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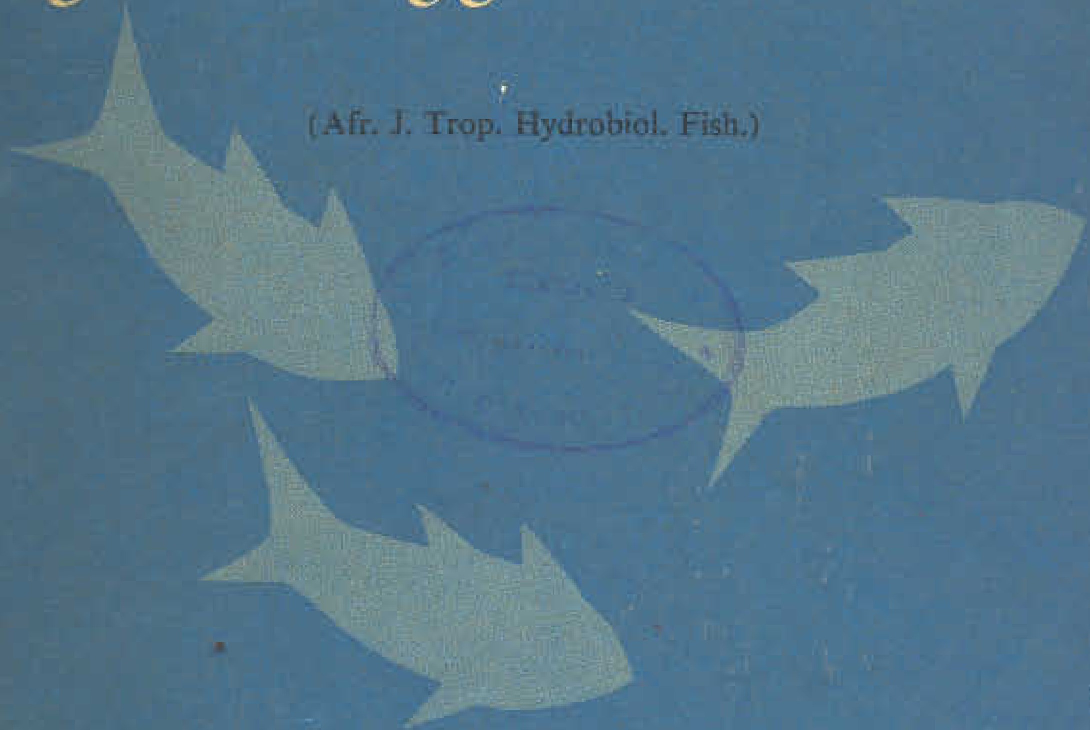

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FISHERY RESOURCE ASSESSMENT AND MONITORING IN THE DEVELOPMENT AND CONTROL OF FISHERIES IN THE LAKE VOLTA

C. J. VANDERPUYE
Volta Lake Research Project

The stock assessment seminar held in Jinja (1970) revealed that methods used for assessing and monitoring fish stock abundance in the various man-made lakes in Africa were as diverse as the lakes. Some were designed to suit local conditions while others were dictated by available materials and manpower. Gill-netting, counting of fish nets, poisoning with rotenone, trawling and survey by echo sounding were some of the methods in use. One investigator used a chance fish-kill to estimate the standing crop. Gill-netting and rotenoning have been used at Lake Volta. These methods have been chosen to suit the nature of the lake bottom which was not cleared of brush and timber before flooding. Thus only stationary gear could be used; the most effective of which has been the gill-net.

The gill-net has many limitations as a sampling gear, but it was considered that since 80% of the commercial catch is by this method, its use would monitor changes in those species vulnerable to capture by the commercial fishery. These are also the species which would need protection when the fishing pressure becomes very intense. It is conceded that by this method we fail to gain an insight into the dynamic changes which go on in that portion of the population not easily vulnerable to gill-net capture. However ,the main concern should be over the portion that is likely to be overfished. This is also in agreement with the work plan of the Volta Lake Research Project which states that the "fish stock assessment programme will aim at obtaining the closest possible assessment of the abundance and distribution of the most important commercial fish species, so that with catch data the maximum possible exploitation may be planned and future catches predicted".

VOLTA LAKE AND ITS FISHERY

Volta Lake was formed as a result of the closure of the dam on the Volta River at Akosombo in May, 1964. The lake has a complex dendritic shape with a long north to south axis. It lies between longitudes 1° 30′ W and 0° 15′ E and latitudes 6° 15′ N and 9° 10′ N. Its northern half reaches deep into the savannah zone while the southern part crosses the forest belt. At maximum water level of 85.3 m (280 ft) above sea level, it has a surface area of 8,727 sq km (3,270 sq miles); a storage capacity of 164.8 cubic km; a shoreline (including islands) of 5,200 km (3,250 miles); a maximum depth of 75 m (246 ft) and a mean depth of 19 m (62 ft).

The main types of gear used on the lake are: gill-nets (including tanglenets), traps,

