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THE FISHERIES OF LAKE RUKWA, TANGANYIKA

by

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Table of Contents

	Page
Errata	00
Addendum*	00
Summary	1
Introduction	1
Background material	1
Geography	2
Historical	2
Hydrology	4
General ecology	7
Ecology of the fish species	9
Commercial exploitation	33
Commercial and research catch rates	35
Processing	36
Production and marketing	37
Discussion	43
Recommendations	46
Bibliography	46
Appendix tables	49
Figures	00

(*In the original text reference to the addendum is made with an asterisk.)

SUMMARY

This survey of the fisheries of Lake Rukwa, Tanganyika, describes results obtained during 1963-1964 and includes comparative material given by previous workers, in particular surveys conducted in 1936 by Ricardo and in 1946 by Swynnerton.

Data is given on the general hydrology of the Lake including chemical analyses, seasonal and annual fluctuations of volume. Cyclical variations of lake level occur every 20/30 years and the level now reaching a new maximum is expected to fall again during the next decade.

The record of fish species from the Rukwa basin is enlarged by 3 genera: Polypterus, Protopterus and Chiloglanis; a summary of the biology and commercial exploitation of 20 species of fish is given.

An historical account of the fish production from the lake and its subsequent marketing concludes that in 1963/64 some 5,328 tons of dried fish products are marketed annually; between 10-62% of this trade is directed towards the Rhodesias and the remainder is absorbed within Tanganyika.

The state of the indigenous fishing enterprise is discussed, and for the improvement of the industry recommendations are given that the marketing of fish products should be immediately investigated and encouraged both abroad and within Tanganyika. Further suggestions include the improvement of water-transport on the lake, the development of improved fishing-craft, fishing-methods, processing methods and further investigation of the biology of the fish-fauna.

INTRODUCTION

At the Freshwater Fisheries Research Co-ordinating Committee's meeting on 22nd May, 1963, it was requested that surveys be conducted on several remote and little-developed lake fisheries in East Africa in order to note the change of the pattern of the fishery since the pre-war period, and to establish a basis on which further improvement of the industry might be considered.

Lake Rukwa was the first of these areas to be investigated and the principal terms of reference of the survey were to conduct:-

(i) investigations into the relative abundance of the various species.
(ii) preliminary studies of the present age structure of the commercially important species.
(iii) assessment of the productivity of the areas, and relative productivity if variable.
(iv) preliminary ecological studies on food, habitat, etc.

BACKGROUND MATERIAL

Published literature contains several references to the fish-fauna of the Rukwa basin; a few notes were made on the indigenous fisheries and a rather incomplete collection of the fish species was taken by the anthropologist, Dr. C. Fuelleborn in 1899, whose collections were later housed at the zoological museum, Berlin. Mr. F.H. Melland in 1910 also made collections of the fish-fauna, now preserved at the British Museum (Natural History) where the material was worked on by Boulenger (1911). A similar analysis of the Berlin collection had already been conducted by Hilgendorf & Pappenheim (1903).

The first organised survey of the lake fisheries was made by Miss C.K. Ricardo and her companion, Miss R.J. Owen, between September and November, 1936, their results being subsequently published (Ricardo 1939a & b). Following a six-week visit in 1939, Mr. G.H. Swynnerton of the Tanganyika Game Preservation Department presented a short note on the changing fish population of Lake Rukwa (Swynnerton 1939) and followed this with a more comprehensive report on "the best means of preserving and developing the Lake Rukwa fisheries so that they can make the maximum contribution to the Territories food supplies", as a result of work at the lake between November 1945 and December 1946 (Swynnerton 1947).

Later Mr. G.J. Lockley, Fisheries Officer of the Tanganyika Ministry of Agriculture, worked on the development of the fisheries between 1948 and 1950, but his reports have, unfortunately, not been accessible (Lockley 1964). In October 1962, Mr. M.M. Hammond was installed as Fisheries Development Officer, Southern Highlands Region, and his jurisdiction covers a major part of the South Lake (Hammond 1964).

The present survey was undertaken in two phases: firstly, between 8th August and 8th September, 1963, during the dry season, and secondly, between 15th January and 16th February, 1964, at the time of the rains.

In addition to the above sources of information, a number of authorities within Northern Rhodesia, Tanganyika, FAO and EACSO have given information and advice; their help is gratefully acknowledged and the specific authority quoted wherever possible.

GEOGRAPHY

Ricardo (1939a) notes that Lake Rukwa is a shallow body of water lying within the west branch of the Rift Valley between Lakes Tanganyika and Nyasa, at an altitude of 820 metres (2,690 feet) above sea level, but the lake level is now quoted as 2,602 feet above mean sea level, (War Office 1949). The floor of the valley slopes down towards the east and the lake lies directly against the eastern rift scarp which rises as a sheer rock wall to about 60 metres (200 feet). On the west side there is a gently sloping alluvial plain from five to twenty miles wide between the lake edge and the western escarpment. Further details of the geology of the rift are given by Grantham (1932) and Willis (1936).

Lake Rukwa comprises a closed drainage basin of 31,000 square miles (Lands & Surveys 1956) in which the main affluent rivers are the Sira and Songwe in the south, the Momba in the west, and the Kawu in the north. Numerous other small rivers arise from the plateau on either side, but these flow only during the rainy season (Vide Fig. 1).

The lake in 1936 was 90 miles long and was divided into two parts: the main permanent southern lake, about 30 miles in length, and the large, relatively shallow, northern extension, which varies considerably in area and which periodically dries completely. The two regions were separated by a narrow bar mostly covered with swamp vegetation, but there were occasional communication channels.

In common with other East African lakes there is a great variation in the level of the lake within different seasons and different years. During the rains the level of Rukwa rises considerably and both lakes, particularly the northern lake, become much larger in area flooding the plains to the north, west and south. Annual variations in the balance between precipitation and evaporation have a more permanent effect on the extent of flooding within the basin.

Geographical evidence (Grantham 1932, Teale 1933) indicates that previously Rukwa must have been a much more extensive lake, reaching 185 metres (600 feet) above the level in 1936. At this stage, it is probable that there was an anastomosis with Lake Tanganyika in the region of Karema. Conversely, there is no evidence that the lake has ever completely dried; the present level is due to a combination of progressive dessication and an extensive accumulation of silt (150 m. = 500 feet) on the bedrock.

HISTORICAL

The following remarks are based upon details published by Gunn (1956) Hailey (1945) Ricardo (1939a & b), and Swynnerton (1947), and on unpublished material supplied by Hammond (1964). Further detailed accounts of the hydrology and marketing in recent years are given in later sections.

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The first records of the lake level were made in 1873 and noted the lake as "medium to low"; Rukwa then appeared to rise to a peak level in 1882, subsequently falling, but showing a second peak in 1904-1905. In these early years, the fishery was entirely indigenous and principally for subsistence, although there were, no doubt, some small quantities of dried fish exported. Between 1905 and 1930 the lake was low and rose to a high level once more in 1935-1940.

During 1922 the adjacent Lupa goldfields were discovered and resulted in a large increase in the European prospecting population; the demand for fresh and dried-fish rose accordingly. Messrs. Maher and Ripley in 1931 were the first Europeans to establish a fishery near the goldfields in the Songwe area. Two years later the organization of the goldfields changed; large companies eliminated the numerous individual European prospectors, more African labour was employed and fed, thus the demand for fish again showed a marked increase. The unemployment of many Europeans and the increased demand for fish in the mines resulted in the first successful European fishery which relied primarily upon shore seines, although gill-nets and trawls were tried without success. In 1936, a minimum mesh limit of 5 in. was imposed by the Government but by 1938 the European enterprise - Rukwa Ventures Ltd., under Mr. G. Savory found it could not compete with the local Wabungu fishermen and as the demand for fish was falling, its operations were suspended. At this stage, Swynnerton (1939) reported on the suspected falling fish population.

At the beginning of 1939, the lake began to fall, then owing to the war local demand increased and Rukwa Ventures Ltd., under Major R.A. Bousfield, was encouraged to commence operations again. The minimum mesh size for seines was reduced in 1941 to 4 in., and in the next year a further European enterprise (managed by Mrs. E. Klapprott) entered the curing and marketing field, purchasing fresh fish from the itinerant African fishermen. In 1944 four European enterprises were given concessions to fish but these concessions were now limited in area. During 1946 Swynnerton was preparing his detailed report on the fishery, the lake level was falling, and there was an apparent reduction in the fish population. In 1949, the Lake Rukwa Fisheries Board was inaugurated and now acted as the sole governing body for fisheries legislation.

A minimum lake level was reached in 1950, but was followed by a slight increase in 1951-52. However, 1954-55 was a period with very little rainfall and the lake level fell accordingly. Over this quinquennium (1950-1955) the demand for fish at the Lupa goldfield declined as the reefs became exhausted, but alternative markets were still available in the Copper-belt of Northern Rhodesia and Katanga in the Belgian Congo.

In 1952 the Fisheries Board noted that the industry was progressing well and that a record number of Tilapia were exported. However, over the next few years it became apparent that the stringent regulations and licensing system for fishermen and marketing agents set down by the Board were not being observed by the African population and proper enforcement was not possible. By 1956 the Board agreed to decontrol fish marketing in the area, although trading licences were still required by the two District Councils concerned (Chunya and Ufipa). At the same time, fishing regulations were relaxed and the minimum size of Tilapia allowed to be offered for sale was reduced from 9 in. to 8 in. total length.

During 1957, the first mention was made of a fishermens' co-operative society, having the principal object of improving the ease of marketing of the dried product, but it was not until 1962 that the registration of this co-operative was possible. The following year, 1958, the value of crocodile and hippopotamus as a source of revenue was emphasized, and indeed Bousfield, the sole remaining European concessionaire on the lake, had since 1948 included crocodile hunting in his operations.

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By 1960 European influence had disappeared from the fishing industry at Rukwa; African fishermen reverted to their traditional individual fishing methods and the Lake Rukwa Fisheries Board began to doubt the value of its controls over the fishery. Lockley had already emphasized in 1951 that the dangers of overfishing by the current methods of exploitation were negligible, and that the greatest danger was that of unavoidable natural dessication - thus, he suggested, that the fishery should be founded on an opportunist basis. Towards the end of 1960 the Fisheries Board was disestablished.

From the low level of the lake during the drought of 1954-55, the level rose gradually until 1961, when heavy rains throughout East Africa caused a large and violent rise of lake level which continued to increase through 1962-63 and appears likely to extend at least through 1964. With this sudden rise the seining beaches have been submerged and new suitable shallow areas are still covered with large quantities of submerged vegetation. Because of this, nylon gill-nets have taken preference over beach seines and it is on this method of fishing that the present industry depends. Catches are generally good, but lack of suitable transport and efficient marketing remain as the major draw-backs in the industry.

The lake is now large in area, spreading widely over the plain of the west and north, and the vegetation comprising the barrier between northern and southern lakes has been submerged.

HYDROLOGY

The rainfall of the Rukwa basin amounts to between 30-40 in. per year (Lands & Surveys 1956) falling mostly between November and April with maximum precipitation in December. The average monthly rainfall figures for Mbeya Meteorological Station over the years 1932-1962 inclusive, given in Table A1 show the typical pattern. The average total annual rainfall figures for all gauges within the basin from 1924-1962 inclusive, have been summarised in Table A2. The first recording stations were situated at Missions, Coffee Estates, and Government Offices and tended to avoid the arid areas, hence, the early records give a rather high average rainfall figure compared to the later more accurate results from a larger number of recording stations throughout the basin.

The considerable variations in the quantity of the total annual rainfall over the Rukwa basin can be noticed in Table A2. Since the basin is totally enclosed the lake level depends upon the balance of annual precipitation and evaporation. However, when precipitation increases, evaporation is frequently reduced because of increased cloud cover and large scale variations of lake level occur; these fluctuations in volume and area have an important effect upon the productivity of the lake.

Gunn (1956) studied the annual pattern of fluctuations of lake level, with especial reference to the shallow North Lake which offer a suitable breeding ground for the red locust: Nomadacris septemfasciata Serville. His table with additional details added after Ricardo (1939b) and Swynnerton (1947) is given in Table A3. Ricardo (1939b) noted the annual fluctuations in level and referred to Gillman (1933) in relating rainfall and lake level with sunspot activity (Vide also Dixey 1953). Further, Swynnerton (1947) noted over the years 1930-1946 a cyclical pattern of water height with peaks in 1930, 1937 and 1941, i.e. with a period of 5-7 years. However, his diagramatic indications of lake levels do not agree with other authors quoted by Gunn (1956). A graph of the lake levels after Gunn and subsequent authors is given in Fig. 2. This figure indicates a cyclical variation in lake level with a period of the order of 25 years with peak levels in 1882, 1904-1905, 1935-1937 and 1962-1963. Fig. 3 after details by the International Red-Locust Control Service (IRLCS 1962 & 1963) shows clearly the immense fluctuations of surface area of the lake, particularly in the north, following the changes in lake level.

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Similar fluctuations of lake level occur from season to season, rising during the rains in November-April and falling to a minimum in October at the end of the dry season. Ricardo (1939b) indicated a seasonal variation of some 60-100 in. and Swynnerton noted a rise of only 6 in. during the unusually small rains of December-January 1946, with a subsequent fall of 51 in. before the onset of the following wet season. He notes that the water does not rise gradually from minimum to maximum over a period of years, but owing to a small size of the drainage basin and the quick run-off in the area, the lake rises suddenly during a single wet season. Details of his records are given in Table 1 and he calculates the average rate of fall between January 30th and November 20th, 1946, was 5 in. per month.

Table 1. Seasonal water levels (after Swynnerton 1947).

4 ecember, 1945	3'9 .75"	= 3.81 feet	gauge installed
30 November, 1945	3'9.75"	= 3.81 feet	rains began
30 January, 1946	4'4"	= 4.33 feet	rains ended - very slight rainfall
January-May, 1946			level slowly falling
June-November, 1946			level falling more rapidly
20 November, 1946	0'3"	= 0.25 feet	lowest daily mean reading
20 November, 1946			rains began, lake starting to rise

Hammond (1946) gives details of readings from his gauge at Mbangala quoted in Table 2.

Table 2. Seasonal water levels (after Hammond 1964).

15 February, 1963	16.7 feet
18 February, 1963	16.7 feet
20 February, 1963	17.1 feet
27 March, 1963	19.2 feet
5 April, 1963	19.6 feet
7 April, 1963	19.8 feet
7 May, 1963	20.0 feet
18 June, 1963	20.4 feet
12 July, 1963	20.3 feet
28 August, 1963	20.2 feet
5 September, 1963	19.8 feet

During early 1964 the levels recorded at the same gauge at Mbangala, rose from 20.75 feet on January 16th to 22.40 feet on February 16th; these and Hammond's figures for 1963 are graphed in Fig. 4. Records of rainfall and lake-level are detailed in Table A.7.

Chemical analyses of lake water have been provided by Ricardo (1939a), Swynnerton (1947) and Hammond (1964), and these details are given in Tables A4, A5 and A6. Owing to the different constituents examined and the different methods of analysis used these samples are not readily comparable; however, a few factors can be compared, and the details are given in Table 3. Firstly, the hydrogen ion concentration ranges between 8.4 and 9.3 indicating a slight alkalinity which is more pronounced when the lake is low (September, 1946). Secondly, the conductivity figures are not directly comparable being measured at 25°C and 20°C respectively, but a usual conductivity of the order of 400 micromhos is indicated. The alkalinity, expressed as carbonate in parts per million (ppm.) is higher when the lake level is low, although Swynnerton's figure does seem particularly high. Similarly chlorides appear in inverse proportions to the lake level, and the turbidity as measured with a secchi-disc increases as the lake level falls.

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Summarising these above comments: as the lake level falls the dissolved constituents of the water become more concentrated, the conductivity and turbidity increase and the pH rises (alkalinity increases). These conclusions imply that with increase of lake level little new inorganic material is added to the lake water by the rainwater run-off over the whole basin - and indeed, measurements of conductivity of three affluent waters in January, 1964, gave readings of 330 micromhos (temporary escarpment stream), 250 mhs., (Songwe River swamps) and 60 mhs., (Luika River). These readings indicate a low level of dissolved salts compared to lake water itself (400 micromhos).

Table 3. Comparative chemical composition of lake water (South Lake)

Date of sample	October 1936	September 1946	June 1963	August 1964	January 1964
Author	Ricardo 1939a	Swynnerton 1947	Hammond 1964	Mann 1964	Mann 1964
Depth (metres)	3.5	3.3	6.7	6.5	7.0
Datum level (feet)	-	-	20.4	20.0	20.9
H_2 ion concentration (pH)	8.5	9.3	8.4	about 8.0	about 8.0
Conductivity (micromhos)	-	-	353.9	400.0	450.0
Alkalinity as CO_3 (ppm)	212.8	1019.0	184.0	-	-
Chlorides (ppm)	25.8	118.0	16.0	-	-
Turbidity (ppm)	-	38.6	120.0	-	-
Turbidity (secchi) (cms)	7.5	-	-	15.0	10.0

Ricardo (1939a) first noted surface water temperature variations in September-November between 22.4°C at 08.00 hrs. to 27.5°C at 16.30 hrs. Swynnerton (1947) tabulates the monthly surface temperatures in terms of a minimum (08.30 hrs.) and maximum (14.30 hrs.) for the year 1946 in Table 4.

Table 4. Surface water temperature variations in 1946 (Swynnerton 1947)

Temperature	Minimum °F	Minimum °C	Maximum °F	Maximum °C
January	79.3	26.3	88.5	34.4
February	80.1	26.7	88.8	31.6
March	80.5	26.9	88.9	31.6
April	80.0	26.7	85.8	29.9
May	77.1	25.1	83.4	28.6
June	71.2	21.8	77.1	25.1
July	68.8	20.4	75.9	24.4
August	no records taken			
September	72.3	22.4	81.4	27.4
October	73.5	23.1	85.6	29.8
November	75.6	24.2	87.2	30.7
December	77.8	25.4	90.8	30.7

During August 1963, offshore surface temperatures taken were:-

0730 hrs - 22.5°C
1415 hrs - 24.6°C
1715 hrs - 24.5°C

and in January 1964:-

1600 hrs - 27.4°C
1830 hrs - 25.5°C

From other sites the surface temperature varied slightly; in January a small escarpment stream at the campsite reached 24.5°C; water from the Songwe Swamps at 27.3°C at 18.30 hrs., the mouth of the Luika River between 23.5°C - 25.0°C, midstream 23.5°C - 24.5°C, and at the base of the waterfall 23.0°C - 24.5°C. These variations in temperature were largely dependent on time of day. A series of temperatures detailed in Table 5, taken on 12th February at a standard point in the Luika Delta rose as the sun warmed the upper reaches.

Table 5. Temperature changes in the outflow of the Luika Delta

08.00 hrs.	- 23.5°C
09.00 hrs.	- 24.0°C
10.00 hrs.	- 24.0°C
11.30 hrs.	- 25.5°C
13.00 hrs.	- 26.5°C
14.30 hrs.	- 27.0°C

The very shallow (30 cm.) sheltered waters of Mbangala seining beach rose to 30.0°C, and at 1.0 - 1.5 m the surface temperature was 28.5°C; further offshore in 6-7 m. surface temperatures were similar to the open lake at about 26.0°C.

Only three dissolved oxygen samples were taken - these were from offshore surface waters on 20th August, 1963, and the results are given in Table 6.

Table 6. Surface-water dissolved oxygen concentrations

Time	Temperature	Oxygen	Comment
07.30 hrs.	22.5°C	5.8 mgs/litre	little scum on surface
14.15 hrs.	24.6°C	11.7 mgs/litre	more scum and water-lettuce
17.15 hrs.	24.5°C	7.1 mgs/litre	very much scum

In still waters the increase of dissolved oxygen at mid-day is almost certainly due to the increased photosynthetic activity of phytoplankton quantities present.

