Causes and effects of the Lake Victoria ecological revolution

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CHAPTER 1

General introduction and Summary

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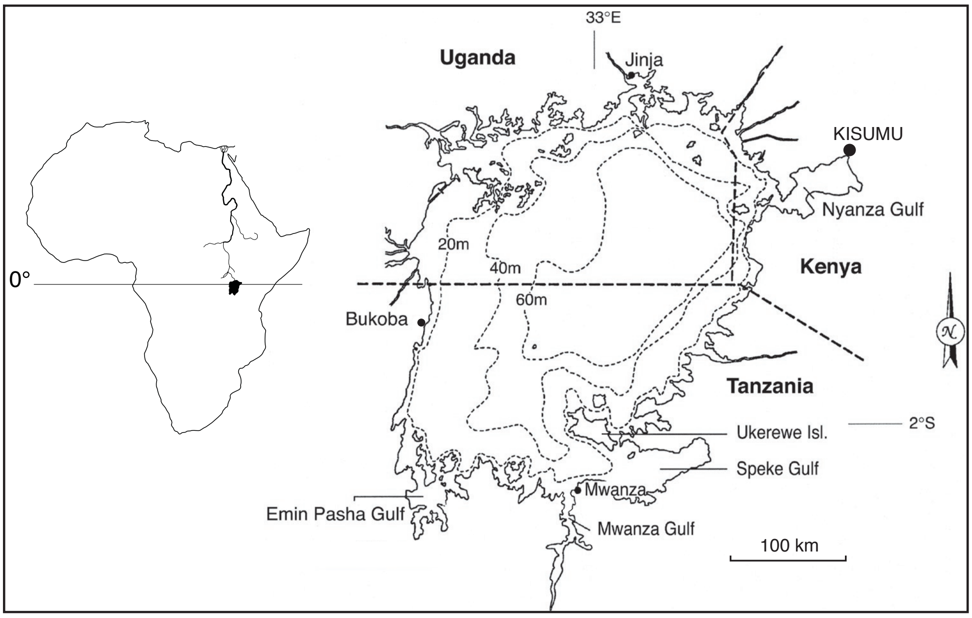

Fig. 1.1 *Map of Lake Victoria*

Lake Victoria and its history

The East African Lake Victoria is the largest tropical lake of the world. It is shared by Tanzania, Uganda and Kenya and straddles the equator. The lake has a surface area of ca. 69000 km^2, a maximum depth of about 80 metres and is situated at an altitude of 1134 m above sea level (Fig. 1.1). The Lake Victoria basin came into existence as a result of tectonic uplifting 400000 years ago (Johnson et al., 2000). The same author indicated that Lake Victoria may have been dried up completely some 14000 years ago (Johnson et al., 1996), a view disputed by Fryer (2004).

N'yanza is the name the local Wasukuma people used for the lake on which shore they lived, the word means "lake". In August 1857 the Englishman John Hanning Speke was the first European explorer to see the N'yanza. He made his discovery at the southern end of the lake near the village of 'Muansa', the present regional capital Mwanza in Tanzania. In honour of his queen he named the lake, Victoria N'yanza. Speke expected this inland sea to be the source of the River Nile, which he proved to be true in July 1862 (Speke, 1863, 1864).

Around 1900 German officials estimated the number of people in "Deutsch Ost Afrika" (including the present Rwanda and Burundi) at 7 million. Tanzania alone is currently inhabited by 39 million people. Almost all these people rely directly on the land for work, income and food. The strong population growth is no exception, as everywhere in sub-Saharan Africa the human population has increased, in particular around the great lakes of East and Central Africa. There are now over 30 million inhabitants unevenly distributed over the Lake Victoria basin (Ntiba, 2001).

