PRELIMINARY STUDIES ON BAMBOO FLOATING CAGE AND NET ENCLOSURE FISH CULTURE IN KAINJI LAKE BASIN

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ABSTRACT

The main objective of this paper is to introduce this new technology aimed at producing fish from almost all available inland bodies of water in Nigeria. The experimental approach embarked upon at Kainji Lake Research Institute is discussed. Results obtained from these experiments would help in identifying the inherent problems of this culture system and in determining the urgently needed information that will serve as management and production guidelines for adapting the technology to local conditions of varying ecological characteristics in Nigeria. Ultimately, the project is aimed at increasing the productivity of fishermen/fish farmers and hastening the development of rural communities.

INTRODUCTION

Amongst the known modern aquaculture systems for increased fish production, cage and net enclosure culture are about the cheapest to operate (Otubusin, 1983).

Unlike pond culture which is one of the earliest and widely practised aquaculture systems cage culture does not compete with other land use for urbanization, agriculture and other industrial development. This culture system is preferred to pond culture because it requires limited investment, allows higher stocking density of fish, ensures complete control of the harvest and generally provides high returns on investment when effectively managed and the fish species and site are suitably selected for the culture system. Fish yield from this system could be as high as 10 to 20 times more than from pond culture considering the surface area/space and the inputs (Anon, 1979).

This system of aquaculture has undoubtedly proved to be one of the main alternatives for fish production in many countries – the catfish farming in the United States of America; trouts raising in Norway and Great Britain; Tilapia/milkfish culture in the Philippines; the serranids culture in Hong Kong and yellow tail and red seabreams raising in Japan are but few examples of the centres of greatest activity utilizing this innovation in aquaculture.

Even though Nigeria is well-endowed with vast bodies of water and resources suitable for this culture system, the potentials are yet to be tapped. Some success have been reported in fish cage culture in some African countries like Tanzania in Lake Victoria (Ibrahim *et al*, 1975), Ivory Coast at Lake Kossou (Coche, 1975; 1977; Shehadeh, 1974). and recently in Egypt (Ishak, 1979). In the Lake Kainji, Nigeria, Konikoff (1975) studied the possibilities for cage culture and noted the great potential for fish culture in the lake area. Ita (1981) also attempted some cage culture experiments in the lake and noted some major constraints to viable cage culture experiments.

The cage, pen and net enclosure project embarked upon at Kainji Lake Research Institute is aimed at maximally exploiting the water bodies of Nigeria through production oriented research on cage, pen and net enclosure culture of fish. The ultimate goal of this project is to increase the productivity of fishermen/fish farmers and accelerate the development of rural communities.

This paper presents some findings from the on-going preliminary studies of bamboo floating cage and net enclosure fish culture in Kainji Lake basin.

MATERIALS AND METHOD CAGE CULTURE

The Site

Two culture sites, namely Kigera III drinking water reservoir located within the Kainji Lake Research Institute Estate at New Bussa and Shagunu Bay on the western side, of the central basin of Lake Kainji (Figure 1) are used for this culture system. Kigera Reservoir, a drinking water reservoir about 0.5 hectare surface area and 2m average depth was constructed by damming a seasonal stream. The reservoir was filled with water just before this study by pumping water from Lake Kainji through a distance of about 1 km. Subsequent water replenishment was from the annual rainfall. The physico-chemical and biological characteristics of Lake Kainji (about 1275 km2 surface area) have been reported by several workers (El–Zarka, 1973; Henderson, 1973; Imevbore and Adegoke, 1975, Adeniyi, 1978).

Cage Construction.

Two types of modules of cages were used in these series of experiments. The first type was a module 9x6m bamboo raft of 6 units fitted with 1x1x1.5m floating net cages (210/9, 10mm mesh size), while the second module was of 9x9m bamboo raft with sixteen 2x2m compartments to which were fitted 1x1x1.5m floating net cages (210/9, 12.7mm mesh size) or 1x1m floating net hapas (for breeding and fry nursery) (Figure 2). Empty oil drums served as floatation devices and 0.3x0.3x0.3m concrete blocks were used for mooring the bamboo raft and cast concrete sinkers (of empty tomato and milk tins) were used for rigging the net hapas and cages respectively. Other construction procedures are as described in Otubusin and Opeloye (1983).

The Culture Studies.

Three grow-out phase studies and two hatchery/nursery studies were conducted.

Study 1: The effect of varying levels of blood meal feeds on fish (Oreochromis niloticus) Production

Three diets of varying amounts of blood meal and corn bran mixed with layer's concentrate in the ratio 3:1 and 1% vitamin mix were tested. The composition and proximate analysis of the feeds are shown in Tables 1 and 2.

Table 1 – Composition of three feed formulations fed to Oreochromis *niloticus* in cages for 120 days

Ingredient	*Feed*		
	I	*II*	*III*
Blood meal	50	25	10
Corn bran/layer's concentrate	49	·74	89
Vitamin mix	1	1	1

Note: Figures are expressed in percentages (%).

Table 2 – Proximate analysis of three feeds used in Study 1

Feed	*Crude Protein*	*Crude Fat*	*Crude Fibre*	*Ash*	*NFE*	*Ca*	*P*
I	49.07	0.61	3.60	5.31	41.41	1.14	0.07
II	46,87	0.25	3.71	6.81	42.36	1.36	0.11
III	31.34	1.26	4.14	5.90	57.36	1.30	0.10

Note: Figures are expressed in percentages.

