Causes and effects of the Lake Victoria ecological revolution
Goudswaard, Pleun Cornelis

CHAPTER 6

The catfish fauna of Lake Victoria after the Nile perch upsurge

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Abstract

Stocks of the indigenous catfish species of Lake Victoria have decreased dramatically since the beginning of the 1980s. This decline coincided with the Nile perch boom and concomitant ecological changes in the lake. In deep water, where Nile perch densities were higher, the decline proceeded more quickly than in shallow water. In the former all catfishes eventually vanished. Of the two largest species, *Clarias gariepinus* and *Bagrus docmak*, juveniles disappeared faster than adults. This indicates that predation by Nile perch may have played an important role in their decline. Other possible impacts were the deoxygenation of deepwater areas and the decline of haplochromine cichlids, which were an important food source for *B. docmak*, *C. gariepinus* and *Schilbe intermedius*. The various catfish species were not all affected to the same extent. The endemic *Xenoclarias eupogon*, which lived predominantly in deep water, may have become extinct. *B. docmak* currently seems to be mainly restricted to refugia in rocky habitats. *Synodontis victoriae* and *S. afrofischeri* are still present in small numbers in shallow littoral areas. *Schilbe intermedius* and *C. gariepinus* seem to be the least affected of the catfishes in littoral and sub-littoral areas. This may be caused, among other reasons, by their smaller habitat overlap with Nile perch than the other species. *S. intermedius* is partly pelagic, and a considerable part of the *C. gariepinus* stock lives in bodies of water surrounding the lake. The patterns of decline of the catfishes are very similar to those observed for haplochromine cichlids in the lake. The importance of catfishes for the fisheries in the lake is currently negligible.

Introduction

In Lake Victoria (East Africa), the largest tropical lake in the world, ten species of catfish are indigenous. Of these, *Bagrus docmak* Forsskåll 1775, *Clarias gariepinus* (Burchell 1822) and *Schilbe intermedius*[1] Rüppell 1832 (Fig. 6.1) have a widespread distribution in Africa. *Synodontis afrofischeri* Hilgendorf 1888, *S. victoriae* Boulenger 1906, *Clarias alluaudi* Boulenger 1906, *C. liocephalus* Boulenger 1898 and *C. werneri* Boulenger 1906 are known only from a part of East Africa. The distribution of *Clariallabes petricola* Greenwood 1956 is restricted to Lake Victoria and the Victoria Nile, while *Xenoclarias eupogon* (Norman 1928) is endemic to Lake Victoria (Greenwood, 1966; Daget et al., 1986). *B. docmak*, *C. gariepinus*,[2] *Schilbe intermedius*, *Synodontis victoriae* and *S. afrofischeri* were the main species supporting a substantial fishery, which produced approximately half of the total annual fish landings of the whole lake before the 1980s. The catfish stock for the whole lake in 1969-1970 was estimated at 90.997 tons (Kudhongania & Cordone, 1974).

Until the 1980s *B. docmak*, *C. gariepinus* and *S. intermedius* were the main top predators of the ecosystem of the lake (Corbet, 1961). In the 1950s another predatory fish, the Nile perch, *Lates niloticus*[3], was introduced into Lake Victoria (Welcomme, 1988). It was expected to feed on the abundant haplochromine cichlids and to boost the fisheries of the lake (Anderson, 1961). Simultaneously, Fryer (1960) warned of probable negative impacts on the ecosystem. The stock of Nile perch increased strongly during the first half of the 1980s, first in Kenya and Uganda (Arunga, 1981; Okemwa, 1981; Acere, 1988; Ogutu-Ohwayo, 1990a), and a few years later in

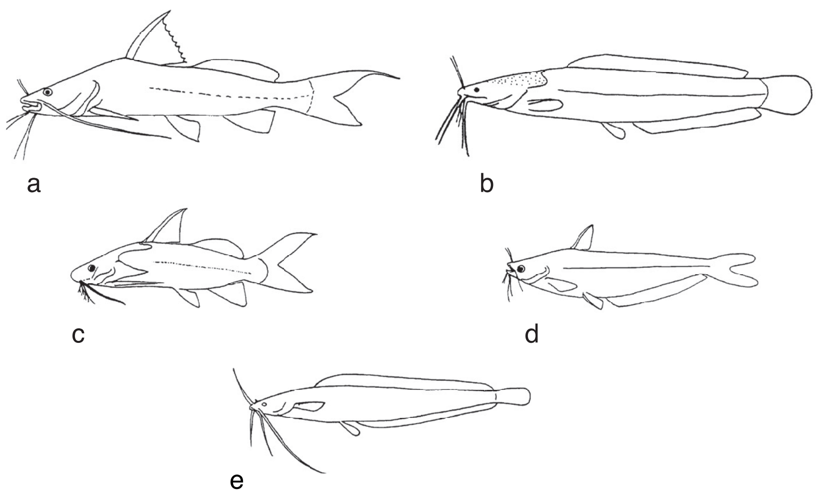

Fig. 6.1. *The main catfishes discussed in this paper. Total length (TL) or fork length (FL) which the fish generally attain in Lake Victoria is given in parentheses: a – Bagrus docmak (70 cm FL): b- Clarias gariepinus (100 cm TL): c- Synodontis spec. Apart from coloration and size S. victoriae (30 cm FL) and S. afrofischeri (15cm FL) look very similar: d- Schilbe intermedius (25 cm FL): e- Xenoclarias eupogon (15 cm TL) (redrawn from Van Oijen, 1995)*

Tanzania (Goudswaard & Ligtvoet, 1988; Barel et al., 1991)

As the Nile perch stock increased, the stocks of many other fish species decreased (Arunga, 1981; Okemwa, 1981; Hughes, 1986; Acere, 1988; Ogutu-Ohwayo, 1990a; Witte et al. 1992a,b). The destruction of the endemic haplochromine cichlid community in particular has drawn widespread attention to the situation as an example of the effects of species introductions into an aquatic habitat (Barel et al., 1985, 1991; Balon & Bruton, 1986; Coulter et al., 1986; Ribbink, 1987; Kaufman, 1992; Wilson, 1992; Witte et al., 1992a,b; Goldschmidt et al., 1993; Lowe-McConnell, 1993, Wanink & Goudswaard, 1994). In this paper it is demonstrated that the stocks of the catfishes have also decreased dramatically since the upsurge of Nile perch and concomitant changes in the lake's ecosystem. The possible causes of this decline are surveyed and the prospects of the catfish stocks and fisheries are discussed.

Material and techniques

The sources of our information can be divided into five categories: (1) Official landing statistics based on data collected by local beach recorders and published by the Fisheries Departments of the Ministries of the Lake Victoria riparian Governments (e.g. CIFA, 1985; 1988; 1990). The reliability of these statistics is arguable because of problems with species identification, lack of supervision of the recorders, lack of equipment and other difficulties (CIFA, 1988). However, it is supposed that the general trends in landings give useful information. The data are annual summaries for Kenya from 1968 until 1987 and for Tanzania from 1958 until 1992. The Tanzanian data from 1971 to 1974 could not be obtained. Data from Uganda are omitted due to incomplete recording over a long period. (2) Daily catch records of commercially operating bottom trawlers reveal important data on catch per unit effort. Three daily trawl record systems were used: (i) Data from a vessel of the Freshwater Fisheries Training Institute Nyegezi, MV Mdiria (120 hp, trawl headrope 25 m, codend mesh 20 or 90 mm[4]), operating within the Mwanza Gulf (Fig. 6.2). Data are available over the period 1973–1987. (ii) Records from fish meal factory boats (170 hp, trawl headrope 21 m, codend mesh 20 mm), targeting haplochromine cichlids around the entrance of the Mwanza Gulf during 1982–1983. (iii) Three trawlers (58 hp, trawl headrope 17 m, codend mesh 70 mm) operating in the Speke Gulf. Data from these ships were available from 1986 until 1990 and were crosschecked at intervals by measuring the complete catch.

Commercial vessels generally made trawl shots of 2 hours. *Synodontis* spp. and *Schilbe intermedius* were not consistently recorded on these trawlers. Moreover, their records underestimate the actual catch since many individuals of these species, entangled in the nets by their serrated spines and were overlooked. (3) Data from MV Kiboko (105 hp, bottom trawl headrope 18 m, codend mesh 20 mm) of the *Haplochromis* Ecology Survey Team (HEST) and the Tanzania Fisheries Research Institute (TAFIRI). This vessel made trawl shots of half an hour. The data from this vessel are the most accurate as data collection had first priority in its

