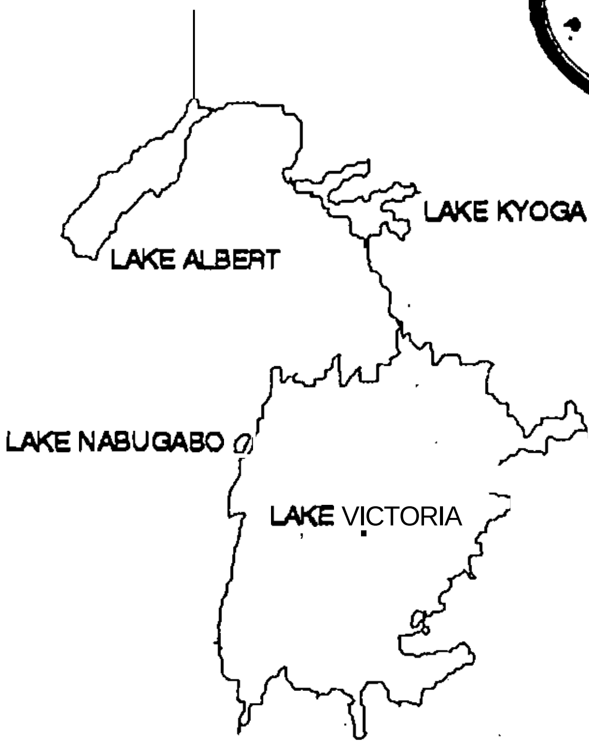
"The Biology, Ecology, **Management and** 'Conservation of the Fisheries of **Lakes** Victoria, Kyoga and **Nabugabo**

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



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CHAPTER II

Changes in Fish Fauna and the Impact of the Introductions on Fish Yield

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Introduction

There have been considerable changes in fish species composition in Lakes victoria, Kyoga and Nabugabo since the Nile perch were introduced. Populations of most of the native species have declined and many species may have become extinct. The original decline in the fish stocks was due to overfishing but the recent and more drastic decline has been attributed to predation by the Nile perch. Nile perch feeds on invertebrates changing to a piscivorous diet with size. Haplochromine cichlids, which were the most abundant fish in Lakes Victoria just before the Nile perch populations started increasing rapidly have been depleted. As more suitable types of prey were depleted in the new habitats, Nile perch switched to other prey types to the extent of feeding even on its own young. There are, fears that the Nile perch will overshoot its food supply, resulting in a reduction of its own population and subsequently a collapse in the fishery (FAD 1985).

Objective

The main objective of this work was to examine changes in fish stocks and the sustainability of the Nile perch based fisheries in Lakes Victoria, Kyoga and Nabugabo by examining changes in:

i. the relative abundance in fish taxa present.
ii. fish species diversity.

study Areas Materials and Methods

The changes in fish species composition and in diversity were examined by analyzing commercial catch records and experimental fishing data collected from Lakes Albert, Victoria, Nabugaboand Kyoga. Analyses were based on: 1) Commercial catch records collected by Fisheries Departments of Uganda, Kenya and Tanzania just before and after the rapid increases in Nile perch stocks. These included, commercial catch records of Lake Kyoga from 1963 to 1989, the Kenyan, Ugandan and Tanzanian regions of Lake Victoria and Lake Albert between 1970 and 1990. 2) Experimental trawl catch composition data collected from Lake Victoria between 1970 and 1992. 3) Experimental catch composition data collected from Lakes Victoria, Kyoga, Nabugabo and Albert between 1988 and 1993.

Experimental fishing was conducted using, gill nets, beach seines and trawl nets. Two seine nets were used. A fine mesh seine net of 10 mm stretched mesh and 20 m in length was used to sample small fish like *R. argentea* and juveniles of larger species. This was the least selective gear and was capable of catching up to the smallest taxa such as *R. argentea*. The second seine net of 100 m length with wings of 102 mm mesh and a bag of 51 mm mesh was used to catch larger fish. Trawling was done only on Lake Victoria using a codend of 19 mm. The data from trawling were compared with earlier surveys. The gill nets used were of 25.4 mm to 305 mm stretched mesh. On each lake, an effort was made to sample different habitat types in respect to location (inshore or offshore), water depth, substrate type, and presence or absence of aquatic macrophytes and other refugia.

