MODERN AQUACULTURE PRACTICES FOR INCREASED FISH PRODUCTION IN NIGERIA

by

S.O. Otubusin
Kainji Lake Research Institute
P.M.B. 666, New Bussa
Nigeria

ABSTRACT

Various modern aquaculture practices applied in fish production especially in Asia are reviewed.

The vast Nigerian aquatic medium of numerous water bodies like rivers, streams, lakes, reservoirs, flood plains, irrigation canals, coastal swamps offer great potentials for aquaculture production, if optimally utilized. But the constraints to modernization of aquaculture in Nigeria amongst other factors are:

Serious shortage of trained manpower;

lack of knowledge on profitability of aquaculture as an industry;

limited availability of fund (or capital);

non-recognition of indigenous trained aquaculture personnel;

inadequate data base on the biology and ecological requirements of endemic fish species with aquaculture potentials;

insufficient data on production and management techniques; and

lack of rational aquaculture development planning.

Recommendations are made towards combating these contraints such that aquaculture can be proven technically and economically feasible as in some countries reviewed.

In the final analysis, concerted efforts at institutional and public sectors need to be mustered for modernizing aquaculture practices for increased fish production at economical level in Nigeria.

INTRODUCTION

Traditionally, aquaculture has been restricted largely to Asia where practices have been developed through trial and error, and passed on through generations. Almost all forms of aquaculture are practised in Asia. There are variations, however, in the size of the farms, level of operations as well as production objectives. Some fish farms combine both the hatchery and fish production activities, while others are either for hatchery or grow out operations. Most of the aquaculture activities are land based involving ponds, rice paddy, and raceways, whilst other fish culture practices are conducted in the natural water bodies like cage, pen, stake, on-bottom, or raft for fin and shell-fishes.

HATCHERIES

Economically productive aquaculture, like agriculture, is heavily dependent upon an adequate supply of seed, of fertile eggs and juvenile fish, with which to stock the ponds, enclosures, and other cultivation systems. Most hatcheries in the region (Asia) are established by the governments although, there are increasing private hatcheries being established recently. The government hatcheries are mainly for the production of freshwater fishes, especially carps, for stocking of open water and for supply to rural fish farms. On the other hand, private hatcheries produce specific species like sea bass (Lates sp.), Paenus sp. and Macrobrachium sp., mainly for supply to local aqua farmers. The target species as well as capital inputs often determine the scale and level of hatchery operations. The hatchery operations can either be an open-door (extensive or semi-intensive) or in-door (usually intensive) depending on the scale of operations and other factors. For example, for Tilapia hatchery, seed can be produced in net enclosures, rice paddies, ponds or in-door under controlled condition. For breeding Nile tilapia, an enclosure which is 1.5 m long, 1 m wide and 1 m deep has been found practical (Anon, 1982). The enclosures are installed in ponds, lakes or along river banks with slow moving water. Breeders (50 - 100 g in weight) are stocked at the rate of three females to one male per enclosure. They are fed with pelleted diet consisting of 25% fish meal and 75% fine rice bran at 3% of fish weight per enclosure in the morning and afternoon. In a period of two weeks, 500 fry per enclosure can be expected. For a 200 sq. m paddy stocked with 50 breeders (40 females and 10 males) and fed rice bran at the rate of 2.5% body weight twice a day for the first month but 5% for the second month, fingerlings yield can be as much as 50 pieces per square meter in two months. Breeding Tilapia in ponds is the most extensive method. It is applicable where ponds are available and when labour is limited. For a 500 sq. m. pond, 200 females and 50 males are needed (5,000 breeders/ha). If natural food is not adequate in the pond, supplemental feeding with fine rice bran at 5% of fish weight per day may be applied. Well managed breeding ponds can yield up to 100 fingerlings per square meter in four months (Anon, 1982). In the case of indoor hatchery, the breeders are stocked at the ratio of 1 male to 4 females in fibre glass tanks or any other suitable container under aeration at the rate of 5 breeders per square meter. They are then reared separately and fed on lab-produced or propagated natural food (plankton) at specific feeding rate (No. of plankton cells/ml). This hatchery operation method yields the highest number of seed/unit area in time if well managed.

