THE PURPOSE, COSTS AND BENEFITS OF FISH INTRODUCTIONS: WITH SPECIFIC REFERENCE TO THE GREAT LAKES OF AFRICA.

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Prepared for a symposium on: The Utilisation of the Resources and Conservation of the Great Lakes of Africa. Bujumbura, Burundi, November 29 - December 01, 1989.

Introduction.

A reduction in native fish stocks and the need to increase fish production for food, recreation, ornamental purposes and to control disease vectors and weeds have often justified and led to introduction of non-native fishes. Some of these introductions have been followed by benefitial and others by undesirable consequences. For instance, introduction of the Nile perch *Lates niloticus* L. and several tilapiine species into lakes Victoria and Kivu have resulted in increases in the quantity of fish available to the people around them. Predation by Nile perch and competition with introduced tilapiine species in lakes Victoria and Kyoga have caused a severe decline and in some cases total disappearance of many of the native fish species. Therefore, the concern about fish introductions arises.

The African Great Lakes (Figure 1) cover an aggregate area of about 150,000 km2. They are important to the local people as a source of fish for food, sources of water for domestic use and avenues of transport. Some of the African Great Lakes, especially Malawi, Tanganyika, and Victoria also harbour the worlds richest lacustrine fish faunas with many endemic species of Cichlidae which have evolved in each lake and are of great scientific interest to students of evolution (Fryer & Iles 1972, Barel et al 1985, Balon & Bruton 1986, Ribbink 1987). There seems to be a conflict of interests between people who would like to harvest the fish from these lakes to feed the people and those who would like to conserve the species flocks of these lakes for evolutionary studies. These lakes are, however, very critical as sources of food in Africa because alternative sources of protein are either scarce or too expensive for most of the local people comapared to the developed countries where there is a greater variety of cheap protein sources.

The native fish stocks of many of the African Great lakes have declined due to human exploitation (Jackson 1971). Because of the high demand for fish, these declines of exploited native species and absence of economically valuable species, in some lakes have led to a call for introduction of alien species not only in Africa but also other parts of the world. The extent to which this has been done is shown by the register of international fish transfers compiled by FAO (Welcomme 1981). At least 160 species of fishes excluding most of those transferred for ornamental purposes have been moved to different parts of the world (Welcomme 1981, 1984). Of these, about fifty species have been introduced to/or between different countries in Africa (FAO/CIFA 1985). Although many of the introduced species have not established themselves to create sustainable populations, those which have done so have resulted either into beneficial or undesirable consquences or both. This has led to mixed feeling for against fish introductions. This paper reviews the purpose and outcomes of fish introductions into some of the Great Lakes of Africa, especially Victoria, Kyoga, Kivu and Kariba in relation to the need to meet the nutritional needs of the people in the region and to conserve the native fish fauna.

Lakes Victoria and Kyoga.

Originally, Lakes Victoria and Kyoga had a fish fauna in which two tilapiine species (Oreochromis esculentus and Oreochromis variabilis) were commercially the most important (Graham 1929, Worthington 1929). There were other species such as; Protopterus aethiopicus, Bagrus docmac, Clarias gariepinus, Barbus species, Mormyrids and Schilbe mysteus which also made significant contributions to the fishery of these lakes. Labeo victorianus formed the most important commercial fishery on the affluent rivers of lakes Victoria and Kyoga (Cadwalladr 1965). Haplochromine cichlids and Rastrineobola argentea were abundant but, because of their small size, were not exploited extensively. Stocks of the originally prefered commercial species were reduced by overfishing in the first half of this century (Jackson 1971). This decline led to a suggestion to introduce other fish species into the lakes so as to improve the fishery.

Nile perch, Lates niloticus L. and four tilapiine species; the Nile tilapia (Oreochromis niloticus L.), Oreochromis leucostictus (Trewavas), Tilapia zilli (Gervais), and Tilapia melanopleura Dumeril were introduced into lakes Victoria and Kyoga during the 1950's and early 1960's (Gee 1964, Welcomme 1964, 1966). The Nile perch were introduced to feed on the small sized haplochromine cichlids which were at that time abundant but not commercially exploited, so as to convert them into larger table fish (Graham 1929, Worthington 1929, Anderson 1961). T. zilli were introduced to feed on macrophytes which were not being utilized by any other commercially important fish but O. niloticus, O.leucostictus, and T. melanopleura, appear to have been introduced to supplement and diversify stocks of the native tilapiines which had declined due to overfishing.

Costs of the introduction.

The introduced species became established first in Lake Kyoga and later in Lake Victoria resulting into increases in commercial fish catches. As stocks of the introduced species increased, those of the native species continued to decline and some eventually disappeared from the fishery. Although some of this decline was caused by other factors, especially overfishing, predation by Nile perch and competition with the introduced tilapiines contributed to the changes in the fishery. The Nile perch feeds on invertebrates during juvenile and sub-adult stages changing to a piscivorous diet with age (Hamblyn 1966, Gee 1969, Okedi 1971, Ogari 1985, Ogutu-Ohwayo 1985). As its populations in lakes Victoria and Kyoga increased, those of other fish species declined (Figure 2). For instance, haplochromine cichlids which were initially abundant in these lakes (Graham 1929, Worthington 1929) and formed at least 80% by weight of the demersal fish stocks of Lake Victoria prior to establishment of the Nile perch (Kudhongania & Cordone 1974, Okaronon et al 1985) declined rapidly after establishment of Nile perch (Figure 2) and are virtually absent in Lake Kyoga and nearly so in many parts of Lake Victoria. Most of the native fish species of these lakes have also been identified among Nile perch stomach contents (Hamblyn 1966, Gee 1969, Okedi 1971, Ogari 1985, Ogutu-Ohwayo 1985, Goudswaard 1988) which provides evidence that the Nile perch contributed to their depletion. Most of the fishery on Lake Victoria is, however, currently based in inshore areas and the fate of the offshore haplochromine stocks is still largely unknown.