Experimental fishing on Lake Albert was difficult. Because of this, commercial fishermen's catches were sampled. These were representative because, the size ranges of gill nets and the seine nets used by commercial fishermen were, with the exception of the fine 10 mm seine net similar in mesh size ranges to those used in experimental fishing on Lakes victoria, Kyoga and Nabugabo. On Lake Albert, fishermen's catches were sampled to represent the gill nets and the 51 mm seine net catches and only the 10 mm mesh seine net was operated.

The total number and weight of each fish taxon captured was recorded to give fish species composition. For Lake Albert, the whole catch from a single boat was treated as above.

Fish species diversity was examined using Shannon-Weaver Index of diversity H'. The Diversity Index H' was estimated using the formula:

$$H' = - \Sigma \text{ p.logDp.}$$

where p. is the proportion of each taxon in the sample.

Results

Changes in commercial catch composition in Lake Victoria

Before stocks of the introduced species started to increase rapidly, twelve to fourteen taxa occurred regularly among commercial catches. Two tilapi ines *(0. esculentus* and *O. variabilis)*, *Bagrus docmac, Protopterus aethiopicus, Clarias gariepinus,* and haplochromine cichlids were the major commercial species. Others included; *Labeo victorianus, R. argentea, Schllbe intermedius,* mormyrids, *Synodontis sp, Barbus sp,* and *Brycinus spp.*

In the Kenyan region, total yield had remained between 14,918 tonnes and 18,677 tonnes between 1970 and 1976. As the introduced species became established, it increased rapidly from 19,332 tonnes in 1977 to 165,802 tonnes in 1990. This was due to an increase in the yield of *L. nllotlcus* from 94 tonnes in 1976 to 71,414 tonnes in 1990 and *O. nlloticus* from 421 tonnes in 1976 to 38,305 tonnes in 1990. The only native species whose yield increased during this period was *R. argentea.* The yield of all other taxa declined and some like *Brycinus spp, Synodontis spp, L. victorianus* and haplochromines disappeared from the catches.

In the Ugandan region, total yield had decreased from 41670 tonnes in 1970 to 9999 tonnes in 1980. As the stocks of the introduced species increased, total yield increased from 17000 tonnes in 1981 to 132,382 tonnes by 1989. This was again due to increases in the contribution of the Nile perch from 13,980 tonnes in 1983 to 101,257 tonnes in 1989 and of *O. niloticus* from 382 tonnes in 1983 to 20,218 tonnes in 1989. The yield of *R. argentea* also increased from less than 100 tonnes before 1984 to 7,052 tonnes by 1989. The landings of all the other taxa declined and some like *Synodontis spp, L. victorianus,* and haplochromines were virtually absent from commercial catches by 1983.

In the Tanzanian region of Lake Victoria, total fish yield increased only slightly between 1970 and 1982. When the stocks of introduced species especially the Nile perch increased from 1983 onwards, the total quantity of fish landed increased rapidly from 72,586 tonnes in 1983 to 216,403 tonnes in 1986. This was again due to increases in landings of Nile perch from 274 tonnes in 1981 to 123,879 tonnes in 1986 and that Nile tilapia from 6,359 tonnes in 1970 to 17,630 tonnes in 1986. The only native species whose yield increased was again *R. argentea* which increased from 252 tonnes in 1976 to 9,825 tonnes in 1986.

The above account shows that total yield increased three to five fold following establishment of the introduced species especially Nile perch and Nile tilapia.

changes in trawl catch composition in Lake Victoria

The changes. in composition and relative abundance of fish species in Lake Victoria was also manifested in experimental trawl catch composition. Haplochromines comprised up to 80% of the demersal fish stocks in Lake Victoria around 1970 and remained the most abundant taxa in the northern part of the lake near Jinja up to 1982. After 1982, the proportion of haplochromines declined from 76.2% in 1983 to 6.9% in 1985. During the same period, the proportion of Nile perch increased from 16.8% in 1983 to 90.4% in 1985 and that of the Nile tilapia from 0.4 % to 23.9% in 1988 with only 2% being made up by the other species. By 1985, haplochromines were virtually absent from trawl catches. Other species namely; *P. aethiopicus, B. docmac, T. z111i, O. leucostictus,* and *Synodontis afrofischeri* Hilgendorf, 1888, were caught in very small quantities. *R. argentea* although abundant was not recorded because it is too small to be retained by the mesh size of the codend used.