In some countries such as Philippines, Thailand and Taiwan, there are numerous "backyard hatcheries" operated by experienced small farmers contributing significantly to the national total fry supply. Modern but large hatcheries are increasing rapidly in view of the vast potential in the fish seed industry. To date, several big enterprises whose primary trades are not fish culture have been involved in establishing large fish hatcheries in many parts of Asia. Since some fish would refuse to breed in captivity, the method of induced breeding playing on the physiological (endocrinological in particular) activities of the fish is gradually being utilized in hatchery operations. Gonadotropin induced breeding is now being widely studied and used in the breeding of carp in China and India, and of other species (e.g. Mullet, Mugil sp in Hawaii). In India, 260 million carp seed were produced in 1978 - 79 from induced breeding (Davy and Chouinard, 1980).

In prawn hatchery, eye-stalk ablation is practised to induce spawning in Penaeus monodon (the giant prawn) (Primavera et al 1978). The larval rearing from nauplii to post larvae is then carried out under intensive method feeding them on plankton like Chaetocerus calcitrans, Brachionus plicatilis etc.

In line with aquaculture hatchery operations, the techniques of handling, incubating and hatching of fish eggs have been developed. These techniques are varied amongst major cultured species and are described in standard texts for fish culture (Hickling, 1971; Hora and Pillay, 1962; Huet, 1970). A variety of incubators and hatching facilities are being used for different and even for the same species of fish. These include ponds, hapas, tanks, jars, troughs, tray etc. Each of them has its advantages and disadvantages, since the use of specific incubators or hatching facilites would depend greatly upon the species of fish and on financial constraints.

Also, notable amongst fish seeds production practices is the artificial sex reversal of genotypic female Tilapia by the use of hormones (Guerrero, 1975; Shelton et al, 1978). Two synthetic androgens, enthyltestosterone and methyltestosterone have been used for masculinizing genotypic female tilapia. This is done by oral administration for varying period (18 - 60 days) in tanks 10 - 60 mg/kg diet (Guerrero, 1979). The "all-male" seeds so produced have definite advantages over mixed-sex culture for the following reasons:

(i) Eliminates unwanted reproduction of tilapia;

(ii) Results in faster growth and higher survival (Van Someren and Whitehead, 1960; Guerrero, 1974); and

(iii) High stocking rates can be applied.

In line with advancement in hatchery operations is the nutritional project for fish seed production especially the Natural Feeds Propagation. The activities often involve isolation, culture, propagation and determination of the efficiency of the natural food source for larval rearing. Organisms commonly utilized as natural food for larval rearing include Brachionus sp, Chaetocerus sp, Chlorella sp, Moina sp, Artemia sp, Oscillatoria sp, Chroococcus sp etc.

PRODUCTION OF MARKETABLE SIZE FISH

Marketable size fish are produced in various ecological habitats using different culture techniques: pond culture, integrated fish farming, intensive fish farming by recirculating and running water using race ways and tanks, pen culture, cage culture (land based or floating), off-bottom culture using raft, on-bottom culture on mud flats and stake and tray culture in intertidal zones.

Pond Culture

This is one of the earliest and widely practised aquaculture systems. About 3.7 million metric tones of fish were produced from brackishwater and freshwater ponds in 1973 (Shang, 1976). Most of the ponds used in Asia are small, ranging from 0.10 ha (catfish farm in Thailand) to about 250 ha (milkfish farm in the Philippines). On the average about 0.5 to 2.5 ha farm size are operated by one or two farmers. In many instances the farms are operated at the family level.

In Asia, most fish-ponds are of earth and mud which promotes natural food productivity for culturing fish low in the food chain such as carps and milkfish. In some cases, the sides of the ponds may be sealed with cement to prevent leaching of acid water from acid sulphate soil as seen in Thailand, or plastic sheets to prevent escape of walking catfish (Clarias sp) or mud crabs (Scylla serrata). In Japan and Taiwan, cement ponds are used for intensive farming of fish and shrimps where running water and a high feeding regime are needed to ensure high production rate.

