ASPECTS OF THE FISHING INDUSTRY AND AN OVERVIEW OF ARTIFICIAL REEFS AND FISH AGGREGATING DEVICES FOR INCREASING FISHERIES OUTPUT AND VIABILITY IN NIGERIA

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ABSTRACT

Aspects of the fishing industry are outlined to explain the concept of fishing systems viability which is often influenced by a combination of factors including biological productivity, as well as technical, economic and social factors.

The productivity of the aquatic environments can be increased by the construction and installation of artificial reefs and fish aggregating devices. These man-made structures provide shelters, food and breeding grounds for fin fish and shell fish. The habitat enhancement techniques are appropriate, efficient, cheap and simple strategic options for increase in fish production. Recommendations for effective utilization and long term management are outlined.

INTRODUCTION

Economic experiences world wide have indicated the need for every nation to be self sufficient in food production. In Nigeria fish is a rich source of animal protein.

The fishing industry creates jobs and source of income to part-time and full-time fishermen and women folks and thereby help to raise their standard of living. It promotes the development and growth of rural settlements e.g. through the small scale fisheries and also the ancillary industries like canoe construction boat building and net manufacturing. As foreign currency earner, the lucrative export trades in shrimps and other fishery products (e.g canned tuna) are beneficial to the national economy to cushion the effect of the structural adjustment programme (SAP). These are some of the bases for ensuring that the fishing industry remains buoyant and does not collapse.

Tobor (1990), and Kusemiju (1992) reported comprehensively on the fishing industry in Nigeria.

Artificial reefs (AR) and Fish aggregating devices (FAD) are not altogether new in Nigeria. They have been observed in various forms by FAO (1969) in Lagos and Lekki flats, Fagade (1969) in Lagos Lagoon, Kusemiju (1973) in Lekki Lagoon, and Reed (1967) in riverine fresh water of Northern Nigeria. They function to create new fishing grounds or improve the existing ones, concentrate fish species for easier, time saving and more efficient fishing and as well reduce fuel costs tremendously. Also the small and young fish are protected from early harvest and predation.

Amongst other consideration including biological, technical, economic and social aspects of the fishing industry which influence the viability of the fishing systems, this paper also gives

an overview of the habitat enhancement techniques which are appropriate, efficient and cheap strategic options for increase in fish production to improve the fish protein content of our food and also to create job opportunities for the fishermen with handsome rewards at all times and seasons.

1.0 ASPECTS OF FISHING INDUSTRY IN NIGERIA

1.1. Fishing Industry in Nigeria includes

(a) The artisanal or small scale or canoe fishery which employs gear types such as the artisanal purse seine net (used by Ghanaians), beach seine net the traps, bag nets or stow nets, gillnets, drift nets, castnets, handlines and longlines. Table 1 shows the number of full-time and part-time small scale fishermen and crafts in Nigeria, between 1980 and 1989.

Tobor (1990) described the characteristics of the sector to include low capital outlay, low operational costs, low technology application, labour intensive, with poor fish distribution network, low revenue generating as well as poor processing methods and high post harvest losses which represents 35 - 40% of landed weight.

(b) The industrial sector engages active fishing gear types mostly the trawl nets mostly double rigged twin trawl nets or even 4 by poaching foreign vessels. Pole and line, purse seine nets and long lines are seldomly employed. It is characterised by high capital outlay on vessels, nets cold storages advanced technology application, with highly trained and experienced manpower, high operational and maintenance costs.

Table 2 shows the number of inshore fishing and shrimping trawlers licenced in Nigeria between 1980 and 1989.