Catch composition of seine nets and gill nets in Lake victoria

Data obtained from experimental beach seines and gill nets in Lake Victoria provide additional evidence of similarities in changes in species composition between commercial and experimental catches in the lake. The catch from the 10 mm seine net, which was the only fishing gear that could retain *R. argentea,* was dominated by *R. argentea,* Nile tilapia and Nile perch. Haplochromines which were originally very abundant formed only 5.77% of the biomass of fish caught in the 10 mm seine net. Nile perch contributed 97% of the catch in gill nets and the 51 mm mesh seine net followed by the Nile tilapia. Haplochromines, mormyrids, *O. leucostictus* and *T. z111ii* were caught in very small quantities.

Changes in commercial catch composition of Lake Kyoga

Fish species composition of Lake Kyoga prior to the establishment of introduced species was similar to that of Lake Victoria. *O. esculentus, O. variabilis, P. aethiopicus, B. docmac,* *C. gariepinus, S. intermedius, Barbus* spp and mormyrids were the major commercial species. Haplochromines were 'also abundant. These remained the dominant species up to the time of the introductions.

Nile perch and the non-native tilapiine species were introduced earlier and spread faster in Lake Kyoga than in Lake Victoria. stocks of the introduced species in Lake Kyoga increased rapidly from 1963 onwards. This resulted in increases in total catch from 18,261 tonnes in 1964 to a peak of 167,200 tonnes in 1978. These increases were due to the contribution of Nile perch which increased from 657 tonnes in 1964 to 71,000 tonnes in 1978 and that of the introduced tilapiines especially the Nile tilapia which increased from 589 tonnes in 1964 to 80,960 tonnes in 1985. The yield of the native tilapiines which had dominated the fishery since its development and that of all the other native species declined. However, total yield declined from 165,000 tonnes recorded at peak production in 1977 to 54,706 tonnes by 1989. During this period, the yield of the Nile perch decreased from 71,000 tonnes in 1977 to a mere 15,00 tonnes in 1989.

Experimental catch composition from Lake Kyoga

As for Lake Victoria, the catch in the 10 mm seine net catches were dominated by Nile perch, Nile tilapia and *R. argentea*. Nile perch and Nile tilapia were again the dominant species in the gill nets and the 51 mm seine. However, the proportion of Nile tilapia was higher in Lake Kyoga than in Lake Victoria. Haplochromines were more commonly encountered in Lake Kyoga than in Lake Victoria. Other taxa which included;T. *zi11ii, O. 1eucocostictus, S. intermedius, P. aethiopicus, C. gariepinus, Barbus spp, S. afrofischeri, L. victorianus,* mormyrids and *Afromastecembe1us frenatus,* were caught in very small quantities. The two originally most abundant tilapiines and the catfish *B. docmac* were not caught at all. From 1991, haplochromine stocks in Lake Kyoga started to increase both in the catches and as prey of Nile perch.

Experimental catches from Lake Nabugabo

There were no commercial catch statistics for Lake Nabugabo. When the Cambridge expedition surveyed the lake in 1962, the most important fish taxa among commercial catches were similar to those of Lakes Victoria and Kyoga and comprised; *P. aethiopicus, B. docmac, S. intermedius, C. gariepinus, O. escu1entus, O. variabl1is* and haplochromines. The expedition also recorded thirteen non-cichlids and eight haplochromines species from experimental samples.

In Lake Nabugabo between 1991 and 1992, the 10 mm seine net was dominated by juveniles of Nile perch, Nile tilapia, *R. argentea* and *T. renda11i*. Nile perch and Nile tilapia were again the most abundant species in the, gill nets and the 51 mm seine net. However, *S. intermedius* was caught in large numbers in gill nets in the lake and contributed 6.96% to the gill net catches. Also *T. renda11i, B. jacksonii* and *T. zi11ii* made significant contributions to gill net catches. Other taxa which included, *C. gariepinus,* mormyrids, *O. 1eucostictus* and *S. afrofischeri* were, as in Lakes

Victoria and Kyoga; caught only in very small quantities.