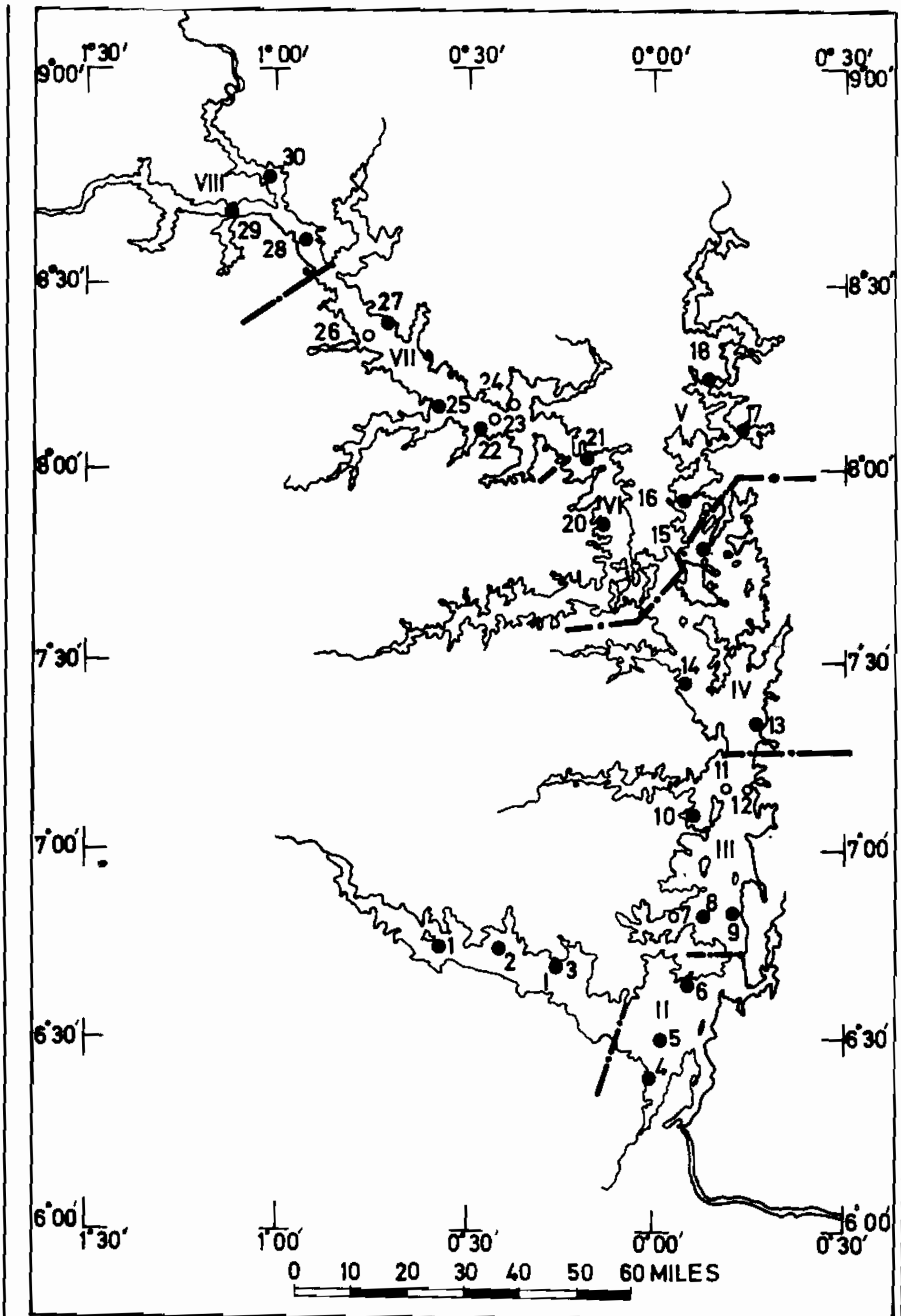

Fig.1–Volta Lake fish population sampling station

Legend: ● = preliminary survey stations

○ = additional stations

longlines, cast-nets and spears. BAZIGOS (1969) estimated that for the first two quarters of 1969 an average of 97,043 units of gill-nets, 859 cast-nets, 2,714 lines and 25,375 traps per day were used. The estimated total fish catch for 1969 was 60,000 tons and 1970, 40,000 tons. Catch is expected to stabilize around 39,000 tons (BAZIGOS 1971). *Tilapia* alone form about 50% of the annual catch. Other important commercial genera are *Lates, Labeo, Hydrocyon, Alestes, Citharinus* and *Distichodus.* There are about 1,000 fishing villages scattered around the lake and the estimated number of full-time fishermen is about 25,000. These work in some 12,500 canoes the majority of which are double-ended planked types. The overall length may range from 5.40 m to 8.40 m (18-28 ft) with a maximum beam of under 0.90 m (3 ft) (DEVAMBEZ 1970). These canoes are usually paddled but can also be sailed in a following wind. There are also a few dug-outs which are heavier and more seaworthy. These are sometimes fitted with a bracket and an outboard motor. All these types of canoe were designed for use in the original river. They have, however, been found to be too small and flimsy to withstand the rough and choppy offshore waters of the lake. Their field of operation is, therefore, limited mostly to the peripheral areas of the lake among emergent trees.

ASSESSMENT AND MONITORING PROGRAMME

Before an effective sampling plan could be designed, a preliminary survey of the fish populations in the lake was carried out (VANDERPUYE and EVANS 1969). The survey used the same eight geographical areas that have been used for catch statistics. This facilitated comparison between stock and catch data. Three stations were established in each area: one deep or open water and two inshore, each located on opposite shores (Fig. 1).

Sampling equipment included monofilament nylon gill-nets of stretched mesh size of 102 mm (4 inches) to 203 mm (8 inches) at 13 mm (½ inch) intervals and multifilament nylon gill-nets of stretched mesh size of 25 mm (1 inch) to 203 (8 inches) at 13 mm intervals. Also used were wire traps, hoop nets, a large scoop net, cast-nets and two small shore seines.

Limnological equipment consisted of: water sampler, thermometer, oxygen determination kit, Secchi disc and a sounding line.

In the course of the field work, approximately 5,000 fish specimens of about 50 different species were captured and examined. Extensive data were also collected. The most important element of the trips was the gaining of familiarity with the lake, trying various field techniques and experiencing the typical problems to be encountered.

The type of sampling plan that was finally decided upon was based on the following facts:

(i) The lake was thinly populated with fish. A standard gill-net unit of area 5,128.08 sq m (55,220 sq ft) comprising mesh sizes from 98 mm to 203 mm at 13 mm intervals fished for 24 nights, caught a total weight of 778 kg (1,716 pounds), or 32.5 kgs (71.5 pounds) per night; the other types of gear proved quite ineffective and cumbersome.

(ii) Limnological sampling could not be effectively carried out alongside the heavy schedule of gill-netting; hence the regular sampling of the limnologists had to be relied upon for comparative data.

(iii) Species diversity increased fairly regularly from the south (more mature and more lacustrine) to the north (less mature and more riverine).

(iv) Depth distribution analysis showed that many species preferred surface waters. For example: In the inshore stations, 83% *Alestes nurse* and *A. leuciscus* were captured in the first 0-1.52 m of the water column; 17% in 1.82 m-3.05 m and none below 6.10 m. Also, 99% *Eutropius niloticus,* were captured in the first 0-3.05 m deep water. There were, however, a few genera like *Lates, Labeo* and *Distichodus* which showed more or less even vertical distribution.

(v) A study of the selectivity of the meshes showed that to get a complete picture of the fish populations, a mesh size range from 13 mm (½ inch) to 203 mm (8 inches) at 13 mm intervals had to be used.

(vi) Variation between one sample and another at the same station was quite great. To improve the estimates of the mean and distribution within the variability range, at least more than one sample had to be taken from one station.

Perhaps the most important decision taken was that with the existing conditions in the lake, direct estimation of the size of fish stocks and for that matter the permissible harvest was not feasible. Therefore, efforts should be directed to determining the level at which fish stocks could be safely harvested without knowledge of the total size of the stocks. It was concluded early that the lake was being underfished. (See below.) The advice to management, therefore, was that fishing intensity should be allowed to increase while changes in population structures were observed. Symptoms expected to show when the fish population started to be fished ruinously hard were: decreasing catch per unit of effort; reduced yield of the larger sized categories; progressively greater proportion of small fish in the landings and decreased catch of the species under heavy exploitation (especially *Tilapia*).

Plan for Gill-net Sampling

Owing to the foregoing reasons, the following sampling plan was adopted, EVANS and VANDERPUYE 1969):

Gill-net would be the principal gear used for sampling. This would be supplemented by rotenoning; although permission for the use of the poison was only granted on a very restricted basis.

At each inshore station a standard sampling unit comprised the following gill-nets: as shown in Table 1a.

The same applied to offshore stations except that the 1.52 m (5 ft) deep nets were omitted. Thus in one sampling round, a total area of 253,625 sq m (2,730,000 sq ft) was screened.

Basically, the 24 sampling stations used during the preliminary survey would be maintained to give a picture of the lake as a whole. For a detailed and stable picture, however, two areas were selected (designated control areas) for more intensive sampling: one representative of the upper riverine half (VII, Fig. 1) and the other of the lower lacustrine half (III, Fig. 1). In each of these areas sampling effort would be four times that of the rest: that is, the number of sampling stations would be increased from three to six and the sampling nights from one to 2 at each station.

The year is divisible into four major seasons and efforts were made to accomplish a round sampling within a season to permit identification of seasonal component of sampling variation.

It was not possible to maintain complete regularity in the sampling programme. The major difficulties encountered were:

(i) lack of sufficient boat-time to enable a round sampling to be completed in three months; the actual period spent, ranged from three to six months and

(ii) inability of the net-repair-team to keep pace with the rate at which nets were torn as a result of snagging on submerged vegetation. Data for a missing mesh-size was normally estimated by

Table 1a

No. of Nets	*...Size*	*Mesh Sizes (Stretched)*
15	30.48 m x 1.52 m	13 mm to 203 mm at 13 mm intervals
15	30.48 m x 3.05 m	13 mm to 203 mm at 13 mm intervals
15	30.48 m x 9.14 m	13 mm to 203 mm at 13 mm intervals

averaging the net catches of the next larger and smaller mesh-sizes.

Rotenone Sampling Programme

Originally, the rotenone was meant to be used in sampling the shallow marginal areas of depth less than 0-1.52 m, that is, areas shallower than could be sampled with our gill-nets. In course of time, however, it became an independent programme with wider objectives. These were:

(i) to obtain a detailed picture of the ichthyfaunal composition of the littoral zone habitats;

(ii) accumulate data on changes in faunal composition; and

(iii) to assess the reproductive success of the various species of fish in the lake as reflected by the number of young fish present in such habitats. The actual depth sampled ranged from 0-75 cm.