In the shallow circulating waters of Lake Rukwa lack of dissolved oxygen is unlikely to become a limiting factor for the fish-fauna even at the lowest depths, although very low oxygen levels may be found in the depths of the thick grass swamps.

GENERAL ECOLOGY

The waters of Lake Rukwa can be classified into several major ecological zones, each of which can be sub-divided into several microhabitats. During the dry season each habitat has its characteristic fish-fauna, but in the wet season the pattern changes as sexually active fish migrate to different breeding areas.

The principal zones as noted in 1964 are as follows:-

1. Inshore grassy shallows. These extend from the broken surfline of the shore into about 2-3 metres of water, with the present high level of the lake the submerged vegetation is thick and consists of drowned trees, bushes and grass, as well as the usual aquatic sedges and reeds. The steep eastern shore of the lake comprises little of this habitat although there is a narrow marginal band of emergent grass. The microhabitats within this zone are the warm extreme sheltered shallows occupied by *Tilapia* fry only; the more exposed sandy-bottomed shallows with large populations of *Engraulicypris*, and the shelter of grass fringes in deeper parts characterised by *Aplocheilichthys*, but also including *Alestes*, young *Hydrocyon*, etc.

2. Inshore rocky areas. These zones occur only rarely where the eastern escarpment falls abruptly into the lake and for a short distance offshore where large boulders have not yet become completely embedded in silt. The microhabitats included in this zone are the waters around the exposed rock surfaces, characterised by the epiphytic browsing Labeo species, and secondly, the sheltered mud bottom occuring between outcrops, inhabited principally by Gnathonemus and Mormyrus.

3. Offshore waters. This zone comprises the major part of the lake with a depth of about 7 m. of water over the typical thick mud bottom. It extends from the margins of the inshore zones to the open waters of the centre of the lake. Here there are only two microhabitats: the mud-water interphase of the bottom typical of Sydnodontis zambezensis; and secondly, the mid and surface waters, between which there is little change in dissolved oxygen concentrations, light penetration or temperature with increase in depth. These surface waters are the typical habitat of Hydrocyon and Schilbe.

4. Swamp waters. Large swamp zones of floating grass and sedges in 4-5 m. of water are found across the south and north ends of the lake where the main river mouths are situated, other smaller zones occur off the river mouths of both eastern, and particularly western shores. The three microhabitats comprise this zone: firstly, the bottom-mud surface, both below open channels and below the fringes of the rafts, where both Synodontis species occur; secondly, the convoluted fringes of the submerged root masses along the channels and pools, also the sheltered fringes of floating rafts drifting in the lake itself, a habitat favoured by Gnathonemus and Clarias; thirdly, the mid and surface waters of the open water of channels throughout the swamp where Hydrocyon occur in large numbers.

5. Lower reaches of the rivers. This zone includes numerous microhabitats dependent on the nature of the bottom, extent of vegetation cover and depth of water. In the wet season two important additional microhabitats are provided by the increased volume of the fresh waters. The fast flowing central river-bed is occupied by the migratory species typically Hydrocyon, Alestes, and Labeo; the shallow flood plains of the river-bed are temporarily invaded by spawning Clarias, Synodontis and later by the juveniles of all these species.

The vegetation of the lake shores ranges from the Acacia tree line with Hyparrhenia rufa through Diplachne fusa, Sporobolus robustus and S. spicatus of the lake-shore grasslands down to the dominant Echinocloa pyramidalis of the flood plains. Where tidal flooding occurs Odyssea jeager thrives, and typical of deeper waters are the water grasses Oryza sp., Leersin sp. and Typha sp. Amongst these grasses the larger masses of papyrus Cyperus largus, ambatch Aeschynomeme elaphroxylon and Sesbania sp. occur, together with masses of floating water-lettuce - Vossia cuspidata.

The exploitation of the fish populations is interfered with by several animals other than the carnivorous fish species: Alestes, Hydrocyon, Schilbe and Clarias. The adult crocodile (Crocodylus niloticus) preys directly on larger fish and frequently takes dead and damaged fish from nets. Until 1948 crocodiles were a great hazard in the beach seine fishery, but in that year an exception was made to the Game Laws and Bousfield began killing those interfering with the fishery, and later whis was extended to a commercial exploitation of crocodiles (Lockley 1949). By 1960, the population had fallen considerably and operations were suspended. Presently crocodiles are rare; occuring only in the extensive inaccessible Songwe swamps and occasionally along the western shore.

Monitor lizards (Varanus niloticus)occur in quite large numbers and probably include small fish in their diet. However, around fishing camps they are common and there they generally feed upon discarded viscera, scales, etc.

Frequently in gill-net catches the fins of fish, particularly the coloured dorsal and caudal fins of breeding Tilapia and sometimes the abdominal body wall of Mormyrus, were found cut in a characteristic pattern by the water tortoise: Pelusios sp. Although the damage was usually slight the fish quickly spoilt and members of commercially important species (Tilapia Mormyrus) were lost in this way. Adult tortoises occured in large numbers just off the Luika River and Songwe swamps, and in smaller numbers along the east shore. Juveniles were found on shallow inshore areas of the Luika River during January-February 1964.

Of the fish-eating birds, white pelicans (Pelecanus onocrotalus) were the most obvious and a large flock fed continuously on juvenile fish in the shallows of the Luika River delta. In the Songwe swamps these birds would also follow the net hauling canoes and take fish accidentally liberated from the meshes. Several other species of birds including kingfishers (Alcedinidae), fish-eagles (Cuncuma vocifer) grebes, herons and storks (Podicipidae, Areidae and Ciconiidae) are typically fish eating types.

Among the mammals hippopotamus (Hippopotamus amphibius) also interfered with the fishery. Being vegetarian they did not take fish, but were frequently blamed for the wholesale loss of nets, and sometimes during the breeding season fishing canoes were attacked and overturned.

ECOLOGY OF THE FISH SPECIES

Of the 24 species of fish whose occurence has been recorded by Ricardo (1939a & b) 18 were taken by this survey. The species not taken include the 3 rare Barbus species - B. pappenheimi, B. salmo, and B. luikae, as well as Leptoglanis rotundiceps and Amphilius platychir similarly noted as rare, occuring only in rivers. No specimens of Clarias hilgendorfi were taken, but this species has only been noted from a small affluent river in North Lake.

In addition to Ricardo's list 3 new records of occurence within the Rukwa basin are given for Polypterus sp., Protopterus sp.* and Chiloglanis sp. Thus the full list of the records from Rukwa is now as follows:-

Polypterus sp.
*Protopterus sp.
*Marcusenius discorhynchus (Peters)
Gnathonemus macrolepidotus (Peters)
Mormyrus longirostris Peters
Alestes imberi Peters
*Hydrocyon vittatus Castelnau (H. lineatus Bleeker)
Barilius moorii Boulenger
Engraulicypris congicus rukwaensis Ricardo
Barbus paludinosus Peters
Barbus lineomaculatus Boulenger
Barbus innocens Pfeffer
Barbus pappenheimi Boulenger
Barbus salmo Pfeffer
Barbus luikae Ricardo
Labeo fuelleborni Hilgendorf & Pappenheim
Chiloglanis sp.
Leptoglanis rotundiceps (Hilgendorf)
Amphilius platychir (Gunther)
Schilbe mystus (Linnaeus)
Clarias mossambicus Peters
Clarias hilgendorfi Boulenger
Synodontis zambesensis Peters
Synodontis fuelleborni Hilgendorf & Pappenheim
Aplocheilichthys johnstonii (Gunther)
Tilapia rukwaensis Hilgendorf & Pappenheim
Haplochromis bloyeti (Sauvage)

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In the following notes given on each species the lengths of fish are always expressed as standard length recorded in metric units. The stages of sexual maturity were identified macroscopically in the field and are defined in Table 7.

In the tables of sexual maturity for each species, the figures given for each category are firstly, the number of fish, and secondly, the size range expressed in mm.

Table 7. Definition of stages of sexual maturity

immature	sex indeterminate
inactive	gonads threadlike, sex usually determinate
inactive-active	gonads thickening, sex determinate; oocytes just visible in female
active	gonads thick, white colour in male; in female oocytes clearly visible, not discrete.
active-ripe	gonads swollen, in male blood and milt oozes when cut; in female oocytes large but not separate
ripe	gonads very swollen, milt fully formed in male; oocytes large and discrete in female
ripe-running	gonadial products easily extruded under pressure
spent	gonads flabby and bloodshot, few oocytes remaining in female; translucent rather than white in male.

Polypterus sp.

A single specimen of 340 mm. total length was presented to Hammond by Mr. V. Warwick of New Ntumbi Reefs, Chunya, at the end of November 1962. The locality was first noted as the Chunya River (? Lupa River) but was later corrected to read "Rungwa River", which is a large affluent in North Lake.

The colouration of the freshly dead specimen was recorded as grey-brown on the upper body with a yellow belly. Lockley (1964) identified the specimen from photographs as Polypterus sp., probably P. ornatipinnis, and noted that this constituted a new record for the Lake Rukwa basin. Hammond (1964) has noted that these fish are also found at Mtemba (? River) near Sumbawanga.

*Protopterus sp.

A single adult specimen of about 600 mm. total length was collected from Lake Rukwa by Hammond (1964) during 1962. Although no specific locality is cited for this specimen, it is certain that a small population of Protopterus exist in the lake and affluent rivers. Local fishermen occasionally take this species, commonly known as "Kambali mamba", on long lines set inshore, but it is rejected as inedible, although in other areas where well known it fetches a high price. The present formalin-preserved specimen has yet to be identified to species level, but comprises a new record for this genus from the Lake Rukwa basin.

*Marcusenius discorhynchus (Peters).

This small uncommon species has been recorded from the Middle and Lower Zambezi, the Kafue, the Rhodesian Congo basin, Katanga, Lake Nyasa, Bangwelu and Lake Tanganyika in addition to the Rukwa basin. Typically, it is found in open rivers and swamps but not in the open waters of the lakes (Ricardo 1939a, Jackson 1961c & d).

From Lake Rukwa no juveniles have yet been captured - the size range of the 104 specimens taken was from 82-165 mm. These specimens were rarely found in surface-set nets or in the 2.5 and 3 in. meshes, but occurred almost entirely in bottom-set nets of 2 in. mesh. A few of the smaller specimens were taken in the 1.5 in. mesh beach seine.

The principal localities for this species were the inshore areas close to grass fringes and fair numbers were taken offshore and in the Songwe River swamps during August. A few specimens were taken

offshore in surface waters particularly when the nets had been fouled by floating grass rafts. This indicates that Marcusenius will follow the shelter and food offered by the root masses of submerged vegetation. During the rainy season the main locality for this species was the mouth of the Luika River delta, and in this connection Jackson (1961c) has already noted that Marcusenius probably moves upstream for spawning.

The analysis of the stages of sexual maturity of fish taken in both August-September and January-February appears in Table 8.

These records indicate that breeding takes place in the late rainy season; both sexes were ripe and yet no ripe-running or spent individuals were observed. The captures during January-February were principally across the mouth of the Luika River, inferring that a spawning migration takes place from the sheltered grassy habitat of the dry season to the deltas or lower reaches of the rivers. This supports the comment that this species probably migrates upstream for spawning (Jackson 1961c).

Table 8. Sexual maturity of Marcusenius discorhynchus.

	August-September		January-February	
	Male	Female	Male	Female
im	5,82-95			
i	1,98	1,85		
ia	3,90-140	2,135-160		
a	2,150-155	22,130-155		
ar	1,135	11,130-145		
r		1,140	5,145-160	11,145-165
rr				
sp		1,140		

Note: the figures for each sex in each category indicate respectively the number of fish, the minimum and maximum standard lengths expressed in mm.

No juvenile Marcusenius have been recorded save for a specimen of 28 mm. total length seined in flooded creek on the Middle Zambesi during the height of the floods (Jackson 1961a).

In Table 8, males appear less frequently than females, but the ratio may be exaggerated by the fact that males appear slightly smaller than females: 155 mm. maximum length compared to 165 mm. Sexually mature fish do not apparently occur below 145 mm. but this figure may well vary between populations; Jackson (1961a) records the largest fish taken from the Middle Zambesi as a male of 310 mm. (total length), whereas Poll (1953) noted from Lake Tanganyika that the largest specimens (140 mm. total length) were ripe or nearly ripe.

Marcusenius like several other mormyrid species shows slight sexual dimorphism; the male when adult exhibits a distinct notch along the anal fin base, which is not apparent in young or female specimens.

Previous authors have noted that this species is predominantly a bottom feeder taking various aquatic insect larvae - particularly Chironimidae, Hemiptera, small caridean crustacea, small gastropod and lamellibranch molluscs and even vegetable fibres. During the survey 15 gut contents were examined of which 3 were empty and the remainder contained numerous anthropod cuticles (probably Chironomidae) and zoo-plankton cuticles (principally Cladocera). During January-February several small unidentified fish eggs occurred, but little or no mud was present and only in one fish examined did small stone fragments occur.

Marcusenius is not abundant and is not taken by the present commercial fishery, except perhaps in small mesh shore seines or fish-traps. However, like other Mormyridae, when taken it is valued for its

high fat and oil content: a comment already emphasised by Jackson (1961c).

Gnathonemus macrolepidotus (Peters)

The species has a wide East and Central African distribution, having been recorded from Kafue, the Northern Rhodesian Congo system, Katanga, Lakes Nyasa, Bangwelu, Mweru and the Lower Zambezi as well as Lakes Rukwa, Ngami and the Rovuma River in Tanganyika. Like Marcusenius it is noted as being typical of rivers and swampy areas rather than open lake waters (Ricardo 1939a & b, Jackson 1961c, Jackson et al 1963).

Within this wide distribution different populations of Gnathonemus can be identified by variations in colouration, lateral line scale counts, depth of the body and proportions of the caudal peduncle. Jackson (1961c) concludes that these different populations will almost certainly be recognised as sub-species in due course.

In Lake Rukwa this fish was commonly taken in bottom-set nets of 2, 2.5 and 3 in. meshes from both inshore and offshore waters. In the Songwe swamps Gnathonemus occurred in fair numbers at the surface along the fringing grass edges and in the open channels. During January and February far fewer specimens were taken from bottom-set nets in open waters although they were more numerous in nets set off the mouth of the Luika River. This distribution differs from Ricardo's comment (1939b) that this species is restricted to the edge of the littoral vegetation. No specimens were taken in beach seine hauls in clear waters adjacent to littoral vegetation during August-September.

Of the specimens dissected 107 were male and 115 were female; there were no immature forms and no juveniles were found. Further analysis of the sexual maturation of the adults is given in Table 9.

Table 9. Sexual maturity of Gnathonemus macrolepidotus

	August-September		January-February	
	Male	Female	Male	Female
im				
i		1,112		
ia	16,165-215	24,175-230		
a	23,136-240	29,145-220		
ar	6,175-215		1,185	
r			61,170,230	61,160-200
rr				
sp				

The majority of both sexes were classified as active in August-September, but in January-February virtually all the fish were ripe. However, no ripe-running or spent individuals were observed, thus perhaps like Marcusenius, spawning does not take place until the later stages of the rainy season, or takes place in upstream areas not investigated.

Sexually mature males exhibiting the typical anal notch, were slightly less numerous than females but tended to be slightly larger; the breeding sizes being between 170-230 mm. and 160-200 mm. respectively. In other populations, these sizes may vary slightly; Jackson (1961d) notes that in Nyasaland waters G. macrolepidotus may grow to total length of 300 mm. or more, compared to 170-230 mm. maximum at Rukwa. Bell-Cross (1960) has already noted a probable annual spawning migration, and the shift of catches in open waters in the dry season to the Luika River mouth during the rains, may be an indication of a similar seasonal upstream movement in Rukwa.

In the 15 gut contents examined grey-green debris was common, together with numerous segmented arthropod larvae (probably chironomids) and zooplankton cuticles. Arthropod cuticles occurred most commonly in August-September, but zooplankton was plentiful in January and February. A little mud, sand-grains and small stones occurred in a few fish and one specimen contained two terrestrial insects. Only one individual examined had an empty stomach.

Other authorities quote the diet of Gnathonemus as including aquatic insects and small animal life (Jackson 1961c), bottom mud, sand grains, pieces of weed, vegetable debris and Chironomidae (Ricardo 1939b).

This species is not regularly taken in commercial surface-set gill-nets and rarely occurs in the beach seines worked over a clear bottom. The abdominal fat content of the body is much appreciated by African consumers and this presently unexploited species could in a smoked form become another valuable export product to Northern Rhodesia and Tanganyika.

Mormyrus longirostris Peters

This mormyrid occurs quite widely throughout Central Africa: in the Middle and Lower Zambezi, the Rhodesian Congo system, Lakes Nyasa, Bangwelu, Rukwa, Mweru, Tanganyika and the Lualaba river. It is absent from the Upper Zambezi and Kafue where it is replaced by Mormyrus lacerda. In rivers it tends to inhabit the deep sheltered waters in the lee of sandbanks and rocky outcrops, and in lakes prefers the deep calmer waters with a muddy bottom down to the limits of suitable dissolved oxygen concentrations (Ricardo 1939a, Poll 1953, Jackson 1961c).

No juveniles have been taken in Rukwa but small forms were taken in considerable numbers during October off the reed beds of southeast Rukwa (Ricardo 1939a). The smallest specimen taken during this survey, an immature fish of 165 mm. occurred in a beach seine haul over a muddy bottom on the southeast of the lake during August. Jackson (1961c) also notes that the young in the Middle Zambezi grow in the protection of submerged grass and other vegetation.

Adult forms were taken in bottom-set gill-nets in inshore swamp, inshore eastern and offshore waters, principally in meshes between 3 and 5 in. Specimens were also taken at the surface in the open channels of the Songwe swamps and particularly in nets set fringing the grass edges of the swamp channels.

Only 116 specimens were taken during January-February compared to 76 over the same period in August-September. Moreover all these specimens were taken in bottom-set inshore nets in the Songwe swamps, Luika River delta and the rocky bottom at Ichesa; no Mormyrus were taken offshore or at the surface. Hammond (1964) reported fairly large commercial catches of adult Mormyrus along the flooded grassy western shores near Ntunje on 5th February, 1964.

A number of specimens were dissected during August and January, the sexual development of these fish was recorded in Table 10. M. longirostris exhibits two common mormyrid features: the development of the left gonad only in adult males the presence of the anal notch.

Table 10. Sexual maturity of Mormyrus longirostris

	August-September		January-February	
	Male	Female	Male	Female
imm	1,165		2,260-280	
i	2,335-385	1,325		1,295
ia	3,225-335	9,260-345	4,225-270	
a	1,355	3,350-355	1,480	
ar	2,355-385	3,355-370		
r			4,380-560	3,360-400
rr				
sp				

The figures indicate that the spawning period occurs only once during the year towards the end of the rainy season. Other populations examined appear to have a rather prolonged breeding season at the time of the rains and spate waters (Bertran et al 1942, Jackson 1961a & d).

The apparent concentration of adults in inshore grassy areas during January-February is probably an expression of the breeding migration already suspected by Jackson (1961d): in these sheltered

waters the adults spawn and the juveniles develop.

From the few individuals recorded as "ripe" it appears that full sexual maturity in either sex is not reached in fish below 360 mm. Smaller fish may show a seasonal advance of sexual maturity but maturation is not complete, spawning does not occur and the gonads may regress until the following season. On the Middle Zambezi, Jackson (1961a) noted first sexual maturity at 360 mm. (total length) and adults were still breeding at the maximum size (708 mm.) recorded. Bertram et al (1942) note that in Lake Nyasa Mormyrus longristris appears to reach sexual maturity at about 300 mm. (total length?).