Changes in commercial catch composition of Lake Albert

The most important commercial taxa in Lake Albert, the original and native habitat of Nile perch, Nile tilapia, *T. zillii* and *O. leucostictus* which were introduced to Lakes Victoria, Kyoga and Nabugabo were in order of importance; *Citharinus citharus, Lates* spp, Nile tilapia, *Bagrus* spp, *Alestes baremose, Hydrocynus forskalii, Synodontis shall,* and *Mormyrus caschive.*

Analysis of commercial catches of Lake Albert,for the period 1971 to 1989 showed that the fish species composition of the lake has not changed much from what was recorded about 60 years ago. Fourteen taxa still occur regularly among commercial catches. *Lates* 'spp, tilapiines (mainly *O. niloticus),* and two pelagic Characid taxa, *Hydrocynus* spp and *Alestes* spp were still among the most important commercial species. The only originally important species which was no longer abundant among commercial catches was *C. citharus.* This species was depleted due to overfishing during the first part of this century.

Experimental sampling carried out on Lake Albert in 1990 to 1992 showed that the commercial catch records gave a good picture of what was present in the lake. *Lates* spp, *Hydrocynus* spp, *Alestes* spp and tilapiines were the most abundant taxa in the sample examined. Even *C. citharus* .which had been feared extinct from the lake were encountered although in very small numbers. Unlike in Lakes Victoria, Kyoga and Nabugabo, where many fish taxa disappeared, no fish taxa have vanished from Lake Albert since the first fishery survey of the lake.

Changes in fish species diversity

The changes in diversity of fish taxa in the Kenyan, Ugandan and Tanzanian regions of Lake Victoria between 1970 and 1990 are compared with Lake Albert in Fig. 2.1. In the Kenyan and Ugandan regions, there were two distinct levels of fish species diversity corresponding to the period before and after establishment of introduced species. In the Kenyan and Ugandan regions, there was no significant change in H' (at 95% confidence level)- before the rapid decline while in the Tanzanian region, H' increased significantly during this period. After the rapid decline in H' in the Kenyan and Ugandan regions, fish species diversity remained at a level below which it did not fall but instead, it started to increase in the Kenyan region of the lake. Also, fish species diversity in Lake Albert increased significantly during the entire period under review probably due to increased exploitation of different species. The regressions of H' against time before and after the steep declines in H' in the Kenyan and Ugandan regions weie parallel suggesting that the rate of change in H' at the lowest recorded level was the same as it was before the rapid increases in stocks of the introduced species but fish species diversity was significantly lower.

There was no further reduction in fish species diversity in the Kenyan and Ugandan regions of Lake Victoria after the lowest recorded level but instead, H' started to increase in the Kenyan region of Lake Victoria. The recovery recorded in the Kenyan region indicates that there is some stabilizing feedback mechanism trying to force fish species diversity towards recovery and stability. Fish species diversity is not likely to decline further due to Nile perch predation and the driving force due to Nile perch predation can be regarded as stable. However, the lowest recorded level in fish species diversity in the Kenyan and ugandan regions after the rapid fall was significantly lower (at the 95% confidence level) than that of Lake Albert for the same period. Fish species diversity in Lakes Victoria, Kyoga and Nabugabo might, although initially higher, stabilize. at a lower level than that of the original habitat of the Nile perch.

Discussion

The composition of fish taxa in Lakes Victoria, Kyoga and Nabugabo have changed from a fishery comprising about 14 taxa to one dominated by three species, *L. niloticus*, *O. niloticus* and *R. argentea*. The fish species diversity of Lakes victoria, Kyoga and Nabugabo is similar but lower than that of Lake Albert, the original habitat of Nile perch and the tilapiines. However, fish species composition and fish species diversity in Lakes Victoria and Kyoga is considered to be stable because *L. niloticus*, *O. niloticus* and *R. argentea* have remained the dominant species in Lake Victoria for over 20 years and for probably a longer period in Lakes Kyoga and Nabugabo. There are also similarities between the current fisheries of Lakes Victoria, Kyoga and Nabugabo and those of Lake Albert. Nile perch and Nile tilapia which are the dominant species in Lakes Victoria, Kyoga and Nabugabo are also among the dominant species in Lake Albert. The two remaining major components of the catch in Lake Albert; *Alestes* spp and *Hydrocynus* spp are both pelagic species and can be regarded as ecologically analogous to *R. argentea* of Lakes Victoria, Kyoga and Nabugabo, at least in respect to resilience and susceptibility to predation by the Nile perch.