The shape and arrangement of the ponds are often determined by the topography of the sites. Since large scale fish pond engineering inputs are often used, the ponds are usually rectangular in shape and more systematically arranged with proper system for water management. Most ponds are about 1 meter deep. Swamp, estuarine flats, burrowed pits, marshes, agricultural low land and reservoirs are often converted into fish ponds.

Management and operation of fish ponds depend highly on the nature and characteristics of the ponds (stagnant, tidal flushing or drainable), species and stages of the stocking materials, level of operations (mono culture, extensive or intensive) and finally, the

the environmental conditions of the ponds (temperature, evaporation rate, salinity in brakishwater ponds, pH etc). For milkfish culture in the Philippines ponds, are usually fertilized to enhance growth of "lab-lab" (Rabanal, 1977), a complex mixture of microscopic plant and animal organisms which develop as a pond scum on the pond bottom. Production can be as high as 3 tons/ha in intensive culture of milkfish (Tang, 1967). For carnivorous fish such as the walking catfish which are heavily fed, production could be as high as 174 tons/ha (FAO, 1976). Yield from milkfish pond culture varies with the level of management but production higher than 2 tons/ha is not uncommon (Chen, 1976).

Integrated Fish Culture

Integrated farming generally contributes to the maximum utilization of resources such as farm land, labour and capital and thus results in higher income, higher productivity and more equitable distribution of farm labour (Lee, 1971). The Chinese are well known to have integrated fish culture with livestocks: carp-cum-fish culture producing fish at the rate of about 5 - 6 tons/ha. In the Philippines, integration of tilapia with pigs yielded about 3.5 tons of fish per hectare in 180 days (Hopkins and Cruz, 1980). From a fish polyculture system (silver carp, grass carp, common carp and tilapia) receiving liquidated cow-manure, Moar et al (1977) reported a daily weight gain of 35 kg/ha i.e. 8t/ha/240 days. Wohlfarth (1978) on the other hand recorded a daily yield of 32 kg/ha (7.6t/ha/240 days) in ponds receiving only duck droppings. Integrated farming using tilapia and carps as stocking materials for ponds and pigs and poultry as the livestock are becoming more popular among rural and even industrial fish farmers in many countries in Asia.

Fish Culture in Rice Paddy

This culture system has been practised in Asia for many centuries. In many countries such as Thailand, India, Malaysia, China and Indonesia, rice paddy fish culture has developed into an important inland fishery not only for the supply of animal protein but also for contributing some income. In India peripheral canals are dug around each plot of paddy and fish production between 700 - 1000 kg/ha can be attained. In the Philippines, the fields are flooded with about 25 cm of water but central canals are built at regular intervals for fish and to facilitate harvesting.

Running Water Culture

This system of aquaculture utilizes adequate supply of well oxygenated water and the efficient means of waste removal for heavy stocking of fish in limited areas such as raceways, troughs, tunnels and tanks. The fish are heavily fed with inexpensive but nutritious feeds. Production from this system of aquaculture is usually high. In Japan, at a flow rate of about 100 kg/litre/sec, 1000 - 4000 tons of carp/ha/yr were produced, whilst at a flow rate of 170 kg/litre/sec, rainbow trout production of 2000 tons/ha/yr was recorded in the United States (Bardach, 1972).

Raceway culture is less practical in the developing countries because of the high cost of production.

Recirculating Systems Culture

Fish culture in recirculating systems have been practised in commercial scale in developed countries. The systems involve technical processes in reconditioning used water and recirculating it. Economy of water and full control of water quality are the obvious advantages of these systems. Under these systems, fish can be reared in very high densities. In Germany, 10 carps can be grown in 40 litres of water in aquarian tanks with fast flow rate of water and strong aeration. Results from Japan show that as high as 4000 kg of common carps can be raised per cubic metre of water (Bardach, 1972). Cost of production using recirculating systems is usually higher than conventional method of fish farming in ponds.