Facing Lake Victoria from a hilltop near Mwanza, the island of Ukerewe can be seen at the other side of the Speke Gulf, just like Speke might have seen it in 1857. In contrast to the surrounding land, the lake looks unchanged. On the beach, like anywhere on the 3220 km long coastline of the lake, fishermen can be seen with their canoes, landing their catch or cleaning and organizing their gillnets. The catches that they are landing are dominated by two large fish species, not present in the Victoria N'yanza in Speke's time: Nile perch, *Lates niloticus* (L.), a large fish predator, and Nile tilapia, *Oreochromis niloticus* (L.), a primary consumer, both originally from Lake Albert and the River Nile.

The fish fauna

In spite of its young age Lake Victoria had an extremely rich fish fauna, comprising several hundred cichlid species (Greenwood, 1974; Witte et al., 1992b; Seehausen, 1996; Kaufman et al., 1997), 17 cyprinid species, 10 catfish species, belonging to 4 families, and 18 other species divided over 5 families (Greenwood, 1974; Van Oijen, 1995). The flock of more than 500 endemic haplochromine cichlid species showed an extreme adaptive radiation. Virtually all habitats and food types were exploited by these haplochromines (Greenwood, 1974; Witte & Van Oijen, 1990). They comprised, for example, species feeding on phytoplankton, algae from substrates, snails and bivalves, insects, zooplankton, prawns, other fish, and more peculiar resources such as cichlid eggs and larvae stolen from the mouth of brooding females. It is remarkable that such a radiation was achieved in a geologically short time span.

The first haplochromine species of Lake Victoria was described by the German taxonomist Hilgendorf in 1888, who described *Chromis obliquidens*, later becoming *Haplochromis obliquidens*. More species descriptions followed and numerous species remain to be described. Many do not exist anymore in the wild and are only found in museum collections. The majority of the haplochromine cichlid species from the open waters of Lake Victoria vanished and only a small number can still be found today (Witte et al., 1992b; 2000; Kaufman & Ochumba, 1993; Seehausen et al., 1997b). For fish biologists and fisheries scientists, watching the few species of haplochromine fishes, currently caught in the open waters of the lake, it is difficult to imagine how once tons and tons of these fishes, comprising hundreds of species, were caught.

Fisheries and species introductions
Graham (1929) was the first to report on the fisheries of the lake, of which he also described the most important commercial species, *Oreochromis esculentus* (Graham, 1928). He found that after the introduction of gillnets in 1905, the fisheries had developed fast, aided by the increased demand for preserved fish in the colonial economy. Increased transport systems facilitated the market and created work and cash for the fishermen. No wonder that the stock of *O. esculentus* soon showed signs of over-exploitation. Graham (1929) noted that also other large fish species such as *O. variabilis*, the lungfish *Protopterus aethiopicus*, and the catfishes *Clarias gariepinus* and *Bagrus docmak* were fished. On the haplochromine cichlids, he remarked: '*So great are their numbers that I have contemplated suggesting trawling for them, in order that they may be used for manure in Kenya Colony'*. Further he wrote on the same page in his report "*It has been suggested to me frequently that Lake Victoria would be improved if its fish fauna included some of the Lake Albert species, such as the Nile perch* (Lates) *or the Tiger Fish* (Hydrocyon)". He followed with "one *must regret that the enormous* Haplochromis *population above referred to, should at present not be utilised, because there is no large easily-caught fish which feeds upon them*". Despite that, Graham warned that an introduced predatory fish could harm the valuable fishery for *O. esculentus*.

Oreochromis leucostictus (Trewavas), *O. niloticus* (L), *Tilapia zillii* (Gervais) and *T. rendalli* (Boulenger) were introduced into Lake Victoria, between 1951 and 1954 after over-fishing of the indigenous *O. esculentus* (Beauchamps, 1958; Welcomme, 1968, 1988; Lever, 1996). Just 25 years after Graham's report was published, Nile perch fingerlings were introduced. This predatory fish species changed the ichthyofauna of the lake completely (Goldschmidt et al., 1993; Pringle, 2005).

Prior to the introduction of Nile perch, fish and fisheries biologists disputed the consequences of the release of Nile perch into the lake (Fryer, 1960; Anderson, 1961; Pringle, 2005). While Nile perch was predicted to be able to convert 'trash' fish to a large consumable fish, the fish was also predicted to be a threat to the valuable tilapia fisheries by finishing the indigenous species (Fryer, 1960). Such a dispute did not take place concerning the introduction of alien tilapiine species.

