NATIONAL AGRICULTURAL RESEARCH ORGANISATION

FISHERIES RESEARCH INSTITUTE

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Background

About 20% of Uganda territory is surface water from which 250,000m tons of fish is produced. In addition to fish exports which earned the country US$ 40m in 1996, fish provides 50% of protein diet of the 20m people

translating into a per capita consumption of 12kg. It is estimated that fishery related activities employ at least one million people.

Mandate

FIRI has the mandate "to promote, undertake and coordinate all aspects of research in fisheries, fish production systems and the water environment, aquaculture and socio-economics while conserving the natural resource base.

Goal

The goal of FIRRI is to generate and transfer improved technologies and policy recommendations aimed at ensuring sustainable fish production and a healthy environment in which fish is produced.

Objective

Governed by its mandate and the sector/policy framework, FIRI's objective in the agricultural modernization strategy is "to increase the quantity, quality and availability of technologies (information), policy advice (recommendations) and methods for the efficient and profitable use of fishery resources that also promotes food security while conserving the water environment.

Specific Objectives

The specific objectives of FIRRI are to:

- Generate technology, and provide information and policy recommendations on fish and fish production systems; and,
- Transfer technologies and policy recommendations generated to uptake pathways.

Programmes

- Limnology and Water Environment
- Capture Fisheries
- Aquaculture
- Post-harvest Fisheries, and
- Socio-economic issues are addressed across programmes

Staff

FIRRI had 97 NARO appointed staff (Annex I) including 22 research scientists, 14 technicians and other support staff at various levels (boat crew, administration/accounts, library and junior staff). Staff changes are detailed in Annex I.

Limnology and Water Environment

Research Objectives

The limnology and water environment research activities seek to understand the environmental basis of and constraints to fishery production. Research in the program generates information on the state and dynamics of the water environment and on its facilitation of and influence on fish productivity.

Constraints addressed

The main constraints addressed by research relate to:
a) changes in physico-chemical features
b) low productivity in some water bodies
c) impact of wetland degradation on fish production and water quality
d) water hyacinth infestation

Research focus

During the period under review activities focussed on:
- The productivity of Lakes Victoria and Kyoga;
- Capacity of wetlands to strip nutrients and pollutants from in-flowing water and their importance as interface fish habitats in lakes; and
- Growth, control and other dynamics of water hyacinth and its ecological and socio-economic impacts on the water environment, fisheries resource and the lake-shore communities.

Achievements

Lakes productivity

The sustainability of high fish production in addition to good water quality were the basis for experiments to resolve water quality deterioration in lakes Victoria and Kyoga during the 1990s. Symptoms of deteriorating water quality particularly in Lake Victoria included changes in water colour from blue to greenish, and increased frequency of dense algal blooms that were associated with widespread fish kills.

During 1997/98 further experiments were carried out to monitor physico-chemical properties and primary production (including phytoplankton species composition). Both lakes Victoria and Kyoga were sampled over the previously determined seasonal factors marked in the moths of January, March, May and October. In addition, zooplankton and benthic macrofauna biomass and abundance were determined. There was continued monitoring of nutrient regimes and spatial patterns in physical characteristics (including water transparency, conductivity, temperature) over lakes Victoria and Kyoga. In addition, similar measurements were carried out to assess the level of productivity in the smaller water bodies (lakes Bunyonyi, Mulehe, Chahafi) in south western Uganda.

As reported previously, it was further shown that increased nutrient loading particularly of phosphorus was responsible for the observed elevated algal biomass in the lakes. As a consequence, increased oxygen consumption as the algae decompose depleted the water column of oxygen during periods of the reported fish kills. In Lake Victoria the oxygenated (aerobic) habitable area was estimated to have been reduced by 50-60%. In Lake Albert, monitoring data gathered indicated shifts in algal species dominance.

Concerning fish-zooplankton interactions, experiments carried during 1997/98 revealed that in general, there are few mostly small-bodied species in Lake Victoria. Inspite of the eutrophication, some cyclopoids were found to be resilient and could be considered the food base of the Mukene (*Rastrineobola argentea*) which exhibits high densities during July and the last quarter of the year.

In addition to experiments on lake productivity, further work on the impact of perturbations in Lake Victoria on the biology of Mukene fish was continued. A major focus of this research was to find out whether changes in productivity mechanisms could affect the feeding of juvenile fish. Therefore, sampling of the water column for zooplankton as well as inshore habitats for fish was carried out over the defined seasons and day time periods

Wetlands

Following the successful inventory and biomass estimates of lakeshore wetland communities in Napoleon Gulf of Lake Victoria, a classification of the dominant plant associations and biomass estimates were made. Remote sensing (GIS) data and area estimates from topographic maps were used to compute cover change between 1960s and 1990s. Replicate experiments inside the interior of swamps and at the lakeshores were made off each dominant vegetation type to evaluate water quality and fish density features. Results showed that for northern Lake Victoria, lakeshore plant community associations could be used to define fish habitat types. The major habitat types thus described (Table 1) can be used for fish monitoring.

Table 1. Major plant communities (habitat types at the shore) identified by the dominant vegetation of the Lake Victoria wetland fringe.

Habitat type	Associated species
1. *Cyperus papyrus*	*Phragmites/Typha* *Ipomea, Melanthera* *Vossia cuspidata* ferns, *Polygonum* & *Cynadon*
2. *Phragmites mauritianus*	Phragmites – *Cyperus* – hibiscus
3. *Vosia cuspidata*	*Vossia* with *Cyperus* *Vossia with Eichhornia*
4. Typha domingensis	*Cyperus* *Phragmites* *Eichhornia*
5. *Sesbania sesban/micrantha*	*Aeschynomene* *Kotschya africana* *Cyperus* *Phragmites*
6. *Eichhornia crassipes*	*Vossia Cuspidata*

The percentage change in the investigated area revealed a reduction of lakeshore wetland cover abundance between 1950/60s and 1990s of 5-10%. The results also showed that water quality and fish density varied with the type of habitat at the shore. If it was clear that the closer to the vegetation, the higher the fish density, thus indicating the importance of vegetation at the shore.

Wetlands buffering capacity

Under this focus, the capacity of wetland buffers to reduce pollutants from the catchment was investigated. Of particular concern are discharges from sewage ponds towards the lake. The nutrients in sewage that in high load lead to changes in water quality of fish habitats were targeted. These are nitrogen and phosphorus. Although the results vary (Table 2) there is a distinct pattern which relates to reduction in the concentration of wastewater as it flows toward the lake.

Table 2. Nutrient concentrations between wetlands and lake

Period/project	site	NH_4N	NO_3N	TN	SRP	TP
11/11/94 Ecotone Protect	Wetland	0.32	18.90		10.80	
	Open lake	0.20	3.80		0.40	
16/11/94 Ecotone Protect		17.26	0.05		6.12	
		7.44	0.02		2.49	
		1.25	0.01		0.38	
20/8/98 LVEMP		42.71	0.85			4.23
		0.14	0.01			0.01
27/11/98 National Water & Sewage Coorporation Ltd	Wetland sub-surface bottom		0.90 0.54			1.52 0.15
	20m away sub-surface bottom		0.34 0.26			1.50 1.28
	300m away sub-surface bottom		0.48 0.20			0.03 0.01

It has been concluded from these results that the optimized potential of wetland buffers to strip wastewater of nutrients depends on:

- Inflows in a larger part of a given wetland,;
- Vegetation density and biomass;
- Sustainable harvesting of wetland vegetation;
- Sediment uptake;

Onsite point- service pre-treatment systems

Water hyacinth

Fringing water hyacinth in Lake Kyoga and Kwania was completely replaced through ecological succession dominated by hippograss. Fringes of the weed occurred along parts of the Victoria Nile and hippograss continued to over shadow fringing water hyacinth in Lake Victoria through ecological succession. No obvious increase in water hyacinth was noted in the sheltered collection bays of Lake Victoria, although active vegetative reproduction occurred in the nutrient-rich Murchison Bay. A rapid increase in the presence of biological control weevils was noted in the lake particularly in the sheltered collection bays of Thruston, Hannington and Waijika. Water hyacinth in these bays had clearly lost vigor and ceased to reproduce vegetatively by March 1998.

