FISHES, MAN AND THE AQUATIC ENVIRONMENT

By

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INTRODUCTION

It is my pleasant duty and honour to address this gathering on this occasion in the series of the University of Lagos Inaugural Lectures. In many universities all over the world, inaugural lectures are organised to formalise the commencement of a Professorial Career. The first Inaugural Lecture in Zoology at the University of Lagos was give in 1971 by Professor C.I.O. Olaniyan and entitled *Animals and Men.* My lecture today is in fact the second Inaugural Lecture by a Professor of Zoology in the University of Lagos. I am very grateful to the University for the opportunity given me to deliver this Inaugural Lecture. I regard it as a forum to to discuss my discipline, elaborate on my contribution to knowledge in this field and largely justify the creation of a Professorial Chair for me in my area of specialisation.

MY DISCIPLINE

My discipline is Fisheries Science with specialisation in Fisheries Biology and Marine Ecology. This is a discipline of unique importance to the University of Lagos. Indeed taking full advantage of its location by the sea, lagoon and river, the University of Lagos is one of the very rare institutions in the world suitable for the development of programmes in Marine Ecology and Fisheries. The University of Lagos crest shows fishes swimming in the aquatic environment. Fisheries and Marine Ecology, therefore, occupy the pride of place among disciplines studied in Lagos.

Fig. 1: The Crest of the University of Lagos

Fisheries Science as a discipline requires a thorough grounding in Chemistry, Biology and Mathematics. The areas of specialisation in the discipline include Fisheries Management, Aquatic Biology, Marine Pollution, Fish Taxonomy, Fisheries Statistics, Fish Diseases, Limnology, Biological Oceanography, Fish Processing and Marketing, Fish Technology, Aquaculture, Fisheries Economics, Fisheries Law and Fish Population Dynamics.

My entrance into Fisheries Science was purely accidential. Just a month or two before graduation from the then University College, Ibadan, I met Dr. Jerry Kukucz, the Project Leader of the United Nations/FAO Project that was carrying out a survey of the fisheries of the then Western Region of Nigeria. After a short chat, he invited me to join his team as the Nigerian counterpart to the FAO Marine Biologist with the promise of a two-year overseas training at the College of Fisheries, University of Washington, Seattle. That was the beginning of my scientific career in the Fisheries. I hope at the end of this lecture today I would have gained a few more disciples to our small but fast growing family of Fisheries Scientists. Whatmore I hope you would leave this assembly and grow your own fish thereby contributing towards solving the problem of insufficiency in fish production in Nigeria.

FISHES AND MAN

What fishes are

Fishes are aquatic, cold-blooded animals, typically possessing backbones, gills and fins. Obviously not included in this definition are aquatic mammals such as whales, seals and manatees; or reptiles such as the aquatic turtles. Fishes are the most numerous of the vertebrates forming about 4.26 percent of the composition of recent vertebrates. Best estimates show that they comprise as many as 20,000 species, although guesses range as high as 40,000 species.

Fishes occur in many different shapes, sizes and colours. There are the pygmies such as the American half-beak, *Hemirhamphus marginatus* which matures sexually at a length of 2.5cm and a dwarf pygmy goby, *Mistichthys* sp from the Philippines which reproduces at sizes less than 1.5cm. There are giants too amongst fishes. The largest living shark, called the whale shark, *Rhincodon typus* attains a length nearly 23.3m and weights of 25 tons or more. There is also the basking shark, *Cetorhinus maximus* which grows to a length of 13.3m. Both of these species are harmless to man, as are in fact most cartilaginous fishes. Sharks may attack and even kill human beings in self defence but do normally feed on them. The food items of sharks consist chiefly of crustaceans, squids and fishes.

Fish as ancestors to man

Fishes evolved in the Devonian Era some 350 million years ago. According to evolutionary theory, which is based on evidence from several sources including fossils, genetics, embryology and comparative anatomy, fishes have a distant place in the ancestry of man. Without this linkage with the fish, man might never have evolved. As reported by Lagler et al (1963) many features of life ways and structure of man originated in fish ancestors. Encompassed are the ground plans and basic functions of the ten organ systems, including such striking features as sight, internal fertilisation, intrauterine nourishment, live birth, and presumably, learning and memory.

In particular, the class of fishes known as Choanichthyes gave us a clue to the evolution of the amphibians and other tetrapods. The Choanichthyes occurred some 300 million years ago and were thought to be extinct. But in 1939, a life specimen was caught off the coast of South Africa. Eleven more specimens have since been caught between the island of Malagasy and East Africa. These are referred to the genus *Latimeria.* In this fish, the paired fins have a central axis with radii on the sides. This type of fin is referred to as Lobate Archiptergium. It is believed that the pentadactyl limbs of the tetrapods including very close relations of man are derived from this type of fin. Some of the fossils also show the nostrils opening directly into the mouth cavity, "choana". Because of these two features, the Choanichthyes were thought to be the ancestors of tetrapods including man.

THE HABITAT OF THE FISH

According to Nikolsky (1963) of the earth's total surface, which comprises approximately 510 million sq km, about 364 million, or 71 per cent is occupied by the surfaces of oceans, seas, lagoons, and other inland water-bodies. The greatest known oceanic depth is about 11,000m. The areas of the oceans with depths greater than 3,000m occupies 51 – 58 per cent of the total sea surface. Such are the dimensions of the habitat in which fishes are distributed. Indeed such a wide expance of water is highway communications medium, nursery, school, playground, drink, toilet, birth place and grave for a fish. The physical and chemical properties of the water which are very important to the fish are dissolved oxygen, temperature, light penetration, salinity and toxic substances. Like man and other animals, fishes are faced with an array of diseases in their habitat. Such diseases include cancer, rickets, blindness, liver disorders and a host of developmental anomalies such as the birth of Siamese twins. Above all, whether they reside in the sea, lagoon or river, fishes suffer the heaviest mortality from man through fishing.

SIGNIFICANCE OF FISHES IN THE LIFE OF MAN

The total world catch of fish for 1986 is put at 91.5 metric tonnes (FAO 1988). Japan is the greatest fish-producing country, catching about 15.3 per cent of the world production. She is closely followed by Peru. Other world major producers of fish are China, Soviet Union and the United States. Fish serves as a major food to man providing a very suitable source of protein. Indeed fish contributes about 10 per cent of the total animal protein intake of man. The world average consumption of fish per head is about 7.5kg per year. The highest average consumption of between 25 – 35kg per year is recorded for Iceland, Portugal, Japan and Norway. The average consumption for the developing countries is very much below average.