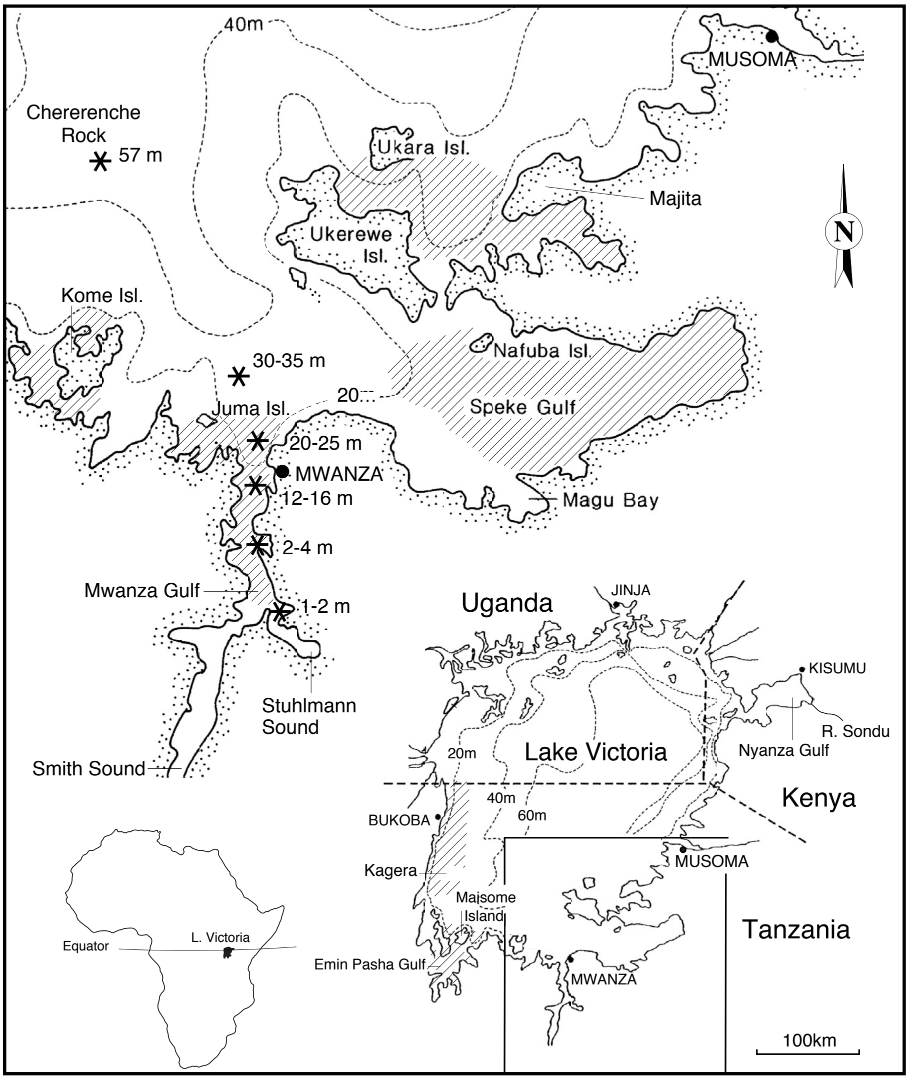

Fig. 6.2. *Map of Lake Victoria, with details of the Mwanza Gulf and Speke Gulf. The main sampling sites are shaded. Stations that were sampled monthly by MV Kiboko are indicated with an asterisk.*

operations. The period of sampling was from October 1984 until July 1990, during which time a major part of the Tanzanian waters of Lake Victoria was sampled by bottom trawling (Fig. 6.2). Most frequently fished was the Mwanza Gulf where five stations, with a soft mud bottom and a depth range from 1.5 m in the south to 35 m in the north, were sampled on a monthly basis. A sixth station in deep (57 m) water, near Chererenche Rock (Fig. 6.2), was fished only until the end of 1986. On a quarterly basis some distant areas also were fished: (i) Kagera – an open water area in the western part of the lake with a mud/clay bottom. The depths that were fished ranged from 4 m in the west to 48 m in the east. (ii) Ukerewe/ Majita – an area surrounded by islands in the eastern part of the lake, north of Ukerewe Island, with a mud and rocky bottom and a depth ranging from 2 m in the south to 48 m in the north. (iii) Speke Gulf – a large bay in the southeastern corner of the lake with a soft muddy bottom and a depth ranging from 2 m in the east to 34 m in the west.

Although the catches of MV Kiboko were checked and recorded in detail, small catfishes may have been overlooked in the bulk of haplochromine cichlids, which dominated the catches until 1985. For this reason the number of small catfishes (small species and juveniles of larger species) in 1984 and 1985 should be regarded as minimum numbers. (4) Some information on juvenile catfishes also was collected from HEST's research transect across the Mwanza Gulf. This transect, with a depth range of 2–14 m, comprised 11 stations (Witte et al., 1992b). With the exception of two of the shallow stations (< 6m deep) all stations had a mud bottom. This transect was sampled frequently between 1979 and 1993 with a small bottom trawler (20 hp, trawl headrope 4.6 m, codend mesh 5 or 15 mm). (5) Data collected by the East African Freshwater Fisheries Research Organization (EAFFRO) during the period 1973–1975 in the Tanzanian part of Lake Victoria. Length-weight relationships and length frequency distributions from 1974 are based upon these data.

Following Greenwood (1974), three depth regions are recognized in Lake Victoria: littoral (< 6 m), sub-littoral (6–20 m), and deepwater (> 20 m). In this paper, the station at the entrance of the Mwanza Gulf with a depth of 20–25m is included in the sub-littoral region. Statistical tests were performed on data collected by MV Kiboko. Standard deviations of the mean catches per year and per depth region were generally large (Appendix 6.1–6.3) and catch sizes were not normally distributed. To test for trends over time and depth ranges the basic catch data were tested with the non parametric Spearman rank correlation test. The results are presented in Appendix 6.1–6.3.

Results

Bagrus docmak

The *B. docmak* from Lake Victoria has been described as *Bagrus degeni* Boulenger 1906. Greenwood (1966) thought it to be identical with *B. docmak* (Forsskåll 1775). Adult specimens of *B. docmak* from other parts of Africa are different in maximum size and head shape from Lake Victoria specimens. Therefore, a revision of the genus *Bagrus* might lead to the restoration of *B. degeni*. However, pending a detailed study the name *B. docmak* is used here.

In 1969–1970 the standing stock of *B. docmak* was estimated at 2788, 22131 and 14766 tons in the Kenyan, Tanzanian and Ugandan waters respectively (Kudhongania & Cordone 1974). Before the increase of the Nile perch, *B. docmak*, together with the tilapiines, was the most important fish species in the official landings from Lake Victoria. In Tanzania approximately a quarter of the fish landings consisted of *B. docmak*

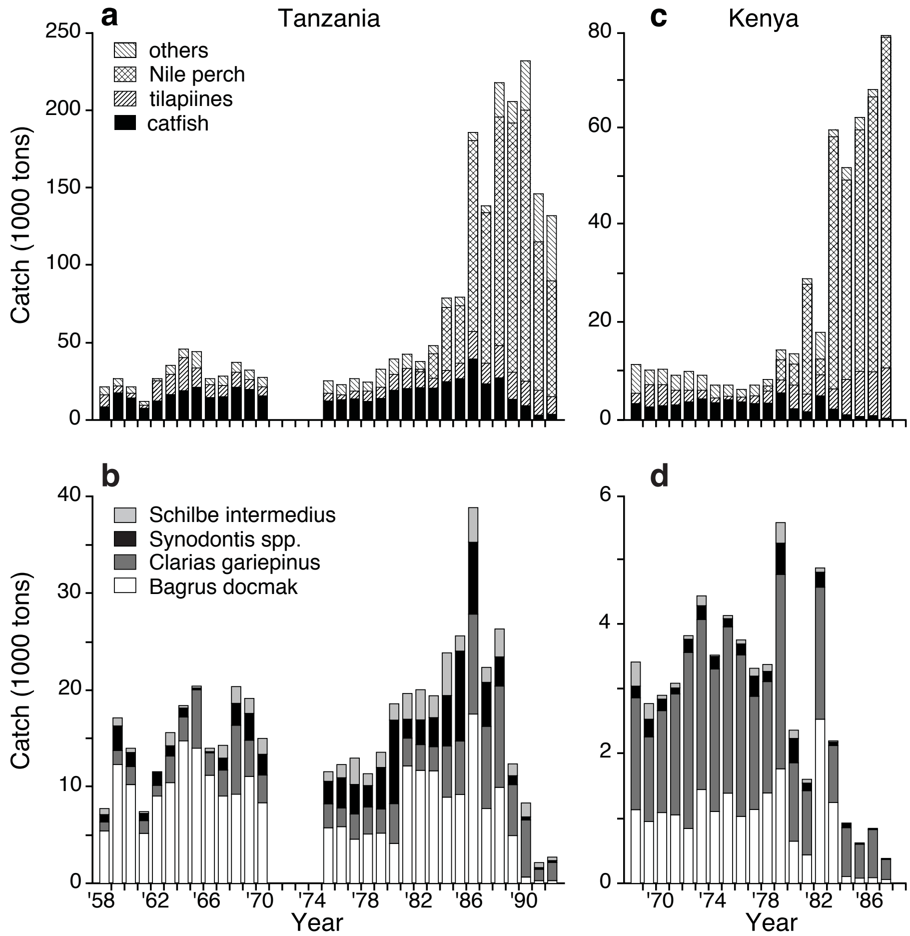

Fig. 6.3. *Composition of commercial fish landings from Lake Victoria: a- total landings and b- catfish landings in Tanzanian waters during the period 1958-1992 (data for 1971-1974 are missing): c- total landings and d- catfish landings in Kenyan waters during the period 1968-1987 (Sources: CIFA 1985,1988, 1990 and the Fisheries Division of the ministry of Tourism, Natural Resources and Environment of Tanzania).*

(Fig. 6.3a,b). Yearly catches fluctuated between 5000 and 17000 tons, but after 1988 they decreased to less than 200 tons. In the Kenyan part of the lake 1000 to 1800 tons were landed annually until 1983, followed by a strong decline (Fig. 6.3d).

B. docmak occurred over a wide depth range. A significant correlation between catch size and depth was found in 1985 (Fig. 6.4; Appendix 6.1). Although all length classes were present in littoral and deepwater stations, big fishes were more common in deep water during the period 1984–1986 (Mann-Whitney U test, $P < 0.001$; Fig. 6.5a).

