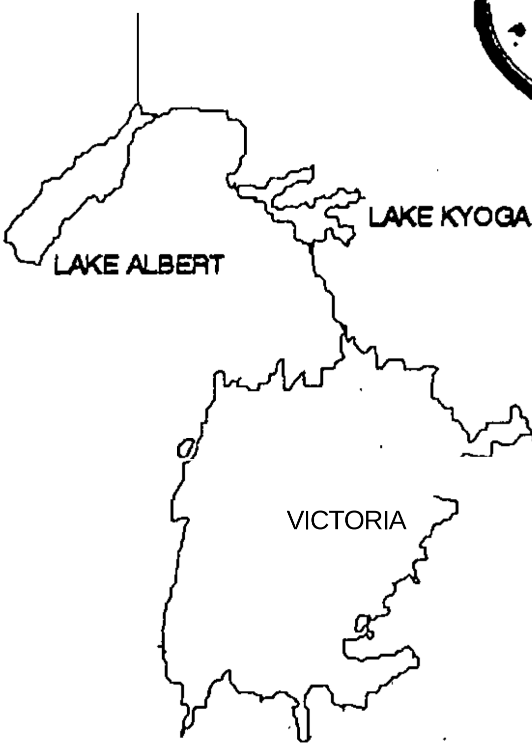
Biology, Ecology, Management and

of the Fisheries of

Victoria, Kyoga and Nabugabo

Nile Perch (Uganda) Project: 3-P-86-0137
Technical Report



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CHAPTER III

The Biology and Ecology of the Nile perch, *Lates niloticus* and the Future of its Fishery in Lakes Victoria, Kyoga and Nabugabo.

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Introduction

Lakes Victoria, Kyoga and Nabugabo had a similar native fish fauna of high species diversity. stocks of most of the native species declined rapidly and some completely disappeared after Nile perch was introduced and became well established. Although, over-exploitation of the fish stocks, competition between introduced and native tilapiines and environmental degradation contributed to the reduction in fish stocks, predation by the Nile perch has contributed much to the recent drastic reductions in fish stock and could even drive the stocks to a total collapse. Nile perch is also currently the most important commercial species in Lakes victoria, Kyoga and Nabugabo and the stability of its stocks is important in the overall sustainability of the fisheries of these lakes. The question that was to be examined in this paper was whether the fisheries of Lakes Victoria, Kyogaand Nabugabo would stabilize and sustain production in the presence of high predation pressure by the Nile perch or whether the Nile perch would drive the fish stocks including itself to a collapse.

It was assumed that Nile perch driven changes in Lakes *Victoria,* Kyoga and Nabugabo would be driven to a level beyond which they would not change further. This would be followed by recovery and stability or the changes would continue to a *point* of collapse. It was assumed that Lake Albert represented the ideal stable state. The changes in the new habitats were expected to be driven through a major change due to Nile perch predation to a stage where there would be no further changes. After *this,* a feed-back mechanism would move the driven variable towards recovery. The variables would then stabilize and oscillate will an amplitude which approximates to what would be recorded in Lake Albert. Alternatively, the changes .would proceed to a stage where the fishery would collapse. The specific hypothesis was that fish species *composition* and diversity, prey selection by the Nile perch and life history characteristics of the Nile perch in the new habitats would change and stabilize.

Methodology

The hypotheses were examined by comparing data collected from Lakes Victoria, Kyoga and Nabugabo at different times after the introduction of the Nile perch.

. The changes in the types of fish taxa present and in fish . species diversity were examined by analyzing commercial catch records and experimental catch composition data collected from Lakes Victoria, Kyoga and Nabugabo before and after the rapid increases in Nile perch stocks and that collected from Lake Albert (see Chapter II). The changes in prey selection and in life history parameters were examined by comparing biometric data collected from Lakes victoria,'Kyoga and Nabugabo during different periods'between 1960 and 1993. The data from the new habitats were classified into nine Blocks with that from Lake Albert representing the tenth Block. The data of each Block for the new habitat was assumed to represent a single stage in the overall evolution of Nile perch driven changes. In this regard, it was assumed that Blocks 1 to 9 represented different stages of Nile perch driven change,s along some continuum in a single lake and that these changes' start at ,the zero point in Lake Albert, move through various stages and return to a situation which is similar or close to that in Lake Albert. The Blocks were arranged ill the following order p,utting ,in mind the time when the Nile perch was introduced and ,when it got firmly established in each lake and the time the data ,was ,collected.