Other predatory fishes such as Salmo trutta L., Onchoricus mykiss Walbann (formerly Salmo gairdneri Richardson), and the black bass Macropterus salmoides Lacepede which have been widely introduced to Africa and other parts of the world for sport and recreation have had effects similar to that of the Nile perch. For instance, M. salmoides were introduced into Lake Naivasha in Kenya where they got established and created successful sport and recreational fisheries (Siddiqui 1977, Welcomme 1981). Subsequently, M. salmoides depleted Poecilia and Gambusia and also contributed to a decline in stocks of tilapiine species which had earlier been introduced into the lake (Siddiqui 1977). The trout and large mouth bass which were introduced in Southern Africa for sport and recreation similarly eliminated three native species (Oreodaimon gnathlambae, Trachyostoma euratotus and Sandelia capensis) (Jackson 1960, FAO/CIFA 1985). In Central America, the predatory peacock bass, Cichla ocellaris (Bloch & Schneider), which were introduced into Lake Gatun Panama extirpated six out of eight previously commomn native fish species of that lake (Zaret & Paine 1973) while in lake Titicaca, the rainbow trout damaged a species flock of some 19 species of Oreotius and Trichomycterus rivulatus (Welcomme 1984).

Apart from the Nile perch, the tilapiine species which were introduced into lakes Victoria and Kyoga also affected the native fish stocks. The introduced tilapiine species were similar to the native tilapiines in ecological requirements and some are known to hybridize (Welcomme 1964, 1966, Fryer & Iles 1972, Mureau et al 1988). The native tilapiines were spatially segregated with the smaller O.variabilis being closer inshore than O.esculentus. When O.leucostictus and T.zilli became established, they occupied the inshore waters with O. variabilis while O. niloticus occupied the more offshore waters with O. esculentus (Welcomme 1964). Subsequently, O. niloticus which is now the dominant tilapiine in these lakes, extended its distribution to the inshore waters. The other tilapiine species seem to have lost ground to O. niloticus as a consequence of competition and/or hybridization. The competitive pre-eminance of O. niloticus among the tilapiines has been established through its successful introduction and eventual diminance in a great variety of lakes in east, central and west Africa as well as Madagascer (Mureau et al 1988).

Displacements of one or more species following introduction of another has also been observed among tilapiine species in other lakes e.g Lake Naivasha (Kenya), Lake Itasy (Madagascar) and Lake Kinneret (Israel) (Siddiqui 1977, Gophen et al 1983, Welcomme 1984). In Lake Naivasha, Oreochromis spilurus Gunther was introduced in 1925 and became abundant during 1950s and 1960s. When O.leucostictus and T.zilli were later introduced in 1956, O.leucostictus hybridized with O.spilurus. This was followed by disappearance, first of O.spilurus and then of the hybrids (Siddiqui 1977). In Lake Itasy, Oreochromis macrochir disappeared after hybridizing with the Nile tilapia (Welcomme 1984). There was also a decline in a native tilapiine, Oreochromis galilaeus after Oreochromis aureus Steindachner was introduced into Lake Kinneret (Gophen et al 1983).

Another possible cost of the introducing new fish species into lakes Victoria and Kyoga could be a change in the lake's environment. There have been increasing incidences of algal blooms on Lake Victoria which have sometimes been accompanied by mass fish kills and deoxygenation of the deeper waters. Although increased eutrophication and incidence of deoxygenation could be due to changing land use practices and increased human population, it could also be a result of alterations in the food chain arising out of changes in the fish communities at different trophic levels (Hecky per com). If these incidencies are indicative of a long term trend, then part of the lake could become anoxic and unsuitable for fish.

Apart from ecological changes, introduction of new fish species can also affect the economic and social life of the people. Fishermen may have to adapt to catching fish of a different size and the consumers have to adapt to eating fish of probably a different taste. The Nile perch was, for instance, not initially very popular among some of the rural population around Lake Victoria partly because it initially contained a lot of fat which sometimes caused diarrhoea. But as the quantity of food available to the predator has decreased, it has become less fatty and more acceptable. The fishermen have also had to obtain stronger and more expensive nets for catching the Nile perch as it grows to a larger size than the native species of Lakes Victoria and Kyoga.

Benefits of the introductions.

The major beneficial outcome of the introduction of Nile perch and the Nile tilapia into lakes Victoria and Kyoga has been the increase in fish catches which has increased the quantity of fish available to the people in East Africa and even provided some fish for export. In Lake Kyoga (Figure 3) the total quantity of fish landed increased from an annual catch of about 4500 tons at the time of introduction of new fishes in 1956 to about 160,000 tons in 1977 to which the Nile perch and the Nile tilapia contributed about 80%. Similar increases occurred in Lake Victoria. In the Kenyan part of the lake, the total quantity of fish landed increased by about four fold from 20,000 tons before the establishment of introduced species, to 90,000 tons after their establishment (Figure 4). In the Tanzanian part (Figure 4) the total landings increased from 64,000 tons to 99,000 tons between 1983 and 1985 due again to increase in the contribution of the introduced species. Detailed catch statistics for the Ugandan part of the lake are lacking, but the trends in commercial catch have been similar to those in the Kenyan and Tanzanian parts of the lake.

