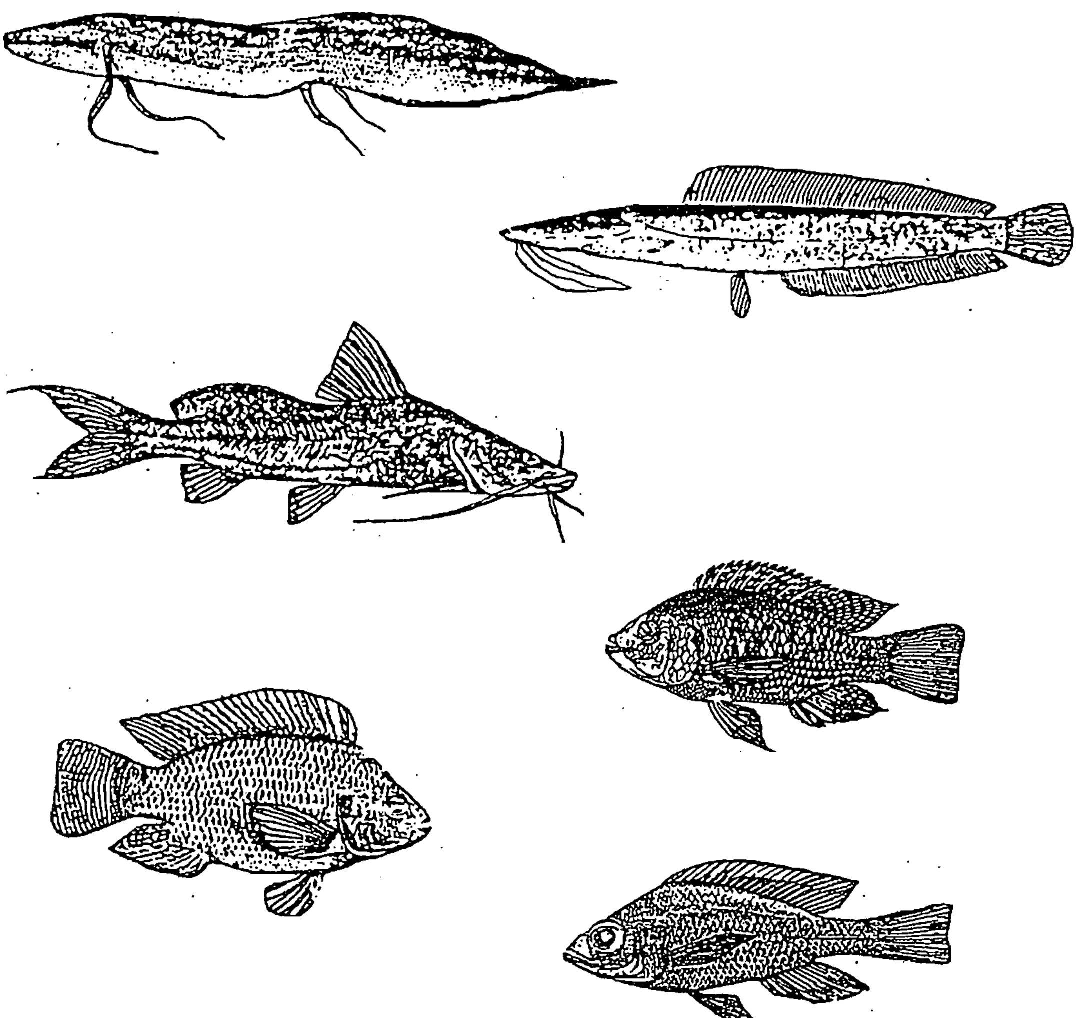
THE FISHERIES AND FISH STOCKS OF LAKE GEORGE

Their Productivity, Exploitation, Management and Conservation



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Abbreviations

ACD	Assistant Country Director
CARE	Cooperation for Assistance and Relief Everywhere
DANIDA	Danish International Development Agency
DFO	District Fisheries Officer
FIRI	Fisheries Research Institute
IBP	International Biological Programme
LDU	Local Defence Units
MSY	Maximum Sustainable Yield
QENP	Queen Elizabeth National Park
QENP - FVCP	Queen Elizabeth National Park Fishing Village Conservation Project
TUFMAC	The Uganda Fish Marketing African Cooperation
UWA	Uganda Wild Life Authority
TL	Total length
FL	Fork length
CAO	Chief Administrative Officer

Background

This report was prepared for the Queen Elizabeth Fishing Village Conservation Project (QENP-FVCP) which was being implemented by CARE International in Uganda. The QENP-FVCP was addressing the issues of increasing pressure on the Queen Elizabeth National Park by the fishing communities living in the park. This was being manifested in the high demand for fuel wood and the high fishing pressure on the fish stocks of lakes George, Edward and the Kazinga channel. The population of the fishing villages has increased significantly and the economy of these villages within the park depend sorely on fishing. The Fisheries Research Institute (FIRI) was requested to carry out an assessment of the fish stocks so as to provide information which would be used in designing development and management policies for enhancing increased and sustainable fish production. The study was confined to the fisheries of Lake George. The fishery of Lake George has been exploited under controlled exploitation but the permitted number of boats was fixed in the 1950s before the human population increased to the current level. Many more people were involved in fishing and it was feared that the fish stocks might not support the human population. The assignment involved preparation of a research proposal, collection of field data and production of a report in a period of eight months.

The study was implemented in three phases. The first phase which lasted two months involved preparation of a research proposal. This was followed by a detailed review of the available literature on the lake so as to identify the information that was already available and the gaps which could be filled in the short period provided for by the study. The literature review forms Section I of this report and also produced the bibliography which is given as Annex 1. The literature review generated a list of key issues that required intervention. This was followed by a field survey which lasted three months. The results of the field survey form Section II of the report. The field survey generated an additional list of issues that needed intervention. The issues arising from the literature review and the field survey were finally presented and discussed at a workshop of representatives of stakeholders of Lake George. The proceedings of the Stakeholder Workshop form Section III of the report. The workshop produced a synthesised summary of interventions. This will form the basis of further actions on the lake.

It is important to note that this study was initially expected to provide information on the magnitude of fish stocks available in the lake for exploitation. A full stock assessment would have required a longer period (two to five years) and resources far above those that were available for the study. However, the information generated by the study provided guidelines on development and management of the lake and a basis upon which further actions can be based.

This work was done with financial support from DANIDA through CARE Denmark to the QENP-FVCP which is being implemented by CARE International in Uganda. The authors are grateful for the support which made this work possible and to anyone who provided information which made production of this report possible. Special thank go to the manager and staff of the QENP-FVCP who gave invaluable support during field surveys. However, the opinions expressed in the report are purely those of the authors and do not in any way represent those of the sponsoring agencies or any of the persons consulted.

Scientific names of fish given in the report with their English and some vernacular equivalents

Scientific Name	English Equivalent	Vernacular equivalent
Oreochromis niloticus	Nile tilapia	Ngege
Oreochromis leucostictus	Tilapia	Bambala
Tilapia zillii	Tilapia	Kajansi
Bagrus docmac	Cat fish	Semutundu
Clarias gariepinnus	Cat fish or Mud fish	Male
Barbus altianalis	Barbels	Kisinja
Protopterus aethiopicus	Lung fish	Mamba
Mormyrus kannume	Elephant snout fish	Kasulu
Petrocephalus catastoma		Bisoma
Labeo forskalii	Carp	Ningu Omuruma (Lunyankole)
Haplochromines: - *Astatotilapia elegans* - *Astatotilapia aeneocolour* - *Astatotilapia schubotziella* - *Astatotilapia oregosoma* - *Astatotilapia macropsoides* - *Astatotilapia nubila* - *Enterochromis nigripinnis* - *Gaurochromis angustifrons* - *Harpagochromis squamipinnis* - *Labrochromis mylodon* - *Lipochromis taurinus* - *Psammochromis schubotzi* - *Schubotzia eduardiana* - *Yssichromis pappenheimi*		Nkejje, Ebinyamuroro

Executive Summary

Lake George is located in the western arm of the East African rift valley and is one of the most productive lakes in Africa. Most of the lake is bordered by the Queen Elizabeth National Park and by an extensive wetland. The wetland is protected under the Ramsar Convention[1]. The lake itself is not a protected area but is supposed to be under controlled exploitation. Only 144 canoes each operating 10 nets of not less than 5 inches stretched mesh or 100 hooks of size 7 or 8 are supposed to operate on the lake.

The lake has, since it was opened to intensive exploitation in 1950, supported a lucrative fishery dominated by a single species, *Oreochromis niloticus* (Nile tilapia). After an initial increase, fish catches declined from an average of 5,000 m.t. between 1960s and 1970s to about 2000 m.t. in the 1980s and the average weight of Nile tilapia landed decreased from 0.9 kg to less than 0.5 kg. The decline has partly been attributed to excessive fishing effort and to use of destructive fishing gears and methods. The lake, however has high potential for fish production. It has a very high algal biomass and an efficient system of recycling nutrients for primary production processes. The algae is fed on mainly by two fish species; Nile tilapia and *Enterochromis nigripinnis* (Nkejje) which form up to 60% of the fish biomass in the lake. There are about 30 other species of fish in the lake (mainly haplochromines) which if harvested could increase production. The lake's resources are also threatened by copper and cobalt pollution and possible infestation by the water hyacinth which has already become a problem in the other large lakes in Uganda. All these factors are a threat to the livelihood of the people who depend on this fishery. Unfortunately, the current magnitude of the stocks and the state of the lake's environment are not known. Most of the available data on the lake was generated over 25 years ago. This survey re-examined the types, population structure and abundance of the fish available for harvesting; the biology and ecology of the abundant species; determined the distribution of fishing effort and the impact of fishing gears and methods.

The survey showed that there were over 500 canoes some of them operating as many as 60 nets or 2000 hooks each. Some of the canoes used nets as small as 3 inches. Considerable quantities of fish are, however, still being landed from the lake and it was estimated at about 7000 metric tonnes of fish being landed annually compared to an average of 4130 metric tonnes in 1960/70. The low value recorded in 1960/70 was because the catch statistics were mainly based on the licensed canoes. At present the canoes operating have increased four fold. The number of exploited species had started to increase at some fish landings through exploitation of *Oreochromis leucostictus* which had not been previously exploited. Fish production from the lake could be further increased through exploitation of *E. nigripinnis* using 1 inch mesh size gill nets set more than 100 metres from the shore, as this mesh size catches mainly *E.nigripinnis* when set 100m away from the shore. Exploitation of these species could be tried under restricted entry using a few fishermen on an experimental basis.

The existing fishing regulations no longer apply to the current situation on the lake. It is therefore recommended that the regulations governing exploitation of the fisheries of Lake

[1]The Convention under which wetlands of international importance are protected

George should be revised to take into account the current state of the fishery. Further research will, however, be required to provide more accurate data on the status of the fish stocks especially regarding stock biomass. In addition, it will be necessary to review the lake productivity mechanisms; examine the sources and extent of pollution and eutrophication in the lake; sensitise communities on dangers of the water hyacinth infestation; integrate the interests of management of the park and wetlands with those of the lake; and coordinate the extension services by bringing together the three Districts sharing the lake and involving them and the user communities in development and management of the fisheries of the lake.

The results of the survey were discussed at a workshop of stakeholders of Lake George. The observations made by the prticipants on the results of the study and other issues facing the lake were as follows:

a). Some participants felt that the number of canoes could be increased to approximately 300, the number of nets could be doubled from 10 to 20, the number of hooks from 100 to 200. It was however, felt that this shou. I not be done until there was adequate scientific data to support it. It was therefore recommended that research should be carried out to verify the allowable effort on the lake.

b). It was generally agreed that the minimum mesh size of gill net used should be reduced from 5 inches to 4.5 inches stretched mesh and the minimum size of hook should be Size 9. On the method of fishing it was recommended that the law banning active gill net fishing should be enforced.

c). On harvesting *Enterochromis nigripinnis*, there were fears that stocks of immature individuals of the larger species may be destroyed by the one inch mesh size gill net that is suitable for harvesting this species. The scientists, however assured the participants that the species was spatially segregated from juvenile of larger species. It was recommended that harvesting of this species could start but under restricted entry.

d). There should be a full inventory of fish species diversity in the lake and efforts made to conserve fish species diversity.

e). Aquaculture should be developed especially in Kasese District to reduce pressure on the lake by improving fry production and supply through rehabilitation of existing fry centres and constructing new ones. Fish farming especially of trout in cold mountainous areas should be investigated. Community based extension agents should be trained.

f). The levels of especially heavy metals such as copper and cobalt along with levels of other pollutants such as agrochemicals, sedimentation and siltation should be assessed both in the lake and in the tissues of fish and appropriate actions taken.

g). There should be monitoring, surveillance, vigilance and sensitization of the people around the lake on the water hyacinth problem to avoid this weed getting into the Lake George. It was specifically recommended that nets from infested lakes should not be moved into Lake George.

h). It was recognised that high rates of human population growth put pressure on the lake's resources at its catchment area. Family planning education should be intensified among the lakeside communities.

j). Basic social amenities were lacking at the landings and there was need for schools, clinics, latrines to better living conditions of the fishing communities.

l). There is need to change the present law on management of fisheries in relation to Lake George but this should be supported by adequate scientific data

m). Any available information on the resources of the lake should be packaged and made available to end-users.

n). There was need to involve local authorities, chiefs, fishermen's organisations etc. in management of the fisheries. The participants suggested setting up a system of formal collaborative integrated management stipulating the roles of different players. There may also be need to give authority to the fishermen to arrest and prosecute defaulters.

o). There should be a body to coordinate management of the lake by the three Districts. This could be termed the Lake George Management Committee. This committee should operate under the overall guidance of the Fisheries Department. It may be necessary to re-centralise fisheries services as is the case with forestry.

p). The three Districts sharing the lake should contribute logistics to facilitate law enforcement on the lake. The Lake Management Committee should, once formed, solicit for funds from donor agencies for management of the lake.

q). Interaction between policy makers, and law enforcement section should be strengthened

r). The activities of different institutions especially the Fisheries Department, the Queen Elizabeth National Park and National Wetlands Management Programme which have a stake in the lake need to be harmonised so that each is aware of what the other one is doing.

s). Overall more detailed research was needed to elaborate on the key issues, especially biomass of fish available for harvesting, the processes that lead to fish production, pollution and eutrophication (over-fertilisation) of the lake.

SECTION I

1.0. THE LITERATURE SURVEY OF INFORMATION ON THE FISHERIES AND FISH STOCKS OF LAKE GEORGE

1.1. Geographical and economic setting

Lake George (Fig. 1) is a shallow lake with a mean depth of 2.5 m, a maximum depth of 4 m and an area of 250 km^2. It is situated astride the equator in the western arm of the East African rift valley at an altitude of 914 m. Most of the lake is bordered by savannah vegetation but the north and north-eastern sections are bordered by wetlands. It has four major effluent rivers. Three of them, River Sibwe, Nsonge and Mubuku originate from the Ruwenzori mountains. The fourth, River Mpanga is a westward flowing tributary of River Katonga. Lake George has a single outflow through an approximately 33 km slow flowing Kazinga Channel into Lake Edward. The lake has three large and several smaller islands. The two large islands, Kankuranga and Akika are close to the western shore of the lake. The bottom of the lake is covered by a thick organic ooze about 3 m deep. Some of the inshore areas have sandy substrate especially around the islands.

Three quarters of the shoreline of Lake George is located in the Queen Elizabeth National Park (QENP) which is under the control of the Uganda Wildlife Authority (UWA). The waters and the fisheries resources of the lake are, however not under the jurisdiction of UWA but are controlled by the Uganda Fisheries Department (UFD) and the local authorities of the Districts bordering the lake. Lake George, together with the adjacent Lake Edward, are the main sources of fish for the heavily populated western Uganda. Analysis of commercial fish catch statistics of Lake George (Dunn 1973, 1989), suggest that the lake has the capacity to produce 3000 m.t. to 5000 m.t. of fish annually. Three of the fishing villages on the lake (Kasenyi, Hamukungu and Kahendero) are within the QENP and the inhabitants of these villages depend mainly on fishing and associated services as other developmental activities are not permitted within the park boundary. The population in the fishing villages is currently estimated at 30,000 people.

Fish is very important in the diet of the people of the Districts around Lake George especially Kasese. The cassava based food (locally known as Bundu) which is the main food of the people of Kasese District requires either meat or fish as sauce. It is very difficult to rear cattle because of the hilly terrain of Kasese District. This leaves fish as the main source of protein and up to 90% of the people of Kasese District depend on fish for sauce.

The wetlands north of Lake George have been declared the first Ramsar Site in Uganda especially as habitat for water birds and are protected under the Ramsar Convention - the Convention under which wetlands of international importance are protected. These wetlands also perform other beneficial functions especially striping of pollutants and also help maintain the water table.

The management of the fisheries, the QENP and the Ramsar site are under different authorities. There is no integration of the different authorities and this can bring antagonism between them and put the resources which they manage in jeopardy.

1.2. Fisheries Regulations Applicable to Lake George

The law for management of fisheries in Uganda is the Fish and Crocodiles Act and its amendments and Statutory Instruments and Orders. Under this Act, it is illegal to catch Nile tilapia of less than 11 inches (28 cm) total length on all water bodies within Uganda.

The Lake George fishery is, according to the regulations under controlled exploitation. Only 144 canoes each of them operating either 10 nets of not less than 5 inches stretched mesh or not more than 100 hooks of size 7 or 8 are permitted to fish on the lake. The nets are accordingly operated passively. However, these regulations are presently not followed due to inadequate enforcement and the changes that have taken place in the fishery since the laws were inacted.

1.3. The Fisheries Resource Base

1.3.1. Lake productivity mechanisms that affect fish production

Lake George is among the most productive lakes in the world. The physico-chemical and biological processes that lead to this high production were examined by the International Biological Programme (IBP) - Royal Society Team between 1967 and 1972. The lake's equatorial setting provides a stable climate which allows maximum production all year round. There is adequate sunlight and temperatures are suitable for organic production. Surface temperature varies between 25-36°C and PH is 8.5-9.5. The lake water mixes daily and this brings nutrients from bottom deposist into the production chain.

Lake George supports a permanent dense population of microscopic aquatic plants (algae). Ninety five percent of the total organic biomass in the lake consists of these algae. The algal community is dominated by blue green algae mainly *Microcystis* sp., *Aphanocapsa* sp. and *Anabeonopsis*. These fix nitrogen from the atmosphere and make it available to other organisms living in the water. These algae form the major source of food of the two most abundant fish species, Nile tilapia and *E. nigripinnis* (Dunn 1972, 1975, Moriarty 1973, Moriarty et al 1973, Greenwood 1966, 1973, 1981; Gwahaba 1975). The algae are also eaten by zooplankton which in turn are eaten by some of the fish in the lake. The zooplankton population is dominated by Copepods (mainly *Thermocyclops neglectus and Mesocyclops leukarti*) followed by Rotifers and Cladocerans. In addition, the lake has a number of invertebrate organisms which live in the mud bottom. These are dominated by lakeflies which include chironomids and chaoborids. These too are eaten by some of the fish species. The distribution and composition of these benthic fauna is determined by the nature of the substrate.

1.3.2. The fish fauna of the lake

Analysis of fish catch statistics shows that only four fish species *Oreochromis niloticus* (Nile tilapia, Ngege), *Protopterus aethiopicus* (Mamba), *Clarias gariepinus* (Male) and *Bagrus docmac* (Semutundu) have been exploited by the commercial fishery of Lake George from the time that the lake was opened to intensive exploitation in 1950 to the early 1990s. Experimental fishing by the IBP Team, shows that the lake contains many more fish species than those occurring in commercial catches. The list of fish species encountered by the IBP team including estimates of biomass, numbers, size and food at that time are shown in Table 1. There were up to 32 fish species belonging to eight families. Pictures of the common fish species of Lake George are given in Figure 2a - f. The ten most abundant species (by weight) were in order of important: *E. nigripinnis, O. niloticus, G. angustifrons, P. aethiopicus, C. gariepinus, B. docmac, H. squamipinnis, O. leucostictus, Aplocheilichthys* and *S. edwardiana*. Haplochromine cichlids were the most abundant taxa and contributed about 60% to total biomass of fish in the lake. This relative abundance of fish in the lake has never been reflected in the commercial catches. For instance, haplochromines (Nkejje), which are the most abundant types of fish are up to now not exploited directly by the artisanal fishery.

The fish population ucture, at that time, can be divided in two size categories (Table 1). The first group consists of those fishes which grow to about 10 cm total length. These include all haplochromine species with the exception of *H. squamipinnis*. The second group consists of the larger species which grow to an adult length of more than 20 cm. These include the two tilapiine species; Nile tilapia and *O. leucostictus* (Tilapia, Bambala) and the predatory species (*P. aethiopicus, C. gariepinus, B. docmac*). This difference in size structure could be used as a management option to have a fishery of large species exploited using large mesh size gill nets (eg. 3 to 5 inches) and one of small species especially haplochromines using small mesh nets (eg. 1 to 1.5 inches) in restricted offshore areas not less than 100m from the shoreline.

Many of the fish species in the lake were spatially segregated (Fig. 3). Of the species examined by the IBP Team, only 11 occurred in all regions of the lake. Fifteen species were found within 100 m of the shoreline. Of the most abundant species, *E. nigripinnis* and *G. angustifrons* had their abundance increasing from inshore to offshore. This separation can allow selective exploitation of the haplochromine species offshore using small mesh size gill nets. This would not be harmful to juveniles of the large commercially important species (*O. niloticus, O. leucostictus*) because juveniles of these species are mainly found within 100 m from the shore (Gwahaba 1974).

Sixteen out of nineteen species of haplochromine species identified in Lake George were endemic to the Lake Edward-George system. Some of these are also very rare. Although these lakes are located in the National Park, none of the fish species in these lakes is protected by the park regulations. It should be noted that large numbers of endemic haplochromine species especially in Lake Victoria and Kyoga were decimated by Nile perch predation and environmental degradation. The highest diversity of haplochromines in Lake George is found within 100 m from the shore. There is need to protect stocks of haplochromines within this part of the lake eg. by not using fishing gears and methods that would destroy their stocks or degrading habitats that are critical to their survival.

There have been no detailed assessment of the fish stocks and examination of the processes that lead to fish production since the IBP-Royal Society work in 1972.

1.4. The impact of human exploitation on the fishery

Considerable changes have taken place in the fishery of Lake George since its development started during the first half of the 20th century. Up to 1930s, the lake supported a subsistence fishery using basket traps and a few gill nets. The fishing effort was low and posed no threat to the fishery. The fishing intensity on the lake started to increase with introduction of synthetic gill nets and long-lines in 1950. Since that time, *O. niloticus* has been the most important commercial species. The 5 inch (127 mm) gill net mesh size limit which was set on this lake seems to have been intended to save adequate breeding stocks of this species. Other species which included; *B.docmac*, *B.altianalis*, *C.gariepinus*, *M.kannume* and *P.aethiopicus* were also landed by the gill net fishery but primarily as bi-catch of the Nile tilapia fishery. Only a limited number of fishermen set long-lines specifically for predatory species (*P. aethiopicus*, *C. gariepinus* and *B. docmac*).

Fishing has been dc.. using small planked canoes operated by two to three fishermen. The gill nets have been operated either passively by setting the nets, leaving them overnight and retrieving them the following day or actively by driving fish into the net by beating the water using sticks. This latter method frightens the fish and makes tilapia and haplochromines which keep eggs and the young in the mouth for protection to spit them and expose them to danger.

Initially fish was marketed through a single outlet (The Uganda Fish Marketing African Corporation -TUFMAC). This monopoly also facilitated collection of catch statistics for the lake. The availability of ready market is likely to have stimulated increase in fishing pressure.

Analysis of fish catch statistics collected by UFD shows that fish catches have declined since the fishery was opened to intensive, exploitation (Table 2 & Figure 4). For the first 10 years, catches remained between 2500 and 3500 m.t.. This was followed by an increase to 5000 m.t. in 1960. This increase was attributed to expansion of breeding grounds and stimulation of breeding by the heavy rains of 1960 and 1961. These high catches were maintained until 1977 after which there was a steady decline to the lowest level of 1487 m.t. recorded in 1985. This drop coincided with the economic depression which followed expulsion of the Indian business community from Uganda which was followed by shortage of fishing inputs and an increase in insecurity. After 1985, there was a slight increase in fish catches probably as a result of improved availability of fishing inputs. This increase could not be sustained and fish catches declined further.

The average size of Nile tilapia also declined alongside catches (Table 2 & Figure 5). At the time the fishery was opened to intensive exploitation, the average size of Nile tilapia landed was 0.91 kg. This initially decreased to about 0.6 kg during the first five years as the larger older members which had accumulated were fished out. It then stabilised at an average of 0.61 kg for 15 years between 1955 and 1970. Thereafter, the weight of Nile tilapia decreased further to an average of 0.53 kg between 1970 and 1980. The size at first maturity i.e. the size at which 50% of the fish in the population are mature also decreased from 26 cm during 1957-1959 to 20.5 cm by 1967-72.