The treatments I, II and III corresponding to feeds I, II and III were assigned to cages using a completely reandomized design. *Oreochromis niloticus* fingerlings (3.1–4.0g) were stocked at the rate of 100/m3 into the cages.early morning on April 10, 1984. Each treatment (diet) was replicated twice. The fish were fed with the pelleted feeds corresponding to their treatments at the rate of 10%, 5% and 3% of the fish biomass during the 1st, 2nd, 3rd and 4th months of the experiment respectively. Feed allowances were adjusted every two weeks based on the estimated fish weight by sampling or by using a feed conversion value of 2.57 (Guerrero, 1980). 10% of the fish stocked were sampled for growth at 30 days interval. Physico-Chemical parameters of the water within the cage module and outside were monitored by the Limnology Division of the Institute (KLRI). The fish were harvested on August 6, 1984.

Study 2: Growth performance and cage-culturability of some fish species endemic in Kainji Lake

Mixed fish species viz: *Citharinus citharus, Clarias* sp, *Oreochromis niloticus, Sarotherodon galilaeus, Alestes dentex, Heterobranchus bidorsalis, Lates niloticus* and *Distichodus* sp., were stocked randomly in cages (2x2x2m and 2x2x3m) between April 16, 1984 and July 4, 1985 at Shagunu Bay to observe their growth performance and cage-culturability. The fish were fed sparingly with feed II as in study 1 about once a week but they were made to subsist mainly on the natural food present in the Lake water. The fish were sampled about monthly for growth rate.

Study 3: The effect of stocking density on tilapia production in floating bamboo net cages in Kigera III Reservoir

The experiment consisted of four treatments (I, 25 fish/m3; II, 50/m3; III, 75/m3 and IV, 100/m3) each replicated in three cages (1x1x1.5m) in a completely randomized design. The fingerlings (4.6–6.7g) were randomly stocked into the net-cages in the early morning of March 16, 1985. The fish were fed with pelleted feed (See Table 3 for the nutrients composition) at 6% of thrie biomass per day. The fish daily ration was adjusted bi-weekly by sampling 20% of the fish for body weight changes.

Study 4: The effect of male: female ratio of Oreochromis niloticus breeders on fry production in floating net-hapas

The breeders were sexed and stocked randomly in net hapas (1x1x1m) in the evening on April 2, 1985 based on the following treatments:–

I	1 Male	1	Female	(10/m3)
II	1 Male:	3	Females	(12/m3)
III	1 Male:	5	Females	(12/m3)

Table 3 – Nutrients composition(%) of ingredients in the diet formulated for study 3

Ingredients	*Amount*	*Protein*	*Fat*	*Carbohydrate*	*Fibre*
Starch (binder)	2.0	–	–	2.0	–
Brewer's waste	40.0	7.32	–	18.36	–
Corn bran	43.5	5.31	3.74	28.01	1.22
Layers' concentrate	14.5	4.71	0.15	–	–
	100.0	17.34	3.89	48.37	1.22

The breeders were fed with pelleted feed I as in study 1, twice daily at 5% of the fish biomass. Sampling for the number of hatchlings (fry) per hapa was carried out immediately the fry were observed to be schooling within the hapa. The breeders were also sampled for growth at about 30 days intervals and the feed ration adjusted accordingly. Some physico-chemical parameters of the water were monitored. The experiment was terminated on June 8, 1985.

Section 5: The effect of different feedstuffs on Tilapia Fingerlings production in floating hapas in Kigera III Reservoir

The diets used in this study were single ingredient feeds: rice bran, corn bran and brewer's waster (Table 4). They were ground singly into powder form and then sieved.

Table 4 – Nutrients composition (%) of the feedstuffs

Feedstuffs	*Crude Protein*	*Carbohydrate*	*Fat*
Brewer's waste	18.8	45.9	–
Rice bran	8.7	56.0	8.7
Corn bran	12.2	65.4	8.6

The experiment consisted of four treatments – I, Brewer's waste; II, Rice bran; III, Corn bran and IV, Control, No feeding, each replicated in three net hapas in a completely randomized design. The fry (0.28 – 0.40 g) were stocked at the rate of 100/m3 in all the hapas on March 15, 1985 early morning. The fish fry were fed twice daily (09.00 hrs and 16.00 hrs), seven days per week at the rate of 20% of their biomass per day. Feed rations were adjusted every week based on the estimated new weight by sampling 40% of the biomass. Some aspects of the physico-chemical parameters of the water were monitored. The fish were harvested on April 26, 1985.

RESULTS AND DISCUSSION

Table 5 shows a summary of the results obtained in study 1. The average growth rate (g per day) for treatments I, II and III were 0.27, 0.31 and 0.39 respectively. There was significant difference in the relative weight gain in treatment II compared with the values in treatments I and III. The high survival rates were partly attributed to proper management of the stock and the physico-chemical conditions of the water in the reservoir during the culture period.

Table 5 – Summary of results for *Oreochromis niloticus* receiving different levels of blood meal feeding in floating cages for 120 days

Items	*Treatments*		
	I	*II*	*III*
Average initial wt. (g)	3.4	3.3	3.8
Average final wt. (g)	20.0	35.0	39.1
Average wt. gain (g)	16.6	31.8	35.4 ns
Relative wt. gain (%)*	497.8	972.5**	956.8
Survival (%)	99.5	99.0	100.0
Total fish production (kg/m3)	1.993	3.465	3.910 ns
Feed Conversion ratio	2.17	1.36	1.67

* Relative wt. gain (%) = $\frac{(\text{Final wt.} - \text{Initial wt.})}{\text{Initial wt.}} \times 100$

ns Not significantly different (P = 0.05) compared with the values of other treatments.

