BIOMASS AND DISTRIBUTION OF COMMERCIALLY IMPORTANT FISH SPECIES IN LAKE VICTORIA (UGANDA), THEIR EXPLOITATION AND MANAGEMENT

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1.0. INTRODUCTION

Until the 1970s, Lake Victoria had a multi-species fishery dominated by the tilapiine and haplochromine cichlids. There were important subsidiary fisheries for more than 20 genera of non-cichlid fishes, including catfishes *(Bagrus docmak, Clarias gariepinus, Synodontis* spp and *Schilbe intermedius)*, the lungfish *(Protopterus aethiopicus* and *Labeo victorianus)* (Kudhongania & Cordone 1974). Stocks of most of these species declined and others disappeared following the introduction of four tilapiines *(Oreochromis niloticus, Oreochromis leucostictus, Tilapia rendalli* and *Tilapia zillil)* and Nile perch *(Lates niloticus)* during the 1950s. Since then the commercial fishery in the Uganda portion of Lake Victoria has been dominated by the Nile perch, Nile tilapia *(Oreochromis niloticus)* and the native cyprinid species, *Rastrineobola argentea* (Mukene).

Lake Victoria is an important source of fish not only for local consumption but also for export. A number of fish processing plants have been constructed along the shores of the lake, 11 of which are licensed to operate in Uganda (Odongkara & Okaronon 1999). The fishing capacity in the Uganda sector increased from about 3200 fishing canoes in 1972 to 8000 by 1990 (Okaronon 1994) and was estimated to be about 10 000 canoes in 1998 (C. Dhatemwa, personal communication). The Frame survey of March 2000 estimated about 16 000 canoes in the Ugandan sector of the lake (Uganda Fisheries Resources Department 2001 , Asila 2001).

This increase in fishing effort and investment was made without clear knowledge of the magnitude of the stocks. There are indications that the fishery yield has declined from 135 000 tonnes (t) in 1993 to 107 000 t in 1997

(Odongkara & Okaronon 1999). The only previous extensive stock assessment exercise undertaken was from 1969 to 1971, before the Nile perch upsurge (Kudhongania & Cordone 1974). Some other bottom trawl surveys were conducted from 1981 to 1985 (Okaronon *et al.* 1985; Okaronon and Kamanyi 1986) and from 1993 to 1997 (Okaronon 1994, Odongkara & Okaronon 1999). The recent fish stock assessment programme, which commenced in 1997, was designed to generate information to underpin management decision making for the fishery. This included estimating the current composition, distribution, abundance, population structure and biomass of the major fish species. The objective of this paper is to provide an overview of the state of the fish stocks in the Ugandan portion of Lake Victoria with particular reference to biomass and distribution of the commercially important fish species, their exploitation and management..

2.0. **STATE OF FISH STOCKS**

2.1. Pre-Nile perch period

The original major commercial FISH species (the tilapiines) were abundant only in sheltered inshore waters of less than 20 m deep and a distance of about one kilometre from the shoreline whereas other cichlids and non-cichlid fish had a wider distribution (Graham 1929).

The trend of the fishery between 1900 and 1970s was of increasing fishing intensity, expansion to more offshore waters and decreasing catch per unit of effort (CPUE). The initial catch rates (numbers of fish per net per night) in 127 mm mesh size of gill nets of 45 m length was in the range of 50 to 100 tilapia *(Oreochromis esculentus)* but by 1968 the catch rates had declined to 0.35 fish per net per night (Jackson 1971). The decline in fish catch rates on Lake Victoria prompted the first fisheries survey in 1927 (Graham 1929) after which a minimum gill net mesh size of 127 mm was recommended and imposed in 1931.