The catch of *B. docmak* per unit of effort of MV Mdiria operating in the

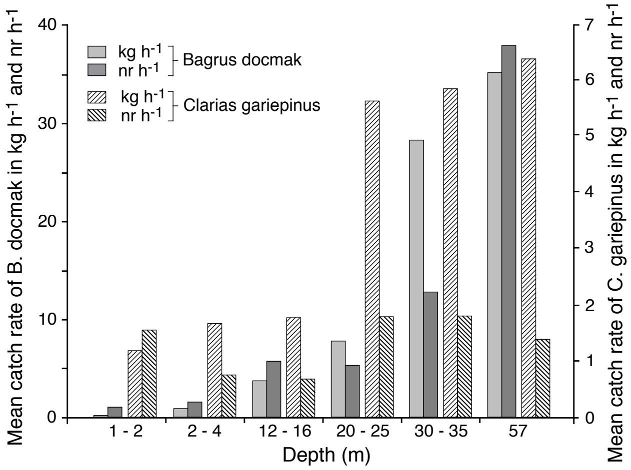

Fig. 6.4. *Mean catch rate (number h^{-1} and kg h^{-1}) of Bagrus docmak and Clarias gariepinus in bottom trawl catches of MV Kiboko at different depths in the Mwanza area in 1985)for standard deviations see Appendix 6.1).*

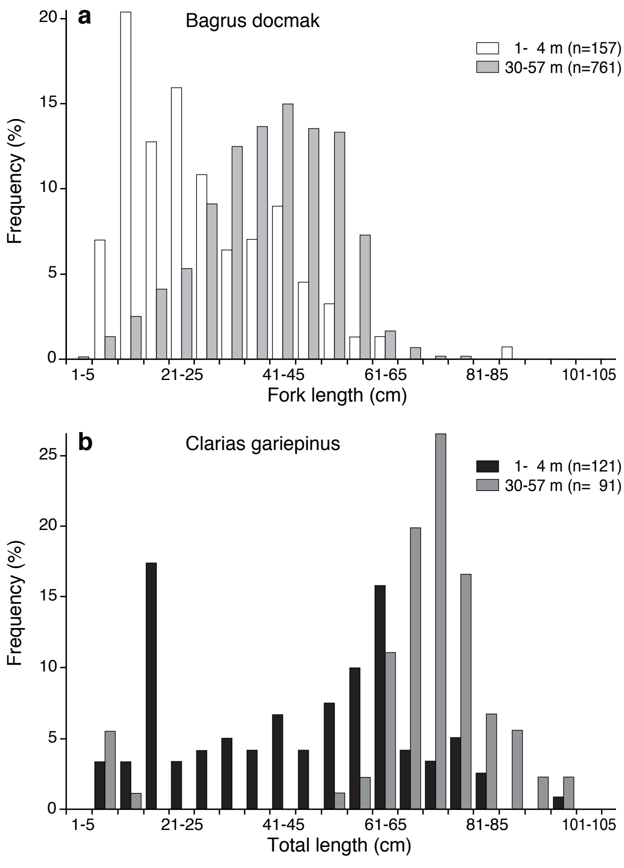

Fig. 6.5. *Lengthfrequency distribution of*
a) Bagrus docmak and
b) Clarias gariepinus in shallow (1-4 m) and deep (30-57 m) water in the Mwanza Gulf area during 1984-1986. Based on 153.5 and 53.5 hours bottom trawling with MV Kiboko in shallow and deep water respectively (n= number of fishes)

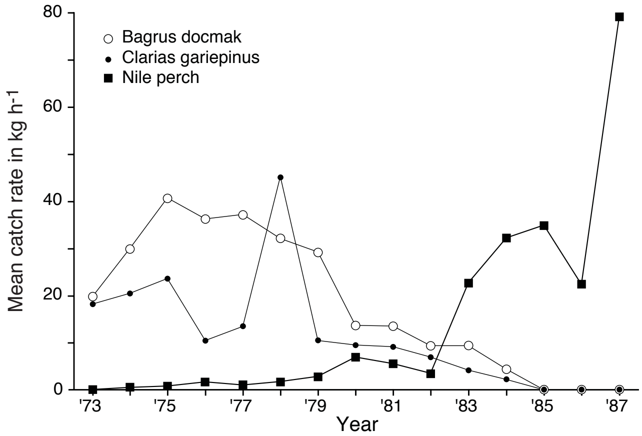

Fig. 6.6. *Mean catch rate of Bagrus docmak. Clarias gariepinus and Nile perch in bottom trawl catches of MV Mdiria made in the Mwanza Gulf (based on 3877 hours trawling with 20 mm codend mesh and 3875 hours trawling with 90 mm codend mesh)*

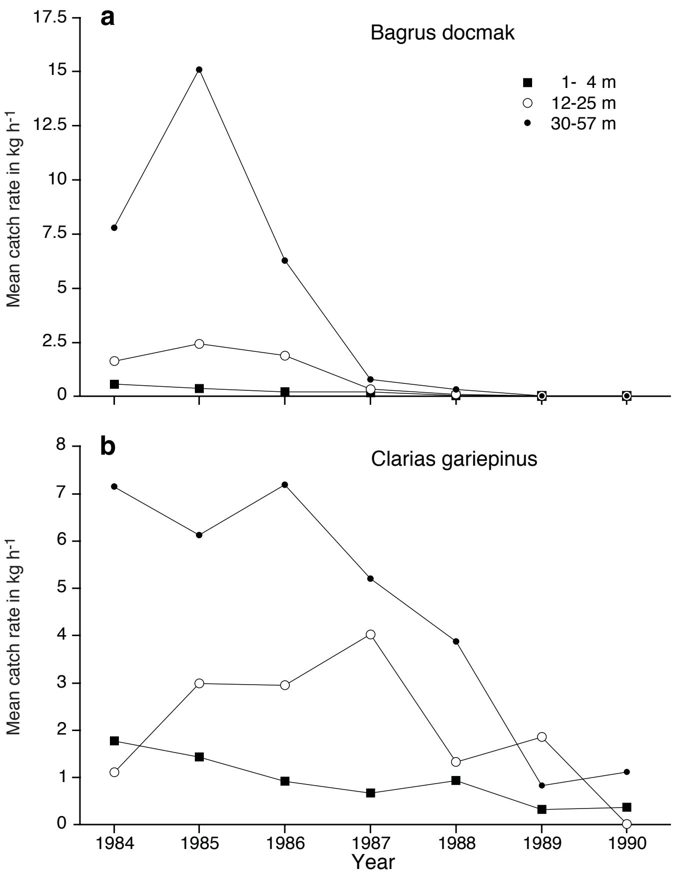

Fig. 6.7. *Mean catch rate of*
a)- Bagrus docmak and
b)- Clarias gariepinus in bottom trawl catches of MV Kiboko made at different depths on the Mwanza area over the period October 1984 until July 1990 (for standard deviation, see Appendix 6.2)

Table 6.1 *Mean catch rate (kg h^{-1}) of Bagrus docmak in trawl shots of MV Kiboko in Kagera and Ukerewe/Majitta area in different months and over different depth ranges. N= number of trawl shots; - = no trawl short made; 0 = no Bagrus caught; + = Less than 0.5 kg Bagrus caught.*

	Depth (m)					
Month	0 - 10	11 - 20	21 - 30	31 - 40	41 - 50	N
Kagera area						
June 85	0	5	41	23	98	13
Nov. 86	-	11	7	13	22	41
Feb. 87	-	0	2	2	0	69
May 86	-	-	0	1	0	39
Sept. 87	-	0	7	1	0	71
Dec. 87	0	6	8	3	16	66
Mar. 88	0	0	2	+	0	70
Aug. 88	0	0	1	2	2	97
Nov. 88	0	0	0	0	3	81
Apr. 88	0	+	0	0	0	75
Ukerewe/ Majitta area						
Jan. 87	0	4	3	7	0	27
Apr. 87	-	6	0	0	0	36
July 87	-	5	5	7	3	50
Nov. 87	0	2	2	3	0	38
May 88	-	0	-	1	0	32

Mwanza Gulf decreased in the 1970s and 1980s, while from the beginning of the 1980s Nile perch catches increased (Fig. 6.6). After 1985, a continuous decline of *B. docmak* was observed in the catches of MV Kiboko at littoral, sub-littoral and deepwater sampling stations in the Mwanza Gulf and the main lake (Fig. 6.7a; Appendix 6.2, 6.3). At the latter stations the decline was greatest. As sampling started only in October 1984, the 1984 data do not represent the mean for the whole year.

Commercial trawlers in the Speke Gulf, together trawling more than 200 hours per month, showed a similar decline (Fig. 6.8a). Trawling at different depth zones in the Kagera and Ukerewe/Majita areas with MV Kiboko also indicated a decline in the catches (Table 6.1).

Chilvers (1969) calculated a L_∞ for *B. docmak* of 82.5 cm standard length (SL). Maturation starts above 20 cm fork length (FL) (Rinne & Wanjala, 1983). The largest individual observed during the present study measured 88 cm SL. The average individual weight of the fishes increased over the period 1984–1987 (Fig. 6.9). Data for 1988 and 1989 are less reliable as they are based on,

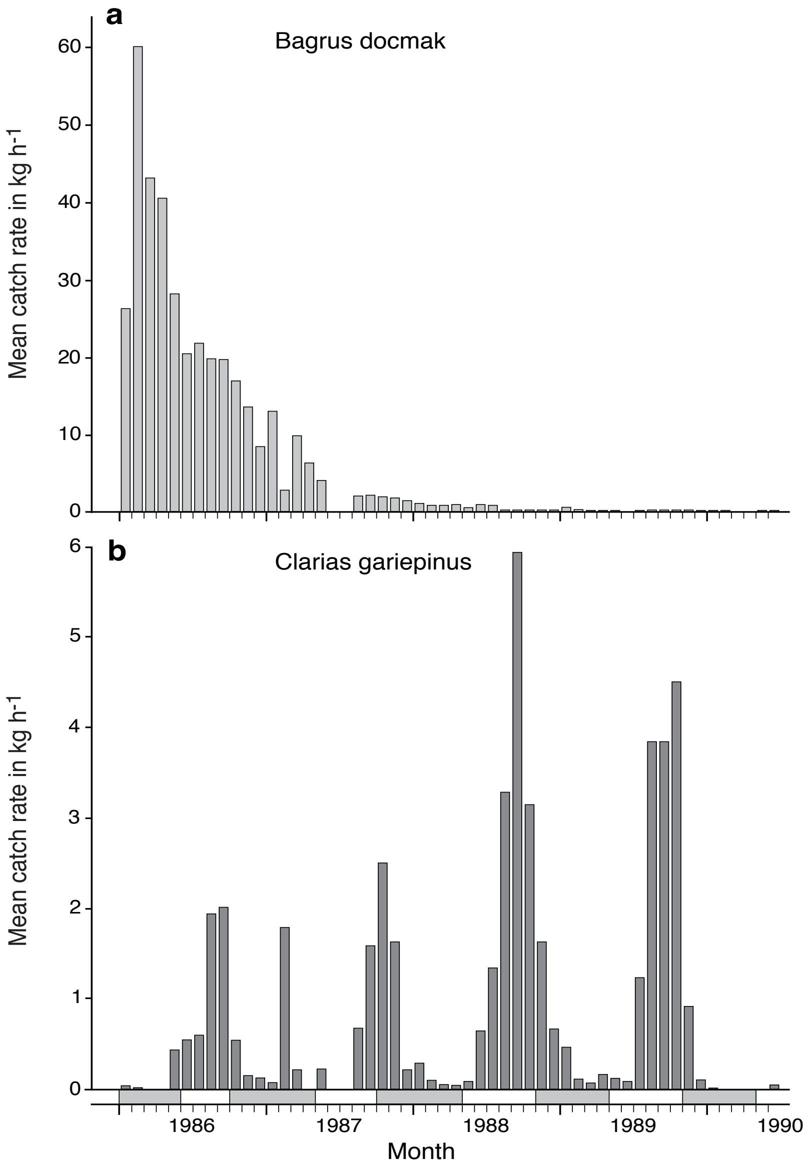

Fig. 6.8. *Mean catch rate of a- Bagrus docmak and b- Clarias gariepinus in bottom trawl catches of three commercial trawlers operating in the Speke Gulf over the period January 1986- June 1990. Based on 12539 hours of bottom trawling. Shaded bars along the x-axis indicate months with more than 75 mm rainfall.*

respectively, 7 and 3 individuals only. From the length-weight relationship for the species (Table 6.2) it appears that the average length increased from less than 35 cm to more than 55 cm FL. As these data were collected from the same sample areas and with the same gear, this indicates that the number of small fishes decreased. In 1982–1983 trawlers of the fishmeal factory still caught a large size range (6–86 cm, mean 28.6 ± 11.4 cm SL, N =1017) of *B. docmak* near Mwanza, with the majority of fishes smaller than 35 cm.

