Impact of water hyacinth, *Eichhornia crassipes* (Mart.) Solms-Laubach, on the fishery of Lake Victoria, Kenya.

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Abstract

Due to heavy infestation of water hyacinth in Lake Victoria catches of *Clarias gariepinus* (Burchell) and *Protopterus aethiopicus* (Heckel), which strongly decreased in the 1980s, increased markedly in 1998. *Tilapia* catches also recorded an increase following the infestation. Landing areas with sheltered bays, which harboured more hyacinth mats, had greater catches of *C. gariepinus* and *P. aethiopicus* than open beaches with little hyacinth mats. The increase in *C. gariepinus, P. aethiopicus* and *Tilapia* catches is attributed to increased food availability and breeding areas due to water hyacinth. Reduction of *Lates niloticus* (L.) in the lake due to overexploitation could have also reduced predation and competition on these species leading to their increase

Key words: Lake Victoria, Water hyacinth, Tilapia, *Clarias gariepinus*, *Protopterus aethiopicus*

Introduction

Water hyacinth, *Eichhornia crassipes* (Mart) Solms-Labauch was first reported in the Ugandan side of Lake Victoria in 1988 (LVEMP 1995; Twongo 1993). Infestation was suspected to have occurred through Kagera River in Uganda. The rapid expansion of the weed was reported to show serious economic, social, health and environmental impacts. Important activities within the fisheries, transport and water quality were affected by spread of the weed. Large mats of water hyacinth posed major obstruction to transport and fisheries operations. Delays in delivering fish catches resulted in deterioration of fish quality and to avoid spoilage operators had to carry ice, which increased operational costs.

Water hyacinth was reported to impact negatively on the health of lakeside communities. It provided habitat for agents of malaria and bilharzia and harboured snakes. It turned water green and dirty making the supply unsuitable for drinking and other domestic use. Reduction of oxygen levels in the water creates and environment unsuitable for fish survival, subsequently reducing species diversity (Gerry *et al* 1997). Lake Victoria, which supports a thriving fishing industry, supplying affordable protein, income and employment to more than 10 million people (Ochumba 1984) was adversely affected by the infestation. Water hyacinth was perceived to affect fisheries through reduced levels of production, a reduction in species diversity, poor quality fish, rising cost of operation resulting in lower income to fishers and higher prices to consumers (LVEMP 1995).

Exploratory bottom trawl and commercial catches of 1958-1970 showed that *Clarias gariepinus* (Burchell) and *Protopterus aethiopicus* (Heckel) were important commercial species in Lake Victoria after haplochromines, *Bagrus docmak* (Porskall) and *Oreochromis esculentus* (Graham) (Bergstrand and Cordone 1971; Kudhogania and

Cordone 1974). There was a decline of *Claria*s spp. *and P. aethiopicus* in the late 1970s and 1980s(Okemwa 1981; Ogutu-Ohwayo 1990). The resultant loss of habitat, pollution, fishing pressure and establishment of *Lates niloticus* (L.) contributed to their decline (Kibaara 1981; Hecky 1993; Muggide 1993; Ochumba and Kibaara 1989). Since then the fishery has been dominated by *L. niloticus*, *Oreochromis niloticus* (L.) and a native cyprinid, *Rastrineobola argentea* (Pellegrin) (Witte and Van Densen 1995).

Recent commercial and trawl catches in Nyanza gulf of Lake Victoria shows an increase of both *C. gariepinus*, *P. aethiopicus* and Tilapia which have been attributed mainly to lake infestation by water hyacinth (Getabu and Nyaundi 1999). Although hyacinth has brought problems to the lake community, the weed also has had positive aspects on the fishery. The paper highlights the need to look at the positive aspects of the hyacinth and discusses factors leading to increase of *C. gariepinus*, *P. aethiopicus* and Tilapia.

Materials and methods

Study area

The Kenyan part of Lake Victoria comprises the main lake and semi-enclosed Nyanza Gulf also known as Kavirondo or Winam Gulf (Fig 1). The lake receives its main flow from several rivers originating from the East Africa Rift Valley. The main geographical, hydrological and physical characteristics of Lake Victoria and Nyanza Gulf have been summarised by Burgis *et al* (1987), Mavuti and Litterick (1991) and Crul (1995). Nyanza Gulf, which comprises the major part of the lake, lies within the equatorial region. The water temperature and solar radiation are relatively constant throughout the year.