OVERFISHING AND UNDERFISHING QUESTION

Three rounds of sampling had hardly been completed by the end of 1969 when the question was posed as to whether or not the lake was being overfished. At that time the gear development team, after comparative studies, had come to the conclusion that monofilament nylon gill-net could catch between two to three times more fish than could be caught with the multifilament nylon gill-net used by the commercial fishery. Before the monofilament nylon net could be introduced to the commercial fishery, it was necessary to know the state of abundance of the stocks lest the lake be overfished. The data available on which a decision could be based were inadequate and not very reliable. Nevertheless, some answer was better than none and after weighing the available facts it was concluded that the Volta Lake was not being overfished (EVANS 1969) for the following reasons:

(i) Large size of lake and light fishing intensity per unit area. The fishery was largely limited to waters within 1,000 metres of shore. Fishing intensity was estimated at eight fishermen and four canoes per mile of shoreline;

(ii) Extensive littoral zone with a varied fish fauna, some of which received only meagre utilization;

(iii) A fishery based upon individual fishing effort with low efficiency gear;

(iv) Large mesh gill-nets in common usage selected mainly adult fishes, which had spawned several times. When the lake was first formed the most common gill-net mesh size was 76 mm (3 inch) stretched mesh. The principal mesh size in use had steadily increased until 140 mm ($5\frac{1}{2}$ inch) was common.

(v) Abundant submerged trees inhibited the harvest of fishes. To avoid damage and loss of gill-nets from unseen submerged trees fishermen were mainly utilizing water less than 5 metres deep. Thus an extensive area of "fish refuge" existed.

COMPARISON OF EXPERIMENTAL AND COMMERCIAL CATCH DATA

The experimental catch data have been divided into catch by large meshed (102 mm to 203 mm) and small meshed (13 mm to 89 mm) gill-nets. TAYLOR (1969) estimated that 83% of the mesh-sizes used in the commercial fishery fall within the range of 102 mm to 203 mm; hence the catch by the

Table Ib. Catch per Mesh Size. All Species Combined for Round 4 (June–September, 1970)

Mesh Size mm.	in.	Weight (Kilos)			%	
13	½		449.715		24.23	
25	1		200.221		10.79	
38	1½		146.805		7.91	
51	2		132.540		7.14	
63	2½		157.203		8.47	
76	3		126.320		6.81	
89	3½		134.604		7.25	
		Sub-total	......	1,346,408	...	72.6
102	4		98.663		5.31	
114	4½		74.015		3.99	
127	5		61.028		3.29	
140	5½		74.090		3.99	
152	6		84.316		4.54	
165	6½		37.060		2.00	
178	7		58.025		3.13	
203	8		21.375		1.15	
		Sub-total	......	508,572	...	27.4

large meshed gill-nets should be comparable in species composition to the catch by commercial **fishery.**

Small Meshed Gill-nets

It was further estimated (ibid.) that only 14% of the commercial fishery used mesh-size smaller than 102 mm. Thus catches by these meshes largely represent species hardly exploited by the commercial fishery. Analysis of catch per mesh-size for Round 4 (Table 1b) (typical of the other rounds), shows that catch by the small meshed nets accounted for 73% by weight of the total realized from experimental fishing. Of this, the 13 and 25 mm meshes contributed 35%. Two species of clupeid (*Cynothrissa mento* and *Pellonula afzeliusi*) alone comprised 23%. Analysis of the other meshes in this category (Fig. 2) has shown that the majority of the catches were mostly adults of small species and only a few juveniles of the commercial species.

Large Meshed Gill-nets

With the same range of mesh sizes, one would expect that the percentage species composition of the experimental fishing catch would approximate that of the commercial fishing catch given the same fishing methods. Comparison of the two (Figs. 3 and 4), however, shows quite remarkable differences. The commercial catch was made up of about 50% of *Tilapla* while the same genus accounted for only about 15% of the experimental catch. On the other hand, *Lates niloticus* was more abundant in the latter than in the former. Other species, too, showed difference to varying degrees. It is believed that the major source of difference came from the grounds fished in two instances. While the experimental fishing attempts to sample all depths of water, both inshore and offshore, and as many habitats as could be identified, the commercial fishery mostly fishes at the periphery of the lake and tries to specialize in the capture of *Tilapia.* Thus pressure on *Tilapia* has been out of proportion to its apparent abundance in the population. *Lates* on the other hand, inhabits the open water zone hence it figures prominently in the catches of the experimental fishing which exploits this zone.

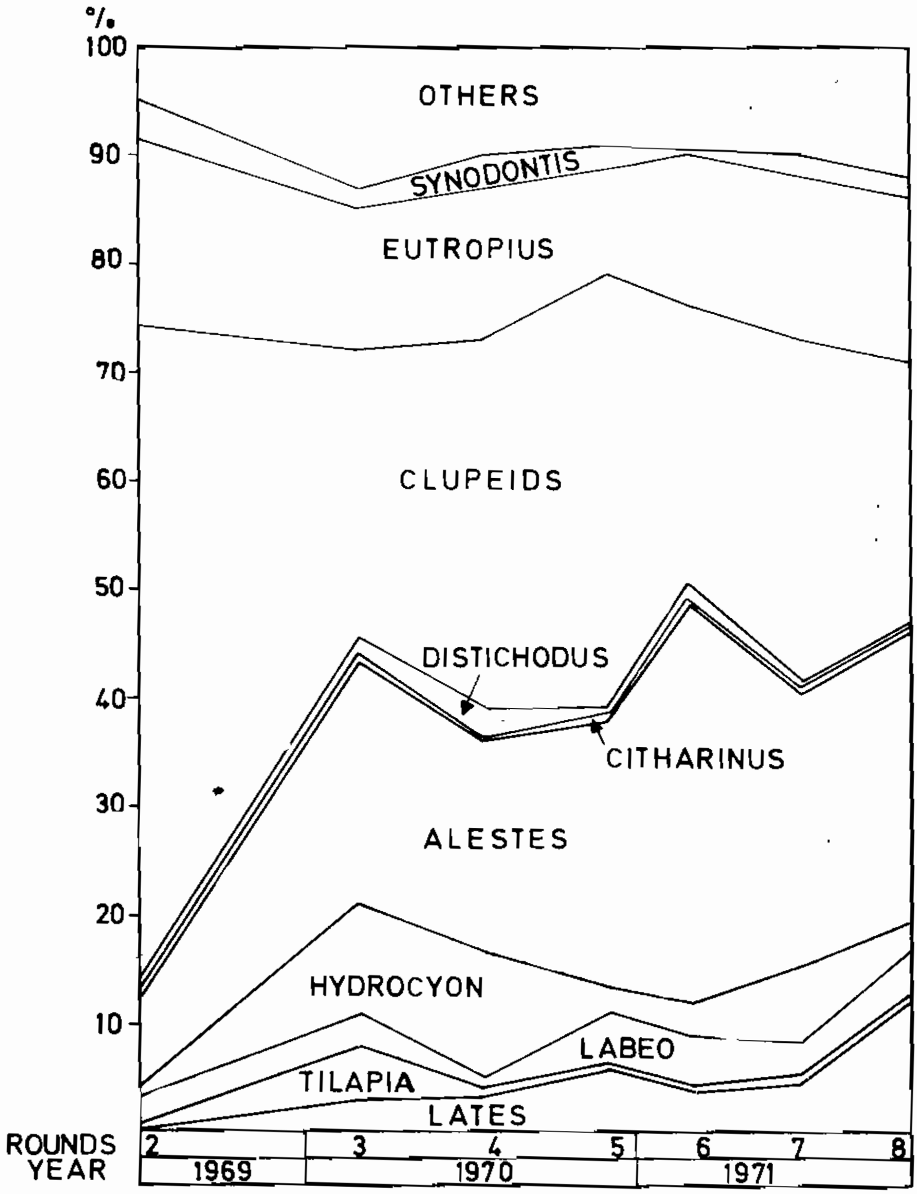

Fig. 2 - Species composition change from 1969 to 1971. catches with small meshed (13-89mm) experimental gill-nets