** Significantly different (P=0.05) compared with the values of treatments I and III.

Note: Figures are means of two replicates.

Table 6 – Means and ranges of physico-chemical parameters in Kigera III Reservoir site for the Floating cages

Parameters	*Means*	*Ranges*
Temperature (oC)	29.4	25.8 – 31.6
Water pH	7.1	6.9 – 7.6
Conductivity (umho/cm)	124	63 – 160
Dissolved Oxygen (mg/L)	3.6	2.8 – 4.8
Suspended solids (mg/L)	21	0 – 40
Turbidity (FTU)	53	15 – 220
No_3 (mg/L)	2.0	1.5 – 2.5
PO_4 (mg/L)	0.47	0.11 – 1.22
Chlorophyll (kg/L)	20.4	14.7 – 32.0

Note: Water samples taken at 1m depth from surface.

The total fish production in this study is comparable to the value 2kg per m3 obtained by Delmendo and Baguilat (1974). Treatment III (10% blood meal feed) recorded the best average gain, survival and total fish production. Performance of this feed could be related to the crude protein level (31.34%) ad the energy/protein ratio of the feed.

The feed with 25% blood meal had the lowest conversion ratio (1.36) which was even better than the ratio (1.7) obtained with 25% fish meal feed by Guerrero (1980). Blood meal aside from having a higher protein content (80%) than fish meal was compensated for its lower arginine, tyrosine, methionine and isoleucine contents by the cereals by-products incorporated in the feed. This result confirmed the observation that 27% protein was suitable for intensive culture of tilapia (ADCP, 1983).

The growth performances of the fish species stocked in Shagunu cages are shown in Table 7. *Citharinus citharus* recorded the highest average growth rate, followed by *Clarias lazera, Oreochromis niloticus, Sarotherodon galilaeus, Distichodus rostratus* and least in *Alestes dentex.* The cage culture method used in this study was more or less the extensive or semi-intensive type because the tocked fish were made to subsist almost entirely on the natural food in the lake.

Table 7 – Growth performances of fish species stocked in floating cages at Shagunu Bay

Species	*Rearing period (days)*	*Mean Size of Fish*		*Average growth rate (g/fish/day)*
		Initial (g)	*At Harvest*	
Citharinus citharus	150	54.0	550.0	3.31
Oreochromis niloticus	150	50.0	475.0	2.83
Clarias lazera	177	135,9	715,0	3,28
Sarotherodon galilaeus	150	30.0	225.0	2.03
Heterobranchus bidorsalis	147	41.8	110.0	0.46
Tilapia zilli	150	14.3	77.3	0.42
Alestes dentex	240	60.0	120.3	0.25
Distichodus rostratus	200	20.0	225.0	1.02
*Lates niloticus**	14	30.0	–	–

**All died before the scheduled sampling period (Stomachs observed empty).*

The planktivorous fish species which often have low protein requirements were mostly favoured. It was therefore, not surprising that the microphagous/planktivorous *Citharinus citharus, Oreochromis niloticus*

The planktivorous fish species which often have low protein requirements were mostly favoured. It was therefore, not surprising that the microphagous/planktivorous *Citharinus citharus, Oreochromis niloticus* and *Sarotherodon galilaeus* recorded high growth rates. Algal growth was observed on the side walls and top covers of the cages. In addition some schools of clupeids were found inside the cages during sampling periods. *Clarias lazera* (an omnivore) could have subsisted on these little sardines in addition to other food sources for growth. The macrophagous *Tilapia zilli*, however, did not grow as fast as the other tilapias cultured. The good performance of *Citharinus citharus* in this study has therefore confirmed the observation of Arawomo (1972) that *Citharinus* sp were no longer bottom dwellers in Lake Kainji. In fact, all the *Citharinus* sp used in stocking the cages were caught by cast-netting around the Shagunu bay. The fish were observed to be browsing on the periphyton that grew on the cage walls.

The summary of the results obtained in study 3 is shown in Table 8. It was observed that the growth rate of the fish generally decreased with the increase in stocking, but the trend was broken by fish in treatment III which had a better average final weight (55.8g) and growth rate (0.23g/day) than treatment II. However, at final harvest it would be possible to state the best stcoking density based on survival rate total fish production and the final mean size of fish.

Table 8 – Summary of results for *Tilapia* sp stocked at different densities as at October 22, 1985

Treatment	*Mean size of fish (g)* *Initial*	*Final*	*Average growth rate (g/fish/day)*
I, 25/m3	5.3	70.6	0.30
II, 50/m3	6.7	52.3	0.21
III, 57/m3	5.2	55.8	0.23
IV, 100/m3	4.6	36.1	0.14

Table 9 – Shows the Summary of results of the effect of male: female ratio of *Oreochromis niloticus* breeders on fry production in floatig net-hapas.