Table 6.2 *The relationship between length and weight for some catfish species in Lake Victoria, expressed as Ln W= a + b x Ln L. W = fresh weight in g; L = length in cm (total length in Clarias gariepinus and fork length in the other species): N= sample size; R^2 = coefficient of determination.*

Species	a	b	N	R^2	Range (cm)
Bagrus docmak	-4.56	3.07	139	0.9801	14.4 - 70.1
Clarias gariepinus	-5.19	3.09	196	0.9873	17.7 - 101.0
Synodontis victoriae	-3.19	2.97	296	0.9537	8.0 - 24.9
Synodontis afrofischeri	-2.32	2.40	57	0.6451	10.6 - 17.2
Schilbe intermedius	-5.25	3.26	174	0.9747	112.0 - 31.9

An increase in mean size of *B. docmak* also was observed in the Bukoba area. The length frequency of *B. docmak* caught by artisanal fishermen with gillnets and hook and line in this area in 1974, revealed that most fishes landed were between 35 and 50 cm FL (range 18–70 cm, mean 44 ± 9.1 cm FL, N = 260; EAFFRO unpublished). In 1987 most fishes caught in this area were between 50 and 70 cm FL (W. Ligtvoet, pers. com.).

By means of a small fish poisoning operation in February 1960, Corbet (1960) found that juvenile B. docmak (size range 3-16 cm, N=41) were the most common non-cichlids on exposed rocky shores. From this he concluded that the species breeds on rocky

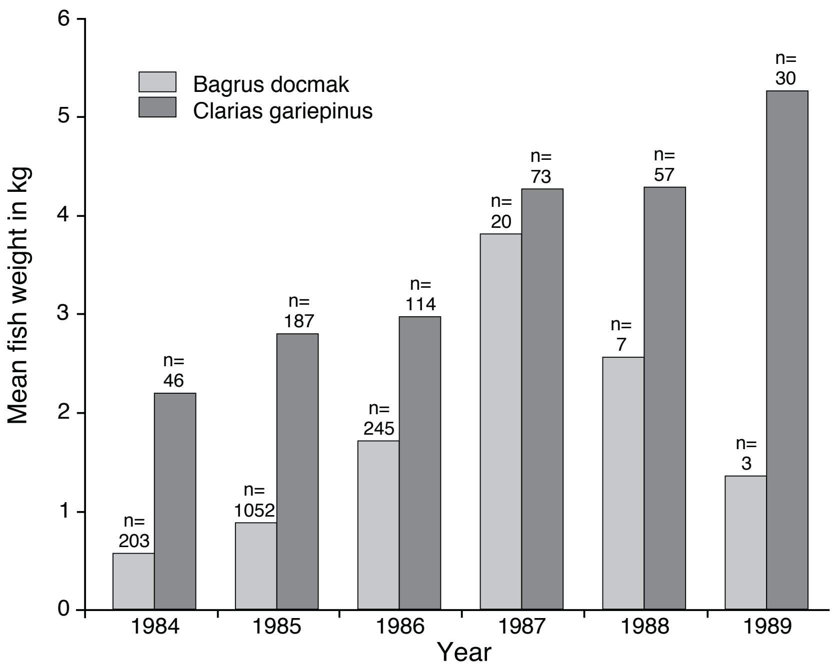

Fig. 6.9. *Mean individual fish weight of Bagrus docmak and Clarias gariepinus in bottom trawl catches of MV Kiboko in the Mwanza Gulf. Number of fishes on which the means are based is given on top of each bar (standard deviations could not be calculated as individual weights were nor scored separately, but only the total weight of all individuals in a catch).*

Table 6.3 *Mean number of juvenile Bagrus docmak and Clarias gariepinus caught between 1979 and 1982 in trawls of 10 min duration at stations on a transect across the Mwanza Gulf. For B. docmak only the four deepest (10-14 m) stations were considered, as it was virtually restricted to that part of the transect. For C. gariepinus all 11 stations (Witte et al., 1992b) ranging from 2-14 m deep were included. N = total number of juveniles (<20 cm TL).*

Month	*Bagrus docmak* (N= 57)			*Clarias gariepinus* (N= 11)		
	Mean number of fishes	St. Dev	Number of catches	Mean number of fishes	St. Dev	Number of catches
January	0.8	± 0.8	4	0.0	± 0.0	10
February	1.8	± 2.6	5	0.3	± 0.4	8
March	0.7	± 1.0	7	0.0	± 0.0	14
April	0.3	± 0.5	7	0.0	± 0.0	11
May	0.3	± 0.7	6	0.0	± 0.0	14
June	0.0	± 0.0	8	0.1	± 0.2	18
July	0.0	± 0.0	6	0.1	± 0.3	14
August	0.2	± 0.4	6	0.0	± 0.0	13
September	0.0	± 0.0	4	0.0	± 0.0	9
October	1.0	± 1.2	6	0.0	± 0.0	11
November	3.5	± 1.5	2	1.0	± 1.8	6
December	3.7	± 3.8	6	0.1	± 0.3	12

shores. In the period 1979–1982 juvenile *B. docmak* (3.0–16.5 cm SL, mean 6.5 ± 2.3 cm SL) were frequently caught along a part of the research transect across the Mwanza Gulf (mud bottoms, 10–14 m deep), particularly between October and March (Table 6.3). This may indicate seasonality in spawning, and shows that the juveniles may leave rocky shores when only 3 cm SL. Only one *B. docmak* (4.3 cm SL, Dec 1987) was caught in 17 catches that were made at the same depths along the transect during 1987 and 1988 (J.H. Wanink, pers. com.), while none occurred in 35 catches made between 1990 and 1993 (O. Seehausen & J. Smits, pers. com.; FW, pers. obs.). Seventy-six hours of angling along rocky shores in 1990 yielded 11 individuals of which the largest was 26.5 cm FL, while the average length was 19.7 cm FL (N. Bouton, pers. com.).

Before the 1980s adult *B. docmak* were known to feed predominantly on haplochromine cichlids in Lake Victoria (Corbet, 1961; Chilvers & Gee, 1974; Okach & Dadzie, 1988). Incidental observations on stomach contents of *B. docmak* from the Tanzanian waters in 1984 and 1985 showed that haplochromines were still the main food item for adults. However, the few large fishes caught in 1988 and 1989 had all fed on oligochaetes and on the small cyprinid *Rastrineobola argentea* (PCG, pers. obs.), which by then had increased substantially in numbers (Wanink, 1991; Witte et al., 1992a).

Before the 1980s *R. argentea* only was found in low quantities in the stomachs of *B. docmak* and oligochaetes were extremely rare food items (Corbet 1961, Chilvers & Gee, 1974).

Clarias gariepinus

Clarias gariepinus was the second most important catfish in the fish landings of Lake Victoria. In 1969– 1970 the standing stock of *C. gariepinus* was estimated at 1936, 14138 and 10885 tons in the Kenyan, Tanzanian and Ugandan waters respectively (Kudhongania & Cordone, 1974). During the 1960s and 1970s commercial landings were more or less stable in Kenya and Tanzania. At the beginning of the 1980s the Kenyan landings decreased (Fig. 6.3d). In the same period the Tanzanian landings initially increased, but subsequently decreased after 1988 (Fig. 6.3b). In 1985 a weak but significant positive correlation was found between catch weight and depth, but not between the number of *C. gariepinus* and depth (Fig. 6.4; Appendix 6.1). The length frequency distributions of *C. gariepinus* at littoral and deepwater stations show that adult fishes prefer deep water while juveniles stay mainly in littoral areas (Fig. 6.5b; Mann-Whitney U test, $P < 0.001$).

Trawl catches of MV Mdiria from the Mwanza Gulf fluctuated in the 1970s (Fig. 6.6). The exceptional peak of 1978 was the result of 6 months (February–July) of high catches in the northern part of the gulf, while in the other months catches were of the level of the previous and following year. In the 1980s *C. gariepinus* decreased in the trawl catches (Fig. 6.6). After 1985 a continuous decline of *C. gariepinus* was observed in the catches of MV Kiboko (Fig. 6.7b, Appendix 6.2, 6.3). The decline of *C. gariepinus* in deep water was stronger than in littoral waters. Commercial trawling in the Speke Gulf between 1986 and 1990 in littoral and sub-littoral waters produced few *C. gariepinus* (Fig. 6.8b). However, catches seemed to increase during 1988 and 1989. In this area a clear periodicity was observed in the catches. During the second half of the year they were higher than in the first half. This periodicity was probably caused by spawning migrations.

The maximum size for *C. gariepinus* found during this study was 122 cm total length (TL). Maturation starts at ca. 40 cm TL (Rinne & Wanjala, 1983). The average individual weight of *C. gariepinus* caught by trawling in the Mwanza Gulf increased over the years 1984–1989 (Fig. 6.9). From the length-weight relationship (Table 6.2) it appears that the average length of 62 cm TL in 1984 increased to above 85 cm TL in 1989. The length frequency distribution of *C. gariepinus* caught by artisanal fishermen with gillnets and hook and line near Musoma in 1974, revealed that most fishes were caught between 25 and 60 cm TL. Data from Mwanza in 1974 are few, but those available fall into the same range (EAFFRO unpublished). *C. gariepinus* caught near Mwanza in 1986–1988 by gillnet fishermen targeting Nile perch ranged from 70–120 cm TL (W. Ligtvoet, pers. com.).