Fish is also a good source of essential vitamins such as Vitamin A, B1, B12, D, E and K. Fish fats as a whole show a higher vitamin level than those of terrestrial animals — this is particularly true of liver oils. In areas with excess fish production, appreciable quantities of the fish are converted into fish meals which are important in the fertiliser and pet-food industries. Sharkskin leather is of commercial importance in the manufacture of shoes and hand bags and as cover for jewellery boxes. Shark-liver oil is used in the tannery industry for leather. Some fishes like *Tilapia* also feed on mosquito larvae and can thus help in the control of malaria fever. In recent years, fishes have been used as experimental animals in the fields of genetics, embryology and animal behaviour.

FISHERIES MANAGEMENT

With increasing world population, there is the need for the management of the fisheries to obtain the maximum sustainable yield. The simplest situation in fisheries management is of a stock of a single species of fish, which does not compete with, eat or form the food of a stock of any other commercially exploited species. The dynamics of such a stock as reported by Tesch (1978) are most simply described by the classic law of population growth which states that at each level of population abundance there is a certain unique natural rate of increase. If the catch taken is equal to this natural increase, the population will be sustained at that level. Transformed into a curve of catch against fishing effort, this relationship in its simplest mathematical form gives a parabola (Fig. 2). The maximum point in this curve precisely defines the maximum sustainable yield.

The attainment of the maximum sustainable yield is apparently a reasonable and definable objective of fisheries management, so that if the stock abundance is less than that corresponding to the maximum sustainable yield, it should be allowed to increase, i.e., less than the sustainable yield should be taken. Conversely, if the abundance is above this level, more than the sustainable yield should be taken.

The effect of exploitation on the fisheries resource by man may be favourable or adverse, depending on the degree to which it is carried. There could be underfishing or overfishing. Underfishing involves the wastage of potential fish stocks and the loss of opportunities to create wealth and enhance welfare. Overfishing, on the other hand, means a running loss on the fisheries resource that must be debited against succeeding generations, which may have a greater need of all food resources in order to maintain their standard of living. The term 'overfished' thus refers to "a state of lower productivity of the whole fishery, than would have existed if exploitation were properly organised" (Johnson, 1967).

Fisheries are managed by regulations through the following methods.

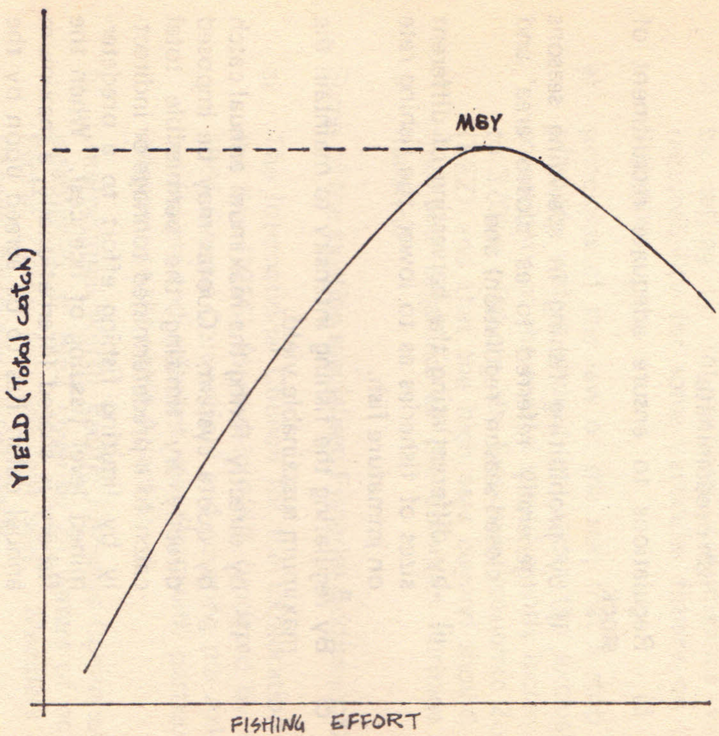

Fig. 2. Concept of Maximum Sustainable yeld (msy) in Fisheries

a) Protection of the size of fish so as to improve the stocks

   i) by mesh-size regulation;

   ii) by prohibiting and landing of fish below a specific size, and

   iii) by prohibiting fishing in areas where small fish predominate.

b) Regulations to ensure adequate recruitment of stock

   i) by prohibiting fishing in spawning seasons (generally referred to as 'closed area' and 'closed season' regulation) and

   ii) by differentiating the harvesting of different sizes of fisheries as to lower the fishing rate on immature fish.

c) By regulating the fishing intensity to maintain the maximum sustainable yield.

   i) by directly fixing the maximum annual catch by quota system. Quotas may be imposed directly by limiting the permissible total catch to a predetermined tonnage or indirectly by limiting fishing effort to a predetermined level (issuing of licences). When the fishery is shared internationally, a maximum annual catch has to be agreed upon by the participants. The national quota is therefore after distributed among all the exploiters.

   ii) by restricting fish gear and ancilliary equipment.

Mechanics of Management

Nations approach the problem of making fisheries management a reality in two ways:

i) by taking appropriate measures in seas off their shores over which they exercise sovereignty (territorial waters), and

ii) by setting up international commissions with responsibility for some particular fishery on the high seas.

a) principles of the law of the sea; that a strip of offshore waters should be under the exclusive sovereignty of the coastal state (recently increased to 320km offshore, the Exclusive Economic Zone (EEZ) and that the high seas beyond should be free and regarded as the common heritage of mankind.

Some of the existing specialised Fisheries Bodies include

a) The International Council for the Exploration of the Sea (ICES) formed in 1902 (updated by the 1964 Geneva Convention) and covering the Atlantic Ocean and adjacent seas (but with particular reference to the north Atlantic).

b) International North Pacific Fisheries Commission established in 1952 covering all waters of north Pacific Ocean and adjacent seas. Members are Canada, Japan and United States.

c) Regional Fisheries Commission for Western Africa (CECAF) established in 1961 as an FAO Regional Body, covering all inland waters and territorial seas of member countries and waters of south east Atlantic. Membership is open to all FAO members with territories in the region.

MY CONTRIBUTION TO FISHERIES BIOLOGY AND MARINE ECOLOGY

In the life of a fisheries scientist, the most beneficial and most rewarding is that part spent on the field collecting samples and making observations. My contributions to fisheries science are in the areas of ecology, age and growth, food and feeding habits, reproductive strategies and population dynamics of fishes. These are some of the areas intimately connected with the exploitation and rational management of a fishery. I later branched into Aquaculture as part of my post-doctoral research.