The commercial catch records also indicate that, at least for the time being, the costs have not been traded off for insignificant benefits to the local people; For instance, 6000 tons of haplochromines that were being landed in the Kenyan part of Lake Victoria prior to establishment have been replaced by about 50,000 tons of Nile perch (Figure 5). The Nile perch is, however, not likely to sustain the high yield realised in the early stages of colonisation of the two lakes when it had abundant prey comprising the haplochromine cichlids but its stocks may settle at a lower level where it can be sustained by the available prey. For instance, the commercial catches of the Nile perch in Lake Kyoga where it was introduced and got established earlier than Lake Victoria have declined (Figure 3) partly due to a reduction in food supply and as a consquence of overfishing of juveniles using beach seine nets (Twongo 1986). The food of the Nile perch in Lake Kyoga has been stable since the late 1970s with a composition similar to that in its native habitat in which Caridina nilotica, Anisopteran nymphs are important in the juvenile and sub-adult stages and a pelagic species (R. argentea) and cannibalism becoming more important during sub-adult and adult stages. It also has a very high reproductive potential and may produce surplous offspring upon which adults can feed in the absence of alternative prey. It may, if properly managed, form a sustainable fishery in lakes Victoria and Kyoga. It may be of interest to note even as a predator, the Nile perch has been among the most important commercila species in its native habitats of lakes Albert and Chad (Hopson 1963, Cadwalladr & Stoneman 1966).

Lake Kivu and the Kariba Reservoir.

Lake Kivu and the Great Kariba Reservoir provide an example within the Great Lakes region where introduced fish have not been associated with prominent disastrous consquences. Both lakes had simple fish faunas; Kivu because of volcanic catalysms and Kariba because of its recent origin. Lake Kariba (5400 km2 and 29 m mean depth) is a man-made lake which was formed in 1958 after damming the Zambezi river along the Zambia - Zimbabwe border. Lake Kariba had about forty indigenous fish species all of which were of riverine origin and were largely restricted to shallow waters down to 15 m depth (Marshall 1987). Lakes Kivu and Kariba however lacked pelagic fish species which could feed on the planktonic organisms which were abundant in them. As a result, the Lake Tanganyika clupeids, Limnothrissa miodon Boulenger, and Stolothrissa tanganicae were introduced (Spliethoff et al 1983, Marshall 1985, 1988). Of the two clupeids, only L. miodon was successful in establishing itself in both lakes (Welcomme 1981).

Benefits of the introductions.

The clupeids were introduced into Lake Kivu in 1958 and 1960 (Spliethoff et al 1983). An artisanal fishery to exploit them started at the beginning of 1980 and was estimated to produce a sustainable yield of 11,300 t annually. Introduction of the clupeids into Lake Kariba took place in 1967 and 1968 (Marshall 1985, 1988). L. miodon became established and were found throughout the lake by 1970. An artisanal fishery of L. miodon started around 1974 and increased to become the most important in the lake (Figure 6) and by 1985, was producing a total catch of about 24,000 t. L. miodon also formed the most important prey of the native commercially and recreationally important predator, the Tiger fish, Hydrocynus vittatus Castelman. This increase in prey availability resulted into an increase in the stocks of the tiger fish. L. miodon from Lake Kariba moved down the Zambezi and got established into Cahora Bassa reservoir in Mozambique to provide a potential annual yield of 8,000 t (Petr & Kapetsky 1983).

Although Dumont (1986) indicates that the introduction of clupeids into Lake Kivu may become an ecocatastrophe, no direct disastrous consquences of clupeid introduction into lakes Kivu and Kariba have as yet been reported (FAO/CIFA 1985). It is also thought (Balon & Bruton 1986) that L. miodon could have prevented Alestes lateralis which is native to River Zambezi from colonising the openwaters of the lake although A. lateralis had for ten years (1958-1968) between the formation of Lake Kariba and introduction of clupeids not succeeded in colonising the open waters of the lake.

Other fishes introduced into Africa.

Apart from the fish species such as those discussed above that have been introduced directly into the some of the Great Lakes of Africa to improve fish production, other fishes which have been introduced or transferred within Africa for aquaculture and the control of disease vectors and weeds have also been accompanied by both beneficial and undesirable consequences. Some fish species like Tilapia rendalli and the Chinese carp, Ctenopharyngodon idella (Valenciennes) which have been widely used for aquaculture and weed control have established in the wild either after escaping from ponds or through deliberate introductions. Some of these species like the Chinese carp and and T. rendali have, besides being benefitial in some areas where they have been introduced, made the habitat less suitable for other species by up-rooting of aquatic vegetation and mixing of water bottoms (Taylor, Courtney & McCann 1984).

Two species, Gambusia affinis Baird & Girard and Poecilia reticulata Peters which were introduced some parts of Africa to control mosquito vectors of malaria parasites were not effective. Instead, G. affinis became dangerous to other fishes by eating their eggs (Welcomme 1981) and P. reticulata caused a decline in native cyprinodonts. But Astatoreochromis alluaudi Pellegrin which was introduced to Cameroon, Central African Republic, Congo and Zaire in 1960s to control snail vectors bilharizia are reported to have been effective in reducting snail populations (Welcomme 1981).

Apart from causing a reduction in the number and abundance of resident species through predation, competition and hybridisation, and altering the environment, fish introductions can be accompanied by transfers of fish parasites and diseases. At least 48 species of fish parasites have become established in different parts of the world as a result of fish introductions (Hoffman 1970). The Asiatic branchiura, Argulus japonicum is thought to have been transferred to Africa during fish transfers and the branchiurans, Argulus japonicum and Argulus rhipidiophorus Monod were transfered to Lake Naivasha along with fish (Fryer 1968). Parasites which occurred on the native fish can also attack introduced species. In Lake Kyoga, argulid parasites which occurred on the native fishes have infected the introduced Nile perch (Ogutu-Ohwayo 1989a).

Other causes of changes in natural fish populations.

