Afr. J. Trop. Hydrobiol. Fish. (1995) 6, 43-50

A decline in Fish catches and the size of *Oreochromis niloticus* in Lake Wamala (Uganda) following human exploitation

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ABSTRACT

The fishery of Lake Wamala has declined since the lake was stocked in 1956 and opened to fishing during the 1960s. Surveys were conducted on the lake during 1975/78 and 1988/92 to investigate the causes of declining fish catches. The lake produced an average of 4000 - 6000 tonnes of fish annually from 1960s through 1970s. Total fish catches decreased from a maximum of 7100 tonnes in 1967 to less than 500 tonnes by 1990s. Catch rates decreased from about 8 kg in the 1960s to less than 1 kg per net per night by 1975. During the 1970s the catch was dominated by *Oreochromis niloticus* (67%) followed by *Clarias gariepinus* (17%), and *Protopterus aethiopicus* (15.1%). By 1990s the proportion of *O. niloticus* had decreased to 45.1% while that of *P. aethiopicus* had increased to 37.6%. These changes seem to have been caused by overfishing resulting from increased fishing effort from the recommended 250 to about 1000 boats and the additional increase in effort through driving fish into the nets by beating water. The maximum size of *O. niloticus* in the fishery decreased from 32 cm total length in 1975/78 to 22 cm in 1988/92 while the size at first maturity decreased from about 21 cm to 14 cm during the period. This has been concurrent with a shift in the mesh size of gillnet used from 127 mm (5") in 1960s to 64 mm by 1990s. Environmental changes, especially in lake level in 1980, may also have affected the fishery.

INTRODUCTION

Lake Wamala is located in Central Uganda about 70 km west of Kampala. The lake was fringed by papyrus (*Cyperus papyrus).* The area surrounding it is mostly agricultural land which normally receives rain throughout the year with two peaks in April-June and October-November, respectively.

Several small rivers of which the most important are Nyanzi, Kabasuma and Bimbye, flow into the lake and the Kibimba River drains it westwards into Lake Victoria via the River Katonga (Fig.1). Following heavy rains in 1961 the open water of the lake expanded from about 100 km^2 to 118 km^2 while the fringing swamps and islands covered about 60 km^2 (UGANDA DEPARTMENT OF LAND AND SURVEYS AERIAL MAPS 1958, 1967). Its maximum depth was 4.3 metres (CHALE, unpublished data).

Lake Wamala was stocked in 1956 with tilapias, namely *Oreochromis niloticus, Oreochromis leucostictus* and *Tilapia zillii,* and was opened to commercial fishing in 1960. Interviews with local fishermen between 1975 and 1978 (OKARONON 1975, 1976, 1977, 1989) revealed that subsistence fishing had been going on long before stocking was done. This subsistence fishing took place along rivers and at river mouths using basket traps made of papyrus stems, and hooks. The fish that were caught were predominantly *Clarias gariepinus* and *Protopterus aethiopicus.* There was no evidence that tilapias occurred in the lake prior to stocking.

Gillnetting is the most prevalent fishing method used by the fishermen. Gillnets of 127, 114, 102, and 89 mm stretched mesh were in common use during 1975/78 while gillnets of mesh sizes down to 51 mm were in use during 1988/92. The legal gillnet size for Lake Wamala is 127 mm stretched mesh. The fishing operation is carried out from small flat-bottomed, wooden canoes. A maximum of 250 canoes are licensed to operate on this lake. Up to 1000 canoes were operating on the lake by 1967. During 1975/78 beating of the water to drive the fish into set nets was a wide spread practice of fishing on the lake. The practice is reported to have started since about 1973 and was also commonly observed during the 1988/92 survey.