Research on ecological impacts of fringing water hyacinth revealed the following results:

- Reduction of dissolved oxygen at the water surface 20m into the weed mat to less than half the level at the mat water interface
- Macro-invertebrate types tolerant to low dissolved oxygen flourished under permanent water hyacinth cover while those that require high dissolved oxygen concentrations declined;
- Relatively more young and the small types of fish sheltered under the edge of water hyacinth mats than along papyrus dominated interfaces. However, most adults of the larger fishes such as Nile tilapia (but not the lung fish and mudfish) tended to avoid water hyacinth fringe.

The integrated water hyacinth control combines physical, mechanical, biological and chemical methods. While the other methods are associated with little disturbance in the ecosystem and less socio-economic and political ratification, the use of chemical herbicides may not be very safe to the environment. Glyphozate and 2,4-D was proposed as possible candidates for use on water hyacinth in the Ugandan waters. Therefore in recognition of these factors, government appointed a Presidential Task Force to advice on the way

forward. In turn, the Presidential Task Force chaired by Prof. Kayanja the NARO Board Chairman assigned FIRRI the task of conducting experiments to determine the acute toxicity level of the herbicides glyphosate and 2, 4-D on aquatic life and assess their bio-accumulation of fish.

During the period under review, replicate experiments were carried out at the institute to determine the following:

- The median lethal dose CLD_{50} of glyphosate and 2, 4-D on juvenile Nile tilapia and Haplochromines at 24, 48, 72 and 96 hours.
- The LD_{50} of the herbicides on macro-invertebrates (*Caridina* and *Gabbia*) over the same indicate exposure periods
- LD_{50} of the herbicides on zooplankton (Cyclopoid copepods) over the same indicated exposure periods.
- LD_{50} of the herbicides on phytoplankton (as algal biomass) over the same indicated exposure periods.
- The levels of bio-accumulation of the herbicides in fish.

Results from the above experiments were submitted to the Presidential Task Force as required.

Other achievements

Several scientists who had been pursuing sandwich post-graduate training completed their studies. Some of the findings in relation to the institute's activities are reported under abstracts/publications.

Capture Fisheries

Research Objectives

Capture fisheries research aims at generating technologies and policy recommendations that enhance rational management of the fisheries to make them sustainable for the benefit of current and future generations.

Constraints addressed

a) over-fishing and over-capitalization
b) inadequate information on composition, abundance and distribution of the fish stocks
c) declining fish species diversity
d) impact of exotic fish species
e) inadequate information on the biology and ecology of the fish species
f) use of destructive fishing gears and methods
g) inadequate mobilization and participation of communities in management of fishery resources
h) varied socio-economic constraints of fisherfolk

Research focus

Research activities undertaken during the period under review include:

a) Monitoring the composition, abundance, diversity and distribution of the fish species in lakes Victoria, Kyoga and Nabugabo.
b) Fishing effort in minor lakes
c) Impact of fishing gears and methods
d) The biology and ecology of the fish species
e) The impact of introduced species

In general, research activities were carried out on the capture fisheries production systems including lakes Victoria, Kyoga, Albert, George and the smaller water bodies comprising Lake Wamala, Nabugabo lakes, Koki lakes, Kyoga minor lakes, the smaller lakes of western Uganda and rivers.

Other achievements

Several scientists who had been pursuing sandwich post-graduate training completed their studies. Some of the findings in relation to the institute's activities are reported under abstracts/publications.

Achievements

Lake Victoria

Lake Victoria used to be a multispecies fishery dominated until the 1970s by the tilapiines and the haplochromine cichlids. Fish were well distributed over the entire water column. Since the establishment of the introduced Nile perch (*Lates niloticus*) around early 1980s, there have been changes in the Lake Victoria fisheries. Catch rates of the most important and desirable species declined. Fish species diversity has declined with over 60% of the species in the lake disappearing or being reduced to negligible quantities due to overfishing. Fish are now confined to well oxygenated shallower waters. Overfishing, predation by the Nile perch, competition with introduced tilapiines have also contributed to the decline in fish species diversity. The lake, which had a multi-species fishery, dominated until the 1970s by the tilapiines and the haplochromine cichilds is currently dominated by three species, the introduced *L. niloticus* and *O. niloticus* and the native *Rastrineobola argentea*. The last lake-wide stock assessment survey was carried out in 1969/71 before the Nile perch upsurge. In addition to the above changes, there has been increasing pressure on the lake fishery as a result of a rapid increase in fish processing plants and export of fish.

Research Objectives

The long-term objective is 'to encourage cooperation between riparian states on fisheries matters, foster technical and scientific exchange and joint research as a prior condition to regional fisheries management'. The Phase II part of the project is intended to provide the knowledge base for the rational management of the fisheries of Lake Victoria.

Constraints addressed

The key constraints addressed included:

- Fish species composition and distribution
- Fish stock abundance
- Water quality
- Social and economic impacts of the management strategies on groups dependent on the aquatic resources

Research Focus

During the reporting period, effort was concentrated on:

- Bottom trawling on the various habitats to assess the fish species composition, their distribution and abundance.
- Experimental gill netting in the shallow waters where trawling is not possible to assess the fish species composition, their abundance and distribution.
- Collection of limnological information to assess the water quality and criteria of the lake.
- Social and economic impacts of the management strategies on groups dependent on the aquatic

resource
- Regional exchange of information through workshops

Achievements

Bottom trawling

Monthly bottom trawling surveys were conducted in the various habitats of the lake covering waters 4-60m deep. The results of the surveys were:

Fish species composition and distribution

A total of 13 fish taxa belonging to 11 genera were recorded from the trawl hauls since during the period July 1997 to June 1998. These were *Bagrus docmac, Barbus* spp, *Clarias gariepinnus, Haplochromis* spp, *Labeo victorianus, Lates niloticus, Mormyrus kannume, Oreochromis leucostictus, O. niloticus, Protopterus aethiopicus, Synodontis afrofischeri, S. victoriae, Tilapia zillii. L. niloticus* contributed 91% by weight followed by *O. niloticus* 4.8% and the haplochromines 1.5%. Fish species decreased with increasing water depth. The bulk of the fish (95.3%) by weight was recorded in waters less than 30m deep. *L. niloticus* and haplochromines were encountered in all the areas sampled while *O. niloticus* and other tilapiines were restricted to waters less than 20m deep.

During the 1969/71 survey of Kudhongania and Cordone (1974)
i) more than 20 genera (excluding the haplochromines) were recorded
ii) the haplochromines contributed to 83% by weight of the trawl catches while *L. niloticus* was less than 0.1% and
iii) the bulk of the fish biomass and the maximum species diversity was similarly recorded in the shallow (4 – 30m) waters of the lake

Fish stock abundance

Preliminary results of the experimental bottom trawl survey on Lake Victoria during the period July 1997 to June 1998 show that the catch rates decreased with increasing water depth and that the bulk of the fish ichthyomass (95.3%) was concentrated in waters less than 30m deep. The mean catch rates averaged 129.9 $kghr^{-1}$ in this zone (4-30m) mean catch rates similarly decreased with increasing water depth; in waters less than 30m deep, the catch rates averaged 797 $kghr^{-1}$, 83% of which was contributed by the haplochromine cichlids.