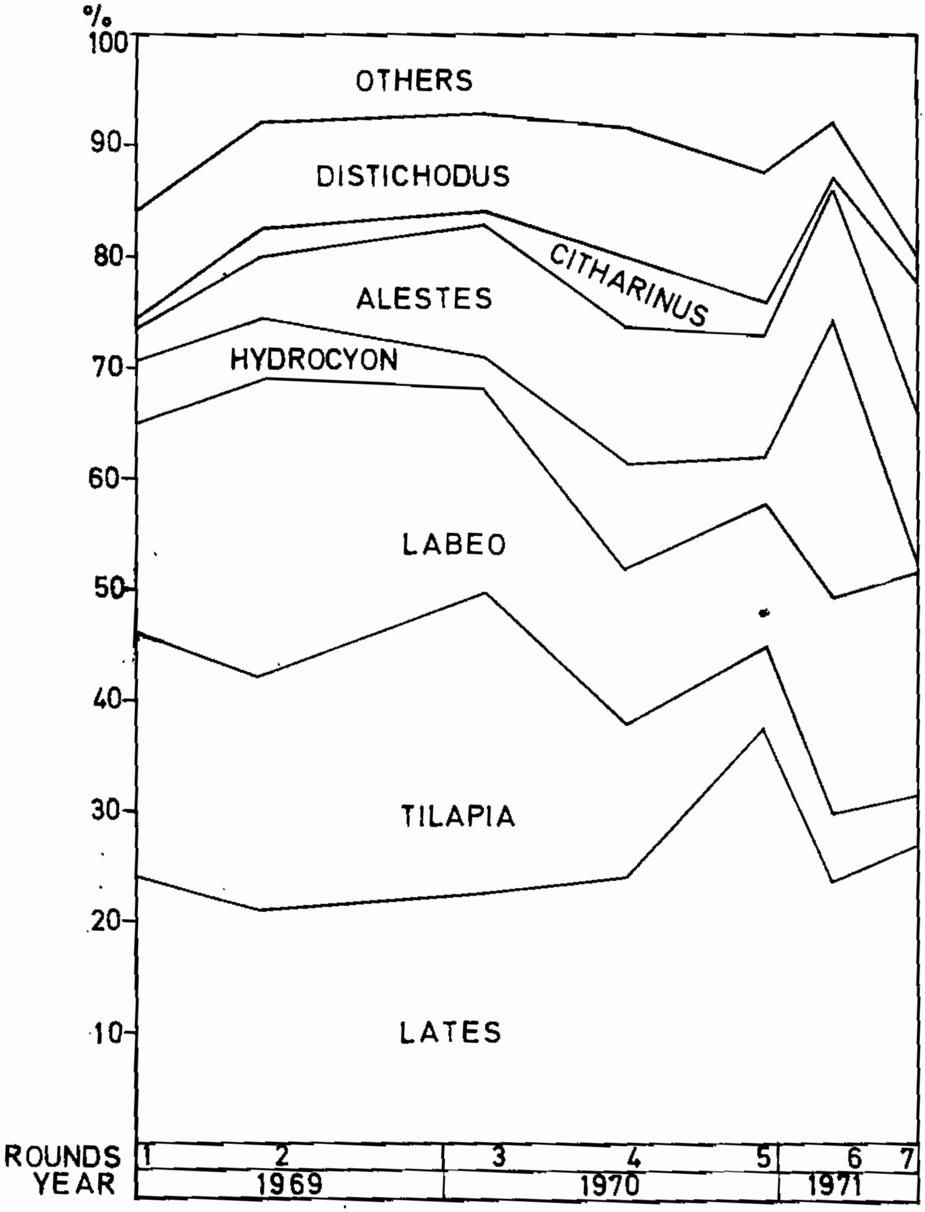

Fig. 3 - Species composition change from 1969 to 1971. Catches with large meshed (102-203mm) experimental gill-nets

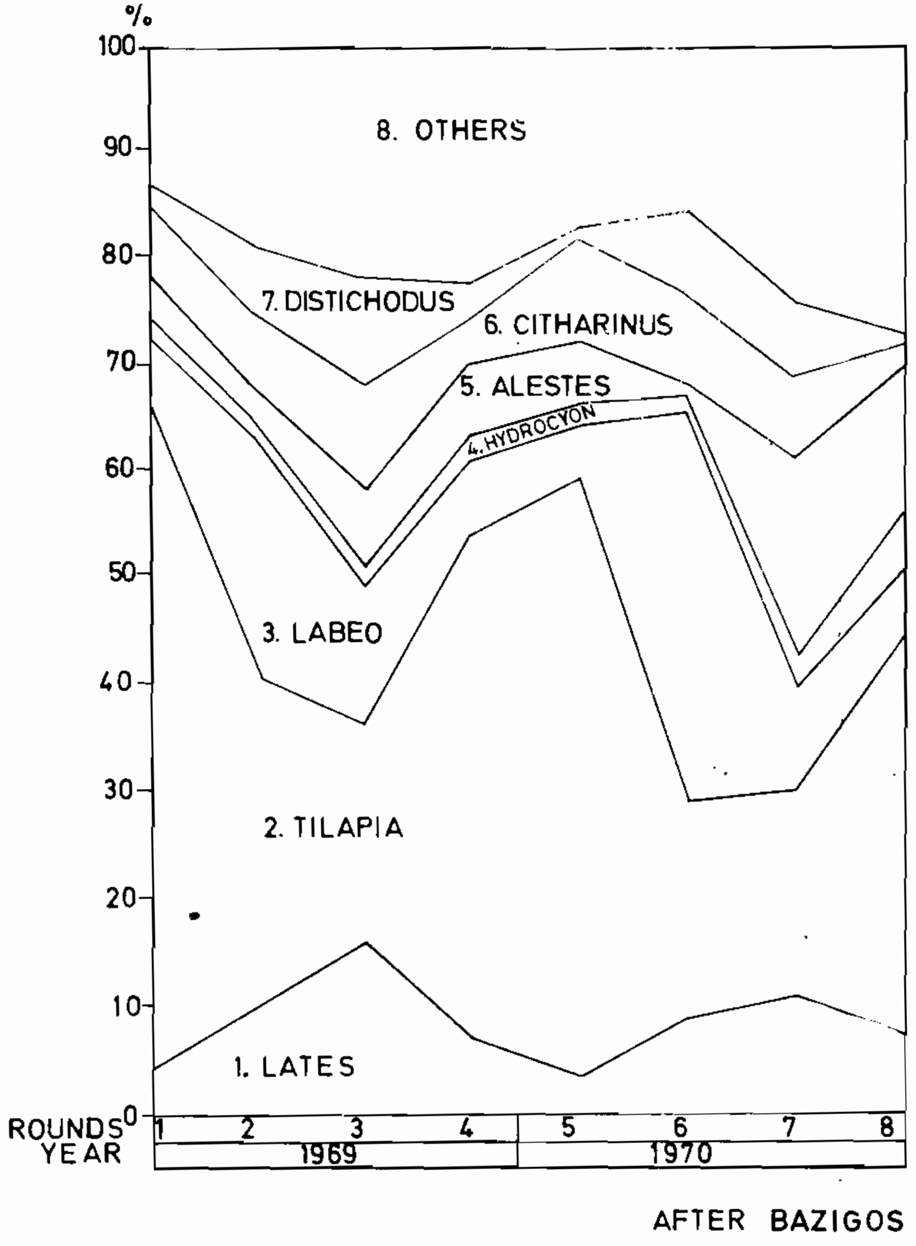

Fig. 4 – Species composition change from 1969 to 1970. Catches by commercial gill-nets