Table 9 – Summary of fry production of *Orechromis niloticus* in floating net hapas

Treatment	*Mean Wt. (g)* *M*	*F*	*No. of frys produced*	*Average No. of fry/ spawn*	*Average No. of fry/ female*	*Average No. of fry/ Prod./ Month*	*Average Wt. gain/ breeder (g/day)* *M F*
I M:F 1:1	106.0 (5)*	72.0 (5)*	1500(1)**	1500	300	750	0.81 0.27
II M: F 1:3	116.7 (3)	66.7	2001(4)	500	222	1000	0.75 0.08
III M: f 1.5	150.0(2)	60.0(10)	670(2)	335	67	335	0.33 0.07

**No. of breeders in parenthesis*
***Total No. of spawninin parenthesis.*

School of fry was first observed 18 days after stocking in treatment II; day 38 in treatment III and day 61 in treatment I. Likewise, spawning frequency in 61 days was highest in treatment II, 4 times; followed by III, 2 times; and least in treatment I, only once. The highest spawning frequency observed in treatment II (1:3) corresponds to the results of Uchida and King (1962) and Guerrero (1976). The delayed spawning and least spawning frequency observed in treatment I (1:1) could be related to the competition among the males for the female breeders.

The high fry production per female breeder in treatment I could be attributed to the high chances of successful fertilization of the female eggs by the numerous number of males in that treatment compared with the low number of males in treatment III. Madu and Ita (1984) on the other hand observed a total number of fry/spawn of 228 and 226 for ratios 1:3 and 1:1 respectively feeding the breeders with a diet of about 30% crude protein. Their figures are indeed lower than the range 225 to 1500 observed in this study. The highest values obtained in this study may be as a result of the richer pellected feed (approximate 50% crude protein) fed to the breeders coupled with the favourable physico-chemical parameters observed throughout the experimental period (Table 10).

Table 10 – Means and ranges of Physico-Chemical parameters in Kigera II reservoir during the period of study 4

Parameters	*Ranges*	*Means*
Water Temperature (°C) A.M.	25–30	27.5
Water Temperature P.M.	26–34	30.0
Air Temperature (°C) A.M.	26–32	29.0
Air Temperature P.M.	28–39	35.5
pH	7.8–8.3	8.05
D. O. (ppm)	3.02–5.68	4.35
Primary productivity (mg/L/day)	0.33–2.34	1.34
Transparency (m)	0.45–0.75	0.54

The floating hapas in the reservoir were regularly flushed by the flow of water through them as if it was a flow-through system. The flow of water also brought along plank onicfood. Comparing the results of ratio 1:1 in this study with those of similar ratio by Madu and Ita (1984) producing 1,281 fry in 5 months (256/month) in indoor concrete tanks and Sado (1984) producing 1,918 fry in 8 months (240/month) in outdoor raceways. The floating hapa method of fry production is more productive.

Table 11 shows the summary of results of Tilapia fry receiving different feedstuffs under study 5.

Table 11 – Summary (means 1/of results of Tilapia fry receiving different feedstuffs for a period of 42 days in floating hapas

Treatment	*Average Wt (g)* Initial	Final	*Average daily Wt. gain 2/ (g/day)*	*FCR*	*Survival*
I. Brewer's waste	0.34	1.19	0.0203 b	7.14 b	94 a
II. Rice Bran	0.40	1.10	0.0167 b	9.12 a	84 b
III. Corn bran	0.33	1.60	0.0302 a	6.53 b	90 a
IV. Control (No feeding)	0.28	1.05	0.0183 b	–	78 b

1/. Means in a column with the same supercript are not significantly different at 5% Duncan Mean Range Test (DMRT)

2/. Average daily weight gain = $\frac{\text{(Final Wt. – Initial Wt.)}}{\text{No. of days}}$

The growth performance of the fish on these feedstuffs could be related to the crude protein, fat and carbohydrate levels of the feed ingredients used. The best growth observed in fish fed with corn bran (64.4% carbohydrate) was similar to that of Coche (1977) who noted that Tilapia *(Sarotherodon.niloticus)* could accept very high levels of carbohydrate diet. In addition, the stability of the three feedstuffs could have contributed to the growth performances of the fish. The corn bran was observed to float almost indefinitely on the water surface in the hapas, thus, allowing the fry to feed on it and utilizing it for growth.

Similarly, treatment III (corn bran) had the best feed conversion ratio of 6.53. The FCR range, 6.53 – 9.12, for the three feedstuffs in this study was similar to the FCR values 5.0 and 8.0 obtained for cereals and rice hulls respectively fed to tilapia (FAO, 1976). The digestibility, stability in water and nutrient contents of these feedstuffs could be attributable to these varying FCT. Corn bran was observed to perform best, based on the FCR, average final weight and the growth rate.

ENCLOSURE CULTURE

Enclosure culture of fish in an unstocked seasonally flooded bay of Lake Kainji at Dogongari, New Bussa.

The Site

This culture system is sited at Dogongari bay, a seasonally flooed enclosed bay located at the south-western side of Lake Kainji (Figure 1).

Enclosure Construction and Inputs

The first trial of this fish culture system was made during the 1983/84 culture season Otubusin and Opeloye, 1983 and 1984). During that trial the cleared bay (total area, 7.9 ha) flooded by the black flood starting November 28, 1983 was blocked shore-to-shore using a mounted nylon net (210/9, 25mm mesh size and length about 150m) on March 5, 1984. Bamboo poles *Bambusa vulgaris* Schrad-ex–Wendel, each about 9m long, served as frame work for the block net (Figure 3). Other construction details are as reported in Otubusin and Opeloye (1983). The serious gale during the early rains contributed to the failure of the first trial (Otubusin and Opeloye, 1984). Based on the experience gained during the first trail, some modifications on the culture system were recommended for implementation in the next trial (Otubusin and Opeloye, 1984).

