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The decline of *Alestes baremose* Boulenger, 1901 and *Hydrocynus forskahlii* (Cuvier, 1819) stocks in Lake Albert: Implications for sustainable management of their fisheries

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Abstract

The fish stocks of Lake Albert face immense exploitation pressure which has led to "fishing-down" of their fisheries, with some larger species having been driven to near-extinction, while others such as *Citharinus citharus* have almost disappeared. Both *A. baremose* (Angara) and *H. forskahlii* (Ngassia) historically formed the most important commercial species in Lake Albert until the early 2000s but recent Catch Assessment Surveys (2007-2013) revealed a sweeping decline in their contribution to the commercial catch from 72.7% in 1971 to less than 6% in 2013. The catch per unit effort also registered a two-fold decline from 45.6 and 36.1 kg/boat/day to 22.6 and 18.1 kg/boat/day for *A. baremose* and *H. forskahlii* respective between 1971 and 2007. Over 50% of illegal gillnets, below the legal minimum limit of four inches (101.6 mm) used on Lake Albert target the two species. Gillnet experiments found the three inch (76.2 mm) gill net mesh size suitable for sustained harvest of the two species. The study concludes that optimal utilization of the two species and probably other non target fish species is achievable through species specific management strategies, coupling species specific licensing, and controlling harvest of juvenile individuals, overall fishing effort and fish catch on Lake Albert and protecting the vulnerable fish habitats.

Key words: Albert Nile, ecosystem approach to fisheries, native species, recruitment overfishing, stock collapse

Introduction

Lake Albert, formerly known as Lake Mobutu Sese Seko is a sensitive environment of international importance and one of the Great Lakes of Africa that lies within the Albertine Rift. It is located between latitude $0^0 15^1$ and $1^0 00^1$ N; longitude $30^0 21^1$ and $31^0 25^1$ E with a surface area of about 5300 km^2. Albert is a major source of fisheries resources sustaining the riparian communities in Uganda and the Democratic Republic of Congo.

The Uganda part of the lake covers 54% of the surface area (Walker, 1972) and is shared between the five riparian districts of Nebbi, Buliisa, Hoima, Kibaale and Ntoroko. Situated in the western part of the great rift-valley at an altitude of 618 m above Sea level, Lake Albert is fed by two major inflowing rivers, Semliki and Kafu in the south, and the Victoria Nile at the northern tip (Holden, 1963). Besides providing a major source of water, employment, food and income to approximately 3 million people living in the surrounding districts (UBOS, 2002), the lake is currently the second largest fishery in Uganda, after Lake Victoria, with fishing as the primary source of food and livelihood among the coastal villages.

The lake supports the most diverse multi-species commercial fisheries in Uganda; the exploited species varying markedly in size at maturity from the small *Neobola bredoi* and *Brycinus nurse* that grow to only a few centimeters in length to the large size species e.g. Nile perch that can grow to over a meter. This variation in size diversity has been singled out the most significant factor limiting the successful enforcement of size limits of fishing gears on the lake.

Globally, stocks of migratory fish species form a major target of commercial fishery and are always in danger of collapse due to intensive harvest of gravid individuals during breeding periods. In Uganda, fishery management is constrained by lack of an effective fishery monitoring and regulatory mechanism, coupled with inadequate budgetary allocations to the fisheries sub-sector resulting into high fishing pressure and a decline in the fishery. The fisheries of Lake Albert in particular are faced with immense exploitation pressure which has led to "fishing-down" of the stocks with some larger species having been driven to near-extinction, while large individuals of others such as *Citharinus citharus* have disappeared (Hecky, 2007).

The last four decades have seen a shift in species composition of the commercial fisheries from the dominancy of the high value large sized species e.g. *Citharinus citharus*, *Nile perch*, *Alestes baremose*, *Hydrocynus forskahlii*, *Disticodus niloticus* and Nile tilapia to only two low value small sized species of *Brycinus nurse* and *Neobola bredoi*.

Both *H. forskahlii* and *A. baremose* which constituted over 70% of the commercial catch in the 1970 currently constitute less than 6% of the 150,000 tonnes of annual catch landed on Lake Albert; while the small *B. nurse* and *N. bredoi* which were insignificant at the time now make up almost 80% of the annual catch from the lake (GoU, 1971; Mbabazi *et al.*, 2012).

Like on all the other water bodies in Uganda, gillnets have remained the most dominant fishing gears where up to 127,000 units are operated in 3300 fishing canoes to harvest the diverse commercial stocks of Lake Albert (NaFIRRI FS technical report 2012, Mbabazi *et al.*, 2012). Although the minimum legal gillnet mesh size limit allowed for harvesting the commercial fisheries on Lake Albert is four inches or 101.6 mm (GoU, 2010 (The fish (FISHING) Rules, 2010), over 65% of gillnets operated on Lake Albert are below the legal limits, out of which > 35% are used to target *A. baremose* and *H. forskahlii*. In Uganda, the two species are only found in Lake Albert and the Albert Nile and fishers targeting them claim that the two species can only be harvested in gillnets of mesh sizes below 3 inches.