When the catch rates of the larger species declined, there was a gradual shift to smaller, originally less preferred fish species particularly the haplochromine cichlids and *Rastrineobola argentea*. The need for changes in fishing strategy so that the harvest represented quantitatively and qualitatively the available stocks, prompted the UNDP/FAO and EAFFRO lake-wide fish stock assessment survey of Lake Victoria in 1969 to 1971. This survey showed that although many fish species were confined to the shallow inshore waters, there were considerable quantities of fish allover the lake and at all depths. The survey again indicated that 83% of the demersal ichthyomass in the lake consisted of haplochromine cichlids with a potential yield of 200 000 t. The other important fish species were *Bagrus docmak* 4.2% by weight, *Clarias gariepinus* 4.1%, *Oreochromis esculentus* 3.8%, *Protopterus aethiopicus* 2.8%, *Oreochromis niloticus* 0.5% and S. *victoriae* 0.4%. *Lates niloticus* catches were insignificant (<0.1%). A mean catch rate of 797 kg h^{-1} was estimated for waters between 4 m and 30 m deep.

2.2. Post Nile perch period

Bottom trawling in the Ugandan waters of Lake Victoria during 1981-1985 (Okaronon *et ai,* 1985; Okaronon and Kamanyi 1986) recorded all but two of the non-cichlid species *Gnathonemus longibarbis* and *Brycinus* sp. found in the 1969-71 surveys. Haplochromines in the trawl catches declined from 91.4% in 1981 to almost zero in 1985, while the contribution of *L. niloticus* increased from 5% to 96% during the same period. The mean catch rate for all fish species combined declined from 595 kg h^{-1} in 1981 to 355 kg h^{-1} in 1983 and to 155 kg h^{-1} in 1985 (Fig. 1).

During the survey of May 1993 to October 1997 (Okaronon 1994, Odongkara & Okaronon 1999), *L. niloticus* contributed 96.5% of the total fresh catch by weight. Fish diversity and abundance decreased with increasing water depth. About 60% of the total fish catch was in waters less than 30 m deep. The mean annual catch in the 4-30 m depth zone was 150 kg h^{-1} (Fig. 1).

2.3. Current state of fish stocks

During the bottom trawl surveys of November 1997 to December 2000, 17 species groups (14 genera) were recorded (Tables 1). *L. niloticus* (Nile perch) dominated the catches (90.1 % by weight) followed by O. *niloticus* (Ngege) (6.7%) and haplochromines (3.1%); all other species together contributed about 0.1 % (Table 1). The catches, in order of importance, were in Zone I – Western, i.e. between Tanzania/Uganda border and Bugoma Channel in Bukakata - (average of 250.6±56.4 kg h(1), Zone II - Central, i.e. between Bukakata and Rosebury Channel in Kiyindi - (195.1 ±22.7 kg h(1) and Zone III (163.3±25.1 kg hr^{-1}). Species diversity was greatest in waters of 10-20 m deep and decreased with increasing depth (Table 1). The highest proportion of the fish (92.2%) was found in waters <30 m deep, the operation area for the artisanal fishermen.

L. niloticus and haplochromines occurred in all areas sampled while 0. *niloticus* and other tilapiines were concentrated in waters less than 20 m deep (Table 1). Few fish were caught in depths greater than 40m, and these were restricted to *L. niloticus*, haplochromines and *Barbus* spp (Kisinja). In waters deeper than 40 m, fish was rarely recorded during bottom trawling. The echosounder indicated no fish at the bottom; the fish signals were concentrated in the depth zone 10-20 m from the surface.

The mean catch rate declined from 228.97±38.14 kg hr^{-1} for all fish species in the 4-10 m depth zone to 6.00 kg hr^{-1} at 40-50 m depth during the survey period 1997-2000 (Table 1). A mean catch rate of 185.94±23.53 kg hr^{-1} was estimated for the 4-30 m depth range where the artisanal fishers operate. This reflects a four-fold decline in fish stock densities in the 4-30 m deep waters from 797 kg hr^{-1} (362 kg $ha\text{-}^{1}$) during 1969/1971 to 186 kg hr^{-1} (85 kg $ha\text{-}^{1}$) for *L. niloticus* in the present study (1997/2000).