Cage Culture

This enclosure method of fish farming is a productive aqua-farming system. Enclosures of varied types have become widespread in use in Asia involving rigid bamboo cages as well as floating net·pens of varied shapes, in freshwater estuaries and in the sea. Cage culture utilizes little physical facilities and space. It is moderately cheap to operate. The cage is either land based (in ponds with regular water exchange rate) or water based (in large body of water such as lakes, rivers etc). The cage could be floating (floating cage) suspended in water as a single cage or a module of net-cages or fixed (stationary cages) which are tied to poles at their corners. Floating cages are popularly used for fish rearing in fresh and coastal waters. Fish farming in cages has been practised for many years in Kampuchea (Cambodia) and Vietnam for raising freshwater fishes (Pantulü, 1976). The technology was later introduced to the Philippines, Indonesia and Thailand where large areas of inland waters are utilized for cage culture. The most recent practice is marine cage culture suitable for sheltered coastal water and lagoons. The marine cage culture of yellow-tail in Japan, Serranids in Hong Kong, Salmons and trouts in Norway and Great Britain are very famous. A production rate as high as 131 kg/m^3 in channel catfish in U.S.A. (Collins, 1972).

Fishpen Culture

Fishpens are one of the most popular culture systems for milkfish (Chanos chanos Forskal) in the Philippines. Fishpens are normally constructed in semi-enclosed bay where the water in the pen can be renewed through flushing generated by tidal current or wind force. The seabed is the bottom of the pen and is not covered. Pens ranging from 5 to 50 hectares at 1 - 2 m deep are very common in Laguna de Bay (Philippines), a eutrophic lake (surface area, $900km^2$; average depth, 3 m) with tidal flushing twice a day. Milkfish fingerlings are first kept in the nursery pen then transferred to the grow-out pen at a stocking density of 20,000 - 40,000 fingerlings per hectare. The fish are usually not given any supplemental feed. However, in some situations, supplemental feeds like rice bran, ice cream cones are fed to the fish. An average production from some 5,000 fish pens in laguna de Bay is 4 tons per hectare (Anon, 1979).

Pen culture in the Philippines commenced since 1967, and the number of fish pens has been increasing to cover more than 5,000 hectares of the lake indicating the high profitability of the enterprise. According to Anon (1979), a fish-pen owner in the lake Laguna realizes an average income of ₱24,863 (US $3,315) whilst the caretakers bag about ₱8,085 (US $1,078). However, the average income for pen (1 - 5 ha) is about ₱1,941 (US $259) per hectare.

Molluscs Culture

The intertidal area of the coast is often utilized for the production of bivalves such as oysters, mussels and clams. The bivalves can be cultured directly on the seabed or using poles or stakes, racks and trays. In deeper water, floating rafts of long-lines are used. Hatcheries have been successfully developed for the production of seeds of some species but most culturists still find it more economical to collect the seeds (spat) from the wild. Culture of estuarine oysters directly on the bottom is being practised but are limited due to high predation, turbidity and difficulty in harvesting.

Culture of oysters using bamboo poles is a common practice in Asia especially in the Philippines and Taiwan because of simplicity and low investment. Production depends on the managerial skill of the oysters growers.

In Sabah, oysters are cultured in wire trays supported by wooden frame work.

Culture of oysters by hanging them from floating raft has been a common practice all over the world. The raft is usually 14 - 15m by 7 - 8m made of bamboo or woods and are suspended by floats. Hollow cement drums, tarred wooden floats, styrofoam floats or tarred oil drums are suitable for floats. Oyster spat collected from the wild are transferred to the growing site where they are hung on the raft. The oysters are allowed to grow for about 8 - 10 months (depending on the temperature of the water) before marketing.

Oyster culture on long-line has been recently practised in Japan, Korea, Taiwan and some other Asian countries. The long-line method is gaining popularity because of the lower initial cost and they can be operated in areas where the sea is rough where raft culture cannot be used.

In Taiwan, the long-line method has been further modified for culture of oyster in shallow waters.

Other Aquaculture Related Practices

The fact that production from aquaculture is related to manageable inputs (such as feed etc) has led to the search for alternative sources of inputs at very cheap cost. Studies were carried out on the culture of earth worm (Vermiculture) for commercial production as a substitute for fish meal.

Guerrero (1980) grew juveniles of the earth worm species, *Perionyx excavatus* in six concrete tanks (2,000 juveniles/tank) to harvestable size (0.3 - 0.5 g). A combination of Murrah bufalo manure and ipil-ipil leaves (2 : 1) was used as bedding material. A total of 126,000 worms, weighing approximately 42 kg fresh weight was produced in 7 months.