The bulk of the fish (about 90% by weight) was recorded in waters less than 30 m deep. *L. niloticus* and haplochromines were encountered at all depth sampled. The tilapiine species were mainly recorded in waters less than 20 m deep. The highest diversity (9 fish taxa) was recorded in Napoleon Gulf. *O. niloticus* were predominantly caught in and around Bunjako Bay, Bomangi Bay, Itome Bay and Ingira Bay. The overall mean catch rates (kg/hour) decreased with depth (Table 3). During the period 1996/97 the mean catch of 149.12 kg/hr was recorded in the 4-29 metres depth zone where the artisanal fishermen operate. The highest mean catches of about 200 kg/hr, during the 4-year period, were obtained in Buvu waters and Sari-Kasuri (in 4-9 metres depth zone), White Stonny and MacDonald Bay (in 10-19 metres depth zone) and Lujabwa Island waters (in 30-39 metres depth zone) (Table 3).

Bugaia (30-39 metres deep) and Jana (40-49 metres deep) were sampled but did not indicate any fish catches during 1996 and 1997. This is because during that period most of the waters deeper than 30 metres showed (on the echo-sounder) no fish below 25 metres from the surface. Lujabwa (30-39), however, indicated fish catches as the area experienced constant mixing resulting from the strong wind from the

Tanzanian side of the lake.

Table 3: The mean annual fish catch (kg/hr) from trawling in the Ugandan part of Lake Victoria between 1994 and 1997.

Depth (m)	Year			
	1994	1995	1996	1997
4-9	143.74	141.91	213.43	113.12
10-19	218.70	112.50	95.74	159.48
20-29	182.05	49.26	90.08	49.31
30-39	194.11	18.25	73.21	305.37
40-49	31.33	24.30	0	0

The mean catch rates of about 150 kg/hr during 1994/97 in the 4-30 metres depth zone is much lower than about 800 kg/hr recorded during the 1969/71 survey. The fishery during the 1969/71 survey was dominated by the haplochromines which contributed 83% of the ichthyomass. The haplochromines have since drastically declined and currently contribute about 0.3%. The decline in mean demersal catches are partly due to the decline in the haplochromines. The high yields of Nile perch in the 1980s were mostly due to the abundance of the haplochromines which was the major prey. Currently the Nile perch depends on the *R. argentea*, *Caridina* spp and its young for food. The future of the lake's fishery which currently depends on Nile perch will very much depend on the continued availability of the above prey species.

Gill netting:

Experimental gill netting was carried out in the inshore waters of Lake Victoria central (Mpigi district) and Lake Victoria west (Mpigi, Masaka, Rakai and Kalangala districts) on monthly basis. The fish species retained included *Lates niloticus*, *Oreochromis niloticus*, *Synodontis afrofischeri*. *L. niloticus* constituted the bulk (over 90% by weight) of the fish retained. In both areas the maximum catch of 0.3 $kgnet^{-1}$ $night^{-1}$ was 1998/99 recorded in the 76.2 mm mesh nets, having dropped from about 2 $kgnet^{-1}$ $night^{-1}$ in 1992/93 to less than 1 $kgnet^{-1}$ $night^{-1}$ in the 76.2 mm mesh nets by 1995/96.

Water quality:

Limnological information was collected monthly at various habitats during the bottom trawling surveys. The exercise was an effort to assess and monitor the water quality of the lake, in particular reference to fish production. During the reporting period, dissolved oxygen was never less than 5 $mg1^{-1}$ in the water column below 25m. The minimum dissolved oxygen requirement for suitable habitats for fish of 5 $mg1^{-1}$.

Socio economics:

Monthly trips were made to fish landing sites, fish markets and fish processing plants to assess the socio-economic impacts of the fishery. Results of these studies are reported separately

Regional workshops:

A number of workshops were held during the year to discuss the progress of the project work on the lake. This involved mainly the socio-economists and limnologists from the three riparian research institutes

Lake Kyoga and Kwania

Lakes Kyoga and Kwania together were the most productive sources of fish in Uganda from the late 1960s (ann. Production ~ 18.400mt). By 1989, production stood at 54,700mt and the down ward trend has continued. These changes have been associated with successive shifts in the types of fish caught. The native "Ngege" declined to negligible catch proportions and by the 1970s, Nile perch (*Lates niloticus*) dominated the fishery informs being replaced by the introduced Nile tilapia (*Oreochromis niloticus*) throughout the 1980s. Of recent, even the Nile tilapia catches have drastically declined, and, Mukene (*Rastrineobola argentea*) has become a dominant feature of the fishery.

Though field investigations, FIRRI established that:

- The average catch per boat had decreased;
- The average size (weight and length) of individual fish caught had decreased;
- The size of the Nile tilapia caught was below that permitted by law;
- There was an influx into the fishery of excessive fishing effort (more boats, more gears) destructive fishing gears and methods.

As a follow-up to these negative attributes, FIRRI conducted a frame survey of the lakes in September 1997. Results from that exercises were computed and compared with frame survey data of 1991.

Achievements (results of the 1997 frame survey in comparison to the 1991 exercise)

- There was an increase in fishing effort from 4045 canoes (1991) to 6501 canoes (1997)
- Seining boats increased from 439 to 886 during the same period and there was excessive use of small mesh size gillnets observed during the survey (Table 1) of the 2567 (65.8%) of the total boats on the lakes, 1276 (49.7%) were using gill net mesh size nets of 4" and below mainly operated actively and catching immature fish and 885 (13.6%) of the total boats were seiners.
- Seining is very destructive in the shallow lakes like Kyoga and Kwania because the net spreads all the way from the top to the bottom of the lake sweeping the entire water column.
- 109 (2.8%) of the total boats in 1997 used mosquito/Lampara seines for Mukene and the common mesh size of the seine was 3mm which is destructive to the juveniles of larger fish species especially in the shallow lake Kyoga. The Nile perch and tilapiines were plenty among the Mukene catches. A number of fishermen interviewed were aware of the dangers of using destructive fishing gears and methods. They felt that the best way to safeguard the fishery was to stop catching immature fish. However, the complaint was that while some of them tried to avoid catching immature fish, they at the same time see their neighbours using the destructive fishing gears and methods which target young fish but get better catches. They suggested that for meaningful intervention, there should be a lakewide approach for all the districts around the lake to join efforts to save the fishery from collapsing.

Table 4. A summary of some basic data collected from the Kyoga Frame Survey in September 1997 compared to that of 1991. Numbers in brackets are percentages

Parameter measured	1991	1997
Tot. No of landings on the lake		266
Tot. No of boats (including transport boats)		7175
Tot. No of fishing boats	4045	6501
Tot. No of dug-out canoes	284 (7.5)	117 (2.97)
No of flat bottomed parachutes	944 (24.9)	2081 (52.83)
No of Sesse planked canoes	2560 (67.6)	1741 (44.2)
No. of boats using gill nets	2924 (79.7)	2567 (65.79)
No. of boats using boat seine	439 (12.0)	886 (22.68)
No. of boats using hooks	186 (5.0)	180 (4.61)
No. of boats using gill nets	0	109 (2.79)

No. of boats using mosquito / Lampara seine	118 (3.2)	161 (4.13)
No. of boats using basket traps		22 (0.86)
No. of gill netting boats using 2" nets		62 (2.42)
No. of gill netting boats using 2.5" nets		137 (5.34)
No. of gill netting boats using 3" nets		95 (3.70)
No. of gill netting boats using 3.5" nets		960 (37.40)
No. of gill netting boats using 4" nets		739 (28.79)
No. of gill netting boats using 4.5" nets		552 (21.50)
No. of gill netting boats using 5" nets		94 (10.62)
No. of gill netting boats using nets of 5" and above		549 (62.03)
No. of seiners using nets of 1.5" mesh		82 (9.27)
No. of seiners using nets of 2" mesh		115 (12.99)
No. of seiners using nets of 2.5" mesh		45 (5.08)
No. of seiners using nets of 3" mesh		
No. of seiners using nets of 4" mesh		

Recommendations

- co-ordination of extension services for the 8 districts around the lake
- mobilise and involve communities in the management of the fisheries
- sensitise the communities on the dangers of using destructive fishing gears and fishing methods
- stop use of seines
- stop use of gill nets less than 5" mesh size and active fishing
- equip field staff to enable them carry out their duties effectively.