Table 2. Fishing Pressure Index of the Import

Commercial Genera

Species	Stock %	Catch %	Fishing Pressure Index
Lates niloticus	38.4	11.0	0.29
Tilapia spp.	6.4	19.5	3.05
Labeo spp.	12.8	9.5	0.74
Hydrocyon spp.	4.43	3.0	0.68
Alestes spp.	11.06	18.5	1.67
Citharinas spp.	3.02	7.5	2.40
Distichodus spp.	11.73	7.0	0.60
Other	12.14	24.0	0.90

The catch and the stock assessment rounds were completed in different periods hence comparison between the two sets of data was difficult. The Round 5 of the Stock and Round 7 of the catch were, however, completed in closely identical periods, that is, October 1970 to January 1971 and November 1970 to January 1971 respectively. Thus error due to difference in periods should be minimal. It could be assumed that the stock data more approximate the true population structure than the catch data, then the ratio: catch percentage/stock percentage, should reflect the pressure being applied on each of the commercial species. This is presented in Table 2. Those values under 1 indicate that the species (or species group) is being under-utilized in relation to its apparent proportion in the population. Those over 1 implies that the species (or species group) is being over-utilized in relation to its apparent proportion in the population. *Tilapia* and *Citharinus* seem to be the most hard-pressed while *Hydrocyon* and *Distichodus* were comparatively, little utilized. Those with high fishing pressure index are naturally those which are concentrated in inshore waters and the index could also be assumed to measure the littoral concentration of the species. Largely, the index should be considered as a rough guide to management as to how the species are being utilized.

Rotenone Sampling

This is the only source of data for absolute standing crop in the Volta Lake. The depth sampled ranged from 0 to 1.8 mm and the ichthyofauna was found to comprise about 60 species (LOISELLE 1971). Of these the following six species comprised 59.5% of the littoral biomass:

Chrysichthys auratus	...	75%
Chrysichthys velifer	...	18.3%
Synodontis nigrita	...	6.8%
Tilapia nilotica ...	...	7.0%
Tilapia galilaea ...	...	13.9%
Polypterus senegalus	...	6.0%

The percentage composition differed from that of the catch in the shallowest gill-nets (1.52 m deep) which was fished in water 1.52 m deep. This was expected since apart from the selectivity of the gill-nets, there was also a size gradation and change in species composition from the margin of the lake into deeper water.

The standing crop varied from 1.2 kgs/ha (1.1 lbs/acre) to 651.7 kgs/ha (580.0 lbs/acre). The average was 170.8 kgs/ha (152.0 lbs/acre).

It was hoped to monitor the degree of reproductive success of those commercial species which use this zone as nursery grounds. The relative abundance of the juveniles of each species should be a good index to the future abundance of the adults. The programme has been temporarily postponed owing to lack of staff and it will be revived as soon as the position improves.

EVALUATION OF THE STATUS OF ABUNDANCE OF THE STOCKS

The fishing pressure index calculated above only indicated that a particular species was not being harvested in relation to its apparent proportion in the population. It does not tell whether a fish (e.g., *Tilapia*) with a high fishing pressure index was being overfished. The ability of a species to withstand a high degree of sustained fishing pressure is to a considerable degree, a function of its biotic potential. Presently, with the biotic potential of the species in Volta Lake not well defined, the nearest approach seems to be a study of the change in the size structure of the population with time. A diminution of the proportion of the large elements has usually been a good indicator of over-fishing. This is especially useful in our situation where age and growth determination of the species have been a problem.

As earlier pointed out, the commercial fishery more or less specializes in the capture of *Tilapia* and could as well be described as a "*Tilapia* fishery". Hence one would naturally expect that any onset of overfishing would first be reflected by that species. Length frequency analysis with this fact in mind has, therefore, been carried out on *T. galilaea* (Fig. 5) which is the commonest species in experimental gill-net catches. Owing to the small numbers normally caught in experimental gill-nets the round to round catches have been grouped into pairs.

The total number caught with the same unit of effort has declined with time. The percentage composition of the various size classes, however, has not appreciably changed in the segment of the population which falls in the exploited phase; that is, size greater than 280 mm (mean size caught by 102 mm mesh). For the three periods the percentages caught were 25.56, 32.72 and 28.71 respectively. Thus the decline in numbers affected all size classes; and a change in lake productivity as the reservoir ages is a more likely cause than increase in fishing pressure. There is evidence from other sources which reinforce this view. Some of these are:

(i) the decline was general and was reflected in all species, including the small-sized ones (especially the clupeids) (Fig. 6) which were being very little exploited;
(ii) the average weight of *Tilapia* in the commercial catch as monitored by the Catch Assessment Team seems to show an upward trend after a dip (Fig. 7);
(iii) the mesh-size used in the commercial fishery is still mostly 102 mm and above. This was revealed by a short subjective survey which was conducted just before the monofilament nets were recommended to the commercial fishery.

TREND IN ABUNDANCE

The long-term planning, ability to forecast future trends in abundance is quite important. This is especially so for a new man-made lake which is characterized, for some time, by an unstable environment and unstable composition of fish species. Observations on Lake Volta have disclosed that the fish populations in the lake have gone through the usual pattern of abundance which has been observed in many man-made lakes. The original Volta River was impounded in 1964 but the lake reached its maximum controlled elevation in 1968. The fish populations as monitored independently by sampling of the stock and of the commercial catch (Fig. 8) has shown that the peak in abundance was reached in the rainy season of 1969. Within a space of three months thereafter, the level had fallen to about half the magnitude. At the new level,

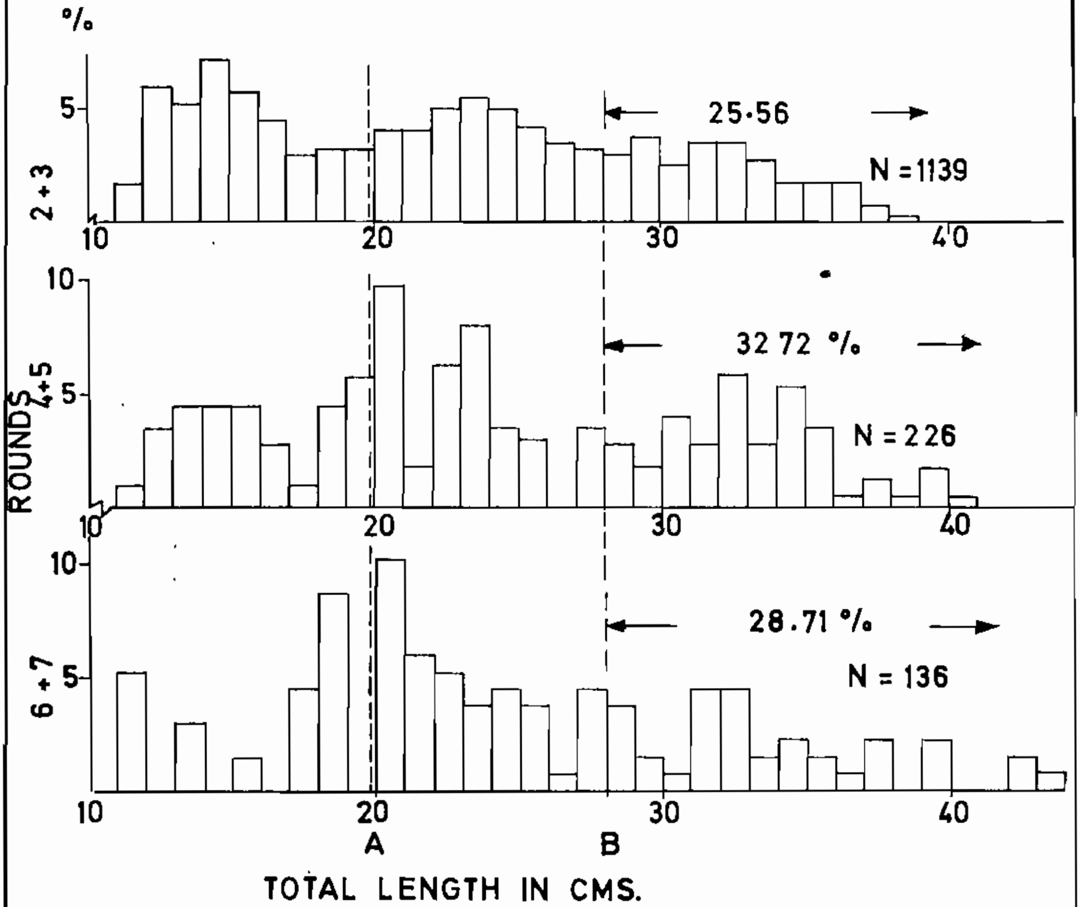

Fig. 5 – *Tilapia galilaea*: percentage change in size composition during the period May 1969 to September 1971