As stocks and the size of Nile tilapia decreased, fishermen, shifted from the legal 5 inch mesh nets to smaller mesh gill nets of 4 and 4.5 inches. The gill net effort was increased by active fishing. Here, three or four nets are set in an arc and the fish driven into the net by beating the water.

The decline in the Nile tilapia fishery seems to have made some of the fishermen to switch to the long-line fishery to exploit the predatory species (*P. aethiopicus, C. gariepinus* and *B. docmac*). This is manifested in changes in the proportion of different species in the catch. Originally, Nile tilapia contributed on average 80% by weight to total fish catches but as the stocks of this fish decreased, the proportion of Nile tilapia declined to as low as 36% in 1991 and that of *P. aethiopicus* and *B. docmac* increased to about 64% in the same period.

The maximum sustainable yield (MSY) and the fishing effort that Lake George can support need to be determined precisely. Analysis of catch statistics recorded by UFD from the time when the fishery was opened to intensive fishing up to 1988 shows that the average total fish catch from the lake has been 3,141 ± 159 m. t and has varied between 1487 and 5097 m.t.. The MSY can, therefore be assumed to be about 3000 m.t.. The fishery has, however suffered from under-recording partly due to the apparently large number of poachers on the lake. The catch estimates recorded by UFD staff are also only based on the licensed canoes and do not estimate for the catches landed by the poachers. The estimates are also based on 250 fishing days per year and yet most fishermen go fishing virtually all the year round. It can therefore, be assumed that the above estimated MSY is lower than the true MSY. The annual catches could be of the order of 4000 to 5000 m.t.. Current estimates of the UFD put annual yield at 5000 m.t. annually.

1.5. Other areas Requiring Intervention

1.5.1. Pollution and Eutrophication

Lake George is adjacent to major mining activities of cobalt and copper. Kilembe mines has been dumping waste which contains cobalt sulphide and heavy metals such as cadmium, copper, lead and zinc near Nyamwamba river. There is visible damage to vegetation along the channel carrying water from these deposits towards the lake. Copper and cobalt contamination extends to the lake and has been detected in aquatic macrophytes, algae, sediments and other organisms in the lake (Bugenyi 1984). Soil erosion from agricultural activities on the steep hills can cause siltation in the lake. Spraying of agricultural crops, especially insecticides used on cotton gardens can also drain into the lake. Pollution from these sources if not controlled can be a threat to fish and other aquatic organisms and can render the fish unsuitable for human consumption. There is need to integrate management of activities in the catchment area with management of the lake.

An estimated 3000 hippopotami live around the lake shores. These hippopotami spend most of their time in the water but feed in grasslands around the lake. Each hippopotamus eats about 30 kg of grass a day and deposits its dung in the water. This transfers considerable quantities of organic matter from the land to the lake. Although this fertilizes the lake and enhances growth of algae, excess production of algae (scientifically known as eutrophication) can have negative effects on production processes in the lake. Movement of a large number of wild animals also causes soil erosion of the marginal areas of the lake.

1.5.2. Post harvest processes of fish

Harvest of fuel wood from the national park for smoking fish is not permitted. Firewood used for smoking at the landings is however collected from the park. It is therefore necessary to minimise the amount of wood that can be used for this purpose. Fish processing methods that consume less fuel wood have been developed and are being promoted by the QENP-FVCP.

1.5.3. Socio-economic causes of practises that threaten sustainability of the resources

A number of socio-economic factors affecting both the fisherfolk and the fisheries extension workers also affects the fishery resources. Retrenchment and decentralisation have resulted into reduction . . fisheries field staff to the extent that there are inadequate staff to manage the resources. Fishermen are thought to have been forced to buy and use undersized nets due to shortage in supply of the suitable nets. There is now ready supply of the nets and fishermen should be encourage to buy and use the right sizes of nets. Poor renumeration of fisheries staff may also have promoted bribery leading to ploriferation in the number of poachers. In some cases the local councils members, fisheries staff, landing committees, police, local defence units (LDUs), Park Authorities, and other community leaders may themselves be involved in fishing mulpractices. In addition, poachers may also be armed making it difficult to effect control measures.

1.5.4. Development of mechanisms of involving user communities in development and management of the fisheries

Enforcement of restrictive regulations by government has not been successful in management of fishery resources not only on Lake George but also other lakes in Uganda. There is need to sensitise and develop a dialogue with the fishing communities as owners and users of the resources by encouraging them to sustainably exploit the resources. There have been attempts to create community based rehabilitation committees to assist in law enforcement on the lake but these have not been effective as they have not taken care of the interests of all fishermen including poachers.

1.5.5. Coordination of management of the Lake between the Districts.

The fisheries of the lake were previously managed directly by UFD. The delivery of extension services has since 1993 been decentralised to the Districts. Lake George is shared between three districts (Kasese, Bushenyi and Kabarole) each of which has a management role on the lake. The Government policy of decentralisation of power to the Districts has complicated management of the fisheries. There is need to develop a mechanism of coordinating management of the fisheries by the Districts which are sharing Lake George. It may be necessary to re-centralise fisheries services as is the case with forestry.

Law enforcement on Lake George is still a centralised activity and Fisheries Department has posted a Law Enforcement Officer at Kichwamba. This officer lacks basic logistics especially funds. Since the revenue from the lake is collected by the Districts, it will be necessary that the Districts contribute to financing law enforcement on the lake.

1.5.6 Linkages between management of QENP and the Ramsar site with that of the lake.

Three quarters of the shoreline of Lake George lies within QENP. The waters and the fisheries resources of the lake are not under the jurisdiction of the park authorities but are managed by the Uganda Fisheries Department. Under the present Uganda National Parks legislations, the park boundary and the jurisdiction of the Park Authorities stops at the water edge. Exploitation of the resources of the lake is outside the jurisdiction of the UWA. The National Wetland Management Program has suggested (Wilson, 1995) that all waters of Lake George could be considered as part of the Ramsar Site. Since the fisheries of the lake are managed by a different authority, the issue of including the entire lake in the Ramsar Site needs to be agreed upon by all interested parties. The issue of management of the Lake George Fishery in relation to management of the QENP and the Ramsar Site also needs to be harmonised.

1.5.7. Development of Aquaculture

As the human population increases the need to increase supply of fish will increase. There is need to promote aquaculture in the districts around the lake especially Kasese District.

1.5.8. Water hyacinth

The water hyacinth has infested the three largest lakes in Uganda (Victoria, Kyoga and Albert) and has already spread to the southern region of Lake Albert from where it can find its way into Lake George. People in the region should be sensitised about the dangers of this weed and fishermen should specifically be requested not to move nets from infested lakes to Lake George. Surveillance should be carried out to ensure that the weed does not spread or establish itself in Lake George.

1.5.9. Database on available information on Lake George

There is need to create a data base of available information on Lake George and its catchment area so that it is readily available to end users.

1.5.10. Fisheries legislation

The fishing legislation and its implementation both on Lake George and other lakes in Uganda needs to be addressed especially in relation to the changes in fish stocks and the current government policy of decentralisation of services to the Districts.

h). Assess pollution and eutrophication of the lake

i). Protect the lake from water hyacinth

j). Develop aquaculture to enhance fish production

i). Develop wood saving fish processing methods

k). Investigate socio-economic causes of unsustainable fishing practices

l). Compile available information of the lake and make it available to end-users

m). Find out if the current fisheries legislation is applicable to the current situation in Lake George or if there is need to change the current legislation

SECTION II

2.0. THE FIELD SURVEY

2.1. Justification and objectives

A rapid assessment of the fish stocks and fisheries of Lake George was carried out between January and April 1997. The purpose of this survey was to assess the current state and provide information that can be used for further development and management of the fishery, and identify areas that need further intervention. The terms of reference for the study are given in annex I to this report.

Given the very short period provided for the study, only few of the issues could be investigated in detail. These included: What fish were present in the lake. Whether there were resources in the lake that were not being exploited and that could be exploited to boost production. The impact of different fishing gears and methods used on the lake. What impact the commercial fishery was having on the stocks. The fishing pressure exerted on the lake and what effort should be allowed.

This information was obtained by:

a). Determining the composition, relative abundance and size structure of the fish species that were being harvested by the commercial fishery;

b). Determining the distribution of fishing effort;

c). Determining the composition and relative abundance of fish species in the lake to find other species that may be abundant in the lake and could be harvested to increase fish catches;

d). Determining the size at which the major fish species should be harvested;

e). Determining the diversity and distribution of fish species in the lake to recommend areas where certain species could be protected to conserve fish species diversity;

f). Determining fishing gear selectivity for different species to establish the impact of different gear types and sizes on different fish species so as to recommend suitable fishing gears and methods for harvesting individual fish species;

g). Examining the existing fisheries management legislations to see whether they were still applicable to the situation prevailing in Lake George.

h). Suggesting other areas that needed further intervention to improve sustainable utilisation of the fisheries of Lake George.

2.2. Methodology

The commercial fishery was examined to determine the types and sizes of fish caught by commercial fishermen, the fishing effort, and the sizes and numbers of fishing gears and crafts used. This was achieved by estimating the composition, population structure, weight of each type of fish, the number and lengths of canoes, the number of fishermen per canoe, the number, mesh sizes and ply of gill nets, the sizes of hooks used and the method of fishing. Fishery yield from the lake was then estimated from the number of canoes, fishing gears and quantities of fish landed per canoe per fishing night. It should be noted that there are only six gazetted and recognised fish landings on the lake.

Experimental fishing was carried out to determine the types, sizes, relative abundance, diversity and distribution of the fish in the lake, fishing gear selectivity, and biological information especially the size at first maturity, length-weight relationships, fecundity and food of the dominant and major commercial species. Experimental fishing was focused on gill nets and hooks which were the main fishing gears used on the lake. The gill nets of 25.4 mm (1") to 152.4 mm (6") and hooks of sizes No. 4 to No. 10 and No. 12 were set to evaluate their selectivity and effects on different fish species in the lake. The gill nets were set in selected locations at inshore and offshore areas to verify spatial separation suggested by Gwahaba (1973). The weight and length of different types of fish caught were recorded. Biometric data of a representative sample of individual species were recorded. Ripe ovaries and stomachs of some species were preserved for fecundity and food estimations. Egg counts and stomach analyses were carried out in the laboratory on preserved samples.

2.3. Results

2.3.1. Commercial catch composition

The relative importance of the different fish species in commercial fishery is illustrated in Figure 6. In the gill net fishery, *O. niloticus, O. leucostictus, P. aethiopicus, C. gariepinus* and *B. docmac* were the dominant fish species while the hook fishery, was dominated by *P. aethiopicus*, *C. gariepinus* and *B. docmac*. A few specimens of *Tilapia zillii, Barbus altianalis* and *Labeo forskalii* were encountered among commercial catches. This was the first time that *T. zillii* and *L. forskalii* were reported in Lake George. *T. zillii* has been widely used in aquaculture throughout Uganda. It could have invaded the lake from aquaculture facilities in the Lake Edward-George basin. *L. forkalii* occurs in such small numbers that it might have not been caught in previous surveys. *O. leucostictus* was not previously exploited and its prominence in commercial catches has increased due to use of small mesh size gill nets of 3 to 3.5 inches. It should also be noted that the other landings, notably Kayinja Kashaka and Mahyoro which were not sampled during this trip also land *B. docmac* and *P. aethiopicus*. The above information may therefore be biased against these species.

The length-frequency distribution of *O. niloticus, O. leucostictus, P. aethiopicus* and *B. docmac* are illustrated in Figures 7 and 8. The size range of these species among commercial catches was: 19 cm to 39 cm total length (TL) for *O. niloticus*, 18 cm to 29 cm (TL) for *O. leucostictus*, 50 cm to 144 cm (TL) for *P. aethiopicus*, and 18 cm to 64 cm fork length (FL) for *B. docmac*. The average weight of fish landed was 350 gm for *O. niloticus*, 230 gms for *O. leucostictus* and 2000g for *P. aethiopicus*. Hence, the weight of *O. niloticus* has decreased from an average of 600 gm recorded during 1960s to 1970s to 350 gm currently.

2.3.2. Distribution of Fishing Effort

There are 6 gazetted fish landings on Lake George. Three of these (Kahendero, Hamukungu and Kasenyi) are within the Queen Elizabeth National Park in Kasese District, two (Mahyoro and Kayinja) are within Kabarole District while the sixth (Kashaka) is located in Kyambura Game Reserve in Bushenyi District.

A physical count of the number of canoes was made at each of the gazetted landings and compared with estimates made by the QENP-FVCP. The number of licensed and unlicensed canoes by landing and District are given in Table 3. There were at least 547 fishing canoes operating on the lake. This number is much higher than the 144 canoes which are supposed to legally operate on the lake.

The fishermen at the different landings used either flat bottomed or Ssese type planked canoes. The size of the canoes at different landings is given in Table 4. The size range of canoes on the lake was 4.7 to 6.8 m but varied slightly between the landings. Generally the Kabarole landings of Mahyoro and Kayinja had slightly bigger canoes than the Kasese landings of Kahendero, Hamukungu and Kasenyi. All the fishing canoes are propelled manually by two fishermen.

2.3.3. Fishing Gears and Methods

The main fishing methods on the lake were gill netting and long lining. The gill nets were operated either actively or passively. Some fishermen were, however observed seining in shallow waters using gill nets during the day. According to the data from Kahendero, Hamukungu and Kasenyi 87% of the canoes were gill netters while 13% were long liners. Of the gill netting canoes, 75% were practising active fishing while 25% were fishing passively. Active fishing is illegal on all water bodies in Uganda and prevalence of this fishing method on Lake George should be addressed.

The distribution of different gill net mesh sizes in the commercial fishery is illustrated in Figure 9. The sizes of nets used on the lake ranged from 3 to 6 inches but the 4.5 inch mesh size was the most popular. Only gill nets of 5 inches and above are permitted by law to operate on Lake George. The fact that most fishermen had shifted to smaller illegal mesh sizes suggests that the fishery might have changed. This issue needs to be addressed.

The number of different sizes of nets per canoe for the passive and active gill net fishery are given in Tables 5a and 5b respectively. In the passive fishery (Table 5a), the number of nets per canoe varied by up to 60 nets per canoe. In the active gill net fishery, fishermen only used 2 to 4 nets of 4.5 inches and below. The most popular mesh size of gill net in the fishery was 4 inches. Each canoe fishing on the lake is legally supposed to operate only 10 nets set passively and active fishing is not allowed on Uganda waters. These issues too need to be addressed.

The hooks encountered on the lake were of sizes 5, 8 and 9. Of these, 57.1% were of Size 8, 28.7% of Size 9 and 14.3% of Size 5. The number of hooks per boat varied from 150 to 2000. Only hooks of size 7 and 8 are supposed to be used on the lake. The number of hooks allowed on the lake is 100 hooks per canoe. This again shows that the situation in the lake might have changed.

2.3.4. Yield estimates

The yield was estimated from the total number of canoes on the lake; the proportion of canoes that fished actively; the proportion of canoes that fished passively; and the proportion of canoes that operated hooks. Gill net fishermen went fishing almost daily. It was assumed that fishermen who operated gill nets went fishing (on average) six days a week ie 312 days a year. The fishermen who went long lining went out less frequently and in some cases spent two days on the lake before returning to the landing. It was assumed that fishermen who operated long lines returned to the landing on average four times a week.

In the gill net fishery, the catch rates per canoe for active fishing was 41.9 kg/canoe/night compared to passive fishing which was 36.3 kg/canoe/night. The catch rate per net for the active fishing was 14.3 kg/net/night compared to only 0.7 kg/net/night for the passive fishing.

The catch rates for gill nets of different mesh sizes operated passively and actively are given in Tables 6a and 6b. Fishermen who operated nets passively used nets of 3.5 to 6 inches while those who operated nets actively used nets of 3 to 4.5 inches. Catch rates were higher for the active than passive gill netting irrespective of the size of net. The high catch rate (kg/net) observed from the 6 inch mesh size nets fished passively Table 6a was due to the large size *B. docmac* which are occasionally caught by big meshes fished passively. Besides, use of large meshes on the lake is not common and only one canoe was sampled using the 6" mesh size net. This observation therefore is not a true reflection of the catch rates compared to the other meshes but just a lucky fishing trip and occasional fertile fishing ground for the species. The high catch rates observed in active fishing were due to the factor that fish is forced into the nets by beating of the water and the fishing is done several times during the fishing operation thus increasing the catches compared to the nets fished passively. In Lake George the reduction of gill net mesh size down to 3" in the commercial fishery has brought *O.leucostictus* in the catches. The species was previously un exploited due to the larger meshes in use then and the species' smaller size at maturity compared to that of *O.niloticus*. The mature *O.leucostictus* is caught most efficiently in commercial fishery in the 3" to 3.5" mesh sizes compared to the larger meshes (Table 7a and 7b). The high catch rates (kg/net) observed in the 3" and 3.5" are due to the abundant *O.leucostictus* which is most efficiently cropped by the two meshes.

The average catch rate for the long line fishery was 53.1 kg per canoe per fishing trip. The estimated catch rate per hook per trip was 0.2 kg.

Of the estimated number of canoes on the lake (547), 71 were long-lining for 208 days a year, 119 were passively gill netting and 357 were actively gill netting for 312 days a year. Using the catch rates per canoe per fishing trip, the annual fish catch from the lake was estimated as 6,800 metric tonnes. Previous estimates by the Uganda Fisheries Department have put the catch estimates from the lake at about 5000 metric tonnes from estimates based on 144 fishing boats and 250 fishing days per year.

2.3.5. Results of Experimental sampling

2.3.5.1. Composition and relative abundance

The composition and relative abundance of different types of fishes among experimental catches by fresh weight and number caught is given in Tables 7a-e and is illustrated in Fig. 10. Haplochromine were the most abundant fish in the lake by weight followed by *O. leucostictus, O. niloticus, P. aethiopicus, C. gariepinus, B. docmac, T. zillii, B. altianalis* and *Petrocephalus catastomi*. However, the number of fish caught, varied with the mesh size of gill net. Haplochromines were mainly caught in gill nets of less than 2.5 inches, *O. leucostictus* in nets up to 4 inches, while *O. niloticus, P. aethiopicus, B. docmac* and *C. gariepinus* occurred in gill nets of mesh sizes up to 6 inches. About 15 species of haplochromines were encountered. Of these only four species: *Enterochromis nigripinnis, Astatotilapia aeneocolor, Gaurochromis angustifrons* and *Harpagochromis squamipinnis* were abundant and contributed over 95% by weight to the haplochromine caught.

Overall, seven fish species namely: *O. leucostictus, O. niloticus, P. aethiopicus, C. gariepinus, B. docmac, E. nigripinnis,* and *H.squamipinnis* are abundant in the lake and could be considered for exploitation.

2.3.5.2. The overall length-frequency distribution for dominant species

The size distribution of *O. niloticus, O. leucostictus, P. aethiopicus. H. squamipinnis* and *E. nigripinnis* is illustrated in Figures 11, 12, 13 and 14. The size range of these species among experimental catches was: 6 cm to 32 cm total length for *O. niloticus*, 5 cm to 25 cm for *O. leucostictus* and 20 cm to 139 cm for *P. aethiopicus*, 8 to 25 cm for *H. squamipinnis* and 6 to 12 cm for *E. nigripinnis*. This clearly showed that there was a big size range of the fish in the lake. These would require a wide size range of gill nets to exploit them. It is clear that since different gill net mesh sizes were used during experimental fishing various age groups (cohorts) were caught as exemplified by various peaks. For example there were three distinct age groups for *O. niloticus,* four for *O. leucostictus* and three for *H. squamipinnis* Figures 11 and 13. This was due to gear selectivity and spartial distribution of the species. There is essentially a single peak for *P. aethiopicus* (Fig. 12) and *E. nigripinnis* (Fig 14) as the former, samples were mainly from hook catches where the majority of the fish were above the size at first maturity while in *E. nigripinnis* the catches were almost exclusively from 1 inch mesh size nets and were all mature. However, the sizes of nets used to catch the smaller species especially among the haplochromines do catch juveniles of large species if operated in inshore waters less than 100 metres from the shoreline and this would be destructive to the fishery of the larger species.

2.3.5.3. Distribution and fish species diversity

Gwahaba (1972) observed that juveniles of the tilapiine species, *O. niloticus* and *O. leucostictus* were mainly found within 100 m from the shore. This area was therefore important for survival of these species. Experimental fishing during this study confirmed that *O. niloticus* and *O. leucostictus* of less 9 cm were mainly confined to shallow inshore areas less than 100 m from the shore (Figs. 15). The highest diversity of haplochromine species was also within 100 m from the shore. Ten of the haplochromine species were found inshore and only eight occurred offshore. Among the haplochromine species, *Astatotilapia aeneocolor* and *Astatotilapia elegans* were mainly confined to within 100 m from the shoreline while *E. nigripinnis*, was confined to waters beyond 100 m from the shore.

2.3.5.4. The size at first maturity of the dominant fish species

In fisheries management, the size of fish that should be exploited is normally set at the size at first maturity ie. the size at which 50% of individuals of a particular species are mature. The logic behind this is that it allows at least 50% of mature individuals in the population to be available to reproduce and sustain the population. The size at which fish should be harvested can, however be fixed at a different level. What is important is that adequate stocks of the species should be available in the population to reproduce and sustain the stocks.

The summary for the size at first maturity of the dominant fish species is shown in Table 8. The sizes at first maturity was 20 cm for *O. niloticus*, 15 cm for *O. leucostictus*, 55 - 59 cm for *P. aethiopicus*, 35-39 cm for *B. docmac*, 9 cm for *H. squamipinnis* and virtually all *E. nigripinnis* samples in this study were mature. The size at first maturity of *O. niloticus* has not changed since the 1967-72 survey.

2.3.5.5 Reproductive potential (fecundity) of the tilapiines

The reproductive potential, ie the capacity of a fish species to reproduce and perpetuate its population can be obtained from examination of its fecundity. Cichlids in general have low fecundity. For instance, *O. leucostictus* produces between 56 and 498 eggs depending on the fish size (Lowe McConnell, 1975) as compared to more prolific species like *P. aethiopicus* which produces 1700 to 2300 eggs and Nile perch which can produce up to 18 million eggs at each breeding. This means that although cichlids guard their eggs many more females are needed to sustain a high population and it would be worthwhile to consider this when fixing the size at which the species should be harvested. Egg counts from Lake George cichlids confirmed that they indeed produce few eggs. Five *O.leucostictus* specimen of 19 cm to 23.5 cm Total length gave a fecundity of 230 eggs to 718 eggs and one *O.niloticus* of 21.2cm TL had 365 eggs. This suggests that the size at which this species is harvested should be set at a level where there should be enough females to sustain the population.

2.3.5.6 The food of the major commercial species

The high fish productivity of Lake George is sustained by the capacity of the abundant commercial species to feed on plant material (the phytoplankton) which is produced in the lake and convert it into fish. Examination of the food of *O. niloticus* shows that phytoplankton and detritus still formed its main food. The phytoplankton were dominated by the blue-green algae mainly *Microcystis, Lyngbya & Merismopedia* spp. The diatoms were the next in importance followed by the green algae. Diatoms consisted of *Surirella, Navicula and Nitzchia* spp while the green algae were dominated by *Rhophidium,* filamentous algae *Cosmorium* and *Scenedesmus* spp. Other items identified included higher plant remains, rotifers and insect remains. Fish remains were identified in *P. aethiopicus, C.gariepinnus and B.docmac* stomach contents. In addition, haplochromines were seen in *B.docmac* stomach contents.

2.3.5.7. Impact of fishing gears and methods on the fishery

Gill net selectivity was determined for *O. niloticus* and *O. leucostictus* which were the main species caught in the commercial gill net fishery and for *H.squamipinnis and E.nigripinnis* which because of their dominance and spatial separation from juveniles of larger species could be exploited using gill nets. Gill net selectivity characteristics for these species is illustrated in Figures 16, 17, 18 and 19 for *O.niloticus, O.leucostictus, H. squamipinnis* and *E. nigripinnis* respectively. For *O. niloticus* gill nets of less than 3 inches caught large proportions of immature fish, those of 3 and 3.5 inches caught some of both mature and immature *O. niloticus* while those of 4 inches and above caught only mature *O. niloticus*. For *O. leucostictus* gill nets of less than 2.5 caught large proportions of immature fish while those of 3 inches and above caught mainly mature *O. leucostictus. E. nigripinis* were caught only in nets of 1 and 1.5 inches and virtually all *E. nigripinnis* caught in these nets were mature. The tilapiine catches in gill net mesh sizes larger than 4 inches fished passively were very low in experimental trials.

