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PAST TRENDS, PRESENT STOCKS AND POSSIBLE FUTURE STATE OF THE FISHERIES OF THE TANZANIA PART OF THE LAKE VICTORIA

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ABSTRACT
The Tanzania part of Lake Victoria is the most important single fishery resource for the country. Past fishing practices caused disparity between the relative abundance in the catches and in the available stocks by over-fishing some species while under-fishing others. Preliminary studies of distribution pattern. biomass estimates, etc, as derived from bottom trawl exploratory data, and the trend of the commereial catch statistics from 1958 to 1970, suggest that many of the commercially preferred species may not have the biotic potential to sustain higher yields under present ecological and fishing regimes. *Haplochromis* and a few other fish might be the only hope. Geographic extension of fishing to deeper waters may not be very promising as species diversification and fish density decline with depth. To develop and manage the fisheries. make full use of the resource and ensure economic and biological perpetuation of the fishery, the appropriate fishing strategy cannot be properly developed overnight.

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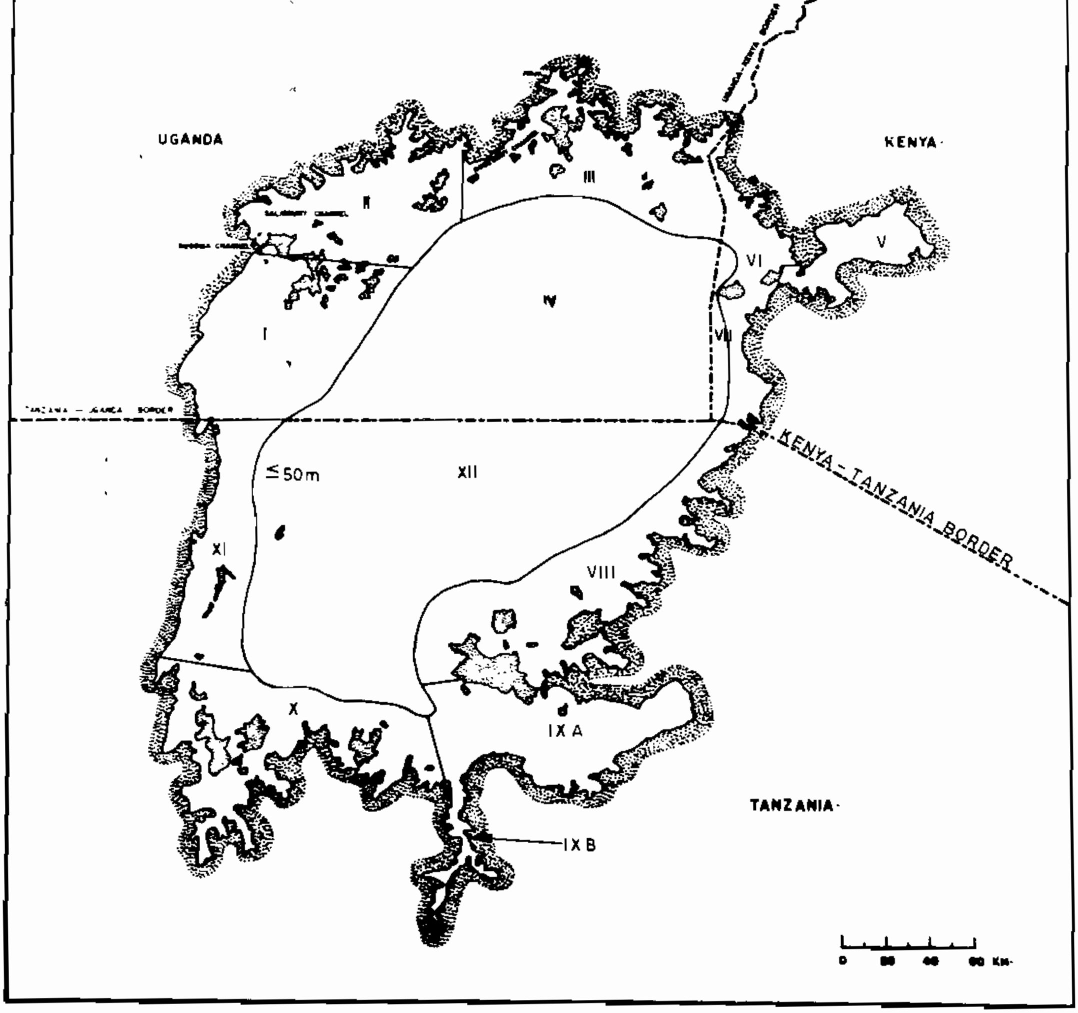
INTRODUCTION

The fisheries resources of mainland Tanzania are comprised of both marine and freshwater sources. The freshwater fisheries, however, are the more important and depend upon Lakes Victoria, Tanganyika, Rukwa, Kitangiri, and other smaller lakes, rivers, swamps, dams and domestic fishponds. Of these, the Tanzania portion of Lake Victoria, which is about 51% of the whole lake area, is the most important single fishery. Its total production was 57% of all the fish caught in the mainland Tanzania in 1965, though only 41.9% in 1968 (TANZANIA ANNUAL REPORTS). It is biologically more productive and contains probably more than 60% of the Lake Victoria's demersal ichthyomass.