Legend: A = average length at first maturity
B = average size at first recruitment into commercial fishery

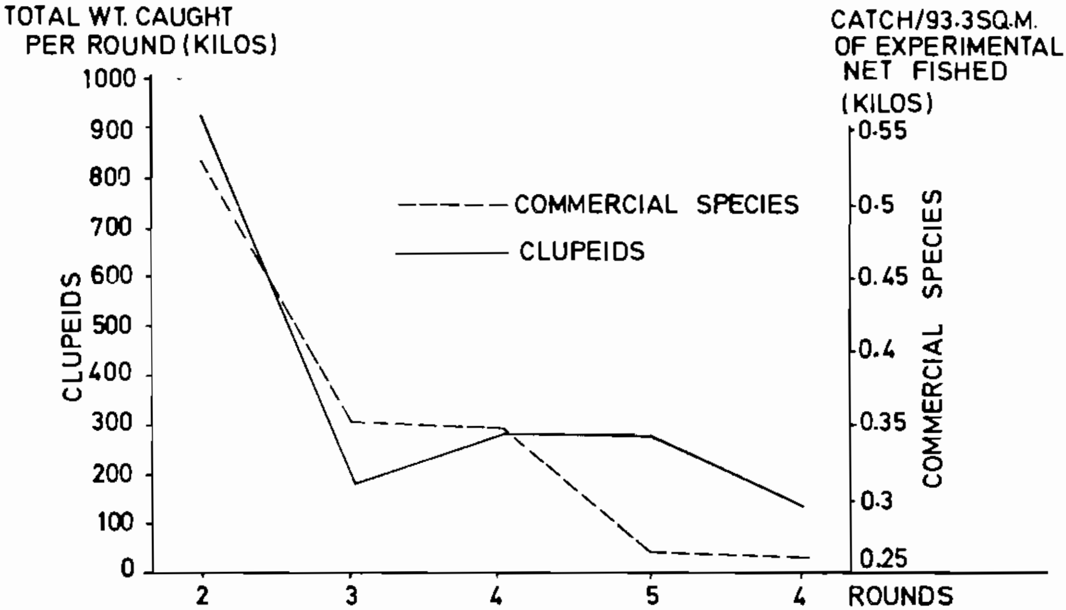

Fig. 6 - Comparative trend in abundance of Clupeids and other species during the period May 1969 to April 1971

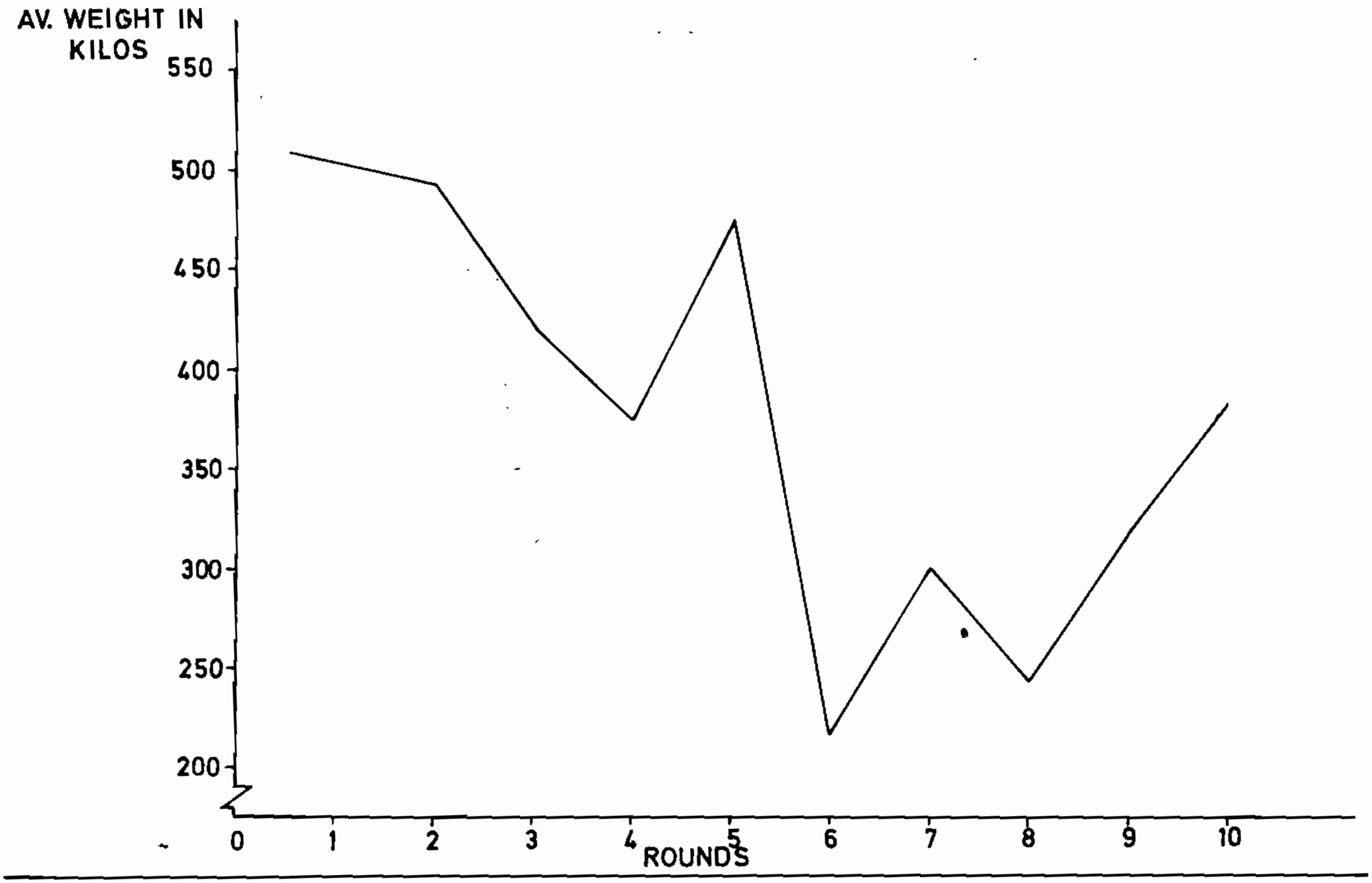

Fig. 7 – Trend in average weight of Tilapia during the period May 1969 to October 1971