For about 6 years starting about 1981 the area around the lake experienced severe dry seasons causing it to shrink and leaving the fringing papyrus swamp dry. By February 1988 the lake had retreated by about 10 metres on average from its 1978 shoreline. There was war in the area from 1981 to 1986. The people fled the area and fishing was abandoned. By 1989 the shoreline had returned to its original level following wet years

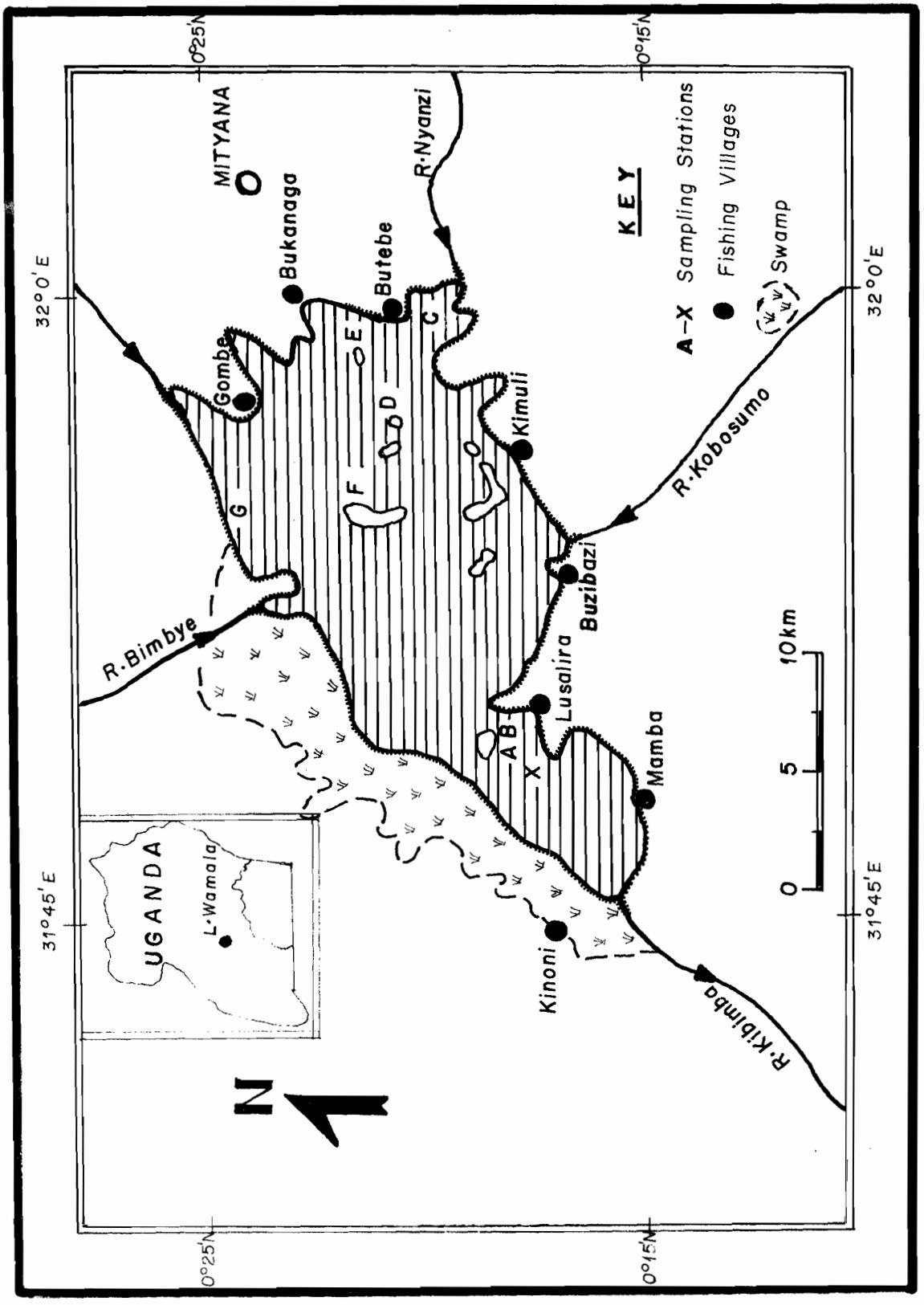

Fig. 1 Map of Lake Wamala showing sampling stations and fishing villages.

that began soon after the end of the "Luwero Triangle" war in 1986. Another drought, which started around July 1991, also affected the lake levels and in March 1992 the water had retreated by at least 12 metres from its level during the survey in December 1991. Lake Wamala is believed to " have been born, to go dry and come back again". The drying and coming back again occurs at an interval of about 30 years. The lake was last observed to dry up and come back again in 1930 and then 1958. The drying up being experienced now is believed to be another round of these happenings.