The Lake Victoria fisheries of Tanzania depend on two main fishes. These are *Bagrus*, which is more important in the western part of the lake and consistently constitutes around

Fig.1. LAKE VICTORIA SAMPLING AREAS



30% of the total commercial catch with 127 mm and 114 mm gillnet mesh-sizes, and *Tilapia*, whose landings are more important in the southern and eastern parts. The current commercial fishing is mostly by nylon gill-nets and beach seine nets, long lines, fish traps, etc., operated from sail or paddle propelled canoes. Other canoes are motored with outboard engines. The distribution of fresh fish is constrained by lack of adequate and rapid transport and by limited organization in storing, handling, processing and marketing practices.

The trend of the fishery over the last 70 years or so has been increased total fishing intensity, geographical expansion to more and more offshore waters, and decreasing catch rates. The fishes known to have been greatly affected by over-fishing include *Labeo victorianus* (GARROD 1961 and CADWALLADR 1969) and *Tilapia esculenta* (GRAHAM 1929 and GARROD, *op. cit.*). Attempts to forestall continued decreasing catch rates included prohibition of small-mesh gill nets, a search for new fishing grounds and new fishing methods, introduction of exotic *Tilapia* (*zillii*, *nilotica* and *leucosticta*) and *Lates niloticus* into the lake, and construction of domestic fishponds. Though such measures have been helpful they have not been successful enough to prevent further decline in catch rates. On the other hand, while catch rates of certain species had been declining, large quantities of under-harvested *Haplochromis* stocks were believed to abound in the lake. Thus, there appears a need for changes in fishing strategy so that the harvest would quantitatively and qualitatively represent available stocks, yet remain within the biological prosperity and economic profitability of the fisheries.

This needed knowledge on the distribution pattern, magnitude and relative abundance of the available stocks which was still lacking by 1967. Hence, the recent exploratory survey of Lake Victoria was geared towards this goal. Details of the materials and methods used in carrying out the survey are given by BERGSTRAND and CORDONE (1971). A general assessment of the fish stocks for the whole lake in relation to possible geographical expansion and technological improvement of commercial fisheries are discussed by KUDHONGANIA and CORDONE (1972). The present report deals with the exploratory survey results of the Tanzania portion as compared with the commercial catch statistics. Recent trends in the various fish catches and their possible future are also considered.

RESULTS

The Tanzania portion of Lake Victoria was sub-divided into 6 sub-areas (VIII-XII) as indicated in Figure. 1. Each area was subsequently stratified by 10 m depth intervals. The distribution of the bottom trawl sampling effort (i.e. number of hourly hauls made) by sub-area and depth stratum is shown in Table 1.

Although there was disproportionality, both in time and space, in our sampling pattern, broad coverage was achieved and the data are considered adequate for several considerations. Our general findings for each of the 6 sampling sub-areas follow below.

Area VIII

This area is from Kenya-Tanzania border to Ukerewe Islands, and the waters are less than 50 m deep. It is generally characterized by having a mud bottom which is hard in some bays (e.g. Suguti Bay). In a few places such as in Musoma region, gravel and sandy beaches are found. There are several papyrus swamps in the gulfs. The area is rich in plankton in the gulfs and bays but rather poor in the deep waters not far from the shore. The total dissolved solids (TDS) expressed as mg/l of $CaCO_3$ is between 80 and 97.

According to the Tanzania annual catch statistics, the major fishes landed at the

Table 1. Distribution of Exploratory Sampling effort[1]

Area	VIII	IXA	IXB	X	XI	XII	Total
Depth (m)	Hauls made:						
4–9	13 (10)	17 (17)	53 (20)	9 (8)	*	—	92 (55)
10–19	28 (26)	35 (31)	18 (9)	32 (26)	3 (3)	—	116 (95)
20–29	35 (27)	23 (22)	—	6 (6)	12 (12)	—	76 (67)
30–39	15 (15)	10 (8)	—	1 (0)	13 (9)	—	39 (32)
40–49	13 (13)	7 (6)	—	2 (1)	13 (12)	—	35 (32)
50–59	—	—	—	—	—	22 (20)	22 (20)
60–69	—	—	—	—	—	17 (14)	17 (14)
70–79	—	—	—	—	—	5 (5)	5 (5)
Totals	104 (91)	92 (84)	71 (29)	50 (41)	41 (36)	44 (39)	402 (320)

[1] Numbers in parentheses reflect successful hauls used in subsequent analyses.
— Does not exist in the area.
* Not sampled.

Table 2. Bottom Trawl Mean Catch Rates (Kg/Hr), by Area, of the Various Fishes in the Tanzania Waters of Lake Victoria