Selectivity of the hooks was examined mainly for *P. aethiopicus* which is the main species in the hook fishery. Selectivity of different sizes of hooks for *P. aethiopicus* is given in Table 9. Hooks smaller than size 9 caught some immature *P. aethiopicus* while those of sizes 8 and below caught bigger and mature *P. aethiopicus.*

2.4. The Relationship between Biological and Fishery Parameters for Major Commercial Fish Species

The relationship between length and weight of an exploited fish species, the size at first maturity for the species and the size of fish caught in gill nets of different mesh sizes provide guidance on the impact of harvesting using different fishing gears on the fishery. The relationship between the length and weight for the three major commercial species of Lake George (Nile tilapia, Bambala and Mamba) and the size at which the species should be harvested; the size of fish that is caught by gill nets of different mesh sizes; and the size of fish occurring among commercial catches are given in Figures 20, 21 and 22 for Nile tilapia, Bambala and Mamba respectively.

2.4.1. Nile tilapia (*Oreochromis niloticus*)

The relationship between the length (L) and weight (W) of Nile tilapia (Figure 20) is described by the equation:

$$W = 0.015L^{3.09}$$

The size at first maturity of Nile tilapia is 20 cm. Only nets of 3.5 inches and below catch Nile tilapia which have not reached the size at first maturity. This suggests that nets of 4 inches and above could be used to harvest Nile tilapia in Lake George. Most of the fish recorded in commercial catches were above the size at first maturity. The above observation suggests that the current fishery does not exploit Nile tilapia smaller than the size at first maturity. However when the pressure on the Nile tilapia and its reproductive potential is considered, it may be necessary to set the size at which Nile tilapia should be harvested above 50% maturity eg. at 100% maturity. This would reduce the risk of catching any immature fish. All Nile tilapia are mature at 24 cm. This means that only nets of 4.5 inches and above do not catch any immature Nile tilapia.

2.4.2. Bambala (*Oreochromis leucostictus*)

The relationship between the length (L) and weight (W) of Bambala (Figure 21) is described by the equation:

$$W = 0.0138L^{3.13}$$

The size at first maturity of Bambala is 15 cm. Nets of 3 inches and below catch some Bambala below the size at first maturity. This suggests that only nets of 3.5 inches and above could be used to harvest Bambala in Lake George. Most of the Bambala recorded in commercial catches were above the size at first maturity. However, as in the case of Nile tilapia, it may be necessary to set the size at which Bambala is harvested above 50% maturity eg. at 100% maturity to avoid catching any immature Bambala. All Bambala are mature at 21 cm. This means that only nets of 4 inches and above would have to be used if we have to avoid catching any immature Bambala.

2.4.3. Mamba(*Protopterus aethiopicus*)

The size at first maturity of Mamba in Lake George is between 50 - 60 cm. and all Mamba of more than 80 cm total length are mature. Mamba is mainly harvested using hooks. Only hooks of Size 10 and below catch some of the Mamba below the size at first maturity. However, some Mamba below the size at first maturity do occur among commercial fishery especially when small hook sizes are used (Table 9) suggesting that the commercial hook fishery may do some harm to the Mamba fishery in the lake by catching immature individuals.

2.5. Discussions and recommendations from the field survey

2.5.1. The current state of the fish stocks

The current estimate of yield is in the range that was estimated for the lake during the 1950s and 1960s. This gives the impression that the lake still has the capacity to sustain fishery productions.

The most abundant species, *E. nigripinnis* remains commercially unexploited. A detailed survey carried out by Gwahaba (1972) and confirmed by this study shows that *E. nigripinnis* is the most abundant fish species in Lake George. The species is most abundant in the open offshore waters, thus being partially segregated from other similar sized fish species which occur in areas 100 metres or less from the shoreline. It could be exploited using a mesh size of gill net as the immature individuals of larger species equivalent to the size of *E.nigripinnis* do not occur in the offshore waters beyond 100 metres from the shoreline. Its exploi.. ion would therefore not harm juveniles of the tilapiines as the size of the tilapiines that would be retained by the gill net mesh size used for *E. nigripinnis* are confined to shallow inshore waters.

The highest fish species diversity were found within 100 m of the shoreline. Juvenile of the larger species especially the tilapiines are also found within this area. There is need to protect this area especially from human interference using small mesh gill nets and habitat degradation.

Catch statistic are vital in monitoring of fisheries resources. However, since decentralisation of government services to the Districts, there has been no effective system of collection of fisheries statistics. There were no officials collecting fisheries statistics at virtually all the landings visited during this survey. The only officials seen at the landings were those collecting landing / market dues from fishermen. Collection of fisheries statistics at the landings on the lake should be reactivated.

2.5.2. Fishing effort

The level of fishing effort on the lake was much higher than that permitted by law. For instance, there were over 500 canoes operating on the lake yet only 144 are supposed to operate; there were up to 60 nets per canoe and yet only 10 are supposed to be used. Some canoes operated as many as 2000 hooks and yet only 100 are allowed. Gill nets of mesh sizes smaller than the legal 5 inch stretched mesh were widely used on the lake. However, analysis of historical information showed that illegal canoes have operated on the lake from the time that restrictions were imposed on the lake. It was not possible to get the information upon which the original restrictions of fishing effort were based. However, as stated earlier, it appears to have been aimed at limiting the number of people operating within the park. The lake has sustained high fish production for a long time in the presence of many illegal canoes operating a higher number of fishing gears than is permitted. This indicates that the lake has the capacity to withstand higher fishing effort than previously set. The number of canoes, nets and hooks to be allowed on the lake could therefore be increased. However, it is not possible to say exactly how many in the absence of detailed research information.

2.5.3. Fishing gears and methods

The size of gill nets and hooks used on the lake was also smaller than the minimum mesh size of 5 inches permitted by law. Based on the results of this survey, a minimum mesh size of 4.5 inch mesh size gill nets would be most suitable for exploiting the Nile tilapia and a minimum hook Size 9 would be most suitable for exploiting *P. aethiopicus*.

Active fishing was rampant on the lake despite the fact that it is illegal on all Ugandan waters. This method increases the fishing effort as the nets are fished several times during the fishing period. Besides, this method of fishing threatens the tilapiines and can force brooding females to spit the young which are usually protected in their mouths. Efforts should be made to enforce the law regarding active fishing.

2.5.4. Fisheries legislation

In view of the above observation, it is clear that the current law on management of fisheries is, in some cases, no longer applicable to the current situation on Lake George. There is need to revise the fisheries legislation to address the current situation.

2.5.5. Summary of key issues arising out of the field survey

It was concluded that:

a). Fish production on the lake could be increased through exploitation of *E. nigripinnis*;

b). There was need to adjust the fishing effort and the mesh size of gill nets and hooks used on the lake

d). The fisheries legislation was no longer applicable to the situation on Lake George and there was need to revise it

e). The current results results of this short study were, in many respects preliminary and more research especially on the magnitude of fish stocks and on suitable fishing effort for the lake should be carried out

SECTION III

3.0. THE STAKEHOLDER WORKSHOP

3.1. Introduction

A workshop of representatives of stakeholders of Lake George was held on 7th May 1997 in Kasese to discuss the fishery survey report. It was attended by fishermen's representatives from all fish landings on the lake, District Fisheries Officers (DFO) of the three districts bordering the lake, researchers from FIRI and the Institute of Ecology, representatives of the Commissioner for Fisheries, the Director FIRI, The Director Uganda Wildlife Authority, Lake George Environmental Economic Study Team and Officials from CARE. The list of participants is given in Appe x 3.2.

The Project Manager of the QENP-FVCP gave an overview of the history and activities of the QENP-FVCP and the questions the project had been addressing.

Lake George has one of the most productive fisheries per unit area of water and these fisheries have been exploited for human benefits for a long time. Three out of six fishing villages on the lake are located within the QENP and the livelihood of the people within these villages depends wholly on the fisheries of the lake. There are however fears that the major commercial fish stocks of this lake are declining. This would put the livelihood of the communities in jeopardy and put the park resource in danger of encroachment by these communities. The QENP-FVCP has been promoting practices for sustainability of resources of the fishing communities especially within the QENP so as to reduce potential uptake of these communities from the park. FIRI was requested to carry out an assessment of the fish stocks of Lake George so as to provide information that the project can use to fulfil its objectives. The workshop was convened to review a draft report of the fishery survey conducted by FIRI on the status of the fish stocks and fisheries of Lake George to enable the stakeholders to give their input before the final report was prepared. The Project Manager emphasised the fact that this should be a participatory workshop and that everyone was to contribute effectively so that the recommendations belong to everyone.

The workshop process was as follows: after the researchers presentation, the participants gave their comments and concerns. The participants then formed groups to discuss the issues raised by the researchers. A synthesised list of concerns and action was then compiled during a plenary. The discussion groups were divided into: Resources Users; Resource Managers, Policy Makers and Extension Workers; Researchers; and Representatives of Donor Agencies and NGOs. The detailed workshop programme is given in Appendix 3.3.

The researchers informed the participants that the study was a rapid assessment of the status of the fishery to provide guidelines against which future actions would be based. Two articles from the New Vision: "*Kasese Fish In Danger*" and "*Uganda Fisheries in Danger*" (Appendices 3.4 & 3.5) were shown. These emphasised the fact that the lake and its resources were in danger. The researchers noted that it was the lives of the people who depend on the fisheries of the lake that were in danger. Action was therefore required to safeguard the livelihood of these people.

The presentation covered the issues raised in the literature review report and the field study as outlined in Sections 1.6 and 2.5 of this report.

3.2. Reactions of the Participants

Fisheries managers noted that one of the problems facing Lake George was that it was difficult to enforce an impossible law - a law which was no longer applicable to the situation pertaining in the lake. The fact that fishermen have been using smaller mesh size gill nets of less than the 5 inch mesh not permitted by law indicated that there was something wrong with the present law. This was confirmed by the survey which indicated that the situation in the lake had changed and there was need to revise the law on management of the Lake George Fisheries. The current data especially on the actual harvestable biomass was however considered inadequate to justify change in the law and particip:, s requested that more research be done. The participants were informed that the government was in the process of revising the Fish and Crocodiles Act and this was to include the Lake George fishery.

It was recognised that communication between political leaders, administrators and Fisheries Department officials needed to be strengthened so that all groups work together to sustainably manage the resource other than appearing to be antagonistic to each other. It was suggested that a Lake George Management Committee should be formed to coordinate management efforts on the lake. This committee could include the LC5 Chairmen of the Districts sharing the lake along with the respective the Chief Administrative Officers (CAOs), DFOs, representatives of fishing communities etc.

Resource management had previously been approached using laws and regulation but people do not like laws. It was necessary to try out change in policy as a pre-requisite for behavioral change. There was need to explore economic instruments eg. incentives to the people on top of the regulations. Resource users were critical in management of the resource. These have groupings and these groupings should be explored and promoted as organs for managing the resources.

Another problem facing fisheries management on Lake George was inadequate funds for law enforcement on the lake. It was suggested that since the Districts collect revenue from the lake, they should contribute towards facilitation of law enforcement. The Lake George Management Committee could, if formed also solicit for funds from donors.

There was need to develop mechanisms to change the attitudes of people so that other species such as *E. nigripinnis* could be exploited and consumed. This would require socio-economic studies and sensitisation of the communities.

It was emphasised that the lake should be looked at not only in terms of fisheries but the entire ecosystem of the watershed. Half of the fish landings on Lake George are within the QENP. The running of these communities and their sustainability is very important to the park. There was need to look at the fisheries harvest not in isolation but in terms of all human needs. For instance, would people need more firewood for smoking the fish? How would this impact the park?. Dry wood was valuable to the integrity of the ecosystem of the park. For instance, termites feed on them and in the process recycles the nutrients. The participants were informed that the hippo population in the park had decreased from the 3000 recorded in 1960s and were only 1200 by 1996. This had reduced their threat to the lake. It was not clear why the wetlands were declared a Ramsar site when they were already protected within the QENP.

It was noted that high rates of human population growth was increasing the pressure on the resources of the lake. Any measure to manage the lake should include control in human population increase. There was need for family planning strategies among the fishing communities and to control immigration into the fishing settlements.

The participants were assured that researchers were at the disposal of all the clients of the fisheries sub-sector (fishing communities, consumers, NGOs such as CARE, policy makers etc). The researchers were available to carry out the work as long as funding was available. The clients were encouraged to keep in touch with the researchers and make them aware of the problems requiring research.

3.3. Discussion Groups and the Synthesised Summary of Interventions

The participants were then divided into groups to discuss the issues listed in the first column of the matrix below. The synthesised list of interventions are given in corresponding columns.

Main Issue	Intervention
Adjustment of fishing effort on the lake	Although some participants felt that there should be no changes, it was generally recommended that the number of canoes could be increased to approximately 300, number of nets could be doubled from 10 to 20, the number of hooks from 100 to 200. There was, however, need to verify the allowable catch and the number of canoes, gill nets, hooks etc.
Fishing Gears and Methods on the lake	On the size of gill nets, it was agreed that the minimum mesh size of gill net used should be reduced from 5 inches to 4.5 inches stretched mesh and the minimum size of hook should be Size 9. On the method of fishing it was recommended that active gill netting should be discouraged.
Harvesting *Enterochromis nigripinnis*	Though the fish may be exploited, there were fears that immature individuals of the larger species may be destroyed by the one inch mesh size gill net that is suitable for harvesting this species. The scientists, however assured the participants that the species was spatially segregated from juvenile of larger species. It was recommended that harvesting of this species could start but under restricted entry.

Main Issue	Intervention
Conservation of aquatic biodiversity	There should be a full inventory of fish species diversity in the lake and efforts made to conserve endangered and rare fish species
Aquaculture development	Aquaculture should be developed in the Districts around the lake especially Kasese to reduce pressure on the lake by improving fry production and supply through rehabilitation of existing fry centres and constructing new ones. Fish farming especially of trout in cold mountainous areas should be investigated. Community based extension agents should be trained.
Pollution and eutrophication	The levels of especially heavy metals such as copper and cobalt from Kilembe mines along with levels of other pollutants such as agrochemicals, sedimentation and siltation should be assessed both in the environment and in the tissues of fish and appropriate actions taken.
Water hyacinth scare	Monitoring, surveillance, vigilance and sensitization of the people on the weed problem should be carried out around the lake. Efforts should be made not to transfer nets from infested lakes into Lake George.
Human population growth	It was recognised that high rates of human population growth put pressure on the lake's resources at its catchment areas. Efforts towards family planning education should be intensified.
Social amenities	Basic social amenities were lacking at the landings and there was need for schools, clinics, latrines to better living conditions of the fishing communities.
The Law on Management of the Fisheries of Lake George	There is need to change the present law in relation to Lake George but adequate scientific data should be availed to support the change.
Information on aquatic resources of the lake	Any available information on the resources of the lake should be packaged and made available to end-users.
Research	More detailed research is needed to elaborate on the key issues, especially biomass of fish available for harvesting, the processes that lead to fish production, pollution and eutrophication (over-fertilisation) of the lake.

Main Issue	Intervention
Communities involvement in the management of the resource	There was need to involve local authorities, chiefs, fishermen etc who are involved in management of the fisheries. The participants suggested setting up a system of formal collaborative integrated management stipulating the roles of different players. There may also be need to give authority to the fishermen to arrest and prosecute defaulters.
Co-ordination among districts	There should be a body to coordinate the management of the lake by the three Districts. This could be termed the Lake George Management Committee. This committee should operate under the overall guidance of the Fisheries Department.
Contribution of the Districts to Logistics of Law Enforcement	The three Districts sharing the lake should contribute logistics to facilitate law enforcement on the lake. The Lake Management Committee should, once formed, solicit for funds from donor agencies for management of the lake.
Interaction between policy makers and law enforcers/field staff	Interaction between policy makers, and law enforcement section should be strengthened
Linkage between UFD, QENP and National Wetland Management Programme	The activities of different institutions especially the Fisheries Department, the Queen Elizabeth National Park and National Wetlands Management Programme which have a stake in the lake need to be harmonised so that each is aware of what the other one is doing.

TABLES

Table 1. The fish species of Lake George. Information on mean biomass (g. m^2), population density (fish ha^1), size range, distribution and food have been included where available (based on: Greenwood 1966, 1973, 1981, Gwahaba 1975). Size is given in total length.

Species	Biomass (g m^2)	Density (fish ha^1)	Maximum size (cm)	Distribution	Food
Enterochromis nigripinnis	6.9	30680	6.8	mainly offshore	suspended phytoplankton
Oreochromis niloticus	2.4	134	45	lake-wide	algae
Gaurochromis angustifrons	1.7	12168	9	mainly offshore	chironomid & chaoborid larvae
Protopterus aethiopicus	1.6	5	130	lake-wide	molluscs & Fish
Clarias lazera (gariepinus)	0.74	7	90	lake-wide	fish
Bagrus docmac	0.4	10	100	lake-wide	fish
Harpagochromis squamipinnis	0.4	187	20.2	mainly offshore	fish & insects
Oreochromis leucostictus	0.4	48	30	lake-wide	algae & detritus
Aplocheilichthys eduardensis	0.2	3568	5	lake-wide	dipteran larvae
Aplocheilichthys pumilus)			5	lake-wide	dipteran larvae
Scubotzia eduardiana	0.1	25	7.9	near shore	plant & dipteran larvae
Astatotilapia alegans	0.05	115	7.3	inshore papyrus	chironomid larvae
Yssichromis pappenheimi	0.05	125	6.1	near shore	zooplankton

Year	Tilapia	Other	Tot.catch	Av. Wt. (kg)
1978	1400	1600	3000	
1979	1734	1560	3294	0.500
1980	1223	1387	2610	
1981	1062	1180	2242	
1982	1011	587	1598	
1983	801	769	1570	
1984	837	839	1676	0.450
1985	809	678	1487	
1986	600	1200	1800	
1987	694	1869	2563	
1988	719	1878	2597	
1989	1016	1771	2787	0.406
1990				
1991	658	1171	1829	0.480
1992				0.440
1993				
1994				0.317
1995				
1996				0.477
1997				0.357

Table 3. The number of canoes at different fish landings on Lake George

Name of landing	District	Physical canoe count	Licensed canoes CARE/Fisheries information	Unlicensed canoes CARE/Fisheries information
Kahendero	Kasese	103	17	50
Hamukungu	Kasese	179	34	60
Kasenyi	Kasese	48	33	7
Mahyoro	Kabarole	113	22	200
Kayinja	Kabarole	31	11	120
Kashaka	Bushenyi	73	28	60
		547	145	497

Table 4. The sizes of fishing canoes at different fish landings on Lake George

Name of landing	No. of boats measured	Size range (m)	Mean total length (m)
Kahendero	19	4.95-6.45	5.67
Hamukungu	28	4.71-6.33	5.57
Kasenyi	17	5.23-6.42	5.71
Mahyoro	27	5.36-6.82	6.20
Kayinja	7	5.48-6.17	5.91
Kashaka	20	5.16-6.60	5.81

Table 5a. The distribution of gill net mesh sizes in the passive fishery

Mesh size (passive)	No. of canoes sampled	Total nets	Average nets per canoe	Percentage in the commercial fishery
3"	0	0	0	0
3.5"	2	15	7.5	2.3
4"	2	29	14.5	4.4
4.5"	8	505	63.1	76.6
5"	2	105	52.5	15.9
6"	1	5	5.0	0.8

Table 5b. The distribution of gill net mesh sizes in the active gill net fishery

Mesh size (Active)	Number of canoes sampled	Total nets	Average nets per canoe	Percentage in the fishery.
3"	6	18	3.0	15.8
3.5"	10	30	3.0	26.3
4"	17	49	2.9	50.0
4.5"	6	17	2.8	14.9
5"	-	-	-	-
6"	-	-	-	-

Table 6a. The catch rates per canoe per net per sampling trip for different gill net mesh sizes operated passively

Mesh size	No. of canoes sampled	Total catch (kg)	Total (nets)	Average catch per canoe (kg)	Average catch per net (kg)
3"	-	-	-	-	-
3.5"	2	24.50	15	12.3	1.63
4"	2	26.78	29	13.4	0.92
4.5"	8	351.60	505	44.0	0.70
5"	2	50.80	105	25.4	0.48
6"	1	18.00	5	18.0	3.60

Table 6b. The catch rates per canoe per net per sampling trip for different gill net mesh sizes operated actively

Mesh size	No. of canoes sampled	Total catch (kg)	Total nets	Average catch per canoe (kg)	Average catch per net (kg)
3"	6	320.6	18	53.4	17.8
3.5"	10	405.9	30	40.6	13.5
4"	17	615.1	49	36.2	12.6
4.5"	6	274.5	17	45.8	16.1
5"	-	-	-	-	-
6"	-	-	-	-	-

Table 7a: The composition (by weight(g)) of fishes caught in different mesh sizes of gill nets on Lake George (Jan. - April 1997). The figures in brackets are percentage contributions to total fresh weight for each mesh size of gill net.

Fish taxa	Mesh size of gill net (inches)										TOTAL
	1	1.5	2	2.5	3	3.5	4	4.5	5	6	
Oreochromis niloticus	2963	5370	4350	5385	20395	18696	15890	8565	5195	925	87734
	(0.55)	(5.43)	(1.33)	(5.85)	(15.52)	(23.47)	(72.89)	(63.63)	(40.36)	(18.78)	
Oreochromis leucostictus	1324	7178	243975	28650	74355	44006	5660				405148
	(0.25)	(7.26)	(74.59)	(31.14)	(56.58)	(52.24)	(25.97)				
Protopterus aethiopicus	75	825	7885	22042	27760	10781		1875	6550		77793
	(0.01)	(0.83)	(2.41)	(23.96)	(21.12)	(13.53)		(13.93)	(50.89)		
Clarias gariepinus	30	1050	5266	4891	2595	1375			1125	4000	20332
	(0.01)	(1.06)	(1.61)	(5.32)	(1.97)	(1.73)			(8.74)	(81.22)	
Bagrus docmac		250	660	770	375	2225		2900			7180
		(0.57)	(0.20)	(0.84)	(0.28)	(2.79)		(21.55)			
Tilapia zillii		85	1755	2140	1715	950	225				6870
		(0.09)	(0.54)	(2.33)	(1.30)	(1.19)	(1.03)				
Marcusenius nigricans	120										120
	(0.02)										
Barbas altianalis			775	80	200						1055
			(0.24)	(0.08)	(0.15)						
Haplochromines	533858	83804	62413	28052	4022	1630	22	120			713921
	(99.16)	(84.76)	(19.08)	(30.49)	(3.06)	(2.05)	(0.10)	(0.89)			
Total	538370	98562	327079	92010	131417	79663	21797	13460	12870	4925	1320153

Table 7b: The composition (by number) of fish caught in different mesh sizes of gill nets from Lake George (Jan. - April 1997). The figure in bracket indicates the percentage contribution of the species to the total number of fish caught in each mesh size of gill net.

	MESH SIZE										TOT
FISH TAXA	1	1.5	2	2.5	3	3.5	4	4.5	5	6	
Oreochromis niloticus	279 (0.58)	228 (5.24)	85 (5.08)	44 (5.62)	100 (11.00)	74 (21.89)	40 (17.02)	17 (80.95)	10 (76.92)	2 (66.7)	879
Oreochromis leucostictus	177 (0.37)	384 (8.82)	525 (31.36)	288 (36.78)	463 (50.94)	216 (63.91)	24 (10.21)				
Protopterus aethiopicus	1 (0.00)	9 (0.21)	29 (1.73)	61 (7.79)	41 (4.51)	18 (5.33)		1 (4.76)	2 (15.38)		162
Clarias gariepinus	1 (0.00)	15 (0.35)	34 (2.03)	21 (2.68)	7 (0.77)	2 (0.59)			1 (7.69)	1 (33.3)	
Bagrus docmac		9 (0.21)	4 (0.24)	4 (0.51)	1 (0.11)	2 (0.59)		2 (9.52)			22
Tilapia zillii		3 (0.07)	25 (1.49)	24 (3.07)	10 (1.1)	10 (2.96)	1 (0.42)				73
Marcusenius nigricans	11 0.02										11
Barbas altianalis			5 (0.30)	1 (0.13)	1 (0.11)						7
Haplochromines	47685 (99.02)	3704 (85.11)	967 (57.77)	340 (43.42)	286 (31.46)	16 (4.73)	170 (72.34)	1 (4.76)			
TOTAL	48154	4352	1674	783	909	338	235	21	13	3	56482

Table 7c. The average number of fish caught in each gill net mesh size of net per night for passively operated nets (data collected from Lake George Jan. - April 1997). The figures in brackets are SE of the mean catch rates. The number (N) is of net nights.