Culture of frog (*Rana* sp.) is also practised in some Asian countries to combat the rising cost of high protein fish feed.

AQUACULTURE PRACTICES IN NIGERIA

Nigeria, even though blessed with several bodies of water (lakes, reservoirs, streams, flood plains, swamp land etc) is yet to tap the potentials offered by aquaculture.

Preliminary experiments in fish culture in brackishwater ponds started at Onikan in Lagos in the early 1940s' by a fisheries organization which was a branch of the Agricultural Department of the Colonial Office (Anon, 1974). A small Fisheries School was also established at Onikan. Some other recorded aquacultural practices include those of Sivalingam (1972; 1974) on the fish culture possibilities around Lagos lagoon and guide to construction of fish ponds respectively. In an earlier trial with Carp fed on groundnut cake, Sivalingam (1968) obtained a yield of approximatel 1,400 kg/ha. In another trial, stocking a 0.203 ha pond with 943 specimens, average weight 43 g of *Chrysichthys nigrodigitatus* and fed a feed composed of groundnut cake, maize, beans, gari and palm oil, a yield of 184 kg of fish was obtained, with a food co-efficient of 1.7 (Sivalingam, 1972). He noted that lack of information on the natural growth rate of *C. nigrodigitatus* was a constraint to estimating the effect of feeding on this fish species. However, he recommended the popularizing of aquaculture by the Government subsidising the entire capital at the initial stages. Some literature also recorded the establishment of some demonstration ponds and commercial fish farms by government agencies in Nigeria more than three decades ago (Anon, 1963; FAO, 1965). Attempts have also been made recently to point to the management roles, potentials and profitability of aquaculture in Nigeria (Sagua, 1976; 1977; Ezenwa, 1979; Igonifagha, 1979; Ita, 1976; 1980). Konikoff (1975) attempted cage culture of Tilapia sp in Lake Kainji using local availble feed ingredients like guinea corn bran, roasted groundnut, yam flour and dried clupeids (abundant yet unexploited fish of Lake Kainji) Otobo, 1977). Konikoff (op.cit) concluded that there was great potential for aquaculture in Lake Kainji area (surface area, 1270 km²) and made recommendations towards achieving these goals.

International organizations especially Food and Agricultural Organization have been fully involved in fisheries development in Nigeria. The most recent and notable was the establishment of the African Regional Aquaculture Centre at Aluu in River State. The objectives of this centre are:-

(a) To develop through research and training, a sound technical base for organized growth of aquaculture in the region, both as small-scale ventures and as large-scale commercial enterprises.

(b) To increase food production in the form of fin fish and/or shelf fish in the region.

(c) To promote rural employment.

(d) To make aquaculture a strong medium not only for saving but also for earning foreign exchange.

One of the immediate objectives of the Centre is to train each year 40 senior aquaculturists from the participating countries. But only 36 trainees were recorded in the first year, 7 (27%) from Nigeria (Anon, 1980). The centre was availed of the entire facilities at the Buguma Brackishwater Fish Farm.

Aside from the FAO assisted project like this, the Government both at the State and Federal levels seemed to have made some attempts or proposals at establishing aquaculture as a means of fish production (Anon, 1974). Even though there are some demonstration fish farms at places like Panyam, Odeda, Oyo, Agodi (Ibadan), Maska, Bagauda, Wuya, Akure, Okigwe, Oluponna (Iwo) etc., the impact of aquaculture is yet to be felt in the country. Certainly, the annual fish production in the country is far below the demand. The shortage therefore, necessitated importation of fish: the value (₦) of stock fish and other fish and fish preparations imported increased from ₦7.3 million in 1974 to ₦38.5 million in 1975, ₦78.6 million in 1977 and ₦141.4 million in 1978 (Table 1). On the other hand, the total fish catch in the country is not increasing appreciably even though, there is some increase in the estimated number of fishing crafts and fishermen (Tables 2 & 3). This is an indication of fish stock depletion in the wild (increased fishing effort with no appreciable increased fish catch). This situation is already evident in the fishery of Lake Kainji (Otubusin, 1978; Ita, 1982). As expected, the population of Nigeria is on the increase (Table 4) signifying also an incrased demand for food. The crude oil production (the nation's major source of income) has steadily increased over the year from approximately 400 million barrels in 1970 to about 651 million in 1975 and approximately 842 million barrels in 1979 (Table 5). In 1982, Nigeria earned ₦8 billion from oil (Business Times, January 24, 1983). The effect of higher private consumption expenditure (PCE) therefore was expected to raise per capital·fish consumption demand (FCD) in Nigeria from 10.5 kg/annum in 1970 to 13.2 kg in 1980 and 14.4 kg in 1985 (Anon, 1974). Based on this scenario, what then could be the problems and/or constraints to modernization of aquaculture for increasing fish production in Nigeria?