Area	VIII	IXA	IXB	X	XI	XII	Overall
Depth range (m)	4–49	4–49	4–19	4–49	10–49	50–79	4–79
Good hauls used: all meshes	91	84	29	41	36	39	320
38 & 19 mm only	(48)	(29)	(4)	(22)	(21)	(34)	(158)
No. of species encountered (excluding *Haplochromis* spp)	19	16	18	15	12	9	19
Haplochromis spp	584.1	560.3	548.1	880.6	610.4	360.4	426.4
Tilapia esculenta	16.3	24.4	114.4	83.1	0.9	—	12.7
T. variabilis	0.1	0.1	1.5	0.8	0.0	—	0.1
T. nilotica	0.0	0.2	24.3	3.4	—	—	1.2
T. zillii	0.0	0.0	0.0	0.2	—	—	0.0
T. leucosticta	—	—	0.0	—	—	—	0.0
Bagrus docmac	41.3	50.3	13.1	24.8	34.1	30.0	29.4
Clarias mossambicus	39.3	28.0	40.6	48.9	9.2	12.0	18.8
Xenoclarias spp	0 1	0.1	0.0	0.1	0.1	0.3	0.2
Protopterus aethiopicus	8 9	24.4	25.2	25.6	9.6	0.3	6.7
Lates niloticus	0.1	—	—	—	0.0	—	0.0
Synodontis victoriae	2 9	9.4	0.3	1.8	2.3	29.2	17.6
S. afrofischeri	0 0	0.0	0.1	0.2	0.0	0.0	0.0
Barbus altianalis	0.2	0.1	0.0	0.1	0.8	—	0.1
Labeo victorianus	0.0	0.7	0.1	0.0	—	—	0.1
Mormyrus kannume	0.6	0.3	0.3	0.0	0.4	0.1	0.2
Schilbe mystus	0.8	5.5	1.1	0.6	0.1	0.1	0.7
Alestes spp	0.0	0.0	0.0	—	—	—	0.0
Mastacembelus frenatus	0.0	0.0	—	0.0	—	—	0.0
Total:	694.7	703.8	769 1	1070.2	667.9	432.4	514.2

N.B. (i) 0.0 × less than 0.05 kg
(ii) — × nothing
(iii) For *Haplochromis* the means were derived from 38 and 19 mm data only.
(iv) The overall mean catch rates (last column) were weighted by area.

Table 3. Bottom Trawl Percentage Frequency of Occurrence, by Area, of the Fishes in the Tanzania Part of Lake Victoria

Area	VIII	IXA	IXB	X	XI	XII
Species:						
Haplochromis spp	100.0	100.0	100.0	100.0	100.0	100.0
Tilapia esculenta	65.3	74.7	100.0	93.8	29.3	—
T. variabilis	10.9	12.1	81.7	47.9	2.4	—
T. nilotica	2.0	5.5	93.0	50.0	—	—
T. zillii	3.0	1.1	1.4	8.3	—	—
T. leucosticta	—	—	5.6	—	—	—
Bagrus docmac	98.0	95.6	94.4	93 8	97.6	74.4
Clarias mossambicus	98.0	100.0	100.0	97.9	70.7	97.4
Xenoclarias spp	25.7	17.5	2.8	18.8	17.1	76.9
Protopterus aethiopicus	53.5	61.5	97.2	85.4	65.9	2.6
Lates niloticus	1.0	—	—	—	2.4	—
Synodontis victoriae	81.2	94.5	43.7	62.5	61.0	97.4
S. afrofischeri	22.8	17.6	28.2	4.2	22.0	17.9
Barbus altianalis	7.9	9.9	—	4.2	17.1	—
Labeo victorianus	10.9	25.3	21.1	16.7	—	—
Mormyrus kannume	13.9	11.0	19.7	4.2	9.8	10.3
Schilbe mystus	64.4	82.4	40.8	35.4	39.0	33.3
Alestes spp	1.0	—	1.4	—	—	—
Mastacembelus frenatus	6.9	1.1	4.2	2.1	—	—

Table 4. Total Mean Catch Rates (Kg/hr), by Depth Zone and Area, From Bottom Trawling in the Tanzania Waters of Lake Victoria

Area	VIII	IXA	IXB	X	XI	XII	Total Mean
Depth Zone (m)							
4– 9	697.2	1009.8	796.3	705.6	*	—	833
10–19	920.4	1066.0	699.0	1210.5	979.1	—	1047
20–29	724.5	394.3	—	937.6	616.8	—	672
30–39	569.6	126.4	—	*	754.9	—	612
40–49	506.8	86.2	—	*	556.9	—	458
50–59	—	—	—	—	—	599.4	599
60–69	—	—	—	—	—	332.7	333
70–79	—	—	—	—	—	55.0	55

*Good hauls not available.

various beaches in this region include *Haplochromis* spp., *Tilapia* spp., *Clarias, Protopterus, Bargus* and *Synodontis.* Musoma has been one of the leading landing places for *T. esculenta.* The Nile perch *(Lates niloticus),* introduced in northern part of Lake Victoria around 1960, is alleged to have been landed for the first time from the Tanzania waters of the lake at Musoma on 10th August 1963.

During the exploratory survey 104 hauls were made and 19 species (excluding the *Haplochromis* taxon) were encountered in this area. The total mean catch rates are shown in Table 2, the mean catch rates by depth are shown in Table 4 and the per cent frequency of occurrence are shown in Table 3. These tables show data for all the areas. The most significant fishes here were *Haplochromis* (84.1% of total weight), *Bagrus docmac* (5.9%), *Clarias mossambicus* (5.7%), *Tilapia esculenta* (2.3%), *Protopterus aethiopicus* (1.3%) and *Synodontis victoriae* (0.4%). Other species formed a total of 0.3% of the total weight. The relative frequency of occurrence of each of the more significant species was more than 50%. *Lates* was encountered only in areas VIII and IX of the Tanzania waters and only on a few occasions. It was encountered more often in the northern part of the lake. However, though *Lates* has spread to most of the inshore waters of the lake, its success in Lake Victoria has not been as significant as it was in Lake Kioga.