From the swept area method, the abundance index for all fish species living within 3-m column of water from the bottom in the 4-40 m depth zone in the Uganda portion of the lake was estimated at around 142 000 t during the period 1999-2000. The abundance for *L. ni/oticus* and O. *ni/oticus* were estimated around 121 000 and 15000 t, respectively, during the period 1999-2000. These figures were interpolated to 694 000 t of *L. ni/oticus* in Lake Victoria of which 307 000 t was estimated for the Uganda portion.

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The abundance index for *L. ni/oticus* was distributed to all length groups on the basis of the length frequency distribution (358 622 fish) of 2 cm to150 cm size range. The abundance indices showed that only 29.3% of the bottom dwelling Nile perch during 1999-2000 was mature fish (>50 cm total length) and the rest were juveniles. All sizes of Nile perch were encountered in all areas surveyed (4-60 m deep waters); the bulk (63% by numbers) of the immature Nile perch «50 cm TL) were caught in waters <20 m deep.

3.0. **EXPLOITATION PATTERNS**

3.1. <u>The original fishery of Lake Victoria</u>

The original major commercial species, the tilapiines, were abundant only in sheltered inshore waters of less than 20 m deep and a distance of about one kilometre from the shoreline whereas other cichlids and non-cichlid fish had a wider distribution (Graham 1929). These waters were easily accessible to traditional fishers who used small fishing boats ranging from simple rafts, to canoes made out of reed bundles and dugout canoes. All were hand propelled and used simple locally made fishing gears, mainly hooks and lines, harpoons and lances, non-return traps, basket traps and seines made out of papyrus. The virgin fishery provided excellent catches that satisfied the demand of the local markets around the lake. Fishing for mainly tilapiines was limited to inshore waters that were also breeding grounds of most fish. Cropping of young fish and brood stocks in these areas was detrimental to the renewability of the fishery resource.

The trend of the fishery between 1900 and 1970s was of increasing fishing intensity, expansion to more offshore waters and decreasing catch per unit of effort (CPUE). Fishing started to intensify with the introduction of efficient cotton flux gill nets in 1905 (Worthington & Worthington 1933); improved communication such as extension of the railway line to Kisumu in 1908 which facilitated the importation of modern fishing gear and supply of fish products to distant markets; the increased demand of fish due to development of urban centres and increasing human population around the lake (Graham 1929, Jackson 1971, Ogutu-Ohwayo 1990).

By 1955, catch rates had fallen to an extent that it was unprofitable to use 127 mm mesh size nets. Most of the fishers began using smaller meshes to catch the then un-exploited length ranges of fish. From that time onwards, the fishers continued shifting to smaller meshes whenever the catches in the larger meshes decreased. This made the 127 mm mesh regulation - instituted and implemented in 1933 (Beauchamp 1955 - so difficult to enforce that it was repealed in Uganda and Tanzania in 1956 and in Kenya in 1961 (Jackson 1971). The removal of the mesh size limit resulted in lack of uniform management policy for the whole lake. The subsequent trend of uncontrolled fishing effort and the continuous decline in gill net mesh size in use led to the collapse of the native tilapia (O. *esculentus)* fishery. During the 1950s the fishing pressure was further increased when synthetic fibre gill nets with greater efficiency and a longer life span than the cotton flux gill nets were introduced in 1951 and communication on the open lake were further improved with the introduction of the out board engine in 1953 (Mann 1969).

3.2. The current fishery of Lake Victoria

The current fisheries on the Ugandan sector of Lake Victoria are dominated by the artisanal fishers using traditional planked boats (estimated at 15 544), operating from about 597 landing sites (Uganda Fisheries Resources Department 2001). A variety of fishing gears and fishing methods based on

221 fishers interviewed randomly on selected fish landing sites (Kamanyi 2000) are shown in Table 2.

