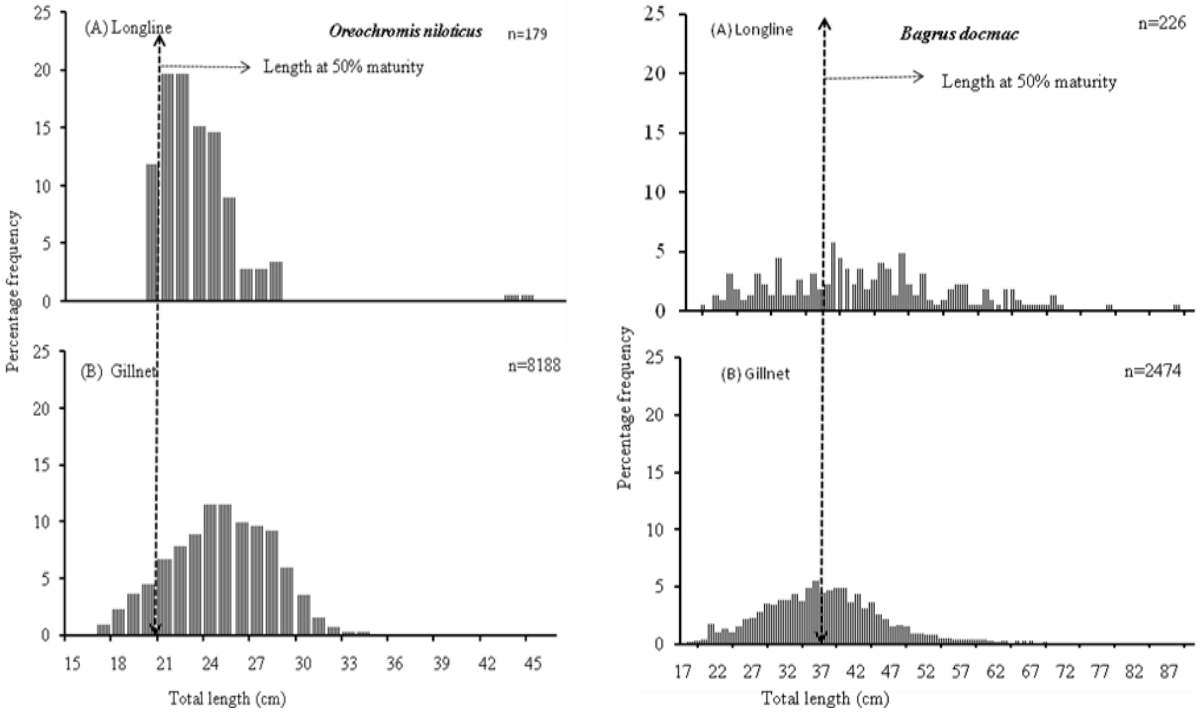

Figure 2. The length (cm) at 50% maturity of *O. niloticus* and *B.docmac* from longline and gillnet for the period of 2011 to 2013 from the Edward – George system.

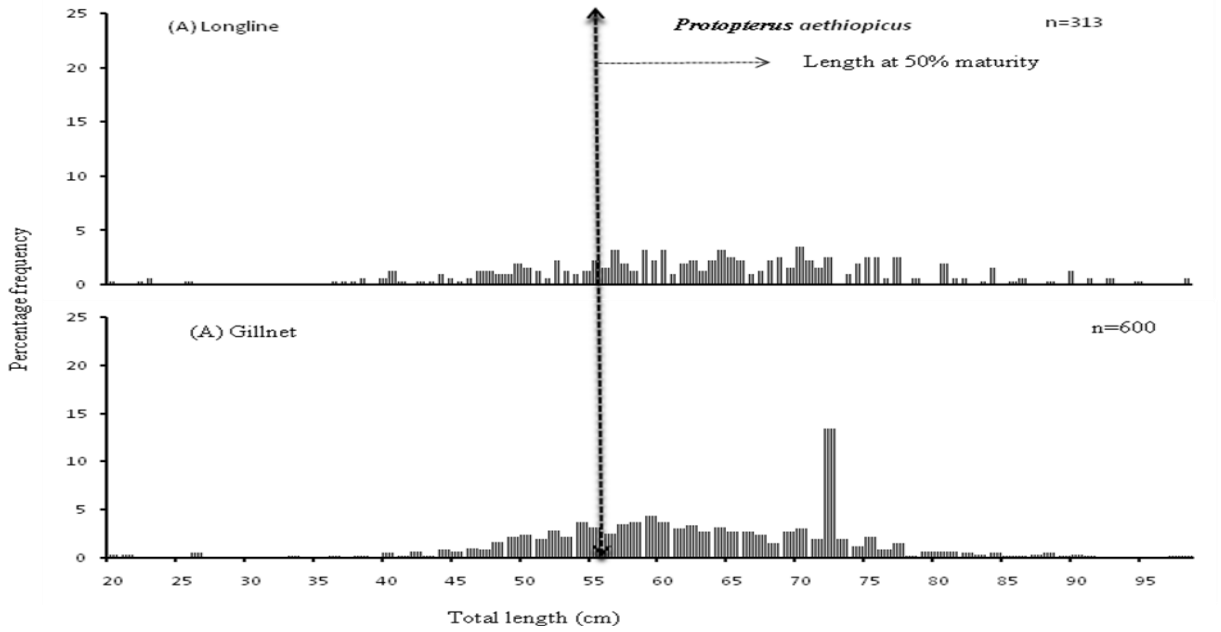

Figure 3. The length (cm) at 50% maturity of *P.eithiopicus* from longline and gillnet for the period of 2011 to 2013 from the Edward – George system.