The lake supported a very profitable commercial fishery throughout the 1960s (Table 1) but from the early 1970s the fishermen started complaining about declining catch rates, which fell from about 8 kg (15 fish) of *O. niloticus* per net per night in 1966 to less than 1 kg per net per night by 1975. SSENTONGO and OKORIE (1971), during "a brief survey of some fish-landings on Lake Wamala", made a number of observations. (1) The fish catches were promising and consisted of *O. niloticus, O. leucostictus, P. aethiopicus* and *C. gariepinus* and that *O. niloticus* dominated the catches. (2) The number of fishermen had increased considerably since 1967 and the catches had dropped. (3) There were many unlicensed canoes and efforts to destroy them had not reduced their number because of a steady supply of new canoes from the villages. (4) Many unlicensed canoes were kept on the floating islands and were never seen by the Fisheries Assistants at the fish landing sites. (5) The gillnet mesh size limit of 127 mm was not adhered to and under-sized gillnets were used by both the licensed fishermen and poachers. (6) There was a serious danger of overfishing attributed mainly to the increasing number of fishermen and the prevalent use of unlicensed canoes and illegal gear.

In response to these problems, resource evaluation studies were started to determine:-

(a) Fish production and the abundance of exploited stocks;
(b) The composition and distribution of fish in the lake;
(c) Size structure of harvestable species; and
(d) The levels of fishing effort.

The results of surveys carried out in 1975/78 and 1988/92 are presented in this paper.

Table 1. The quantity of fish taken from Lake Wamala, 1960 - 1986
(Source: Uganda Fisheries Department).

Period	*Total Catch (tons)*	*Oreochromis niloticus* %	*Oreochromis leucosticus* %	*Clarias gariepinus* %	*Protopterus eathiopicus* %	*Fishing Canoes*
1960	1 000					
1961	1 000					
1962	2 000					
1963	2 100					
1964	2 100					
1965	4 800					450
1966	6 600					
1967	7 100	61.7	12.2	7.7	18.3	1000
1968	5 600	71.1	8.8	5.8	14.3	
1969	5 300	77.4	2.9	7.7	12.0	
1970	6 000	73.5	5.7	6.2	14.5	
1971	5 200	59.4	22.3	5.1	13.2	
1972	4 100	68.2	3.3	8.7	19.8	
1973	4 300	57.4	1.6	10.9	30.1	
1974	6 500					
1975	6 300	77.0	3.2	5.7	14.1	
1976	4 300	61.9	2.0	11.8	24.5	
1977	1 100	60.0	2.6	10.5	26.9	
1978	1 800	55.5	0.9	10.6	33.1	
1979	2 000					
1980	1 000					
1981	3 800					
1982	500					

Note: No reliable commercial catch records have been taken since about 1982 considering the war in the area and illegal fishing thereafter.

3. MATERIALS AND METHODS

Five week-long surveys were conducted between 1975 and 1978 with another six from 1988 to 1992. Two identical fleets of gillnets each consisting of 14 nets, ranging in size from 25 mm to203 mm stretched mesh and joined end to end, were used for experimental fishing during the surveys. All the gillnets were 26 meshes deep and 90 m long before hanging except the 25 mm to 89 mm stretched mesh nets which were 45 m long. The nets were set daily around 1400 hours local time and collected the following morning around 0800 hours. The fish that were caught were sorted into species, and each fish weighed, measured and sexed. The condition of their gonads was determined according to Kesteven's classification (BAGENAL and BRAUM 1971).

Records of commercial catches were made at the landings and fish samples selected for data on species, weight, length, sex and condition of gonads. Oral interviews were conducted with fishermen and Fisheries Department staff on the lake. Fisheries statistics data for the lake was gathered from the Fisheries Department records.

SURVEY RESULTS

Fish Production and the abundance of exploited stocks.

