**LAKE VICTORIA ENVIRONMENT MANAGEMENT PROJECT**
**(LVEMP)**

# SYNTHESIS REPORT ON FISHERIES RESEARCH AND MANAGEMENT

## TANZANIA

**Prepared by**
**Prof Y.D. Mgaya**
**National Consultant**

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| BMU | Beach Management Unit |
| CAN | Calcium Ammonium Nitrate |
| CAS | Catch Assessment Survey |
| CBO | Community Based Organization |
| CIFA | Commission for Inland Fisheries of Africa |
| COMESA | Common Market for Eastern and Southern Africa |
| CPUE | Catch per Unit Effort |
| DO | Dissolved Oxygen |
| DOP | Dissolved Organic Phosphorus |
| EAC | East African Community |
| EAFFRO | East African Freshwater Fisheries Research Organization |
| EIA | Environmental Impact Assessment |
| ESAURP | Eastern and Southern Africa Universities Research Programme |
| EAHC | East Africa High Commission |
| EU | European Union |
| FAO | Food and Agriculture Organization of the United Nations |
| FDF | Fisheries Development Fund |
| FIRRI | Fisheries Resources Research Institute |
| FIQA | Fish Inspection and Quality Assurance |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GHP | Good Hygiene Practices |
| GIS | Geographic Informtion System |
| GoK | Government of Kenya |
| GLOW | Great Lakes of the World |
| GLP | Good Laboratory Practices |
| GMP | Good Manufacturing Practices |
| GoT | Government of Tanzania |
| GoU | Government of Uganda |
| HACCP | Hazard Analysis and Critical Control Points |
| HEST | Haplochromine Ecology Survey Team |
| HIV/AIDS | Human Immunodeficiency Virus / Acquired Immune Deficiency Syndrome |
| HPI | Heifer Project International |
| IDRC | International Development Research Centre |
| IFIP | Inland Fisheries Planning, Development and Management in Eastern/Central/Southern Africa Project |
| IFMP | Implementation of Fisheries Management Plan |
| IUCN | International Union for Conservation of Nature |
| KMFRI | Kenya Marine and Fisheries Research Institute |
| LAN | Local Area Network |

| | |
|---|---|
| LVEF | Lake Victoria Environment Fund |
| LVEMP | Lake Victoria Environmental Management Project |
| LVFO | Lake Victoria Fisheries Organization |
| LVFRP | Lake Victoria Fisheries Research Project |
| LVFS | Lake Victoria Fisheries Service |
| IDA | International Development Agency |
| JICA | Japan International Cooperation Agency |
| MCS | Monitoring, Control and Surveillance |
| MRAG | Marine Resource Assessment Group |
| MSOP | Manual of Standard Operating Procedures |
| MSY | Maximum Sustainable Yield |
| NCCO | National Cold Chain Organisation |
| NFQCL | National Fish Quality Control Laboratory |
| NGO | Non Governmental Organization |
| NFFTI | Nyegezi Freshwater Fisheries Training Institute |
| NIMR | National Institute for Medical Research |
| PCC | Project Component Coordinator |
| SACCOS | Savings and Credit Cooperative Society |
| SAS | Statistical Analysis System |
| Sida/SAREC | Swedish International Development Agency / Swedish Agency for Research Cooperation |
| SoA | Sulphate of Ammonia |
| SPSS | Statistical Package for Social Sciences |
| SRP | Soluble Reactive Phosphate |
| SRSi | Soluble Reactive Silicon |
| TAFIRI | Tanzania Fisheries Research Institute |
| TANFIS | Tanzania Fishery Information System |
| TANU | Tanganyika African National Union |
| TBC | Total Bacterial Count |
| TC | Ttal Coliforms |
| TP | Total Phosphorus |
| TCRS | Tanganyika Christian Refugee Services |
| TSP | Triple Super Phosphate |
| TWPF | Tanzania Wildlife Protection Fund |
| UNDP | United Nations Development Programme |
| UNIDO | United Nations Industrial Development Organization |
| URT | United Republic of Tanzania |
| VicRES | Lake Victoria Research Initiative |
| WHO | World Health Organization |
| WOTRO | Netherlands Foundation for the Advancement of Tropical Research |

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# EXECUTIVE SUMMARY

Lake Victoria is the largest tropical lake in the world with a surface area, 68,800 $km^2$ (Bootsma and Hecky 1993). The lake is shared by three countries, with 51% share in Tanzania, 43% in Uganda, and 6% in Kenya. Its land catchment area of 193,000 $km^2$ is distributed as follows: Tanzania 44%, Kenya 22%, Uganda 16%, Rwanda 11%, and Burundi 7%. The shoreline of the lake is approximately 3,450 km, 50 % (1,750 km) is in Uganda, 33% (1,150 km) is in Tanzania and 17% (550 km) is in Kenya.

The Lake Victoria is endowed with invaluable fishery resources that are contributing enormously to the livelihood of the communities and the riparian states in terms of food security, employment, wealth generation, foreign earnings and other multiplier effects. The lake (Tanzania side) accounts for over 60% of the total national inland fish production. The lake is also an important source of water for domestic, industrial and small scale agriculture. It is also an important transport corridor between major towns around the lake and a number of villages, settlements, beaches and numerous islands.

Steady population growth in the lake basin over the years resulted in deterioration of water quality and fisheries resources. Consequently Lake Victoria Environmental Management Project (LVEMP) was started in 1997 as a five-year project with the main aim to rehabilitate the ecosystems in and around the lake with a long-term objective to introduce environmentally and socially sustainable economic development in the three riparian governments of Kenya, Tanzania and Uganda.

The volume of data and information generated by Fisheries Research and Fisheries Management components of LVEMP during the 8 years of implementation of Phase 1 of the LVEMP activities from July, 1997 to June 2002 and a bridging period of 3 years and half which extended the project from July 2002 to December 2005, promted the three riparian countries of Kenya, Uganda and Tanzania together with GEF and the World Bank to consider conducting an exercise to analyze, consolidate and synthesize data and knowledge generated during the period. This assignment was accomplished through a consultancy which involved one International Consultant and one National Consultant assisted by the Project Component Coordinators and Task Leaders of the Project and under the over all coordination of the LVEMP Secretariat.

The synthesis of the data and information in this report has lead to conclusions and some recommendations that could be used to guide management of the fisheries resources of Lake Victoria. The relevant conclusions and recommendations are highlighted for each major area as presented below.

**Small Water Bodies in the Lake Basin**

Satellite lakes, rivers, ponds, dams and floodplains in the catchment have been singled out as important faunal reservoirs for Lake Victoria endangered species. Several fish species currently known to be rare in the main lake are represented in isolated groups of small water bodies in the Lake basin supporting fisheries of the riparian communities. These habitats and resources therein are severely impacted by human activities. Studies should be mounted to restore damaged habitats in order to boost the recovery of endangered and threatened species such as lungfish (*Protopterus aethiopicus*) and the Ningu (*Labeo victorianus*).

**Life History Indicators of the Nile Perch**

The modal size for Nile perch has been progressively decreasing and size at first maturity for both females and males has been decreasing from 110 cm and 60 cm TL respectively recorded in 1990 to 54 cm for males and 77 cm for females observed in 2002. These changes seem to be driven by increased fishing pressure in the lake. If the current high exploitation rate is maintained, it is likely that the average size of Nile perch will decrease even further. Fisheries managers can reverse this trend by reducing the overall fishing effort.

Nile perch exhibits trophic dynamics characterized by a shift in from a diet predominantly comprising haplochromines to *Caridina nilotica*, anisoptera nymphs, its own juveniles, *Rastrineobola,* tilapiines with very few haplochromines. Recent data indicate an increasing importance of haplochromines in the diet. *Oreochromis niloticus* was a phytoplanktivorous and bottom feeder but it is now becoming increasingly omnivorous with *Caridina nilotica*, chironomids, chaoborids, molluscs and bottom detrital matter consumed as well. The changes in Lake Victoria environment which include dramatic shifts in phytoplankton species composition in response to eutrophication are partly responsible for the observed trophic dynamics. It is recommended that effort should be directed towards conducting investigations into the relationship between fisheries and environment (water quality) in Lake Victoria.

**Fisheries Data Collection and Frame Surveys**

Lake Victoria fishing effort has been increasing with time since 1965. CPUE (i.e. catch per boat) fluctuated with time but remained stable. The fish catches in Lake Victoria fluctuated with an increasing trend up to 1986 whereby more than 57% of the catch comprised Nile perch. In 1987 CPUE of haplochromines decreased dramatically while that of Nile perch increased steadily up to the period 1996-2000. However, reliability of the statistics after 1996 is questionable because catch assessment survey (CAS) was disrupted as a result of nation-wide retrenchment of public servants and decentralisation. This must be recognised as a severe limitation to management of the fishery. LVFO introduced SAMAKI database in an effort to harmonise CAS in Lake Victoria.

Studies to develop the CAS programme utilising BMUs have been started and show some promise. BMUs appear to hold considerable data on catches from all boats but collation of the data is inadequate. It is recommended that mechanisms to use BMUs for catch assessment surveys are investigated more fully, especially if the responsibilities can be linked to revenue collection activities. It is recommended a simple catch assessment protocol is designed which provides basic data on daily catch (weight) per species landed, effort (proportion of boats fishing) and length frequency. This must be coordinated by the Division of Fisheries but linked to BMU activities.

**Information and Database**

On information and database, a review of literature pertaining to Lake Victoria has been produced and is available on the Tanzania LVEMP website. However, there are limitations in internet access and library resources; consequently it is recommended the TAFIRI database centre establishes a local area network (LAN) that allows online access to many sources of information, including electronic journals, subscriptions to online journals. Financial resources should be made available to facilitate procurement of literature search engines rather than collecting back issues of journals because it is more cost effective and would allow wider dissemination in the region. Regional institutions should collectively support and contribute to this initiative, rather than duplicating purchase of expensive journals, etc. In the long run it is expected that this would improve access to information nationally and regionally.

**Stock Assessment**

Fish stock assessments in Lake Victoria have involved the use of bottom trawls conducted by the following research vessels, Ibis during the period 1969/70, R.V. TAFIRI II from 1995-1996 and R.V. Victoria/Explorer during 1999/2000. Recent efforts in 1999 to 2001 have seen the use of hydro-acoustic techniques. Some conclusions that can be drawn from these surveys include the following.

- The fish species diversity in the bottom trawl surveys in Lake Victoria has declined from a multi-species dominated by the haplochromines during the 1969/70 survey to a fishery of a few species currently dominated by the introduced Nile perch, followed by *Rastrineobola argentea* and Nile tilapia. The dominance of the haplochromines has now declined from 71% (by weight) in 1969/70 to 2.0% in 1988 and is showing recovery with a contribution to bottom trawl catches estimated at 5.7% during 1999/2000 survey.
- Total fish biomass estimates using acoustic and bottom trawl surveys during the period 1997-2001 were higher than the values obtained during

the last lake wide survey of 1969-1971. This confirms the observation that the productivity of the Lake Victoria system has increased since the early 1970s and also reflects expansion of the standing stock from the low levels of the early 1970s (0.402 x $10^3$ tonnes) to the current one of 2.17 x $10^6$ tonnes.

- Fish standing crop was approximately four times as high in inshore waters compared to offshore waters. The standing crop was also high around the islands compared to the open offshore areas. This makes their targeting by fishermen easier and can lead to over fishing.
- In the light of the present exploitation rates regular trawl surveys to monitor the changes in the fish stocks should be continued and that all habitats including waters >40 m should be covered. Surveys of un-trawlable areas including water columns above about 3 m from the bottom should be done using graded gill nets.

**Fish Quality Assurance**

The Lake Victoria Environmental Management Project has been instrumental in enabling the Fisheries Division to strengthen its fish quality assurance system through the establishment of National Fish Quality Control Laboratory in Mwanza. This laboratory is responsible for the verification of effectiveness and efficiency of quality management systems in fish processing establishments as a requirement to the international market. This intervention has ensured that fish and fisheries products from Lake Victoria are safe and of high quality for both local consumption and the export markets. For these achievements to be sustained, more resources need to be availed through public-private sector partnerships. To this end attention is drawn to the following recommendations:

- Regular courses should be organized and attended by the fish inspection staff to enable them keep abreast with new technologies in fish inspection techniques.
- The landing sites and the fish processing plants should be routinely audited, verified and inspected for compliance to Fish Quality Control and Standards Regulations of 2000.
- All landing sites should be improved and modernised to assure quality of fish and fisheries products.

**Aquaculture Extension**

Aquaculture development in the lake zone was revived through support provided LVEMP towards extension services. TAFIRI and Fisheries Department staff were given direct and indirect support for mobilizing, sensitizing, awareness creation, training, monitoring, control, development and management of fish ponds. A mixture of approaches was used over the duration of the project from meetings, discussions, lectures, hands-on training, and demonstrations by extension workers.

Some of the innovations which have been introduced include the technology of producing fingerlings of *Clarias gariepinus* through artificial spawning. LVEMP also supported production of *Oreochromis niloticus* fingerlings for distribution to local communities. The following recommendations are made in the light of the current status of aquaculture development in the lake zone:

- Aquaculture development should be properly planned and all barriers removed so that it can bring meaningful economic benefits to the practitioners and the riparian districts as a whole.
- Aquaculture extension should be strengthened by training more workers and practitioners, enhancing the capacity of existing pool of researchers and recruiting more research staff, and allocating more funds to the sub-sector. Furthermore, there is need to manufacture fish feeds locally and introduce more innovative technologies in the production of fingerlings in hatcheries.

**Socio-economics**

The Lake Victoria fisheries continue to remain a crucial resource to support the livelihoods and well being of the riparian communities and the country at large. The opportunities that the lake provides in terms of employment and its contribution to the national economy among others make fisheries one of the most important sectors for regional development. From a socio-economic dimension, it is recommended that efforts should be devoted to understanding the society in which fisheries operate. The communities' contradictions and potential synergies need to be considered when dealing with these communities. It is expected that such an understanding will enable planners direct fisheries resource exploitation to avenues that should improve social welfare of these riparian communities.

**Fisheries Co-management**

Fisheries co-management as an alternative to centralized command and control fisheries management is being advocated as a solution to the problems of resource use conflicts and overexploitation. LVEMP played a key role in the introduction of co-management through formation of Beach Management Units (BMUs) in the lake zone. Since the introduction of the co-management programme, BMUs have continued to work in collaboration with Fisheries staff to curb illegal fishing practices, participate in data collection for Catch Assessment Surveys and Frame Surveys, beach hygiene and sanitation, environmental conservation amongst others.

The BMUs which have been established lake wide as models of co-management are an important institution and therefore should be recognized and given all support to enable it effectively perform its functions. The support that needs to be extended should be in the form of facilities and enactment of by-laws. Since BMUs constitute stakeholders who are direct beneficiaries of the resource, giving them full power and entrusting them with the responsibility of management of the resource would bring about its conservation, protection and sustainability, which is in line with the overall goal of National fisheries policy.

**Phytoplankton and Zooplankton**

Changes in the limnochemistry of Lake Victoria which involved reduced silica and elevated phosphorus and nitrogen have lead to a shift in dominance from microalgal communities dominated by diatoms such as *Aulacoseira* (*Melosira*) and green algae to blue-green algae. *Aulacoseira* formed the main food of the native commercially important tilapiine *Oreochromis esculentus,* and its reduction might have affected stocks of this species. The dominance of BGA including toxic forms, could have led to reduction of available food for the native fish species. BGA are less digestible and provide poor quality food that may have contributed to the reduction or loss of planktivorous haplochromines and tilapiines that once flourished in Lake Victoria.

Trends in the dynamics of the zooplankton over the years have shown progressive change in both abundance and diversity but the community structure of zooplankton still comprised three groups, namely the rotifers, cladocerans and copepods. The high relative abundance of cyclopoid copepods in Lake Victoria and the small water bodies in the basin affords them a high value for fish production, as this item is important in the diets of pelagic and larval fishes. It is worthy noting that the standing stocks of the planktivorous dagaa, *R. argentea* have progressively increased from 1999 to 2001, partly suggesting a dependable and stable food base for this fish.

Since observed changes in phytoplankton and zooplankton are partly related to reduced water quality in the lake, there is need for reduction of nutrient loads and pollutant input into the nearshore areas of Lake Victoria through treatment of municipal and industrial effluents. It is recommended that an effective water quality monitoring system and research be continued to ensure collection of data and information for informed decision-making.

**Fish Levy Trust**

Fish Levy Trust study conducted through LVEMP, proposed the establishment of a special fund namely Lake Victoria Environment Fund (LVEF), which once operational will lay the foundation for generating public revenue from fishing and using them to sustain further environmental protection activities in the Lake Victoria Basin. The LVEF should be a facilitation and co-financing mechanism allowing stakeholders to make better use of their own resources. This fund will not receive direct contributions from any source other than the export royalty stream. Local level stakeholders will be required to contribute, but to specific activities, rather than to the fund itself. The riparian states have agreed that certain activities such as credit schemes which provide incentives to increase fishing effort, activities that are peripheral to sustaining the fisheries resources and activities of Fisheries Department and Local Authorities will not be funded by the Trust fund. For effective operationalisation of the Fish Levy Trust, it is recommended that the establishment of Lake Victoria Environment Fund be supported by legislation, preferably a new Act.

# CHAPTER ONE

# INTRODUCTION

*Y.D. Mgaya*
*University of Dar es Salaam*
*Faculty of Aquatic Sciences and Technology*
*P.O. Box 60091, Dar es Salaam*

## 1.1 Background

Lake Victoria is the largest tropical lake in the world with a surface area, 68,800 km$^2$ (Bootsma and Hecky, 1993). The lake is shared by three countries, with 51% share in Tanzania, 43% in Uganda, and 6% in Kenya. The lake is roughly square in shape, its greatest length and width being approximately 400 and 300 km respectively. It lies at an altitude of 1,135 km above sea level and is situated between the great plateau stretching between the western and eastern rift valley. Much of the lake is relatively shallow (maximum depth, 96 m in the northeast, average depth, 40 m). Its land catchment area of 193,000 km$^2$ is distributed as follows: Tanzania 44%, Kenya 22%, Uganda 16%, Rwanda 11%, and Burundi 7% (GoK/GoU/GoT, 1996; Fig. 1.1). The shoreline of the lake is approximately 3,450 km, 50 % (1,750 km) is in Uganda, 33% (1,150 km) is in Tanzania and 17% (550 km) is in Kenya. The lake bottom is mainly covered by thick layer of organic mud, with patches of hard substrate, sand or rock (Scholtz *et al.*, 1990). The shoreline is characterized by numerous sheltered bays and gulfs which make it very irregular and impart heterogeneity and ecological differentiation to the lake limnochemistry and biota.

The drainage basin on the Tanzanian part of Lake Victoria is characterised by small (satellite) water bodies which include Lake Malimbe and the lower Kagera lakes complex and flood swamp (lakes Rusha, Kalenge, Katwe, Ikimba, Burigi, Rwakajunju and Ngoma), the Masirori swamp (Lake Kubigena) and the Kirumi ponds. Major rivers draining into Lake Victoria are Mara, Mori, Suguti, Grumet, Simiyu, Rubana, Suguti, Ngono, Magogo, Mbalageti, Moame and Kagera (Fig. 1.1). These satellite water bodies are shallow with maximum depth in the range 1.8 m and 8 m (Katunzi, 1998).

Lake Victoria and its inflowing rivers contribute significantly towards ecological, biophysical, cultural and socio-economic development along its shoreline, catchment area, within the islands as well as the livelihood of the communities far and beyond its catchment area. The lake supports Tanzania in terms of food, transport and communication, tourism, water supply for domestic, agricultural and industrial use, waste water disposal, recreation, sport and biodiversity conservation. The lake is also vital for weather and climate modulation. The dominant socio-economic activities in the lake and its catchment include agriculture, fisheries, marine transportation, recreation, and water supplies for domestic and industrial use in the urban centres on its shoreline. Agriculture and fishing remain the dominant socio-economic activity of most of the population within the catchment area, though mining is also an important economic activity around Mwanza, Mara and recently Kagera (Tulawaka in Biharamulo) region. Urban development (Mwanza, Bukoba and Musoma) is also on the increase.

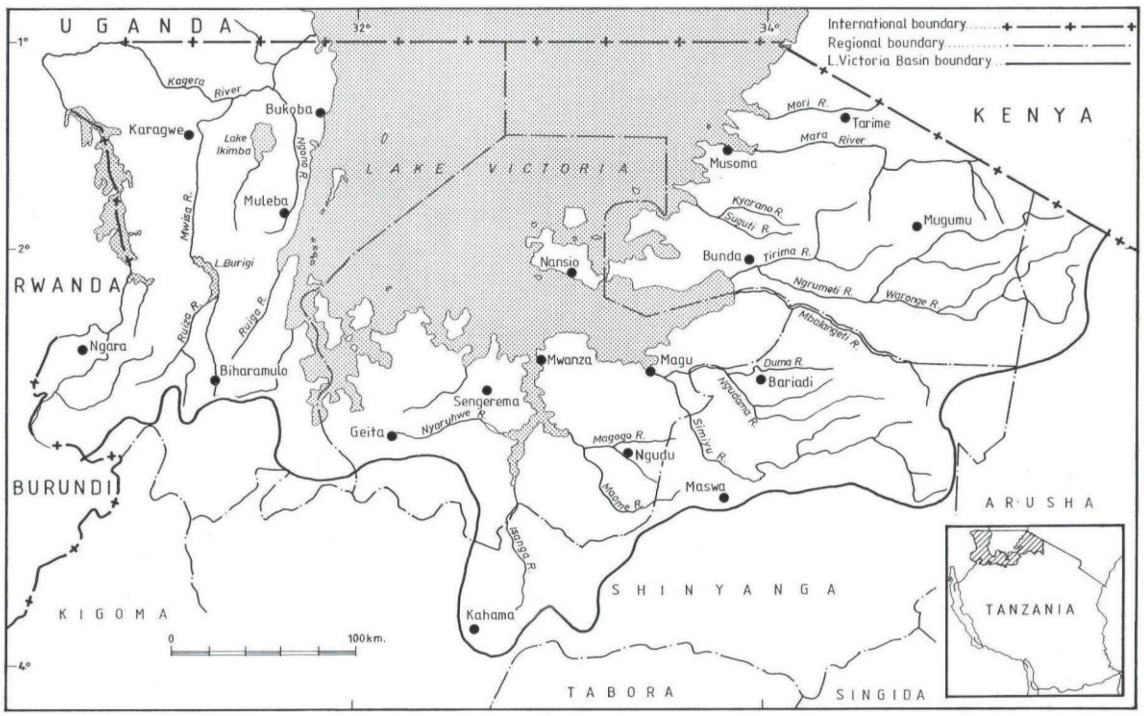



Figure 1.1: Map of Lake Victoria (Tanzania) showing the major rivers, catchment area and urban centres.

The Lake Victoria is endowed with invaluable fishery resources that are contributing enormously to the livelihood of the communities and the riparian states in terms of food security, employment, wealth generation, foreign earnings and other multiplier effects. The lake (Tanzania side) accounts for over 60% of the total national inland fish production and is estimated to contribute annually over 250,000 mt. Fish and fishery products from this lake provided a significant quantity of protein/food amounting to 262,572.06 mt in 1996 valued at more than Tsh 81.6 billion. In the year 2004 total Nile perch and its products exported from Lake Victoria was 47,343,453.82 mt. and they generated US $ 100,376,716.16 as foreign exchange earning (Fisheries Division, 2004). The lake provides income and employment to over 77,000 full time fishermen operating a total of 22,653 vessels (Fisheries Division, 2005) and over 500,000 people are employed formally or informally in fisheries related activities. In addition, there are more than 4 million people living in the Tanzania catchment of the lake and other millions in other parts of the country who benefit directly or indirectly in the form of food or income from the lake fishery. The lake is also an important source of water for domestic, industrial and small scale agriculture. It is also an important transport corridor between major towns around the lake and a number of villages, settlements, beaches and numerous islands.

## 1.2 History

### *1.2.1 Lake Victoria Environmental Management Project*

Lake Victoria used to have a rich well balanced fish species complex prior to the 1960's. Post 1960's is characterised by greatly changed fish species composition. The huge haplochromine flock is reduced to near extinction and only pockets of some species may be seen in protected bays and inlets acting as refugia (Witte *et al.*, 1992). The two endemic *Oreochromis esculentus* and *O. variabilis* have almost disappeared in the lake. Non-cichlid endemic genera which were well represented but now seldom seen include *Barbus, Protopterus, Mormyrus, Labeo, Gnathonemus, Rastrineobola, Synodontis, Clarias, Bagrus, Schilbe,* and *Alestes* (GoK/GoU/GoT, 1996).

Many reasons have been advanced for the decimation of important fish species in Lake Victoria, but certain events in the lake can be directly associated with species decline. There have been introductions of exotic tilapiines, notably *Oreochromis niloticus, O. leucostictus, tilapia zillii* and *T. rendalli*, in the 1950's and 1960's. The voracious Nile perch, *Lates niloticus* was found to have entered the lake in the early 1960's. Further, bad fishing practices and overfishing have greatly contributed to the decimation of Lake Victoria fish species. Further, degradation of the environment leading to siltation, eutrophication and pollution has contributed to species inability to successfully utilize habitats for survival (GoK/GoU/GoT, 1996).

The increasing population pressure and socio-economic activities in the lake basin have resulted into changes in land use, water quality, biodiversity, wetlands and fisheries. Fish stocks have been decreasing, biodiversity has declined, algal blooms are frequent and turbidity which reduces water transparency continued to increase due to increased eutrophication. The water hyacinth *Eichhornia crassipes* continued to spread over the lake and interfered with light penetration, dissolved oxygen, fish breeding sites, landing beaches, recreation, lake transport and the lake ecosystem (GoK/GoU/GoT, 1996).

The lake is being polluted through industrial effluent as well as domestic and urban wastes, sewage, land degradation, destruction of wetlands and urban and agricultural run-off. In the basin, soil erosion became a major problem leading to serious water pollution through concentration of dissolved phosphates, nitrates and pesticides as well as increased sediments in the water body.

It was realised that the environmental concerns described herein needed to be addressed through an integrated and concerted effort. The three riparian states further realised that rational utilisation and conservation of Lake Victoria can only be achieved through cooperating in planning exploitation, management, and monitoring of the resources. Unfortunately previous efforts by the riparian countries at joint management of the lake collapsed with the demise of the East African Community in 1977. Threats to the lake ecosystem continued unabated. This prompted the Governments of Kenya, Uganda and Tanzania to initiate plans for the formulation of a Lake Victoria Environment Management Programme. Consequently, on 5$^{th}$ August 1994 the three Governments signed a Tripartite Agreement that would lead to a cooperative framework for lake basin management including the lake as well as its catchment.

Lake Victoria Environmental Management Project (LVEMP) was started in 1997 as a five-year project with the main aim to rehabilitate the ecosystems in and around the lake with a long-term objective to introduce environmentally and socially sustainable economic development in the three riparian governments of Kenya, Tanzania and Uganda. LVEMP was designed as a comprehensive and holistic regional development programme and is being implemented nationally in Kenya, Tanzania and Uganda but is being coordinated regionally within the scope of the Treaty of the East African Community. The purpose of LVEMP is, therefore, to stabilize the observed long-term trend in the (i) deterioration of water quality of Lake Victoria due to nutrient enrichment, (ii) land degradation due to soil erosion as a result of deforestation and poor agricultural practices in its catchments, (iii) destruction of wetlands, (iv) infestation with water hyacinth, (v) destruction of biodiversity, (vi) destructive fishing practices, and (vii) increasing pollution loads from industrial and municipal sources (GoK/GoU/GoT, 1996).

#### *1.2.2 Fisheries Research and Management and Components of LVEMP*

Technically LVEMP is implemented through activities that are spread across ten components which include Fisheries Research and Fisheries Management. Others components include Establishment of the Lake Victoria Fisheries Organization, Water Hyacinth Control, Water Quality and Quantity Monitoring, Industrial and Municipal Waste Management, Wetlands Management, Catchments Afforestation, Land Use Management and University Capacity Building.

The Fisheries Research component has the objectives of generating and providing information on the ecology of the lake and its catchments, the biology of its flora and fauna, the impact of environmental factors on the lake ecosystem and the socio-economic implications of use of the lake's resources, in order to ensure the sustainable exploitation and management of the fisheries, conservation of aquatic biodiversity, integration of lake productivity processes into fisheries enhancement and management, reduction of degradation of fish habitats, involvement of communities and creation of information centres for dissemination.

The objectives of Fisheries Management component are to promote, support, guide and ensure proper management and optimum utilization of the fisheries resources and aquaculture practices in the Lake Victoria basin for the benefit of the riparian population and the global community. Its activities included the harmonization of fisheries regulations of the three countries, the identification and establishment of closed fishing areas, the setting up of Beach Management Units to enhance co-management and to guard against illegal and destructive fisheries practices, the establishment of fish quality assurance laboratories, the improvement in fish handling and processing practices and the completion of over 115 micro-projects that comprised investments of up to US$ 15,000.00 each in community water supply, sanitary facilities, local roads, health facilities and schools.

## 1.3 Objectives of LVEMP and Justification of the Present Consultancy

The expectations from the outset was that the outcomes of the LVEMP activities would "be species distribution and habitat maps, information on the genetic make-up and diversity of different populations, understanding of the causes of decline of fish species, understanding of the impact of environmental changes on the biology, behaviour and survival of declining species, guidelines for species conservation and restoration, an updated bibliography of Lake Victoria and its fisheries.

During the last seven years of the LVEMP, extensive biotic field surveys have been conducted in the three countries and all the data were analysed to provide the required fish biology, fisheries and biodiversity data and baseline information. In addition, policy recommendations have been formulated and appropriate technologies have been packaged to address fisheries management issues. This is contributing towards improved ecological efficiency, greater biodiversity and ecological balance in the lake system.

While fisheries research and management components have been able to collect large amounts of data and information during the LVEMP and from other sources, analyses are often basic and data are not always used to their full potential. In addition, data collected by different components are rarely integrated and analytical output is only to a limited degree translated into proposed management actions. Consequently, there is need to analyse the data, in a quantitative manner using appropriate methods, and to summarize the information gained and place it in the context of information existing before the LVEMP and also the information that may have been generated by other entities. This will lead to getting a complete picture of past trends and the current status of the fisheries and biodiversity of Lake Victoria and its catchments in line with the expectation of the LVEMP. The information gathered and lessons learnt would, further, help give direction to the process of preparation of the next phase of the project.

## 1.4 Scope of this Report and Methodology

The process that led to the development of this synthesis report involved mainly two working sessions which brought together all contributors and a national stakeholders' workshop. These two activities were preceded by an inception workshop which reviewed the terms of reference of the international and national consultants. Furthermore, the participants determined the outline for the national report; established a time frame for completion of the reports including a common format for report preparation. They also reviewed data available for the report; assigned responsibilities for writing individual sections of the national report and reviewed and analyzed required data for the complete report.

During the national working sessions, compilation of the various chapters involved the consolidation, analysis, synthesis and the development of trends; the interpretation of data, spatial and temporal variability, inter-species relationships, behaviour of species as well as impact of environmental changes on biodiversity and the causes of species decline. The report writing process involved access and use of the data produced through the activities of the Fisheries Research and Management Components of the LVEMP, literature sources from libraries and data and information from other entities operating on Lake Victoria.

Throughout the preparation of this synthesis report, the Project Component Coordinators (PCCs) cooperated with both National and International

Consultants. The PCCs coordinated the collection of data by chapter contributors and participated in the analysis, consolidation and synthesis of all data. The national consultant supervised the consolidation and formatting of the data in order to bring out spatial dimensions and trends. He worked with the PCCs to produce national data summaries and reports, and provided technical guidance to ensure production of quality reports. The National Consultant worked with the two PCCs to prepare for the Working Sessions and the National Workshop.

This synthesis report documents changes in biodiversity, fisheries, industry and management that have taken place over the recent decades. It provides an overview of the present knowledge and status of the fish and fisheries of the lake as well as identifying past changes and continuing trends that may require closer monitoring or remedial action. The aim of the report is to provide detailed information and spatial resolution at the national level to support fisheries decision making on the lake's fisheries resources. This report is structured into chapters and sub-chapters. There are fourteen main chapters in the Report including an Introduction. The main conclusions of the study and recommendations for future interventions are presented in the last chapter.

# CHAPTER TWO

# HISTORICAL TRENDS IN FISHERIES RESEARCH IN TANZANIA

*E.F.B Katunzi[1] and S. Mahongo[2]*
*Tanzania Fisheries Research Institute*
*[1]P. O. Box 475, Mwanza*
*[2]P.O. Box 9750, Dar es Salaam*

## 2.1 Introduction

LakeVictoria research activities date back to the beginning of the last century (Graham, 1929; Akiyama *et al*., 1977). Over the years, the lake has undergone dramatic ecosystem changes reflecting the decline of biodiversity and ecosystem changes**.** This was imminent following a drastic decline and even probable extinction of some fishes particularly the haplochromines that used to comprise more than 80% of the ichthyomass in the lake (Kudhongania and Cordone, 1974; Ogutu–Ohwayo, 1990; Witte *et al*., 1992; Witte *et al*., 1995). The causal events were more associated with predation by Nile perch, over-fishing, eutrophication, human and natural activities in the drainage basin, industrialization, urbanization and agricultural developments (Goudswaard and Ligtvoet, 1988; Barel *et al*., 1991). These finally caused disruption of the trophic dynamics of the lake and consequent accumulation of algae and detritus (Hecky, 1993; Hecky *et al*., 1994; Lowe-McConnell, 1992; Ogutu-Ohwayo, 1990).

## 2.2 Fish and Fisheries

Lake Victoria was once the home of an expansive icthyomass fauna comprising haplochromines, *Labeo victorianus*, *Brycinus* spp., *Barbus* spp., *Mormyrus* spp. and *Synodontis* sp. with *Oreochromis esculentus* and *Oreochromis variabilis* forming the backbone of the fishery (Graham, 1929; Greenwood, 1966; Ogari, 1984).

*Oreochromis esculentus, Protopterus aethropicus, Bagrus docmak, Clarias gariepinus* and haplochromines were the important commercial species. Over-exploitation as a result of effort and efficient exploitation technologies depleted the stocks, leading to introductions of tilapiines, i.e. *Oreochromis niloticus, O. leucostictus, Tilapia rendalii, Tilapia zillii* and later *Lates niloticus.* Research activities were designed to address isssues related to the introduced species and the abundant haplochromines. In the mid-1950's Lake Victoria had a diverse fish fauna comprising 29 genera and about 350 species. Of these the haplochromines comprised about 80% of the demersal fish stocks (Kudhongania and Cordone, 1974), (Greenwood, 1974). During the 1960s, research indicated the lake to be dominated by a multispecies fishery with species estimated to be over 350 comprising more than 28 genera. Heavy exploitation of tilapiines i.e., *O. esculentus* and *O. variabilis* caused a decline of these species. Further intensive and efficient gillnet fishery (Fryer, 1973; Marten, 1979), and increased demand for fish protein exerted much pressure on the resources particulary *Labeo victorianus* (Boulenger), *Brycinus* spp., *Mormyrid* spp. and *Barbus altianalis* Boulenger 1900 in the 1970's leading to their decline.

To boost fisheries, Nile perch (*Lates niloticus*) was introduced into the lake in the 1950's. The suggestion that *L. niloticus* be introduced into Lake Victoria as a means of utilizing the abundant haplochromines that were commercially unimportant and almost regarded as "trash fish" in the fauna was first reported in 1928 (Graham, 1929). The introduction was further aimed at managing the fishery, by permitting an extension of the fishing grounds into the deeper offshore waters and the use of a wider variety of gear for exploitation. This was meant to release fishing pressure on "*Oreochromis*" whose habitat was within the shallow inshore areas of the lake (Anderson, 1961). Predation by Nile perch further added the pressure to the resources (Ogari and Dadzie, 1988; Ogutu-Ohwayo, 1990; Mkumbo and Ligtvoet, 1992).

For the first time the haplochromine group was made known to science in the $19^{th}$ century (Hilgendorf, 1888) as a sub-genus within the genus *Chromis*. Boulenger (1906) assigned full generic status to *Haplochromis*. Much later, Greenwood (1979, 1980) classified the haplochromines of the Lake Victoria basin into 28 genera (Greenwood, 1974). The haplochromine alone accounted for more than 500 species (Greenwood, 1974; Witte *et al.*, 1992; Seehausen, 1996). These encompass the recent discoveries in the southern part of Lake Victoria particularly where the HEST group (van Oijen, 1981; Seehausen, 1996; Seehausen *et al.*, 1998) reported eleven and 100 more rocky cichlids respectively.

They were widely distributed, occupying almost all the aquatic systems within the basin *vis-à-vis* rocky shores, swamps, satellite lakes, dams and rivers. Up to eleven trophic groups were identified mostly in the Mwanza Gulf (Witte *et al.*, 1992). These included phytoplanktivores, detritivores, algal grazers, plant (higher plants) eaters, molluscivores, zooplanktivores, insectivores, piscivores, parasite eaters, paedophages and scale-eaters. Greenwood (1974) had earlier identified five trophic groups in the northern part of the lake basin. These included insectivores, piscivores, molluscivores, plant-eaters and scale-eaters. The haplochromines converted numerous protein sources; detritus, algae, zooplankton, insect larvae, molluscs and many others into fish protein for consumption by higher trophic levels (Christian, 1995). They were crucial in maintaining the ecosystem that supported other food fishes, as well as the high biodiversity associated with the lake basin (Worthington, 1929; Greenwood, 1965; 1966; Trewavas, 1983).

## 2.3 Environmental and Phytoplankton Studies

Several studies on the limnology of the lake have indicated two major environmental regimes of alternating wet and dry seasons (Worthington, 1930; Fish, 1952; 1957; Newell, 1960; Talling, 1957; 1966; Akiyama *et al.,* 1977; Melack, 1979; Ochumba and Kibaara, 1989). Oxygen levels could be tolerable for a number of species down the lake up to 50 m deep and fish could be caught at such distances (Kudhongania and Cordone, 1974). Anoxic conditions are currently occurring in relatively shallower conditions. Thermal stratification and mixing in the lake are the major physical properties known to control changes in the chemical and biological characteristics of the lake (Talling and Talling, 1965; Talling, 1969; Beadle, 1981; Talling and Lemoalle, 1998; Hecky *et al.,* 1996; Mugidde, 2001; Gichuki, 2003).

Environmental parameters involving water quality have also been shown to have an impact on the losses in the biodiversity. Increased eutrophication and sedimentation over the years have greatly affected light penetration and had an impact on the reproduction of the cichlids (Seehausen *et al.*, 1997). Research had indicated ecosystem changes that have been initiated as a result of global environmental change. Phosphorus and nitrogen concentrations in the lake have doubled in the last 20 years while soluble reactive silica has decreased by 7 fold. Reported cases of total nitrogen in the inshore shallow bays and gulfs had indicated high concentrations over the recent years compared to offshore regions.

The first comprehensive algal studies were done during the 1950's and 1960's, and reported a predominance of large diatoms particularly from the genera *Melosira* (now called *Aulacoseira*), *Stephanodiscus* and *Nitzschia* (Talling, 1966). A 1966 study in the offshore waters of the lake showed that diatoms increased in numerical abundance during periods of isothermal mixing of the whole water column (Talling, 1966). Cyanobacteria on the other hand dominated the epilimnion during thermal stratification, while *Ceratium brachycerus* (a dinoflagellate) showed erratic variation. Green algae however remained sparse throughout the season. According to Verschuren *et al.* (2002), Lake Victoria was stable between about 1820 and 1940, with *Cyclostephanos*, and *Aulacoseira* making a large proportion of diatoms (80% and 15%, respectively) and *Nitzschia acicularis.* The abundance of these three taxa started to increase between about

1940 and the early 1960, with *Nitzschia acicularis* comprising 50% of the diatom community.

The lake in general is considered among the highest productive lakes with high rates of phytoplankton primary production (Mugidde, 1992; 1993; Ogutu-Ohwayo *et al*., 1996). Phytoplankton biomass evaluated as chlorophyll-*a* or as biovolume has increased by 6-fold or more since the 1960's (Talling, 1966; 1987; Mugidde, 1992; 1993; Kling *et al*., 2001) to the present values ranging from 2.5 to 660.0 $\mu g\ l^{-1}$.

The algal community has greatly changed over the years and this has been attributed to modification of the water chemistry and physical environment (Akiyama *et al*., 1977; Hecky, 1993; Hecky *et al*., 1996; Lehman *et al*., 1998; Lung'ayia *et al*., 2000; Kling *et al*., 2001; Mugidde, 2001). Recent reports show that *Aulacoseira* (*Melosira*) and *Cyclostephanos* that made up 70%-99% of the diatom biomass in the lake have now been replaced by *Nitzschia* (Kling *et al*., 2001).

There has been an increase of diatoms since 1960's despite a 7-fold reduction in soluble reactive silica in the water column (Kling *et al*., 2001). A wide variety of cyanobacteria (blue-green algae) that were consistently low in the 1960's now appear more frequently and filamentous heterocystous cyanobacteria such as *Cylindospermopsis* make up a large fraction of the algal community of the lake. Green algae now occur in very low abundance and several desmids no longer exist.

Recent analysis of phytoplankton samples reveals some similarities and differences with the situation observed during the past years. *Microcystis* sp., *Anabaena* sp., *Lyngybya* sp., *Merismopedia* spp., *Aphanocapsa* sp., *Nitzschia* sp. that were recorded by Talling (1987), Komarek and Kling (1991), and Akiyama *et al.* (1977) were also recorded during recent surveys. Some species like *Surirella* sp., *Cymatopleura* sp., *Rhizosolenia* sp. and *Melosira (Aulacoseira*) sp. that were recorded by Talling (1987) were either not recorded or rarely encountered during 2000-2004 studies in the Tanzanian part of the lake (Mbonde *et al*., 2004). Quite large number of *Anabaena* and *Microcystis* were observed reaching the high value of $2.3x10^7$ and $1.3x10^6$ cells/l, respectively (Mbonde *et al*., 2004).

Reports show that *Aulacoseira* (*Melosira*) and *Cyclostephanos* that made up 70%-99% of the diatom biomass have now been replaced by *Nitzschia* (Kling *et al*., 2001). The thinly silicified *Nitzschia acicularis* comprises about 94% of the total diatom abundance, while in the whole phytoplankton community, Cyanobacteria dominates lake wide, especially during November-January (Kling *et al.,* 2001; Mbonde *et al.,* 2004). The species shift is interpreted as evidence for silicon limitation due to the increased diatom growth. This reduction matched with the increased occurrence of massive cyanobacterial bloom. Currently, phytoplankton biomass evaluated as chlorophyll-*a* or as biovolume has increased by 6-fold to the values ranging from 2.5 to 660.0 µg $l^{-1}$ (Kling *et al*., 2001).

## 2.4 Changes in Primary Production

Low algal biomass composed mainly of diatoms was reported in earlier limnological surveys with offshore chlorophyll-*a* ranging from 1.2 to 5.5. mg. $m^{-3}$ and 10-15 mg. $m^{-3}$ inshore (Talling, 1966). The increase in algal biomass is indicated by higher chlorophyll- *a* concentration. For instance, from the research done in November/December 2003 (Kishe, 2004), the following values were recorded. 170.7 µg/l at Suguti, 124 µg/l at Nyamirembe and 102.8 µg/l at Nyamikoma. These values are much higher than than 21 µg/l recorded by Talling (1966) in the Nyanza Gulf and 78 µg/l recorded by Ochumba and Kibaara (1989) during algal blooms. This increase in algal biomass is coupled with increase in nutrient enrichment as recorded during the survey. Unlike the low concentrations of nitrate recorded in the study done in Mwanza Gulf by Akiyama *et al.* (1977) which were always below 5 µg/l, and phosphorus below 15 µg/l with higher concentration of about 44 µg/l at the bottom. We recorded up to 308.1 µg/l of Nitrate at Magu, 166.7 µg/l at Nyamikoma, 90.1µg/l at Cholle, and 78µg/l at Nyamirembe. The highest phosphorus value (137.7 µg/l) was recorded at Magu bay, while Talling (1965) recorded a phosphorus concentration of 10 µg/l. In the last survey the results obtained by Kishe (2004) agree with those of Lehman and Branstrator (1994) who reported that phosphate concentration has been doubled.

Surface water in 1960-61 periods was always near saturation with atmospheric oxygen (94-100%), except during mixing (90%) in July. Low oxygen conditions were only recorded below 55 m (less than 0.7mg/l) and complete de-oxygenation (below 0.1 mg/l) (Talling, 1966). These ecological changes in the lake have been attributed to increased anthropogenic activities due to population increase. Of importance is the intensification of land use and increased agricultural run-off of nutrients into the lake (Lowe-McConnell, 1992). The levels of urban and industrial pollution are also reportedly increasing in the lake townships of Mwanza, Bukoba and Musoma. Agricultural expansion has led to the removal of riparian vegetation that acted as natural filter, aggravating the nutrient-rich status of the lake.

## 2.5 Zooplankton

The zooplankton community of Lake Victoria comprises of three groups i.e., the rotifers, cladocerans and copepods (Akiyama *et al*., 1977; Mavuti and Litterick 1991; Mwebaza-Ndawula, 1994; Waya, 2003; 2004).

Prior to the introduction of *L. niloticus* the relative proportions of the major taxa ranked as cyclopoids > calanoids > rotifers and cladocerans in terms of density (no./$m^2$) in the stations near the shore, but in the open water stations the diaptomids became equal or even dominant over cyclopoids (Rzoska, 1957). Past history shows that zooplankton community of Lake Victoria is dominated by cyclopoid copepods and their developmental stages in terms of abundance and biomass (Akiyama *et al*., 1977; Mavuti and Litterick, 1991; Mwebaza-Ndawula, 1994; Branstrator *et al*., 1996). This scenario differs from the work of Worthington (1931), who reported calanoid copepod to be dominant and the presence of cladocerans in large amount.

Zooplankton species composition over the years has shown some changes (abundance and diversity) but the community structure still comprises the three groups—the rotifers and two subclasses of the Crustacea, the Cladocera and Copepoda (Waya, 2003; 2004; Chande *et al*., 2004). Factors regulating the density and production of zooplankton have been identified as temperature, food and predation (Herzig, 1994; Hart *et al*., 1995). Currently food condition and predation among others seem to be the important factors affecting density and biomass in Lake Victoria. The Copepoda population is comprised of 9 species namely, *Thermodiaptomus galeboides, Eucyclops* spp., *Mesocyclops* sp., *Thermocyclops emini, Thermocyclops incisus, Thermocyclops neglectus, Tropocyclops confinnis,* and *Tropocyclops tenellus.* Cladocera is represented by 8 species *Alona* sp., *Bosmina longirostris, Ceriodaphnia cornuta, Chydorid* spp., *Daphnia lumhortzi* (Helm.), *Daphnia barbata, Diaphanosoma excisum* and *Moina micru*. Rotifera comprises of 19 species, namely *Ascomorpha* sp., *Asplanchna* spp., *Brachionus angularis, Brachionus calyciflorus, Brachionus caudatus, Brachionus falcatus, Brachionus forficula, Brachionus patulus, Brachionus leydig, Filinia longiseta, Filinia opoliensis, Keratella cochlearis, Keratella tropica, Keratella quadrata, Lecane bulla, Lecane inermas, Polyarthra* spp., *Synchaeta* spp., and *Trichocerca* spp. (Waya, 2003; 2004; Waya and Mwambungu, 2004; Chande *et al*., 2004).

Apart from diversity, the zooplankton abundance has also been fluctuating with time and in space. Crustacean zooplankton and rotifers are almost universally distributed in pelagic and littoral regions of Lake Victoria (Worthington, 1931; Rzoska, 1956; Akiyama *et al*., 1977; Mavuti and Litterick, 1991; Mwebaza Ndawula, 1994; Waya, 2003; 2004; Chande *et al*., 2004). Throughout the year the zooplankton community is dominated by cyclopoid copepods less than 30 m. whereafter the calanoids dominate (Waya and Mwambungu, 2004; Waya, 2004).

## 2.6 Macroinvertebrates

The Lake Victoria is home to a great variety of macroinvertebrates (>2 mm body length) taxa (e.g., oligochaetes, turbelarians, molluscs, insect larvae and crustaceans). Most of the taxa are associated with bottom sediments (macrobenthic) others with vegetation along the lake shore and the littoral zones (macro-littoral invertebrates) and others are free swimming in littoral or offshore (macro-pelagic invertebrates). Information of the past history on macroinvertebrates in Lake Victoria basin Tanzania is very scant. It has been noted that since 1986 the abundance of macroinvertebrates such as *Chaoborus edulis*, the atyid prawn *Caridina nilotica*, oligochaetes, ostracods, molluscs, *Chironomus*, insect nymphs of Anisoptera and Ephemeroptera, have increased compared to the previous years (Mbahinzireki, 1992; 1994; Budeba, 2003). The eutrophication that has been reported throughout the lake seems to have provided favourable conditions for the flourishing of *C. nilotica* and other microinvertebrates in the lake (Hecky, 1993; Mwebaza-Ndawula, 1998; Mwebaza-Ndawula *et al.*, 1999; Budeba, 2003).

## 2.7 Small Water Bodies

Small water bodies which include satellite lakes, rivers, ponds, dams and floodplains in the catchment have been singled out as important faunal reservoirs for Lake Victoria endangered species **(**Maithya and Jembe, 1998; Katunzi, 2003). Several fish species currently known to be rare in the main lake are represented in isolated groups of small water bodies in the lake basin supporting fisheries of the riparian communities (Katunzi, 2003). They are exploited at various levels merely for subsistence. Besides being important economic units, these small water bodies provide microhabitats that act as temporary fish feeding habitats and breeding nurseries for a number of species.

Satellite lakes, unlike Lake Victoria are Nile perch free and the structural barriers around the lakes and low oxygen regimes associated with them have hampered invasion by the perch. This has kept these areas intact with a balanced foodweb. Common to most of these lakes are wetland covers, which play a very important role in regulating and controlling the activities in these water masses (Carter, 1995). For instance, the interwoven thick mass of macrophytes does not provide easy access to these lakes for both the resource exploiters and physical-chemical forces directed to them.

Studies in satellite lakes are very recent as there are no records before 1997. There is no time series observations made on these aquatic systems over the past years. However, recent studies have given light on the importance of these habitats (Lyimo and Sekadende, 2001; Katunzi 2003; Katunzi and Kishe, 2004).

A number of aquatic habitats in the basin include minor Lakes (Burigi and Ikimba, Malimbe), Rivers (Kagera Mara Simiyu Rubana Suguti and Mori), and associated ox-bow lakes (Fig. 2.1). These constitute a large assemblage of water bodies that harbour biodiversity and are of interest to scientists and riparian communities. Such extensive minor waters support a community and are essential to the health, welfare and economy of the local population (Dugan, 1990; Stuart, 1990).

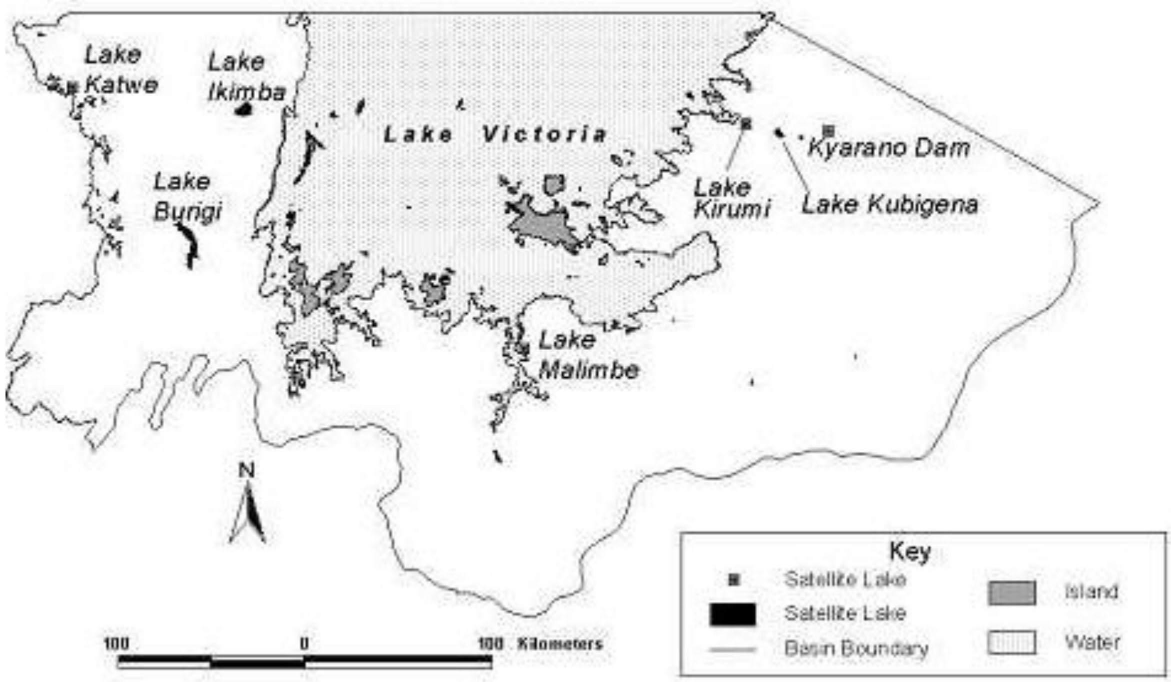



Figure 2.1: Satellite lakes around Lake Victoria.

## 2.8 Aquaculture

Aquaculture practice in the lake region is very recent. A baseline study conducted by Bwathondi *et al*. (1998) in western side of the lake indicated that aquaculture was acceptable in the region due to reliability of the rains. The most favoured fish species for culture were the *Bagrus docmac* (Mboju), *Oreochromis niloticus* and

*Clarias gariepinus*. Farmers reported to have been feeding fish with food leftovers (matoke and ugali) and crop leaves (cassava, yams, bananas, potatoes etc.). A total of 50 fishponds having a pond size range of 100 $m^2$ to 500 $m^2$ with the majority less than 200 $m^2$ were recorded. Fish species cultured were *Oreochromis niloticus, Clarias gariepinus, Protopterus aethiopicus, Tilapia* spp. and *Oreochromis leucostictus.*

In Mara Region a baseline study by Bwathondi and Mahika (1997) recorded about 28 fish ponds in the region, of these 75% were found in Tarime District, Musoma District (14.3%) and Serengeti District (10.7%). Most fish species cultured in fish ponds were *Oreochromis niloticus, Clarias gariepinus,* and *Protopterus aethiopicus*.

## 2.9 Socio-economics

The importance of socioeconomic studies in lake Victoria came into being after realization of changes in various socioeconomic, environmental and biological indicators like population pressure, level of investments in the fisheries, socioeconomic activities and general decline of fish stock and fish stock diversity in the basin which resulted into changes in fisheries resources, land use patterns, water quality, biodiversity and wetland resources.

In this regard, the socioeconomic research aimed at providing data and information for sustainable management and better utilization of aquatic resources in order to alleviate poverty amongst the communities, create wealth and sustain the resources for the present and future generations.

In view of this, the socioeconomic studies were basically dealing with two sub-themes namely;

- Sustainable management of aquatic resources with greater community participation.
- Improved living standards of communities dependent on aquatic resources through better management of resources, fish farming, fish and other fish product marketing and development projects.

Human activities on Lake Victoria basin have considerable impact on sustainable exploitation of the resources. While in the past, emphasis was more on natural science research, it has not adequately addressed human related problems. The involvement of the above projects in undertaking socioeconomic studies in Tanzanian part of the lake, and especially the LVEMP project whose principal aim is to involve the communities in management and conservation has brought more recognition of its importance in resolving some human impacts on exploitation and wise-use of the resources.

Since 1997, the research activities on Lake Victoria have been donor driven by various agencies like the World Bank, EU, IUCN, and Sida-SAREC. Other minor studies were conducted under UNDP/FAO/IFIP and International Development Research Centre (IDRC) sponsorship in late and early 1990's. The above named projects covered various socioeconomics studies as outlined below and documented in (Medard *et al.*, 2002; 2003).

**Lake Victoria Environmental Management Project: Phase I (LVEMP I)**
This project mainly aimed at:

- Compilation of national socioeconomic research and dimensions on the Fisheries Sector of Lake Victoria (National).
- Community participation in fishing industry from production to marketing: Overview on factors influencing involvement in fishing industry of Lake Victoria, Tanzania.
- A report on the impact of fisheries on the resources along the shores of Lake Victoria.
- Study on communicable diseases, health and saniation along the Lake Victoria fishing communities in Tanzania.
- Study on how to make BMUs more effective.

**Lake Victoria Fisheries Research Project –Phase II (LVFRP II)**
The project addressed issues related to:

- Fish marketing study.
- The Co-management survey.
- Survey of Lake Victoria fishers.
- Participatory rural appraisals in five beach studies (2-Tanzania, 2-Uganda and 1-Kenya).
- An Assessment of the nutritional status of fishing and farming commmunities in Lake Victoria basin, Tanzania.

**Implementation of Fisheries Management Plan (IFMP/LVFO)**

- The impact of slot size measure on Nile perch fishery, Tanzania.
- Identification, analysis and establishment of BMUs in Tanzania.

**International Union for Conservation of Nature (IUCN): The Socioeconomics of the Nile Perch Fishery**

- Cross border fishing and fish trading
- Rural user groups in fishing communities

## 2.10 Conclusion

The foregoing discussion on historical trends in fisheries research in Tanzania has clearly shown that there are many gaps in data and information which render the exercise of showing trends in various indicators of ecosystem health non-feasible. These gaps are a result of research effort that has not been coordinated and consistent over time.

# CHAPTER THREE

# ENVIRONMENTAL QUALITY

*C. Mwakosya[1], Y.D. Mgaya[2], and S. Mahongo[1]*
*[1]Tanzania Fisheries Research Institute*
*P.O. Box 9750, Dar es Salaam*
*[2]University of Dar es Salaam*
*Faculty of Aquatic Sciences and Technology*
*P.O. Box 60091, Dar es Salaam*

## 3.1 Introduction

Environmental studies such as physico-chemical parameters, nutrients levels, phytoplankton and chlorophyll-*a* concentrations produce results that serve as indicators of the status of an ecosystem. During 1980's several changes took place in Lake Victoria including eutrophication of the Lake with prolonged periods of anoxia in deep waters as reported by Ochumba and Kibaara (1989), Hecky and Bugenyi (1992), Mugidde (1993), and Hecky *et al.* (1994). Thermal stratification which is causing hypoxia in the Lake was known since 1930's (Worthington, 1930) and is restricted to the deepest waters (>60m) and during short rainy period (Talling, 1957; 1966). Seasonal patterns in Lake Victoria are influenced by rainy and dry seasons (Akiyama *et al*., 1977). Currently the lake is continuously hypoxia below 50 m depth and is frequently subjected to severe hypoxia in the area between 25 m and 50 m (Kaufman, 1992). Stratification is known to build-up during rainy season (Talling, 1966; Akiyama *et al*., 1977) while complete mixing occurs during the dry season. The limnological surveys of the Tanzania waters of Lake Victoria revealed a number of features, which include thermal and oxygen stratification, eutrophication and high primary production (Budeba, 2003).

### *3.1.1 Background Information*

During the 1980's limnological research focused on fisheries. The events in Lake Victoria have shifted attention to the conservation of the lake and sustainable exploitation of natural resources as reported by Lowe-McConnell *et al*. (1992). Limnological studies made so far focused on eutrophication and changes in the ecosystem (Ochumba and Kibaara, 1989; Hecky and Bugenyi, 1992; Kaufman, 1992; Hecky, 1993; Hecky *et al*., 1994). The dramatic events in Lake Victoria and the threat facing biodiversity have contributed to increased attention to limnological studies. The observed high eutrophication in Lake Victoria has been associated with land-based activities such as fertilizer application in agriculture, deforestation, pastoralization, industrial activities, domestic effluent, mining and poor agricultural methods (Hecky, 1993). The loss of water transparency due to increased eutrophication and unconsumed organic matter reduce light penetration, which in turn impairs vision in species that uses eyes for mate selection. The collapse of haplochromines in the 1980s has been associated with the introduction of Nile perch coupled with loss of vision hence poor selection of mates (Witte *et al*., 2000). In addition, release of nutrients into Lake Victoria changes the chemical properties of water with respect to its suitability for consumptive, industrial and agricultural uses (Kenyanya, 1999).

Regarding limnological information, Graham (1929) reported on the first fishing survey of 1927 to 1928 of which information on some physical and chemical characteristics of the lake were described. During that survey the limnological observations were made by Worthington (1930, 1931). Another contribution to the limnological information was made by Freshwater Biological Association from U.K. (Talling, 1987). Akiyama *et al.* (1977) reported on another limnological research which started in 1973 and later on from 1978 the study was continuously being carried out during HEST/TAFIRI project. During implementation of LVEMP, TAFIRI has also been able to produce various survey reports for the main lake, satellite lakes and inshore areas on the environmental parameters.

## 3.2 Justification

Water quality in Lake Victoria has declined greatly owing to eutrophication arising from increased inflow of nutrients into the lake. Eutrophication to a large extent depends on the levels of temperature, oxygen and nutrients in the water column. Excess nutrient loading has resulted into high algal populations and blooms, which cause taste and odour problems, high water treatment costs, algal toxins, de-oxygenation, associated pathogens, and alteration of consumer food webs.

Study of physico-chemical properties of the water bodies can be related to the distribution and abundance of fish species. For example, dissolved oxygen levels in the lake can lead to mapping of habitable areas for fish. Likewise a parameter such as Secchi disk transparency can provide information on the extent of turbidity in the lake. This in turn, can be related to the distribution and diversity of fish species e.g. the haplochromines.

## 3.3 Results

### *3.3.1 Indicators for Environmental Quality*

The following indicators for environmental quality are considered under this section: Nutrients levels, amount of rainfall and its distribution, water transparency, amount of dissolved oxygen, temperature, micro-contaminants, and pesticides.

### *3.3.2 Nutrients Levels/Changes*

Available data on nutrient levels in the lake indicate that silica (SRSi) levels have been decreasing from 69.8 µM in 1961 to 1.8 µg/l in 2004 (Table 3.1). Nitrate ($NO_3$-N) and phosphate (SRP) concentrations on the other hand have been increasing during the same period (Table 3.1).

Nutrients dynamics in the satellite lakes in the Lake Victoria basin was reported in 2003 and 2004 (Table 3.2). Total phosphorus (TP), dissolved organic phosphates (DOP) and ammonium were reported to be increasing with depth for all five lakes. Generally, soluble reactive phosphorus (SRP), nitrites, nitrate and silicates were decreasing with increasing depth; however, in some lakes the opposite was true (Table 3.2).

Table 3.1: Some chemical parameters measured from Lake Victoria between 1961 and 2004. These values are reported for certain sections of the lake hence do not give a lake wide picture. (*Concentrations values between 1961-1991 are in µM and those from 2002-2004 are in µg/l*).

| **Nutrient** | **1961** | **1988** | **1991** | **2002** | **2003** | **2004** |
|---|---|---|---|---|---|---|
| SRSi | 69.8 | 7.1 | 2.0 | 1.4 | 0.3 | 1.8 |
| $NO_3$-N | 0 | 0.2 | 7.07 | 71.7 | 81.4 | 75.1 |
| SRP | 0.42 | 0.23 | - | 1.2 | 34.5 | 50.5 |
| Total P | 1.52 | 1.13 | - | 95.7 | 83.5 | 94.5 |
| Source of data | Talling and Talling (1965) | Hecky and Bugenyi (1992) | Lehman and Branstrator (1993) | TAFIRI survey (2002) | TAFIRI survey (2003) | TAFIRI survey (2004) |

Table 3.2: Some chemical parameters measured from five satellite lakes (Ngoma, Rwakajunju, Kalenge, Mitoma and Rushwa) between 2003 and 2004.

| **Nutrient** | **2003** | | **2004** | |
|---|---|---|---|---|
| | Lowest | Highest | Surface | Bottom |
| TP (µg/l) | 151.7 ± 43.1 | 541.1 ± 206.8 | 57.36 - 267.92 | 42.45 - 254.72 |
| SRP (µg/l) | 6.6 ± 1.0 | 19.1 ± 3.0 | 7.46 - 10.80 | 8.99 - 16.28 |
| DOP (µg/l) | 17.0 ± 4.5 | 50.6 ± 7.2 | 11.13 - 22.12 | 5.59 - 27.06 |
| TDP (µg/l) | | | 20.06 - 32.92 | 14.89 - 36.05 |
| TPP (µg/l) | 126.3 ± 40.3 | 471.4 ± 212.6 | 37.30 - 235.01 | 27.56 - 218.67 |
| Ammonium (µg/l) | 61.6 ± 13.4 | 139.5 ± 103.3 | 48.59 - 92.67 | 40.58 - 519.90 |
| Nitrites (µg/l) | 3.5 ± 0.4 | 5.0 ± 0.5 | 1.07 - 1.94 | 1.23 - 2.13 |
| Nitrates (µg/l) | 22.9 ± 2.7 | 51.9 ± 17.3 | 3.29 - 5.04 | 2.95 - 6.29 |
| Silicates (µg/l) | 8.1 ± 0.7 | 24.2 ± 3.9 | 6.25 - 24.67 | 6.33 - 27.08 |

### *3.3.3 Total Annual Rainfall*

Piper *et al.* (1986) reported on temporal and spatial differences in rainfall for the period 1956–1978. Stations on the west side of the lake (Bukoba and Kagondo) recorded high value of average seasonal rainfall for that period (maximum value for January to May was above 300 mm and for September to December the value was close to 200 mm). The south and east side of the lake stations (Mwanza and Musoma) were having a maximum rainfall value during January close to 200 mm while for September to December it was less than 150 mm.

Analysis by Mkumbo (2002) indicated that there was a highly significant difference in total annual rainfall between years as well as between three lake regions (Kagera, Mwanza and Mara). Kagera region indicated highest records of annual rainfall period from 1980 to 1995 thereafter from 1996 to 2000 the region was receiving lowest rainfall (Fig. 3.1). Mara region received lowest annual rainfall for the period 1980-1995.