The stomach contents of 8 individuals were examined; of these two were empty and the remainder contained many segmented anthropod larval cuticles (probably Chironomidae), occasional small gastropod molluscs, and aquatic insect larvae (Odonata), a little mud and vegetable debris. M. longirostris almost certainly feed on the extensive muddy bottom and root masses of floating grass islands. The elongate lips are used to selectively pipette the invertebrate prey from the muddy environment. A similar diet has been noted for other populations to comprise mainly Chironomidae, caddis lavae, oligochaetes, small molluscs and caridean crustacea, occasional zooplankton as well as traces of mud, sand and small pieces of weed. (Ricardo 1939a & b, Bertram et al 1942, Poll 1953 and Jackson 1961c).

Mormyrus is occasionally taken in surface-set gill-nets and beach seines of the commercial fishery, and like the other mormyrid species contain large quantities of abdominal fat and fetches a high price in the fish trade, being considered good eating by the African consumers. The exploitation of this species could be very profitably increased by the use of bottom-set gill-nets of about 4 in. mesh. This gear would also take other species of commercial interest: Tilapia, Hydrocyon and Clarias, but generally would not retain the troublesome smaller species particularly Synodontis.

Alestes imberi Peters

This small, but very widespread characid species occurs in the Lower and Middle Zambezi, the Limpopo, Southern Rhodesia, the Congo basin, Lake Nyasa, Bangweulu, Rukwa, Tanganyika and the Rovuma River. In West Africa it occurs in the Volta basin and in the Ivory Coast. Alestes imberi tends to occur in large sporadic shoals inshore near vegetation in lakes with only the largest specimens venturing into open waters. It is common in rivers and particularly in the slow running waters of river deltas (Ricardo 1939a, Poll 1953, Daget 1954, Jackson 1961c & d).

No juvenile Alestes imberi were taken in the few mosquito seine hauls made in August-September but many were taken in the extensive mosquito hauls during January-February. The standard lengths of these juvenile specimens ranged from 9 mm. upwards, but smaller specimens may have been taken; it has not yet always proved possible to separate juvenile Alestes and Hydrocyon below about 12 mm.

Most juvenile specimens were taken from shallow sheltered shallows with a grass and weed cover at Mbangala seining beach, at Outspan and near Bousfield's house. The depth of water was between 1.0 and 0.25 m. and the temperature about 28.5°C. A few further specimens were taken in framed mosquito hauls in the bay off the Luika River, both near the surface and near the bottom in waters at about 26.0°C. A few specimens were taken from an exposed sandy beach near the Luika, but no identifiable specimens were taken from the delta, nor any reaches of the Luika River below the falls. The number of specimens taken appeared to increase from the 18th January up to the last mosquito hauls taken on the 14th February.

Although no juveniles were taken from the Luika a series of fish-eggs were collected during early February from the outflow of the River. Some of these eggs were matured in ventilated containers in the delta waters and the fry obtained have typical characid body-form. At the same period ripe-running adult Alestes were taken in the lower reaches of the river but ripe-running Hydrocyon were also found in

large numbers around the delta although Hydrocyon did not appear to penetrate the downstream reaches of the River to the same extent as Alestes.

During August-September adults were principally taken in seine hauls with the 1.125 in. net at Mbangala seining beach, but were also taken in smaller numbers in inshore and swamp areas at the surface especially where the 2 in. net was fouled by floating grass masses. Specimens of a similar size were also taken inshore near thick grass fringes at Kasisi. In January-February all catches were with 2 in. surface set gill-nets: no large seine being worked. Alestes occurred in open waters of the lake, fringing grass in the Songwe Swamps, inshore along the eastern coastline and in large numbers around the mouth of the Luika River. Adult specimens, including ripe-running males were taken in mosquito-hauls from shallow grassy margins of the lower reaches of the Luika.

The stages of sexual development of 153 specimens dissected were recorded in Table 11.

These results indicate that spawning takes place in the early rainy season during January-February. The majority of these specimens, and indeed all the adult males, were taken from the mouth and lower reaches of the Luika River where spawning probably takes place. This breeding migration into upstream waters has already been described for A. imberi (Jackson 1961a) and also for the related A. macropthalmus and A. lateralis, but not A. grandisquamis (Jackson 1961c). Jackson (1961a) also notes that A. imberi appears to have a distinct short spawning period.

The apparent absence of males in catches during August-September is probably due to the difficulty of identifying males in the younger stages, and secondly, as borne out by the January-February records, the males are considerably smaller than females. The minimum size at which sexual maturity is reached in the Rukwa population appears to be 110 mm. or less for males and 125 mm. or less for females. The maximum length recorded (185 mm) approaches the maximum length recorded for Lake Tanganyika: 170 mm. (Poll 1953).

Previous workers have described the omnivorous but predominantly carnivorous diet of Alestes, including juvenile fish, aquatic and terrestrial insects (Odonata, Hemiptera, etc.), small gastropods, zooplankton, seeds and plant fragments of various kinds (Ricardo 1939a & b, Swynnerton 1947, Poll 1953, Jackson 1961a, c & d). During this survey 21 stomachs were examined, 4 were empty, and the remainder included various aquatic and terrestrial insects, zooplankton cuticles, particularly Cladocera, vegetable debris, small quantities of phyto-plankton and even small quantities of posho. The latter was discarded from a posho-mill but is deliberately scattered by the women-folk on the surface of shallow river pools to attract Alestes, which are then captured in scoop baskets, (Ricardo 1939a).

This species is not presently an important constituent of the commercial catch, and is only occasionally taken for subsistence by the women-folk as the river-pools recede, and in basket traps worked at the margins of the rivers during the floods. It is, however, a valuable fish: for instance, the high oil content of Alestes nigrilineatus varies seasonally between 5-27% (Auffret & Tanguy 1948). A more concerted effort in the rivers during the flood and ebb periods could produce useful catches of Alestes imberi. Other species (A. dentex and A. baremose) when sundried comprise a valuable insect-free product in West Africa (Allen & Chaux 1961, Mann 1962).

Table 11. Sexual maturity of Alestes imberi.

	August-September		January-February	
	Male	Female	Male	Female
im	11,72-142		1,110	
i		14,81-160		
ia		7,130-170		1,170
a				
ar				
r			2,130-135	89,125-185
rr			4,110-130	15,135-175
sp				9,145-175

Hydrocyon vittatus Castelnau*

This species of tiger-fish has a pan-African distribution; being recorded from the Senegal, Niger, Volta, Nile, Congo, Zambezi and Limpopo Rivers, as well as lakes Albert, Rudolf, Tanganyika, Rukwa, Mweru, and Bangweulu. It is, however, absent from Lakes Chad, Edward, George, Victoria and Nyasa. This fish occurs typically in well oxygenated waters of swamp channels, large rivers and open lakes, but is not found in small streams or swamps except when spawning (Jackson 1961c, Greenwood 1958). In Lakes Albert and Rudolf Hydrocyon vittatus prefers the inshore waters as opposed to the deeper waters populated by H. forskalii, but in the shallower lakes and in the absence of competition with other Hydrocyon species it is widespread.

For a number of years this species has been known as H. lineatus, but Barnard (1948) pointed out that Castelnau's species vittatus (1861) is perfectly valid and should take preference over Bleeker's lineatus (1862)*

In Lake Rukwa juvenile specimens did not occur in the few mosquito-hauls attempted in August-September, but large numbers were taken during January-February. The most specimens ranging between 9-75 mm. were taken in the shallow waters of Mbangala seining beach where the depth of water reached 1 m. and the surface temperature 28.5°C. Amongst this grass cover Hydrocyon inhabit the surface rather than the bottom half-metre above the mud-sand substratum. No specimens were taken from the extremely shallow inshore waters (30 cm. deep) where the temperature rose to 30.0°C.

Further offshore specimens of the size range 9-15 mm. were taken in framed mosquito-hauls at the surface, and these catches continued in open waters up to the exposed shallows of the Luika River delta at a temperature of about 26.0°C. However, not a single specimen was taken in or above the Luika delta, although as already described in the section under Alestes, numerous fish-eggs resulting in a fish of characid proportions on hatching were taken in the outflow of the river. A few small specimens were taken in sheltered water at Outspan and also near Bousfield's House - both these localities were adjacent to the outflow of cold escarpment streams. The smallest specimens of Hydrocyon identified (9mm. standard length) are slightly smaller than the minimum size (13-15 mm. total length) previously recorded by Jackson (1961c). No juvenile Hydrocyon were taken in open waters of the lake in any gear.

Adult fish were taken in large numbers during both visits to the lake. During August-September specimens were taken principally in the surface-set nets between 2.5 in. and 5 in. mesh, although lesser numbers did occur in bottom-set nets in inshore waters. In offshore waters catches were mostly in surface nets, but very large catches were also obtained from bottom and surface hauls within the Songwe swamps. During the second visit smaller catches were obtained in inshore bottom and surface areas, but fair numbers were taken in open surface-waters. However, by far the largest hauls of all were made in shallow waters off the Luika River delta.

A large number of specimens of this important predator were dissected, and the gonads of these fish are classified in Table 12.

Table 12. Sexual maturity of Hydrocyon vittatus.

	August-September		January-February	
	Male	Female	Male	Female
im	24,110-260			
i	6,130-250	5,180-330	1,250	5,210-255
ia	16,235-350	15,200-395	3,250	12,250-320
a	7,235-370	10,240-430	2,245-260	
ar	11,310-370	3,360-400	2,280-285	4,270-430
r	8,260-460	5,350-410	35,240-370	126,250-480
rr	7,295-365		204,230-390	8,280-410
sp	1,410		51,240-400	19,280-440

The nil return for immature forms during January-February is merely a reflection of the number of small specimens caught in mosquito seines but not dissected. Firstly, these results show that although a few ripe individuals were recorded during August-September spawning is concentrated during Janurry-February. Indeed, although the fishing effort varied on d fferent dates and results are not strictly comparable, it was noted that peak numbers of ripe and running females were recorded from the mouth of the Luika River on the 28th January and of spent females on the 1st February. Spent males were recorded after the 28th January and peak numbers occurred on the 1st February. These comments indicate that the spawning period was very brief and during 1964 in the Luika River area, was concentrated between 28th January and 1st February. Increased freshwater flow in the river is a likely factor in stimulating spawning; rainfall (recorded at Mbangala) was relatively heavy on 23rd and 25th January and also on the 28th and 31st January (See Table A7). These results entirely support comments by Jackson (1961a, b & c) that breeding only takes place on a very few days each year when the rains have swollen the rivers and that a spawning migration is undertaken up rivers and into small streams. Jackson (1961a) does, however, note that the temperature of flood-water is not the main factor correlated with spawning; on the Middle Zambezi there is a little temperature fluctuation during the floods. He also adds that the females spawn a very great number of eggs in very shallow water among the stems of grasses and other submerged and partly submerged vegetation. It is not yet known how long the eggs take to hatch nor even whether any sort of a nest is made. Spawning is suspected to take place at night. Males appear to be generally smaller than females and the minimum breeding sizes appear to be 230 mm. for males, and 250 mm. for females.

Hydrocyon vittatus is a voracious predator and has an enormous influence upon the population of other fish species below 200 mm. in length. During the survey of Rukwa a large number of gut contents of adult fish were examined, and the frequency occurence of the different prey types is tabulated below (Table 13).

Table 13. Frequency of occurrence of prey types of Hydrocyon vittatus.

August-September			January-February		
empty	64	52%	empty	63	88%
indet. fish	24	20%	indet. fish	7	10%
insects	9	7%	Tilapia	1	1%
fish (Barbus sp.)	9	7%	Schilbe	1	1%
water beetles	7	6%			
Synodontis	3	2%			
Hydrocyon	2	2%			
sand & mud	2	2%			
Tilapia	1	1%			
Caridea	1	1%			
fish eggs	1	1%			

These results confirm the carnivorous diet of adult H. vittatus already noted by Ricardo (1939a), Swynnerton (1947), Poll (1953) and Jackson (1961c). The high percentage of empty stomach contents found in January-February indicated that these fish do not actively feed over the breeding season. This is not due to the absence of suitable prey; juvenile fish of a suitable size range were indeed more plentiful in the shallows and open waters of the Luika delta during January-February than during August-September.

No juveniles were dissected but Jackson (1961c) observes that very young Hydrocyon take zooplankton, normally changing to a fish diet between 56-89 mm. However, if suitable fish prey is not available adults continue to take any available aquatic insect material.

The size of prey taken by fish examined during the survey ranged from 4.8-43.7% predator length. This maximum figure is of the same order as the 40% maximum length noted by Jackson (1961c).

The same author (1961a) discusses growth rate of H. vittatus in the Middle Zambezi which is particularly rapid; from length-frequency data he came to the conclusion that fish had reached 140-180 mm. at the end of the first year and about 250 mm. at the end of the second year. This means that fish in Rukwa do not reach full sexual maturity until the end of their second year. Such a long period of sexual development of a carnivore could account for the wide range of adult size in a population with a typically short spawning season.

As with many carnivores this species is a host to a number of parasites, amongst which numerous nematodes and an occasional cestode in the body cavity are the most obvious. Other intestinal, muscular and vascular parasites no doubt occur, but their effect on the human consumer will be negligible, particularly if the flesh is cooked.

Hydrocyon is not often taken by the present commercial fishery as it easily passes through or breaks the thin ply of the loosely set surface-nets. The catches of this species could be easily increased by the use of surface-set nets of thick-ply (210/6, 210/8) with meshes of 3-5 in., and rigidly laced along the headlines by the half. The flesh, readily preserved by sun-drying and light smoking, has an excellent taste and a high percentage of protein.

Engraulicypris congicus rukwaensis Ricardo

Engraulicypris congicus rukwaensis is endemic to Lake Rukwa, but other species of this genus are common in lakes throughout East and Central Africa. The typical habitat of the small shoals are the inshore open and offshore surface waters (Ricardo 1939b, Bertram et al 1942, Greenwood 1958, Jackson 1961d, Jackson et al 1963).

Adults of this species ranging up to 90 mm. total length were taken by Ricardo (1939b) in small mesh seine nets along the southeast edge of the lake but the largest specimens taken by this survey were 45-47 mm. standard length. Swynnerton (1947) noted that this species rarely exceeds 100 mm. Adults occurred in turbulent waters below the Luika falls, at several sites downstream in fast flowing waters, in the delta, and more rarely in the inshore waters of the open bay off the Luika River.

Juveniles ranging from 8 mm. upward were taken in large numbers in mosquito seines in inshore shallows at Mbangala, Outspan, Bousfield's House, and in the spillway of the adjacent small escarpment stream. However, none were taken in extreme inshore shallows, nor in extremely open waters of the lake and few specimens occurred amongst the grass of the inshore shallows. Framed mosquito-hauls near the bottom, and near the surface, produced large numbers in the Luika Bay, while the largest hauls were taken in inshore surface fringing the grassy margins of the shore-line.

No specimens of this species were dissected, but three specimens from the Luika delta 39 mm. in length appeared to include two ripe females and an indeterminate male. Neither Ricardo (1939a & b) nor Swynnerton (1947) have recorded any data on breeding.

For E. minutus in Lake Tanganyika, Poll (1953), suggests reproduction takes place in coastal bays and lagoons where the young are only found; not occurring in the pelagic plankton. Examination of the maturing gonads indicated a spawning period concentrated during the rains of the early part of the year. Conversely, Jackson et al (1963) notes that E. sardella of Lake Nyasa is the only endemic pelagic fish; this species produces large numbers of floating eggs and larvae which have been occasionally found in the pelagic plankton hauls, but it is emphasised that not all the evidence supports the account of a pelagic life history.

Since no specimens of E. rukwaensis were dissected no records can be given of the stomach contents and feeding habits. Similarly neither Ricardo (1939a & b) nor Swynnerton (1947) give any details of its diet. Jackson (1961c) says that E. moeruensis like other members of the genus is a zooplankton feeder. Worthington (1933) has already demonstrated planktonic crustacea, diatoms and blue-green algae in the gut of E. sardella while Jackson (1961d) and Jackson et al (1963) record a similar basic zooplanktonic diet, as does Greenwood (1958) for E.bredoi and E. argenteus from lakes Albert, Victoria and Kyoga. However, Poll (1953) makes a surprising note of Hymenoptera and Hemiptera in the gut of adult E. minutus from the pelagic waters of Lake Tanganyika.

On Lake Rukwa this species is presently of no commercial importance but may sometimes be included in the subsistence fishery. Bertram et al (1942) and Swynnerton (1947) recorded that is is highly valued as food and bait by the African populations of Lake Nyasa and Rukwa north lake respectively. The fact that Engraulicypris will congregate around a light source at night was indicated by Jackson (1961c) and Proude (1963) describes light-fishing experiments for E. argenteus on Lake Kyoga using a lift net. Catches of up to 180 lbs. (wet weight) have been obtained; the dried product is popular in certain areas and a similar fishery might advantageously be organised on Lake Rukwa.

Barilius moori Boulenger

The distribution of this species is limited to the basins of lakes Rukwa, Tanganyika and possibly Kivu. It is uncommon in the lakes themselves but favours sandy estuaries and particularly shallow fast flowing waters in rivers over a stony bottom (Poll 1953). Ricardo (1939a & b) took a few fish between 70-140 mm. in seine hauls along the sandy west shore of Rukwa and further specimens in the Luika river below the falls. During February 1964 a single specimen of 140 mm. was taken in the shallow rapids of the lower reaches of the Luika river.

This specimen was not dissected and no details are given of the reproduction or diet of this species. However, Ricardo (1939a & b) and Poll (1953) record a diet of young fish and aquatic insects, while Poll adds that breeding certainly takes place in affluent rivers where mature adults and juveniles are found presumably in the rainy season.

Barbus innocens Pfeffer

This small species of fish is recorded from lakes Rukwa and Nyasa, and the rivers Wami and Mkata of Nyasaland. It occurs in streams, estuaries and along sandy shores of the lakes (Bertram et al 1942, Jackson 1961d).

Ricardo (1939a & b) recorded this species from the affluent Zimba River, the Luika River, both above and below the falls, and commonly along a sandy beach on the western shore. During August-September specimens ranging between 18-39 mm. were taken in clear water over a mud-sand bottom at Mbangala, at the campsite, and from clear waters over a sandy bottom both above and below the falls at Kasisi.

Between January-February individuals of 13-37 mm. standard length were captured. These specimens occured below the Luika falls, in downstream areas of the Luika and its delta, always where the current was not excessive and where reed, grass or weed cover was available. Similarly individuals were taken in the thick grassy margins of a small escarpment stream near its mouth at Bousfield's House. Beyond the

Luika delta specimens were taken in framed mosquito-hauls near the bottom, particularly over the sandy shallows of the delta, but also in smaller numbers over the soft mud bottom further offshore. No specimens were taken in deep offshore waters either at the surface or at the bottom. Along the shores of the lake B. innocens occured in quite large numbers in sheltered shallows with grass and weed cover, over sand or mud bottoms. From these comments it would appear that in Rukwa the preference for sandy bottoms is not so emphasized as in Lakes Tanganyika and Nyasa.

No specimens of this species were dissected during the survey and no comments can be made on the feeding. However, Worthington (1933) and Fryer (1959) note that in Lake Nyasa this fish appears to grub about on the bottom and its gut contents include insect remains, ostracods and vegetable debris.

Similarly, no detailed observations were made on breeding, but a few juvenile Barbus of indeterminate species were collected during the second survey. This small Barbus species may, in general, be found to have a peak breeding period during the wet season.

This species presently offers no commercial interest because of its small size and lack of numbers, but could possibly be of interest to collectors of tropical aquarium fish.

Barbus lineomaculatus Boulenger

As presently defined this species is widespread in southern Africa, reaching from Kenya, Tanganyika and Katanga down to Natal and Transvaal. Like several other widespread species its characters are very variable within its range and a number of sub-species and geographical varieties will probably be defined in due course. Typically B. lineomaculatus occurs in upland streams and marshes but not in extensive open waters (Poll 1953, Jackson 1961c).

Specimens from Lake Rukwa do not readily agree with Boulenger's description (1909-16) but agree with Poll's (1953) diagnostic characters, save that the length of the posterior barbel is equal to, rather than nearly twice the diameter of the eye. However, specimens examined during this survey were much smaller (10-45 mm. standard length) than collections by Boulenger (type: 67 mm. total length), Ricardo (33-60 mm. standard length) and Poll (45-82 mm. total length).