TABLE 1: NUMBERS OF FULL-TIME AND PART-TIME SMALL SCALE FISHERMEN AND CRAFT IN NIGERIA 1980-1989

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
NO OF FISHERMEN										
FULL-TIME	312,460	280,540	240,902	199,349	144,499	174,619	237,455	252,711	259,083	272,062
PART-TIME	146,605	160,052	176,057	272,773	197,720	127,615	171,517	184,754	188,767	198,185
TOTAL	459,065	440,592	416,959	472,122	342,219	302,234	408,972	437,461	447,850	470,250
NO. OF CRAFT										
MOTORISED	13,205	18,712	19,583	20,165	20,401	19,812	16,008	16,128	16,016	16,024
NON MOTORISED	120,518	101,430	85,656	109,390	89,237		61,125	60,516	61,128	61,131
TOTAL	133,723	120,142	105,239	129,555	109,638	-	77,133	76,644	77,144	77,155

SOURCE: FEDERAL DEPARTMENT OF FISHERIES 1990

TABLE 2: LICENSED IN SHORE FISHING TRAWLERS 1980 - 1989

(Source: Federal Department of Fisheries Lagos 1990)

IN SHORE TRAWLERS

Years	Fishing	Shrimping	Sub Total
1980	45	35	80
1981	45	39	84
1982	52	34	86
1983	81	39	120
1984	96	37	133
1985	116	47	163
1986	173	77	250
1987	170	82	252
1988	210	162	372
1989	158	282	440

*Licensed for trawling in Nigeria.

1.2 **Estimates of Fish Production and Demand in Nigeria**

The fish production from all sources is shown in Table 3.

The artisanal sector contributed averagely 89.7% while the industrial sector produced a paltry of about 4% annually.

Estimates of the fish demand based on 12kg per caput consumption by the projected population of Nigeria (now 88.5 million) with a growth rate of 2.1% are shown in Table 4. Extrapolation of the local fish production therefore gives an indication that the fish demand far outstrips the supply. The need to increase local fish production is very urgent. The trawlers increased from 80 in 1980 to 440 in 1989 an increase of about 550% while the fish produced or caught by the trawlers increased correspondingly from 13,631 tonnes to 33,645 tonnes an increase of 24.6%. The catch per trawler was 170.4 tonnes in 1980 and 61.2 tonnes in 1989. This gave an indication of a decline in the rate of fish production or in the revenue generated relative to the fishing efforts or investments.

Table 5 shows the level of exploitation of fin fish resources. There is therefore a need to rationalize the fishing effort e.g by venturing into the deeper water or into foreign countries where Nigeria has gone into bilateral fishing agreement.

Fadayomi (1986) estimated the Financial Internal Rate of Returns of fishing the pelagic and demersal inshore and offshore waters to be between 20 and 45% still indicative of economic viability.

TABLE 3: LOCAL FISH PRODUCTION (TONNES) FROM ALL SOURCES IN NIGERIA 1980-1989

SECTORS	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1. SMALL SCALE FISHERIES										
(i) Coastal & Brackish Water	274,158	323,916	377,693	376,984	246,784	140,873	160,169	145,755	185,181	171,332
(ii) Inland: Rivers & Lakes	188,409	157,867	119,527	146,267	112,219	60,510	106,967	103,232	112,443	132,122
Sub-Total Small Scale	462,567	481,783	497,210	523,251	359,003	201,383	267,136	248,987	297,624	303,454
2. TRAWL FISHERIES										
(i) Fish	11,667	7,070	17,348	13,951	22,992	23,766	22,419	21,383	32,740	28,411
(ii) Shrimps	1,964	2,541	1,513	5,294	2,656	2,376	2,623	3,517	2,868	5,234
(iii) EEZ	–	–	–	–	–	–	–	–	941	–
Sub-Total Trawl	13,631	9,611	18,861	19,245	25,650	26,142	25,042	24,900	36,549	33,645
3. AQUACULTURE	–	–	–	20,476	22,012	15,000	14,881	15,227	15,764	25,607
TOTAL LOCAL PRODUCTION	476,198	491,394	516,071	562,972	406,665	242,525	307,059	289,108	349,937	362,706

SOURCE: FEDERAL DEPARTMENT OF FISHERIES 1990

TABLE 4 PROJECTED POPULATION OF NIGERIA AND FISH DEMAND 1991 - 2000

(with a population growth 2.1% and 12kg fish consumption per person)

Year	Population	Fish Demand (Million tonnes)
1991	88.50	1,06200
1992	90.36	1.08432
1993	92.26	1.10712
1994	94.20	1.13040
1995	96.18	1.15416
1996	98.20	1.17840
1997	100.26	1.20312
1998	102.37	1.22844
1999	104.52	1.25424
2000	106.71	1.28052

