MAJOR FACTORS TO INFLUENCE THE FUTURE PROSPECTS FOR FISH PRODUCTION AND BIODIVERSITY IN LAKE VICTORIA

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ABSTRACT

Uncontrolled fisheries exploitation, nutrient loading and the proliferation of water hyacinth appear to be the major factors which would strongly influence future prospects for fish production and biodiversity in lake Victoria. There is, thus, justifiable need to tame these factors in order to sustain sound production and biodiversity levels of the lake.

Key Words: Exploitation, nutrient loading, water hyacinth, production, biodiversity.

A. INTRODUCTION

Lake Victoria traditionally supported a cichlid fish fauna consisting of two indigenous tilapiine species (Graham, 1929) and, through endemic explosive speciation (Greenwood, 1965), more than 300 species of haplochromines (van Oijen et al, 1981). In addition, there were about 50 non-cichlid fish species in the lake (Lowe-McConnel, 1975). Four exotic tilapiine species were later introduced during the early 1950's (EAFFRO. 1964) while the Nile perch (**Lates niloticus** L), a predator, was introduced in 1954 (Amaras, 1986).

The co-existence of more than 350 fish species in one lake clearly illustrated the community diversity which some tropical lacustrine systems could support. However, despite the high diversity, the traditional commercial fishery depended on relatively few of the taxa (Table 1). And since the early 1980's Lake Victoria has been experiencing dramatic decline in species diversity with the intriguing simultaneous phenomenal increase in total annual fish yield. The sudden decline is species diversity again demonstrates the fragility of tropical fish communities to ecological and anthropogenic perturbations.

The decline in fish species diversity in Lake Victoria was attributed to predation by Nile perch although the combined effects of uncontrolled exploitation, interspecific competition and hybridization had more profound impact on the decline of the indigenous commercial fish species as discussed by Kudhongania et al (1992). While Lates was largely responsible for the decline of the haplochromine stocks, the same authors further showed that trawling, where it occurred on a commercial scale, was more damaging to the haplochromines than predation by Nile perch. With the current fishery dominated by three species (L. niloticus, Oreochromis niloticus and Rastrineobola argentea), this paper considers the major factors likely to influence the future prospects for fish production and biodiversity in Lake Victoria.

B. FACTORS LIKELY TO INFLUENCE FUTURE PROSPECTS FOR LAKE VICTORIA RESOURCES

1. The influence of Exploitation, predation, competition and hybridisation

Factors largely responsible for the established decline in species diversity in Lake Victoria were uncontrolled exploitation, predation, competition and hybridization (Kudhongania, et al, 1992). In the context of the three commercially dominant fish species now (Nile perch, Nile tilapia and Rastrineobola) hybridisation is unlikely to influence prospects for future changes in fish populations. In addition, direct competition either for food or breeding space within the Lake Victoria ecosystem is unlikely to be significant.

With regard to predation, there are strong signals suggesting that a predator/prey system described by L. niloticus, O. niloticus and R. argentea can sustain a viable fishery on Lake Victoria, if the influence of other factors was stayed.

(i) The stocks of the prey species (O. niloticus and R. argentea) increased with increasing populations of the predator (L. niloticus) (Ssentongo and Welcomme, 1985). This suggests that the two prey species are somehow resilient to predation by Lates.

(ii) Commercially viable populations of O. niloticus and L. niloticus have co-existed for years in their endemic systems such as lakes Albert and Turkana (Kudhongania et al, 1988). The feeding habits of Nile perch, which involve the selection of the most abundant prey (Hopson, 1972) including cannibalism, tend to ensure that Lates would not over-exploit its prey resources.

(iii) In Lake Tanganyika over 90% of the annual fish harvest comes from four species of Lates (formerly Laciolates) and their two principal prey clupeid species (Bayona, 1988) although with cyclic variations in the relative abundance of the predator/prey components in the catch (Roest, 1988). This shows that predator/prey systems involving Lates can sustain commercially viable fish stocks, if other factors were absent.