The modifications implemented were (Figure 4):–

(a) partial bunding of the bay in addition to blocking with the net used in the first trial.

(b) blocking of the unbunded part i.e., the channel along which flood water flows in from the lake, using 2" – meshed fencing wire, with G.I. pipes (2" diameter, 20ft length) as frame work.

(c) rip-rapping of the water channel inlets into the enclosure (from the upper zone) with bamboo poles and fencing wire to control influxt of debris.

The fourth modification i.e. the excavation of about 2 ha of the total surface area of the enclosure for increased water retention and all-year round fish culture was only partially implemented due to non-availability of an excavator.

For the second trial culture, the enclosure was flooded by the black flood starting October 29, 1984 and the water level peaked on January 2, 1985 with a total water surface area of about 4 ha. The G. I. pipes were installed and the fencing wire affixed on January 20, 1985. The enclosure water inlet from the lake was finally blocked with the blocknet on February 14, 1985 in the early evening. The enclosed fish (brought in by the lake flood) were fed at the rate of 7 bags of brewers waste per week as from February 18, till the first harvest on 28 March, 1985

RESULTS AND DISCUSSION

Table 12 shows the summary of the fish harvest from the enclosure. Harvesting started when the water surface area was about 0.2 ha and the fish were already concentrated in the small water volume.

The total fish harvest was about 58 kg. The table size fish constituted 22.3% and 54.8% of the total harvest by number and by weight respectively while the fingerlings constituted 77.7% and 45.2% by number and weight respectively. Of the table size fish, *Tilapia* sp were the most abundant in terms of number and weight – 63.0% and 72.0% respectively. The other abundant fish species in the harvest in terms of number and/or weight are *Bagrus* sp and *Chrysichthys* sp. The abundance of these fish species (Families Cichlidae and Bagridae) was not surprising because Ita (1978) observed that the cichlids have restricted distribution and are confined to the shallow inshore waters while Ajayi (1972) noted that *Bagrus* sp. and *Auchenoglanis* sp., frequent inshore and offshore shallow waters. Since about 4 ha of the enclosure was impounded by the black flood at the peak water level, the total harvest of about 58 kg is undoubtedly less thatn the estimated average productivity of the flood plains in Africa which is about 40 kg/ha/year (FAO, 1978).

This culture trial was successful in that the modifications made at the enclosure withstood all hazards and fish harvest was possible; even though thousands of fingerlings (average wt 5g) escaped through the 1" (25 mm) meshed net used in blocking the enclosure, leaving only the bigger fingerlings as recorded in Table 12.

Table 12 – Shows the summary of the fish harvest from the enclosure

Fish species	*No.*	*%*	*Wt*	*%*	*Mean Wt. (g)*	*Wt. range (g)*
Tilapia sp.	360	63.0	22,825	72.0	63	33–567
Bagrus sp	9	1.6	3,950	12.5	439	310–950
Clarias	2	0.4	300	0.9	150	120–180
Auchenoglanis sp	2	0.4	1,000	3.2	500	450–550
Alestes sp	2	0.4	110	0.3	55	50–60
Chrysichthys sp	194	34.0	3,187	10.0	16	12–17
Heterobranchus sp	2	0.4	350	1.1	175	125–225
Sub–Total	571	100.2	31,722	100.0		
Tilapia fingerlings	1,890	94.9	24,570	–	13	10.4–18.5
Auchenoglanis "	100	5.0	1,500	–	15	10.0–23.0
Bagrus "	2	0.1	47	–	24	15.0–27.0
Sub–Total	1,992	100.0	26,117			
Grand Total	2,563	57,839.				

PROSPECTS AND PROBLEMS

Even though floating bamboo net-cage and net-enclosure fish culture systems are still very new in Nigeria, they undoubtedly have great potentials in augumenting fish production from the country's vast inland (and even marine) bodies of water including mining paddocks.

The cage culture module system when perfected is transferrable to fishermen families for operation at family unit basis. An advantage of this technology is that it is relatively simple and can be operated at small and large scale production levels. Several modules of cages can be linked together depending on the level and target of operation. More so a "vertically" integrated system can be operated wherein there are modules for broodstock development, hatchery, sursery, and finally the grow-out phase. The cage culture system is useful not only for production high quality protein cheaply but also in cleaning up eutrophic waters e.g. sewage lagoons through the culture and harvesting of caged planktivorous species. Tropical water bodies offer better opportunities for extensive and semi-intensive cage and pen culture systems since many of the commercially important species such as the tilapias, carps and even citharinids feed readily on natural macrophyte, plankton and detrital production. Lake Kainji (surface area 1,275 km2) the largest man-made reservoir in Nigeria offers great opportunities for cage, pen and enclosure culture of fish at extensive and semi-intensive levels but its potentials are yet to be harnessed. An estimated annual fish production of 765,000 metric tonnes is possible from these culture systems utilizing only 10% of the lake total surface area at a production rate of 6 kg/m3/year.

Considering the ecological variabilities in these culture systems, there are plans to establish cage culture out-stations for research, demonstration and training in certain zones of the country viz: Tiga Lake in Kano; Oguta Lake in Imo State; Ero Reservoir in Ondo State and Shiroro Lake in Niger State, while Lake Kainji serves as the national headquarters (at Shagunu Bay). More research into absolute dependence on locally available material inputs for this culture system will be intensified in order to considerably reduce the total cost of production.