TABLE 5: STATE OF EXPLOITATION OF FIN FISH & SHELL FISH RESOURCES IN VARIOUS BODIES OF WATER IN NIGERIA

Source: Tobor 1990

Bodies of water	State of Exploitation of the resources	Remark
Lake Chad Kainji Lake	Intensively exploited " "	Management measures to be strictly enforced to prevent over exploitation.
Other natural lakes & reservoirs	Unknown to moderately and intensively exploited	Often subjected to obnoxious methods. Extensive resources evaluation required.
Rivers & flood plains	Moderately to intensively exploited	Obnoxious methods widely used. Strict conservation measures required.
Coastal & brackish water	Intensively exploited	Conservation measures required to protect commercially important resources e.g. the bonga, sardines juvenile shrimps and fish in nursery grounds.

2.0 DEVELOPMENT PROGRAMMES

Various development programmes and policies have been embarked upon by the Federal and States government to improve the industry. Kusemiju (1992) enumerated and elucidated comprehensively development programmes which spanned three decades (1962 - 1992).

Tobor (1990) summarized the low performance records of development plans to be due to afaulty implementation machinery, under utilization of research findings and developed technologies, inadequate funding of capital projects shortage or lack of trained manpower for project implementation, wrong investment decisions resulting in a disproportionate financial outlay for the industrial sector at the expense of the artisanal sector which contributes over 75% of the local fish production and poor statistics.

2.1 Various aspects of the development programmes to enchance increases in fish production could not be sustained e.g. the percentage or degree of motorisation of the canoes with outboard and inboard engines. High rate of inflation escalated prices of fishing inputs such as the outboard engines, nets, canoes, and spare parts (for maintenance and repair jobs) out of the reach of fishermen. Table 6 shows the 1982 and 1992 market prices of selected fishing inputs and percentage increases. The 1992A prices are prederegulation of March 1992 when one doller sold for N10.00 and inflation ranged between 600 and 1600 - 1992B prices are after 1992A.

The low technological skill of the fisher-folks to carry out routine maintenance does not help the situation and training is recommended.

TABLE 6: 1982 AND 1992 MARKET PRICES OF SELECTED FISHING INPUTS AND PERCENTAGE INCREASES

Fishing Inputs	1982 (N)	1992A (N)	1992B (N)	% Increase 1982/92B
OUTBOARD MOTORS (HP)				
5	600	9,850	21,231.38	3,538.00
8	1,000	15,918	29,031.60	2,903.20
15	1,300	20,326	38,153.01	2,934.80
25	2,000	24,306	44,364.72	2,218.20
40	3,000	34,875	59,076.68	1,769.20
Lead Sinker (2m x 0.15m)	2.0	150	250	1,250.00
floats (20 x 70 x 14mm)	0.35	15	20	5,714.00
Net bundle (19.4m x 50m) PAR 75 tex)	450	950	1,700.00	377.80

*1992A Prederegulation of March 1992
(N10 = 1 U.S. Dollar); 1992B After 1992A N18< 1 U.S. D)

The training programs at the Federal College of Fisheries and Marine Technology and allied institutions should be tailored to meet this need. Also low level utilization of fish finders sonars and echo sounders to be improved.

The situation is exacerbated by rising cost of fuel especially Automotive gas oil (AGO) used by trawlers and other fishing vessels, as well as petrol and lubricating oil resulting in increase in operational cost which is reflected in the high cost of fish to the consumers who grudgingly bear the burden.

Fuel saving devices such as the propeller nozzles in boats, and larger mesh at the front part of the trawl are recommended. A downward review of the cost of AGO fuel is desirable.

2.2 The development of the petro-chemical industry to include local production of synthetic fibers and other raw materials required for manufacturing of nets, twines and ropes should be of national priority to supply the domestic needs, and export others to fetch foreign currency.