When considering the impact of introduced fish species in an ecosystem, it is important to note that some of the changes that accompany introduction of non-native fishes may be caused by other factors other than the introduced species. Foremost among these other factors are fishing intensity and fishing practices. For instance, in Lake Victoria, changes in fishing practices contributed to the recent changes in the fish stocks (Ogutu-Ohwayo 1989b). After the reduction in the larger originally more prefferred species, the fishing effort shifted to the smaller originally less preffered haplochromines and R. argentea (Pellegrin). As a result, small mesh gillnets of 38 - 46 mm (1.5-18 inches) and seine nets of similar size ranges were introduced to harvest haplochrimines. A fine seine nets of 10 mm were introduced to harvest R. argentea. These small mesh nets crop juveniles and affect recruitment of the larger individuals. In Lake Naivasha, overfishing and Salvenia infestation contributed to a decline of fish stocks (Siddiqui 1977). A 14 cm mesh had been used on the lake in the 1950s to catch tilapine species. But as their number declined, the mesh size was reduced first to 13 cm and later to even smaller meshes of 7.5 to 10 cm which resulted into cropping of immature individuals. In addition, Salvenia infestation which occurred on Lake Naivasha in 1964 encroached on the shallow inshore sheltered spawning grounds of the tilapiines. In Lake Kariba, exploitation of the clupeid using fine mesh seine nets, contributed to a decline in stocks of the Tigerfish, but this decline was, as in the case of the Lake Victoria L. victorianus (Cadwalladr 1965), concurrent with gillnetting of gravid individuals on breeding migrations (Marshall 1985).

Haplochromine cichlids.

The cichlids stocks have been a major concern in discussions of concervation of the fish stocks of the East African Great Lakes and have contributed much to the highly negative worldwide feelings about Nile perch introduction into Lake Victoria. This is because these cichlids have been very useful in evolutionary studies. The rapid depletion of the Lake Victoria haplochromine cichlids seems to have been due to the apparent inability of haplochromine species to withstand heavy exploitation. Although they had been regarded as one group, they consist of many species, estimated in the case of Lake Victoria to be more than 300 van Oijen et el 1984). Individual species have a limited range of ecological tolerance and a low standing stock. Females produce few eggs which they carry in their mouth for protection and the young are similary protected. For each brooding fish either caught or eaten, its young are also destroyed. They cannot therefore recover easily from heavy exploitation whether this is due to human exploitation or another predator. Haplochromine stocks of Lake Victoria had actually started to decline by the mid 1970s as a result of exploitation (Benda 1979). A trawl fishery which begun in the Tanzanian waters of Lake Victoria during 1970s had also reduced the catch rates of haplochromines to less than half after only six years of trawling (Goudswaard & Witte 1985). Similar changes occurred in the Lake Malawi cichlid stocks with 20% of the species disappearing after only three years of trawling (Turner 1977a, 1977b, Coulter et al 1986,). This means that if the Lake Victoria haplochromines were to be conserved, they should have been exploited as little as possible or not at all. This was unlikely in this region where fish is a much needed commodity. Infact all the East African governments were planning to invest in a trawl fishery for haplochromines on Lake victoria before Nile perch became established.

Rationale and protocol on fish introductions.

The foregoing account indicates that fish introductions although benefitial can create unwanted and often unforeseen consequences. The evaluation of an introduced species either as a success or disaster can, therefore, be subjective depending upon the person expressing the opinion. This can be seen from the reactions that followed the introduction of the Nile perch and several tilapiine species into lake Victoria and Kyoga (Barel et al 1985) and that of the clupeids into lakes Kivu and Kariba (FAO/CIFA 1985, Dumont 1986). People from industrialised countries who have a variety of protein sources have tended to emphasise conservation of the lakes and the species in them apparently for scientific value. The poorer nations who depend upon these lakes as the cheapest source of food need to exploit them to feed their people. This has become more critical in Africa as human populations have increased and the native fish stocks of te Great lakes decreased. The target of most African government around the Great lakes is to increase fish production to feed the people. The increase in fish production recorded is some lakes where new fish species have been introduced may encourage then to press for more introductions especially into those lakes that have been depleted of their commercially desirable species.

There are alternative ways of enhancing fish production without introducing non-native fishes, e.g. by breeding the native fishes in hatcheries and restocking them in the lakes or through aquaculture. Aquaculture has, for example, been useful in production of fish in many underdeveloped countries, especially in South-East Asia. Aquaculture may not also allow for efficient use of the large pelagic areas of the Great Lakes. The other approaches such as the breeding of fishes in hatcheries may require resources and technology which is not currently available in the region. The low-tech way would be to introduce new species.

The fishes that have been introduced to some lakes do provide a basis upon which some decision on fish introductions can be made. Introduction of large predatory fishes like the Nile perch, the black bass and the salmonids would lead to a decline in resident fish stocks and should therefore only be done in those lakes where conservation of the resident species is not a priority. Some species like the Nile tilapia are aggressive competitors and have replaced the native species in many lakes where they have been introduced, and as in the case of Lake Kyoga, resulted into a probably a better tilapia fishery. This species could be suitable for stock enhancement in other lakes from which tilapiine species have been depleted or are of inferior quality. Others fish species like the the clupeid, L. miodon in lakes Kivu and Kariba have improved fish catches without any prominent damage to the environment. This suggests that certain fish species may for the purpose of producing food be better suited to a range of lake environments than others. However, because of the deleterious effects that have been associated with some fish introductions, and because individual countries have the right to develop and manage water resources located in their national boundaries, and many of the lakes are shared by more than country, there is urgent need to develop some guidelines to help identify and avoid the bad effects of fish introductions.

Some guidelines have already been drawn up in various parts of the world. In the U.S.A, the Fish and Wildelife Services and most state agencies have established regulations which prohibit importation of undesirable species and all states have regulations prohibiting unauthorised release of non-native fish species in their waters (McCann 1984). The International Council for the Exploration of the Sea (ICES) and the European Inland Fisheries Advisory Committee (EIFAC) have worked out a Code of Practice to be followed when considering introduction or transfer of inland aquatic organisms (FAO/CIFA 1985).