The study area was divided into four zones (Fig 1) as follows:

Zone I
Inshore gulf, shallow with an average of 5 m with several sheltered bays. The region is influence by drainage of several major rivers (Sondu and Nyando), which pass through rich agricultural areas. The area also receives municipal effluents. The site had the heaviest water hyacinth coverage, with several regions with permanent cover.

Zone II
Inshore gulf, deep with an average of 20 m and few sheltered bays. River Oluoch drains the region, which pass through a rich agricultural area. The area receives municipal effluents and had occasional water hyacinth coverage.

Zone III and IV
Offshore open waters, shallow with an average of 5 m with the shores exposed to heavy wind and wave action. The River Kuja drains into Zone III River Yala, which pass through rich agricultural areas drains Zone IV. The area has no major municipal influence and was rarely covered by water hyacinth.

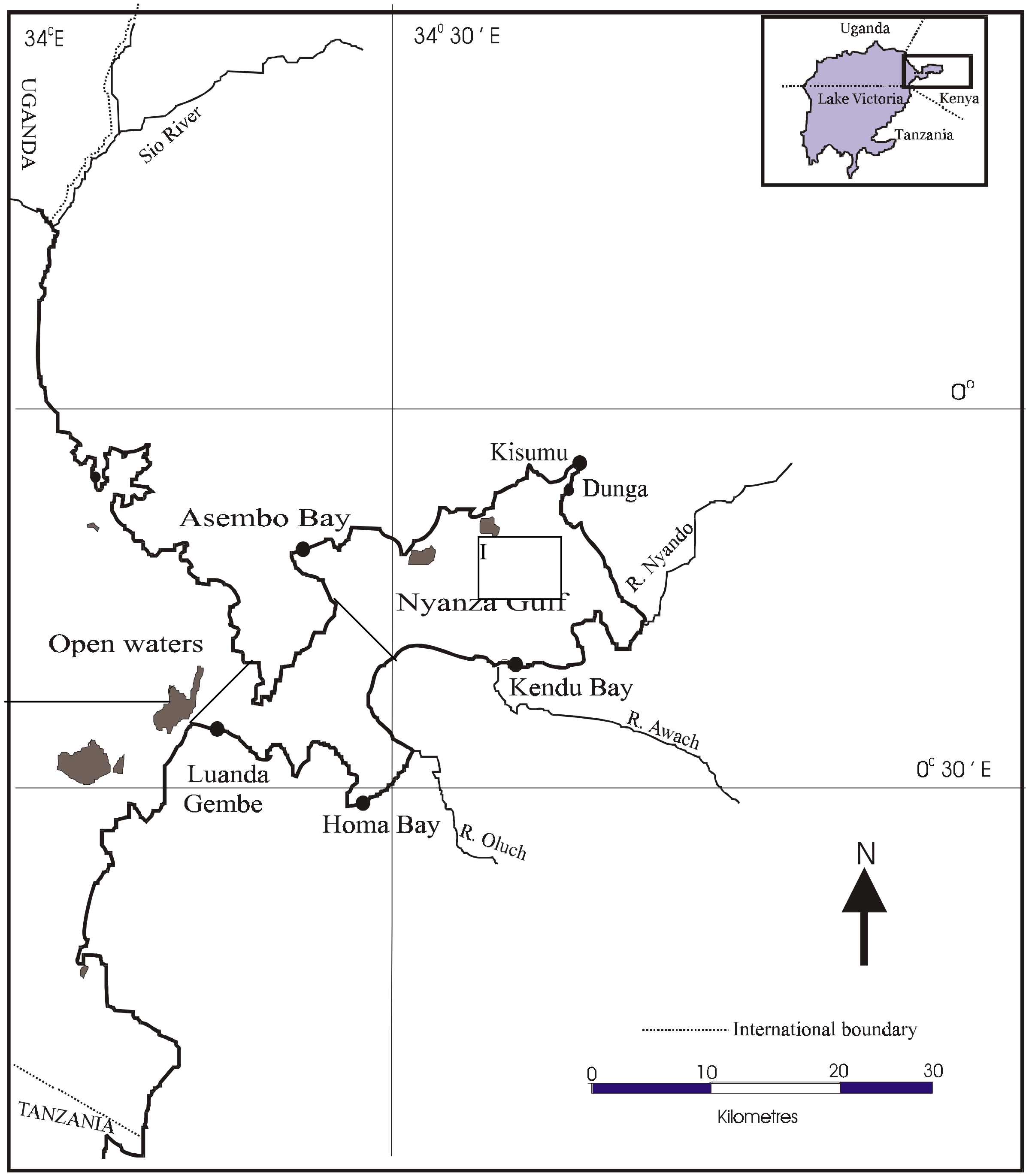

Fig. 1: Map showing the sampled zones of the Nyanza Gulf, Lake Victoria.

Sampling

On each day of sampling the catches of from 5-10 boats selected randomly from targeted landing sites were recorded (Fig. 1). Parameters recorded for each sampled fishing boat were number of crew, gear type, size, time and duration of fishing. Catches were sorted into species and