Chapter five: Discussion

Fishing effort, fish species composition and relative abundance on the Lake Edward- George system.

Species diversity have been changing overtime, recently 8 fish species were identified as compared to 32 that were observed in the early 1970's in just on Lake George alone and out 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 1and 2).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 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 from the entire water body (Table 2 and figure 2). 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 *et. al.,* Kamanyi and Mwene, 1990). 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 lead to harvesting a lot the juvenile fishes in addition to what 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" (Table 2). This is a big danger to the ecosystem and the biodiversity in general.

Population structure of the commercial fish species on the Lake Edward-George system.

The phases in the reproduction cycles have been developed by various scientists in order to come up with the rightful phases in the maturity cycles. This method is used to evaluate the quality of length frequency samples and the status of the respective population or fishery. And thus the reproduction cycle of the fishes tend to show how and when the fishes reach maturity stages (Faroese and Binohlan 1999, Kamanyi *et al.*, Brown-Peterson *et al.,* 2011). 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 (figures 2 and 3). 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. Besides the high fishing effort that has intensified on the Edward-George system, it also 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. The dwarfism is believed be as a result of the water body condition like the high silicate compounds in the ecosystem (Gwahaba 1973, Burgis *et al.*, 1973). 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.

Have the Marine Protected Area (MPAs) 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 (Table 3 and 4). The fisheries resources have been declining overtime (Figure 4) despite the fact that there are some observed gaps in the historical data (Ogutu-Ohwayo *et. al.*, 1997, Okaranon and Kamanyi, 1989, Gwahaba, 1973 in the fisheries of Lake Edward – George system (figure 5). This report tend to show trends in the yield from both the protected and unprotected from 2011 to 2013 as has fluctuated much (Table 7). 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 6), 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.

Table 7.Annual fish 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

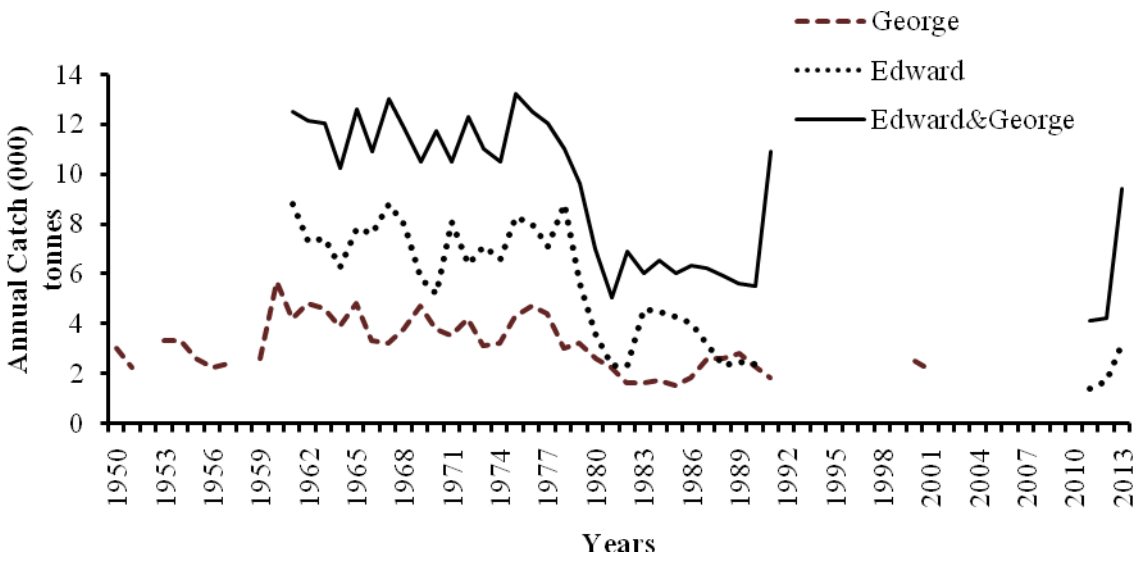

Figure 4.Trends in annual fish catches (metric tonnes (000) in Lakes Edward – George system, Uganda since 1960s to 2013.

Conclusion and Recommendations

This report 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 legalize the 4.5" mesh particularly to the Lake Edward- George by the fisheries managers until changes in the fisheries is realized 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.

But still some observations were noted that needs government intervention since fisheries contributes to the GDP of this nation Uganda and these are as follows:-

a) Acute shortage of facilities servicing the fisheries sector at the fish landings and hence deliberate efforts should be made to improve them.

b) Lack of basic sanitation facilities, especially public toilets and portable (safe) water, at most landing sites in the basin. The local leadership at BMUs, local government and Community Based Organisations levels should strive to provide these amenities.

c) There were a large number of illegal gill net mesh sizes most especially on the Lake George system compared to others. Therefore efforts should be made to remove illegal sizes of gill nets and other fishing gears for the management of the fisheries resources.

d) A need to reconsider and gazette the landing sites that were not considered more especially with the increasing population on this site like Nyakera in Kamwenge district.

e) A need to work as a team both the Fisheries managers and the Marine unit in the Game parkers to ensure that illegal fishing can be reduced on the water bodies.

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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