The most recent adhoc surveys by NaFIRRI between 2007 and 2013 on the commercial catches of Lake Albert detected relatively high proportions of juvenile individual of both the target and non target species in gillnet mesh sizes below four inches, highest being recorded in gillnets below 2.5 inches used to target *A. baremose* and *H. forskahlii* and usually operated in the shallow waters, river mouths and lagoons of Lake Albert.

There was also a decline in catch rates (CPUE in kg/boat/day) of *A. baremose* and *H. forskahlii* over the same period. Earlier studies (Wandera and Balirwa, 2010; NaFIRRI 2007 cited in Hecky, 2007) confirmed such sites as critical habitats for fish breeding and protection against predation due to availability of enormous food resources and aquatic vegetation for refugia.

Although the lake fishery continues to maintain its multi-species nature under a heavy exploitation pressure, a sweeping decline in catches of the high value species that grow to large sizes, particularly *A. baremose* and *H. forskahlii*, amidst lack of effort to reverse the trend is a cause of management concern for the Lake Albert fisheries. Inadequate scientific fisheries biological data (e.g. gillnet mesh size selectivity, abundance, distribution, size at first maturity, feeding and fecundity) on *A. baremose* and *H. forskahlii* impedes formulation of species specific ecosystem based management options for the diverse fisheries of the lake, which also affects the enforcement of the existing conflicting fisheries regulations on the lake.

There is need for accurate and time specific information on fisheries dynamics of the Lake Albert production system to facilitate sustainable management of its fisheries (McCluskey and Lewison, 2008). An ecosystem based approach to management, suitable for a multispecies based system like Lake Albert could guide the utilization of the diverse fisheries of Lake Albert.

The current information on key biological aspects of *A. baremose* and *H. forskahlii* obtained through experimental gillnetting in the diverse habitats of the northern portion of Lake Albert (Fig. 1) and evaluation of the commercial catches landed in canoes targeting the two fisheries forms a building block upon which policies and regulations to guide their utilization without compromising sustainability of the other fisheries resources of the lake will be formulated.

Materials and methods

Study area

Six experimental gillnet sites (Fig. 1) were selected in the northern portion of Lake Albert based on habitats described by Worthington (1929), Holden (1963) and Wandera and Balirwa (2010) and sampled for six consecutive months from October 2013 to March 2014. They include the shallow open areas influenced by rivers (Wanseko river mouth and River Waaki separating Buliisa from Hoima district), the deep open waters (Wanseko open and Butiaba open) and the lagoons (Butiaba and Kabolwa). A total of 17 fish landing sites (Fig. 1) were assessed for commercial catches through adhoc Catch Assessment Surveys (CASs) on Lake Albert between 2007 and 2013.

Fishing effort and fish catch estimates

Frame Survey data was collected on the Uganda side of Lake Albert in 2007 and 2012 following standard operating procedures (SOPs) detailed in LVFO (2007c). The Frame surveys enumerated all fishing inputs (effort) on the lake i.e. number of landing sites and their GPS locations, number of fishers, types and number of fishing boats and their mode of propulsion, number of fishing gears used by size and target species and mode of operation of the fishing gears.

Evaluation of commercial catches landed at the 17 landing sites (Fig. 1) in the five riparian districts was done through adhoc Catch Assessment Surveys (CASs) conducted between 2007 and