CONSTRAINTS TO MODERN AQUACULTURE IN NIGERIA

(i) Manpower

The major constraint to aquaculture development in Nigeria is the serious shortage of competent trained personnel. However, aquaculture is both a science and art. Apart from the scientific basis, an aquaculturist depends on in his decision in the management strategies. his success is highly subject to his mastery of the art. Even though there is gradual proliferation/proposal of fish farms all over the country, without adequate trained manpower the projects may not be productive.

(ii) Funding

The National Development Plan of the country gives a degree of priority to Agriculture and food production related projects including aquaculture but the eventual release of funds could be problematic or not forth-coming. The project soon become grounded and cannot be carried out to fruition. Pond culture for example, often requires high capital input for pond engineering and construction especially for large scale commercial fishculture. Banking institution on the other hand, are very reluctant to fund aquaculture projects because they doubt the profitability of the venture.

(iii) Lack of Knowledge on the Profitability Of Aquaculture Industry

Since aquaculture is not yet established as an industry in Nigeria, many private enterpreneurs who could have invested heavily in the ventrue are very hesitant. The Government institutions likewise are doubtful of fully funding the project for lack of data to prove the profitability of aquaculture.

(iv) Insufficient Data on Aquaculture Production and Management Techniques

The lack of experimental approach to aquaculture projects in Nigeria is quite evident in the paucity of literature on aquaculture in the country even though 'modern' aquaculture was reported to have begun in Nigeria since four decades ago. Ita (1980) also noted this set back in aquaculture development in Nigeria.

(v) Inadequate Data Base on the Biology and Ecology of Candidate Aquaculture Species Endemic In Nigerian Waters

Whereas the vast bodies of water (total drainage area excluding Lake Kainji, 275,000 km^2) in Nigeria contain over 100 endemic fish species which could perform very well in aquaculture production, not much is known about their aquaculture potentials. For example, the techniques for mass fingerling production of the catfish *Chrysichthys nigrodigitatus* 'Obokun' are yet to be achieved. The lack of knowledge on the fish to becultured, therefore, makes the aquaculture planning, management and development unrealistic.

(vi) Lack of Rational Aquaculture Development Planning

Lack ofrational planning is one of the major set backs to orderly development of aquaculture industry and leads to non-fruition of the projects. On the other hand, in the planning stage of aquaculture projects, indigenous trained aquaculturists are not fully involved. For instance, an aquaculture planning committee made up basically of non-fisheries or related personnel is bound to be faulty in its planning.

(vii) Non Recognition of Indigenous Trained Aquaculture Personnel

Often than not, serious doubts have existed in some quarters (especially in developed countries) on the ability of developing countries to produce enough food (also fish) to keep pace with rising population and economic demand. Even though the Nigerian is a competent and trained aquaculture personnel, expatriate fish culturist (called an 'expert' but may not be as competent) is preferred by the Nigerian labour employer. It should be realized that the Nigerian fish culturist owes more to his country at least by virtue of being a bona fide and also a bumper harvest of fish from Nigerian pond etc., will be progress and better life for him and the community (who were taxed to train him).

RECOMMENDATIONS

For increased fish production using modern aquacultural practices, all these constraints and all other unlisted set backs and problems to aquaculture in Nigeria must be seriously tackled.