2.3 **Quality and model tests of fishing gear:**

Non effectiveness or inefficency of a fishing gear may be due to poor designs or use of inferior materials. These can be alleviated by testing the models in the flume tank prior to the construction of the prototype. Also quality tests of nets, twines and rope are desirable. These cost effective services to enchance the performance of the fishing gear can be provided cheaply at the Nigerian Institute for Oceanography and Marine Research Lagos.

2.4 The industrial fishery sector crowded with fishing/shrimping trawlers should try to embrace some other fishing methods especially longlining or pole and line for tuna e.g with cheaper 10 - 15m boat as practised in Senegal.

2.5 **Boatyard and canoe construction facilities:**

Functional boatyards are limited or few in Nigeria. The services provided can be improved and at a cheaper rate if existing boatsyards (e.g Yelwa - Yauri boat yard) are better equipped and well funded. Old ones e.g. Opobo boatyard should be resuscitated to promote local production to save foreign currency used presently to purchase fishing vessels from foreign countries and also provide employment opportunities for Nigerians.

Stability should be the watchword in canoe/boat construction and adequate safety measures and device as well as functional storage facilities (if necessary) should be provided.

2.6. The construction of more jetties and cold storage facilities at the shore especially in remote locations is necessary to facilitate take off and discharge of fish. According to Ajayi *et al* (1989) there is also the need to remove or reduce the drudgery invloved in moving the big canoes at the coastal beaches e.g by use of rollers or hand operated haulers. It can be a joint venture in each community. Apart from the labour a lot of time is wasted in order to ride the turbulent waves in and out fo the beach.

2.7 **Fiscal Policies and Financial Institution**

There is need to create the enabling financial environment to foster fisheries development and growth. The removal of import duties on fishing inputs and the spare parts is

desirable; this should be reflected in the retail prices of these items.
The government subsidy on fishing inputs should not be lost in the steam of bureacuratic transactions and sharp practices between the port and the end users. Ajayi (1991) expatiated that the 50% subsidy or artisanal fishing inputs was in reality and effectively 20% only when tariffs, local handling charges and bureaucratic overheads were discounted.

Banks are also very reluctant to give loans for commercial fishing ventures because of the high risks invloved. Fisheries projects which require moratorium are neglected in favour of buying and selling e.g importation of frozen fish.
This is partly due to the mopping up of raw cash by the CBN which inadvertently creates cash scarcity. The ripple effect is the high inter bank prime lending rate (up to 100% and over) for overnight borrowing subject to roll over for a short time. This is not good for the industry. The CBN should relax the moping up of raw cash and also introduce other appropriate monetary instruments. A higher percentage of the agricultural loan should be disbursed to fishing industry.

2.8 Insurance Scheme

Kusemiju (1986) advocated for a separate fisheries insurance scheme because of the ecological setting and system of operation which present risks different from those facing agricultural projects practised on land.
The risks and losses include:

(i) loss of life, fishing crafts and gear due to capsizing of canoe or vessel or attack by saw fishes and sharks.

(ii) damage or loss of nets and other fishing accessories that are swept away by trawlers.

(iii) fire accidents on board fishing crafts

(iv) risks of life and properties due to attack by pirates.

(v) major breakdown of engine or accidental damage to boat hull (at jetty) requiring large sums for repairs. To minimize loss or damage to engines, search techniques for prompt retrieval of outboard motors accidentally dropped at sea need to be improved as suggested by Ajayi et al (1989).

(vi) Many insurance houses do not undertake marine or fisheries related insurance schemes and when they do it is difficult or impossible to make claims because of unfavourable technical bottlenecks that are created.

3.0 WATER BODIES IN NIGERIA

Nigeria (latitudes 4° 16'E) is endowed with large bodies of water which can be utilized effectively for the installation of artificial reefs and fish aggregating devices. It has a coastline of approximately 850km bordering the shallow brackish water systems in the south and the Atlantic Ocean in the Gulf of Guinea in the North. The brackish water area, (creek, estuaries and lagoons), represents about 0.48 million hectares (see Table 7); The shallow maritime area covers 2.67 million hectares up to 50m depth or about 4.0 million hectares up to 20m depth (Table 8).

It is also endowed with large bodies of rivers, such as the Niger and Benue; natural lakes e.g. Chad; man-made lakes e.g. Kainji, Tiga and Bakolori; as well as reservoirs, flood plains and ponds.