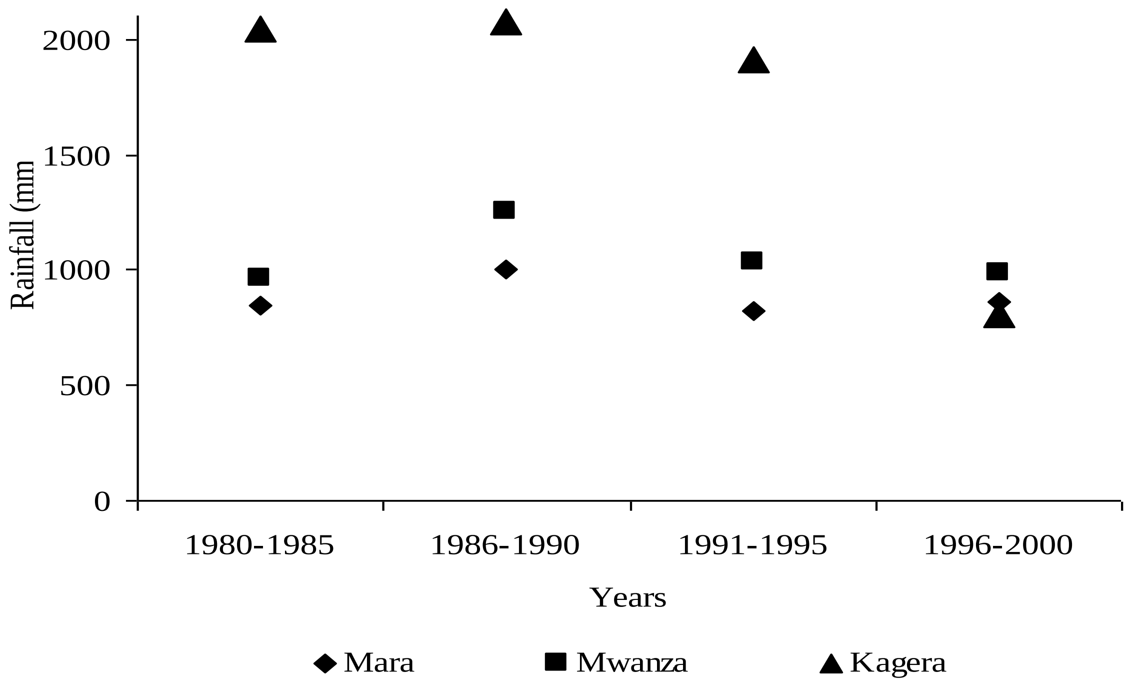



Figure 3.1: Mean annual rainfall (mm) for the different time periods within Lake Regions (Mara, Mwanza and Kagera) from 1980 to 2000 (Source: Mkumbo, 2002).

Long-term rainfall data for the Lake Victoria zone is presented in Figs. 3.2a-c. The rainfall pattern exhibits two seasons, long rainy season from March to May and a short rainy season which starts from October to December. It can be seen from Fig. 3.2a-c that rainfall amount increases from east to west of the lake.

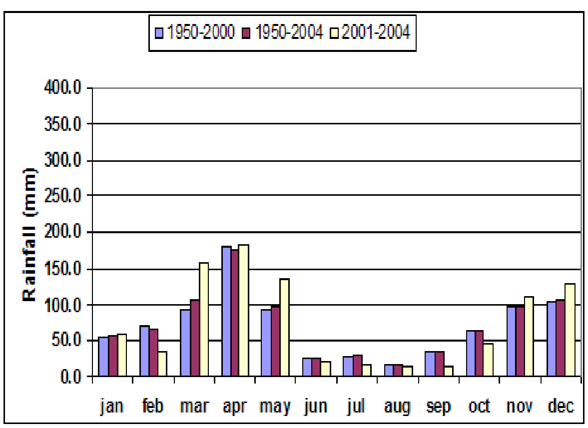



Figure 3.2a. Average monthly rainfall for Musoma.

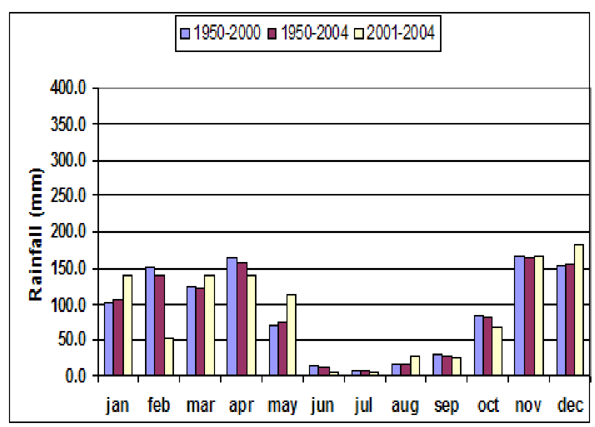
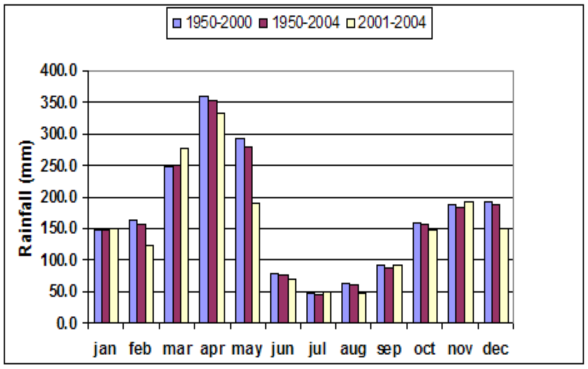



Figure 3.2b. Average monthly rainfall for Mwanza.




Source of data: Water Resources Department, Ministry of Water and Livestock Development.

Figure 3.2c. Average monthly rainfall for Bukoba.

### *3.3.4 Water Transparency*

Evaluation of water transparency can be done using secchi disk readings. Secchi disk transparency typically varies between 10 and 15% transmission (Wetzel and Likens, 1991). The highest water transparency in the satellite lakes for 2003 was recorded in Lake Rwakajunju with an average of 0.83 ± 0.1 m and the lowest record was in Lake Ngoma with an average of 0.49 ± 0.02 m (Katunzi *et al.*, 2003). Generally water transparency for that year indicated an increasing trend from the inshore shallow waters to deep offshore waters in all the sampled satellite lakes. For the year 2004 highest record was also observed in the same Lake Rwakajunju (0.98 m) while lowest record was found in Lake Rushwa (Katunzi *et al.*, 2004). On the inshore areas Chande (2004) reported highest transparency at Rubafu bay (1.57 m) and lowest at Magu bay (0.31 m) (Table 3.3).

Table 3.3: Physical characteristics of Lake Victoria waters at various inshore stations during November and December 2003.

| Station | Depth (m) | | Temperature ($^oC$) | | Transparency (m) |
|---|---|---|---|---|---|
| | Surface | Bottom | Surface | Bottom | |
| Chole | 0.5 | 3.4 | 26.3 | 25.6 | 0.7 |
| Magu | 0.5 | 2.4 | 26.0 | 25.1 | 0.31 |
| Nyamikoma | 0.5 | 5.5 | 26.3 | 26.0 | 1.25 |
| Suguti | 0.5 | 5.4 | 27.5 | 26.3 | 1.06 |
| Mara | 0.5 | 4.4 | 26.4 | 25.7 | 1.19 |
| Shirati | 0.5 | 6.7 | 26.6 | 26.2 | 1.38 |
| Mori | 0.5 | 7.6 | 26.6 | 26.0 | 0.94 |
| Nyamirembe | 0.5 | 4.4 | 25.4 | 25.0 | 0.80 |
| Rubafu | 0.5 | 6.5 | 25.6 | 24.8 | 1.57 |

Worthington (1930) reported Secchi disk readings at Speke Gulf in January 1928 at the depth of 5-7 m to be ranging from 0.6 to 0.95 m using 20 cm white disk.

The readings for February 1928 taken at Emin Pasha Gulf at a depth of 10 m was 1.8 m. Akiyama *et al*. (1977) reported Secchi disk results taken in Mwanza Gulf at a depth of 8 m for the period April-December 1973 to be ranging from 1.4 to 1.8 m and for the period January to December 1974 the values ranged between 1.1 and 1.9 m. Van Oijen *et al.* (1981) reported Secchi disk readings of 1.8-2.5 m for the same area at a depth of 7-14 m during the period February to April. Secchi readings for Mwanza gulf at the depth of 7-14 m ranged between 0.7 and 0.9 m in 1986 (HEST, 1986). Secchi disk readings for Mwanza gulf for the period March to May 1987 at the depth of 7-14 m ranged from 0.85-1.25 m (de Beer, 1990). Mkumbo (2002) also reported relatively lower Secchi disk readings for the month of February during 2000-2001 while the values were higher for August in both years (Fig. 3.3).

### *3.3.5 Dissolved Oxygen*

Distribution of dissolved oxygen is affected by stratification and can closely reflect the three main phases of thermal stratification. During 1960-1961 oxygen concentrations were close to saturation (94-103%). Hecky *et al.* (1994) reported that during the period October 1990-1991 offshore waters contained less oxygen than 1960 and anoxia was frequently encountered below 45 m affecting up to 50% of the bottom area. On the surface waters oxygen level was saturated throughout the year.

Mkumbo (2002) reported that oxygen concentration in the shallow inshore waters (<30 m) of the lake ranged from 6.6-7.8 mg/l and from 10.3 mg/l in the surface waters at the offshore stations to 0.28 mg/l in bottom waters in February. Mean oxygen concentrations varied from 8.02 ± 0.73 mg/l in the surface waters to 3.2 ± 4.36 mg/l in the bottom waters at 68 m deep. Data from TAFIRI surveys for the years 2002 to 2004 indicated mean dissolved oxygen ranging from 8.4 ± 1.2 to 10.0 ± 0.9 (Table 3.4). Kulekana (2003 ) reported oxygen concentration in seven satellite lakes ranging from 6.9 mg/l to 16.2 mg/l for surface waters while bottom waters ranged from 6.4 mg/l to 16.0 mg/l for the year 2000 (Table 3.5).

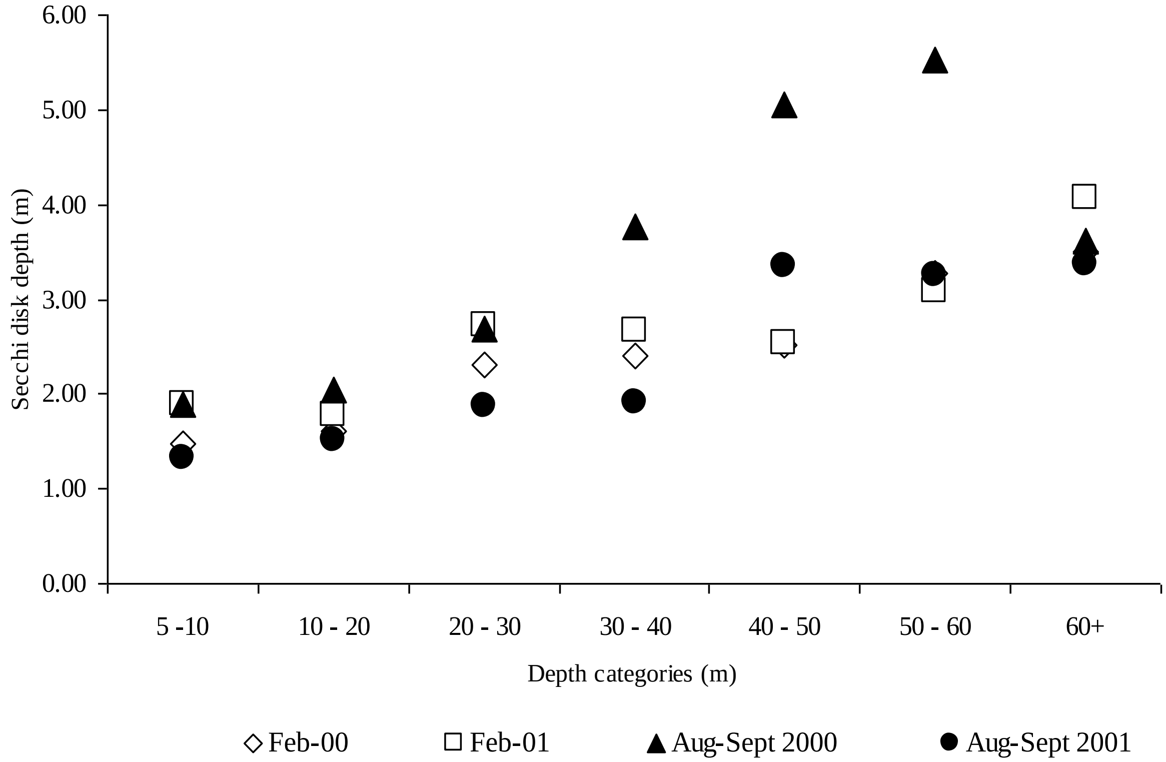



Figure 3.3: Secchi disk depth (m) in average 10 m depth categories sampled at various stations within Lake Victoria during wet season in February (2000 and 2001) and dry season in August (2000/2001) (Source: Mkumbo, 2002).

Table 3.4: Physical characteristics of the Lake from 2002 to 2004.

| Year | Temp (°C) | DO ($mgl^{-1}$) | Secchi (m) | No. of stations sampled |
|---|---|---|---|---|
| 2002 | 25.0 ± 1.1 | 8.4 ± 2.3 | 1.6 ± 0.7 | 65 |
| 2003 | 24.6 ± 0.6 | 8.4 ± 1.2 | 2.5 ± 1.2 | 37 |
| 2004 | 23.0 ± 0.6 | 10.0 ± 0.9 | 2.1 ± 0.7 | 15 |

Source: TAFIRI surveys data.

Table 3.5: Physical parameters measured during satellite lakes surveys Sept/Oct. 2000, March/April 2001 and August 2004.

| **Year** | **Lake** | **Temp (°C)** | | **DO (mg/l)** | |
|---|---|---|---|---|---|
| | | Surf. | Bot. | Surf. | Bot. |
| Sept-Oct 2000 | Kirumi ponds | 24.1 | | 11.0 | |
| | Kyarano Dam | 23.65 | 24.0 | 11.9 | 11.4 |

| Year | Lake | Temp (°C) | | DO (mg/l) | |
|---|---|---|---|---|---|
| | | Surf. | Bot. | Surf. | Bot. |
| | Mara River | 24.1 | 23.8 | 9.25 | 8.8 |
| | Buswahili | 21.3 | 23.0 | 6.9 | 6.4 |
| | L. Malimbe | 26.05 | 28.0 | 16.2 | 16.0 |
| | L. Burigi | 25.2 | 24.7 | 9.1 | 11.2 |
| | L. Katwe | 23.9 | 25.2 | 10.15 | 10.01 |
| March-April 2001 | Kirumi ponds | 28.2 | 29.9 | 7.65 | 8.3 |
| | Kyarano Dam | 24.9 | 27.6 | 6.25 | 6.4 |
| | Mara River | 25.95 | 26.6 | 2.0 | 2.0 |
| | Buswahili | 27.4 | 29.0 | 1.3 | 1.2 |
| | L. Malimbe | 32.9 | 34.0 | 9.4 | 16.0 |
| | L. Burigi | 28.2 | 34.0 | 8.25 | 7.0 |
| | L. Katwe | 23.85 | 27.4 | 6.9 | 4.5 |
| | L. Ikimba | 30.9 | 32.0 | 7.5 | 6.9 |
| Aug. 2004 | Ngoma | 24.0 | 22.9 | 6.7 | 1.3 |
| | Rwakajunju | 24.0 | 23.7 | 5.2 | 1.1 |
| | Kalenge | 25.1 | 24.1 | 7.1 | 1.0 |
| | Mitoma | 25.7 | 25.1 | 6.6 | 2.9 |
| | Rushwa | 24.1 | 24.0 | 5.4 | 1.3 |

Source: Kulekana and Kishe satellite lakes surveys (2000 and 2001); Katunzi *et al.* (2004).

### *3.3.6 Temperature*

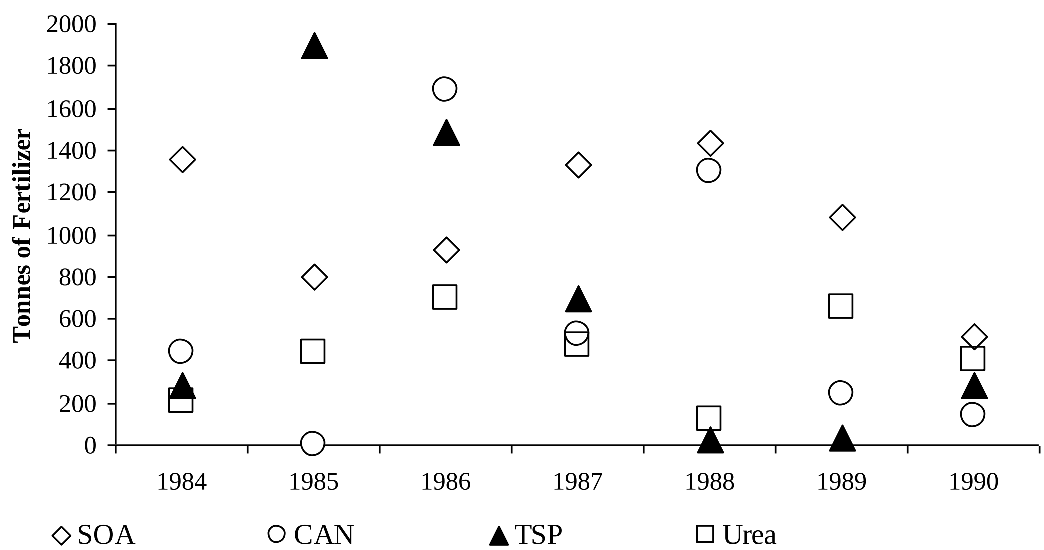
During the period 1973-1974 Akiyama *et al.* (1977) reported lower water temperatures in dry season (22°C and 23°C) and higher temperatures (24°C and 26°C) during rainy season. Crul (1993) reported that air temperatures in the lake are quite uniform and the seasonal difference does not exceed 3°C. Lake temperature for the years 2002-2004 ranged from 23.0 to 25°C according to TAFIRI surveys.

On the general thermal structure of the lake, Talling (1957; 1966), Graham (1929), Worthington (1930), Fish (1957) and Newell (1960) characterised the annual stratification cycle of the lake in three phases. Phase 1 (September to December) marked with rising water temperature at the surface from 24°C to 25°C and bottom from 23.5°C to 24°C; phase 2 (January to May), the heat content of water column rises to maximum around March after that cooling begins, and phase 3 (June to August), surface water temperature falls to minimum and it is the coolest and most windy period of the year.

Data from TAFIRI surveys conducted in November and December 2003 reveal temperatures ranging from 25.4-27.7°C for the surface waters while for the bottom waters the range was from 24.8-26.3°C (Table 3.3). Temperatures were higher in satellite lakes for the periods September/October 2000 and March/April 2001 (Table 3.5).

### *3.3.7 Utilization of Fertilizers*

The annual utilization of artificial fertilizers for three lake regions (Mara, Kagera and Mwanza) indicated a fluctuating trend with relatively lower values observed in 1990 (Fig. 3.4). Consumption of Sulphate of Ammonia was highest on average followed by Triple Super Phosphate. Utilization of Urea was still at lower averages.




**Key: SoA –** Sulphate of Ammonia; **CAN –** Calcium Ammonium Nitrate; **TSP –** Triple Super Phosphate.

Figure 3.4: Annual frertilizer consumption (tonnes) for three regions Mara, Mwanza, and Kagera within Lake Victoria Basin.

## 3.4 Discussion

### *3.4.1 Nutrient Dynamics*

In aquatic systems where light is not a limiting factor nutrients become essential for the growth and general performance of primary producers. Lake Victoria receives nutrients from various sources such as agriculture, domestic and industrial waste water and autochthonous sources. Water quality in Lake Victoria has declined greatly owing to eutrophication, which leads to high algal blooms.

Satellite lakes indicated a hyper-eutrophic condition for the years 2003 and 2004 with higher nutrient concentrations especially total phosphorus than in the main Lake Victoria. A plausible explanation for the higher concentrations of phosphates ($PO_4$-P) and nitrates ($NO_3$-N) is the increased application of fertilizers in the banana, coffee and maize plantations around the satellite lakes and high concentrations of livestock in the vicinity of the lakes (Katunzi *et al.*, 2003; 2004).

The satellite lakes also indicated higher silicate ($SiO_2$-Si) concentration levels than Lake Victoria for the years 2003 and 2004. The availability of dissolved silica can have a marked influence on the productivity and succession of algal populations (Wetzel, 2001). Eutrophication promotes plant growth as well as favouring changes in floral and faunal species composition and may lead to loss of biodiversity. Enhanced plant growth often disrupts normal functioning of the aquatic ecosystem and may lead to deterioration in ecosystem health and values such as recreational and aesthetic attributes.

### *3.4.2 Spatial and Temporal Distribution of Rainfall*

The distribution of rainfall is mostly influenced by the two seasons (dry and rainy) occurring in the area. Generally dry season extends from June to September while rainy season is from October to May. Within rainy season October to December experiences light rains and then followed with dry spell between January and February then follows heavy rains between March and May. Atmospheric temperature, wind speed and wind direction have direct influence on rainfall (Mkumbo, 2002). Rainfall from the 3 index stations (Musoma, Mwanza and Bukoba) for the long-term period and the period 2001-2004 did not show any significant changes in trend.

### *3.4.3 Water Transparency*

Spatial and temporal fluctuations of water transparency in Lake Victoria can be linked with eutrophication and can significantly be reduced during algal blooms (Ochumba and Kibaara, 1989; Budeba, 2003). The difference in the water transparency reflects the amount of suspended particles and plankton in the water. Bottom type and depth also influence water transparency (de Beer, 1989), as well as the stirring-up of sediments during periods of mixing and the silt load of inflowing rivers during the rainy season. High water turbidity limits light penetration in the water and therefore lowers photosynthetic activities in the water by phytoplankton. Further, reduced lake transparency leads to low visibility, which is believed to have affected the diversity of haplochromines as they are particularly specific in choosing mates, and use visual cues of bright male colouring to identify mates of their own species (Seehausen *et al.*, 1997).

### *3.4.4 Dissolved Oxygen and Thermal Stratification*

Distribution of dissolved oxygen in the water column is strongly affected by thermal stratification (Crul, 1993). Seasonal variation of dissolved oxygen reflects the phases of thermal stratification. General inshore waters are observed to be well oxygenated from surface to bottom compared to deeper inshore waters where low oxygen levels can be observed. The annual cycle of thermal stratification and destratification also influences distribution of dissolved oxygen in the lake. Destratification allows oxygen rich surface water to reach the hypolimnion thus causing higher oxygen concentration at deeper depths. Stratification on the other hand, limits the exchange and supply of oxygen thus resulting into oxygen depletion in bottom waters. The seasonal hypoxia which is common in the Lake Victoria is known to affect fish distribution and stocks on a seasonal basis (Hecky *et al.*, 1994; Mugidde, 2001).

## 3.5 Conclusions

The current blooms of undesirable algae (e.g., cyanophytes) and excess biomasses in Lake Victoria will continue to be a problem unless nutrient loading (particularly phosphorus) and conditions of anoxia and high rates of denitrification are curbed. Consequently any management strategies that will be put in place to protect water quality of the lake should give high priority to actions that control nutrient loads that stimulate growth of algal blooms and other aquatic plants. This should dampen some of the negative impacts of high algal biomass such as excess oxygen demand and nutrient-and light-limited algal growth. Phosphorus reduction will lead to reduction in cyanophyte blooms, including genera known to produce phycotoxins such as *Anabaena*. Effort to reduce allochthonous inputs of nitrogen from terrestrial sources are likely to be offset by increased nitrogen input by nitrogen-fixers. It is expected that reduced plant biomass will improve lake transparency and expand the euphotic zone and also reduce organic loading to the stratified, anoxic deep waters and ultimately improve productivity of fisheries, particularly demersal stocks.

## 3.6 Recommendations

- Continuous monitoring of the environmental parameters should be maintained for a better understanding of the dynamics the lake ecosystem.
- Treatment of both industrial and domestic sewage before releasing to the main lake should be done to reduce pollution of lake waters. Municipal and industrial effluents should be of acceptable nutrient concentrations and ratios so as to reduce proliferation of algal biomass and weeds, such as water hyacinth.
- Best practices in agriculture and other activities (e.g. mining, industrial production) which result in pollution of the lake should be advocated. Reduction of nutrient loads requires watershed management and good soil conservation practices aimed at reducing extensive vegetation clearing, soil erosion and vegetation burning.

# CHAPTER FOUR

## LIFE HISTORY INDICATORS

*E.F.B Katunzi*[1] *and Y.D. Mgaya*[2]
[1]*Tanzania Fisheries Research Institute*
*P.O. Box 475, Mwanza*
[2]*University of Dar es Salaam*
*Faculty of Aquatic Sciences and Technology*
*P.O. Box 60091, Dar es Salaam*

## 4.1 Introduction

Life history parameters when monitored over time can give indication of the performance of the species in the ecosystem. They give a direction of success or failure in which case appropriate measures can be accordingly devised. Life history traits like growth, reproduction, and mortality can be regarded as principal factors in the survival of the fish (Stearns, 1992). Under pressure due to exploitation and other environmental changes, the fish will be forced to increasing the growth rate and switch to early reproduction (Noakes and Balon, 1982). Due to compromise between reproduction and somatic growth, this early maturation can cause stunted growth (Roff, 1992; Stearns, 1992). However, for the larger fishes, reaction could be through increase in fecundity. This chapter examines life history indicators of three commercial species in Lake Victoria, namely Nile perch, Nile tilapia and the cyprinid 'Dagaa' *Rastrineobola argentea*.

## 4.2 Lates niloticus

Nile perch, *Lates niloticus* Linnaeus, 1758, is a predatory fish of high commercial and recreational value. It can grow to a length of two meters and a weight of 200 kg. Nile perch was introduced into Lakes Kyoga, Nabugabo and Victoria in Uganda from Lake Albert during the 1950's and early 1960's (Hamblyn, 1961; Arunga, 1981; Welcomme, 1988). Eight specimens from Lake Turkana were introduced in the Kenyan part of Lake Victoria at Kisumu in 1963 (Odero, 1979). The fish was introduced to feed on the small-sized haplochromine cichlids, which were at that time abundant and relatively unexploited for conversion into larger fish of greater commercial and recreational value (Anderson, 1961).

### *4.2.1 Length Frequencies*

The modal lengths, proportions of big fishes and length frequency trends over the years have been changing in response to environmental and exploitation pressure (Figs. 4.1, 4.2 and 4.3). Data collected in the years 1985-1990 on Tanzanian side with bottom trawls has confirmed a sharp fall on percentage compositions of fishes larger than 80 cm total length (Fig. 4.3). This is also accompanied by a sharp decrease of modal lengths for the corresponding years (Figs. 4.1 and 4.3). For the years after 1999, there is progressive increase of both large fishes and modal length increase. Increased fishing effort could be the main cause of the observed changes. However, environmental factors such the lake's limnochemistry could also explain the observed fluctuations in fish populations.

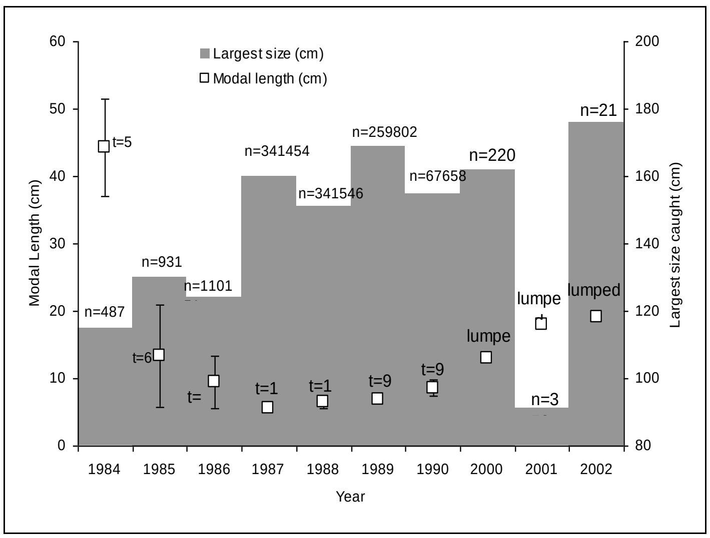



Fig. 4.1: Modal length and largest size caught for *Lates niloticus.*

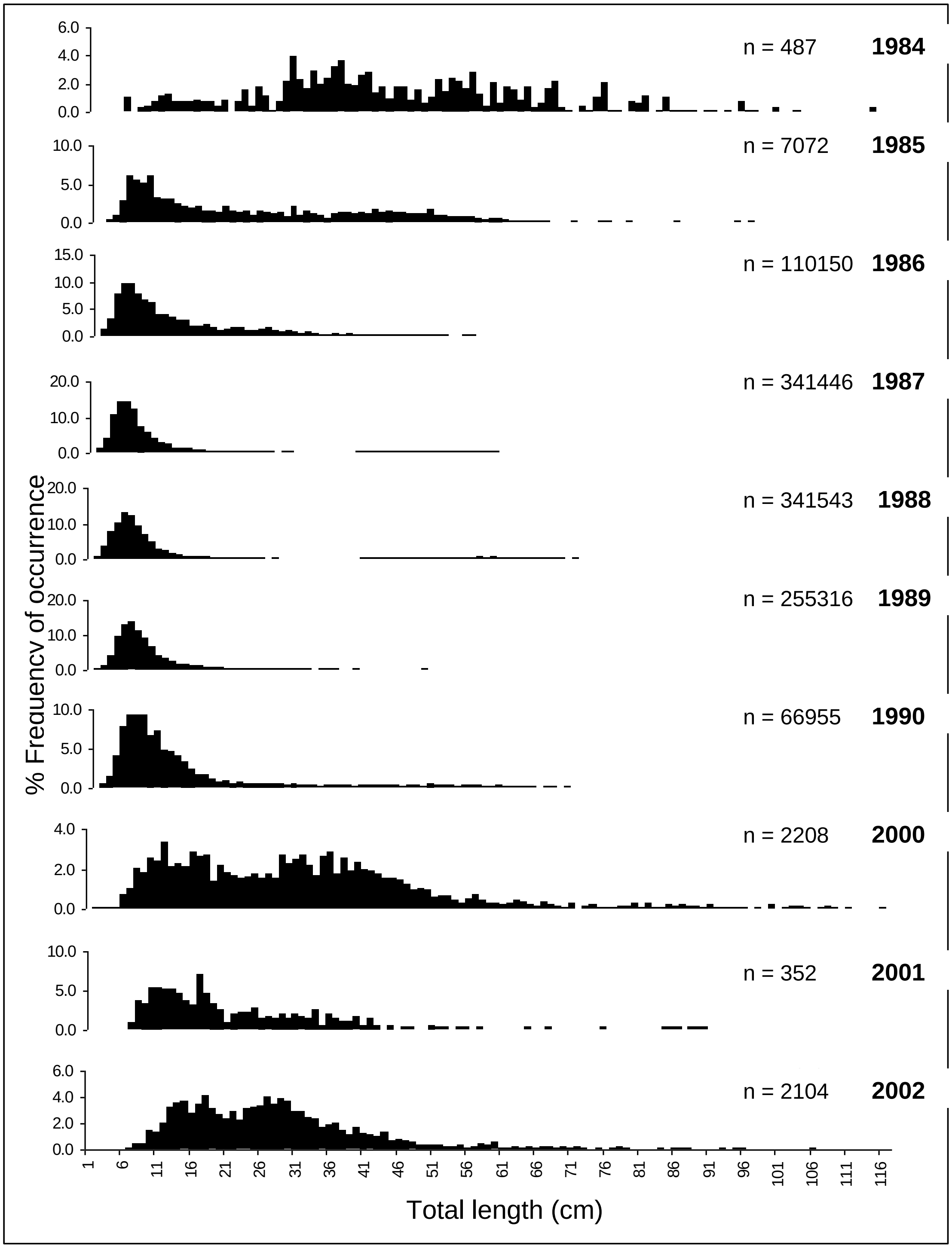



Figure 4.2: Length frequency distribution for *Lates niloticus* in the experimental catches from which Tanzanian part of the Lake. There are no data for the period 1991-1999.

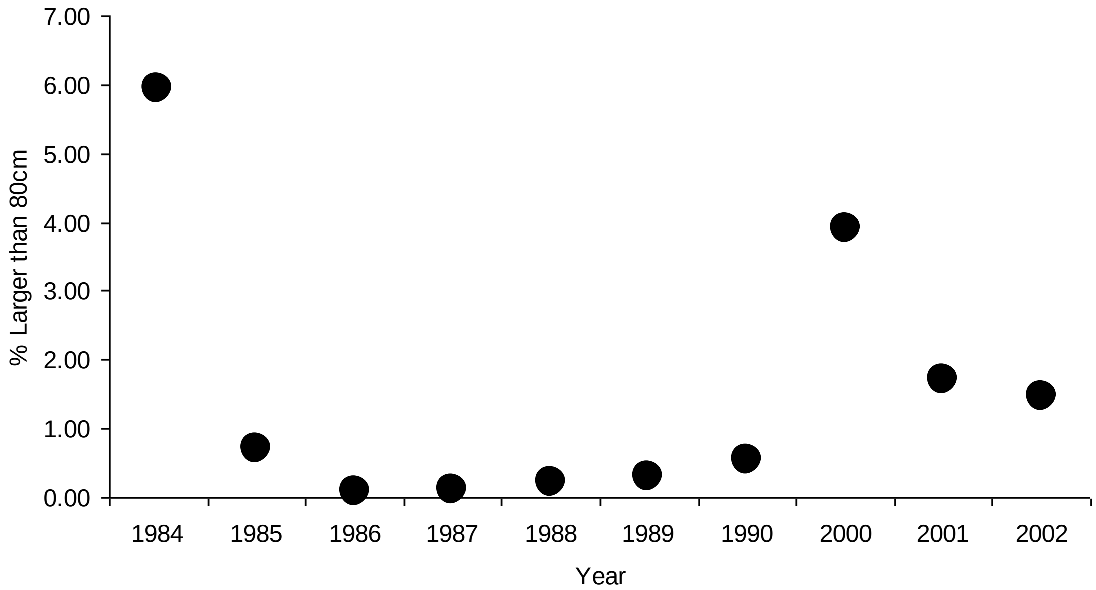



Figure 4.3: Proportion of fish larger than 80 cm TL for *L. niloticus.*

### *4.2.2 Reproduction*

Size at first maturity indicates the how well the species responds to environmental and anthropogenic pressures (e.g. fishing). Soon after the Nile perch introduction, the size at first maturity of male Nile perch was between 30-34 cm total length for males and 33-35 cm for females (Okedi, 1974). Acere (1985) recorded the length of 54 cm for males and 69 cm for females. The trend of events changed to males maturing at 50-65 cm and females at 60-95 cm as per Oguttu-Ohwayo (1989). In Tanzania, size at first maturity for females and males in Mwanza Gulf, Tanzania (1988 - 1989) was at 110 cm and 60 cm TL, respectively (Ligtvoet and Mkumbo, 1990). In 2002 Mkumbo (2002) recorded a decrease when she noted the lengths for males and females to be at 54 cm for males and 77 cm for females (Fig. 4.4). This drop could probably be attributed to increase in fishing pressure, changes in food availability and the lake environment. However, it is difficult to confirm, as the same trend is not given by the growth parameters and the decrease is not consistent (Fig. 4.5).

Generally, males of *L. niloticus* attain maturity at a smaller size than females based on the growth rate data (Hughes, 1992). Using the parameters of the von Bertalanffy growth function and the relationship of $t_m = t_0 - \ln(1 - L_m/L_\infty)/K$, (Froese *et al.*, 2000), where $t_m$ is the age at first maturity and $L_m$ is the size at first maturity, Mkumbo (2002) calculated the age at first maturity for males and females of *L. niloticus* at 1.6 years and 2.5 years respectively.

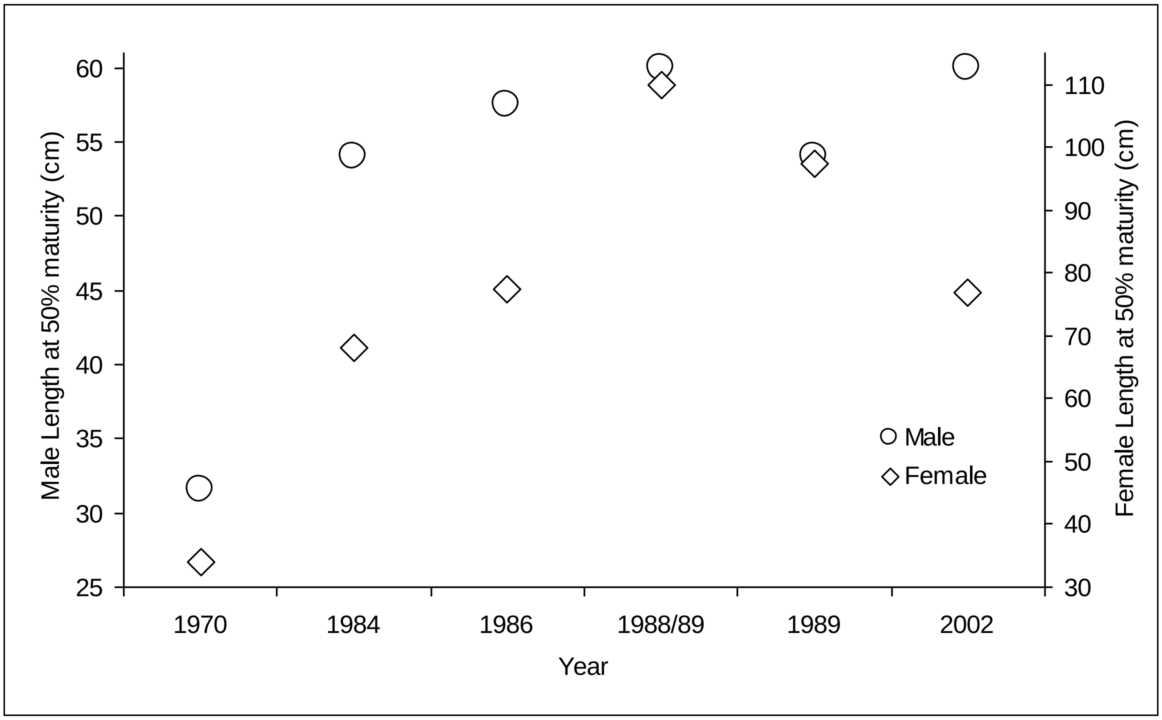



Figure 4.4: Size at 50% maturity for *Lates niloticus.*

*Sources:*

| | |
|---|---|
| 1970 | Okedi (19710 |
| 1984 | Acere (1984) |
| 1986 | Ogutu-Ohwayo (1988) |
| 1988/89 | Ligtvoet and Mkumbo (1990) |
| 2002 | Mkumbo (2002) |

### *4.2.3 Growth*

From Lake Victoria, specimens could grow up to 190 cm TL (Acere, 1985) and 200 cm TL (Okemwa, 1984). Females grow to a much larger size than males. Ligtvoet and Mkumbo (1990) reported the growth increments of 28, 28 and 21 cm $yr^{-1}$ for 3 fishes that were tagged in Mwanza area at lengths of 32, 47 and 51 cm respectively. Asila and Okemwa (1999) reported a growth increment within that range (29 cm $yr^{-1}$) from tagged fishes. The differences and inconsistency observed in the estimated growth parameters could possibly be explained by the differences in the size of the catch populations. With bigger sizes in the sample the higher the $L_\infty$ and the lower the $K$ (Fig. 4.5).

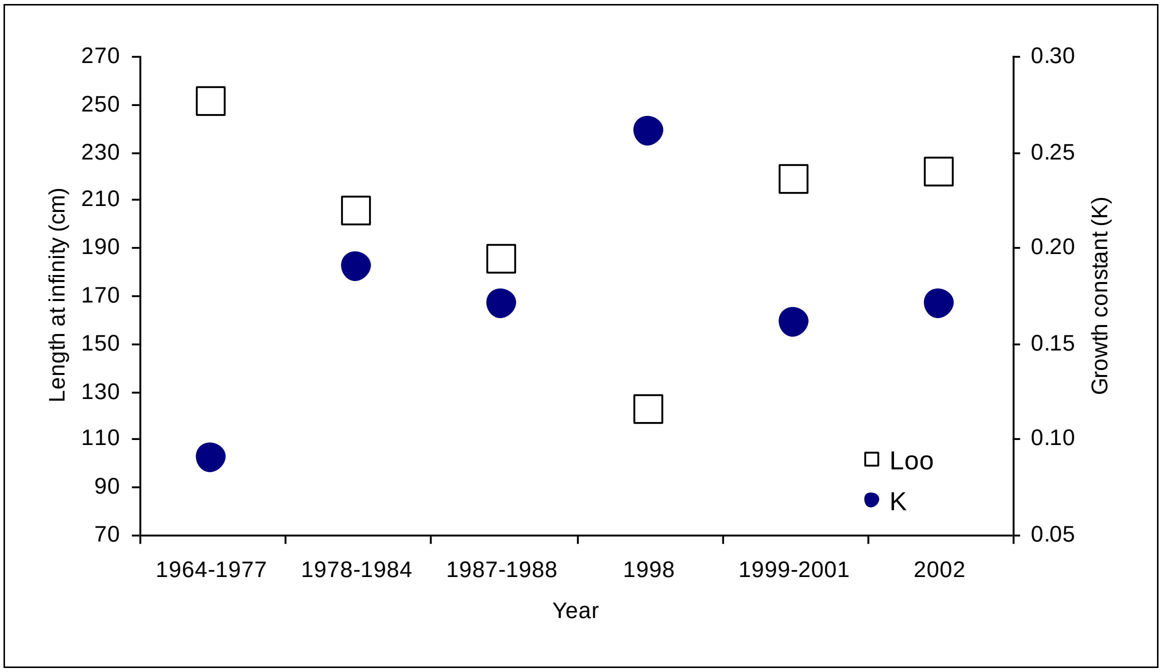



Figure 4.5: Length at infinity and growth constant, K, for *Lates niloticus*.

*Sources:*

| | |
|---|---|
| 1964-1977 | Ligtvoet and Mkumbo (1990) |
| 1978-1984 | Acere (1985) |
| 1987-1988 | Asilla and Ogari (1988) |
| 1998 | Mkumbo and Ligtvoet (1990) |
| 1999-2001 | Asilla and Okemwa (1999) |

### *4.2.4 Distribution*

Nile perch has a lakewide distribution at depth range of 0 - 60 m (Goudswaard and Witte, 1985; Ligtvoet *et al.*, 1995; Okaranon *et al.*, 1999; Mkumbo and Ezekiel, 1999). The littoral rocky habitat is possibly one of the few habitats in Lake Victoria that has not been invaded by *Lates* (Witte *et al.*, 1992). This habitat has a spectacular assemblage of haplochromines not known to exist elsewhere in the lake. The highest catch rates of Nile perch in the Tanzanian area in 1985 were obtained from waters between 16 and 50 m deep (Goudswaard and Witte, 1985). Results of bottom trawl surveys conducted under LVFRP (1999 – 2001) recorded the highest catch rates at depths 4 to 20 m with a remarkable decline in catch rates at depths below 50 cm TL.

### 4.2.5 *Spatial and Temporal Distribution*

The fish is endemic in lakes Albert, Rudolf, Turkana and Tana; and the Nile River basin but introduced in lakes Victoria, and Kyoga. However, juveniles of length <30 cm in lakes Chad, Turkana and Albert are mainly distributed in the shallow inshore waters (Hamblyn, 1962; Gee, 1966; Hopson, 1962). The batho-spatial distribution pattern exhibited a decline in *Lates* stock abundance with depth, similar to that observed in 1969/1970 (Kudhoghania and Cordone, 1974) but with differences in the depth ranges of high abundances (Mkumbo, 2002). Below 50 m depth, an abrupt drop of mean catch rates was observed unlike the 1969/70 surveys where the drop was below 70 m deep. This is probably linked to changes in the physical/chemical characteristics of the lake and the presence of a hypoxic layer below 50 m (Hecky *et al.,* 1994; Ochumba, 1995).

### 4.2.6 *Food and Feeding*

**Feeding habits and adaptations**

Between 1968 and 1977 haplochromines were the dominant prey of most sizes of Nile perch in Lake Victoria. By 1988, the major types of prey eaten by the perch in Lake Victoria had changed to *Caridina nilotica*, anisopteran nymphs, Nile perch juveniles, *Rastrineobola,* tilapiines with very few haplochromines (Ogari and Dadzie, 1988; Mkumbo and Ligtvoet, 1992). These remained the major types of prey of the Nile perch in Lake Victoria between 1995 and 2000 period with proportions of haplochromines increasing significantly (Fig. 4.6).

A decline in the importance of haplochromines in Lake Victoria was accompanied by a relative increase in *R. argentea* (Mkumbo and Ligtvoet, 1992). However, as haplochromine stocks improved, Nile perch reverted to feeding more on haplochromines (Mkumbo, 2002) suggesting that the fish shifts to *R. argentea* in the absence of haplochromines. It also suggests that *R. argentea* may be a less preferred prey than haplochromines.

**Ontogenic shifts in diet**

During these periods, Nile perch of less than 20 cm mainly ate *C. nilotica, R. argentea*, anisopteran nymphs and chironomids. Those of 20 cm to 60 cm mainly ingested *R. argentea*, anisopteran nymphs, *C. nilotica*, tilapiines, juvenile Nile perch and to a less extent haplochromines, those of 60 cm to 100 cm mainly ate *R. argentea,* Nile perch juveniles, tilapiines and haplochromines while those of more than 100 cm depended almost solely on tilapiines and Nile perch juveniles. The ontogenic shift in the diet of Nile perch is further illustrated by studies done in Tanzania and Kenya. The diet of Nile perch <20 cm TL was dominated by *Caridina*, contributing more than 70%. Between 20 cm and 60 cm TL, *Caridina* dominance decreased from 48% to about 30%, as Nile perch switched to feeding on haplochromines, which contributed more than 70% of the diet. In large fish (>90 cm TL) Nile perch became cannibalistic with its own juveniles contributing about 30% of the diet. Other fish prey such as *Clarias* (7%), *Oreochromis* (8%) and *Barbus profundus* (7%), also became important and the contribution of haplochromines declined to about 50%. The contribution of dagaa was low (<16%) in all sizes of Nile perch <100 cm TL, and absent in the stomachs of larger fish (Mkumbo, 2002).

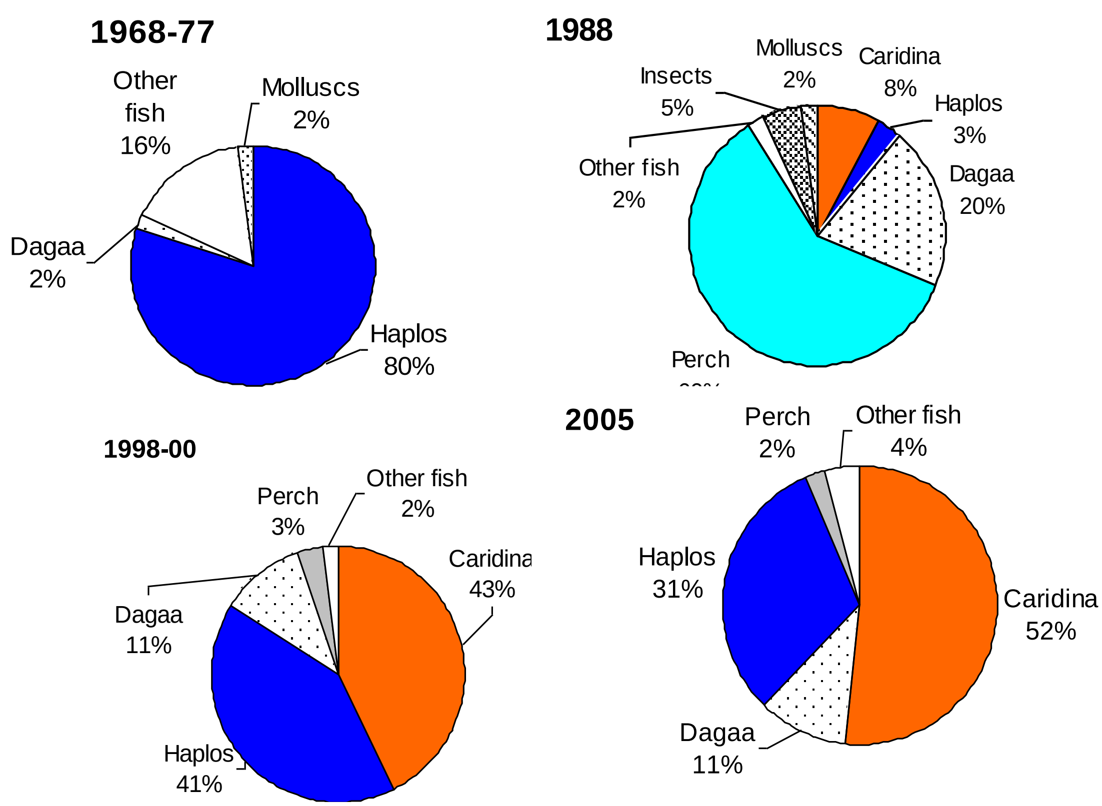



Figure 4.6. Shifts in feeding habits of Nile perch for the period 1968-2005.

## 4.3 Rastrineobola argentea

### *4.3.1 Introduction*

*Rastrineobola argentea* is endemic from the Victoria Nile and lakes Kyoga, Nabugabo and Victoria (Corbert, 1961; Greenwood, 1966; Howes, 1984). The species has been able to survive alongside the voracious Nile perch *Lates niloticus* (Ogutu-Ohwayo, 1995). Over a long time the fish has not attracted attention of both scientists and investors. This could probably have been due to its small size and low abundance especially before the decline of the haplochromines. Exploitation of Dagaa is first reported as a light fishery in the mid-1960's (Okedi, 1981). The fishing is reported to have flourished after the reduction of the haplochromines due to overfishing and predation (Barel *et al.*, 1991; Reynolds *et al.*, 1995). Currently the species is second to Nile perch in abundance and importance in the lake fisheries.

### *4.3.2 Distribution*

*Rastrineobola argentea* has been described as an offshore surface dweller (Greenwood, 1974). The later pelagic existence by the species could have been a result of displacement by the more competitive zooplankvorous haplochromines while following the downward movement of the zooplankton (Wanink, 1998). Further colonization of the species followed the disappearance of the dermersal haplochromines. Parasitism also was known to have an impact on the distribution of the fish. The physical environment factors like light and oxygen also have an impact on the distribution of fishes. Diel migration has been noted for this species (Fig. 4.7).

Dagaa is known to be nocturnal. Wanink (1992) observed majority of the adult fishes to be concentrated in the upper part of the water column in the night but during the daytime they were found close to the bottom with a small population at the surface but mostly parasitized by *Ligula intestinalis*. Juvenile dagaa >35 mm SL were abundant in surface trawls made during daytime but could not be caught from surface trawls at night. It is thought that they occupy intermediate depths. Night catches from the surface trawl show that the size of adult dagaa increases with water depths and distance from the shore (Wanink, 1998) (Fig. 4.8).

### *4.3.3 Absolute Fecundity*

The absolute fecundity (+ SD) for of dagaa in 1987 was 1073 ± 313 eggs (n=22). However, Okedi (1974) reports fecundity of 2282 ± 1065 (n=36) for the period between 1970 and 1974. The difference is significant (Mann-Whitney U-test; $p<0.01$). This could be a result of dwarfism since a positive correlation exists between the size of dagaa and absolute fecundity.

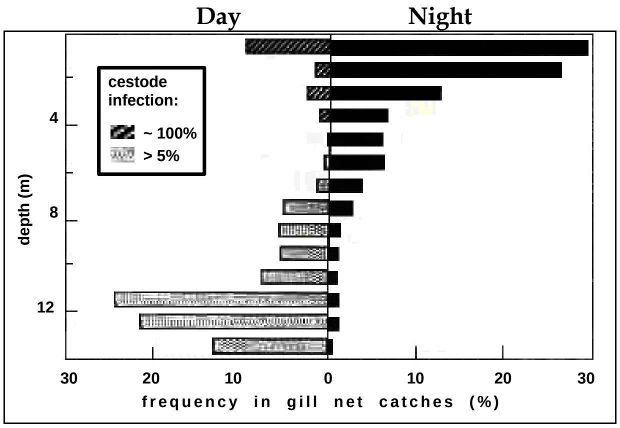
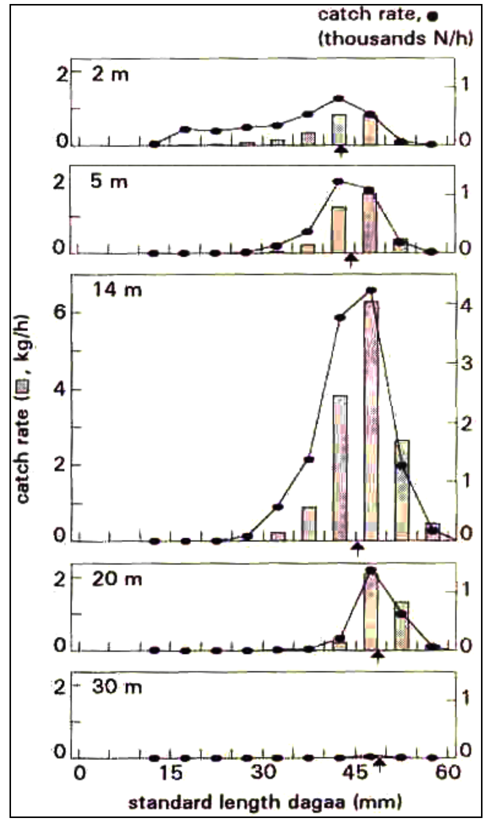



Figure 4.7: Vertical distribution of *Rastrineobola argentea* during day and night in the Mwanza Gulf (Wanink, 1998).

Figure 4.8: Horizontal distribution of *Rastrineobola argentea* over five stations in the Mwanza Gulf (Wanink, 1998).




### *4.3.4 Length Frequencies Distributions*

The modal lengths have been changing since 1970-2005 from 7 cm to 4.2 cm (Fig. 4.9). The decrease has been a result of increased fishing pressure, and reduction of somatic growth at the expense of reproductive expansion (Wanink, 1988). A further decrease in the mean modal length of the population for the years 2002 and 2005 has also been observed (P. Nsinda, pers. comm.).

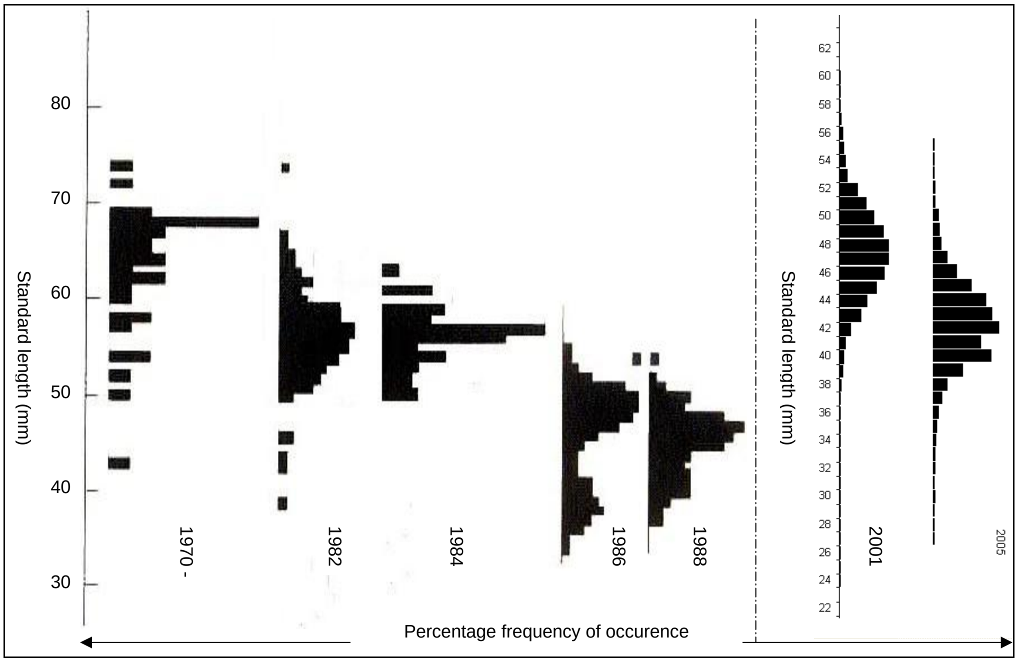



Figure 4.9: Length frequency distributions of *Rastrineobola argentea.* (Source: Wanink, 1991; 2001 for 1970-1988 data; Nsinda, unpublished data, for 2005 data).

## 4.4 Oreochromis niloticus

### *4.4.1 Introduction*

*Oreochromis niloticus* was introduced into Lake Victoria in 1950's together with other non-indigenous tilapiines including *Oreochromis leucostictus* Trewavas, *Tilapia zillii* Gervais and *Tilapia rendalii* Boulenger from Lake Albert (Welcomme, 1967). The fish however, had been introduced into the lake as early as 1930's (Lowe-McConnell, 1958; Fryer and Iles, 1972), but only established in the late 1960's (Welcomme, 1967) along with the voracious predator Nile perch, *Lates niloticus* Linnaeus. *O. niloticus* appeared in commercial catches in 1960 constituting less than 1% of the landings (Welcomme, 1967). By 1965, it featured prominently in the commercial catches and currently it is the most commercially important tilapiine, whereas the native species of *O. variabilis* and *O. esculentus* have largely disappeared (Witte and van Densen, 1995; Othina and Tweddle, 1999). Currently, *O. niloticus* constitutes the third most commercially important fishery in Lake Victoria, after the introduced *Lates niloticus* and endemic cyprinid, *Rastrineobola argentea* Pellegrin.

### 4.4.2 *Food*

*Oreochromis niloticus* was from the beginning a phytoplanktivorous and bottom feeder (Welcomme, 1968). However, later observations indicated that in Lake Victoria, the food of *O. niloticus* became more diversified and including *Caridina nilotica* Roux., chironomids, chaoborids, molluscs and bottom detrital matter (Fig. 4.10).

Njiru *et al.* (2004) found that the diet of *O. niloticus* varied with increasing size, although all size classes >5 cm TL consumed all important food items. Zooplankters (cladocerans and copepods) were the major food of *O. niloticus* under 5 cm TL, and were of little importance to fish larger than 15 cm TL. Insects were also of little importance to the diet of small *O. niloticus* (<5 cm), but were major food items of larger fish. Algae, fish and plant material were consistently important to all size groups below 55 cm TL. Fish <10 cm TL did not consume molluscs.

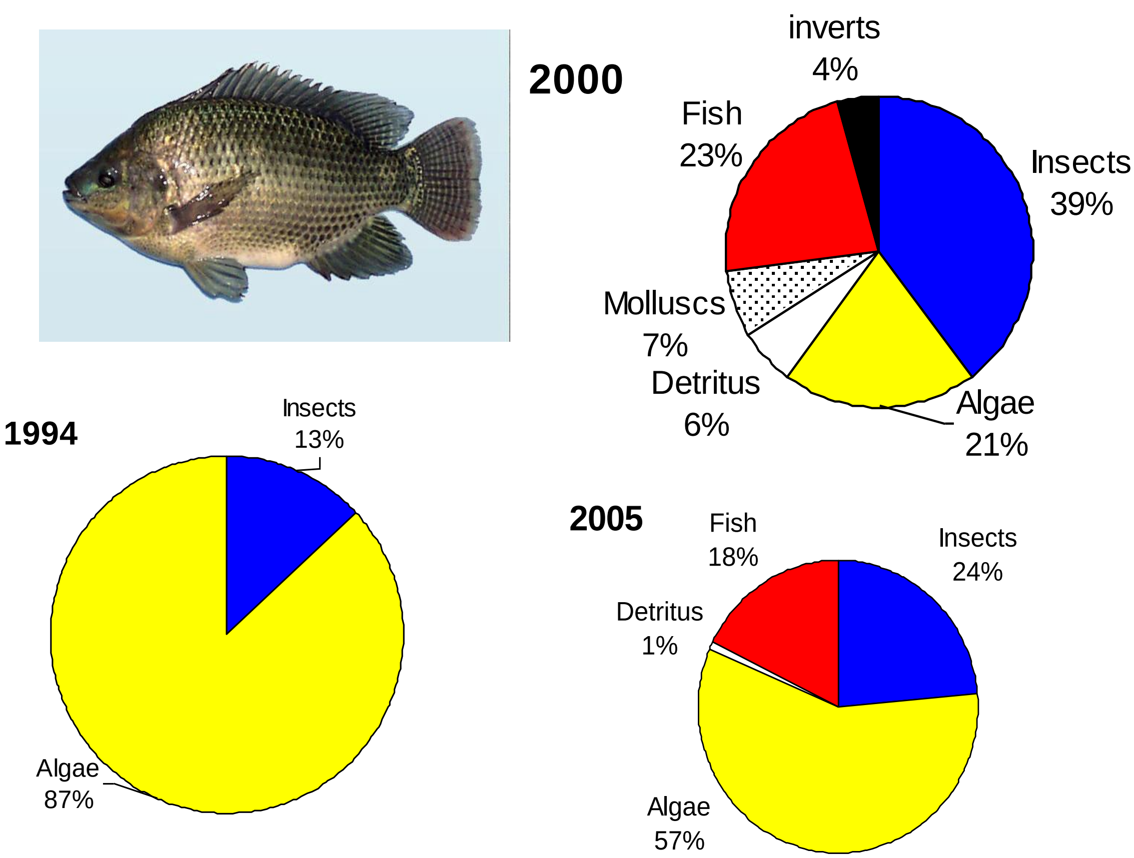



Figure 4.10: Shifts in feeding habits of Nile tilapia for the period 1968-2005.

### *4.4.3 Fecundity*

The fecundity of *O. niloticus* has increased from 340-3706 eggs for fish of 17-57 cm TL (Lowe-McConnell, 1955), to 864-6316 eggs for fish of 28-56 cm TL (Lung'ayia, 1994) to 400-8879 eggs for fish of 26-39 cm TL (2,000-11,400 eggs; Chande, 2000). The increase in fecundity could also be a mechanism to compensate for the intensive fishing pressure in the lake. In stable environment fish put more effort into somatic growth as opposed to gonadal development. This tactic is more likely to increase their chance of survival and reproduction in subsequent years (Cowx, 1998).

### *4.4.4 Length Frequency Distributions and Size at First Maturity*

The percentage frequency distributions over the years are shown on Fig. 4.11. Time series data on the population characteristics of the species is very scanty on the Tanzanian side. However, trawl data for the years 1984-2002 have indicated an increase on the proportions of relatively bigger fishes despite the heavy fishing pressure as a result of increased local and foreign market. The success of the species to sustain the fishing pressure could be due to the ability of the species to expand the food range (Njiru, 2000). This is further supported by the increase in the growth curvature K for various years as follows: 0.25 for 1985-1986 (Getabu 1992), 0.35 for 1980-1990 (Dache, 1994), 0.56 for 1988-2000, all in Kenyan waters (Njiru, 2003). It can also be said that the increase in fishing effort on the Tanzanian part of the lake might possibly explain the decrease in the size at first maturity of the *O. niloticus* in Lake Victoria (Fig. 4.12).

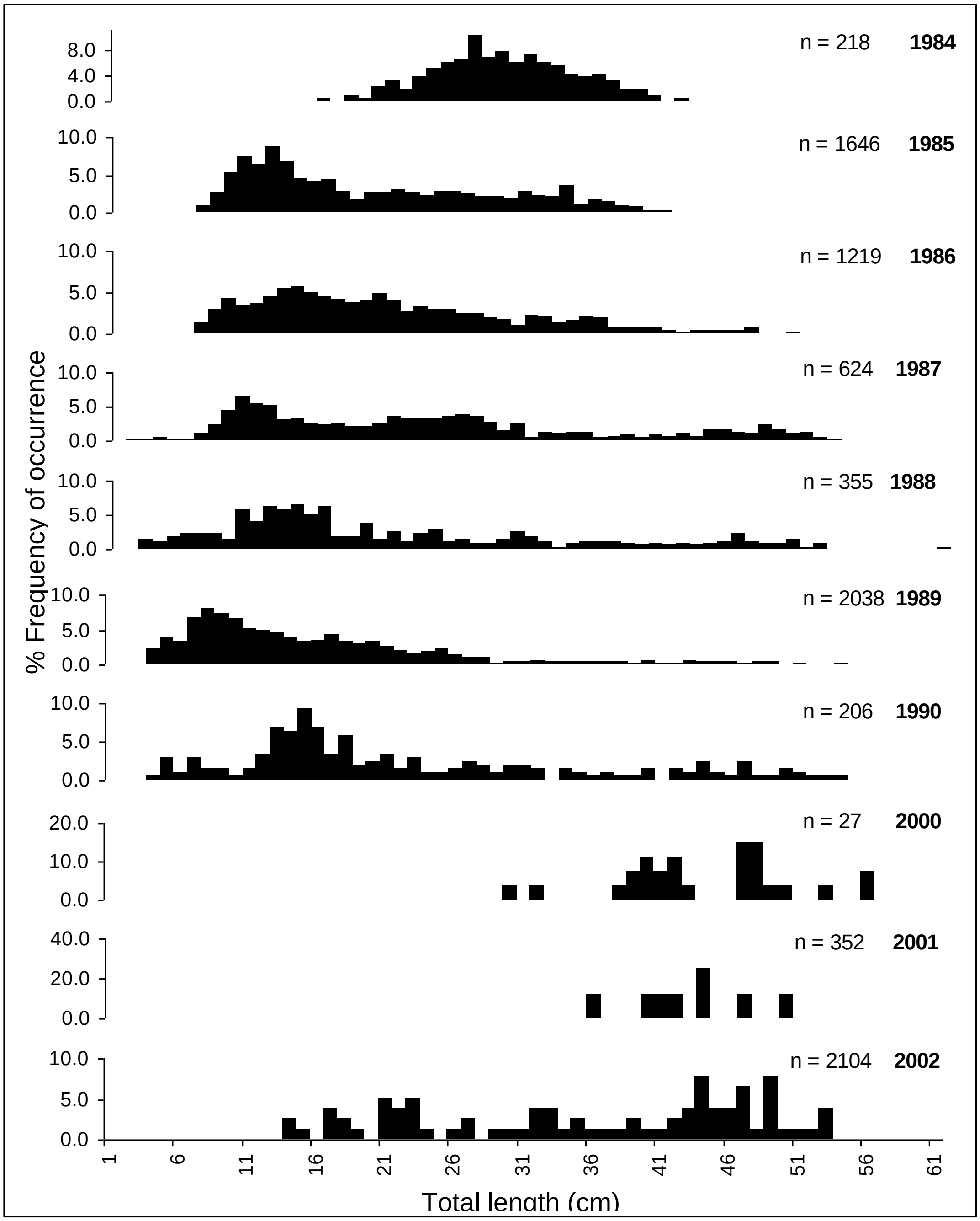



Figure 4.11: Length frequency (total length) distributions for *Oreochromis niloticus.*


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Figure 4.12: Length at 50% maturity for *Oreochromis niloticus* (For 1968 fish length measured as SL (cm), the rest as total length).
*Sources:* 1968: Welcomme (1968); 1976: Wanjala and Marten (1976); 1992: Ogari and Asila (1992)

## 4.5 Conclusions

The data on important life history indicators (e.g., length at maturity; growth and mortality estimates; length-frequency data; trophic interactions; spatial and temporal distribution, and fecundity) for the three commercially important species are sparse and do not form long time series to facilitate definitive conclusions about the resources. However, LVEMP intervention has provided some data and information which form the basis of the following concluding points on the Nile perch:

- Available data indicate that total mortality and thus fishing mortality have changed over time but without a discernible trend.
- The batho-spatial distribution pattern exhibited a decline in Nile perch stock abundance with depth, an indication of reduction in aerated habitats as a result of eutrophic conditions.
- The Nile perch disrupted the ecosystem by simplifying the food web through elimination of haplochromines from many interactions and shortening of food chain.
- Size at first maturity of Nile perch exhibited a declining trend. This drop could be attributed to increase in fishing pressure, changes in food availability and the lake environment.