Research activites in the Lagoon

In Nigeria, an appreciable part of my research was carried out in the Lekki Lagoon. The Lekki Lagoon with a surface area of about 247 km^2 supports a major fishery. Prior to 1969 when I started work in the lagoon, little was known about the hydrobiology and fishes in the lagoon. I undertook a two-year investigation of the physico-chemical parameters and fish fauna of the lagoon. In the *FAO Report* (1969), it was suggested that the Nigerian government might usefully consider the possibility of dredging a new channel at the narrowest point across the present land strip between Lekki Lagoon and the Atlantic Ocean, in order to solve the problem of safe anchorage in the Western part of Nigeria. If such a project were to be undertaken, my study would represent a documentation of the present physico-chemical conditions and the fishes in the lagoon prior to any future development (Kusemiju, 1981).

For sampling purposes, the Lekki Lagoon was divided into six stations (Fig. 3). Fishing was done in each station by beam trawl. In all, 144 days-light and 37 night-time hauls were made in the lagoon. During each trip, data were collected on the air, surface, and bottom temperature; salinity, pH, oxygen content and water transparency. A total of 35 fish species were caught in the lagoon during the two years of survey. By number the catfish *Chrysichthys*

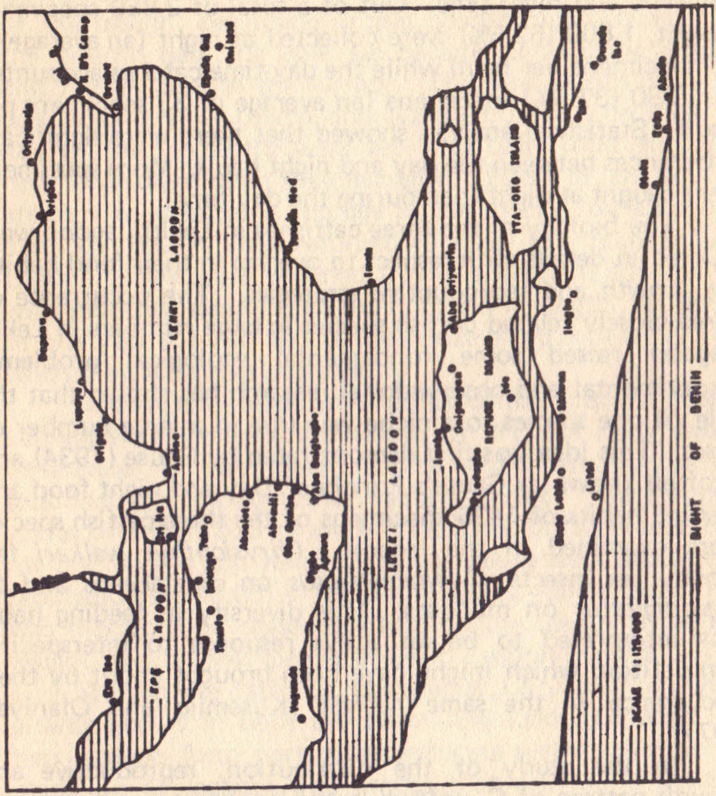

Fig. 3 Map of Lekki Lagoon and its Environs

filamentosus was the most abundant species in Lekki Lagoon accounting for 27.4 per cent of the total catch. Four other species, *Elops lacerta, Pellonula afzeliusi, Chrysichthys walkeri* and *Tilapia zilli* also occurred in large numbers and were caught in the lagoon throughout the year.

Day and night variations in the catch of fishes in the lagoon were studied. 33 hauls each were made during both day-time and night-time. Out of a total of 2,880 specimens caught, 1,800 (62.5%) were collected at night (an average of 55 specimens per haul) while the day-time catches accounted for1,080 (37.5%) specimens (an average of 33 specimens per haul). Statistical analysis showed that there were significant differences between the day and night hauls. More specimens were caught at night than during the day time.

The biology of the three catfishes in Lekki Lagoon were studied in details with respect to overlap in their food habits, age, growth and reproductive strategies. The occurrence of three closely related catfish species in large numbers in Lekki Lagoon raised some fundamental ecological problems. Experimental and observational research has shown that the rule of one species to a niche was true in a large number of cases. This idea was first demonstrated by Gause (1934) and is often known as Gause's Principle. Day and night food and feeding habits of 1436 specimens of the three catfish species were examined in the lagoon. *Chrysichthys walkeri* fed mostly on insects, *C. filamentosus* on crustaceans and *C. nigrodigitatus* on molluscs. This diversity in feeding habit was interpreted to be an active response to interspecific competition which might have been brought about by their occurrence in the same habitat (Kusemiju and Olaniyan 1977).

In the study of the distribution, reproductive and growth pattern of *C. walkeri* in the lagoon, it was discovered that the two other catfishes species in the lagoon migrated into Oshun and Oni Rivers to reproduce. The spawning behaviour of *C. walkeri* however was problematic and solution was not found to it for two years of investigation. A fisherman who had fished for over thirty years in the lagoon finally gave a clue. A trap made of bamboo poles was set about one metre below the water surface for the the trap, eggs were shed and immediately fertilised by sperms spawning couple. About 2 a.m. the gravid couple entered from the male. The day-old cluster of eggs were collected from the trap and incubated in the laboratory. The aquarium water temperature during the incubation period ranged from 20 – 30°C (which corresponded to bottom water temperature of 23.3 – 30.0°C of the lagoon where the catfish spawns in nature). The eggs hatched on the third day and the larvae, with heavy yolk sacs, accumulated on the bottom of the trough remaining in that position for two days. By the seventh day, the yolk sac became completely absorbed and the fry rose to the surface. The total length of the fry was from 0.81 – 0.9cm and averaged 0.86cm on their first day of life. The fry were fed with baby food during the first three days when they averaged 1.22cm in length. In an attempt to determine the age of the species (by known age method), the fry were returned to a fish apartment in Lekki Lagoon. They were retained in the apartment for one year with monthly sampling of their growth in length. At the end of one year the fish had a mean size of 15.6cm and 23.6cm when they were two years old.

To compare the growth pattern of this species under the varying environmental conditions of dry and rainy seasons, differences in the mean lengths and mean weights were examined on the computer using a t–test. The computed values of t with 373 df were 0.1123 and 0.0131 respectively for the lengths and weights. These values were less than the tabulated t_{375} (0.05) = 1.980 – 1.960 (2–tailed test). There was therefore no seasonal effect on the length growth and weight gain for this species in Lekki Lagoon (Kusemiju 1976)

Still on the catfishes, the species, *Chrysichthys nigrodogitatus* occurs in both the Lagos and Lekki Lagoons. The two lagoons form part of an intricate system of waterways made up of lagoons and creeks that are found along the coast of Nigeria from the Benin Republic border to the Niger Delta. They are connected to the Gulf of Guinea via the Lagos Harbour. A racial study was carried out on the catfish, *C. nigrodigitatus* from both lagoons using meristic and morphometric characters to determine variations between the two populations and how far these might have been affected by ecological factors. The fish samples were collected from both lagoons with an interval of three days

The meristic characters used were number of dorsal, pectoral, pelvic and anal rays, and number of left and right gill rakers. The morphometric characters used were standard lengths and head lengths. For the analysis of the counts, the conventional chi square test of homogeneity was employed on the meristic characters, while a t–test was also carried out on the left and right gill rakers. In evaluating the significance of differences in head length and standard length, the methods of regression analysis, a t–test and analysis of variance were employed.