Fish taxa	Catch per net per night									
	1 N=41	1.5 N=41	2 N=40	2.5 N=40	3 N=42	3.5 N=36	4 N=39	4.5 N=37	5 N=36	6 N=33
Oreochromis niloticus	7.00	3.71	1.75	0.68	1.93	1.72	0.77	0.35	0.19	0.06
	(4.71)	(1.94)	(0.59)	(0.22)	(0.31)	(0.35)	(0.17)	(0.10)	(0.07)	(0.04)
Oreochromis leucostictus	2.08	6.12	12.33	5.30	8.64	5.28	0.44			
	(1.77)	(3.45)	(4.15)	(1.25)	(1.94)	(1.37)	(0.20)			
Protopterus aethiopicus	0.03	0.12	0.45	0.65	0.81	0.17		0.03	0.06	
	(0.03)	(0.05)	(0.12)	(0.17)	(0.19)	(0.08)		(0.03)	(0.04)	
Clarias gariepinus	0.03	0.32	0.50	0.30	0.12	0.06			0.03	0.03
	(0.03)	(0.13)	(0.18)	(0.10)	(0.07)	(0.04)			(0.03)	(0.03)
Bagrus docmac		0.10	0.10	0.08	0.02	0.06		0.03		
		(0.06)	(0.06)	(0.04)	(0.02)	(0.04)		(0.03)		
Tilapia zillii		0.07	0.23	0.18	0.10		0.03			
		(0.05)	(0.13)	(0.08)	(0.07)		(0.03)			
Marcusenius nigricans	0.13									
	(0.09)									
Barbas altianalis			0.10	0.03						
			(0.06)	(0.03)						
Haplochromines	907.90	59.02	17.68	6.10	0.62	0.08	0.03	0.03		
	(197.18)	(14.09)	(3.09)	(1.40)	(0.36)	(0.08)	(0.03)	(0.03)		

Tables 7d. Relative abundance by fresh weight and catch rates of haplochromine species in 1 inch mesh size gill nets between inshore and off shore stations

Species	Inshore			Offshore			Overall		
	Tot Wt (g)	% WT	Catch rate g/net	Tot Wt (g)	% Wt	Catch rate g/net	Wt(g)	% WT	Catch rate g/net
Astatotilapia aeneocolor	48180	53.0	4818				48180	27.6	22294.3
Astatotilapia elagans	157	0.17	15.70				157	0.09	7.5
Astatotilapia macropsoides				15	0.01	1.4	15	0.009	0.7
Astatotilapia oregosoma				868	1.03	78.9	868	0.49	41.3
Astatotilapia schubotziella	1229	1.35	122.9				1229	0.70	58.5
Enterochromis nigripinnis	34621	38.08	3462.1	72408	86.38	65882.5	107029	61.26	5096.6
Harpagochromis squamipinnis	1379	1.52	137.9	2134	2.54	194.0	3513	2.01	167.3
Gaurochromis angustifrons	3585	3.95	358.5	7671	9.15	697.4	11256	6.44	536.0
Lipochromis taurinus	28	0.03	2.8				28	0.02	1.3
Psammochromis schubotzi	667	0.73	66.7	117	0.14	10.6	784	0.45	37.3
Schubotzia edwardiana	846	0.93	84.6	220	0.26	20	1066	0.61	50.7
Yssichromis pappenheimi	210	0.23	21	384	0.46	34.9	594	0.34	28.3

Tables 7e. Relative abundance by number and catch rates of haplochromine species in 1 inch mesh size gill net between inshore and off shore stations

Species	Inshore			Offshore			Overall		
	Tot No.	% No.	Catch rate	Tot No.	% No.	Catch rate	No.	% No.	Catch rate
Astatotilapia aeneocolor	4739	46.05	473.9				4739	23.92	225.7
Astatotilapia elagans	17	0.17	1.7				17	0.09	0.8
Astatotilapia macropsoides				14	0.15	1.27	14	0.07	0.7
Astatotilapia oregosoma				91	0.96	8.27	91	0.46	4.3
Astatotilapia schubotziella	92	0.90	9.2				92	0.46	4.4
Astatotilapia nubila									
Enterochromis nigripinnis	4793	46.57	479.3	8368	87.87	760.73	13161	66.41	626.7
Haplochromis limax									
Harpagochromis squamipinnis	77	0.75	7.7	144	1.51	13.09	221	1.12	10.52
Gaurochromis angustifrons	410	3.98	41	838	8.80	76.18	1248	6.30	59.4
Lipochromis taurinus	3	0.03	0.3				3	0.02	0.1
Psammochromis schubotzi	63	0.61	6.3	8	0.08	0.72	71	0.36	3.4
Schubotzia edwardiana	81	0.79	8.1	25	0.26	2.27	106	0.53	5.0
Yssichromis pappenheimi	17	0.17	1.7	36	0.38	3.27	53	0.27	2.5

Table 8: The size at first maturity for the dominant fish species in Lake George.

Species	Size at first maturity (cm) TL	Size at which all fish are mature (cm) TL
Oreochromis niloticus	20.0	24.0
Oreochromis leucostictus	15.0	23.0
Protopterus aethiopicus	55-59	75-79
Harpagochromis squamipinnis	9.0	15.0
Bagrus docmac	35-39 FL	50-54 FL

Table 9: Selectivity of different sizes of hooks for *Protopterus aethiopicus* from different experimental fishing on L. George.

Size range	Hook Size							
(cm)	12	10	9	8	7	6	5	4
40 -45	3							
46-50	3	1						
51-55	10	4						
56-60	18	6	5		2			
61-65	10	9	5	1	1	1		
66-70	5	5	1	[illegible]	2			
71-75	2	5	3	2		1		1
76-80	2		2	3	1	1	1	
81-85	1							
86-90					1	1		
91-95								
96-100					1	1		
101-105								
106-110							1	
Total	54	30	16	10	8	5	2	1

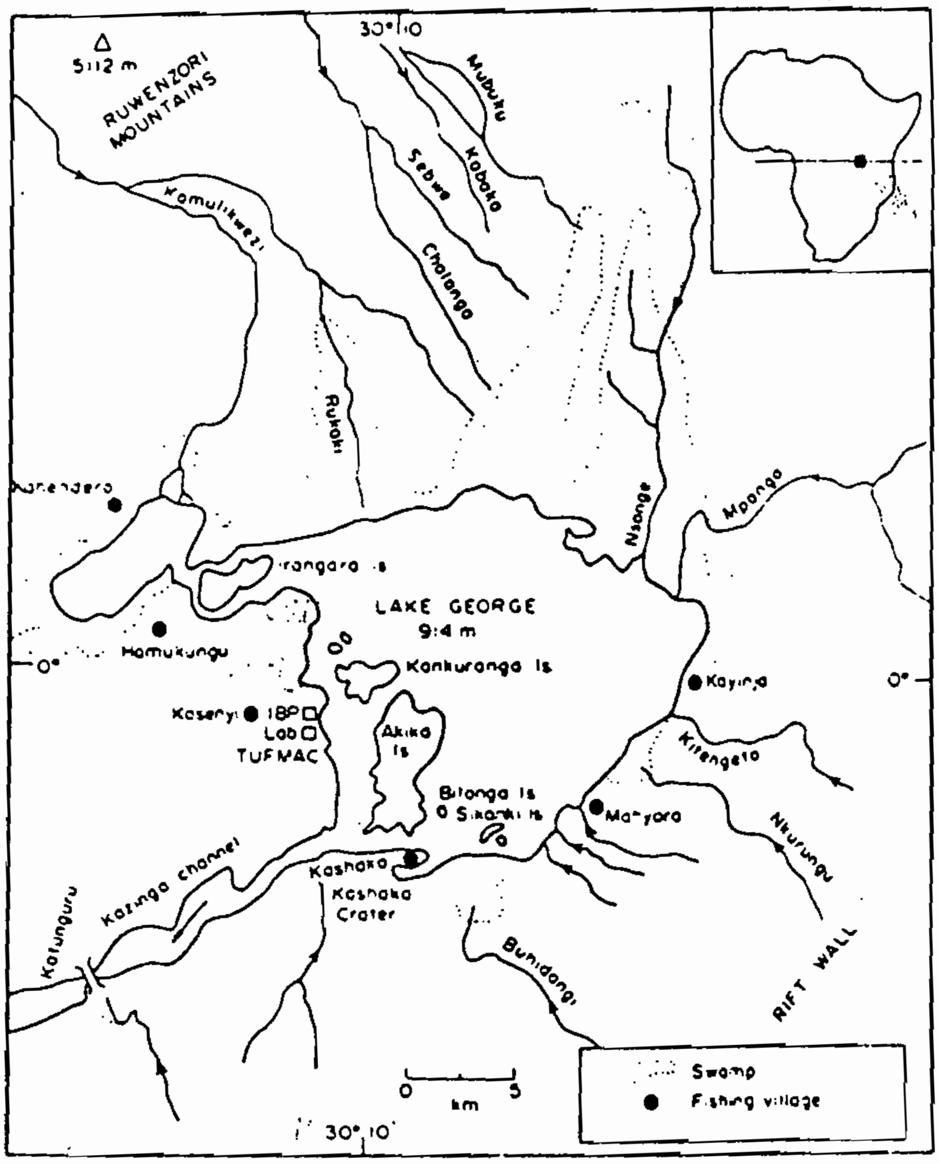
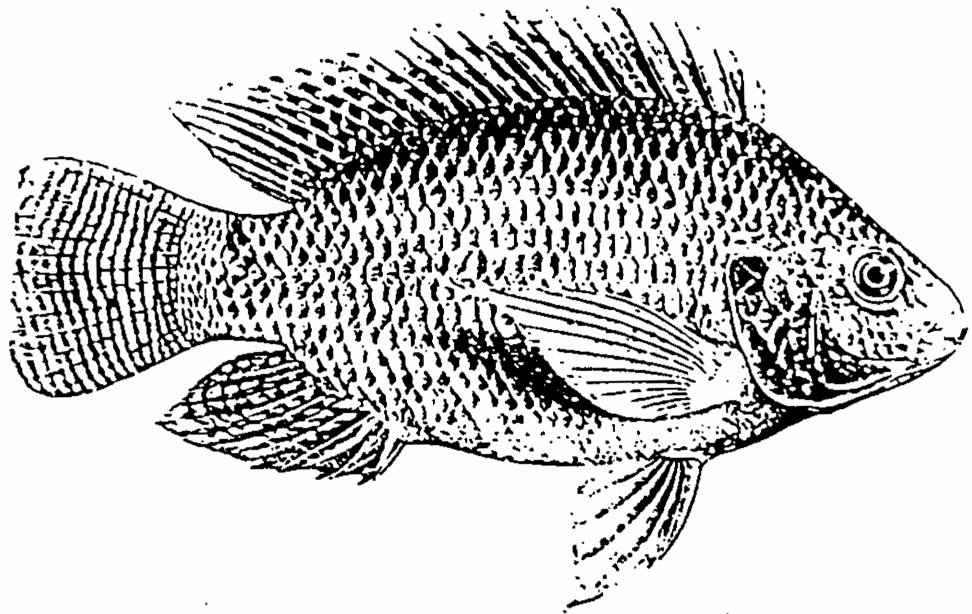


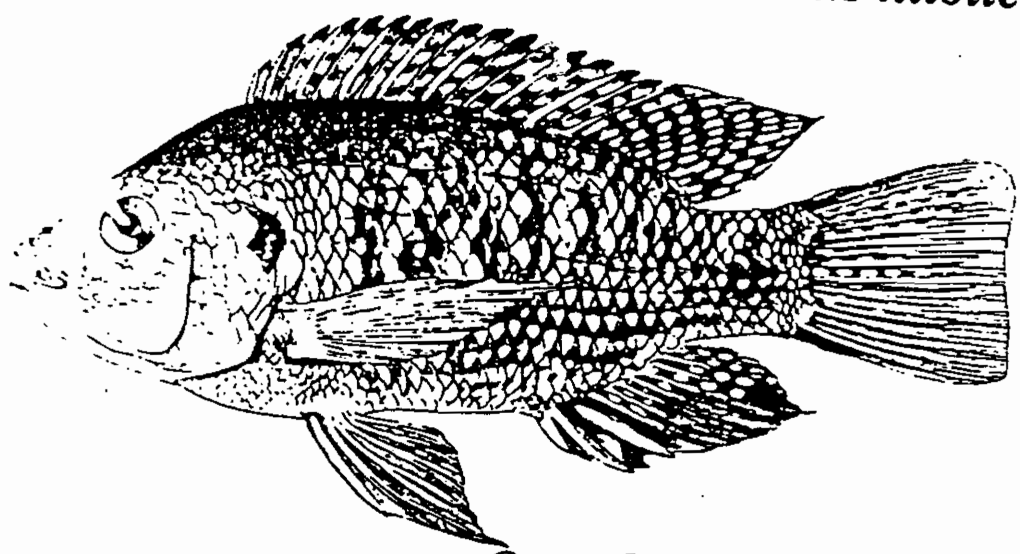
Figure 1. The map of Lake George showing inflowing rivers, swamps and fishing villages (based on Gwahaba, 1972)

Common Fishes of Lake George

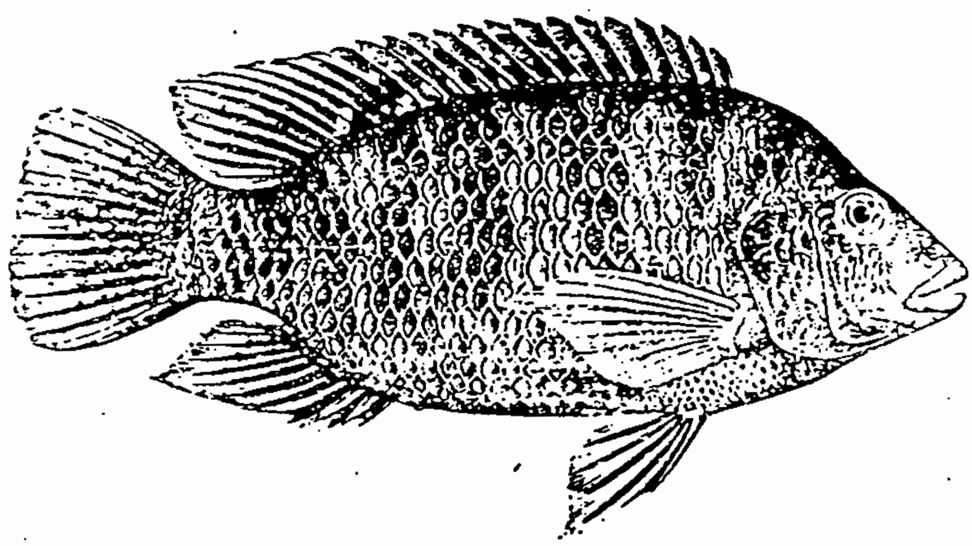
(Based on Green 1966, 1981)