Total yield of Lakes Victoria, Kyoga and probably Nabugabo increased following establishment of introduced species. It, however appears that these fisheries will not sustain the peak yields recorded in these lakes. Total yield from Lake Kyoga where Nile perch established earlier than Lake Victoria has declined. Although this was attributed to intensive use of small mesh beach seines which cropped immature Nile perch and Nile tilapia, disrupted courtship of tilapiines on breeding grounds and destroyed nests, the declines were more prominent among Nile perch populations and could have been partly due to the reduction in haplochromines which were originally the most preferred and vulnerable prey of Nile perch.

The large quantities of fish landed in Lakes Victoria and Kyoga soon after establishment of the introduced species especially Nile perch were initially supported by large quantities of vulnerable haplochromine cichlids which at that time formed the main prey of Nile perch. These haplochromines were depleted and are no longer abundant. The depletion of haplochromine prey could have contributed to the decline in the Nile perch yield recorded in

Lake Kyoga. This is supported by the fact that the proportion of Nile perch in experimental catches has increased since the stocks of haplochromines in the lake started to improve.

The factors that have facilitated improvement of haplochromine stocks in Lake Kyoga would be useful in enhancement of some of the fish species that have been depleted from Lakes victoria, Kyoga and Nabugabo due to the presence of the Nile perch. The increase in haplochromine stocks in Lake Kyoga has coincided with the invasion and spread of the water hyacinth *Eichhornia crassipes* (Martius) Solm. The water hyacinth invaded Lake Kyoga in 1988 and became well established between 1991 and 1992. The floating beds of the water hyacinths might be providing cover and allowing the haplochromines whose remnants had taken cover in marginal macrophytes, to recolonize the lake and multiply. Although the hyacinth is a dangerous weed which should be controlled, it can provide a valuable habitat as long as it is kept under control and has been observed to support a large and diverse community.

Even if haplochromines stocks in Lakes victoria, Kyoga and Nabugabo improved, it appears that these will consist of a few specific types that can persist in the presence of the Nile perch. Only a few species have so far recovered in open waters of Lake Kyoga. Generally the lakes to which Nile perch is native have very few haplochromine species; Lake Albert has four and Lake Turkana only three. The only exception is Lake Tanganyika, which has haplochromine species-flocks, but these occur in the presence of different species of *Lates*. Also the Lake Tanganyika haplochromines are confined to rocky inshore areas where they can take shelter from *Lates* spp. In Lake Victoria, it is also the rock-dwelling haplochromines which have been least depleted (see Chapter VI). Therefore, protection of refugia such as rocky outcrops and marginal vegetation will be beneficial to the preservation and recovery of haplochromines and other species in Lakes victoria, Kyoga and Nabugabo.

Apart from the introduced species especially Nile perch, other factors especially over-exploitation and environmental degradation have and are likely to affect stability and sustainability of fish stocks in Lakes Victoria, Kyoga and Nabugabo.

Over-exploitation and use of destructive fishing practices -contributed greatly to depletion of fish stocks in Lakes Victoria and Kyoga prior to establishment of the Nile perch and the tilaplines. Whereas, *Brycinus nurse* and the prawn, *Caridina nilotica* which are major prey of Nile perch in Lake Albert are not commercially exploited in that lake, *R. argentea* is heavily exploited in Lake Victoria and even C. *nilotica* is being exploited in some parts of Lake Victoria. Juvenile Nile perch which are major prey of sub-adult and adult Nile perch are also heavily exploited. Infact there is already a decline in the size of *R. argentea* in Lake victoria due to the combined effect of predation and human exploitation. Control of exploitation of *R. argentea*, juvenile Nile perch and, C. *nilotica* will contribute greatly to the stability of fish stocks in Lakes Victoria, Kyoga and Nabugabo.

The above changes in fish species diversity in Lake Victoria has also been concurrent with major environmental changes. Algal biomass in Lake victoria has increased two to three fold. Accumulation of excess dead organic matter has increased oxygen demand and led to development a deep anoxic layer whose volume has been increasing. Spread of the low oxygen water to the surface has often resulted in mass fish kills. The increases in algal production are stimulated by increased nutrient inputs into the lake from the catchment area and from the atmosphere. Control of the activities that increase nutrient inputs into the lakes will also be beneficial to the stability in fish stocks.