# CHAPTER FIVE

# STOCK ASSESSMENT OF COMMERCIAL FISH SPECIES OF LAKE VICTORIA

*A.I. Chande[1] and Y.D. Mgaya[2]*
*[1]Tanzania Fisheries Research Institute*
*P.O. Box 90, Kigoma*
*[2]University of Dar es Salaam*
*Faculty of Aquatic Sciences and Technology*
*P.O. Box 60091, Dar es Salaam*

## 5.1 Introduction

An understanding of the historical patterns of exploitation of any fishery is a prerequisite in any attempt to carry out stock assessment. What is known about abundance of fish populations and how the stocks respond to exploitation comes primarily from the analysis of catch records (King, 1995). Consequently, management of fisheries relies on the outputs of stock assessment for which a well organized data collection system is required (Cowx, 1996).This can be done either from what is being landed i.e. fisheries dependent data collection or from research surveys i.e. fisheries independent data collection.

As early as 1928 the need to monitor the status of Lake Victoria's fisheries was expressed when gillnet catch per unit of effort (CPUE) started to decline (Lowe-McConnell, 1997). Underlying these efforts was the recommended use of 127 mm (5 inches) mesh size for gillnets in early 1930's and the introduction of exotic fish species to boost the production in early 1950's for whole lake. *Tilapia melanopleura, T. zilii, Oreochromis leucostictus* and *O. niloticus* were introduced in the lake (Welcomme, 1968). Nile perch (*Lates niloticus*) was also introduced in the late 1950's and early 1960's (Arunga, 1981; Welcomme, 1988). The effect of these introductions to the fishery and ecology of the lake was not immediately realized. Catch rates and the total yield continued to decrease for the next twenty years. With the decrease in catch rates smaller gillnets of 38 to 46 mm (1.5 to 2 inches) were used to harvest smaller fish. These included; *Synodontis* spp., *Schilbe intermedius, Barbus profundus, Brycinus* spp., and the haplochromines in the late 1960s (Marten, 1979). Beach seines also increased in the early 1970's to catch the haplochromines but also captured large numbers of spawning and juveniles of tilapiines (Marten, 1979), escalating the effect of decline in catch rates. In the same period, light fishing for the cyprinid, *Rasrineobola argentea* (dagaa) developed. The dagaa light fishery used very small mesh sizes (8 to 13 mm), which was harvesting juveniles of both haplochromines and tilapiines (Mkumbo, 2002).

The need to define the status of the stocks was raised by the research institutions of the three riparian states, EAFFRO (East African Freshwater Fisheries Research Organization) and aided by FAO/UNDP carried out the first lake-wide bottom trawl survey in 1969/1971 (Mkumbo, 2002). Apart from bottom trawl surveys, acoustic surveys have also been used to estimate fish stock abundance worldwide including Lake Victoria (Ona, 1999).

## 5.2 Justification

Changes in species composition in any ecosystem have profound impact in the food web and eventually to the ecosystem in general. Similar changes have occurred in Lake Victoria. The haplochromines encompassed many trophic specializations, these included detritus/phytoplanktivores, zooplanktivores and the piscivores. There were many other changes within the ecosystem. The changes were linked with the excessive fishing pressure, predation and competition among the species subsequently shifted the multi-species fishery of the lake to a three species fishery which include; Nile perch (*L. niloticus*), the pelagic cyprinid dagaa (*R. argentea*) and the introduced tilapiine (*O. niloticus*). Few studies have been conducted to assess the stocks of the common fish species and others. As such it has been difficult to trace the trends of the fish stocks which are important in planning management measures. This exercise of preparing the synthesis aims at identifying gaps and recommending further studies.

## 5.3 Results

**Indicators**

- Total catch (Yield)
- Catch per unit area (density) or Standing crop
- Catch rate (catch per unit effort)

### *5.3.1 Stock Abundance from Trawl Catches*

**Temporal changes of abundance**

Changes with time in the abundance of different fish species using four research vessels are presented in Tables 5.1 and 5.2. Trends in the changes cannot be considered because the vessels were not standardized. Table 5.1 gives data on trawl surveys conducted in Mwanza Gulf using R.V. Kiboko. The results showed that, the catch rates of the haplochromines decreased very steeply from 338.23 kg/hr in 1984 to only 3.99 kg/hr in 1987. In 1988 the catch rate was almost negligible whereby only 0.27 kg/hr was recorded. There was a high correlation between time and catch rates from 1984 to 1990 (Table 5.1), the catches decreased with time ($R^2$ = 0.735). The trend of catches of the haplochromines was opposed by that of the Nile perch. The catch rates of *L. niloticus* increased very steeply from 39.10 kg/hr in 1984 to 126.56 kg/hr in 1987, thereafter the catches decreased with time to 66.54 kg/hr in 1990. There was a high correlation in the changes of the catch rates of Nile perch with time ($R^2$ = 0.7312). The other fish species showed a decreasing trend with time.

Table 5.2 presents catches of different fish species using three research vessels; Ibis, R.V. TAFIRI II and R.V. Victoria/Explorer. Nile perch dominated in the catches from 1989 to 2000; but haplochromines predominated before this time. In 1969/1970, the haplochromine catch was 450.2 kg $hr^{-1}$ and constituted 71% of the total catch. Twenty-four other species were caught; Nile perch catch was negligible (1.0 kg $hr^{-1}$). The contribution of the other species, e.g. *Oreochromis esculentus, Bagrus docmak, Clarias gariepinus, Protopterus aethiopicus* and *Synodontis victoriae,* was more than 10 kg $hr^{-1}$ of the catches.

Furthermore, surveys using R.V. TAFIRI II carried out in 1995 and 1996, showed that, Nile perch catch rate increased from 191 kg $hr^{-1}$ (almost 100% of the catch), in 1995 to 279.9 kg $hr^{-1}$ (91%) in 1996. Other species in the catch included haplochromines, *Schilbe intermedius* and *O. niloticus,* but their contribution was minor (Table 5.2). Nile perch contributed 91.6% of the catches (249.11 kg $hr^{-1}$) during 1999/2000 survey using R.V. Victoria Explorer while haplochromines had reappeared and became an important component of the catch (32.7 kg $hr^{-1}$ representing 5.7% of the total catch).

The trends of catch rates with time for the Nile perch (predator) and the haplochromine (important prey) were estimated by standardizing the engine Horse power (HP) of the four research vessels to 150 HP, that of R.V. TAFIRI II. The results are presented as Fig. 5.1. Generally there was an inverse relationship, as the Nile perch increased the haplochromines decreased. For example, during 1969/70 the abundance of the haplochromines recorded the highest (375.17 kg/hr) and the Nile perch recorded the least (0.83 kg/hr), showing a typical predator – prey relationship. Thereafter the catch rate of the Nile perch increased and peaked in 1987 (180.86 kg/hr) while that of the haplochromines decreased to only 5.71 kg/hr in the same year. Between 1988 and 1990 the abundance of Nile perch decreased and ranged from 95.0 kg/hr to 110.14 kg/hr. The abundance of the haplochromines remained extremely negligible up to 1996 when there was a recovery, recorded 10.4 kg/hr. The abundance of the haplochromines showed even a higher recovery in 1999 whereby 32.7 kg/hr was recorded, thereafter the abundance decreased.

Table 5.1: Fish species catch rates (kg $hr^{-1}$) from trawl catches in Mwanza Gulf using R.V. Kiboko during 1984 – 1990.

| **Species/Years** | **1984** | **1985** | **1986** | **1987** | **1988** | **1989** | **1990** |
|---|---|---|---|---|---|---|---|
| *Lates niloticus* | 39.10 | 62.28 | 101.40 | 126.56 | 77.10 | 86.10 | 66.54 |
| *Bagrus docmak* | 1.36 | 5.82 | 3.23 | 0.61 | 0.19 | 0.06 | 0 |
| *Clarias gariepinus* | 1.71 | 2.64 | 2.68 | 3.01 | 1.59 | 1.11 | 0.34 |
| Haplochromines | 338.23 | 214.27 | 61.09 | 3.99 | 0.27 | 0.50 | 1.27 |
| *Protopterus aethiopicus* | 26.77 | 16.32 | 5.37 | 2.30 | 4.60 | 0.81 | 0.99 |
| *Schilbe intermedius* | 0.61 | 0.69 | 0.88 | 0.86 | 0.25 | 0.16 | 0.26 |
| *Tilapia* species | 5.24 | 5.79 | 5.20 | 3.45 | 1.39 | 2.22 | 1.34 |

Table 2: Fish species catch rates (kg $hr^{-1}$) sampled by the three research vessels; Ibis, R.V.TAFIRI II and R.V. Victoria Explorer during 1969/70 – 1999/2000.

| **Species/Reasearch vessels** | **Ibis** | **R.V. TAFIRI II** | | **R.V. Victoria Explorer** |
|---|---|---|---|---|
| | 1969/1970 | 1995 | 1996 | 1999/2000 |
| Haplochromines | 450.15 | 0 | 10.44 | 32.71 |
| *Oreochromis esculentus* | 17.46 | 0 | 0 | 0 |
| *O. variabilis* | 0.68 | 0 | 0 | 0 |
| *O. niloticus* | 2.73 | 0 | 3.37 | 4.86 |
| *O. leucostictus* | 0 | 0 | 0 | 0 |
| *Tilapia zillii* | 0.13 | 0 | 0 | 0 |
| *Bagrus docmak* | 29.38 | 0 | 0 | 0.18 |
| *Clarias gariepinus* | 20.95 | 0 | 0 | 0.73 |

| **Species/Reasearch vessels** | **Ibis** | **R.V. TAFIRI II** | | **R.V. Victoria Explorer** |
|---|---|---|---|---|
| | 1969/1970 | 1995 | 1996 | 1999/2000 |
| *Xenoclarias eupogon* | 0.26 | 0 | 0 | 0 |
| *Protopterus aethiopicus* | 11.88 | 0 | 0 | 2.71 |
| *Lates niloticus* | 1.00 | 191.20 | 279.90 | 249.11 |
| *Synodontis victoriae* | 12.51 | 0 | 0 | 0.18 |
| *S. afrofischeri* | 0.10 | 0 | 0 | 0.04 |
| *Barbus profundus* | 0 | 0 | 0 | 0.31 |
| *B. altianalis* | 0.32 | 0 | 0 | 0.23 |
| *Labeo victorianus* | 0.17 | 0 | 0 | 0.02 |
| *Mormyrus kannume* | 0.31 | 0 | 0 | 0 |
| *Schilbe intermedius* | 0.63 | 0 | 0.89 | 1.67 |
| *Brycinus* spp. | 0 | 0 | 11.92 | 0.54 |
| *Afromastacembalus frenatus* | 0 | 0 | 0 | 0 |
| *Gnathonemus longibarbus* | 0 | 0 | 0 | 0 |
| *Rastrineobola argentea* | 0 | 0 | 0 | 2.80 |
| *Caridina niloticus* | 0 | 0 | 0 | 0.01 |
| **Total** | 548.66 | 191.2 | 306.53 | 296.1 |

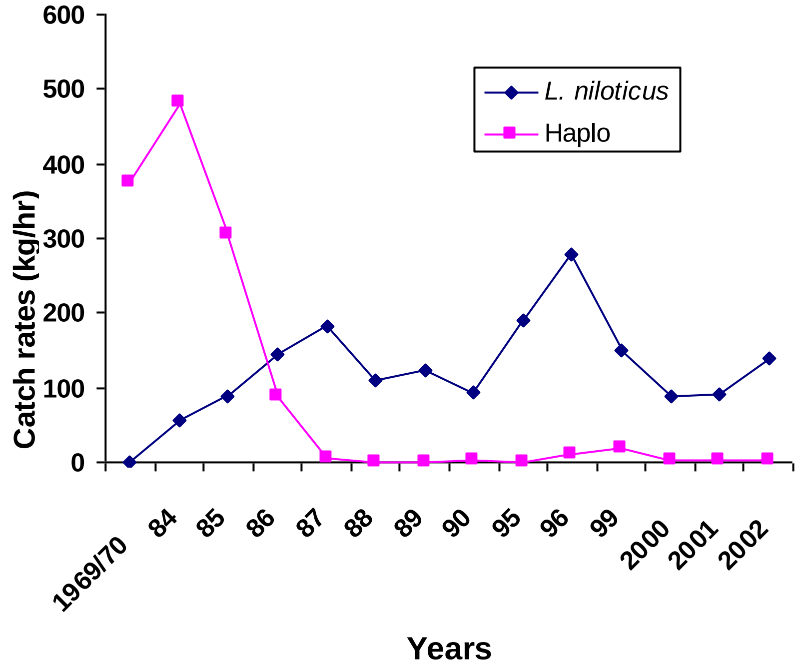



Figure 5.1: Trends of catch rates (kg/hr) of *Lates niloticus* and haplochromines during 1969/70 - 2002 from trawl catches of standardized (Horse Power) research vessels.

### *5.3.2 Spatial Changes of Abundance*

Trawl surveys to estimate abundance (cpue) of different fish species were carried out by R.V. TAFIRI II from 2000 to 2002 in different areas within Tanzania (Fig. 5.2) and the results are presented in Tables 5.3 to 5.5. The results show that different fish species distributed differently in different areas, but *L. niloticus, O. niloticus* and the haplochromines were the most common fish in many areas. *Lates niloticus* was the most abundant; the highest catch rate in 2000 was 197.5 kg/hr, recorded in Mara bay. The least was recorded at Shirati bay (40.4 kg/hr). During 2001 the highest abundance was recorded at Bunda hills (227.0 kg/hr) followed by Bulamba (170.67 kg/hr), both are within the Speke gulf. The least was recorded at Magu bay (24.0 kg/hr). Bawmann gulf had the highest abundance during 2002 (481.07kg/hr) followed by Bulamba in the Speke gulf (173.59 kg/hr).

*Oreochromis niloticus* was highly abundant at Nyamirembe during 2000 and 2001 whereby 63.2 kg/hr and 37.07 kg/hr was recorded respectively while in 2002 the species was most abundant at Shirati bay (47.82 kg/hr). The haplochromines were observed at each site except at Baumann Gulf whereby none was encountered during the whole sampling period, the catch rates in other areas ranged from 0.1 kg/hr to 10.09 kg/hr.

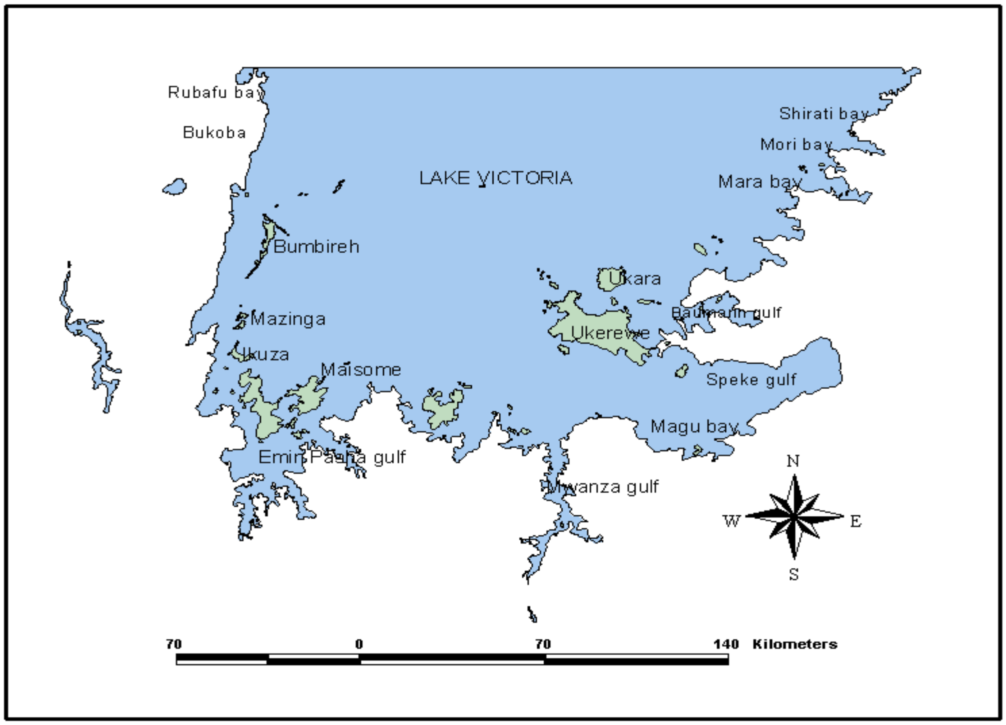



Figure 5.2: Map of Lake Victoria showing sampling stations.

Table 5.3: Catch rates (kg/hr) of different fish species from R.V. TAFIRI II catches from different sites of Lake Victoria during 2000.

| **SPECIES** | **SITES** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Karumo | Bulamba | Ramadi | Magu bay | Bunda hills | Mara bay | Mori bay | Shirati bay | Bauman n gulf | Luchiri bay | Chato bay | Nyamirem be |
| *Lates niloticus* | 69.3 | 89.6 | 61.6 | 85.8 | 119.5 | 197.5 | 78.5 | 40.4 | 83.3 | 110.0 | 47.6 | 77.3 |
| *Oreochromis niloticus* | 0 | 2.7 | 4.2 | 0.11 | 1.9 | 1.6 | 9.7 | 4.2 | 35.5 | 1.7 | 9.8 | 63.2 |
| Haplochromin es | 1.7 | 0.9 | 7.1 | 2.3 | 0.1 | 1.1 | 3.5 | 0.8 | 0 | 2.0 | 0.1 | 0.2 |
| *Schilbe intermedius* | 0 | 1.1 | 2.3 | 0.2 | 0.3 | 0 | 2.91 | 0 | 0 | 0.23 | 0 | 0.02 |
| *Synodontis afrofischeri* | 0.14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.04 | 0.13 | 0 |
| *Synodontis victoriae* | 0.01 | 0.03 | 0 | 0.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0.22 | 0 |
| *Brycinus sadleri* | 0.07 | 0 | 1.90 | 0.5 | 0.13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Protopterus aethiopicus* | 202.0 | 0 | 0.38 | 3.0 | 0 | 0 | 0 | 0 | 19.0 | 5.75 | 0 | 0 |
| *Barbus* sp. | 0.08 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bagrus docmak* | 0.40 | 0 | 0 | 2.0 | 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Clarias gariepinus* | 0 | 0 | 1.17 | 2.83 | 0 | 0 | 0 | 0 | 2.0 | 0 | 0.25 | 2.34 |
| *Labeo victorianus* | 0 | 0.02 | 0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 5.4: Catch rates (kg/hr) of different fish species from R.V. TAFIRI II catches from different sites of Lake Victoria during 2001.

| **SPECIES** | **SITES** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Karumo | Bulamba | Ramadi | Magu bay | Bunda hills | Shirati bay | Rubafu bay | Luchiri bay | Chato bay | Nyamirembe |
| *Lates niloticus* | 102.0 | 170.67 | 94.33 | 24.0 | 227.0 | 94.33 | 31.0 | 44.0 | 94.8 | 28.37 |
| *Oreochromis niloticus* | 0 | 0.67 | 0 | 0 | 8.0 | 0 | 1.0 | 0 | 0 | 37.07 |
| Haplochromines | 1.0 | 1.07 | 6.13 | 3.0 | 3.0 | 6.13 | 3.0 | 1.0 | 0.14 | 0.23 |
| *Schilbe intermedius* | 0 | 5.54 | 0 | 1.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Synodontis afrofischeri* | 0 | 0.27 | 0 | 0 | 0 | 0 | 0 | 3.0 | 0 | 0 |
| *Synodontis victoriae* | 0 | 0.37 | 0 | 0 | 0 | 0 | 0 | 0 | 11.33 | 0 |
| *Brycinus sadleri* | 0 | 0.4 | 5.39 | 0 | 13.0 | 5.39 | 0 | 0 | 0 | 0 |
| *Brtcinus jacksonii* | 0 | 0.1 | 2.27 | 0 | 5.0 | 2.27 | 0 | 0 | 0 | 0 |
| *Protopterus aethiopicus* | 69.0 | 0 | 8.0 | 5.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bagrus docmak* | 0 | 0 | 0.03 | 4.0 | 0 | 0.03 | 0 | 0 | 0 | 0 |
| *Clarias gariepinus* | 0 | 0 | 0 | 1.0 | 0 | 0 | 4.0 | 0 | 0 | 0 |

Table 5.5: Catch rates (kg/hr) of different fish species from R.V. TAFIRI II catches from different sites of Lake Victoria during 2002.

| SPECIES | SITES | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Karumo | Bulamba | Ramadi | Magu bay | Mara bay | Mori bay | Shirati bay | Rubafu bay | Chato bay | Bowman gulf |
| *Lates niloticus* | 116.78 | 173.59 | 17.42 | 21.34 | 98.34 | 166.99 | 76.22 | 136.0 | 97.69 | 481.07 |
| *Oreochromis niloticus* | 0.83 | 3.46 | 4.7 | 0 | 10.40 | 0 | 47.82 | 5.37 | 20.33 | 20.07 |
| Haplochromines | 1.30 | 2.52 | 10.09 | 3.54 | 0.13 | 0.83 | 0.45 | 4.27 | 1.23 | 0.04 |
| *Schilbe intermedius* | 0.16 | 0.70 | 0.16 | 0.55 | 0.19 | 0.02 | 2.0 | 0.02 | 0 | 0 |
| *Synodontis afrofischeri* | 0.03 | 0.01 | 0 | 0 | 0 | 0.13 | 0.5 | 0 | 0.53 | 0 |
| *Synodontis victoriae* | 0.12 | 0.14 | 6.80 | 0.15 | 0.01 | 0 | 0 | 0.01 | 0.16 | 0 |
| *Brycinus sadleri* | 0.21 | 0.02 | 1.19 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 |
| *Brycinus jacksonii* | 0 | 0.01 | 0.52 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Protopterus aethiopicus* | 4.22 | 0 | 0 | 21.33 | 0 | 0 | 0 | 0 | 0 | 2.0 |
| *Bagrus docmak* | 0.07 | 0 | 0.33 | 0.56 | 0 | 0 | 0.73 | 0 | 0 | 0 |
| *Clarias gariepinus* | 0 | 0 | 0 | 6.01 | 17.0 | 0 | 0 | 1.78 | 0 | 0 |
| *Barbus* sp. | 0.01 | 0 | 0 | 0.01 | 0 | 0.67 | 0 | 0.26 | 0 | 0 |
| *Tilapia zillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0.33 | 0.10 | 0 | 0 |

### *5.3.3 Biomass Estimates by Swept Area Method*

Abundance index estimates for different depth ranges is given in Table 5.6. Highest stock densities for Nile perch were at the depth range of 30-39 m. Other species have higher abundances in the shallow waters of less than 20 m deep. These were mostly *O. niloticus* and *Protopterus aethiopicus*. Relative high abundances for the other species were also observed at depths below 50 m. These were mainly *Barbus profundus* Greenwood, 1972, *Synodontis victoriae* Boulenger, 1906 and some piscivorous haplochromine species.

Table 5.6: Standing crop and biomass indices (± 95% CL) from different depth ranges for Nile perch and other species from bottom trawl surveys in the Tanzanian waters during 1997–2001.

| | | | **Nile perch** | | **Other species** | |
|---|---|---|---|---|---|---|
| Depth range (m) | No. of hauls | Water Area by Depth ($km^{-2}$ *1000) | Standing crop ($t\ km^{-2}$) | Biomass (t*1000) | Standing crop ($t\ km^{-2}$) | Biomass (t*1000) |
| 1-9 | 85 | 5.303 | 7.0388 ±0.65 | 37.327 ±3.43 | 1.6491 ±0.38 | 8.7451 ±2.0 |
| 10-19 | 160 | 3.284 | 9.8932 ±0.31 | 32.489± 1.03 | 0.8992 ±0.07 | 2.9529 ±0.25 |
| 20-29 | 120 | 3.841 | 10.258 ±0.32 | 39.401 ±1.24 | 0.3073 ±0.05 | 1.1804 ±0.19 |
| 30-39 | 103 | 4.221 | 12.211 ±0.52 | 51.544 ±2.21 | 0.1843 ±0.04 | 0.7781 ±0.2 |
| 40-49 | 53 | 4.256 | 9.8496 ±1.02 | 41.920 ±4.34 | 0.071 ±0.09 | 0.3022 ±0.4 |
| 50-59 | 15 | 5.467 | 5.7194 ±2.5 | 31.268± 13.65 | 0.6206 ±1.3 | 3.3929 ±7.13 |
| 60+ | 1 | 13.006 | 2.1446 | 27.892 | 0.7379 | 9.5971 |

Abundance index estimates for the three riparian countries gives proportion contribution from each of the three national waters. Tanzanian waters supported the highest proportion followed by Uganda and Kenya. An average biomass of Nile perch for the whole lake was estimated at 693,674.3 t. The estimates are only for Nile perch, which contributed 91.6% of the total catch and thus implying a total abundance of 757 286.3 t for the stocks in Lake Victoria. *R. argentea* (Dagaa) is not included, as the method used for sampling is not applicable for the species.

### *5.3.4 Stock Abundance from Hydro-acoustic Survey*

**Nile Perch**

The mean fish biomass index averaged from the estimates of five hydro-acoustic surveys conducted between August 1999 and August 2001 was 2.17 x $10^6$ tones, corresponding to a standing crop of 31.0 t $km^{-2}$, of which Nile perch constituted of 59.3%, dagaa 22.4%, haplochromines 15.0%, *Caridina* 1.1% and other species 2.2%. The standing crops of Nile perch during the period 1999-2001 (Table 5.7) were higher in inshore areas (Zones 1 and 3) compared to offshore areas (Zones 2 and 4). August surveys values were higher than those of February surveys. The extrapolated total biomass indices are presented in (Table 5.8).

Table 5.7: The standing crop of Nile perch (t $km^{-2}$) in Lake Victoria during the period August 1999-August 2001(adjusted for calibration for August 2000).

| Standing crop indices (t $km^{-2}$) | | | | | | |
|---|---|---|---|---|---|---|
| Zone | Aug 1999 | Feb 2000 | Aug 2000 | Feb 2001 | Aug 2001 | Mean |
| 1 | 35.4 | 26.48 | 35.14 | 15.88 | 28.82 | 28.34 |
| 2 | 17.55 | 10.94 | 8.33 | 7.41 | 7.69 | 10.38 |
| 3 | 53.32 | 25.30 | 38.85 | 29.94 | 25.65 | 34.61 |
| 4 | 19.65 | 11.70 | 8.16 | 2.22 | 17.53 | 11.85 |
| All | 125.92 | 74.42 | 90.48 | 55.45 | 79.69 | 85.24 |
| Mean | 31.48 | 18.61 | 22.62 | 13.86 | 19.92 | 21.30 |
| SE | 8.30 | 4.22 | 8.33 | 6.05 | 4.72 | |

Table 5.8: Total extrapolated biomass indices of Nile perch for the whole Lake Victoria for the period August 1999 to August 2001.

| Total biomass indices of Nile perch (t) extrapolated for the whole lake | | | | | |
|---|---|---|---|---|---|
| Zone | Aug 1999 | Feb 2000 | Aug 2000 | Feb 2001 | Aug 2001 |
| 1 | 451,896 | 338,619 | 449,263 | 203,073 | 368482 |
| 2 | 338,285 | 210,778 | 160,308 | 142,764 | 148213 |
| 3 | 729,121 | 345,975 | 531,278 | 409,492 | 350760 |
| 4 | 417,375 | 248,520 | 173,496 | 47,201 | 372507 |
| **Total** | **1,936,677** | **1,143,891** | **1,314,345** | **802,530** | **1,239,961** |

The distribution of fish standing crop indicated that it was four times higher in coastal waters (up to 25 m depth) than in the offshore region of the lake (deeper than 40 m). This ratio was much higher for fish occurring close to the bottom. The mean standing crop of Nile perch in relation to that of other species in Lake Victoria is presented in Fig. 5.3. Despite the declining trend in the biomass index for the species it had the highest standing crop.

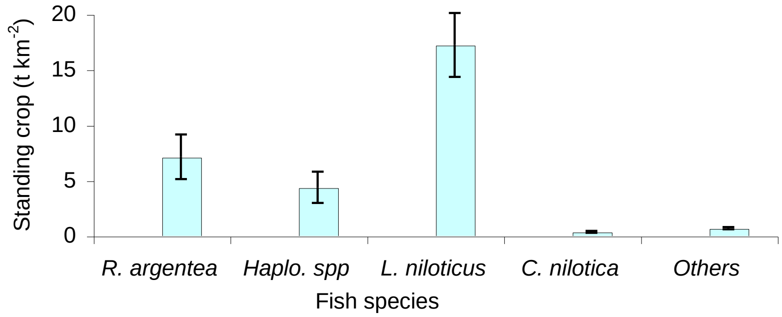



Figure 5.3: Standing crop (combined for all surveys, 1999 - 2001) of major fish species of Lake Victoria, East Africa, vertical error bars represent standard error. (Source: LVFRP report, 2002).

The variation of the standing crop of Nile perch with time is presented in Fig. 5.4. Two-way analysis of variance without replication was used to test if there were significant differences between the mean standing crops in the different zones and during the different survey periods. There were significant differences between the means of the standing crop among the different zones and during the different periods of sampling ($F_{3,5}$ $P < 0.1$ at the critical 0.05 level of significance). The results indicate strong spatial and temporal influences on the distribution of the species in Lake Victoria.

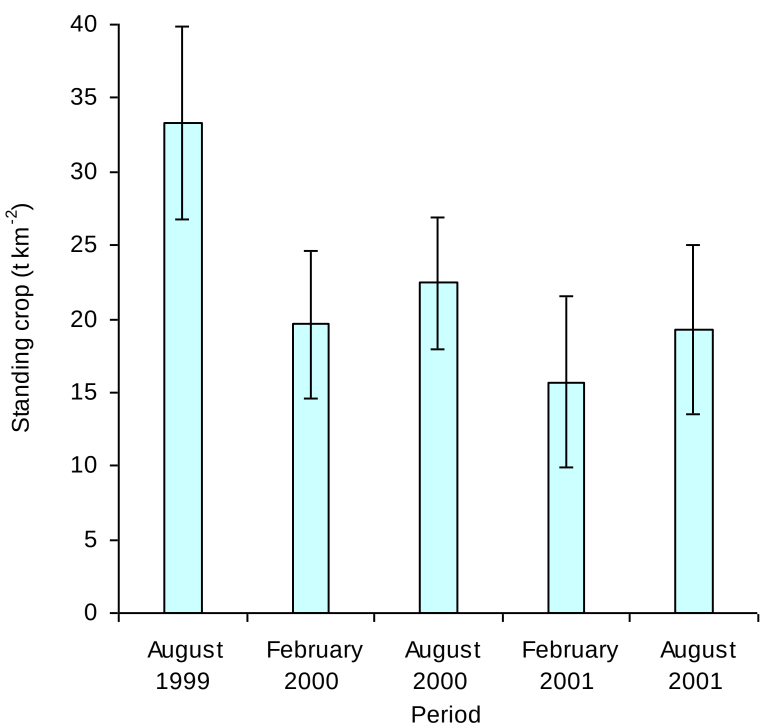



Figure 5.4: Variation in the standing crop of *L. niloticus* in Lake Victoria during the period August 1999 - August 2001, vertical error bars represent standard error. (Source: LVFRP Report, 2002).

***Rastrineobola argentea***

The acoustic biomass estimates of *R. argentea* showed significant differences amongst the five surveys (Table 5.9) (Kruskal-Wallis H test; $P < 0.005$) with the highest biomass estimate in January/February 2001 survey (875,903 t) and the lowest biomass estimate in August/September 2000 survey (196,372 t). The mean total biomass (± 95% CL) of *R. argentea* for the five surveys was 476,902 ± 339,308 t.

Table 5.9: Total biomass and biomass of *R. argentea* in Lake Victoria derived from the five acoustic surveys.

| Survey | Total (t) | *R. argentea* (t) | % of *R. argentea* to total biomass |
|---|---|---|---|
| August 1999 | 2,380,674 | 245,265 | 10.3 |
| January/February 2000 | 1,910,625 | 514,194 | 26.9 |
| August/September 2000 | 2,145,449 | 196,372 | 9.2 |
| January/February 2001 | 1,905,556 | 875,903 | 46.0 |
| August/September 2001 | 2,504,676 | 552,776 | 22.1 |

The overall contribution of *Rastrineobola argentea* to the total biomass ranged from 9% in August/September 2000 to 46% in January/February 2001 with an average of 22%. *Rastrineobola argentea* contributed more to the total biomass during the January/February period (Table 5.9).

**Haplochromines and other minor species**

Acoustic biomass estimates of haplochromines ranged from 141,432 t to 649,867 t (Table 5.10) with an average (± 95% CL) of 337,014 ± 188,262. Higher estimates were found in the August/September surveys. The 'Others' category included all the additional species, which could not be individually determined, notably *Brycinus profundus, Synodontis* spp. and Nile tilapia, *Oreochromis niloticus*. The mean total biomass (± 95% CL) of others was 47,611 ± 8,619 t.

Table 5.10: Total biomass of haplochromines and other minor species in Lake Victoria derived from the five acoustic surveys.

| Survey | Haplochromines (t) | Others (t) |
|---|---|---|
| August 1999 | 155,180 | 39,371 |
| January/February 2000 | 149,644 | 70,509 |
| Aug/September 2000 | 588,946 | 34,465 |
| January/February 2001 | 141,432 | 50,570 |
| Aug/September 2001 | 649,867 | 43,141 |

***Caridina nilotica***

The lake wide acoustic surveys showed that *C. nilotica* was highly abundant and widely distributed in Lake Victoria. The abundance of *C. nilotica* showed both seasonal and spatial variation. The results show that environmental parameters, which also showed seasonal variations, had a considerable influence on the abundance of *C. nilotica* in Lake Victoria (Budeba, 2003). Lake Victoria exhibits thermal stratification during October to April and complete mixing between June and September of every year. During thermal stratification dissolved oxygen in the bottom waters especially in deep water areas becomes lower than 1 mg $L^{-1}$ but in some areas dissolved oxygen can be as high as 6 mg $L^{-1}$ during thermal stratification. The lake shows signs of advanced eutrophication such as low water transparency, high algal biomass, occurrence of algal blooms and anoxia. *Caridina nilotica* has higher tolerance to very low dissolved oxygen, thus eutrophication conditions in Lake Victoria favours its proliferation in the lake.

### *5.3.5 Abundance from Gillnet Catches*

Catch assessment surveys conducted in 1999 and 2000 showed that motorized boats with gillnets had the highest CPUE of 69.26 and 73.19 kg $day^{-1}$ respectively compared to the other gears. There was a marked difference in CPUE between motorized gillnet boats and gillnet boats with sails, 69.26 kg $day^{-1}$ and 31.10 kg $day^{-1}$ respectively in 1999 and 73.09 kg $day^{-1}$ and 39.26 kg $day^{-1}$ respectively in 2000. This lead to further assessment of CPUE for motorized gillnet boats which had information on the number of nets from October 1997 to December 2000 (Table 5.11). Catch per boat appeared to have increased by 13.8% from October 1997 to December 2000 and the number of nets per boat increased by 100% indicating marked decline in CPUE. Catch per net declined by almost 60%. The fishermen vary the fishing techniques from active gillnetting to triple mounting of nets; two to three nets are joined vertically so as to cover the whole water column. Such mounted nets are also tied to canoes with outboard engine and towed slowly over a large distance. All are attempts to increase CPUE.

Table 5.11: Changes in catch rates (kg net$^{-1}$) and number of gillnets per boat for Nile perch fishery from 1997 to 2000 in Tanzanian waters.

| Year | Catch rates (± 95% CL) (kg boat$^{-1}$) | Number of nets boat$^{-1}$ (± 95 CL) | Catch rate (kg net$^{-1}$) |
|---|---|---|---|
| 1997 | 65.69 ± 21.39 (N = 17) | 45.5 ± 8.53 | 1.45 |
| 1998 | 58.35 ± 13.24 (N = 49) | 51.3 ± 6.54 | 1.14 |
| 1999 | 77 .0 ± 30.74 (N = 21) | 99.14 ± 12.9 | 0.78 |
| 2000 | 74.79 ± 12.75 N = 37) | 90.16 ± 9.1 | 0.83 |

## 5.4 Discussion

### *5.4.1 Trawl Catches*

Stock abundance fluctuated over the years, but due to changes in species composition and data collected by different research vessels of differing efficiency under varying sampling programmes, it was not possible to established trends. However, when haplochromines dominated in the early 1970's catch rates were more than 400 kg hr$^{-1}$ (Table 5.2), but fell dramatically. As haplochromines declined, Nile perch increased in the early 1980's. Despite differences in the vessel used, Nile perch catch rates followed an increasing trend throughout the 1980's and 1990's. This is clearly shown after standardizing the Horse powers of the vessels (Fig. 5.1). The increase in the abundance of the Nile perch was parallel to the decrease in the abundance of the important prey item the haplochromines.

Seasonality in environmental factors greatly influenced the distribution and abundance of Nile perch stocks. Temporal distribution of the Nile perch stock appeared to have a cyclic pattern in relative abundances, following the period of complete mixing of the water column, i.e. June to August. Mixing causes relatively even distribution of oxygen as well as food items in the water column and in turn the distribution of Nile perch and its availability to the bottom trawl, while the period of January – March with lowest abundances is the period of thermal stratification.

The batho-spatial distribution pattern exhibited a decrease in stock abundance with depth. High catch rates were recorded at the depth range of 30-39 m, different from 1995 (Witte *et al.*, 1995) observations when highest catch rates were at 15-25 m depth. Changes in prey species and their distribution and abundances together with the variations in environmental parameters were probably the influencing factors.

An overall mean annual biomass index ranging from 330 439.7 t to 344 690.2 t, was determined for the Nile perch stocks in Tanzanian waters, with an overall mean density of 9.87 t $km^{-1}$, and for the whole lake was 693 674.3 t with a mean density of 10.56 t $km^{-1}$ Nile perch contributed 91.6% of the total catch equivalent to total abundance of 757 286.3 t for the fish standing crop excluding dagaa in Lake Victoria (Mkumbo, 2002). However, hydro-acoustic results gave a mean biomass index of $2.17 \times 10^6$ t corresponding to standing stock biomass of 31.0 t $km^{-1}$, of which *L. niloticus* constituted 59.3%, *R. argentea* (dagaa) 22.4%, haplochromines 15.0%, *Caridina nilotica* 1.1% and other species 2.2% (Getabu *et al.*, 2002).

Nile perch seem to form aggregations, as very high densities up to 33 t $km^{-2}$ were found in one area while the adjacent area could be with less than 2 t $km^{-2}$. Such behaviour contributes to the threat of severe stock collapse, as the fish are more vulnerable to capture if the distribution patterns are known. The trawl surveys conducted during the Lake Victoria Environmental Project (2000 – 2002) showed that different fish species were distributed differently in different areas. This could be attributed to a combination of factors including food items and environmental factors. For example, there was a high abundance of Nile perch in the Speke gulf which was coupled with the good recovery of the haplochromines (the important prey).

Although the current biomass estimates seem to be comparable to previous estimates and predictions, (Bundy and Pitcher, 1995; Moreau, 1995) and thus the effect of the excessive effort to stock biomass is not evident, the present size composition of the stocks and of the catch, and the aggregating behaviour of Nile perch as an important commercial fish species calls for management interventions for the sustainability of the fishery.

### *5.4.2 Hydro-acoustic Surveys*

**Nile perch**

The fluctuations of the standing crops among the four zones suggest long-term movements of Nile perch during different seasons or changes in population size. There were conspicuous differences in the standing crop in different areas. The aggregation in high densities in small areas (enclaves) inshore waters makes their targeting by fishermen easier and can lead to over-fishing.

The results presented on biomass and distribution of Nile perch in Lake Victoria are the first of their kind on which to base future stock assessments. There was no previous baseline acoustic data to serve as a reference for survey design and data collection. There were therefore a number of biases relating to the reliability of the results obtained. Fish behaviour studies have not been undertaken in Lake Victoria. Lack of information on fish behaviour makes it difficult to ascertain the accuracy of both bottom trawl and acoustic survey estimates. The results presented can therefore be regarded as indices of abundance. They indicate useful trends about variability of stocks of Nile perch over the entire period of the surveys, which can be used for management purposes.

Since there have been no acoustic surveys for estimating fish biomass and distribution in the past, the results of this study are compared with estimates from studies using other methods. The total fish biomass estimates obtained from the hydro-acoustic study ranged from $1.9 \times 10^6$ – $2.5 \times 10^6$ tonnes with a mean of $2.17 \times 10^6$ tonnes, which corresponded to a mean standing crop of 31 t $km^{-2}$. The mean biomass index was estimated as $1.29 \times 10^6$ tonnes. The maximum sustainable yield estimated from this figure using Cadima's formula ($MSY = 0.5 (Y + MB)$) (Bundy and Pitcher, 1995) was 348,184 tonnes, where the yield ($Y$) used is the estimate of the total landings in the year 2000 of 220,000 tonnes for the whole lake (Mkumbo, 2002) and the natural mortality ($M$) is that estimated in the Kenyan sector ($M = 0.37$).

Total demersal biomass estimates from the bottom trawling surveys conducted over the same period as the hydro-acoustic surveys indicated a modest increase in the lake wide Nile perch stock peaking at approximately 900,000 tonnes in 1999 and decreasing thereafter to approximately 620,000 tonnes at the end of 2000. The average biomass estimate of Nile perch using the swept area method by lake sector (country) were estimated as 306,000 tonnes for Tanzania 266,000 tonnes for Uganda, and 48,000 for Kenya giving a total of 620,000 t (Mkumbo, 2002). The *MSY* corresponding to this figure is approximately 220,000 tonnes which is lower by a factor of 1.583 of the acoustic *MSY* estimate for the species. Both the acoustic and bottom trawl surveys biomass estimates were higher than the total fish estimates obtained during the last lake wide survey of 1969-1971 (Kudhongania and Cordone, 1974). The total biomass estimates from the lake wide survey of 1969-1971 were $6.79 \times 10^5$ tonnes, which corresponded to a standing crop of 9.27 t $km^{-2}$ (Kudhongania and Cordone, 1974). The total estimates did not include the estimates of dagaa, since this was a bottom trawling survey. If the total demersal estimate is raised by a factor of 0.5 to account for fish in the water column, then the biomass estimate becomes $1.36 \times 10^6$ tonnes, which is still much lower than the current acoustic estimates. This confirms that the productivity of the Lake Victoria system has increased since the early 1970's and also reflects expansion of the standing stock from the low levels of the early 1970's (0.402 x $10^3$ tonnes) to current one of 2.17 x $10^6$ tonnes.

### *5.4.3 Spatial and Temporal Variation in the Biomass of R. argentea*

The biomass of *R. argentea* estimated from the five surveys showed an increasing trend over time but with significant seasonal variations. The increase in the biomass of *R. argentea* started in the 1980's following the establishment of the introduced Nile perch and the decrease in haplochromines (Wanink, 1991) and is still increasing. Several factors have been suggested for the increase of *R. argentea* in the lake. The niche shift to the bottom layers after the decline and almost disappearance of the haplochromines (Wanink and Witte, 1998) has enabled *R. argentea* to exploit the chironomid larvae and *Caridina* (Wanink, 1998) which increased strongly in the 1980s (Witte *et al.*, 1995). The disappearance of most of the haplochromines may have reduced competition for food with *R. argentea* (Witte *et al.*, 1992). In addition, reduction of generation time and increased growth rate are thought to have contributed to increase in the biomass of *R. argentea* (Wanink, 1996).

Possible reasons for further increase in the biomass of *R. argentea* include decrease in the biomass of the predator Nile perch as indicated by a decrease in commercial catches in the Kenyan part (Njiru *et al.*, 2002) and Tanzanian part of Lake Victoria (Mkumbo *et al.*, 2002) which may have resulted in reduced predation pressure and also provided spare niche for colonisation. Further increase in the biomass of *R. argentea* may also have been contributed by the decrease in the infestation of *Ligula intestinalis* which has been found to affect maturation and reduce fecundity in the species (Tumwebaze, 2003).

### *5.4.4 Changes in the Biomass of Haplochromines*

In the 1980's, the pelagic community of Lake Victoria changed considerably following a decline of the haplochromines and increase in *R. argentea* (Ogutu-Ohwayo, 1990; Witte *et al.*, 1992). The decline in haplochromines is thought to have been mainly due to predation by Nile perch (Witte *et al.*, 1992) although overfishing and changes in the environment are thought to have contributed also (Harrison *et al.*, 1989; Seehausen *et al.*, 1997). During the second half of the 1990's, a recovery of haplochromines was observed in the southern part of the lake (Witte *et al.*, 2000) and in the northern part (Namulemo, 1999). The species showing recovery are mainly the zooplanktivores; *Haplochromis (Yssichromis) pyrrhocephalus* and *H. (Y) laparogramma* (Witte *et al.*, 2000). Trawl catches of haplochromines during the five acoustic surveys had a bigger percentage of *H. (Y) laparogramma*. Further increase in haplochromines may be contributed by a decline in Nile perch catches as indicated by a decrease in commercial catches in the Kenyan part (Njiru *et al.*, 2002) and Tanzanian part of Lake Victoria (Mkumbo *et al.*, 2002).

***Caridina nilotica***

The fresh water shrimp *C. nilotica* is widely distributed and highly abundant in almost all habitats in Lake Victoria. *C. nilotica* is abundant in deep open offshore waters and is extremely abundant in the inshore bays, in littoral and sub-littoral regions in the beds of submerged vegetation (Budeba, 2003). The findings of the present study are consistent with the findings of Goldschmidt (2000) who reported increased densities of the shrimp in the littoral areas along vegetated margins and rocky shores; Budeba (2003) who reported the occurrence of larger *C. nilotica* in the near shore, among littoral rooted macrophytes and expanses of water hyacinth (*Eichhornia crassipes*), and Fryer (1960) reported two species *C. nilotica* and *C. africana* and two forms of *C. nilotica* in Lake Victoria one between the beds of submerged vegetation and in the littoral waters and another with epibenthic distribution in the sub-littoral and deep waters. However, Lehman *et al.* (1996) reported on the occurrence of immature *C. nilotica* in the offshore waters. They suggested the possibility of an ontogenetic habitat shift by the species. The juveniles may be pelagic, nocturnal and migratory, which move to the refuge of macrophytes vegetation near shore when they increase in body size makes them too vulnerable to visual predation. The dominance of *C. nilotica* juveniles in the offshore waters was also attributed to intense predation on the adults (Ignatow *et al.*, 1996). The occurrence of *C. nilotica* in different habitats is an indication of successful establishment of the shrimp in Lake Victoria (Budeba, 2003). Members of the genus *Caridina*, and the Atyidae in general, are successful in tropical systems where year-round rates of biological metabolism and oxygen demand at sediment surfaces are high in comparison to temperate lakes (Beadle, 1981). Despite the high abundance of *C. nilotica* in Lake Victoria, their distribution and abundance showed spatial and temporal variability.

### *5.4.5 Temporal Variations*

The observed temporal variation in distribution and abundance of *C. nilotica* in Lake Victoria over the study period was probably linked to the seasonality in the climatic conditions of the lake (Budeba, 2003). The climate of the lake consists of two major seasons, the rainy season and the dry season. The rainy season is further divided into short rains, between October and January, and the long rains between March and May of every year with some slight changes from year to year. The high abundance of *C. nilotica* during the rainy seasons indicated by the present study was probably related to food resource availability, where a lot of decaying organic matter enters the lake from the inflowing rivers and runoffs (Budeba, 2003).

Heavy rains are frequently associated with strong winds, which favour mixing of the water column, influencing nutrient and oxygen availability (Mkumbo, 2002). As a result phytoplankton production increases, followed by zooplankton and finally piscivores. Thus, seasonality in environmental factors greatly influenced the distribution and abundance of *C. nilotica*.

### *5.4.6 Batho-spatial Variations*

The spatial variation in the distribution and abundance of *C. nilotica* observed in the present study was linked to key environmental parameters (dissolved oxygen, water temperature, algal biomass, water conductivity and water transparency), bottom nature and depth strata of the lake (Budeba, 2003). Areas with dense lake grass beds and those covered by water hyacinth (*Eichhornia crassipes*) showed high abundance of *C. nilotica* (Budeba, 2003).

Depth was an important aspect in the distribution and abundance of *C. nilotica*. Abundance increased with depth in the acoustic surveys. Deepwater stations had very low dissolved oxygen concentrations during stratification, but these areas indicated high abundance of *C. nilotica* (Budeba, 2003). Deepwater areas tended to have lower dissolved oxygen which *C. nilotica* can tolerate and possibly use as a refugia against predation from Nile perch.

### *5.4.7 Changes in Trophic Interrelationships*

It is a well-established fact that stocks of *C. nilotica* in Lake Victoria increased tremendously over the past three decades following the collapse of haplochromine cichlids in the lake (Goldschmidt, 2000; Budeba, 2003). Many haplochromine species that are now either extinct or scarce were once competitors of *C. nilotica* for algae and detritus; others were specialized predators on the prawn (Goldschmidt, 2000).

### *5.4.8 Gillnet Catches*

Historical data show the increase in effort and the shift from small mesh sizes to larger mesh sizes as the Nile perch fishery developed. Currently, however, there is a shift towards smaller mesh sizes, as a result of the excessive effort and the decrease in catch per unit of effort (CPUE), plus fishermen innovating different catching techniques as drifting or towing of gillnets and the vertical joining of gillnets to cover the whole water column.

The decreasing trend in CPUE found for Tanzania was prevalent in the other two countries. The double or triple mounting of gillnets to increase the catch rates reported in Tanzania was also observed in Kenya and Uganda (Mkumbo, 2002), while any increase in CPUE is fundamentally harvesting juveniles which constitute of 80% of the Nile perch catch. The slight increase in CPUE for gillnet motorised boats and gillnet paddled boats recorded in Tanzanian waters could be explaining by the changes in fishing practise. Motorised vessels explore distant fishing grounds whilst using triple stretched gillnets to cover more of the water column. The gillnet paddled boats are the ones operating relatively inshore and tend to use meshes below 5” so as to catch the tilapiines and other inshore species like *Brycinus* and *Schilbe*, but catch Nile perch juveniles coincidentally. The yield estimated for 1999 was almost 20 % less than the 2000 yield probably due to the export ban of Nile perch to the EU markets resulting in few boats fishing because of low prices. The ban was lifted at the end of 1999, which increased the demand resulting in an increase in the proportion of boats fishing in 2000. The gillnet fleet which was once dominated by 7-9 inches mesh size (Ligtvoet and Mkumbo, 1991) has become dominated by 5-6 inches.

## 5.5 Conclusions

- The current biomass estimates from trawl surveys indicated a slight declining trend over time, which was also observed in the hydro-acoustic results. The distribution patterns give an indication of seasonal dependence influenced by the hydrographic conditions.
- The mean total standing stock of Nile perch for Lake Victoria based on hydro-acoustic surveys was estimated at $2.17 \times 10^6$ tonnes. The lowest total standing stock estimate was $1.905 \times 10^6$ of February 2001 and the highest was $2.505 \times 10^6$ of August 2001. There was no specific trend of the total fish standing stock in the lake over the period of August 1999 and August 2001. Fish standing crops were approximately four times as high in inshore waters compared to offshore waters. The standing crops were also high around the islands compared to the open offshore areas.
- In February fish tended to aggregate in high densities in much smaller areas (enclaves), inshore. This makes their targeting by fishermen easier and can lead to over fishing
- There is a high biomass of *C. nilotica* in Lake Victoria, despite the presumably high predation pressure by commercial important fish species and anoxic conditions in the lake. This is due to their ability to tolerate eutrophic and anoxic condition and lessen predation from the Nile perch, which is intolerable in low oxygen areas. Also the disappearance of

detritivore haplochromines in the lake has favoured the proliferation of *C. nilotica* through competitive release effect.

- The Maximum Sustainable Yield (MSY) for the whole lake was 348,184 tonnes from the acoustic survey and 220,000 tonnes from the trawl surveys (1999 – 2002 surveys).

## 5.6 Recommendations

- Monitoring of environmental parameters including dissolved oxygen, turbidity, temperature and nutrients should be carried out regularly since they are of equal importance to that of the fish stocks in order to have a meaningful conclusion.
- Nile perch needs close and continuous monitoring as management actions are implemented so as to track any changes before it becomes too late and the predicted collapse observed.
- Since acoustic surveys are probably one of the methods of obtaining the useful information on trends in the abundance of the major fish species in Lake Victoria, the current time-series of acoustic surveys should continue and the methods improved as much as possible.
- Acoustic sampling at night should be avoided because fish species and other organisms rise to similar depths and mix and are distributed close to the surface where they are not accessible to the acoustic methods.
- The biomass estimates of *R. argentea* showed significantly higher estimates in deeper waters suggesting that more catches could be obtained by extending fishing of *R. argentea* to deeper waters.
- Biomass estimates of *R. argentea* from acoustic surveys should be regarded as indices of the abundance until further work has been done to confirm the accuracy of the Target Strength function used to convert the acoustic measurements to biomass.
- The fishing practise using gillnets needs to be further investigated as passive gillnets or towed or single or triple mounted have different influences on the catch per unit of effort (CPUE).

# CHAPTER SIX

# AQUACULTURE AND FISHERIES EXTENSION

*Shoko, A.P.A.*[1]*, Hoza, R.*[2] *and Mgaya, Y.D.*[3]
[1]*TAFIRI, Sota Station*
*P. O. Box 46, Shirati, Mara Region*
[2]*Fisheries Division Headquarters*
*P. O. Box 2462, Dar es Salaam*
[3]*University of Dar es Salaam*
*Faculty of Aquatic Sciences and Technology*
*P.O. Box 60091, Dar es Salaam*

## 6.1 Introduction

Fish supply to the population of Lake Victoria basin is limited due to several reasons such as fish export trade and the decline in catches from the main lake. The export trade of fish especially the Nile perch (*Lates niloticus*) and the decline on its catches contribute to inadequate supply of fish protein to the riparian communities and other people living outside the basin. Given the increasing demand for fish and limited supply of fish from natural capture fisheries there is need to promote fish farming practice in the basin. Fish production from the main lake has decreased due to several reasons, such as, increased use of destructive fishing methods, high fishing pressure, the introduction of Nile perch (*L. niloticus*) and disappearance of indigenous fish species. In 1988 the catch per unit effort (CPUE) decreased from 110 kg per canoe for motorized and non motorized gillnet canoes to 40 kg per canoe in 2000 (Mkumbo, 2003). This decrease in fish catch rates creates a room for fish farming practice at both small and commercial scale. Fish farming will increase fish supply and socioeconomic benefits to the riparian communities.

Despite the fact that fish farming in the Lake Victoria basin was introduced during the colonial rule (Fisheries Division Annual Report, 1967; Bwathondi and Mahika, 1997) yet the activity has not developed significantly. There have been some efforts made by the government of Tanzania since independence towards fish farming development in the basin. Unfortunately, those efforts did not result into any significant development; fish farming practices remained at subsistence level. Emphasis on fish farming research and development in the Lake Victoria basin started in early 1960's when fish ponds where established at Malya fish farm in Kwimba district, Mwanza region (Fisheries Division Annual Report, 1967). Other initiatives started during 1990's where baseline surveys (Bwathondi *et al.*, 1993, 1998; Bwathondi and Mahika, 1997) were conducted to explore its potential. The basin harbours a high potential in aquaculture development due to availability of permanent source of water throughout the year in certain areas such as, Tarime in Mara region and Muleba and Bukoba in Kagera region. There is also an abundant supply of animal manure which is very important in fish pond fertilization. In addition, there is inadequate supply of fish to people living far away from the main lake.

The inception of Lake Victoria Environment Management Project (LVEMP) in 1997 made deliberate effort to promote fish farming in the basin. Such effort include training of fisheries extension staff on fish farming development, training of farmers on pond construction and management, construction of demonstration fish ponds, establishment of breeding pond as source of fish fingerlings. These activities were carried out at Fisheries Research Institute (TAFIRI) and Nyegezi Freshwater Fisheries Training Institute (NFFTI) in Mwanza and Magoma village in Tarime district, Mara region.

There have been some efforts by Non Government Organizations (NGOs) and Community Based Organizations (CBOs) in promoting fish farming activities. Such efforts though uncoordinated have made positive impacts towards fish farming development. By recognizing the efforts done by NGOs and CBOs, LVEMP project established a collaborative mechanism with these organizations in order to promote fish farming practices in the basin. The recent inception of a Sida/SAREC funded projects "Victoria Research Initiative (VicRES)" have initiated several sub-projects on fish farming research and development with the aim of improving fish yields and income generation to local communities.

Fisheries extension services started during the colonial government. It has been responsible for dissemination of information on available fish stocks, sustainable fish harvesting practices, improved fish handling and processing methods, proper care and maintenance of fishing gears. Other activities include fishing demonstrations, promotion of fish consumption as food and it is the bridge between resource users, managers and researchers. However fisheries extension service has been interrupted because of inadequate trained staff, budgetary constraints, and institutional structure. Lake Victoria Environment Management Project (LVEMP) has supported fisheries extension service to a larger extent. These efforts have to continue in future because fishers are using illegal gears and there is loss of income due to poor fish handling and processing methods, inadequate dissemination of information, absence of fishers associations and inadequate market information among others.

These efforts collectively have resulted into vibrant activities of fish farming practice in the basin. However, rises and falls have characterized developments in fish culture practice in the Lake Victoria basin-Tanzania over time. Bwathondi *et al.* (1997; 1998) observed that donor supported post-colonial aquaculture initiatives failed because they were top-down arrangements made between the governments and funders typically alienating the farmer. The current approach by LVEMP to enable farmers own the activity deviates significantly from the experience of the past. Farmers are provided with technical support such as pond siting, construction, management and simple fish feed formulation techniques by using locally available materials and left to develop spontaneously. Also community-based breeding ponds have been established in collaboration with farmers which make the supply of fish fingerlings easier. People including interested farmers are also encouraged to establish private plants for producing fish farming inputs for sale such as fish feeds and commercial hatcheries for fish fingerlings. Such approaches will make the activity sustainable and succeed even after the project comes to an end.

## 6.2 Justification

The fishing industry of Lake Victoria is threatened by rampant illegal fishing practices such as beach seines, monofilaments, water splashing and mosquito nets particularly in the fish breeding areas, fishing grounds and river mouths (Fisheries Division, 2003). For example, according to the Lake Victoria Frame Survey of 2002 the number of beach seines and mosquito seines increased from 999 and 3,251 to 1,452 and 4,803 in year 2000 and 2002 which was an increase of 45.5% and 47.7%, respectively (Fisheries Division, 2003). On the other hand the increasing population pressure, industrial development and other socio-economic activities in the Lake basin have resulted into changes of water quality, fisheries biodiversity, wetlands and land use. These have resulted into decreasing fish stocks and fisheries biodiversity in general (Benno, 2003).

In Tanzania the private sector, community and non-governmental organizations have an important role to play in the development, management and sustainable utilization of the fisheries resources. This sector possesses diverse experience, expertise and capacity in various fields of the fisheries sector. The active involvement of the private sector and NGOs in the fisheries sector would enhance investment; improve business and general management in the fishing industry. The possible area of participation is technical assistance and cooperation in the development of aquaculture practices.

According to FAO (1988) in countries with rapidly expanding human populations natural waters (oceans, lakes etc.) no longer meet the growing demand for fish due to over fishing and water degradation from poor watershed and waste disposal management. In addition, fish supply in areas that are far from natural waters is very low. Demand for fish appears to be much greater than the supply (FAO, 1988). This is also true for Lake Victoria basin and Tanzania in general. There is great demand for fish in the Lake Victoria basin and there are suitable areas for fish farming activity. Aquaculture is considered important in increasing fish production in rural areas and can be integrated with crop and animal husbandry. Thus fish farming practice in the Lake Victoria basin could increase the level of fish supply to the riparian communities and contribute to the livelihoods of the poor people through improved food supply, employment and income.

## 6.3 Results

### *6.3.1 Fish Farming Potential*

Results from the baseline studies by Bwathondi *et al.* (1993, 1998); Bwathondi and Mahika (1997); Mahika *et al.* (2001) and Mbilinyi and Shoko (2002) conducted in the Tanzanian part of Lake Victoria basin, showed that there is a high potential for fish farming development. This potential is indicated by favourable conditions for fish farming activities such as suitable soil, permanent source of water from rivers and numerous springs. Other indicators for fish farming potential include suitable temperature and abundant animal manure which is very important in fishpond fertilization. It was further established that fish farming is mostly favoured in the districts of Tarime (Mara region), Muleba, Bukoba Rural and Urban (Kagera region). Recent study by Shoko and Onyango (2005) reported Ngara district in Kagera region to be another important potential area for fish farming. However Mwanza region is the least in fish farming development because of inadequate supply of water. The basin also has diverse wetlands, which if wisely utilized could be used for fish farming without deteriorating its primary role. In addition, the basin has people who accept fish farming practice; this is another opportunity that should be tapped to promote fish farming.

### *6.3.2 Culture Systems*

In Lake Victoria basin, the most important fish farming system is pond culture of Nile Tilapia (*Oreochoromis niloticus*) and African catfish (*Clarias gariepinus*). Cage culture of tilapia species was experimented in late 1960's and 1980's in Nyegezi Freshwater Fisheries Training Institute (NFFTI) and Tanzania Fisheries Research Institute, Mwanza Centre (NFFTI, 1972; Bwathondi *et al.*, 1998). A study is being conduced on integrating rice culture with *C. gariepinus* with the aim of increasing income of both fish and rice. Experimental studies are being conducted on the relevance of integrated agriculture-aquaculture (IAA) system with the aim of increasing farm yields and income. Another study currently underway is on system designs and guidelines for wetlands based aquaculture. Few farmers are practicing fish-cum animal such as cattle, chicken and ducks culture system.

### *6.3.3 Number, Size and Yield of Fishponds*

Existing records show that fish farming in the Lake Victoria basin started way back in the colonial rule in 1950's. The Malya fish farm in Kwimba district, Mwanza region was established for promoting fish faming and restocking Lake Victoria (Fig. 6.1) (Fisheries Division Annual Report, 1967, 1968; Bwathondi and Mahika, 1997). Furthermore, fish farming was introduced in Kagera and Mara regions in 1960's by Fisheries Department (Fig. 6.1). Available records show that during this period fish farming practice increased as evidenced by 612 and 707 fish ponds in 1967 and 1968, respectively (Fig. 6.1). Fish farming practice in the basin was almost stagnant between 1970's to early 1990's as indicated by only 14 to 26 fish ponds from 1970 to 1998, respectively. However, things changed for the better from late 1990's to 2005 as evidenced by a significant ($p<0.05$) increase in number of fishponds from 148 in 2000 to 404 in 2005 (Fig. 6.1). An average fish pond yield of 1823 $kgha^{-1}$ was reported by Shoko and Matola (2004) from the potential areas (Fig. 6.1). The study however reported no significant difference ($p>0.05$) in pond yields between the potential areas of the districts of Muleba and Bukoba in Kagera and Tarime in Mara regions. Because of lack of consistent data on fish pond production the increase in number of fish ponds was not correlated with the yields.

Results further indicated an increase in average size of fish ponds in Mara and Kagera regions of Lake Victoria basin, Tanzania (Fig. 2). The sizes of the two dams (16,500 $m^2$ and 30,000 $m^2$) in Tarime district which were constructed and stocked in 1967 and 1968 (Fisheries Division Annual Report, 1967) are not included in Fig. 6.2. There is no information on the pond sizes from Mwanza region. Number of people involved in fish farming activities in the whole basin increased from 60 in 1998 to 500 fish farmers in 2005. Available information does not indicate the number of people involved in fish farming before 1998.