Block O. Lake Albert, 1989 to 1992; the original and native ,habitat"of Nile perch stocks which were introduced into Lakes Victoria, Kyoga and Nabugabo.
Block 1. Lake Victoria, 1964 to 1967; soon after introduction of Nile perch and when haplochromines were still abundant.
Block 2. Lake Victoria 1968 'to 1977; before Nile perch were well established and haplochromines were still abundant.
Block 3. Lake Victoria 1982; the year when Nile perch population sincreased rapidly in the northern region of Lake Victoria but when haplochromines were still abundant.
Block 4. Lake victoria, 1988 to 1992; after haplochromines had been depleted and were no longer important as prey
Block 5. Lake Nabugabo 1991 to 1993; after Nile perch were well established, haplochromines had been depleted.
Block 6. Lake Kyoga, 1967 to 1968; after Nile perch were well established and haplochromines had been depleted and were no longer important as prey.
Block 7. Lake Kyoga 1978 to 1980; ten years after Block 6.
Block 8. Lake Kyoga 1988 to 1990; ten years after Block 7.
Block 9. Lake Kyoga 1991 to 1993; when haplochromines were starting to recover and were again becoming prominent as prey

Some life history characteristics vary with size of the Nile perch. The type, size (length), and number of prey ingested by the ,Nile perch in most habitats varies with its length (Worthington 1929, Hamblyn 1966, Gee 1969, Okedi 1970, Ogutu-Ohwayo 1985, Hopson 1972). Nile perch of less than 20 cm total length feed predominantly on invertebrates, those of 20 cm to 60 cm on invertebrates and fish, those of 60 cm to 100 cm on small fish prey such as *Rastrineobola argentea* Pellegrin and those of more than 100 cm on large fish prey such as *Oreochromis niloticus*, L. Males mature at about 55,cm total, length while females mature around 95, cm (Holden 1963, Hopson 1982). These variations could affect comparisons of changes in life history characteristics depending On the size range of the Nile perch which had been examined in each Block. On this basis, data of each Block were grouped in length classes as follows:

Class A: <20 cm - immature and feeding mainly on invertebrates.

Class B: >=20 cm and <60 cm - immature females and mature or maturing males feeding on invertebrates and fish.

Class C: >=60 cm and <100 cm - Mature males and maturing or immature females feeding on many small fish prey especially *R. argentea* in Lakes Victoria, Kyoga and Nabugabo and *Alestes* spp in Lake Albert.

Class D: >=100 cm - All mature and feeding mainly on *one* or two large fish prey especially O. *niloticus* in Lakes victoria, Kyoga and Nabugabo and *Hydrocynus* spp in Lake Albert.

The life history characteristics were first examined for each Length Class within each Block and the differences between the classes compared. Comparisons were then made for each length class (or for specific length classes combined) between the Blocks. The results were finally compared with the conceptual model.

Changes in fish species composition and diversity

stocks of the Nile perch started to increase rapidly in 1965 in Lake Kyoga and in 1977, 1982 and 1983 respectively in the Kenyan, Ugandan and Tanzanian regions of Lake Victoria. By that time, haplochromine were the most abundant fish in Lake Victoria and formed the main food of Nile perch. The changes in fish species diversity following increases in Nile perch stocks are illustrated together with corresponding changes in haplochromine stocks Figure3.1. As the Nile perch stocks increased, there was a rapid fall in haplochromine stocks and in overall fish species diversity. This decline was not due to a shift in fishing effort to the larger species especially Nile perch. Experimental trawling in the same part of the lake confirmed that as the catch rates of Nile perch increased, those of haplochromines declined drastically. By 1990, there were signs that haplochromines were again showing up in commercial catches indicating that the stocks had been driven to the lowest level possible and were starting to recover.

Before establishment of the Nile perch, about 14 fish taxa occurred regularly among commercial catches. After establishment of the Nile perch, the number of fish taxa in the new habitats decreased to only three species; the two introduced species; *Lates niloticus* L. and *Oreochromis niloticus* L. and one native species, *Rastrineobola argentea* Pellegrin. These remained the dominant species for about 30 years in Lake Kyoga where Nile perch were introduced first and have remained the dominant fish species in Lakes Victoria and Nabugabo since establishment of the Nile perch. This suggests that these three species are resilient to predation by the Nile perch. Since then stocks of other taxa especially the haplochromines have started to recover again starting with Lake Kyoga where Nile perch were introduced and got established earlies't and followed by parts of Lake Victoria.