Oreochromis niloticus was the most important species in the commercial fishery and in 1975/78 it contributed over 50% of the total catch. Since the lake was opened to commercial fishing the catches have ranged between 500 and 7100 metric tons per annum (Table 1).

During 1975/78 the highest catch of 3.2 kg (for all fish species) per net per night was obtained from the 89 mm mesh experimental gillnets followed by the 102 mm mesh gillnets which recorded 2.0 kg per net per night (Table 2). In contrast, the highest catches of 3.1 kg per net per night was obtained in the 64 mm mesh gillnets, declining to about 1 kg in the same mesh- size gillnets during 1988/92.

The composition and distribution of fish in the Lake.

The catch from the experimental gillnets in 1975/78 consisted of *O.niloticus* (67%), *Clarias gariepinus* (17%), *Protopterus aethiopicus* (15.1%), *O. leucostictus* (0.8%), *Tilapia zillii* and a few haplochromine species (Table 2). The species composition was similar in 1988/92 except that the mean proportion of *O. niloticus* had fallen to 45.1% while *P. aethiopicus* had risen to 37.6% (Table 2).

The size structure of harvestable fish species

In 1975-78 the average total length of *O. niloticus* in the lake was around 22 cm, largest mode was at 23 cm. The fish ranged from 12-32 cm and there were around five (5) length-classes (Fig. 2). In contrast, during 1988/92, the average length (of *O. niloticus)* was around 15 cm, the size range was

Table 2. Catch per unit of effort (percentage by weight) for different fish species caught in experimental gillnets of various mesh sizes fished in Lake Wamala

		51	64	76	89	102	114	127	140	152	165	178	203	MEAN
Protopterus aethiopicus	1975-78	1.9	2.1	2.8	7.4	12.9	37.2	30.4	39.0	0.0	0.0	0.0	46.6	15.1
	1988-92	1.8	2.8	41.2	84.0	86.6	48.8	69.5	0.0	32.6	0.0	0.0	100.0	37.6
Clarias garipinus	1975-78	2.6	6.4	8.4	8.1	12.1	24.2	37.3	43.5	44.6	0.0	0.0	48.8	17.0
	1988-92	0.0	1.8	5.8	11.6	8.2	45.7	30.1	0.0	66.1	0.0	0.0	0.0	17.3
Oreochromis niloticus	1975-78	94.3	90.4	87.7	82.2	75.0	38.6	32.4	17.4	55.4	0.0	100.0	5.0	67.0
	1988-92	98.2	95.4	53.0	4.4	5.2	5.5	0.4	0.0	1.3	0.0	0.0	0.0	45.1
Oreochromis leucostictus	1975-78	0.3	1.0	0.9	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
	1988-92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tilapia zillii	1975-78	1.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1988-92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other species	1975-78	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1988-92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total CPUE (Kg/night)	1975-78	0.8	1.9	1.8	3.2	2.0	1.9	0.8	0.7	0.5	0.0	0.04	0.8	0.0
	1988-92	1.9	3.1	0.9	0.5	1.2	0.9	2.2	0.0	1.1	0.0	0.0	0.3	

from 11-22 cm and there was only one clear size class (Fig.2). Fifty percent (50%) of *O. niloticus* were observed to spawn at around 14 cm total length during 1988/92 while in 1975/78 fifty percent of the fish were estimated to spawn at 21.2 cm and 20.3 cm total length for the male and female, respectively (Fig. 3).

The experimental gillnets with stretched mesh sizes below 64 mm retained mostly immature *O. niloticus* (less than 16% mature) (Table 3). The 64 mm mesh experimental nets retained fish within 13.0 - 24.0 cm total length and mean of 16.7 mm TL but 91.6% of fish taken were mature. The catch from the 76, 89 and 102 mm mesh experimental nets had a mean of 20.3 cm TL and size range 14.0 - 28.0 cm, mean of 23.8 cm TL with size range of 18.0 - 31.0 cm TL and mean of 23.8 cm TL with size range of 20.0 - 30.0 cm TL, respectively, with over 99% of the fish mature. The legal 127 mm mesh experimental gillnets retained fish of size 23.0 - 33.0 cm TL with a mean of 27.2 cm TL with all the fish mature.