The potentials of the enclosure culture system for increased fish production when fully developed are immense. Integration of this culture system with poultry, cattle rearing and paddy rice cultivation is also feasible. When perfected, the enclosure culture system is anticipated for introduction to fishermen/farmers communities along the lake. Incidentally, Lake Kainji is blessed with numerous bays suitable for enclosure culture. A good example of this type of enclosures is at the Soochow State Fish Farm, Lake Chinging in China where duck manure from the duch house built at the shore provides nutrients for the adjacent fish enclosures. Approximately 10,000 ducks and 1,000 pigs are housed along 8 to 10m wide embarkment, extending roughly 2 km into the lake (de la Cruz, 1980).

The major problems confronting this project are inadequate funding for research inputs, handy field kits for monitoring of physico-chemical and biological parameters of the water bodies and shortage of trained oersonnel for the proposed outstations. Private fishery-oriented organizations and aquacultural consulting firms like Ibru Organization; Almarine Nigeria Limited; Ritsever (Nigeria) Limited; Midland Industrial Fisheries (Nigeria) Limited and many others could be partners-in-research by generously funding this type of project, the great potentials of which are yet to be harnessed in Nigeria.

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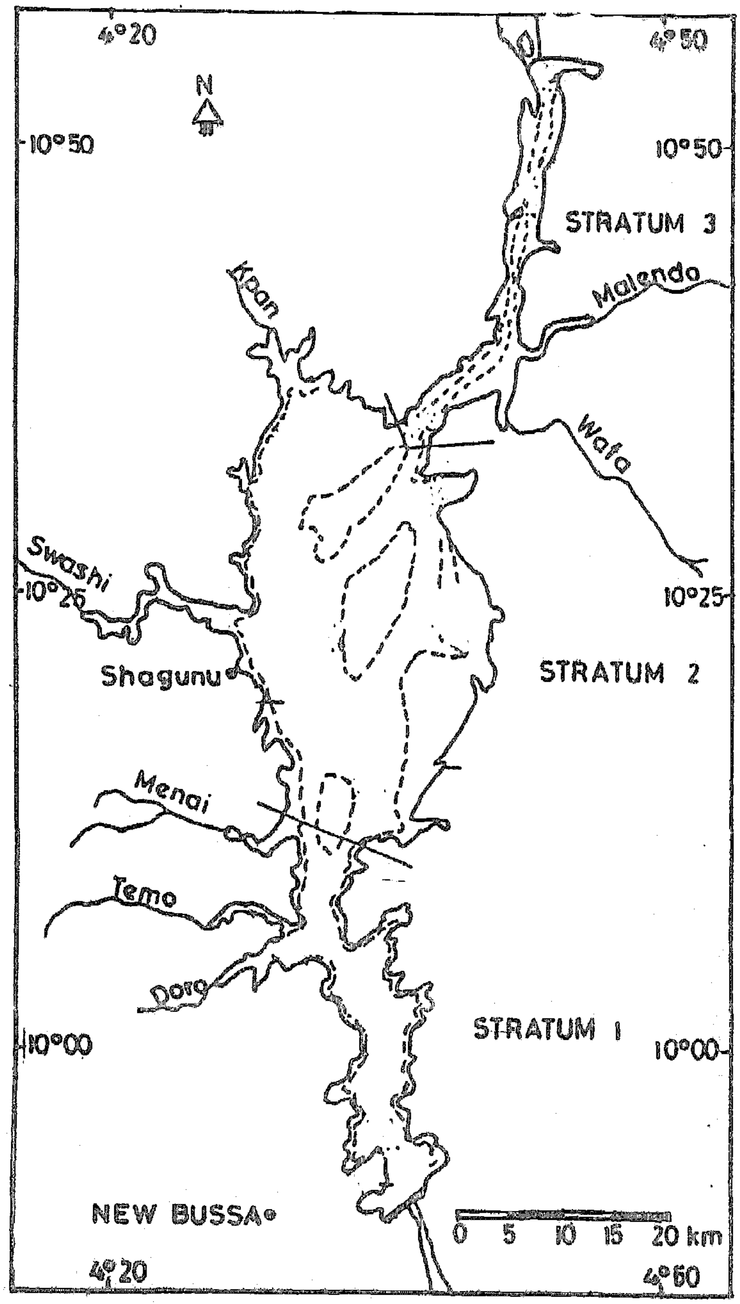