Before the rapid increases in ,stocks of the Nile perch, fish species diversity in Lake Victoria was higher than that of Lake Albert. After the rapid increases in Nile perch stocks, fish species diversity declined to a significantly lower level where it remained for sometime before starting to increase. This indicates that fish species diversity has been driven to a level below which

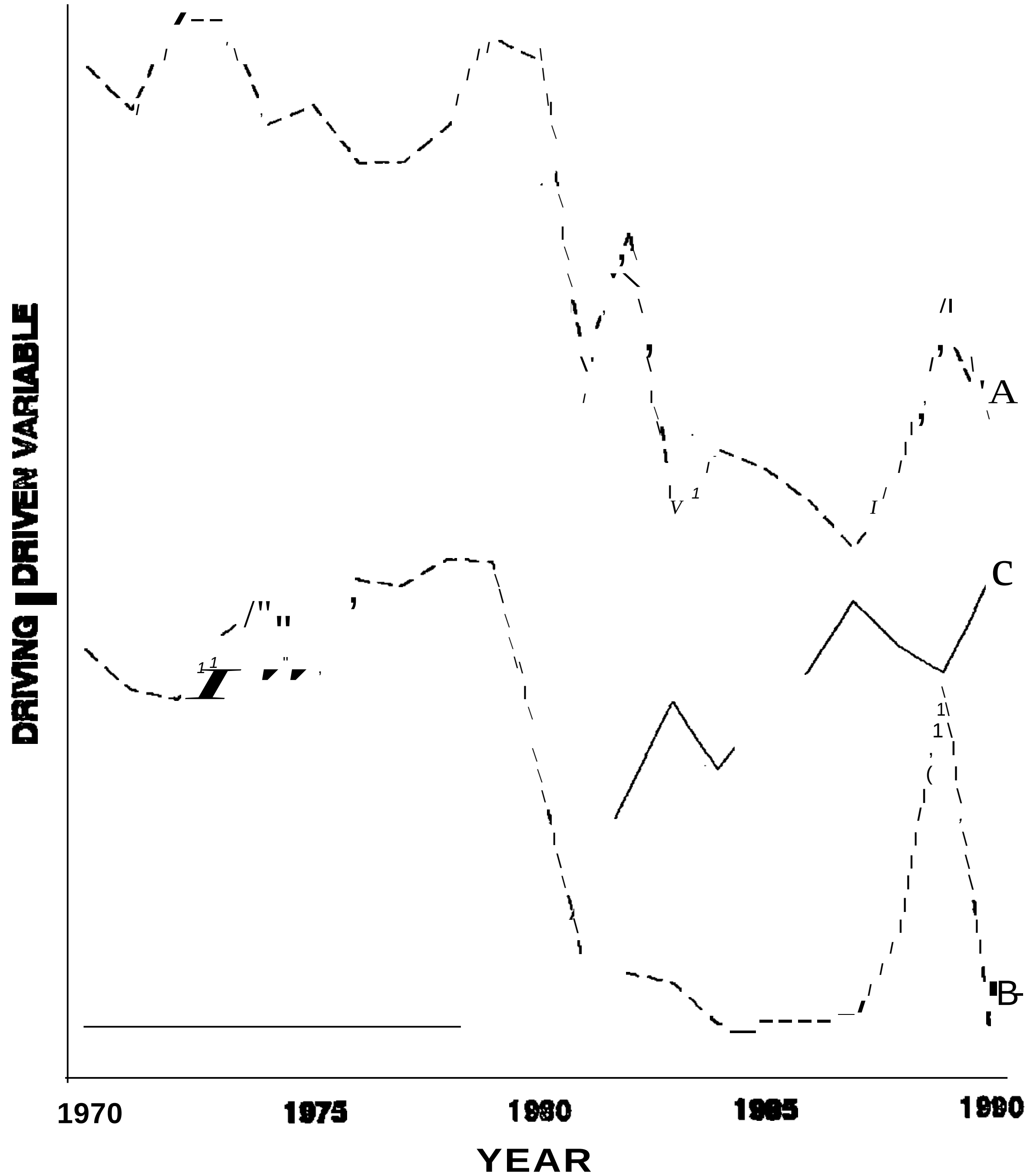

Figure 3.1. Changes in two driven variables; fish species diversity (A) and the contribution of haplochromines (B) with increases in the driving the contribution of Nile perch (C) to commercial catches in Lake Victoria.

it would not fall any further and a feed-back mechanism was pushing fish species diversity towards recovery.