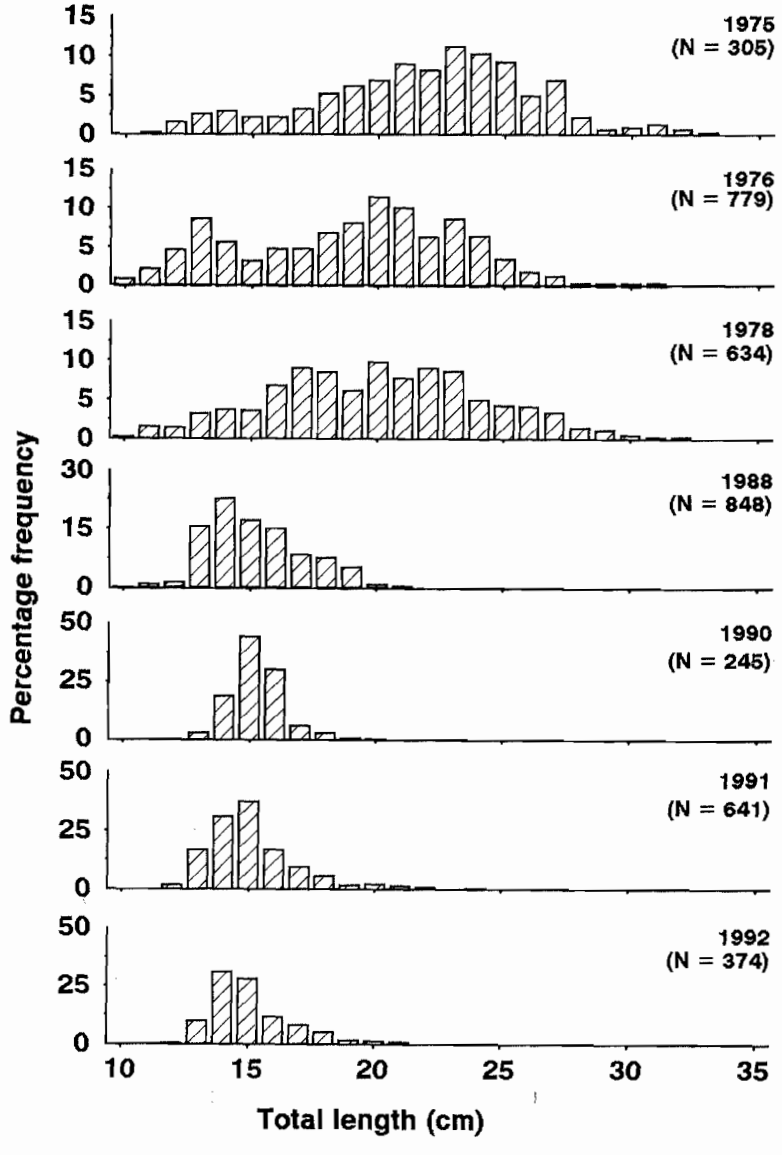

Fig. 2. Length frequency distribution of *Oreochromis niloticus* in Lake Wamala.