Conclusion

Fish species diversity in Lakes victoria, Kyoga and Nabugabo has decreased to the lowest level possible and has started showing signs of recovery. The fishery can therefore be considered to be potentially stable. However, uncontrolled human exploitaion and environmental degradation are of sufficient magnitude to precipitate a fishery collapse. These factors should be monitored and appropriate measures instituted if these fisheries are to sustain production.

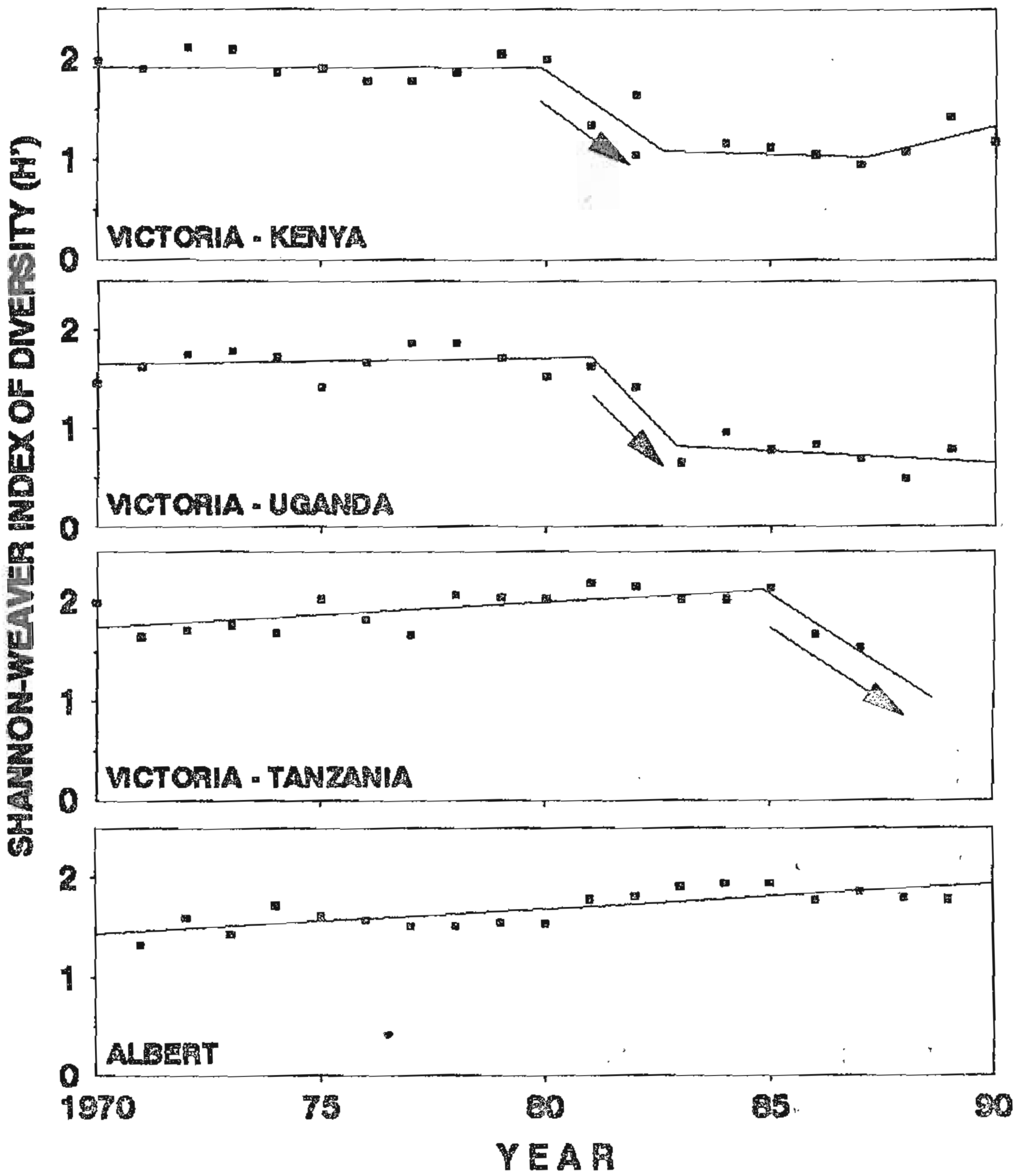

Figure 2.1. Changes in fish species diversity in Lakes Victoria and Albert between 1970 and 1990. The arrowheads show the period of rapid fall in species diversity. Line segments were fitted by least square regression.