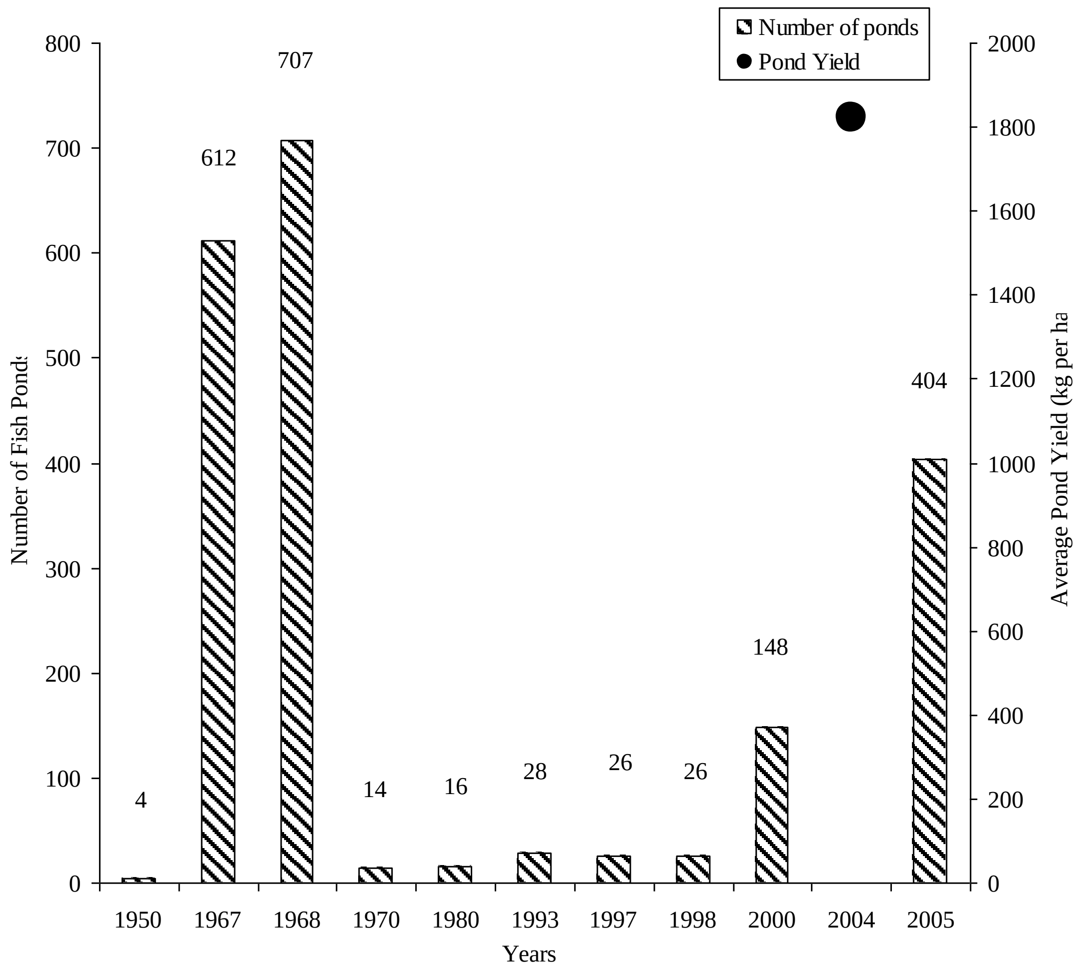



Figure 6.1: Total number and average yield of fish ponds in the Lake Victoria basin, Tanzania.

*Sources:*

| | | |
|---|---|---|
| 1950 | Mwanza Region | Bwathondi and Mahika, 1997 |
| 1967 | Kagera and Mara Region | Annual Report, 1967 |
| 1968 | Kagera Region | Annual report, 1968 |
| 1970 | Kagera Region | Bwathondi et al., 1998 |
| 1980 | Mara Region | Bwathondi et al., 1993 |
| 1993 | Mara Region | Bwathondi et al., 1993 |
| 1997 | Mwanza Region | Bwathondi and Mahika, 1997 |
| 1998 | Kagera Region | Bwathondi et al., 1998 |
| 2000 | Lake Victoria Basin | Mahika et al., 2001 |
| 2005 | Lake Victoria | Annual Report, 2005 |

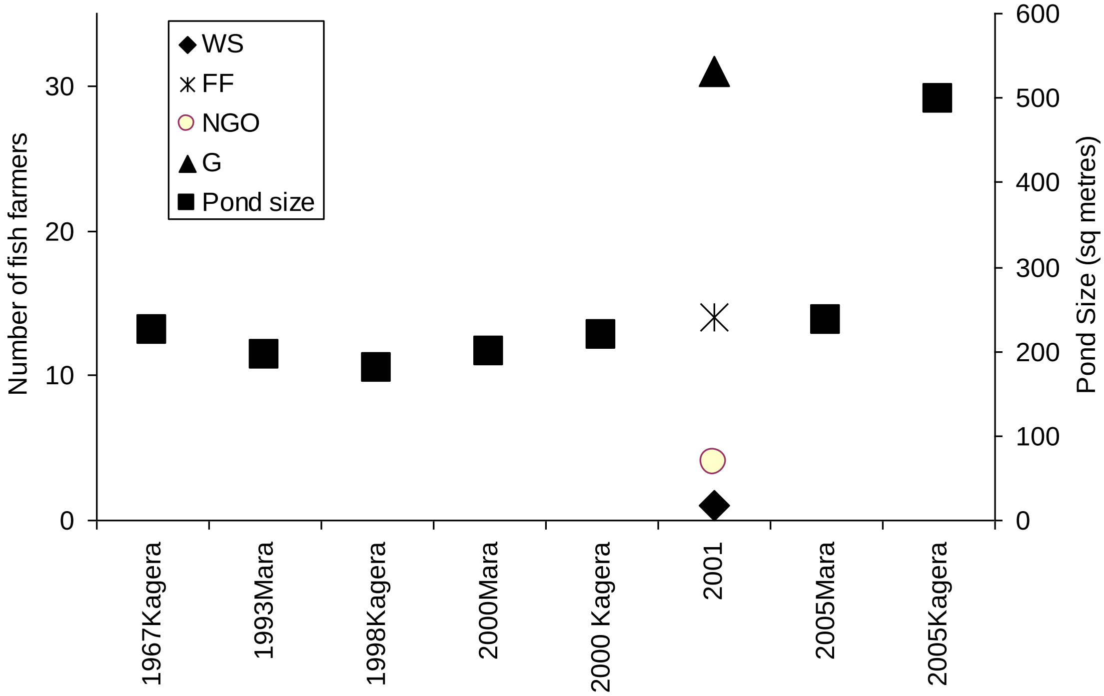



Figure 6.2: Average size of fishponds and sources of fingerlings in the Lake Victoria Basin, Tanzania.

Key: WS = Wild Sources; FF = Farmer to Farmer; NGO = Non Governmental Organizations; G = Government.

### *6.3.4 Fish Species under Cultivation*

The survey conducted in the basin recorded several fish species to have been cultured in different areas of the lake basin over the years. Table 1 summarizes the type of fish species cultured from 1967 to 2005. Through research it was established that Nile tilapia (*Oreochromis niloticus*) and African cat fish (*Clarias gariepinus*) were the preferred culture species with *O. niloticus* being the most preferred species. Since 1997 emphasis was given to culture of these two fish species. However, a study by Shoko and Onyango (2005) found that *O. leucostictus* was cultured in some fish ponds supervised by NGOs and CBOs due to poor knowledge of the identification of fish species by some of these organizations, hence mistaken *O. leucostictus* for *O. niloticus*.

Table 6.1: Type of fish species cultured in the Mara, Mwanza and Kagera regions of Lake Victoria basin, Tanzania.

| Region | 1967 | 1993 | 1997 | 1998 | 2000 | 2005 |
|---|---|---|---|---|---|---|
| **Mara** | | *O. niloticus* | | | *O. leucostictus* | *O. niloticus* |
| | | *C. gariepinus* | | | *O. niloticus* | *C. gariepinus* |
| | | *Oreochromis* spp. | | | *Tilapia* spp. | *O. leucostictus* |
| | | *P. aethiopicus* | | | *C. gariapinus* | |
| | | Tilapiines | | | | |
| **Mwanza** | *O. esculentus* | | *O. niloticus* | | | *O. niloticus* |
| | *T. zillii* | | *C. gariepinus* | | | *C. gariepinus* |
| | *T. andersoni* | | Tilapiines | | | *O. leucostictus* |
| **Kagera** | *T .zillii* | | | *Bagrus docmac* | *O. leucostictus* | *O. niloticus* |
| | *T. melanopleura* | | | *O. niloticus* | *O. niloticus* | *C. gariepinus* |
| | *T. esculentus* | | | *C. gariepinus* | *C. alluadi* | *O. leucostictus* |
| | *T. machrochir* | | | *Tilapia* species | *Barbus altianalis* | |

### *6.3.5 Adoption of Technologies*

Cage culture technology was developed at Nyegezi Freshwater Fisheries Training Institute and TAFIRI in 1970's and 1990's respectively (Fisheries Division Annual Report, 1972; Bwathondi *et al*., 1997). This technology is yet to be adopted by fish farmers in the basin. Poor fish pond management has been reported to be responsible for low fish pond yields over the years (Fisheries Division Annual Report, 1968; Bwathondi *et al*., 1993; 1998; Bwathondi and Mahika, 1997; Mahika *et al*., 2001; Mbilinyi and Shoko, 2002). Pond fertilization techniques of using crib was recommended and adopted by fish farmers for pond management. Fish farmers adopted stocking fish at appropriately low density which is 2 fish fingerlings per square metre and feed their fish with diets containing cotton seed cakes as the main ingredients twice per day (Shoko, 2002; Shoko *et al*., 2003; Shoko, 2004).

Through research it was established that it is difficult for farmers to obtain fingerlings of African cat fish despite their preference to culture it. This fish species does not reproduce in captivity. Thus the technology of producing fingerlings of *C. gariepinus* through artificial spawning was introduced and people are adopting it. Already one farmer has adopted the technology by 2004 and in 2005, 15 farmers were in the process of adoption.
A few farmers (2 in Kagera region and 5 in Mara region) have adopted the integrated agriculture-aquaculture (IAA) where aquaculture is incorporated with other farm enterprises such as animal and crop husbandry.

### *6.3.6 Extension Services*

**Training of fish farmers and service providers**

Th extension officers in collaboration with researchers and non-governmental organizations (NGOs) have trained farmers on various aspects as indicated in Fig. 6.3. The training covered general fish culture techniques, artificial spawning of *C. gariepinus* and integration of aquaculture with other farm enterprises such as crop and animal husbandry. The number of people trained on fish farming rose from 82 in 1998 to 355 in 2003 and dropped to 72 in 2005 (Fig. 6.3).

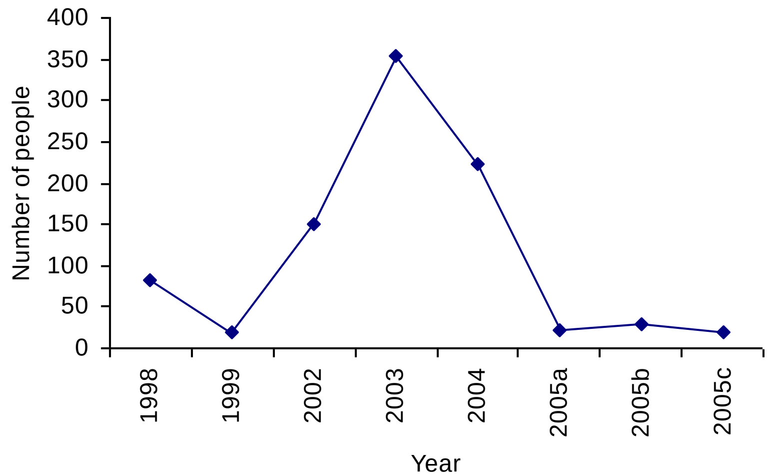



Figure 6.3: Number of people trained and the type of training offered (see below for type of training offered and source of data)

| **Year** | **Type of training** | **Source** |
|---|---|---|
| 1998 | General Fish culture techniques | Mally and Mbilinyi (1998) |
| 1999 | Artificial insemination of *C. gariepinus* | Bwathondi et al. (1999) |
| 2002 | General fish farming techniques | Mogabiri Agricultural Extension Centre (pers. comm.) |
| 2003 | General fish farming techniques | Mogabiri Agricultural Extension Centre (pers. comm.) |
| 2004 | General fish farming techniques | Mogabiri Agricultural Extension Centre (pers. comm.) |
| 2005a | Artificial insemination of *C. gariepinus* | Magoma (pers. comm.) |
| 2005b | Integrated aquaculture-agriculture (IAA) | Shoko and Onyango (2005) |
| 2005c | General fish farming techniques | Shoko (pers. observ.) |

**Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs)**

Studies (Bwathondi *et al.*, 1993; Mahika *et al.*, 2001; Shoko and Onyango, 2005) recorded a number of non-governmental organizations and community based organizations involved in providing fish farming extension services. These NGOs have been in operation for an average of 15 years. The oldest and youngest organizations are Tanganyika Christian Refugee Services (TCRS) in Ngara district and Serengeti District Development Programme (DDP) which have been in operation for 31 and 1 year, respectively. Fish farming extension services offered include pond preparation, fertilization and the general pond management including harvesting (Shoko and Onyango, 2005). A list of these organizations and their areas of operation is summarized in the Table 6.3.

Table 6.2: NGOs and CBOs offering fish farming extension service.

| **Name of Organization** | **CBO or CBO** | **District** | **Region** |
|---|---|---|---|
| 1. Norwegian Peoples AID<br>2. Faiders Group | NGO | Biharamulo | Kagera |
| Tweyambe Fishing Enterprise | CBO | Muleba | |
| Daily Action Development Trust | NGO | Bukoba | |
| 1. Tanganyika Christian Refugee Service (TCRS)<br>2. Relief Development Society (REDESO) | NGO | Ngara | |
| 1. Ecovic<br>2. Heifer Project International (HPI) | NGO | Nyamagana | Mwanza |
| 1. Community Based Health Program Promotion (CBHPP)<br>2. Serengeti District Development Program (DDP)<br>3. Serengeti Farmers Association (SETA) | NGO | Serengeti | Mara |
| Mogabiri Farmers Extension Center | NGO | Tarime | |
| Buhemba Farmers Extension Centre | NGO | Musoma Rural | |

From: Shoko and Onyango (2005).

**Fish fingerlings production centres**

During 1950's and 1960's when fish farming was introduced in the basin fish fingerlings were obtained form Malya fish farm and Rwamishenye breeding ponds in Mwanza and Kagera regions, respectively. Fish fingerlings from Malya fish farm were supplied to areas as far as Kahama and Tabora. Also Nyalutiti dam which was owned by Rulenge Refugee Camp in Ngara distrct, Kagera region was used to supply fingerlings to fish ponds in the Rulenge (Fisheries Division Annual Report, 1968). Malya fish farm station collapsed after the grant from Food and Agriculture Organization/International Development Agency

(FAO/IDA) stopped, whereas Rwamishenye breeding ponds collapsed after the government ran short of funds. Thereafter fish fingerlings were sourced haphazardly.

Some effort however was made by the churches such as Mennonite and Lutheran. By year 2000 quality fish seed production was still a serious problem. Efforts were made by Nyegezi Freshwater Fisheries Training Institute, Mwanza and the Mennonite church in collaboration with Lutheran church in Arusha of supplying fish fingerlings to the farmers. According to Mahika *et al.* (2001) most respondents (62%) indicated to have obtained fingerlings from NFFTI (Fig. 2). Other sources of fish fingerlings included farmer-to-farmer delivery and wild sources (Fig. 6.2). In 2000 the pond fish stocking results showed that the targeted fish species which are *O. niloticus* and *C. gariepinus* constituted only 23% and 11%, respectively. Although the above institutions supplied fish fingerlings to farmers, the fingerlings were of poor quality.

Since 1997 LVEMP project took deliberate measures to produce quality fish fingerlings of *O. niloticus* by establishing fish breeding ponds at Nyegezi Freshwater Fisheries Training Institute and TAFIRI, Mwanza. Breeding ponds established at Nyegezi NFFTI and TAFIRI were used as source of fingerlings to fish farmers. Breeding ponds were also established in Magoma village in Tarime district with the aim of bringing fish fingerlings production centres close to the community. In addition, fingerlings produced from farmers' ponds have been used by other fellow farmers due to inadequate supply of fingerlings from NFFTI and TAFIRI. Experimental tanks were also established in TAFIRI, Mwanza for conducting fish farming research on nutrition, artificial spawning of *C. gariepinus* and training farmers. All these activities are aimed at developing appropriate fish farming technologies in order to enhance fish production and alleviate poverty in the three regions. Following LVEMP intervention, Fisheries Management component in collaboration with TAFIRI supplied a total of 21,743 fish fingerlings of *O. niloticus* to fish farmers in the Lake Victoria basin from 1999 to 2005 (Fig. 6.4). Kagera region received the highest number of fingerlings (11,670) followed by Mara region (6,068) and finally Mwanza region (3,930). Apart form Lake Victoria basin some fingerlings were supplied to Morogoro region (700) and Tabora region (1740). Also a total of 2,800 fingerlings of *C. gariepinus* were produced by TAFIRI Mwanza researchers in collaboration with Heifer Project International (HPI) an NGO based in the Lake Victoria zone. The fingerlings were supplied to fish farmers in Misungwi, Mwanza. There are no records on number of fish fingerlings distributed in the basin before 1999.

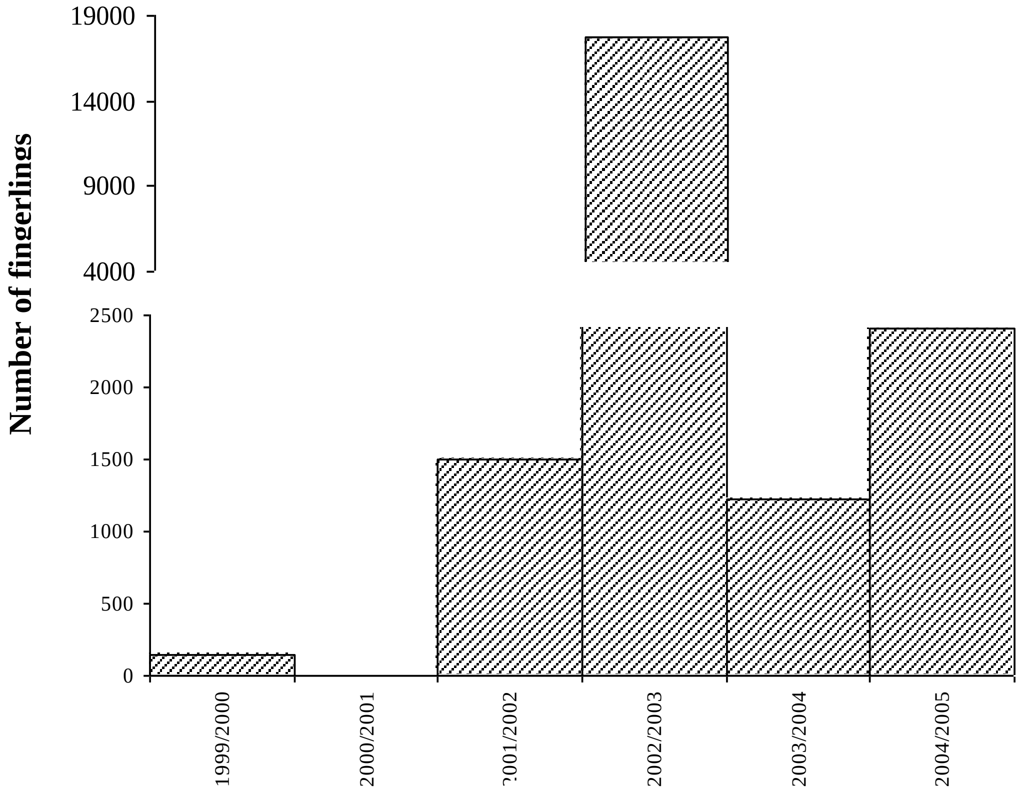



Figure 6.4: Number of fish fingerlings of *Oreochromis niloticus* distributed in the Lake Victoria Basin from 1999 to 2005.

**Training on lift net and live bait fishing operation**

During the colonial era fishers of the Tanzanian part of Lake Victoria were using gillnets of 5, 3 and 2.5 inches mesh size. The only other type of net in general use on the Lake was the shore seine (East African High Commission, 1953). In addition, fishers had no vocational training in their work. They learnt fishing through experience and from those who have been in the industry for many years (Fisheries Division Annual Report, 1967). After the establishment of Fisheries Division in 1965 fisheries extension officers started to train fishers on the use of different fishing gears such as gillnetting and long lining. Generally fishers admitted that the methods taught to them by fisheries officers were better than those that they were using before (Fisheries Division Annual Report, 1967).

The training on improved fishing methods was reviewed during LVEMP project in 1998. A total of 71, 29 and 30 fishers were trained in Mwanza, Kagera and Mara in respectively. Training in Mwanza was conducted in 1998, whereas that for Mara and Kagera was conducted in 2003. Training covered the advantages of live bait and fishing operations against other modified fishing operations. At the end of the training session fishing experiments were done to evaluate the training performance (Mbaya., 1998; Madundo., 2003).

**Development of fish farming Strategic Plan**

Efforts to develop aquaculture in the Lake Victoria basin started during the colonial regime and continued after independence in 1961. However, aquaculture development was not supported by a strategic development plan until 2005 where a draft plan was developed. The strategy is geared to implement the National Fisheries Sector Policy and Strategy Statement of 1997.

### *6.3.7 Stocking of Small Water Bodies*

Reports available show that during 1950's and 1960's substantial number of smaller water bodies referred to as public reservoirs were constructed and stocked with different fish species in the Lake Victoria basin (Fisheries Division Annual Report, 1967; 1968). According to Bailey (1968) fish fingerlings were distributed to public reservoirs. Available records only mention Malya dam in Kwimba district, Mwanza region which was constructed and stocked with fish during the colonial rule. Kyarano dam in Butiama village, Bunda district in Mara region was constructed in 1985 and stocked with tilapiines in 1994 by Fisheries Division (E. Kilosa, pers. comm.). Bwathondi *et al.* (1993; 1998) and Bwathondi and Mahika (1997) recorded several dams in the Lake Victoria basin which were "self stocked" (i.e. fish entered the dams from rivers without deliberate attempt by man) by tilapiines and catfishes. Such dams include 45 dams in Mara region, 25 in Mwanza and one dam in Kagera regions. Deliberate efforts were made by TAFIRI to stock two dams in 1997, 3 dams in 2003 and 2005 each in Mara region. Generally there had been no deliberate efforts made by the government to put emphasis on fish farming on small water bodies in Tanzania.

## 6.4 Discussion

### *6.4.1 Fish Farming Potential*

Results have shown that Lake Victoria basin has potential to increase fish farming production but this potential has not been fully tapped for food production. Deliberate efforts should be made to tap this potential through improved technologies, urge the private sector to invest in aquaculture and sensitize farmers of Lake Victoria basin to practice fish farming. It has been indicated that Africa has physical potential for expansion of aquaculture which could increase production levels (Pedini, 1997). Studies (Bwathondi *et al.*, 1993, 1998; Bwathondi and Mahika, 1997; Mahika *et al.*, 2001; Mbilinyi and Shoko,

2002) indicated that poor development in fish farming in the basin was mainly due to lack of expertise due to inadequate extension services and good quality fish seeds and feeds, lack of financial backing by financial institutions and reliance of government on external support. It was also reported that most fish farmers lacked self-initiative in developing fish farming while others regarded it as a hobby or part time activity. Fish farming being a potential source of protein and income can only be realized through proper planning, management and correcting of the setbacks. Fish farming practiced in the basin is mostly subsistence which could not contribute significantly to the welfare of the people. Fish farmers should be made to consider fish farming as an important undertaking not only for protein provision but more importantly for income generation. Governments must consider the aspect of financial and institutional arrangements for small-scale operators to benefit from this sub-sector of the economy.

### *6.4.2 Culture Systems*

From the results pond culture is the only culture system in the Tanzanian part of Lake Victoria basin. The pond culture system is mainly semi-intensive practiced by subsistence farmers in static earthen ponds. Development of fish farming is not only measured by the number of culture systems practiced but rather the yields obtained from a particular system. Freshwater pond culture has shown greater promise in East and Central Africa despite the fact that fish yield is still low. Fish yields from ponds can only be realized through proper pond management. Shoko and Matola (2004) reported poor fish pond management from Lake Victoria basin where most fish ponds were not fertilized and fish were not fed. Some fish ponds were choked with grass and completely abandoned. Fish pond culture has proved successful in other parts of the world such as Asia (Roger *et al.*, 1995). Fish pond management can be realized through integration of fish culture with other farm enterprises particularly crop and animal husbandry. The common rationale to justify fish farming development in Africa has been that of fish pond *per se* as a stand alone enterprise. Fishponds have been promoted almost exclusively as a source of fish production. This has made fish farming be considered as a part time activity and more time devoted to other activities which led into less time for attending fish. Efforts to link fish culture with other livestock production such as poultry by small-scale resource-poor farmers have not worked well because technological packages were proposed which did not consider their perspectives and resources (Roger *et al.*, 1995). Fish yields have usually been poor because most of the farms were nutrient-starved; this led to thousands of fishponds abandoned. The current efforts of sensitizing fish farming communities around the Lake Victoria basin, Tanzania to integrate fish farming in the overall farm enterprises through integrated aquaculture-agriculture should be encouraged. Under such an integration a fish pond in most cases a newly introduced enterprise can be integrated into on-going farm activities, relying largely on-farm residues as pond inputs especially feeds and/or fertilizer and increase fish production. In such systems a fish pond can have a pivotal role in supporting other activities, e.g. fertile water for dry- season gardening vegetables, and increased production of existing crops with pond mud used for fertilization of nutrient-depleted fields. Maximum fish farming production for income generation and poverty alleviation will be realized through this kind of integration.

#### *6.4.3 Number, Size and Yield of Fishponds*

From the results there was an increase in number of fish ponds in 1960's; the activity almost collapsed between 1970's and 1990's and increased again from late 1990's to 2005 (Fig. 6.1). This trend could be explained by the fact that donor supported post-colonial initiatives failed because they were top-down arrangements made between the government and funders typically alienating the farmers (Bwathondi *et al.*, 1997; 1998). Those initiatives collapsed after the funds were exhausted. Furthermore, during 1970's to 1980's low priority was given to fisheries activities, more emphasis were given to other sectors of economy such as agriculture, wildlife, human settlements, and education, among others (URT, 1982).

The advent of LVEMP in 1997 made deliberate initiatives on fish farming practice. The project deviates significantly from the experience of the past and farmers were provided with technical support and left to develop spontaneously. Though fish fingerlings were provided to fish farmers free of charge in the pilot districts people became interested and the activities spilled over to other areas. This is evidenced by a significant increase in number of ponds during this period.

Despite the fact that there is no data recorded on fish pond yields from the basin, a study by Shoko and Matola (2004) reported a yield of 1,823 kg $ha^{-1}$ from pilot areas. Such results agree with the pond yield reported elsewhere in the tropics. Bardach *et al.* (1972) reported that where monoculture of tilapiine such as *O. niloticus* is practiced with fertilization and supplementary feeding yields of between 1,000 kg $ha^{-1}$ to 2,500 kg $ha^{-1}$ could be achieved. Bjørneseth (1992) and Mafwenga (1994) reported an average fishpond yield of 1,400 kg $ha^{-1}$ and 1,900 kg $ha^{-1}$ respectively from Mbeya, Iringa, Arusha and Ruvuma regions of Tanzania. Although the increase in number of fish ponds was not correlated with the yields in this issue due to lack of data, there is hope of high fish yields in future. On the other hand maximum fish pond yields could be achieved through proper fish pond management. The fact that fish pond yields of 1990's from Tanzania fish ponds do not differ from the yields of 2004 indicates that fish pond management has not changed. To obtain maximum fish pond yields deliberate efforts should be made to improve fish pond management in the Lake Victoria basin.

The size of fish ponds is an important aspect in attaining maximum fish pond yields. Despite the fact that fish farming in the basin started during the colonial era (Fisheries Division Annual Reports, 1967;1968) yet most of the ponds were small (less than 100 $m^2$) which resulted into low fish yields. In their study Shoko and Matola (2004) reported that 96% of the ponds sampled had an average area of 166 $m^2$. Fish farming experience has shown that very small ponds do not contribute to the welfare of the fish. To attain maximum fish pond yields it is recommended that fish farmers should not construct growout ponds of less than 200 $m^2$ (Collart, 1997) and the stocking density should be 2 fish fingerlings per square metre. The pond should be constructed to allow sunlight and heat reception to promote natural primary and secondary productivity. Fish farming practice in the Lake Victoria basin should target this category. From Fig. 6.2 there is a slight increase in pond sizes. Although this increase may not be significant, it is a sign that people are moving from small fish ponds to bigger sizes.

### *6.4.4 Fish Species under Cultivation*

Results have shown that both indigenous and exotic fish species have been cultured in the basin. Probably the culture of indigenous fish species in the basin was caused by the fact that Lake Victoria was dominated by those species prior to 1980's. People from the basin prefer indigenous fish species because of their delicacy (Bwathondi *et al.*, 1998). According to FAO (1994) many indigenous fish species are preferred by consumers but have not yet been fully tested as candidate species for aquaculture.

Nyegezi Freshwater Fisheries Training Institute reported a positive growth of *O. esculentus* in cage and pond culture experiments. In another experiment *T. zillii* showed positive growth under pond culture (NFFTI, 1972). *O. variabilis* was reported to show better growth performance when fed on cotton seed cake containing diet than the soya bean meal and a feed mixed with cotton seed cake and soya bean referred to as composite diet (Shoko, 2002). Furthermore, Shoko (2002) reported that *O. variabilis* showed better individual fish growth when stocked in lower (one fish per litre) than high (3 fish per litre) and medium (2 fish per litre) stocking densities. With such results researchers and managers should make sure that findings of this nature are adopted and practiced by the interested fish farmers. The results could be tested in the pilot areas to assess their performance and finally introduced to farmers upon success. Studies showed that people from Kagera region prefer to culture Mboju *Bagrus docmac* (Bwathondi *et al*., 1998) whereas those from Luo land in Mara region prefer Kamongo *Protopterus aethiopicus (*Bwathondi *et al*., 1993). Such fish species could be more accepted for culture by these people than any other species once their culture technology is established. Nile Tilapia (*O. niloticus*) though exotic to Lake Victoria is the most preferred cultured fish species in aquaculture in the basin due to its proven high qualities for aquaculture. In addition most of its culture technologies are well known. Efforts should be made to promote the culture of this species as well.

Despite the efforts made by LVEMP to establish fish breeding ponds for fish fingerlings, the demand seemed not to be met following more people becoming attracted to aquaculture. Efforts should be made to establish more breeding ponds particularly of *O. niloticus* in the districts where fish farming is practiced. This will reduce the cost involved in transporting fingerlings and also reduce the mortality.

### *6.4.5 Adoption of Technologies*

Results have shown that most experimental works do not go beyond the laboratory buildings. Once a study is completed there is no any initiative to make sure that the results of the work are extended for adoption by farmers. Fish farming development in the Lake Victoria basin and Tanzania in general will only be achieved through development of simple technologies suitable to local conditions. The rapid aquaculture development in countries like China for example was strongly backed by research and technology development (Hishamunda and Subasinghe, 2003).

### *6.4.6 Extension Services*

Despite the efforts made by the Government in providing extension services to farmers yet this service is inadequate. Results have shown that little training was conducted by the Government and NGOs. Studies by Mahika *et al.* (2001) reported a number of NGOs which were performing commendable role in fish farming extension services though their activities were uncoordinated. In a recent study (Shoko and Onyango, 2005) about 14 NGOs were recorded to provide fish farming extension in the basin (Table 6.3). Some of these organizations are deep rooted in the communities such that it becomes difficult for anybody to be accepted by farmers without passing through the NGO. It was reported that these NGOs are playing an important role despite the weaknesses observed which need to be corrected (Shoko and Onyango, 2005). Experience has shown that a collaboration that involves a partnership that involves scientists, extensionists and most importantly, the farmers themselves has proven successful in fish farming development (Roger *et al.*, 1995). In this partnership farmers are given opportunity to study, discuss and learn from each other and develop the strategies for improvement together.

The biggest obstacle to fisheries development is inadequacy of effective fisheries extension service. In order to accelerate social economic development in the fishing communities an extension programme on how to use modern methods and techniques is essential. On the other hand the National Fisheries Policy recognize the importance of effective fisheries extension services and for that matter has policy statement and education, aquaculture development, community participation, fisheries information management among others (URT, 1997). The Fisheries Division started to provide effective fisheries extension service when fishers were trained at Nyegezi Freshwater Fisheries Training Institute (NFFTI). The training was on engine repair and maintenance, fish handling and processing using improved methods, gillnetting, long lining and fish farming among others. This training programme was terminated in 1966 (Fisheries Division Annual Reports, 1967). Generally the fishers who were trained admitted that the training was useful to them. Proper training and especially demonstration of improved fishing methods, fish handling and processing will improve efficiency and increase income to the community.

#### *6.4.7 Smaller Water Bodies*

Fisheries in small water bodies usually operate at a basic level and could provide opportunity for the poor people to supplement their diet. Results have shown that there were some efforts to stock smaller water bodies referred to as public reservoirs during 1960's. Although reports do not show the exact number of these reservoirs but available information shows that fish yields and income was generated from these waters and fishing activities was conducted (Fisheries Division Annual Reports, 1967; 1968). Observations have shown that there are dams in the Lake Victoria basin. These could be stocked with fish species for aquaculture and subjected to simple management techniques and harvested by using simple gears such as small baskets and long line. The same could be done for temporary dams and harvested before dry season starts. Communities should be taught about proper management of these dams for sustainable management of the fishery. Such efforts could provide fish and income to the people riparian to these water bodies.

## 6.5 Conclusions

Lake Victoria basin has great potential for fish farming development which has not been tapped for food production. Fish farming development in the Lake Victoria basin has not developed significantly. The constraints for fish farming development in the basin reported since 1960's have not been fully addressed. Fish farming practice is mostly subsistence which could not contribute to the welfare of the people. The common culture system is pond culture practiced in excavated earthen ponds. Poor fishpond management such inadequate feeding and fertilization contributes to low fish pond yields.

The fish stocks of the three commercial fish species namely *L. niloticus*, *O. niloticus* and *Rastrineobola argentea* are heavily exploited. The demand of Nile perch for foreign and domestic market is increasing. The demand of *R. argentea* and *O. niloticus* is increasing at the same magnitude. On the other hand poverty is increasing among most riparian communities of Lake Victoria. Fish farming practice is another alternative source of income to the riparian communities. Furthermore fish farming could help to reduce fishing pressure on capture fisheries and contribute to the conservation of lake biodiversity. Ultimately fish farming will generate income to the people, which is in line with the Government effort to alleviate poverty in the country.

## 6.6 Recommendations

The recommendations are as follows:

i. There should be data collection on quarterly bases by District Fisheries Officers on fish farming practice and submitted to the Fisheries Headquarters. Information to be gathered should include the following:
   a. Number and size of stocked fish ponds
   b. Fish pond yields and income generated
   c. Number of men involved in fish farming practice
   d. Number of female involved in fish farming practice
   e. Type and amount of fertilizers and fish feeds used

ii. Detailed basin wide surveys on fish farming practice should be conducted each year.

iii. Fish farmers should be encouraged to keep records of their inputs and outputs of their farms for easy monitoring and planning.

iv. Close government supervision through frequent visits to farmers and provision of technical support should be reinforced.

v. More community based fish breeding ponds should be established in potential districts for provision of fish fingerlings to farmers. Fish fingerlings should not be supplied to farmers free of charge.

vi. To increase fish pond yields farmers should be encouraged to integrate fish farming with other farm enterprises such as crop and animal husbandry.
vii. Government should ensure smooth supervision and coordination of fish farming activities. Collaboration between governments, researchers and NGOs should be encouraged and coordinated.
viii. The government should promote the farming of *Clarias gariepinus* to increase live bait production (Nile perch fishery) and reduce exploitation pressure on wild stocks.
ix. The Government in collaboration with the University of Dar es Salaam should establish a national modern hatchery for quality fingerlings production.
x. Fish Farming Strategic and Development Plan should be internalized by different stakeholders such as local governments, universities, NGOs and CBOs for implementation.
xi. The Government should recognize science and technology as the most important drivers of productivity and make funds available for development of aquaculture technology suitable to local situation.
xii. The Government should effectively use the aquaculture strategic plan to promote fish farming in the Lake Victoria basin and the rest of the country.
xiii. Deliberate efforts should be made by the government to consider small water bodies as aquaculture potential areas. Dams should be stocked with fish species and subjected to simple management techniques for providing protein and income to the communities.

# CHAPTER SEVEN

# SOCIO-ECONOMICS OF LAKE VICTORIA FISHERIES

*P.O. Onyango*
*TAFIRI, Sota Station*
*P. O. Box 46, Shirati, Mara Region*

## 7.1 Introduction

### *7.1.1 Background*

Lake Victoria has inflowing rivers that contribute significantly towards ecological, biophysical, cultural and socio-economic development along its shoreline catchment area and the numerous islands within it. The dominant socio-economic activities in the lake and its catchment are agriculture and fisheries. These are the mainstay activities of most people. Among these activities its fishery has created much attention and called for a great deal of efforts for its sustainable use. This attention can be attributed to the fact that the fishery contributes a GDP of about 3% to the economies of the lakes riparian countries. Besides these two activities, gold mining in Geita and Nyamonge and tourism in Serengeti national park and Rubondo game reserve are other activities, which have become very important.

Around the lake there are several communities whose lives have depended on the fish resources of the lake since the lake was formed 400,000 years ago (Johnson *et al.*, 2000). In fact, these communities have interacted with the lake to the extent that it has become part and parcel of their lives. Ensuring decent living conditions for these riparian communities requires among others sustaining a healthy fish stocks. This is better achieved through an understanding of and respect for fishers' cultures and socio-economic conditions. The fishing communities living riparian to the lake in Tanzania include; Kuria, Simbiti, Sukuma, Haya, Kerewe, Luo and Jita (SEDAWOG, 2000). The Kerewe, Luo, Sukuma and the Jita communities are known to be historical fishing communities (Onyango, 2004; Geheb, 1997). In this sub-chapter, the socio-economic characteristics of the fishers from these communities are presented. In particular the sub-chapter explore how changes in fisheries issues through time both at micro- and macro-level have affected the value system and individual behaviour of the riparian communities. The sub-chapter looks at the fishers, processors, and traders, fishing gears, markets and prices, demographic characteristics, diseases, perception on resource status and public expenditure.

## 7.2 Results

### 7.2.1 *Basic Fishery Information in Tanzania*

In Tanzania, most fish is harvested from fresh waters of lakes Victoria, Tanganyika and Nyasa as the main sources. Of the total fish production in the country, Lake Victoria generates the highest, with an annual average of more than 60% of the total country production. It is also worth noting that most of the fish caught in Tanzania especially from the freshwater bodies is through artisanal fishery. The term artisanal used here imply small-scale fishing composed of all beach-landing fishing units, whether of the traditional variety (e.g. canoes, rafts) or of a new type (e.g. beach landing plywood boats) (Plateau quoted by Bagachwa, 1992). Besides the artisanal fishery, there is also industrial fishing going on in the country. In Lake Victoria for instance, Bagachwa *et al.* (1992) quotes ESAURP survey of 1987 that there were 7 trawlers operating in the lake. However it was around mid 1980's that trawling and beach seining were banned from the lake and since then there is no existence of trawling (except for research) in the lake. Today, fishing is only artisanal; there is no industrial fishing (Fisheries Division, 2005).

### 7.2.2 *Employment*

The fisheries of the lake have continued to be a source of employment to a substantial population. The fisheries have created employment to fishermen, fish processors and fish traders. In fact between 1993 and 2000 Kulindwa (2001) reports that employment in the fisheries sector has been going up (Fig. 7.1).

Recent estimation in terms of numbers indicates that the lakes' fisheries provide employment to about 500,000 people in Tanzania (Odongkara *et al.*, 2005) comprising fishers, fish traders, and fish processors and net menders. This however seems to be a gross underestimation of employment because one kilogram of fish is handled by between 8-13 people (Box 1) between the beach and the fish processing factory door and/or final consumer for the fish that is processed locally. Based on this estimate, the fishery on the Tanzania part could be employing about 2.6[1] million people. This is a strong case for employment creation. Although data on fishers has been difficult to get, Kulindwa (2001) found out that the overall employment in the sector has been increasing (Fig. 7.1) between 1993 and 2000 with 54% from 35,291 to 77,997 people.

[1] If 1 Kg is handled by about 13 people, then based on total production from the Tanzanian part of the lake which is 200,000 metric tones, the total employment is about 2,600,000 people.

Box 1: Number of people involved in handling a kilo of Nile perch fish.

It is estimated that a kilo of fish is handled by between 8-13 people. The breakdown of these people is as follows. On average there are 4 (four) fishermen per boat. When they land the fish, there is a (1) carrier who takes the fish from the boat to the waiting trucks. At the truck, there are 3 (three) people, the person who weighs the fish and takes records, there is another 1 (one) person who loads the truck with the already weighed fish and then there is 1 (one) truck driver. These excludes those who offload the truck at the factory door, clean the fish Banda at the beaches where fish is weighed, net menders, boat repairers, bait suppliers for Nile perch among others. This makes a total of 10 (ten) people. For fish that is processed locally, there are women at the beaches who purchase the fish from fishermen, they either sell the fish to a processor or process it themselves and then the traders who purchase the fish either transports it to the market places or use bicycle or vehicle transporters. All this excludes persons involved in research and management.

Source: Onyango P. O. Unpublished data.

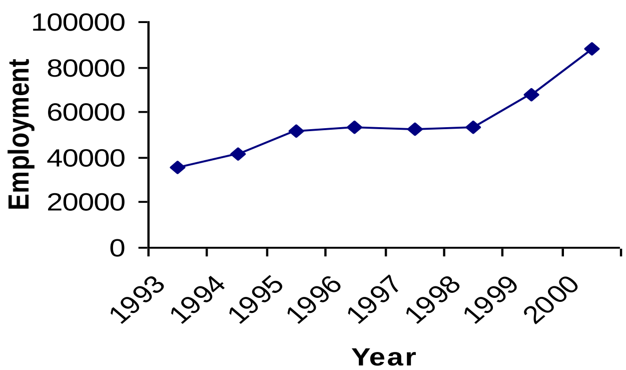



Figure 7.1: Trend of employment in Lake Victoria fisheries 1992-2000 (Kulindwa, 2001).

### *7.2.3 Numbers of Boats and Types of Fishing Gears*

**Types of gears**

Various gear types have dominated the fishery of the lake. The common ones have been an assortment of traditional gears, trawl nets, gill nets, hooks/longlines, beach seines, Dagaa seines and lift nets. Gill nets were initially made from sisal (brought by the colonialists) before changing to use nylon, beach seines were traditionally made from banana ropes and were very popular around the islands of Ukerewe (Onyango, 2004). These gears are still being used to date. Table 7.1 summarizes the gears that have been used in the lake and the periods, which they were used.

Table 7.1: Types of fishing gears and years they were used in Lake Victoria.

| **Year** | **Gears** | | | | | | | | **Reference** |
|---|---|---|---|---|---|---|---|---|---|
| | **Traditional gears** | **Trawl nets** | **Gillnets** | **Hooks/ Longlines** | **Beach seines** | **Scoop nets** | **Dagaa Seines** | **Lift nets** | |
| Before 1900 | X | | | X | X | X | | | Garrod quoted by Geheb, 1997 |
| 1900 | X | | X | X | X | X | | | Worthington and Worthington, 1993 |
| 1920 | X | | X | X | X | X | | | |
| 1940 | X | | X | X | X | X | | | FD Annual reports |
| 1960 | X | | X | X | X | X | | | FD Annual reports |
| 1980 | | X | X | X | X | X | X | X | FD Annual reports |
| 2000 | | X | X | X | X | X | X | X | Frame survey, 2000 |
| 2005 | | X | X | X | X | X | X | X | Frame survey, 2004 |

The gears that have been used in the fisheries of the lake are varied (Table 7.1 and Fig. 7.2). Outboard engines, hooks and gillnets are the oldest gears still existing in the fisheries. As can be seen from all the figures, the intensity of the use of these gears is concentrated almost in one period. This is the Nile perch proliferation period. Gill nets have more than doubled between 2000 and 2002.

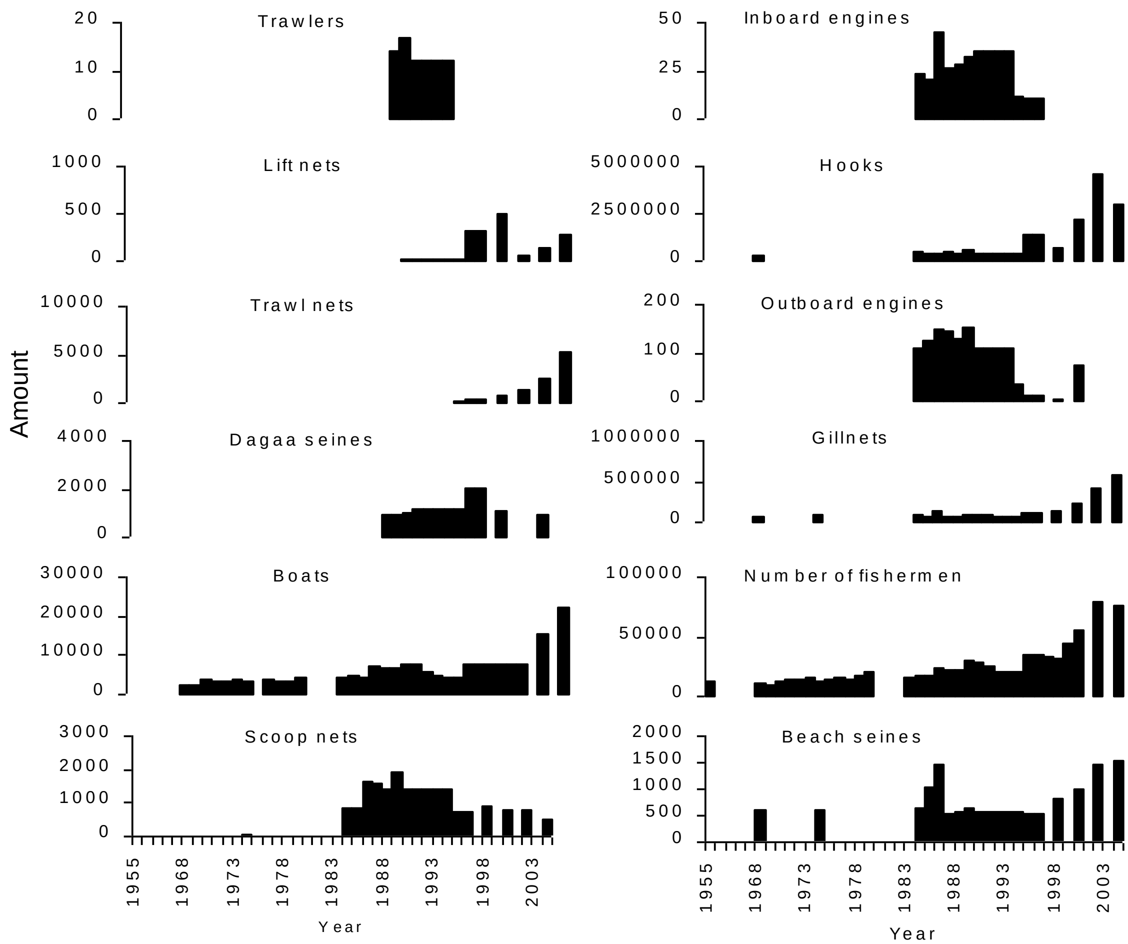



Figure 7.2: Trend in changes in fishing effort between 1955 and 2005.
(Source: Fisheries Division statistics)

The use of hooks (long lines) also expanded from 485,545 in 1984 to 3,040,773. There is currently more use of hooks in the fishery because gillnets have become very hard to guard due to piracy and probably the cheap cost of purchasing the hooks vis-á-vis gillnets.

### *7.2.4 Fishing Effort*

There has been observed increase in fishing effort since 1950s in the fisheries of the lake. This is evidenced by several factors such as, changes in fishing types, improvements in the gear types in use, increased number of boats, and gear types (Figure 7.2). The various boats that have been used in the lake are: canoes of various types such as dugout, Karua, Sesse, and Taruma. A description of these boats is summarized in Table 7.2. The increase in fishing effort since 1950s is statistically significant as shown by the p-values of the fishing gears in Table 7.3.

Table 7.2: Types of boats used in Lake Victoria.

| S/N | Type of boat | Description of Boat | Reference |
|---|---|---|---|
| 1 | Dugout canoe | A boat carved of a log of wood (tree trunk). It has no joints and no planks | Hoekstra 1992 |
| 2 | Sesse canoe | A modified dugout canoe pointed at both ends. The bottom is V-shaped. The sides are made of planked wood | Hoekstra 1992 |
| 3 | Taruma | An improved Sesse canoe. The bottom is V-shaped. It is mostly used in deeper waters because of its stability. It is made of planked wood and can be modified for use of an outboard engine. | Hoekstra 1992 |
| 4 | Karua | Has a flat bottom. It is made of planked wood and is mostly used in shallow waters | Hoekstra 1992 |
| 5 | Raft | Has a float bottom and it is made from reeds (Phragmites karka). It used in fishing Tilapia. | Witte and Densen 1995 |

Table 7.3: Summary statistics of Lake Victoria fishing effort, Tanzania (Source: Fisheries Division statistics).

| Summary statistics | Number of fishermen | Number of boats | Gillnets | Beach Seines | Scoop nets | Hooks | Dagaa Seines | Lift nets | Trawl nets | Out engi |
|---|---|---|---|---|---|---|---|---|---|---|
| Standard Deviation | 18123 | 4330 | 134374 | 420 | 608 | 1136330 | 682 | 141 | 1234 | 62 |
| Variance | 328460183 | 18752371 | 18056377458 | 176749 | 369653 | 1291245325131 | 464845 | 19873 | 1522181 | 3783 |
| Standard Error | 3625 | 945 | 28649 | 90 | 130 | 242266 | 145 | 30 | 263 | 13 |
| Skewness | 2 | 2 | 3 | 1 | 0 | 2 | 0 | 2 | 3 | 0 |
| Kurtosis | 3 | 7 | 7 | 0 | -1 | 6 | -1 | 3 | 11 | -2 |
| lower 95% c.i. | 21718 | 5392 | 63145 | 488 | 637 | 327028 | 367 | 18 | -33 | 36 |
| upper 95% c.i. | 36680 | 9335 | 182302 | 861 | 1176 | 1334669 | 971 | 143 | 1061 | 91 |
| sign test p-value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum of sign ranks (med = 0) | 325 | 231 | 190 | 190 | 171 | 171 | 91 | 78 | 153 | 120 |

### *7.2.5 Fish Processing and Trade*

Fishing in the lake was initially for home consumption/subsistence and any trade in fish products was through barter trade. In rare occasions was fish given as part of a peace deal (barter fish in anticipation that the residents of the place you stay will not chase you away or fight you) in the villages where fishers camped while fishing (Onyango, 2004). Processing on the other hand was basically smoking. However, processing and trade has changed with the changes that have been witnessed in the lake. For instance, it is reported that before the proliferation of Nile perch, Happlochromis was the most traded fish from the lake (Table 7.4). This fishery had however very little economic value and remained food for most communities living around the lake. In 1970's, there were market campaigns and creation of a trawl fishery and related industrial processing, but all these efforts proved to be quite unprofitable and the level of exploitation of the Happlochromines remained low. During and after the proliferation of Nile perch, new processing techniques such as smoking by use of kilns, salting and sun drying became quite intensive.

Table 7.4: Fish species traded and processed before and after 1982.

| **Year** | **Indicators** | | | **Authority/Reference** |
|---|---|---|---|---|
| | **Species traded** | **Marketability** | **Processing** | |
| Before 1982 | *Happlochromis*<br>*Synodontis victoriae*, *Bagrus docmac* | Poor | Sun drying and smoking | Dhatemwa, 1982; Nyholm and Whiting, 1975; Onyango, 2004 |
| 1988 | *Happlochromis*<br>Tilapia | Poor | Sun drying and smoking | Reynolds and Greboval, 1988; |
| 1990 | Nile perch<br>Dagaa<br>Tilapia | Gaining momentum | Smoking<br>Sun drying | Maembe, 1990 |
| 1993 | Nile perch<br>Dagaa<br>Tilapia | Intensive | Smoking<br>Sun drying<br>Frying | SEDAWOG, 1999; |
| 1999 | Nile perch<br>Tilapia<br>Dagaa | Very intensive | Industrial<br>Sun drying<br>Salting<br>Smoking<br>Frying | SEDAWOG, 1999 |
| 2000 | Nile perch<br>Tilapia<br>Dagaa | Very intensive | Industrial<br>Sun drying<br>Salting<br>Smoking<br>Frying | |

Fish processing and trade is undertaken in small-scale. It is the main income-generating activity for women in fishing villages. It used to involve processing and marketing other goods but currently it is exclusively undertaken as the main activity. Prior to establishment of industrial fish processing in the early 1990s, smoking was the main method for artisanal fish processing employed at the landing sites. Although this is on the decline now, it is considered in addition to boat building to have caused about over 60,000m3 of wood to be cut and therefore causing deforestation and environmental degradation over a number of islands and at landing sites. Since smoking entails the use of firewood, over the years many forests have been depleted of trees and other vegetation. Packaging of processed fish also involves the use of baskets made from macrophytes as well as grass and shrubs. As the volume of fish trade grows, more of these materials have been harvested from the shoreline vegetation, including the wetlands, leading to their depletion.

### *7.2.6 Fish Prices*

The prices of fish from the lake have generally been low. Before the proliferation of Nile perch, fish was sold on a piece basis; one piece of fish was sold at an average price of Tshs 0.6[2] in 1960s. When Nile perch dominated the catches, prices started to increase. Although there was an increase in prices they still remained low. Towards the end of the decade of 1990s and early decade of 2000, prices moved to a landmark of about Tshs 1000 (1 USD). The prices remained stable for a long period of time. One other observation that has been made about prices is that, they have remained inelastic despite changes in quantities supplied (Reynolds and Greboval, 1998). Today price remains the single most important factor that has actually hindered individual fisher's development due to their low level compared to artisanal mining of gold and tanzanite.

### *7.2.7 Marketing Destinations International by Country and Quantity*

**Fish Products Exported**

The major commercial fish species from the lake include Nile perch, Nile tilapia and Dagaa. From these species, Nile perch is the major export commodity. The exports consist mainly of several Nile perch products. These include: belly flaps, dried fish, fishmeal, fillets, fish chest, fish frames, fish maws, fish offals, fish skin, head and gut, Nile perch chips, Nile perch steak, off-cuts, kayabo, fish oil, and Nile perch carcass. Exports of these fish products keep on varying from year to

[2] In current prices

year. In terms of weight exports are dominated by fillets (Table 7.5). Then exports of belly flaps, fishmeal and fish maws follow fillets. Export of belly flaps have however increased substantially in the last two years from 4,667,216 in 1997-1998 to 25,475,605 in 2002-2004.

Table 7.5: Fish product exports by weight (kg) between 1997 and 2004.

| Products | 1997-1998 | 2000-2001 | 2002 and2004 |
|---|---:|---:|---:|
| Belly flaps | 4,667,216.0 | 4,757,827.00 | 25,475,605.0 |
| Dried fish | 274,435.9 | 12,050.70 | 5,495.3 |
| Fillets | 59,477,051.7 | 62,229,073.50 | 30,361,734.3 |
| Fish chest | 0.0 | 0.00 | 362,199.0 |
| Fish frames | 510,472.3 | 966,702.00 | 484,704.0 |
| Fish maws | 1,417,291.0 | 2,695,496.18 | 2,326,796.8 |
| Fishmeal | 1,766,377.0 | 5,763,554.70 | 2,094,650.0 |
| Fish offals | 394,967.0 | 1,171,660.00 | 222,870.0 |
| Fish skin | 0.0 | 0.00 | 1,043,844.0 |
| H and G | 20,000.0 | 1,769,426.00 | 2,467,728.0 |
| NP chips | 110,204.3 | 0.00 | 6,200.0 |
| NP steak | 0.0 | 0.00 | 200.0 |
| Off cuts | 497,151.9 | 144,720.00 | 334,737.0 |
| Kayabo | 0.0 | 43,650.00 | 17,615.0 |
| Fish oil | 121,220.0 | 0.00 | 0.0 |
| NP carcass | 456,080.0 | 0.00 | 0.0 |

Source: Fisheries Division. NP = Nile perch; H and G = whole head and gutted.

**Export Destinations**

The Nile perch products are exported to Europe, Australia, Asia, Africa and America. The quantity of exports to Europe exceeds all other areas except for 2000 when exports to Africa were the highest (Fig. 7.3). The reason for these high exports to Africa was because it was during this time that fish exports to Europe were banned. Our second highest export destination is Africa. In Africa Kenya and Republic of South Africa leads in importing fish products from the lake, in Europe there are several countries which import fish from the lake, however since Tanzania started exporting it is only Gibraltar which has lead twice (1997 and 2001) in importing fish products from the lake in addition to other five other countries namely Poland (1998) Portugal (1999), Netherlands (2002) and Italy (2004), while in Asia its Japan and Hong Kong (Fig 7.4). It should be noted that exports to Kenya and Uganda do not end in these countries but are re-exported to Europe. The major factor for exporting to Kenya is that most Fish Processing establishments in Tanzania have sister establishments in Kenya and Uganda, as such these companies combine all their exports and send them as one consignment

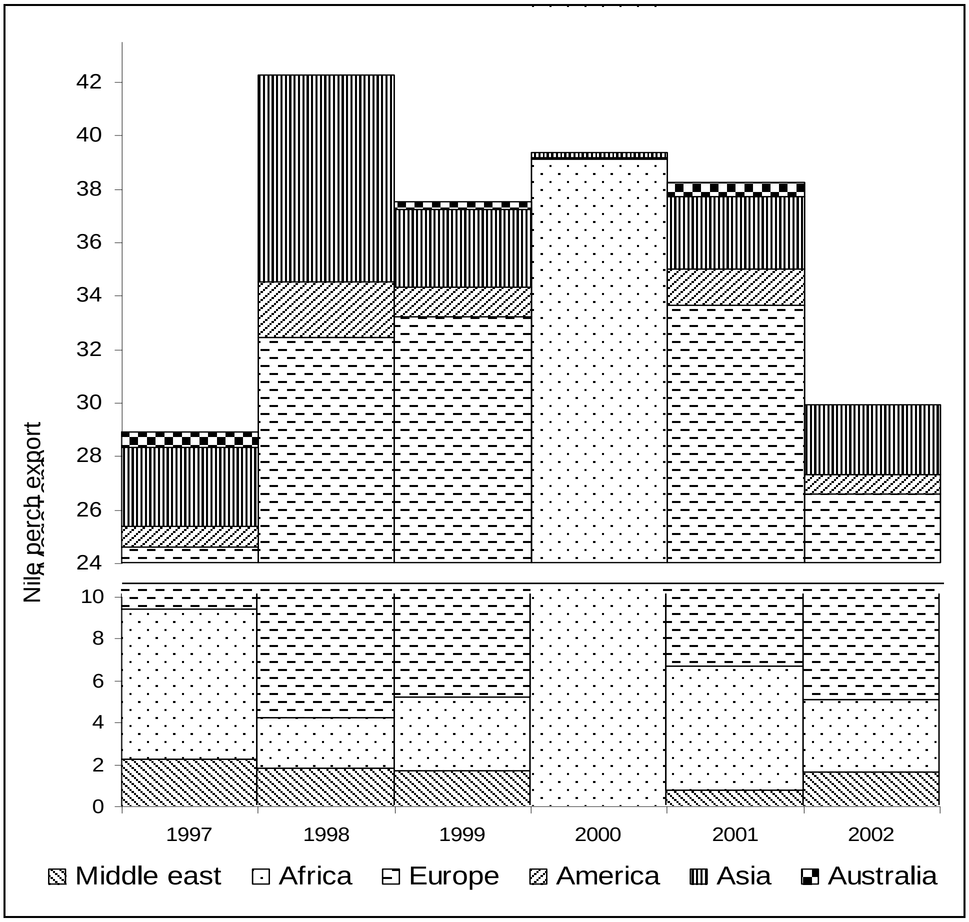



Figure 7.3: Comparison of exports to six destinations between 1997 and 2004.

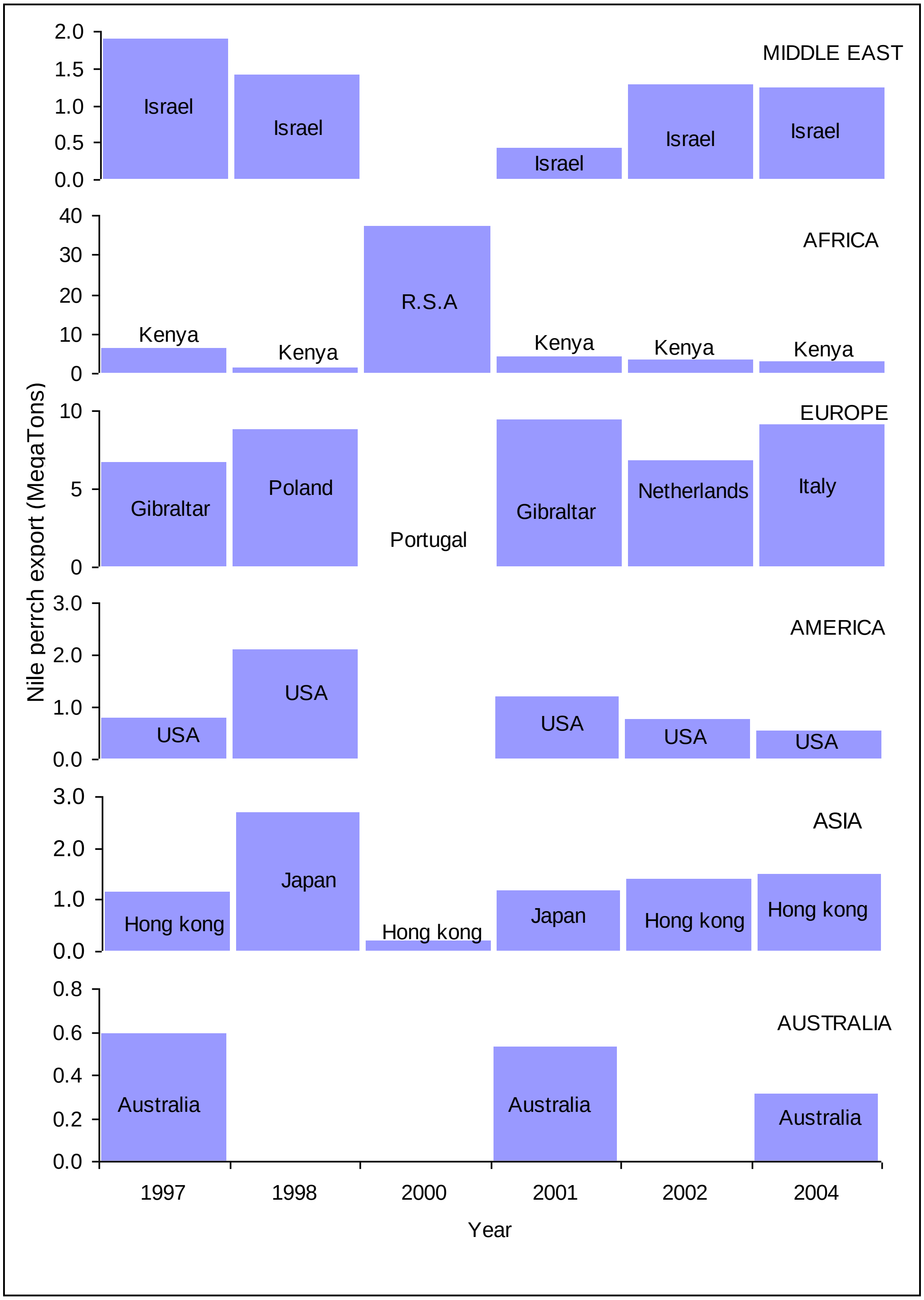



Figure 7.4: Comparison of the countries leading in importing Tanzania's fish products.

### *7.2.8 Per Capita Fish Consumption within the Basin*

There is no data available for protein intake of Lake Victoria fish by the riparian communities. However data available from FAO indicates that contribution of fish as animal protein to the Tanzanian population has remained somewhat stable since 1976 to 2001 (Table 7.6).

Table 7.6: Contribution of fish in animal protein.

| **Year** | **Percent** |
|---|---|
| 1976-78 | 34.4 |
| 1979-81 | 31 |
| 1982-84 | 32.8 |
| 1985-87 | 35.6 |
| 1988-90 | 38.3 |
| 1991-93 | 31.3 |
| 1994-97 | 32.6 |
| 1998-01 | 31.8 |

Source: FAO Database

### *7.2.9 Literacy Rate among Fisherfolk*

From various studies as shown in Table 7.7, most of the fisherfolk have low-level education attainment. Very few fisherfolk have actually not got any education while those who have gone to any college are very negligible.

Table 7.7: Education level of fishers.

| | Reference | | | | |
|---|---|---|---|---|---|
| | **Leendertse 1993** Kagera | **Kulindwa 2001** | **Kisusu and Onyango 2003** | Muro et al. 2005 | Kilosa et al. 2004 |
| **Various levels** | Percent | | | | |
| Primary | 66 | 82.4 | 82.1 | 70.8 | 88 |
| Secondary | 12 | 12.3 | 11.2 | 7.1 | 12 |
| College | 1 | 0.5 | 0.4 | 1.6 | 0 |
| No Schooling | 11 | 4.6 | 6.3 | 20.5 | 0 |
| Informal | 0 | 0.2 | 0 | 0 | 0 |

### *7.2.10 Infection Rates of Bilharzias, HIV/AIDS, Malaria and Others*

Health is a major problem that faces the riparian communities in Tanzania. The main health problems include but not limited to intestinal parasites, HIV/AIDS and malaria.

It is reported that out of the ten known intestinal parasites of medical importance in Tanzania, eight have been prevalent in the riparian districts for the last decade (Ministry of Health reports). Seven of these are actually endemic and their prevalence is shown in Table 7.8 (Muro *et al.*, 2005). Malaria for instance continues to be a serious health problem especially Africa south of Sahara. It is estimated that about 300 to 500 million people are infected with malaria parasite and 2-4 million deaths occur each year worldwide as a result of malaria. In 1990 malaria (10.8%) and respiratory diseases (10.8%) were the highest burden diseases to population living Africa south of Sahara (World Bank, 1993). Today, an estimated one million deaths can be attributed to malaria in Africa every year; most of these are children under five years (Mascie-Taylor and Karim, 2003). In Tanzania malaria is a major health problem in terms of morbidity and mortality, particularly among pregnant mothers and under fives (Ministry of Health, 2001).

Table 7.8: Prevalence of intestinal parasite and schistosomiasis in the riparian districts.

| **Intestinal parasite** | **% Overall** | **% Kagera** | **% Mwanza** | **% Mara** |
|---|---|---|---|---|
| *Schistosoma mansoni* | 43.7 | 17.2 | 59 | 54.7 |
| Hookworm | 28.4 | 27.1 | 37.7 | 19.8 |
| *Ascaris lumbricoides* | 14.6 | 41 | 2 | 1 |
| *Trichurus trichuira* | 12.7 | 38 | 0.4 | 0.2 |
| *Strongyloides stercoralis* | 4.2 | 1.7 | 6.2 | 4.9 |
| *Entamoeba histolytica* | 21 | 29 | 19.3 | 14 |
| *Giardia lamblia* | 4.8 | 6 | 2.8 | 5.4 |

Adapted from Muro *et al.* (2005).