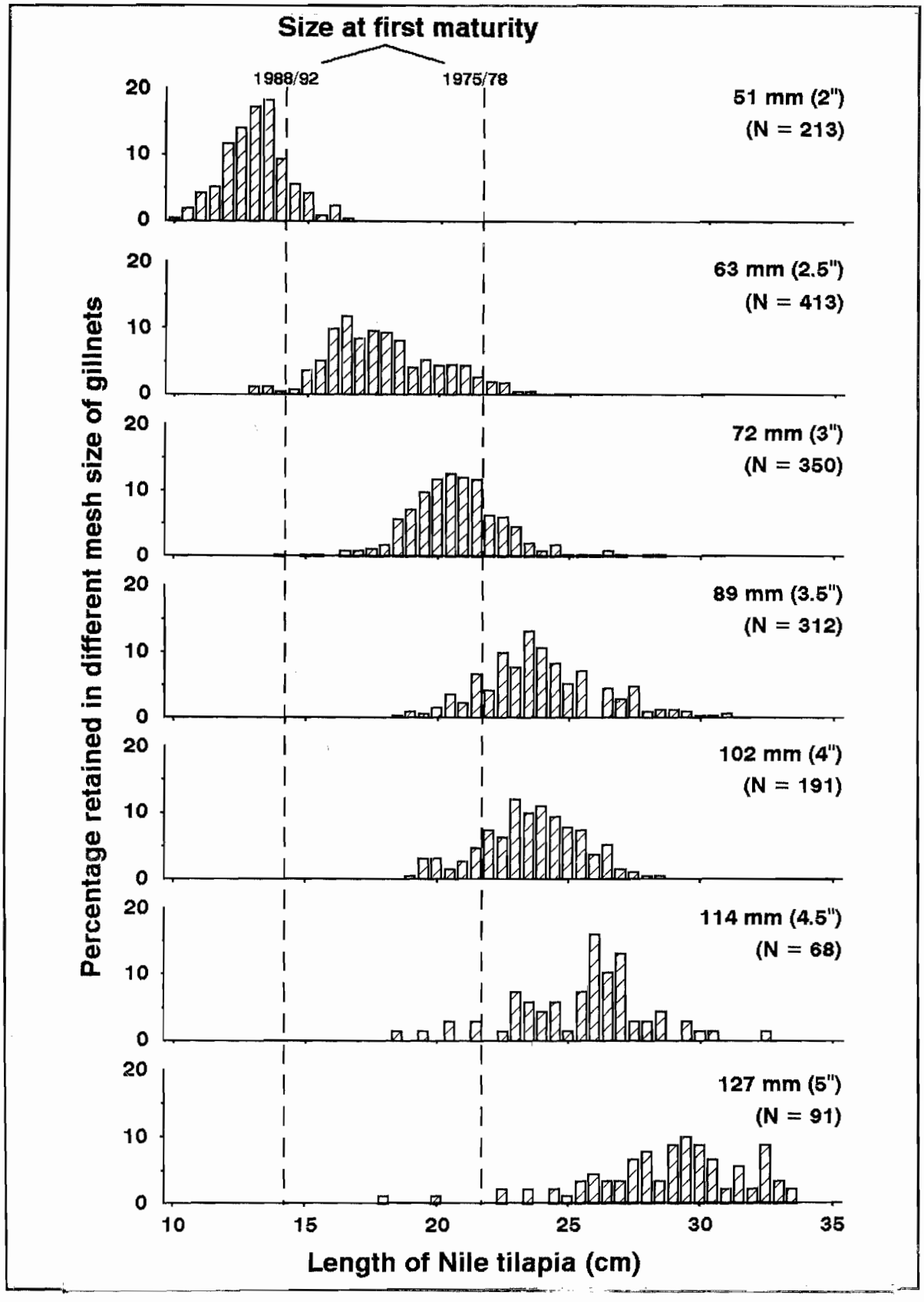

Fig. 3. Gillnet Selectivity of Nile Tilapia in Lake Wamala.

Table 3. Retention characteristics of various mesh size gillnets for *Oreochromis niloticus* caught from Lake Wamala during the period May 1975-November 1978. (E = Experimental nets; C = Commercial nets)

	FISH SPECIMENS CAUGHT				
	Mesh size (mm)	Number	% Mature	TOTAL LENGTH (cm)	
				Mean	Range
E	25	47	0	7.5	6.0 - 9.0
E	38	161	4.3	11.8	8.0 -14.0
E	51	280	15.7	12.9	10.0 -22.0
E	64	429	91.6	16.7	13.0 -24.0
E	76	346	99.1	20.3	14.0 -28.0
E	89	344	100	23.0	18.0 -31.0
E	102	199	100	23.8	20.0 -30.0
C	102	569	100	23.3	18.0 -32.0
E	114	53	100	25.0	19.0 -31.0
C	114	34	100	27.2	23.0 -31.0
E	127	24	100	27.2	23.0 -33.0
C	127	46	100	28.8	25.0 -34.0

