Distribution and abundance of fish stocks in Lake Victoria, Tanzania

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Abstract: Trawl surveys to assess the stocks of Lake Victoria for estimates of biomass and yield, together with the establishment of exploitation patterns, are being undertaken under the Lake Victoria Fisheries Research Project. Preliminary surveys to establish the sampling stations and strategy were carried out between October 1997 and February 1998. Three cruises to cover the whole of the Tanzanian waters were undertaken with a total of 133 sampling stations. Data on catch rates, species composition and distribution were collected.

Three sampling areas were designated: area A stretches from Kome and Buhiru islands in the south west, north eastwards to the south west of Ukerewe island; area B is from the Tanzania-Kenya border southwards to the north west of Ukerewe island; area C covers from the Tanzania – Uganda border southwards to Kome island. In each area, almost the same distribution pattern over depth was found. *Lates niloticus* formed over 90% of the total catch. Most *L. niloticus* were from 5 – 40 cm TL. Abundance was stable with depth, although few fish were found deeper than 40 m. Catch rates varied considerably between stations and areas. Area A had the highest catch rates with little variation over the stations. There is an indication of recovery of species diversity compared with the surveys of RV Kiboko (1985 & 1989).

Introduction

Lake Victoria fish stocks and the fisheries have undergone remarkable changes over the past 20 years. Signs of overfishing were reported as early as 1970 when catch rates for tilapia dropped from 50-100 fish per 50-m long gillnet with 127-mm stretched mesh (Worthington 1933) to less than 5 fish (Ssentongo 1972). *Lates niloticus* (L.) and tilapiines introduced in the late 1950s further altered the fishery. Although this brought undeniable benefits to the economy (Greboval 1990), a number of native fish species disappeared or have decreased to very low levels. The lake's ecosystem and food web have changed and indeed are still in the process of change, thus affecting the fisheries and the lake resources in general (Ogutu-Ohwayo 1990a; Witte, Goldschmidt, Wanink, van Oijen, Goudswaard, Witte-Maas & Bouton 1992; Mkumbo & Ligtvoet 1992). Increased pollution and clearing of the peripheral wetlands (Hecky 1993; Kaufman 1992; Muggide 1993; Ochumba & Kibaara 1989), which served as fish nursery grounds, may be seriously affecting the fisheries and the lake resources in general. Many food fish species as *Oreochromis esculentus* (Graham), *Bagrus docmak* (Forsskål), *Clarias gariepinus* (Burchell), *Labeo victorianus* Boulenger and the haplochromines (once important for fishmeal) have almost disappeared. More recently, even *L. niloticus*, the most important fish in the fishery, has shown signs of declining (Othina 1999; Mkumbo & Cowx 1999).

With this change in the fishery resources, a number of management measures were effected, including a ban on beach seines and under-sized mesh nets (less than 127 mm stretched mesh) in 1994, and a ban on trawlers in 1996.

Despite increased total fishing effort, efficiency of fishing gear and extension of the fishing grounds to maintain the yield, there has been a progressive decline in catch per unit of effort (CPUE) and mean size of fish caught (Ligtvoet & Mkumbo, 1992; O. Mkumbo, unpublished data) in the Nile perch fishery.

Tanzania shares the resources of Lake Victoria with Kenya and Uganda and thus there is a need for cooperation in management. The lake-wide stock assessment project under the Lake Victoria Fisheries Research Project (LVFRP) funded by EU was therefore implemented. The stock assessment objectives of the project include the derivation of estimates of biomass, exploitation rates, and the fish distribution patterns. This paper examines the trends in the status of the fishery based on experimental trawling since November 1998, and compares the situation with similar data from the HEST/TAFIRI RV Kiboko 1985-1989 surveys.

Materials and methods

Sampling

The Tanzania part of Lake Victoria was divided into three areas (Fig. 1). Area A stretches from Kome and Buhiru islands in the south west, north eastwards to the south west of Ukerewe island, including Speke Gulf and Mwanza Gulf. Area B is from the Tanzania-Kenya border southwards to the north west of Ukerewe island. Area C covers the Kagera waters from the Tanzania – Uganda border southwards to Kome island, including Emin Pasha Gulf (Fig. 1).

The sampling stations were allocated using gridlines of five nautical mile squares based on degrees and minutes of latitude on hydrographic charts. In each square, one sampling station is allocated depending on depth. In very deep waters, stations are ten to fifteen nautical miles apart. Different depth ranges were covered depending on the actual depth of a given square. A total of 133 stations were established but only 103 were trawled with the rest either having rocky substratum or anoxic hypolimnion with persistent thermocline.

The research vessel, RV Victoria Explorer, length 17m and a 250-HP engine, was used for bottom trawling with a net of 22.6-m head rope and a codend of 25-mm mesh. Towing speed was 3-3.6 knots and trawling duration was 30 minutes.

Earlier data were collected by HEST/TAFIRI (1985, 1987) using the R.V. Kiboko with an 18-m head rope and trawling speed of 3 knots. These data were also compared with data collected using the R.V. TAFIRI II in 1996, which used a 13.5-m head rope and trawling speed of 2.5 knots. These vessels operated in the same area (Mwanza Gulf and Speke Gulf).

Data recording and analysis

During the present survey, treatment of the catch depended on its size. If it was small, the entire catch was sorted into species, weighed, and every fish measured (TL cm) and weighed (g). If the catch was too large to handle in the time before the following sample was landed, the larger fish above about 35 cm TL were sorted from the catch and measured individually. The remaining small fish, <35 cm TL, were sub-sampled by taking three shovelfuls of fish from the thoroughly-mixed heap of fish on deck. A key proviso was that the sample must be of about 200 fish, thus the number of shovelfuls of fish to be taken depended on the average size of fish in the sample. The weights of the sub-sample and full sample from which the sub-sample was taken were used to obtain the raising factor.

On each day, catches of the last haul were gutted to determine sex and maturity and for analysis of stomach contents. Fish were selected randomly for determination of the sex and status of sexual maturity. The latter was based on the classification of Hopson (972), where fish in classes I-III were immature and those in classes IV-VI were mature.

Results

Fish species composition and distribution

Lates niloticus dominated the catches in all three areas (Table 1), contributing 90% of the catch in area A, 99.4% in area B and 84.8% in area C. In areas A and C, haplochromines contributed 2% of the total catch. All other species contributed less than 1% of the total catch. Area A had the highest number of species caught followed by area C and B (Table 1). Thirteen species groups were recorded, which is considerable less than in 1970 (Table 2). Note, this treats several species of haplochromine cichlids as one category and the number of haplochromine species in the lake at the present time is considerably lower than in the past.

Comparison of recent catch rates with historical data (Table 3) shows a decline from 787 kg ha^{-1} in 1969/1970 to 316.7 kg hr^{-1} in 1985, and a further drop to 101 kg hr^{-1} in 1989. More recently, catch rates have increased again due to the contribution from Nile perch (Tables 1 & 3).