There were no differences between the dorsal, pectoral and pelvic rays of *C. nigrodigitatus* from both Lagos and Lekki Lagoons, and no significant statistical difference with reference to the anal ray counts, but significant difference on basis of left and right gill raker counts. The numbers of anal-rays were fewer while the gill rakers were higher in Lagos Lagoon compared with Lekki Lagoon population. There was thus an inverse relationship in number of gill rakers and anal rays in both localities.

The difference in gill raker counts might have occurred as a result of environmental fluctuations. The salinity of Lagos Lagoon in the area where the samples were collected ranged from 0.5°/oo to 15°/oo. Bottom water temperature ranged from 24.6° to 31.8°C. Salinity conditions in Lekki Lagoon during the study however ranged from o.04 to 0.3°/oo while the bottom water temperature ranged from 22.7° to 29.8°C. Lagos and Lekki Lagoons differ in their salinity gradients. Hence the difference in gill ranker counts of *C. nigrodigitatus* may have occurred as a result of isolation caused by differences in salinity gradients in the two lagoons. The difference observed in the number of gill rakers may mark the beginning of differentiation between the brackish water and freshwater populations of this species which in future may call for different management strategies of the catfish fishery in both lagoons (Kusemiju, 1975).

Further major contributions was on the age and growth determination in the catfish, *Chrysichthys nigrodigitatus* by use of the dorsal spine. It has long been claimed in fisheries literature that the conventional methods for age determination are often difficult for tropical fishes. This notwithstanding, Bayagbona (1968) used the otolith method to age the croaker, *Pseudotolithus typus,* while Fagade and Olaniyan (1972) applied the length-frequency method to age *Ethmalosa fimbriata* in the Lagos Lagoon. In the work published jointly with Ezenwa, we used the annual rings on the first dorsal spine apparently for the first time in fisheries biology in ageing the catfish, *C. nigrodigitatus* (Ezenwa and Kusemiju 1981). From back-calculations it was found that the mean total length of the species in the Lagos Lagoon when the first annulus was formed was 18.5cm, 32.6cm for second annulus, 43.5cm for the third annulus and 53.9cm for the fourth annulus. It was also shown that this species in Lagos Lagoon attained the age of four years.

Before leaving the catfishes alone, I wish to recall that based on this research findings and other data collected from Lekki Lagoon, I proposed since 1974 a pilot scheme which initially would yield about 200 metric tonnes of sizeable catfishes. The commercial feasibility of introducing catfish farming into similar water bodies in Nigeria was also documented. The implementation of the suggested schemes would have no doubt made a significant impact on the development of the fishing industry in Nigeria. Unfortunately like most research findings in Nigeria, my ideas are still tucked away in the library.

The biology of the clupeid, *Pellonula afzeliusi* in the Lagos and Lekki Lagoon were also studied. The clupeid, *Pellonula* is a new fishery resource in major rivers and man-made lakes in Nigeria. Otobo and Imevbore (1979) estimated the potential worth of this species in Kainji Lake, Nigeria at over 3,000 metric tonnes. Aspects of the biology of this species have also been studied in Volta Lake, Ghana by Reynolds (1969, 1970) and Vanderpuye (1971). In spite of the abundant biological data on this species from man-made lakes, comparative data from the lagoons was lacking. Thus we undertook studies on *Pellonula* in Lagos and Lekki Lagoons with particular reference to the growth, reproductive strategies, and food and feeding habits, as a complement to the already existing information on the biology of this new fishery resource in West Africa (Kusemiju and Awobamise, 1983, Kusemiju et al, 1983). I shall highlight one curious aspect of fish behaviour, indeed animal behaviour from the results. Unlike what was reported for *Pellonula* from Kainji and Volta Lakes, this species did not feed on fish in Lekki Lagoon. It was the only pelagic fish occurring in the lagoon and it refused to eat its own young ones. In Lagos Lagoon, it fed on young of another clupeid, *Ethmalosa fimbriata* but did not eat its own young ones. The substitution of another pelagic fish for its own juveniles was remarkable and stress the opportunistic element in the feeding habbit of this species.

Research activities in the sea

My research activities in the marine environment have centred mainly on trends in the Nigerian trawl and shrimp fishery. I shall highlight part of my contribution to shrimp biology. The shrimps belonging to the family *Penaeidae* is made up of three species in Nigerian waters. *Parapenaopsis atlantica* is found in shallow waters below 25m depth. The pink shrimp, *Penaeus duorarum (notialis)* is found from 25 – 55m while the third species, *Parapenaeus longirostris* is found in the deep waters beyond 55m. The ecological implication of this pattern of distribution is obvious. My research centred on the bionomics and distribution of the commercial pink shrimp. The main objective was to assemble information concerning the ecology, the early stages in the life-history and other biological facts concerning the pink shrimp and to relate such information to the productivity and the stability of the shrimp fishery.

With the expansion of frozen shrimp exports from Nigeria, the need for locating grounds where bigger sizes of shrimps are available and determine the time of the occurrence has become a necessity. A detailed study was carried out on the monthly variation in abundance as well as size-depth distribution of the shrimp off the coast of Lagos. The shirimp population off Lagos coast has the extensive Lagos Lagoon as its nursery ground.

Longhurst (1965) reported the occurrence of the pink shrimp mainly offshore in 27 – 55m depth. Preliminary trips conducted during this study confirmed this range in distribution and sampling was therefore confined to 25 – 55m. Two continuous trips were made each month sampling at the 5m intervals between 25 – 55m depth. This plan was carried out for the twelve months of the year and the hauls were limited to one hour instead of the usual three hours made by the commercial fishermen. In all 52 hauls were made.