Lake George

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. 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 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; sensitize 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.

Lake Wamala

Lake Wamala is the only lake in Mubende District. Its area varies from 100 to 180 km^2. There has been concern over the health of the fishery and its sustainability. Tilapia, which forms the main fishery in the lake, is stunted and its overall health is poor. The Commissioner for Fisheries requested FIRI to investigate the problem. A team of scientists examined the available information and then visited the lake in October 1996. The following were the findings and recommendations.

Lake Wamala originally had an impoverished native fishery consisting of *Protopterus aethiopicus* (Mamba) and *Clarias gariepinus* (Male). In 1956, the fishery was improved by stocking Tilapia (Ngege) species, *Oreochromis niloticus* (Nile tilapia) and *O. leucostictus*. Nile tilapia established itself and the lakes was opened to commercial fishing in 1960 under controlled exploitation. Only 250 boats using gill nets of five inches stretched mesh size were permitted to fish on the lake.

There have been major changes in the fishery and in the lake habitat since the lake was open to exploitation. Fishing effort increased beyond the permitted level to about 1000 boats by 1967 due to inadequate supervision. Fish catches which had increased from about 1000 m.t in 1960 to a peak of 7100 m.t in 1967 and had remained between 4000 and 6000 m.t annually from 1965 to 1976 declined to less than 1000 m.t. The size at first maturity decreased from 21 cm during 1970s to 14 cm during 1990s. The maximum size of Nile tilapia has decreased from 32 cm in 1970s to 22 cm by the 1990s. There was a shift in the mesh size of gill nets used on the lake from 5 inches during the 1970s to 2.5 inches by the 1990s. The volume and area of the lake have decreased, with shoreline receding by about 0.5 km in some places and the depth decreasing from an average of 4.3 m to about 1.7 m. The fish were heavily infested with nematode parasite.

Kyoga Minor Lakes

Fish species diversity in the major lakes especially Victoria and Kyoga has declined drastically due to various human induced factors. Studies have shown that some of the fish species, whose populations were decimated from lakes Victoria and Kyoga do survive in satellite lakes or in refugia in the main lakes. Most of

these satellite lakes are located in the Lake Kyoga basin. The Kyoga satellite lakes consist of about 24 lakes of varying sizes most of which are surrounded by a swamp extending from the eastern shores of the main lake. In addition to containing some of the species depleted from the main lakes due to Nile perch predation, Kyoga satellite lakes contain colourful ornamental fishes which are being collected and exported without considering sustainability of the resources. Knowledge of the stocks of fishes in the Kyoga satellite lakes is important in conservation and sustainable utilisation of biological diversity in these lakes. A survey of the fish fauna of minor lakes including the Kyoga minor lakes has been initiated to search for some of the native fish species lost from the main lakes.

Seven minor lakes; Agu, Nyaguo, Gigate, Lemwa, Kawi Nakuwa and Nawampasa were surveyed. Data was also collected from the eastern end of the main Lake Kyoga at Iyingo where the extensive swamp within which the minor lakes are located begins. A total of 55 fish species were identified from these lakes. Cichlids contributed 67% of the fish caught of which 86% were haplochromines belonging to 13 genera. These covered all major trophic groups which once dominated lakes Victoria and Kyoga before the introduction of the Nile perch. A number of un described haplochromine species were collected. Of the haplochromines 87% were of types either extinct or almost extinct from lakes Victoria and Kyoga. The native tilapiine species of lakes Victoria and Kyoga, *Oreochromis esculentus* and *O.variabilis* which had become very rare in the two lakes still occur in these small lakes. 105 Samples of haplochromine and 27 of other fish species were preserved and kept in the FIRI Museum and are now part of reference material for fisheries students from local and international institutions. As a result of this survey, the Commissioner for Fisheries suspended collection of ornamental fish directly from Lake Nawampasa for export pending the final recommendation from this study, as there was evidence that certain species were being depleted. A documentary film on these lakes is to be prepared in 1997/98.

Minor Lakes of Western Uganda

There are many small lakes in Western Uganda especially in Kisoro District. Some of these are not very productive. There have been demands from local authorities especially of Kisoro District to enhance fish production from these lakes. One field trip was made to the lakes in Kisoro during 1997 to assess the state of the fishery in order to make proposals on any potential for fish production from these lakes. The activities undertaken included: gathering information on the history of the fishery, collection of commercial catch effort and gear data and experimental fishing.

There are four minor lakes in Kisoro District (Mutanda, Mulehe, Chahafi and Kayumbu). Fish were introduced in these lakes in 1968 but some of the species never survived. The fishery of these lakes consists of Tilapia, Mirror carp, *Clarias carsoni, Clarias mossambicus*, Haplochromines, Red shrimps and edible frogs. Mirror carp and Red shrimps are absent in lakes Mutanda and Mulehe while *C. mossambicus* and Haplochromines are not in lakes Chahafi and Kayumbu. Commercial catch records show that the total annual catches from these lakes has increased from 8 m.t in 1994 to 11 m.t in 1995 and 15mt in 1996 apparently due to a temporary closure of lakes Chahafi and Kayumbu between 1993 and 1994.

There are only dugout canoes on these lakes numbering 33, 12, 16, and 34 for fishing on lakes Mutanda, Mulehe, Chahafi and Kayumbu respectively. Fishing is done using gill nets of mesh sizes 3 to 5 inches mesh, hooks are of size 8 for *C. mossambicus*, and basket traps which haplochromines, shrimps and edible frogs. Commercial catch records from the four lakes showed that the catch is made up of Tilapia, 23% is Mirror carp, 14% *C. carsoni* and *C. mossambicus*, 11% haplochromine, 7% red shrimps and 3% edible frogs. The main problem that has hindered research on these lakes was luck of funds. It was agreed with local authorities that a detailed research proposal be prepared by FIRI with a review to soliciting for funds.

Rivers

River fisheries play an important role as sources of fish for rural households far removed from lakes. Therefore, following a request addressed in a stakeholder seminar for further evaluation of the riverine environments particularly the River Nile, a preliminary survey of the Victoria Nile was undertaken. In addition, other requests related to impact assessments of proposed dams on the river were followed up with preliminary assessments of the Victoria Nile between Masindi port and Karuma falls

Laboratory activities

During the period under review, various laboratory/office equipment (computers, microscopes, analytical balance, and incubator) were acquired. These contributed to refined analyses from different experiments conducted under the programs. In addition, several innovations and equipment fabrication were carried out. These included fabrication of mid-crater small trawl net adapted to zooplankton and juvenile fish sampling. A macro-invertebrate sampling/washing sieve and alternative pH and temperature probes were designed and fabricated. As well, adaptive protocols were formulated. AAS technology in heavy metal analyses, waste water sampling and analyses.

Marine Services

The marine section serves the function of providing serviceable vessels for use on the lake. The institute has two serviceable vessels RV. IBIS, RV. MPUTA and MV Commorant. The former is used mainly under the Lake Victoria Fisheries (Regional) Research Project while RV. Mputa is used under Water hyacinth project and other activities in the limnology program. MV Commorant broke down several years ago. Both RV Ibis and MV Mputa are also available for use by scientists from outside FIRI on activities based on Lake Victoria. Other smaller open canoes are also available for use but are under control of the programs

RV Ibis was scheduled to make 12 cruises of 14 days duration under LVFRP. Other activities are additional while MV Mputa was scheduled to make 5 day cruised monthly.