Oreochromis niloticus

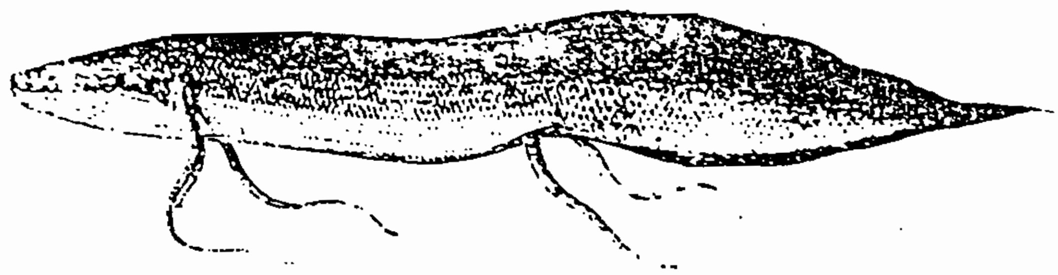


Oreochromis leucostictus

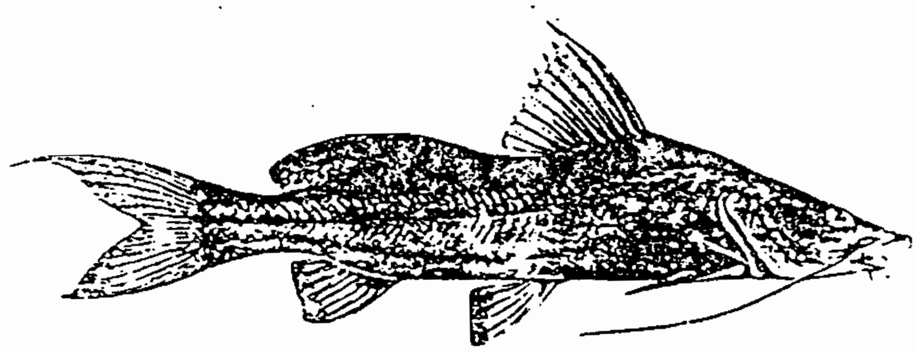


Tilapia zillii

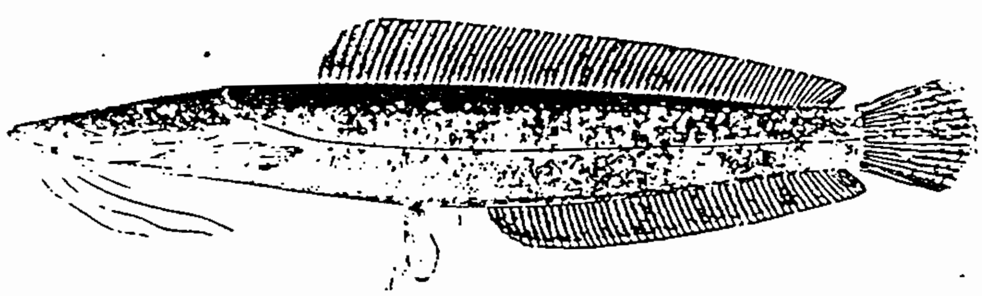
Figure 2a



Protopterus aethiopicus

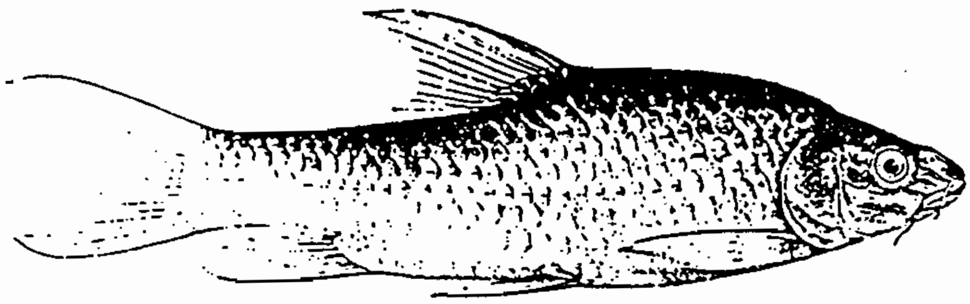


Bagrus docmac

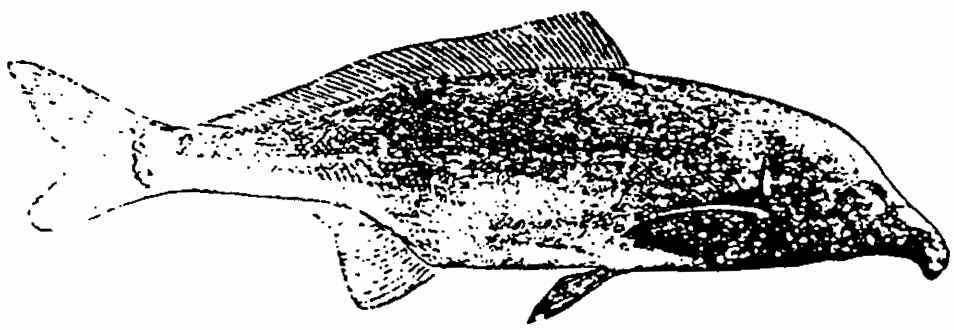


Clarias gariepinnus

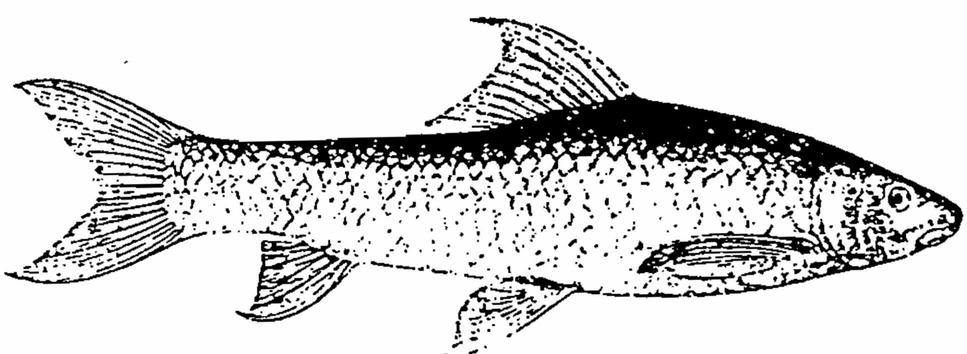
Figure 2b



Barbus altianalis

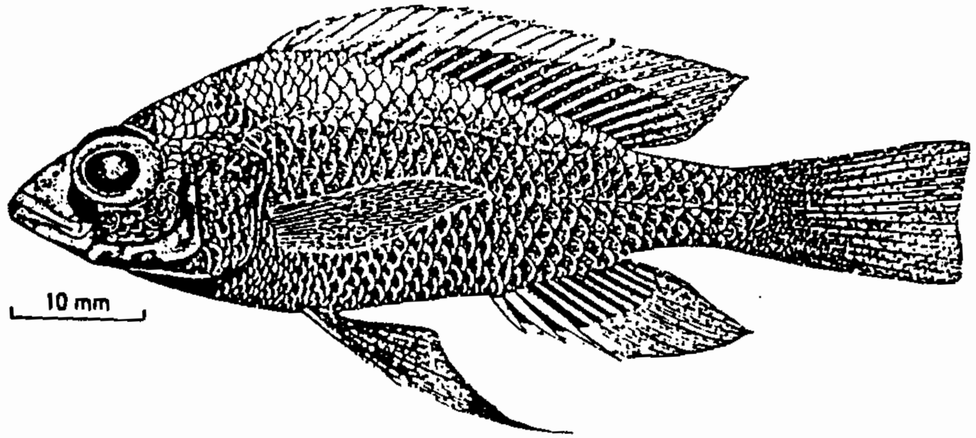


Mormyrus kannume

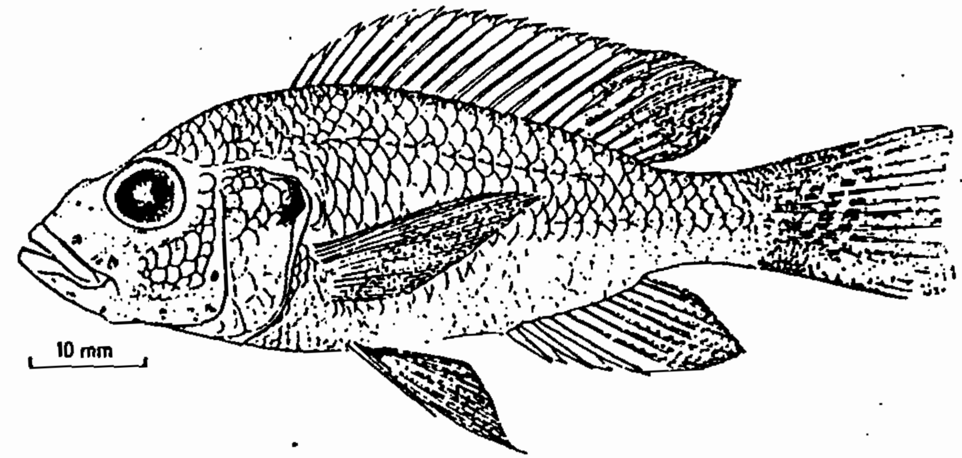


Labeo forskalii

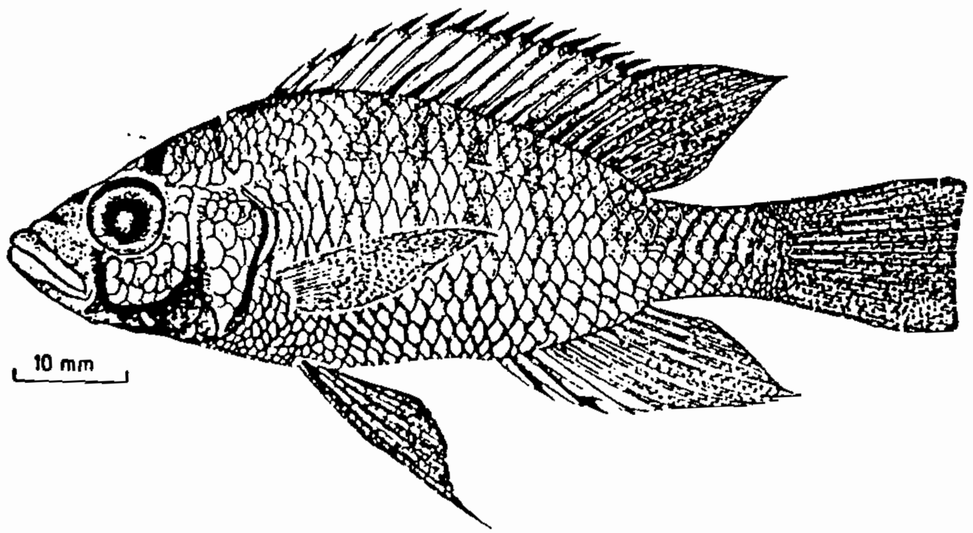
Figure 2c



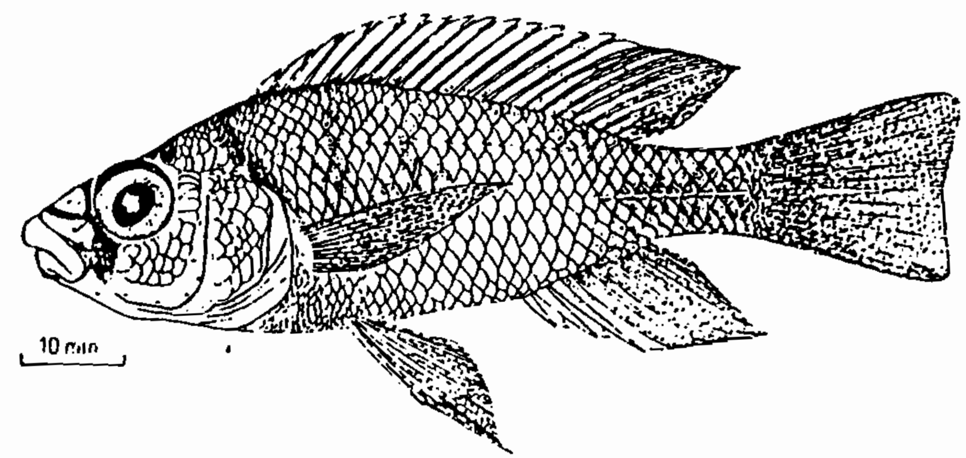
Enterochromis nigripinnis



Gaurochromis angustifrons



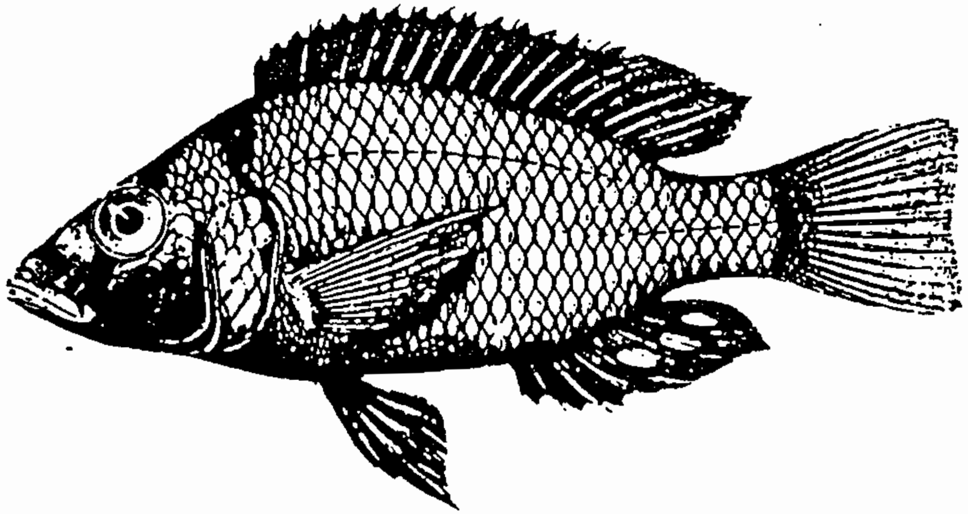
Astatotilapia aeneocolour



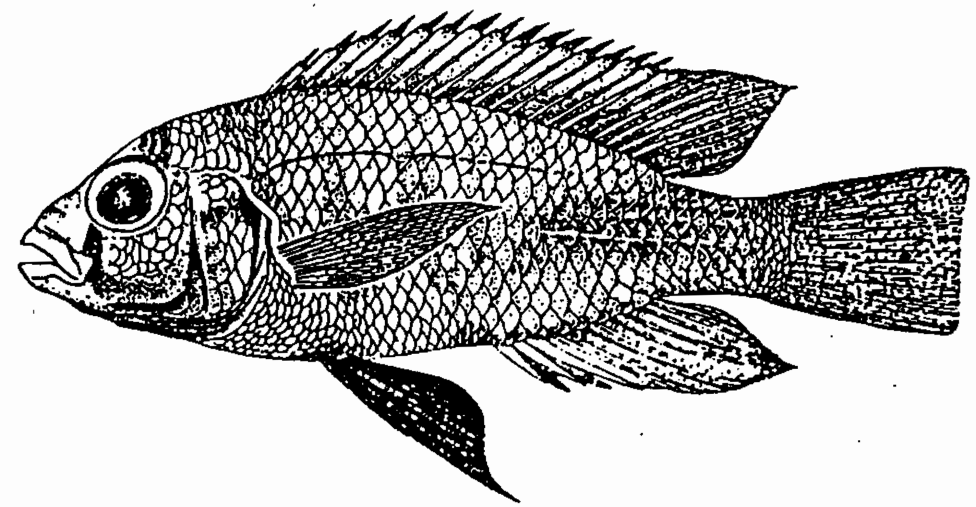
Schubotzia eduardiana

Figure 2d

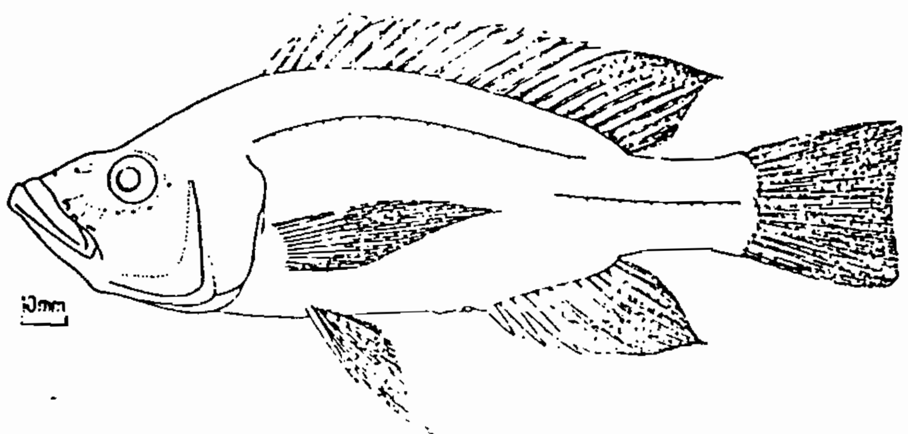
Fishes of Lake George (Based on Greenwood 1966, 1981)



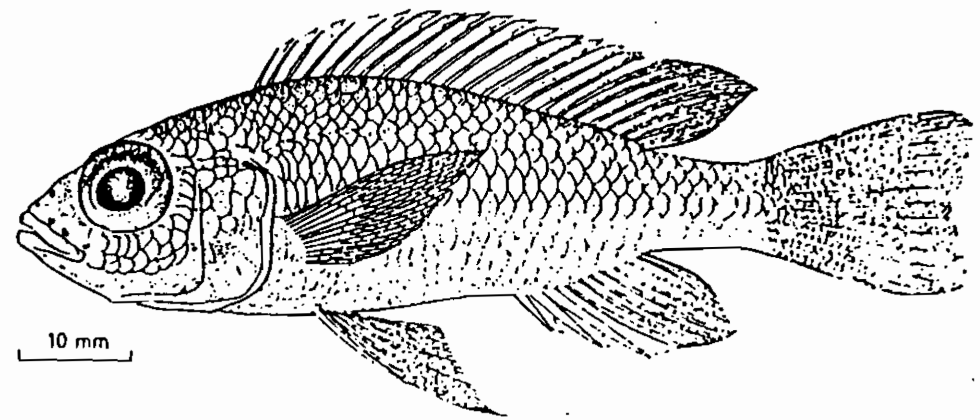
Psammochromis schubotzi



Astalotilapia elegans



Harpagochromis squamipinnis



Astatotilapia oregosoma

Figure 2e

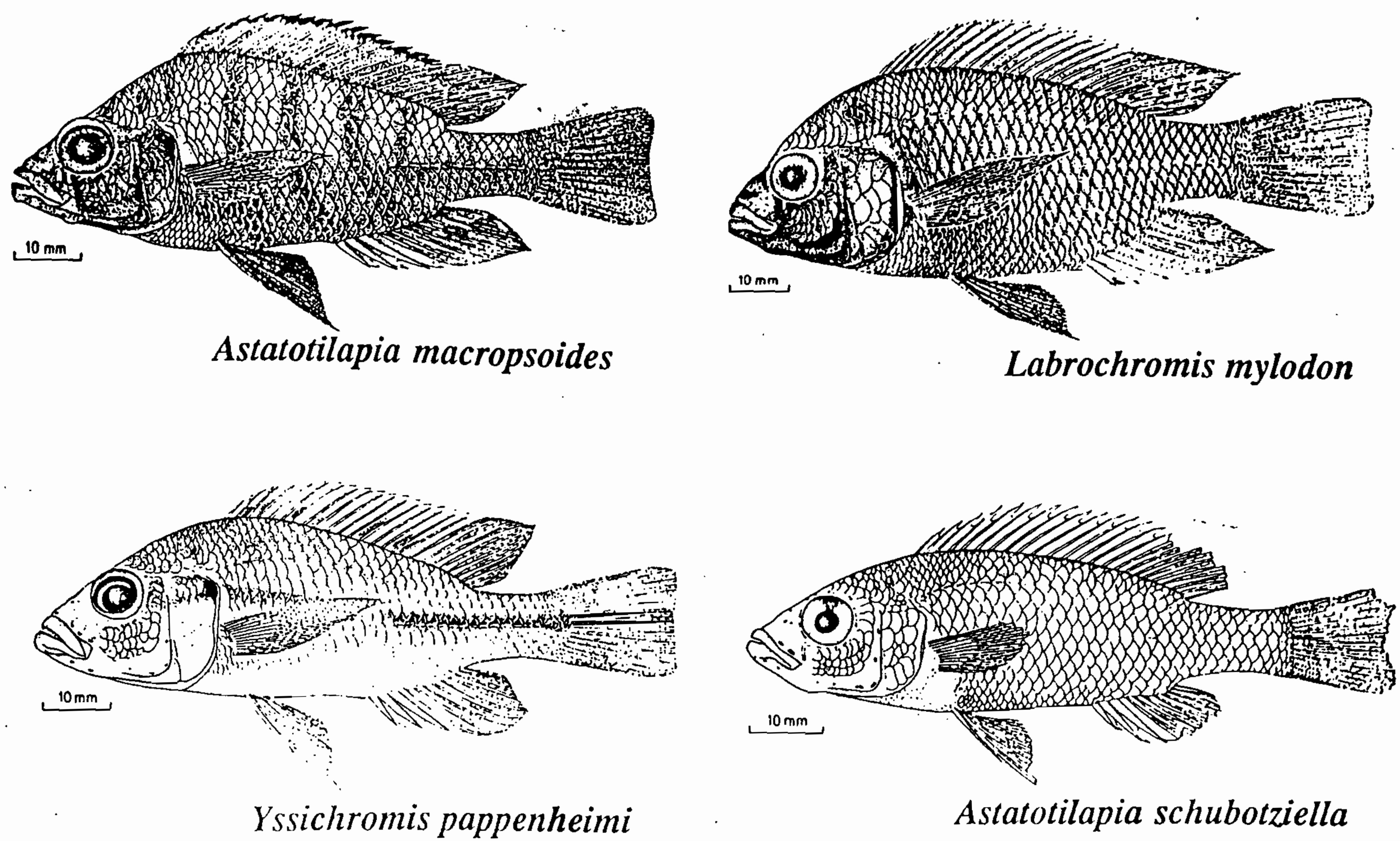

10 mm
Astatotilapia macropsoides
10 mm
Labrochromis mylodon
10 mm
Yssichromis pappenheimi
10 mm
Astatotilapia schubotziella

Figure 2f

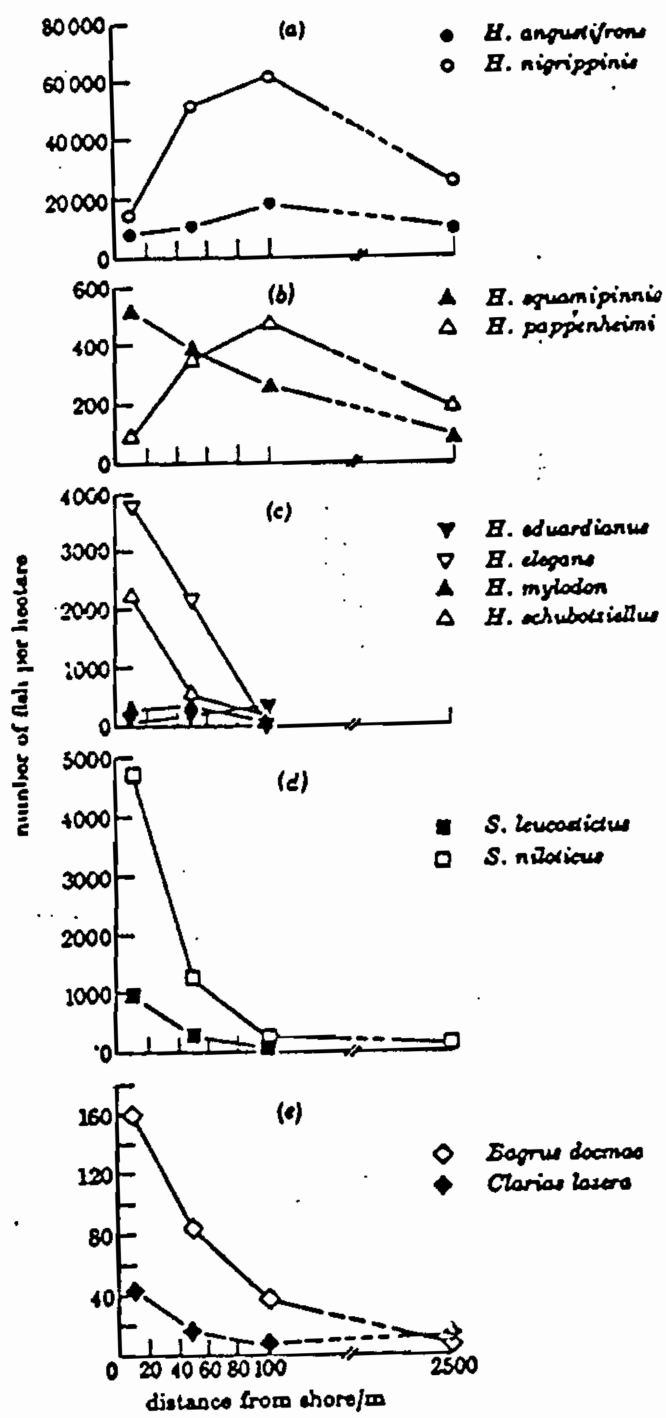


Figure 3. Spatial separation of the most abundance fish species in Lake George (based on data in Gwahaba 1972).

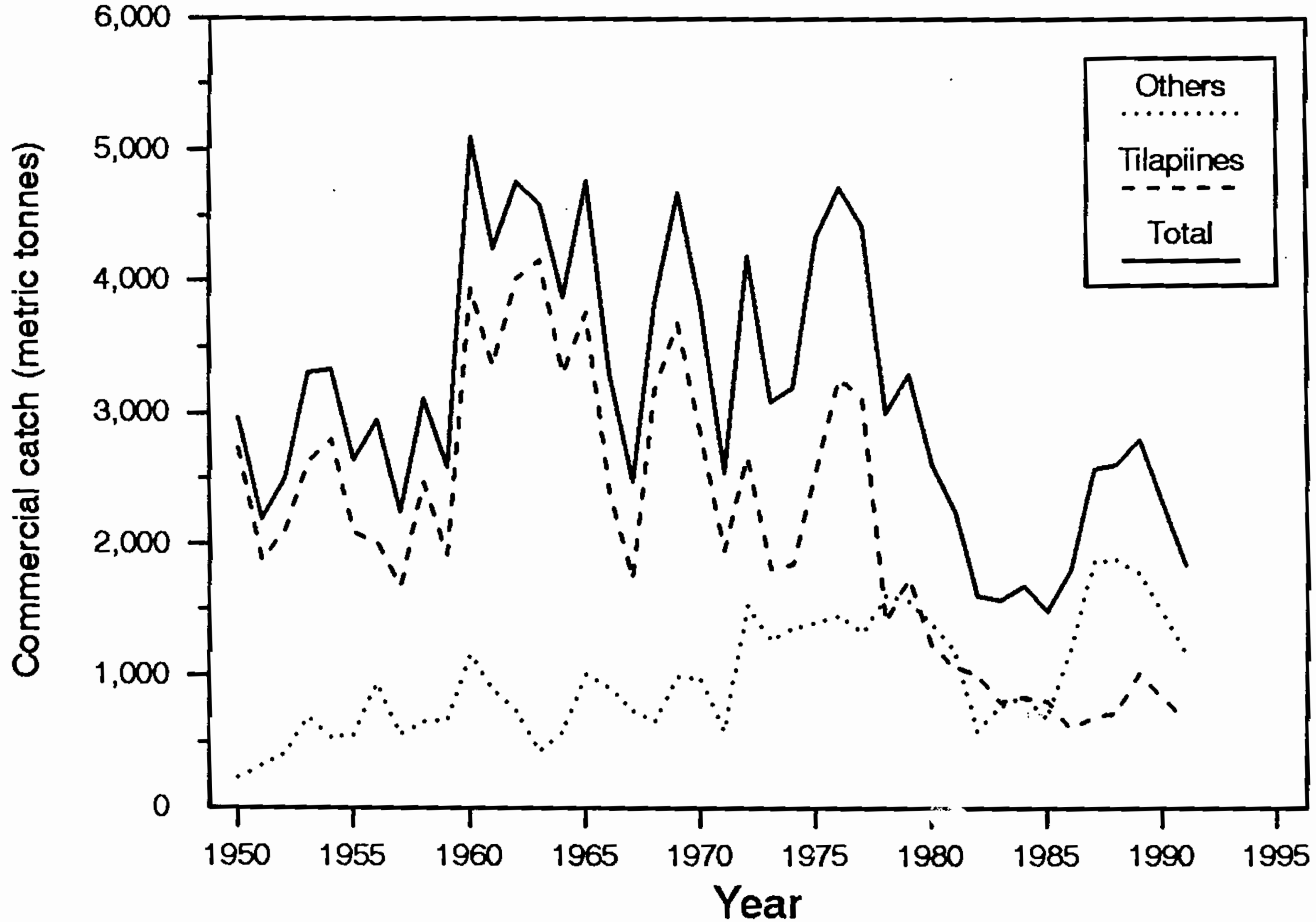


Fig.4. Changes in commercial catches of Lake George between 1950 and 1991

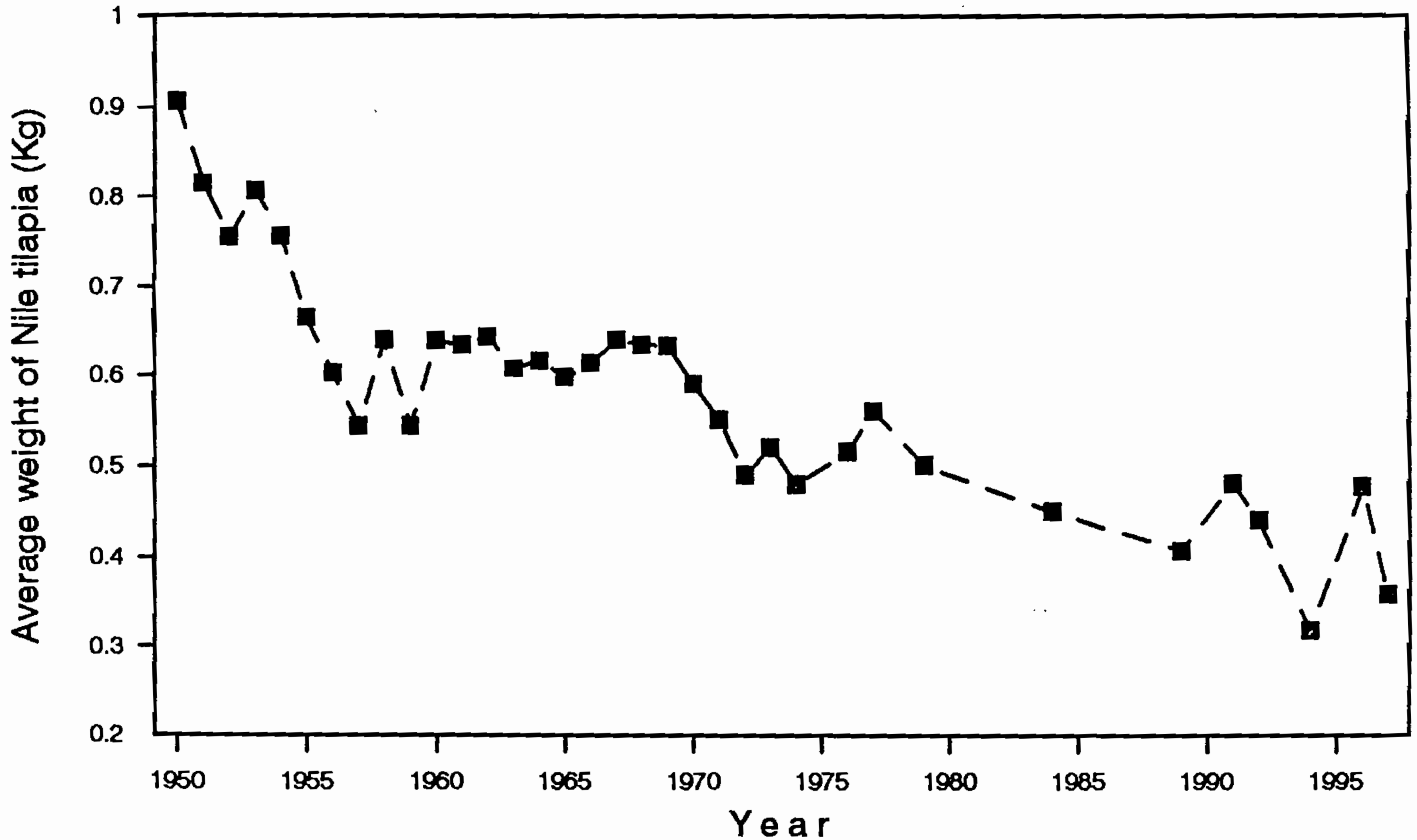


Fig.5. The change in the average weight in Nile tilapia landed following opening up of the fishery to intensive exploitation

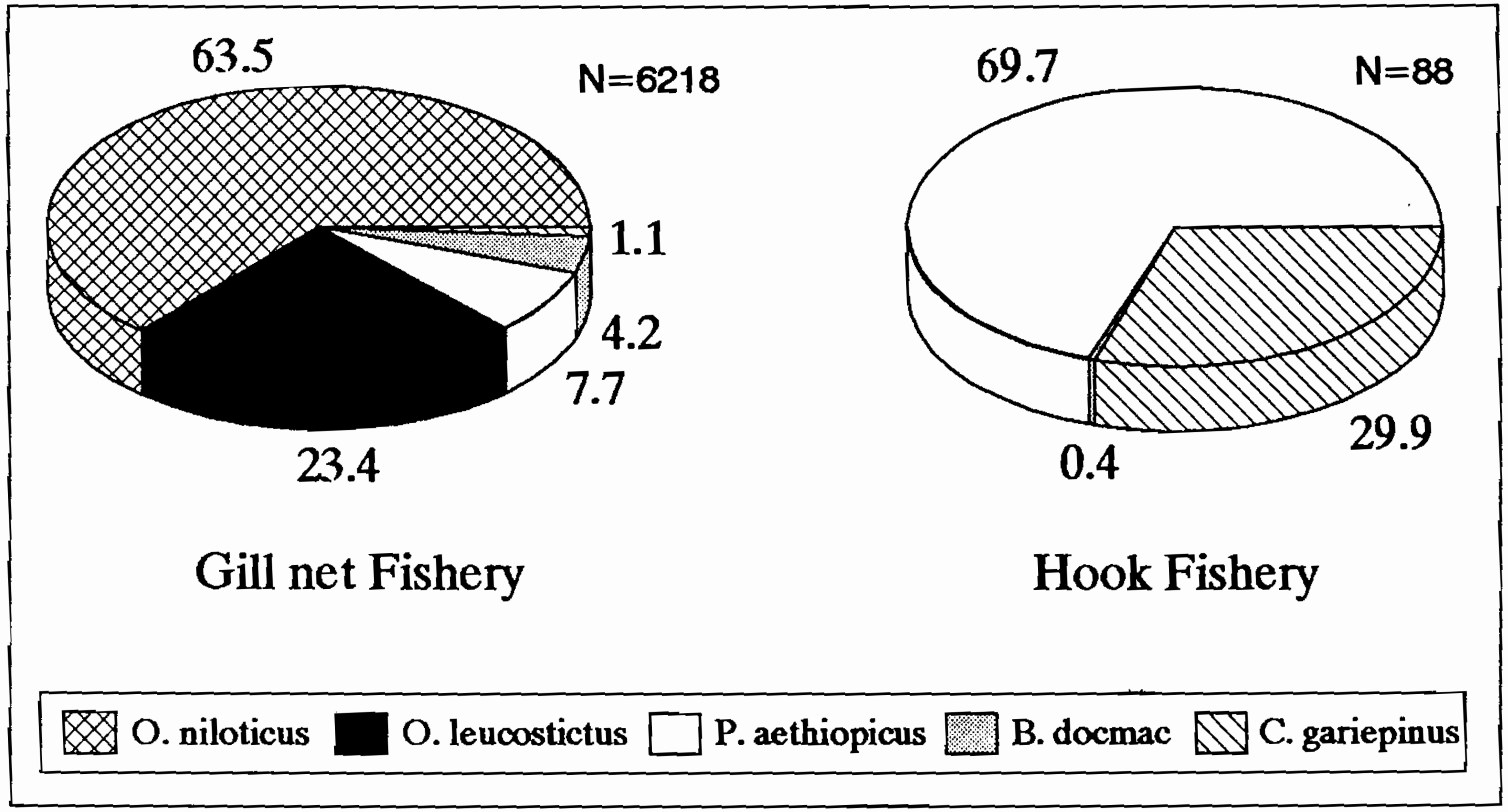


Figure 6. Relative importance (%) of fish species by weight in commercial gill net and hook fishery on Lake George