Catch rates for *L. niloticus* during the experimental trawl surveys varied between regions (Table 1). The area A catch rate was 247 kg hr^{-1}, while in B and C it was 360 kg hr^{-1} and 85 kg hr^{-1} respectively. The high catch rates of Area B were influenced by very high catches in Mihuru Bay/Masonga Bay (1400 kg hr^{-1}). Catch rates for other species were less than 1 kg hr^{-1}, except for haplochromine cichlids (2–6 kg hr^{-1}).

Catch rates exhibited little variation with depth in all regions (Fig. 2). The abundance of fish was similar throughout the depth ranges, except in the deeper waters (>50 m) where few fish were found. The absence of fish in the deep waters was associated with the presence of a thermocline at depths between 25 and 35 m.

Population characteristics of **Lates niloticus**

The majority of fish caught were between 5 and 45 cm TL, well below the age at first maturity for the population (see later). However, a greater contribution of larger fish was found compared to Uganda and Kenya (Getabu & Nyaundi 1999; Okaronon *et al.* 1999). Seasonal trends in size distribution of Nile perch (Fig. 3) showed evidence of a number of cohorts. These were well discriminated in November and December but less so in the March to May period. However, a new cohort of juveniles appears to have recruited to the fishery in April/May, and this was well defined in later months. These data will be analysed for growth and mortality parameters once a full year's data are available.

A similar trend in frequency distribution was found in the unpublished data of HEST from 1986 (Fig. 4). However, the recruitment to the fishery appeared to be later in 1986, occurring around August, and dominating the catches thereafter.

Zonal differences in the size distribution of Nile perch were difficult to discriminate because of a large contribution of newly recruited individuals in the sample from Zone B (Fig. 5). If this contribution is ignored, there appears to be little difference in the population structure between zones.

Similarly, little variation in the size structure of the catches from differing depths was found (Figs 6, 7 & 8). Perhaps the only notable difference was the relative absence of small individuals in deeper waters.

A total of 3474 fish were analysed for sex and sex maturity; 2792 (80%) were immature, 483 (14%) were mature males and 199 (6%) were mature females. The size at first maturity showed a decrease in size over time in both sexes. The size at first maturity was similar in the three zones in Tanzania (Fig. 4; Table 4). Females matured at a slightly greater size (55 cm TL) than males (53 cm TL). The marginal variation in Lm_{50} between the zones was attributable to differences in the time the samples were taken, i.e. each zone was sampled on consecutive months, and the small number of mature fish sampled, especially for females.

The diet of Nile perch was characterised by *Caridina nilotica* (Roux), haplochromine cichlids, and, to a less extent, *Rastrineobola argentea* (Pellegrin) in all three zones (Fig. 10). *Caridina nilotica* was the predominant food of the smaller size groups and decreased in importance with increasing size. Nile perch become piscivorous at about 10 cm TL and fed mainly on haplochromines. The contribution of fish to the diet increases with size, and larger Nile perch (>50 cm) were generally piscivorous. Some evidence of cannibalism was found in larger individuals.

Differences in diet were found between zones (Fig. 10). In particular, the diet of Nile perch in the Mwanza zone was characterized by haplochromines.

Discussion

Nile perch has a lakewide distribution and occurs in virtually every habitat (Ligtvoet *et al.* 1995); but it is also reported that oxygen concentration is the main limiting factor (Ochumba 1987). The low catches in zone C in 1998 could be due to low oxygen levels as this was during the heavy rains (El Niño). The situation changed in 1999 and this was during the period of maximum mixing in the lake (Talling 1966).

Distribution of Nile perch with depth is also influenced by oxygen profiles (Ochumba 1987). Variation in catch rates with depth differed with different seasons of the year. In some areas no catch was recorded below 30 m deep. Recording of limnological parameters alongside the trawls will help explain such differences.

Catch rates from the different areas sampled indicated marked variations with time/season, areas and depth, and it is very important to have a thorough coverage of all the three variables before any estimates of biomass can be derived for management purposes.

Species diversity was much lower than recorded by Kudhongania and Cordone (1974) (Table 2), but there is an indication of recovery when compared with 1985-89 (Table 3) (Ligtvoet *et.al.* 1995). The present species composition is closer to the 1969/70 composition but with marked differences in the catch rates for the different species.

The importance of haplochromines in the diet of Nile perch in the Mwanza zone is supporting evidence for an increase in the stocks, evident in trawl catches.

During the 1969/1970 surveys, the average catch rate for haplochromines was 450 kg hr^{-1} and for *L. niloticus* 1.0 kg hr^{-1}. Other species, *O. esculentus*, (18 kg hr^{-1}), *B. docmak* (29 kg hr^{-1}), *C. gariepinus* (21 kg hr^{-1}), *Protopterus aethiopicus* Heckel (12 kg hr^{-1}) and *Synodontis* spp. (13 kg hr^{-1}), had high catch rates compared to the current surveys. Some of these species had relatively high catch rates in the 1985 survey but by 1989 the catch rates had decreased (Table 3). *Lates niloticus* catch rates increased from 75 kg hr^{-1} in 1985 to 95 kg hr^{-1} in 1989 and 247 kg hr^{-1} in 1997 in area A.

Juvenile fish, <50 cm TL, dominated the populations of *L. niloticus* in each zone. This suggests good recruitment to the population, but the relatively small numbers of large, mature fish is of concern.

The size at first maturity has declined since the late 1980s, and is low compared to other populations (Table 5). This drop can probably be attributed to increased fishing pressure during the efforts and changes in the lake environment. However, it is difficult to confirm this because of the lack of empirical data on fishing effort (Mkumbo & Cowx 1999) and limnological changes which have occurred in recent years. This will be the subject of further investigation through the project. Notwithstanding, the intense fishing pressure on the stocks is undoubtedly causing the population to respond by reducing size at maturity and this must be addressed in management considerations.

Further research to complement the trawling programme is underway. Bottom trawling covers a very small proportion of the water column and this will be supported by hydroacoustic surveys, which have already shown the fishes to be distributed in the surface and the middle waters as well as on the bottom. In addition to the bottom trawling and hydroacoustic surveys, multimesh, multidepth gillnetting surveys will be conducted and fishery-dependent data will be collected (Nsinda 1999). Data from all surveys will be combined to estimate the biomass, yield and distribution of the stocks.

The survey programme to data has elucidated a number of key issues which will be examined once a complete year's data are available from the monthly trawl surveys. These data will be used to derive population parameters for the Nile perch stocks on which management measures can be formulated. This will be reported to the next FIDAWOG workshop.