Because of the differences in the economic state, the guideline on fish transfers in Africa may be different from those drawn for developed countries. FAO regional fisheries bodies such as CIFA (Committee for Inland Fisheries of Africa and its sub-committees) have made an initiative to formulate guideline for consideration of any candidate species for introduction into the inland waters of Africa (FAO/CIFA 1985). A number of African aquatic scientists who should be concerned about the needs of their people are now carrying out research on the region. Some Hydrobiological societies like the Hydrobiological Society of Eastern Africa (HYSEA) have been formed in the region. These should be sufficiently supported and become vigilant to influence and guide decisions on fish introductions or transfers in the region.

The subject of conservation of fish species will be delt with in more detail elsewhere. I would, however, like to end by mentioning that before a new fish species is introduced into a lake efforts should be made to keep some record of the species already present in that lake. This can be done by collecting and keeping some live specimens in water impoundments ponds or aquaria. Some permanent record of existing diversity can also be kept by making comprehensive museum collections of dead preserved specimens and by collecting biological data and keeping records of existing species. Many African governments may however not have funds for projects like this such that funds for such initiatives and research may have to come from outside Africa.

Conclusions.

The need to improve fish production to feed people around the Great Lakes of Africa may lead to a call to introduce new fish species into some of these lakes. Introduction of new fish species into a lake can, besides the intended beneficial outcome be accompanied by disastrous consquences for the native species. Large piscivorous predators like the Nile perch deplete resident fish species in those lakes where they are introduced and should be avoided. Some species like the Nile tilapia have displaced one or more native fish species but may result in a potentially more productive fishery than the species they have displaced and this may justify their use in stock enhancement in some lakes. Other species like L. miodon have not been accompanied by prominent disastrous consquences and could be used to create fisheries where pelagic fisheries are lacking. The decision whether to introduce a particular species or not will depend upon the needs of a particular country. But since many of the lakes are shared between more that one country, there should be an international code of practice to guide decision on fish transfers especially in shared lakes.

Acknowledgements.

This paper was prepared while I was on a study leave at the University of Manitoba and the Freshwater Institute in Canada. I am grateful to Dr. K.W. Stewart and Dr. R.E. Hecky for reading and commenting on the manuscript and to Dr E. Fee for preparing the figures. I am also grateful to the the International Development Research Centre (IDRC) who are funding my study programme at the University of Manitoba and the International Limnological Society (SIL) for inviting me to attend the meeting and providing travel funds.

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CAPTIONS TO THE FIGURES.

Figure 1. The major water courses of the Great Lakes of Africa.

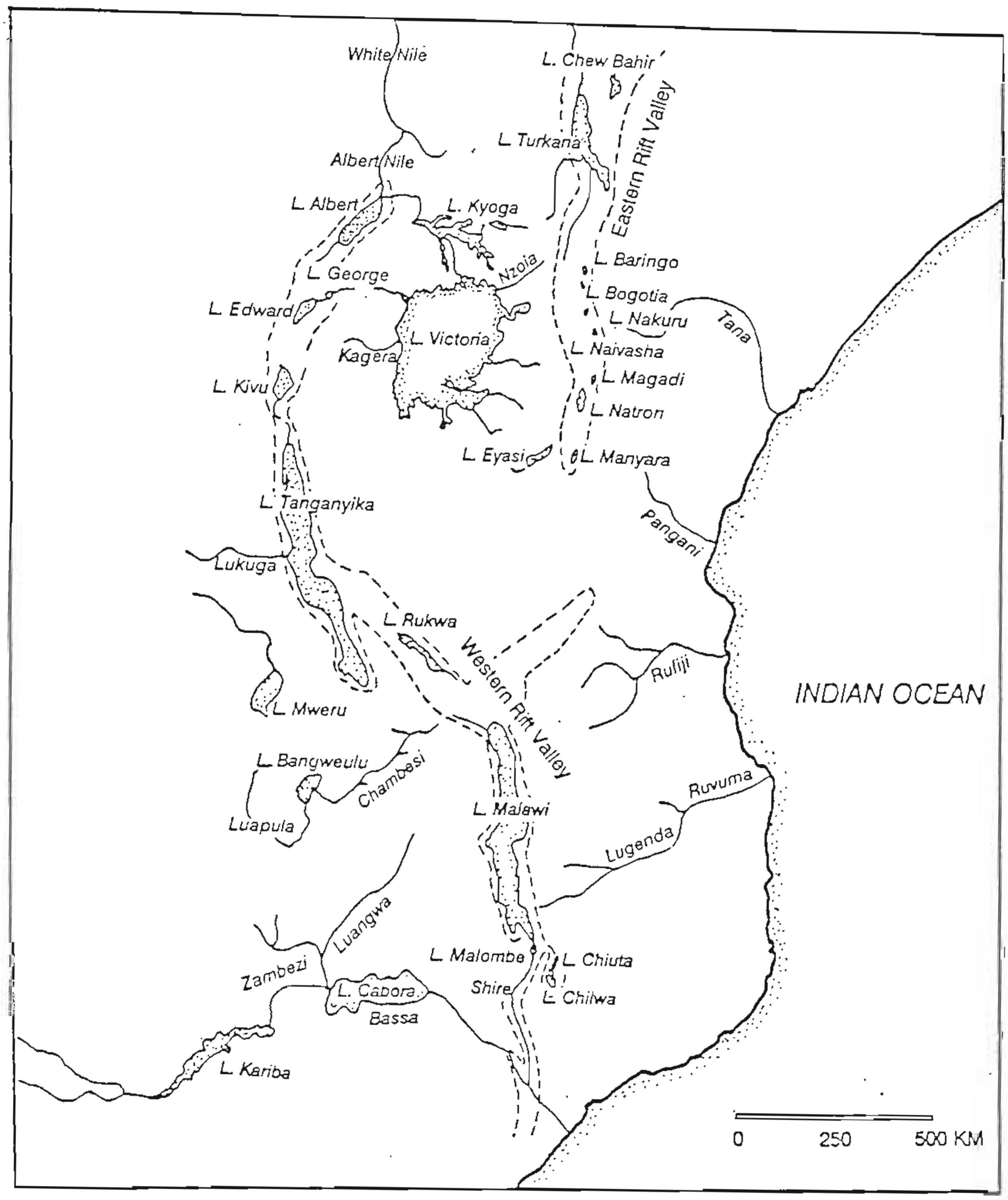
Figure 2. Changes in commercial fish catches of the major fish species from the Kenyan waters of Lake Victoria from 1968 to 1985 to illustrate changes in catch composition following establishment of the Nile perch and the Nile tilapia.