Prey selection

The types of prey ingested by the Nile perch in Lakes Victoria, Kyoga and Nabugabo over different periods is illustrated in Figure 3.2. Soon after the introduction, haplochromine cichlids constituted the main prey of Nile perch in Lakes Victoria, Kyoga and Nabugabo. Following the rapid increases in Nile perch stocks, haplochromine cichlids were depleted and became less important as prey. *Caridina nilotica* and anisopteran nymphs then became the dominant prey of juveniles while *R. argentea*, juvenile Nile perch and O. *niloticus* became the food of larger Nile perch in the three lakes. The only exception was the absence of C. *nilotica* in Lake Nabugabo. There was no further change in the type of prey ingested by Nile perch for 23 years in Lake Kyoga where the predator were introduced earliest suggesting that these types of prey could not be exterminated by the Nile perch. Since then, stocks of haplochromines have started to recover and have again become important as prey in Lake Kyoga in addition to the above types. Similar trends are developing in Lakes Victoria and Nabugabo. With the exception of *R. argentea* which are absent in Lake Albert, the types of prey ingested in the new habitats are now similar to those ingested in Lake Albert. In Lake Albert, the role of *R. argentea* is taken over by *Alestes* spp which like *R. argentea* are pelagic species and can be regarded as ecologically analogous. These observations strengthen the argument that prey selection by the Nile perch in the new habitats has reached the types on which it would stabilize.

Additional evidence of stability in prey selection has also been demonstrated by changes in the sizes and numbers of prey ingested in the new habitats compared to Lake Albert and other native habitats. Soon after introduction of the Nile perch, the average sizes and numbers of prey ingested increased evenly with predator size (Fig. 3.3). After haplochromines had been depleted, the sizes and numbers of prey ingested by different sizes of Nile perch in Lakes Victoria, Kyoga and Nabugabo changed and followed a pattern similar to that in Lake Albert. Therefore, prey selection by the Nile perch in Lakes Victoria, Kyoga and Nabugabo stabilized. The major question that remains is whether these prey types can sustain Nile perch stocks.

Length weight relationships and condition of the Nile perch

The changes in length-weight relationships of Nile perch in Lakes Victoria, Kyoga and Nabugabo over different periods is illustrated in Figure 3.4 and the changes in the condition factor in Fig. 3.5. When haplochromines were still abundant, Nile perch in the new habitats were significantly heavier than those in Lake Albert and other native habitats. After the haplochromines had been depleted, the weight of the fish relative to its length and K decreased. The length-weight'relationships and K values for Lake Kyoga, where Nile perch were introduced earliest declined to levels which are comparable to those in Lake Albert. The condition factor