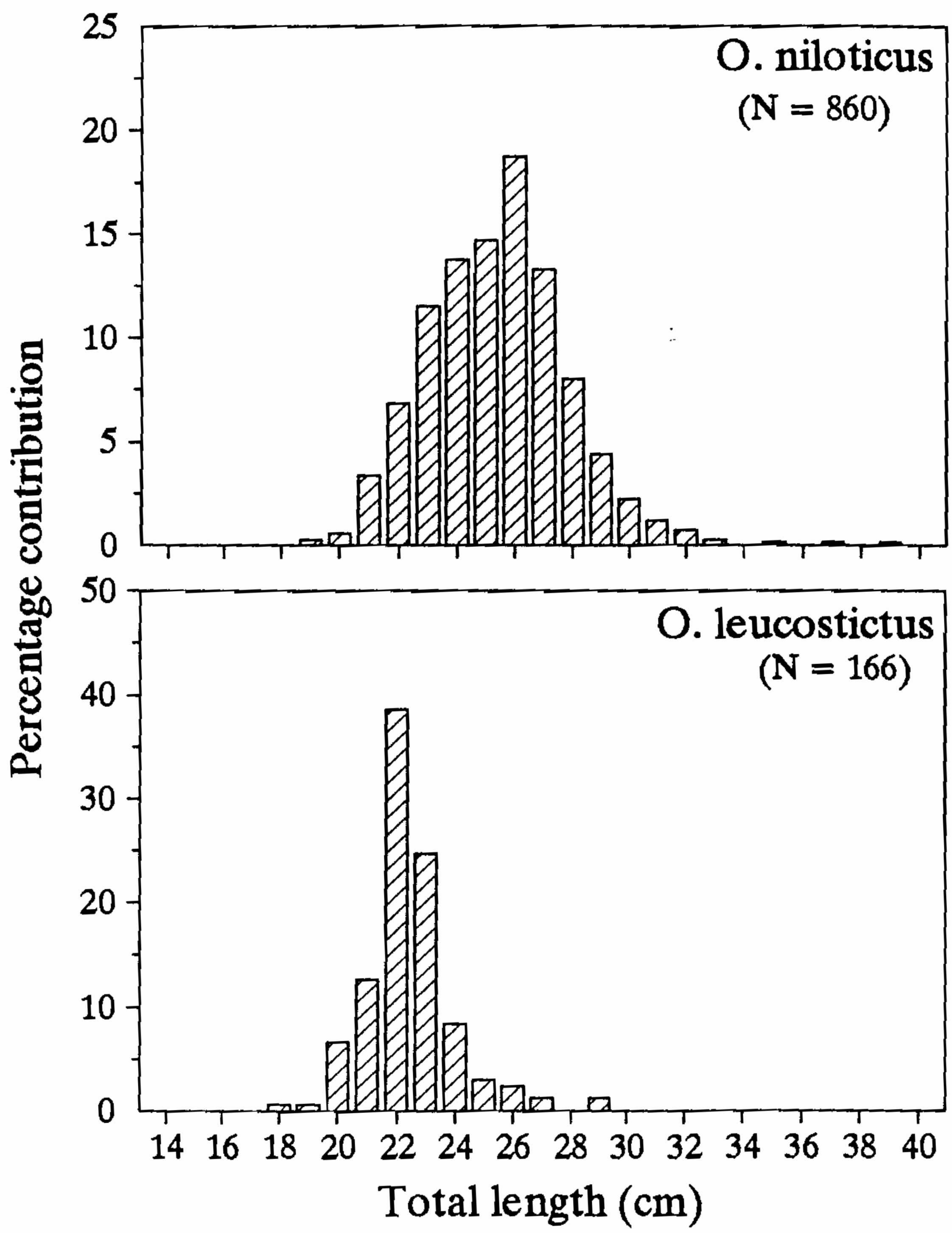


Figure 7. Length - frequency distribution of O. niloticus and O. leucostictus among commercial catches

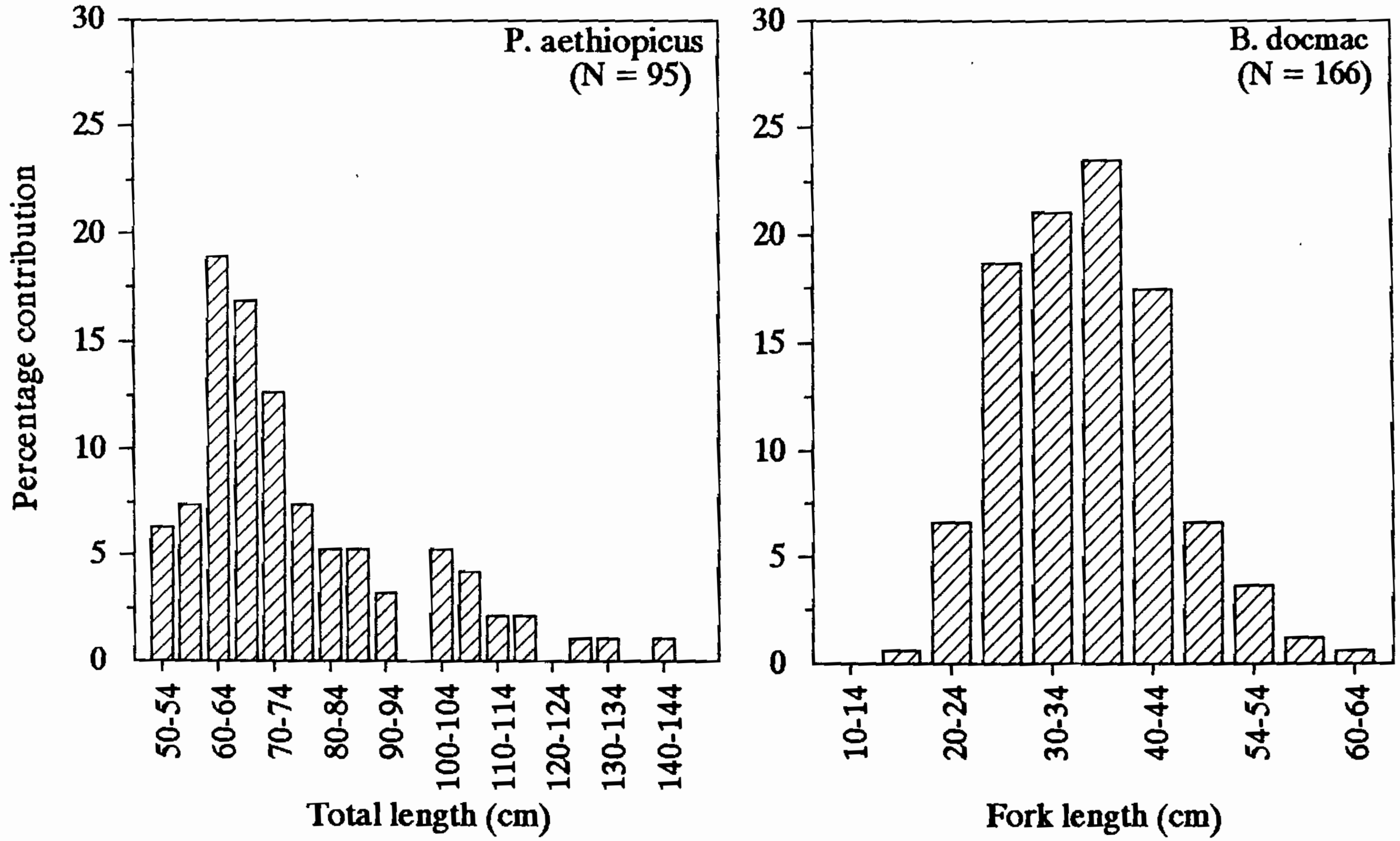


Figure 8. Length - frequency distribution of Mamba (P. aethiopicus) and Semutundu (B. docmac) among commercial catches

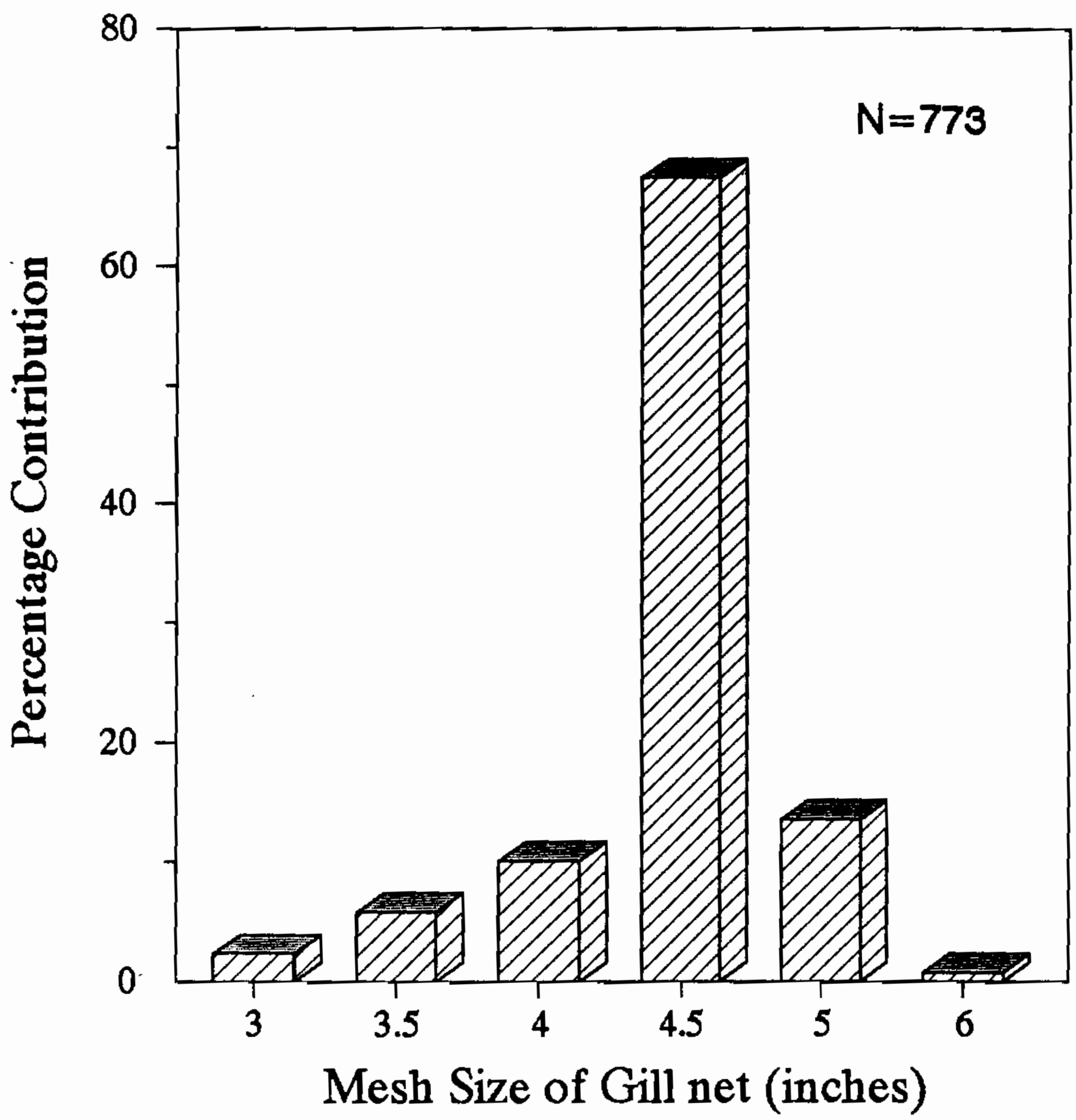


Figure 9. The Distribution of different sizes of gill nets in the commercial fishery on Lake George

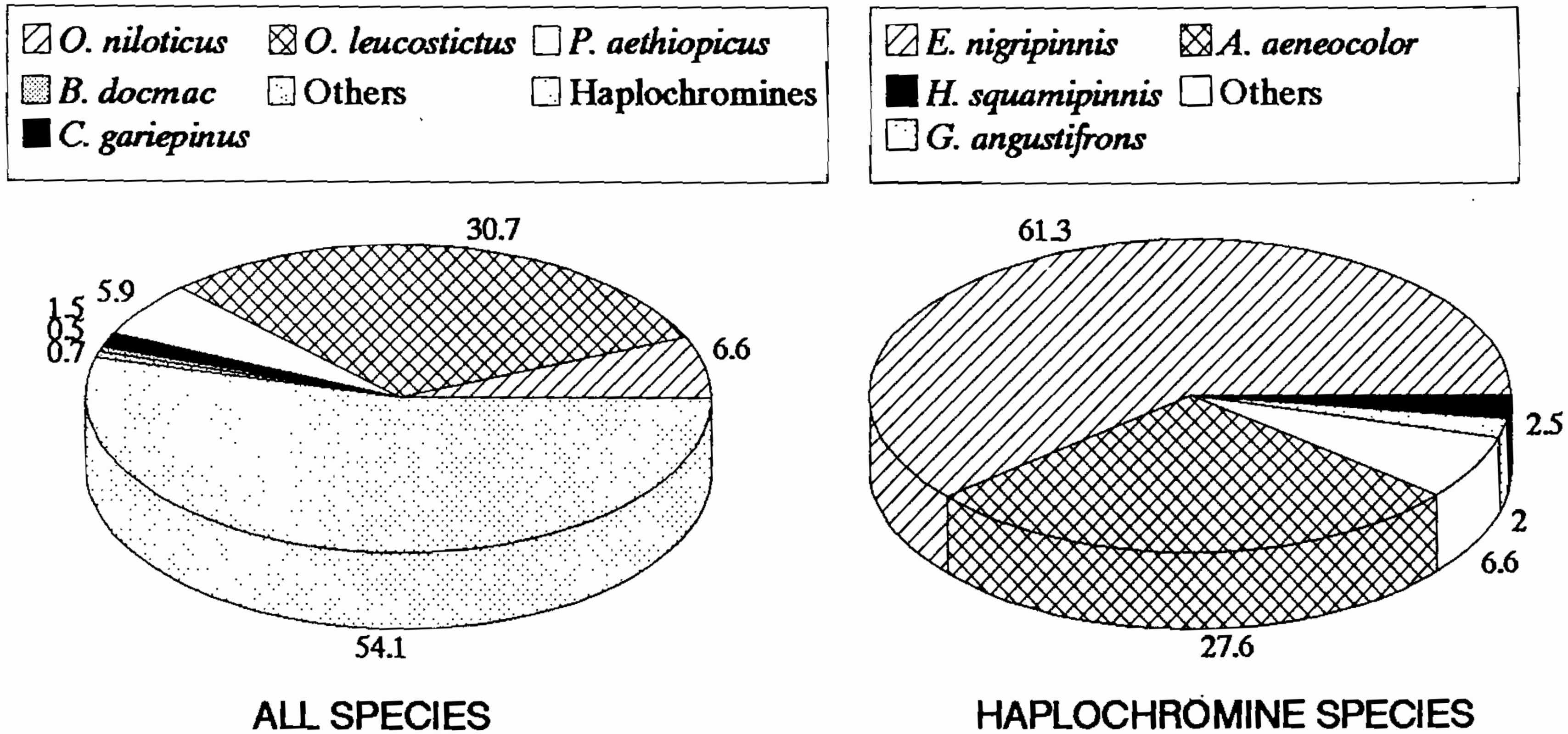


Fig. 10. Percentage contribution of different species by weight in experimental catches in Lake George.

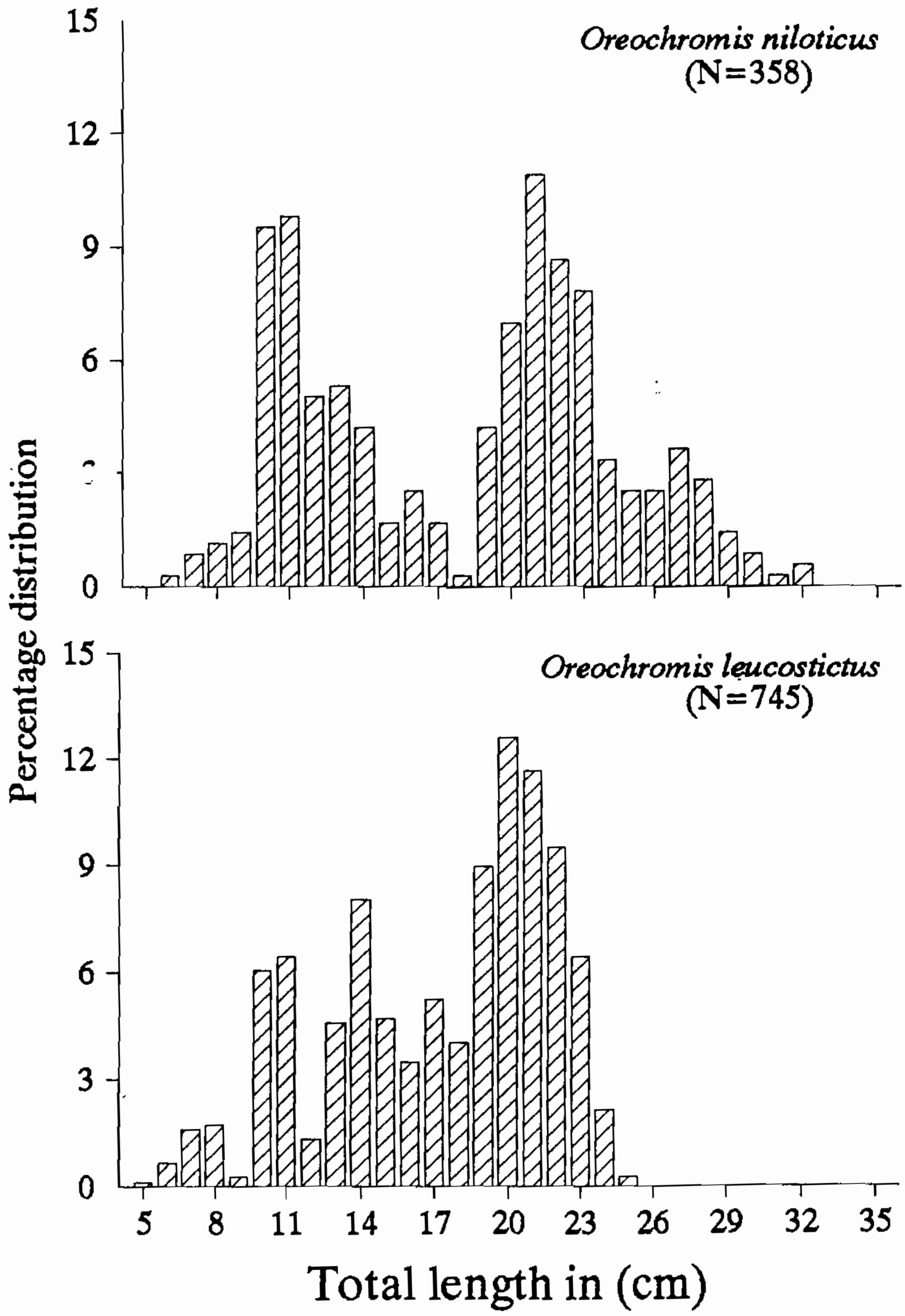


Figure 11. Length frequency distribution of (a) O.niloticus and (b) O. leucostictus from experimental catches

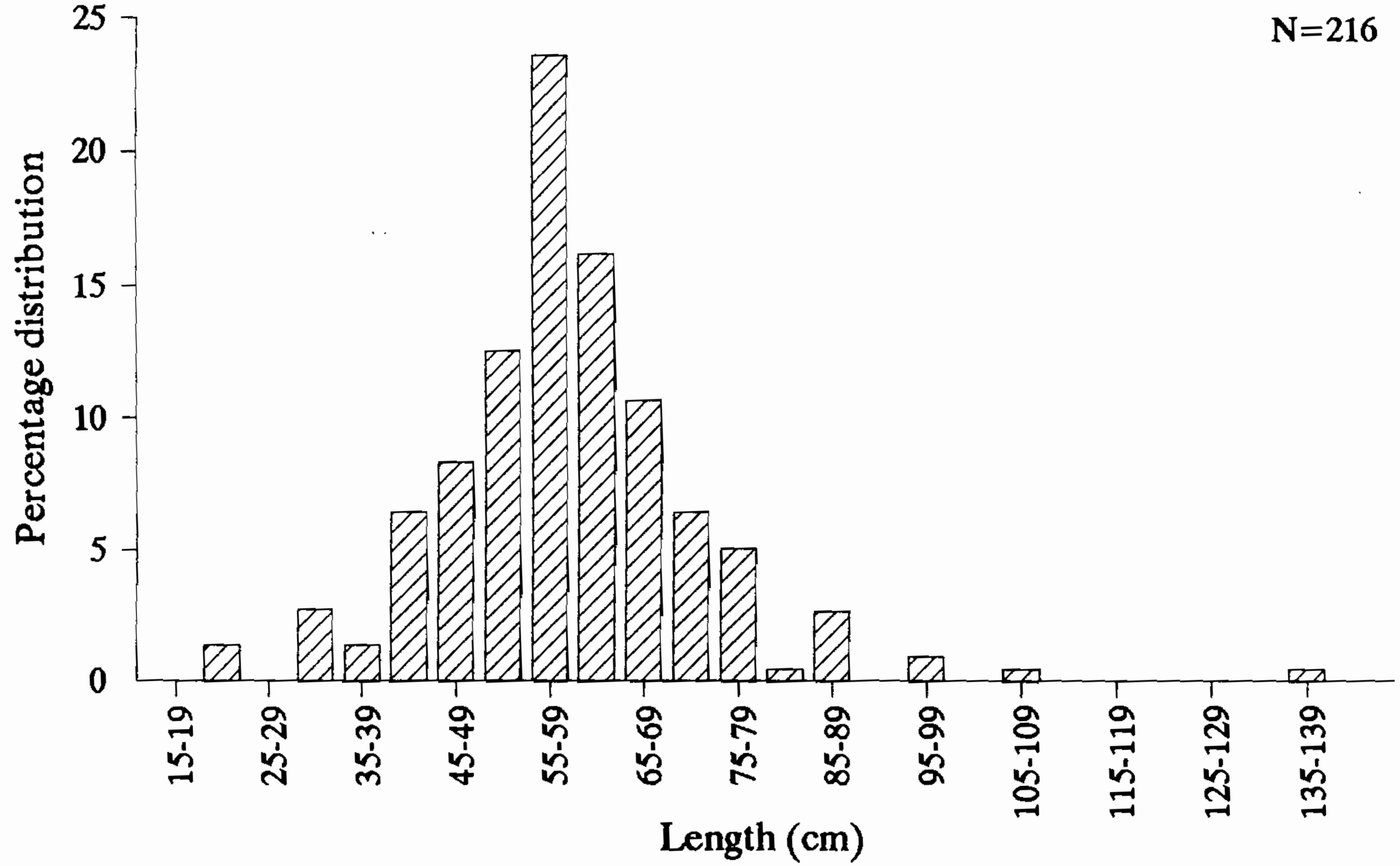


Fig. 12. Length frequency distribution of P. aethiopicus from experimental catches