weighed (nearest kg). Weights recorded daily were raised by a function of number of boat landed to give monthly estimates for a given beach. Data from sampled beaches were then summed up on a monthly basis and, a monthly and annual means were then computed. Estimate of annual total catch was given by:

$$AC = CPBD * FD * B,$$

where *AC* is the annual catch (t), *CPBD* is the mean annual catch per boat^{-1} (Kg), *FD* is the number of fishing days (365 or 366), and *B* is the mean number of boats fishing daily.

Results

Total landings in Kenya waters of Lake Victoria of native species (mainly *P. aethiopicus* and *C. gariepinus*) increased dramatically from 4.5 tonnes 1996 to 16.3 tonnes 1998 (Fig. 2). Tilapia also increased from 6.4 tonnes in 1997 to 12.5 tonnes in 1999. Haplochromines maintained low catches of about 1 tonne increasing to 2.6 tonnes in 2000. Total catches of *P. aethiopicus* and *C. gariepinus* were higher than *Protopterus* (Fig 3). The highest catches of *C. gariepinus* and *P. aethiopicus* were from zone I and the least in zone IV (Fig 4). No catches were recorded when the landing sites were completely covered by water hyacinth.

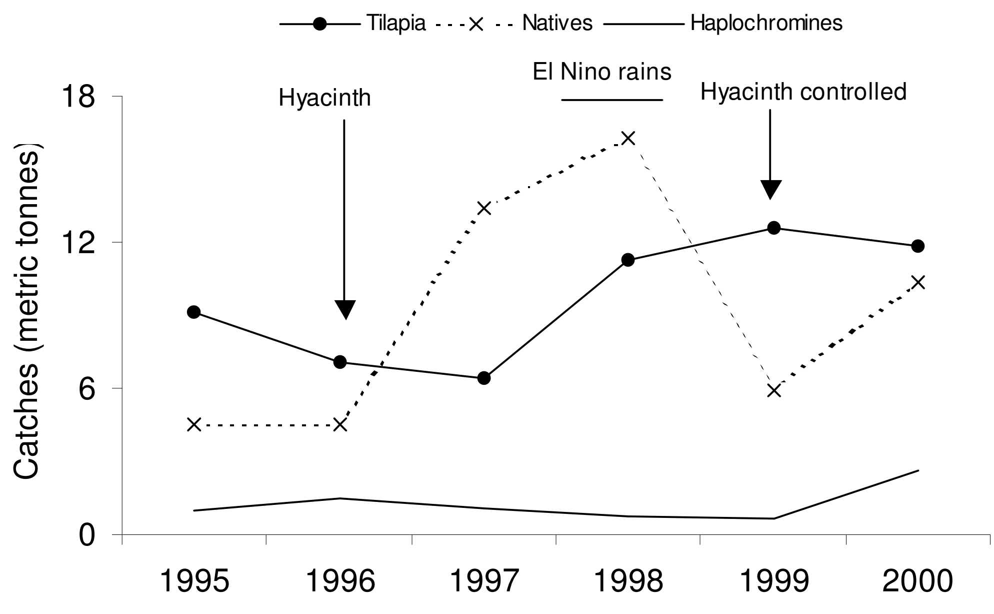

Fig. 2: Annual catches of tilapiines, haplochromines, and other species (*Clarias, Protopterus, Schilbe, Synodontis*) from Kenya waters of Lake Victoria.