The monthly index of abundance for the pink shrimps is shown in Fig. 4. The average catch of shrimps per one hour haul varied from 3.6 – 19.6kg. The lowest catch was recorded in March and the highest in December. In general, the best catches were obtained in July, and during December and January. The pink shrimp occurred mostly between 25 – 55m, the best catches were however made in the dry months at depths of 40 – 55m. The size composition varied

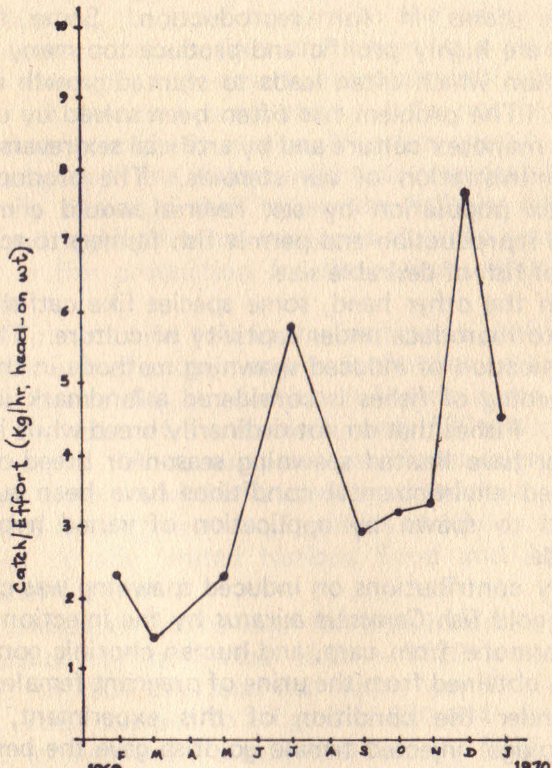

Fig. 4. Monthly Variation in abundance of Pink Shrimp, *Penaeus duorarum* off Lagos coast.

considerably from month to month even in the same depth zone. There was no clear-cut relationship between average size of shrimp and depth of water. Bayagbona et all (1971) noted the same lack of clear-cut pattern in size composition and depths for the shrimp population of the Niger Delta. This conclusion showed dissimilarity from that recorded for *Penaeus duorarum* off the coast of Mexico by Iversen et al (1960) and is a pointer on how biological investigations can be explored to increase fish production (Kusemiju, 1975)

Research studies in aquaculture

One of the major constraints facing fish culture or aquaculture is inadequate supply of fish fingerlings. There are extreme cases in fish reproduction. Some fishes like *Tilapia* are highly prolific and produce too many offsprings a situation which often leads to stunted growth of the offsprings. The problem has often been solved by use of predators, monosex culture and by artificial sex reversal through the administration of sex steroids. The production of a monosex population by sex reversal would eliminate unwanted reproduction and permit fish farmers to achieve high yields of fish of desirable size.

On the other hand, some species like catfishes simply refuse to reproduce under captivity or culture. The successful application of induced spawning methods in the controlled breeding of fishes is considered a landmark in fisheries science. Fishes that do not ordinarily breed while in confinement or have limited spawning season or breed only under restricted environmental conditions have been successfully induced to spawn by application of varied hypohysation methods.

My contributions on induced spawning was carried out on the gold fish *Carassius auratus* by the injection of pituaitary hormone from carp, and human chorinic gonadotropin (HCH), obtained from the urine of pregnant females.

Under the condition of this experiment, the HCG (full dosage) injected female goldfish gave the best result – complete ovulation with spawning and successful fertilisation and incubation. The eggs of the goldfish hatched in 48 hours at a water temperature of 25 – 25.6°C. From the second day of life, the fry were fed several times a day with boiled egg yolk and baby fish food. The fry averaged 6.5mm in length on the seventh day after hatching. The results so obtained will be useful in the propagation from spawning to successful rearing of fish fry (Kusemiju and Bowman, 1982).

FISHERIES SITUATION IN NIGERIA

As the vast and constantly increasing population of human beings on earth requires greater and greater quantities of food, and as the food production on land becomes limited in scope, man must turn to the sea and other water bodies for survival.

In Nigeria, the need to turn to the resources of the waters becomes more serious and urgent as a result of the Sahelian drought and desert encroachment which have affected our livestock production. I do not hesitate to predict that in order to survive, Nigerians must turn to the living resources of the waters within the next decade. In this part of my lecture, I shall review the fisheries situation in Nigeria and highlight some strategies that can result in self-reliance in fish production for the nation within the next five years.

Fish plays a vital role in the ntrition of Nigerians. It is a principal animal protein source in the diet. As important as fish is in the diet, production in Nigeria is not sufficient to meet the needs of the nation's nearly 100 million people. The per capita fish consumption at present is estimated at 9.0kg per annum and this is considered too low when compared with the ntritional requirements of 19.0kg per annum stipulated by the United Nations Food and Agricultural Organisation (FAO).

A breakdown of the total fish production in Nigeria for ten years during the period 1980 – 1989 is presented in Table 1. In 1980, the total fish supply was 597,342 metric tonnes. This increased to a figure of 920,484 metric tonnes in 1982 followed by a steady decline. By 1985, the total fish supply had dropped to a very low figure of 304,229 metric tonnes. The figures increased to 676,693 metric

TABLE I

NIGERIAN FISH PRODUCTION 1980 – 89
(IN METRIC TONNES)

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
TOTAL	597,342	669,163	920,484	694,380	553,926	304,229	372,301	498,150	463,540	676,693
SHRIMPS	1,964	2,541	1,513	5,294	2,658	2,376	2,623	3,517	2,868	5,234

Source: Federal Department of Fisheries (1990) tonnes in 1989. The estimated fish demand for the nearly 100 million population is 1.90 million metric tonnes. There is thus a deficit of nearly 1.22 million metric tonnest of fish needed by Nigeria to satisfy the nutritional requirements of her people. The catch of shrimps, a major source of foreign exchange has increased steadily reaching a figure of 5,234 metric tonnes in 1989.

Statistical analysis of Nigerian fish and shrimp production in terms of catch per unit effort however shows our fisheries in a state of near disaster. In the period 1980 – 82 when the number of fishing trawlers operating in Nigerian inshore waters was 80 – 86, the catch per trawler averaged 6,000 metric tonnes. There has been a steady decline in catch per trawler reaching the very low level of about 800 metric tonnes per trawler in 1989 when 440 licensed trawlers operated in Nigerian waters. If these trawlers must operate at a profit margin, the consumers must bear the brunt of their operation. You can now appreciate why the price of fish has gone up by 600 per cent over what it was four or five years ago. The typical landing of this sector is shown in Table 2 and is seen to be made up of small-sized croakers, a situation which represents an increase in landed tonnage but a running loss on our marine resources. A situation where mainly small-sized fishes are landed is a pointer to overfishing and requires immediate remedy to avoid total collapse of the fishery.