Area IXA

Speke Gulf is generally deep with mud and sand bottoms. There are a few bays and several papyrus swamps but the shoreline is not very irregular. The few affluent rivers are dominated by Ruwana. The TDS is between 80-97 but the eastern half of the gulf, which is known to be a good fishing ground, is richer in plankton than the western half. Apart from the major commercial species of Lake Victoria, *Schilbe mystus* (a very popular fish in this region) is also landed in commercial quantities from the gulf.

From our bottom trawl catches, the most significant fishes were *Haplochromis* (79.6%), *Bargus docmac* (7.1%), *C. mossambicus* (4.0%), *T. esculenta* and *P. aethiopicus* (3.5% each), *S. victoriae* (1.3%) and *Schilbe mystus* (0.8%). The frequency of occurrence of these fishes was more than 60%. The rest of the other species encountered formed only 0.2% of the total weight and, except for *Labeo,* the frequency of occurrence was less than 20% for each of them. The gulf appeared to be good fishing ground in the shallow waters (0-20 m) but the catches dropped off suddenly in the deeper waters. This area yielded the highest mean catch rates for *Bagrus, Labeo* and *Schilbe.* Although only a total of 375 specimens of *Labeo* was landed (with a record catch of 2.4 kg in an hour tow in the 10-19 m zone) and though most of the *Schilbe* caught were small, this area seemed to possess the highest population densities of *Labeo, Schilbe* and *Alestes* spp. for the whole lake. The three taxa command a high degree of popularity on the markets, but have become very rare in commercial catches made in several other areas, particularly in the northern part of the lake. It appears very necessary to prevent overfishing of these species in this gulf, which could act as a nucleus for the biological survival and economic catch rate rebirth of these fishes.

Area IXB

Mwanza Gulf is shallow, elongate and narrow and has a very irregular shoreline. Its maximum depth is less than 20 m. It is very rich in nutrients and the O_2-concentration is at full saturation most of the time. The TDS is between 80-97. The bottom is mostly mud which is soft in several places, and the shore is often fringed with papyrus swamps. It is characteristically a habitat of high productivity.

Mwanza has been one of the major fish landing centres. It is famous for its *T. esculenta,* particularly from the prolific Smith Sound region. The gillnet was first introduced in the Tanzania part of the lake at Mwanza in 1908 (GRAHAM, *op. cit.*). Then, the *Tilapia* catches were said to be 80-100 fish per net and constituted 60% of the total catch (by weight). But this was reduced to 25% in 1958 and, following the removal of mesh restrictions in 1957 and unrestricted use of seine nets, to only 8% by 1959 (TANZANIA ANNUAL REPORTS). It has been a relatively good fishing ground for other *Tilapia, Protopterus* and *Clarias.*

The results of 71 bottom trawl hauls made in this area suggest that this gulf is generally a good fishing ground though the catches were sometimes reduced due to substantial amounts of mud picked up in the trawl. All the 5 *Tilapia* spp. were encountered but *T. esculenta, nilotica* and *variabilis* were more significant than observed elsewhere in the lake. The preponderance of the *Haplochromis*, which forms more than 80% of the lake's ichthyomass harvestable by bottom trawling, was obscured by the unusually high catches of *T. esculenta.* This was the only area in the lake where *T. esculenta* occurred in every haul that was made. The mean catch rates (kg/hr) for *Haplochromis* and *T. esculenta* are compared below for each depth zone.

	Depth zone	
Taxon	4—9	10–19
T. esculenta	145.7	44.7
Haplochomis	84.4	245.3

In the 4-9 m zone *T. esculenta* catches were always higher than the *Haplochromis* catches whenever large codend mesh sizes (57 mm and over) were used. The *T. esculenta* record hourly catches were 330.0 kg in the 4-9 m zone and 153.0 kg in the 10-19 m depths.

The overall significance, by weight, of the major species (but using only small mesh codend data for the *Haplochromis* taxon) was: *Haplochromis* (71.3%), *T. esculenta* (14.9%), *C. mossambicus* (5.3%), *P. aethiopicus* (3.3%), *T. nilotica* (3.2%), *B. docmac* (1.7%) and the rest (0.3%). It should be pointed out that although generally higher catches than elsewhere were recorded for *T. esculenta, C. mossambicus* and *P. aethiopicus*, most of the specimens caught in this area were generally smaller than observed anywhere else in the lake. This area, though very productive, is likely to have been overfished. *Bagrus,* whose catches are best in waters of intermediate depths of 10-50 m range, had its lakewide poorest catches in this area (probably because the gulf is muddy and shallow). It is rather unfortunate that *Labeo* trawl catches constituted only about 0.01% of the total when it is remembered that gillnet catches of this fish were 12.8 fish per net in 1956, and constituted 10.5% of the Mwanza total landing in 1958 (TANZANIA ANNUAL REPORTS).

Area X

This is the area between Mwanza Gulf and Igusa channel in waters less than 50 m deep. The shoreline is serrated by a gulf and numerous large and small bays. The area is characterised by many islands and channels, and the few affluent rivers are small. There are many papyrus swamps and the bottom is mud with gravel in some areas. The area is very rich in plankton and O_2-concentration is near saturation most of the time. The TDS is in the range of 80-97. Though potentially a good fishing ground, Commercial fishing in this area is rather limited by the poor transport facilities so that fishing incentive has remained lower than in other equally good fishing grounds.