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Table 1. Species composition by weight and percentage from the three sampling zones

Species	Area A			Area B			Area C		
	Total wt(kg)	%	kg hr^{-1}	Total wt(kg)	%	kg hr^{-1}	Total wt(kg)	%	kg hr^{-1}
Lates niloticus (L.)	5053.41	89.97	246.51	3596.99	99.36	359.70	1611.10	84.27	84.79
Haplochromines	123.17	2.19	6.01	21.95	0.61	2.20	38.52	2.01	2.03
Oreochromis niloticus (L.)	7.41	0.13	0.36	0.00	0.00	0.00	8.24	0.43	0.43
Barbus spp.	0.13	0.00	0.01	0.52	0.01	0.05	1.01	0.05	0.05
Bagrus docmak (Forsskål)	1.70	0.03	0.08	0.00	0.00	0.00	4.98	0.26	0.26
Rastrineobola argentea (Pellegrin)	0.34	0.01	0.02	0.00	0.00	0.00	0.65	0.03	0.03
Synodontis spp.	0.27	0.00	0.01	0.00	0.00	0.00	0.33	0.02	0.02
Protopterus aethiopicus Heckel	7.50	0.13	0.37	0.00	0.00	0.00	0.18	0.01	0.01
Clarias gariepinus (Burchell)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mormyrus kannume Forsskål	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00
Brycinus spp.	16.75	0.30	0.82	0.00	0.00	0.00	0.00	0.00	0.00
Schilbe intermedius Rüppell	1.64	0.03	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Labeo victorianus Boulenger	1.48	0.03	0.07	0.00	0.00	0.00	1.20	0.06	0.06
Molluscs	403.07	7.18	19.66	0.60	0.02	0.06	245.50	12.84	12.92
Totals	5616.90			3620.10			1911.80		
Total fishing hrs	20.50			10.00			19.00		

Table 2. Bottom trawl mean catch rates (Kudhongania & Cordone 1970)

Species	Depth (m)								Mean
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	kg hr^{-1}
Haplochromines	493.8	800.2	639.5	507.5	448	486.3	196.3	29.6	450.2
Oreochromis esculentus (Graham)	54.1	28.3	4.4	0.5	0				17.5
O. variabilis (Boulenger)	3.2	0.2	0	0					0.7
O.niloticus (L.)	10	0.9	0						2.7
O. leucostictus (Trewavas)	0.2								
Tilapia zillii (Gervais)	0.4	0	0						0.1
Bagrus docmak (Forsskål)	18	39.9	39.3	36.8	34.4	38.8	27.6	0.2	29.4
Clarias gariepinus (Burchell)	26.7	37.1	31.6	20.7	15.1	14.5	14.8	7.1	21.0
Xenoclarias eupogon (Norman)	0	0.1	0.1	0.3	0.4	0.6	0.3	0.3	0.3
Protopterus aethiopicus Heckel	33.3	23.1	7.3	5.5	1.6	0.5			11.9
Lates niloticus (L.)	2	0.6	0.4						1.0
Synodontis victoriae Boulenger	0.4	1.7	7	9	11.2	26.5	29.4	14.9	12.5
S. afrofischeri Hilgendorf	0.1	0.1	0.1						0.1
Barbus altianalis Boulenger	0.4	0.5	0.3	0.2	0.2				0.3
Labeo victorianus Boulenger	0.1	0.4	0						0.2
Mormyrus kannume Forsskål	0.4	0.4	0.3	0.4	0.9	0.1	0		0.3
Schilbe intermedius Rüppell	0.9	1.8	1.3	0.6	0.3	0.1	0		0.6
Brycinus spp.	0								
Aethiomastacembelus frenatus (Boulenger)	0	0	0	0					
Gnathonamus longibarbis Hilgendorf	0	0							

Table 3. Trawl catches in the Mwanza Gulf using R.V. Kiboko

Species	1969/1970 Catch		1985 Catch		1989 Catch	
	kg hr^{-1}	%	kg hr^{-1}	%	kg hr^{-1}	%
Bagrus docmak	13.1	2	3.7	1	0.2	0
Clarias gariepinus	40.6	5	1.8	1	0.9	1
Protopterus aethiopicus	25.2	3	16.8	5	1.5	2
Lates niloticus			75.3	24	94.6	97
Oreochromis niloticus	24.3	3	0.1	0	0.8	1
O. esculentus	114.4	15	0.0	0	0.0	0
O. variabilis	1.5	0	0.0	0	0.0	0
Haplochromines	548.1	71	219.1	69	0.0	0

Table 4. Proportion of mature fish and age at first maturity (Lm_{50}) in Nile perch populations in the Tanzanian sector of Lake Victoria

Zone	Number of fish				Length at first maturity	
	Immature males	Mature males	Immature females	Mature females	Males	Females
Zone A	349	56	131	20	54.5	60.0
Zone B	292	55	127	37	47.5	55.0
Zone C	457	46	94	13	49.5	49.0
Total	1098	157	352	70	53.0	55.0

Table 5. Age at first maturity (Lm_{50} TL, cm) for various Nile perch populations

Water body	Males	Females	Reference
Lake Albert	60	85	Helder (1963)
Lake Chad	50	60-65	Hopson (1972)
Lake Kyoga	50	84 –96	Ogutu-Ohwayo (1990)
Blue Nile	60	60	Kenchinjton (1939)
Lake Victoria (Speke Gulf)	76-80	86-90	TAFIRI (1990 unpublished)

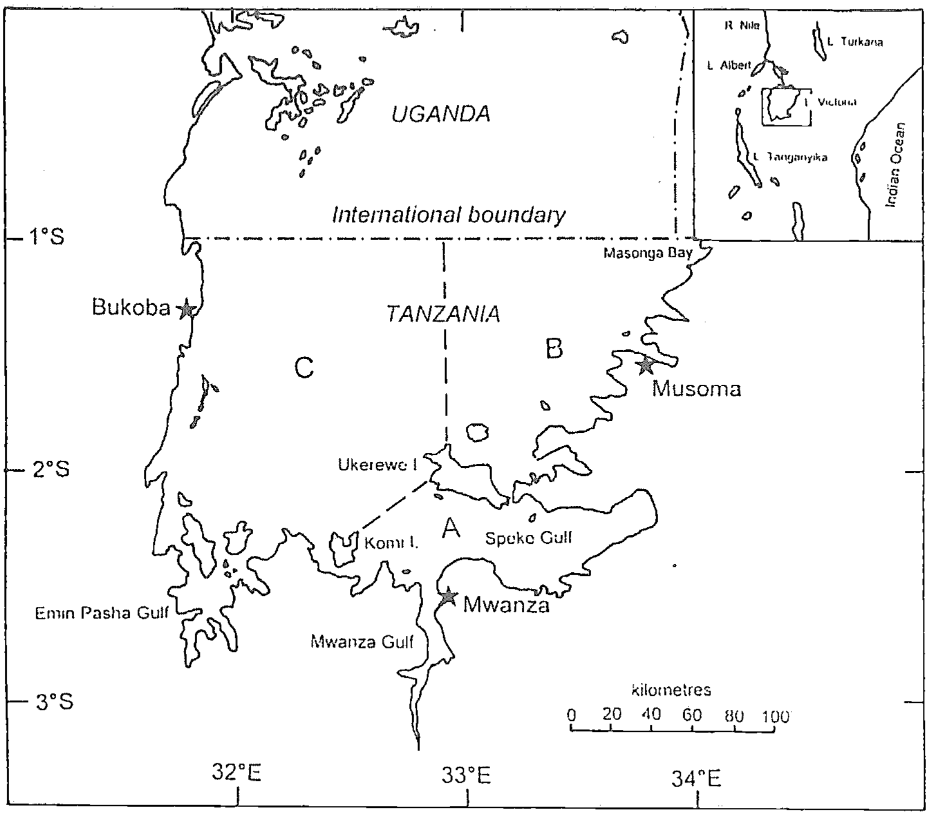

Figure 1. Map of the Tanzanian waters of Lake Victoria, showing the three areas into which the lake is divided for the trawl surveys.