During the Catch Assessment Survey (CAS) in January-March 1989 (Okaronon and Kamanyi 1989), gillnets were also the major fishing gear used by fishers in the Uganda sector of the lake. Other gears noted were the seine nets, cast nets (prohibited in Uganda), and hooks on long lines. Gillnets of mesh sizes ranging from 101.6 mm (4 inches) to 304.8 mm (12 inches) were in common use. The most popular mesh sizes of nets were 203.2 mm (45.5% of the total number of nets counted) and 127 mm (22.8%). These nets targeted the Nile perch and Nile tilapia. The 127 mm mesh nets retained Nile tilapia that were mature (Fig. 2) and the majority of Nile perch that were immature (Fig. 3). Considering the size at first maturity for the male Nile perch to be 50 cm TL and 95-110 cm TL for females and the size at first maturity for Nile tilapia as 26 cm TL (Ogutu-Ohwayo 1988), the nets below 127 mm mesh retain mostly immature fish.

3.3. Spatio-temporal exploitation patterns

At the beginning of the 20th century the native fishery depended on few predominantly near-shore fish taxa. O. *escu/entus* was the most important commercial species followed by O. *variabi/is* (Graham 1929, Mann 1969, Jackson 1971, Ogutu-Ohwayo 1990). Other important species included P. *aethiopicus* Heckel 1851, B. *docmak* Forskal 1775, C. *gariepinus* Burchell *1822*, *Barbus* sp., mormyrids and S. *intermedius* Linnaeus 1758. *L. victorianus* Boulenger 1901 formed the most important commercial species in the affluent rivers of the lake's basin (Cadwalladr 1969). Haplochromine cichlids and *R. argentea* Pellegrin 1904 were abundant but, because of their small size and low market value, were not originally exploited on a large scale.

The upsurge of the introduced fish species especially Nile perch has coincided with a phenomenal increase in total annual fish yield. The increase in exploitable fish stocks arising out of establishment of Nile perch has attracted major investments in the fishing industry transforming the fish markets from local to broad sections of the East African region and overseas markets.

Large-scale commercial and overseas fish export ventures have been established around the lake in Uganda, Kenya and Tanzania (Reynolds et al 1995). The rapid expansion of the fish filleting capacity around the lake has significantly increased export earnings to the extent that in 1996/97 Financial Year fish exports were next to coffee in overall national exports in Uganda fetching US$41.37 million (Ministry of Planning and Economic Development 1997).

The total catch from the Ugandan waters of Lake Victoria fluctuated around 35000 t between 1961 and 1969, declined during the 1970s and early 1980s before beginning to pick up again in 1983 (Fig. 4). Lake Victoria was leading fish production up to 1969 during which period it was contributing between 30% and 40% of national fish production. After 1969, most of the fish production in Uganda came from Lake Kyoga before Lake Victoria fishery began to pick up and surpass that of Lake Kyoga in 1987. During 1990, fish production from Ugandan waters of Lake Victoria was estimated at 119 900 t (49% of national fish production) down from 132400 t (62% of national fish production) during 1989 and 135 000 t (48.8% of national production) in 1993. Fish production in Lake Victoria (Uganda) has been fluctuating between.103 040 t (47.1%) and 106 000 t (48.5%) since then.

Since 1987 the major fish species landed by the artisanal/commercial fishers operating on the Uganda waters of Lake Victoria were Nile perch, the tilapiines (mostly Nile tilapia) and Mukene. The other fish species *Bagrus, Barbus, Clarias, Mormyrus, Protopterus* and *Synodontis sp* constituted about 3% of the total production in 1989. In 1995 fish production, in order of importance, was Nile perch (61.8%), Nile tilapia (23.3%), Mukene (12.9%), *Mormyrus* spp. (0.6%), P. *aethiopicus* (0.5%) and *Clarias* spp. (0.2%). The landed commercial catches of Nile perch in the Ugandan sector of the lake drastically increased during the 1980s from below 5% during the 1970s to about 86% of the total landed catch by weight in 1988.