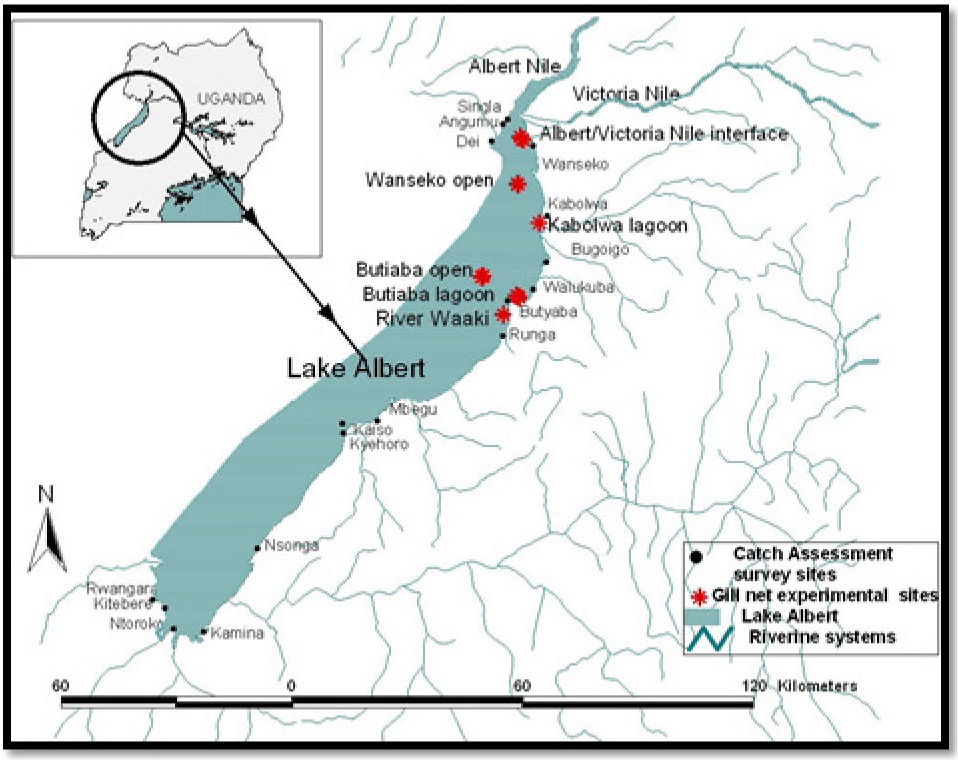

Figure 1. Sites on Lake Albert sampled through experimental gillnetting (*) between 2013 and 2014 and ad hoc Catch Assessment Surveys (Ï%) between 2007 and 2014 depending on the habitat.

2013 following SOPs described in LVFO (2007b). For each sampled boat targeting *A. baremose* and *H. forskahlii*, the following information was recorded; date of sampling, boat type, season, number of days fished per week, time of fishing (Day/night), mode of boat propulsion, number of crew per fishing boat, type and number of gears used and their sizes.

The catch landed in each sampled boat was segregated to species level. The number and total weight (kilogram) of each species landed in each sampled boat was then separately recorded. The price per kilogram of each of the two species was recorded. Individual lengths (centimeters) and weight (grams) of the species were recorded on appropriate field data forms. The fish were then split open to examine their sex and level of maturity of the gonads (LVFO, 2007a; Brown-peterson *et al*., 2011).

Population structure of *A. baremose* and *H. forskahlii* on Lake Albert

Fish samples were obtained from the six gillnet experimental sites through gillnetting surveys following SOPs detailed in LVFO (2007a) for collecting fisheries biological information and from commercial catch landed by fishers through CASs. For experimental gillnetting, three fleets of graded multifilament gillnets of mesh size 25.4 mm to 139.7 mm at an interval of 12.7 mm plus mesh sizes 152.4 to 254 mm at 25.4 mm intervals were set and left for overnight at the experimental sites.

Each fleet was set at varying distances apart. These were retrieved the next morning and the fish caught was removed, sorted and grouped to species level per fleet and mesh size (Greenwood, 1966; Witte and van Oijen, 1990; Seehausen, 1996). For both commercial and experimental catches, the numbers and weights (grams) of each other species (constituting the by-catch) encountered save for *A. baremose* and *H. forskahlii* were measured and recorded on appropriate data capture forms.

For *Alestes baremose* and *Hydrocynus forskahlii*, records of fork length (cm), standard length (cm) and weight (grams) of each individual fish was measured and recorded by fleet and mesh size. The fish were then incised and examined for sex and gonad maturity, based on a 7-point scale (Bagenal and Braum, 1978; Lowerre-Barbieri and Barbieri, 1993; LVFO, 2007a) and a 5-point scale modified by Brown-Peterson *et .al.*, 2011.

Indigenous knowledge (IK) of fishers on breeding seasons and habitats for *A. baremose* and *H. forskahlii* was also obtained at the six CAS landing sites through a structured questionnaire.

Data processing and analysis

Fishing effort and catch estimation

All data collected was entered and analysed in excel spreadsheet to determine quantities and trend of fishing effort targeting *A. baremose* and *H. forskahlii* and annual yield from the two species. The Geographical Positioning System (GPS) locations of landing sites sampled for both experimental and commercial catch data were plotted and digitized on a map (Fig. 1) in Arc GIS 10.0. The CAS indicators calculated included mean catch rates (kg per boat per day), the total annual fish catches (C), and beach value of the catch. The Catch per unit effort (CPUE) was calculated for all the sampled gillnet boats landing *A. baremose* and *H. forskahlii*. The total annual yield for each of the two species was determined by multiplying mean catch rates (CPUE) by average days fished per boat and by the total number of boats fishing the two. Their annual percentage contribution was calculated as a proportion of their individual annual yield to the total yield from the Lake. Gross beach income was calculated by multiplying their total annual catches by the average price per kilogram of each species.

Population structure of *A. baremose* and *H. forskahlii* on Lake Albert

Relative abundance was calculated by site and gillnet mesh size for the two fish species and expressed as number of fish per gillnet per night. By-catch ratios were computed as proportion of total number of individuals of none target species (by-catch) to that of the target species (*A. baremose* and *H. forskahlii*). Species diversity was determined per site using Shanon-Weaver and Marglef indices of diversity.