(i) Manpower

More aquaculture personnel at both degree and non-degree levels must be trained. It should be noted that aquacultural practices embrace: Marine Biology, Water Chemistry, Oceanography, Fish Nutrition, Fish Pond engineering, Hatchery Management, Economics, Sociology, Genetics and various sciences and Humanities. The production of degree, diploma and certificate holders in Natural Sciences and Agricultural Studies by Nigerian Universities is not adequate (Table 6). Apart from training more of higher cadre Aquaculture personnel abroad, more middle and low cadre personnel should be trained locally. Nigerian Agricultural institutions should therefore, be expanded to train these highly needed manpower. At least six Nigerian Universities should establish College (or Department) of Fisheries which could be attached to the existing Faculties of Agriculture. Applied fisheries is recommended for inclusion in the curriculum of primary and post primary institutions to animate them with the roles and potentials of aquaculture. Along side with this, every school farm should integrate aquculture with their agricultural projects.

Established Department of Fisheries and other fisheries institutions (e.g. Federal Freshwater Fisheries School, Federal Fisheries School, NIOMR etc) should collaborate with River Basin Development Authority in their localities for aquaculture teaching and practical needs. This collaboration will go a long way in optimal utilization of human and material resources.

National Youth Service Corps members who are graduates of Natural Science, Agriculture or related fishery sciences should be attracted to aquaculture project and given proper orientation at any of the collaborated Fisheries Institutions for a few weeks, then given on the job exposure at aquaculture projects sites. On completion of his National Service he should be absorbed and made to render services to the aquaculture project for about one year before he is sent to an aquaculture institution for further training. This is recommended to be a continuous exercise.

Interested school certificate holders should also be attracted to the aquaculture projects and trained to fill the manpower needs as appropriate.

These trained personnel will eventually fill the different cadres of and at the same time serve in the subsequent aquaculture training, research, development and extension projects.

(ii) Fund

With more trained manpower, aquacultural practices will be more productive at least the profitability will be more evident when data and other economic information are produced. Banking institutions can then be convinced about the profitability of the venture. Government participation however, should come first and foremost in form of funds to aquaculture projects. In the case of pond culture, it should be realized that cost of pond construction alone constitutes more than 50% of the total production cost, therefore, any loan given may not be amortized until after some years of operation.

Homestead ponds can be constructed for families or communities more or less free of charge by the government and then managed by the group concerned.

(iii) On Profitability of the Industry

Full government and institutional participation as recommended above would have gone some way to yield the needed results to the aquaculture industry.

(iv) Data on Aquaculture Production and Management Techniques

With trained aquaculture personnel (fish nutritionist, water chemistry, Hatchery Management, Pond Management, Aquaculture Economist etc) and all other factors for aquaculture production and management, more orderly and planned development of aquaculture can be achieved producing the needed data which will serve as guide lines for further development of the industry.

(v) Indigenous Trained Aquaculture Personnel

Nigerian aquaculture personnel should be challenged by being given the responsibility to research on and develop the aquaculture of this country. Even though collaboration with foreign aquaculture personnel should be encouraged for exchange of technical know-hows, the onus will lie on the Nigerian aquaculturist if more fish cannot be produced using our vast water resources.

(vi) Data Base On Biology and Ecological Requirements of Endemic Fish Species

Some amount of work have been done on the biology and ecology of Nigerian fish species but more studies need to be done specifically on how such fish species can be exploited for aquaculture production. Such studies should normally include the distribution, abundance, seasonality, growth rate, fecundity, hardiness, and all other parameters that are pointers to acceptance of the fish species for cultural purposes.

(vii) Rational Aquaculture Development Planning

With specialists trained in all facets of Aquaculture, it will become evident that with the assistance of the qualified specialists the Government will be able to draw up workable plans for aquaculture development. The plans will be such that show the concrete objectives to be achieved and the right procedures to be followed.

CONCLUSION

It is the view of the author that serious shortage of competent trained aquaculture personnel is the main constraint amongst others to aquaculture development in Nigeria.