Ita *et al.*(1985) estimated the inland water bodies to cover approximately 12.5 million hectares as shown in Table 9.

Table 7

ESTIMATED AREA OF MAJOR LAGOONS, ESTUARIES AND LOWER RIVER SECTORS THAT ARE FRINGED BY MANGROVE

Brackishwater System	State	Brackishwater area in km²	
		Based on Federal Survey mpas	Based on Radar Mosaica 1/
Epe Lagoon	Lagos	(	-
Lagos Lagoon	Lagos	(460	-
Lekki Lagoon	Lagos	(-	-
Ogun Lagoon	Ogun	26	-
Benin River	Bendel	150	109
Escravos River	Bendel	150	160
Forçados River	Bendel	120	201
Ramos River	Rivers	50	46
Dodo River	Rivers	-	-
Pennington River	Rivers	21	17
Kulama River	Rivers	10	12
Fishtown River	Rivers	5	5
Sangana River	Rivers	37	-
Nun River	Rivers	67	52
Brass River	Rivers	94	91
St. Nicholas River	Rivers	44	21
San Barbara River	Rivers	49	48
San Bartholomeo River	Rivers	84	81
Sambreiro River	Rivers	117	132
New Calabar River	Rivers	92	163
Bonny River	Rivers	124	180
Andoni River	Rivers	160	117
Imo River	Rivers	-	51
Kwa River	Cross River	-	7
Cross River	Cross River	750	510

1/ Nduaguba (1983) estimated areas using available Side-Looking Airborne Radar Mosaics

SOURCE: Ssentongo et al (1983)

TABLE 8: SURFACE OF CONTINENTAL SHELF (0 - 200M DEPTH)

Continental Shelf	Total surface area (ha)
(0 - 10m depth)	510,000
(10 - 50m depth)	2,160,000
(50 - 200m depth)	1,430,000
Total	4,100,000

Source: F. Domain (1980).

TABLE 9: SUMMARY OF WATER SURFACE AREAS OF LAKES, RESERVOIRS AND MAJOR RIVERS IN NIGERIA SOURCE (ITA ET AL 1985)

WATER BODIES	AREA (ha)
Lake Chad (Nigerian Sector)	550,000
Kainji Lake	127,000
Major Rivers (Anambra, Benue, Cross, Imo, Akwa Ibo, Ogun, Oshun, Niger, (less Kainji and Jebba Lake)	10,812,210.18
Cattle, Fish and Flood plains:	7,764.56
Reservoirs:	275,534.91
Flood palins:	515,000
Miscellaneous stagnant Pools of seasonal rivers	200,000
Burrow pits and mining paddocks: ..	108
Total =	12,487,617.65 ha

4.0 ARTIFICIAL REEFS AND FISH AGGREGATING DEVICES:

4.1. Classification:

The artificial reefs and fish aggregating devices are man made objects specifically placed or fixed in water to attract fish. They can be classified based on the area of installation viz: bottom, midwater or the surface. It is more common to refer to the floating structures as Fish Aggregating Devices (FAD) or Floating Fish Aggregating Devices. (FFAD). Other criteria for classification include shape, size, material and target species.

4.2 Functions:

The structures contribute to the enrichment of marine life by providing

(a) shades or shelters (from strong currents) and hiding places for protection from predators.

(b) a firm substrate for attachment (e.g of sessile life forms)
(c) a source of food e.g. planktons and algae
(d) spawning or breeding and nursery areas
(e) as visual or even auditory reference point for orientation of some pelagic fishes e.g. tuna.

Artificial reefs and FADS can be deployed for some other purposes e.g. to prevent trawlers from using certain areas reserved for artisanal fishermen.

4.3 Material and Forms:

Materials used for the construction of artificial reefs and fish aggregating devices are numerous, and present different characteristics as shown in Table 10. Some of the Varieties used in Nigeria are stated below and the recommended cheap locally available material include:

(a) discarded scraps e.g. worn out drums or worn out automobile tyres (Fig. 1) or old PVC pipes and blocks which can be installed separately or in conjuction with plant parts.