Figure 3. Changes in total commercial landings and catch composition from Lake Kyoga after establishment of Nile perch and Nile tilapia.

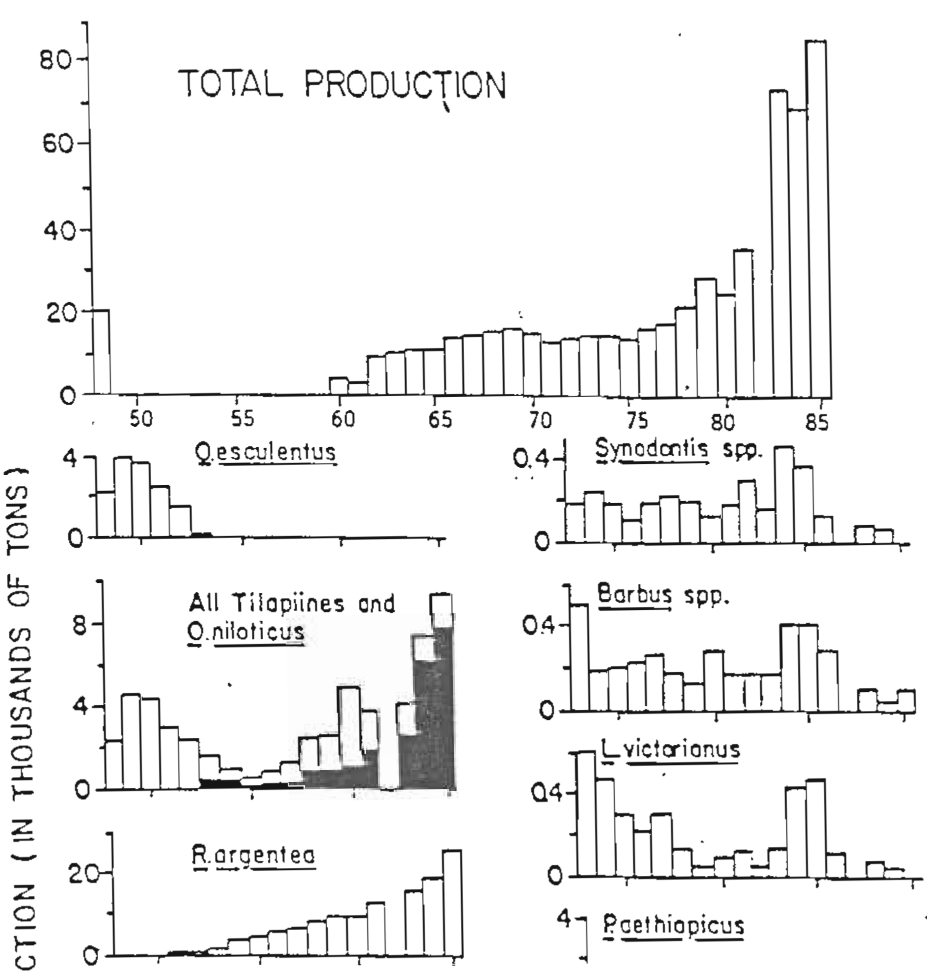
Figure 4. Changes in commercial fish catches from the Kenyan and Tanzanian waters of Lake Victoria from 1960 to 1985 showing the contribution of the Nile perch to the total landings.

Fugure 5. The increases in the quantity of the Nile perch landed and the associated decline of haplochromine stocks in the Kenyan waters of Lake Victoria from 1968 to 1985.