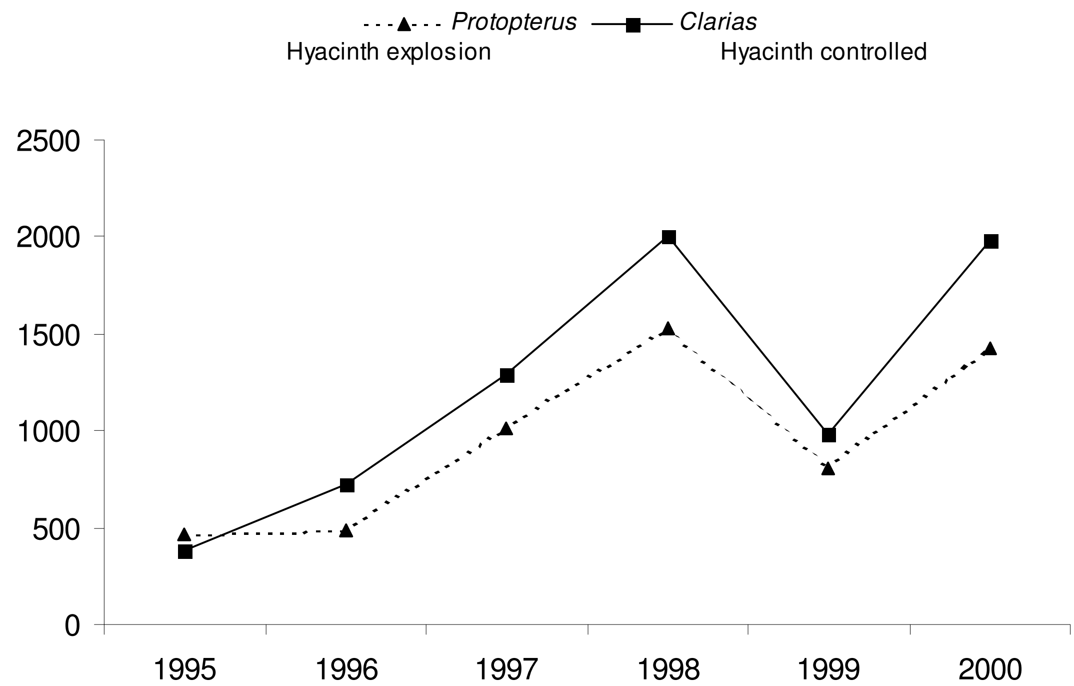

Fig. 3: Annual catches of *C. gariepinus* and *P. aethiopicus* from Lake Victoria, Kenya.

Effort expressed as boat days shows a slight increase as from 185 boat days in 1995 to 299 boat days 1999 reducing again to 199 boats days in 2000 (Fig 5).