Fig. 1. Map of Kainji Lake

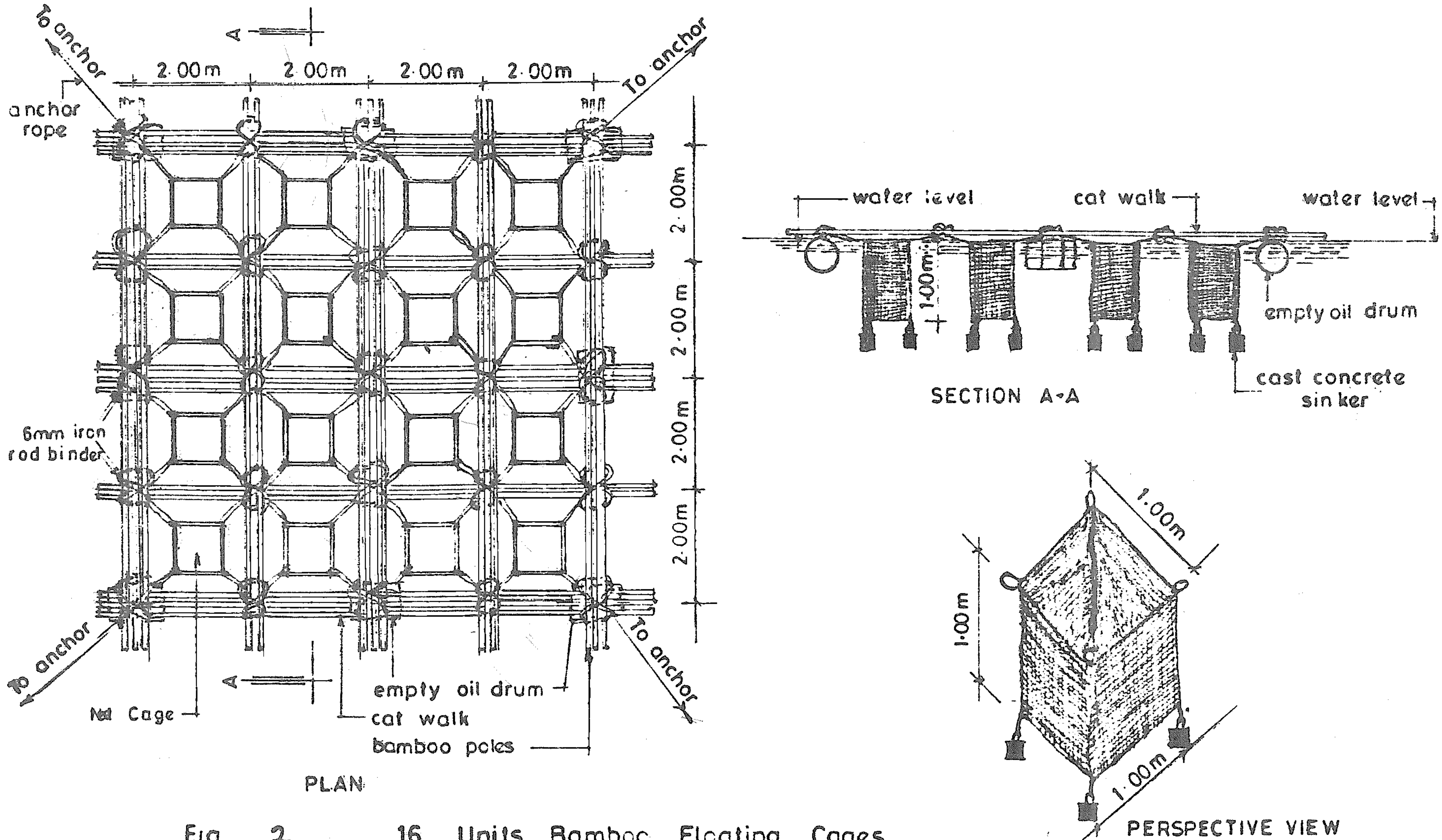

Fig 2 16 Units Bamboo Floating Cages

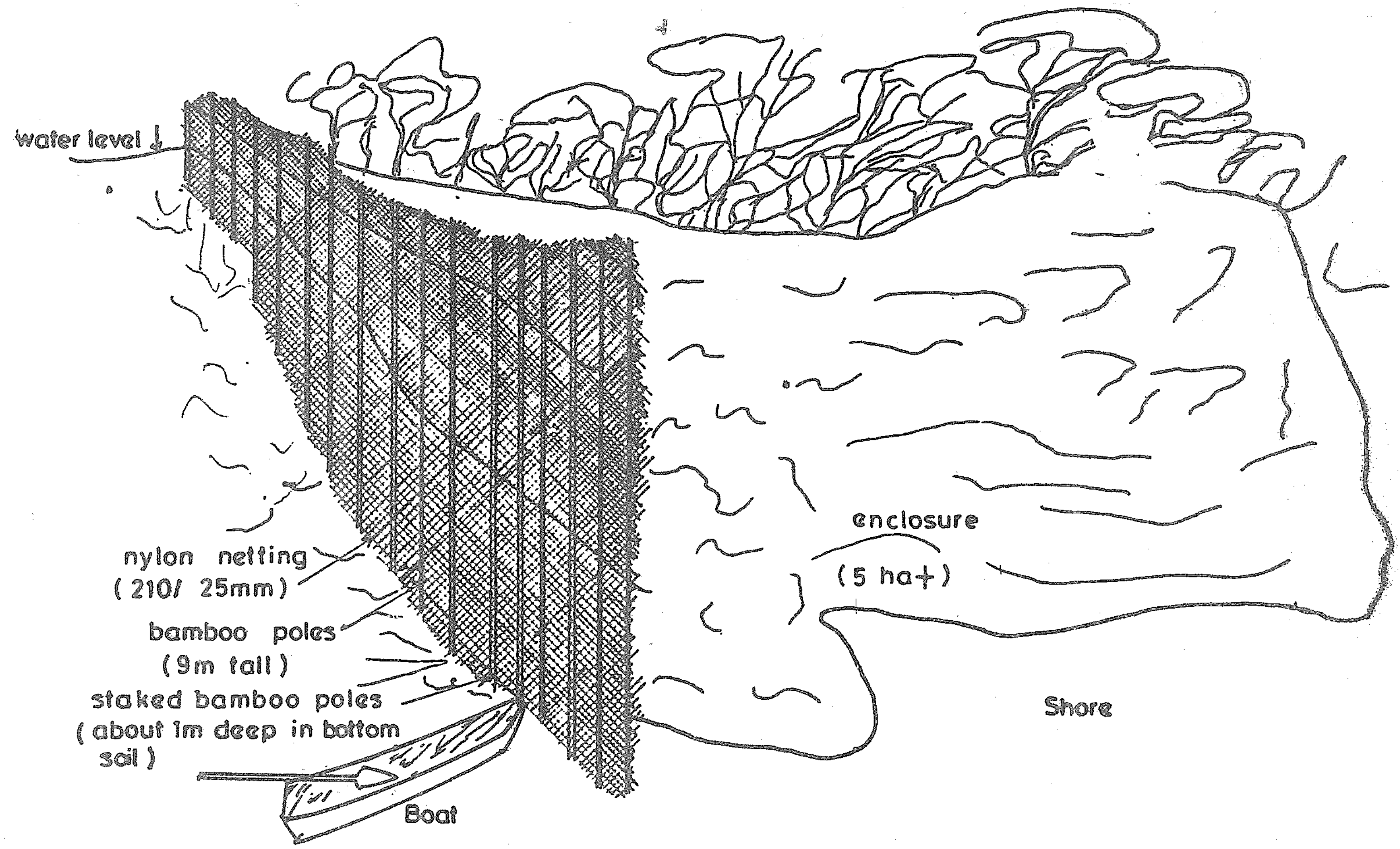

Fig. 3. Bamboo Net Enclosure Fish