During the 1989 CAS of the Uganda sector of Lake Victoria, a total of 8 fish species groups were recorded in the commercial artisanal fish catches. These included *Bagrus* sp., *Barbus* spp, *L. ni/oticus,* P. *aethiopicus,* 0. */eucostictus,* O. *ni/oticus,* O. *variabi/is,* and *Ti/apia zi/lii* (Okaronon and Kamanyi 1989). During this survey the tilapiines and *L. ni/oticus* contributed 49.3% and 49.1% of the total landed catch by fresh weight, respectively, although a year earlier (1988) the contributions from the tilapiines and *L. ni/oticus* to the commercial catch was estimated at 11% and 86% by weight, respectively (Uganda Fisheries Resources Department 1988).

The fishery of the Uganda sector of the lake is already showing symptoms of decline in annual yield despite the increasing fishing effort (Okaronon 1994, Fig. 4). Basing on the biology of *L. ni/oticus* and O. *ni/oticus* (Balirwa 1989, Fryer & lies 1972, Ogutu-Ohwayo 1988), exploitation would be the main process to influence sustainability of increased fish catch levels of the three major commercial fish species in the future fishery of the lake. The lake continues to have unlimited entry for the number of fishers and fishing gears and there is gradual expansion of the fishing industry fuelled by establishment of fish processing factories which can lead to overfishing and collapse of the new fishery if there is no regulation of fishing effort.

4.0. **FISHERY MANAGEMENT OPTIONS**

4.1. The need for management regulation

and the fishing pressure on Lake Victoria are very high. It is, therefore, logical to set the gillnet limit for the Nile tilapia at 100% maturity to ensure enough spawners in the population. In Lake Victoria, 100% maturity for Nile tilapia is at 28.5 cm TL. This would require a minimum gillnet mesh size of 127 mm (5 inches) (Fig. 2)

The size at first maturity for male Nile perch is 50 cm TL and 95-110 cm TL for females (Ogutu-Ohwayo 1988). This would mean that the minimum mesh size suggested above for the Nile tilapia would crop immature Nile perch (Fig. 3). However, biological and ecological considerations may justify setting the minimum mesh at 127 mm (5 inches). Nile perch up to 50 cm TL feeds predominantly on invertebrates especially *Caridina nilotica* and dragonfly nymphs. At this size it plays a beneficial role as it converts the invertebrates into consumable commodity fish. After this length Nile perch feeds on Mukene *(R. argentea),* juveniles of Nile perch and Nile tilapia and concentrates on Nile tilapia after about 95 cm TL (Uganda Journal 1998). Large Nile perch are, therefore, destructive to other commercially important fishes after 50 cm TL. Use of mesh sizes which crop Nile perch that feeds on other commercially important fish species would, therefore, be beneficial to the fishery by reducing predation pressure on the only two other commercially important fish species (O. *niloticus* and R. *argentea)* in Lake Victoria. This size range of Nile perch of about 50 cm TL coincides with the mesh size limit suggested for the Nile tilapia. This further suggests that the minimum size of Nile perch permitted should be set at 50 cm TL. It has previously been recommended (Schindler *et al* 1995; Ogutu-Ohwayo 1985) that fishing pressure on Nile perch of the size range which feeds on other commercially important fishes should be increased.

Use of beach seine nets, most of which are 51 mm to 102 mm (2 to 4 inches) mesh size has been rampant on Lake Victoria. From Fig.3, it is clear that small mesh sizes of gill nets mainly catch juvenile Nile perch of a lower length than that permitted by the current law. The dragging of beach seines on the lake bottom and near the lake margins furthermore destroys nests and breeding ground and disrupts courtship of Nile tilapia. Use of these nets should be prohibited.

4.2. Current management of Lake Victoria fishery exploitation

The legal framework on Lake Victoria is still largely an open access fishery, such that very few restrictions apply to canoes and gear used.