Although accurate records on malaria is had to locate, the data that is available which is based on health centers/facilities records is not very reliable because many people treat malaria at home and malaria drugs are available even in several private medicine shops. There are numerous illness and deaths due to malaria that are not reported, which occur at home. Malaria epidemic has been reported in Tarime district and Muleba in 1998 (Garay, 1998). Out of the four *Plasmodium* spp. known to cause malaria i.e. *Plasmodium falciparum, P. vivax, P. ovale* and *P. malariae*, *P. falciparum* is the most common in Africa. Muro *et al.* (2005) reports that within the riparian districts there is an overall malaria prevalence of 11.7%. They note that between males and females, there is no significant difference in the infection rates. However, prevalence among under-fives is highest at 20.7%. This reduces with age with the lowest prevalence found among the age group 45-49 (2%) and 35-39 (3.1%).

HIV/AIDS has been acknowledged as a national disaster in Tanzania. World Health Organization estimated that Tanzania had 2.2 million people living with HIV/AIDS (WHO quoted by Muro *et al.*, 2005). This number has risen quite fast from 109,863 people who were reported to have AIDS in the country in 1986 and 549,315 in 1998. The magnitude of the epidemic varies geographically, for instance in Mwanza region, rural communities have a lower (3.8%) HIV prevalence than roadside settlements and urban areas (7.7%) (Grosskurth *et al.*, 1995). The fishing villages are highly vulnerable because of the daily cash flow that they have. HIV infection is predominantly through sexual contact thus an understanding of sexual behaviour is important in designing and implementing appropriate interventions. There is a wide knowledge about sexually transmitted diseases such as HIV/AIDS among the riparian communities. About 99% of these communities have heard about HIV/AIDS. Out of these people, 89.3% are certain that HIV/AIDS is spread through sexual contact. About 54.8% state that it is spread through contaminated needles/injections. There are however some communities in Sengerema district where there are misconceptions about the spread of this disease. These communities claim that shaking of hands or any contact with an infected person causes transmission. Within the riparian districts, about 93.8% are aware of the existence of condoms although only 69.4% believe that condoms are used to protect against the infection. Among the adults, 98% believe that condom use helps protect against infection. The perceptions about HIV/AIDS particularly with regards to transmission and preventive mechanisms have improved in the recent past. In 1996 over 30% of the riparian communities believed that there was no ways to avoid HIV/AIDS while in 2004 there are only about 13% who has the same belief. This perception on ways of HIV/AIDS spread has not changed for the past decade in the Tanzania population including the riparian communities.

An overall assessment of health facilities reveals that 45.5% of all the health facilities in the riparian districts have enough rooms to accommodate all important health services. About 55% of the health facilities have pumped/tap or shallow well water (Muro *et al.*, 2005). All essential types of medical and delivery equipment were available in all the health facilities and are in satisfactory working condition except for screens, sphygmomanometer and adult and child weighing scales most of which were defective. The availability of health personnel is summarized in Table 7.9.

Table 7.9: Proportion of health personnel in health facilities of selected riparian villages.

| Health personnel cadre | % Health facilities with a particular health personnel (N=11) |
|---|---|
| Clinical personnel (AMO, CO, ACO) | 100 |
| Trained nurse (Nurse MWs, PH nurse) | 63.6 |
| Medical attendants (nurse assistant) | 100 |
| Laboratory assistant | 18.2 |
| Trained microscopist | 27.3 |
| Health officer or Health assistant | 27.3 |
| MCH Aides nurse | 45.4 |

Source: Muro *et al.* (2005).

### *7.2.11 Age Distribution*

Table 7.10: Population by age from different selected sources.

| | Reference | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Kilosa et al. 2004**[3] | **Leendertse 1993** | Population census | | | TDHS[4] | TKAPS[5] | TDHS | TRCHS[6] |
| | | **Kagera** | 1967 | 1978 | 1988 | 1991-2 | 1994 | 1996 | 1999 |
| Age groups | Percentage | | | | | | | | |
| Less than 15 years | 0 | 31 | 43.9 | 46.1 | 45.8 | 46.8 | 49.3 | 47.2 | 46.8 |
| Between 15 and 60 | 39 | 63 | 50.5 | 49.9 | 49.9 | 49.3 | 46.4 | 48.5 | 49.1 |
| Over 60 | 61 | 2 | 5.6 | 4 | 4.3 | 3.9 | 4.3 | 4.3 | 4.1 |

Table 7.10 shows the population structure by broad groups. From the table, the first two columns showing percentages shows figure from the lake basin. The rest of the columns are national census surveys as well as demographic household surveys taken at different times. The information indicates that in the country the population is young. In fact about half of the population is less than 15 years and about another half is between 15-60 years. The reasons for these proportions could not be established. A personal observation that has been made is that currently the fisheries are dominated by young people of between 15-30 years.

[3] The categorization of the groups were less than 18 years, between 18-40 and above 40 years.
[4] Tanzania Demographic Household Survey
[5] Tanzania Knowledge, Attitudes and Practices Survey
[6] Tanzania, Reproductive and Child Health Survey

### *7.2.12 Gender Participation in Fishing, Processing and Trade*

Tanzania's lake basin population is estimated at about 6.9 million with an annual growth rate of 2.6%. This population includes the regions of Mara, Mwanza, Shinyanga and Kagera. The male female ratio is 49% male against 51% females. In addition to this about 85% of the total population of the basin lives in rural areas of which 70% are females, full time smallholder farmers. Women are involved in agriculture, mining sector (although at very low levels), fisheries and service sector. Within the fishing sector, most women are involved in processing and trading in fish products (Table 7.11).

Women have all along been marginalized in a number of decision-making areas. It is out of this that a policy has been drawn to ensure that a 30% involvement of women is achieved whenever representation in any activity is desired.

Table 7.11: Comparison of gender participation in fisheries.

| | Reference | |
|---|---|---|
| | Kisusu and Onyango (2001) | |
| | Male | Female |
| Fishing (%) | 99.5 | 0.5 |
| Processing (%) | 54.7 | 45.3 |
| Trading (%) | 88.1 | 11.9 |
| **Total** | **86.6** | **13.4** |

### *7.2.13 Perception of Stakeholders to the State of the Fisheries*

A summary of perceptions of various groups is outlined in Table 7.12. More changes were observed in later surveys. The over fishing of the tilapiine species resulted in the decrease in their catch and a subsequent increase and dominance of non-cichlids in the landings (Okeyo-Owuor, 1999). The number of haplochromines also continued decreasing. However in the 1970's and 1980's, the haplochromines species appear to have fallen dramatically. Besides these changes, there are various areas in which fishers and managers and other stakeholders had disagreements and agreements. These are outlined in Tables 7.13 and 7.14.

Table 7.12: Perceptions of fishers, researchers and government officers on the state of fisheries.

| Year | Indicator (Perception on the state of fisheries) | | | Reference |
|---|---|---|---|---|
| | Fishers | Researchers | Government | |
| 1900-910 | Fishing perceived as livelihood | Worried on the reducing Tilapia sizes | | Geheb 1997 |
| 1911-1920 | Fishing perceived as livelihood | Very happy about the species diversity over 500 species of cichlids | Concerned about exploitation of the fish resources | Okeyo-Owuor 1999<br>Ligtvoet et al. 1995<br>Graham 1929 |
| 1921-1930 | Fishing perceived as livelihood | Very happy about the species diversity over 500 species of cichlids | | Okeyo-Owuor 1999<br>Ligtvoet et al 1995 |
| 1931-1940 | Fishing perceived as livelihood | Very happy about the species diversity over 500 species of cichlids | | Okeyo-Owuor 1999<br>Ligtvoet et al. 1995 |
| 1981-1990 | | Worried about ecology of the lake, fish diversity decline and eutrophication | Worried about sustaining incomes from Nile perch fishery | Wilson 2000, |
| 1991-2000 | Concerned about reduction in catches (from 45 tonnes to 15 tonnes per boat) and long fishing trips | | | Witte 1995, Mkumbo, 2002 |
| 2000 - | Fisheries management is legitimate<br>Worried about corruption | Worried about the pressure on fish resources (Increase in n umbers of fishermen from 11,923 in 1955 to 76,765 in 2004; fishing gears especially hooks from 296,500 in 1968 to 3,040,773 in 2004 among others) | Worried about dwindling incomes from the fishery | Wilson 2000 |

Table 7.13: Areas that fishers and managers disagree with regard to fisheries related issues.

| Year | Areas of disagreements | Reference |
|---|---|---|
| 2000 | There would be no catches if a fisher does not use a small mesh-size gear<br>That there should be no more fishers/boats/nets to be allowed in the lake<br>Conflict among cross-border fishing and fish trade | SEDAWOG 2000<br>Heck et al. 2004 |

Table 7.14: Areas of consensus among fishers and fisheries managers.

| Year | Areas of consensus | Reference |
|---|---|---|
| 2000 | (i) There was less fish than there were five years before<br>(ii) Fishing trips have become longer than they were five years before<br>(iii) There is less fish diversity than there were five years before<br>(iv) There are more boats than they were five years before<br>(v) Fish sizes are smaller than five years before<br>(vi) Fish was paying less than it did five years before<br>(vii) Involvement of all stakeholders' especially local community in fisheries management. | SEDAWOG 2000 |

### *7.2.14 Public Expenditures and Public Revenue, Proportion to the GDP*

Data on public expenditure has not been easy to get, this is because the incomes generated from the fisheries are taken to the treasury where disbursement is not released as per the income source but as per the government budget. However, an LVEMP study by Kulindwa (2001) indicates that public expenditure has been increasing. In fact Nile perch has been the greatest contributor to this expenditure due to the exports from its products. The fisheries contribution to the GDP has grown from strength to strength (Fig. 7.5).

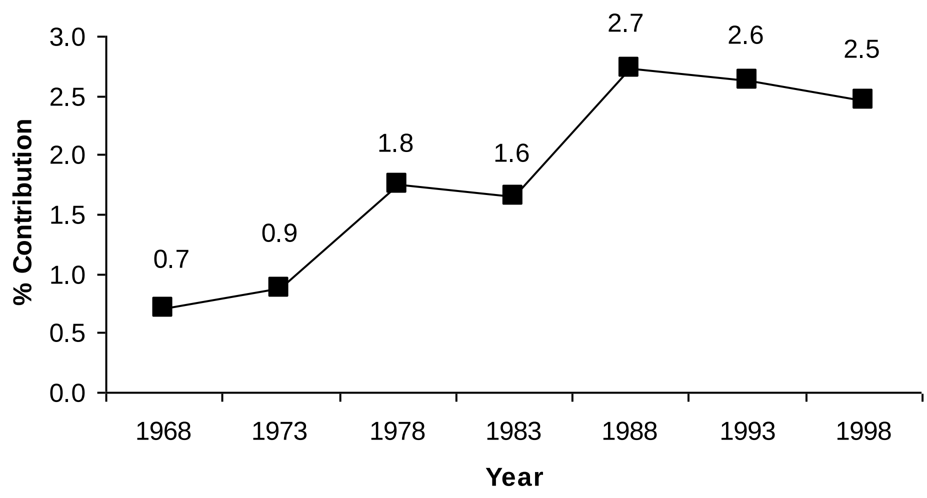



Figure 7.5: Lake Victoria contribution to GDP in Tanzania.

## 7.3 Discussion

The fisheries of Lake Victoria continue to remain a crucial resource to support the livelihoods and well being of the riparian communities. In addition to this, the opportunities that the lake provides in terms of employment and its contribution to the national economy among others make fisheries one of the most important sectors for regional development. However, fisheries cannot be looked at in isolation when designing any development plans for the lake basin. There are other sectors, which are impacting upon the fisheries. These include agriculture, mining, infrastructure, industrial and the service sectors. Agriculture is a major sector that has continued to provide employment even to fishers. In fact, in Lake Victoria there are no professional fishers, but fishing is practiced alongside agriculture (SEDAWOG, 2000). Many fishers have used fishing as a source of income generation where as agriculture has been used to provide staple food and green vegetables that are usually essential for family food (Onyango, 2003). But there has been a problem with the agricultural sector. The increasing fishing effort on the Lake Victoria basin waters has been attributed to limited alternative livelihood opportunities in the region, leading to increased entry into the fisheries. A number of factors have been responsible for this, namely the failing agriculture, narrow economic base of the riparian economies and limited training and skills among the local populations. As a result, fisheries have been perceived as more paying than many other activities in the region. According to the East African Community (EAC) (EAC protocol), Lake Victoria Basin has been designated as an economic growth zones basically due to its various resources majorly its fisheries.

There is an increased pressure on the fish stocks as evidenced by the increased numbers of fishing gears boats as well as fishers. Moreover, the fishery has changed from subsistence to commercial especially with the introduction of Nile perch. The data from the synthesis indicates that trading and processing have improved from simple sun drying to industrial processing. Despite the importance of the lake, there are changes, which have been observed. From a socio-economic angle, the introduction of Nile perch has brought a lot of changes within the riparian communities. The noticeable ones include changes in institutional structures with regard to management and individual behaviour. Historically, the institutional structure that existed was that of individual fishing communities who viewed fisheries as part of the community system. This changed with the coming of the colonialists when a regional body, the Lake Victoria Fisheries Service (LVFS) established in 1947 looked at the fisheries of the whole lake. This was transformed into East African Freshwater Fisheries Research Organization (EAFFRO) but was disbanded with the breakup of the East African Community in 1997. At this time each of the riparian countries formed their individual fisheries authorities. However, in 1980's the species changes amongst other factors that were observed called for efforts to jointly manage the lake. This saw the birth of Lake Victoria Fisheries Organization (LVFO). Besides institutional changes, perception on the fisheries have also changed from being subsistence to commercial attracting a substantial number of even communities who have not been involved in fishing, especially those who come from the hinterland, improvement in gear technology and a changed market and processing systems.

## 7.4 Conclusions

(i) Lake Victoria is an important social and economic resource for the riparian communities.

(ii) The observed increases in the number of fishers, gears, fish traders and processors as well as trading and processing systems reflects a changed perception on the lakes fisheries from being a subsistence to a commercial resource.

(iii) The fisheries of the lake are currently operating under a new socio-cultural environment from that of the historical fishing communities. It is however not very clear whether the new socio-cultural set up is embedded within the cultural set up of these communities.

(iv) The fisheries of the lake remains artisanal by nature, industrial and trawl fishing are banned.

(v) Collection and storage of employment, fish trade and processing (artisanal), and fish prices data needs are highly underdeveloped or very poor.

## 7.5 Recommendations

Efforts should be devoted to understanding the society in which fisheries operate. The communities' contradictions and potential synergies need to be considered when dealing with these communities. In addition such an understanding should enable planners direct fisheries resource exploitation to avenues that should improve social welfare of these riparian communities.

On areas where there is inadequate data such as employment, prices, trading and processing, the Fisheries Division remains as the custodian of fisheries statistics in the country should be capacitated to collect and compile/process such data for easy retrieval.

The changing world is greatly impacting upon the riparian communities. A new society that dominates the current world where economics is taking center stage demands a quantitative approach to analyzing qualitative issues. However, social issues on which the riparian communities are deeply rooted do not easily blend well with the quantitative analysis. For this reason it is important to explore how social issues such as power, socio-cultural capital and taboos can be used to address the concerns of the riparian communities through their application in managing the fish resources.

# CHAPTER EIGHT

## ESTABLISHMENT OF INFORMATION AND DATABASE

*Kayanda, R.[1], Mahongo, S.[1], Nsinda, P.[1], Mrosso, H.[1], Mlaponi, E.[1], Katunzi, E.[1], Mairi, J.[2], Maige, B.[2]*
*[1]Tanzania Fisheries Research Institute*
*[2]Fisheries Division*

## 8.1 Introduction

The aim of establishing information and database for Lake Victoria is to provide adequate and timely information and improve on its accessibility for the overall sustainable benefits from the lake. The beneficiaries range from the local communities, fisher-folk, and fishery managers to scientists and groups interested in wetlands, bio-diversity and other global scientific concerns.

The first fisheries survey to generate information on the Lake Victoria took place in 1927 (Graham, 1929). Thereafter, information was gathered by various organizations like the EAFFRO in 1948. It has however, been difficult to keep track of the immense data collected due to poor storage mechanisms. Consequently, it is difficult to access quality information on fisheries, environment and other socio-economic issues.

There are several databases on Lake Victoria some of which are manned at individual and institutional level. These include SAMAKI information system, GIS database, Bibliographic database, Reference manager, Satellite lakes database. The SAMAKI is a strong starting point for information management in the region, Library management information system and Directory of scientists. It is however, recognized that fisheries institutions are still handicapped in the areas of information handling, database infrastructure, capacity and skilled manpower.

Therefore, a set of specific objectives were enacted to address these constraints, these include compilation of updated bibliographies on Lake Victoria, establishment and updating databases on Lake Victoria, availing information to stakeholders, setting up electronic communication network, developing library capacity, developing database skills, increasing number of literature by ordering books and subscribing to journals, and improving availability of data analysis software.

### *8.1.1 Background*

In the past, there have been several efforts to address national fisheries information needs. For example, in early 1990's, frame-survey data input software (TANFIS) was developed for Tanzania with FAO support (LVEMP, 2000). In addition, there were limited established mechanisms for acquisition, processing and storage of information generated from research and management activities, for instance, Mous (1995) demonstrated the use of Lotus 123 program to analyse length-girth and length-weight relationships, the length at 50% maturity and length frequency distribution.

Therefore, a systematic mechanism for acquisition, processing, storage and dissemination started in 1999 when the Regional Task Force was established to kick-start the process of development of the required databases, establish mechanisms and modality for data storage, processing and exchange. The Task force assessed the status of data resources, facilities and personnel in the fisheries and associated institutions. For a better understanding of the actual status of the resources in the implementing institutions, strategic visits were planned to some of the key institutions in each country within the lake basin. Therefore, it is after this time when the work of Information and Database started.

## 8.2 Justification

A proper acquisition, storage, retrieval and dissemination of research information are very vital to inform the management of Lake Victoria fisheries. That is why it is very important to take stock of what is available and establish trends and time series of as many aspects related to this subchapter as possible in order to identify gaps to be addressed in the future.

## 8.3 Results

### *8.3.1 Projects Engaged in Fisheries in Lake Victoria*

The number of donor-funded projects since 1977 when Haplochromis Ecology Survey Team (HEST) funded by the Netherlands Foundation for the Advancement of Tropical Research (WOTRO) was inaugurated has increased. This project ran for 15 years up to 1992 and was operational only on the Tanzanian part of the lake. In 1988 another regional project funded by the International Development Research Centre (IDRC) started. It dealt with gillnet selectivity for the Nile perch and ended in 1992. Regional Project for Inland Fisheries Planning, Development and Management in Eastern/Central/Southern Africa (IFIP) is another project that was operational from 1989 to 1998. Lake Victoria Fisheries Research Project (LVFRP) (regional project) phase I funded by the European Union started in 1995 up to 1997. This was a pilot project that dealt with planning. Research activities started in 1997 when LVFRP phase II started. This project dealt mainly with stock assessment and ended in 2002. Another regional project that started at the same time with LVFRP phase II is the Lake Victoria Environmental Management Project (LVEMP) funded by the World Bank.

Other regional projects that are currently going on are Implementation of Fisheries Management Plan (IFMP, dealing with fisheries management), International Union for Conservation of nature (IUCN, dealing with socio-economic of fisheries), FAO/COMESA dealing with value added products of fisheries, TAFIRI-TITECH dealing with ecology of haplochromines, Victoria Research (VicRES) under the Inter-University Council of East Africa funded by Sida/SAREC dealing with catchment, wetlands and water body. Fig. 8.1 shows an increase in number of projects engaged in fisheries. It can be seen that there is a sharp increase from 2000 to 2005.

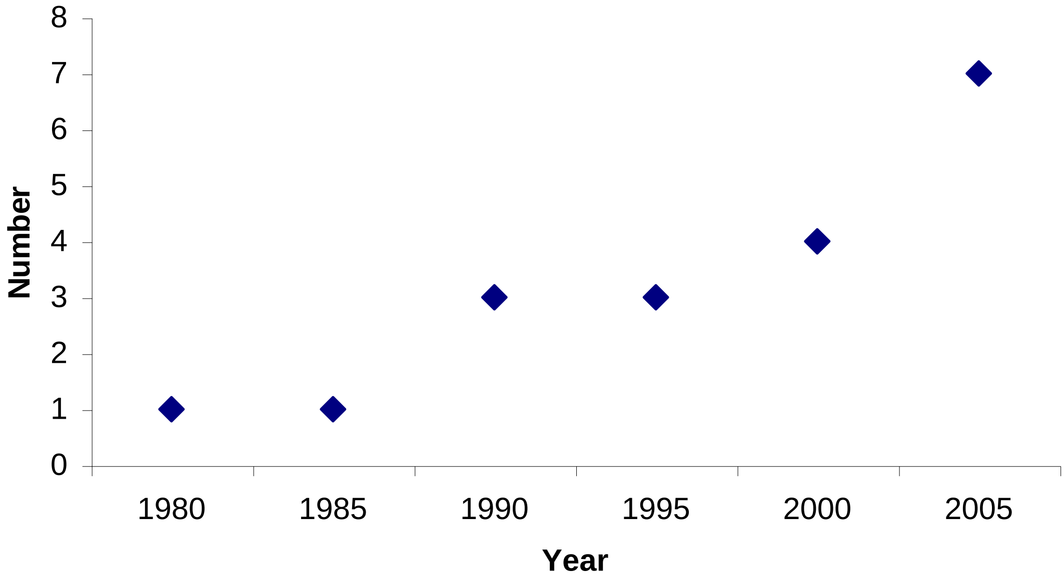



Figure 8.1: Number of projects engaged in fisheries over years.

### *8.3.2 Number of Visitors*

Visitors came from different countries and institutions like Hull University in UK, Waterloo University in Canada, Wageningen in the Netherlands, Lake Tana Fisheries Research Centre in Ethiopia, Crete University in Greece, World Bank, IUCN, FAO, UNIDO, JICA, Rhodes University, MRAG, the EU, and others.

Researchers and lecturers from training institutions have visited the fisheries offices. These came from Ukiriguru, TPRI, FIRRI, KMFRI, NIMR, University of Dar es Salaam, Sokoine University of Agriculture, Makerere University, Kyambogo University, Saint Augustine University of Tanzania, and Nyegezi Freshwater Fisheries Training Institute. In addition, students from primary and secondary schools, and at university level visited the fisheries offices. Moreover, journalists, fish farmers and NGOs visited the offices (Fig. 8.2).

### *8.3.3 E-communication*

E-communication is a rich source of information (World Library) and a critical resource for collaboration and communication. In addition, through the Internet, different information related to fisheries can be obtained freely by using appropriate search engines and specific sites. Table 8.1 shows development of Internet access by type of connection in fisheries offices. Regional fisheries offices and TAFIRI Mwanza have satellite connection. In addition, Local Area Network (LAN) has already been installed at the Fisheries Division headquarter in Dar es Salaam and plans are underway to have this facility installed in Lake Zone offices.

Table 8.1: Internet access by type of connection.

| **Year** | **Internet connection** |
|---|---|
| Before 2000 | No Internet connection |
| 2000 | Dial up |
| 2005 | Satellite and LAN |

### *8.3.4 Computers and Accessories*

Computers and related accessories have experienced a drastic change over time; from 1988 when the first computer was received (Comodore) to modern HP computers with high processing speed, storage and efficient operation system (Windows XP). Fig. 8.3 shows the rate at which computers (desktops and laptops) were procured at different periods. However, computers procured before 2000 are not operational and those procured between 2000 and 2003 are old and outdated. Therefore, it is 34 computers procured between 2004 and 2005 that are in good working condition.

Data storage and back up devices have also advanced from Ditto Tape, floppy, Zip Discs to CD-ROM. Since the number of computers has increased drastically, some scientists store data in more than one computer and use backup facilities supplied with windows. Recently, storage via the Internet e-mail accounts is gaining popularity due to the fact that data can be retrieved anywhere as long as there is Internet connection (Table 8.2). Memory sticks (flash disks) are as well coming up as temporary storage devices and backup systems for small sized files.

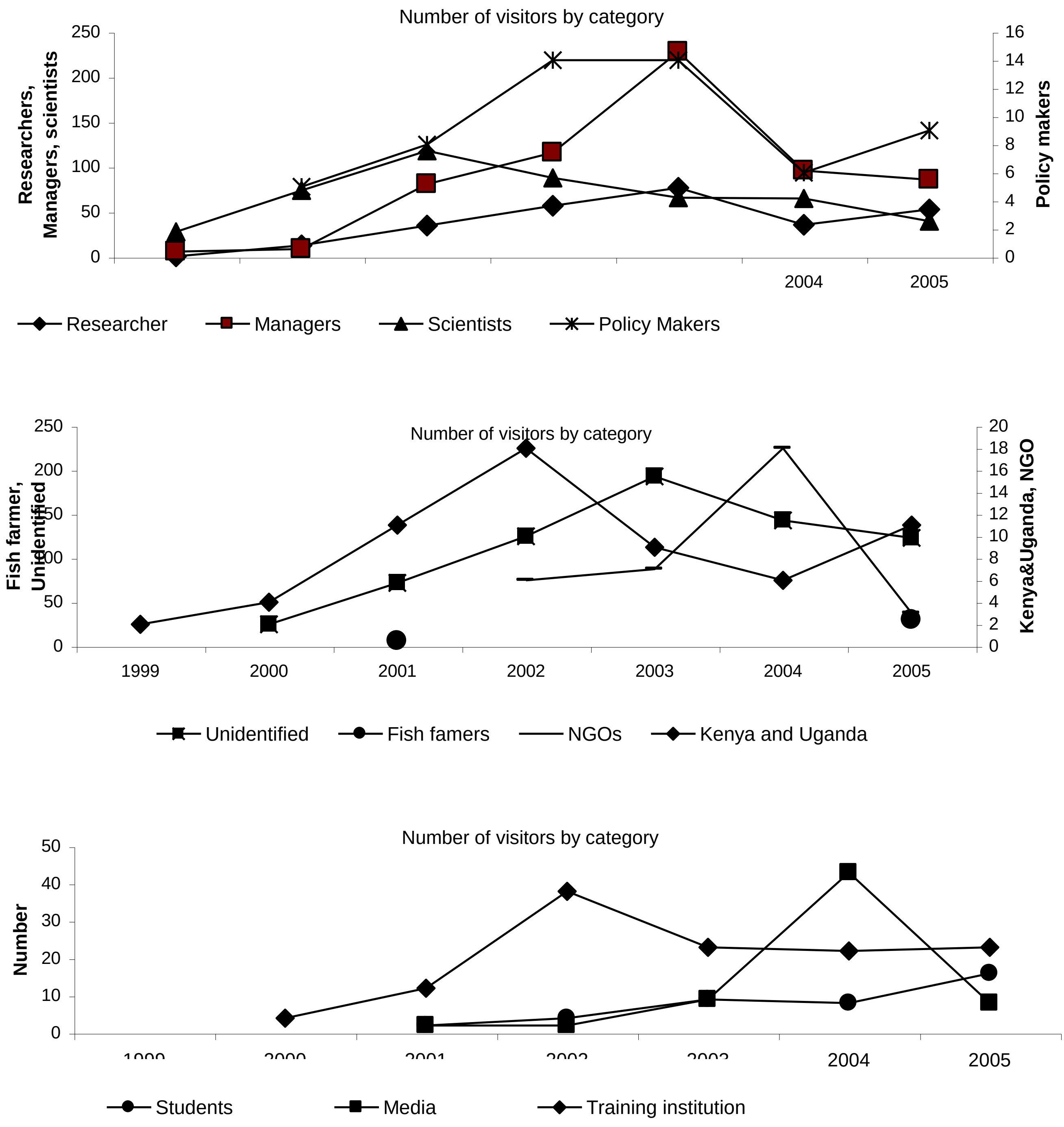



Figure 8.2: Number of visitors to fisheries offices.

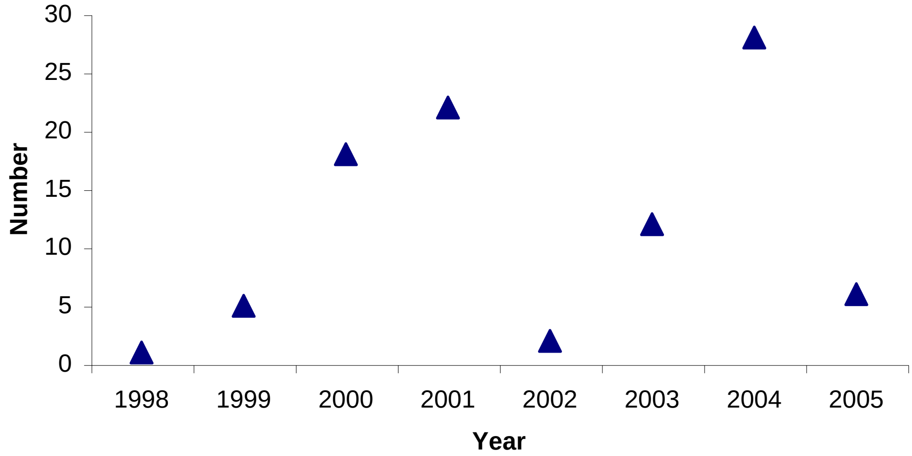



Figure 8.3: Number of computers procured by year.

Table 8.2: Trend in back-up systems.

| 1999 | 2000 | 2001 | 2002 | 2004 | 2005 |
|---|---|---|---|---|---|
| Ditto tape drive | | | | | |
| Floppy | Floppy | Floppy | Floppy | Floppy | |
| | Zip drive | Zip drive | Zip drive | Zip drive | |
| | | CD-ROM | CD-ROM | CD-ROM | CD-ROM |
| | | | | Internet | Internet |
| | | | | Computer | Computer |
| | | | | | Memory sticks |
| 2 | 2 | 3 | 3 | 5 | 4 |

### *8.3.5 Number and Type of Software for Data Analysis*

Software for data analysis has seen a transition phase from Lotus 123 before 2000 to modern statistical software like MS-Excel that offers features that make working in a spreadsheet environment fast and easy, Systat 10.0, StatPlus, SPSS, SAS, and Statistica. In addition, spatial data analysis software like ArcView that offers possibility of capturing, storing, checking, integrating, manipulating, analysing and displaying geo-referenced data has also increased capacity of scientists and managers alike to visualized data for easy and fast decision making processes.

Golden Surfer is a powerful grid based graphics program that interpolates irregular spaced XYZ data into a regularly spaced grid. It produced a number of maps, which include contour maps, vector maps, wireframe maps, image maps and shaded relief maps that are simple to comprehend. Other programs like Resampling, Mantel, Statplus and Sylvac logger have been very instrumental for producing quality publications that meet the International standard. Table 8.3 summarises these software by type and year. It can be seen that 2002 and 2004 have the highest number of software. This could be attributed to a number a reasons some of which are the increased number of projects and returning scientists from studies abroad.

### 8.3.6 *Number of Databases Available*

A database is a collection of facts, stored and processed, to generate an output. It facilitates storage and easy retrieval of information for planning, management and decision making by the stakeholders to meet pre-defined objectives. For Lake Victoria fisheries a number of databases have been developed and procured over the years (Table 8.4). From before 2000 and after 2000, all databases were procured from different sources, but from 2001 to 2005 some of the databases were developed internally using MS-Access program due to increased human capacity.

Table 8.3: Number and type of software.

| Type of Software | Before 2000 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|
| **Data Entry only** | Lotus | Excel | Excel | Excel | Excel | Excel | Excel |
| **Data Analysis only** | Statistix | | | | | | |
| | ARTFISH | | | | | | |
| | | SAS | SAS | SAS | | | |
| | | | Systat | Systat | Systat | Systat | Systat |
| | | | | Resampling program | Resampling program | Resampling program | Resampling program |
| | | | | Mantel Test | Mantel Test | Mantel Test | Mantel Test |
| | FiSAT | FiSAT | | | | | |
| | PASGEAR | PASGEAR | PASGEAR | PASGEAR | PASGEAR | PASGEAR | PASGEAR |
| | | | | ArcView | ArcView | ArcView | ArcView |
| | | | | Surfer | Surfer | Surfer | Surfer |
| **Data Entry and Analysis** | | | | | | StatPlus embedded in Excel | StatPlus embedded in Excel |
| | SPSS for DOS | SPSS for Win | SPSS for Win | SPSS for Windows | SPSS for Windows | SPSS for Windows | |
| | | | | Statistica | Statistica | Statistica | Statistica |
| | ARTFISH | | | | | | |
| **Data logger** | | | | Sylvac logger | Sylvac logger | Sylvac logger | Sylvac logger |
| **Total** | 7 | 5 | 5 | 11 | 10 | 11 | 10 |

Table 8.4: Number of Databases.

| **Before 2000** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|---|
| TANFIS | | | | | | |
| REFERENCE | | | | | | |
| | FishBase | FishBase | FishBase | FishBase | FishBase | FishBase |
| | | | SAMAKI Database | SAMAKI Database | SAMAKI Database | SAMAKI Database |
| | | Reference Manager | Reference Manager | Reference Manager | Reference Manager | Reference Manager |
| | | Library Management Information System | Library Management Information System | Library Management Information System | Library Management Information System | Library Management Information System |
| | | | Directory of scientists | Directory of scientists | Directory of scientists | Directory of scientists |
| | | | | | | Satellite lakes database |
| | | | | | | GIS Database |

### *8.3.7 Number of Data Sets Available in Digital Format by Type and Category*

Data stored in digital form have an advantage of efficiency in exchange, retrieval and editing than data stored in hard copies. In this context digital data falls within three categories depending on the way it is stored. These are Database (digital computer aided program for storage and retrieval of data), CD-ROM (physical storage system) and Spreadsheets (digital computer aided program for calculating and data storage and retrieval). Within each category, there are five data set types; these are ecology, distribution, taxonomy, socio-economics and reference (literature). Reference dataset has moved from 6 (Fish Biology and Biodiversity conservation, Environmental Pollution, Hydrology, geology and climate, Limnology, ecology and wetland ecosystems, Aquaculture and Socio-economics) in 2001 to 8 (Fisheries, Aquaculture, Socio-economic, Post-harvest, Environment, Biodiversity and conservation, Capacity building and others) data types in 2005. In addition, socio-economic data sets are still in spreadsheets and CD-ROM as they have not been entered into SAMAKI database due to some modifications in the database that need to be done before keying in data. SAMAKI is the most important database as it has several sub-databases for frame surveys, catch assessment, socioeconomics, reference and trawl survey.

As regards spreadsheet category data has not been quantified, but there is still a lot of information contained in spreadsheets that need to be put into the database. This dataset is with individual scientists and not stored centrally. All database and spreadsheet categories are stored onto CD-ROMs.

### *8.3.8 Number of BSc, MSc and PhD Holders*

Training at different levels (BSc, MSc and PhD) is one among the objectives of any fisheries, both management and research institutions in order to increase capacity for fisheries management. There was one PhD holder in TAFIRI for the period 1985-1999 and started to increase after the year 2000. While the number of MSc holders has been increasing throughout, that of BSc holders increased from 1980 to 1985, then declined sharply until 1995 when it started increasing again very sharply to the year 2000 and declined slightly to year 2005 (Fig. 8.4).

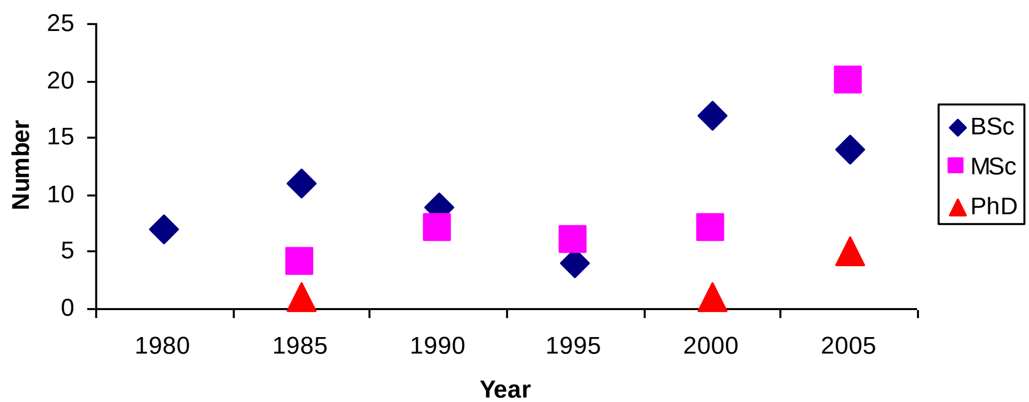



Figure 8.4: Number of BSc, MSc and PhD holders in TAFIRI.

### *8.3.9 Publications by Scientists and Managers*

A number of information from research and management has been published through different platforms. Some have been published as books, scientific papers, theses, dissertations, technical documents, conference proceedings, newsletters and others. Accordingly, fisheries under LVEMP produced a number of publications both published and unpublished (unpublished documents are those survey reports and papers that were not presented during the scientific workshops) (Fig. 8.5). In addition, peer reviews are publications in the Tanzania Journal of Science (volume 30, special issue on Lake Victoria and two papers from the normal issue). In addition, there are 23 chapters for two books

(Biodiversity of Lake Victoria: Its Conservation and Sustainable Use and The Biology and Ecology of Lake Victoria Fishes: Their Development and Management). LVFRP produced 17 technical documents containing several papers from different disciplines addressed by the project. Other publications on Lake Victoria are explained in section 8.3.12.

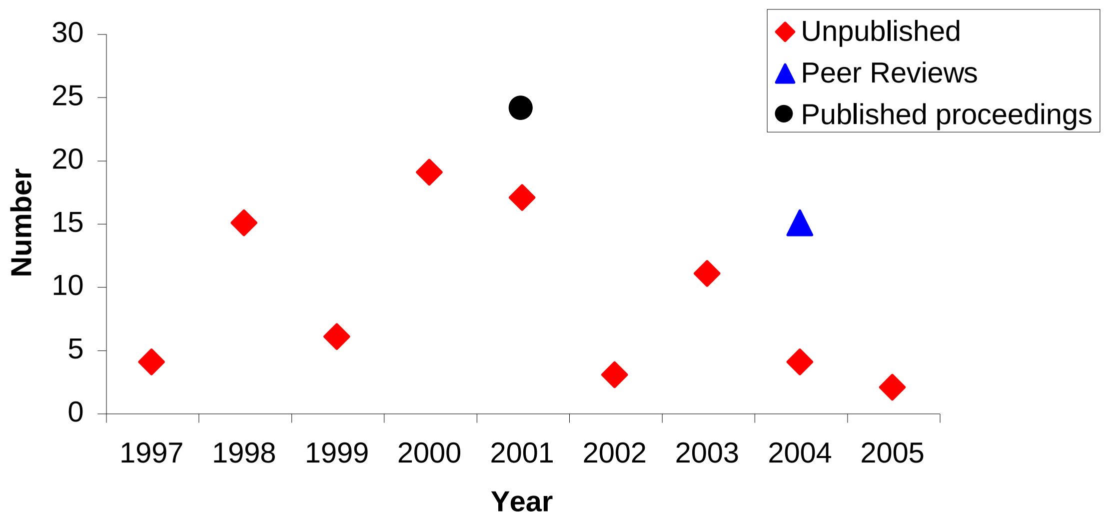



Figure 8.5: Number of publications by LVEMP.

### *8.3.10 Number of Scientists and Managers with Basic Scientific Database Knowledge*

As regards to basic computer skills all scientists and managers at BSc and above have basic computer skills and can work independently except six out of sixty nine. In addition, five-district fisheries officers out of fourteen can work independently using computers. However, as regards to basic scientific database knowledge the number is reduced to six out of sixty nine, distributed equally between research and management.

### *8.3.11 Library Facilities*

Library materials (books, journals etc.) are still few to suffice ever-increasing demand for information by scientists and managers (Fig. 8.6). The library has been receiving books, periodical and journals from various sources, some of which are donor-funded projects (LVFRP, LVEMP) and training institutions abroad that have collaboration with the fisheries institutes in Tanzania, like Agricultural University of Wageningen and others.

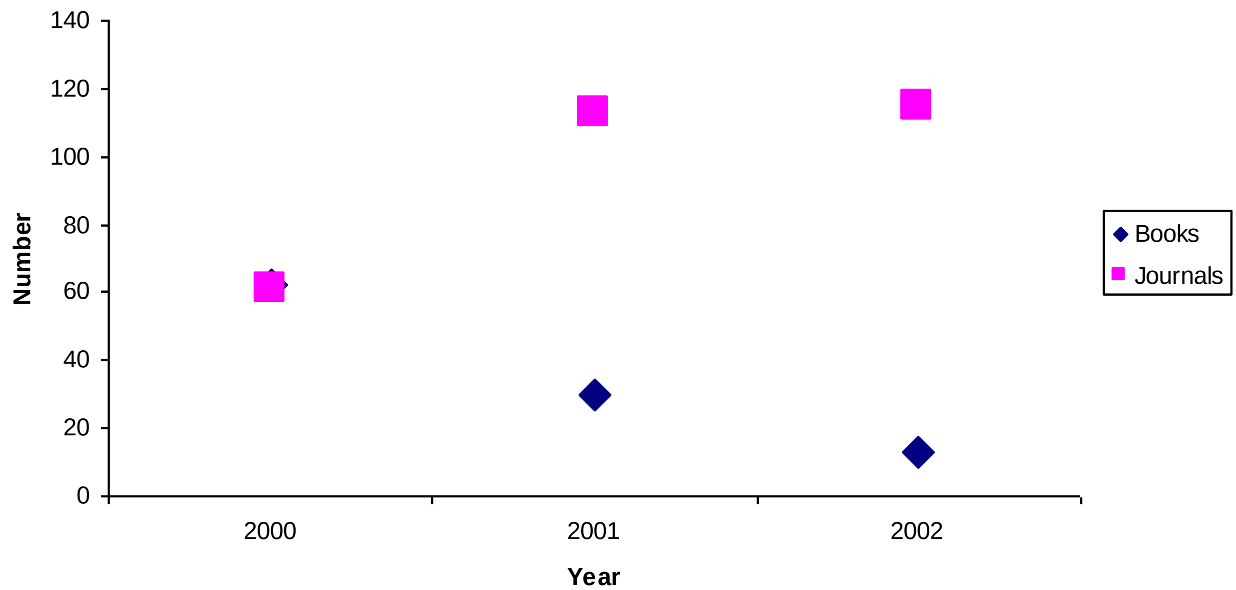



Figure 8.6: Number of books and journals held in TAFIRI library.

### *8.3.12 Number of Lake Victoria Bibliographies Available*

A number of bibliographies has been downloaded from the Internet and stored in the reference manager database. In addition, bibliographies from conferences like Lake Victoria 2000, National and Regional Scientific Conferences under LVEMP, GLOW III, theses, technical documents, national (Tanzania Journal of Science), regional (African Journal of Tropical Hydrobiology and Fisheries) and international journals have been very instrumental sources. Moreover, Acere *et al.* (1989a,b), Crul *et al.* (1988, 1995) and LVFRP (1999) were reviewed to enrich the current bibliography version. Acere *et al.* (1989a) (1467 entries), Acere et al. (1989b) (570 entries) were merged to produce Crul et al. (1995) with 2180 entries, repeated references were deleted. The current bibliography that was last updated in 2002 has 1519 entries with six categories (Table 8.5) and a regional harmonisation of bibliographical categories has been achieved (Table 8.6).

Table 8.5: Number of bibliography by category.

| **Category** | **Number** |
|---|---|
| Fish biology and biodiversity conservation | 899 |
| Environmental pollution | 111 |
| Hydrology, geology and climate | 41 |

| Category | Number |
|---|---|
| Limnology, ecology and wetland ecosystems | 114 |
| Aquaculture | 61 |
| Socio-economics | 293 |

Table 8.6: Consolidated classification of bibliography.

| Major categories | Sub categories |
|---|---|
| Fisheries | Biology and ecology |
| | Stock assessment |
| | Taxonomy/morphology |
| | Genetics |
| | Statistics |
| | Gears and methods |
| Aquaculture | Feeds formulation |
| | Pond management |
| | Seed production |
| | Fish breeding |
| | Brood stock |
| | Cage culture |
| | Polyculture |
| | Integrated fish farming |
| Socio economic | Fishing communities |
| | Marketing |
| | Human health/Nutrition |
| Post harvest | Fish handling and processing |
| | Fish quality |
| Environment | Hydrology |
| | Geology |
| | Limnology |
| | Wetlands |
| Biodiversity and conservation | Birds |
| | Mammals |
| | Reptiles |
| | Amphibians |
| | Fish |
| | Macrophytes and Microphytes |
| | Macro- and Microinvertebrates |
| Capacity building | Extension/Training |
| Generalities/Others | This part will capture any other papers, covering issues on management |

### *8.3.13 Number of Subscriptions to Scientific Journals*

Scientific journals are valuable sources of scientific and management information of aquatic resources. The library has been receiving journals in hard copies through LVEMP that subscribed to 15 journals for 2001 and 2002 (Table 8.8).

Table 8.8: List of journals subscribed by TAFIRI.

| Year | Journal |
|---|---|
| 2001/2002 | Hydrobiologia: The International Journal on Limnology and Marine Sciences |
| | The Journal of Systems and Software |
| | Aquaculture International |
| | Aquatic Botany |
| | Environmental Pollution |
| | Journal of Animal Ecology |
| | Bulletin of Environmental Contamination and Toxicology |
| | Behavioural Ecology |
| | Reviews in Fish Biology and Fisheries |
| | Environmental Biology of Fishes |
| | Ecology Letters |
| | Journal of Ecology |
| | Aquatic Biology and Ecology |
| | Soil Biology and Biochemistry |

### *8.3.14 Number of Digitised Old and New Literature Sets*

The library and information centre does not have the capacity to digitise literature. However, a number of literature sets has been downloaded via the Internet and stored in the library both in hard copies and digital form (CD-ROM). In addition, a number of literature sets has been received in CD-ROMs from FAO, Limnology of Great Lakes and Great Lakes of the World (GLOW) (Table 8.9).

Table 8.9: Number of digital literature sets.

| Year | Journal/CD-ROM | Number |
|---|---|---|
| 2000 | FAO | 1 |
| 2001 | FAO | 1 |
| 2002 | FAO, GLOW | 2 |
| 2003 | Marine Biology | 136 |
| | Aquaculture | 167 |
| | Fish Biology | 120 |

| Year | Journal/CD-ROM | Number |
|---|---|---|
| | FAO | 1 |
| 2004 | Limnology of Great Lakes, FAO | 2 |
| 2005 | Limnology of Great Lakes | 5 |

## 8.3 Discussion

The number of BSc holders increased from 1980 to 1985 and then dropped drastically up to 1990. This is due to government policy of freezing employment hence there was no recruitment during the period. From 1990 to 1995 a sharp increase is observed due to government policy of replacement of staff after death of an employee. During this time also, HIV/AIDS related deaths were on the rise in all sectors. In addition, donor-funded projects increased and trained a number of staff. Lack of funding was also observed through MSc and PhD trend, as fund started to flow through projects, the number increased sharply. For instance, fisheries had only one PhD holder up to 1999 when a second PhD was obtained. But, between 2000 and 2005 five PhDs were acquired through donor-funded projects. Therefore, number of staff with BSc, MSc and PhD correlates with the number of fisheries related projects.

It was not possible to establish the time a staff had acquired basic computer skills. It was however agreed to look at the current status of which all managers and scientists having BSc and above were assessed. It was found that almost all scientists and managers have basic computer skills and can work independently. Moreover, further training in the area of data handling, processing and storage is required.

A lot of information has been collected and published since 1927 when the first survey was conducted (Graham, 1929). The number of publications reported herein (Tables 8.5, 8.6 and Fig. 8.5) is by no means exhaustive. The importance of Lake Victoria is not only manifested by the number of publications, but also by the number of visitors to the fisheries offices (Fig. 8.2). It is observed that number of foreigners (scientists) increased drastically between 1999 and 2000, and decreased gradually thereafter. Politicians have also shown an interest to visit the fisheries offices mostly to get information that might guide them in making informed decisions as far as the management of the Lake Victoria is concerned. The increase in the number of visitors can be attributed to awareness campaign by LVEMP and Fisheries Division. Students, media and teachers and lecturers from training institutions have also shown an interest in the Lake Victoria.

The librarians at the newly established Fisheries Library at TAFIRI Mwanza lack experience as far as management, information exchange and document delivery are concerned. The library has two librarians trained at certificate level since 1998. The workload is very high for the current number of staff and recruitment and training of the current staff is necessary. In addition, the number of materials (Fig. 8.6) is still very low which discourages scientists and managers alike from visiting the library.

## 8.4 Conclusions

Research and management activities require information and database. This can be achieved by increasing capacity for capturing, processing, storing, retrieving and publishing information on the Lake Victoria, hence having informed stakeholders who can participate fully in the management process. This calls for more investment in building the capacity, both technical and human, to efficiently and effectively manage information generated through various activities in and around Lake Victoria.

## 8.5 Recommendations

- Fisheries have inadequate number of personnel with basic scientific database management. Therefore, the ministry should set aside enough funds for training.
- Establishment of LAN to all fisheries offices should receive attention. LAN will facilitate access to e-journals, books and other related resources, thus cutting down the budget for stocking hard copies.
- Fisheries research and management still need powerful computers, specialized software and databases for thematic areas not adequately covered by the SAMAKI database.

# CHAPTER NINE

## HISTORICAL TREND IN FISHERIES MANAGEMENT

*R.B. Hoza[1], Y.D. Mgaya[2] and P.O.J. Bwathondi[3]*
*[1]Fisheries Division Headquarters*
*P.O. Box 2462, Dar es Salaam*
*[2]University of Dar es Salaam*
*Faculty of Aquatic Sciences and Technology*
*P.O. Box 60091, Dar es Salaam*
*[3]Tanzania Fisheries Research Institute*
*P.O. Box 9750, Dar es Salaam*

## 9.1 Introduction

The management of the fisheries of Lake Victoria has had several failures and successes. The failures have been attributed to the inability of carrying out the management exercises due to lack of knowledge upon which to base the management plan or due to the illiteracy among the stakeholders and the attitudes of the then colonial rulers on the management of the fishery of the lake. For example, during the colonial era (before independence in the years 1950 – 1953) the colonial government had un-harmonized different laws and regulations on the fisheries of the three riparian States of Kenya, Tanganyika and Uganda (Lake Victoria Fisheries Service, 1953) Fisheries. Whereas Kenya and Uganda had Fish and Crocodile Act to govern the fishery in the two countries / Kenya and Uganda in Tanzania, there was the Fisheries Ordinance and Trout Protection Ordinance (Tanganyika Territory, 1950) to control the fisheries of the then Tanganyika Territory. The colonial rulers considered fish as a native food and of little economic value. Therefore the management of the fishery took less government intervention.

Attempts to manage the lake date as far back as 1927 when the first survey was conducted by Graham (1929). At that time, it was noted that the gillnet fishery was negatively affecting the stocks. Thus a minimum mesh size of 5 inches was set by 1933. However, gillnets were first introduced in the Tanganyika waters of Lake Victoria in 1908 at Mwanza (Fisheries Division, 1965). When gillnets were introduced to Lake Victoria the fishery was mainly subsistence with only a small percentage for sale in the local market. But as the demand for fish increased more fish were harvested and this resulted into an over fishing in the lake.

It is argued that by 1953, the introduced seine nets (which were long drag nets) contributed to the decrease in catches in the lake. It was reported that controlling the prices as was the case for Kenya and Tanganyika reduced the number of fish landed in the markets in Mwanza and Kisumu. In Uganda, however, the prices for tilapia were not controlled hence the landings increased.

Prior to 1953, the Kenyan rules governing the management of Lake Victoria had not been harmonized with those of Tanganyika and Uganda. This led to allowing the use of 2½ inches mesh size gillnets. These nets were proved un-harmful to the Tilapia stocks and additionally these nets also caught other fishes, which were either predators or competitors to the tilapias. The use of seine nets was allowed in the lake until otherwise found necessary to curtail. In Tanganyika, the licensing was hampered by lack of ground support, particularly vessels and less staffing. As a result of this most fishermen fished without fishing license. It should be remembered that the Rules and Regulations were not effective prior to 1951. In Uganda, the use of 4 inches was considered illegal. The mosquito nets were in use even before 1955. Implementation of the ban of illegal nets was difficult in Uganda since then nets were made of synthetic fibers as such can be left in the water for longer hours/days and only lifted to remove the fish and then put back to the water. In Addition, the Colonial Government established Lake Victoria Fisheries Board, which was mandated to provide recommendations for the management of the fishery resources of Lake Victoria. For example in 1956 the board had a meeting to review the mesh sizes of gillnets in the lake (Lake Victoria Fisheries Service, 1953 and 1955/1956).

It has been recorded that fishers in the Tanganyika waters were licensed by the local authorities because of inadequate staff. As a result a large number of fishers were operating without licences and caused discontent among those who were licensed.

The future of fisheries development in Tanzania commenced in 1965 when the Fisheries Division was established under the Ministry of Agriculture. A Director was appointed and an Administrative structure was designed, to administer the Fisheries and to implement the development plans. The major activities, which were carried out by the Fisheries Division, were Training. In Mwanza the regional Fisheries Officer was responsible for training since 1960/61 and by middle of 1965 there were 24 pre-service students, 20 trainees from the Tanganyika African National Union (TANU) Youth Fishing Unit, 14 Fishermen and 12 Leaner-boat-builders. However, there were no fisheries training facilities, no equipment and no teachers at Nyegezi apart from board and lodging. However, Nyegezi Training Institute became the nucleus of the Ministry of Agriculture and training started and by the end of the year the number of trainee increased to 41 pre-service students, 15 National Service-men, 24 fishers and 12 Learner-boat-builders. Furthermore plan however, were made to establish a Certificate Fisheries Training Centre for field staff and fishers at Mbegani, Bagamoyo and a Diploma level Training Institute for Field Officers at Kunduchi, Coast region. Mbegani Training Center and Kunduchi Training Institute became operational in 1966.

## 9.2 Justification

The management of fishery resources in Tanzania can be divided into four historical periods. The pre-colonial period, when the fishery resources were managed under traditional rules. During that period human destruction was minimal because the demand of fish and fishery products was low because the population was small, processing and preservation methods and transportation network was poor. This period was followed by the colonial period when some fisheries regulations were enforced in the Great Lakes and certain rivers with introduced exotic fish species like the trout. In general the fishery was characterized by poor traditional fishing methods, very few motorized fishing vessels, poor fishing processing and preservation methods. This period was followed by two post-independence periods: the State owned economy (1961-1985), and the Liberalised economy (1986-2005). Evolution of fisheries management under the four periods is described in Table 9.1

Based on the trends of the decline in the stocks, all the riparian states have embarked on effect Litive fisheries Monitoring, Control and Surveillance (MCS) programme. Currently the programme is geared towards education the stakeholders on the effects of destructive fishing gears and methods and the destruction of such gears. Since the intensive MCS exercise is hardly more than 6 months old, one may not speak of its success. However, field results are confirming that the stock size particularly the young fish are increasing. This is positive and should be encouraged.

The stock assessment project carried out by the European Union (EU) – Lake Victoria Fisheries Research Project (LVFRP) revealed further that the stocks are declining. It is worldwide knowledge that different scientists develop and use different tools for stock assessment. Usually, different tools are developed to deal with different stocks. The data obtained by LVFRP (2001) gave alarming information on the deterioration of the sex ratio of the Nile perch with only a handful of mature females. If this is the case, then the recruitment pattern of fish in the lake may be adversely affected by the capture of large females. To save the breeders, it has been recommended by the LVFRP project to institute a slot size of 50 – 85 cm TL for Nile so that the large females may be given the chance to spawn. The riparian states have been enforcing the slot size of Nile perch since 2000.

## 9.3 Results

Table 9.1: Evolution of Lake Victoria fisheries management during colonial and post-independence periods.

| | Issue/Event | Status | | |
|---|---|---|---|---|
| | | Colonial | Post independence | |
| | | Before 1961 | 1961 – 1985 (State owned economy) | 1986 – 2005 (Liberalized economy) |
| 1 | Extension Service | | | |
| | Training to national Fisheries Staff on extension and management skills | There were no national Fisheries training institutes | Training was provided by Nyegezi, Mbegani and Kunduchi Fisheries Training Institutes and higher and medium training institutes within and outside the country | Training has been provided by Nyegezi, Mbegani and Kunduchi Fisheries Training Institutes and higher and medium training institutes within and outside the country |
| | Training to fishers on long lining, trawling, gillnetting, engine repair and maintenance and gear repair | Nil | Done at Nyegezi Freshwater Fisheries Training Institute (NFFTI) and Fisheries extension staff | Nil |
| | Training to fishers on lift net fishery and live bait fishery | Nil | Nil | Training has been conducted by Fisheries extension staff in collaboration with experienced fishers |
| | Training to fishers, processors and traders on improved fishing methods and improved fish handling and processing | Extension services were provided by colonial staff | Training was provided by national trained fisheries staff | Training continued to be provided by national trained fisheries staff |

| | Issue/Event | Status | | |
|---|---|---|---|---|
| | | Colonial | Post independence | |
| | | Before 1961 | 1961 – 1985 (State owned economy) | 1986 – 2005 (Liberalized economy) |
| | methods | | | |
| | Training to fish inspectors, managers and workers of fish processing plants, Beach Management Units (BMUs) on fish quality control and safety assurance aspects<br><br>Training on Fisheries Policy of 1997 | Nil<br><br>Nil | Nil<br><br>Nil | Training provided by Government, Higher learning and private institutions<br><br>Training provided to Fisheries extension staff |
| 2 | Fisheries Policy and Fisheries Legislation | | | |
| | Documented National Fisheries Policy in place<br><br>National Fisheries Policy harmonized in the riparian states | Nil<br><br>Nil | Nil<br><br>Nil | National Fisheries Sector Policy and Strategy Statement is in place and approved by the Government in 1997. Its overall goal is promote conservation, development and sustainable management of the fisheries resources for the benefit of present and future generations Fisheries Division became the Competent Authority on issues related to fish quality control and safety assurance.<br><br>Nil |
| | National Fisheries Legislation in place | Trout Protection Ordinance Cap. 160 enacted in 1929 provided for the protection of species in highland streams | Fisheries Act No. 6 of 1970 provides for the Minister to make Regulations for the | GN 276 of 1.9.1989 prohibits possessing and using of poison to kill fish.<br>GN 369 of 10.3.1994 prohibits to use |

| | Issue/Event | Status | | |
|---|---|---|---|---|
| | | Colonial | Post independence | |
| | | Before 1961 | 1961 – 1985 (State owned economy) | 1986 – 2005 (Liberalized economy) |
| | | for sport fishing and did not cover Lake Victoria.<br><br>Fisheries Ordinance No. 36 enacted in 1950 provided for establishment of Boards for specified water bodies. Such Boards were empowered to make their own Regulations and<br>did not cover Lake Victoria<br><br>Regulations to control fish nets in Lake Victoria became effective since 1951 | protection, conservation and wise use of natural resources. Regulations relevant to Lake Victoria include:<br>GN 5 of 21.1.1982 prohibit fishing in closed fishing areas<br>Local Government (District Authorities) Act No. 7 of 1982 Section 169<br>Local Government (Urban Authorities) Act No.8 of 1982 Section 71 provides for Local Government to manage fishery resources in their jurisdictions. | beach seine nets, Dagaa nets <10 mm and gillnets < 5”<br>GN 370 of 7.10.1994<br>Prohibit use of trawl nets<br>GN 189 of 6.6.1997 Amendment of fines from TShs 20,000 to 100,000<br>GN 624 of 9.10.1998 20<br>Amendment of fines to not less than TShs 300,000<br>GN 193 of 1.8.2003 prohibit fishing and sale of Nile perch < 50cm – >85cm total length (slot size)<br>GN 300 of 8.9.2000 Fish Quality Control and Standards Regulations 2000,<br>Fisheries Act No. 22 of 2003 provides for the Minister to be responsible for policy formulation and implementation of the Act for sustainable conservation, development and management of fishery resources |
| | Registration and licensing of fishing vessels and licensing of fishers | Done under Colonial Regulations | Done under Fisheries Act No. 6 of 1970 | Done under Fisheries Act No. 6 of 1970 and Fisheries Act No. 22 of 2003 |
| | National Surveillance Unit in place | Nil | Nil | Established under the Fisheries Act No. 22 of 2003 |
| | National Fisheries Development Fund in | Nil | Nil | Established under the Fisheries Act |

|  | Issue/Event | Status | | |
|---|---|---|---|---|
|  |  | Colonial | Post independence | |
|  |  | Before 1961 | 1961 – 1985 (State owned economy) | 1986 – 2005 (Liberalized economy) |
|  | place<br><br>Co-management in place<br><br>Fish Levy Trust Fund for Lake Victoria in place<br><br>National Fisheries Legislation harmonized | <br><br>Nil<br><br>Nil<br><br>Nil | <br><br>Nil<br><br>Nil<br><br>Nil | No. 22 of 2003<br><br>Incorporated in the Fisheries Act no. 22 of 2003<br><br>National Fisheries Development Fund established under Fisheries Act No.22 of 2003<br><br>Establishment of Fish Levy Trust Fund for Lake Victoria is at different stages of implementation<br><br>Areas of harmonization have been identified and Tanzania has incorporated those areas in the Fisheries Act No. 22 of 2003 |
|  | Lake Victoria Convention in place | Lake Victoria Fisheries Service | Nil | The Convention was signed in 1994 by the riparian states. Article XVIII of the Convention provides for the Organization to perform any legal act that is necessary for carrying out of its functions. |
| 3 | Fish quality control and safety assurance | | | |
|  | Traditional and improved fish handling and processing methods | Traditional smoking, smoke kiln, salting and sun drying | Traditional smoking, smoke kiln/or Chorkor kiln, salting, sun drying | Traditional smoking, Chorkor kiln, salting , sun drying, chilling, freezing and introduction of insulated |

| | Issue/Event | Status | | |
|---|---|---|---|---|
| | | Colonial | Post independence | |
| | | Before 1961 | 1961 – 1985 (State owned economy) | 1986 – 2005 (Liberalized economy) |
| | | | and an experimental processing plant was established at NFFTI. | containers for holding fish |
| | Industrial fish processing | Nil | One plant was established in Mwanza to process Haplochromis | 11 Nile perch processing plants have been established in Lake zone regions and by 2005 eight establishments are operational |
| 4 | Fish marketing for export trade | | | |
| | Fish export market in East Africa | Smoked and salted fish of indigenous fish species were exported to Kenya and Uganda | Smoked, salted and sun dried fish indigenous and exotic fish species were exported to Kenya and Uganda, | Smoked, salted and sun dried fish indigenous and exotic fish species have been exported to Kenya and Uganda |
| | Fish export market outside East Africa (Smoked and salted Nile perch and *Rastrineobola argentea)* | No smoked and salted fish of indigenous fish species were exported outside the country | Smoked, sun dried and salted fish of exotic and indigenous fish species were exported to Burundi, Rwanda and Zaire | Smoked, sun dried and salted fish of exotic and indigenous fish species have been exported to Burundi, Rwanda, Zambia, Malawi and Zaire |
| | Fish export of fresh, chilled and frozen Nile perch and its products | Nil | Fresh Nile perch were exported to Kenya | Chilled and frozen products of Nile perch have been exported to Europe, Asia, Australia, Middle East, USA, etc. |
| 5 | Aquaculture | | | |
| | Training to Fisheries extension officers | Nil | Training was provided | Training have been provided by |

| | Issue/Event | Status | | |
|---|---|---|---|---|
| | | Colonial | Post independence | |
| | | Before 1961 | 1961 – 1985 (State owned economy) | 1986 – 2005 (Liberalized economy) |
| | (long and short courses) and farmers | | by NFFTI and Fisheries extension staff | NFFTI, Higher and medium learning within and outside the country and Fisheries extension staff institutions |
| | Establishment of fingerlings breeding ponds | Nil | NFFTI, Malya and Rwamishenye fish breeding ponds were established | Nyegezi (TAFIRI), NFFTI and several farmers have been producing fingerlings to farmers |
| | Aquaculture development strategic plan in place | Nil | Nil | Draft is in place and will be completed by end of November 2005 |
| 6 | Fisheries collaborative management (Co-management) | | | |
| | Co-management introduced in major and minor waters | Nil | Nil | 511 Beach management Units (BMUs) established from 1998 to 2000 in Kagera, Mara and Mwanza regions |
| | Self and joint patrols between BMUs and Fisheries Staff in place | Nil | Nil | Both self and joint patrols are being conducted |
| | BMUs participate in maintenance of beach hygiene and sanitation and management of floating barges | Nil | Nil | Beach hygiene and sanitation in 575 (2004 Lake Victoria Frame Survey) beaches are being maintained by BMUs and ten floating barges are being managed by BMUs |
| | National BMU operational manual in place | Nil | Nil | The manual has been printed and distributed to Lake Victoria zone and riparian states. Distribution to other |

| | Issue/Event | Status | | |
|---|---|---|---|---|
| | | Colonial | Post independence | |
| | | Before 1961 | 1961 – 1985 (State owned economy) | 1986 – 2005 (Liberalized economy) |
| | | | | regions in Tanzania is ongoing as well as its translation into Kiswahili. |
| | National guidelines for establishing BMUs in place | Nil | Nil | Final draft is in place and final document will be printed and distributed by end of November 2005 |
| 7 | Fisheries Association | | | |
| | Fishermen's Association in place | Nil | Fishermen's Associations/Co-operatives were formed in Kagera, Mara and Mwanza regions | Most of the Associations/Co-operatives died a natural death. However, fish traders have started to establish associations/co-operatives but fishers are not involved. |
| | BMUs Savings and Credit Co-operatives Societies (SACCOS) in place | Nil | Nil | BMUs have started to establish SACCOS in Kagera, Mara and Mwanza regions and are at different stages of registration |
| 8 | Research and Development | | | |
| | Biological, limnological, stock assessment, and socio-economic studies | Done by East African Freshwater Fisheries Research Organization (EAFFRO) and private individuals | Carried out by EAFFRO and International Organizations and private institutions and individuals | Carried out by TAFIRI, Fisheries Division, higher learning and private institutions and International Organizations within and outside the country |
| | Lake Victoria Fisheries Organization (LVFO) in place | Nil | Nil | Established by a convention signed by the three countries in 1994 |
| 9 | Regional and National Projects | | | |
| | Haplochromis Ecological Survey Team | Nil | Conducted taxonomy, | Conducted taxonomy, ecological |

| | Issue/Event | Status | | |
|---|---|---|---|---|
| | | Colonial | Post independence | |
| | | Before 1961 | 1961 – 1985 (State owned economy) | 1986 – 2005 (Liberalized economy) |
| | (HEST) funded by the Netherlands Government | | limnological and ecological studies on Haplochromis, Nile perch and *Rastrineobola argentea* on the main lake | studies and limnological studies on Haplochromis, Nile perch and *Rastrineobola argentea* |
| | Inland Fisheries Planning, Development and Management in Eastern/Central/Southern Africa (IFIP) – FAO and UNDP funded project | Nil | Nil | Conducted socio-economic studies<br>Procured research equipment |
| | Lake Victoria Fisheries Research Project (LVFRP) - EU funded project phase 1 | Nil | Nil | Long and short courses were provided to TAFIRI staff. |
| | Lake Victoria Fisheries Research Project (LVFRP) EU funded project phase 2 | Nil | Nil | Conducted fish stock assessment on Nile perch and *Rastrineobola argentea,* limnological and socio-economic studies on the main lake only |
| | Lake Victoria Environmental Management Project (LVEMP) World Bank and GEF funded project | Nil | Nil | Field and research equipment have been procured and training (long and short courses) have been provided to Project Staff.<br><br>Management interventions have been executed by Government implementing institutions |

| | Issue/Event | Status | | |
|---|---|---|---|---|
| | | Colonial | Post independence | |
| | | Before 1961 | 1961 – 1985 (State owned economy) | 1986 – 2005 (Liberalized economy) |
| | | | | Biological, ecological, limnological and biodiversity studies on both main lake and satellite lakes, Socio-economic, Aquaculture and information and data base studies have been conducted |
| | International Union for Conservation of Nature (IUCN) project | Nil | Nil | Socio-economic studies and training to BMUs were conducted |
| | Implementation of Fisheries Management Plan (IFMP) Project | Nil | Nil | Field and research equipment will be procured<br><br>Management interventions are at different stages of implementation by relevant institutions<br><br>Stock assessment, trawl, hydro–acoustic, gill net, experimental fishing, catch assessment surveys, biological and environmental data collection are at different stages of implementation<br><br>Capacity building is at different stages of implementation |

## 9.4 Discussion

The riparian communities of Lake Victoria, the Partner States and the global community are benefiting in one way or another from the fishery resources of the lake. However, there are environmental threats, which include rapid deterioration of the lake water quality due to increased nutrients and effluents discharges from towns and industries around the lake. Infestation of the lake by water hyacinth, increased nutrient enrichment and effluents discharges, increased algal growth is causing de-oxygenation, threatening the artisan fisheries and biodiversity, disappearance of indigenous fish species, mismanagement and destruction of wetlands among others (GoK/GoU/GoT, 1996). All these environmental concerns lead to loss of lake biodiversity and short and long term socio-economic benefits and values to the people and the country as a whole.