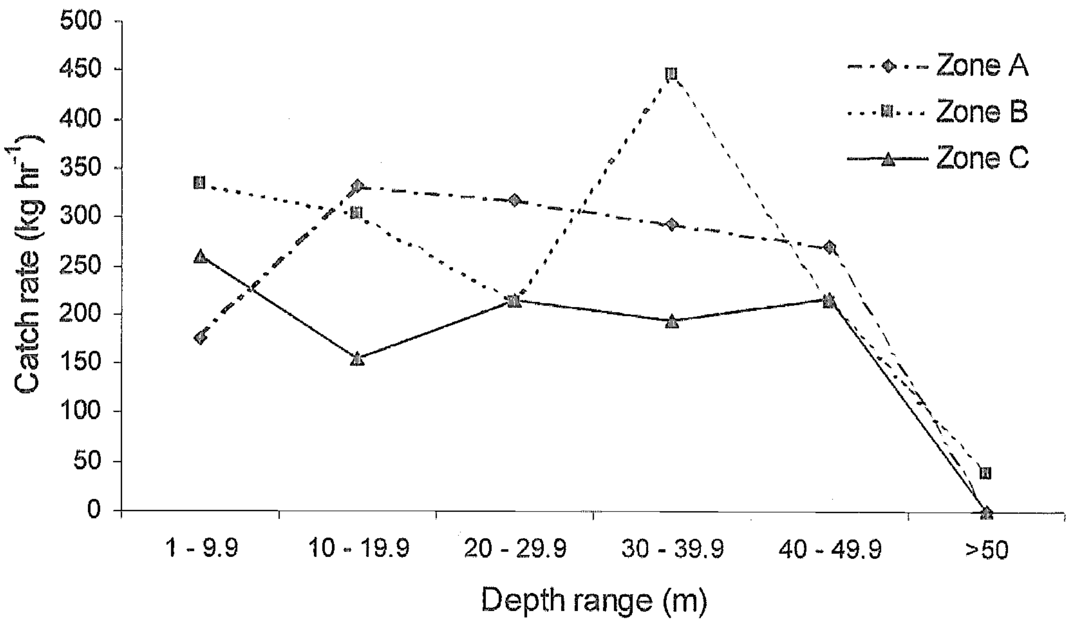

Fig. 2. Change in mean of catch rates (kg hr^{-1}) from experimental trawling in different zones of the Tanzanian waters of Lake Victoria with depth.

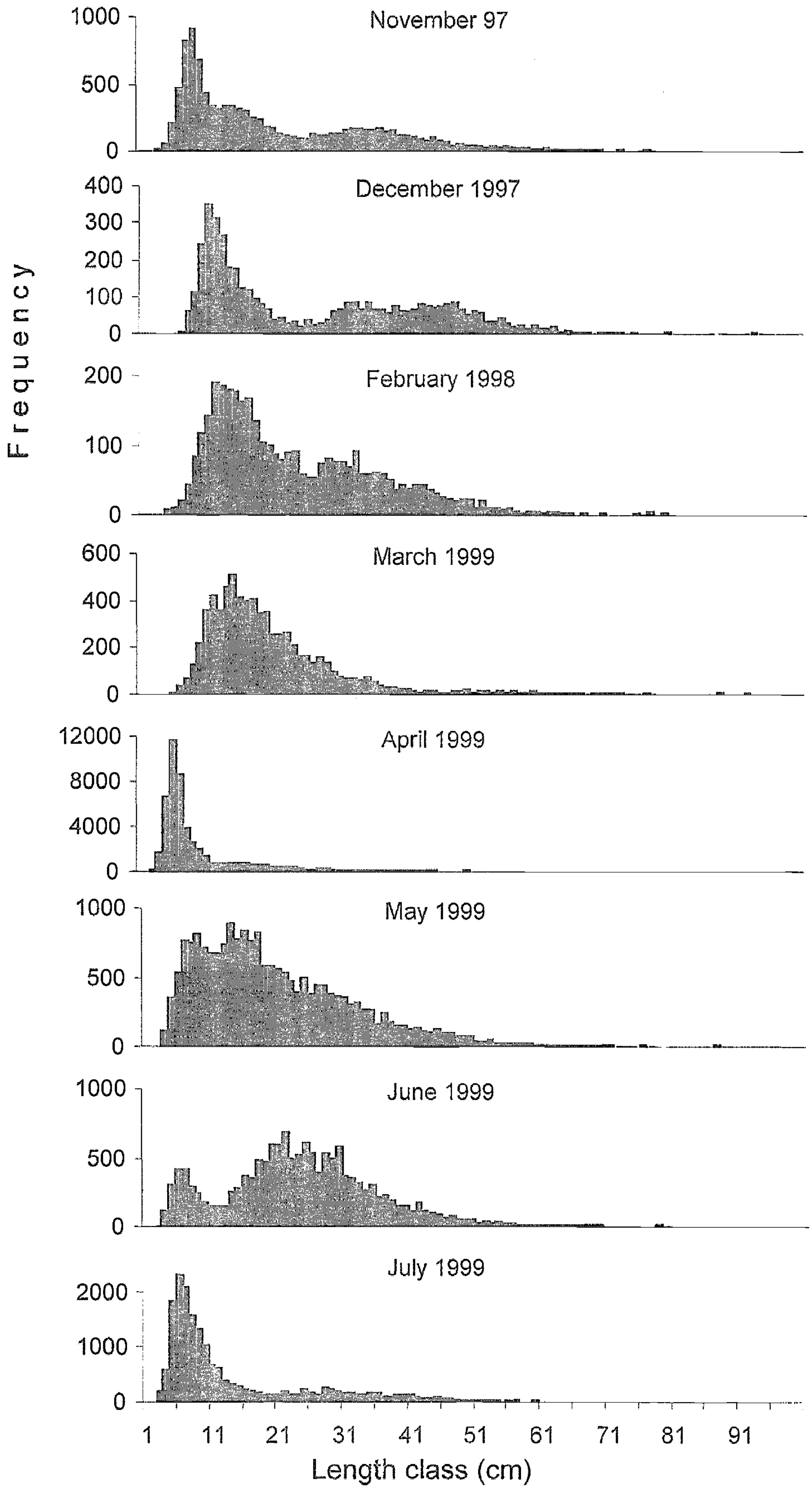

Fig. 3. Length frequency histograms of Nile Perch caught by trawling in the Tanzanian waters of Lake Victoria between November 1997 and June 1999.