The mode and tempo of exploitation would remain one of the major candidates for influencing the future prospects for fish production and biodiversity in Lake Victoria. The major problem with current fishing practices on the lake is the existence of unlimited entry practices into the fishery (Ssentongo and Welcomme, op. cit.) coupled with lack of effective control on the types and numbers of gears in use. Prolonged use of uncontrolled mesh-size gill-nets, beach seines, cast nets, lift nets, trawl nets, fishing pressure etc. have detrimental effects on the stocks, including the capture of immature fish and interference with breeding and nursery strategies. In addition, the recent appearance of more than 30 fish processing plants situated in Kenya, Tanzania and Uganda, in the face of increasing demographic pressures in the riparian countries, is likely to impose further fishing pressure on the fish stocks of Lake Victoria. Already there are indications that the annual landings and catch rates have started to fall, with the average size of the individual fish landed declining (Kudhongania and Coenen, 1991). For instance seven years ago the average size of the Nile perch landed at Masese was about 9 kg but by 1990 the size had declined to only 2 kg (Okaronon, J. per. comm., 1991).

Increase in haplochromine densities have been observed in areas where certain types of fishing gears have been banned, (e.g. Ogari and Asila, 1990) despite the presence of Nile perch populations in the same areas. This suggests the positive effect which regulated fishing practices could have on fish species biodiversity. The cyprinid flock of Lake Lanao was destroyed in less than 25 years through unregulated fishing (Echelle and Kornfield, 1984).

2. Changes in the water environment characteristics

It has been found that the dramatic decline in fish species diversity coincided with significant changes in water quality and nutrient chemistry of Lake Victoria (Hecky and Bugenyi, 1992, Bugenyi, 1991). The changes in water quality are being driven by increasing amounts of nutrient in-puts from land run-off; industrial, urban and domestic effluents; and rain.

Increasing agricultural demands have led to more intensive vegetation clearing, deforestation, draining of swamps for growing rice, etc. and to the use of more pesticides, fertilizers and other agro-chemicals (Bugenyi, 1984) leading to allochthonous loading of the lake through soil erosion. Industrial effluents are derived from textiles, mining, smelting, food and fish processing, brewing, cooking oil mills, abattoirs, coffee, soap, paper, tanneries and other factories scattered within the catchment area of Lake Victoria. The rain (ca 1450mm per year), falling on a surface area of Ca 69,000km^2, is loaded with atmospheric materials derived from bush fires, industries and other anthropogenic activities. Given that the flushing time of Lake Victoria is 140 years, the retention time of these in-puts is expected to be quite high.

Changes in nutrient loading have encouraged prolific growth and heavy algal blooms (eutrophication). Apart from increased phytobiomass, the densities of macrophytes, molluscs, oligochaetes, chaoborids, chironomids, Caridina nilotica, R. argentea, O. niloticus and L. niloticus have also increased although the temporal order is not clear. Excessive algae die and decay, leading to deoxygenation of the water and subsequent massive fish kills (Bugenyi 1984, Ochumba 1987). The decline in fish species diversity has led to transformation of the food chains involving reduced herbivory and detritivory which is hastening eutrophication (Bugenyi and Balirwa 1989). Extensive eutrophication decreases the hypolimnetic volume habitable by fish and other organisms during seasonal stratification.

Forecasts for global temperature increments through the greenhouse effect, albeit minimal in the tropics (1-2°C), may lead to prolonged thermal stratification in lake Victoria (Hecky and Bugenyi, op. cit.). Prolonged thermal stratification may lead to the accumulation of pollutants in the sediments, increased anoxia, reduced productivity and biotic diversity of benthic organisms and demersal fish.

3. Invasion by Water hyacinth

Wetlands/ecotones are known to have the highest biological activity and productivity in lake ecosystems (Jorgensen and Loffler, 1990) and they comprise both aquatic and terrestrial components of production. They are important as filters (for suspended matter and toxic substances) and as buffers (for the water environment), and are essential nurseries for many organisms, including important fish species.