Size at first maturity was calculated in males and females of the two species separately by determining the proportion of mature and immature fish in different length classes of fish (Nikolsky, 1963; Bagenal and Braum 1978; Witte and Densen, 1995; Morgan and Hoenig, 1997; LVFO, 2007a; Brown-Peterson *et al.*, 2011). The sex ratio was estimated by determining the number of males and females in the total sample of the fish in different experimental sites to give an indication of the reproductive capacity of the two species in the different sites.

Length frequency distribution curves were generated for the commercial data to determine the size structure and exploitation patterns for the two species. A correlation relationship between size at first maturity, gillnet mesh size and size of fish (*A. baremose* and *H. forskahlii*) harvested was then established. Baranov's principle of geometric similarity, described in Hovgard *et al.* 2000 which states that gillnet selectivity is only dependent on the size of the fish relative to that of the mesh was used in determining gillnet mesh size selectivity for the two species.

Results

Fishing effort and catch estimates of *A. baremose* and *H. forskahlii* on Lake Albert

The two species *A. baremose* and *H. forskahlii* were found to be harvested in only gillnets of mesh sizes below the legal minimum of 101.6 mm (the Fish (Fishing) Rule, 2010) allowed for harvesting the commercial fisheries of the lake. Of the undersize gillnets used on Lake Albert (Fig. 3), over 35% are used to target the two species of *Alestes baremose* and *Hydrocynus forskahlii* (Fig. 4).

Majority (64%) of the undersize gillnets used to harvest the two species are below (2.5 63.5mm) while another 22% range and only 14% stretch to 76.2mm.

A reduction in catch rates of major commercial fisheries as earlier reported by von Sarnowski, 2004 where the CPUE reduced from 83 fish per net in the 1980s to merely four fish per net in early 2000s and Cadwalladr and Stoneman, 1966 where *C. citharus* moved from the first position in the late 1920s (Worthington, 1929) to eleventh position in 1965 has continued steadily. The catch rates in boats targeting *A. baremose* and *H. forskahlii* on Lake Albert (Fig. 2) reduced from 22.6kg/boat/day and 18.8 kg/boat/day in 2007 to 7.0kg/boat/day and 6.3kg/boat/day in 2013 respectively. There are data gaps between 1971 and 2007 but available baseline information (DFR, 1971) indicated a twofold decline in the two species between the 1971 and 2007 (Fig. 2). In the same period, the contribution of the two species to the lake-wide annual catches also sharply reduced from 42% to 1.3% and from 30.4% to 1.0% for *A.*

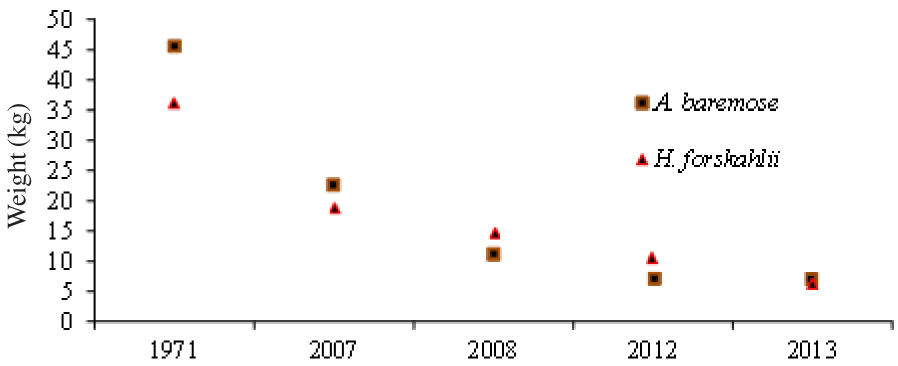

Figure 2. Trend of catch rates of *Alestes baremose* and *Hydrocynus forskahlii* in the commercial catches on Lake Albert expressed as Catch per Unit Effort (kg/boat/day).