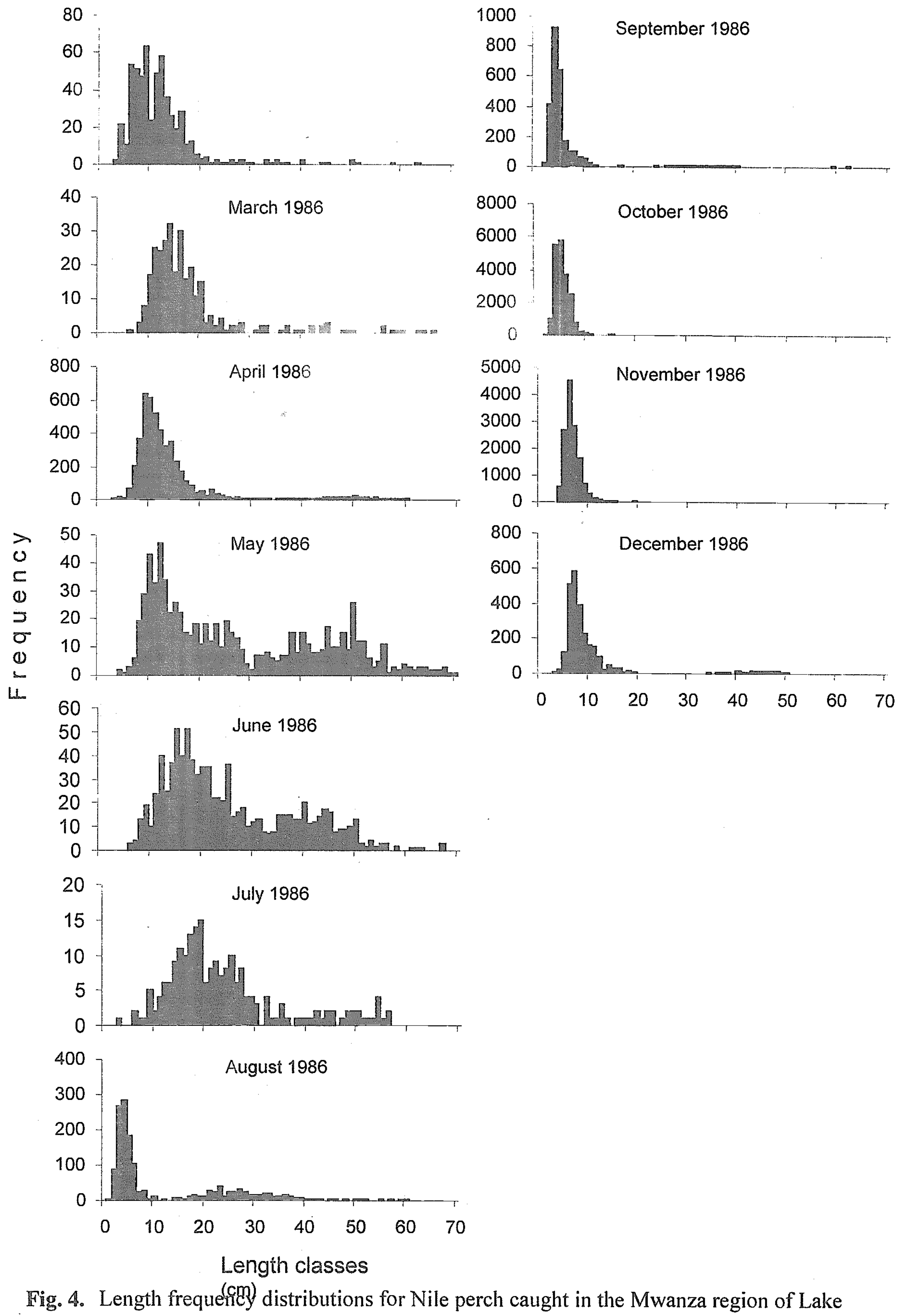

Fig. 4. Length frequency distributions for Nile perch caught in the Mwanza region of Lake Victoria in 1986 (Data source HEST unpublished).

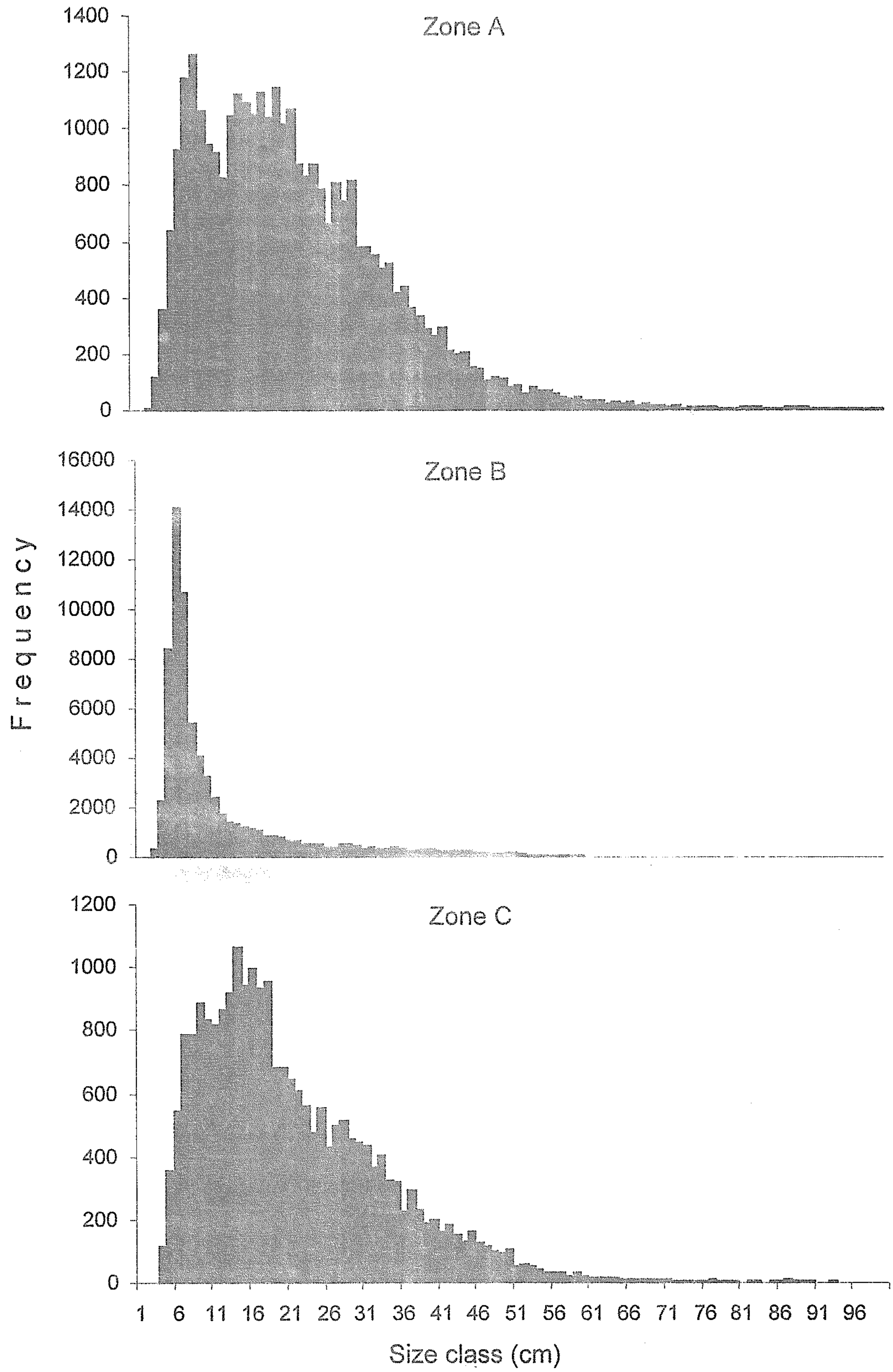

Fig. 5. Length frequency distributions for *Lates niloticus* from bottom trawling in three zones of Lake Victoria, Tanzania, November 1997 to June 1999.