B. lornae described by Ricardo (1943) from Lake Bangwelu is now considered by Jackson (1961c) to be merely a lacustrine sub-species of B. lineomaculatus.

This species was first recorded from the Lake Rukwa basin by Ricardo (1939a & b) who noted captures of 29 specimens from above the Luika falls, 2 from below the falls and no specimens from the lake itself. These individuals ranged between 33-60 mm. standard length.

During August-September 184 specimens 16-45 mm. in length were taken from open shallows at Mbangala, from offshore waters at the campsite, and from the lower reaches of the escarpment stream below the waterfall at Kasisi. Between January-February considerable numbers were taken in various localities; in the strong swirl at the bottom of the Luika falls medium quantities occured but in calmer waters in grass margins further downstream fewer species were found. Medium numbers were caught in the mosquito-hauls over mud-sand with little or plenty of grass cover in the delta of the Luika where a cool current was flowing. A few individuals were taken over similar mud-sand substrates close inshore at Mbangala at the campsite and the mouth of the stream at Bousfield's House. However, the largest numbers of this species were fished with the framed mosquito net towed fast just above the mud bottom in the Luika Bay and in the adjacent offshore waters. Barbus lineomaculatus was not apparent in similar surface hauls.

No specimens of this species were dissected and no details are given of its breeding habits. However, larger numbers weretaken in January-February than in August-September or in September-November by Ricardo (1939a & b). Lengths ranged from 16-45 mm (January-February) 10-42 mm. (August-September) and 30-66 mm. (September-November), which indicate that breeding may not be restricted to any particular period of the year.

Stomach contents were not examined, but Poll (1953) from Lake Tanganyika specimens notes a diet including insect debris.

Like B. innocens this species is unimportant owing to its small size and scarcity of numbers. The interest of aquarists is probably the only commercial possibility.

Barbus paludinosus Peters

This species has an almost pan-African distribution, ranging from the Nile and Ethiopia, through East and Central Africa, Angola, the Orange River, nearly reaching Natal. B. paludinosus tolerates a wide range of hydrological conditions and is found in muddy marshy areas, rivers and large lakes, although it is not recorded from high altitude fast-flowing streams (Jackson 1961c, Greenwood 1962).

Like the other Barbus species described with a very wide distribution, the characters of B. paludinosus are very variable and a number of sub-specific populations occur in different geographical areas. Greenwood (1962) has noted that the length of the third spinous dorsal ray is generally characteristic of different geographical populations; however, specimens from Lake Rukwa itself and the affluent Luika River show distinct differences in the length of the dorsal spine, but it is doubtful whether these specimens do, in fact, comprise separate populations.

During this survey a few specimens were taken between August-September; 10 specimens ranging 34-90 mm. occured below the waterfall of the escarpment stream at Kasisi, 9 of these in the shelter of a large stone and the other specimens along the sheltered grassy fringes of the lower reaches of the same stream. Another specimen of 90 mm. was taken with the serrated dorsal spine entangled in a surface-set gill-net fished just offshore at Kasisi.

Between January-February, 18 specimens 32-68 mm. were captured; 1 fish occured at the base of the Luika falls and another individual in the more sheltered waters of grassy margins at the same locality. A further 3 specimens were taken from the shallow grassy margins of the Luika further downstream, and 6 specimens in the shallow sheltered rivers of the Luika delta. The remaining 3 specimens were taken in inshore mosquito seines at the campsite, Bousfield's House, and from a framed mosquito-haul taken offshore.

Ricardo (1939a & b) took B. paludinosus 40-120 mm. in length in considerable numbers from open waters near the shore in North Lake - but noted its relative absence in the open waters of South Lake.

No specimens were dissected, but a specimen of 60 mm. taken from inshore surface water of the east coast in January appeared to be a ripe female. Similarly no details of breeding habits are given by this survey, nor by Ricardo (1939a & b) nor Swynnerton (1947).

B. paludinosus offers no commercial interest other than that of a tropical aquarium fish also noted for the other Barbus species.

Barbus sp.

Among the large numbers of Barbus species taken in various mosquito seine hauls during early 1964 there appear a few fish which do not agree with the description of the 6 Barbus species previously described (Ricardo 1939a & b) from Lake Rukwa. The specific identification of these few small Barbus specimens is yet to be attempted.

Labeo fuelleborni Hilgendorf & Pappenheim

Labeo fuelleborni is indigenous to Lake Rukwa but is closely related to Labeo victorianus, indeed it was originally described by Hilgendorf & Pappenheim as a sub-species of L. victorianus, but was later raised to a specific rank by Boulenger (1905). This species occurs throughout the lake but appears more abundant in shallow inshore waters rather than the open lake (Swynnerton 1947) although Ricardo (1939a) noted Labeo as being common along the western shore, but scarce in other parts.

Adults were taken during this survey in bottom-set nets of 2-3.5 in. mesh gill-nets between August-September; a few from open waters and from inshore eastern areas, but best catches were taken off the flooded grassy areas, particularly in the Songwe swamps. A few specimens were taken in surface-set nets over the same period; offshore when the nets were fouled by grass islands, otherwise most specimens were taken close to fringing grass in the channels of the Songwe swamps. The smallest individuals (130-220 mm.) were taken in the 1.125 in. seine-net worked in shallows off Mbangala seining beach.

In the early part of 1964 adult specimens were taken in 2-3.5 in. mesh nets; a few from open waters (bottom and surface), slightly more from inshore eastern waters (bottom set), from the Songwe swamps (both urface and bottom), and a large number from a rocky bottom at Ichesa. But the largest numbers were taken at night in bottom-set nets off the mouth of the Luika River.

Ricardo (1939a & b) took young fish ranging 60-85 mm. standard length in large numbers along the sandy western shore, and other fish between 40-90 mm. in the Luika River, both above and below the falls. No juvenile specimens have yet been identified from the mosquito-hauls made in either August-September, nor during January-February.

Analysis of the stages of sexual maturity of the adults captured during both parts of the survey are summarised in Table 14.

Table 14. Sexual maturity of Labeo fuelleborni.

	August-September		January-February	
	Male	Female	Male	Female
im	6,130-220		1,175	
i	2,220-240	1,235		1,220
ia	21,215-290	34,195-310		
a	15,205-285	4,265-290		
ar	1,280	2,255-275		1,280
r		1,270	33,210-300	98,220-310
rr			33,195-280	6,265-310
sp			2,230-250	20,230-300

The records show, as already suggested by Swynnerton (1947) that reproduction is concentrated during the rainy season (January-February). Some fish, however, also appeared "active-ripe" and "ripe" in August - a point noticed by Ricardo (1939a). A wide dispersal of the adults was typical of the August-September period, but the large catches of ripe fish at the mouth of the Luika River in January-February is evidence of an upstream spawning migration, which is typical of other Labeo species. The occurence of more spent fish than ripe-running might indicate that spawning takes place in upstream areas not investigated, or that the female ripe-running phase covers only a very short period perhaps only when stimulated by other sexually active fish in a suitable locality.

Sexually mature males ranging between 195-300 mm. appear slightly smaller than mature females: 200-310 mm., and the number of females (168) appears to exceed the number of males (107). However, this ratio, and the minimum sizes of sexual maturity for males (195 mm.) and females (200 mm.) may be biased by the fact that specimens below 200 mm. length were not retained by the smallest (2 in.) mesh used.

As already noted no juveniles have been identified during this survey, but Ricardo (1939a & b) recorded during September-November small forms (60-85 mm. standard length) from the sandy west shore, and young specimens (40-90 mm.) in the Luika River at the same period. This last record is of particular interest since she notes specimens from both above and below the Luika falls, which have been for a number of years, impassable in the upstream direction. If correct for this locality this record implies a permanent adult population of Labeo surviving and breeding in the upper reaches of the Luika River, which during the dry season is reduced to a series of stagnant pools.*

Ricardo (1939a) and Swynnerton (1947) record for Labeo fuelleborni a diet composed of mud, finely divided organic matter and vegetable debris. Some 3 gut contents examined in January-February contained mud, mucus and colourless vegetable fragments. Although no detailed observations were made, the intestines of this species were usually full, even amongst the large numbers of breeding fish examined. Like other Labeo species L. fuelleborni appears to browse on the epiphytic algal growths, as well as on settled phytoplankton and vegetable material which is more abundant around the shores of the lake than in the open waters.

Labeo species in other waters comprise a large part of the commercial catch, but in Lake Rukwa Labeo are dispersed during the dry season and are not taken in the commercial surface-set nets of 4.5-6in. mesh. In the wet season bottom set nets of 2.5 and 3 in. mesh are laid in inshore sites and the catch is predominantly Labeo (see Table 8) now concentrated and migrating to the breeding grounds. A large-scale exploitation of this species during the reproductive period would not be favourable, but increased catches of Labeo could be obtained by continuing the use of bottom-set nets of a suitable size throughout the dry season. The flesh of Labeo is readily accepted by the African consumer.

Schilbe mystus (Linnaeus)

This small predator, with a maximum length of 300 mm. has a wide African distribution, ranging from the Nile, the rivers of West Africa, the Chad basin, East Africa, the Congo Basin, and the Upper Zambezi. Schilbe mystus is, however, absent from Lakes Rudolf and Tanganyika.

It occurs typically in large rivers and lakes, but not in smaller waters and upland streams (Greenwood 1958, Jackson 1961c). Ricardo (1939a) records S. mystus as common in open and littoral waters, but rare in the swamps of Rukwa and Bangwueulu, whereas Daget (1954) suggests that in the Upper Niger it is as common in stagnant waters and swamps as in running waters. In the larger, deeper lakes it appears restricted to coastal waters.

During the Rukwa survey only 3 juvenile forms were captured; in a mosquito haul through thick weed at Mbangala seining beach in February 2 specimens of 39 mm. were taken, whilst the smallest specimen of 9 mm. S. L. was taken, in a framed mosquito haul in surface waters adjacent to Mbangala seining beach at the end of January.

Adults were more plentiful and occured in August-September in 2-3.5 in. nets both on the bottom and at the surface, but were most common in surface nets particularly when set off grass fringes; large catches were taken in these habitats in the Songwe swamp and at Kasisi. During January-February still larger catches were obtained, principally in surface waters by night, in the Songwe swamps and off the Luika delta. Catches in bottom-set nets, and in the surface-set nets by day were much smaller. During the rainy season the fish were slightly larger, and were taken in 2-4 in. mesh nets, but there did not appear to be any shift of the population to particular breeding areas.

A number of specimens were dissected during both parts of the survey and these records of sexual maturity obtained are detailed in Table 15.

Table 15. Sexual maturity of Schilbe mystus.

	August-September		January-February	
	Male	Female	Male	Female
im				
i		8,140-235		
ia	7,150-260	51,115-260		6,170-200
a	2,165-190	15,135-265		1,205
ar				27,180-270
r			55,145-200	238,160-280
rr				17,170-210
sp		3,190-215	5,170-190	20,175-205

Greenwood (1958) notes that in Lake Victoria Schilbe may breed during the rains, Daget (1954) records spawning during the flood season of the Upper Niger, and Jackson (1961c) adds that in Northern Rhodesia breeding occurs during the first half of the rains. The above records of sexual development in Lake Rukwa show clearly reproduction taking place during the rainy season, but in contrast to Jackson's observations, little spawning has taken place by the middle of the rainy season. It must also be noted that 3 spent females were recorded in August-September, and a similar record of a single ripe male was made by Swynnerton (1947) in September, but all Ricardo's specimens were "quiet" between September-November.

There is apparently no well-defined spawning area, although the 3 juveniles were taken in mosquito hauls in flooded grassy margins of the lake. Likewise Daget (1954) notes that the large shoals of young fish tend to inhabit the shallows along the river bank on the Upper Niger.

Sexual maturity is apparently attained by males at 145 mm., and by females at 160 mm., but these records and the ratio of the sexes are biased by the fact that males are smaller (145-200 mm.) than females (160-280 mm) and are not all retained in the smallest gill-nets employed. Thus, the minimum breeding sizes of Schilbe mystus may, in fact, be smaller than here recorded.

The stomach contents of this species were also examined, and the frequency occurence of the food types is analysed in the following Table 16.

Table 16. Frequency occurence of prey types for Schilbe mystus.

	August-September	January-February
empty	21	14
indet. fish	8	14
insect remains	4	11
sand, mud, debris	4	1
water beetles	2	1
weed & phytoplankton	2	5
zooplankton	1	-
Odonata larvae	1	4
Tilapia	1	1
fish eggs	-	9
Barbus	-	4

The records in this table show clearly that this species is primarily a predator on insects and small fish including young Tilapia, Alestes, Barbus sp. and probably Engraulicypris and Aplocheilichthys when available. The size range of fish prey was 9-35 mm., with an average length of 22 mm. Sand, mud weed, debris, zooplankton and phytoplankton are probably taken incidentally rather than deliberately. Fish eggs were taken when available during the wet season and at the same time drowned terrestrial insects were more common.

Similar records of its diet have been made by Ricardo (1939a & b), Swynnerton (1947), Daget (1954), Greenwood (1958) and Jackson (1961c), which includes small fish, aquatic insect larvae, aquatic worms, small

gastropod molluscs and vegetable debris. Daget (1954) also notes that this species are intermittant feeders; the belly is sometimes greatly distended by the large quantity of food taken.

Like other predators this species is relatively heavily infected with parasites; Ricardo (1939a & b) records large numbers of nematode worms in the coelomic cavity, similarly during this survey nematodes were common, together with intestinal and coelomic cysts and occasional tapeworms (Cestoda) also occuring.

Schilbe mystus is not presently taken by the commercial fishery but is like other fish with a high lipid content readily appreciated by the African consumer. Ricardo (1939a) has already suggested that this species could be most conveniently exploited by hand-lining.

Clarias mossambicus Peters

This catfish species is widely distributed throughout East Africa from the Nile and Ethiopia down to the Zambezi. As presently defined C. mossambicus appears to occupy the central segment in the geographical cline of Clarias species which reach from C. gariepinus in S. Africa to C. lazera of North Africa (Jackson 1961c).

Typically this fish can be found over mud-sand bottoms in small rivers, dams, swamps, lagoons, estuaries and inshore waters of the larger lakes, but it seldom ventures into deep open waters of these lakes (Poll 1953, Greenwood 1958, Jackson et al 1963).

In shallow Lake Rukwa Ricardo (1939a & b) has recorded Clarias mossambicus as abundant throughout North and South Lakes in both inshore and offshore waters. During this survey adult Clarias were taken both offshore and inshore areas principally in bottom-set nets but also in surface waters. Particularly large numbers were taken in nets set fringing the grass in the Songwe swamps, and when the nets were badly fouled in this zone this species composed the entire catch. A number of small specimens were taken in a beach seine over a soft muddy bottom in shallow waters at Mbangala.

A single juvenile specimen of 12 mm. standard length was recorded from a mosquito-seine haul in the outflowing waters of the Luika delta during the middle of Feburary. This wash-down mechanism has already been used to explain the dispersion of young Clarias from the shallow spawning areas (Greenwood 1955).

The gonads of a number of dissected specimens were examined and classified in Table 17.

Table 17. Sexual maturity of Clarias mossambicus.

	August-September		January-February	
	Male	Female	Male	Female
im	1,350		1,260	
i	4,142-410	1,480	11,230-640	8,240-450
ia	11,270-730	17,170-700	35,320-700	310-820
a	6,275-450	7,200-460	9,430-740	
ar	7,430-500		3,550-580	
r			12,360-830	18,390-560
rr				1,360
sp		2,430-460		3,500-800

Swynnerton (1947)first suspected that it was unlikely that Clarias reproduced in the lake itself but probably migrated into rivers and spawned large numbers of ova in reedbeds and inundatedgrassy areas at the beginning of the rains. Later Greenwood (1955) recorded a spawning of C. mossambicus from Lake Victoria occuring overnight in a small swampy affluent stream during the rainy season. This has since been supported by Jackson (1961c & d) describing a spawning migration into shallow weedy waters, and on the Zambezi he notes that juveniles are found in quantity in drying muddy pools as the floods recede.

Greenwood (1958) notes: "Clarias eggs are small (about 2 mm. in diameter) and are attached by an adhesive disc to plants and debris in the bottom of the stream. Early development is rapid and the young fishes hatch within 36 hours after fertilization ..... The young remain in the stream about 6 weeks and then apparently swim to the lake. During their first year, or even two, the young reappear in the stream whenever these are connected with the lake".

The results of the present survey also support the view that spawning takes place during the rainy season, and the single ripe-running female was recorded at this time from the fringing grass of the Songwe swamps. The records also indicate that not all fish spawn at this period; large numbers of both sexes remained inactive during January-February.

The minimum size at sexual maturity for both sexes appears to be 360 mm. standard length in this population reaching a maximum size of 1100 mm. Greenwood (1958) quotes 500 mm. as the minimum breeding size of Clarias from Lake Victoria which reach a maximum size of 1200 mm., and 250-400 mm. for the shorter C. mossambicus population from Lake Kyoga.

The 2 spent females recorded during August-September could be fish which spawned during the previous rainy season but whose ovarian regression was particularly slow.

Stomach contents of dissected specimens were examined during both visits and the frequency occurrence of food categories is listed in Table 18.

Table 18. Frequency occurrence of food types for Clarias mossambicus.

empty	21
weed, phytoplankton and vegetable debris	13
aquatic and terrestrial insects	9
indet. fish	4
mud and stones	3
zooplankton	2
frog	1
Tilapia	1
gastropod mollusc	1

Although diet is predominantly fish and insects a wide range of other animal and vegetable matter is taken. The largest prey taken was a Tilapia of 190 mm. in the gut of a specimen 710 mm. in length; this was about the maximum size that this Clarias could take and amounted to 27% of the predator length. Other authors also refer to its carnivorous and predatory diet including fish, insects, molluscs and plants (Poll 1953, Jackson 1961a) but Greenwood (1958) adds that a few specimens appear to feed exclusively on plankton.

Typically this carnivore is fairly heavily parasitised and usually contained a number of nematodes in the coelom, together with cysts embedded in the intestine and mesenteries. Ricardo (1939b) noted that many specimens were covered with the copepod parasite Argulus africana Thiele, but none of these parasites were observed on fish during this survey, although a single free-living specimen of an argulid was taken in a mosquito-seine haul at Mbangala seining beach.

Clarias is relished by the African consumer throughout the continent for its taste and high lipid content. Presently it is not taken in large quantities by the commercial gill-net fishery of Lake Rukwa, and a high proportion of the catch of this species is utilized for home consumption. The most convenient method of increasing the exploitation of this valuable species might be to encourage hand-lining along the shore and long-lining in the inshore and offshore waters.

Chiloglanis sp.

Some 9 specimens of Chiloglanis between 9-13 mm. standard length were taken in mosquito-net hauls in the fast out-flowing current of the Luika River delta, and one individual in a framed mosquito-net hauled fast and deep in the bay off the Luika River during January-February. The final identification of this species remains to be

confirmed but these specimens do constitute a new record for this genus within the Rukwa basin.

Synodontis zambesensis Peters.

Synodontis zambesensis is widely recorded throughout East Africa from the Webi-Shebeli (Ethiopia-Somalia) down to the Zambezi. It occurs most commonly in shallow inshore water over a mud bottom, and does not extend into the deeper waters of the larger lakes (Ricardo 1939a, Jackson 1961c).

Some 11 juvenile specimens ranging 12-19 mm. in standard length were taken from Lake Rukwa during early 1964 in mosquito-seine hauls through thick weed and grass cover at Mbangala seining beach, and also in framed mosquito-hauls near the bottom in the adjacent Luika Bay. A similar habitat of quiet weedy flooded backwaters of the Middle Zambezi is described by Jackson (1961c) during the wet season.