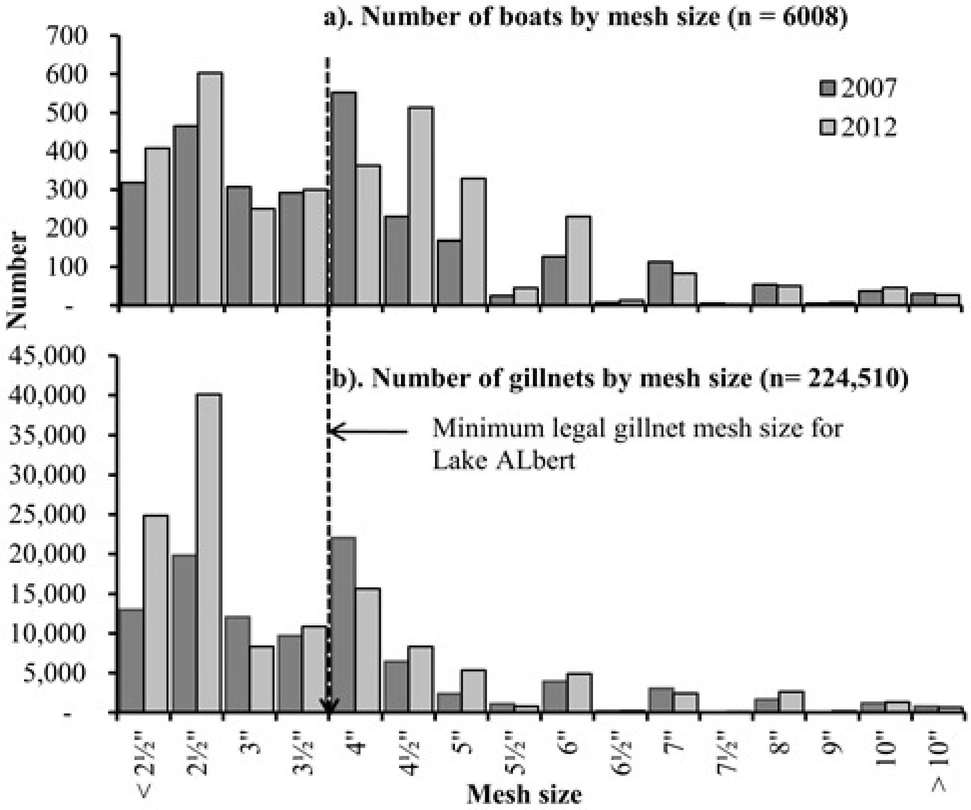

Figure 3. Number of boats (a) and gillnets (b) by mesh sizes used in harvest the fish stocks on Lake Albert, 2007 - 2012.

Figure 4. Proportion of gillnets targeting *A. baremose* and *H. forskahlii* on Lake Albert (2012 Frame Survey)

baremose and *H. forskahlii* respectively (Table 1).

Although systematic commercial catch data collected between 2007 and 2013 shows relative stability in annual contribution of the two species, there was a sudden increase in annual contribution of *H. forskahlii* from barely 1.0% to slightly above 4% in 2012 and 2013. There was also a reduction in mean sizes (weight, Table 4 and length, Fig. 4) of fish harvested in the commercial catches for the period 1971 to 2013. Reductions in catch rates, annual catches and mean size for the two species however show a corresponding increase in average prices per kilogram weight of the two species (Table 2).

The current overall contribution of the two fish species is just slightly higher than 5% from the over 80% reported in the 1950's (Cadwalladr and Stoneman, 1966). As the catch rates and contribution of the two investigated species to the commercial catches continued to reduce, the average price per unit kilogram weight of the two species maintained a continuous rise (Table 2). Between 2007 and 2013, the average price per kilogram of *A. baremose* increased from 1000 to 3500

Table 1. Comparison of annual catches (000) tonnes and gross beach values (million USD) of *A. baremose* and *H. forskahlii* with the overall annual catch of Lake Albert 1971 to 2013

Species	*Alestes baremose*			*Hydrocynus forskahlii*			Lake Albert Overall
Year	Catch	%	Value	Catch	%	Value	catch
1971	4.10	42.30	-	3.00	30.40	-	9.70
2007	1.90	1.31	1.20	1.50	1.03	0.70	144.90
2008	1.80	1.23	1.32	1.50	1.03	0.80	146.20
2012	1.70	1.12	1.70	6.70	4.42	6.40	151.60
2013	1.62	1.06	1.78	6.30	4.12	6.40	152.80

Note: Table includes modifications from Mbabazi *et.al.*, 2012 and GoU, 1971

Table 2. Trends of beach values in Uganda shillings per kilogram of *A. baremose* and *H. forskahlii* landed in the commercial catches on Lake Albert

Year	*Alestes baremose*			*Hydrocynus forskahlii*		
	Minimum	Average	Maximum	Minimum	Average	Maximum
1971	-	-	-	-	-	-
2007	1000	1000	2500	500	800	2500
2008	500	1800	3500	500	1100	6000
2012	1000	2300	5000	700	2300	4000
2013	1000	3500	8000	500	4600	6000

Uganda shillings while that of *H. forskahlii* increased from only 800 to 4600.

Population structure of *A. baremose* and *H. forskahlii* landed in the Lake Albert (2007-2014)

Earlier studies on Lake Albert were focused on fish species diversity (Wandera and Balirwa, 2010) and fishing effort (Mbabazi *et al*., 2012) but no specific study has ever documented size at 50% maturity for most of the commercial fish species on the lake, including *A. baremose* and *H. forskahlii*. Size at first maturity calculated separetely for male and females of the two species suggested male to mature at a smaller length (cm) than their counterpart females (Table 3).

The study also revealed that *H. forskahlii* mature at a smaller size than *A. baremose*. While, a comparison of size at first maturity recorded for the two species in the protected Murchison Nile revealed a substantial difference in the two systems, a similar trend was observed with respect to maturity of females and males.