Results from 50 bottom trawl drags made in this area suggest that it is one of the best fishing grounds in the lake. The most important fishes were *Haplochromis* (82.3%), *T. esculenta* (7.8%), *C. mossambicus* (4.6%), *P. aethiopicus* (2.4%) and *B. docmac* (2.3%). The mean hourly catch rates of each of these fishes exceeded 20.0 kg and the frequency of occurrence was more than 90%. It should be pointed out that this area was the second to Mwanza Gulf in yielding high *T. esculenta* catches. But unlike the *Tilapia* caught from Mwanza Gulf, many of the fish here were much larger and a few appeared to be "senile". This is not surprising for an area with relatively low fishing intensity.

Area XI

This is the area between Igusa Channel and Tanzania-Uganda' border in waters less than 50 m deep. It is characterised by an almost straight shoreline with very few bays that don't extend much into the land. Thus poorly sheltered, it is wide open to wind action. There are a few small affluent rivers and the bottom is mostly mud in the south but sandy with some rocks in the north. It is relatively poor in plankton though rather rich close to the shore.

Bukoba, one of the best fish landing places in the Tanzania waters of the lake, is located in this area. It is characteristically a *Bagrus* fishery where the *Bagrus* catch per net was 5 fish in 1927 (GRAHAM, *op. cit.*), 2.8 fish in 1960 and formed 30% of the total landing in 1964 (TANZANIA ANNUAL REPORTS).

No experimental fishing was done in the 0-10 m zone. Results of 41 tows made in the 10-49 m depth range suggest that the most important fishes in this area are *Haplochromis* (91.4%), *B. docmac* (5.1%) and *Clarias* and *Protopterus* (1.4% each). It is rather poor in *Tilapia* as reflected from our fishing results and from commercial catch statistics. Our catch results may have given unrealistic relative abundance data for *Tilapia* and *Protopterus*, because shallow waters (0-10 m) where these fish are expected to be more concentrated, were not sampled. The habitat type of this area, however, does not seem to favour the abundance of these taxa.

Area XII

This is the central section of the deep waters (50-79 m) and forms about 56% of the Tanzania part of Lake Victoria. There are two major, though small, islands in the area: Bukerebe (Alice) and Godziba islands. The bottom is mud and the waters have a generally sparse plankton density though when the lake is thermally stratified (October to mid-June) the bulk of the water is the more or less nutrient-rich hypolimnion (KITAKA 1971).

It is reasonable to assume that this area has not been commercially fished to any extent. Any virgin stocks in the lake would be expected to be found in such an area. However, the results of 44 bottom trawl hauls made in these waters indicate that species diversification and fish population density are much reduced. Only 9 taxa were encountered and of these, only 4 occurred in the deepest zone (70-79 m). The important fishes in the area were *Haplochromis* (83.3%), *B. docmac* (6.9%), *S. victoriae* (6.8%) and *C. mossambicus* (2.8%). No *Tilapia* were encountered and only 2 specimens of *P. aethiopicus* were caught from this area (in the 50-59 m depth zone). Catch rates of *S. victoriae* became increasingly higher with increasing mean depth, but appeared best in the 40-69 m depth range. Other bathymetrically eurytopic fishes in the lake (*Haplochromis*, *B. docmac*, *C. mossambicus* and *Xenoclarias*) became less significant in the deep waters particularly in the deepest zone (see Table IV). Thus, the fair catches from

Table 5. Total Mean Catch Rates by Depth for the Whole Tanzania Section of Lake Victoria

Depth (m)	4–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79
No. of hauls used	59	95	52	32	31	20	14	5
Species:								
Haplochromis spp	628.0	884.6	551.5	534.4	397.5	525.6	242.4	38.9
Tilapia esculenta	89.0	46.4	9.9	0.7	—	—	—	—
T. variabilis	1.1	0.3	0.0	0.0	—	—	—	—
T. nilotica	12.2	1.5	—	—	—	—	—	—
T. zillii	0.4	0.0	—	—	—	—	—	—
T. leucosticta	0.0	—	—	—	—	—	—	—
Bagrus docmac	23.2	44.2	52.9	40.1	30.6	33.4	35.7	0.0
Clarias mossambicus	34.9	43.2	39.9	21.7	14.9	12.9	13.0	5.4
Xenoclarias spp	0.0	0.0	0.2	0.2	0.3	0.5	0.2	0.0
Protopterus aethiopicus	41.3	19.3	8.6	5.7	1.7	0.7	—	—
Lates niloticus	—	0.1	0.0	—	—	—	—	—
Synodontis victoriae	0.6	2.5	5.7	8.2	12.0	26.1	40.4	10.7
S. afrofischeri	0.0	0.1	0.0	0.0	0.0	0.0	0.0	—
Barbus altianalis	0.1	0.2	0.3	0.4	0.2	—	—	—
Labeo victorianus	0.2	0.6	0.0	—	—	—	—	—
Mormyrus kannume	0.7	0.4	0.2	0.4	—	0.1	0.0	—
Schilbe mystus	1.6	3.3	2.8	0.7	0.3	0.1	0.0	—
Alestes spp	0.0	—	—	—	—	—	—	—
Mastacembelus frenatus	0.0	0.0	0.0	—	—	—	—	—
Total	833.0	1046.7	672.0	612.5	457.5	599.4	331.7	55.0