(b) ship wrecks available

(c) near shore oil drilling platforms and oil rigs also serve secondarily as fish shelter and are effective in aggregating shoals of fish.

(d) logs, bamboo and other plants floating rafts are used in coastal waters.

(e) floating water weeds e.g. water hyacinth *(Eichhornia crassipes)* fenced with bamboo and staked into a stationary position in shallow brackish water/fresh water serve as fish shelters. Fish also hide in the hollow bamboo stem.

TABLE 10: CHARACTERISTICS OF MATERIALS USED FOR THE CONSTRUCTION OF ARTIFICIAL REEFS AND FISH AGGREGATING DEVICES

Material	Lifespan	Cost	Crevices and Chambers
Plants and Plants' part e.g. Bamboo stem, palm fronts, Mangrove plants and water weeds	4-8 months	Cheap/free	Good
Old PVC pipes	Long	Free	Very good
Old drum	3-5 years	Cheap/free	Very good
Old worn out typres	Long	Free	Excellent
Concrete structures	Long	High	Excellent
Obsolete/functional oil rigs	Long	Free	Good
Fiber glass reinforced plastic (FRP)	Long	High	Good
Old FRP Canoes	Medium	Low/free	Good
Shipwrecks	Medium	free	Excellent
Other floating structures of synthetic nets	Long	Very high	Excellent

(f) the brush park fishing referred to as ACADJA in the West Africansub-region is constructed with plant parts and branches (1 - 4m long) e.g. fronds of oil palm, *Elaies guineensis* and mangrove plants, *Rhizophora Tacemosa* staked in 1 - 3.5m shallow and calm water. Old worn out tyres and plastic pipes may be added to provide hiding chambers for fish (Fig. 2).

(g) Bundles of brush or palm fronds placed (not staked) in calm water close to shore act as shelter for lagoon and fresh water shrimps and other fish species. They are surrounded with a baby seine net. The palm fronds are dragged gently to the shore while the seine net is dragged/pulled out of water to collect the fleeing shrimp/fish.

(h) In fresh water bodies e.g. rivers triangular plot of branches are staked in the river bed with the apex of the triangle upstream (Reed 1967). They are referred to as "Daikan kifi" meaning house of fish in Hausa.

(i) Worn out or damaged synthetic nets can also be used to construct FAD as shown in figure 3. In developed countries like Japan and U.S.A. synthetic nets and other costly fabrications e.g. steel, reinforced or pre-stressed concrete, rubber and fiber glass reinforced plastrics are employed.

4.4 Design and Placement of Structures

There are no general rules in the design and placement of structures.

(i) the amount of materials used and the area/volume covered are directly related to fish production. Attractiveness generally increases with greater size.

(ii) the vertical relief is important especially in deep waters.

(iii) the complexity of the structure in relation to spatial arrangement number of chambers and spaces for fish to hide.

(iv) texture and composition of the materials. Some materials decay rapidly e.g. plant parts while some do not e.g. tyres.

4.5 Fish Behaviour

The first target of artificial reef is to attract fish and other organisms which react to the introduction of new structures. Thierry (1988) defined five criteria of fish behaviour viz:

i) Rheotaxy - orientation with respect to the current direction.
ii) geotaxy - orientation with respect to the coast or shore.
iii) thigmotaxy - physical contact with the reef.
iv) phototaxy - response to light
v) chemotaxy - response to olfactive stimulus as well as auditory response to sound.

4.6 Area of Influence:

The area around the AR or FAD where fish species are caught is referred to as the "enchanced fishing zone". This has been observed by many workers to range between 200 - 300m for mid water and surface fishes and 1 - 10m for benthic fishes. The zone is not usually circular becuase fishes tend to congregate either up or down current in response to the availability of food.

4.7 Estimate of Production and Potential Yield

In general the artificial reefs and fish aggregating devices provide more fish (by weight) than the open water which may contain more fish species (families); a few families are attracted more than others by the AR or FAD. Comparative yields from tropical ecosystem by Lowe - Mc Connell (1987) indicated that the "acadja" fish parks gave the heaviest yields without artificial feeding. Fishes twice a year, acadjas are reputed to yield the equivalent of 8 metric tonnes ha^{-1} yr^{-1} of mixed species (Welcome 1972).