Many trained and experienced aquaculture personnel abound in most Asian countries where fish culture started as a tradition. Currently, the region (Asia) produced 80% of the world's total of 6 million tons through aquaculture (Wagel, 1977). Other main Asian countries that contribute significantly to world fish production through aquaculture are Japan, Indonesia and the Philippines. A very large proportion of the fin fish production (75%) is from freshwater ponds, lakes and reservoirs. The total drainage area of the rivers and ponds (except Lake Kainji) in Nigeria is 275,000 km² (27.5 million hectare), added to this is the vast coastal brackish-water neglected swamp land. A judicious exploitation of all these available water bodies in aquacultural practices (pond culture, integrated aquaculture, pen and cage culture, raceways, aquatic ranching etc) will surely contribute immensely to increased fish production in Nigeria.

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Table 1 - Imports of stockfish and other types of fish, 1974-78

Commodity	Values (₦ millions)				
	1974	1975	1976	1977	1978
Stockfish	2.1	24.3	39.3	13.9	19.5
Other fish and fish preparations	5.2	14.2	37.3	64.7	121.9
Total	7.3	38.5	76.6	78.6	141.4

Source: Review of External Trade, Nigeria, 1978. Federal Office of Statistics, Lagos, Nigeria.

Table 2 - Annual fish catch by weight (tons) in Nigeria

Year	1971	1972	1973	1974	1975	1976	1977	1978	1979
Catch (tons)	409,537	437,971	465,126	473,220	466,236	494,766	504,014	518,567	535.435

Source: Federal Department of Fisheries, Nigeria

Table 3 - Estimated number of fishing crafts and fishermen

Year	Inshore Trawlers		Artisanal Canoes		Fishermen	
	Fishing	Shrimping	Powered	Non-Powered	Full-time	Part-time
1971	13	26	4,204	90,923	n.a.	n.a.
1972	26	29	5,364	90,523	n.a.	n.a.
1973	27	30	6,224	91,732	247,806	106,133
1974	33	39	7,850	10,032	269,354	115,363
1975	33	30	8,240	20,381	279,413	119,670
1976	30	29	11,704	122,633	289,682	124,140
1977	43	36	12,187	125,256	297,317	127,421
1978	38	49	10,118	128,129	293,309	121,989
1979	44	49	12,510	121,218	312,306	133,846

Source: Federal Department of Fisheries, Nigeria

Table 4 - Estimated population of Nigeria

Year	Thousand
1963	55,670
1970	66,331
1971	68,003
1972	69,732
1973	71,484
1974	73,308
1975	75,139
1976	77,152
1977	79,010
1978	80,991
1979	83,020
1980	87,002
1981	89,612
1982	92,303
1983	95,071
1984	97,923
1985	100,860

Source:- National Population Bureau and Anon, 1974.

Note: 1963 Estimates are derived from the census taken at that date. Subsequent years figures are projections by the National Population Bureau.

Table 5 - Production of crude oil

Year	Production
1970	395,835,689
1971	558,678,882
1972	643,206,685
1973	750,593,415
1974	823,317,838
1975	651,506,761
1976	758,058,380
1977	765,937,709
1978	692,269,121
1979	841,634,055

Source:- Nigerian National Petroleum Company

Note: + July to December 1977.

Table 6 - Degree awards by Nigerian Universities at first degree, post-graduate, diploma and cetificate levels in Natural Science and Agricultural studies

Type of Course	1971	1972	1973	1974	1975	1976	1977
Natural Science							
1st Degree	448 (18)	416 (15)	525 (16)	620 (18)	685 (15)	621 (13)	800 (13)
Post-Graduate	20 (11)	26 (15)	23 (10)	21 (9)	6 (2)	4 (2)	7 (6)
Diploma & Certificate	-	26 (15)	-	-	-	21 (2)	5 (0.5)
Agric. Studies							
1st Degree	128 (5)	260 (8)	214 (7)	285 (8)	326 (8)	421 (9)	326 (5)
Post-Graduate	29 (22)	4 (2)	9 (4)	8 (4)	6 (2)	43 (18)	7 (6)
Diploma & Certificate	2 (0.5)	4 (2)	1 (0.2)	2 (0.3)	25 (2)	24 (2)	7 (0.7)

( ) - In brackets are corresponding percent of total awards of all Universities courses e.g. in 1971, 18% of all 1st degree awards by Nigerian Universities was in Natural Science.

Source: National Universities Commission