Table 6. Species Percentage Frequency of Occurrence by Depth Interval During Bottom Trawling in the Tanzania Waters of Lake Victoria

Depth Interval (m)	4–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79
Species:								
Hiaplochromis spp	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Tlapia esculenta	100.0	92.9	73.1	28.1	3.1	—	—	—
T. variabilis	70.9	34.7	3.0	1.5	—	—	—	—
T. nilotica	56.4	32.7	—	—	—	—	—	—
T. zillii	9.1	2.0	—	—	—	—	—	—
T. leucosticta	7.3	—	—	—	—	—	—	—
Bagrus docmac	98.2	96.9	97.0	100.0	90.6	85.0	85.7	3.0
Clarias mossambicus	100.0	100.0	91.0	100.0	90.6	100.0	92.9	100.0
Xenoclarias spp	1.8	7.1	26.9	43.8	62.5	70.0	92.9	60.0
Protopterus aethiopicus	100.0	83.7	64.2	43.8	15.6	5.0	—	—
Lates niloticus	—	1.0	1.5	—	—	—	—	—
Synodontis victoriae	58.2	76.5	91.0	90.6	96.9	95.0	100.0	100.0
S. afrofischeri	27.3	19.4	34.3	18.8	21.9	30.0	7.1	—
Barbus altianalis	5.5	9.2	10.4	9.4	6.3	—	—	—
Labeo victorianus	38.2	25.5	16.4	—	—	—	—	—
Mormyrus kannume	25.5	20.4	10.4	9.4	—	10.0	14.3	—
Schilbe mystus	65.5	65.3	79.1	71.9	53.1	40.0	35.7	—
Alestes spp	1.8	—	—	—	—	—	—	—
Mastecembelus frenatus	9.1	5.1	3.0	—	—	—	—	—

this area consisted mostly of *Haplochromis, Bagrus, Clarias* and *S. victoriae*, and were generally made from the 50-59 m zone. Thus, most of the deep section of the lake is poor in demersal fish productivity and diversity.

Estimates of the Demersal Ichthyomass

Data for all the 6 areas were combined. The total mean catch rates by depth zone for each species are given in Table 5 and the corresponding percentage frequency of occurrence are given in Table 6. The mean catch rates were used to estimate the demersal ichthyomass of each depth stratum. We used the methods outlined by ALVERSON and PEREYRA (1969); and, as applied to Lake Victoria data, by KUDHONGANIA and CORDONE *(op. cit.)*.

The biomass estimates are presented in Table 7 which shows the standing stocks of each species by depth zone, the total ichthyomass for the Tanzania part of the lake, the density of the fish (mean kg/ha) and the relative abundance of each species given as per cent of the total weight. It is seen that *Haplochromis* constitutes more than 80% of the total demersal ichthyomass harvestable by trawls. The order of significance by taxa was *Haplochromis* (85.3%), *Bagrus docmac* (5.7%), *Clarias mossambicus* (3.7%), *Synodontis victoriae* (3.4%), *Tilapia esculenta* (2.5%) and *Protopterus aethiopicus* (1.3%). However, the significance of *Tilapia* spp. and *Protopterus* may have been underrated because our sampling did not cover the 0-4 m depths where these fish might have been more concentrated.

It might be pointed out that ¼ of the Tanzania waters of the lake (0-29 m section) carries nearly 50% of the estimated ichthyomass whereas 56% of the area (50-79 m range) carries only 36% of the demersal fish biomass. The area percentages and corresponding biomass proportions for each depth zone are also shown in Table 7. It is evident that with bottom trawling, the deep waters are very poor indeed. Thus, geographical expansion of fishing to deeper waters may not be very encouraging as there are fewer species at lower densities. *S. victoriae* which is more abundant in deep waters, *Haplochromis* which is ubiquitous, though at lower densities in the 60-79 m range, and *B. docmas and C. mossambicus* are the only fishes to be expected in commercial quantities from the deep waters of the lake.

Potential Yield for Haplochromis

The *Haplochromis* biomass (i.e. fish of harvestable size of at least 5.0 cm, Lt) of approximately 320,000 metric tons was used to derive a preliminary estimate of the potential yield. We used GULLAND'S (1970) approximate model for estimating potential yield from data on virgin ichthyomass. How the model was applied to the *Haplochromis* in Lake Victoria is explained by KUDHONGANIA and CORDONE *(op. cit.)*. The potential yield for *Haplochromis* in the Tanzania waters of the lake is roughly 114,233 metric tons as compared with the annual harvests for 1958-1970 given in Table 8 as derived from the Tanzania Fisheries Annual reports. Much higher *Haplochromis* catches could probably be sustained.

Past Trends of the Commercial Catches in Relation to Present Biomass Estimates and Possible Future Yields

The annual commercial catch estimates from the Tanzania part of Lake Victoria between 1958-1970 are reproduced, from the Tanzania Fisheries Annual Reports, in Table 8. Other relevant parameters are also given. Total catches, estimated number of fishermen and *T. esculenta* catches for each year are plotted in Fig. 2a (right hand side). Fluctuations were intuitively smoothed out to yield the curves indicated on the left hand side of Fig. 2a. There does not appear to be a relationship between the number of fishermen and the catches.