### *9.4.1 Extension Service*

The fundamental handicap to fisheries development includes inadequate capital and education, and poverty is a barrier to development (Fisheries Division, 1968). Prior to independence in 1961 there was no National Fisheries training institutes. Since the establishment of Fisheries Division in 1965 training has been provided within and outside the country. Fisheries staff have continued to advise and train fishers on the establishment of Fisheries Associations, adoption of improved fishing methods, preservation and processing and handling methods, aquaculture development, beach sanitation and hygiene.

### *9.4.2 Fisheries Policy and Fisheries Legislation*

Fisheries Policy provides guidelines for fisheries conservation, protection, development and management in the sector. Prior to independence there was no documented National Fisheries Policy. The Fisheries Division was officially established in 1965 under the Ministry of Agriculture. In 1997 the First National Fisheries Sector Policy and Strategy Statement was launched by the Government. The overall goal of the National Policy is *to promote conservation, development and sustainable management of the fisheries resources for the benefit of present and future generations.*

The Trout Protection Ordinance was enacted in 1929 (Tanganyika Territory, 1929) with the aim of protecting trout in 24 streams in the country (Trout Protection Ordinance, 1929). However, the Trout Protection Ordinance was found to be inadequate and the Colonial Government enacted the Fisheries Ordinance in 1950 (Fisheries Ordinance, 1950). The Ordinance dealt primarily with Marketing Boards and Lake Victoria was not governed by the Ordinance.

The fisheries of Tanganyika continued to operate under the colonial law until after independence in 1961 after which in 1970 a new Fisheries Act was instituted. Under the Fisheries Act of 1970 a number of regulatory issues were included and Fisheries Regulations were developed to ensure smooth implementation of the Act (Table 9.1). The Fisheries Act No. 6 of 1970 provides for the Minister responsible for fisheries wide powers to manage, protect and develop the fishery resources (Fisheries Act, 1970) Since the Act was instituted during the One-Party System, a number of issues were addressing the National Policy on Socialism and Self-reliance. The approval of the Fisheries National Policy in 1997 by the Government and the changes made by the Government on developing national economy from state owned to liberalized economy forced the Fisheries Division to repeal and replace the Fisheries Act No. 6 of 1970 with a new Fisheries Act No. 22 of 2003. The new Act provides for the Minister to be responsible for policy formulation and implementation of the Act for sustainable conservation, development and management of fishery resources (United Republic of Tanzania, 2004).

The management of fishery resources of Lake Victoria requires joint management and common strategies through harmonized National Fisheries Policy and Legislation. The Partner States have initiated the process to harmonize the National Fisheries Legislation and the implementation is at different stages of implementation. The three countries have signed a convention for the establishment of Lake Victoria Fisheries Organization (LVFO) which entered into force in 1996. The objective of the Organization *'shall be to foster cooperation among contracting Parties, harmonize national measures for sustainable utilization of the living resources of the lake and develop and adopt conservation and management measures* (LVFO, 2001).

### *9.4.3 Fish Quality Control and Safety Assurance*

Fish deteriorate rapidly after catching and therefore it is essential to preserve fish immediately after catch so that it can be processed, exported, transported to distant domestic markets or consumed later. The traditional fish processing methods that were used in Lake Victoria included fish smoking. However, the products, which came from the traditional methods, were of poor quality and processed fish did not last longer. Smoke kiln was introduced by 1950's to improve the traditional method (Lake Victoria Fisheries Services, 1953).

After independence fisheries extension services were strengthened and more improved fish processing and handling methods such as salting, chorkor kiln, freezing and chilling were introduced. Important processing methods include fish smoking using chorkor kiln and salting for both Nile tilapia and Nile perch, sun drying for *Rastrineobola argentea (Dagaa)*, icing for Nile perch and Nile tilapia. In addition, modern preservation methods are being applied for the processed fillets in the processing plants; these include chilled and frozen products for the domestic and export markets.

### *9.4.4 Fish Marketing for Export Trade*

In 1965 it was reported that the Tanzanian part of Lake Victoria contained the most important commercial fisheries in East Africa. In addition to supplying fish to local markets, fish was exported to Kenya and Uganda. In 1968 the export of processed fish from West Lake region to Uganda went down, but exports were made to both Kenya and Uganda from Ukerewe Island (Fisheries Division, 1968). It was observed that there were high demands of fish for the two neighbouring countries, which could be met by Tanzanian production. However, it was reported that poor roads, communication and distribution facilities hindered the distribution of fish to different market designations. In addition lack of capital often limits their capacity to buy in bulk as well as poor fish processing methods.

Fish and fishery products from Lake Victoria took a new trend in mid 1980's when the Nile perch boom was observed. The export of fresh, smoked, salted Nile perch and dried *Rastrineobola argentea* to Burundi, Uganda Rwanda, Zaire and Kenya increased the income earnings to the fishers and fishmongers as well as the national income. In early 1992 the Nile perch fish processing plants were established in the lake zone such that fish production on Nile perch increased and Nile perch fillets and other products found market in Europe, Far East, Middle East, and USA among others. The major importers of Nile perch fillets from Lake Victoria include EU countries and in 2004 the total export was 42,354 tones valued at USD 100.1 million and the total Royalty to Fisheries Division was Tshs 6.4 billion (Fisheries Division, 2004).

### *9.4.5 Aquaculture*

During the colonial era there was little effort made to promote aquaculture in Lake Victoria basin. After independence farmers were trained on aquaculture development and two fish breeding ponds namely Malya and Rwamishenye were established. By the end of 1968 there were 705 stocked fish ponds in the Western Lake region (Fisheries Division, 1968). However, from 1970's to early 1990's fish farming activities continued at a lower level until 1997 when fish farming was again promoted and by mid 2005 there were a total of 404 fish ponds in Lake Victoria zone. The major problems in fish farming have been absence of aquaculture development strategic plan, inadequate supply of quality fingerlings, inadequate supply of water in some parts, poor feeding, cropping and stunted growth.

### *9.4.6 Fisheries Collaborative Management*

There is a weakness in enforcing the existing law and regulations in the fishing industry, particularly now when there is an increasing demand of fish for domestic and external markets. Over-fishing, use of illegal fishing gears (beach seines, mosquito nets, under meshed gill nets etc) and other illegal fishing practices are rampant particularly on fish breeding areas, fishing grounds and estuaries. These practices threaten the fishing industry and are contrary to the objectives of the Fisheries Act No. 6 of 1970 that include protection, conservation, development and wise use of the fishery resources (United Republic of Tanzania, 1970).

Fisheries co-management as an alternative to centralized command and control fisheries management is often suggested as a solution to the problems of resource use conflicts and overexploitation. In 1997 the Government realized that it could manage the fishery resources properly in partnership with stakeholders (Fisheries Division, 1997). Collaborative Fisheries Management was introduced for the first time in Mwanza Gulf in 1998 by forming in every landing site a Beach Management Unit (BMU). More than 511 BMUs were formed in all twelve riparian districts by July 2000 (LVEMP, 2001).

Since the introduction of the co-management programme, the Beach Management Units have continued to work in collaboration with Fisheries staff to curb illegal fishing practices, participate in data collection for Catch Assessment Surveys and Frame Surveys, beach hygiene and sanitation, environmental conservation among others. The Fisheries Act 2003 has incorporated co-management. The BMUs members have been empowered to enforce the Fisheries Act 2003 for sustainable management and development of the fishery resources (Fisheries Act, 2003).

### *9.4.7 Fisheries Association*

The attempts to organize fishers to form Fisheries Organization/Association started back in mid 1960's. It was found that most fishermen work in remote areas and were not organized in form of an organization as result they were placed in an unfavorable position. Although fishermen are making reasonable income, individually has no bargaining power and usually fishmongers are exploiting them. Attempts were made to foster co-operation amongst fishermen and one association was officially registered in 1968. In addition, there were unregistered associations; however, the associations had common problems such as lack of capital, poor leadership, and lack of competent and honest managers to run the associations (Fisheries Division, 1968).

Most of these young associations died a natural death and since the inception of Lake Victoria Environmental Management Project attempts have been made to sensitize the fishing communities through the Beach management Units members to establish Savings and Credit Cooperative Societies (SACCOS). The aim is to establish formal Fisheries Associations from grass root level to national level, which will provide a forum for fishers to air their problems, related to fish price and other related issues. These initiatives have started to bear fruits and today there few registered SACCOS such as Kayenze (Ilemela District), Burugu, Kiemba and Suguti (Musoma Rural District) and there are several, which are in the process of registering their SACCOS such as Chole, Kigongo Ferry, and Mwasonge (Misungwi District) (Figure 9.1).

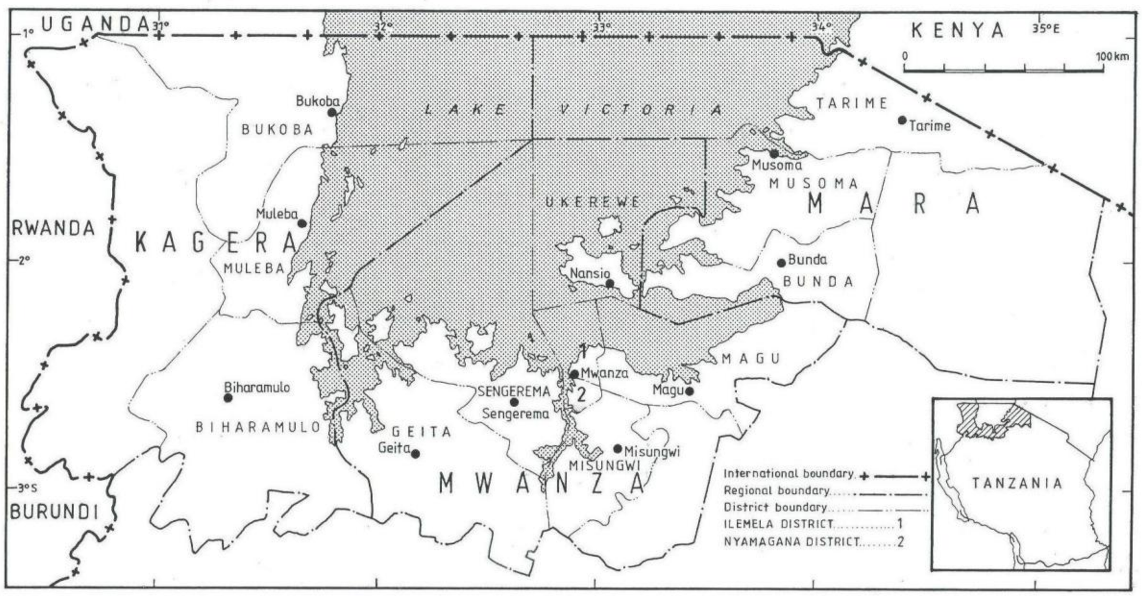



Figure 9.1. Administrative districts bordering Lake Victoria. Some of these districts have established SACCOS.

### *9.4.8 Research and Development*

The Fisheries Division does not undertake research work on fisheries since the colonial era. During the colonial era until 1977 fisheries research work was under East African Freshwater Fisheries Research Organization (EAFFRO) with its Headquarters in Jinja, Uganda. The studies carried out by EAFFRO were on limnology stock assessment, and socio-economics.

Despite the collapse of the EAC in 1977, research on fisheries of the three East African States continued, but now carried out by individual countries. In Kenya Fisheries Research work was carried out by the Kenya Marine and Fisheries Research Institute (KMFRI) whereas in Uganda Fisheries Research work was carried out by the Ugandan Fisheries Resources Research Institute (FIRRI). In Tanzania, Fisheries Research activities were handed over to the Fisheries Research Institute (TAFIRI), which was instituted in 1980 by Act of Parliament No. 6. In 1982 the Government of Tanzania established Tanzania Fisheries Research Institute with an Act of Parliament to take care of fisheries research work in the country. Fisheries Management issues of Lake Victoria were handed over to Food and Agriculture Organization of the United Nations (FAO) under the CIFA – Subcommittee for Lake Victoria (from 1977 to 1994) when the Lake Victoria Fisheries Organization (LVFO) was formed and a convention was signed in 1994 by the three Partner States of Kenya Tanzania and Uganda.

### *9.4.9 Regional and National Projects*

Despite the work done by EAFFRO existing records do not show that before independence there were fisheries research and management projects geared to develop fisheries management activities in the Tanzania part of Lake Victoria. The first project on Lake Victoria was Haplochromis Ecological Survey Team (HEST) funded by the Netherlands Government from mid 1970's to early 1990's. The project conducted research on taxonomy, limnology and ecology of Haplochromines and *Rastrineobola argentea*. Other projects which have been implemented in Tanzania were Inland Fisheries Planning and Development in Eastern/Central/ Southern Africa (IFIP) which dealt with socio-economic studies. The IFIP project was followed by the Lake Victoria Fisheries research project funded by European Union. The project was dealing with capacity building in terms of training and equipment, limnology, stock assessment of *Lates niloticus* and *Rastrineobola argentea* and socio-economic studies. The project developed a fishery management plan for Lake Victoria.

Lake Victoria Environmental Management Project was established by a tripartite agreement signed by the three countries in 1995. The project has been implemented since July 1997 to 31$^{st}$ December 2005. The project has implemented fisheries research and management activities including biological, biodiversity, ecological, aquaculture, socio-economic and information and data base studies. Fisheries management interventions include surveillance, co-management, aquaculture development, frame surveys, fish quality control, curbing fish post harvest losses, Fish Levy trust study among others. The Implementation of Fisheries Management Plan (IFMP) Project is a five-year (2000-2008) regional project funded by EU. It would support fisheries research and management activities (Table 9.1). All these past and ongoing projects have been generating information for fisheries development to support Government efforts towards sustainable conservation, protection, development and management of Lake Victoria fishery resources for the benefit of present and future generations in the three riparian states.

## 9.5 Conclusion

The Lake Victoria fishery, which was initially a multi-species fishery, is now dominated by only three species, namely the Nile perch (*Lates niloticus)*, the Nile tilapia (*Oreochromis niloticus)* and *Rastrineobola argentea*. Due to the complexity of the fishery of the lake and their multi-species character, any sound management strategy should include these three species together with the others. The activities that are necessary for any sound management strategy of the lake should therefore include, fisheries statistics, stock assessment of the species, the biology of the major species, the gears used, socio-economic aspects of the exploitation of the major stocks including their marketing, the status of the ecosystem of the lake basin and non fisheries issues that impact on the lake fishery. To achieve this, the results of the major projects, namely Haplochromis Ecological Survey Team (HEST), Lake Victoria Fisheries Research Project (LVFRP) and Lake Victoria Environmental Management Project (LVEMP) must be analysed and adopted in the management strategy.

Fisheries development in Lake Victoria should foster the use of sustainable harvesting methods, more improved/modern and better fishing gear and equipment. Emphasis should be on the use of inexpensive but effective techniques and equipment through trained fishermen. It should be possible for local people to buy better quality fish regularly when fishing terminals and fish receiving stations are built. These should have provisions for the processing, storage and distribution of fish and fishery products to market places in the country.

## 9.6 Recommendations

Training would equip manpower to do their jobs better and thus meet development targets. Training has to continue at all levels from fishers, small scale and large-scale processors, farmers, Government Staff among others. Publicity has to continue and attempts should be made to communicate with fishers on regular basis, so that they continue to lean aspects of fisheries developments. The same is true for farmers who should be taught on fish farming development, and consumers should be taught about the qualities of fish available. Fisheries Associations/Organizations should be promoted so that they can play a large part in the development process. Establishment of

SACCOS, which is a product of grouping stakeholders into larger units, will create a forum for fishers to negotiate with fishmongers on better fish prices.

The Government should continue to provide guidance on fisheries development through appropriate Policy and Legislation in collaboration with Local Authorities, BMUs/fishing communities, Community Based Organizations, Non Governmental Organizations and the Private Sector, so that the fishery resources of Lake Victoria and its basin are sustainably managed, harvested and developed for the benefit of the riparian communities and the people of Tanzania.

# CHAPTER TEN

# FISHERIES STATISTICS OF LAKE VICTORIA

*F. Sobo[1] and Y.D. Mgaya[2]*
*[1]Fisheries Division Headquarters*
*P.O. Box 2462 Dar es Salaam*
*[2]University of Dar es Salaam*
*Faculty of Aquatic Sciences and Technology*
*P.O. Box 60091, Dar es Salaam*

## 10.1 Introduction

The fishery resources of Lake Victoria have been monitored as early as 1950's (EAHC, 1953). Fisheries catch records have been kept since 1959 and the catches of various species are known with a considerable degree of accuracy (Fisheries Division, 1966). Fish production was estimated from number of fish caught, while the fishing inputs like fishing vessels, fishing gears and fishermen were enumerated. However, the process and methods of how to estimate catches of various species from number of fishes caught were not elaborated (Fisheries Division, 1966).

Initially, East African Freshwater Fisheries Research Organisation devoted a considerable amount of effort in analysis of the fisheries records of the fish caught in Lake Victoria (EAHC, 1959). The organisation assessed the trends in the various fisheries and fluctuations of the fishing effort. The Ministry responsible for fisheries was given a mandate to produce annual fisheries statistical reports following the establishment of Fisheries Division in 1965. Data collection and processing procedures were not standardised during the period 1960's through 1980's. However, in the 1990's FAO came up with a standardised estimation process of using frame survey and sample surveys of catch and effort data from daily catches and related effort.

The Fisheries Division maintains a statistical data collection and processing unit which has evolved in three phases from 1970 as a manual process, then computerised in 1989 and improved in 1993. The three phases are based on a sampling method which is completed by base data from annual frame surveys. Sampling for the first two phases entails a non-random 16 days per month per sampling site involving as many vessels as possible, whereas in the new phase the days are random and involves all vessels which land per day. The advantage of the new system is that it can produce desired periodical estimates whereas the former produced annual estimates only.

## 10.2 Justification

Fisheries statistics is an important tool in the management of fisheries resources. The information obtained from fishing input and output is used in the short and long term management plans. For that matter fisheries statistics must be collected, analysed and managed. It is essential for the management agency that the most appropriate and accurate information for management of the fishery be continously collected, processed and provided in a timely manner. Reliable and accurate information is crucial because only well informed decision makers can make good decisions.

Fisheries statistics of Lake Victoria is important because it is the only way of showing the behaviour of different exploited fish species. The data can tell among other things whether the fishery is at optimal or critical point. Furthermore the data can provide market information, fishing effort, presence or absence of illegal fishing gears among others (Fisheries Division, 2005). The fisheries data collected from Lake Victoria are used in the management of a fishery as well as for commercial and scientific purposes. The data shows exploited fish and associated species, economic information about the fishers and the markets of catches (Fisheries Division, 1967; 1968; 1969). Some of the data which are being collected in Lake Victoria are frame surveys, catch assessment surveys and export information.

### *10.2.1 Frame Survey*

Frame survey is an inventory of fish producing factors such as number of landing sites, number of fishermen, number of fishing vessels and gears by type and size. It is also a description of fishing and landing activity patterns, processing and marketing patterns, as well as describing supply centre for goods and services (FAO, 1998). The frame survey also refers to a fisheries census which is mainly the fishing effort obtained by complete total enumeration. The main objectives of frame survey are:

i. To secure data on the current fishing effort i.e., number of fishermen, fishing vessels, number of fishing gears by type and size and some socio-economic information on available facilities at the landing beaches;
ii. To provide raising factor for estimation of the fish caught when data are collected on sampling basis i.e. to get estimation on fish production;
iii. To provide sampling frames for various surveys being conducted and those to be conducted in the future;
iv. To provide data that can be used for estimation of fish stock (stock assessment).

Before 1960's, frame surveys were not conducted but the number of fishermen and fishing gears were reported as part of fisheries statistics recorded at the fish landing beaches (Fisheries Division, 1967). After the establishment of Fisheries Department in 1965, fisheries frame surveys were conducted on an annual basis from 1967 to 1991 (Table 1) by using fisheries staff. Due to expansion of fisheries activities in Tanzania, the division decided to conduct frame surveys biannually from 1992. However, the surveys were sometimes delayed by lack of funds and logistical problems thus stopping the surveys as was the case during the period 1992 to 1995 and from 1995 to 1998. In 2000, the riparian states sharing Lake Victoria, under Lake Victoria Environment Management Project (LVEMP) and Lake Victoria Fisheries Organisation (LVFO) agreed to conduct harmonised frame surveys simultaneously. From there, the three riparian states agreed to continue with harmonised frame survey so as to avoid double counting of the fishermen as they occasionally move from one landing site to another and even to another country.

### *10.2.3 Catch Assessment Survey (CAS)*

The recorded history of Lake Victoria fisheries starts in the early years of 19$^{th}$ century (EACSO, 1967). Historical data retrieved from Lake Victoria Fisheries Service annual reports show that by 1953 catch assessment surveys were carried out in all fish landing sites lake wide (EAHC, 1958). The data were recorded in data sheets in terms of fish species, number of fish (in pieces) caught, number of fishers and vessels. During the post independence period, fisheries management activities were placed under the Ministry of Agriculture, Forests and Wildlife and Lake Region Fisheries officer was given the task of preparing annual statistics report for the Tanzanian part of Lake Victoria. From 1986 to 1996 the catch assessment survey data were collected only at the selected landing beaches and the data were analysed centrally through computers at Fisheries head office in Dar es Salaam. The data were collected for the whole month involving as many vessels as possible. The collected data were extrapolated with the number of fishing vessels by gear type (from frame survey data) to get the estimated total catch.

## 10.3 Results

### *10.3.1 Frame Survey*

The results of fisheries frame survey from 1967 to 2004 are presented in Fig. 10.1 and Appendix 10.1. Fig. 10.2 indicates an increasing trend in the number of fishermen ($r^2 = 0.83$) and fishing vessels ($r^2 = 0.81$) from 1965 to 2004. The general observation is that, there is an increase in effort on Lake Victoria fisheries activities.

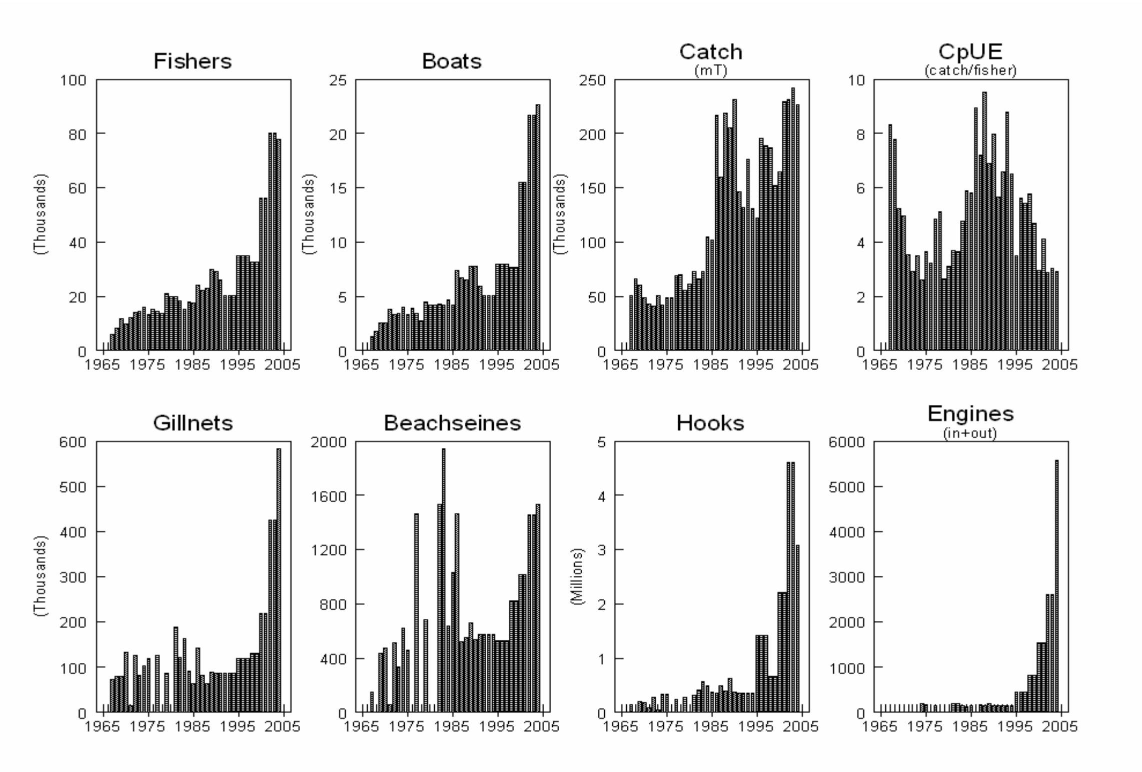



Figure 10.1: Frame survey results for the period 1967-2004.

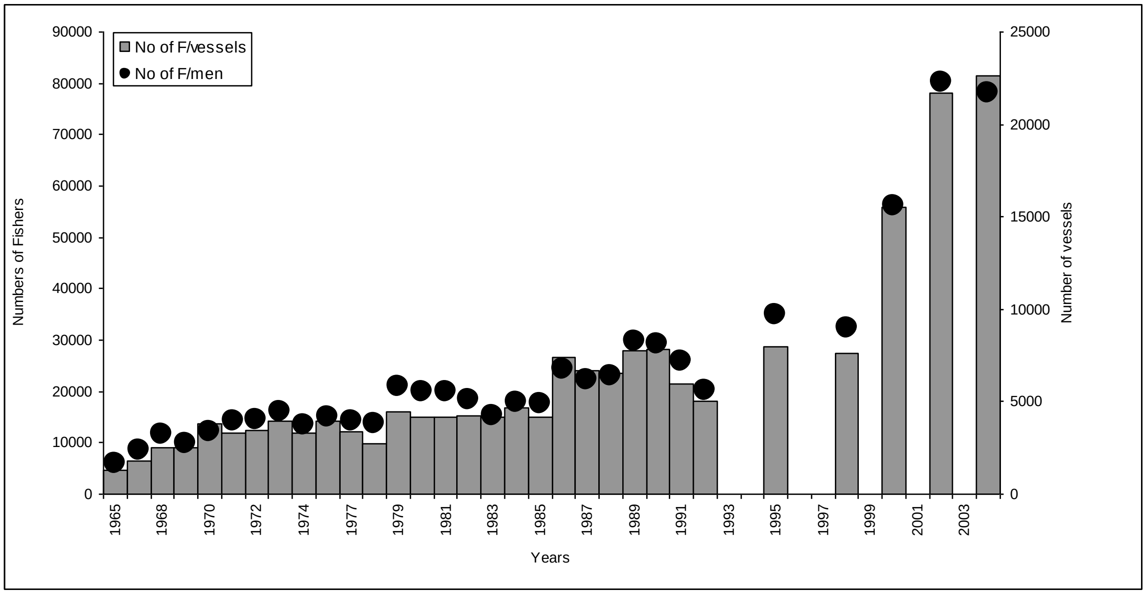
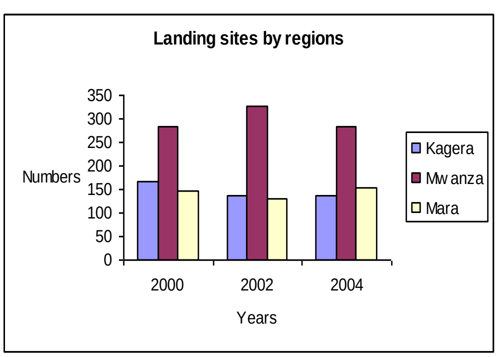



Figure 10.2: Lake Victoria fishing effort 1965 – 2004.

### *10.3.2 Fishing Effort for Regions Bordering Lake Victoria*

Results for the joint frame survey conducted during 2000 to 2004 indicated that, in general, number of landing sites decreased by 4% whereas regionally Kagera and Mara show a slight decrease, followed by a very small increase of landing sites (Fig. 10.3). In Mwanza, the number of landing sites increased by 15% from 2000 to 2002 and then decreased by almost 15% from 2002 to 2004 (Fig. 10.3). In 2004 the number of fishermen dropped by 2,056 from 80,053 to 77,997 recorded in 2002 and 2004, respectively. This was a decrease of 2.6%. The drop was recorded in Mwanza only while Kagera and Mara regions recorded an increase (Fig. 10.4). The regional figures are disaggregated by district and shown in Fig. 10.5. The trend in number of fishing vessels showed an increase in general although in Mwanza there was a drop in fishing vessels (Fig. 10.6).



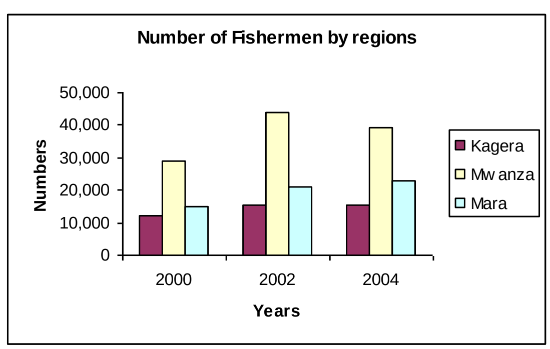




Figure 10.3: Landing sites by regions. Figure 10.4: Fishermen by regions.

According to results obtained in 2004, the mode of propulsion used in Lake Victoria fishing crafts is mostly paddles (63%), followed by motorised (24%) and sailing (12%). The trend for number of outboard engines showed an increase for the period 2002 to 2004 (Appendix 10.1) which indicates that fishers are forced to move further into deeper waters in search of fish than it was before. Fishing gears mostly used in Tanzanian part of Lake Victoria include gillnets of various mesh sizes, longline and handline hooks, scoop nets, lift nets, traps, beach seines and small seines. Total number of gillnets showed an increasing trend during the period 2000–2004 (Appendix 10.1). In most cases the commonly used mesh size is 5″ although the government prohibits the use of small mesh sizes but fishers are still using them. The use of beach seines is also continued although the gear is strictly prohibited to be used in Lake Victoria.

### *10.3.3 Catch Assessment Survey*

Figure 7 shows the estimated fish production of Lake Victoria from 1959 – 2004. Before 1997, the observed data were reliable and accurate since collection and analysis of the data at the Fisheries Division was adequate. The data from 1997-2004 are estimates which are not as accurate since there were no enumerators to collect fisheries data as was the case in the past. Hence the results presented in Appendix 10.1 for the period 1997-2004 were obtained by multiplying average catch per boat landed in reference to estimated figure of the previous year times the number of fishing boats available at the district in question.

CPUE of the most important species i.e. *Lates niloticus,* haplochromines*, Clarias, Dagaa* and the four indigenous species of tilapia were calculated in relation to number of fishing vessels available (Fig. 10.8). The CPUE of *Lates niloticus* increased since the start of it's fishery in late 1980's and showed the highest CPUE of 19.22 mt in 1995 as this was the period of export of Nile perch fillets. During the period 1995 to 2000 the CPUE decreased to 16.07 mt/boat/year, pointing to declining stock size. The CPUE of haplochromines increased slightly from 6.3 in 1970 to 9.9 mt/boat/year in 1975, and decreased to 0.1 mt/boat/year in 1995. This decline might be attributed to heavy predation by Nile perch (Bwathondi, 1987). All species of tilapia showed the same trend of decreasing CPUE from 1970's to 1990's with exception of *Oreochromis niloticus* which peaked in 1985, decreased slightly in 1990's and increased to 2.0 mt/boat/year in 2000.

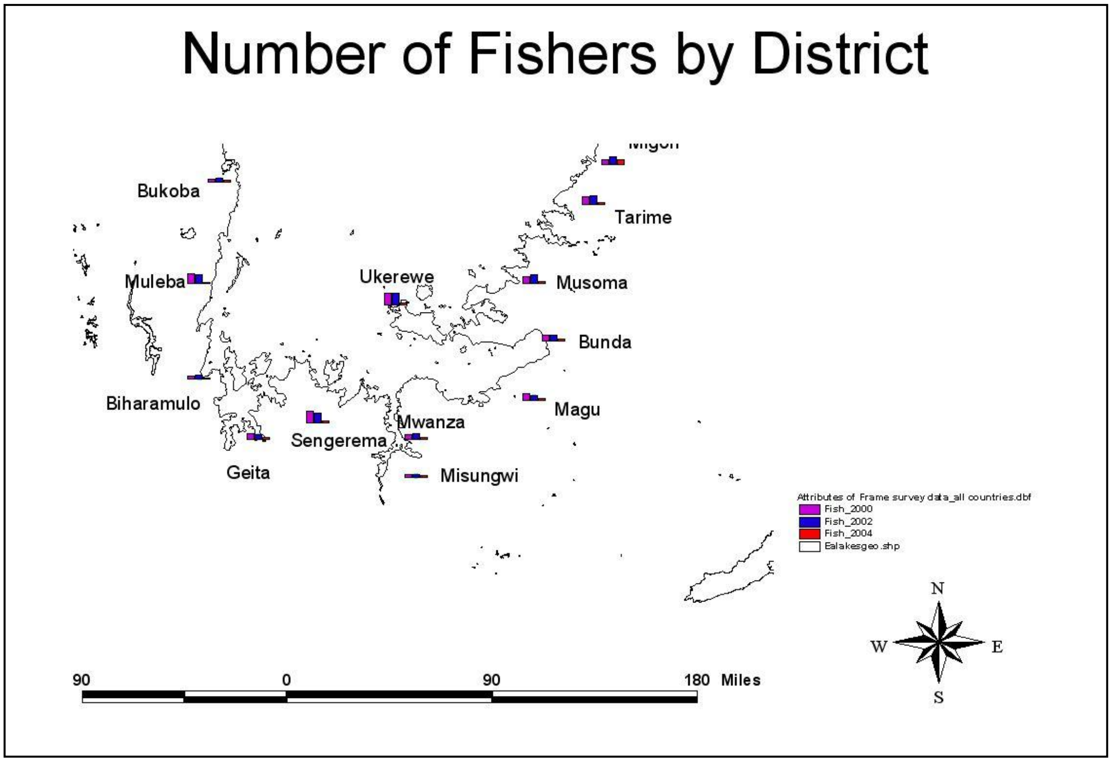



Figure 10.5: Number of fishers by district.

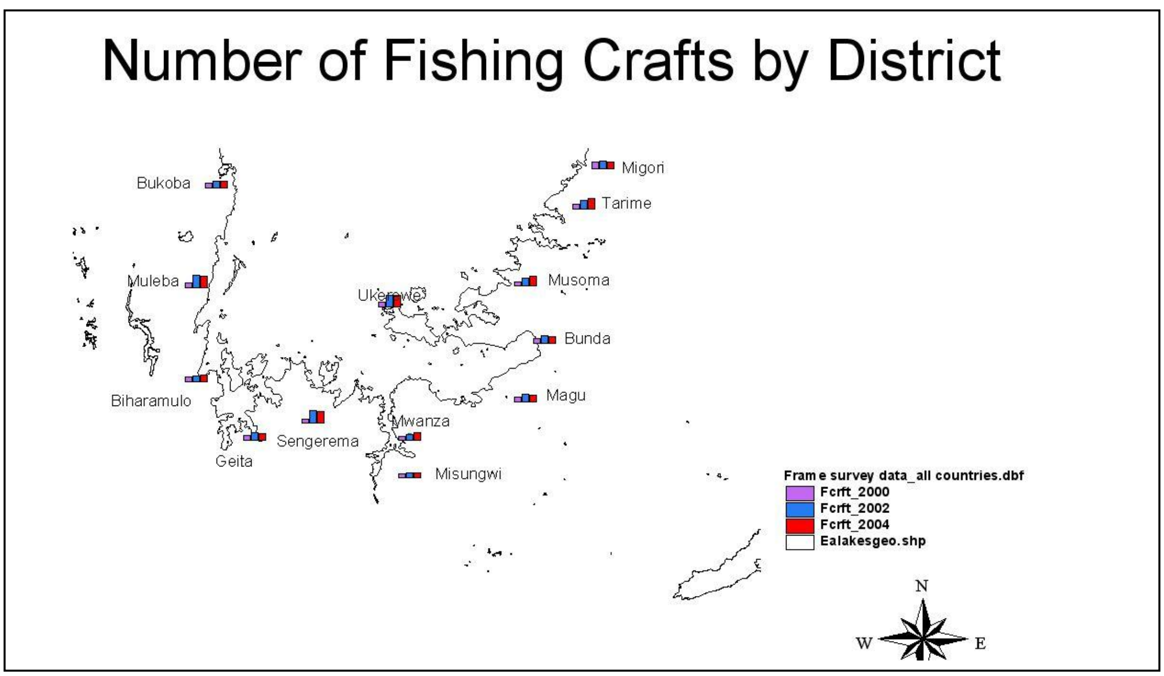



Figure 10.6: Number of fishing crafts by district.

Comparison of large and small mesh gillnets revealed that nets below 5″ mesh size had the highest CPUE in 1995 but subsequently dropped while CPUE for gillnets above 5″ fluctuated with no discernible pattern over the years (Fig. 10.9). CPUE (measured as tons/boat/yr) fluctuated over the years (1967-2004) with no significant relationship with time ($r^2 = 0.01$) (Fig. 10.10).

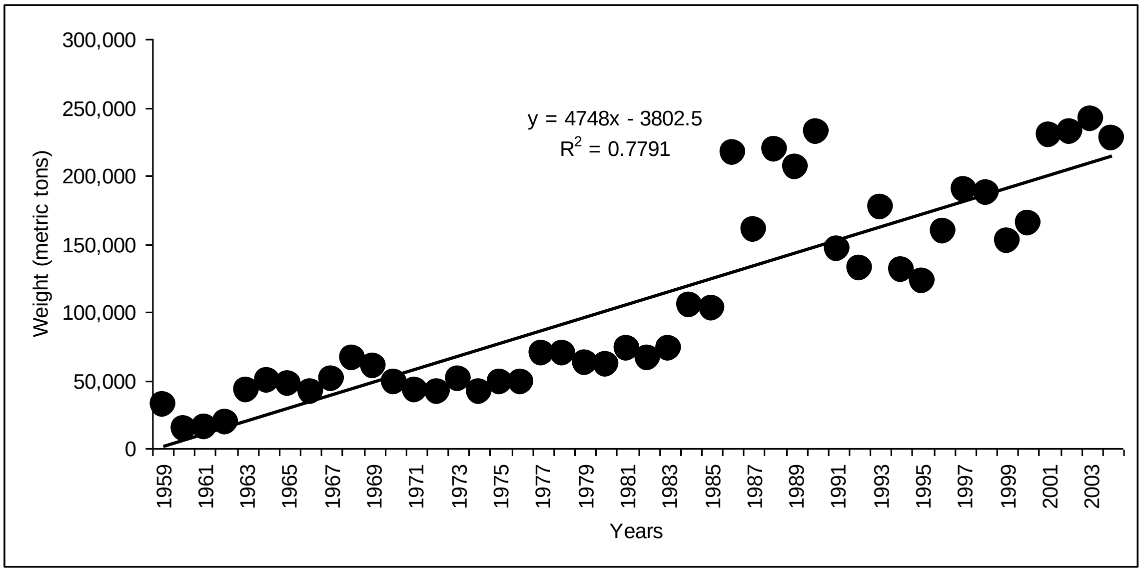



Figure 10.7: Lake Victoria fisheries production from 1959 – 2004.

### *10.3.4 Current Initiatives in Data Collection and Processing*

Among the objectives for the establishment of LVFO is to "serve as a clearing house and data bank for information on Lake Victoria fisheries and promote the dissemination of information, without prejudice to industrial property rights, by any appropriate form of publication" (LVFO, 2001, p. 4). A regional working group has been established with the support from European Union (EU) funded IFMP (Implementation of Fisheries Management Plan) project. The group comprises of members from Fisheries Division head office, Fisheries research institutions and few district fisheries officers based in the regions bordering Lake Victoria. The group developed SOP (Standard Operating Procedures) for catch assessment surveys. Surveys for sampling sites had already been conducted based on randomly selected landing sites. However, the sampling is sometimes systematically selected as it depends on the accessibility to the landing site and the availability of fisheries staff at the landing site in question or presence of active beach management unit members. The collected information includes weight and value of fish by species and by boat and gear types according to size.

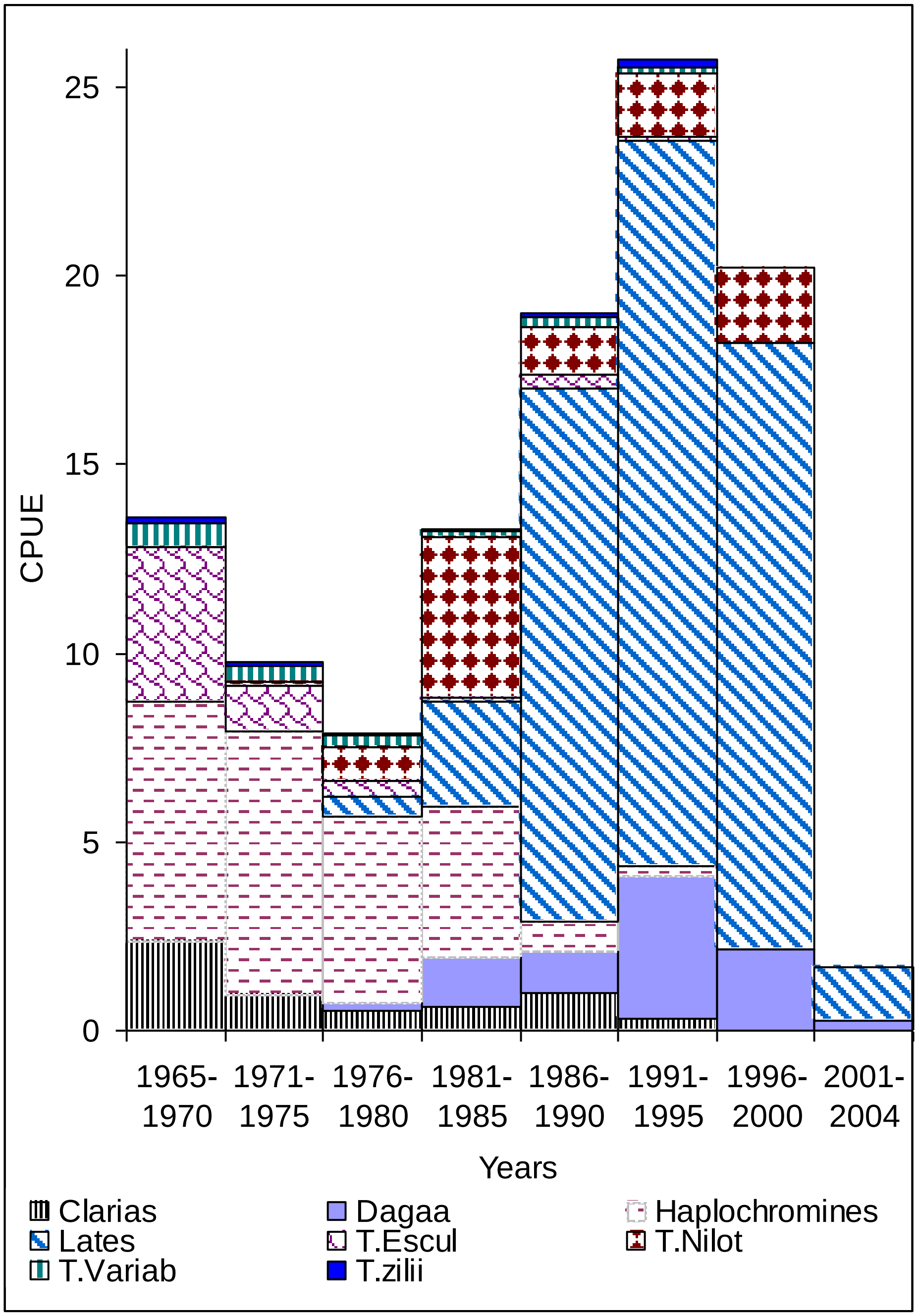



Figure 10.8: CPUE (catch/boat/year) of the most important species in Lake Victoria from 1965 – 2004. *T. variab = Oreochromis variabilis; T. zilii = Tilapia zillii; T. escul* = *Oreochromis esculentus; T. nilot* = *Oreochromis niloticus.*

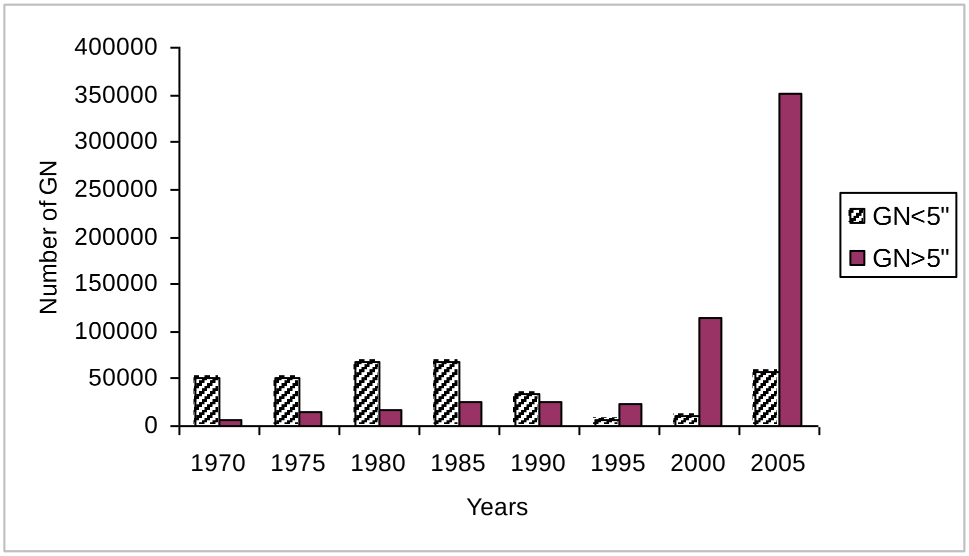



Figure 10.9: Comparison of small and large mesh sizes. GN = Gill nets.

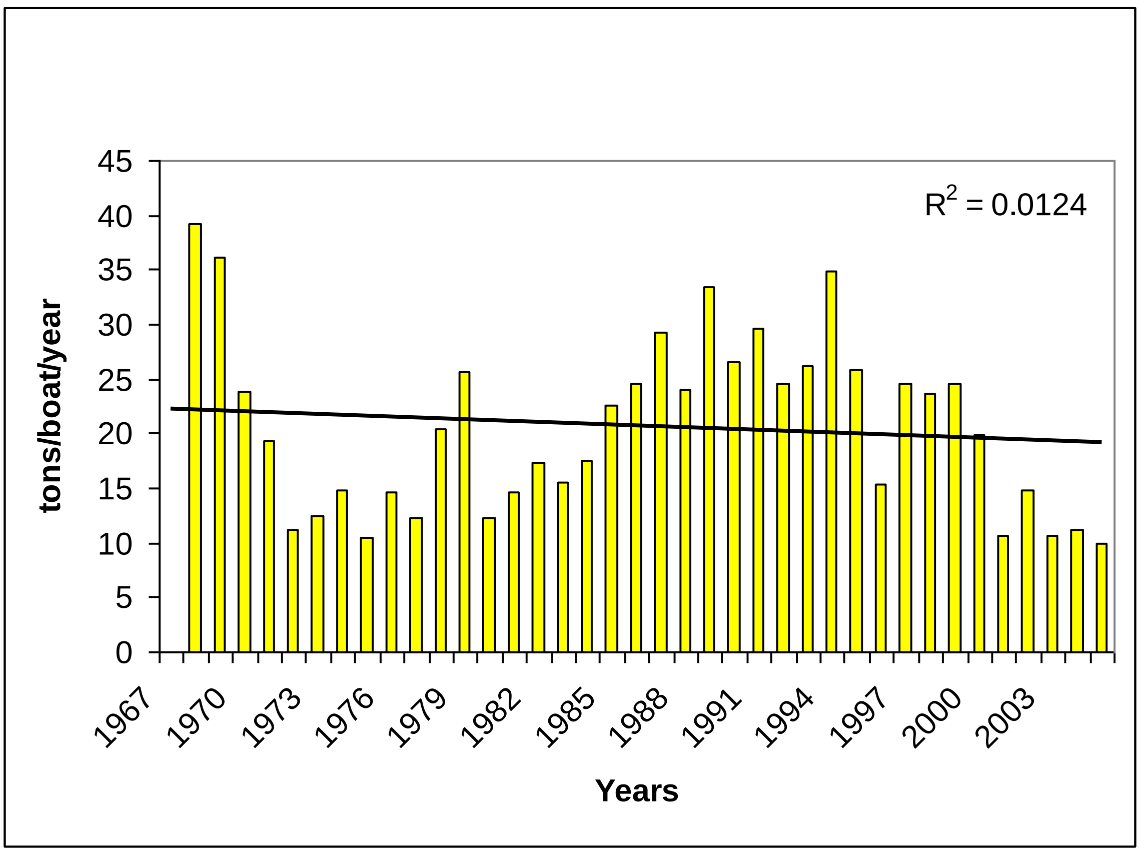



Figure 10.10: CPUE (catch/boat/year) for Tanzanian part for the period 1967-2004.

## 10.4 Discussion

### *10.4.1 Frame Survey Data*

Generally Lake Victoria fishing effort increased with time from 1965 to 1991 (Fig. 10.1). There was a decrease in fishing effort in 1992, which could be explained by the fact that the government imposed a ban on export of whole fish to Uganda and Kenya during the period 1992/93. However, from 1995 the effort in terms of fishermen and vessels increased by 73% and 57% respectively, presumably a result of the growth in the Nile perch export trade.

The joint frame surveys conducted in 2000, 2002 and 2004 showed a rapid increase in the number of fishing vessels and fishermen on the Tanzanian part of Lake Victoria compared to previous years (Fig. 10.2). This is likely due to better coverage during the joint surveys which cover the whole shoreline of Tanzania from the border with Kenya on the eastern part of the lake to the border with Uganda on the western part of the lake (including the islands). In addition, the joint surveys are conducted simultaneously and for a short time thus the chance of double counting of the effort was completely minimized.

Statistically, there is a very high correlation (Pearson correlation, $r = 0.997$, $p = 0.000$) between the increase of fishermen and fishing vessels in Lake Victoria fishery with respect to time. In most cases the fishing vessels available in Lake Victoria do not take more than 5 fishers when going out fishing. With this restriction in fishing vessel capacity, the high correlation reported here is not surprising.

The data on fishing gear indicate that gillnets with 5" mesh size are very popular. The trend for this type of gear increased from 15,160 in 1995 to 272,224 in 2004. The data also revealed that, there is an increase in the use of gillnets with bigger mesh sizes compared to those with smaller mesh sizes. This is due to the fact that from 1996 the "Retention Scheme" started to be implemented where district authorities were given money from Fisheries Development Fund for fisheries development activities. In most cases surveillance has always been well funded, hence greater compliance. However, beach seines seem to increase in numbers although the government prohibits their use. The non-compliance is probably driven by higher catch rate by the gear hence bigger profits, but could also be a result of very low fines for the culprits i.e., Tshs 300,000/= or a 3-year jail sentence.

### *10.4.2 Catch Assessment Survey*

CPUE (i.e., catch per boat) fluctuated with time (Fig. 10.9). The observed catch per boat reached 39 mt/boat/year in 1967. This could be explained by the fact that during that time fishery was accessed by few fishers and abundance was higher. As the years went by, more fishers entered into the fishery thus the CPUE dropped down to 11 mt/boat/year in 1972. However with the advent of the Nile perch fishery, the CPUE rose again to 29 mt/boat/year in 1987 and reached 34.97 mt/boat/year in 1993. CPUE fluctuated downwards from 1998 and reached 11, 11 and 10 mt/boat/year in 2000, 2002 and 2004 respectively.

Available data indicate dramatic changes in the type of fishing gear used in Lake Victoria from 1967–2004 (Appendix 10.1). There is an increase in gillnets with large mesh sizes >5″ while those with <5″ mesh sizes decreased in numbers (Fig. 10.8). This can be explained by the enhanced surveillance conducted along the lake by the fisheries staff at the district level which implements the slot size policy. This means that only those gears with bigger mesh size can catch the required slot size of 50 – 85 cm total length.

The fish catches in Lake Victoria fluctuated with an increasing trend up to 1986 whereby more than 57% of the catch comprised Nile perch. In 1987 CPUE of haplochromines decreased dramatically while that of Nile perch increased steadily up to the period 1996-2000 (Fig. 10.8). Catch assessment process collapsed in 1997, consequently the provisional data reported for Lake Victoria from 1997 are inadequate to conclude that the observed decline in fish catches from 1998–2002 is a direct result of the higher fishing effort. The possibility that there is a general decline of stocks in the lake cannot be ruled out.

Fisheries Division has made some effort towards improving the reliability of Lake Victoria fisheries statistics. In 2000, there was some training at the district level for data collection and processing. LVFO introduced SAMAKI database for frame survey, catch assessment analysis and all related information concerning fisheries statistics for the whole of Lake Victoria. The database was installed in Mwanza, Mara and Fisheries head office computers. However, this database has not been used due to lack of capacity (manpower and technology) at the district level in Mwanza and Mara. Consequently the data are centrally analysed in the Head office in Dar es Salaam.

The reasons that led to the collapse of collection and analysis of fisheries statistics in the first place, include the following:

- Most of the data enumerators were retrenched at the district level, and the few who remained were mobilised for revenue collection by the district authorities.
- Tanzania Fishery Information System (TANFIS) software introduced by FAO in 1993 to improve data analysis was incompatible with new MS Windows and the computers used were broken. In addition, there was no repair due to lack of funds at Fisheries Division.
- The project "*Strengthening fisheries statistics*" was over by then and there were no funds readily available for any development of fisheries statistics in Tanzania.
- Inadequate human resource capacity (data analysts and programmers) at the Fisheries Division head office. The division has only 4 staff at the Statistics Unit.

## 10.5 Conclusion

Effective fisheries management depends on statistics of the fishery for providing data that can be used in the evaluation of fisheries objectives. Therefore the need for reliable and accurate fisheries information in Lake Victoria cannot be overemphasised.

As discussed above information on fish catches in the Tanzanian part of Lake Victoria from 1997 to 2005 is not reliable. The use of trained fishers and BMU members in fisheries data collection can go a long way in solving the problem of inadequate fisheries staff in districts.

## 10.6 Recommendations

- Fisheries Division as the custodian of fisheries statistics in Tanzania should put in place mechanisms for improving data collection, analysis and management so that reliable and accurate information can be available in a timely manner. It has been suggested earlier that the government can use fishermen and BMU members in data collection since the exercise requires enough manpower at the source. Community participation in data collection will enhance a feeling of "ownership" of the fishery resources among the community members and motivate them to implement conservation measures. This may be seen as the first step in preparing the communities to take up their role in a community–based approach in the management of the fish resources in Lake Victoria.
- Capacity building in database design, implementation and management should be considered for those who are working in Fisheries Division in the Statistics Unit. As the SAMAKI database is already in place, there is a need for the Division to train all those working in fisheries statistics on

how to use it. In addition, computers and accessories should also be in place at the district level so that they can be used in data entry.

- Government institutions working under the LVFO should establish fisheries statistics data centre in the three states to facilitate retrieval of data in a timely and convenient manner at the national level.

Appendix 10.1: Characteristics of Lake Victoria Fisheries (Tanzanian part) 1967 – 2004.

| Years | No. of Fishermen | No. of Fishing vessels | Weight in metric tons | Catch per boat | Total GN | BS | Hooks | No. of engines OB | IB |
|---|---|---|---|---|---|---|---|---|---|
| 1967 | 6,077 | 1,289 | 50,574.00 | 39 | 73,037 | 154 | 138,702 | 0 | 0 |
| 1968 | 8,413 | 1,815 | 65,661.00 | 36 | 80,573 | | | | 0 |
| 1969 | 11,517 | 2,538 | 60,321.00 | 24 | 79,030 | 433 | 210,005 | 0 | 0 |
| 1970 | 9,738 | 2,495 | 48,292.00 | 19 | 133,979 | 478 | 188,424 | 0 | 0 |
| 1971 | 12,091 | 3,785 | 42,552.00 | 11 | 14,798 | 60 | 92,473 | 0 | 0 |
| 1972 | 14,131 | 3,302 | 40,925.00 | 12 | 125,782 | 515 | 282,621 | 0 | 0 |
| 1973 | 14,582 | 3,426 | 50,721.00 | 15 | 81,022 | 339 | 47,069 | 0 | 0 |
| 1974 | 15,917 | 3,976 | 41,525.80 | 10 | 103,394 | 621 | 341,090 | 200 | 0 |
| 1975 | 13,381 | 3,332 | 48,602.20 | 15 | 120,423 | 457 | 335,835 | 164 | 1 |
| 1976 | 15,037 | 3,918 | 48,250.00 | 12 | | | | | |
| 1977 | 14,327 | 3,398 | 69,230.40 | 20 | 126,993 | 1,462 | 241,922 | 140 | 12 |
| 1978 | 13,666 | 2,727 | 69,999.00 | 26 | | | | | |
| 1979 | 20,937 | 4,457 | 55,126.00 | 12 | 87,675 | 681 | 280,979 | | |
| 1980 | 19,787 | 4,199 | 61,402.00 | 15 | | | | | |
| 1981 | 19,787 | 4,199 | 72,846.70 | 17 | 189,762 | | 324,443 | 194 | 8 |
| 1982 | 18,262 | 4,245 | 66,316.90 | 16 | 121,674 | 1,530 | 407,791 | 201 | 6 |
| 1983 | 15,194 | 4,141 | 72,585.70 | 18 | 164,203 | 1,945 | 563,058 | 115 | 34 |
| 1984 | 17,827 | 4,650 | 104,989.10 | 23 | 91,524 | 640 | 485,545 | 108 | 24 |
| 1985 | 17,556 | 4,160 | 102,003.30 | 25 | 63,199 | 1,029 | 373,741 | 125 | 21 |
| 1986 | 24,241 | 7,404 | 216,406.95 | 29 | 143,218 | 1,464 | 350,850 | | |
| 1987 | 22,207 | 6,667 | 159,915.17 | 24 | 81,310 | 523 | 492,126 | 146 | 26 |
| 1988 | 22,926 | 6,546 | 218,544.80 | 33 | 62,544 | 556 | 390,938 | 130 | 28 |
| 1989 | 29,816 | 7,757 | 205,474.20 | 26 | 90,007 | 659 | 621,550 | 154 | 35 |
| 1990 | 29,095 | 7,797 | 231,547.30 | 30 | 87,778 | 537 | 369,444 | 111 | 35 |
| 1991 | 25,900 | 5,948 | 146,310.10 | 25 | 87,778 | 573 | 359,444 | 111 | 35 |
| 1992 | 20,064 | 5,041 | 132,191.30 | 26 | 87,817 | 573 | 359,444 | 111 | 35 |
| 1993 | 20,064 | 5,041 | 176,264.45 | 35 | 87,817 | 573 | 359,444 | 111 | 35 |
| 1994 | 20,064 | 5,041 | 130,538.63 | 26 | 87,817 | 573 | 359,444 | 111 | 35 |
| 1995 | 34,832 | 7,953 | 121,891.47 | 15 | 119,048 | 528 | 1,419,687 | 441 | 11 |
| 1996 | 34,832 | 7,953 | 195,201.83 | 25 | 119,048 | 528 | 1,419,687 | 441 | 11 |
| 1997 | 34,832 | 7,953 | 189,000.00 | 24 | 119,048 | 528 | 1,419,687 | 441 | 11 |
| 1998 | 32,403 | 7,618 | 187,000.00 | 25 | 130,195 | 826 | 674,318 | 825 | 5 |
| 1999 | 32,403 | 7,618 | 151,500.00 | 20 | 130,195 | 826 | 674,318 | 825 | 5 |
| 2000 | 56,060 | 15,489 | 165,000.00 | 11 | 218,708 | 1,019 | 2,212,571 | 1,530 | 10 |
| 2001 | 56,060 | 15,489 | 229,336.90 | 15 | 218,708 | 1,019 | 2,212,571 | 1,530 | 10 |
| 2002 | 80,053 | 21,660 | 231,560.20 | 11 | 425,888 | 1,454 | 4,608,998 | 2,610 | 0 |
| 2003 | 80,053 | 21,660 | 241,710.19 | 11 | 425,888 | 1,454 | 4,608,998 | 2,610 | 0 |
| 2004 | 77,997 | 22,653 | 226,530.00 | 10 | 583,699 | 1,532 | 3,081,885 | 5,576 | 0 |

Key: GN = Gill nets; IB = Inboard; OB = Outboard

# CHAPTER ELEVEN

# FISH QUALITY ASSURANCE

*Stephen A. Lukanga[1] and Y.D. Mgaya[2]*
*[1]Fish Quality Control and Safety Assurance*
*P.O. Box 1213, Mwanza, Tanzania*
*[2]University of Dar es Salaam*
*Faculty of Aquatic Sciences and Technology*
*P.O. Box 60091, Dar es Salaam*

## 11.1 Introduction

Lake Victoria fisheries resources are of great socio-economic, nutritional and food security significance to over 30 million people in the region as well as to international communities. Fish has for the last 10 years become a major export commodity in the region and has made riparian governments as well as other stakeholders realise that it is a socio-economic asset, which must be sustainably managed.

Prior to the establishment of Nile perch processing plants in Lake Victoria, the major processing methods were artisanal fish smoking, salting and sun-drying. These artisanal processing methods were used to increase the shelf life of the final product due to the fact that poor rural roads and distribution facilities were prevented the distribution of both fresh and processed fish to distant domestic markets. However, the quality of the final product was poor due to the lack of ice for lowering temperature soon after harvesting. The commercial or industrial processing methods were started early 1990s for producing mainly Nile perch fillets for export to international markets (Europe, Japan, Middle East and Australia). Apart from fillets there are by-products which are in use, such as, fish frames/carcass, off-cuts, belly flaps and fish maws. These are either sun-dried or salted for export to Rwanda, Burundi and Democratic Republic of Congo. Currently, there are eleven fish processing plants along the Tanzanian side of Lake Victoria and all of them have adopted the implementation of Hazard Analysis and Critical Control Points (HACCP) programme. The total cumulative exports of Nile perch fish and fishery products from Lake Victoria for the last nine years (1995 to 2004) was 318,222.034 tons valued at USD 703,795,418 (F.O.B value) of which the Fisheries Division received at total of Tanzania Shillings (TAS) 34.68 billion (USD 32.94 million) as royalty.

Since the major proportion of the catch (about 90% of Nile perch) is processed in fish factories for international markets, thus *dagaa* (*Rastrineobola argentea*), tilapiines and other species are locally processed for both human consumption and animal feed. For example, *dagaa* are sun-dried for both human consumption and animal feed depending on the quality of the raw materials and final products while tilapia are gutted and washed for freezing in town centres where individual dealers freeze them for local markets in Arusha, Dar es Salaam and Dodoma.

## 11.2 Justification

Nile perch as food and wealth has attracted global and domestic concerns. European Union countries enforced the provisions of Directive 91/493/EEC with intermittent audit/inspection missions, which have revolutionalized the Fish Quality Assurance practices around Lake Victoria. At the same time the country has revolutionalized industrial fish processing by increasing public awareness on fish quality assurance issues. According to Fisheries Act No. 6 of 1970 (now Act No. 22 of 2003), Food Act No. 10 of 1978 and the Fish Quality Control and Standards Regulations of 2000, the Fisheries Division is the Competent Authority on all issues related to Fish Quality Assurance such as control fish handling, monitoring of fish establishments, fish marketing and addressing sanitation and hygiene so as to sustain due diligence clientele. The need for lake wide compliance with international and customary requirements forced the Fisheries Division to provide short and long courses to the Fish inspectors and laboratory technicians, instituting traceability chains, construction and equipping national laboratory, and conducting regular monitoring and analysis of microbiological and chemical parameters in fish, water and sediments. The fish traders, Beach Management Unit (BMU) members, fishers and fish handlers were trained on health sanitation and hygiene on proper fish handling practices. All these are done in order to ensure our fish and fishery products are of good quality and safe for human consumption.