The wetlands of the Lake Victoria basin with a coastline of 3440 km is extensive enough to adequately stimulate the production and biodiversity of the lake. Unfortunately the zone has been invaded by the water hyacinth Eichhornia crassipes, Martius). The water hyacinth has spread to many parts of the lakes shores and proliferates in inshore areas with high nutrient content (Twongo et al. 1992). These are the same areas where many fish species breed, nursery, shelter and feed. Studies have shown that the water weed leads to the following negative/effective:

- Reduced oxygen (due to w. h respiration, decay and shading off solar rediation and thus preventing photosynthesis which produces oxygen).
- Reduced pH (because of increased respiratory carbon dioxide).
- Increased transparency (due to reduced phytoplankton growth).

- Due to the low oxygen levels, reduced floral and faunal diversity (plankton, macrophytes, invertebrates, fish).
- Increased anoxia (when the plants die).
- Massive loss of water (through evapotranspiration).

The weed is distributed by currents, winds, boats, rafts, its prolific vegetative reproduction by stolons and by its long-lived seeds (Harley, 1990; Twongo, et al. 1992). This implies that the potential for further proliferation and spread of the weed is quite high. It is no wonder that E. crassipes has been described as the world's worst aquatic weed (Harley, 1990).

Indications of increasing nutrient load in Lake Victoria as described above suggest further expected proliferation and spread of the water hyacinth. Increasing proliferation of the water hyacinth would impose serious uncertainities in the prospects for fish production and biodiversity in Lake Victoria.

C. CONCLUSIONS

(1) The future prospects for fish production and biodiversity in Lake Victoria will be influenced mainly by three broad factors:

- mode and pressure of resource exploitation.
- load of allochthonous materials and energy.
- water hyacinth dynamics.

(2) Exploitation has been one of the major factors responsible for the dramatic decline in species diversity in Lake Victoria and elsewhere. Prolonging unctonrolled fishing practices involving unlimited entry, unlimited types and numbers of fishing gears may impair long-term fish production potentials. It is, therefore, necessary to develop suitable exploitation and management strategies (see Ogutu-Ohwayo, et al. 1989) which would stimulate long term socio-economic viability of the aquatic resources.

(3) Anthropogenic activities within the Lake Victoria basin are continuously increasing the load of nutrient in-puts into the water system, leading to eutrophication. Excessive phytobiomass production, in the absence of sufficient grazers, is limiting oxygen and light regimes in wider areas of the lake, and thus threatening long-term production and biodiversity. Effective arrangements to control nutrient loading would be needed to reverse the trend.

(4) The possibility for prolonged thermal stratification due to the greenhouse effect is worrisome as such an occurrence might enhance the negative effects of nutrient loading. It is necessary to cooperate with the international community in controlling the gases responsible for the greenhouse effect.

(5) The water hyacinth has the potential to reduce fish production and biodiversity if unchecked. The weed prefers, and thereby takes over, the inshore zone with the highest biological activity. Strategies for controlling the spread and proliferation of the water hyacinth in Lake Victoria and associated water systems need to be set and implemented urgently.

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Table 1: Major Commercial Fish Species From Lake Victoria (1958)

	Taxon	Percentage by weight
1.	Oreochromis esculentus	23.2
2.	Bagrus docmac	21.0
3.	Haplochromines	18.0
4.	Labeo victorianus	10.5
5.	Oreochromis variabilis	8.0
6.	Protopterus aethiopicus	6.0
7.	Clarias mossambicus	3.5
8.	Synodontis sp.	2.9
9.	Schilbe mystus	2.7
10	Mormyrids	2.3
11	Barbus sp.	1.1
12	Alestes sp.	0.6
13	Other	0.2
	Total	100.0

REFERENCES

Amaras, J. Ofulla (1986): The truth about the Nile perch. The Standard, Tues. July 22, 1986.

Bayona, J.D.R. (1988): A review of the biology, productivity and fish predation in Lake Tanganyika. CIFA Occ. Paper No. 15: pp. 1-17.

Bugenyi, F.W. (1984): potential aquatic environmental hazards of agro-based chemicals and practices in a developing country, Uganda. Proc. Int. Conf. Envir. Haz. Agrochem. Vol. 1: pp. 461-473.