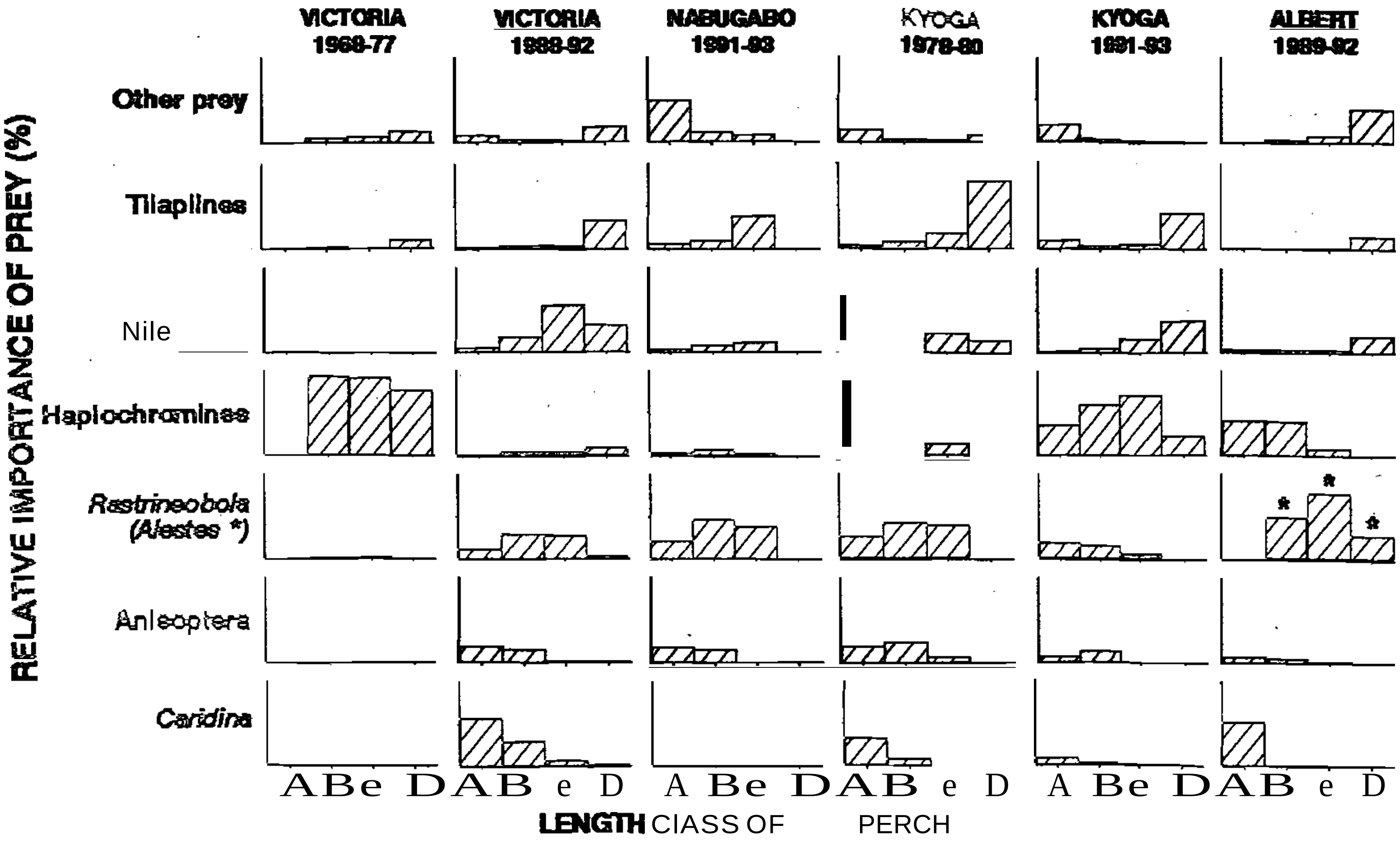

Figure 3.2. of by of A: <20
B: >=20 cm & cm, C: >=60 cm & <100 cm and D: >=100 cm In
and Albert different periods.