Adults were taken in large numbers in bottom-set nets of 2-3 in. meshes throughout the lake but particularly in inshore areas and the Songwe swamps during both visits. A few individuals were taken in surface-set nets particularly in the Songwe swamps and when fouled by floating grass islands. There was, however, no noticeable change in distribution of the population between the dry and wet-season investigations. Large numbers occurred over the mud and sandy shallows at Mbangala seining beach and were taken in the 1.125 in. mesh seine. Some 189 adult specimens were examined and the stages of sexual development are recorded below in Table 19.

Table 19. Sexual maturity of synodontis zambesensis

	August-September		January-February	
	Male	Female	Male	Female
im	1, 70			
i	2, 90-110	15,100-170		
ia	8, 70-110	15,100-170		
a	4,100-155	3,110-155		
ar	13,110-170	8,132-195	1,125	
r	1,125		16,120-165	88,110-190
rr		3,130-145		3,150-170
sp		20,130-190	3,155-160	

The figures for the ratio of the sexes and the minimum size at sexual maturity are strongly biased by the absence of small specimens not retained in the smallest nets, particularly during January-February. However, it is noted that males are generally smaller (maximum 165 mm.) than females (maximum 190 mm.) and that maturity is reached at least by the 110-120 mm. class fish.

The remaining records are rather confused, but the majority of fish in August-September were classified as inactive to active-ripe, whereas by January-February almost all fish were ripe, thus indicating a peak of breeding activity during the rains. However, some fish appeared to be capable of spawning during the first visit and a similar note was made by Ricardo (1939a) between September-November when 75% of her specimens were ripe-running females and the remainder were quiet. Similarly, Swynnerton (1947) noted active signs of breeding between February-September and he concluded that reproduction was not limited to any specific month within this period.

Spawning probably takes place predominantly overnight in shallow flooded grassy areas in a cold freshwater environment such as in river margins and minor river deltas. No spawning activity was observed but local fishermen agreed that it was dangerous to wade in the Luika delta at night during February owing to the numbers of Synodontis underfoot.

The gut contents of several specimens were examined, of these 12 were empty and the remaining 23 contained small pieces of weed and vegetable debris, Odonata larvae, chironomid larvae, terrestrial insects, gastropod molluscs, fish-scales, zooplankton, phytoplankton, and some

sand and mud. The wide diversity of the diet has already been emphasised by Ricardo (1939a), Swynnerton (1947) and Jackson (1961c).

This small species is particularly common in the Lake and can be readily taken in small mesh bottom-set gill-nets, although owing to the barbed pectoral and dorsal spines it is particularly difficult to handle. It is not presently of commercial interest, but Swynnerton (1947) comments that it makes excellent eating.

Synodontis fuelleborni Hilgendorf & Pappenheim

This small uncommon species is endemic to Lake Rukwa, but is closely related to S. afro-fischeri of Lake Victoria, indeed Ricardo (1939b) notes that it is almost impossible to distinguish specimens from these localities on the slight morphological differences.

No juvenile specimens were taken and only 40 adult fish were captured. These occurred principally in 2 in. bottom-set gill-nets set in the Songwe swamps, although isolated specimens did occur in the offshore eastern, rocky (Ichesa) and riverine (Luika delta) areas.

The stages of sexual development are recorded in Table 20.

Table 20. Sexual maturity of Synodontis fuelleborni.

	August-September		January-February	
	Male	Female	Male	Female
im				
i				
ia				
a		2,120-130		
ar	1,115	10,120-140		
r		6,120-135		14,120-140
rr				1,130
sp				1,140

These results are not sufficient to draw any direct conclusions, but it seems likely that S. fuelleborni like S. zambesenis reproduces mainly ring the rains, although breeding can continue to September. Once again the males appear smaller than females, and sexual maturity is reached at least by 120 mm.

The gut contents of 10 fish were examined, and like S. zambesensis were found to contain mud, weed and vegetable debris, but no aquatic insect remains. The length of gut was, however, noted to be longer than that of S. zambesensis:

S. zambesensis	standard length	170 mm.	length of gut	40 mm.
S. fuelleborni	standard length	140 mm.	length of gut	52 mm.

The weed content was much more finely divided than in the gut of the more common species. These facts may indicate a more dominant vegetable component than in the diet of S. fuelleborni.

This species is not presently of any importance and is so scarce and small that it is never likely to yield significant catches. Presumably the flesh is appreciated as is the sister species.

Aplocheilichthys johnstonii Gunther.

This small cyprinodont species is recorded also from Lake Nyasa, the Zambezi and Zululand (Ricardo 1939a, Jackson 1961c & d), but the systematics of this genus are confused and A. johnstonii may well be later merged with other wide-spread species.

In other localities, it occurs amongst submerged vegetation in shallow sheltered waters, and indeed, in Lake Rukwa it is recorded from mosquito-seine hauls around the flooded grassy margins of the lake and in the Luika delta. A few individuals were taken from sheltered muddy

shallows of the Luika river immediately above the delta, but no captures were noted further upstream in more turbulent waters.

The range of size of these specimens was 12-26 mm. standard length and although no specimens were dissected, one female of 25 mm. appeared to be ripe-running. Little is known of its reproduction, which for some species may be pelagic, or as for this species, associated with the dessication of residual pools. Food for other members of this genus is recorded as including aquatic insect larvae and zooplankton (Greenwood 1958).

From a nutritional point of view this small uncommon fish is of no value, but it is, however, a convenient and attractive aquarium fish.

Tilapia rukwaensis Hilgendorf & Pappenheim.

This single Tilapia species is endemic to Lake Rukwa and forms the basis of the present commercial fishery. It is recorded as being abundant throughout the lake in both inshore and offshore waters, but has not been recorded from the rivers, although a pair of dwarfed specimens were noted from the delta of the Zimba river (Ricardo 1939a & b, Swynnerton 1947).

Ricardo (1939b) notes this endemic species as Tilapia nilotica rukwaensis Hilgendorf & Pappenheim which she elevates to full specific rank: T. rukwaensis H. & P. Surprisingly, this species was not catalogued by Boulenger (1909-16).

During the present survey the adults were abundant and were principally taken in gill-nets of between 3.5 and 5 in. mesh. Large catches occurred in offshore, inshore eastern, and Songwe swamp waters in both bottom and surface-set nets. During January-February a particularly large catch was taken by bottom-set nets in the sandy-muddy shallows off the Luika delta, but no significant change was noted in the distribution of the whole population between the wet and dry seasons.

Young fish, ranging between 29-275 mm. were taken in the 1.125 in. beach-seine used during August-September at Mbangala, but this gear was not worked during the second visit.

Juveniles of 8-85 mm. were observed in small quantities during August-September in the warm shallow pools in the mouth of the dry Luika river, in the clear shallows at Mbangala seining beach, and in similar shallows off the campsite. During January-February mosquito-net seines were worked extensively and large numbers of fry between 9-30 mm. were taken in inshore shallows between the extreme littoral waters and inshore grassy areas covered by one metre of water. No specimens were recorded from the Luika river except at the downstream margins of the delta, nor did they occur in the surface or bottom hauls of the framed mosquito-net in the Luika Bay nor further offshore. Small specimens, therefore, appear to inhabit the shallow fringes of the lake where cover from submerged vegetation is available. T. rukwaensis were the only species to occupy the extreme inshore turbid shallows which reached a temperature of 30.3°C during the day compared to 28.8°C in the deeper grassy margins. A similar tolerance to relatively high temperatures is recorded for other Tilapia species by Welcomme (1964).

A large number of young and adult specimens were dissected and the records obtained for the stages of sexual maturity are given below in Table 21.

Table 21. Sexual maturity of Tilapia rukwaensis.

	August-September		January-February	
	Male	Female	Male	Female
im	30,29 -195		5,145-205	
i	9,175-240	5,102-190	2,190-205	6,144-200
ia	38,130-240	29, 87-225	25,180-230	59,160-260
a	25,165-270	41,155-285	20,170-280	27,170-240
ar	18,190-255	30,205-260	10,210-240	9,210-250
r	10,225-275	14,200-285	51,210-280	29,200-260
rr	3,220-245	8,210-245	1,270	17,210-260
ap		2,210-220	2,240	6,225-250

Ricardo (1939a & b) commented that the main breeding season is in the rains: December-February, with ripe fish tending to move inshore. Swynnerton (1947) noted that a peak percentage of ripe fish is found between December-February in inshore waters, and between September-October in offshore waters. Both authors conclude that reproduction is not confined to the rainy season, but that spawning fish do occur in small numbers throughout the year.

The results of the present survey show that over August-September the majority of Tilapia were in the inactive-active stages, with some 11% of the females classified as ripe. During the second visit the majority of fish were still classified as inactive-active, but the percentage of ripe females had risen to 19%.

Swynnerton (1947) closely examined a large number of female gonads and concluded that unlike non-cichlids, the ova did not all mature simultaneously but that the gonad exhibited a multiple stage development. He cites some females mouth-brooding their fry with their ova in various stages of development, and similar observations were made on 3 fish during 1963-1964.

Table 22. Distribution of Tilapia in each category of sexual maturity expressed as percentages.

	August-September				January-February			
	Inshore		Offshore		Inshore		Offshore	
	Male	Female	Male	Female	Male	Female	Male	Female
i	13	5	4	2	1	3	4	5
ia	36	24	38	19	21	33	29	47
a	18	28	32	38	16	20	21	15
ar	18	20	17	30	7	9	14	3
r	13	12	6	8	52	23	29	11
rr	4	9	2	2	-	11	4	11
sp	-	2	-	-	2	1	-	8

Examination of the above Table 22 shows that the percentage of breeding adults of both sexes was greater inshore than offshore during both visits, and that the percentage of ripe females is greater during January-February than August-September. These results confirm that peak breeding occurs in inshore areas during the rains, but contrasts with Swynnerton's second observation that another peak percentage of ripe fish is found offshore during September-October.

Males of the same stage of sexual development are generally smaller than females, and the minimum breeding sizes of the lake population are 210 mm. for males and 200 mm. for females; Swynnerton quoted the usual size at sexual maturity as 230-250 mm. total length at an age of 9-12 months. Ricardo (1939b) notes 2 specimens of 120-140 mm. preparing to breed in the Zimba river; the male had the typical dark male colouration and the female gonad was classified as ripe. She considers these specimens as a dwarf riverine variety of the T. rukwaensis population.

Swynnerton (1947) and Lowe (1955) have already noted that small Tilapia lay fewer smaller eggs than older fish and Swynnerton quoted a range of 66-1236 ripe ova in 13 fish examined with an average of 692. However, he has also noted that a single spawning may not void all the ova; some are probably retained and are spawned after the first brood has reached independence of the maternal mouth. A ripe running female of 245 mm. standard length was dissected: the gonad of 17 gm. contained 1260 ova which were pear shaped with a major axis of 3.88-3.90 mm. and a minor axis of 2.40-2.46 mm. Judging from the size of mouth-brooded fry and independent juveniles, the young fish are brooded up to a standard length of 8-9 mm.

Previous authors have noted the distinct change in colouration of many Tilapia species over the breeding period and T. rukwaensis follows this pattern. The female has a light green colouration dorsally, shading to a white ventral surface with in the younger fish, a series of 6 vertical lateral dark bars which are less distinct on adult fish. The fins are all white-translucent, the throat is entirely white and the small anal papilla is white, orange or red in colour. At the active-ripe stage the body and fins are still the typically light colour but the throat occasionally develops a speckled dark pigmentation auteriorly. The anal papilla is small, sometimes setaceous and is coloured orange-red. In the ripe-running and spent stages females have a slightly darker body colouration, the tips of the dorsal are tinged with red, and the caudal extremities are tipped with white or orange. The throat is white, speckled or dark anteriorly (also swollen when fry present in mouth) and the anal papilla is of medium length (10-20 mm.) sometimes setaceous and usually orange coloured.

The male, however, exhibits a more marked change of colouration; during the inactive phase the typical female light-coloured body, white throat and small white or orange anal papilla are apparent. In the next stage, the throat shows specks of dark pigmentation anteriorly, but the papilla is still small (less than 10 mm.) and usually white or red. Active fish are characterised by darkening body and fins, the anterior throat dark and speckled posteriorly, and a papilla reaching 10-20 mm. still white or red coloured. By the active-ripe stage the body and median fins are dark though the tips are not yet coloured, the throat is entirely dark and the anal papilla is large, yellow, orange or red in colour. The climax is reached at the ripe and ripe-running stages; the body and median fins are almost black, or often with an irridescent green-blue sheen - particularly noticeable on the operculum. The caudal is tipped with red, and the dorsel has an orange margin along its length. The throat is black, the anal papilla is long (up to 30 mm.) and setaceous, coloured white, yellow or orange.

Owing to the high turbidity of the lake water very few observations have been made on the breeding behaviour of Tilapia but Lowe (1958) has separated Tilapia species into 3 categories dependent on breeding behaviour. Tilapia rukwaensis fits the description of her "maternal-brooding" group characterised as follows:

1. Only male develops breeding colours and defends spawning territory.
2. Male spawning territories are colonies on definite spawning grounds.
3. Only males make nests.
4. Very little courtship precedes spawning which is very rapid.
5. Female carrying eggs (in mouth) moves away from spawning area.
6. Polygamy usual: male fertilizing eggs from a succession of females which spawn in his nest.
7. Only female broods, does not feed while doing so: male feeds little while actively guarding the nest.
8. Brooding females seek shelter of plant beds and may make long migrations between spawning and brooding grounds.
9. Eggs are only momentarily on the bottom, so poorly oxygenated bottom water may not limit spawning area.
10. Mostly algal-feeders using phytoplankton, epiphytic and bottom algae according to availability.
11. Found in open lakes some distance from shore as well as shallow waters of swamps and rivers.
12. Considerable movements occur between feeding and breeding grounds; young are left in shelter of weeds and later move to open water.

T. rukwaensis males show a distinct breeding colouration, although this must seldom be visible in the extremely turbid waters. The female usually carries the developing eggs - though Swynnerton (1947) notes that in times of stress males may also brood eggs; feeding activity ceases or is reduced in breeding adults (vide infra); brooding females occur in weed and grass beds and the young are left in the shelter of these beds and progressively move into the open waters. T. rukwaensis is an algal feeder (vide infra) and is distributed throughout the lake in inshore and offshore waters. In contrast, however, the inshore spawning grounds have not yet been well defined and no nests have been observed; spawning and brooding areas appear adjacent and between these no lengthy migrations are undertaken. The dissolved oxygen level in Rukwa is not low and probably does not limit spawning areas, although lack of a suitable sandy substratum may do so.

The stomach contents of a few individuals were examined and found to contain phytoplankton, green-brown debris, small pieces of weed, a few planktonic Cladocera but surprisingly no Copepoda, and a little grey-mud suspended material. Similar results have been obtained by Ricardo (1939a & b) and Swynnerton (1947) who also noted that the stomachs of breeding fish were more often empty or half-empty than those of non-breeding fish.

Most adult and young specimens were parasitised by a few nematodes in the pericardial cavity, but no other parasites were noted either from the gills, coelemic cavity or body surfaces.

The commercial value of this species is very great; dried-smoked Tilapia forms the major product of the previous and present fishing industry on Lake Rukwa. The extent of this trade is discussed elsewhere.

Haplochromis bloyeti (Sauvage).

This, the only other cichlid species from the area is recorded from Lake Rukwa, Lake Manyara, and the Kandoa and Mbusini rivers in Tanganyika. Specimens from Rukwa were originally described as Tilapia fuelleborni by Hilgendorf & Pappenhein (1903) but Ricardo (1939b) notes that this name should be synonymous with H. bloyeti (Sauvage).

It was previously recorded from minor pools of water during the dry season but not in the lake itself (Ricardo 1939a & b). Similarly, during August-September eleven specimens were taken; 9 of these ranging 15-70 mm. from a very small stagnant stream near Kasisi, one of 22 mm. from grassy fringes below Kasisi waterfall, and a 41 mm. individual from warm shallows off the dry Luika River mouth. Between January-February five specimens ranging 17-35 mm. standard length were taken in mosquito-seine hauls amongst grass in the Luika delta, over a sandy-mud grassy area at Bousfield's House and three specimens amongst thick weed cover in the shallows of Mbangala seining beach.

Ricardo (1939a & b) noted a ripe male of 70 mm. (total length) and the nine specimens from Kasisi in September 1963 are classified in Table 23.

Table 23. Sexual maturity of Haplochromis bloyeti.

	August-September		January-February	
	Males	Females	Males	Females
a		1,46 mm.		
ar	3,49-57 mm.	1,42		
r	1,67	2,47-49		
rr				
sp		1,39		

Specimens taken during the rainy season were not dissected, but it appears that reproduction occurs during the dry-season, and perhaps throughout the year. No further details of the feeding or breeding of this species were noted.

This rare fish is of no possible commercial value, though like other small rare species, may be of particular interest in tropical freshwater aquaria.

Commercial exploitation

No direct census of the fishing population on the lake has been attempted but in some previous years licences were required by fish-traders and fishermen. Distinction has always been made between the local Wabungu residents, other immigrant fishermen from the heavily populated area of Tukuyu, and Wageni ("foreigners") from Nyasaland and Northern Rhodesia.

Swynnerton (1947) noted registration commencing in 1945 with a total of four local commercial fishermen and in 1946 the figures were 120 Wabungu fishing for subsistence only, 172 Wabungu in the commercial trade, and 3 foreigners engaged in the trade. He estimated that there were in fact about 250 permanently active fishermen on South Lake in 1946 together with a number of seasonal migrants.

In 1949 Lockley (1964) noted that fishing was restricted to the Ubungu chiefdom and was centred at Kipindi, Kilinga and Ichesa where there were 116 licensed fishermen, but in practice only 50-60 canoes actively fished. Between October 1949 and April 1951 fishing was limited to subsistence catches only, but by 1952 the commercial fishery had re-opened. The licensing categories had now changed and the figures for 1952 were a total of 135 fish-traders and fishermen, while in 1953 there were 52 traders and 320 fishermen (Hammond 1964). It must, however, be emphasised that these figures are rather unrealistic; there is widespread evasion of the licensing regulations which are in any case applied only to the South Chunya district, not including the Mbeya, Ufipa or North Chunya sections of the lake. None of the figures given include details of the few European concessionaires permitted on the lake at different periods.

During 1963-64 Hammond (1964) organized a voluntary registration of canoes (Table 24) which were recorded from southeast Rukwa. Assuming the usual complement of two fishermen per canoe this amounts to 200 active fishermen along 15 miles of the east coast. Inferring a similar density of fishing population along the whole 200 miles of habitable coastline, the total number of active fishermen on the lake is approximately 3,000. The same figure has also been independently quoted for this total population of fishermen in 1962 by the Co-operative's Officer, Southern Highlands Region (Hammond 1964).

Table 24. Canoe registrations (after Hammond 1964).

Village	No. of Canoes
Maleza	3
Mbangala	24
Mambiwe	8
Ichesa	10
Kikongoro	8
Mkungu	13
Njila	14
Kifimbo	11
Msongezi	8

The fishing methods used on the lake were first noted by Ricardo (1939a) as being the "luelo" scoop-nets used by the African fishermen and large beach seines worked by the few European concessionaires. Swynnerton (1947) described the luelo as a triangular net hung from a V-shaped support consisting of 2 poles. The mesh, woven from a thread derived from old motor-tyres was usually 3-3.5 in. in the upper part reduced to 2 in. in the bag. Although a minimum mesh of 4 in. was introduced for all gear in 1941, Swynnerton noted that this regulation was not enforced for luelo nets until 1946-47. The gear was used on foot in the shallows of the lake or rivers and also from canoes in more

open waters. The catch consisted almost entirely of Tilapia with occasional Clarias, Synodontis and other species. In addition to the luelo Swynnerton described the following traditional fishing methods which are still occasionally used.

Basket traps of woven grass with a funnel entrance are set in barrages across the rivers or set singly on the margins of rivers, swamps and the lake being baited with posho. The catches in the lake include Clarias, Synodontis and the freshwater tortoise (considered inedible by the Wabungu) while in the rivers "any" fish can be taken.