Culture. Dogongari Bay Lake Kainji

(not to scale

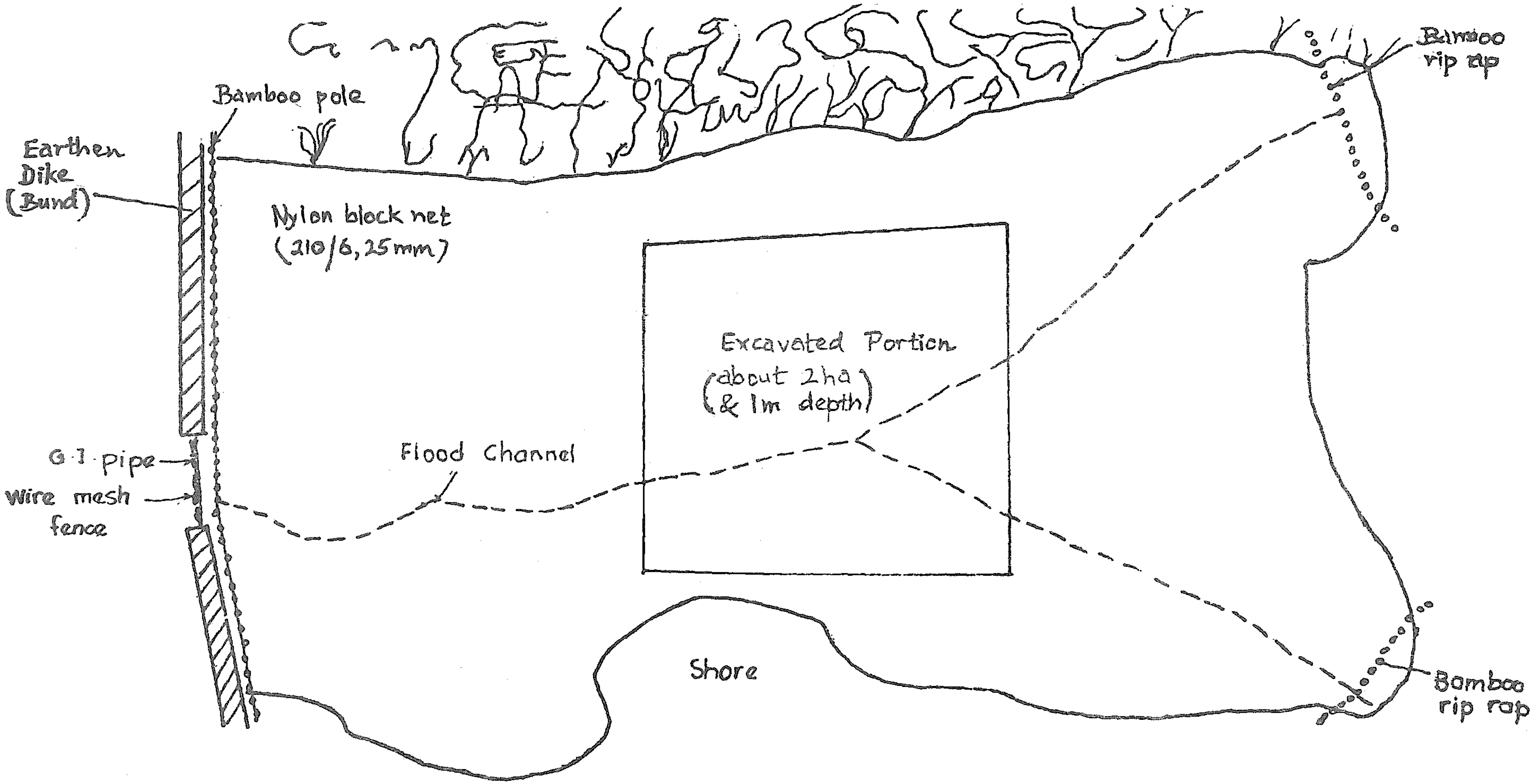

Fig 4. Profile of Dogongari Bay Fish enclosure project modifications (approx Total area: 7.9 ha.)