In the period 1979–1982 juvenile *C. gariepinus* (3.5–8.0 cm, mean 5.7 ± 1.7 cm SL) were occasionally caught along the transect across the Mwanza Gulf (Table 6.3). In 114 catches that were made on the transect between 1987 and 1993 no *C. gariepinus* were present (J.H. Wanink, O. Seehausen & J. Smits pers. com., FW, pers. obs.).

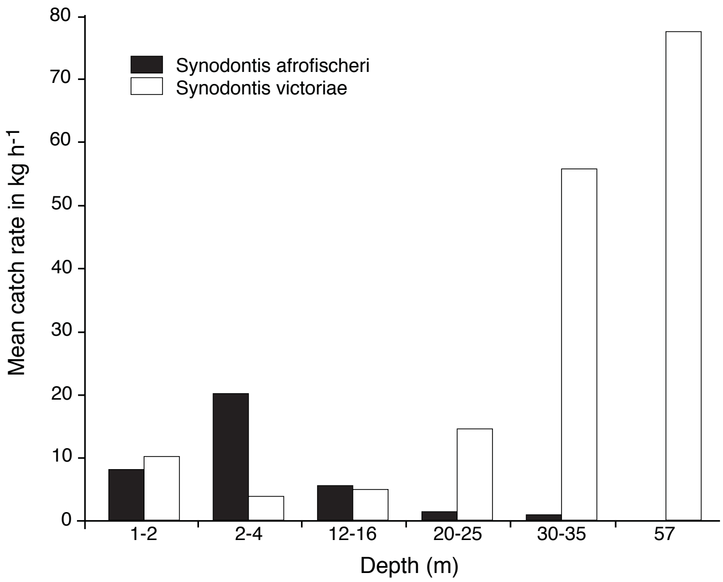

Fig. 6.10. *Mean number of Synodontis afrofischeri and S. victoriae in bottom trawl catches of MV Kiboko at different depths in the Mwanza area in 1985 (for standard deviation, see Appendix 6.1).*

Incidental stomach analysis before 1985 revealed that *C. gariepinus* fed mainly on haplochromines (P.C.G., pers. obs.), which corroborates the results of earlier studies (Corbet, 1961; Mwebaza-Ndawula, 1984). Stomachs from fishes caught in 1989 and 1990 contained oligochaetes, prawns (*Caridina nilotica*), the cyprinid *Rastrineobola argentea* and juvenile Nile perch (P.C.G. pers. obs.). These food items were of little or no importance in the earlier stomach content analyses (Corbet, 1961; Mwebaza-Ndawula, 1984). *Clarias gariepinus*, usually juveniles, were found in the stomach of Nile perch on several occasions, the largest being 48 cm TL (P.C.G. pers. obs.).

Synodontis victoriae and *S. afrofischeri*

In Lake Victoria two bottom dwelling species of *Synodontis* exist: *S. victoriae* and *S. afrofischeri*. Although fishermen know how to distinguish these species on the basis of their coloration and distribution, they are not separated in the catches. Commercial landing records are lumped together for this reason. The length-weight relationship for the two species is different (Table 6.2). In general *S. victoriae* is larger than *S. afrofischeri* (Table 6.2; Greenwood 1966). They mature at 9 and 8 cm FL respectively (Rinne & Wanjala, 1983).

Although the landings of *Synodontis* in some areas of Lake Victoria were comparable to those of *Clarias gariepinus* (e.g. Fig. 6.3b), the economic value was considerably lower. *Synodontis* used to be a bycatch of tilapia and *Schilbe* fisheries. A small number of fishermen targeted *Synodontis*, usually with old tilapia gillnets set around rocks in deep water or near papyrus fringes.

As in other parts of the lake (Greenwood, 1966; Kudhongania &

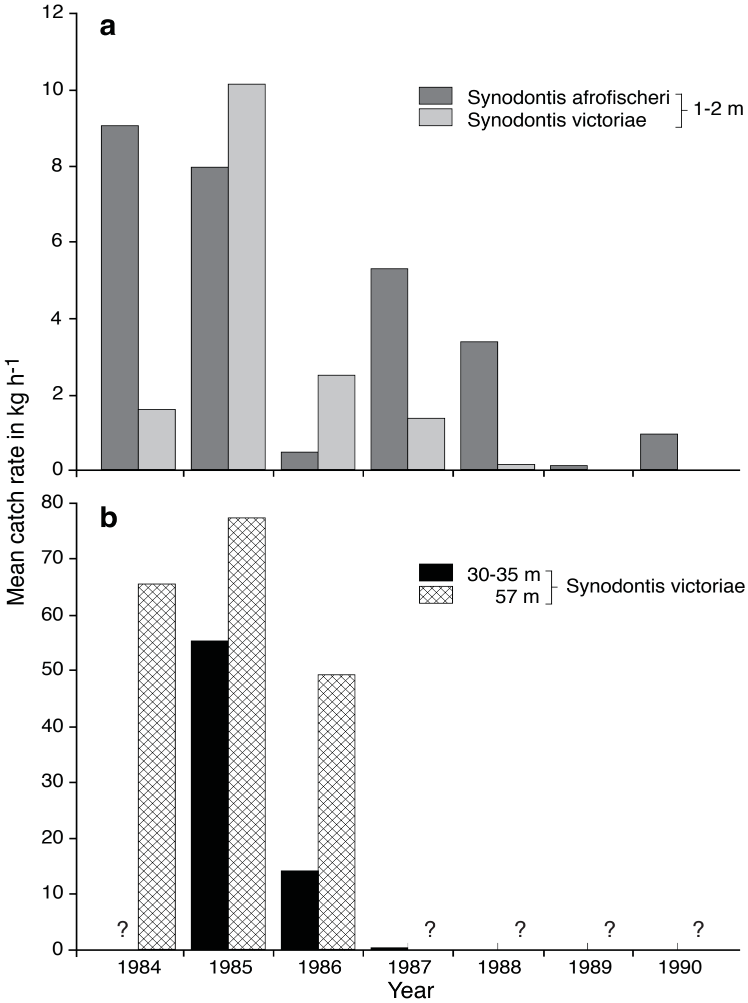

Fig. 6.11. *Mean number of Synodontis in bottom trawl catches of MV Kiboko in the Mwanza area over the period 1984-1990:*
a) S. afrofischeri and S. victoriae at 1-2 m depth:
b) S. victoriae at depths of more than 30 m. In 1984 no catches were made at 30-35 m: in 1987-1990 no catches were made at 57 m depth (for standard deviation, see Appendix 6.3).

Cordone, 1974), there was a tendency for *S. afrofischeri* to be commoner in the littoral and sub-littoral regions of the Mwanza Gulf than in deep water. However, decrease of catch size with depth in 1985 was not significant (Fig. 6.10; Appendix 6.1). Densities of *S. victoriae* increased with depth. The stock for the whole lake in 1969–1970 was estimated for *S. victoriae* at 23 209 tons and for *S. afrofischeri* at 51 tons (Kudhongania & Cordone, 1974). The latter probably was an underestimate as the major distribution of *S. afrofischeri* seems to be in water less than 4 m deep, while the stock estimate was based on areas with depths of more than 4 m.

The catches of both species declined during the 1980s (Fig. 6.11a,b; Appendix 6.3). *S. victoriae* disappeared completely from the deepwater stations, where the catches used to be highest; after 1987 not a single individual was caught in water more than 20 m deep. At

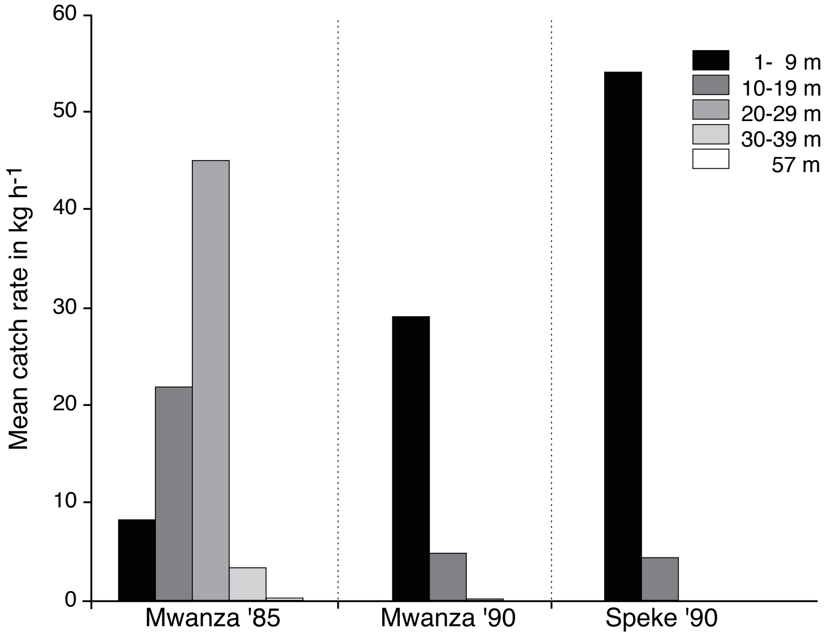

Fig. 6.12. *Mean number of Schilbe intermedius in bottom trawl catches of MV Kiboko in 1985 and 1990 at different depths in the Mwanza Gulf and Speke Gulf (for standard deviation, see Appendix 6.1, 6.3).*

the littoral stations the two species were still occasionally observed in the trawl catches in 1990. *S. afrofischeri* has been caught recently several times between rocks (O. Seehausen, pers. com.).

Both species feed predominantly on insects and molluscs. In the diet of *S. afrofischeri* insects are more important and in the diet of *S. victoriae* molluscs (Corbet, 1961). Despite their sharp spines, both *Synodontis* species are eaten by Nile perch. In two cases specimens up to 26 cm TL were found in Nile perch stomachs.