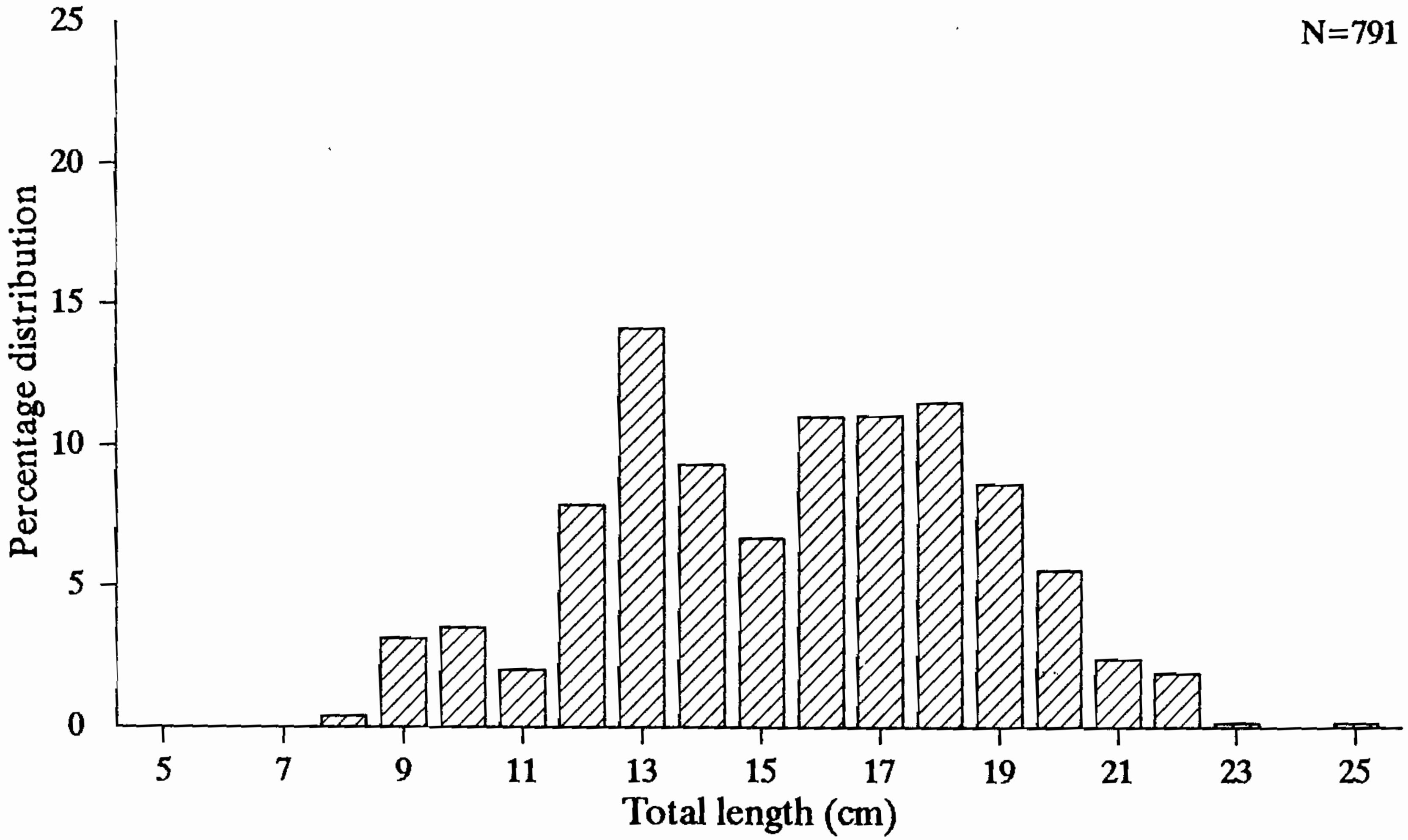


Figure 13. Length frequency distribution of H. squamipinnis caught in experimental gill net catches

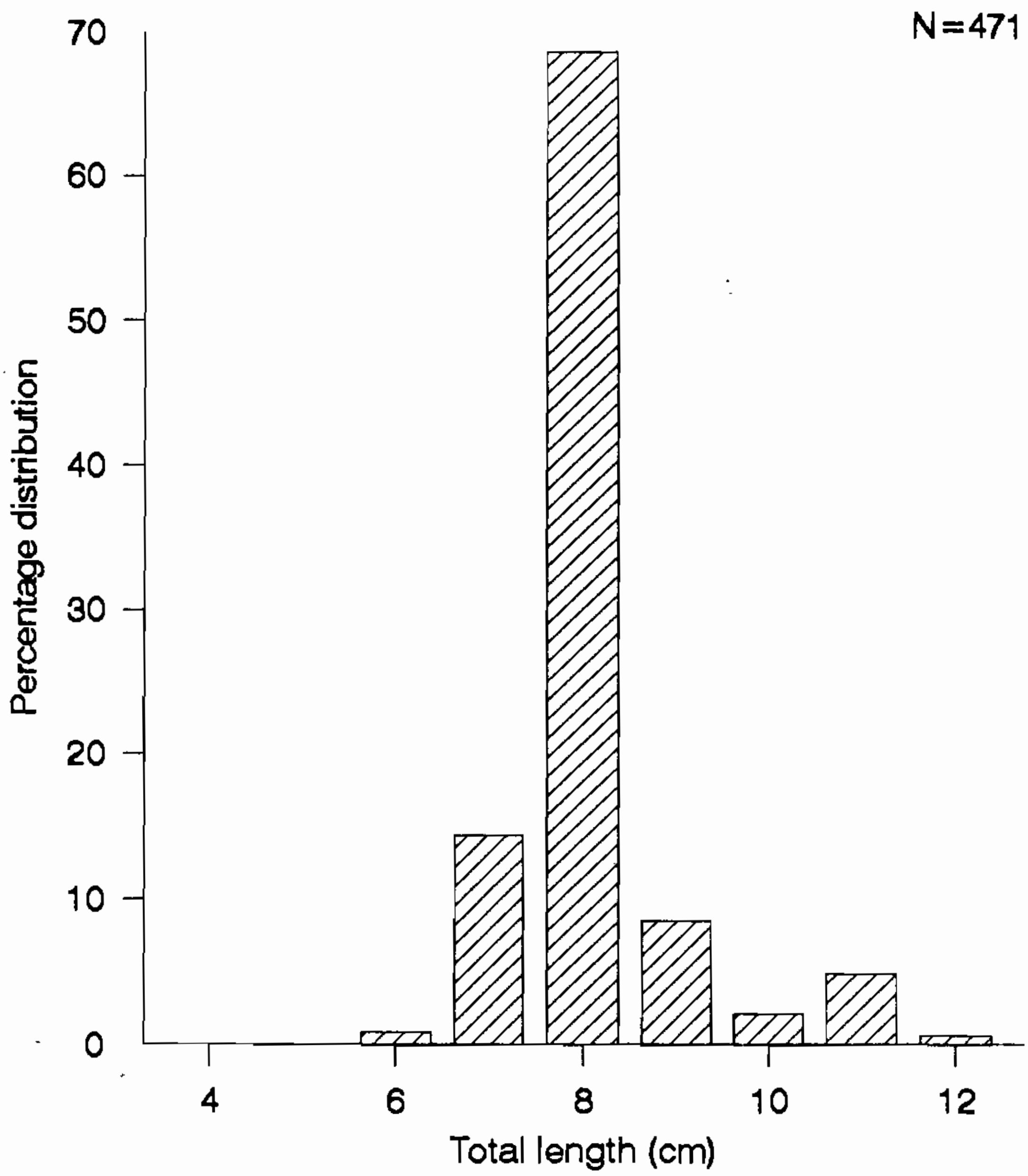


Figure 14. Length frequency distribution of Enterochromis nigripinnis in experimental gillnet catches

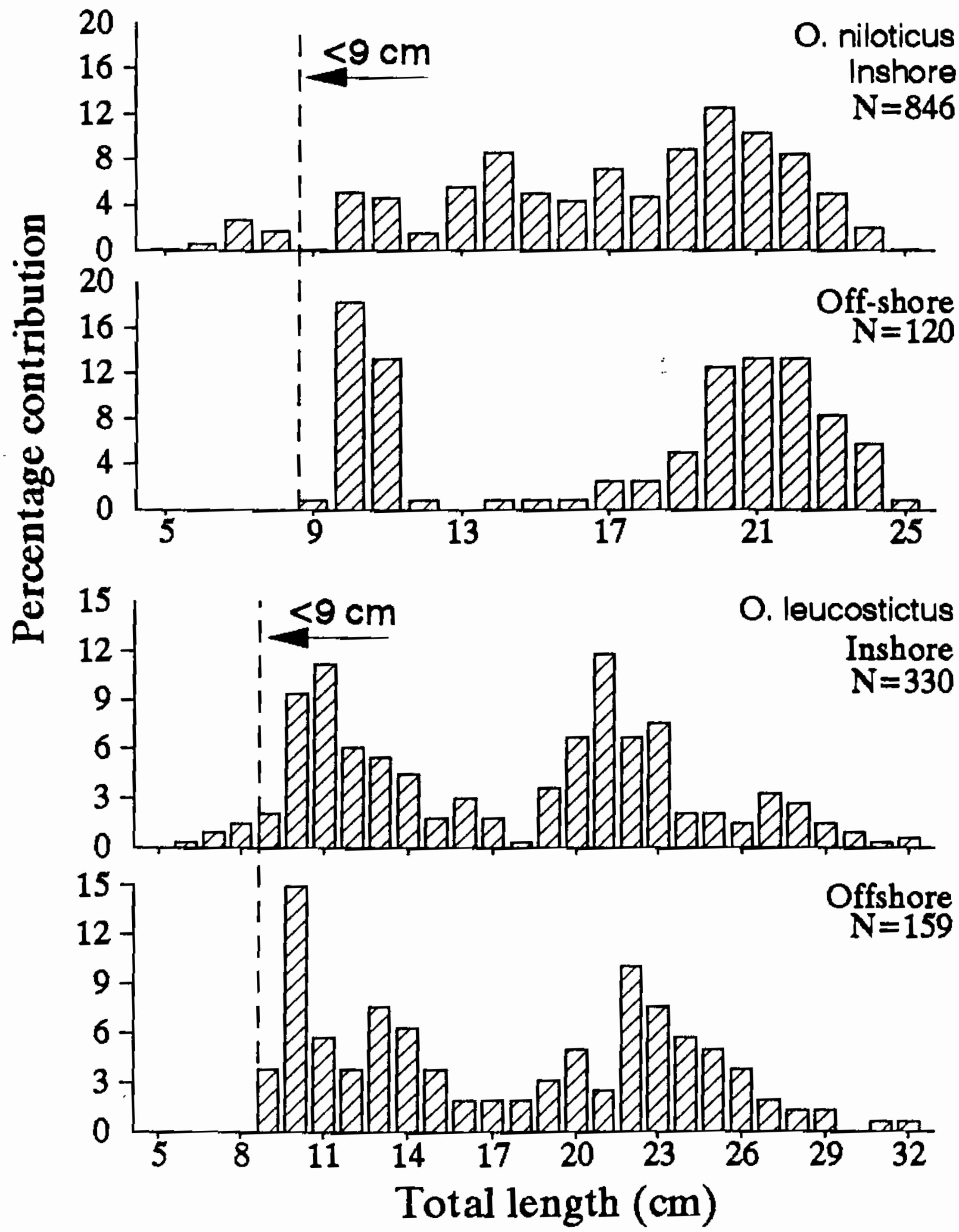


Figure 15. Size distribution of O. niloticus and O. leucostictus inshore (<100 m) and offshore (>100 m)

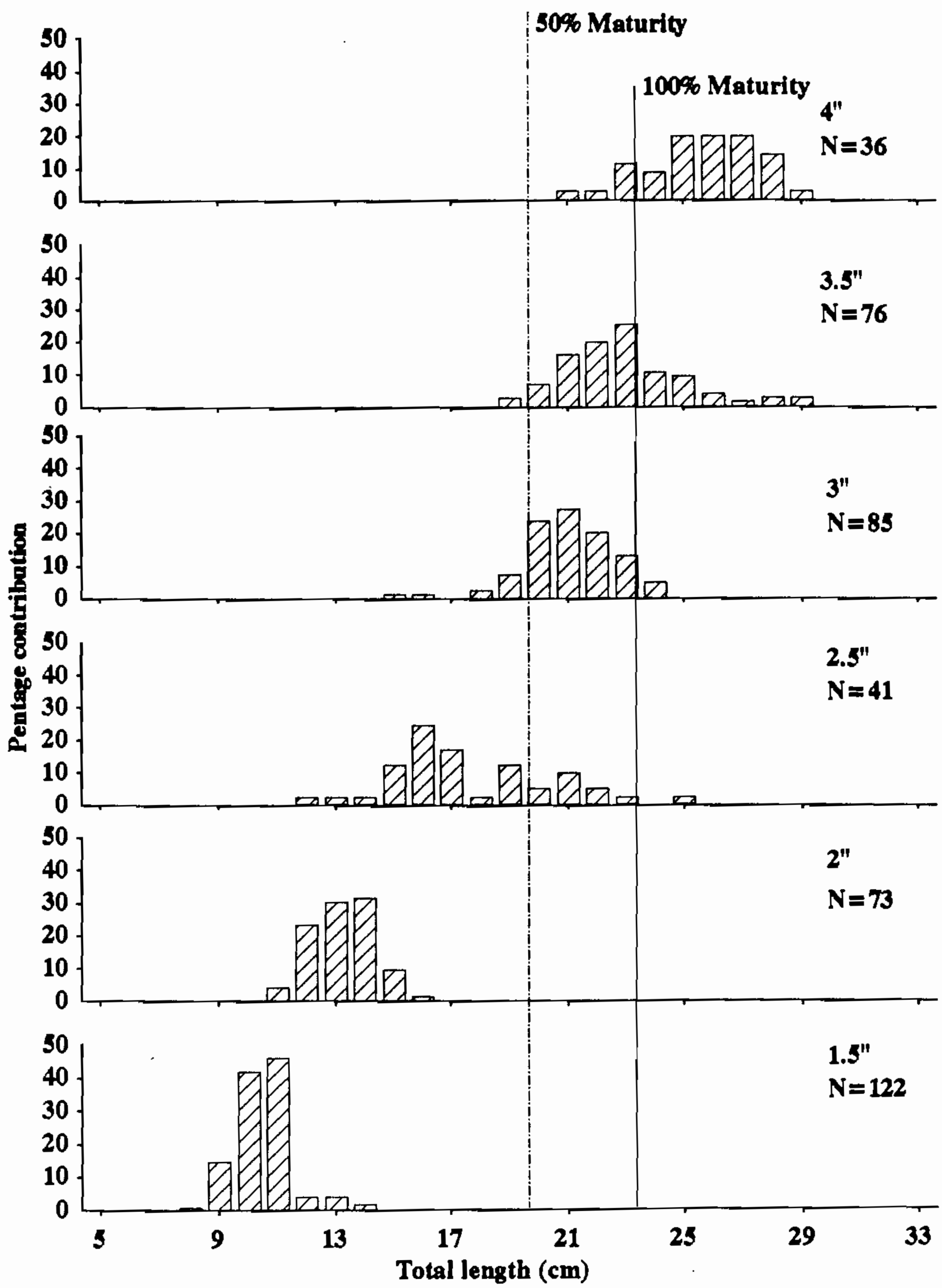


Figure 16. Gill net mesh size selectivity of Oreochromis niloticus from experimental passive gill nets

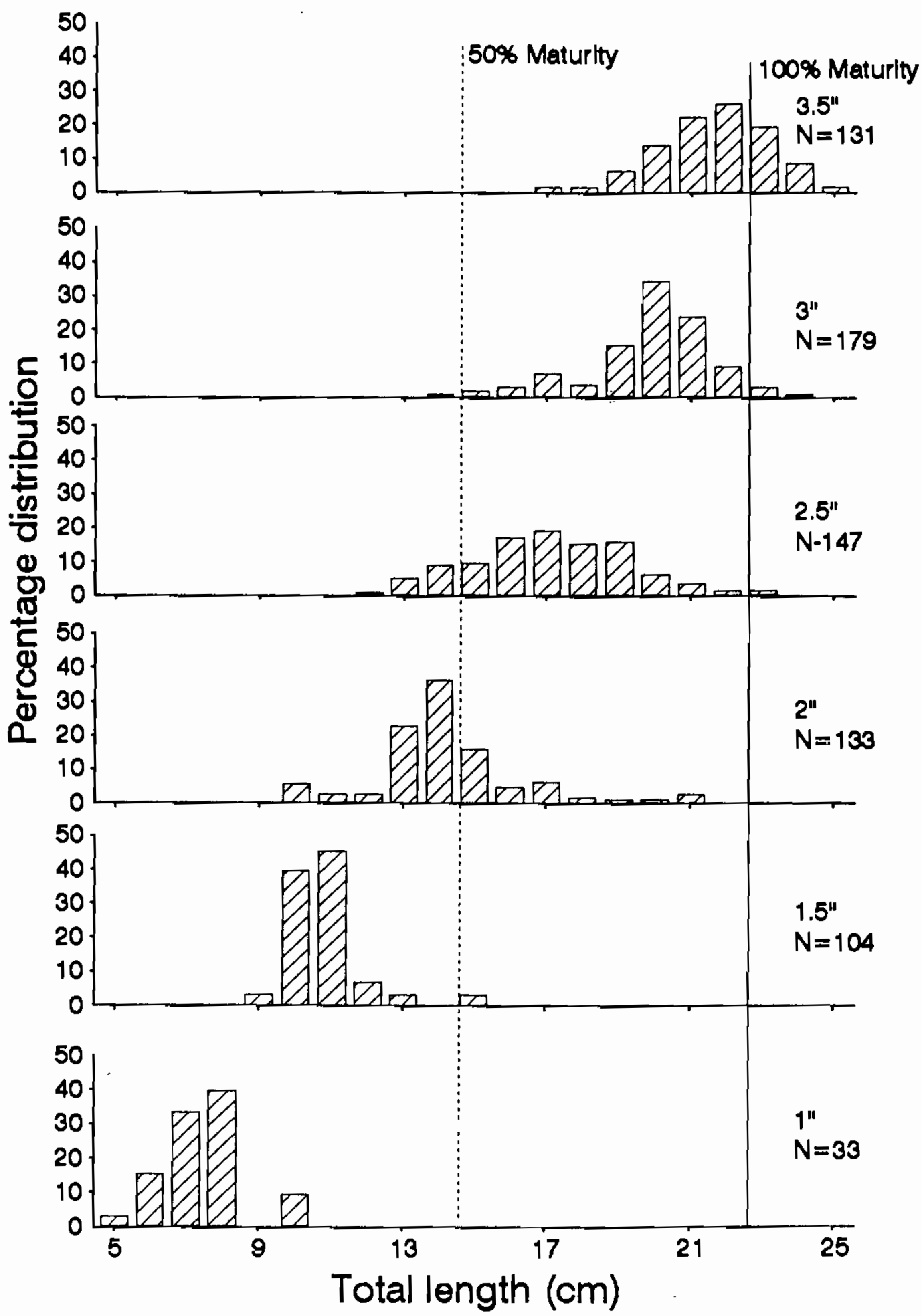


Figure 17. Length frequency distribution of O.leucostictus from passive gill net mesh sizes.

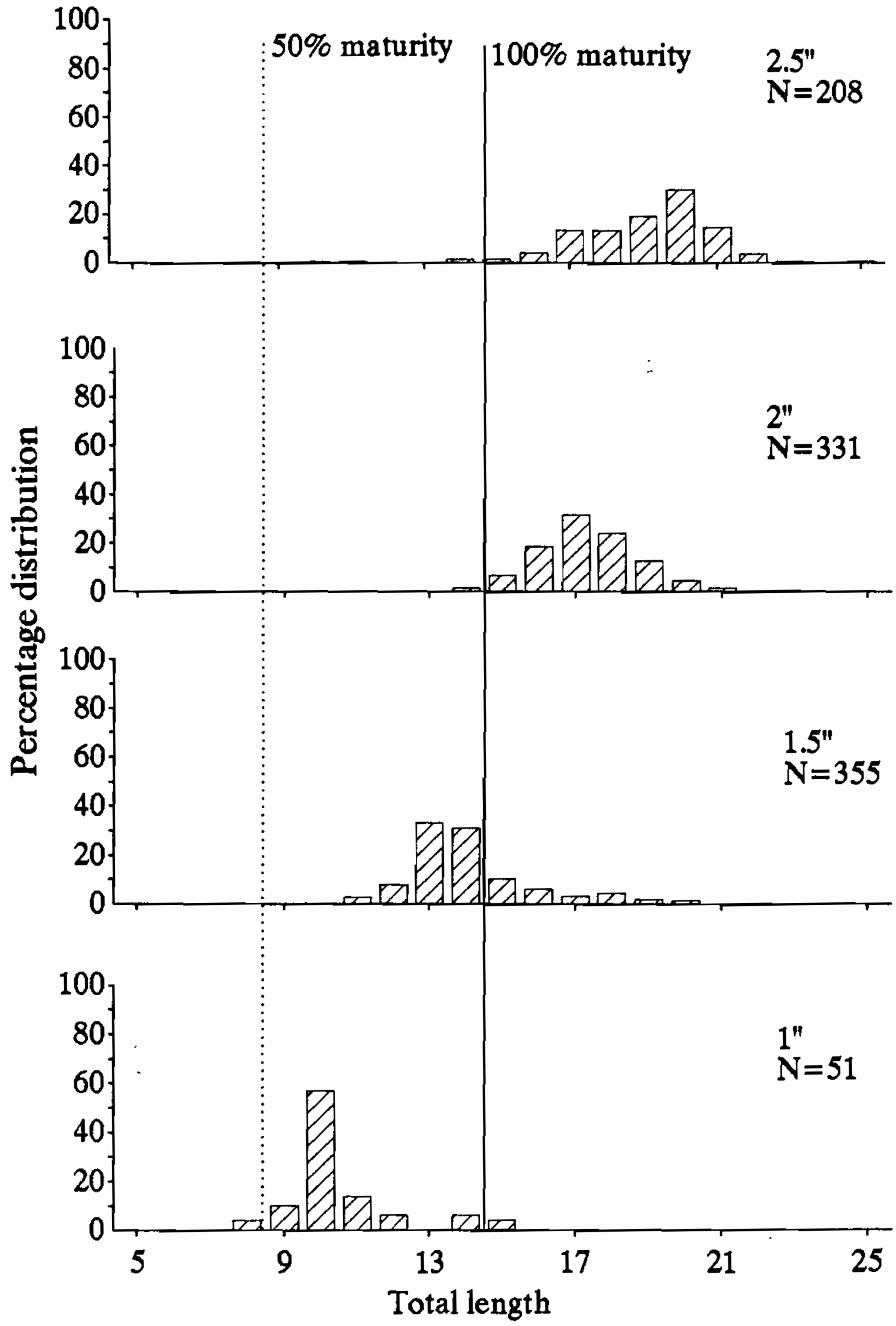


Figure 18. Gill net selectivity of H. squamipinnis from passive experimental gill net catches

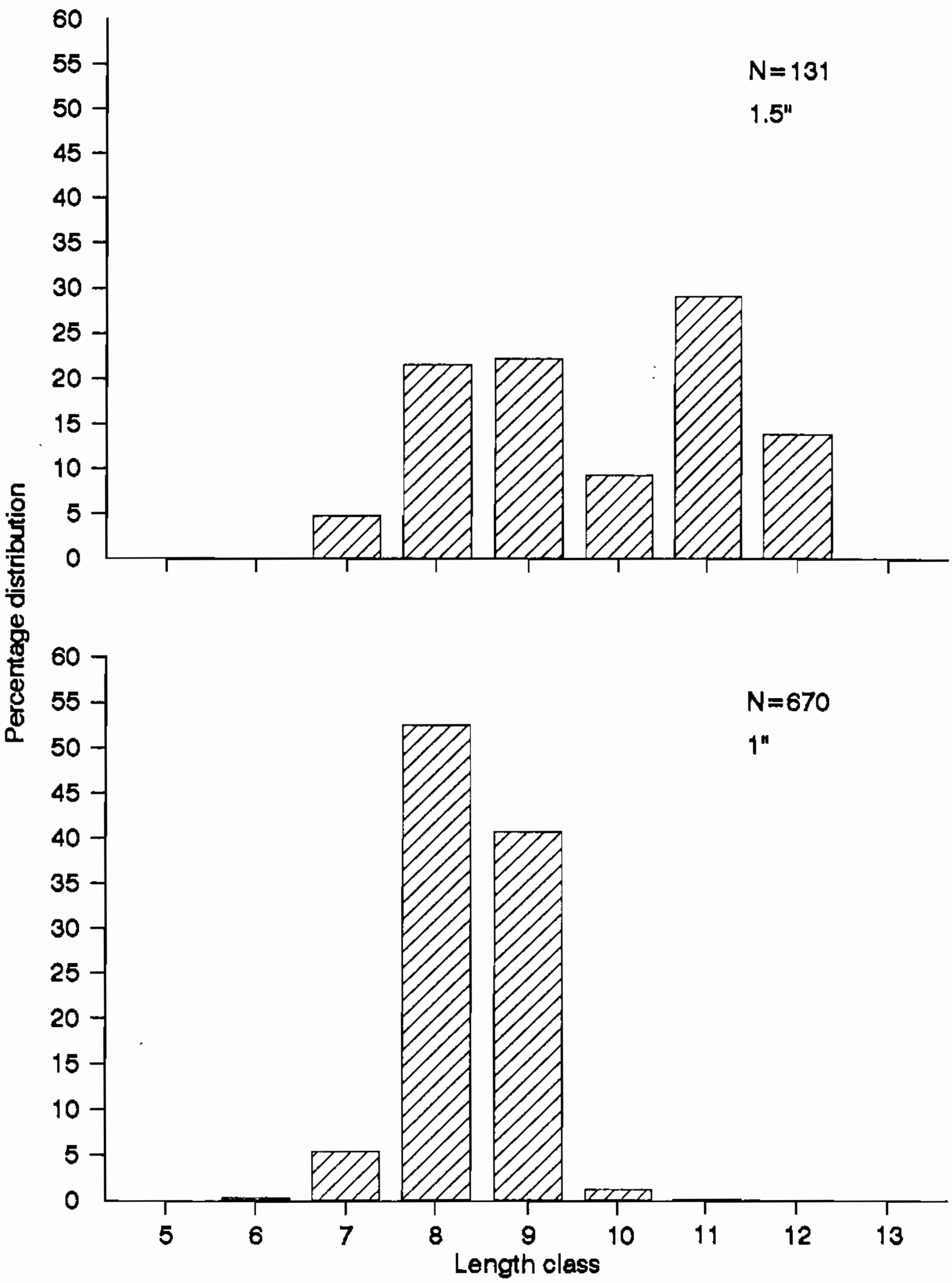


Fig.19. Length frquency distribution of Enterochromis nigripinnis caught in passive experimental fishing in Lake George Data collected Jan - April 1997