Analysis of the shrimp fishery presents an equally pathetic picture. 282 shrimp trawlers fished in Nigerian waters in 1989 compared with 39 shrimp trawlers in 1983. The catch per vessel decreased from 130 metric tonnes in 1983 to 18.6 metric tonnes in 1989. The shrimps are exported and the only thing probably keeping the shrimp vessels in operation is the dollar value of the Nigerian shrimps. The shrimp landings are so low to make one suspect that the boat owners might be falsifying their catch returns to the Federal Department of Fisheries. Catch per unit effort based on the performance of vessels owned by the Federal Department of Fisheries and the Nigerian Institute of Oceanography and Marine Research will be a better index for assessing the Nigerian shrimp population. The rush into the fisheries sector must be controlled, otherwise, there will be a complete collapse of the Nigerian trawl fishery within the next two or three years. A reasonable approach will be to control the fishing effort through the number of trawlers licensed to fish using the quota system. The mesh-size regulation must also be strictly enforced to allow the young fish to mature and reproduce. For additional increase

TABLE 2

ACTUAL LANDINGS OF A TRAWLER IN A LAGOS PORT (JANUARY – FEBRUARY 1986)

Species	Total Landing (KG)	Percentage
Small Croakers	4,970	69.4
Medium Croakers	65	0.9
Large Croakers	0	0
Small Shiny Nose	0	0
Medium/Large Shiny Nose	0	0
Small Sole	104	1.5
Medium Sole	50	0.7
Large Sole	0	0
Catfish	232	3.2
Ray	311	4.3
Skate/Shark	0	0
Medium Grunter	43	0.6
Large Grunter	0	0
Small Barracuda	0	0
Medium/Large Barracuda	0	0
Bonga	74	1.0
Miscellaneous	441	6.2
Small Shfimps	876	12.2
Large Shrimps	0	0
Lobsters	0	0
	7,166	100.0

in fish production from the marine sector, attention must be directed towards the expansion of the artisanal coastal fisheries (canoe fishery) and the distant water fishery (for Sardinella and tuna fishing). The gear used for fishing by the canoe fishery is highly selective towards the large specimen. The fishing operations thus allow for proper conservation of the fisheries resources in this sector. The main bottleneck to production in the distant water fishery is provision of capital. This can be achieved by enterprising Nigerian businessmen going into partnership ventures with Japanese or Korean boat owners.

Aquaculture

Apart from the resources from the sea, fish farming offers the greatest opportunity for mass production of fish for Nigerians. The risks are less than in the marine sector. I therefore suggest the mass mobilisation of various bodies – private sector, local government areas (LGA), River Basin Development Authorities, Universities, schools and colleges and individuals into fish farming or aquaculture. Interestingly, some large companies including oil companies have gone into agriculture-farming. Such companies should go into fish farming too. In Cote d'Ivoire, Shell has successfully established high yield fish farm projects. Over a million hectares of brackish water suitable for fish culture are available in areas where major oil companies operate in Nigeria. If only 10,000 ha of these are utilised for brackish water fish culture, about 40,000 metric tonnes of fish will be produced.

Each local government in the country should establish a fish farm project of at least 20 ha. Assuming a total of 500 LGAs embark on such a project and producing four tonnes per hectare per annum from two croppings, a total of 40,000 metric tonnes of fish will be produced at the local government level. Reservoir Authorities should be made to stock fish into their reservoirs. With an envisaged 0.25 million hectares of reservoirs all over the country and producing 200 kg per hectare per annum, it is possible with adequate stocking and management to obtain 50,000 metric tonnes of fish per annum. Nigerian universities can make useful contribution to increased food production in the country by setting up fish farm projects to feed the university community and their environs. Fish farming is a viable project and should readily attract loans from commercial banks. Fisheries Research Institutes and Departments should set up experimental and demonstration fish farms that can easily yield fish and revenue. Just as schools take to farming, they should also go fish farming. If the call to go fish farming is heeded by institutions of higher learning, schools and colleges, an additional 50,000 metric tonnes of fish can be produced from this source. Individuals should also grow their own fish either at the backyard or in tanks in their homes. You can grow fish just as you grow vegetables and other crops.

ENVIRONMENTAL ISSUES

Over the years in attempts to get the maximum yield from the resources of the environment for his social benefit man has polluted and degraded the environment. Where no adequate steps are taken to prevent damage to the environment, the end results in many cases have led to environmental disasters and the need to conserve man himself.

But first let me on behalf of all aquatic ecologists in this country and elsewhere congratulate the Federal Government of Nigeria on the establishment of the Federal Environmental Protection Agency (FEPA). Indeed the FEPA Decree No. 58 of 30 December, 1988 will stand out as one of the greatest legacies the present administration will leave behind for Nigerians.

Types and Sources of Water Pollutants

Quite a great variety of pollutants are produced by man and these invariably find their way into the aquatic environment. I shall highlight a few of the pollutants if only to point out how badly man has abused and misused the aquatic environment.

Domestic pollution involves sewage and other organic materials which reduce oxygen and affect the lives of aquatic organisms. Bodies of water receiving sewage undergo gradual destruction. A study case made by Willen (1972) is Lake

Malaren, the third largest Lake in Sweden – 115km in length, 65km in breadth, and maximum depth about 66 metres. Around the lake were located metal, engineering, food, chemical, and pulp and paper industries. The lake received sewage from about 1,100,000 persons. Noted ecological changes included

> Changes in p^H conditions of the water which in turn caused fish killing and affected development of fish eggs.
>
> High concentration of nitrogen and phosphorus with detrimental effects on plants and animals in the lake.

Since 1968 however about 70 functional sewage plants have been equipped with chemical treatment plants and the lake has gradually recovered.

According to Akpata and Ekundayo (1975) the Lagos City Council in 1973 dumped approximately 26 million litres of untreated sewage into the Lagos Lagoon. This was an act of pollution. It is necessary to study how such pollution affects aquatic organisms with respect to public health. Sewage pollution for example is responsible for transmission of typhoid and other micro-organic diseases through shellfish especially oysters and fishes in several ways.

> Sewage has high oxygen demand resulting in the depletion of oxygen in the water.
>
> Sewage settles on the bottom, and this has a damaging affect on oysters, eggs and larvae of fishes.
>
> Sewage has high fertility effect, organisms not favourable to the welfare of the fishes may be produced in large numbers.

Luckily the Lagos State Government has banned the 'pail system'. It is hoped that sewage from Nigerian major cities will be properly collected and treated and not just dumped into the lagoons and rivers where they will seriously damage or eliminate the fisheries resource and other aquatic organisms.

Industrial Pollution

Industrial pollution involves discharge into the aquatic environment of toxic substances or of organic industrial by-products which will directly or indirectly affect animals including man. Of the toxic heavy metals discharged into the environment by man, I shall highlight the mercury crisis. Jackson (1979) reported the disaster from Japan in which eighty people died as a result of eating fish from Minimata Bay contaminated by mercury. The mercury in the Japanese incident was a by-product of a plastic plant, and before the source was cut off, scores of Japanese men, women, and children died, became insane or developed neurological symptoms of mercury poisoning. The same findings in fish and other foodstuffs from lakes, rivers throughout the United States prompted quick controls on mercury pollution in those areas, and in some cases, fishing was banned in the effected waters. With the high level of industrialisation in Nigeria, there is no proof that is mercury criss of early 1970 is not with us.