## 11.3 Results

### *11.3.1 Export Statistics*

In 1950s, most of the fish taken from Lake Victoria were consumed in areas very close to the lake because of poor rural roads and distribution facilities which prevented the distribution of both fresh and processed fish to distant domestic markets. Although there are no export data, however, the existing records show that fish exports from Lake Victoria were carried out in 1950's with products such as smoked and salted fish being exported to both Kenya and Uganda from various processing camps in Tanzania waters. Fishmongers from Kisumu were reported to buy fish from Musoma at various times of the year in 1968 (Fisheries Division, 1968). During that time, exports were in the form of fish, fresh, chilled or frozen and dried fishery products. It was shown that in year 1965, Fisheries Division had a plan to establish an Experimental Fish Processing station at Nyegezi with aim of improving the smoking, drying salting and otherwise processing fish for local as well as export sale (Fisheries Division, 1965). This was successfully implemented and contributed a lot to the improvement of the preservation of fish and fishery products.

The importance of the lake with respect to exportation of fish and fishery products came into effect in early 1990s when Nile perch (*Lates niloticus*) started to be processed and exported in the form of fish fillets. This can be economically demonstrated by the amount of fish exported and income generated for the country. The total export of Nile perch and its products for the year 2004 was 42,354.5 tons valued at USD 100,079,167.16 (F.O.B value) of which the Fisheries Division received at total of Tanzania Shillings (TAS) 6.41 billion as royalty. The export statistics of fish and fishery products for the period of 1986 – 2004 are given in Table 11.1.

Table 11.1: The export statistics of fish and fishery products for year 1986 – 2004.

| Year | Weight in Kg | FOB Value in TShs | FOB Value in US$ | Royalty in TShs |
|---|---|---|---|---|
| 1986 | 3,990.00 | 455,104.00 | 11,325.34 | 22,754.00 |
| 1987 | 23,546.00 | 1,693,231.50 | 42,136.37 | 69,936.40 |
| 1988 | 29,888.50 | 2,210,033.69 | 54,997.09 | 285,063.65 |
| 1989 | 886,441.00 | 35,382,680.00 | 445,086.00 | 319,184.00 |
| 1990 | 334,885.00 | 44,374,328.00 | 237,560.15 | 1,937,555.00 |
| 1991 | 138,364.00 | 48,386,346.15 | 1,318,551.22 | 1,405,703.50 |
| 1992 | 174,059.00 | 116,697,374.56 | 384,480.75 | 5,871,525.46 |
| 1993 | 6,358,578.00 | 2,719,443,141.05 | 3,802,208.25 | 144,686,154.31 |
| 1994 | 10,505,872.50 | 5,344,108,936.20 | 14,779,081.70 | 278,194,833.70 |
| 1995 | 13,959,640.40 | 8,123,293,805.24 | 14,912,558.60 | 436,006,348.07 |
| 1996 | 21,430,749.38 | 20,189,797,023.80 | 53,732,200.00 | 1,229,177,044.00 |
| 1997 | 28,379,336.00 | 41,786,110,963.20 | 69,856,515.60 | 2,507,119,861.70 |
| 1998 | 41,911,639.00 | 46,004,541,133.80 | 69,942,331.00 | 2,760,272,584.50 |
| 1999 | 25,914,079.00 | 38,554,978,033.50 | 53,312,521.50 | 2,317,852,331.50 |
| 2000 | 38,868,023.70 | 44,004,581,785.80 | 55,493,815.50 | 2,640,205,863.80 |
| 2001 | 39,025,829.70 | 74,928,607,542.35 | 86,178,585.67 | 4,685,276,229.20 |
| 2002 | 29,212,341.71 | 83,005,557,292.23 | 88,231,655.07 | 4,980,333,437.53 |
| 2003 | 37,165,851.20 | 114,786,412,340.89 | 112,056,067.54 | 6,708,288,905.43 |
| 2004 | 42,354,543.82 | 108,289,741,909.00 | 100,079,167.16 | 6,416,124,562.45 |
| **TOTAL** | **336,677,658** | **587,986,373,005** | **724,870,845** | **35,113,449,878** |

Source: Fisheries Division Annual Statistics Report 1985 – 1996 and 1997-2004 unpublished reports.

The export statistics trends of the fish and fishery products for the period 1986 – 1992 and 1993 – 2004 are given in Fig. 11.1. It is evident that between 1986 and 1992 there was no significant increase in exports by weight per year ($R^2$=0.07) as compared with the period 1993 – 2004 which showed there was significant increase in exports per year ($R^2$=0.72).

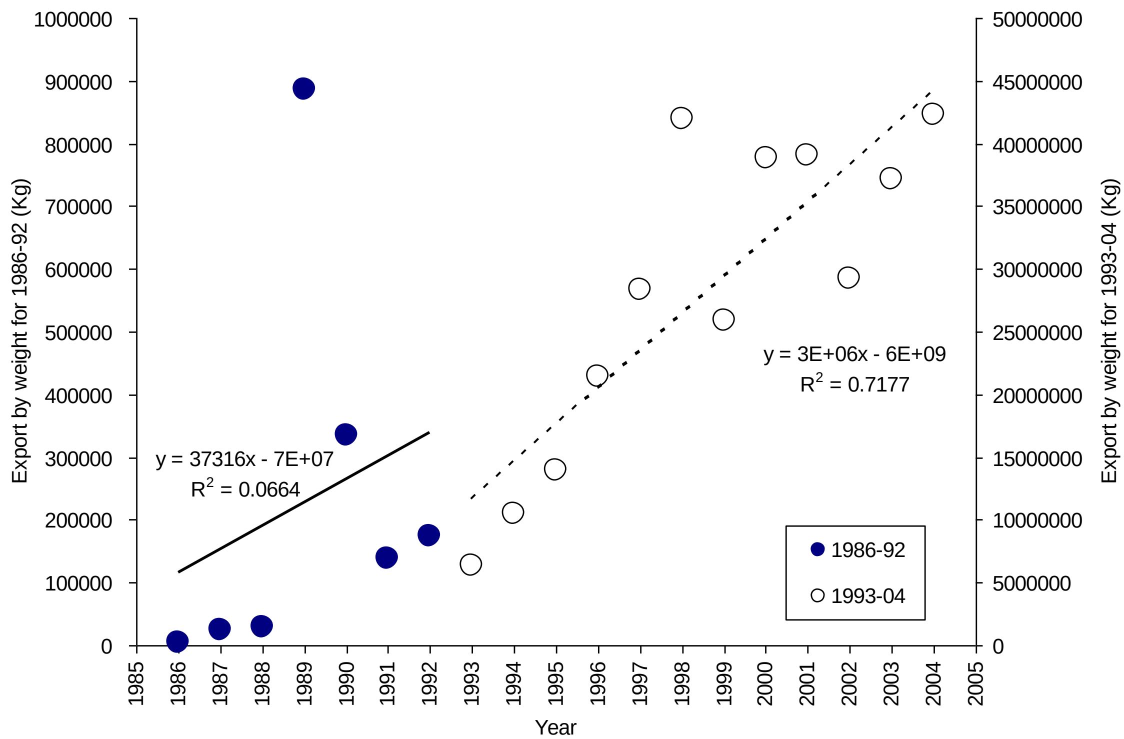



Figure 11.1: Export trends for fish and fishery products for the period 1986 – 2004.

The sudden drop of the trend for year 1999 and 2002 was due to the import ban imposed by single largest European markets caused by the allegations that our fish and fishery products were contaminated by pesticides as well as implementation of slot size 50-85 cm in the fish processing plants, respectively.

The Nile perch processing plants are dedicated to packing and export of fresh chilled, frozen fillets, whole head and gutted (H and G) and fish maws. The major part of this production is exported to European countries, USA, Japan, Australia and Middle East. Other main forms besides fillets, whole H and G and fish maws are Nile perch carcass, dried fish, fish offal, Nile perch chips or off cuts, fish meal, belly flaps, fish skin and fish oil which are exported to Burundi, Democratic Republic of Congo, Rwanda, Kenya, Malawi and Uganda.

### *11.3.2 Fish Processing Establishments*

The fish processing industry in Tanzania ranges from sophisticated state of the art facilities (commercial) to small artisanal operations producing traditional fish and fishery products for the domestic markets. Artisanal processing involve smoking, dry salting, sun drying. A chorkor type kiln is used and a wire mesh is spread on an enclosed rectangular enclosure because of shortages of fuel-wood. Alternatively, dry salting was used from similar raw materials (poor quality tilapia and Nile perch). *Dagaa* is sun dried on shore sands, on flat rock or hard and dry soils, the process is not always hygienic because the *dagaa* is not salted before drying so as to kill micro-organisms. In 1973, it was reported that an experimental fish processing plant was established at Nyegezi Freshwater Fisheries Institute to prepare frozen tilapia fillets, which later on appeared to be a less profitable operation than was originally thought (Freshwater Fisheries Institute Nyegezi, 1973). This was due to labour intensive nature of the operation and the low filleting yield. A better way of trading was found to be in the form of fresh fish or even deep frozen whole fish. The deep frozen tilapia was sent by air to Dar es Salaam (Kilimanjaro Hotel) and eventually market was regular when National Cold Chain Organisation (NCCO), which was a marketing body of perishable foodstuffs, was established.

Industrial or commercial processing started when Nile perch was largely taken by processing plants for filleting. The Nile perch is quite suitable for filleting, yielding 40% fillets and 60% offals. According to Gibbon (1997), in 1996 these factories were a mixed bunch, ranging in appearance from a small converted type godown without running water and with just one or two small plate freezers and small flake ice machine. Kenya was the first country to open bigger processing plants by the end of 1980s; their owners started buying fresh Nile perch in Tanzania through their agents who were provided with motorized collector boats, vans and trucks. Between 1992 and 1993, Tanzania imposed a ban on export of whole (and semi processed) fish to Kenya and that forced processors to establish processing plants in Tanzania. These new market forces have brought significant positive changes on fish handling and processing techniques. By the year 2005 the total number of fish processing plants is eleven with a total combined installed capacity of 910 tons/day which is equivalent to 332,150 tons/year (Table 2). However, only eight fish processing plants are operational. The other three plants have stopped processing due to management problems.

The data in Table 11.2 show that all fish processing plants are currently operating under capacity. This is caused by expansion of their processing capacity by upgrading of the production line in order to cope with changes in science and technology. As a result there are incentives for fishers to harvest more to meet the increasing demand but still do not suffice the required capacity.

Table 11.2: List of fish processing establishments and their capacity.

| S/N | Name of Factory and Location | Year Established | Installed Capacity (tons/day) | Production Capacity (tons/day) |
|---|---|---|---|---|
| 1 | Vicfish Ltd. – Mwanza | 1992 | 140 | 75 |
| 2 | Tanperch Ltd. – Mwanza | 1992 | 120 | 50* |
| 3 | Mara Fish Packers Ltd. – Musoma | 1992 | 50 | 25* |
| 4 | Tanzania Fish Processors Ltd. – Mwanza | 1993 | 120 | 80 |
| 5 | Mwanza Fishing Industries Ltd –Mwanza | 1994 | 60 | 50 |
| 6 | Omega Fish Ltd. – Mwanza | 1997 | 70 | 10 |
| 7 | Nile Perch Fisheries Ltd – Mwanza | 1997 | 100 | 70 |
| 8 | Chain Food International Ltd. – Mwanza | 1999 | 15 | 10* |
| 9 | Prime Catch (Exporter) Ltd. – Musoma | 2000 | 150 | 50 |
| 10 | Musoma Fish Processors Ltd – Musoma | 2001 | 60 | 45 |
| 11 | Kagera Fish Company Ltd. – Kagera | 2003 | 25 | 10 |
| **Total** | | | 910 | 445 (49%) |

Key: * Currently not operational.

### *11.3.3 Post-Harvest Losses and Processing Methods*

Post-harvest losses for Tanzania Fisheries are estimated at 25–40% of the total production whereby 10–15% is of Nile perch. These data were obtained during a study carried out by Nanyaro and Makene (1998) in Mwanza Gulf, on the fish losses at fish landing beaches, fish handling in the water, at the markets and during transportation. These data suggest that there is poor fish handling and processing and poor infrastructure in the fishing industry in terms of fishing boats, landing sites, fish transportation, storage, pre- and post-processing handling and market conditions.

In order to have a clear trend of the losses there is a programme of collecting data for post-harvest losses from selected Nile perch processing plants. The programme started in 1999 with the aim of curbing post-harvest losses particularly on Nile perch in order to maximise benefits to the riparian communities and nation as a whole. These data are collected twice per week from each of the following selected fish processing plants:

i. Kagera Fish Company Ltd – Kagera region
ii. Nile Perch Fisheries Ltd – Mwanza region
iii. Tanzania Fish Processors Ltd – Mwanza region
iv. Mwanza Fishing Industries Ltd – Mwanza region
v. Prime Catch Ltd – Mara region

The trends for average post-harvest losses for data collected from selected Nile perch processing plants for the period 1999–2001 and 2002–2005 are given in Fig. 11.2. It is evident that between 1999 and 2001 post-harvest losses per year decreased followed by abrupt increase in post-harvest losses for the period 2002–2005 caused by the implementation of regulation related to slot size in the Nile perch processing plants which stipulates that Nile perch below 50 cm and above 85 cm should not be processed. As a result fish to be used as raw materials for producing fillets for export purpose were rejected thus led into loss with respect to export market.

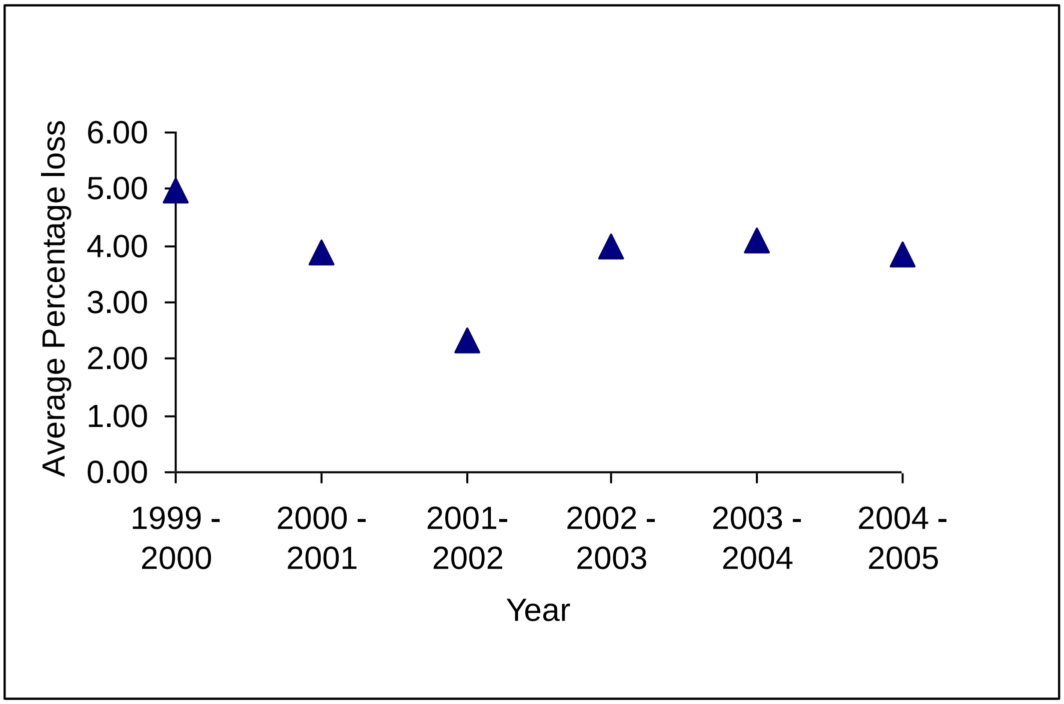



Figure 11.2: The trend for post harvest losses for the period 1999–2005.

In case of Nile tilapia (*Oreochromis niloticus*) which is another important commercial fish species for domestic markets, it is sold in the form of smoked, fresh or frozen fish. Most of these products are of poor quality due to delay in icing, use of dirty (re-use) ice, long distances from the source to deep freezing points, poor handling practices, unhygienic handling and processing environments, defective cold stores, inefficient deep freezers, poor transportation network, poor packaging among others. Another important species is *dagaa* (*Rastrineobola argentea*); these are dried by spreading on the ground (sandy beaches) and/or rocks for sun drying purposes. On those open drying areas, the end product is usually impregnated with sand particles and is automatically of low quality in terms of microbial counts, because the drying places are unhygienic i.e. dirty beach environment and insects like blow-flies that are associated with human and animal activities.

### 11.3.4 *Inspection at Fish Landing Sites*

Tanzania has trained Fisheries staff (long and short term training) and members of the Beach Management Units (BMUs) on fish quality assurance aspects. A total of 29 local fish inspectors (District Fisheries Officers) are available along the Lake Victoria and trained in areas of fish handling and processing practices, identification of poisoned fish, the use of all checklists at landing site, sampling protocols of fish, water and sediments from the lake. These are responsible for duties in fisheries management including monitoring, control and implementation of quality and safety standards.

### 11.3.5 *Gazettement of Fish Landing Beaches*

Fish landing site refers to a specified selected site along the beach where fishermen dispose of their catch for the first time after fishing. The site should be big enough to accommodate many boats, fishers and traders. It should allow future development such as building of workshops for traders and processors, ice plants and other necessary facilities like jetty, toilets and provision of clean tap water. The site should have good accessibility for traders. Sheltered areas like bays with all weather roads are highly recommended. The selected area should be free of any pollutants, no siltation and should have a deep water to allow boats or fishing vessels of different sizes to anchor.

According to the Frame Survey of Lake Victoria year 2000, 2002 and 2004, the number of fish landing sites on the Tanzania part of the lake was 598, 594 and 575 respectively, which are spread over 1,150 km of coastline. Out of these, there is a total of 53 identified fish landing sites for gazetting and improvement at a level of having basic infrastructure to facilitate general hygiene and cleanliness including a jetty/floating barge to facilitate loading and off-loading. The facilities to be provided include clean running water; toilets with showers; clean containers for holding ice and office accommodation for site management. The main objective of the intervention is to improve quality of landed fish, handling, processing and marketing. So far 10 fish landing sites have been improved to a level of having floating barges and other sanitary facilities. The improved landing sites are Kayenze, Mihama, Namasabo, Ito, Nkome Mchangani, Kitua, Bwai, Nyang'ombe, Kome and Kijiweni. Apart from these, other landing sites have been improved to a level of having racks for landing fish; toilets for public use and have in place a strategy for general maintenance of sanitation.

### 11.3.6 *Levels of Contaminants Both at Landing Sites and Factories*

There is monitoring of microbiological, pesticides, heavy metals and trace elements in some commercial fish species, water and sediments of Lake Victoria. The National Fish Quality Control Laboratory (NFQCL), located within the Nyegezi Freshwater Fisheries Training Institute in Mwanza deals with microbiological analyses. This laboratory became operational in 1997. Due to the fact that there is no laboratory in Tanzania that is accredited, samples of fish, water and sediments are sent abroad to South Africa Bureau of Standards which is an accredited laboratory for pesticide and heavy metals residues analysis. However, the Fisheries Division has initiated a process of establishing an accredited referral National Laboratory by constructing a new building, which is completed and is in the stage of equipping with analytical instruments. This laboratory will cater for both microbiological and chemical analysis. During the period 1997 to 2004, 1523 samples of fish fillets, 69 whole fish, 457 water and 207 sediments were analyzed for pesticide residues.

**Microbial checks**

These microbial checks are carried out in order to verify the quality and safety of fish and fishery products from all Nile perch processing plants. The samples of fish fillets are collected at least twice per week per each factory and analysed for the following parameters: Total Bacterial Count (TPC), Total Coliforms (TC), and *Staphylococcus aureus*. In addition, pathogenic bacteria including *Vibrio cholerae*, *Salmonella* sp. and *Shigella* sp. are also analysed. Likewise, fish processing plants have their own in-house laboratories for own checks.

The results for testing TPC, TC, *Staphylococcus aureus, Vibrio cholerae* and *Salmonella / Shigella* sp. in the Nile perch fillets collected from fish processing plants are summarised in Table 11.3. The results obtained from the monitoring programme showed that *Vibrio cholerae* and *Salmonella / Shigella* sp. were not detected in any Nile perch fillet samples collected from fish processing plants. This indicates that there has been compliance with quality standards. For the case of TPC, TC, and *Staphylococcus aureus,* the results obtained showed that the levels of bacterial counts for samples collected from fish processing plants were within International standards (Table 11.3).

Table 11.3: List of micro-organisms and recommended limits.

| ***Parameters*** | **Mean value of counts per year** | | | | **Standard** |
|---|---|---|---|---|---|
| | 2001 | 2002 | 2003 | 2004 | |
| [i] Total Bacterial Count / g (TPC) | $5.55 \times 10^3$ | $8.74 \times 10^3$ | $6.59 \times 10^3$ | $3.39 \times 10^4$ | $1 \times 10^5$ |
| [ii] Total Coliform /g | $3.59 \times 10^1$ | $5.83 \times 10^1$ | $7.54 \times 10^1$ | $3.54 \times 10^1$ | $4 \times 10^2$ |
| [iii] *Staphylococcus aureus/g* | $1.57 \times 10^1$ | $7.66 \times 10^1$ | $3.22 \times 10^1$ | $2.40 \times 10^1$ | $5 \times 10^3$ |
| [iv] *Salmonella/Shigella* / 25g | Not detected | Not detected | Not detected | Not detected | Absent |
| [v] *Vibrio cholerae*/g | Not detected | Not detected | Not detected | Not detected | Absent |

*Source: National Fish Quality Control Laboratory Nyegezi.*

**Pesticide residues**

Pesticide levels are monitored because they are used in agricultural activities in the three regions and due to the allegations made in 1999 by European Union market that fish and fishery products from Lake Victoria contained pesticides. Frequency of monitoring is quarterly for Nile perch fillets from fish processing plants, twice per annum in lake fish, water and sediments. Collections of fish fillets from fish processing plants, fish, sediments and water from the Lake Victoria started in 1999 and collected from 23 identified sampling stations and sent abroad to the South Africa Bureau of Standards accredited laboratory. The criteria for selection of these sampling stations are (i) the likelihood of risks arising from agricultural and land use practices as well as the wash down from rains, (ii) places (landing beaches/fishing grounds) where there are big volumes of fish and intensive fishing, and (iii) areas with possibility of pollution from industries and mining areas.

The common pesticide residues, which are normally assessed in samples of fish fillets, whole fish, water and sediments, are given below:

**Polychlorinated Biphenyl (PCBs):**

2,4′-Dichlorobiphenyl (PCB-8), 2,4,4′-Trichlorobiphenyl (PCB-28)
2,2′, 4,5,5′-Pentachlorobiphenyl (PCB 101)
2,2′, 3,4,4′, 5′-Hexachlorobiphenyl (PCB 138)
2,2′, 3,4′, 5,5′-Heptachlorobiphenyl (180)
2,3,3′-Trichlorobiphenyl (PCB 20)
2,2′, 5,5′-Tetrachlorobiphenyl (PCB52)
2,3′, 4,4′, 5-Pentachlorobiphenyl (PCB 118)
2,2′, 4,4′, 5,5′-Hexachlorobiphenyl (PCB 153)

**Organochlorines (OCs):**

Alpha-BHC, Lindane, Heptachlor, Aldrin, DDT (sum of op-and pp-DDT), pp-DDE and pp-DDD), Dieldrin, Methoxychlor, Endosulfan *alpha and βeta.*

**Organophosphates (OPs):**

Dichlorvos, Mevinphos, Sulfotep, Diazinon, Parathion-methyl, Chlorpyrifos-methyl, Fenitrothion, Pirimiphos-methyl, Malathion, Parathion, Chlorpyrifos, Chlorfenviphos, and Profenophos.

**Pyrethroids (PT):**

Cyhalothrin, Cyfluthrin, Cypermethrin, and Detamethrin.

None of these pesticides, however, were detected (ND) in fish, water and sediments (Table 11.4). According to EU Directives 86/363/EEC for foodstuffs of animal origin as amended by Council Directive 2000/24/EEC for part A of Annex II, the Maximum Residue Allowance Levels (MRLs) for PCBs is 2 mg/kg and for the organochlorides (OCs) and organophosphates (OPs), MRLs is 0.05 mg/kg.

Table 11.4: Pesticide residues results in fish, water and sediments.

| Description of Pesticide residues | | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|
| Polychlorinated Biphenyl (PCBs) | Fish | ND | ND | ND | ND | ND | ND |
| | Water | | | | | | |
| | Sediments | | | | | | |
| Organochlorines (OCs) | Fish | ND | ND | ND | ND | ND | ND |
| | Water | | | | | | |
| | Sediments | | | | | | |
| Organophosphates (Ops) | Fish | ND | ND | ND | ND | ND | ND |
| | Water | | | | | | |
| | Sediments | | | | | | |
| Pyrethroids (PT) | Fish | ND | ND | ND | ND | ND | ND |
| | Water | | | | | | |
| | Sediments | | | | | | |

**Source: National Fish Quality Control Laboratory Nyegezi**

**Heavy metals and trace elements**

Heavy metals and trace elements in fish, water and sediments are normally assessed in order to monitor possibility of pollution from industries and mining areas. Several studies have been conducted between 1996 and 2003 on heavy metal pollution in Lake Victoria (Ikingura, and Akagi, 1996; Migiro, 1997, Kondoro and Mikidadi, 1998; DHV Consultants BV, 1998; Mohamed 2000; Campell, 2001; Kishe, 2001, Kishe and Machiwa, 2003, Machiwa *et al.*, 2003). The analysed heavy metals in fish samples were arsenic, copper, zinc, lead, cadmium, chromium, mercury and nickel (Table 11.5). The Nyegezi laboratory has a monitoring programme in which samples are collected twice per annum in fish, lake water and sediments.

Table 11.5: The results for determination of heavy metals in fish flesh (muscle) in µg/kg.

| **Heavy metals and Trace elements** | **Results in µg/kg** | | | | | | **Standard** (MAL (mg/Kg) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | EU | CODE X |
| Arsenic | <1 | <1 | <1 | <1 | <1 | <1 | 0.00 | 0.00 |
| Cadmium | <1 | <1 | <1 | 2 | <1 | <1 | 0.05 | 0.00 |
| Copper | 330 | 165 | 192 | 232 | 103 | 134 | 0.00 | 0.00 |
| Chromium | <1 | <1 | <1 | <1 | <1 | <1 | 0.00 | 0.00 |

| Heavy metals and Trace elements | Results in μg/kg | | | | | | Standard (MAL (mg/Kg) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | EU | CODE X |
| Lead | 5 | 11 | 4.5 | 11 | 7 | 8 | 0.20 | 0.00 |
| Mercury | 3 | 143 | 150 | 148 | 49 | 78 | 0.50 | 0.00 |
| Nickel | <1 | <1 | <1 | <1 | <1 | <1 | 0.00 | 0.00 |
| Zinc | 8257 | 9001 | 8357 | 12040 | 753 | 3086 | 0.00 | 0.00 |

*Source: National Fish Quality Control Laboratory Nyegezi*

The results obtained showed that heavy metals and trace elements in whole fish and Nile perch fillets were below the Maximum Allowable Levels (MALs) as developed by EU and Codex/WHO (Table 11.5).

### *11.3.7 Fish Factories with Hazard Analysis and Critical Control Point (HACCP) Plan*

The Hazard Analysis and Critical Control Points (HACCP) is a preventive system of control designed to minimize or eliminate the risk of food safety hazards. It was developed in 1991 by EU through Directive 91/493/EEC and the Food and Drugs Administration (FDA) in December 1995 in order to systematically manage all the stages of production with focus on prevention of any hazards that might arise in the form of physical, biological or chemical which might also be caused by the species and its environment or by the processing methods. The system requires fish processing plants to understand the hazards and use hazard prevention methods during processing establish limits for process controls and take action if and when those limits are exceeded. In addition, fish factories are required to document the operation of their system.

In Tanzania, the implementation of HACCP system throughout the production chain has been adopted since 1997. The traditional one which required testing of the end product has been abandoned and replaced with HACCP system. All the eight operational Nile Perch processing plants have adopted the Hazard Analysis and Critical Control Point programme and workers are strictly adhering to their respective Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP) and Good Laboratory Practices (GLP). Due to the successful adoption of HACCP plan, a fish export ban imposed by EU countries in March 1999 was lifted in October 1999 and export for Nile perch resumed in February 2000.

### *11.3.8 Areas of Harmonisation*

Lake Victoria being a shared ecosystem by Kenya, Tanzania, and Uganda requires a collective approach to deal with its various problems. The riparian states have decided to harmonise National Fisheries Legislation, various management measures, Fish Quality Assurance guidelines among others for sustainable conservation, management and development of Lake fisheries resources. The major objectives of Fish Inspection and Quality Assurance (FIQA) harmonization efforts are:-

i. To ensure that the same standards pertaining to fish quality assurance and safety are commonly applied in the three riparian states,
ii. To ensure safety and uniformity of quality of fish and fishery products from the three riparian East African states for both internal and export markets,
iii. To lay ground for the establishment of a regional referral laboratory, documentation systems, information dissemination and storage,
iv. To put in effect the provisions of East African Community Treaty on standardization, certification, harmonization, sustainable natural resources management and their rational utilization, among others, and
v. To guarantee long term sustainable economic benefits to the people of East Africa.

So far, the comprehensive Code of Practice with a detailed Inspectors Guide and Manual of Standard Operating Procedures (MSOP) is being developed for operationalisation by the Partner States.

### *11.3.9 Legislation on Fish Quality Assurance*

The importance of legislation with respect to the fish quality and safety assurance was emphasized even in the 1950s when the Fisheries Ordinance was enacted. It dealt with marketing boards and in 1961 it was found inadequate for the independent Tanganyika. As a result, a new Fisheries Act No. 6 of 1970 and Rules were prepared and there is a section dealing with improvement of sanitary conditions in the handling and marketing of fish. The Fisheries Act of 1970 was followed by Food Act No. 10 of 1978 and the Fish Quality Control and Standards Regulations of 2000. The Government has enacted the Fisheries Act No. 22 of 2003 to replace and repeal Fisheries Act of 1970. The new Fisheries Act has incorporated new development and objectives of the National Fisheries Policy of 1997. The new Fisheries Act of 2003 provides adequate implementation of the safety and quality of fish and fishery products from the point of capture through to the consumer.

## 11.4 Discussion

Fish quality assurance can be traced from fishing operations where proper handling of the fish is is advocated up to processing of the fish in the factories. During LVEMP certain innovations and technologies were undertaken such as improvising floating barges and designing and modifying fishing boats, collecting boats and trucks for handling fish and today these initiatives are yielding good results. Efforts are being made to promote powered boats instead of sails and paddling due to the fact that they are fast in reaching major landing sites as a result have no adverse effect on the quality caused by delay in harvesting time and transportation. In order to monitor the trend of improvement, data for post harvest losses at selected fish processing plants are collected and analysed.

Investment in a fish business trading with external markets requires careful consideration of the available fishery resources intended to be processed, and then distributed, i.e., stable stock at the particular time. The exports from Lake Victoria were started even before 1950's; most of the fish and fishery products exported were in the form of fresh, dried, smoked and salted. The export business in the 1950's to late 1980's was initially dominated by traders taking the fish and fishery products as far as Burundi, Democratic Republic of Congo, Rwanda, Malawi, Kenya and Uganda. During this period, little information with respect to records were available i.e., there was no proper monitoring of the export records. This export market existed in infancy state up to early 1990's, when Nile perch industrial processing emerged and dominated the export market. The successful increase in exports of fish and fishery products has contributed to the introduction of retention scheme in Fisheries Division by year 1996, in which more funds were available to monitor, control and make surveillance in the areas of harvesting, landings, processing and distribution.

The total export of Nile perch products for the last 11 years (1993–2004), showed a significant increase in weight, this means our products meet customer requirements and ensure safety and confidence to the consumer. However, in 1999 there was a remarkable decline in the total export of Nile perch products whereby 25,914.079 metric tons valued at USD 55,321,521.5 (F.O.B. value) were exported. The decline in the export of Nile Perch products was caused by the 11-month European Union import ban on Nile perch products from the lake which was effectuated from March 1999 to February 2000. The same trend appeared in 2002 which was caused by the implementation of slot size of 50–85 cm for Nile perch in order to curb processing of immature fish in the riparian states. The total annual export was 29,212.3 tons valued at USD 88.2 million. The Lake Victoria Fisheries Organization (LVFO) Council of Ministers has directed the Fisheries Departments of the three countries sharing the lake to implement the various management measures including the slot size in order to sustain the fishery resources of the lake. As a result, less quantity of raw materials was available for processing due to the fact that most of the fishermen are forced to change their fishing nets.

According to FAO (2000), Nile perch fishery started in the early 1980's and gradually built up from about 43,000 metric tons in 1985 and reached a peak in 1990 where by 180,000 metric tons were recorded before starting to fall to about 152,000 metric tons in 1996. Mkumbo (2000) has estimated that the *Lates niloticus* landings have increased from 116,462.25 tons in 1999 to 138,323.85 tons in 2000. Generally, the export statistics showed fluctuations with a peak in 2004 whereby a total of 42,354.5 tons valued at USD 100,079,167.16 (F.O.B value) were exported.

Currently, these fish processing plants operate under capacity due to inadequate supply of the raw materials (Nile perch). This has been contributed by the processing plants to upgrade their production lines in order to cope with change in science and technology and meeting competitive environments. The total combined installed capacity is 910 tons/day which requires 332,150 tons of fish per year. In 2004, the total export was 42,354.5 tons/year, in which fish fillets accounted for 30,312.90 tons/year, that is approximately 124,300 tons of Nile perch were processed (based on 41% cut to fillet). The data show that there is a need to control the fish processing capacity (overcapacity) in the three riparian states in order to avoid loss of socio-economic benefits to the riparian communities in East Africa.

The post-harvest losses data collected from the selected Nile perch processing plants are used as an indicator of either improvement or failure in the handling and preservation of raw materials (Nile perch) at harvesting, landing beaches, during transportation of the same and processing in the establishments. Generally, it has been found that there was a gradual decrease in the Nile perch post-harvest losses for the last six years which was attributed to several factors including: (i) training of the stakeholders e.g., fishermen, fish collectors, fish processors and other fish handlers in the landing sites on different aspects of fish quality control and safety assurance; proper use of ice; (ii) good design of fish handling and transportation facilities such as insulated fish containers, box body transport trucks used in storing ice and transportation of raw fish respectively. Little information is available, however, in the post-harvest losses for the other two commercial fish species, i.e. *O. niloticus* and *R. argentea.*

Although there is a big number of fish landing sites compared to the staff available, all the activities related to fish receiving, weighing, washing, sorting and selling of fish to fish collectors and other traders supplying fish to domestic markets are under control. This is possible, due to the fact that most of the operation and maintenance of these sites are under responsibility of the Local Authority such as the Village governments and Beach Management Unit members.

The introduction of floating platforms and racks for fish handling and landing has considerably minimized the contamination of fish because before these measures fishes were landed on polluted water and sand where microbial load is high. Also provision of trays for holding fish and construction of toilet for public use has improved fish quality and beach hygiene and sanitation.

The determination of levels of contaminants both at landing sites and fish processing plants is inevitable due to the fact that consumers get an assurance that fish and fish products from Lake Victoria meet appropriate standards for safety, quality and integrity. Furthermore, the National Fish Quality Control Laboratory was established for the verification of effectiveness and efficiency of quality management systems in fish establishments as a requirement to the international market, especially lucrative European Union market.

Apart from the adoption of HACCP programme in production line, there are environmental problems related to the fish processing industry, these include poor treatment of waste water and fish remains, poor sanitation in the beaches due to high population growth and lack of sanitation facilities. These problems have negative impacts to the environment such as water and air pollution as well as transmission of water borne diseases to the riparian communities. Also, polluted water and contaminated beaches are affecting fish quality. Therefore the HACCP programme should be emphasized from upstream to the production line in order to improve fish safety and quality. The deterioration of fish starts soon after hauling from water, thus any temperature abuse might lead into low quality and finally loss. The change from traditional way of own-check system to adoption of HACCP system is regarded as an indicator for in attitudinal change.

## 11.5 Conclusion

Fish quality control and safety assurance has been successful because Fisheries Division is the Competent Authority in all matters related to fish quality assurance. Samples for microbial checks are now carried out in National microbiological laboratory. Inspectors have acquired skills and knowledge on matters related to fish quality assurance. The government has gazetted Fish Quality Control and Standards Regulations of 2000, which empower fish inspectors to control and monitor the fish quality assurance matters effectively.

The export market has forced the Government to take appropriate measures on issues related to fish quality assurance. These measures include adoption of HACCP programme, implementation of GMP, GHP and GLP among others by all Nile perch processing plants. Provision of floating barges to fish landing sites, portable water, fencing, access roads and sanitary facilities for enhancement of resource management. Nile perch post-harvest losses have been reduced. All these measures are geared to improve fish quality for better market opportunities, high prices and better socio-economic status of fishermen and the national economy.

## 11.6 Recommendations

All fish processing plants operate below their maximum installed capacity due to inadequate supply of fish. At the same time the demand of fish for both domestic and export markets is increasing. This provides an incentive to fishers to harvest more and is contrary to the concept of sustainability on Lake Victoria fishery resources.

- It is recommended that the riparian states have to take joint actions to control the fishing effort and processing capacity of the processing plants such as the introduction of quota system to all Nile perch processing plants in the riparian states.
- The private sector has to be sensitized and encouraged to invest and produce value added products from Nile perch and other commercial fish species in order to reduce pressure on the fish stocks, maximize profits and increase socio-economic benefits to the people and national economy.
- The fish post-harvest losses for the three important commercial fish species is not known from upstream to consumers. In future, studies have to be conducted to determine post-harvest losses for the three commercial species (*L. niloticus, O. niloticus* and *R. argentea*) from fishing grounds, landing sites, during transportation and at the domestic markets.
- Government should speed up the accreditation of the National Fish Quality Control Laboratory at Nyegezi to minimize costs of sending samples outside the country.
- Government should prepare the necessary conditions for establishment of Referral Fish Quality Control Laboratory.

# CHAPTER TWELVE

# FISH LEVY TRUST

*R.B. Hoza[1] and Y.D. Mgaya[2]*
*[1]Fisheries Division, P.O. Box 2462 Dar es Salaam*
*[2]Faculty of Aquatic Sciences and Technology*
*University of Dar es Salaam*
*P.O. Box 60091, Dar es Salaam*

## 12.1 Introduction

The Lake Victoria fishing industry earns substantial revenue to the Government. In 2004 the total export from Lake Victoria was 42,355 tones valued at USD 100,109,166.79 (Fisheries Division, 2004). However, the fishing industry is being affected by several problems like the disappearance of indigenous fish species, eutrophication, illegal fishing practices, increasing fishing effort, encroachment in the fish breeding areas, increase in fishing effort and general degradation of the lake ecosystem.

Currently the Fisheries Division operates a revenue retention scheme to boost funds for the fisheries sector. However, the revenue collected from the scheme is not sufficient to finance fisheries management, research and training hence the need to establish a self-financing mechanism for Fisheries management and ecosystem conservation. A Fish Levy Trust study was conducted from May 2000 to February 2001; its major objective was to lay the foundation for generating public revenues from the major commercial activity on the lake, namely fishing, and using them to sustain further environmental protection activities in the Lake Victoria Basin. The study found out that the collection of export royalty is effective and efficient. The analysis of maximum possible revenues from the fishery under the present taxation structure indicates that the maximum was 1.4 times that which was charged to the fishery and over 3 times that which was accruing to the state (LVEMP 2002).

After the completion of the study the Government considered consultants recommendations and decided to establish a single National Fund namely Fisheries Development Fund (FDF) to cater for environmental protection activities in all major and minor water bodies (fresh and marine waters) in Tanzania.

On the other hand the then three reports on Fish Levy Trust Fund were harmonized and submitted for consideration by the members of the Regional Policy and Steering Committee of LVEMP and directed that each riparian state has to establish a Fish Levy Trust Fund for Lake Victoria.

## 12.2 Justification

Fish production for the whole lake is currently estimated to be between 400,000 to 600,000 metric tons worth USD 400 to 600 millions. In Tanzania the total export of Nile perch and its products for the last eight years (1997-2004) was 79,645.86 tons valued at USD 212,165,184.33 (F.O.B value) of which the Fisheries Division received at total of Tanzania Shillings (TAS) 13.11 billion as Royalty (Fisheries Division, 1997-2004). The contribution of fish and fishery products to the Gross Domestic Product (GDP) has varied from 3.02% in 1991 to 2.63% in 1999 (Kulindwa, 2001). The export and GDP values show the importance of the fishery resources to the National economy, socio-economic development, biodiversity conservation, environmental protection, among others in the country.

On the other hand, the lake is at the moment under intense pressure from human activities and natural processes with serious environmental implications; the most obvious of fisheries concern being the disappearance of indigenous fish species, eutrophication, illegal fishing practices, increasing fishing effort, encroachment in the fish breeding areas, increase in fishing effort and general degradation of the lake ecosystem. All these environmental threats represent a serious loss of income to the fishermen and traders; loss of food/protein and foreign exchange to the national economy (LVEMP, 1996).

The fisheries management activities have been hampered by inadequate budget before independence and after independence in 1961. On the other hand, illegal fishing practices were observed during colonial regime (Lake Victoria Fisheries Service Annual Report, 1953 and 1955/56). The illegal fishing practices continued to threaten the existence of different fish stocks in the lake. Other problems observed were over-fishing, absence of Fisheries Regulations prior to 1951, poor fish handling and processing methods, high fish post harvest losses, poor access roads and transport among others. In 1970's the Government decided to introduce a decentralised system in fisheries management as a way of strengthening fisheries management activities in the country where the Local Authorities were given certain responsibilities. The scope and responsibilities of Local authority have continued to expand. To day the Local Authority are in charge of issuing fishing licences for fishers and vessels, registration of fishing vessels, collection of fisheries statistics data, law enforcement, involvement in the conservation of aquatic resources, coordination of extension services among others (Fisheries Division, 1997).

With those changes the Fisheries Division remained with major roles and responsibilities such as formulation of the policy and overseeing its implementation, sectoral planning and budgeting, formulation and review of legislation, law enforcement, licensing, and revenue collection among others.

However, all these changes didn't bring the expected results of reducing over-fishing, enhancing conservation of fish biodiversity, environment among others.

Experience gained over the years has shown that alternative mechanisms and sources of fund are required to finance fisheries management activities in order to sustain the fishery resources for the benefit of the people and the nation. Based on the above facts the Government in 1996 allowed the Fisheries Division to establish a revenue retention scheme, which became effective in 1996/97 (LVEMP 2002).

Revenue retention scheme is an arrangement allowing a sector or department to use all or part of the controlled revenue from a particular sector for furtherance of the activities of the sector or department. Retention is allowed for sectors that generate income. There is no law for establishment of a revenue retention scheme. The Treasury maintains that the main purpose of retention scheme is to re-invest the funds in the sector from which the revenue is collected with the aim of generating further revenues from that same sector. To warrant extension of the scheme therefore, there must be an increasing trend in revenue collection because "retention is meant for revenue enhancing activities."

Under Lake Victoria Environmental Management Project a study on Fish Levy Trust was conducted by the UK consultants MacAlister Elliot and Partners in association with M-Konsult of Tanzania from May 2000 to February 2001. The final draft report of the study was discussed at a national stakeholders' workshop that was held in February 2001 in Mwanza.

The objective of the study was to "lay the foundation for generating public revenues from fishing activities and using them to sustain further environmental protection activities in the Lake Victoria basin."

The study was designed to cover four core areas namely:

a) **The analysis of current revenues and revenue collection system in the fisheries sector**
b) The proposal of options for a revised system of revenue collection
c) Analysis of the impacts and effects of the proposed revised system
d) Proposal for the disposal of collected revenues

## 12.3 Results

### *12.3.1 Local Government Revenue*

The Local Governments were collecting less revenue than what should be collected. It was estimated that the annual Local Governments collection was TAS 656,300,000.00; this amount can be increased to TAS 1,603,500,000.00 with improved revenue collection system. Furthermore, it has been estimated that the maximum annual Local Governments collection can reach TAS 2,315,500,000.00, which was 1.4 times of the estimated annual revenue collection of TAS 656,300,000.00.

Human resources at district level are not adequate to carry out the task of revenue collection on a 24-hours/day and year basis. The current structure of remuneration at district level does not contribute to the efficient execution of normal duties, including revenue collection, by Local Government staff.

#### *12.3.2 Central Government Revenue*

The collection of export royalty is on the whole effective and efficient. Currently the royalty is being charged at a fixed tariff per kilogramme for Nile perch and its products. This system has dismissed any further argument about appropriate levels of export price. Evasion of royalty payment for the official export of fresh and frozen Nile perch products is not easy. The under-declaration of weight of fillets is considered to be unlikely under the present market conditions, as irregularities in shipment weights would run the risk of consignment rejection or delay in the EU with potentially serious losses for the exporter. The present system of contracting of private agents is very un-transparent and legally permits a very significant proportion of collected revenues to be taken as profits by agents. In addition fishers sustain significant losses of revenue through the use of tampered scale by purchasing fish traders.

Currently fishing effort is not controlled in the lake. It is suggested to regulate fishing, either directly or by regulating the Nile perch processing industry by introducing a quota system for the long-term sustainability of the Nile perch fishery resources.

## 12.4 Discussion

#### *12.4.1 The Application of Collected Revenues*

Taking into consideration that the objective of Fish Levy Trust study was to lay the foundation for generating public revenue from fishing and using them to sustain further environmental protection activities in the Lake Victoria Basin, it was proposed to establish a special fund namely Lake Victoria Environment Fund (LVEF).

#### *12.4.2 Rationale for Lake Victoria Environment Fund*

The establishment and operation of the Lake Victoria Environment Fund is made on the basis of two key premises:

**i) Revenue streams**
The primary public revenue stream from the fishery is that of the export royalty. Local Government revenues are also potentially significant, but there are high demands on it at local level and are more difficult and expensive to collect effectively.

**ii) Local Government Autonomy**
In the proposed Lake Victoria Environment Fund it has been assumed that it would be difficult and politically wrong to oblige Local Governments to spend revenues from fisheries in a particular way, like to contribute to the central or regional fund.

### *12.4.3 Conceptual Operation of the Lake Victoria Environment Fund*

There are two fundamental concepts behind the proposed Lake Victoria Environment Fund

i) The Lake Victoria Environment Fund should be a facilitation mechanism. It should be a co-financing mechanism allowing stakeholders to make better use of their own resources.
ii) The Lake Victoria Environment Fund will not receive direct contributions from any source other than the export royalty stream. Local level stakeholders will be required to contribute, but to specific activities, rather than to the fund itself.

Qualifying activities will be as follows:

a) Habitat protection and enhancement
b) Water Hyacinth Control
c) One off patrols
d) Infrastructure associated with shoreline cleanliness like toilets, landing facilities, fish drying facilities, among others.
e) Training and awareness raising related to preservation of the fisheries environment.

Activities that should not be financed include:

a) Capital or operating costs for credit schemes
b) Individual private investment
c) Central Government tasks including statistical surveys, data collection, and regular patrols
d) Subscriptions to other institutions such as LVFO
e) Fisheries research

f) DSA, travel, among others

### *12.4.4 Revenue Sources for Lake Victoria Environment Fund*

LVEF will receive funds from export royalties, at a proposed rate of between 4% and 6% of collected revenues. Other sources of funds should be occasional funds from donor contributions, revenues from environment related penalties, among others. Stakeholders will be required to contribute between 10 to 30% of the cost of activities; the rate could be varied depending on stakeholder activity. The LVEF would in essence be an accelerating mechanism, multiplying stakeholder funds.

### *12.4.5 Management of Lake Victoria Environment Fund*

It has been proposed that the Lake Victoria Environment Fund should be managed by a board of trustees, with representatives from the Processing industry, the Fisheries Division, the Ministry of Natural Resources and Tourism and a small selection of District level stakeholders (possibly on a rotation basis).

The fund should have a small core of technical staff (2 persons), answerable to the trustees and responsible for the technical and financial appraisal of proposals, accounting, among others. On constitution of the fund, various details will need to be established in a clear and public manner including:

i) The remit of the fund
ii) Audit and accounting procedures
iii) The process for application for funding from the Lake Victoria Environment Fund
iv) Levels of Lake Victoria Environment Fund / Stakeholders contributions
v) Qualifying activities

### *12.4.6 Qualifying Organizations / Entities*

It was recommended that requests for financing should not be entertained from individuals or other non-institutional bodies.

#### *12.4.7 Execution of Approved Activities*

Approved projects / activities will be executed by the requesting body (District Fisheries Office, NGO, Fisher group, Beach Management Units (BMUs), among others), and not by the LVEF. Technical and financial audit would however, be the responsibility of the LVEF.

#### *12.4.8 Foreseeable Risks on Running the LVEF*

Two implicit risks are proposed as follows:

a) Local Governments may choose not to use any of their increased revenue for co-financing projects with the LVEF.
b) The LVEF and indeed the entire economic status of the fishery as a whole depend upon the continued and successful operation of the processing and export industry. Should the latter fail, the LVEF too would fail.

#### *12.4.9 Revision of the Legal Framework*

The establishment of Lake Victoria Environment Fund and revision of revenue collection mechanisms require legal status, which would involve making an amendment of some laws in order to give a legal mandate for "a special fund". It is clear that the LVEF will accumulate funds from part of export royalties, which are levied under the Fisheries Act No. 6 of 1970. As the case of Roads Fund and Tanzania Wildlife Protection Fund (TWPF), legislating the establishment of LVEF is inevitable and would necessitate an enactment of a new Act. A new Fisheries Act of 2003 has been enacted to replace and repeal the Fisheries Act No 6 of 1970. However, the Fish Levy Trust Fund is not incorporated in the new Act because it is waiting for the Government approval. The following procedure is proposed:

i) The Government to amend the Fisheries Act No. 22 of 2003 for the establishment of the LVEF and use of export royalties
ii) The Government to prepare a Bill enacting a new Act for the establishment of LVEF

The Act should state the main objective of the LVEF, which is to generate revenues from fishing and use them to sustain further environmental protection activities in the Lake Victoria basin. This objective is in line with an overall goal of the National Fisheries Policy, which is "*to promote conservation, development and sustainable management of the Fisheries Resources for the benefit of present and future generations.*"

Furthermore a schedule would be necessary for clear explanation of the tenure of office of the Trustees, Fund Manager and the Accountant of the Board, conditions of service and frequency of Board meetings in each year.

Based on study findings it was found out that export royalty continues to dominate public sector revenue streams from fisheries. At the local level revenue is dominated by that from Fish Levies. The collection of Central Government revenues is efficient and effective. The collection of Local Government revenues is efficient but not effective. The present system of the contracting of private agents is very un-transparent and legally permits a very significant proportion of collected revenues to be taken as profits by the agents. Fishers sustain significant losses of revenue through the use of tampered scale by purchasing fish traders. Based on the study findings it was concluded that:

i) A revised system for the contracting of levy agents should be refined and implemented. This should include Public tendering for contracts under transparent condition and established minimum contract values on the basis of a 30/70 (or better) division of expected revenues between the agent and the Local Government. Contracts should however continue to be fixed price.
ii) In the short term there should be no changes to the mechanism for the collection of Central Government revenues. In addition, in the medium term the implementation of a quota based system for the management of Lake Victoria should be considered. There are however, a considerable amount of consultations, analysis and policy development yet to be done before such a system could be put in place.
iii) A special fund for environmental protection activities should be established – the Lake Victoria Environment Fund
iv) The LVEF should receive revenues from the export royalties, the allocation of funds being controlled at the level of the Treasury. The LVEF should not receive direct contributions from local Governments.

### *12.4.10 Steps Undertaken by the Government and LVEMP*

After the submission of the final report on Fish Levy Trust to the Government the following actions were taken both by the Government and LVEMP.

**Fisheries Department**

Tanzania is surrounded by four major water bodies namely the Indian Ocean and the three great lakes of Africa which are Lakes Victoria, Tanganyika and Nyasa. Furthermore the country has diverse river systems, numerous wetlands and other minor waters. All these have a significant contribution to the livelihood of our people and are equally threatened by increase of population, environmental degradation and poverty, among others. Based on the above reasons it was therefore, found that the Government cannot establish similar separate fund for each water body like LVEF. Instead, it was decided to establish one fund for all major and minor water bodies to cater for environmental protection activities, among others. Consequently Fisheries Division has decided to establish a **Fisheries Development Fund (FDF),** which has been incorporated in the new Fisheries Act No. 22 of 2003. This new Act repeals and replaces the Fisheries Act No. 6 of 1970.

### Legal status of Fisheries Development Fund (FDF) in Tanzania

The Fisheries Division is planning to operationalize the Fisheries Development Fund (FDF) after July 2005. This is the date when the Fisheries Act No. 22 of 2003 and the Principal Fisheries Regulations would come into force. Under Part VII (Financial Provisions) of the Fisheries Act No. 22 of 2003 the resources of the Fund shall come from:

a) Any such sum as may be appropriated by the Parliament;
b) Any sum or property which may any manner become payable into the Fund;
c) Any income generated by any project financed by the Fund, due allowance being made for any necessary expenses which must be met by any such project;
d) Grants, donations, bequests or such sum contributed by any private individuals, corporate bodies, foundations and international organizations, within or outside the country;
e) Any such funds legally acquired from various sources.

Furthermore, there shall be a committee of Fisheries Development Fund appointed by the Minister, which shall be responsible for the management of the Fund.

### Lake Victoria Environmental Management Project

The final report was submitted to the Regional Policy and Steering Committee of LVEMP in June 2004. The members of Regional Policy and Steering Committee directed the Fisheries Management Component in the three Partner States to prepare a regional harmonised report from the three Studies. The regional harmonised report on Fish Levy Trust study was prepared and submitted to the Regional Policy and Steering Committee in April 2005. The members of Regional Policy and Steering Committee approved the establishment of a Fish Levy Trust Fund in each country and directed the Fisheries Management Component in collaboration with the LVEMP National Secretariat to prepare a business plan, which will show sources of funds and activities to be funded for a period of five years.

**Programmes to be Funded**

The Fish Levy Trust Fund will finance the following major programmes:

i) Management, Research and Development which has been allocated 85% of the total budget
ii) Administration which has been allocated 15% of the total budget

Under Management, Research and Development programme the following Components will be implemented:

i) Natural resources sustainability which has been allocated 46.75% of the total budget
ii) Industrial Development which has been allocated 29.75 % of the total budget
iii) Human Capital Development has been allocated 8.5% of the total budget

The key priority areas to be implemented under each Component are as follows:

*Natural Resources Sustainability*

i) Habitat protection and enhancement
ii) Water hyacinth control
iii) One-off patrols and
iv) Training and awareness raising related to preservation of the fisheries environment

*Industrial Development*

i) Improvement of Fish Landing and Storage Facilities
ii) Construction of Dry and Cold Storage Facilities
iii) Encourage Use of Ice on Artisanal Fishing Vessels
iv) Encouraging Value Added Products
v) Fish Post Harvest Losses Study
vi) Construction of Access Roads
vii) Construction of Fish and Fishery Products Consumer Markets

*Human Capital Development*

The training programmes shall include special training that are not simply augmenting Government programmes of a general nature such as entrepreneurship skills, leadership skills, environmental conservation, safety and quality of landed fish, among others. The training will be given to fishers, traders, processors (small scale), Fisheries Staff among others.

The funds for implementing activities under Management, Research and Development (MR and D) Funds will be accessed by relevant stakeholders as follows:

i) Annual competitive applications
ii) Commissioning an MR and D
iii) Collaborative joint venture MR and D activity

iv) Activities related to sustaining the fishery resources such as closed season and closed breeding areas, regular monitoring and evaluation of the resources availability, regulating access to the resources being exploited, activities involving the communities in resource management, among others.

Evaluation criteria for accessing the Fish Levy Trust Funds shall be developed along the following lines:

i) Projects proposal from persons with institutional linkages
ii) Co-financing ability of the applicant
iii) Attractiveness along the line of clearly defined outcomes relevant to the Trusts` MR and D objectives
iv) Feasibility attractiveness with planned outputs sufficient to achieve the planned objectives

**Organization, Management and staffing**

The Fund shall be governed by a Board of Trustees, which shall be assisted by a Technical Committee and a small Management Team.

***Composition of the Membership of the Board of Trustees***

The Board of Trustees shall be composed of 8 members as follows:

i) One member from the Ministry of Finance
ii) One member from the Ministry responsible for Fisheries matters
iii) One member from the Ministry responsible for the Environment
iv) One member from a strong National Fisheries Association representing the NGO community
v) The Head of the Authority, Department or Directorate responsible for Fisheries in the country
vi) A representative of the BMUs representing Civil Society at the most effective co-management level
vii) A representative from a national public university with strong fisheries research and training background
viii) The Operations and Fund manager who shall be the Secretary to the Board of Trustees

At least two members of the Board must be women

***The Technical Committee***

The Board of Trustees shall have a Technical Committee, which shall have an advisory role and shall have 5 members from the following institutions:

i) One member from the Fisheries Research Institute
ii) One member from the Fisheries Department
iii) One member from the Water Resources Management Department
iv) One representative from a riparian district
v) One member form Attorney General Chambers

***The management***

Fish Levy Trust Fund's management shall have the following core staff:

i) The Fund and Operations Manager
ii) The Finance Officer
iii) The Administrative Officer

**Status of implementation**
The business plan for the Fish Levy Trust Fund has been prepared. The business plan has made analysis on the strengths, weaknesses, opportunities and threats of the Fish Levy Trust Fund. In addition, the business plan shows the vision, mission, functions, programmes and operations, organization, management and staffing and financial plan projections for five years.

***Vision and Mission***
The Fish Levy Trust Fund vision is to utilize funds generated from within the Fisheries sector to create conditions whereby all actors and stakeholders work together to attain a Lake Victoria Basin with resources that are sustainably managed and communities that have a high and equitable standard of living.

The Fish Levy Trust Fund's mission is to realize its vision by collecting and mobilizing financial resources largely from within the fisheries sector and facilitating the availability of funds in a cost effective way to its core functional areas of natural resources sustainability, industrial development and human capital development.

### *12.4.11 Functions of Fish Levy Trust Fund*

The Fund will have the following functions but not limited to:

i) Receive and manage funds from fish levies
ii) Mobilize its resources towards protection of fish breeding areas
iii) Facilitate and conduct training for transfer of skills and competencies in monitoring, control and surveillance for BMUs and Fisheries staff
iv) To conduct and support research relevant to stock assessment, critical habitat identification, determination of fishing effort

The financial plan projections have the following components:

i) Core budget for business plan
ii) Financial strategy
iii) Funding priorities
iv) Investments
v) Financial projections

### *12.4.12 Financial Projections*

The Fish Levy Trust Fund's financial objective is to ensure adequate and stable funding for its mission. The core budget will finance the Fund's basic governance and programme component activities.

Two Scenarios of financial projections have been prepared using information presented in the Fish Levy Trust study and current data obtained from the Ministry of Natural Resources and Tourism. Cash flow under Scenario 1 has utilised historic data from export royalty for the years from 2000 to 2004. Scenario 1 assumes the lowest export royalty rate of 2 % that makes available a total of TZS 128 million, in the first year of Business Plan (2005/06). This amount of money is inadequate considering the initial budget of TZS 827 million for the first year. Cash flow under Scenario 2 has utilised historic data from export royalty for the years from 2000 to 2004. This Scenario seeks to establish the level of funding that can sufficiently cover the envisaged initial programme component costs. This Scenario set an export royalty rate of 13 % that makes available a total of TZS 834 million, in the first year of Business Plan (2005/06), which covers well the envisaged initial programme. The Cash Flow projections for a five yeas horizon in the two Scenarios are summarised in the Table 12.1:

Table 12.1: Financial Projections in Tanzanian Shillings.

| Year | Scenario I | | Scenario II | |
|---|---|---|---|---|
| | Total Receipts | Total Expenditure | Total Receipts | Total Expenditure |
| 2005 | 128,322,491 | 827,380,000 | 834,096,193 | 827,380,000 |
| 2006 | 136,021,841 | 876,604,600 | 884,141,965 | 876,604,600 |
| 2007 | 144,183,151 | 928,730,476 | 937,190,483 | 928,730,476 |
| 2008 | 152,834,140 | 986,181,705 | 993,421,912 | 986,181,705 |
| 2009 | 162,004,189 | 1,044,642,807 | 1,053,027,226 | 1,044,642,807 |

Under scenario 1 the total receipt for year one (2005) will be TZS 128,322,4910 and total expenditure will be TZS 827,380,000 with a deficit of income amounting to TZS 599,057,509. The total receipt in year five (2009) will be TZS 162,004,189 and total expenditure will be 1,044,642,807 with a deficit of income amounting to TZS 882,638,618.

For scenario 2 the total receipt for year one (2005) will be TZS 834,096,193 (2005) and total expenditure will be TZS 827,380,000 with excess of income amounting to TZS 106,716,193. In year five (2009) total receipts will be will be TZS 1,053,027,226 and total expenditure will be TZS 1,044,642,807 with excess of income amounting to TZS 8, 384,419.

The annual estimated costs for the initial programme component activities are as follows:

i) Natural resources and sustainability TZS 300,000,000

ii) Industrial Development TZS 309,000,000
iii) Human Capital Development TZS 110,000,000
iv) Trust Fund Administration TZS 108,380,0000

The total initial costs required to operationalize the Trust Fund is estimated at TZS 827,380,000.

## 12.5 Conclusion

It has been agreed by the riparian states that certain activities such as credit schemes which provide incentives to increase fishing effort, activities that are peripheral to sustaining the fisheries resources and activities of Fisheries Department and Local Authorities will not be funded by the Trust fund.

The financial projections indicate that scenario two can provide a substantial amount of fund to the Trust Fund while scenario 1 cannot provide adequate fund that can finance activities that have been identified for the Trust Fund. Based on the above analysis Scenario two can generate adequate fund for the Fish Levy Trust Fund to realise the objectives of the Fund.

## 12.6 Recommendations

Scenario 1 has shown that 2% from the export royalty from Lake Victoria/Retention Scheme cannot generate adequate revenue for the Fish Trust Fund. It is therefore recommended that scenario 2, which set a rate of 13% is the best scenario that can sustain the envisaged programme. Furthermore the establishment of Fish Levy Trust Fund should be supported by legislation.

# CHAPTER THIRTEEN

# CO-MANAGEMENT IN LAKE VICTORIA FISHERIES

*A. Mahatane[1], Y.D. Mgaya[2], R.B. Hoza[1] and P. Onyango[3]*

*[1]Fisheries Division, Ministry of Natural Resources and Tourism*
*[2]Faculty of Aquatic Sciences and Technology*
*University of Dar es Salaam*
*3Tanzania Fisheries Research Institute*
*Sota, Mara*

## 13.1 Introduction

Sustainability of the fishery resources and the accruing benefits requires sound management measures. In Lake Victoria, management of the fisheries can best be understood in three eras. These are; the Pre-colonial, Colonial and Post-colonial era. Under each era, there were regulations, which aimed at ensuring sustenance of the resources for continued benefits to communities and the nation in general. The type of challenges on the fishery resources dictated the kind of regulations, which were in force in each era. This chapter therefore presents the trend of management regime that has been used during the three eras and analyses the Monitoring, Control and Surveillance (MCS) outputs with regard to law enforcement and compliance to fisheries regulations.

## 13.2 Justification

Over the years the population around the lake has increased including industries and other Socio economic activities in the lake basin like agriculture, mining and livestock keeping. These developments and activities have brought changes in the water quality, fisheries biodiversity, wetlands and land use. Fish stocks have been decreasing, biodiversity declined and water quality deteriorated (GoK/GoU/GoT, 1996; Mkumbo 2002). The regulations that are in place to address the respective issues have not been effectively enforced because of several reasons among them the Central Government, over the years has been doing it without involving other stakeholders. These regulations are based on a Fisheries Act No. 6 of 1970, which has been repealed and replaced by the new Fisheries Act No. 22 of 2003. There are Subsidiary Legislations for the effective implementation of the Act. The Act provides for the protection, conservation, development, regulation and control of fish, fish products, aquatic flora and products thereof and for matters incidental thereto and connected therewith. There are subsidiary Legislations specifically for Lake Victoria. They include prohibition on the use of destructive fishing gears like beach seines, gill nets of less than 5” mesh size, dagaa nets of less than 10 mm mesh size, water splashing and other fishing practices such as weirs and diving. The Fisheries Act provides for penalty for offences to any person found guilty of contravening the Act or any regulation made under the Act. In the case of the first offender the fine charged is not less that three hundred thousand Tanzania Shillings (about USD 300) or imprisonment of three years or both as stipulated in the Fisheries (amendments) Regulations of 1998. Second, offenders are fined five hundred thousand Tanzania shillings (about USD 500) or imprisonment of five years or both.

The fisheries legislation on Lake Victoria can be considered as adequate for sound management for the lakes fish resources. But major problems that have been experienced include effective enforcement of these regulations and compliance to them. This has resulted in illegal fishing practice and destruction of environment. The reasons that have been advanced for this state is the non-involvement of fishers in the management of the fish resources.

The failure under the command and control regime of the central system is has been noted to be due to the following reasons:-

(i) Inadequate resources to employ Fisheries Staff and management operations. This problem has been compounded by the retrenchment of a substantial number of staff about a decade ago (1996) under the Government streamlining Policy.

(ii) Resource users have not participated in the formulation of the Fisheries Management Policies and objectives and measures for the sustainable utilization of the fish resources, conservation of biodiversity and environmental protection. They have also not taken part in the evaluation of these policies, objectives and measures.

(iii) The Central and Local Governments have not r considered resources users views and opinions on resource management.

(iv) Management by the Central Government System has inculcated into community members a feeling that of non-ownership of the fish resources. Consequently the communities have relaxed in conserving the resource and more often than not depended entirely on the Government for the overall management of the resource.

(v) The Central System discourages partnership, sharing of power and responsibility with the beneficiaries.

(vi) Existence of poor relationship between the Government staff and community members have undermined efforts and measures put in place by the Government to sustain the resource, conserve biodiversity and protect the environment.

(vii) Huge financial resource is required under the Central system to meet the management operational costs and this always adversely affects the level of outputs because more often than not, funds are inadequate.

Realizing the eventualities of excluding communities in the Management of the Fisheries resource, the Government developed and included a provision of Co-management in the National Fisheries Policy of 1997. The Policy accommodates communities as a vital part in the planning, development and management of the Fisheries resources in order to achieve the desired objectives and sustainability of the fish resources.