Production figures of small acadja' observed in Lagos lagoon averaged 2.28 metric tonnes ha^{-1} yr^{-1} Campbell (1987) gave a report on acadja, floating weed and an empty control pen (each $100m^2$ enclosed with 14mm mesh nylon (PA) net left for 1yr) which yielded 80.5kg, 18.2kg and 11.7kg respectively. This confirms the above figure of 8 tonnes ha^{-1} yr^{-1} for the acadja. *Sarotherdon melanotheron* constituted 79% by weight between 1988 and 1989 the actcial tonnage of fish mostly tuna (skip jack and yellow fin) caught in locations of coastal FAD ranged between 5 and 36 tonnes per 5 to 15 days trip.

Table II gives a modest estimate of the potential yield from artificial reefs and fish aggregating devices in fresh, brackish, and coastal waters up to a depth of

TABLE II: ESTIMATES OF POTENTIAL FISH YIELD FROM ARTIFICIAL REEFS AND FISH AGGREGATING DEVICES

Water Bodies	Total Surface area (Million Hectares)	2.5% of the Area	Catch per Unit Effort (tonnes ha^{-1} yr^{-1})	Yield (tonnes/ annum)
Fresh water (rivers,lakes) etc.	12.49	0.312	2.28	711360
Brackish water (creeks, lagoons estuaries)	0.84	0.021	2.28	47880
Coastal water (up to 50m depth)	2.67	0.067	5.00	335000
Total	16.00	0.400	-	1,094,240

50m. For economic reason the shallower water is good for the placement of ARs or FADs because the anchor chain or rope may form the bulk of the cost of construction. Excluding

other sources of fish production the modest estimated yield of 1.094 million tonnes per annum (c.f. projected fish demand shown in Table 4) is highly encouraging and readily recommends the artificial reefs and the fish aggregating devices as strategic options for increased fish production and to enhance viable fishing systems in Nigeria.

4.8 Recommendations of ARs and FADs

Artificial reefs and fish aggregating devices are good to create fishing opportunities, reduce user conflicts, save time and fuel as well as reduce drudgery sometimes associated with (aimless) capture fishery.

However the following salient points and recommendations are note worthy for effective and efficient management purposes.

4.8.1 The duration of installation of the ARs or FADs should be properly assessed to allow for better growth of the individual fish. Not less than 2 months may be desirable Welcome (1972) indicated that large fish shelters allow exponential increase and growth of fish, rather than act as refuge trap.

4.8.2 The ARs and FADS should be designed constructed and installed to promote the growth of juvenile fish. Gorham and Alevizon (1989) observed that unravelled polypropylene rope streamers were very effective to increase juvenile fish abundance. They were colonized quickly by algae and invertebrates which served as food. Miclat and Miclat (1989) recommended that two types of ARs should be constructed; those for fishing and those constructed in protected areas to induce recruitment of fish and other organisms and to contribute to habitat improvement.

4.8.3 For economic reasons, the use of cheap locally available materials should be encouraged, preferably rot-free materials old worn out e.g worn-out rubber tyres.

4.8.4 Fisheries laws and regulations on the use of coastal, brackish water and freshwater resources should apply to ARs and FADs e.g. obnoxious fishing within or around the installations remained banned.

4.8.5 The AR or FAD should remain as much as possible a communal property just like any natural resources. Otherwise we may be dealing with the issue of 'certificate of occupancy' sooner than later.

4.8.6 It is not desirable to mass introduce the ARs and FADs. This may result in diminshing returns. The introduction should be gradual and monitored by fishery administrators who base their assessments and decisions on research findings. Linkages among the concerned government agencies, Federal Department of Fisheries (FDF), States Fisheries Division, Research Institutes and of course States Agricultural Development Programmes Offices (ADPs) and fishermen must be made to have well-coordinated developemnt programmes.

Fig 1: Worn out tyres used to aggregate fish in Lagos lagoon.