It is not the first time that Nile perch occurred in the Lake Victoria area. Archaeological excavations showed the presence of this species in Miocene deposits in the Kenyan part of the present Lake Victoria basin (Greenwood, 1953). The claim of a kind of re-introduction of Nile perch into Lake Victoria is incorrect as the Miocene Nile perch inhabited a totally different ecosystem, which existed before the formation of the present Lake Victoria basin. Nile perch must have gone extinct at that time when the ancient lake dried up. Desiccation and large lake level fluctuations are not uncommon on the African continent as there are several dried lakes e.g. Lake palaeo-Makgadikgadi (Joyce et al., 2005) and lakes that are drying up now e.g. lakes Chad and Turkana (Beadle, 1981).

In the pre-Nile perch ecosystem the ichthyofauna of the present Lake Victoria, was dominated by the haplochromine species, which made up 80% of the demersal ichthyomass (Kudhongania & Cordone, 1974). After the Nile perch boom in the 1980s, this perch dominated the ichthyofauna and the haplochromines in the sub-littoral and open waters had almost vanished. The lake fauna changed from a unique and highly endemic East African fauna to a one, which is dominated by Nilotic Soudanian faunal elements.

Eutrophication

During the 1980s, eutrophication in the lake strongly increased. This resulted in algae blooms (Ochumba & Kibaara, 1989; Hecky, 1993; Mugidde, 1993), decreased levels of dissolved oxygen (Kaufman, 1992; Hecky et al., 1994; Wanink et al., 2001) and decreased water transparency (Seehausen et al., 1997a; Witte et al., 2005). Sediment cores indicated that eutrophication of the lake had already begun in the 1930s and correlated with the increase of the human population along the lakeshore (Verschuren et al., 2002). Disappearance of the phytophagous haplochromines after the Nile perch boom, may have contributed tot he phytoplankton blooms in Lake Victoria (Goldschmidt et al., 1993)

The aim of this thesis

As witnesses of the changes in recent times, many fish and fisheries biologists have taken their responsibility to describe what they saw, heard and experienced concerning the changes in the lake. A large number of publications has emerged from these biologists. The publications of Ogutu-Ohwayo (1990a,b, 1999), Kaufman, (1992), Kaufman & Ochumba (1993), Witte et al., (1992a,b, 1995), Wanink (1998, 1999) and several others solidly document the effects of an "experiment" that cannot be repeated. The Lake Victoria experience is an instructive example when considering introductions of alien fishes into other water bodies. Such introductions pose a permanent threat to the existing biodiversity.

During the past decade a new generation of biologists emerged which produced an increasing number of publications referring to the post-Nile perch ecosystem. As several of these authors did not know the pre-Nile perch system by own observation, their publications often include speculative views on what actually happened e.g. Verschuren et al., (1998, 2002); Guruvitch & Padilla (2004). While Nile perch was regarded as the main cause of the ecological changes in the lake (Barel et al., 1985; Ribbink, 1987; Ogutu-Ohwayo, 1990a,b; Kaufman, 1992; Witte et al., 1992a,b; Goldschmidt et al., 1993), some authors doubted the impact of Nile perch and mentioned over-fishing as the main cause of the species change (Acere, 1988; Harrisson et al., 1989; Kudhongania et al., 1992; Bundy & Pitcher, 1995; Kudhongania & Chitamwebwa, 1995). Eutrophication and the concomitant decline of oxygen concentrations and water transparency were also seen as the cause of these changes (Hecky et al., 1994; Bundy & Pitcher, 1995; Seehausen et al., 1997b; Verschuren et al., 1998, 2002). Overemphasizing the effects of long-term processes like eutrophication and fisheries is understandable for those who have not observed the species change happening in a very short time.

The field data presented here were obtained from the Tanzanian waters in the period before, during and after the Nile perch boom and thus recorded what changes actually took place in the area.