Generally, the size structure of *A. baremose* and *H. forskahlii* landed in the commercial fisheries on Lake Albert showed a gradual shift from that dominated by mature individuals (2007) to that majorly constituted of the small sized immature fish in 2013-2014 (Fig. 5). The catch of immature fish in gillnets targeting the two species earlier repoted by Kamanyi (1996) has increased to a level where catches of the two species is mainly

Table 3. Size at 50% maturity of *A. baremose* and *H. forskahlii* on Lake Albert

Species	Lake Albert		Victoria/Murchison Nile	
	A. baremose	*H. forskahlii*	*A. baremose*	*H. forskahlii*
Female	19.5	18.7	22.5	20.1
Male	17.3	16.4	20.7	19.2

Table 4. Adjustments in mean sizes (weight) of individual fish of A. baremose and H. forskahlii harvested in the commercial fisheries on Lake Albert (1980s -2013)

Year	Average weight (grams)			
	Alestes baremose	n	*Hydrocynus forskahlii*	n
1980	800	-	800	-
2004	300	-	300	-
2007	247	3,573	251	8065
2008	229	7,681	167	8775
2012	115	5,028	186	7531
2013	167	4,207	190	6234

Note: Data for 1980 and 2004 obtained from Von Sarnowski, 2004

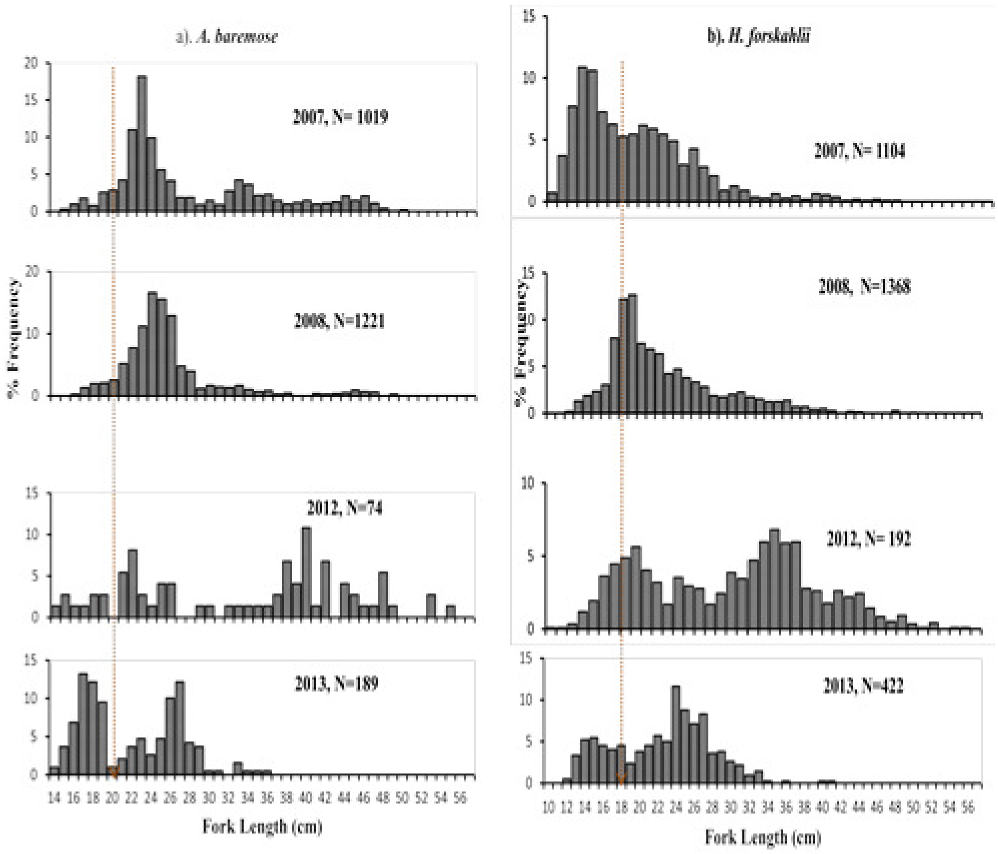

Figure 5. Size structure of *A. baremose* and *H. forskahlii* harvested in the commercial catches on Lake Albert for the period 2007 to 2013.

dominated by small individuals not exceeding 36 cm (Fig. 5).

Gillnet selectivity and diversity for *A. baremose* and *H. forskahlii* on Lake Albert

Percentage frequency of *A. baremose* and *H. forskahlii* per size class was plotted against fork length (cm) for mesh size (25.4 mm to 76.2 mm) of the experimental gillnets set in different habitat sites (Fig. 5). There was no individual of *A. baremose* and *H. forskahlii* encountered in gillnets above 76.2 mm (3 inch) mesh size.

All individuals recovered from the 25.6 mm mesh sizes were below size at 50% maturity but the proportion of immature individuals progressively reduced from the 25.6 mm gillnet mesh size towards the 76.2 mm mesh size, where majority of individuals caught were mature (Fig. 6). Similarly, the proportions of juvenile fish of the non target species were highest in mesh size 25.4 mm across all gillnet experimental sites and least in the 76.2 mm gillnets.