RV Ibis

During the period June 1997 to July 1998, MV Ibis made the following cruises: -

a) 6 cruises of 5 days duration to various lakes/zones of the LVFRP. These were made in the months of June, July and August 1997 and 2 in September and October 1997
b) 6 short cruises were made in the Napoleon Gulf and surrounding bays. These were made in August, October and December 1997
c) 1 cruise of 12 days duration was made in areas between Kiyindi and Bukakata waters. This was made in October 1997.
d) 1 cruise of 3 days duration was made to Bugaia waters for limnological work during October 1997.
e) 4 cruises of 10 days duration to the three zones of the LVFRP. These were made during the months of February, March, April and June 1998.
f) 2 cruises of 5 days duration was made with scientists from FAO to install weather station on Bukasa and Dolwe Island.

The utilization of RV Ibis was therefore average totaling to 101 working days in a year. There is room for more activities for the vessel. The machinery is still in operational state. They only need regular maintenance to keep in service. The only major problem experienced was the breakdown of echo sounder, which now needs replacement. Other breakdowns were quickly fixed since the financial resources were available.

MV Mputa

MV Mputa made 7 Lake Cruises of 3 days duration to Bugaia Island during the period. These were mainly to do limnological work. They were done on monthly basis from November 1997 – June 1998. The utilisation of the vessel was low totaling to 24 days only. The reason could be that many activities were combined and done on RV Ibis for economy.

Aquaculture

The aquaculture program continued with research work to address the aquaculture production constraints that had been identified and prioritised. Therefore during the period under review, the program focussed on fry production and on-farm feed preparation. Extension linkage activities included training workshops and seminars with fish farmers and extension staff and distribution of fish fry to farmers. A significant amount of the work was done through collaborative research with Makerere University. A total of 75,680 fish fry have been distributed to 23 districts in Uganda. These fry include 8400 *T. zillii,* 44280 Mirror carps and 23000 Nile perch.

Fish feed formulation and testing the impact of feeds on fish growth

Feeds were compounded based on the results of biochemical analyses of feed ingredients done the previous year. These formulae were given to farmers to try out on their ponds. This is done in order to assess the results obtained and the station from the MSc. Thesis on Feed formulation and impact of feeds on the growth of *O. niloticus* in the field. However, there were no further analyses carried out due to lack of funds and personnel. The food ingredients, *Rastrineobola* and maize bran etc. were collected and processed for use in the daily fish feeding routine at the station.

Achievements

a) Performance with the feed of 32% CP gave similar results to those obtained at the station under the MSc study in ponds that were not overstocked.
b) Ponds fed on this same ration that were over populated still presented stunted growth
c) Population control in tilapia ponds is essential if optimal growth is to be achieved within a specified period of time.
d) The prolific breeding of Nile tilapia resulted in several generations which utilised same feeds, making it difficult to estimate food intake of the experimental populations

Mirror carp (Cyprinus carpio) breeding

Mirror carp have been kept at Kajjansi fisheries experimental station since December 1957, when they were introduced from Israel. Despite having spent almost 40 years in Uganda, lack of carp fry is still a problem hindering wide distribution of the species. Upon identifying the causes of low fry production and survival efforts were directed towards increasing fry production during the period under review.

Several ponds were prepared by clearing ponds and trenches of grass, they were dredged to clear the mud and fenced using crisscross sisal netting to keep out predators. The ponds were limed to kill parasites and fertilized. The brood stocks were stocked and fed. The following studies were made.

The preferred breeding substrate was *Pistia* spp, papyrus tops (*Cyprus papyrus*) because it was readily available at the station. The findings from last years MSc. Thesis indicated that the attachment of Mirror carp eggs was good. Pond breeding technologies were utilised whereby spawning, larval and fry rearing were done within the same pond. This is because there were no adequate funds available to purchase the materials necessary for induced breeding and the aquaria were not functional. Predator control was done by liming the ponds.

Mirror carp fry production at the station was increased by about 20%. It was found that predators were the cause of a significant fry losses. These included birds and frogs. Studies will be done in the on-coming year to address this issue.

Post-harvest Fisheries

An efficient post-harvest technologies in the fishing industry are essential in getting maximum value from the fisheries. The fisheries post-harvest programme has as its main objective to generate technologies that reduce post-harvest losses in fish products. Therefore, during the period, the programme carried out trials in improved handling, processing, packaging, storage and marketing of fish products. Different products were demonstrated at the National Agricultural and Industrial exhibitions in both Jinja and Kampala. However, due to its strategic importance, this programme was later in 1998 selected to institute status.

Fisheries Socio-economics

The socio economics sub-program links a number of studies covering a broad range of issues cutting across all the programs of the institutes. These studies form an integral part of the Institute effort to contribute, through knowledge and technology, towards the goal of sustainable and efficient utilisation of the nation's fisheries resources, with all the due consideration for the environment.

Objective:

The sub-program seeks to empower decision makers in the public, private and community circles through *information* to take appropriate decisions in the management, exploitation and utilisation of the fisheries resources.

Research focus

- Analysis of the structure and functioning of fishing communities.
- Determination of optimum levels of fisheries resource exploitation: social and economic issues.
- Assessment of costs of production, enterprise profitability and competitiveness of operating units.
- Assessment of technology alternatives and evaluation of economic losses.
- Investigations into fish marketing systems, demand, supply and consumption studies.
- Assessment of performance of the fishing industry.
- Analysis of macroeconomic and policy issues

The sub-program carried out its objectives through the following projects:

- Fish commodity systems economics (Uganda) project
- Use and protection of water resources in Lake Victoria through sustainable management of wetland ecotones: Socio-economics component.
- East African Great Lakes Project
- Water Hyacinth Research Project: Socio-economic impacts.
- Lake Victoria Regional Fisheries Research Project: Socio-economics component.
- Lake Victoria Environmental Management Project - Socio-economics Sub-component:

Achievements:

1. Fish Commodity Systems Economics (U) Project

The Fish Commodity Systems Economics (U) Project was concluded during the year. It was funded by the International Development Research Centre (IDRC) of Canada and the government of Uganda and implemented as a collaborative research involving a number of local and regional institutions.

The overall goal of the project was to improve social and economic performance in the fisheries sector, by generating information that would facilitate and improve decisions and policies by the Government, NGOs and private entrepreneurs in fisheries.

A final technical report was produced and in addition, specific study reports were prepared, covering:

- Characteristics of the fish producers, processors, marketing group and consumers.
- Assessment of the contribution of Nile perch, Nile tilapia and *Mukene* fisheries to total GDP, employment, income and diet.
- The utilisation of *Mukene*, as human, animal and fish feeds
- Viability of fishing enterprises on Uganda waters
- Model of successful fishing communities for the purpose of extracting lessons for adoption by other communities.

2. East African Great Lakes Project

The East African Great Lakes Research project is a collaborative research between FIRI and Michigan State University. It is funded by the Government of Uganda and McArthur Foundation. Its goal is the enhancement of the well being of fishing communities on Lake Victoria

A draft report was prepared, documenting the socio economic impacts of the changes occurring in the fisheries of Lake Victoria on the lakeside communities.

3. Wetland Ecotone Project: The Social Science Component.

This is a multi-disciplinary research project, implemented in collaboration with the Institute of Ethnography, University of Zurich, Switzerland, with funding support from the Swiss National Science Foundation. Its goal is the utilisation of the ecotone wetlands for purification of water supply through sustainable community management and utilisation of the ecotone resources.

Considerable data collection was done, workshops and exhibitions held and a model of sustainable utilisation of wetland resources based on partnerships between research, policy organs, local authorities and resource users is being finalised

4. Water Hyacinth Research Project: Socio-economic impact studies:

This study is part of a big investigation of the impacts of the water hyacinth infestation on Uganda waters. It focuses on the social and economic impacts.

A preliminary report of the impacts was produced, covering fishing activities, transport, health and the environment of lakeside communities.