Hooks and lines baited with whole Engraulicypris, Barbus sp. or pieces of other larger species were commonly set for several days in the swamps and shallows, being anchored to a pole thrust into the bottom. These lines inspected daily take Clarias and Hydrocyon, the former species being particularly common during the rains. Hand-lining was sometimes practised near the European fishing centres where the predators Clarias and Hydrocyon were attracted and caught on the material discarded in the shallows during the gutting operations.

Large Clarias specimens were speared daily during their upstream migration during the rainy season while Engraulicypris and Barbus sp. used for both food and bait were taken in the Ufipa area with basket and body-cloth scoops fished in the shallows. Also illegal vegetable intoxicants and poisons were spread on the surface of small bodies of water and the drugged fish collected by hand from the surface.

The European fishery which began in 1931 was dependent on fence-traps in the backwaters and swamps near Ntunje but later between 1935-6 gill-nets, trammell-nets and trawls were tried though with little success and beach-seines emerged as the most successful method.

These seines woven from old motor tyre thread were commonly 100-150 yards in length, 3 feet deep in the wings but deepening towards the codend with a mesh of 4 in. (minimum legal size). The sisal warps were 200-400 yards long and the net was set from a small flat-bottomed boat. Larger nets of thicker ply were also made and used particularly when crocodiles were a considerable menace but fishing was easier and catches slightly larger with repeated hauls of small seine rather than with a single haul of a very large net. The catches were principally Tilapia; Clarias, Hydrocyon, Synodontis, etc., were also taken but not generally processed, but supplied to the fishermen employed in lieu of wages and rations.

With the changes of lake level and subsequent fouling of the seining beaches with marginal vegetation the European organized seine fishery has collapsed and the present active African commercial fishery is dependent on gill-nets. The nylon surface-set nets 4-6 in. mesh are threaded loosely onto the head and footlines of synthetic twine and are arranged roughly by the third. This method of hanging is particularly suitable for slow swimming fish with a laterally compressed body form, indeed catches from both inshore and offshore waters are almost entirely Tilapia with occasional Mormyrus, Hydrocyon and Clarias.

A few bottom-set nets of 2.5-3 in. mesh are fished inshore during the rainy season and the catch of these nets is composed principally of Labeo with a few Clarias, Hydrocyon, Synodontis and Schilbe. Details of catches by bottom and surface-set commercial nets are given in Table A8 and the costs of suitable netting and twine in Table 25.

Table 25. Current prices of nylon netting.

Ply	Quantity	Mbeya	Mbangala	Comment
210/4	100 yds.	Shs.20-28	Shs.28	Meshes 4, 4.5, 5 in.
210/6	100 yds.	Shs.40	-	Meshes 4, 4.5, 5 in.
210/9	100 yds.	Shs.64	-	Meshes 4, 4.5, 5 in.
210/12	7 oz.	-	Shs.4	Headline

Floats and buoys are made of sections of ambatch trunk: Aeschynomene (Herminiera) elaphroxylon); the sinkers and anchors are suitable stones picked up along the shore. A few migrant fishermen use imported cork floats but when lost these are replaced by ambatch floats.

With the concentration of mouth-brooding female Tilapia in sheltered inshore grassy areas during the rainy season a few driving-nets are employed; a short length of 3-4.5 in. mesh net is staked out on the shallows and passes are made along each side of the net frightening the Tilapia from shelter into the meshes. No other species are taken by this method.

The numbers of nylon gill-nets voluntarily registered with Hammond (1964) from villages around southeast Rukwa during his census are detailed in Table 25A.

Table 25 Analysis of numbers of gill-nets.

Village	4 in.mesh		4.5 in.mesh			5 in. mesh			
	210/3	210/4	210/2	210/3	210/4	210/2	210/3	210/4	210/6
Mbangala	-	1	3	47	27	-	37	85	7
Kikongoro	-	-	-	18	2	-	-	1	-
Ichesa	-	-	-	38	-	-	13	4	-
Mambiwo	-	-	1	44	-	-	16	-	-
Maleza	1	2	4	18	-	9	27	3	-
Mikungu	-	-	-	31	4	-	126	9	-
Kifimbo	-	-	-	2	-	-	9	-	-
Mgomba	-	-	-	-	3	-	-	-	5
Itumbi	-	-	-	-	-	-	-	3	-

The indigenous dugout canoe described by Swynnerton (1947) is still the most common craft on the lake. Carved from the large trunks of Acacia albida, Cordyla africana or Kaya sp. these small unstable canoes are said to last 3-5 years; no preservative is used and the cost in 1946 was Shs.40/- to 70/-. European enterprises constructed small flat-bottomed boats for use in the seine fishery; these were stable, planked craft built locally and cost Shs.300/-. Presently there are two motor boats of about 40 feet o.a. working on the lake; propelled by outboard or inboard engine they ferry passengers, goods and fish products between the centres of Mbangala and Sumbawanga and the isolated fishing encampments on North Lake. A single clinker-built canoe 22 feet o.z. is used by the Fisheries Officer and a pair of Sesse-type canoes, with large outboard engines have also been imported from Mwanza.

Commercial and research catch-rates.

Although no detailed investigation was attempted of the relative productivity of different areas of the lake it is apparent that the intermittently shallow North Lake is more productive than the permanently inundated South Lake. The present temporary increased production in the north is evidenced in three ways; firstly, many local fishermen are dissatisfied with catches in the south and large numbers have migrated to the North Lake. Secondly, the mesh of surface-set gill-nets employed in the north ranges over 5-6 in. whereas in the south 4-5 in. nets are more usual. Thirdly, records of the catches by commercial fishermen (see Table A 8) show catch rates at Kasisi (North Lake) in September some three times greater than at Mbangala-Ntunje during either August-September or January-February. This present temporary high level of productivity in the North Lake is exaggerated by a previous concentration of effort on South Lake and by the previous absence and present relative low level of fishing effort in the north.

No details are given but catches of the full range of mesh sizes was greater in both August-September and January-February from bottom-set nets in the Songwe swamp area than either inshore eastern or open-water regions, which showed similar catch-rates during both

visits. For surface-set nets similar results were obtained; catches from the Songwe swamp were rather larger during January-February and August-September than from the other two areas, both showing similar rates of catch.

It is also noted from Table A.8 that research nets took a larger proportion of Hydrocyon and less Tilapia than commercial nets of similar mesh; this is a reflection of the thinner twine and loose mounting of the commercial nets compared to the more rigid and robust research nets of thick ply. Catches of Tilapia in both research and commercial nets were, however, greater during January-February than August-September, probably as a result of the inshore migration and increased activity of breeding Tilapia during the rains.

Considerable differences in calculated catch-rates of commercial nets worked by Mann at Mbangala and local fishermen at Ntunje during August are most probably due to inaccurate records favouring the figure for the Wabungu, and secondly, the fewer fishings by Mann, which on one occasion was affected by fouling and folding.

Bottom-set research nets of 2.5 and 3 in. meshes showed similar catch rates in January-February and August-September but bottom-set commercial nets of these same meshes set also during the rains took far larger proportions of Labeo than the research nets; the reasons for this are possibly the different mounting of the commercial nets (not observed) or more probably the use of more suitable fishing sites. Large catches of Labeo were in similar research nets in the Luika delta but have been omitted from the calculations because of the unique locality not fished by local fishermen.

Processing

From Rukwa virtually no fish is consumed fresh except for local subsistence; the traditional African methods of processing described by Ricardo (1939a) and Swynnerton (1947) are still commonly used to preserve the commercial catch. The Tilapia are descaled, gutted, divided, and are then left to dry in the sun for 2-3 days lying on low screens of branches or on the roofs of huts. Sometimes, particularly in the rainy season, smoking is carried out over small wood fires in conjunction with sun-drying. The product which will last for several days, is packed and lashed between two wooden frames ready for transport.

Other species are processed differently; the few large Clarias are eviscerated, coiled and impaled upon a stick and are hot-smoked for a day or so. This product is uncommon but is widely appreciated by the African consumer. The few specimens of Hydrocyon taken are descaled and eviscerated; transverse cuts are made on the body and the fish is sun-dried or smoked and like other uncommon species is usually reserved for local consumption. The viscera and female gonads of Tilapia are frequently collected after cleaning and the masses of ova and mesenteric fat are cooked; the lipids so extracted are highly valued for cooking.

During the period of the European fishery Tilapia were sun-dried and smoked in the same manner as the indigenous fishery, although the process was alittle more efficient and hygienic. Lipid extracts of Tilapia viscera and Clarias flesh were sometimes painted on the dried Tilapia product to increase the lipid content and perhaps improve the flavour. Sun-dried Tilapia were noted to keep for 4-8 days during dry weather, but sun-dried Clarias lasted only for a short period of time. During the rains a combination of sundrying and smoking was practised; the appetising Tilapia could last 14-42 days in the dry season but much less during the rains, and consequently was not suitable for storage or long-distance transport.

In 1946 the sun-drying and salting method of preservation already known on Lake Victoria was tried; the product lasted at least 60 days, was relished by the African consumers in some areas and had the further advantages that it consumed no firewood, and stimulated the local production of salt at Ivuna. However, this product did not take hold on the market perhaps owing to the unhygienic preparation of the fish and the unethical handling of the African labour by this particular European enterprise (Lockley 1964).

At one stage (1942) "haddock fillets" were prepared for the European market by scalding, filleting and brine-soaking the Tilapia. Subsequently, the fillets were cold-smoked for 36-48 hours and the final tinned product was noted to last indefinitely, but this product disappeared with the decline in numbers of the European consumer population.

Swynnerton himself (1947) experimented a little with curing; he gutted and cleaned Tilapia, soaked it in brine for 12 hours and then smoked it for 36 hours. The product kept well for as long as 60 days in the wet season and samples sent to potential buyers were favourably received but with the decline of the European enterprises this technique disappeared.

Production and marketing

Prior to 1920 the Wabungu people of the shores of southeast Rukwa were not an important fishing community and fish was taken only for subsistence; no export trade existed. However, with the development of the adjacent Lupa goldfields from 1922 onwards there was increasing demand for fish products amongst both the African and European labour on the Lupa reefs. In 1931 the first European fishery based on the lake near Ntunje was supplying fresh Tilapia to Mbeya at 5 cts. each, and the sundried product in relatively small quantities to Lupa, Mbeya, Iringa and Tukuyu where it sold at 25 cts. a fish.

Ricardo (1939a) noted the African and European commercial ventures in 1936 supplying dried smoked Tilapia to the goldfields, to the railhead at Itigi, and to the labour of the sisal plantations at Tabora and Morogoro. Demand first exceeded the supply and fish products were sold at 5 cts. each at Lupa and 10 cts. each at Tabora and Morogoro. Later that year the goldfields slumped and local demand fell, but the difficulties of transport to distant centres of consumption were too great; local sales could not compete with local African competition and the European enterprise closed operations in 1938. A slight improvement in the local market later that year came too late to save this concessionaire.

With the outbreak of world war in 1939 the goldfields revived and further attempts were made to re-open the European controlled commercial fishery. Production increased as more concessionaires were admitted and the price of fish rose slightly from 5 cts. in 1939 to 7 cts. in 1941. By 1942 "haddock-fillets" destined for the European consumer were marketed as far afield as Kenya.

Swynnerton (1947) collected in 1946 a great deal of information on the industry; in this year the Lupa goldfields were becoming worked out and the local demand for fish product was falling. Processed Tilapia cost 5 cts. each at the lake shore and in bundles of 200-250 fish weighing 80-90 lbs. were head-loaded by itinerant traders to Makongolosi (1.5 days), Kuntugas (2 days) and Chunya (3 days) where they fetched 10 cts. each. European concessionaires bought fresh fish from African fishermen at 4 cts. each at the lake shore and some fresh fish was still supplied to Saza Mines. Table 26 gives some details of the current prices of Tilapia in 1946.

Table 26. Prices of Tilapia products in 1946 (after Swynnerton 1947).

Place	Distance (miles)	Price per Tilapia (cents)	Comment
Lake shore	0	10	Europeans sell at 10 cts. African at 5 cts.
Saza	12	15	
Makongolozi	25	20	
Chunya	50	20	17 cts. for agents for resale in Mbeya.
Mbeya	95	30	

Dried salted Tilapia for the African market were sold at Shs.15/- per hundred plus Shs.1/50 packing and freight charges. Similarly, cold-smoked "haddock" for the European market fetched 17.5-20 cts. per pair in Chunya, or tinned Shs.1/75 for 1 lb., Shs.2/- for 2 lbs. and Shs.8/50 for 6 lbs.

In 1947 Lockley (1964) noted a European production of some 1,850,000 Tilapia weighing 900 tons (fresh wet weight) and estimated a total African-European production from the lake as 3,500,000 fish or 1,600 tons (fresh wet weight). However, he suggested that European production was only being maintained at the expense of more intensive fishing. A great potential market was said to exist in the Southern Highlands Region, but large stocks of dried - smoked Tilapia were accumulated in Chunya and had to be destroyed. The reasons for this he suggested were the seasonal competition of "dagaa" from Lake Tanganyika, which although more expensive (6 ozs. dagaa cost 30 cts.) than Tilapia (6 ozs. Tilapia costs 15 cts.) can be readily divided into small portions, and secondly, the Indian traders at Chunya were attempting to fetch unnecessarily high prices and profits for the product.

By 1948 production was falling; for instance in October, 86,000 Tilapia (43 tons fresh wet weight) and 23,000 Clarias were marketed by European enterprises, while African catches in Chunya district were estimated at 9,000 Tilapia and 500 other fish species. However, it was noted that fish products of all kinds commanded a higher price in Northern Rhodesia than Tanganyika owing to the considerable demand in Copper-belt area.

The low rainfall for a number of years culminating in the exceptionally poor rains of 1948-49 resulted in the lowest level of the lake within living memory. Fishing still continued to remove 100,000 Tilapia per month and Lockley (1964) recommended that the commercial fishery be suspended and that crocodile hunting, begun the previous year, should be increased. Itinerant trading was stopped and the sale and export of dried fish products was prohibited in Mbeya and Chunya districts but the African subsistence fishery was still permitted.

The following year 1950 rains were better but the lake was still not restored to its former level. Wabungu fishermen resorted to traditional methods for subsistence; seining was impossible along shores with a vegetation belt 0.25 to 1.00 mile wide. The market for dried fish at the Lupa goldfields has now completely closed and it was suggested that African fishermen should be exempted from licence fees which were too expensive to collect.

During 1951 the lake rose covering submerged vegetation but the commercial fishery was not yet permitted although traditional African methods did well; for instance 306 canoe days produced 5,692 Clarias weighing 8,500 lbs. (fresh wet weight). 1952 saw the resumption of the European industry; between February-December Bousfield marketed 934,049 Tilapia worth Shs.69,486. The total number of licensed fish-traders and fishermen was recorded as 135. Maximum price controls were established by the Lake Rukwa Fisheries Board as follows for Tilapia in good condition:

	Wholesale	Retail
Fresh Tilapia	30 cts. each	30 cts. each
Hot-smoked Tilapia	105 cts. per lb. net	20 cts. each
Salt " "	110 cts. per lb. net	21 cts. each

The following year the industry picked up; marketing some 1,505,000 Tilapia worth Shs.105,484 and some 48,000 Clarias but the concessionaire could not recruit sufficient labour of his own and was forced to buy Tilapia from African fishermen at 5 cts. each. However, during the suspension of the European enterprises 1949-52 African fishermen had contrary to regulations, built up a distribution system of their own through sales to itinerant traders. In 1952 African catches increased; itinerant traders offered 7 cts. per Tilapia compared to

Bousfield's 5 cts. African fishermen and traders demanded the right to define their own markets and realising the impossibility of controlling this trade the Fisheries Board made licences available for African traders to purchase from registered fishermen. The result of this was to make fish product available in new and remote areas of Chunya and Mbeya districts, although the European concessionaire had by the end of the year large stocks of Tilapia which could not be sold. Once again supply exceeded the bulk demands.

During 1954 the marketing regulations limiting purchases at established posts by licensed traders for cash only, together with the levy of 5 cts. per 25 fresh fish sold and the prohibited export of fish from the Southern Highlands Region except for approved agents, were lifted. Some 1,309,000 Tilapia were marketed by the concessionaire alone between October 1953 and October 1954, large quantities of this smoked-dried product going to the Rhodesia copper-belt, and large numbers were distributed locally by African traders.

In 1955 the orders for the Copper-belt were not repeated and the commercial fishery began to succumb to marketing difficulties. The Fisheries Board noted that its marketing controls were unnecessary, and Lockley (1964) emphasised that with current fishing methods there was little danger of permanent damage to the fish stocks; natural lake level fluctuations presented a far more serious hazard from which the Tilapia fishery had quickly recovered. Thus, it was concluded that the fishery should be exploited on opportunist lines and the Board decided to de-control the fishery for a trial period.

The following year (1956) the Board reduced the minimum legal size of Tilapia to 8 in. total length and the European commercial fishery ceased, although it was still active in the processing and marketing field. Within the Chunya district 180 fishermen sold catches to 150 licensed traders, whereas a survey, in fact, noted some 300-400 active traders. At the lake shore the price of Tilapia was 10 cts. each irrespective of size and the traders who smoked, packed and transported the fish products obtained between 40 to 250 cts. per fish in Chunya, Mbeya and Tukuyu. This apparently large profit angered the fishermen and a Fisherman's Co-operative Society was suggested as a possible remedy to the marketing problems developing; the Southern Highlands Region was unable to absorb the full output from Rukwa.

In 1957-1958 the fishermens' co-operative society was inaugurated but appeared unsuccessful and was unable to discipline its members. It was noted that non-African enterprise had shown an understandable lack of interest in the industry since the drought of 1948-52. However, the high quality of the Rukwa product was remembered within Northern Rhodesia and it appeared that there were good chances of re-starting the export trade. The following year trading licences were increased to Shs.60/- p.a. for Tilapia and Shs.25/- p.a. for other species in an attempt to eliminate the large number of part-time "foreign" traders and to improve membership of the co-operative which possessed a single comprehensive licence. However, large purchases by unlicensed traders continued in the Ivuna district.

In 1960 the Board before dissolution, noted that the imposition of controls on fishing and marketing were not justified, being difficult to enforce and apparently detrimental to the trade.

In 1961 enquiries for Rukwa products from Kitwe, Northern Rhodesia, flagged when vendors quoted 70 cts. per fish at Tunduma, an excessive figure when Tilapia cost 15-40 cts. on the lakeshore. The next year representations were made by the Northern Rhodesian Fish-traders Union to ensure that the marketing of fish for Tanganyika and Rhodesia should be entirely in African hands. At the same time, comment was made by Dibbs (1964) on the fishermens' co-operative - he noted that the society should be the sole channel for marketing fish and that fishermen should process and pack the fish under the society's supervision. The many "foreign" traders have their own channels of distribution and were not enthusiastic to join and yet are probably the more enterprising and progressive entrepreneurs.

At the present time, 1963-64, markets for dried smoked Tilapia are found within both Tanganyika and the Rhodesias. From North Lake fish products collected from isolated fishing camps are transported by canoe or motor-boat to either Mbangala or the landing point near Sumbawanga, from which point fish is carried by lorry direct to the main market centre at Abercorn, passing through the border at Mosi... From settlements on South Lake fish is usually ferried to Mbangala, but large quantities also pass through Ivuna, and thence to Northern Rhodesia via the Customs Post at Tunduma.

Collections made at Mbangala pass over the rough mountain road through Chunya to Mbeya, where three separate routes diverge; firstly, exports to the Rhodesias are directed westward through Tunduma, secondly, supplies of Tilapia are transported southwards to the populated coffee area around Tukuyu and Kyela, and thirdly, distribution eastwards to the rest of Tanganyika including Arusha, Dar-es-Salaam, Iringa, Kilosa, Mwanza, Njombe, Songea, Tabora, etc., travels along the Great North Road.