Fish species diversity based on Shanon-Weaver and Marglef indices of species diversity was higher in the riverine habitats except at River Waaki mouth, followed by lagoons and least in the deep open waters of the lake (Table 5). Wandera and Balirwa, 2010 earlier

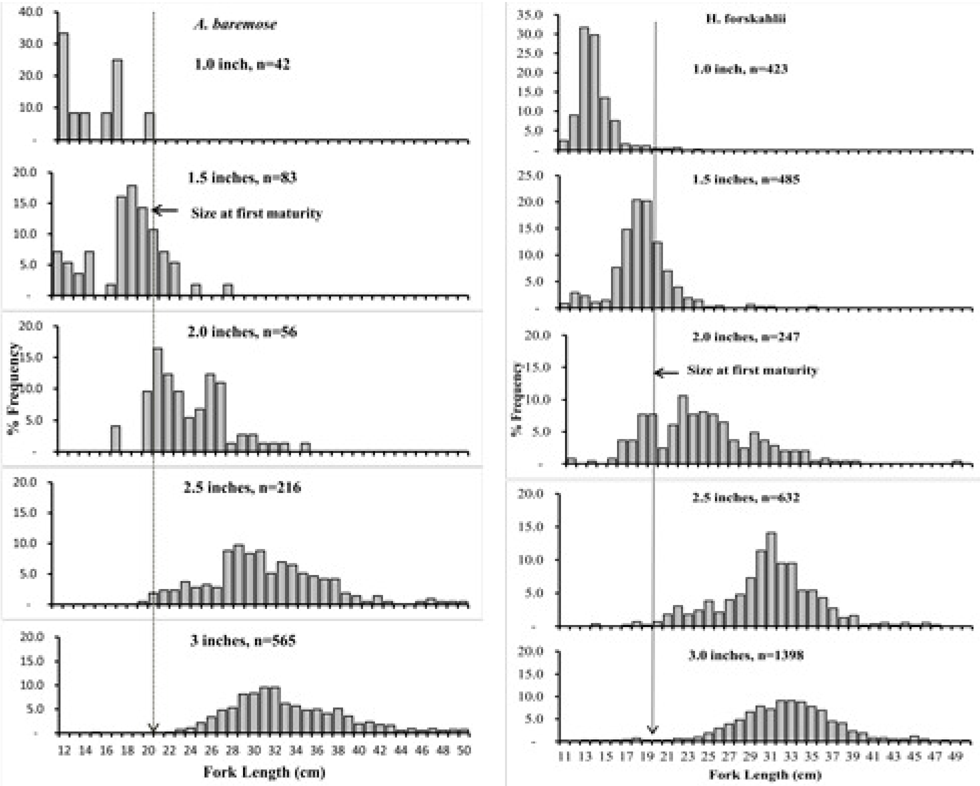

Figure 6. Size structure of *A. baremose* and *H. forskahlii* caught by different gillnet net mesh sizes on Lake Albert generated from experimental gillnetting data collected between October 2013 and May 2014.

Table 5. Variations in species diversity across the gillnet experimental sites sampled on Lake Albert

Site	Shanon-Weaver Index of Diversity	Margalef Index of Diversity
Butiaba open	1.70	1.67
Wanseko open	1.96	2.13
Butiaba lagoon	2.10	2.44
Kabolwa lagoon	2.01	2.49
River Waaki	1.76	1.88
Wanseko River Mouth	2.68	4.84

observed a similar trend for majority of the commercial species exploited on Lake Albert.

Discussion

Many studies (Cadwalladr and Stoneman, 1966; Kamanyi, 1996; Von Sarnowski, 2004; Mbabazi *et al.*, 2012) have already reported overfishing on Lake Albert. There has been a persistent decline in catch rates, mean sizes (length) and weights of individuals and annual catches of the major commercial fisheries, but particularly of *A. baremose* and *H. forskahlii*.

Between 1994 and 1999, a reduction in catches from four lorry loads a week to none was observed in one of the fishing villages around Lake Albert (Von Sarnowski, 2004). The average weight of the tigerfish (*H. forskahlii* and *A. baremose*) was also reported to have reduced from average weight of 0.8kg per individual in the 1980s to 0.3 kg in 2004 and their average weights currently stand at 0.5 kg and 0.4 kg.

Inadequate systematic and judicious fisheries biological data on the multi-species commercial fish stocks of Lake Albert continue to be the single most limiting factor in the formulation of appropriate guidelines and policies to guide the utilization and management of the diverse fisheries of the lake (Von Sarnowski, 2004; Mbabazi *et al.*, 2012). Previous major fisheries studies on Lake Albert (Worthington, 1929; Holden, 1963; Wandera and Balirwam, 2010) concentrated on fish species diversity, habitat description and fishing effort. No species specific study had previously been undertaken to document trends and impact of harvesting technologies on stocks of the major commercial fish species.