The adoption of co-management in the management of the fish resources was deemed necessary because of numerous advantages, the outstanding ones are the following:-

(a) The fishers acquire more control over the fisheries, which they effectively own as a community, and there is a greater trust between them and the Government. The collaboration between the two has the following benefits:

    (i) Fishers are motivated to take a longer term management perspective (sustainability) and enforcement of the regulations is more effective because the regulations have a high level of acceptance and so compliance and self enforcement are high and therefore, transaction costs of institutions for fishery management are reduced (efficiency benefit).

    (ii) It guarantees a rapid recovery of fish species that are otherwise in the danger of extinction.

    (iii) Fishing communities are empowered to decide on wise use of resources.

    (iv) Fishing Communities have the sense of ownership over the resources.

(b) Fishers cooperate with Government in planning, development, protection and conservation of the fishery resource and environment.

(c) Fishers share the costs and benefits of improved management and hence reduce costs to the Government.

(d) Conflicts between fisher groups are efficiently resolved by themselves.

(e) Fishers and Government Authorities are willing to share data and fishers' understanding of fishery (indigenous knowledge) is taken advantage of in the management of the resource.

(f) The fishers usually organize themselves to maintain and enhance their position among other stakeholders e.g. water users, fish traders in the Community.

In an effort to implement the collaborative aspect of the Policy, the Government included a section of Co-management in the new Fisheries Act No. 22 of 2003. Further to this action, between 1998 and 2000, under the Lake Victoria Environmental Project (LVEMP), Beach Management Units (BMUs) were established as an avenue for the fishers to participate in the management of the lake (co-management). In implementing this activity, a total of 511 BMUs were established on the Tanzania side of the lake.

## 13.3 Chronological History of the Management Regulations

### *13.3.1 The Pre Colonial Era*

The period considered is before the year 1885 when the country became under German rule. There is no record on how formal fisheries management was implemented during this time. However, the fishing communities around the lake had their Regulations. These Regulations included territorial use rights whereby families living closer to a particular lake area fished from that part without interference from others and they also had access rights to the fishing areas adjacent to their residence. The communities fished using simple gears (traps, baskets) and crafts for subsistence requirements and once in a while exchanged fish for other food items e.g. flour (Onyango, 2004).

### *13.3.2 The Colonial Era*

The Colonial period lasted from 1885 to 1961, under the Germans and British. During this period, cash crops (tea, coffee and cotton) were introduced and intensified around the Lake region. Towns were also set up as trade centers, these included Musoma (on the Southern side) and Bukoba (on the Western side). Transport and Communication were established to connect these towns which were also administrative centers with other areas of the territory.

Consequent to these developments coupled with a growing population in the region, there was a high demand for fish. To meet this demand, fishing pressure on the fish stock intensified causing a significant decline especially on the much favoured fish, the Nile tilapia, *Oreochromis niloticus* (Ligtvoet *et al.*, 1995). The decline of fish stocks prompted researchers to recommend to the administration to ban usage of fishing nets of less that 5" mesh size. This was legislated in 1950 but it was never enforced in the then Tanganyika until 1953. The enforcing Body was the Lake Victoria Fisheries Service (LVFS) which was established in 1947. At this time there were two ordinances (Trout Protection Ordinance of 1929 and Fisheries Ordinance of 1950) but were not applicable to Lake Victoria.

### *13.3.3 Post Colonial Era*

After independence in 1961 the Government's recognition of the importance of Lake Victoria fisheries to the communities and the nation as whole was manifested by the creation of the Fisheries Division in 1965.

Over the years, the Nation's legislative and Policy framework has been developed to allow the country's participation in International and Regional bodies on affairs related to fisheries. At the International level the country is signatory to the FAO Code of Conduct for Responsible Fisheries which recommends Monitoring, Control and Surveillance (MCS) to be proportional to the level of fishing activities. At the Regional level Tanzania is signatory to the LVFO Convention of 1994.

Internally there is a comprehensive Legislation in place with Fisheries Regulations to control access to the fishery, control gears, protect habitat and regulate cross border fishing and trading. Authorised personnel and procedures are outlined in the Legislation with the ability to inspect and search, seize, detain, destroy illegal gears (with court order) arrest and prosecute. Authorities are also empowered to inspect fish and fishery products in respect to health and hygiene and quality assurance. There is capacity to impose fines on offenders. The Beach Management Units (BMUs), the fishing communities groups are recognized by the Legislation and have improved Monitoring, Control and Surveillance at the local level.

The power of enforcing officers is vested in the Fisheries Act No. 6 of 1970 and Subsidiary Legislation. This Act has been repealed and replaced by the Fisheries Act No. 22 of 2003. However, the latter would become operational on a date, which the Minister may approve by notice to be published in Government gazette. The Fisheries Act No. 6 of 1970 repealed and replaced both the Fisheries Ordinance and Trout Protection Ordinance. The new Act No. 22 of 2003 has wider scope to include aquaculture development, participation of community groups, Fish Quality Standards, establishment of a Surveillance Units, Fisheries Development Fund (FDF) and makes provision for sustainable development, protection, conservation, regulation and control of fish, fish products, aquatic flora and its products and related matters.

The Fisheries Act No. 6 of 1970 is applied together with the Principal Fisheries Regulations No. 319 which was gazetted in 1989. These Fisheries Regulations repealed and replaced the ones, which had been gazetted in 1973. The change of Regulations was prompted by the developments in the fishing industry, which could not be contained by the previous regulations.

From time to time it has been necessary to amend some of the fisheries Principal Regulations in order to keep abreast with the dynamic fishing industry.

### *13.3.4 Flexibility of the Act and Powers of Authorised Officers*

Vide the Act, the National Fisheries Management is the responsibility of the Fisheries Division under the Ministry of Natural Resources and Tourism, which also provides advice and guidance to the Local Authorities on matters related to Fisheries Management.

The new Fisheries Act No. 22 of 2003 invests the power of enforcement on Authorised officers who include the Director of Fisheries or any Fisheries officer or a member of the BMU or other persons authorized in writing by the Director who issues an identification card to a person so authorised to exercise any power or to discharge any duty under the Act or Subsidiary legislation made under the Act, (Section 2 of the new Fisheries Act. No. 22 of 2003). Like the old Act, the new Act is flexible in the sense that any management action required to be taken, can easily be incorporated in the Fisheries Regulations under the Act. The various powers vested to Authorised Officers including BMUs cover halting aircraft and vessels, inspection and search of vessels, houses and premises, seize and detain, sell the seized fish and product, arrest and prosecute offenders (Fisheries Act No. 22 of 2003).

### *13.3.5 Aims, Objectives and Rationale on the Management Regulations*

The overall goal of the National Fisheries Policy (1997) is to promote conservation, development and sustainable management of the fisheries resources for the benefit of the present and future generations. Implementation of the policy is done through its instrument, the Act and regulations. Acts and regulations are amended or changed to control threats on the resource biodiversity, environment or health of consumers whenever there are scientific facts obtained through research by a formal Institution indicate that the fishing gears and techniques, fish handling, processing, packing and distribution are threatening sustainability of the fisheries resource, biodiversity, environment and consumers health respectively.

In this respect since 1970 when the first Fisheries Act was enacted there has been changes of the Fisheries regulations. The First Principal Fisheries regulations were legislated in 1973, Amendments of some of the regulations were made in 1978 and 1982.

### *13.3.6 Development of Management Policies Including the National Fisheries Development Policy and Strategy; and Fisheries Act and Roles among Stakeholders*

Until after the Colonial era there was no Fisheries Policy. The present Policy was developed in 1997. The aims of the policy include: to regulate, protect, promote, conserve, develop and sustainably exploit and utilize fish and other fishery products to provide food, employment, and income and earning foreign exchange through export.

There is a set of strategies contained in the Policy for its implementation. The strategies cover the following areas: (a) Fisheries development and management, (b) Training, (c) Trade in fish and fishery products, (d) Aquaculture, and (e) Research.

### *13.3.7 The Fisheries Act*

As stated above, until 1970 (nine years after independence) fishing was not adequately regulated by the Law for sustainable exploitation. The Trout Protection Ordinance Cap. 160 of 1929 protected the Trout fish in the cold streams of the Northern and Southern highlands for sport fishing (Trout Ordinance Cap. 160 of 1929). The Fisheries Ordinance Cap. 36 of 1950 provided for the establishment of Boards for specified water bodies some of which were private properties. Such Boards were empowered to make their own management regulations including sustaining own administrations financed from licenses and levies. The fisheries administration was therefore fragmented.

Furthermore, Lake Victoria was not governed by these Ordinances. Section 2 of the Fisheries Ordinance defined, "waters" as all Territorial inland water of the Territory; except the waters of Lake Victoria and its island and excluded all waters of the Territory under private ownership. Section 30 concluded by stating that nothing in the ordinance or any provision made shall have any effect in relation to the waters of and island of Lake Victoria (Fisheries Ordinance Cap. 36 of 1950).

Until 1970 when the Fisheries Act was enacted, Fishing continued to be managed by administrative orders.

The Fisheries Act No. 6 of 1970 recognized under development of the Sector and so provided for the enactment of the Principal Fisheries regulations to regulate the industry whenever situations demanded so in order to contain threats to the sustainability of the resource. The first Principal Fisheries regulations were put in place in 1973 and others subsequently replaced these in 1978, 1982, and 1989.

Since 1989 important seven amendments have been made on some of the Regulations of the Principal regulation by Government Notice (GN) to contain situations, which were posing threats to the Lake resources. The following amendments were made:

a) Government Notice No. 5 of 22nd January 1982 - proclaiming 24 areas as closed fishing areas from 1st January – 30th June of every month. The aim is to protect the brooder fish and the fingerlings.
b) Government Notice No. 369 of 10th March, 1994, prohibition of use of beach seines, under mesh sized gill nets (less than 5") and Dagaa nets of (less than 10 mm). The main aim is to protect the immature fish of the respective fish species from being caught.
c) Government Notice No. 370 of 7th October, 1994 banning of trawlers from fishing on Lake Victoria. The purpose is as for Government Notice No. 369 of 10th March, 1994.
d) Government Notice No. 189 of 6th June, 1997 – by this Government Notice no one is allowed to possess a beach seine leave alone fishing with this gear. This Government Notice also increased the levels of fines to be melted to offenders from twenty Tanzanian shillings to not more than one hundred thousand.
e) Government Notice No. 624 of 9th October, 1998 made the fine stiffer to not less than three hundred thousand shillings or a jail term of 3 years imprisonment to first offenders or both. For second offers the fine is not less than five hundred thousand shillings or a jail term of five years or both.
f) Government Notice No. 193 of 1st August, 2003 which prohibits fishing and possessing or processing or exporting or trading a Nile perch fish of less than 50 cm total length. By the same Government Notice Nile perch fish of more than 85 cm total length are covered with similar restrictions.

The control of quality standards of fish becomes very important especially after the increase in the demand for fish on the internal and export markets in the late nineties. To cater for this development, the Fish Quality Control and Standards, Government Notice No. 300 of 2000 was legislated. These Regulations covered all aspects of fishing, handling, processing, distribution HACCP in the upstream areas, at establishments, at internal markets and exit points.

These amendments not withstanding, the fishing industry has been so dynamic so much that a new Act had to be enacted. In this respect a "participatory" new Fisheries Act No. 22 of 2003 is in place. The new Act provides for co-management of the all the fishing waters in the country including Lake Victoria. Within this framework of co-management, the stakeholders who take part in the management include: the Fisheries Division, Local Government, Non-governmental organizations, Private sector and fishers (fishermen, traders, processors, net and boat menders and crew members). Their responsibilities are highlighted here below

### *13.3.8 Responsibilities of Stakeholders*

Various institutions and stakeholders are involved in the implementation of the Fisheries Policy. Their roles are spelt out in the Policy so as to avoid mix ups and even conflicts. The stakeholders and respective roles and responsibilities are as follows:

1) **The Fisheries Division**
The overall responsibility is Fisheries Management and Administration which entails, formulation of the policy and oversee its implementation, sectoral Planning and Budgeting; Formulation and Review Legislation, Law Enforcement and Surveillance, Monitoring and Evaluation of the sector performance, Management Information System, Manpower Planning and Human Resources Development, Extension Services, Research, Training and Curriculum Development, co-ordination of other stakeholders, Licensing of Fishing boats with more than 11 m length overall (LoA), Fish and Products Exported and International Cooperation and Collaboration. This has been traditionally the responsibility of the Division since it was established.

2) Under the decentralization systems local Government are the authority at the local level and therefore they assume responsibility of the Government and for that matter they are responsible for the following; registration of all fishing vessels including those with more than 11 m LoA, issuing vessel licences for vessels of less than 11 m LoA and fishermen thereof, co-ordination of extension services, law enforcement and surveillance, issuing of by laws and participation in the formulation of regulations, revenue collection emanating from various fees, involvement in the conservation of fisheries resources and environment, proposition of areas with conservation and biodiversity values for subsequent gazettement as protected areas, involvement in the management of the conservation areas, for example, closed fishing and breeding areas, promotion of aquaculture and quality seed production. Some of the responsibilities have changed over time and shared out with fishers.

3) **Local Communities**
The local communities are the direct beneficiaries of the resource and are daily in contact with the resource. Under the new law they (through the BMUs) have been empowered by the new Fisheries Act section 18 (1) to co-manage the resource with the Government. Their role and responsibilities are; conservation and management of the fisheries resources, formulation and enforcement of the by laws, collection of fisheries statistics, oversee beach sanitation and hygiene resolution of conflicts, ensure security and cleanliness of the barges and other installed infrastructure, and educating and raising awareness of community members on the effects of fishing malpractices on the resource, biodiversity and environment. These are new responsibilities that were assigned to them by the new Act and regulation.

4) **Non Government Organizations (NGOs)**
The NGOs have not in the past been taken on board until 1997 (in the new Fishery Policy) when their involvement was defined as to enhance capacity and foster sustainable development of the fisheries sector. Their responsibilities are; awareness, creation and extension services, capacity building, technical assistance, financing of fisheries and environmental activities, and promotion of gender roles.

5) **Private Sector**
This sector enhances investment, improves business and general management in the fishing industry, revitalize financing operations and marketing of fishery products. All these entails the following responsibilities: sustainable harvesting and utilization of fisheries resources, facilitation and financing investment in the fisheries sector, provision of employment and fisheries inputs and services, production of fish products, marketing of products, application of biodiversity guidelines in fisheries management, environmental impact assessment (EIA) in fisheries investment and investment in environmental sound production technologies.

6) **Regional and International Community**
These are partners in the sustainable development of the fisheries resources and their roles are; provision of financial assistance, capacity building, facilitation to implement international obligations and promotion of technical cooperation.

7) **Government Agencies and Other State Machinery**
Their role is to assist in the management for fisheries administration and environment conservation**.**

With the commencement of more collaborative forms of management, these different actors got different responsibilities in the decision making process and management, from setting objectives, collecting information, formulation and implementation of measures and evaluation of measures and objectives against indicators. The trend in changes in the roles is highlighted in Table 13.1. The information in the table shows that a number of fisheries management roles are slowly being shared with the fishers. It is only one role that still remains with the government that is setting of management objectives.

Table 13.1: Trend in changes of roles in fisheries management.

| Position in decision making process | Roles | 1955 - 1975 | 1975 – 1995 | 1995 – 2005 |
|---|---|---|---|---|
| Setting objectives | | G | G | G |
| | Setting by laws | | | F |
| Collection of information | collection of statistics | R, M | R, M, G | F, M, G |
| | Collection of experimental catch data | R, M | R, M, G | R,F |
| Implementing measures | registration of fishers | M | M, G | F, G |
| | enforcement | M | M, G | F, M, G |
| | collection of fees | G | G | F, P |
| | Conflict resolution | G | G | F, G |
| | beach hygiene and sanitation | G | G | F |
| Evaluation of measures | | M | M | F |
| | Etc. | | | |
| Evaluation of management objectives | Etc. | M | M | M, F |

Legend: F = Fishers M = Department of Fisheries (Fisheries Management) R = Fisheries Research P = Private Sector N = NGO's G = Government (Ministry of Fisheries; Local Government).

### *13.3.9 Enforcement Statistics*

One of the major threats to the sustainability of the fishery resource, conservation of biodiversity and protection of environment, which was identified by fishermen, fish traders, fish processors, farmers at the consultative meetings, was the prevalence of fishing malpractices. The common ones were the beach seines, under mesh sized gillnets and dagaa nets of less than 10 mm and water splashing ("Katuli"). These gears are banned since 1994. Efforts and energies in co-management since 1998 have been directed towards doing a way with these gears.

### *13.3.10 Trends in Enforcement Performance*

Patrols under Co-management arrangement have been implemented from 1998 when BMUs were introduced. Under this arrangement BMUs conduct patrols in areas under their jurisdiction and also collaborate with the Fisheries surveillance staff and other Government agencies, when the Government organizes such patrols. BMUs patrols are usually not facilitated by the Government. BMUs have to meet the operational costs with funds sourced from income generating activities undertaken by the respective BMUs.

The outcome of patrols from 1999 – 2005 is presented in Table 13.1 (for combined results), Table 13.2 (for BMUs alone performance) and Table 13.3 (for Government patrol results). Table 13.4 presents the frame survey results on illegal gears, so that they are compared with patrol results to gauge success. Table 13.5 highlights illegal fishing gears recorded during frame surveys (Tanzania side) conducted from 1998 – 2004.

Table 13.2: Culprits apprehended and confiscated illegal gears and immature fish by combined effort of BMUs and the government from 1998 – 2005.

| Year | Culprits | BSN | GNs<5" | DNs <100mm | Mono-filament | Katuli | Boats | Hooks | Trawl net | Immature NP | Trawler | NT(Kg) | Other species | OBE | Lamps |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1999 | 25 | 2395 | 7095 | 1096 | 0 | 201 | 2 | 0 | 4 | 0 | 1 | 0 | 0 | 2 | 13 |
| 2000 | 131 | 769 | 6086 | 390 | 3 | 138 | 35 | 0 | 0 | 800 | 0 | 26 | 58 | 0 | 0 |
| 2001 | 172 | 1221 | 11628 | 578 | 0 | 281 | 94 | 2200 | 0 | 2759 | 0 | 2560 | 422 | 0 | 0 |
| 2002 | 175 | 951 | 20623 | 2805 | 6 | 207 | 35 | 0 | 0 | 10614 | 0 | 0 | 546 | 0 | 0 |
| 2003 | 140 | 1182 | 20277 | 300 | 82 | 135 | 62 | 0 | 0 | 10748 | 0 | 64 | 390 | 0 | 0 |
| 2004 | 149 | 948 | 3625 | 229 | 475 | 232 | 52 | 0 | 0 | 3700 | 0 | 0 | 0 | 0 | 9 |
| 2005 | 162 | 724 | 3853 | 211 | 218 | 42 | 32 | 0 | 0 | 6294 | 0 | 0 | 0 | 0 | 0 |

BSN = Beach seine nets; GNs = Gill nets; DNs = Dagaa nets; NP = Nile perch; NP = Nile tilapia; OBE = Out board engine

Table 13.3: Culprits apprehended and confiscated illegal gears, and immature fish by BMUs from 1998 – 2005.

| YEAR | CULPRITS | BSN | GNs<5" | DNs <10mm | MONO-FILAMENTS | WATER SPLASHING (KATULI) | BOATS | NP (KG) | NT (KG) | FISH SPECIES. | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998/1999 | 14 | 36 | 409 | 16 | | 16 | 2 | | | | BMUs established in pilot areas |
| 1999/2000 | 127 | 225 | 2248 | 64 | 3 | 72 | 24 | 800 | 26 | 58 | BMUs established Lake wide |
| 2000/2001 | 101 | 387 | 4768 | 90 | | 129 | 36 | 359 | 2560 | 422 | Functional BMUs lake wide |
| 2001/2002 | 82 | 313 | 5003 | 64 | 6 | 106 | 35 | 10614 | | 546 | Functional BMUs lake wide |
| 2002/2003 | 89 | 396 | 5913 | 66 | 82 | 134 | 62 | 10748 | 64 | 390 | Functional BMUs lake wide |
| 2003/2004 | 91 | 124 | | 35 | 127 | 115 | 31 | 3700 | | | Functional BMUs lake wide |
| 2004/2005 | 46 | 84 | | 19 | 81 | 42 | 32 | 3500 | | | Functional BMUs lake wide |

BSN = Beach seines, GNs = Gill nets, DNs = Dagaa nets, NP = Nile Perch, NT = Nile Tilapia.

Table 13.4: Enforcement statistics on fisheries department patrols for the period 1997/98 - 2004/2005 (culprits apprehended and illegal gears, boats and immature fish confiscated).

| YEAR | CULPRITS | BSN | GNs<5" | DNs<10MM | MONO-FILAMENTS | WATER SPLASHING (KATULI) | HOOKS | TRAWL NETS | TRAWLER | BOATS | OUTBOARD ENGINES | PRESSURE LAMPS | NP (KG) | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1997/1998 | | | | | | | | | | | | | | Financial resource, land and water transport facilities were lacking |
| 1998/1999 | | 2268 | 6555 | 903 | | 185 | | 4 | 1 | | 2 | 13 | | |
| 1999/2000 | | 505 | 3768 | 284 | | 66 | | | | 11 | | | | |
| 2000/2001 | 67 | 807 | 6816 | 416 | | 152 | 2200 | | | 50 | | | 2400 | |
| 2001/2002 | 87 | 616 | 15588 | 2708 | | 101 | | | | | | | | |
| 2002/2003 | 47 | 771 | 14325 | 211 | | 1 | | | | | | | | Statistics are for six months (July 2002 - December 2002. |
| 2003/2004 | 56 | 8 | 3606 | 181 | 348 | 117 | | | | | | 9 | | |
| 2004/2005 | 80 | 617 | 3835 | 181 | 137 | | | | | | | | 2794 | Statistics are as on March, 2005. |

BSN = Beach seines, GNs = Gill nets, DNs = Dagaa nets, NP = Nile Perch, NT = Nile Tilapia

Table 13.5: Illegal fishing gears recorded in frame survey in Lake Victoria (Tanzania side, 1998 – 2004).

| Year | Beach Seine | Gillnets <5″ | Mosquito nets <10 mm | Katuli | Mono-filaments |
|---|---|---|---|---|---|
| 1998 | 826 | 11771 | 8 | - | - |
| 2000 | 999 | 18128 | 3267 | - | - |
| 2002 | 1454 | 96832 | 4830 | - | - |
| 2004 | 1532 | 57376 | 0 | - | 5041 |

The trends in the confiscated gears and levels of success are compared to frame survey results (Figs. 13.1–13.3). Trends in numbers of culprits apprehended and confiscated vessels are presented in Fig. 13.4. There is a positive correlation between immature Nile perch and confiscated undersized gill nets (Fig. 13.5a–b). The same trend is true for immature Nile perch and confiscated beach seines (Fig. 13.6a-b).

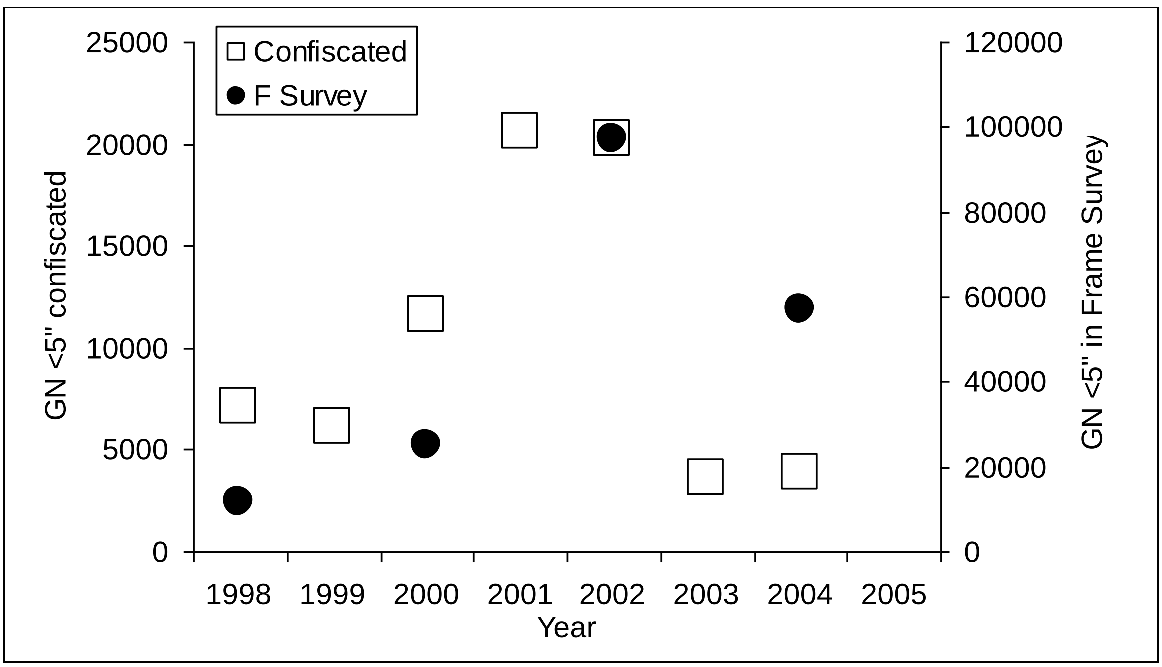



Figure 13.1: Trend of gillnets (GN) under 5″ confiscated, 1998 – 2005 compared to frame survey results for 1998 – 2004.

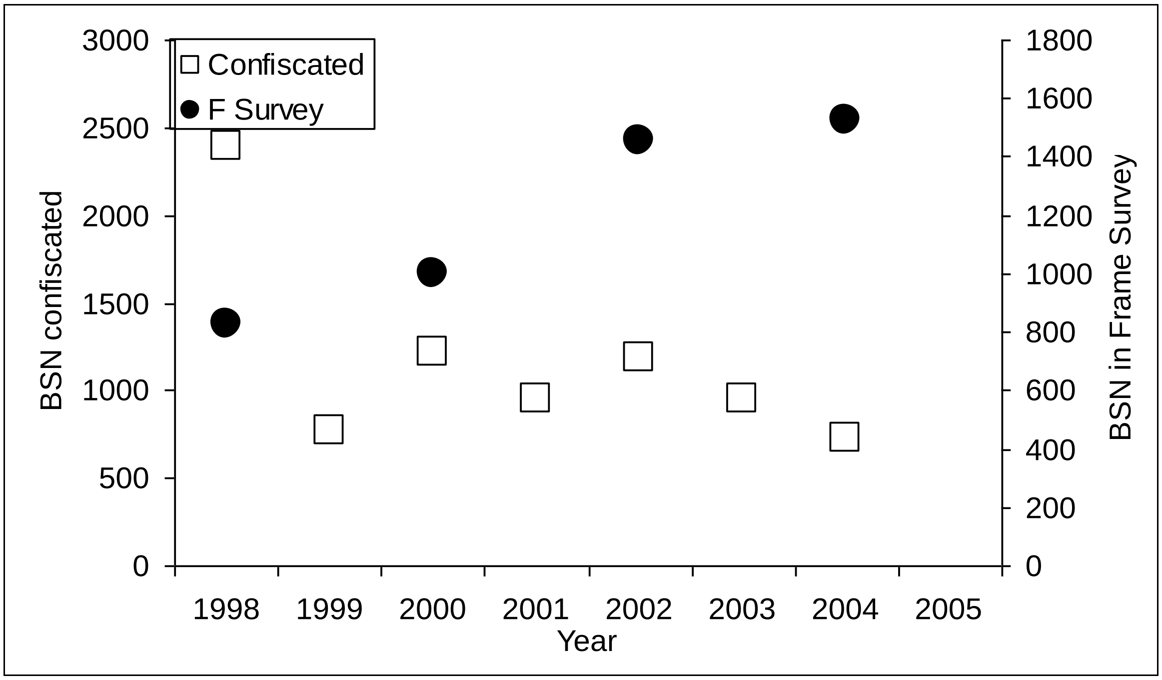



Figure 13.2: Trend of Beach seines (BSN) confiscated, 1998 – 2005 compared to frame survey results for 1998 – 2004.

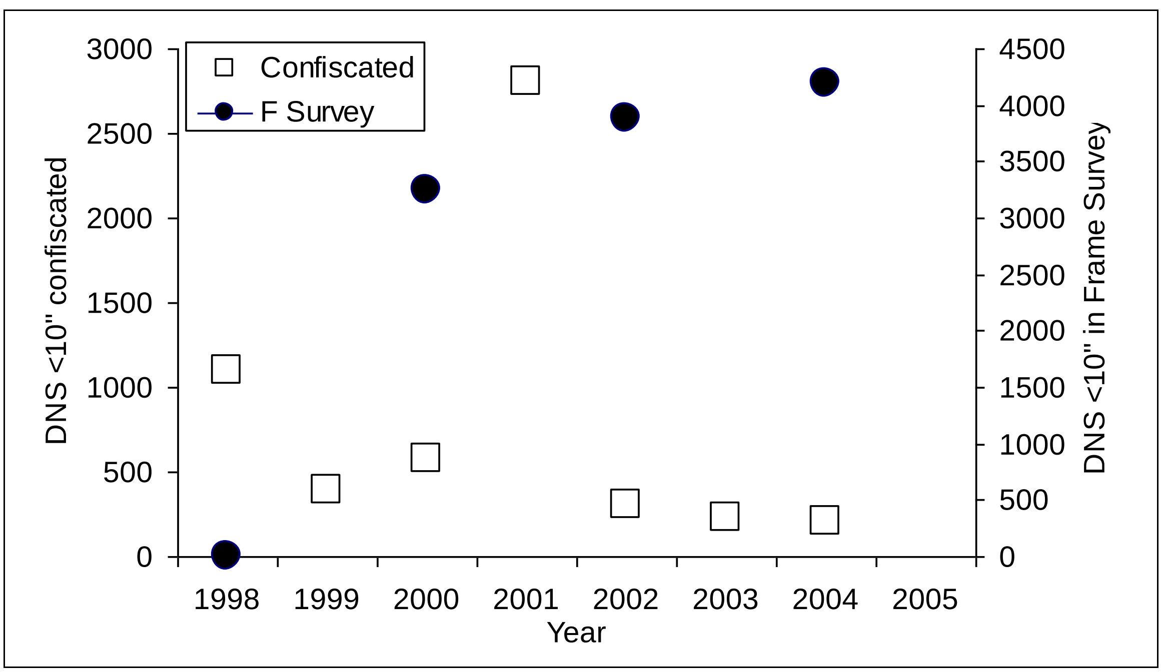



Figure 13.3: Trend of Dagaa nets (DNS <10 mm) confiscated, 1998 – 2005 compared to frame survey results for 1998 – 2004.

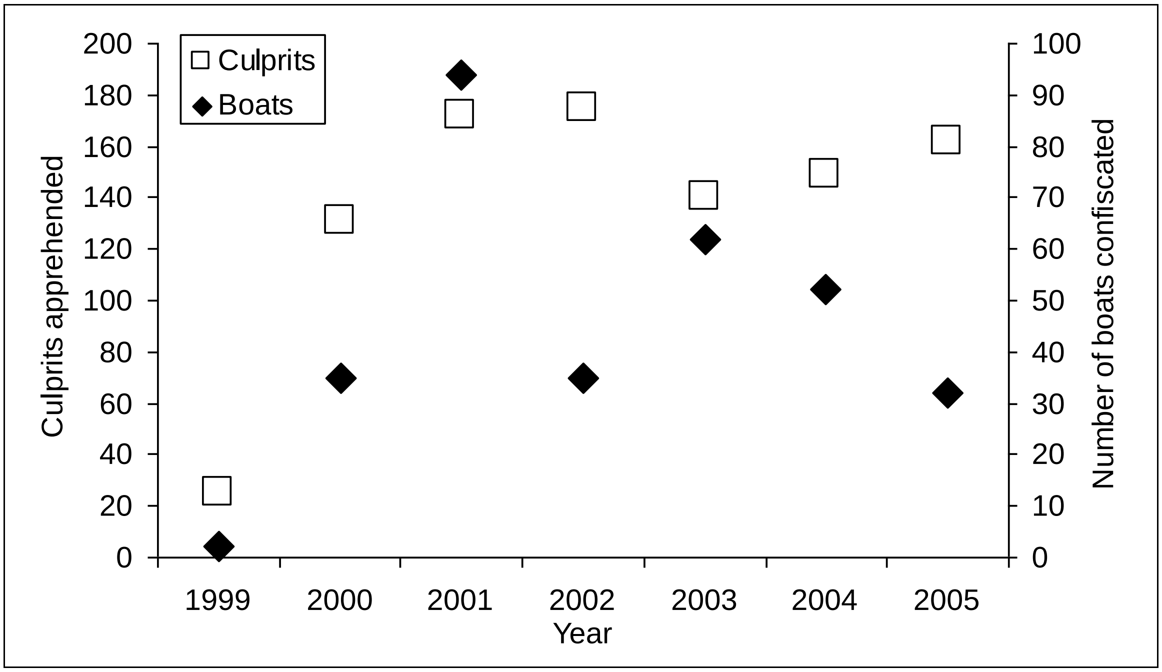



Figure 13.4: Trend of culprits apprehended, 1999 – 2005 compared to number of boats confiscated.

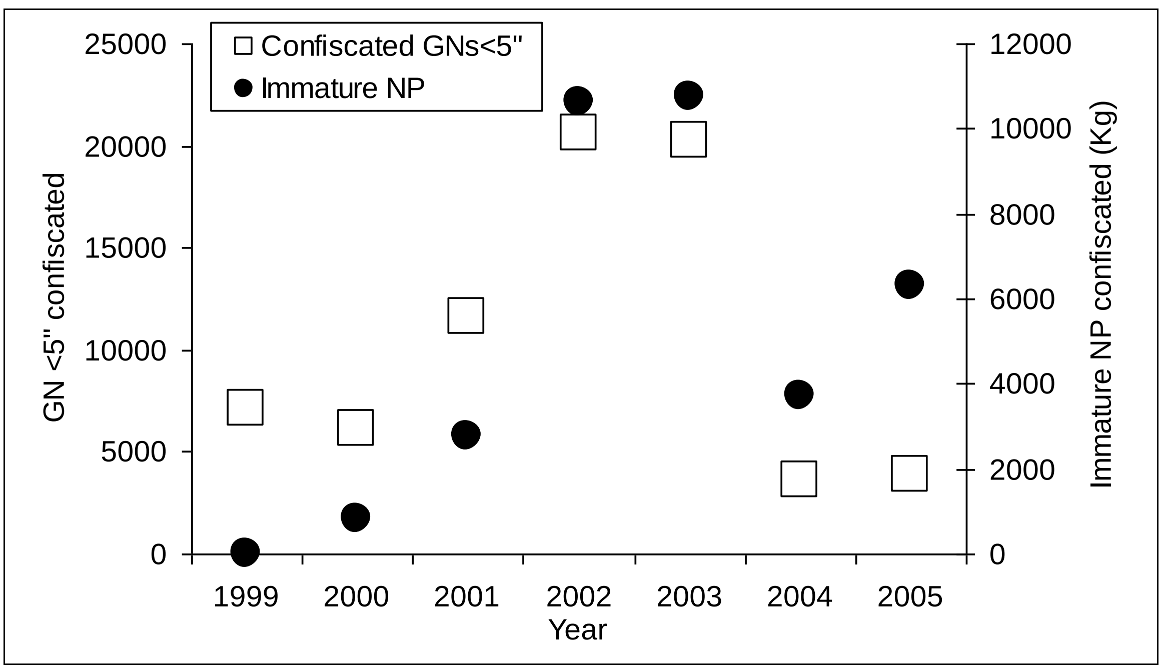



Figure 13.5a: Trend of immature Nile perch (NP) confiscated, 1999 – 2005 in relation to number of gillnets (GN) confiscated.

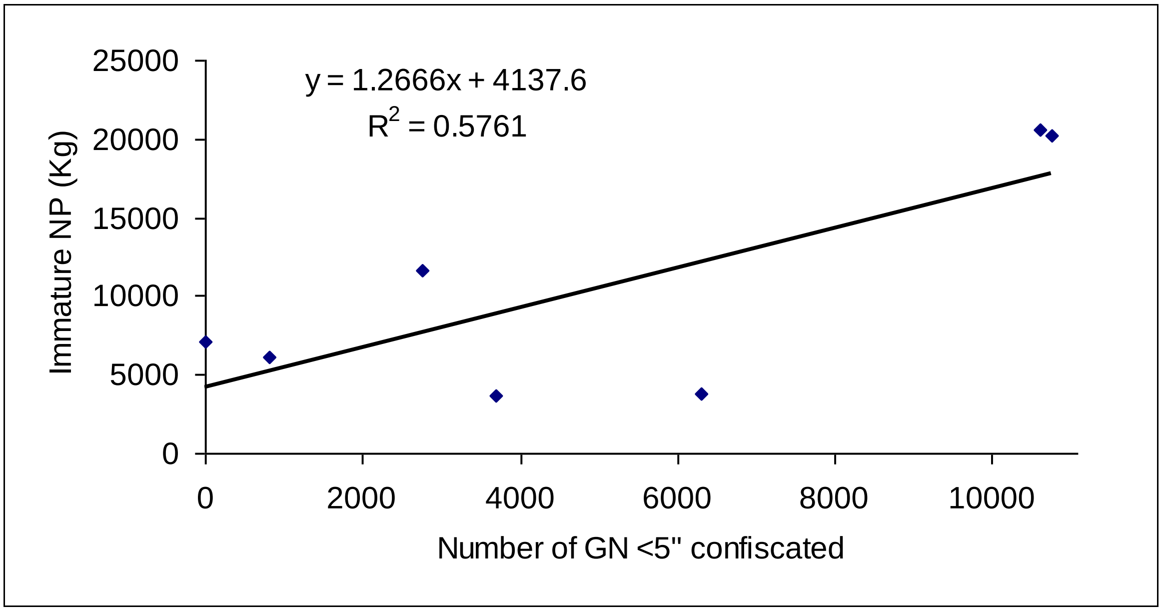



Figure 13.5b: Correlation between confiscated immature Nile perch (NP) and under mesh gillnets (GN).

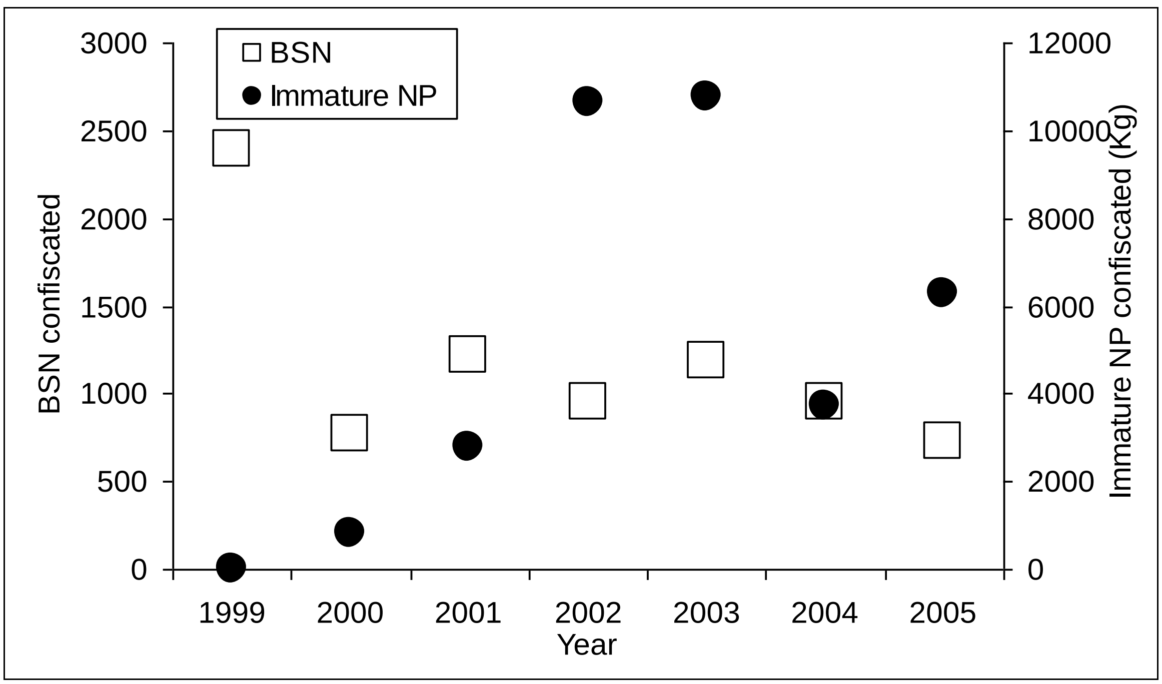



Figure 13.6a: Trend of immature Nile perch (NP) confiscated, 1999 – 2005 in relation to number of beach seines (BSN) confiscated.

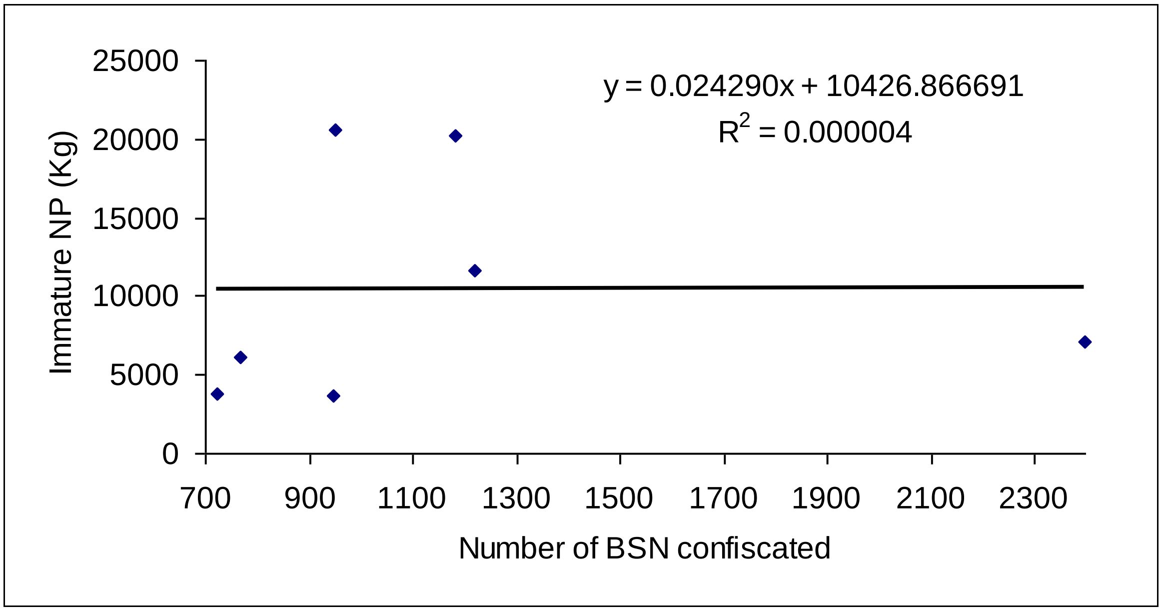



Figure 13.6b: Correlation between confiscated immature Nile perch (NP) and beach seines (BSN).

**Gill nets less than 5 inches mesh size**

There is an increasing trend from 1998/99 to 2001/2002 (Figure 1). There is however a similar trend of the GN <5″ apprehended as the number of immature Nile perch confiscated. The two years after 2003, the number confiscated decreased by about six times. With the exception of the last two years (2004, 2005) the number confiscated has been more than or equal to the frame survey figures (1998, 2000 and 2002). The frame survey figure of 2004 is far above the number of gears confiscated. This shows that there is ineffective law enforcement.

**Beach seines**

The number of beach seines confiscated has been decreasing with time after 1998 when the largest number (2395) was confiscated (Figure 2). The lowest number (724) was confiscated in 2004. The patrols have not yet had effects on curbing beach seines because the frame survey results show that the beach seines which have been confiscated are fewer than those still in the field (Table 5). Thus, ineffective enforcement of fisheries regulations and low compliance to these regulations.

**The Dagaa nets of less than 10 mm**

Generally there is a decreasing trend from 1998 to 2004 except for 2001 when the number went up (Fig. 13.3). On the other hand, frame survey results show an increasing trend of these gears from 1998 to 2004 (Fig. 13.4), which is an indication that there are more of these gears in the field than confiscated.

**Culprits apprehended in relation to boats confiscated**
Generally the number of boats confiscated and culprits apprehended follow a similar increasing trend from 1998 to 2003. However, thereafter the boats decreased while the culprits increased. The anomaly cannot be explained with the information available.

**Immature Nile perch confiscated as related to under-mesh sized gill nets**
There is a corresponding increasing trend between the amount of immature Nile perch and under-mesh sized gill nets confiscated from 1998–2003 (Fig. 13.5). Immature Nile perch are also caught in beach seines.

## 13.4 Discussion

Before the independence of Tanzania, local communities managed the fisheries in a way that it provided for their needs; later after independence the management system changed hands from local communities to the central government. However, since of late there is a steady move back to the local communities and in fact, a wider group of stakeholders.

Monitoring Control and Surveillance seem to be the dominating responsibility that the Fisheries Division would wish to involve local fishers. This has entailed conducting patrols is to curb illegal fishing gears particularly the beach seines, under-mesh sized gill nets and dagaa nets of less than 10 mm. The patrols, which have been conducted through co-management from 1998 to 2005, have had different effects on each type of a fishing gear. The reasons for this result are discussed under each gear type.

**Under-mesh sized gill nets**
The number of gears confiscated increased gradually from 1998 to 2002 and the following years the number dropped (Figure 1). In the first two years (1998–2000) the contribution by BMUs was not very substantial because this was the time when BMUs were being established around the lake. The two years that followed (2001–2003) a substantial number of these gears was confiscated (Fig. 1).

Thereafter the number decreased by about six-fold from 20,623 confiscated in 2002 to 3625 in 2004 and 3853 in 2005. The decline in number of gears confiscated may be attributed to the decreased support from LVEMP. It was at this time that the first phase of the project was ending. The project facilitation enabled District Fisheries officers to conduct patrols and make frequent follow-ups to BMUs. In a situation of limited funding patrols and follow-ups to BMUs were equally limited.

**Beach seines**

There is a declining trend of the number of confiscated beach seines from 1999 to 2005 (Fig. 13.2). The largest number was confiscated in 1998 (2395 beach seines) and the number decreased by about 3 times in 2004, indicating that the patrols, which are conducted against this gear, are not yielding good results. The three frame survey results of 2000, 2002 and 2004 (Fig. 13.2) indicate that beach seines are increasing. This is an indication that fishermen are not abandoning using this gear. There are reasons why this is happening. Beach seines have good returns in shortest time than other fishing gears. When offenders are fined, the amount (Tshs 300,000) is too small to teach them lessons. In addition fishermen escape easily from apprehension because they are normally warned before hand of an approaching patrol unit by their colleagues through mobile phones which are now possessed by most fishermen. Lastly some of the owners have social influences in the fishing communities so much that BMUs shy away from apprehending such personalities.

**Dagaa Nets of less than 10 mm mesh size**

While the number of dagaa nets under 10 mm mesh size in possession of fishers (according to frame surveys) was increasing, the number confiscated was on the declining trend (Fig. 13.3). The exceptionally high number of confiscated nets in the year 2001 may be attributed to a special operation against piracy conducted on the lake in that year.

Dagaa nets are operated in open water and catch only one type of fish, *Rastrineobola argentea* (dagaa). The community feels that the gear has no harm on the stocks and environment. Worse still the riparian states (Kenya, Tanzania and Uganda) have not agreed yet on the right mesh size to harmonise. These circumstances have influenced BMUs to the extent that they ineffectively enforce the regulation on dagaa nets except the Government surveillance units.

### *13.4.1 Priories of the Fisheries Sector*

The fisheries resources are one of the important natural resources the country possesses. These resources as aforesaid contribute to the supply of food, employment of the people and generate substantial incomes to the riparian communities and the government earns foreign exchange on exported fishery products. In order to properly manage the resource for its sustainability and the accrued benefits, the Ministry has a Sector Policy in place since 1997 in which priorities are embodied. Further to this milestone, there is a new Fisheries Act No. 22 of 2003 which accommodates recent developments in the fishing industry.

The policy's overall goal is, to promote conservation, development and sustainable management of the Fisheries resources for the benefit of the present and future generations. There are 13 main areas to which development efforts are directed (URT, 1997). Those areas are the following:

a. Improved resources management and control: The government would use efficiently the available resources to increase fish production so as to improve fish availability as well as contribute to the growth of the economy.
b. Improved training and education: The government would assess the training needs in the sector and optimally use national and international institutions on the basis of the needs.
c. Improved knowledge of the Fisheries resources base: The government would enhance knowledge of the Fisheries resources base.
d. Efficient utilization and marketing: The Government would improve, utilization of the Fisheries products and the marketing thereof.
e. Applied/strategic research: The government would promote research programmes, which are responsive to the Fisheries Sector.
f. Aquaculture development: The Government would promote small scale and semi intensive aquaculture systems with simple technologies and low capital investment, and sound utilization of the ecological capacity of water based areas to diversify incomes and diets.
g. Community participation: The government would improve involvement of fisher communities in the planning, development and management of fisheries resources.

For each of the above areas there is a set of strategies which would be implemented to achieve the desired outcomes.

## 13.5 Conclusion

Lake Victoria has been managed under mainly three management regimes. Before the colonial period, the fishery was purely community managed, during the colonial period up to and including the 1990's, a central authority managed the lake. Recently a partnership arrangement (co-management) is thought to be the best way to manage the fisheries of the lake. This regime is still not fully developed.

Fisheries Policy and regulations for managing the lake have been quite elaborate over the years and cover virtually all areas that are necessary for sustaining the fisheries.

There is no clear structure as to how all the stakeholders identified to co-manage the lakes fisheries should be involved in the management.

Performances of BMUs since they were established between 1998 and 2000 have been remarkable and significant on some gears like under-mesh sized gill nets.

The continued presence of illegal fishing gears and practices poses a question of whether co-management has really involved local fishers in legitimizing fisheries regulations. In other words, have the local fishers participated in formulation of the regulations?

The increase in gears such as monofilament, culprits being apprehended and the high levels of under size gillnets as well as high numbers of beach seines raise questions on the effectiveness of enforcement of fisheries regulations.

There have been changes in the roles performed by various stakeholders in the fisheries.

## 15.6 Recommendations

The introduced co-management regime for the management of the lakes fisheries needs to be strengthened through empowering BMUs and other stakeholders in undertaking their assigned roles.

A clear co-management structure need to be designed to enable all stakeholders in the fisheries perform their management roles complimentarily

There is need to widen the co-management responsibilities to cover not only enforcement of regulations. It is important to strengthen such responsibilities as conflict resolution, data collection and control of access to fishing grounds.

There is need for more efforts to legitimize the fisheries regulations among fishers so as to be able to improve compliance to the fisheries regulations.

There is need to establish an evaluation system where the elaborate fisheries regulations are checked against their effectiveness in improving fish catches and fish stocks.

# CHAPTER FOURTEEN

# OVERALL SYNTHESIS REPORT CONCLUSIONS

## Introduction

Lake Victoria fisheries have shifted from multispecies dominated by haplochromines, *Labeo victorianus, Brycinus* spp., *Barbus* spp., *Mormyrus* spp., *Synodontis* spp., *Oreochromis esculentus*, and *O. variabilis*, to a commercial fishery dominated by three introduced species, Nile perch (*Lates niloticus*) and Nile tilapia (*O. niloticus*) and an endemic cyprinid, *Rastrineobola argentea* (Dagaa). The quality of Lake Victoria waters has also been changing over the years due to eutrophic conditions exacerbated by elevated nutrient loadings. Synthesis of available information points to eutrophication as one of the driving forces in alteration of the fish habitat and fish food, which in turn, affects the bountiful fish resource of Lake Victoria. Consequently, the challenges associated with the management of the commercial fishery of Lake Victoria relate to obtaining a clear understanding of the role of water quality in observed lake-wide ecosystem changes. The other challenge is to understand the fisheries in the light of standing stocks, temporal and spatial distribution, habits, breeding, feeding and maximum sustainable yield. Both challenges call for a rigorous data collection and lake wide monitoring system to collect limnochemical, ecological, biological and catch and effort data in order to have a scientific basis in the evaluation of the effect of management practices on the exploitation of the fishery.

The intervention made by LVEMP has generated data and information that have lead to a greater understanding of various aspects of the fisheries of Lake Victoria. The synthesis of this information has come up with conclusions and some recommendations that could be used to guide management of the fisheries resources of Lake Victoria. The relevant conclusions and recommendations are highlighted hereunder.

## Small Water Bodies in the Lake Basin

Satellite lakes, rivers, ponds, dams and floodplains in the catchment have been singled out as important faunal reservoirs for Lake Victoria endangered species. Several fish species currently known to be rare in the main lake are represented in isolated groups of small water bodies in the Lake basin supporting fisheries of the riparian communities. These habitats and resources therein are severely impacted by human activities. Studies should be mounted to restore damaged habitats in order to boost the recovery of endangered and threatened species such as lungfish (*Protopterus aethiopicus*) and the Ningu (*Labeo victorianus*).

## Life History Indicators of the Nile Perch

The modal size for Nile perch has been progressively decreasing and size at first maturity for both females and males has been decreasing from 110 cm and 60 cm TL respectively recorded in 1990 to 54cm for males and 77cm for females observed in 2002. These changes seem to be driven by increased fishing pressure in the lake. If the current high exploitation rate is maintained, it is likely that the average size of Nile perch will decrease even further. Fisheries managers can reverse this trend by reducing the overall fishing effort.

Nile perch exhibits trophic dynamics characterized by a shift in from a diet predominantly comprising haplochromines to *Caridina nilotica*, anisoptera nymphs, its own juveniles, *Rastrineobola,* tilapiines with very few haplochromines. Recent data indicate an increasing importance of haplochromines in the diet. *Oreochromis niloticus* was a phytoplanktivorous and bottom feeder but it is now becoming increasingly omnivorous with *Caridina nilotica*, chironomids, chaoborids, molluscs and bottom detrital matter consumed as well. The changes in Lake Victoria environment which include dramatic shifts in phytoplankton species composition in response to eutrophication are partly responsible for the observed trophic dynamics. It is recommended that effort should be directed towards conducting investigations into the relationship between fisheries and environment (water quality) in Lake Victoria.

## Fisheries Data Collection and Frame Surveys

Lake Victoria fishing effort has been increasing with time since 1965. CPUE (i.e. catch per boat) fluctuated with time but remained stable. The fish catches in Lake Victoria fluctuated with an increasing trend up to 1986 whereby more than 57% of the catch comprised Nile perch. In 1987 CPUE of haplochromines decreased dramatically while that of Nile perch increased steadily up to the period 1996-2000. However, reliability of the statistics after 1996 is questionable because catch assessment survey (CAS) was disrupted as a result of nation-wide retrenchment of public servants and decentralisation. This must be recognised as a severe limitation to management of the fishery. LVFO introduced SAMAKI database in an effort to harmonise CAS in Lake Victoria.

Studies to develop the CAS programme utilising BMUs have been started and show some promise. BMUs appear to hold considerable data on catches from all boats but collation of the data is inadequate. It is recommended that mechanisms to use BMUs for catch assessment surveys are investigated more fully, especially if the responsibilities can be linked to revenue collection activities. It is recommended a simple catch assessment protocol is designed which provides basic data on daily catch (weight) per species landed, effort (proportion of boats fishing) and length frequency. This must be coordinated by the Division of Fisheries but linked to BMU activities.

## Information and Database

On information and database, a review of literature pertaining to Lake Victoria has been produced and is available on the Tanzania LVEMP website. However, there are limitations in internet access and library resources; consequently it is recommended the TAFIRI database centre establishes a local area network (LAN) that allows online access to many sources of information, including electronic journals, subscriptions to online journals. Financial resources should be made available to facilitate procurement of literature search engines rather than collecting back issues of journals because it is more cost effective and would allow wider dissemination in the region. Regional institutions should collectively support and contribute to this initiative, rather than duplicating purchase of expensive journals, etc. In the long run it is expected that this would improve access to information nationally and regionally.

## Stock Assessment

Fish stock assessments in Lake Victoria have involved the use of bottom trawls conducted by the following research vessels, Ibis during the period 1969/70, R.V. TAFIRI II from 1995-1996 and R.V. Victoria/Explorer during 1999/2000. Recent efforts in 1999 to 2001 have seen the use of hydro-acoustic techniques. Some conclusions that can be drawn from these surveys include the following.

- The fish species diversity in the bottom trawl surveys in Lake Victoria has declined from a multi-species dominated by the haplochromines during the 1969/70 survey to a fishery of a few species currently dominated by the introduced Nile perch, followed by *Rastrineobola argentea* and Nile tilapia. The dominance of the haplochromines has now declined from 71% (by weight) in 1969/70 to 2.0% in 1988 and is showing recovery with a contribution to bottom trawl catches estimated at 5.7% during 1999/2000 survey.
- Total fish biomass estimates using acoustic and bottom trawl surveys during the period 1997-2001 were higher than the values obtained during the last lake wide survey of 1969-1971. This confirms the observation that the productivity of the Lake Victoria system has increased since the early 1970s and also reflects expansion of the standing stock from the low levels of the early 1970s ($0.402 \times 10^3$ tonnes) to the current one of $2.17 \times 10^6$ tonnes.
- Fish standing crop was approximately four times as high in inshore waters compared to offshore waters. The standing crop was also high around the islands compared to the open offshore areas. This makes their targeting by fishermen easier and can lead to over fishing.
- In the light of the present exploitation rates regular trawl surveys to monitor the changes in the fish stocks should be continued and that all habitats including waters >40 m should be covered. Surveys of un-

trawlable areas including water columns above about 3 m from the bottom should be done using graded gill nets.

## Fish Quality Assurance

The Lake Victoria Environmental Management Project has been instrumental in enabling the Fisheries Division to strengthen its fish quality assurance system through the establishment of National Fish Quality Control Laboratory in Mwanza. This laboratory is responsible for the verification of effectiveness and efficiency of quality management systems in fish processing establishments as a requirement to the international market. This intervention has ensured that fish and fisheries products from Lake Victoria are safe and of high quality for both local consumption and the export markets. For these achievements to be sustained, more resources need to be availed through public-private sector partnerships. To this end attention is drawn to the following recommendations:

- Regular courses should be organized and attended by the fish inspection staff to enable them keep abreast with new technologies in fish inspection techniques.
- The landing sites and the fish processing plants should be routinely audited, verified and inspected for compliance to Fish Quality Control and Standards Regulations of 2000.
- All landing sites should be improved and modernised to assure quality of fish and fisheries products.

## Aquaculture Extension

Aquaculture development in the lake zone was revived through support provided LVEMP towards extension services. TAFIRI and Fisheries Department staff were given direct and indirect support for mobilizing, sensitizing, awareness creation, training, monitoring, control, development and management of fish ponds. A mixture of approaches was used over the duration of the project from meetings, discussions, lectures, hands-on training, and demonstrations by extension workers.

Some of the innovations which have been introduced include the technology of producing fingerlings of *Clarias gariepinus* through artificial spawning. LVEMP also supported production of *Oreochromis niloticus* fingerlings for distribution to local communities. The following recommendations are made in the light of the current status of aquaculture development in the lake zone:

- Aquaculture development should be properly planned and all barriers removed so that it can bring meaningful economic benefits to the practitioners and the riparian districts as a whole.
- Aquaculture extension should be strengthened by training more workers and practitioners, enhancing the capacity of existing pool of researchers

and recruiting more research staff, and allocating more funds to the sub-sector. Furthermore, there is need to manufacture fish feeds locally and introduce more innovative technologies in the production of fingerlings in hatcheries.

## Socio-economics

The Lake Victoria fisheries continue to remain a crucial resource to support the livelihoods and well being of the riparian communities and the country at large. The opportunities that the lake provides in terms of employment and its contribution to the national economy among others make fisheries one of the most important sectors for regional development. From a socio-economic dimension, it is recommended that efforts should be devoted to understanding the society in which fisheries operate. The communities' contradictions and potential synergies need to be considered when dealing with these communities. It is expected that such an understanding will enable planners direct fisheries resource exploitation to avenues that should improve social welfare of these riparian communities.

## Fisheries Co-management

Fisheries co-management as an alternative to centralized command and control fisheries management is being advocated as a solution to the problems of resource use conflicts and overexploitation. LVEMP played a key role in the introduction of co-management through formation of Beach Management Units (BMUs) in the lake zone. Since the introduction of the co-management programme, BMUs have continued to work in collaboration with Fisheries staff to curb illegal fishing practices, participate in data collection for Catch Assessment Surveys and Frame Surveys, beach hygiene and sanitation, environmental conservation amongst others.

The BMUs which have been established lake wide as models of co-management are an important institution and therefore should be recognized and given all support to enable it effectively perform its functions. The support that needs to be extended should be in the form of facilities and enactment of by-laws. Since BMUs constitute stakeholders who are direct beneficiaries of the resource, giving them full power and entrusting them with the responsibility of management of the resource would bring about its conservation, protection and sustainability, which is in line with the overall goal of National fisheries policy.

## Phytoplankton and Zooplankton

Changes in the limnochemistry of Lake Victoria which involved reduced silica and elevated phosphorus and nitrogen have lead to a shift in dominance from microalgal communities dominated by diatoms such as *Aulacoseira* (*Melosira*) and green algae to blue-green algae. *Aulacoseira* formed the main food of the native commercially important tilapiine *Oreochromis esculentus,* and its reduction might have affected stocks of this species. The dominance of BGA including toxic forms, could have led to reduction of available food for the native fish species. BGA are less digestible and provide poor quality food that may have contributed to the reduction or loss of planktivorous haplochromines and tilapiines that once flourished in Lake Victoria.

Trends in the dynamics of the zooplankton over the years have shown progressive change in both abundance and diversity but the community structure of zooplankton still comprised three groups, namely the rotifers, cladocerans and copepods. The high relative abundance of cyclopoid copepods in Lake Victoria and the small water bodies in the basin affords them a high value for fish production, as this item is important in the diets of pelagic and larval fishes. It is worthy noting that the standing stocks of the planktivorous dagaa, *R. argentea* have progressively increased from 1999 to 2001, partly suggesting a dependable and stable food base for this fish.

Since observed changes in phytoplankton and zooplankton are partly related to reduced water quality in the lake, there is need for reduction of nutrient loads and pollutant input into the nearshore areas of Lake Victoria through treatment of municipal and industrial effluents. It is recommended that an effective water quality monitoring system and research be continued to ensure collection of data and information for informed decision-making.

## Fish Levy Trust

Fish Levy Trust study conducted through LVEMP, proposed the establishment of a special fund namely Lake Victoria Environment Fund (LVEF), which once operational will lay the foundation for generating public revenue from fishing and using them to sustain further environmental protection activities in the Lake Victoria Basin. The LVEF should be a facilitation and co-financing mechanism allowing stakeholders to make better use of their own resources. This fund will not receive direct contributions from any source other than the export royalty stream. Local level stakeholders will be required to contribute, but to specific activities, rather than to the fund itself. The riparian states have agreed that certain activities such as credit schemes which provide incentives to increase fishing effort, activities that are peripheral to sustaining the fisheries resources and activities of Fisheries Department and Local Authorities will not be funded by the Trust fund. For effective operationalisation of the Fish Levy Trust, it is recommended that the establishment of Lake Victoria Environment Fund be supported by legislation, preferably a new Act.

## NATIONAL STAKEHOLDERS WORKSHOP RECOMMENDATIONS

The draft national synthesis report on the the Fisheries Research and Fisheries Management was presented during the three-day stakeholders workshop which was jointly held with the Water Quality and Ecosystem Management component at the BoT Conference Hall in Mwanza from 26th to 28th September 2005. The report was discussed and several recommendations/issues were raised. There were useful contributions from representatives of riparian Districts, Directors, NGOs and all participants. Major areas of agreement were arrived at and the following recommendations were made with a view to proposing them for consideration in the preparation of Phase II of the LVEMP.

### Fisheries Research

- Monitoring of the established indicators should be continued and funds made available for this purpose. This will facilitate tracking of fluctuations in fish populations vis-à-vis changes in the environmental parameters.
- Gaps in the information related to fisheries and the environment should be addressed fully in LVEMP II. This will provide empirical evidence that links changes in the environment and fluctuations in fish stocks and biodiversity.
- The investment made in developing the human resource capacity (e.g. PhD holders) should be sustained through timely maintenance of the infrastructure (laboratory and field gear) and an attractive staff retention scheme to minimize attrition.
- The role of the lake environment (e.g. eutrophication, toxic blue-green algae, anoxia, etc.) in influencing fisheries productivity should be systematically investigated and results applied in management of fish stocks.
- Biodiversity hotspots and fish breeding habitats including riparian wetlands, small water bodies and river mouths should be identified, mapped and protected through enacting a legislation to safeguard them from haphazard encroachment.
- Persistent occurrence of health problems related to poor hygiene amongst fishing communities is attributed to little sensitization and poor formal education. Therefore there is need for thorough sensitization and public awareness programmes as a preventive measure.
- There is need for a multi-sectoral and interdisciplinary approach involving all sakeholders in trying to restore the quality of the waters of Lake Victoria.

## Fisheries Management

- There is a dire need to create alternative income generating activities for the fisherfolk to generate improved household incomes and to draw their attention away from Lake Victoria. Consequently, there is need to encourage investment in aquaculture.
- Local government should take the lead in developing aquaculture as an income generating activity. This should be accompanied with development of hatchery technology to ensure a steady suppy of fingerlings.
- To bring about rationalization, optimal and sustainable utilization and biodiversity protection of the Lake Victoria fishery resources, there is need to improve Monitoring, Control and Surveillance (MCS) capacity on the lake. It is therefore recommended that support to MCS Unit of the Department of Fisheries in the lake zone be continued and improved through the support of the LVEMP in its second phase.
- There is need to establish a database for fisheries that include type of boats, size of boats, motorized, non-motorized, number of fishers, type of fishers, type of gear used, etc. that will be updated frequently. To do this Fisheries Division should create a budget line to implement this recommendation.
- The complexity of the lake environment and basin activities call for involvement of all a multitude of stakeholders in the management of the lake and its fisheries. To this end there is need to integrate science and technology in addressing a complex of environmental and management issues facing Lake Victoria.
- The retrenchment of government staff during the 1990s left the Fisheries Division with inadequate number of personnel. There is need to build adequate capacity to carry out monitoring for both scientific and management purposes. This will be achieved through recruitment of enough staff, training staff sufficiently and procurement of sufficient equipment.
- Collection of Lake Victoria fisheries should be fully revamped and strengthened. Fisheries Division needs to collaborate with other stakeholders including donors to ensure that fisheries statistics are collected on a regular basis from more landing stations than is presently the case.

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