Bugenyi, F.W. (1991): The effects of limnological factors and the changing environemnt on the fisheries of northern Lake Victoria. Seminar on the Management of the Fisheries of Lake Victoria: 6-8, August 1991, Jinja, Uganda.

Bugenyi, F.W. & J.S. Balirwa (1989): Human intervention in natural processes of the Lake Victoria ecosystem. In Slanki, J & S. Hervdek (Eds): Sympo. Biol. hung. Conservation and Management. pp. 311-340.

EAFFRO (1964): East African Freshwater Fisheires Research Organization, Annual Report. 1964.

Echelle, A.A. & I. Kornfield (Ed) (1984): Evolution of Fish species Flocks. University of Maine at Oron Press, Oron pp. 251-254.

Fryer, G. & T.D. Iles (1972): The cichlid Fishes of the Great Lakes of Africa. Oliver & Boyd, Edinburgh.

Graham, M. (1929): The Victoria Nyanza & Its Fisheries. A report on the fishery survey of Lake Victoria 1927-1928. Crown Agents, London.

Greenwood, P.H. 91965); Explosive speciation in African lakes. Proc. Roy. Inst. 40 No. 184: pp. 256-269.

Harley, K.L.S. (1960): The role of biological control in the management of Water hyacinth, Eichhornia Crassipes. Biocontrol News & Information Vol. 11, No. 1 pp. 11-22.

Hecky, R.E. & F.W. Bugenyi (1929); Hydrology & chemistry of the African Great Lakes and water quality issues: Problems & solutions. Mitt. Internat. Verein. Limnol. 23: 45-54.

Kudhongania, A.W., R. Ogutu-Ohwayo & T. Twongo (1988): The Nile perch in Lakes Victoria & Kyoga: An asset or liability? UFFRO Occ. Paper no. 15.

Kudhongania, A.W. & E.J. Coenen (1991): Trends in fisheries development, prospects and limitations for Lake Victiroa (Uganda). Seminar on the Management of the Fisheries of Lake Victoria, 6-8 Aug. 1991, Jinja, Uganda.

Kudhongania, A.W., T. Twongo & R. Ogutu-Ohwayo (1992): Impact of the Nile perch on the fisheries of Lakes Victoria & Kyoga. Hydrobiologia 232: 1-10, 1992.

Lowe-McConnell, R.H. (1975): Fish Communities in Tropical Freshwaters. Their distribution, ecology and evolution. Longman, London & New York.

Ochumba, P.B.O. (1987): Periodic massive fish kills in the Kenyan part of Lake Victoria. Water Quality Bulletin 12: pp. 119-122.

Ogari, J. & A. Asila (1990): The state of the Lake Victoria Fisheries, Kenyan waters. CIFA FAO Fish. Rep. 430, pp. 18-23.

Ogutu-Ohwayo, R., T. Twongo, S.B. Wandera & J.S. Balirwa (1989): Fishing gear selectivity in relation to their manufacture and to the management of Fisheries of the Nile perch, the Nile tilapia & Rastrineobola argentea (Mukene) in Lakes Victoria and Kyoga. UFFRO Occ. Paper No. 16.

Roest, F.C. (1988): Predator-prey relations in Lake Tanganyika and fluctuations in the pelagic fish stocks. CIFA Occ. Paper No. 15, pp. 104-129.

Ssentongo, G.W. & R.L. Welocmme (1985): Past history and current trends in the fisheries of Lake Victoria. FAO Fish Rep. 335: pp. 123-135.

Twongo, T., F.W. Bugenyi & F. Wanda (1992): The potential for further proliferation of water hyacinth in Lakes Victoria & Kyoga and some urgent aspects for research. CIFA Sub-comm. for Lake Victoria Feb. 1992, Jinja, Uganda.

Van Oijen, M.P.J., F. Witte & E.L. M. Witte-Maas (1981): An intorudction to ecological and taxonomic investigations on the haplochromine cichlids from the Mwanza Gulf of Lake Victoria. Neth. J. Zool. 31: pp. 149-174.