Size at maturity for two species, only found in Lake Albert and Albert Nile is documented for the first time by this study. This information will guide development of sustainable species specific management options on Lake Albert.

The high proportion of gillnets below 101.6mm mesh size (Fig. 3) recommended on Lake Albert (the Fish (Fishing) Rules, 2010) as documented in Cadwalladr and Stoneman (1966) and Mbabazi *et al.* (2012) is a clear indication of an unsustainable fishery of the lake. The gradual shift in species composition of the commercial species from the high value species that grow to large sizes (> 50cm) to the low value species that grow to a few centimeters (< 10cm) further confirms the situation. Some of the most popular fish species that dominated the commercial catch from the 1920s up to the late 1950s e.g. *Citharinus citharus* and *Hydrocynus vittatus* Worthington (1929) are almost extinct and only one individual of *Citharinus citharus* was recently (December, 2013) recorded in the commercial catches at each of the landing sites of Wanseko and Abok.

Unless deliberate efforts are taken, the rate of decline in the mean catch rates (Fig. 1) and mean sizes (Table 4) of both *A. baremose* and *H. forskahlii* and a further reduction in their contribution to the commercial catch (Table 1) projects a comparable scenario observed for *C. citharus* and *H. vittatus*. *Alestes baremose* was the most shore frequenting species dominating the commercial catch in the 1960s (Cadwalladr and Stoneman, 1966) but now hardly constitute 2% and the two species currently constitute less than 7% of the annual commercial catch. These observations depict a fishery in danger of collapse.

The high diversity of species in both the lagoons and river mouths and the comparably high proportion of immature individuals in gillnets sets in these habitats stresses the need to protect them from fishing activities. Wandera and Balirwa (2010) and Hecky (2007) identified such habitats as vital fish breeding sites, given the abundant food resources and calm environment suitable for both the spawning mothers and their offspring.

The new paradigm of ecosystem approach to fisheries management demands a shift from the ordinary single species to the multi-species management (FAO, 2003; Morishita, 2007), where efforts to mitigate harvest of immature individuals and by-catch of the non target species, and protection of vulnerable ecosystems besides involving the user communities as co-managers of their natural resources are desired.

It is now apparent that the two species of *A. baremose* and *H. forskahlii* cannot be harvested in gillnets above 76.2 mm as no single representative individual was encountered in gillnet meshes above this mark. This observation is in line with earlier assertions by fishermen targeting the two species who maintained that the current minimum legal gillnet mesh size of 101.6 mm allowed on Lake Albert does not allow harvest of their target species.

The high proportions of immature individuals recorded in gillnets < 63.5 mm mesh size (Fig. 6) and the presence of very few immature individuals coupled by the least by-catch of non target species in the 76.2 mm mesh gillnets deployed in deep open waters suggest that the 76.2 mm mesh gillnets set in deep open waters to target the two species is sustainable for their utilization.

There are variations in fishing regulations on both the Uganda and Democratic Republic of Congo (DRC) side of Lake Albert. Whale as there is a fishing holiday on the DRC side, fishing on the Uganda side of the lake is throughout the year. The conclusions and recommendations of this study should therefore be treated cautiously with respect to the Lake Albert fisheries on the DRC side.

Conclusion

This paper for the first time reveals an important biological discovery of size at 50% maturity for the two species. This information will form a basis for designing species specific management options including setting gillnet mesh size limits for the two species for their sustaible utilization. The progressive decrease in mean catch rates, mean sizes and annual catches of *A. baremose* and *H. forskahlii* landed in the commercial catch on Lake Albert clearly confirms a declining stock for both fisheries on the lake.

The earlier claims by fishers targeting the two species in Lake Albert and the Albert Nile that the two species are not exploitable in gillnets above 76.2 mm are justified by the study given the fact that no single representative individual was recovered from mesh sizes above the 76.2 mm mark for both the commercial and experimental catches.

The study therefore recommends the use of the 76.2 mm mesh size gillnets in harvesting the two species but when deployed in the deep open waters. It is urgent that the current fishing regulations (the Fish (Fishing) Rules, 2010) on Lake

Albert be revised to a more comprehensive species specific management policy document for the diverse commercial species exploited on Lake Albert (FAO, 2003).

There is need to reduce and license fishing effort targeting *A. baremose* and *H. forskahlii* on Lake Albert to levels that allow their sustained utilization. The study demonstrates a high diversity of species in lagoons and river mouths as earlier indicated (Hecky, 2007; Wandera and Balirwa, 2010). Mapping and zoning off these vulnerable but important habitats on Lake Albert from any fishing activities is highly recommended.

It is also very vital that the existing fishing regulations that restrict use of prohibitive fishing gears on Lake Albert are strengthened. The fisheries regulations in the two countries sharing Lake Albert need to be harmonized if a sustainable fisheries management approach is to be achieved.

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