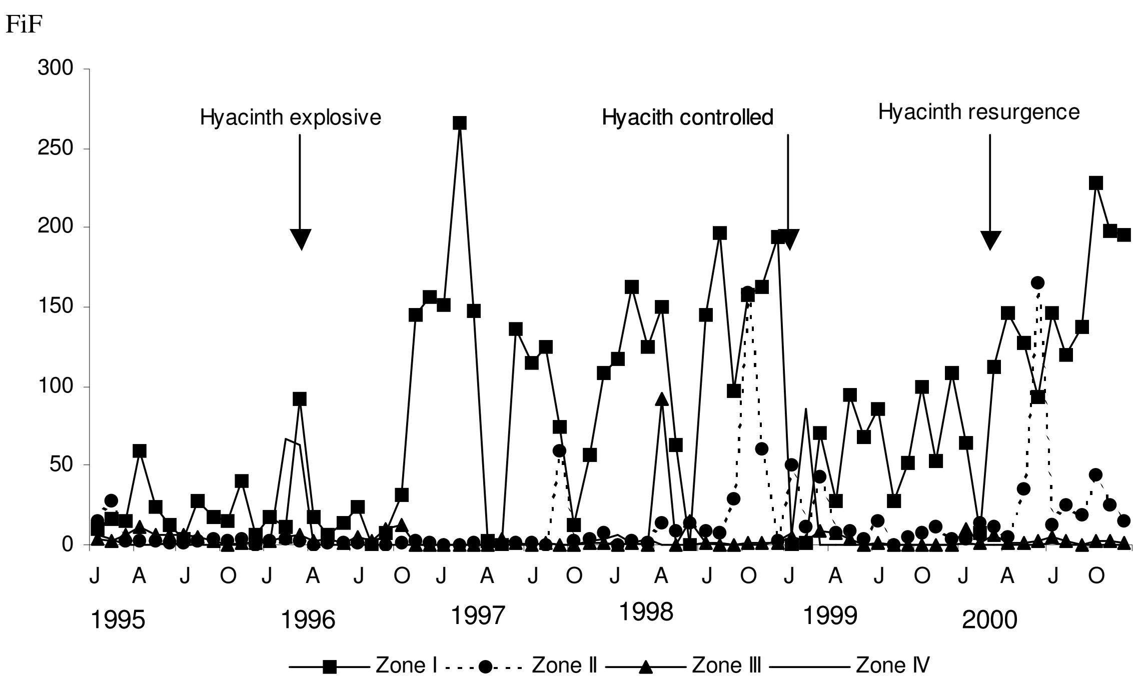

Fig. 4a: Monthly catches of *C. gariepinus* from different zones of Lake Victoria, Kenya.

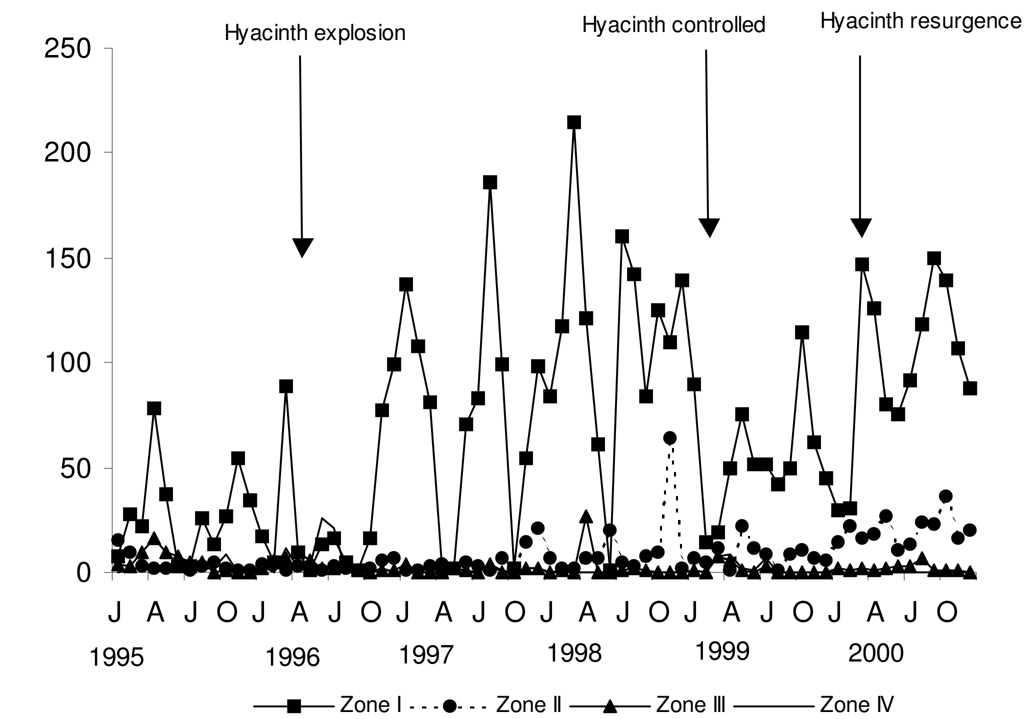

Fig. 4b: Monthly catches of *P. aethiopicus* from different zones of Lake Victoria, Kenya.