Table 7. Fish Biomass Estimates, for the Tanzania Waters of Lake Victoria, from Bottom Trawl Catch Data

Depth interval (m)	0–9[1]	10–19	20–29	30–39	40–49	50–59	60–69	70–79	Total	%	Mean
Area (ha)	309060	340300	301040	274930	438570	698360	773810	631420	3767490		Kg/ha
% of total area	8.2	9.0	8.0	7.3	11.6	18.5	20.5	16.8			
Species:											
Haplochromis spp	38817.8	68931.2	33415.4	29384.5	34752.3	73411.6	37669.1	4899.9	321281.8	82.94	85.28
Tilapia esculenta	5903.0	3158.0	469.6	38.5	0.0	—	—	—	9569.1	2.47	2.54
T. variabilis	68.0	20.4	0.0	0.0	—	—	—	—	88.4	0.02	0.02
T. nilotica	809.7	102.1	—	—	—	—	—	—	911.8	0.24	0.24
T. zillii	6.2	0.0	—	—	—	—	—	—	6.2	0.00	0.00
Bagrus docmac	1532.9	3008.3	2510.7	2204.9	2684.0	4665.0	5525.0	—	22130.8	5.71	5.87
Clarias mossambicus	2311.8	2940.2	1890.5	1193.2	1306.9	1801.8	2011.9	681.9	14138.2	3.65	3.75
Xenoclarias spp	0.0	0.0	6.0	11.0	26.3	69.8	31.0	0.0	144.1	0.04	0.04
Protopterus aethiopicus	2738.3	1313.6	409.4	313.4	149.1	97.8	—	—	5021.6	1.30	1.33
Lates niloticus	—	6.8	0.0	—	—	—	—	—	6.8	0.00	0.00
Synodontis victoriae	43.3	177.0	270.9	450.9	1052.6	3645.4	6252.4	1363.9	13256.4	3.42	3.52
Barbus altianalis	6.2	13.6	18.1	22.0	17.5	—	—	—	77.4	0.02	0.02
Labeo victorianus	12.4	40.8	0.0	—	—	—	—	—	53.2	0.01	0.01
Mormyrus kannume	49.4	27.2	6.0	22.0	—	14.0	0.0	—	118.6	0.03	0.03
Shilbe mystus	111.3	224.6	132.5	38.5	26.3	14.0	0.0	—	547.2	0.14	0.15
Total Biomas	52410.3	79963.8	39129.1	33678.9	40015.0	83719.4	51489.4	6945.6	387351.6	99.99	102.80
% of total biomass	13.5	20.6	10.1	8.7	10.3	21.6	13.3	1.8			
Mean Kg/ha	169.6	235.0	130.0	122.5	91.2	119.9	66.5	11.0			

Table 8. Annual Commercial Landings (in Metric Tons) from The Tanzania Waters of Lake Victoria

Year	1958	1959	1960,61	1962	1963	1964	1965	1966	1967	1968	1969	1970	average Catch/ Year	%
Species:														
Haplochromis spp	4736	4219	2490	2985	7452	3964	2631	1928	14471	21063	20527	17716	8682	22.4
Tilapia esculenta	6077	2571	1422	1408	11042	19789	11722	7642	5736	8176	5230	4911	7144	18.4
T. variabilis	2092	2134	1538	880	2135	1469	958	922	1360	1499	1452	1025	1539	4.0
T. zillii	—	1.4	—	37	476	294	273	396	358	725	292	423	328	0.8
Bagrus spp	5528	12420	5250	9218	10482	14827	14076	11213	9105	9293	11085	8422	10068	25.9
Clarias spp	916	1394	1303	1078	2750	2499	6057	2312	2802	7164	3852	2860	2916	7.5
Protopterus spp	1566	1172	1701	1051	3628	3699	8462	3327	3098	5125	5005	4985	3568	9.2
Synodontis spp	759	2651	760	1423	1086	968	152	198	1212	2248	2695	2237	1366	3.5
Barbus spp	306	481	371	127	466	464	517	244	1177	476	299	320	437	1.1
Labeo spp	2760	1722	255	97	1052	398	1017	279	1493	483	599	708	914	2.4
Mormyrus spp	608	1566	510	339	398	524	599	198	1111	426	299	236	568	1.5
Schilbe spp	726	907	212	149	1369	274	241	396	1383	1818	1595	1612	890	2.3
Alestes spp	161	208	112	22	206	244	158	141	446	757	997	233	308	0.8
Other spp	—	—	—	—	—	—	—	—	—	—	—	2604	—	—
Total catch	26235	31302	15924	18814	42542	49413	46863	29196	43752	59353	53927	48292	38801	
,, fishermen	12150	12000	6864	?	8629	8659	6077	5795	8413	11517	9738	12091		
,, canoes	2050	2131	1226	?	1917	1740	1289	1230	1815	2538	2495	3785		
,, gill-nets	48582	62333	37202	?	51557	51524	50488	45871	73037	80573	79030	133979		
Mean catch/ fishermen	2.2	2.6	2.3	?	4.9	5.7	7.7	5.0	5.2	5.2	5.5	4.0		
mean/canoe	12.8	14.9	13.0	?	22.2	28.4	36.4	23.7	24.1	23.4	21.6	12.8		
Mean/net	0.54	0.50	0.43	?	0.83	0.96	0.93	0.64	0.60	0.74	0.68	0.36		
Average men/ canoe	6	6	6		5	5	5	5	5	5	4	3		