Although duties are not levied by either Northern Rhodesia or East Africa on the dried-smoked fish products exported, records are kept of the quantities passing the border. The figures for Tanganyikan exports and Rhodesian imports after Bowmaker (1964) and Hammond (1964) are given in Table A9. Comparison of figures for May-December 1962 show a large anomaly which is probably due to innacurate recording by East African authorities. Similar anomalies appear for individual months of 1963, but the annual totals agree quite well. In both cases the higher Rhodesian figures are probably more accurate. Additional records are also quoted for Abercorn, but no equivalent East African records have been forthcoming.

Taking Swynnerton's (1947) and Bowmaker's (1964) equivalents of 3 dried-smoked Tilapia per pound, the annual totals of fish in transit through the main centres of Mbangala, Ivuna, Njila and Milepa are given in Table 27 and comprise a total production figure for 1963 of 11,935,144 lbs. dry weight of Tilapia. Import figures for Rhodesia via Tunduma and Abercorn amount to 1,210,280 lbs. total for 1963. Thus, it appears that only 10% of the annual Rukwa production is absorbed by the Rhodesias. This figure could, however, be modified by taking Hammond's (1964) figure of 4-6 dried Tilapia to the lb. and by allowing far greater entries to the Rhodesias than actually recorded.

Table 27. Weight (lbs.) of Tilapia products in transit through main centres (after Hammond 1964).

1963	Mbangala	Ivuna	Njila	Milepa
March	163,476			
April	261,392			
May	172,722			
June	170,323			
July	81,419	195,080		
August	102,079	610,030		
September	162,674	1,182,427		213,946
October	115,509	1,256,047	30,059	143,317
November	90,066	555,433	38,568	76,863
December	109,394	209,460	40,139	
January				
February				
12 months' Total:	1,746,622	8,016,954	453,064	1,736,504

Hammond (1964) has since March 1963 organised a census of the distribution pattern of Rukwa products by road, with control posts at *Mbangala, Ivuna, Njila and Milepa,/ of the numbers of fish by destination shows 77 per cent of the trade through Ivuna directed towards Rhodesia, similarly 59 per cent from Milepa, 27 per cent from Mbangala, and none from Njila. It must be noted that part of the trade through Mbeya may also be exported. The percentage of the total produce exported to the Rhodesias is calculated at 62 per cent; this contrasts markedly with the previous calculation indicating 10 per cent exported. The conclusions

*See erratum: ; Summaries of which are given in Tables 27 + 28. Analysis ..

are that the declared destinations are not always correct, and that the quantities crossing the border are greater than officially recorded. The true export figure would be expected to be between 10 and 62 per cent of the total production.

A summary of fish production figures for the lake from 1931 to date is given in Table A 10.*

Table 28. Percentage distribution of Rukwa Tilapia products (after Hammond 1964).

Destination	Mbangala	Ivuna	Njila	Milepa	Total
Rhodesias	26.0	76.8	–	59.0	62.0
Mbeya	59.2	5.5	29.1	2.2	18.5
Tukuyu	13.4	15.0	62.9	12.3	15.3
Iringa	0.2	0.9	–	–	0.6
Tanga	–	0.3	–	4.2	0.5
Dar-es-Salaam	0.8	–	7.9	1.7	0.5
Songea	–	1.3	–	–	0.8
Tabora	–	0.1	–	–	0.1
Mpanda	–	–	–	13.2	1.0
Sumbawanga	–	–	–	7.3	0.5
Kyela	0.3	–	–	–	0.1

European enterprise is presently absent from the industry which is entirely in the hands of African enterpreneurs who are responsible for fishing, processing and marketing the fish products.

Table 29. Current prices of fish products at Lake shore.

Species	Prices: cents per fish	
	Fresh-wet	Dried-smoked
Tilapia	20	20-25
Clarias	20-60	50-100
Labeo	15	20-25
Schilbe	10	15
Synodontis	10	10
Hydrocyon	50	60-100
Mormyrus	–	60-70

A list of current prices for the various fish species at the lake-shore are given in Table 29. Figures are quoted as price per fish which is common throughout the marketing network, save that in markets of the Rhodesias the cost per pound is used. There is apparently little variation in price with season, but allowance is made for the widely differing sizes of some species; the main product Tilapia varies little in size however.

Current retail prices fetched by dried-smoked Tilapia products in more distant markets are detailed in Table 30.

Table 30. Current price per Tilapia in retail markets.

Market	Distance (miles)	Price Cents	Comment
Mbangala		20-25	Lakeshore
Mbeya	100	25-60	
Tukuyu	152	50-70	40 cts.small fish
Tunduma	171	50-60	little for sale
Abercorn	113-257	36-62	(sold per lb.)

The cost of transport for fish products have not been investigated in any great detail but examples of charges over main routes are given below in Table 31.

Costs by road vary by season and by local demand; E.A.R. & H bus services offer lower charges than commercial lorries but only small quantities can be carried. Conversely, Landrover transport is expensive, but carries a small load which is sometimes more convenient.

Although bulk markets for Rukwa products were previously found in Northern Rhodesia it appears that in recent years sales have become more difficult. In the first place new fisheries at Lakes Kariba and Bangweulu since 1962 and 1960 respectively have offered more competitive products to Rukwa Tilapia, and although the quality is said to be inferior, the transport costs over short well-maintained roads are less.

Table 31. Costs of Transport for dried Tilapia products.

Journey	Vehicle	Cost per Tilapia (cts.)
Kasisi-Mbangala	Motor-boat	4
Kasisi-Mbangala	Lorry	5
N.W. Lake-Mbangala	Motor-boat	5
Mandaa-Mbangala	Motor-boat	3
Mbangala-Mbeya	E.A.R. & H. bus	2
Mbangala-Mbeya	Lorry	3-4
Mbangala-Tukuyu	Lorry	3-4
Mbangala-Mbeya	Landrover	5
Mbangala-Iringa	Landrover	15

During the early months of the year the rains and legal restrictions on fishing on lakes Kariba and Bangweulu raise the price of Rukwa Tilapia to a premium, but later during the year when restrictions are lifted Hammond (1964) discovered that there was a glut of fish and that there was difficulty in finding profitable markets for Rukwa products; indeed he quoted better possibilities at Mwanza (Lake Victoria) than in the Rhodesias.

Secondly, fresh-frozen fish products are becoming more popular with the wealthier consumers on the Copperbelt; Rukwa is presently unable to enter this remote market without the provision of refrigerating facilities at the lake and expensive insulated or refrigerated transport.

Thirdly, a cash deposit amounting to 20% of the vehicle's value is required by the Northern Rhodesian Customs Authorities from lorry owners temporarily importing their vehicles to Tanganyika to collect fish. In addition to this burden there is presently no available freight travelling north to Tanganyika, nor should fish be unobtainable, are there any other suitable products moving southwards; passengers are forbidden to travel on foreign vehicles within Tanganyika. The sole concession allowed is the free import of a small quantity of cheap fuel for use in the vehicles within Tanganyika.

A few Tanganyikan traders transport fish from Mbeya to Rhodesia; the same difficulties owing to lack of return freight apply and passengers are not permitted within Rhodesia. A similar cash deposit is required by the East African Customs on the temporary export of the lorry, the object being to eliminate the effective change in value due to differing rates of import duty on vehicles in the two countries.

Hammond (1964) gives the following example of the export of a quantity of dried-smoked fish from North Lake to Ndola on the Copperbelt. He notes that a single lorry load of 50,000 - 60,000 Tilapia must be shared amongst six to eight retail agents in order to dispose quickly of this perishable product and to fetch an optimum price of Shs.1/50 - Shs.2/50 per lb. or about 44 cents each (Details in Table 32).

Table 32. Analysis of wholesaler's profit (after Hammond).

50,000 Tilapia at 20 cts. each	Shs.10,000
transport North Lake - Mbangala	600
transport hire Ndola and return	1,600
	Shs.12,200
Retail 48,000 Tilapia at 44 cents each (2,000 spoilt)	12,120
Total profit	8,920
Profit per buyer (7 buyers)	1,274

Hammond notes that this profit of Shs.1,274/- is considered too small for several weeks work and an investment of about Shs.3,000/-.

Of the market within Tanganyika for Rukwa fish products nothing is known save the quantitative distribution of dried-smoked fish deduced by Hammond (1964) from his census (see Table 28).

It must, however, be emphasised that Hammond's figures are not complete and as already stated the final destination is not always correctly quoted. However, in the absence of any other information on the distribution of fish products within Tanganyika these details provide a very useful general view of the internal fish-trade.

Discussion

Although some details have been given of the social, economic and hydrological conditions in the lake area in previous years, it is unfortunate that data on the fishing industry collected in 1939 by Swynnerton (1939) and between 1948-50 by Lockley (1964) has not been available. It would be proper to retrieve these reports before they are completely lost.

Data on the general hydrology of the lake will obviously be of direct importance to the proper development of the fishing industry and its associated trades, and in particular variations in lake level and surface area are directly of consequence to IRLCS concerned with the control of the red-locust whose major breeding grounds are in the flood plains of central and north Rukwa. Rainfall records for the Rukwa basin continue to be collected by the Tanganyika Meteorological Dept., but details of lake level are presently only recorded by Hammond (1964) in his occasional visits to the lake. Gauges installed by the Water Development & Irrigation Department on the western shore of the lake were apparently unsuitable for the sudden large increases in lake-level that occur and data has never been recorded from these points. Records of lake-level should be continued regularly at the present gauge at Mbangala and a more permanent datum mark might conveniently be installed on the steep eastern rocky shore near Ichesa.

Some data has now been accumulated on the ecology of the fish fauna of Lake Rukwa but little or no work has been carried out on a more broad survey of the aquatic environment. In this connection, it must be emphasised that the crocodile population, exploited almost to the point of extermination between 1948-1958, could with careful management comprise an important export trade which could far exceed the inconvenience, damage and losses sustained by the fishing industry through crocodiles. Similarly, the present large hippopotamus population could provide a considerable amount of meat annually without severely reducing their numbers if exploited by a controlled shooting programme. The major part of Lake Rukwa and large areas of the surrounding country presently comprise a controlled area where game is plentiful and in which licensed hunting is permitted; this tourist attraction must be preserved and its value carefully assessed as when the development of fishing and agriculture within the Rukwa area comes into conflict with nature conservation.

The efficiency of the present indigenous fishery could profitably be increased in a number of different ways. Firstly, the unstable leaky dugout canoes should be replaced gradually by planked canoes which would be less extravagant in the use of timber, more robust, more seaworthy and would increase the effective area of fishing operations. Clinker-built canoes are perhaps unnecessarily strong and expensive for the relatively calm waters of Lake Rukwa, but Ssese-type canoes of which two examples have already been introduced on the lake would appear to be most suitable. New craft should be provided with a square transom on which an outboard engine could be readily fitted; however, probably not for a number of years will it be economic to use outboard engines for fishing although canoe-transport on the lake should benefit greatly by their immediate introduction.

Secondly, the commercial catches could be markedly increased by improving the catch-efficiency of the nets and by the exploitation of fish stocks which are presently ignored. The present thin-ply nylon gill-nets are fragile and although the thin nets take greater proportions of Tilapia than thicker nets the meshes are easily broken, yet no attempt is made to repair these breaks and nets are fished until catches are hardly worth recovering. The regular repair of nets would improve the catches, but perhaps the fishermen are unwilling to invest more time and money in the repair of gear which may be stolen.

With the introduction of mechanised craft on the lake, to avoid damage, nets would need to be clearly marked by large buoys rather than the present half-submerged ambatch or papyrus floats. The registration and marking of nets, although another unpopular burden on the fisherman should reduce the present common theft of nets left in the lake at night in some areas.

As already emphasised in previous sections the commercial fishery on the lake is presently concentrated on the Tilapia population, and the resources of all other species are virtually ignored. No fish species are entirely inedible and research catches have shown that fish landings can be increased easily and immediately by extending the scope of the present fishing methods.

With the present exceptionally high level of the lake and for several years to come as the lake recedes beach-seining will be impracticable owing to the hazards of submerged littoral vegetation; thus, in the immediate future fishing will be mostly gill-netting. The present surface set fleets of 4-6 in. mesh should be extended to include nets of 3-4 in. mesh of a thicker (210/4, 210/6) ply; catches of Hydrocyon or Clarias would increase but generally small immature Tilapia would not be retained by the thick small meshes. Bottom-set nets presently set only during the rainy season for Labeo should be set throughout the year; meshes of 2.5-4.5 in. would take significant quantities of Hydrocyon, Clarias, Mormyrus and Gnathonemus but thick meshes of 2.5 in. and above would not retain large quantities of the troublesome Synodontis species. Long-lining and hand-lining, presently used in river-mouths and swamps should be encouraged along the margins of the lake for the capture of the predators Hydrocyon, Schilbe and Clarias.

The present dried-smoked Tilapia products keep for only 30 days in the dry season and for much less in the wet season; losses of the processed fish are considerable and efforts must be made to improve the product. A combination of salting and sun-drying tried in 1944 appeared to be successful and extended the period of storage to 60 days in dry weather. Further trials of this product should be encouraged and the marketing possibilities investigated; salted-fish is frequently unpopular with inland African tribes. In addition, improved methods of processing will also be required for the commercial catches of other species of fish: Hydrocyon, Clarias, Schilbe, Labeo, and Gnathonemus which have a higher lipid content than Tilapia; sun-drying and light-smoking are rarely sufficient to produce a fish-product which will last more than a week without decomposition. Two very acceptable methods of long-term storage of fish products - canning and freezing - are not feasible in the present state of the industry as construction and operation costs would be heavy and there would be little market for the expensive products within Tanganyika with its particularly low per capita income.

The transport system for the export of fish products from the fishing centres to the major markets is presently responsible for considerable losses within the trade. Canoe transport for dried-fish products on the lake, paddled by the fisherman himself, is exhausting, hazardous and time-consuming when fishing could be continued. Similarly, motorised transport by water or by land is infrequent and unreliable; the soaking of the fish and delays en route quickly increase the percentage losses of the dried fish by decomposition. Thus, there is an urgent need for the development of an efficient transport system in the lake area. Roads or motorable tracks are scarce and are expensive to construct and maintain; with the present high level of lake water transport would appear most suitable as the capital involved would be far less and the centres of fishing activity would always be accessible.

Although as indicated above fish production from the lake could readily be increased it is doubtful whether at the present time increased exports could be absorbed by the existing markets. Bulk markets which previously existed in the Copperbelt areas of Northern Rhodesia, of Katanga and in the Lupa goldfields have now disappeared owing to increased internal Northern Rhodesian production, the confused political situation in Katanga and the exhaustion of the Lupa reefs respectively. No new markets have yet been defined within either Tanganyika or adjacent territories and the industry must now develop alternative markets for its present outlook before any consideration is given to increased fish production from the lake. Unfortunately, the quantity of the fish exports to the Rhodesias has recently been considered as a potential source of revenue to the Tanganyika local and national governments; levies have been imposed covering one cent per fish, Shs. 120/- p.a. per fishing license, Shs. 120/- p.a. per trading license, and Shs.800/- p.a. per export license (Hammond 1964). These restrictions all tend to increase the difficulty of marketing fish products, particularly within Northern Rhodesia at a time when the necessary alternative markets are not yet available within Tanganyika and the overall results is to depress rather than to encourage the fishing industry on Lake Rukwa.

The Northern Rhodesian government now anxious to encourage its own fishing industries on Lakes Kariba and Bangweulu is contemplating the imposition of an import tax on foreign fish products, the effect of this duty together with internal Tanganyika levies would be to eliminate the present Rhodesian market for Rukwa _Tilapia_ products, except perhaps for a short period during the early months of the year while a closed-fishing season operates in the Rhodesias.

Whilst the present water-level of Lake Rukwa is maintained fish production will continue at a relatively high level without any change in the intensity of fishing effort. With the expected fall in lake level in future years production will rise further but will fall again as the lake reaches a minimum size. At this stage, it would probably be advisable to suspend intensive commercial fishing operations in order to preserve the fish stocks. These contemplated changes in productivity of the lake do mean, however, that there is little security in the fishing industry of Rukwa, this fact will restrict the amount of capital which might be invested and hence the degree of mechanisation within the industry. In such a flexible little mechanized concern the numbers of immigrant fishermen working on the lake form a useful experienced labour reserve although their profits should be encouraged to circulate more within Tanganyika.

A great deal more basic information is required on the biology of the fish fauna, in particular of the endemic species _Labeo fuelleborni_, _Tilapia rukwaensis_, etc., as well as the non-endemic species whose breeding biology remains to be defined and the juvenile stages described. Indeed Rukwa may offer a suitable site for the investigation of breeding and subsequent development of the young stages of several anadromous fish; where the larger rivers are interrupted by falls in the lower reaches reproduction must be concentrated in the limited downstream areas below the falls. Under these conditions the discovery of developing embryos and fry might perhaps be easier. Since all the fish genera except _Barbus_, _Clarias_ and _Synodontis_ are monotypic there can be little confusion in the identification of juvenile specimens; indeed it should prove possible to distinguish juvenile _Hydrocyon_

from juvenile Alestes and Engraulicypris down to about 9 mm. standard length. Similarly, since H. vittatus is the only Hydrocyon species present the juveniles can be accurately defined without confusion with H. forskali which occurs together with H. vittatus in other major lakes.

Recommendations:-

1. That an immediate investigation should be undertaken to define the present markets for fish products within Tanganyika and the possibilities of encouraging increased sales of Rukwa fish both within Tanganyika and the neighbouring territories.

2. That the establishment of improved motorised water-transport on Lake Rukwa should be investigated and implemented.

3. That further biological investigations should be continued and concentrated on the endemic and commercially important species of the fish fauna.

4. That improved fishing craft, fishing gear, fishing methods and processing techniques be introduced as the demand for Rukwa fish products develops.

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Table A1. Summary of rainfall at Mbeya Meteorological Station 1932-62. (after Meteorological Department, E.A.C.S.O., 1964) (expressed in inches)

Month	Minimum	Maximum	Average
January	4.33	13.41	7.81
February	1.44	10.57	6.48
March	1.41	10.50	6.35
April	1.77	11.94	4.55
May	-	2.14	0.67
June	-	0.35	0.05
July	-	0.24	0.02
August	-	0.56	0.04
September	-	1.10	0.10
October	-	2.70	0.60
November	0.23	10.59	2.04
December	0.31	15.63	5.98

Table A2. Average annual rainfall Rukwa Basin 1924-62. (after Meteorological Dept., E.A.C.S.O.) (expressed in inches)

Year	Samples	Rainfall	Year	Samples	Rainfall
1924	1	40.72	1944	20	43.19
1925	1	58.26	1945	22	35.12
1926	1	38.53	1946	23	33.26
1927	1	47.25	1947	24	37.26
1928	3	33.50	1948	23	30.32
1929	4	30.46	1949	23	25.88
1930	4	41.48	1950	29	38.27
1931	5	40.38	1951	28	48.73
1932	6	38.55	1952	29	35.43
1933	6	40.19	1953	28	35.81
1934	5	34.21	1954	28	30.80
1935	9	36.57	1955	28	36.20
1936	10	44.49	1956	23	44.80
1937	10	36.25	1957	23	43.33
1938	11	37.01	1958	24	39.86
1939	12	35.73	1959	24	39.69
1940	14	37.99	1960	23	39.18
1941	16	44.63	1961	25	51.33
1942	17	42.92	1962	18	51.66
1943.	20	33.61			

Table A4. Chemical analysis of Lake water by Ricardo 1939a.

Specific gravity		1.00055	
Sodium		149.4	mg/litre
Potassium		19.4	"
Lithium		Nil	"
Calcium		12.2	"
Magnesium		4.6	"
Iron		0.8	"
uminium		1.5	"
Chloride		25.8	"
Sulphate		2.9	"
Nitrate	less than	0.3	"
Nitrite	less than	0.003	"
Phosphate		0.3	"
Silica		76.7	"
Total alkalinity as $CaCo_3$		212.8	"
pH (in field)		8.5	"

Comment: analysis by Government Chemist, London. November, 1937.