5. Lake Victoria Regional Fisheries Research Project: Socio-economics component.

This is a regional project supported by the European Union aimed at strengthening the management of Lake Victoria.

Specific objectives of the socio-economic aspects of the investigations include:

- To contribute towards the formulation of a management plan for the fisheries of Lake Victoria;
- To develop a process by which relevant interest groups can participate in resource management;
- To provide an understanding of the social and economic impacts of management strategies on fishing communities.

During the year, the first of the studies was started, covering investigations into the marketing of Lake Victoria fish.

Different marketing levels have been identified, including the fishermen's level, processors and traders, consumers and industrial processors.

Data collection under the fishermen's survey has been done.

6. Lake Victoria Environmental Management Project - Socio-economics Sub-component:

Socio-economics Research is one of five sub-components under the Fisheries Research Component of LVEMP, implemented by the Fisheries Research Institute.

The aim is to provide information which would be used to improve management of the lake resources in order that local communities will increase their benefits from the fishery, while sustaining the ecosystem from which the benefits arise.

The objectives include:

- analyse and disseminate data from previous and ongoing projects.
- community involvement in harvesting up to marketing of fish,
- how activities of fisherfolk contribute to environmental degradation, nutrition, health and other social amenities of lakeside communities,
- alternative management systems incorporating different stakeholders,
- the contribution of fisheries to the three national economies, and
- the consequences of changes in fishing policies.

Activities undertaken during the year included:

- inception activities including formulating workplans and budgets;
- literature search and review to establish existing knowledge on the areas of investigations.
- national workshop to plan activities and discuss collaboration and agree on modalities for community participation.
- start of data collection, involving sample surveys;
- processing of the data collected, using appropriate applications software.

Collaboration and Linkages

FIRI collaborated with other NARO institutes and was especially involved in retaining working relationships with FOSRI (previously the post-harvest program under FIRI). Other collaborators included the Uganda Fisheries Department, several departments at Makerere University, the Directorate of Water Development (DWD), National Water and Sewage Cooperation (NWSC), the National Wetlands Program (NWP), and NGOs. International and regional collaborators included research institutions around Lake Victoria i.e. the Kenya Marine Fisheries Research Institute (KMFRI) in Kenya, and the Tanzania Fisheries Research Institute (TAFIRI). Collaboration on the international scene included the Universities of Waterloo, Florida, Wageningen and Zurich on fish habitat and water quality studies; Boston, and Leiden on fish taxonomy, and several others involved with student exchanges and supervision of research topics.

Lake Victoria Wetlands and the Ecology of the Nile tilapia, ***Oreochromis niloticus*** Linne'

PhD Thesis by John Stephen Balirwa, Agricultural University of Wageningen – The Netherlands.

Abstract

An ecological study of wetlands was undertaken in northern Lake Victoria (East Africa) between 1993 and 1996 with a major aim of characterizing shallow vegetation-dominated interface habitats, and evaluating their importance for fish, in particular, for the stocked and socio-economically important *Oreochromis niloticus* LINNE' (the Nile tilapia). From field and laboratory experiments, five major habitat types could be defined by the type of the dominant emergent macrophyte at the shore from the more than 40 identified plant species along a 110-km shoreline. These were: *Cyperus papyrus* L. (papyrus), *Phragmites mauritianus* Kunth (reeds), *Typha domingesis* Pers. (bulrush), *Vossia cuspidata* (Roxb.) (hippo grass), and the alien floating *Eichhornia crassipes* (Martius) Solms-Laubach (water hyacinth). From digital data, considerable long term changes in the shoreline wetland landscape of the lake were discerned and appeared primarily associated with increasing human activity (e.g. agriculture, biomass harvests) which had resulted into a 5% reduction of wetland cover. In spite of the absence of a well developed euhydrophyte community (e.g. *Potamogeton* and *Ceratophyllum*), and increasing infestations with *E. crassipes* mats, the width of the littoral zone was established as being about 50 – 70 m away from the shallow (less than 1 m deep) vegetation fringe sloping to between 2 and 4 m in depth at its outer fringe. Hydrological influences associated with seasonal changes (the alternation of rainy with dry periods) explained most of the observed variation in abiotic (e.g. Si, tot.-P., soluble reactive-P., NO3-N, pH, temperature) and biotic (phytoplankton, macrofauna, fish) factors, but there was also significant ($p < 0.05$) variation due to vegetation, distance from the shore out towards open water and interaction effects between these factors. At least 30 species of fish were identified from the shallower (up to 2.5 m deep) vegetated habitats in contrast to 10 species from the deeper (4 – 8 m) open water habitats. There were other significant ($p < 0.05$) spatial and temporal differences in habitat use by fish. Species diversity was dominated by haplochromine species but three stocked species (the Nile perch, *Lates niloticus* L., *O. niloticus* and *Tilapia zillii*) contributed at least 90% of the estimated numerical and biomass densities of which, the Nile tilapia was the most important component making up 45 – 65% of the biomass. Season was a major factor in size-related abundance patterns but generally, most of the Nile tilapia biomass was associated with *Phragmites-Vossia-Typha*-dominated habitats that were also important for small (< 15.0 cm juvenile) fish. The shallow vegetated habitats were found to be ecologically important for the Nile tilapia for sheltering and feeding, and, it was also found that Lake Victoria Nile tilapia were significantly more fecund (with 3723±147 eggs per female) and had a higher condition index than populations of the species in Lake Kyoga (also stocked) and Lake Albert (a native habitat). It was inferred that these differences could be a result of a better nutritional base in Lake Victoria where the species was shown to be omnivorous (with detrital and animal foods as major dietary items) contrary to the previously believed herbivorous (phytoplankton) habits. Successional patterns associated with water hyacinth and the strong hydrological influences on shallow vegetated habitats imply that basin disturbances could therefore be a major threat to water quality and the fisheries.

Limnological conditions, distribution and abundance of zooplankton and ***R. argentea*** and their trophic interactions in Lake Victoria

Ndawula – Mwebaza L., PhD. Thesis, University of Vienna, Austria

Abstract

The diet, spatial-temporal distribution and abundance patterns of the pelagic cyprinid, *Rastrineobola argentea* (Pellegrin) and zooplankton were investigated in conjunction with limnological conditions in northern Lake Victoria, between September 1994 and October 1996. Samples were collected from the shallow inshore and deep open waters. Fish and zooplankton were sampled with a small mid-water trawl net of 5-mm stretch mesh size and a schindler trap respectively from the surface, mid-waters and near bottom vertical positions. Concomitant measurements of temperature, dissolved oxygen (DO), light attenuation, Secchi depths and chlorophyll-a were made. Water column structure exhibited seasonal alternation of thermal stratification (October – March) and mixing march-July), synchronous in inshore and offshore waters. Oxygen depletion (up to <1.0mg $O_2 1^{-1}$) was common in the hpolimnion during stratification in contrast with high DO throughout the water column during turnover. Vertical distribution of fish and zooplankton revealed higher concentrations above the oxcyline during stratification while a near homogenous dispersion occurred during mixing.

Low zooplakton-high fish densities inshore contrasted with high zooplankton-low fish densities offshore. Low water transparency-high extinction coefficients inshore contrasted with high water transparency-low extinction coefficients offshore.

Phytobiomass was nearly twice as high inshore compared to offshore. Zooplankton community was dominated by cyclopoid copepods, with minor proportions of diaptomids, cladocerans, rotifers etc. Higher, relative proportions of diaptomids and cladocerans, in the historical (1961) sample, however, prompted suggestions of long-term changes in zooplankton community structure. Most zooplankters attained highest numerical abundance during the annual turn over, (July), declining thereafter to lower levels in subsequent months. Zooplankton size distribution in December 1995 indicated lower relative abundance of large copepods inshore compared to offshore, while both copepods and cladoceran showed higher abundances (inshore) during July 1996. Pelagic fish community was dominated by *R.argentea* and the three cohabiting taxa exhibited different seasonal patterns of abundance. *R. argentea* fed heavily on cyclopods with minor supplements from diaptomids and cladocerans.