Indeed from the results obtained during the January 1991 International Research Workshop on the Lagos Lagoon Ecosystem coordinated by me and organised under the UNESCO/COMARAF Project, the scientists detected the presence of organic matter, heavy metals and hydrocarbons at various locations in the lagoon, all pointing to a highly polluted water. The pollutants arose as effluents from the numerous industries and sewage sites in Lagos metropolis. The effluents would have to be properly monitored to ensure a cleaner lagoon environment. Participants were however happy to note that the Federal Enviranment Protection Agency (FEPA)has already set up guidelines for control of effluents from the industries. With industrialisation and subsequent pollution of the aquatic environment, there is a major threat to aquatic life in Nigeria waters. The fishing grounds where the fishes are caught are not only polluted, the inshore areas where they reproduce are also being gradually damaged by pollution. These nursery grounds are being dredged, filled, and polluted with both sewage and heavy metals. There is need for immediate remedy.

Oil Pollution

Oil is one of the most widespread contaminants of the aquatic environment. In the petroleum industry, oil spillage is a major disaster. Crude oil is not a single chemical but a conglomeration of many substances of widely different toxicities and effects on the environment. Massive destruction of marine life occurs immediately after a spillage. A wide range of fish, shellfish, crabs, shrimps are affected. Bottom-living fish and molluscs are killed off and washed ahore. Even when the dead fishes have disappeared, years later appreciable fractions of the oil spill can still be found in organisms surviving in the affected area. So oil spill is a long-term damage.

Although accidental oil spills are spectacular events and attract great public attention, according to the *FAO Report* (1971), they are responsible for only about 10 per cent of the total amount of oil entering the marine environment. The remaining 90 per cent of the oil contamination originates in the normal operation of oil-carrying tankers, merchant and naval vessels, offshore production, refinery operations and the disposal of oil-waste materials (Table 3). Despite the danger posed to the marine environment and its adjacent creek, some of these sources of oil pollution can be

Table 3: Estimated Direct Petroleum Hydrocarbon Losses to the Marine Environment

	1975	1980
	(Million tons)	
Tankers	0.805	1.062
Other ships	0.705	0.940
Offshore production	0.320	0.460
Refinery operations	0.450	0.650
Oil Wastes	0.825	1.200
Accidental Spills	0.300	0.440
TOTAL	3.405	4.752
Total Crude Oil Production	2,700	4,000

Source: FAO (1971)

controlled and the amount of petroleum entering the environment can greatly be reduced by the establishment of broad-based environmental monitoring programmes. One is glad to note that some oil companies, e.g., Shell Nigeria are aware of their social responsibilities in this regard and are seriously initiating baseline and post-impact assessment studies in attempt to reduce oil pollution to the barest minimum.

Water Hyacinth Menace

Water hyacinth, *Eichhornia crassipes* (Mart) menace is a major environmental problem that has plagued the riverine areas of Nigeria since 1985. Its rapid growth has clogged major waterways and created problems associated with navigation, national security, irrigation and drainage, water supply hyro-electricity and fishing in many countries.

The first surge of the weed in Nigeria was noticed in September 1984 along the Badagry Creek in Lagos State where the weed formed a 'mat' over the water surface. By January 1985, it had spread to the creeks and lagoons in Lagos and its environs.

Investigations by the team of scientists from University of Lagos revealed that the surge of the weed entered Nigerian waters via the Porto Novo creek (Benin Republic) which is connected to and flows into the Badagry Creek. Our prediction then was that if immediate and adequate steps were not taken to check the weed, the Lagos Lagoon system would become the avenue for spreading the weed into other parts of the Nigerian waterways including Epe, Lekki and Mahin Lagoons (Kusemiju et al, 1985). That warning was not heeded then. By 1986 the weed had crossed the Lagos Lagoon and has since covered most of the intricate system of waterways made of lagoons and creeks along the coast of sough-western Nigeria up to Bendel State and beyond.

Since the first surge of water hyacinth originated from our neighbouring country, a preliminary trip was made to Benin Republic in January 1986. Field trips were conducted in company of scientists and officials from Benin Republic.

A trip was made to the Porto Novo Creek which flows into Nigeria and which has its water supply from the So and Queme Rivers. The Queme River, the main source of water hyacinth in Benin Republic is about 527km long. Water hyacinth was found in the low valley area of Hetin Sotia located 10–15km from Porto Novo. Water hyacinth normally starts growing from January to July in the So and Queme Rivers. By September/October, the weeds are pushed into the Porto Novo Creek from where they travel for a distance of about 100km before entering into Nigerian waters on-route to the sea via the Lagos Harbour (Fig. 5). The rate of flow is such that water hyacinth will reach the Lagos Harbour around December each year. It is important to highlight this Benin Republic source, since a definite solution must be found at the source (probably through a bilateral initiative) to prevent the annual surge from our neighbouring country. Water hyacinth has in fact become an ECOWAS problem having now infested Nigeria, Benin Republic, Togo, Ghana, Cote d'Ivoire and Senegal.

In most countries with water hyacinth problems, three methods have usually been employed for its control, namely, mechanical harvesting, biological and chemical control. The system adopted however depends on several considerations. Even within the same country, different methods must be considered based on specific locations and workability. In Nigeria, experience on the water hyacinth problem in the past few years confirms the need for a mixture of strategies in tackling the problems in the wide variety of water bodies which are already infested. In doing so, the cost effectiveness and environmental impact of whatever control strategy is employed must be borne in mind.