Fig. 2 An acadja fish shelter in Lagos lagoon.

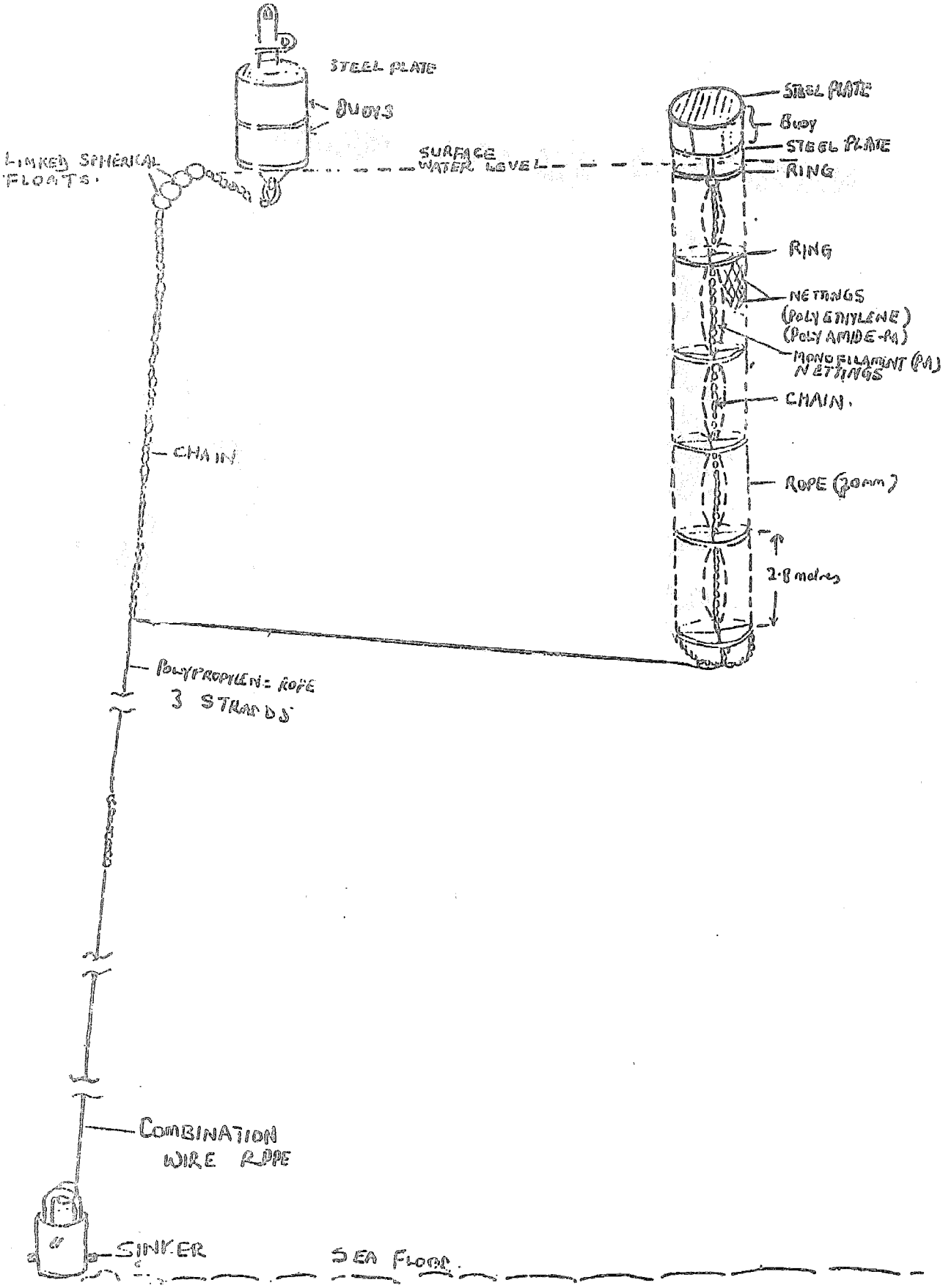

FIG 3 ; DIAGRAMMATIC REPRESENTATION OF FISH AGGREGATING DEVICE.

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