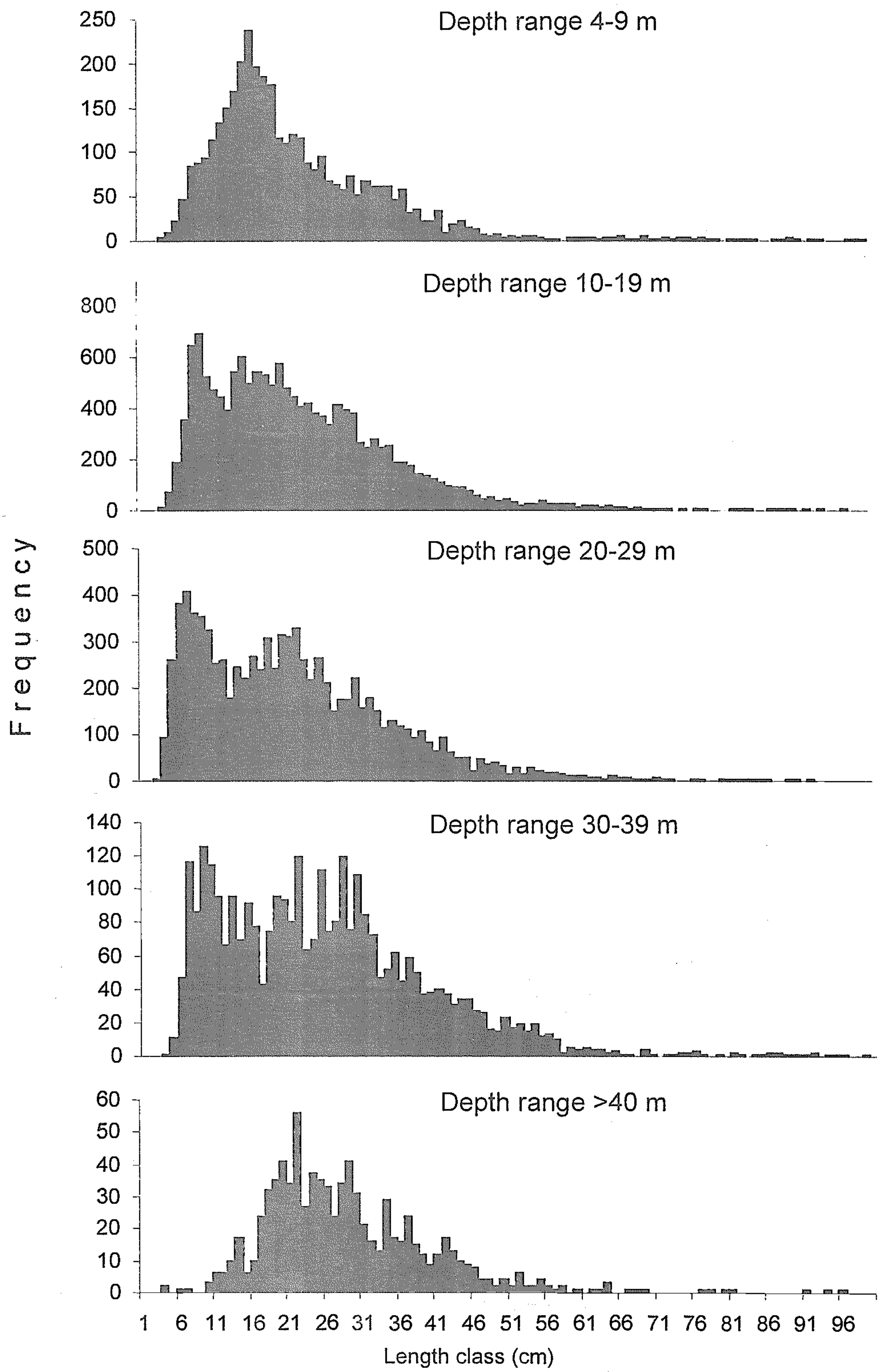

Fig. 6. Length frequency distributions for *Lates niloticus* from bottom trawling in different depths of Lake Victoria, Tanzania - Zone A, November 1997 to July 1999.