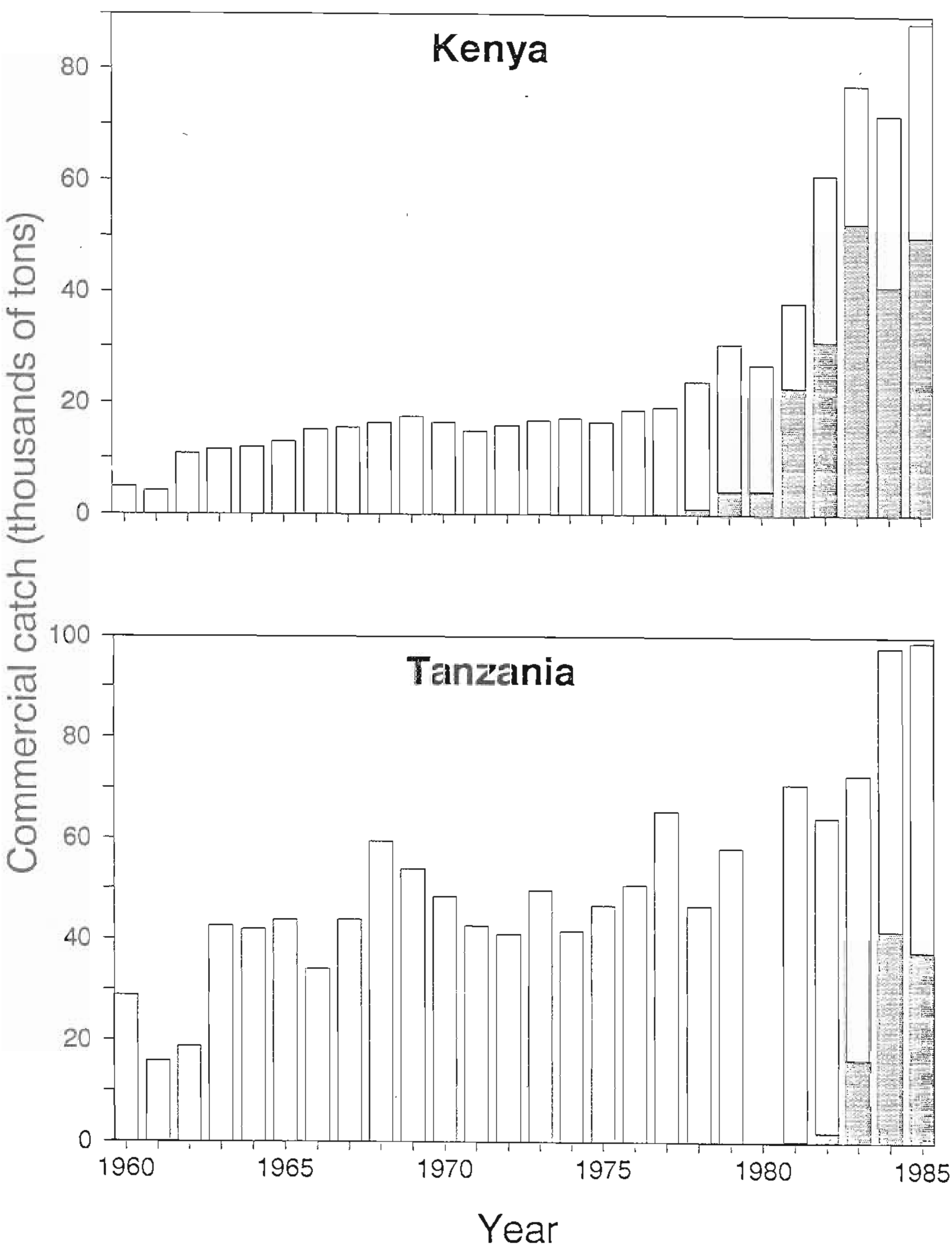
Figure 6. Changes in the total commercial catch of Limnothrissa miodon in Lake Kariba from 1974 to 1985 (Based on data in Marshall 1988).



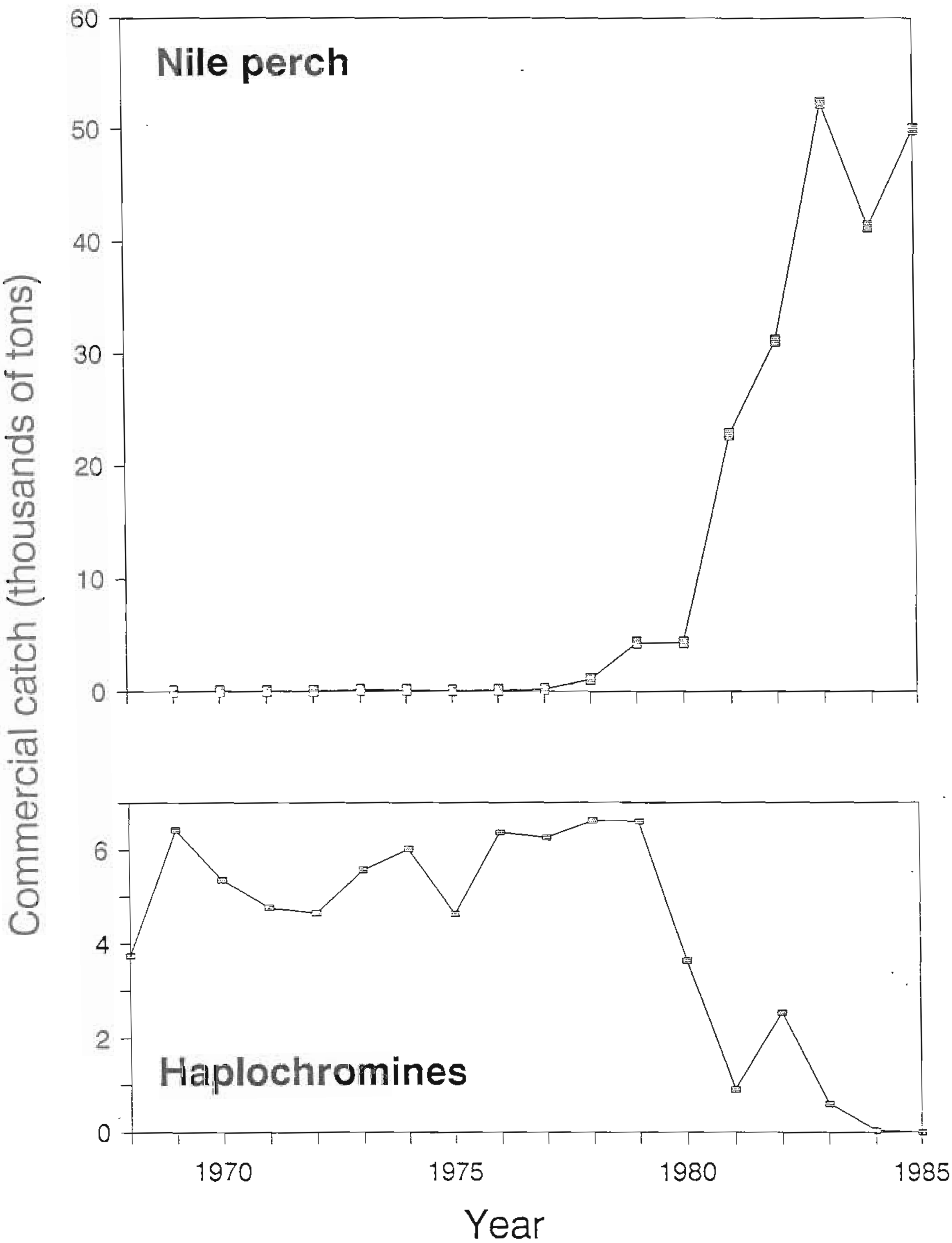
White Nile
L. Chew Bahir
L. Turkana
Eastern Rift Valley
Albert Nile
L. Albert
L. Kyoga
L. Baringo
Nzoia
L. George
L. Bogotia
L. Edward
L. Nakuru
Tana
L. Victoria
Kagera
L. Naivasha
L. Magadi
L. Kivu
L. Natron
L. Eyasi
L. Manyara
L. Tanganyika
Pangani
Lukuga
L. Rukwa
Western Rift Valley
Rufiji
INDIAN OCEAN
L. Mweru
L. Bangweulu
Chambesi
Ruvuma
L. Malawi
Luapula
Lugenda
Luangwa
L. Malombe
L. Chiuta
Zambezi
Shire
L. Cabora
Bassa
L. Chilwa
L. Kariba
0
250
500 KM