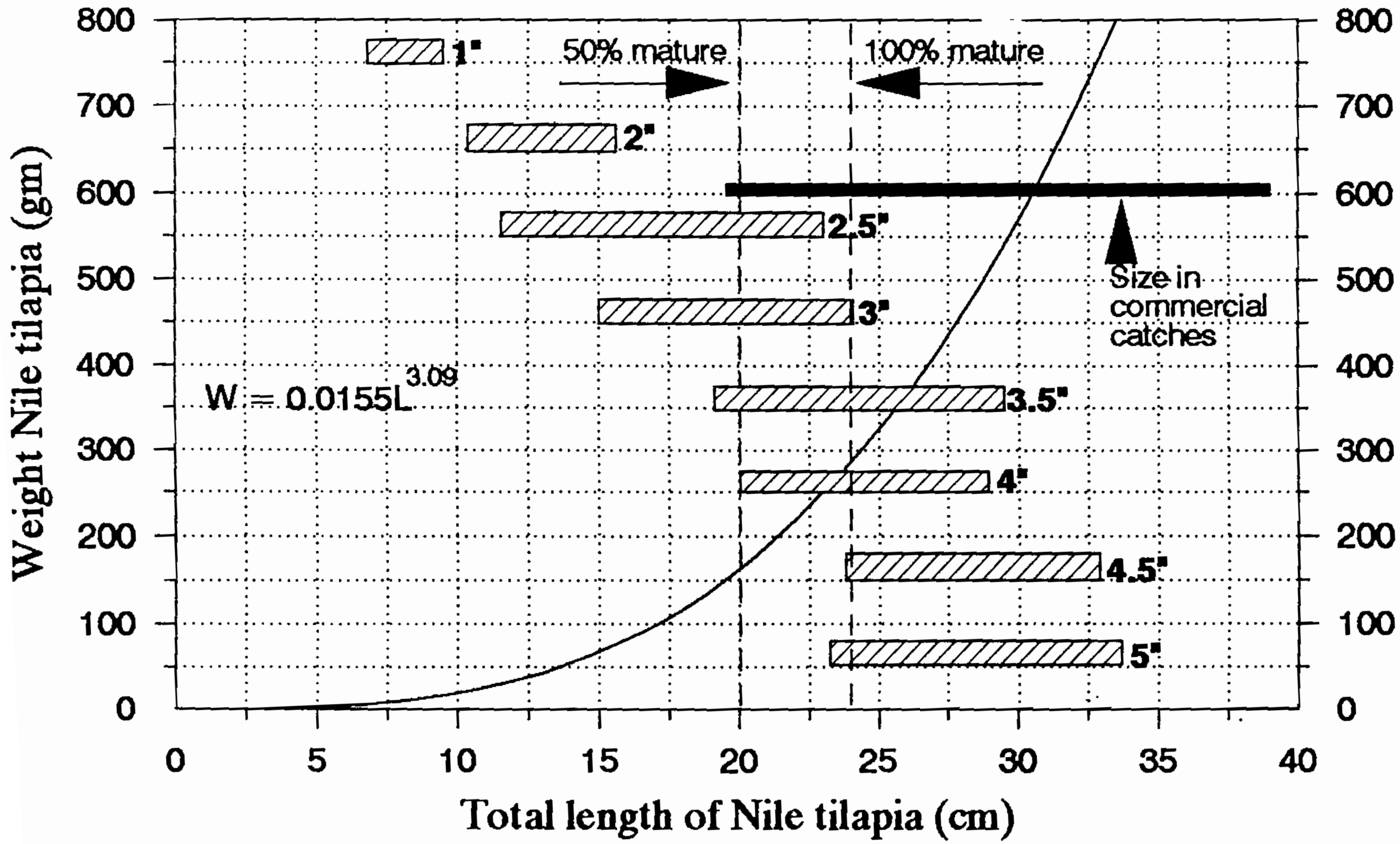


Figure 20. The length range of Nile tilapia caught in gill nets of different sizes in relation to size at first maturity of the fish

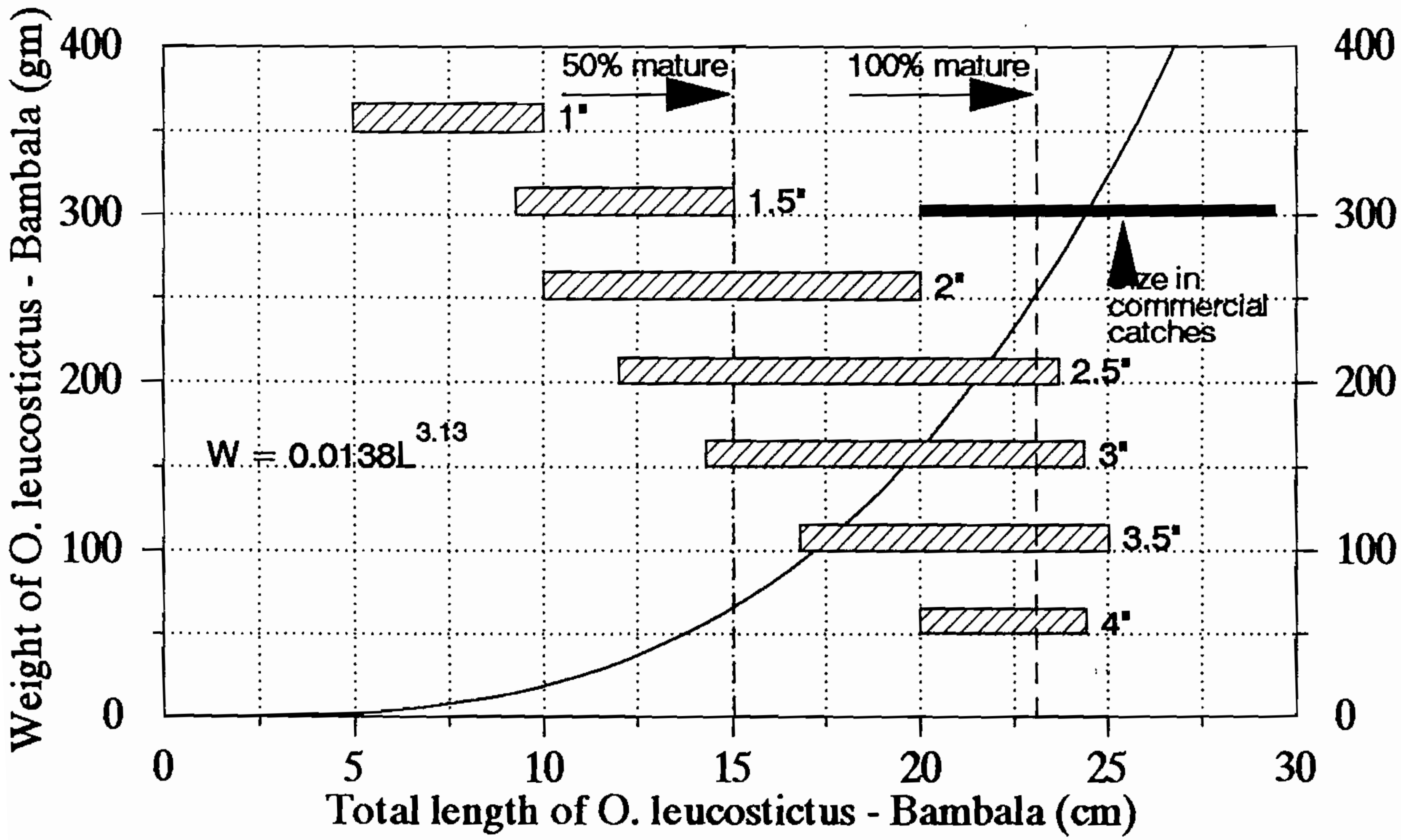


Figure 21. The length range of Oreochromis leucostictus caught in gill nets of different sizes in relation to size at first maturity of the fish

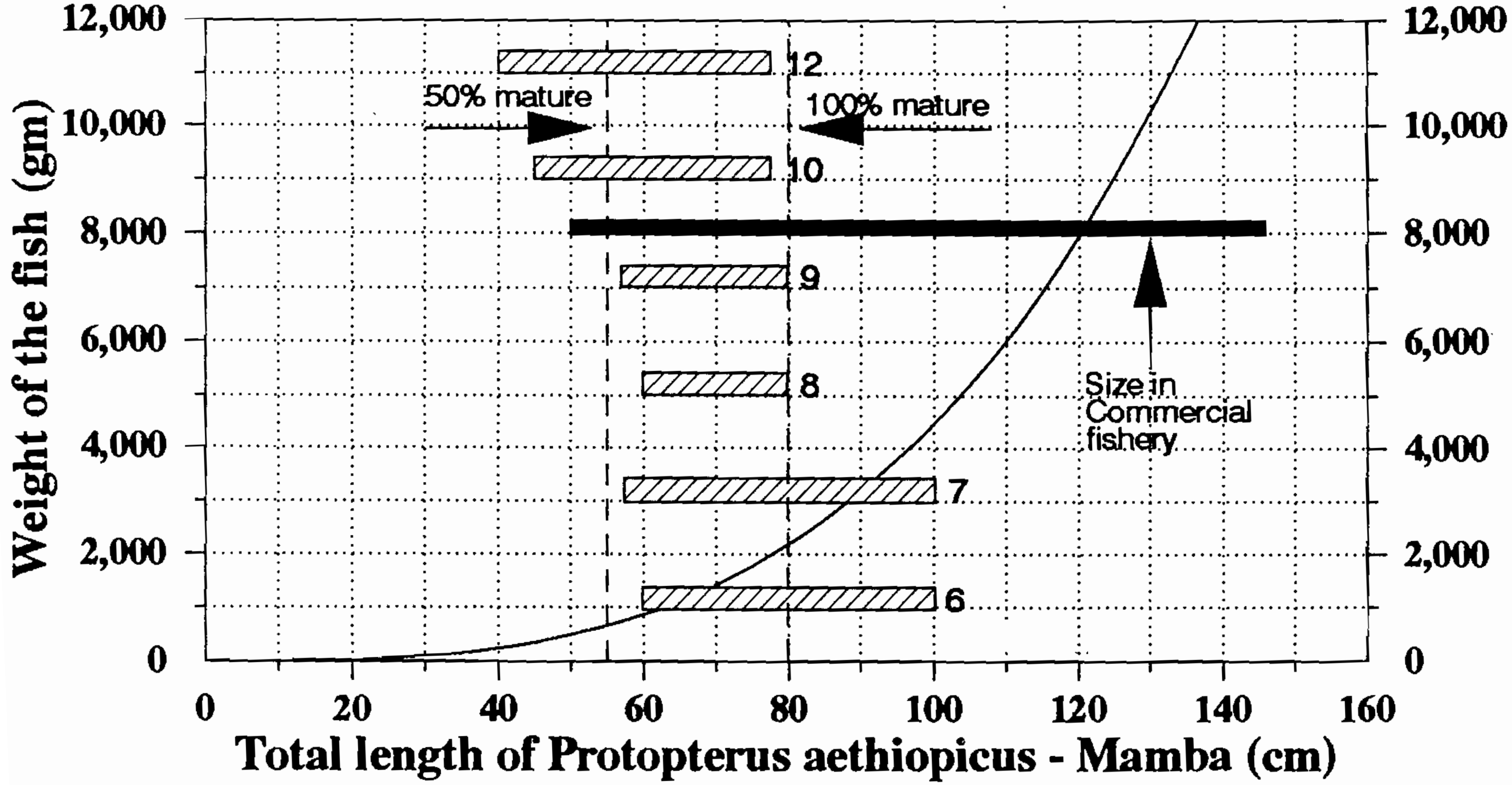


Figure 22. The length range of P. aethiopicus caught in hooks of different sizes in relation to size at first maturity of the fish

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Appendix 3.1 The schedule of activities given to the consultant by CARE

Fish stock assessment on Lake George

Background

In order to address probiems of increasing pressure on Queen Elizabeth National Park, manifested in the high demand for fuel wood by fishing village communities residing in the park, and declining fish stocks on Lakes George, Edward, and Kazinga Channel, a concept project, Queen Elizabeth National Park fishing village conservation Project (QENP-FVCP), was conceived by CARE in 1989. With the support from DANIDA through CARE. Denmark, a two year pilot Project was approved and funded.

The project started Januar 1996 and was officially launched in March '96 at a start-up workshop that was attended by all Project key stakeholders. The Project now has a logical framework and a draft monitoring and evaluation plan. A baseline survey is in the process of being concluded.

Problem Statement

The waters in question constitute a "closed-access fishery". The number of canoes/boats officially registered to exploit this fishery is 409 and was fixed in the early 50s. The population then was minimal (fishing camps) but has increased significantly to 30,000 people. It is also necessary to note that the economy of the fishing villages is virtually 100% dependent on fishing.

The theoretical Maximum Sustainable yield (MSY) for Lake George is in the range of 3000 tons/yr and that of Lake Edward is 5000 tons/year (Dr. Ian Dunn 1989). Presently, official statistics indicate that the yield for Lake George is 5000 tons/yr and that of lake Edward is 6000 tons/yr (Fisheries Dept.). It is without doubt that these figures do not account for the illegal fish catch. The present level of exploitation of fish resources threatens the Biological optimum fishing rate. There is excessive exploitation of juveniles (under recruitment age) which risks the spawning stocks and hence depletes the fishery.

To date, many people are involved in fishing and thus the Effort has greatly increased and fishing malpractices become rampant. This is manifested by the present low catches, use of undersized nets and hooks, size of fish at landings, destructive fishing methods in use, illegal landings, landing at night, fishing in breeding areas etc. It is feared that the Total Allowable Catch (TAC) has been exceeded and overfishing has set in.

It is therefore imperative to carry out a study to establish the current Fish Stock base. The results of the study should provide the following information:

- Whether it is necessary to restock the Lakes
- Laws to be enforced to reduce the malpractice's on the Lakes
- What extension methodologies to be emphasized to improve the situation

Objectives for the Research:

The goal of the study will be to generate knowledge on the current status of the fish stocks, which will be used in designing development and management policies for enhancing sustainable fish production from the lake while conserving the natural resource base.

This will be achieved by:

a) determining the composition, relative abundance and distribution of fish stocks;
b) estimating the optimal fishing effort for exploiting these stocks;
c) determining the impact of fishing gears, methods and the most suitable fishing gears and methods for exploiting the stocks;
d) determine fish species diversity and the factors that promote conservation of biodiversity;
e) examining the biology and ecology of the major commercial species especially the size at first maturity; reproductive potential, breeding grounds etc.;
f) identify socio-economic causes of unsustainable practices; and
g) identifying mechanisms of involving communities in development and management of the fishery resources.

Specific Tasks, to be performed.

1. Prepare a research proposal on how this study will be carried out, including the methodology, the duration and the budget. This will be reviewed by CARE, Fisheries Department (FIRI) and (UWA) to determine which researcher handles the study.
2. Present the Proposal in 1 above to CARE, UWA and Fisheries Department, (FIRI).
3. Meet the Project Manager and ACD - Program and agree on the schedule of visits to the project area.
4. The consultant should contact the Commissioner Fisheries Department and establish what the department's expectations are, and who from the department could serve as a regular contact for the consultancy in the course of undertaking this assignment.
5. Review the documents from the Fisheries department related to fishing industry in the waters of Lake George and pick what is relevant while carrying out the assignment.
6. Carry out the study
7. Present the draft study report to CARE, Fisheries Department and other key stakeholders at a one or two day workshop for appropriate feedback.
8. Finalize the study report incorporating all feedback and hand it over to the ACD Program.

Specific Outputs:
1. The research proposal
2. The draft study report
3. The final study report

Time Frame

This study will be carried out starting October, 1996 and ending April, 1997. The research workplan is attached.

Appendix 3.2. LIST OF PARTICIPANTS

NAME	OCCUPATION	STAKE	ADDRESS
1. Glenn Bush	ODA Representative	Donor	
2. Musinguzi K	Fisherman	Resource user	Kahendero Fishing Village
3. Kyeyune K	Fisherman	Resource User	Katunguru Fishing Village
4. Tibazimanya	Fisherman	Resource User	Kashaka Fishing Village
5. Okalebo	Fisheries Officer	Resource Manager	P. O. Box 51 Bushenyi
6. Wabulya Faith	Fisheries Officer	Resource Manager	P. O. Box 4, Entebbe
7. Ndoleriire Patrick	Ag. Chief Park Warden	Resource Manager	P. O. Box 22, Mweya
8. Odongkara	Researcher	Researcher	P. O. Box 343, Jinja
9. Kamanyi J	Researcher	Researcher	P. O. Box 343, Jinja
10. Mugume F	Researcher	Researcher	P. O. Box 343, Jinja
11. Wadanya Jack	Senior Fisheries Officer	Policy Maker	P. O. Box 102, Entebbe
12. Buga Mike	Regional Fisheries Officer	Resource Manager	Kichwamba
13. Ndyabarema Robert	Project Coordinator	Donor	CARE, P. O. Box 181, Kasese
14. Wadunde O	Senior Extension Officer	Resource Manager	P. O. Box 343, Jinja
15. Wandera S.B.	Researcher	Researcher	P. O. Box 343, Jinja
16. Rutahaba E	Fisherman	Researcher User	Hamukungu Fishing Village
17. Mbaga Kaana	District Fisheries Officer	Resource Manager	Kasese
18. Magezi D	Fisherman	Resource User	Katunguru Fishing Village
19. Bagonza G	Fisherman	Resource User	Kasenyi Fishing Village
20. Bitalimpumura	District Fisheries Officer	Resource Manager	P. O. Box
21. Kambe A	Chief Research Officer	Researcher	P. O. Box 22, Mweya
22. Abigaba J	Fisherman	Resource User	Kayinja Fishing Village
23. Kaheeru J	Fisherman	Resource User	Mahyoro Fishing Village
24. Ogutu-Ohwayo R	Researcher	Researcher	P.O. Box 343, Jinja
25. Nyakahuma J	Rep. Chief Administrative Officer	Policy Maker	P. O. Box

NAME	OCCUPATION	STAKE	ADDRESS
26. Asiimwe B	District Economist	Policy Maker	P. O. Box
27. Rumanzi C	Fisheries Officer	Donor Represenative	CARE, P. O. Box 181, Kasese
28. Nganda P	Project Manager	Donor Respresenative	CARE, P. O. Box 181, Kasese
29. Polly Dolan	Population & Environment Fellow	Researcher	CARE, P. O. Box 181, Kasese
30. Kazoora C	Environment	Researcher	

Appendix 3.3

QUEEN ELIZABETH NATIONAL PARK FISHING VILLAGES CONSERVATION PROJECT

WORKSHOP ON THE STATUS OF FISHERIES AND FISH STOCKS OF LAKE GEORGE

WEDNESDAY 7TH MAY 1997

WORKSHOP PROGRAMME

TIME	ACTIVITY
9.00 a.m	Registration of Participants
9.30 a.m	Opening Remarks by QENP. FVC Project Manager
10.30 a.m	TEA
11.00 a.m	Presentation of the draft report Chairman - Philemon Nganda Rapporteur - Jonna Kamanyi and S. Wandera
	Reactions: -District Fisheries Officers (Bushenyi, Kasese, Kabarole) -Commissioner Fisheries -Director Fisheries Research Institute -Uganda World Life Authority -Lake George Environmental Economic study
1.00 p.m	LUNCH
2.00 p.m	Multi-disciplinary Groups to discuss report and recommend actions to be taken Chairman - Odongkara Rapporteur - Owori Wadunde -Resource Users (Fishermen) -Resource managers and policy makers -Donor representatives/Non-government organisations -Researchers
	TEA
4.00 p.m	Plenary: to discuss group reports and make recommendations on actions/actors Facilitators - Ogutu-Ohwayo
	Closing Remarks -Manager QENP. FVC Project -Representatives - Kabarole District Authorities

Appendix 3.4

Kasese fish in danger

LAKE George and Edward fish resource is threatened with depletion due to rampant catching of immature fish, government officials in Kasese have said, reports John Nzinjah in Kasese.

"There is rampant illegal fishing on Lakes George and Edward and very soon there could be no fish, which is a dangerous situation to the future generation," the LC 5 boss Kasese noted. Mr Bamusede Bwambale blamed the situation on failure by the fisheries department to curb illegal fishing on the lakes. He said catching of immature fish was going on unabated

A fisheries assistant, Mr Kana Mbaga, told *The New Vision* that curbing illegal fishing and catching immature fish is the responsibility of the zonal fisheries officer based in Kichwamba, Bushenyi. A source in the regional fisheries office said their department does not receive funds from the mother ministry. The source said that for the last ten years they had not been funded to patrol the lakes. "But the situation is grave," the source admitted.

Assistant Resident District Commissioner Joseph Mbuse threatened to arrest fish mongers who sell immature fish.

"If the fisheries department officials have failed to do their job, for us we shall round up those people bringing immature fish to our markets," Mbuse warned last week in an interview with *The New Vision*.

Meanwhile, Katwe fishermen have urgently appealed to government to institute measures to ensure that Lakes George and Edward are not depleted of their fish resources, reports **John B. Thawite.**

From New Vision of 15th April 1997

Appendix 3.5

DISTRICT NEWS

Uganda Fisheries in danger

Report from Lake George

By Tumwine Yasin

Fishermen on Lake George are carrying out prohibited fishing practices and nobody seems to care.

A tour of the lake and neighboring villages in Kabarole, Bushenyi and Kasese Districts last month turned up one village with over 2,000 immature fish killed in one day. This is not unusual.

Illegal fishing practices thrive in this fertile fishing ground. Dangerous methods, known locally as *taikun* and *omwoko*, are commonplace. Both techniques involve hitting the water surface with devices that produce deafening sounds for immature fish, causing them to die en masse and float to the surface. Mature fish flee the area, settling in places less suitable for breeding.

Taikun and omwoko are prohibited in Section 27 of the 1996 Uganda Wildlife Bill. The Fish and Crocodiles Act, as amended in 1967, also provides "control of fishing, conservation, purchase, sale, marketing and processing of fish and catching of crocodiles."

Ugandan law prohibits fishing without a license and even with a license it is illegal to kill or injure fish using poison or noxious substances.

At least 80% of the fishing activities I witnessed on Lake George were illegal. When a Local Council Chairman, who refused to give his name, was asked why he doesn't apprehend the illegal fishermen, he said, "that is the work of the fisheries officers." Other government officials concerned with fisheries refused to speak about the issue.

Tumwine Yasin is a Presenter with the Voice of Toro, 101 FM.

Report from Lake Edward

By Jackson Katarikaawe

The immature fish that make it to the dinner table are known locally as *maama yagimpa yoona*. This means "mother gave it all to me," referring to children being served whole fish as opposed to small pieces of fish.

The children may be happy, but Lake Edward's fish stock faces sure depletion if the practice continues. Harvesting immature fish is akin to eating the seeds for next year's crop. The lake has already lost all its *nkejje* (Haplochromines). It would be a tragedy to let other species perish as well.

How are these fish being caught? At all landing sites along the lake I found fishermen using sub-standard, small gauge nets. A lot has been said about this but nothing is being done to stop it. Local leaders are said to be involved in fabricating unlicensed boats that use the nets.

With fishmongers are on the increase, Lake Edward's fish stock faces total depletion if the harvesting of immature fish is not stopped.

Jackson Katarikaawe is the South Western Area Representative for the East African Wildlife Society, Uganda Chapter.

From Nature Watch of 25th April 1997