Schilbe intermedius

The stock of *Schilbe intermedius* was estimated in 1969–1970 at 646 tons (Kudhongania & Cordone, 1974). In concordance, the contribution of *S. intermedius* to the commercial landings of Lake Victoria has always been of minor importance (Fig. 6.3), although consumers appreciate the species. Some specialised fishermen operate during the rainy season in the river mouths when fishes migrate to flood plains for breeding (Whitehead, 1959). Their catch is only occasionally included in the official records. For this reason these records are unreliable.

In 1985 most *S. intermedius* were caught at a depth of 10–29 m (Fig. 6.12, Appendix 6.1). There was a positive correlation between catch rate and depth over the depth range 1–25 m (Spearman corr. = 0.2541, $P < 0.001$) and a negative correlation over the depth range 25–57 m (Spearman corr. = -0.5663, $P < 0{,}001$). The correlation over the total depth range was weakly positive. Kudhongania & Cordone (1974) also found highest densities between 10 and 29 m depth. In 1990 *S. intermedius* was found in the Mwanza and Speke Gulf

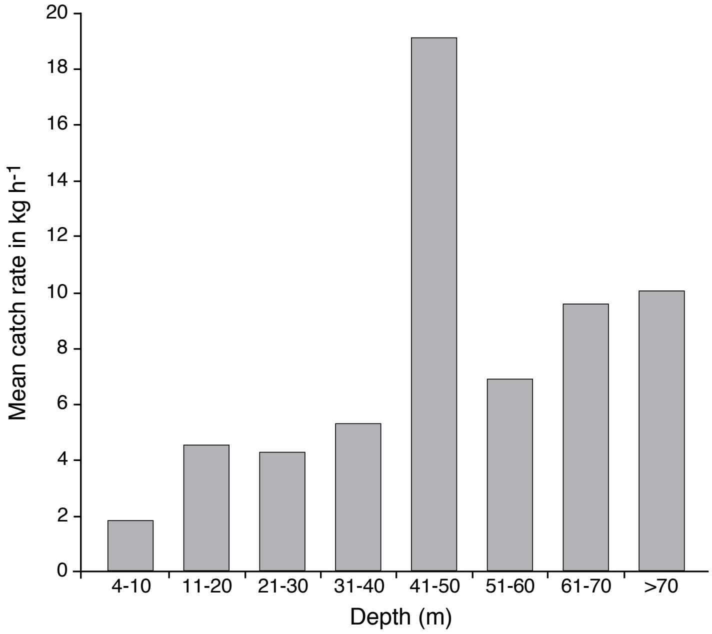

Fig. 6.13. *Mean number of Xenoclarias eupogon in bottom trawl catches of MV Ibis at different depth zones throughout Lake Victoria (Data from Gee, 1969).*

mainly in shallow waters, less than 10 m deep. The number of *S. intermedius* caught at depths between 20 and 39 m had decreased strongly (Fig. 6.12, Appendix 6.3) and a negative correlation was found between catch rate and depth range for both Mwanza Gulf and Speke Gulf (Appendix 6.1).

The largest fish encountered during this study was 42 cm FL having a weight of 1190 grams. Maturing starts between 11 and 13 cm FL (Rinne & Wanjala, 1983). Occasionally an adult *S. intermedius* (maximum size 22.5 cm FL) was found in a Nile perch stomach.

Before the Nile perch upsurge fishes (mainly haplochromines) predominated in the diet of *S. intermedius* (Corbet, 1961). In 1989–1990 *S. intermedius* was found to feed on aquatic insect larvae (mainly Odonata) and on the cyprinid *Rastrineobola argentea* (P.C.G., pers. obs.). A specimen collected in 1991 in the Mwanza Gulf had fed on oligochaetes and the prawn *Caridina nilotica* (O. Seehausen, pers. com.).

Xenoclarias eupogon

Xenoclarias eupogon is a commercially unimportant species and consequently not recorded in the landing statistics. The stock of this deepwater species was estimated in 1969–1970 at 447 tons for the whole lake (Kudhongania & Cordone, 1974). The species is not easy to discriminate from juvenile *Clarias gariepinus*. The principal anatomical differences are the absence of the suprabranchial respiratory organs and a reduction in the suprabranchial chamber in *X. eupogon* (Greenwood, 1966; Gee, 1975), and the absence of a free area between the end of the dorsal and anal fin base and the caudal fin origin (Fig. 6.1; Van Oijen, 1995). However, in contrast to juvenile *C.*

Table 6.4 *Mean catch rate of Xenoclarias eupogon in bottom trawls of MV Kiboko at Cherenche (57 m deep).*

Year	Catch rate in (numbers h^{-1})	St. dev.	Trawling time (h)
1984	18	25.1	3.5
1985	0.6	2.0	8.0
1986	0.3	1.1	6.5

gariepinus (Fig. 6.5b) this small species prefers the deeper parts of the lake (Fig. 6.13; Greenwood, 1966; Gee, 1970, 1975; Kudhongania & Cordone, 1974).

During the present study a maximum size of 18 cm TL was found for *X. eupogon*, which corroborates Greenwood's (1966) data. Sexual maturity is reached at ca. 11 cm SL (Gee, 1975).

Xenoclarias eupogon was found at Chererenche (57 m deep) in declining numbers (Table 6.4). In the Kagera area between 1986 and 1989 trawling in water of more than 40 m deep for 22.5 hours produced not even a single individual. In November 1987 five *X. eupogon* were caught at 35–36 m depth, west of Majita, in a trawl shot of half an hour. Despite intensive trawling until July 1990, these were the last individuals encountered.

The food of *X. eupogon* consists almost entirely of chironomid and *Chaoborus* larvae and pupae (Gee, 1975).

Discussion

Decline in the catfish stocks

In general the trawl catches of all catfish species in the Tanzanian part of Lake Victoria declined strongly during the 1980s (Fig. 6.6, 6.7, 6.8a, 6.11, 6.12; Table 6.1, 6.4; Appendix 6.2, 6.3). Similar declines were observed in trawl catches in Ugandan waters and several years earlier in the Kenyan part of the lake (Fisheries Department Kenya, 1988; Acere, 1988; Ogari & Asila, 1992). The decline was strongest in deepwater areas and least in the littoral areas (Fig. 6.7, 6.11, 6.12; Appendix 6.2, 6.3). The strong decrease in catches of *Schilbe intermedius* in water more than 10 m deep and the increase in shallower water (Fig. 6.12), suggest that this species made a habitat shift towards the littoral zone. However, high catch rates in the littoral zone were observed only in 1990 and not in earlier years (there is even a weak negative correlation between catch rate and time at the shallowest station; Appendix 6.3). Moreover, in 1990 only part of the year has been sampled. Further data are needed to establish whether *S. intermedius* made a similar habitat shift as has been observed for *Haplochromis laparogramma* (Witte et al., 1995).

The total catfish landings in the 1980s both in the Tanzanian and the Kenyan waters corroborated the trawl data. The initial increase in landings of catfish in Tanzania during the 1980s (Fig. 6.3b) may be due to an increased fishing activity for large Nile perch in which large catfishes were a bycatch.

It should be noted that, with the

possible exception of *Xenoclarias eupogon*, the catfishes discussed in this paper also inhabited the affluent rivers of Lake Victoria (Whitehead, 1959; Daget et al., 1986; Ochumba & Manyala, 1992). We have no information about trends in catches in rivers. However, until March 1988 they were still frequently caught in the Sondu-Miriu River in Kenya (Ochumba & Manyala, 1992).

Impact of the fisheries

In the Mwanza Gulf two mortality factors may have contributed to the declining trawl catches for *Bagrus docmak* and *Clarias gariepinus* in the 1970s and 1980s (Fig. 6.6, 6.7): (1) Intensive trawl fishing, which developed after 1973; (2) Predation by Nile perch, which strongly increased during the 1980s. In this area it is not possible to unravel the effects of these two factors. However, for both species trawl catch rates were relatively high down to depths of 70 m (Kudhongania & Cordone, 1974). As these remote deepwater areas were hardly fished, the stocks were probably under exploited. This holds particularly for *B. docmak*. Consequently, it is unlikely that the lake-wide decline of *B. docmak* and *C. gariepinus* has been caused by over-fishing. This is supported by the observation that for both species the decline was strongest in the lightly fished deepwater areas (Fig. 6.7a,b).

For the smaller catfishes no extensive specialised fishery existed; they were bycatches in gillnet and beach seine fisheries. *Synodontis afrofischeri* used to occur mainly in littoral and sub-littoral areas, while *S. victoriae* and *Xenoclarias eupogon* were found particularly between 40 and 80 m depth (Fig. 6.10, 6.13; Gee, 1970, 1975; Kudhongania & Cordone, 1974). Although the bulk of the stock of the two latter species occurred in areas that were hardly fished, they were almost eliminated by the end of the 1980s.

The fishery on *Schilbe intermedius* concentrated mainly on schools ascending rivers during the rainy season for spawning (Whitehead, 1959). Such a fishery, involving blocking off river mouths with gillnets, proved extremely harmful to the cyprinid *Labeo victorianus* (Cadwalladr, 1965). It is striking that, despite this type of fishery, *S. intermedius* was affected relatively little in the littoral areas in the 1980s (Fig. 6.12; Appendix 6.3).

In conclusion, there are no indications that over-fishing played a major role in the decline of the catfishes in Lake Victoria, particularly where deepwater stocks are concerned.

Impact of the Nile perch

Including our own observations, all catfishes studied in this paper have been encountered in stomach contents of Nile perch (Hamblyn, 1966; Gee, 1969; Okedi, 1971; Hughes, 1986; Ogari & Dadzie, 1988; Ogutu-Ohwayo, 1990b; Mkumbo & Ligtvoet, 1992; Ochumba & Manyala, 1992), albeit in low frequencies. *Clarias gariepinus* appeared to be the most common catfish in the diet of Nile perch. It was reported in all studies, whereas *Synodontis* sp., the second in importance, is only referred to in five publications. Compared to the haplochromine cichlids, which were the main prey of Nile perch up to the 1980s (Hughes, 1986; Ogutu Ohwayo, 1990b; Ligtvoet & Mkumbo, 1990; Mkumbo & Ligtvoet, 1992) predation on catfishes seems almost negligible. However, the following conditions should be considered:

(1) The total demersal ichthyomass of Lake Victoria consisted of more than 80% haplochromines and less than 15% catfishes (Kudhongania & Cordone, 1974). In the littoral and sub-littoral areas, where most Nile perch for food studies were collected, haplochromines dominated even more; (2) Only part of the populations of the two most abundant catfishes, *Bagrus docmak* and *C. gariepinus*, was a potential food source for Nile perch, as these catfishes attain a size that is too big for Nile perch to eat. Ligtvoet & Mkumbo (1990) calculated the relationship between total length and maximum mouth gape (MG) of Nile perch as: MG = 0.112 × TL + 0.43. This means that a Nile perch with the modal length of 70 cm TL could swallow a *C. gariepinus* with a head width of 8.27 cm, which would have a total length of ca. 35 cm. In conclusion, the relative predation pressure of Nile perch on small catfishes may not have been very different from that on haplochromines.