In this thesis I want to elaborate on the different processes that took place concomitantly and try to establish their role in the changes that were observed in the Lake Victoria ecosystem.

In chapter 2 the colonisation process of Nile perch in Lake Victoria is described. It is argued that the decline of haplochromines decreased predation on and competition with juvenile Nile perch and facilitated the survival of these young fishes. Consequently the immigration of sub-adult and adult Nile perch in an area may have paved the way for successful recruitment. Chapter 3 concerns the distribution of Nile perch in Lake Victoria. In contrast to the expectations and in spite of its supposed low hypoxia tolerance, Nile perch occupied deeper waters than in its native areas. A study of its depth distribution in relation to environmental factors revealed that both depth and dissolved oxygen levels in the lake determine the seasonal distribution patterns of Nile perch. In chapter 4, diel vertical migration patterns of the major fish species of Lake Victoria are described in the periods before and after the Nile perch upsurge. For most fish species vertical migrations could be explained by pursuit of prey rather than by escape from predators.

Chapter 5 indicates why shrimps grew in abundance in the post Nile perch system and discusses the impact of their strong increase on the recruitment of Nile perch. Chapters 6 to 8 describe the changed abundance in respectively catfish, lungfish and tilapiines during the past decades. In these chapters the impacts of fisheries, eutrophication, habitat-destruction, competition with introduced species and Nile perch predation are discussed for each of the above-mentioned species (groups). Predation by and competition for prey with Nile perch may explain the decline of several of the catfish species. The decline of African lungfish in the lake may reflect the impact of over-exploitation by the fishery, habitat destruction and a low level of Nile perch predation. The decline of the indigenous tilapiines seems to have been caused by over-fishing and by the competitive dominance of the introduced *O. niloticus*. In the last chapter the interactions between native species, introduced species, fishery and environmental impacts, discussed in the previous chapters, are all moulded in one diagram in order to visualize their coherence and to evaluate the changes in Lake Victoria.

Tilapia and Nile perch

ALLOW ME space to answer letters by Mr. Ezekiel Okemwa, Research Officer, Freshwater Fisheries Research Station, Kisumu, which appeared in *The Standard* of February 17, 1978. Although I agree with his research findings, I wish to add that shortage of Tilapia stocks in Lake Victoria (Kenya side) is due to too many fishermen operating in a small area of Nyanza Gulf in Lake Victoria. Catches of Tilapia species in Lake Victoria (Tanzania and Uganda side) is good. This can be proved by visiting Busia Market and seeing the number of fresh and dried Tilapia brought from Uganda to Kenya for sale.

For Mr. Okemwa and other Research Officers' information, please take note that Nile Perch (Lates niloticus linne) or *Mputa* were stocked in Lake Victoria and Kioga from Lake Albert in August, 1954. The species in question were stocked by myself assisted by fish scouts at that time Agustino Kyomya, Benwa Magadu, Peter Karakaba and others — under the directive of the then Senior Fisheries Officer, Mr. Alex M. Anderson, of Entebbe Fisheries Headquarter.

(Sgd) J. OFULA AMARAS,
Kakamega.

DAILY NATION, MONDAY, MAY 18, 1987

The truth about Nile Perch

I would like to correct a report attributed from Natural Resources Officer, Mr Peres Kangera of Tanzania's Western region of Kagera and Prof. B. O. Buanyondi, director-general of the Tanzania Fisheries Research Institute that the Nile Perch did not originate from Kenya's Lake Rudolf (now Lake Turkana) (see Nation April 13).

I have said in the past that it is assisted by Ugandan Fisheries Staff M/s Augustine Kyonya Benesa Magadu, Peter Kasakasa, who stocked Nile Perth in both Lake Victoria and Kyoga from Lake Albert-Butiabar, in August 1954.

The record concerning the stocking of Nile Perch in Lake Victoria should be corrected accordingly by the fisheries department in Kenya, Tanzania, Uganda and others who are concerned. Whoever needs more information could contact me through Box 932, Kakamega.

J. Ofulla Amaras,
Kakamega.