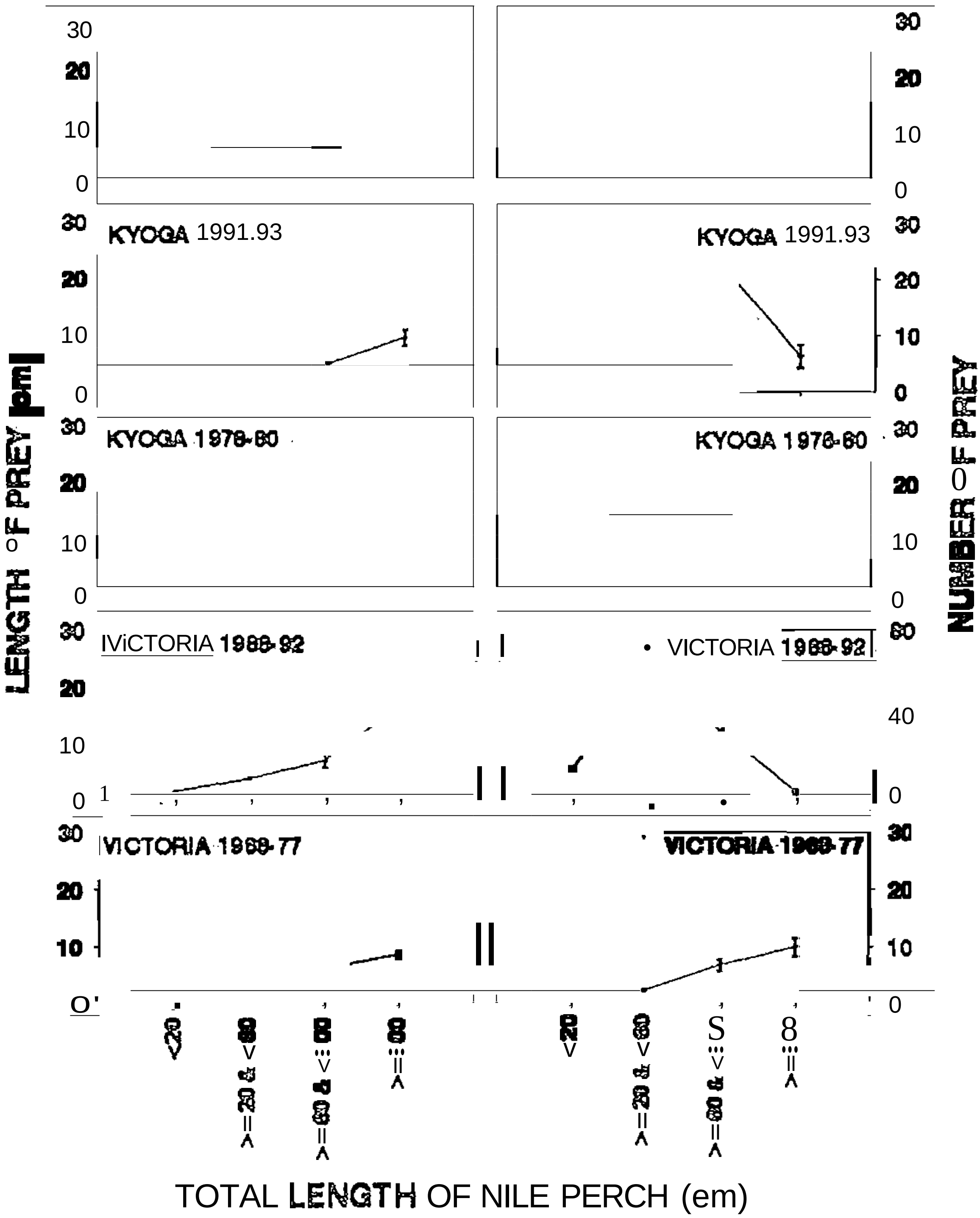

Figure 3.3 The average length and the average numbers of prey ingested by of various length classes In Lakes

bars represent 1 SE of mean.

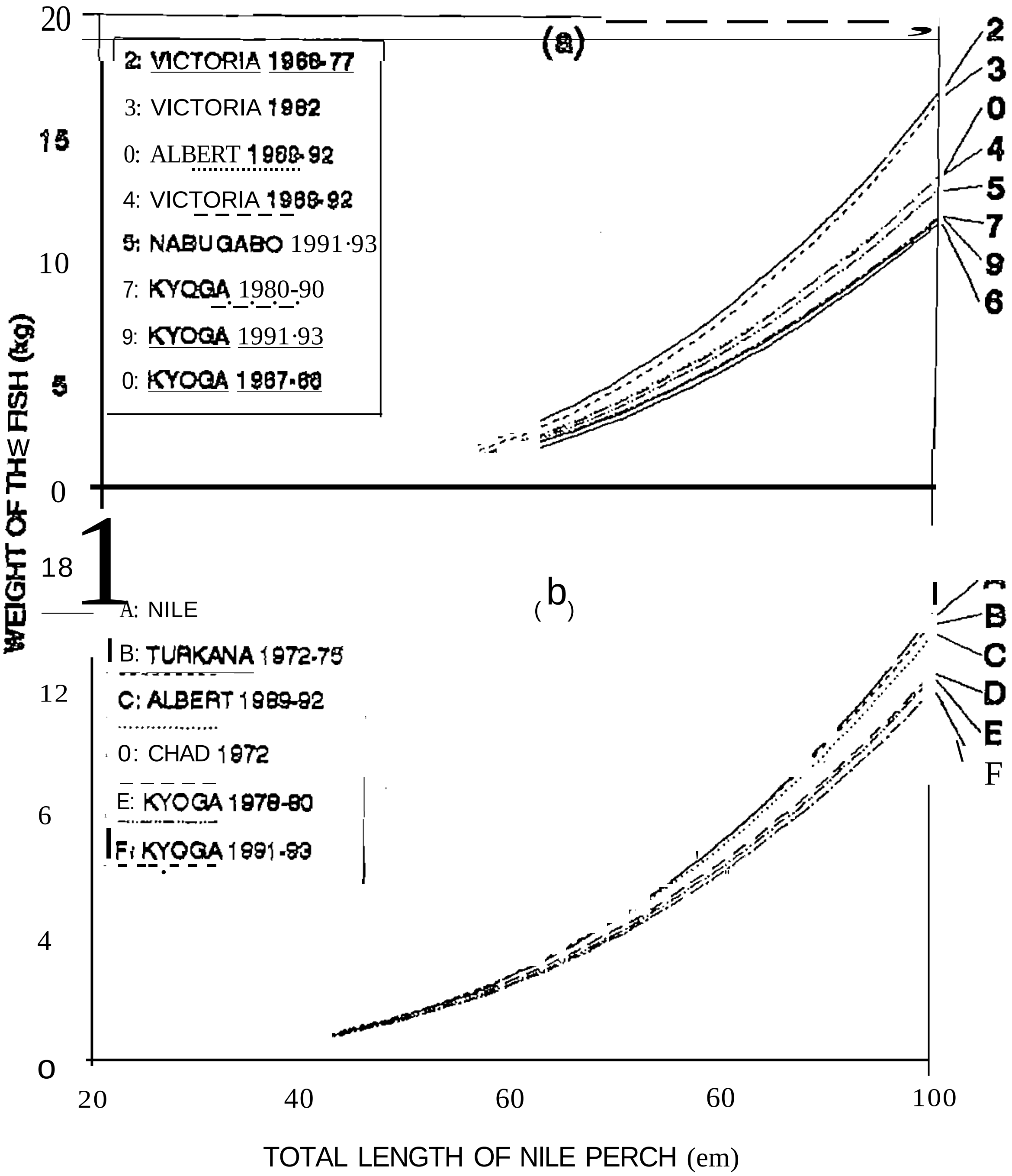

Figure 3.4 (a) of of >=20 and <*100* em In Lakes Victoria, during perids and (b) or of perch of with that of several native habitats.