Proportions of diaptomids and cladocerans in the diet of historical(1966) and modern (December 1995) fish diet suggests substantial decline in their relative contributions. No major and consistent variations in diet composition were observed on different sampling dates, day and night samples of different vertical positions in the water column. Dominance of the diet by cyclopoids seemed to be largely due to their much greater pelagic abundance, higher species diversity and wide size range of food particles. Sustained prominence of cyclopoids in the environment may be partly explained by high productivity under warm tropical conditions where a taxon may be maintained at high concentrations despite heavy predation.

Distribution, relative abundance, population structure and food of surviving haplochromine cichlids in the littoral areas of Napoleon Gulf (Lake Victoria)

G. Namulemo, MSc thesis, Makerere University - Uganda

Abstract

Prior to the introduction and establishment of Nile perch *Lates niloticus*, haplochromine cichlids were the most abundant and speciose group of fishes in lakes Victoria, Kyoga and Nabugabo. They occupied virtually all trophic levels and played an important role in the flow of organic matter in these ecosystems. Following the establishment of Nile perch, stocks of haplochromines declined rapidly, and some species completely disappeared. This was accompanied by drastic changes in biological and physico-chemical conditions in Lake Victoria. Recent studies on fish stocks of Lake Victoria have been confined to offshore waters. In this

study, the distribution, relative abundance and food of surviving haplochromine cichlids in littoral areas of Lake Victoria were examined to find out the species diversity in the zone and specifically the food of the haplochromines. The data were compared with historical data to see whether the distribution, relative abundance, and diet of the haplochromines have changed and what role the surviving haplochrome species were playing in the trophic ecology of the lake. The study was based in the Napoleon Gulf of Lake Victoria.

Twelve fish taxa were recorded. By number, the Nile perch *Lates niloticus*, dominated the catch (42.3%) followed by haplochromines (30.7%), *Oreochromis niloticus* (12.2%), *Tilapia zillii* (8.9%), *Synodontis afrofischeri* (2.3%), *Brycinus sadleri* (1.9%), *Mormyrus kannume* (0.5%), *Oreochromis leucostictus* (0.4%), *Synodontis victoriae* (0.4%), *Clarias gariepinus* (0.2%), *Oreochromis variabilis* (0.1%), and *Protopterus aethiopicus* (0.1%). Fish diversity and abundance decreased with increasing distance from the shoreline and varied between stations. It was highest at Rwamafuta (1.12), followed by Kikondo (1.1), Kiryowa (1.07), Kirinya (0.74) and Cliff (0.61).

Twenty three haplochromine species were recorded. These were, in order of numerical abundance, *Astatoreochromis alluaudi* (17.9%), *Astatotilapia "unicuspid"* (14.8%), *Prognathochromis paraguiarti* (12.7%), *Paralabidochromis "yellowbody"* (10.6%), *Paralabidochromis "goldchest"* (9.8%), *Harpagochromis guiarti* (7.5%), *Astatotilapia nubila* (6.5%), *Astatotilapia "bicuspid"* (4.2%), *Neochromis "scraperteeth"* (3.2%), *Neochromis nigricans* (2.8%), *Paralabidochromis crassilabris* (1.6%), *Paralabidochromis "velvetblack"* (1.6%), *Paralabidochromis "yellowbars"* (1.3%), *Neochromis pseudonigricans* (1.2%), *Paralabidochromis "rockcribensis"* (0.9%), *Astatotilapia sp.* (0.8%), *Paralabidochromis "shortsnout"* (0.7%), *Parabidochromis "blue deep-body"* (0.6%), *Ptyochromis xenognathus* (0.5%), *Paralabidochromis "sharpteeth"* (0.4%), *P. "bigeye"* (0.4%), *P. chilotes* (0.2%) and *P. "curved head"* (0.2%). Species diversity and abundance of haplochromines also decreased with increasing distance from the shoreline. It was highest at Kiryowa (1.52), followed by Kikondo (1.12), Rwamafuta (0.72), Kirinya (0.54), and Cliff (0.52).

Most of the haplochromine stomachs examined contained larval insect remains, namely chironomid larvae and pupae, chaoborid larvae and pupae, ephemeropteran nymphs, *Odonata* nymphs and some trichopteran nymphs. Some haplochromines had remains of molluscs in their stomachs and others had *Caridina nilotica*. A few stomachs also contained fish remains in addition to insect remains. Some plant remains (aquatic weeds) and filamentous green algae were also encountered in some haplochromine stomachs.

This study has shown that overall fish species diversity in the shallow near shore areas has, as in the case of offshore areas decreased. However, the diversity in the shallow inshore areas is higher than offshore especially the inshore areas with macrophyte cover and areas with rocky habitats. Among haplochromines very few trophic groups are still present. Most surviving haplochromines are insectivores with a few molluscivores and prawn-eaters with very little phytoplanktivory and detrivory. Primary production is no longer channeled via the haplochromine food chain.

The impact of the introduced Nile perch (***Lates niloticus***) on the foraging ecology of non-cichlid predators in the Lake Victoria Basin

John P. Olowo, MSc thesis, University of Florida

Abstract

Coincident with the rapid increase in the populations of the introduced predatory Nile perch (*Lates niloticus*) in Lakes Victoria, Kyoga, and Nabugabo was a dramatic decline in the populations of many native species. Most notable has been the disappearance of over half of the estimated 600+ endemic haplochromine cichlids in Lake Victoria; however, several non-cichlids have also declined or disappeared, many of which were

critical components of the pre-Nile perch fishery. This study examined the impact of Nile perch on the distribution and feeding habits of non-cichlid predators in the Lake Victoria basin through: a) a comparative study of the foraging ecology of two large predatory catfishes that have declined dramatically since the increase in numbers of introduced Nile perch and b) an examination of the foraging ecology and habitat use of one non-cichlid species that has persisted in abundance with Nile perch.

A survey of Lake Nabugabo over 3 years revealed that both *Brycinus sadleri* and Nile perch were most abundant in the offshore (20 m) areas of exposed transects. Diel samples indicated activity peaks for *B. sadleri* at dusk and dawn, when Nile perch were also most active. However, the activity peak for *B. sadleri* preceded that of Nile perch at dusk and occurred after it at dawn. Gut content analyses revealed *B. sadleri* to be primarily insectivorous, while Nile perch were both piscivorous and insectivorous. The diet composition of gut contents of *B. sadleri* was compared to the diet activity of various invertebrates in the lake. Different invertebrates dominated the gut contents at different times suggesting migratory activity to different feeding ground. The food of *B. sadleri* was similar between the pre- and post-Nile perch eras. The comparative study of lake with ant without Nile perch suggested a shift to a broader diet in the presence of Nile perch which may permit flexibility in activity. I conclude that minimal overlap in food habits and activity may permit persistence of *B. sadleri* in lakes with introduced Nile perch.

The impact of water hyacinth *Eichhornia crassipes* (Mart) Solms on the abundance and diversity of aquatic macroinvertebrates along the shores of northern Lake Victoria, Uganda

Wanda Fred Masifwa, (M.Sc. Thesis Abstract, 1997, IHE, Delft, The Netherlands)

Key words:
Water hyacinth, impact, abundance, diversity, aquatic macroinvertebrates, Lake Victoria.

Abstract

This study examined the impacts of water hyacinth on the abundance and diversity of aquatic macroinvertebrates in the littoral areas of northern Lake Victoria in Uganda. The littoral comprised of fringing mats of *Eichhornia crassipes* (Mart) Solms (water hyacinth) to the lakeward of *Cyperus papyrus*; water hyacinth mats undergoing colonisation by *Vossia cuspidata* (Roxb.) Griff.; and a typical *Cyperus papyrus* L shore with no outer floating mat of water hyacinth.