June, 1960 to June, 1961.
Data from Tanzania Fisheries Annual Reports

Data for all fishes were similarly processed fielding the smoothed trend catch curves presented in Fig. 2b. The catch trends emerge into three categories:

(a) Species whose catches have been continuously decreasing over the 12-year period *(Labeo, Mormyrus* and *T. variabilis).*

(b) Those whose annual catches increased for some time and then started to decrease *(T. esculenta, Bagrus* and *Barbus).*

(c) Those whose catches have been more or less increasing over the period *(Haplochromis, Synodontis, T. zillii, Protopterus, Clarias, Schilbe* and *Alestes).*

Some possible explanations for these trends are suggested as follows:

(1) During the period under consideration, there was an increasing use of small mesh gillnets and beach seines. Smaller meshes retain the small fishes, including the juvenile of large species, thus increasing the landed weight.

(2) As the catch rates from the shallow inshore waters continued to decline, there has been increasing extension of fishing to more and more offshore waters. Species more abundant in deep waters would be landed in higher quantities, those which are more or less eurybathic would not be expected to show a decline in their catches and the oligobathic species would probably show decreasing landings.

(3) There were heavy floods in 1961 which increased the level of the lake more than 2 m above any previously known records. The depressing or favourable effects of the resultant ecological regimes would be reflected in the populations of the species affected.

Bearing these three possible explanations in mind, we find that the fish taxa in group (a) above are essentially oligobathic. Their annual landings and mean size on the markets have continued to decline. None of the three suggested explanations seems to have been positive in maintaining high catches. It would appear that these fishes have been so overfished that their biotic potential, under similar ecological conditions and fishing practices, is highly depreciated. Our conclusion is supported by the works of GARROD (1961) and CADWALLADR (1969) that *Labeo* has been overfished. By inference, *T. variabilis* and *Mormyrus* which show a similar trend in their annual catches, have been overfished also.

The species in group (b) show a marked peak in their trend curves shortly after the floods. This suggests that the effects of the floods, directly or indirectly, favoured the population "build-up" of these fishes (WELCOMME 1966). However, use of beach seine nets might have contributed to the increased landings for *T. esculenta* and *Barbus* which are oligobathic. On the other hand the catches started decreasing after the flood peaks and the general size of these fishes on the markets has also been going down. One would be induced to believe that these fish are also in danger of overfishing. *T. esculenta* is known to have been overfished (GRAHAM 1929, GARROD 1961) so that *Bagrus* and *Barbus*, which show a similar trend, might have been overfished also on the commercially fished grounds. This is in agreement with the prediction that decreasing the gillnet mesh size would eventually decrease the catches of these three taxa (BEVERTON 1959).

The catch trend curves for the 7 taxa in group (c), though continuously increasing, appear to be reaching or have reached their maximum peaks. The increase in catches could have resulted from decreasing mesh size for the small and juvenile fishes and due to the effects of the floods in case of *Protopterus* and *T. zillii*. Evidence adduced from bottom trawl data and considerations of the batho spatial distributional pattern of the fishes suggest that not many of the species, even in this group, are capable of sustaining much higher yields. Only *Haplochromis*, *Synodontis victoriae* and probably *Clarias* could be expected to yield higher catches. *Clarias* may have the potential for higher yields because it is ubiquitous. *S. victoriae* has the potential because it is more abundant in deep waters untouched yet by commercial fishing. And higher yields could be anticipated for *Haplochromis* because this is the most ubiquitously preponderant taxon whose catches have remained relatively low due to the selective properties of the commercial gear.

Thus, the significant selectivity by the commercial gear and the limitedness of fishing to inshore waters have deviated the commercial catches from the available biomass. *Haplochromis* and *Synodontis* are relatively less abundant in commercial catches than suggested by their biomass estimates. Most other species, on the other hand, are relatively higher in the catches than in the biomass estimates. It would appear necessary, therefore, to change the present fishing practices so that the harvest more closely reflects the available stocks. Bottom trawling, as a supplementary fishing method, would be adequate.

However, as several species have continuously declined in catches, while many don't appear to have the capacity for much increase in yields, any proposed changes must be carefully considered. Any additional fishing stress might do more damage than good. Besides, there are social and biological constraints on one hand and economic and developmental aspirations on the other (see KUDHONGANIA and CORDONE, *op. cit.*) which call for multidisciplinary planning for trawl fishery development on Lake Victoria.

SUMMARY

Comparison between exploratory biomass estimates and commercial catch statistics for the Tanzania part of Lake Victoria suggests that there is disparity between the relative abundance in commercial catches and in experimental estimates for most of the species. This has been due to the selective properties of the extant commercial gear and to the geographical limit of fishing activities.

Hence, the need for modification of commercial fishing practices. Supplementary trawling would be adequate. However, many of the commercially commanding species may not be potentially capable of sustaining increased fishing stress so that a trawl fishery would be economically sound and biologically safe if planned mostly for *Haplochromis*, *Synodontis* and probably a few other fish. Demographic and nutritional considerations require that current available stocks should be harvested for direct human utilisation. Bio-socio-economic aspects of the fishery call for further studies before undertaking full-scale trawl fishing on the lake in order to forestall possible irreparable negative consequences.

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