Table A.3 History of Rukwa lake-levels (based on Gunn 1956).

Period	Lake-level quoted	Authority
Before 1873	unknown	-
1873 Sept-Oct.	Medium-low : levels as 1936	Waller 1874 White Fathers (Ricardo 1939a)
1880 April	fairly high	Thomson 1880
1882 Oct.	very high	Kaiser 1883
1883-1888	unknown	-
1889 Nov.	low	Johnston 1890, Cross 1891
1893 July	low	v. Wissmann 1893
1897 early	very low	Langheld 1897
1897 Aug.	low	Wallace 1898
1897 Nov.	very low	Ramsay 1898
1898 ?	dry	Springade 1904
1899	dry	Dantz 1903
1899 Oct.	low	v. Prittwitz
1880-1899	North lake completely dry	White Fathers (Ricardo 1939a)
1901 Oct.	much higher	v. Prittsitz
1904	very high	Meyer 1909
1905	very high	Mateo (Albrecht 1952)
1910	whole North Lake dries	Melland 1910
1920	dry	White Fathers, Mateo
1921-1928	(unknown) dried up completely	White Fathers (Ricardo 1939a)
1929	low (drought over all E.Africa)	White Fathers
1930	filled up	White Fathers
1933 Nov.	fairly high	Michelmore 1937
1934 April	deep	Michelmore 1937
1935	deeper	Swynnerton 1946
1936	went down, medium-low	Swynnerton 1946, Ricardo 1939a
1937	very high	D.C.Ufipa, Lea & Webb 1939
1938	very high	Michelmore in litt.
1939-41	high, falling	Bousfield
1942	high, falling	Mateo
1945 Feb.	boat on North Lake	Forrester
1946	medium?	IRLCS
1947	medium?	IRLCS
1948	low	IRLCS, Lockley & Hammond 1964
1949	dry	IRLCS, Lockley & Hammond 1964
1950	dry, North Lake small	IRLCS, Lockley & Hammond 1964
1951	fairly dry	IRLCS, Lockley & Hammond 1964
1952	floods in plains	IRLCS, Lockley & Hammond 1964
1953	dry	IRLCS, Lockley & Hammond 1964
1954	North Lake almost entirely dry	IRLCS, Lockley & Hammond 1964
1955	dry	Lockley & Hammond 1964
1956	rising	Hammond 1964
1957	rising	Hammond 1964
1958	rising	Hammond 1964
1959	rising	Hammond 1964
1960	rising	Hammond 1964
1961	violent rise	Hammond 1964 IRLCS 1962
1962	very high	Hammond 1964 IRLCS 1963
1963	highest level within memory	Hammond & Mann 1964 IRLCS 1962
1964	very high?	Hammond & Mann 1964

Table A5. Chemical analysis of lake water by Swynnerton 1947.

pH	9.3	
Turbidity	386	parts per million
Alkalinity as $CaCo_3$ (= 0.0204N)	1019	"
Total hardness as $CaCo_3$	46	"
Free ammonia	0.1	"
Albuminoid ammonia	0.7	"
Nitrates as nitrogen	1.0	"
Nitrites	absent	"
Oxygen absorbed 10 min. at 100°C.	24	"
Chlorides as chlorine	118	"
Total solids at 100°C.	2.010	"

Comment: Sample collected 17.00 hours, 12th September, 1946. Report by Government Chemist, Dar-es-Salaam "The water seems to contain a high proportion of alkaline bicarbonate".

Table A6. Chemical analysis of lake water by Hammond 1964.

Turbidity	120.0	parts per million
Free ammonia	0.02	"
Albuminoid ammonia	0.04	"
Nitrate as Nitrogen	Nil	"
Nitrite as Nitrogen	Nil	"
Chloride	16.0	"
ouride	0.5	"
Calcium	12.0	"
Magnesium	3.8	"
Sodium	–	"
Metals	Nil	"
Total solids	454.0	"
pH	8.4	"
Conductivity	353.9	micromhos at 25°C.
Oxygen absorbed from N/80 $KMno_4$ in 4 hr. at 80°F	3.5	parts per million
Alkalinity as $CaCo_3$	40.0	"
Carbonate hardness	46.0	"
Non-carbonate hardness	Nil	

Comment: Samples taken 9th June, 1963, analysed 28th June by W.D. & I.D., Mbeya. Appearance turbid, colourless. A soft water showing signs of heavy organic pollution, unsuitable for domestic & drinking use.

Table A7. Rainfall and lake-levels at Mbangala, Lake Rukwa, 1964.

	Rainfall (in.)	Lake level (ft.)		Rainfall (in.)	Lake level (ft.)
January 1	-	no record	February 1	-	21.50
2	-	"	2	-	21.55
3	-	"	3	1.10	21.65
4	0.12	"	4	-	21.70
5	-	"	5	-	21.60
6	1.28	"	6	-	21.80
7	-	"	7	-	21.65
8	0.58	"	8	1.70	22.05
9	-	"	9	-	22.00
10	-	"	10	-	22.15
11	0.20	"	11	-	22.20
12	0.21	"	12	-	22.10
13	0.04	"	13	0.54	22.25
14	-	"	14*	-	22.30
15	-	"	15	-	22.25
16	-	20.75	16	-	22.40
17	0.06	20.65	17	not recorded	
18	0.19	20.70	18	"	
19	0.20	20.80	19	"	
20	-	20.75	20	"	
21	-	20.90	21	"	
22	-	20.95	22	"	
23	0.06	21.05	23	"	
24	0.98	21.95	24	"	
25	0.35	21.10	25	"	
26	-	21.15	26	"	
27	-	21.20	27	"	
28	0.39	21.35	28	"	
29	-	21.30	29	"	
30	-	21.75			
31	0.65	21.45			

Table A9. Imports & Exports of fish products officially recorded.
(after Bowmaker 1964 & Hammond 1964) (expressed in lbs. dry weight)

	Tunduma				Abercorn
	1962		1963		1963
	Tanganyika	N. Rhodesia	Tanganyika	N. Rhodesia	N. Rhodesia
January	-	-	1 350	9 020	Nil
February	7 800	-	2 650	32 500	Nil
March	-	-	7 300	23 800	Nil
April	24 560	-	13 960	66 500	Nil
May	1 428	17 070	61 210	69 455	14 730
June	32 350	33 640	60 200	36 700	30 050
July	48 143	34 270	61 045	30 000	31 776
August	78 800	67 130	110 543	65 460	90 232
September	13 500	75 530	93 538	89 000	47 250
October	33 100	168 550	133 038	112 200	75 530
November	21 200	27 050	25 000	30 000	81 439
December	2 200	33 350	16 265	30 000	39 420
Yearly total	345 780	684 885	586 079	594 635	615 645

Table A8. Ca[illegible] rates for certain commercial an[illegible] [illegible]esearch nets

SURFACE-SET NETS (Results expressed as gms/hr./50 yds set)

AUGUST-SEPTEMBER	Tilapia	Hydrocyon	Clarias	Other spp.	Total	Comment
4.5 in Research	77.0	366.1	-	29.0	473.1	All localities
4.5 in Commercial (Mann)	81.7	25.2	14.4	-	121.3	Few records
5 in Research	62.8	246.2	95.2	14.7	418.9	All localities
5 in Commercial (Mann)	85.8	26.2	-	-	112.0	Few records
5 in Commercial (Ntunje)	206.8	7.2	14.9	-	228.9	Rough census
5 in Commercial (Kasisi)	583.4	20.7	25.0	-	629.1	Accurate census
JANUARY-FEBRUARY						
4.5 in Research	150.6	225.3	130.8	12.5	519.2	All localities except Luika Delta
4.5 in Commercial (Mbangala)	199.8	142.8	303.5	-	646.1	Accurate census
5 in Research	73.2	126.2	92.5	5.66	297.5	All localities except Luika Delta
5 in Commercial (Mbangala)	228.3	31.2	27.5	3.4	290.4	Accurate census

BOTTOM-SET NETS (Results expressed as gms/hr./50 yds set)

AUGUST-SEPTEMBER	Labeo	Hydrocyon	Clarias	Other spp.	Total	Comment
2.5 in Research	124.6	38.2	12.3	482.2	603.3	All localities
3 in Research	117	35.2	28.0	182.4	363.2	All localities
JANUARY-FEBRUARY						
2.5 in Research	97.0	7.9	37.6	158.3	300.8	All localities except Luika Delta
2.5 in Commercial (Mbangala)	300.0	54.0	-	93.7	447.7	Accurate census
3 in Research	127.3	21.8	91.0	92.2	332.3	All localities except Luika Delta
3 in Commercial (Mbangala)	289.2	36.4	25.0	14.5	365.1	Accurate census

Table A10. Summary of Tilapia production from Lake Rukwa 1931-63 (following Swynnerton 1947)

	Lakeshore Tilapia Price (cents)	Number marketed (by Europeans)	Fresh wet weight (tons)	Comment
1931-35	5	-	-	no records
1936-38	5	1 336 400	650	
1939	5	236 444	115	
1940	6	773 892	377	
1941	7	998 749	486	
1942	7	924 983	450	
1943	7	1 056 234	514	
1944	7	1 400 902	682	
1945	8	1 705 167	830	
1946	8	1 749 500	851	
1947	11	c. 1 850 000	900	
1948	7.5	c. 1 500 000	730	
1949	7	c. 1 200 000	584	
1950	-	Nil	-	
1951	-	Nil	-	
1952	7	c. 1 000 000	535	
1953	-	c. 1 505 000	732	
1954	-	c. 1 309 000	637	
1955-62	-	-	-	no records
1963	20	c.36 000 000	17 500	includes African enterprises production

ADDENDUM

Throughout, for Tanganyika, read Tanzania, except Lake Tanganyika which remains unchanged; for the Rhodesias read Zambia and Rhodesia, for Northern Rhodesia read Zambia, for Belgian Congo read Congo Republic (Kinshasha), for Lake Nyasa read Lake Malawi.

Protopterus: Poll (1961) has already recorded *Protopterus annectens brieni* Poll 1961 from the Rukwa basin. Vide Poll M. (1961) Revision systematique et variation geographique des Protopteridae de l'Afrique Centrale. *Ann. Mus. Roy. Afr. Centrale, Tervuren*, series in 8° *Sci. Zool.* (103) : 1-53.

Hydrocyon vittatus: (Castelnau) 1861, synonymous with *H. lineatus* Bleeker 1862, is now correctly named *Hydrocynus vittatus*, Castelnau 1861. Vide Barnard, K.H. (1948) Report on a collection of fishes from the Okovango River, with notes on Zambezi fishes. *Ann. S. Afr. Mus.*, 36 (5), 407-458.

Marcusenius discorhynchus Peters 1852, is now considered by Myers (1960) to be a member of the new genus *Cyphomyrus* as *C. discorhynchus* (Peters) 1852. Vide Myers, G. (1960), The mormyrid genera *Hippopotamyrus* and *Cyphomyrus*. *Stanford Ichth. Bull.* 7.

Labeo fuelleborni: *Labeo* spp. are adept at penetrating upstream under extremely difficult conditions and thus the lacustrine and riverine populations may not be separate as implied here. But on the other hand, Greenwood (1962) in discussing *Barbus paludinosus* considered separate populations from the lake and the Luika river, and noted significant differences between these two populations.

Production & Marketing: Taking the total weight of dried fish products moved through the main centres each year as 5,328 tons (11,935,144 lbs. in Table 27) and considering that the equivalent fresh wet weight is three times the dry weight, then the annual yield of *Tilapia* products from Rukwa is 15,984 tons (fresh wet weight). Adding a nominal 10% for local consumption, etc., the total annual yield of all fish products is estimated at 17,500 tons (fresh wet weight).

Since Mr. S.A. Jaleel and Mr. B.J. Lumby have in hand an account of fish marketing and production from both the marine and freshwater fisheries of Tanzania, the section of this addendum intended to cover production data since 1964 has been omitted entirely.

Additional References:-

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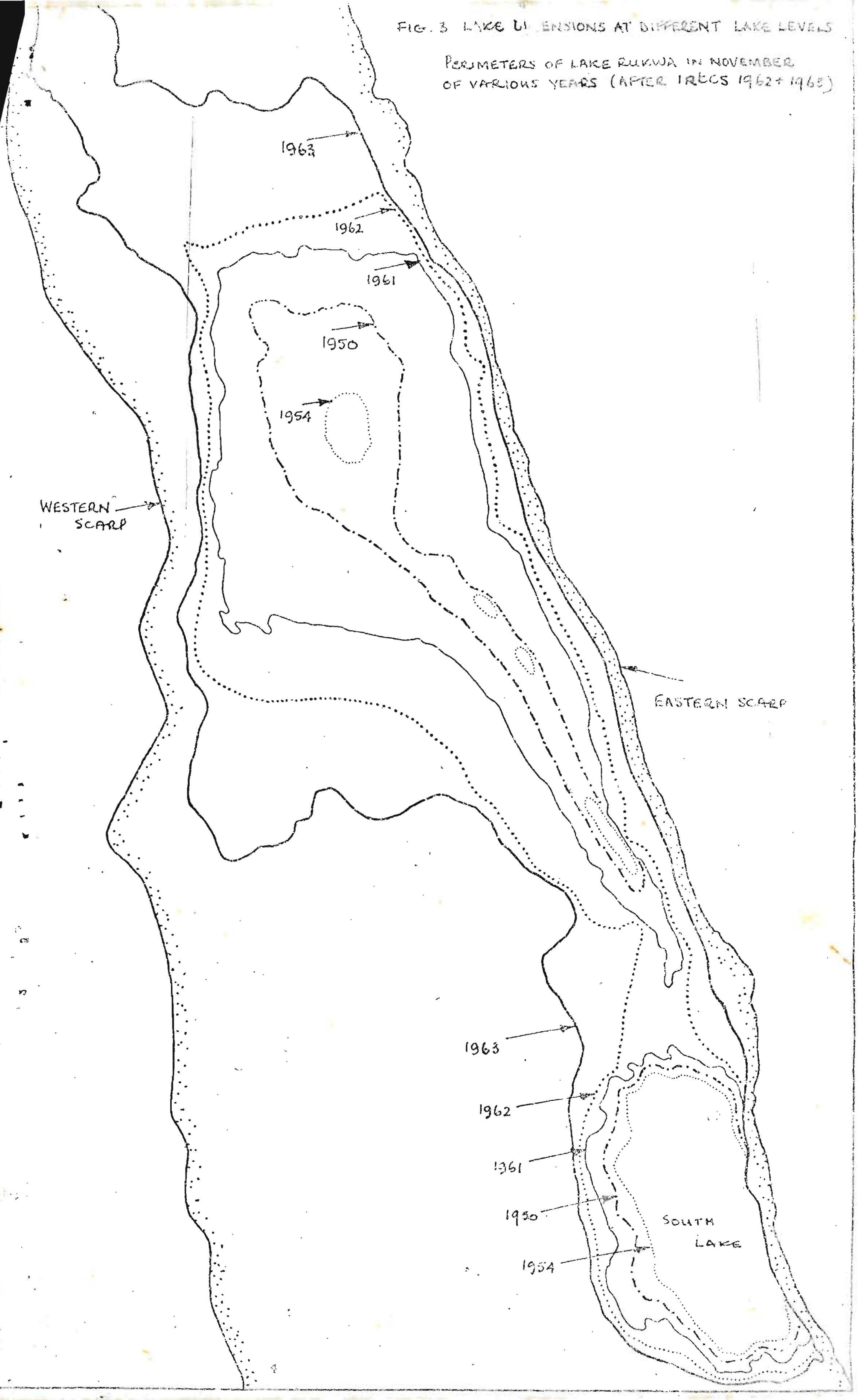
FIG. 3 LAKE DIMENSIONS AT DIFFERENT LAKE LEVELS

PERIMETERS OF LAKE RUKWA IN NOVEMBER OF VARIOUS YEARS (AFTER IRECS 1962 + 1965)



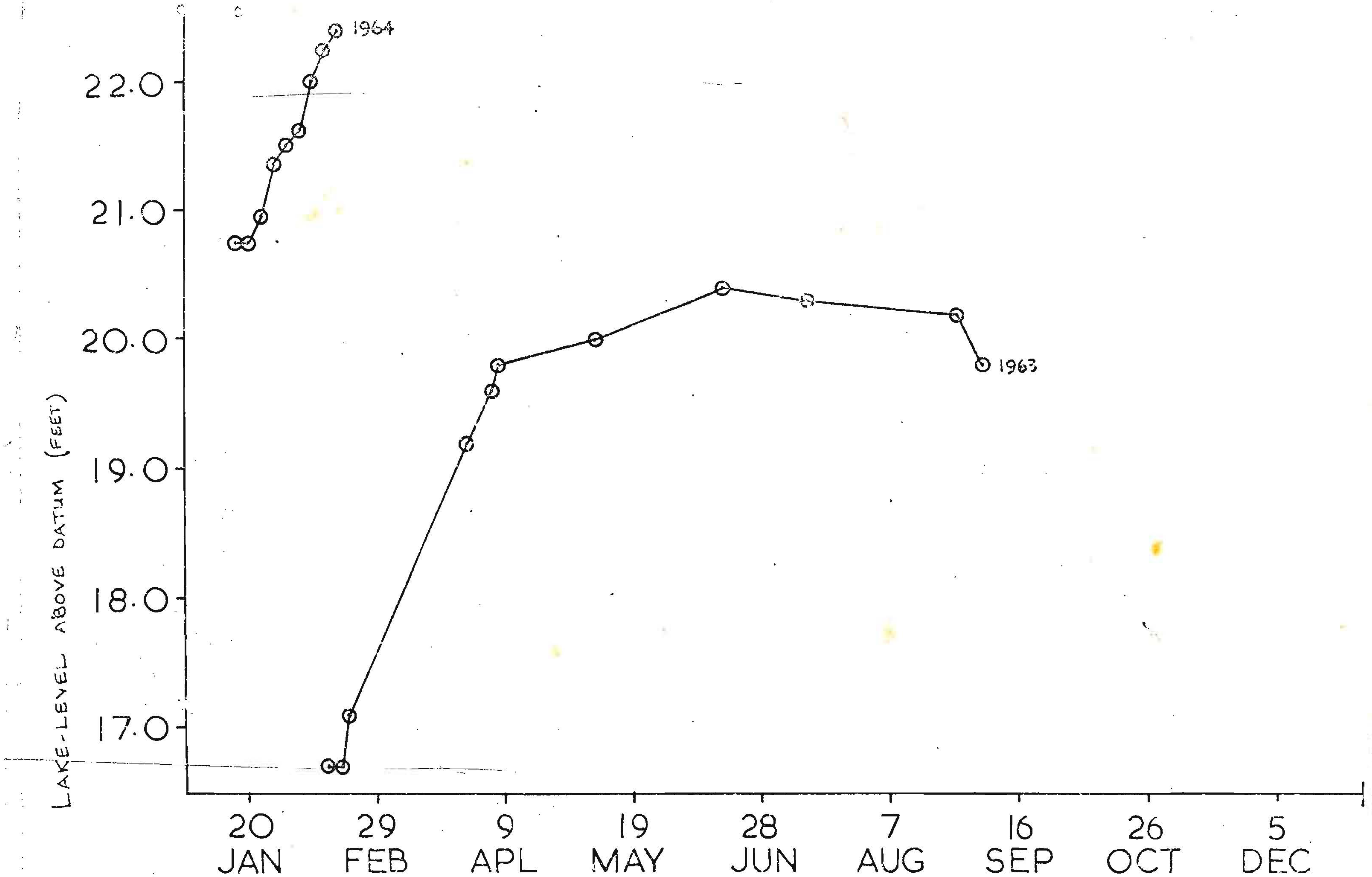


FIGURE 4. G H OF LAKE-LEVELS FOR 1963 AND 1964 (AFTER HAMMOND 1964 AND MANN 1964)