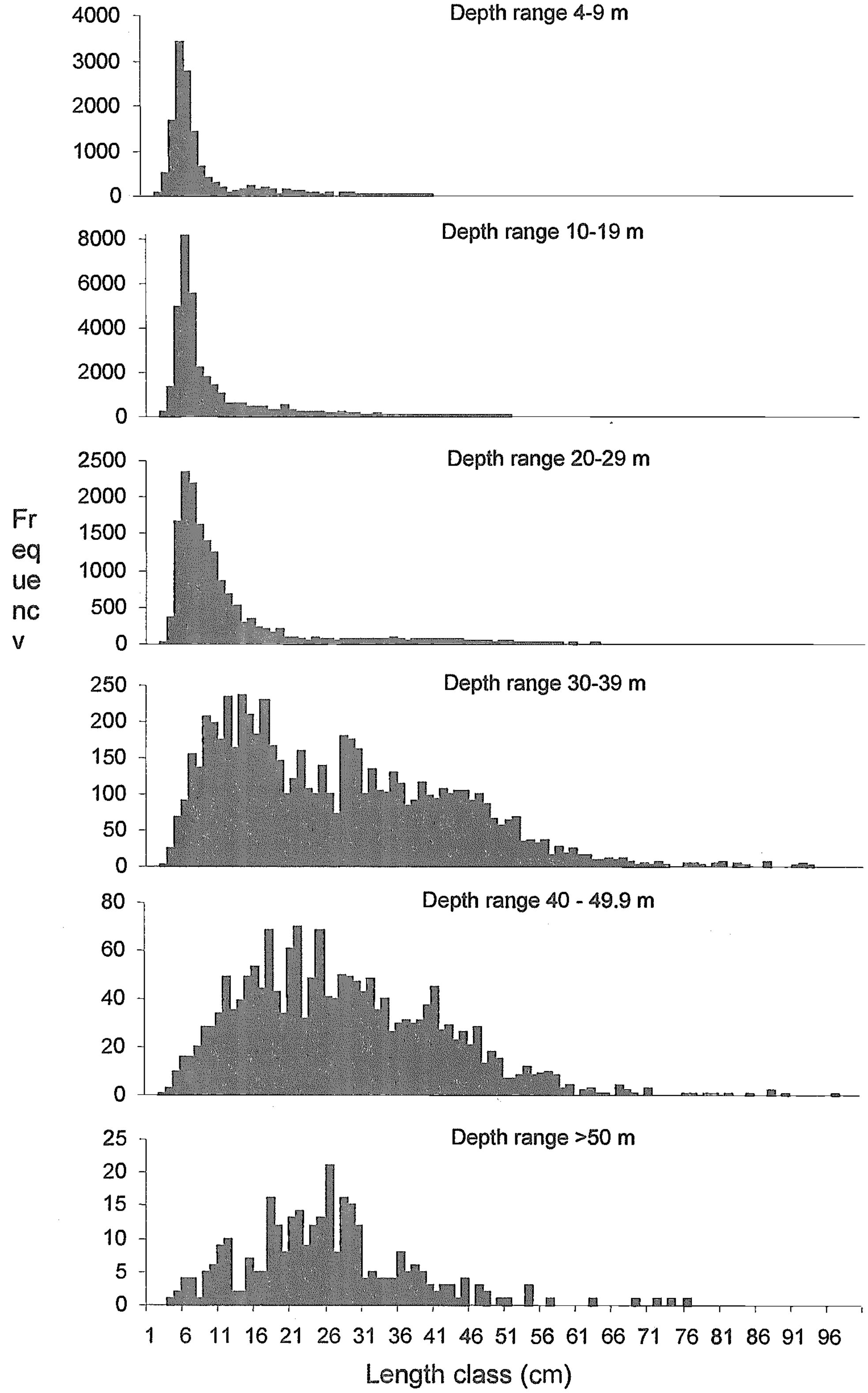

Fig. 7. Length frequency distributions for *Lates niloticus* from bottom trawling in different depths of Lake Victoria, Tanzania - Zone B, November 1997 to July 1999.

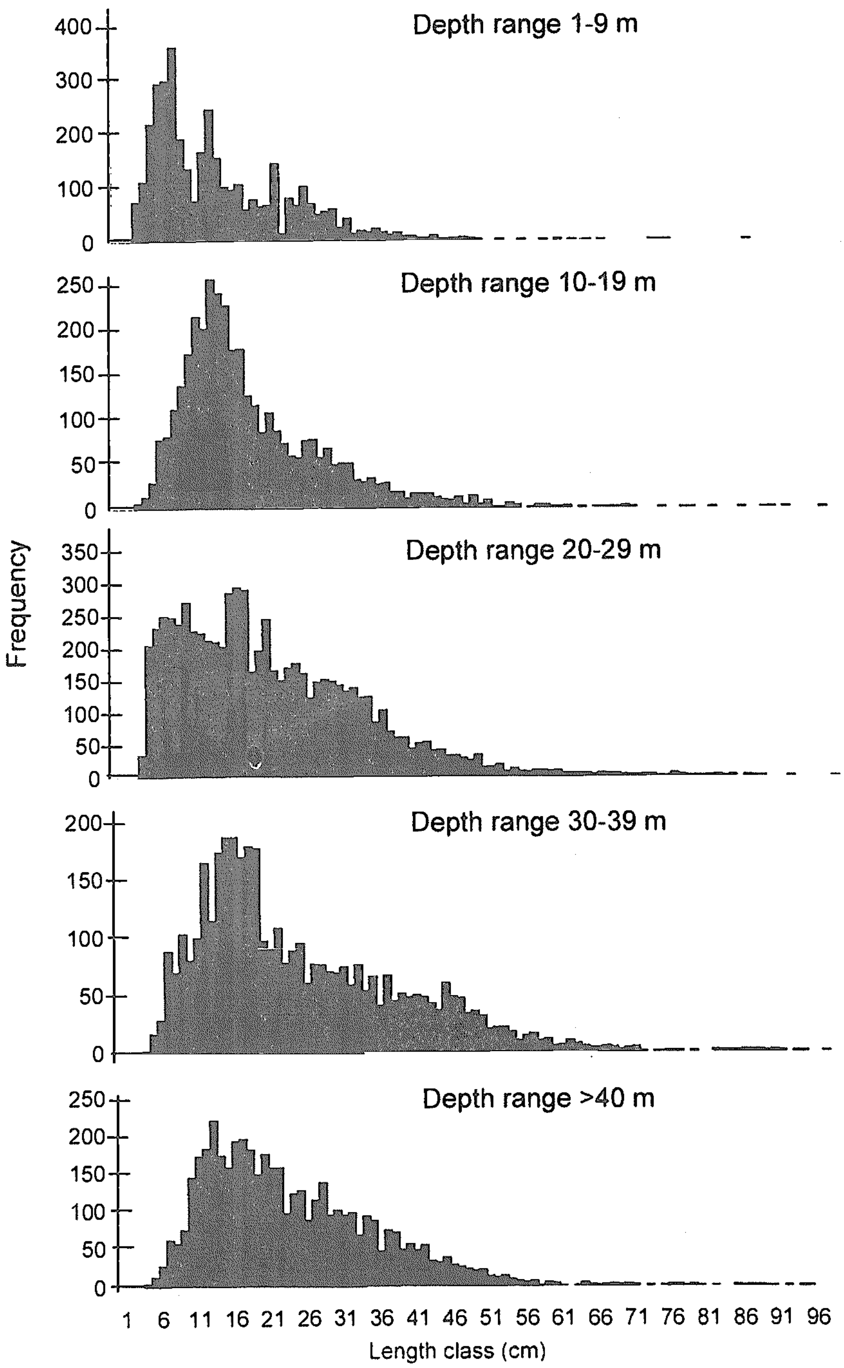

Fig. 8. Length frequency distributions for *Lates niloticus* from bottom trawling in different depths of Lake Victoria, Tanzania - Zone C. November 1997 to July 1999.