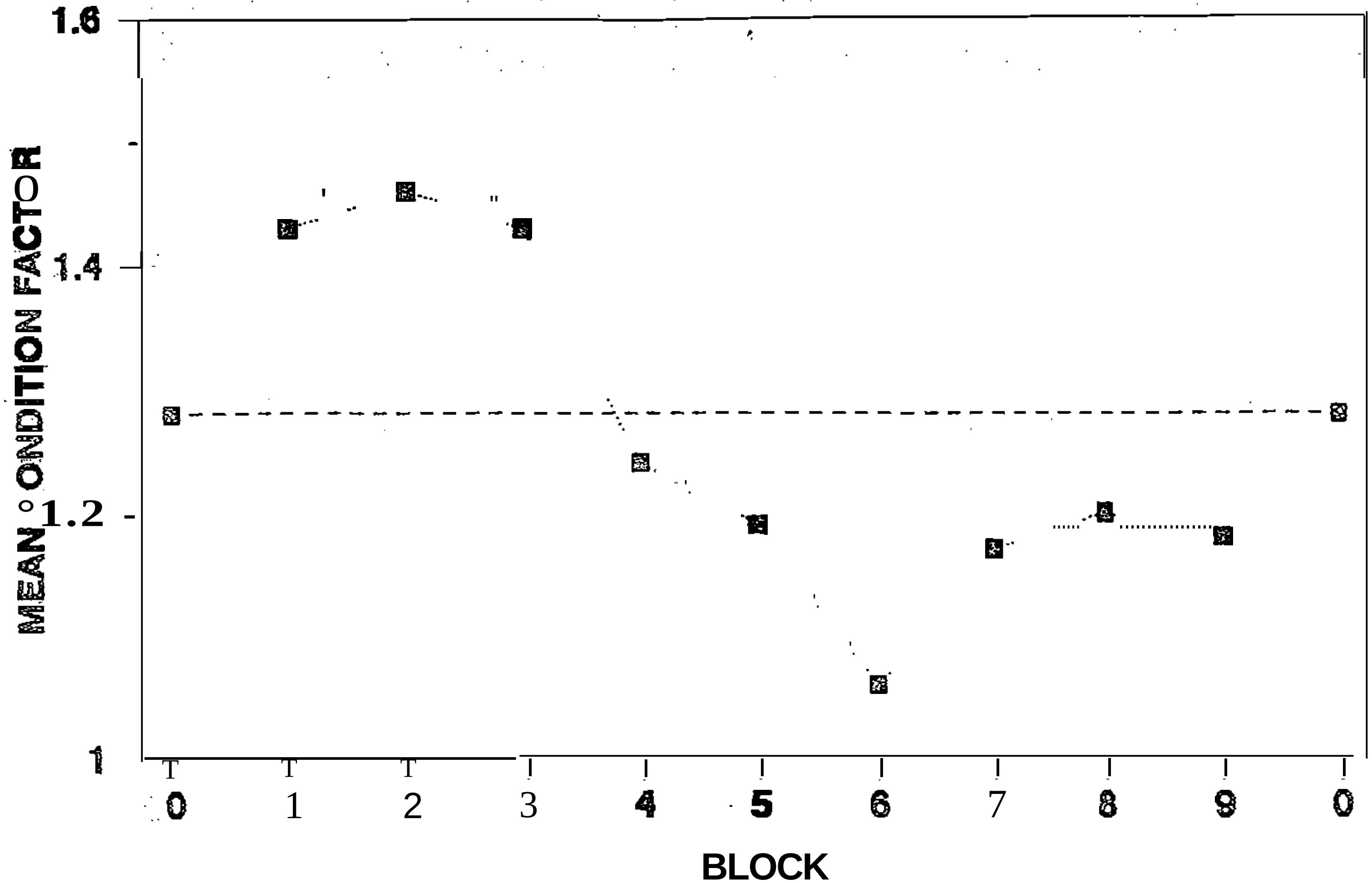

Figure 3.5 Mean condition factor of Nile >=20 and <100 cm
The give the Lake of K and
connects the different Blocks of the new habitats. The arrowheads show the predicted level at might stabilize in the new habitats.

of Nile perch in Lake Kyoga has not changed significantly for 26 years and the values recorded in Lakes Victoria and Nabugabo after depletion of haplochromines were not significantly different from those of Lake Kyoga and Albert. This suggests that the condition of the Nile perch had stabilized. However, although statistical analysis gives a no significant difference verdict, graphical analysis suggests that Nile perch in the new habitats is in a slightly poorer condition than in Lake Albert, and several other native habitats (Fig. 3.5). Therefore, the condition of the Nile perch in the new habitats may be inherently unstable. Further stress on the, food supply e.g. through heavy human exploitation of prey could depress the condi'tion further and have detrimental effects on Nile perch stocks. The main prey types of Nile perch are commercially exploited in Lake Victoria and Kyoga.