DISCUSSION

During the 1975/78 and 1988/92 surveys on Lake Wamala, commercial catch landings consisted of the four fish species observed by SSENTONGO and OKORIE (1971) and in the experimental nets *T. zillii* and haplochromine species were, in addition, recorded; *O. niloticus* dominated the catches. The decline in the landed commercial catch of fish by about 93% from 7100 tons in 1967 to 500 tons by 1982 may be attributed to the increase of fishing effort soon after the lake was opened to commercial fishing in 1960. An aerial count in October 1965 gave 450 canoes on the lake, up to 1000 canoes were estimated to be operating on the lake by May 1967, and over 700 canoes were operating during the survey period 1975/78, instead of the licensed figure of 250 canoes (UGANDA FISHERIES DEPARTMENT 1965, 1967; OKARONON 1989). Similar declines in catch rates of fish attributed to increased fishing effort were also observed in Lake Victoria (BEAUCHAMP 1955).

There is a rapid decline in numbers of *O. niloticus* retained in the experimental nets during 1975/78 starting at 23 cm total length in the population curve. Similar observations were made for *O. niloticus* in Lake George (Gwahaba 1973). This decline is an indication that some of the nets the fishermen were using caught fish that were as small as 24 cm total length using the 102 mm and 114 mm mesh (stretched) nets, as opposed to the 127 mm mesh (stretched) nets which are effective at 29 cm total length.

As observed during the survey in 1975/78 and also in 1988/92, most of the fishermen do not only set the nets, but in addition, they beat the water with a long pole to drive the fish into the nets. The beating of the water (referred to as beating the nets) was aimed at raising the effort and it involved use of two nets instead of fishing ten set nets per canoe per night as was legally permitted. It has been observed that fishermen beating the water may use only two nets a night but may beat them perhaps ten times or more (FRY and KIMSEY 1960, GWAHABA 1973). These two nets may catch even up to ten times as many fish per night as the ten set nets. Presumably, as the fish population declines, the fishermen tend to beat their nets more frequently than before. In lake

Wamala the practice was in 1975/78 observed to extend to around 10.00 hrs in the morning.

The shift in the range over which maturity occurs may suggest an indication that *O. niloticus* have dwarfed or stunted. In Lake Wamala *O. niloticus* were observed to have matured at around 14 cm total length in 1988/92 as opposed to over 20 cm total length during 1975/78. It was further observed that *O. niloticus* larger than 20 cm total length were rarely retained by the experimental nets during 1988/92, thus the common use of the 51 mm and 64 mm mesh gill-nets by the fishermen during the period. Dwarfing of cichlids is usually associated with physical restriction imposed on the fish habitat and is usually accompanied by a general speeding up of the reproductive process involving early maturation at a relatively small size (GWAHABA 1973).

During the period 1981-86 the area around the lake experienced a severe dry season which caused the lake to shrink by at least 10 metres from its 1978 shoreline. Another drought, which started around July 1991, also affected the lake levels. In addition, the lake falls in the "Luwero Triangle" which was in war during 1981-86. The war caused the people around the lake to flee, abandoning fishing.

For a period of six years (1981-86) the size of the lake reduced while the fish continued to reproduce. Fishing mortality during this period was almost zero. Thus the fish population continued to increase while the size of the lake was decreasing. The dwarfing of the fish observed during 1988/92 may, therefore, be attributed to the reduced size of the lake and, consequently, the reduced food for the fish.

ACKNOWLEDGEMENTS

I wish to sincerely thank the staff of the Uganda Fisheries Department on Lake Wamala and at Entebbe for their assistance and cooperation. Many members of UFFRO/FIRI assisted in various ways and I am particularly grateful to Dr. R. Ogutu-Ohwayo and Mr. J. Kamanyi for their useful suggestions. Thanks are also due to Messrs L. Muhoozi, S. Bassa, F. Moini and J. Were and Ms Joyce Akumu for the role they played in the field and laboratory. Mrs Ruth Byekwaso typed the manuscript and Mr. S.N. Sowobi made the figures.

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