The law instituted and implemented in 1933 prohibited gillnets with meshes less than 127 mm, but this was repealed by Uganda in 1956 (Okaronon 1990, Okaronon and Wadanya 1991). The removal of the restriction on gillnet mesh sizes left the fisheries administrators with few other tools for direct control of the fishery. The law as presently constituted stipulates that the only prohibited gear on the Uganda sector of Lake Victoria are gillnets with a stretched length greater than 90 metres and a depth exceeding 30 meshes. There is, however, no limitation on the number of nets that can be used when set separately. There are no restrictions placed on the number of fishing canoes allowed to operate on the Uganda sector of the lake; it is only required that each canoe be licensed by Uganda Department of Fisheries Resources. Through the Statutory Instrument No. 15 of 1981, it was laid down that the legal minimum size of fish to be caught in the Uganda sector of Lake Victoria for Nile perch (L. *niloticus)* is 440 mm (18 inches) TL and for Nile tilapia (O. *niloticus)* be 280 mm (11 inches) TL. In Uganda, suggestions on the review of the Fisheries legislation were put forward (Dusabe 1995) on management and sustainability of the fisheries. Appropriate fishing technologies for sustainable fish production on Lake Victoria have been put forward (Kamanyi 1996).

Given the various developments and threats to the future of Lake Victoria fisheries, and local and commercial interests of those who depend on these fisheries for sustenance and profit, it is now increasingly necessary that more concrete and clear-cut policy measures be formulated and implemented. The recommendations for appropriate fishing gears and fishing methods for the major commercial fish species are summarized in Table 3.

Recent reviews of the 1964 Uganda Fish and Crocodile Act resulted in prohibition of use of seine nets and trawling, increasing fishing vessel license fees, creating Industrial Fish Processing licenses; this was in addition to limiting size of Nile perch and Nile tilapia to be caught. The reviews of the Act resulted in the separation of the extension from law-enforcement in 1992 leading to the existing Fishing Regulations and Control Unit (FRCU) (Kizza 1998).

The Local Government Act of 1997 has conferred to the decentralized line Ministry staff as extension staff. Out of the 53 staff in the Fisheries Department in 1998, 35 were for FRCU. Five of these are responsible for the five lake zones, one of which is Lake Victoria. These measures mandate FRCU, on behalf of Government, MAAIF (Ministry of Agriculture, Animal Industry and Fisheries) and the Fisheries Resources Department, to effectively manage the optimal exploitation of the fisheries resources.

The concept of involving communities around the lake to participate in internalising local fisheries related issues is becoming widely acceptable. Thus the Uganda fisheries industry is in partnership. The industry is now trying to nurture and foster stronger bonds between policy makers, researchers, extension workers and other stakeholders. The communities around Lake Victoria and elsewhere are being sensitised to respect the resources, have a sense of ownership and use them responsibly. This is being spearheaded by various donor agencies and projects that include Lake Victoria Environmental Management Project (LVEMP), Lake Victoria Fisheries Research Project (LVFRP) and Lake Victoria Fisheries Organisation (LVFO). Water Hyacinth Control Unit has a community participatory component. It is hoped that these communities will for example safe guard immature fish from exploitation, protect and scout closed areas and seasons; they are also expected to disseminate and impart precautionary messages on the utilization of the resources. Through the formulation of democratic and credible organisational structures, community participation can successfully be undertaken.

The improvement of fisheries management can only be successful if there is an established communication between all parties involved; these include the scientists, the administrators, decision makers and fishers (Okemwa 1991). All of them should cooperate in measures to manage the resource. Administrators should consider scientific advice, for example, on the level of effort to be used in the fishery. On the other hand, scientists should consider socio-economic factors that sometimes take precedence over biological objectives. Fishers should be made to understand that fisheries management is in their interest, so that they can harvest the resource more profitably and on a sustained basis. There should always be dialogue to promote better understanding among scientists, administrators, decision makers and fishers (Larkin 1982). The lack of dialogue and communication between the different parties involved in fisheries is considered as one of those factors that led to disastrous effects on the fishery, for example, decline in fish production.

RECOMMENDATIONS

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