There has as yet been no improvement in K following the recent increases in haplochromine stocks in Lake Kyoga. The nutritional gain that may have accrued from improved food supply appears to have been invested into growth. Nile perch grew faster in Lake Kyoga(mean growth rate 28.4 cm by end of first year), where the haplochromines were recovering than in Lakes Victoria (18.9 cm) and Nabugabo (18.4 cm) where the predator depended more on other types of prey. The faster growth rates in Lake Kyoga can be attributed to an improvement in food supply due to the recovery in haplochromine stocks in the lake. If this is the case then, growth rate in the new habitats may initially have been higher due to abundant food supply and then deteriorated alongside the decrease in food supply.

Reproductive Biology

Size at first maturity

Male Nile perch in Lake Albert matured between 50-59 cm total length and females between 80 - 100 cm (Worthington 1929 and this study). When haplochromines were abundant, male and female Nile perch in Lake Victoria matured at a smaller size (30-45 cm for males and 40-50 cm for females). After haplochromines had been depleted, male and female Nile perch matured at larger sizes (50-59 cm for males and 80-100 cm for females). The later values are comparable to those for Lake Albert.

Sex ratios

Sex ratios of Nile perch in the new habitats over different periods are given in Table 3.1 together with values reported in some native habitats. When haplochromines were still abundant and formed the main prey of Nile perch, the proportion of females to males was higher than in Lake Albert. After haplochromines had been depleted, the proportion of females in the population declined to a significantly lower level. This decline can be associated with the decrease in food supply. It is probably energetically more expensive to produce females than males. Reduction in the proportion of the females in the population may reduce the capacity of the Nile perch to replace its stocks.

Table 3.1. Sex ratios of *L. niloticus* in different water bodies. The ratio is given as the number of females corresponding to 100 males. The ratios not significantly different from a 1:1 ratio are marked with asterisks.

Water body	Fish size	No of males	No of females	Sex Ratio
Albert	>=20	350	391	112*
Victoria 1964-67	>=20	2482	2110	85*
Victoria 1968-77	>=20	231	255	110*
Victoria 1982	>=20	397	285	72
Victoria 1988-92	>=20	3040	702	23
Nabugabo 1991-93	>=20	326	104	32
Kyoga 1967-68	>=20	129	114	88*
Kyoga 1978-80	>=20	1131	593	52
Kyoga 1988-90	>=20	1299	818	63
Kyoga 1991-93	>=20	1551	834	54

(b). Some values reported in literature

Water body	Fish size	No of males	No of females	Sex Ratio
Chad	>30	2779	1694	61
Turkana	>20	499	425	85*
Blue Nile	<107	59	69	117*
Kyoga		435	282	65
Victoria		935	944	101*
Victoria	<120			43

Fecundity

Nile perch has the ability to reproduce enormously. Fecundity is proportional to the cube of the length and the species can produce up to 16 million eggs at each spawning. The male biased sex ratio therefore seems to be compensated for by the very high fecundity. It seems that in a stressed habitat, there are more mature males than females. This reproductive tactic offers the potential for rapid establishment and rapid recovery in case of overfishing and other environmental stresses. It also produces enough young to provide food for adult Nile perch and sustain the stocks.

Conclusions

Fish species diversity in Lakes Victoria, Kyoga and Nabugabo decreased following establishment of the Nile perch, reached a level below which it did not decrease further and has started to increase. Prey selection by the Nile perch changed alongside the changes in fish species diversity to types which are similar to those ingested in Lake Albert. The weight and condition factor of the Nile perch which were initially higher have decreased to values which are comparable to those recorded in Lake Albert. Nile perch which initially matured at smaller sizes now matures at sizes comparable with those in Lake Albert and other natural habitats. The only cause for concern is the apparently low condition factor but this difference is not significant. Also, the proportion of females in the population has decreased to lower values than in native habitats but this may be compensated for by the very high fecundity. The above observations provide sufficient evidence that Nile perch driven changes in Lakes Victoria, Kyoga and Nabugabo have stabilized and the fishery can therefore sustain production if properly managed. However, over-exploitation of the fishery resources including major Nile perch prey, and environmental degradation are of sufficient magnitude to precipitate a fishery collapse. These factors should be monitored and appropriate management measures put in place if these fisheries are to sustain production.