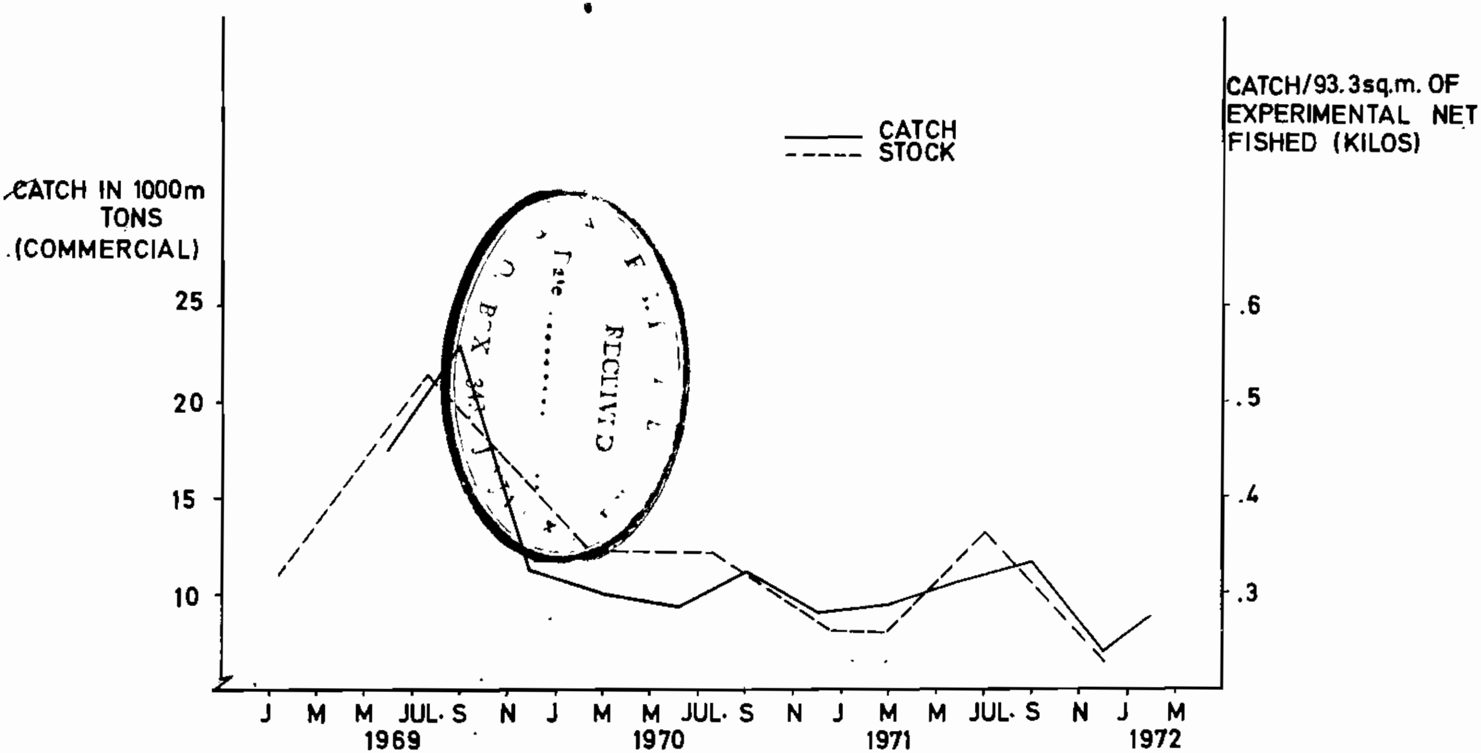

Fig. 8 - Changes in abundance as shown by commercial catch and stock sampling

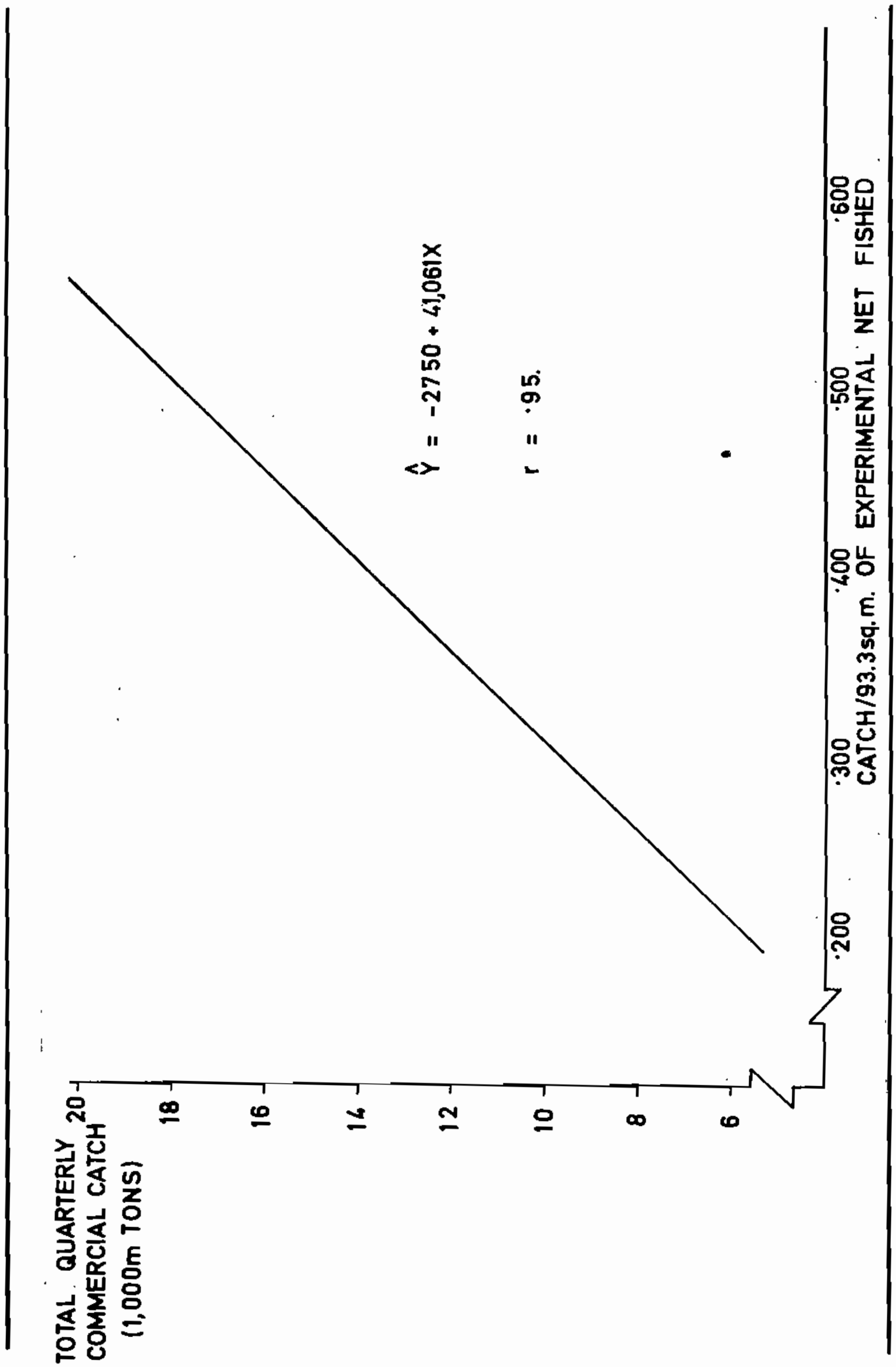

Fig. 9- Experimental and commercial catch relationship

the amplitude of fluctuation is considerably smaller, and one may predict that the stability level of yield would only be a small percentage removed from the present one. In fact, BAZIGOS (1971) has proposed that the yield pattern has followed the Gompertz curve and that the established zone of fluctuation of the expected yield has an upper limit of 45.14 kg/ha (39,092 tons/year) (empirical yield of the year 1970) and a lower limit of 42.90 kg/ha (37,250 tons/year) lower asymptote value of the curve.

Total catch for 1971 (39,800) falls well within the prediction. In many reservoirs, however, pattern of productivity has not always followed earlier predicted lines. For example, KIMSEY (1957) concluded from his observation on 38 California impoundments that the decline in fishery is followed by recovery and stabilization at a new and lower level. In Clearwater Lake, Missouri, in the early sixties, angler harvest (pounds per acre) was over twice as great as the level at which the stabilization was indicated at the end of five years; moreover, the rate of catch (fish per hour) was higher a decade later (STROUD 1967). Studies on the fish populations in Lewis and Clark Lake (WALBURG 1964) and Lake Francis Case (GASAWAY 1970) both main stem reservoirs on the Missouri River, on the other hand did not show such a recovery. Thus it may be too early now to predict what the ultimate level of fluctuation may be in Lake Volta.