There are several indications that Nile perch predation indeed played a role in the decline of the catfishes: (1) The lake-wide decline in the landings occurred only after the increase of the Nile perch in the 1980s; (2) After the Nile perch boom, particularly the smaller individuals of both *C. gariepinus* and *B. docmak* disappeared, resulting in an increase of the mean individual weight (Fig. 6.9). In contrast, over-fishing generally results in a decrease of larger individuals; (3) The strongest declines seem to have occurred in deepwater and sub-littoral areas (Fig. 6.7, 6.11, 6.12) where Nile perch densities were highest (Fisheries Department Kenya, 1988; Goudswaard & Ligtvoet, 1988). It is striking that a similar pattern was found for the haplochromine cichlids (Witte et al., 1992b).

Besides predation, competition for food may have played a role in the case of *B. docmak*, *C. gariepinus* and *Schilbe intermedius*. Haplochromine cichlids were the main prey of these catfishes (Corbet, 1961; Chilvers & Gee, 1974; Mwebaza-Ndawula, 1984; Okach & Dadzie, 1988). Until they virtually disappeared, haplochromines also were the major food source for Nile perch (Hamblyn, 1966; Gee, 1969; Okedi, 1971; Ogutu-Ohwayo, 1990b; Mkumbo & Ligtvoet, 1992). Consequently, the Nile perch boom must have caused an enormous increase in competition for haplochromines. However, alternative food sources became available after the collapse of the haplochromines. There was an approximate fourfold increase in biomass of the pelagic cyprinid *Rastrineobola argentea* (Wanink, 1991; Witte et al., 1992a). Before the decline of the haplochromines this species was the second most important prey of *S. intermedius* and it also was occasionally eaten by *C. gariepinus* and *B. docmak* (Corbet, 1961). Currently it must be an easily accessible prey for *S. intermedius*, as the two species show the same daily vertical migration patterns (Goudswaard et al., unpublished). The bottom-dwelling *B. docmak* and *C. gariepinus* now regularly feed on *R. argentea*. They exploit the adult *R. argentea* fraction which occupies the bottom layers during daytime (Wanink, 1992; Wanink et al., 1996). The prawn *Caridina nilotica* increased strongly in biomass (Witte et al., 1992a; Goldschmidt et al., 1993; Kaufman & Ochumba, 1993). Before the Nile perch expansion the three piscivorous catfishes already included *C. nilotica* in their diet (Corbet, 1961) and, according to Graham (1929), this species even may have been an important food source for *B. docmak* living in deep water. The vast amounts of juvenile Nile perch, which are now frequently observed in trawl catches, are also a potential food source for the piscivorous catfishes. Juvenile Nile perch were indeed found in stomachs of *Clarias gariepinus* during this study.

Circumstantial evidence indicates that benthic invertebrates like oligochaetes, insect larvae and molluscs also increased after the decline of the haplochromines (Kaufman, 1992; Mbahinzireki, 1992 & pers. com.; Witte et al., 1992a). Oligochaetes were found in stomachs of *C. gariepinus*, *S. intermedius* and *B. docmak*. In earlier studies (Corbet, 1961; Chilvers & Gee, 1974; Mwebaza-Ndawula, 1984; Okach & Dadzie, 1988) oligochaetes were not encountered in these fishes or were extremely rare.

Obviously it is difficult to establish unequivocally the role that competition has played in the decline of the piscivorous catfishes. It is likely that at the onset of the Nile perch boom there was competition for haplochromines. However, it is difficult to estimate to what extent the increase of alternative food sources has released this competition. For the molluscivorous and insectivorous *Synodontis* species the disappearance of the once dominant haplochromines certainly must have decreased competition for these foods. The same would hold for *Xenoclarias eupogon*, which also fed predominantly on insects.

Environmental impacts

Besides changes in fish species composition and the food web (Ogutu-Ohwayo, 1990b; Ligtvoet & Witte, 1991; Witte et al., 1992a), other changes also have occurred in Lake Victoria during the past decade. Dense blooms of blue-green algae and associated low oxygen levels began to be regularly observed (Ochumba & Kibaara, 1989) and water transparency decreased accordingly (Witte et al., 1992a). In deeper water (below 45 m) anoxia was measured for prolonged periods (Kaufman, 1992; Hecky, 1993), whereas formerly it was rare and appeared only in the near vicinity of bottom sediments (Talling, 1966). Both eutrophication and the disappearance of the detritivorous and phytoplanktivorous haplochromines, which used to feed on blue-green algae, may have played a role in these changes (Kaufman, 1992; Hecky, 1993; Goldschmidt et al., 1993), but so far as the phytoplankton blooms are related to the disappearance of haplochromine cichlids this is an indirect effect of the Nile perch boom.

The hypoxic and anoxic conditions in the deeper parts of the lake may have contributed to the rapid decline of the catfish stocks in these areas. Beverton (1992) demonstrated that when two or more threats operate together (e.g. high predation pressure and low oxygen concentrations) the result may be more dangerous than the sum of their independent effects. For the decline in the sub-littoral and littoral waters, where hypoxic conditions were less severe, the role of such environmental effects is less plausible. Finally, it should be noticed that Nile perch, which is now flourishing throughout the lake, is probably more sensitive to hypoxic conditions (Fish 1956) than those catfishes that used to inhabit the deepwater areas of Lake Victoria. *Clarias gariepinus* in particular is well known for its hardiness (Greenwood, 1966).

Less affected species
Of the species discussed here, *Clarias gariepinus* and *Schilbe intermedius* seem to be affected to a lesser degree by the ecological changes in the lake than the other catfishes (Fig. 6.8b, 6.12; Appendix 6.3).

S. intermedius is partly pelagic and thus may avoid predation by Nile perch. Both spatial segregation and the feeding behaviour of Nile perch (Hamblyn, 1966) could contribute to this predation avoidance. The observations on *S. intermedius* are very similar to those on some of the pelagic zooplanktivorous haplochromines and *Rastrineobola argentea*. Pelagic haplochromines were less affected than bottom-dwelling haplochromines, and *R. argentea* even increased after the Nile perch upsurge (Wanink, 1991; Witte et al., 1992a).

As *S. intermedius* spawns in rivers, its juveniles may be safe from predation by juvenile Nile perch, which tend to live in shallower waters than adults (Ogari, 1985).

C. gariepinus is not restricted to the lake, but inhabits virtually every body of water in the region, such as rivers, swamps, rice fields, sewage channels and gravel pits. Consequently a considerable part of the *C. gariepinus* stock of the Lake Victoria basin lives beyond the reach of the Nile perch. Littoral areas of the lake may be replenished by *C. gariepinus* from surrounding bodies of water. Moreover, small temporary streams also serve as breeding sites for *C. gariepinus* living in the lake (Greenwood, 1966). Particularly around the Speke Gulf, where *C. gariepinus* did not decrease in the trawl catches (Fig. 6.8b), there are many surrounding bodies of water. The hardiness of this species and its outstanding ability to feed on a wide variety of foods (Corbet, 1961; Greenwood, 1966; Mwebaza-Ndawula, 1984) may have contributed to its relative success in surviving recent changes in the lake.

Prospects for the catfishes and the catfish fishery
Catfishes once contributed between a third and half of the total fish landings of Lake Victoria (Fig. 6.3a,c). However, since their dramatic decrease in the 1980s they are no longer of economic importance. *Clarias gariepinus*, *Synodontis victoriae*, *S. afrofischeri* and *Schilbe intermedius* currently produce small bycatches in fisheries in littoral areas. In the Mwanza area *Bagrus docmak* seem to be restricted to refugia in rocky habitats. Nile perch generally do not intrude into the holes and crevices between rocks (N. Bouton & O. Seehausen, pers. com.). Beside the rock-dwelling haplochromine cichlids, several other fish species of Lake Victoria were able to survive in this habitat (Witte et al., 1992a,b; Seehausen & Witte, 1994a). However, recent observations revealed new threats for these refugia, e.g. increased fishing activities for bait, establishment of the water hyacinth, (*Eichhornia crassipes*), and increased water turbidity (Seehausen & Witte, 1994a). The ecosystem of Lake Victoria is still in a state of flux (Kaufman, 1992, Witte et al. 1992a). After they had almost vanished, a reappearance of some haplochromine species was observed in littoral and sub-littoral areas of the lake (CIFA, 1990; Ogutu-Ohwayo, 1990b; Seehausen & Witte, 1994b; Witte et al., 1995). For the Kenyan waters, where the Nile perch upsurge and other ecological changes were manifested before they did in the rest of the lake, a small recovery of

catfishes in the littoral zone in 1988–1989 was also reported (Ogari & Asila, 1990). As yet it is not clear to what extent this recovery will proceed. However, it is unlikely that catfishes will be able to attain their original stock sizes as long as Nile perch remain an important component of Lake Victoria's fish fauna and other ecological features, such as the severe anoxia in deep water, do not change.