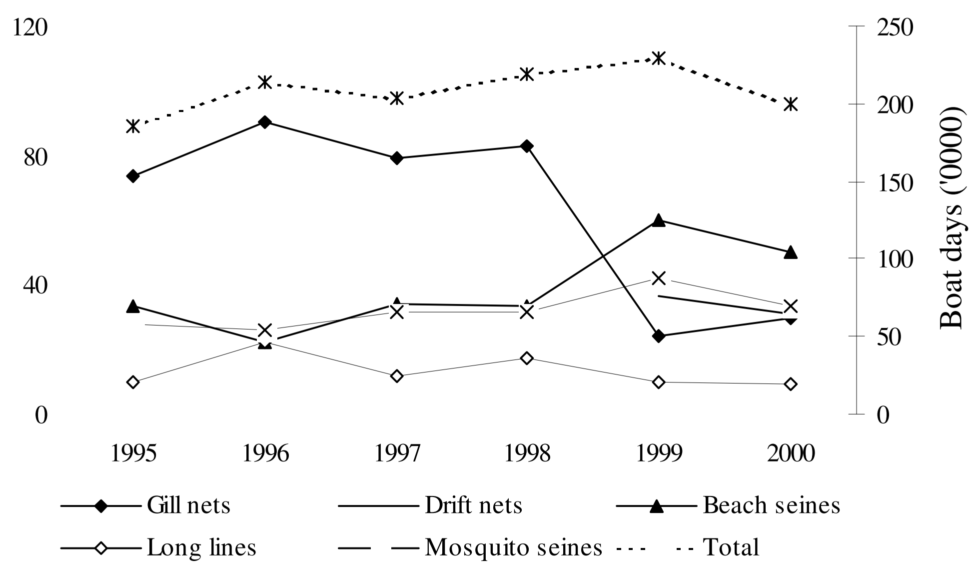

Fig. 5: Annual effort (boat days X10,000) for the main gears used in Lake Victoria, Kenya. Secondary axis represents total effort for the gears.

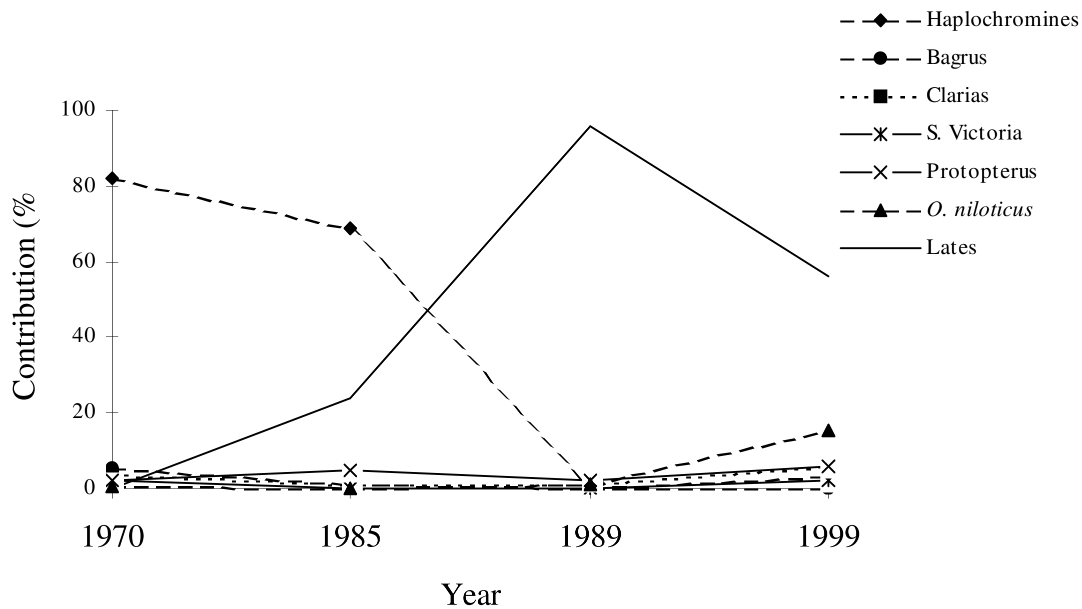

Fig. 6: Contribution of the major fish species in trawl catches in Lake Victoria, Kenya. (*Source: Kudhong'ania and Cordone, 1974; Okemwa, 1981; Getabu and Nyaundi, 1990)*

Discussion

Native fish species important in the 1950-1970s have declined, and *L. niloticus* and *R. argentea* catches have increased since the mid 1980s (see Ogutu-Ohwayo 1990 for review). The increases in *L. niloticus* and *R. argentea* have been attributed to increase in fishing effort (Othina and Tweddle 1999). Available records shows that catch per unit effort (CPUE) have increase annually from 82 kg boat day^{-1} in 1986 to 180 kg boat day^{-1} in 1989, which was mainly due to explosion of *L. niloticus* (Othina and Tweddle 1999). The decline of native species was mainly due to over fishing, predation and competition by *L. niloticus* (Ogutu-Ohwayo 1990; Witte and Densen 1995) and ecological changes occurring in the lake (Ochumba 1984;Crul 1995).