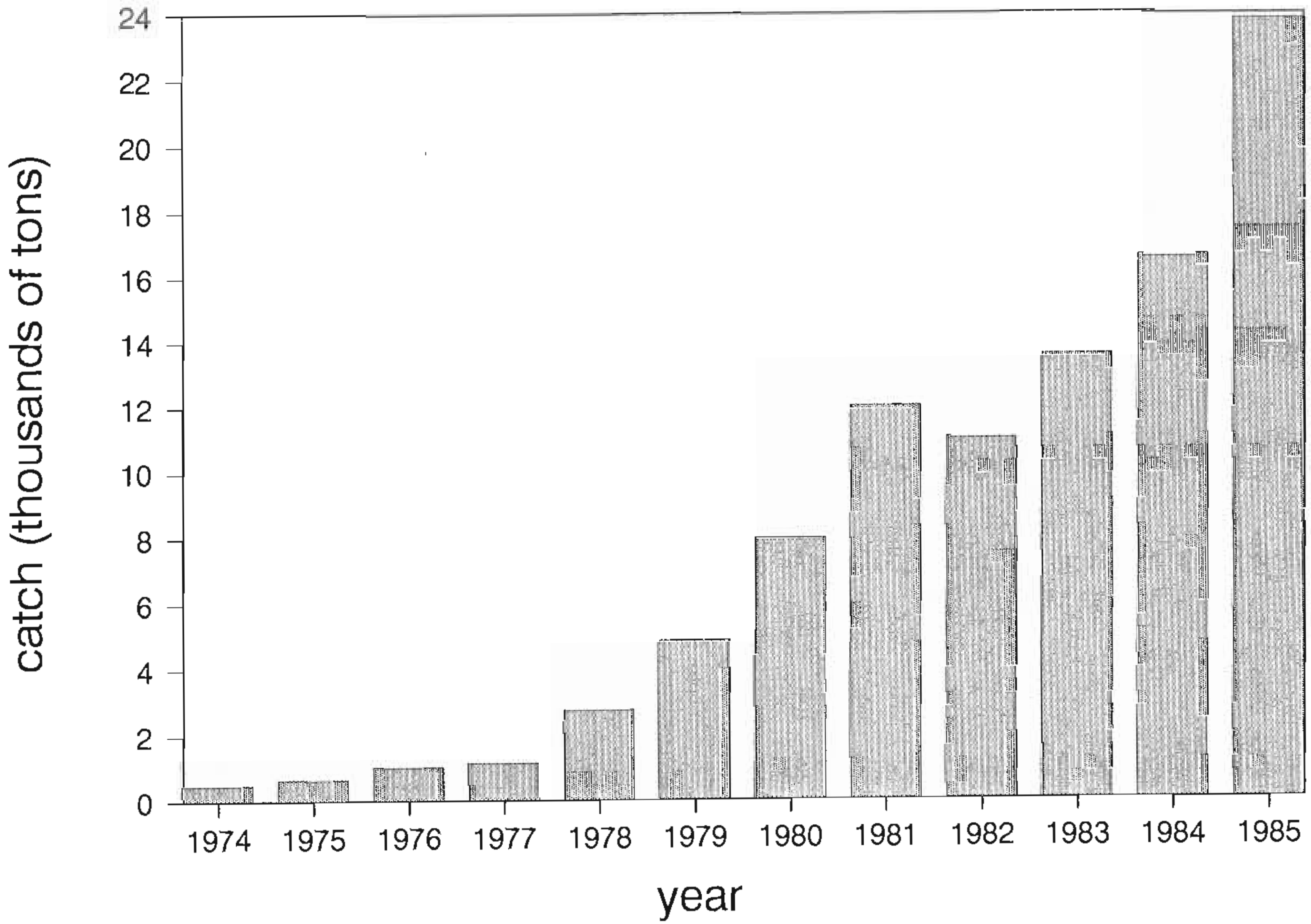
TOTAL PRODUCTION
O.esculentus
Synodontis spp.
All Tilapiines and
O.niloticus
Barbus spp.
L.victorianus
R.argentea
P.aethiopicus
CTION (IN THOUSANDS OF TONS)



Kenya
Tanzania
Commercial catch (thousands of tons)
0
20
40
60
80
100
1960
1965
1970
1975
1980
1985
Year



Nile perch
Haplochromines
Commercial catch (thousands of tons)
Year
0
10
20
30
40
50
60
0
2
4
6
1970
1975
1980
1985



24
22
20
18
16
14
12
10
8
6
4
2
0
catch (thousands of tons)
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
year