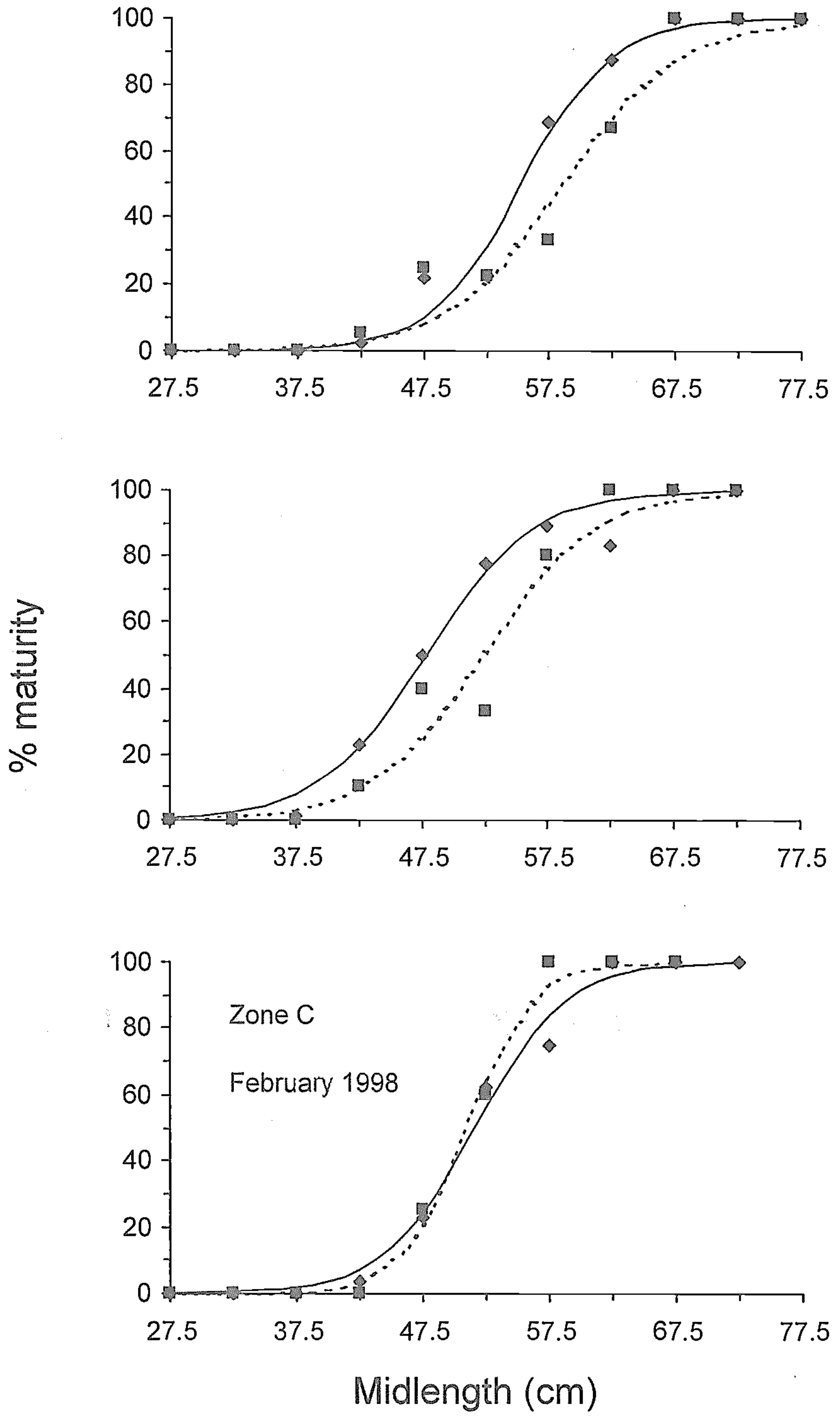

Fig. 9. Length at matuirity (Lm50) for male (solid line and diamond symbols) and female (dashed line and square symbols) Nile perch in different zones of Lake Victoria in Tanzania.

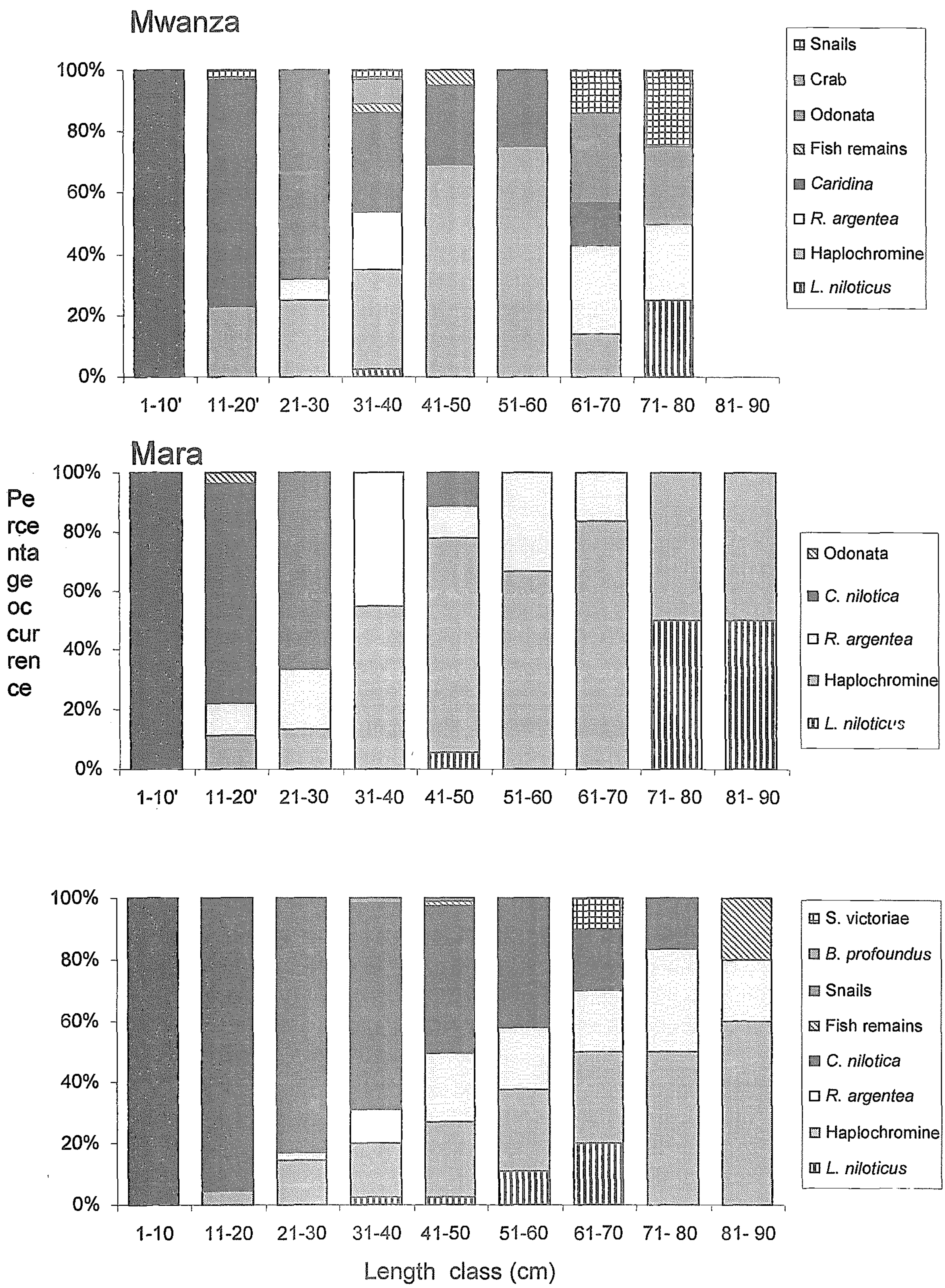

Fig 10. Percentage composition of the diet of Nile perch of different size groups from three zones (Mwanza, Mara, Kagera) of Lake Victoria in Tazania