Trawl survey of 1997-1999 shows an increase of *C. gariepinus, P. aethiopicus* and haplochromines compared to 1970s and 1980s (Fig 6). This increase was attributed to a number of factors. Firstly, the reduction in *L. niloticus* stocks has reduced predation pressure on *C. gariepinus, P. aethiopicus* and haplochromines, or their prey, and removed competition. Secondly the infestation of the lake by water hyacinth has provided optimal conditions for breeding and growth of *C. gariepinus, P. aethiopicus* and haplochromines.

C. gariepinus is found mainly in shallow inshore waters, swamp and major affluent rivers (Greenwood 1966; Gichuki and Odhiambo 1994). Infestation of Lake Victoria by the water hyacinth has increased the swampy area offering more feeding, and breeding areas. Water hyacinth has introduced considerable organic matter at the bottom and experimental trawling caught a wide variety of invertebrates, especially Ephemeroptera and Gastropoda, and highlighted an increase biomass of haplochromines. Insects and haplochromines are major diet components of *Clarias* and *Protopterus* while gastropods are preferred diet for *Protopterus* (Corbet 1966; Pabari 1999).

Coverage of water hyacinth also causes de-oxygenation of water, and at times anoxia below the dense mats (Gerry *et al*. 1997). *P. aethiopicus* is an obligatory breather while *C. gariepinus* can survive in foul stagnant water due to accessory organs enabling them to utilise atmospheric air (Witte and Densen 195). Tilapias are known to be very resistant to low levels of dissolved oxygen in natural water bodies or even in ponds (Balarin and Hatton 1979).

The localized de-oxygenation could have thus played a role in the increase in *P. aethiopicus*, *C. gariepinus* and tilapia because they could occupy areas that Nile perch could not occupy because of its intolerance to low oxygen levels.

Finally, it is possible that El Niño effects, particularly intense rainfall, increased flows in the affluent and provided suitable conditions for breeding of these species in flooded areas adjacent to the rivers, thus increasing recruitment.

In Uganda and Tanzania waters of Lake Victoria, where extensive water hyacinth were less prevalent, catches of *Clarias* and *Protopterus* reminded low, especially in between 1997-1999 where *Clarias* and *Protopterus* was only caught in low numbers (mean catch of 0.05kg hr^{-1} and 0.2 kg hr^{-1} respectively in Uganda and 0 kg hr^{-1} and 7.5 kg hr^{-1}in Tanzania) in waters between 10 and 19 m deep (Mkumbo 1999; Okaronon 1999). This is the opposite of Kenya where elevates catches of *Clarias* and *Protopterus* were found in association with hyacinth mats. This latter effect was possibly related to many fishing grounds being closed in Nyanza Gulf following heavy infestation by hyacinth. Beach seining a common fishing method in shallow part of the lake was drastically reduced. These phenomena could have given fish time to reproduce and grow.

The down trends of catches in 1999 were attributed to reduction in water hyacinth and over fishing. The hyacinth has been substantially reduced in the lake by biological control using weevils. The fishers who targeted the fish have overexploited the stocks due to the high value of the species on the local markets. The increase in these species in 2000 could be attributed to resurgence of water hyacinth and reduced fishing pressure on the species.

The upshot of studies on the relationship between water hyacinth presence and status of the fisheries is to debate whether the remaining water hyacinth in the lake should be removed. Most fishers indicate that the mats should be left in areas where they do not impend other economic activities. However, biological control cannot be contained and it is unlikely that selective removal is possible. Whatever the outcome, it is imperative that the effect of water hyacinth on fisheries production is monitored in the long-term to provide an understanding of the interactions between the fish population dynamics and hyacinth prevalence.

Acknowledgement
We wish to acknowledge the Kenya Marine and Fisheries Research Institute (KMFRI) staff involved in data collection and compilation. The financial support was provided by Lake Victoria Fisheries Research Project (Ref.: ACP-RPR 227).

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