Extinction

Unlike the haplochromine cichlids, most catfishes in Lake Victoria are not stenotopic, nor are they restricted to the lake proper. Only *Xenoclarias eupogon* was thought to have a distribution that was limited to the lake itself (Daget et al., 1986). Recently, Ochumba & Manyala (1992) reported catches of this species in the Sondu-Miriu River. Though samples were taken weekly between April 1986 and March 1988, *Xenoclarias eupogon* were only collected in May (mean number $month^{-1}$ = 44) and August (mean number $month^{-1}$ = 1). If the identification was correct it seems that this species only ascends rivers for a brief period, possibly for spawning. In contrast, Gee (1970) suggested that *Xenoclarias eupogon* spawns on or near steep shelving rocky shores adjacent to deep water. Both *Synodontis* species occur throughout the drainage system, i.e. in some satellite lakes, affluent rivers and the Victoria Nile (Greenwood, 1966). Provided their taxonomic status is correct (e.g. see remark about *Bagrus docmak* on p. 26) the remaining catfish species have a wider distribution. Consequently, their strong decline in Lake Victoria does not threaten these species with immediate extinction. However, it will decrease their genetic diversity (Wilson, 1990; Beverton, 1992). Concerning *Xenoclarias eupogon*, however, the situation is far more serious. The species is no longer found in what was originally its main habitat. Unless it has been able to survive in refugia (e.g. in rivers or between rocks) we may have yet another example of an endemic species (genus!) in Lake Victoria that is threatened with extinction or has already disappeared.

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(Footnotes)

[1] De Vos & Skelton (1990) have re-identified the species formerly accepted in literature to be *Schilbe mystus* as *S. intermedius*.

[2] The four *Clarias* species in Lake Victoria could not always be identified to the species level in the field. However, *C. gariepinus* dominated the catches

[3] Though Nile perch in Lake Victoria is generally considered to be *Lates niloticus* its exact taxonomic status is uncertain (Harrison 1991).

[4] Mesh sizes throughout the paper refer to stretched meshes

Appendix 6.1.

Mean catch rate (kg^{-1} and/or n^{-1}) + standard deviation of catfish species in bottom trawls of MV Kiboko at different depth ranges in the Mwanza area in the first complete year of sampling (1985). For Schilbe intermedius data of 1990 (January-July) for both Mwanza area and Speke Gulf are included. N = total number of catches; Spearman corr. = correlation coefficient and significance level of Spearman rank correlation test over all individual catches against depth. - = no catches made.

Species	Catch rate	Year	1 - 2 m	2 - 4 m	12 - 16 m	20 - 25 m	30 - 35 m	57 m	N	Spearman corr.	
B. docmak	kg h^{-1}	1985	0.2±0.6	0.8±1.9	3.7±5.7	7.7±12.0	28.1±24.4	35.1±63.1	321	0.5920	p<0.001
B. docmak	nr h^{-1}	1985	1.1±2.6	1.6±2.0	5.6±4.3	5.2±5.5	12.6±10.6	37.8±80.8	321	0.5263	p<0.001
C. gariepinus	kg h^{-1}	1985	1.2±2.7	1.7±4.7	1.8±4.4	5.6±11.2	5.8±9.9	6.4±7.1	321	0.1865	p<0.001
C. gariepinus	nr h^{-1}	1985	1.6±2.5	0.8±1.5	0.7±1.3	1.8±3.0	1.8±2.5	1.4±1.8	321	0.0904	p=0.106
S. afrofischeri	nr h^{-1}	1985	8.0±26.2	19.9±88.2	5.3±14.4	0.9±2.0	0.6±1.1	0	321	-0.0695	p=0.214
S. victoriae	nr h^{-1}	1985	10.1±28.0	3.8±9.5	4.7±7.4	14.2±22.6	55.3±89.0	77.3±95.4	321	0.3441	p<0.001
S. intermedius	nr h^{-1}	1985	10.9±26.9	5.6±11.0	23.0±55.8	46.0±89.1	3.4±5.4	0.3±0.7	321	0.1588	p<0.010
S. intermedius	nr h^{-1}	1990	15.8±32.6	42.7±107.3	4.9±12.2	0.1±0.4	0	-	138	-0.4724	p<0.001
Speke Gulf				1 - 9 m	10 - 19 m	20 - 29 m	30 - 39 m			Spearman corr.	
S. intermedius	kg h^{-1}	1990		54.0±94.8	4.2±13.1	0.0±0	0.0±0	-	76	0.4826	p<0.001

Appendix 6.2.

Mean catch rate (kg h^{-1}) + standard deviation of catfish species in bottom trawl catches of MV Kiboko at different depth ranges in the Mwanza area. Data of 1984 and 1990 do not represent the mean over a whole year as the period of sampling was from October 1984 until July1990.
N = total number of catches: Spearman corr. = correlation coefficient and significance level of Spearman rank correlation test over all individual catches against date.

Species	Depth	1984	1985	1986	1987	1988	1989	1990	N	Spearman corr.	
B. docmak	1-4 m	1.1 ± 2.0	0.6 ± 1.6	0.3 ± 2.0	0.3 ± 1.7	0.0 ± 0.4	0	0	628	-0.4543	p<0.001
B. docmak	12-25 m	3.6 ± 4.2	5.5 ± 9.0	4.6 ± 14.8	0.6 ± 2.5	0.2 ± 1.7	0.2 ± 1.1	0	702	-0.6391	p<0.001
B. docmak	30-57 m	33.1 ± 40.3	20.1 ± 46.3	4.5 ± 7.1	0.3 ± 1.0	0.1 ± 0.5	0	0	244	-0.6975	p<0.001
C. gariepinus	1-4 m	2.0 ± 3.7	1.5 ± 4.1	0.9 ± 3.2	0.7 ± 2.5	0.9 ± 2.8	0.3 ± 1.1	0.4 ± 1.1	628	-0.1825	p<0.001
C. gariepinus	12-25 m	0.7 ± 1.4	3.0 ± 7.6	2.9 ± 7.6	4.0 ± 9.4	1.3 ± 4.2	1.8 ± 7.2	0	702	-0.2158	p<0.001
C. gariepinus	30-57 m	7.0 ± 12.2	6.0 ± 9.2	6.9 ± 8.7	5.2 ± 8.4	3.9 ± 8.8	0.8 ± 3.5	1.1 ± 3.8	244	-0.3042	p<0.001

Appendix 6.3.
Mean catch rate (n^{-1}) + standard deviation of catfish species in bottom trawl catches of MV Kiboko at different depth ranges in the Mwanza area. Data of 1984 and 1990 do not represent the mean over a whole year as the period of sampling was from October 1984 until July 1990. N= total number of catches: Spearman corr. = correlation coefficient and significance level of Spearman rank correlation test over all individual catches against date. - = no catches made. Depth in meters.

Species	Depth	1984	1985	1986	1987	1988	1989	1990	N	Spearman corr.
B. docmak	1-4	1.3±1.9	1.4±2.2	0.2±1.0	0.1±0.5	0.0±0.2	0	0	628	-0.4598 p<0.001
B. docmak	12-25	6.1±4.4	5.8±4.8	2.6±6.2	0.2±0.5	0.0±0.3	0.0±0.3	0	702	-0.6657 p<0.001
B. docmak	30-57	15.6±16.2	30.2±40.1	10.9±17.0	1.4±4.1	0.5±1.9	0	0	244	-0.7203 p<0.001
C. gariepinus	1-4	0.9±1.3	1.0±1.9	0.4±1.3	0.2±0.5	0.4±1.1	0.3±0.9	0.6±2.5	628	-0.1902 p<0.001
C. gariepinus	12-25	1.0±2.3	1.0±2.1	0.9±2.0	0.7±1.7	0.3±0.8	0.2±0.8	0	702	-0.2342 p<0.001
C. gariepinus	30-57	2.6±3.7	1.7±2.3	1.6±2.0	1.1±1.8	1.0±2.0	0.1±0.5	0.9±2.3	244	-0.2835 p<0.001
S. afrofischeri	1-2	9.0±36.6	8.0±26.2	0.4±1.4	5.3±29.3	3.4±5.9	0.1±0.4	0.9±2.0	272	-0.1687 p<0.006
S. afrofischeri	2-4	0.1±0.2	19.9±88.2	0.6±2.7	1.2±3.6	1.4±4.5	0.0±0.3	0	356	-0.1438 p<0.007
S. afrofischeri	12-16	0.7±1.3	5.3±14.4	4.7±11.5	0.3±0.8	0.1±0.3	0.0±0.2	0	437	-0.4429 p<0.001
S. afrofischeri	20-25	0	0.9±2.0	0.1±0.7	0	0	0	0	265	-0.3377 p<0.001
S. afrofischeri	30-35	-	0.6±1.1	0.1±0.5	0	0	0	0	208	-0.3333 p<0.001
S. afrofischeri	57	0	0	0	-	-	-	-	36	
S. victoriae	1-2	1.6±2.7	10.1±28.0	2.5±4.7	1.4±7.1	0.1±0.7	0	0	272	-0.4312 p<0.001
S. victoriae	2-4	0.1±0.6	3.8±9.5	1.9±3.9	0.9±3.5	0	0	0.1±0.4	356	-0.2093 p<0.001
S. victoriae	12-16	0	4.7±7.4	3.1±7.8	0.1±0.6	0.0±0.2	0	0	437	-0.4346 p<0.001
S. victoriae	20-25	0	14.2±22.6	10.5±24.2	0.1±0.5	0	0	0	265	-0.5682 p<0.001
S. victoriae	30-35	-	55.3±89.0	14.1±17.9	0.1±0.4	0	0	0	208	-0.6415 p<0.001
S. victoriae	57	65.4±53.2	77.3±95.4	49.1±77.7	-	-	-	-	36	-0.3145 p<0.063
S. intermedius	1-2	42.6±55.5	10.9±26.9	3.5±8.2	2.4±4.6	2.6±4.6	2.8±7.0	15.8±32.6	272	-0.1866 p<0.002
S. intermedius	2-4	2.5±4.4	5.6±11.0	2.4±6.4	16.0±52.1	9.7±30.4	6.4±19.0	42.1±107.3	356	-0.0416 p<0.433
S. intermedius	12-16	0.9±1.4	23.0±55.8	45.9±103.8	30.1±35.4	14.6±27.4	2.5±5.3	4.9±12.2	437	-0.1783 p<0.001
S. intermedius	20-25	0	46.1±89.1	19.0±63.6	4.2±12.7	0.6±1.4	0.2±0.5	0.1±0.4	265	-0.5212 p<0.001
S. intermedius	30-35	-	3.4±5.4	2.8±8.3	0.3±0.8	0.0±0.3	0	0	208	-0.4616 p<0.001
S. intermedius	57	1.1±2.1	0.3±0.7	0.3±0.7	-	-	-	-	36	-0.0657 p<0.698