Numerical abundance (Nos.m^{-2}) and diversity (No of taxa) of macroinvertebrates recovered from pure *Eichhornia crassipes* and the *Eichhornia-Vossia* succession increased from the fringe of the *Cyperus papyrus* towards the open water. In the typical *Cyperus papyrus* fringe, in the absence of the water hyacinth, abundance was highest at the papyrus/open water interface and dropped off sharply towards open water. The Shannon-Weaver diversity index (H') of macroinvertebrates decreased progressively from pure *Eichhornia crassipes* stands, to *Vossia/Eichhornia* beds and *Cyperus papyrus* stands (H' =0.56, 0.54 and 0.34, respectively) but were not significantly different. Dissolved oxygen decreased from open water into vegetation where it approached anoxia.

Water hyacinth appeared to enhance the abundance and diversity of aquatic macroinvertebrates at the interface with the open water. The impoverished abundance and diversity of the macroinvertebrates deeper into the vegetation mats suggested negative environmental impacts of the water hyacinth when the fringe is too wide. Further research is recommended to establish the optimum width of the fringe of stationery water hyacinth that promotes maximum abundance and diversity of aquatic macroinvertebrates and, possibly, of

other aquatic life.

Growth ***of Phragmites mauritianus*** and its role in purification of presettled wastewater in mesocosms (experimental tanks) in Uganda.

Stephen B. K. Sekiranda M.Sc. abstract 1997. IHE-DELFT, the Netherlands

Keywords: constructed wetlands, *Phragmites mauritianus*, wastewater treatment, Uganda

Abstract

Constructed wetlands have been shown to perform well, not only for municipal sewage, but also for agricultural and industrial water, land fill leachate, acid-mine drainage and urban storm runoff. Their use is currently wide spread and is a simple solution for controlling water pollution facing small communities, industries and agriculture. However, they have not been used in Uganda. The high-tech conventional wastewater treatment approaches are expensive due to high cost capital investment, operation and maintenance. Consequently, within Uganda's economy of scale, they are unattainable. Stringent discharge standards to protect the environment and prevent the demise of water quality have to be met and complied with, and hence the need to look toward low cost, effective treatment methods to achieve upgrading of wastewater to general, acceptable discharge standards.

The potential for operational and maintenance simplicity, and low cost treatment effectiveness, makes constructed wetlands emerge as a cheaper and economic option for wastewater treatment in Uganda. A pilot constructed wetland system project in Jinja-Uganda is going to assess the capacity of locally abundant wetland macrophtyes: *Cyperus papyrus* and *Phragmites mauritianus* to treat wastewater. As synoptic experiment to the pilot project, the examination and utility of *Phragmites mauritianus* to treat presettled primary waste for Phosphorus (P), Nitrogen (N). Biological oxygen demand (BOD_5), chemical oxygen demand (COD) and Suspended solids (SS) in 40-litre bucket reactors of constructed wetlands and effects on growth were investigated. Locally available growth substrata, laterite-gravel was used in six buckets. In the four of the buckets, the macrophyte was floated in wastewater. Two Controls were plant free with and without the laterite-gravel respectively.

The results showed that the macrophyte grew better when rooted in laterite gravel than when floated and effectively treated wastewater to advanced secondary and possibly tertiary water quality levels. The general removal efficiencies found for laterite-gravel rooted *Phragmites spp* and in parentheses, the laterite-gravel control reactor respectively were: 61% (63%) for BOD_5, 73% (53%) for COD, 80% (45%) for SS, 92% (70%) for TP, 93% (58%) for o-PO_4, 95% (87%) for KTN, 99% (95%) for NH_4-N, 42% (0%) for NO_2—N and 60% (26%) for NO_3—N. For floating Phragmites and in brackets, the wastewater plant free control respectively, the removal efficiencies were: 57% (57%) for BOD_5, 73% (43%) for COD, 73.8 % (42%) for SS, 75% (41%) for TP, 71% (0%) for o-PO4, 89% (83%) for KTN, 98%(95%) for NH_4-N,)% (0%) for NO_2—N and 55% (0%) for NO_3—N. The macrophyte presence did not seem to significantly influence carbon removal, but it enhanced nutrients removal. It can be concluded that laterite-gravel rooted *Phragmites* is more efficacious than floating *Phragmites* for wastewater treatment.

The factors affecting fishing effort and their effects on fish catches as selected

landings on Lake Victoria.

Muhoozi L. I., MSc thesis, Makerere University - Uganda

Abstract

In a fishery, the fish catch is partly determined by the type, number and size of fishing gear, the manpower on the fishing vessel and the fishing ground. In the Lake Victoria gill net fishery these fish catch attributes are dependent on the size and mode of propulsion of the fishing boat and the mode of operation of the gill nets. This study, conducted at six fish landing sites: Masese, Lingira, Bugonga, Kasenyi, Lambu and Kasensero on the Uganda sector of Lake Victoria, investigated how the size of fishing boats, mode of propulsion of fishing boats (motorised or manual), mode of operation of gill nets (active or passive) were related to the number of gill nets, number of boat crew, fishing grounds, the quantity and species composition of the fish catch and hence the income to the fishers.

There was significant increase in the overall mean number of gill nets per boats with increase in boats size (ANOVA test, $F_{6,499} = 124.1782$, $P<0.05$) from 20.9 $\pm$ 2.3 nets in 5.0-5.9 m long boats to 88.6 $\pm$ 11.8 nets in 11.0-11.9 m long boats. Bigger boats required more crew such that the number of crew increased with increase in boat size, from an average of 2 men in boats <8.0m to 3 men in large boats. The proportion of large gill net mesh sizes >127 mm (5 inch) also increased with increase in boat size from 40.4% in 5.0 - 5.9 m long boats to 100% in boats >10.0 m long. The majority of large boats $\geq$8.0 m long were motorised and fished in far offshore waters targeting Nile perch whereas nearly all boats <8.0 m long were manually powered and fished in inshore waters targeting both Nile perch and Nile tilapia. Boats operating gill nets actively fished very close to the shoreline targeting Nile tilapia. Nile perch contributed 97.7-100% of the catch in boats $\geq$8 m long whereas Nile tilapia and other fish species contributed 31.0- 59.9% in boats <8 m long. 73.6-89.0% of Nile perch caught by boats <8.0 m long were $\leq$50 cm TL whereas <17% of Nile perch in larger boats were $\leq$50 cm TL. The overall mean fish catch rates increased significantly with increase in boat size (ANOVA test, $F_{6,513} = 15.0367$, $P<0.05$) from 12.6 $\pm$ 1.9 kg in 5.0-5.9 m long boats to 78.2 $\pm$ 16.4 kg in 11.0-11.9 m long boats. Actively fishing boats at Masese and Lingira carried about half the number of nets carried by passively fishing boats but there were no significant differences in the average mean total weights of fish landed by both categories of boats (ANOVA test $F_{1,181} = 3.8999$, $P<0.05$). Thus, active operation of the gill nets raised the catch rate per net twofold from 0.43 $\pm$ 0.11 kg in passively fishing boats to 0.96 $\pm$ 0.15 kg in actively fishing boats.

These observations indicate that full exploitation of the *L. niloticus* fishery of Lake Victoria up to offshore waters would require promotion of use of large motorised boats that use large numbers of large mesh sized nets and land desirable sizes of fish and putting restrictions on number of boats and/or mesh size of gill nets of manually powered boats that operate in inshore waters and land mainly immature fish. The management of the *O. niloticus* fishery should focus on discouraging the active operation of gill nets, reducing the number of boats operating inshore waters and preventing further reduction of gill net mesh sizes.

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