Table 3a. Total Quarterly Commercial Catch from 1969 to 1972

Round	Period	Weight in metric tons
0t	May 1969–July 1969	17,522
02	Aug. 1969–Oct. 1969	22,927
03	Nov. 1969–Jan. 1970	11,326
04	Feb. 1970–Apr. 1970	10,008
05	May 1970–July 1970	9,637
06	Aug. 1970–Oct. 1970	11,280
07	Nov. 1970–Jan. 1971	8,988
08	Feb. 1971–Apr. 1971	9,608
09	May 1971–July 1971	10,890
10	Aug. 1971–Oct. 1971	11,797
11	Nov. 1971–Jan. 1972	7,489
12	Feb. 1972–Apr. 1972	8,859

Table 3b. Catch per 93.3 sq.m (1,000 sq. ft.) of Experimental Gill-net Fished from 1968 to 1972

Round	Period	Catch/93.3 sq. m. of experimental gill-net (Large mesh sizes only)
01	Dec. 1968–Mareh 1969	.325
02	May 1969–Oct. 1969	.532
03	Dec. 1969–May 1970	.351
04	June 1970–Sept. 1970	.348
05	Oct. 1970 –Jan. 1971	.266
06	Feb. 1971–Apr. 1971	.262
07	May 1971–Sept. 1971.	.366
08	Sept. 1971–Feb. 1972	.232

Tables 3a and 3b show trends in abundance as reflected by commercial and experimental catches. The commercial catch data are estimates of total landings for a quarter while the experimental catch data are the actual catch per 93.3 sq m (1,000 sq ft) of gill-net fished during the period shown against a round. The relationship is further illustrated in Fig. 8. The trend in the two sets of data is quite close. The calculation of the coefficient of correlation is, however, fraught with considerable difficulties owing to the different periods and their different lengths in which samplings were carried out. A way out was found by intrapolating one set of data against the other. The important assumption was made that the relationship between two points was linear. In this respect, the experimental fishing values were considered fixed and the corresponding catch values were read off the graph. The new relationship is defined and illustrated in Fig. 9. The high significant correlation (P=0.01) indicates that for the period investigated the stock data could be used to predict the catch data.

It must be noted, however, that the apparent constant ratio should change with change in fishing effort. If the stock programme is kept constant, changes in amount or types of gear in the commercial fishery should be accompanied by a change in the ratio. Hence the parallel methods are most valuable in confirming changes in effort characteristics of the commercial fishery.

DISCUSSION

The first phase of the project which ended last year was mainly research oriented. The second phase would be devoted principally to development and extension work.

The assurance from the stock assessment team that the lake was not being overfished paved the way to encourage the importation of the monofilament nets into the country. The first shipment sold out very quickly and the demand for it has been great. The delay in arrival of the consignments would allow time to assess the effect of the new net on the stocks. Some minor improvements, too, have been suggested in the existing gear (loc. cit.). Some of these are: addition of small floats on the headline of the deep set nets and introduction of plastic covered wire mesh for making traps.

Consequent upon the discovery that much of the ichthyomass in the lake is tied up in the clupeids, various experiments are in progress aimed at their mass harvest. The previous unsuccessful experiments on light attraction seem now to be making headway and indications are that it might be successful. A special large scoop net has been designed and seems to be working effectively. Catch analysis has been carried out on the lines of determining the best mesh and twine size for the gill-net fishery (VANDERPUYE 1971).

Improvement in gear without extending the area of operation of the present commercial fishery would lead to overfishing of those species which are abundant in the shallow water areas (especially *Tilapia*). This will amount to local overfishing. The fishery must necessarily expand into deep water to avoid this. The constraint in the expansion of the fishery into open water has been the unsuitable canoe. In realization of this, the project has engaged the services of a boatbuilder on a high priority basis to design a more seaworthy boat.

Before the formation of the lake there were certain regulations governing fishing in inland waters in Ghana. These regulations have so far not been applied to the Volta Lake since they have been found to be anachronistic. Their general review awaits results of scientific studies on the Volta Lake. They include mesh-size restriction, ban on the use of moving gear as well as poisons and explosives.

The mesh-size restriction no longer has any meaning because growth rate of fishes in the lake is higher than it was in the original river. The fish of a same age, have now a bigger size than before. Moreover, the increased space and the ever-present standing trees in the lake basin, ensures sufficient escapement of the brooding stock. If anything at all, the result of the experimental fishing has shown that rational exploitation of all species would involve the encouragement of the use of the small meshes. The biomass tied up in the small fishes (captured with mesh-size less than 102 mm) could be as high as 70%. This is presently little utilized.

The ban on the use of moving gear like beach-seines and trawl, needs careful study and possibly review. The beach-seine sweeps the very shallow water areas which are also the nursery grounds of some of the commercial species mostly of the Cichlid group. LOISELLE (loc. cit.) found from extensive rotenoning of the shallow waters that the

Cichlids comprised 30% of the littoral biomass. *Tilapia galilaea* and *T. nilotica* alone accounted for over 66% of this number. Hence the extensive use of the beach-seine would not be very conducive to the *Tilapia* fishery. A surface or mid-water trawl on the other hand could be used in open water areas. With the presence of standing trees at the bottom of the lake it could be designed to skim the surface waters. This would not conceivably do much damage to the fish population.

The reservoir serves the primary purpose of regulating flows for generation of hydro-electric power. Normally, the lake reaches the maximum level during the months of October and November. The minimum level is reached just before the flood period which usually starts in May. The seasonal rise and fall is usually kept between 2.10 to 3.30 metres (7-11 ft). Although no study has been carried out to determine the effect of the water level fluctuation on those species which spawn in the marginal shallow waters, it is considered that the general rise and fall is gradual and the magnitude so moderate that the probable effect on these species may not be very drastic.

SUMMARY

Gill-netting and rotenoning have been used for assessing and monitoring fish stock abundance in Volta Lake. The lake and the main gear types used on it have been described. Before a gill-net sampling plan was set up, a preliminary survey was undertaken which largely determined the final form of the plan. An investigation as to whether or not the lake was being overfished concluded that it was being underfished. Commercial and experimental catch data analyses disclosed that the adults of the small species were being little utilized. Commercial sized species were also not being harvested according to their apparent proportion in the population. Production is presently fluctuating between approximately 37,000 and 40,000 tonnes. A high correlation between commercial and experimental catch was realized. Developments which have followed in the wake of stock assessment and monitoring studies include: introduction of monofilament nylon net, development of a special scoop net to permit mass harvest of clupeids after they have been attracted to light, and the design of a larger canoe which would help to extend the fishery into open water. New regulation and management policies will have to be formulated in the light of new findings before a rational exploitation of all the species can be achieved.

RESUME

Les pêches au filet maillant et à l'ichthyotoxique roténone ont été utilisées pour estimer et contrôler l'abondance du stock de poisson du lac Volta. Le lac et les principaux types d'engins qui y sont utilisés sont décrits. Avant qu'un programme d'échantillonnage au filet maillant soit mis sur pied, une expertise préliminaire détermina le programme définitif. Il fut conclu d'une investigation tendant à découvrir si oui ou non le lac étaiit, surexploité qu'il était, en fait, sousexploité Les analyses des données des prises commerciales et expérimentales démontrènt que les adultes des petites espèces étaient peu utilisés. Les espèces de taille commerciale n'etaient pas exploitées selon la proportion apparente des population. A l'heure actuelle, la production varie entre 37,000 et 40,000 tonnes. Selon les renseignements, il existe une bonne corrélation entre les prises commerciales et les prises expérimentales. Les développements qui ont suivi l'estimation des stocks et les études préliminaire comprennent: introduction de filets de nylon monofilament, perfectionnement d'une épuisette spéciale permettant la récolte massive des clupéides après quils aient été attirés par le feu, et le projet d'une pirogue qui devrait aider à étendre la pêche au large. De nouveaux réglements et

politiques d'aménagement devront être formulés à la lumière des nouvelles observations avant qu'une exploitation rationnelle de toutes les espèces puisse être obtenue.

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