Mechanical Control/Harvesting

Harvesting is a useful method for water hyacinth control but there are serious bottlenecks. To be effective, the harvesting method has to be fast enough to outpace the reproductive potentials of water hyacinth. According to Khan and Thyagarajan (1988), under the most favourable

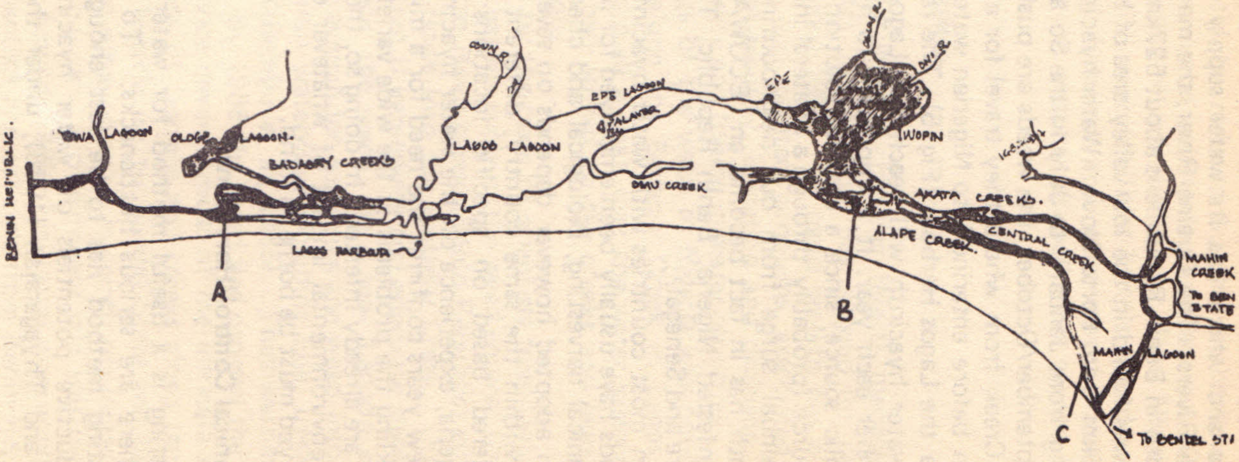

Fig. 5 : Lagoons and Creeks of South-Western Nigeria

conditions, ten plants can multiply to 600,000 in only eight months. To be effective, therefore, the harvesting rate must be equal to or more than the growth rate.

So far, mechanical harvesting has not been a continuous exercise in Nigeria. Most of it has been done to combat a surge or to open up already blocked waterways. There is bound to be a reocurrence except harvesting is backed up with regular mopping.

There is also the problem of disposal. For Nigeria, dumping in selected sites may be useful. For example Badagry Creeks where the shores are sandy dumping may be successful but in Alape, Akata, Mehin and Igbekoda Creeks (Ondo State) and Epe/Lekki Lagoons which are swampy and water-logged for most of the time, the weeds when dumped gradually find their way back into water especially after a rain. In these areas, the weeds must be moved to proper dry and suitable sites for dumping and burning. Utilisation of harvested plants is also suggested to solve the problem of disposal and also to meet at least partially the cost of harvesting.

Biological Control

It is believed that on the long-term basis, biological control will be relatively cheaper than other methods of control. By far the most successful agents are the weevils.

For the past few years I have also advocated the use of the grass carp (even as a pilot project). The grass carp has been shown to be a very effective methods of water hyacinth control in several countries including Indonesia, Phillipines, Guyana (Soerjani, 1984, Baruah, 1984). In the process, the weed is cleared and one gets sizeable fish thereby contributing to fish production and improving the economy of the riverine people who now regard water hyacinth as a menace. According to Soerjani (1984), in Indonesia, in a water hyacinth monoculture, fish of 6-8cm with a density of 4 – 16,000/ha reduced water hyacinth population of about 1,200 ton/ha with 48 -- 83% compared to the potential growth in two weeks.

Along the Nigerian coastline, the creek from Aiyetoro/ Idiogba (Ondo State) to Ago Nana (Bendel State) offers a new dimension in water hyacinth management and utilisation. Here the fishing activity of the people has been mixed with rearing of pigs, goats and cattle that graze on *Paspalum sp* growing along the creek. These animals have been found to utilise water hyacinth directly from the edge of the creek. Thus the use of water hyacinth for livestock management can be considered as vital option in the weed control strategy.

Chemical Control

Though chemical control of water hyacinth is possible, the main objectives to its large scale use in the Nigerian situation include the following:

i) The rural population use the creeks, rivers and lagoons for domestic and drinking purposes in view of lack of pipe-borne water. Indeed over 80 per cent of people of Ilaje area depend on this as their main source of water for life. The nearly 30 fishing villages on the periphery of Lekki Lagoon (a major area of water hyacinth infestation) drink the water directly.

ii) The lagoons and rivers are major sources of fishing and nursery grounds for early development of many species of fishes and shrimps. Such aquatic animals and sessile moluscs will be contaminated.

iii) Chemical spraying will result in serious pollution problems as the water weeds decay.

iv) The unforeseen toxic effects of residual chemical on aquatic organisms and man.

Indeed according to Obeid (1984), after chemical spraying of water hyacinth in the White Nile, the local people who live close to the river complained of stomach ache and intestinal troubles – effects that were traced to the chemical spraying. Harley (1989) also warned that there was an environmental cost in using herbicides. Residues of herbicides in the water and sediments may affect the aquatic environment and kill fish directly or by reduced levels of dissolved oxygen caused by decaying weeds. The pity of it all is that the chemical control treatment must be continued indefinitely or the infestation will regenerate from scattered plants and seeds and the on-slaught on the environment will continue.

This lecture is not against use of chemcials, but it must be limited to channels or canals where they will do only a little havoc. Such usage must also be borne on tested experiments.

Salt-Water Control

My laboratory and field experiments show that at salinity of 5 per cent or above, water hyacinth experienced high mortality and died completely under continued exposure to salinity (Kusemiju, 1988). High salinity could therefore serve as a very useful environmental factor in the control of water hyacinth. As part of the strategies for water hyacinth management in Nigeria, it is therefore suggested that channels be opened up

i) to join the Atlantic Ocean at a point between Benin Republic border and Badagry;

ii) between Lekki Lagoon and the Atlantic Ocean, and

iii) between Alape Creek and Atlantic Ocean at Ore-Oke Iwamimo in Ondo State.

If this suggestion is accepted, it will be the first time any nation would adopt this system in water hyacinth control. It will be cost effective.

RECOMMENDATIONS

1) The Nigerian inshore trawl fishery is in a state of near collapse. There is overfishing and too many trawlers are fishing. Immediate steps must be taken to remedy the situation. In order to ensure a high maximum sustainable yield and regular recruitment from the inshore waters of Nigeria, all trawlers (except those undertaking research activities) should be banned within 3km off the Nigerian coast. The Federal Department of Fisheries should be adequately funded to enforce this regulation and rehabilitate the Nigerian fisheries sector.

2) In order to keep down the pressure on the Nigerian inshore fishery, the quota system must immediately be introduced and no single company should operate more than five trawlers.

3) Fishing Regulations relating to mesh-size of nets and size of fish landed in Nigeria should be reviewed and heavier penalties imposed on offenders.

4) Nigerians should engage in distant water fishery for tuna and sardinella in order to meet our fish needs.

5) Aquaculture or fish farming offers the greatest opportunity for mass production of fish for Nigerians. There should therefore be mass mobilisation of various bodies — the private sector, Local Government Areas, Reservoir Authorities, Universities, Schools and Colleges and individuals into fish farming. The campaign to grow your own fish should start now.

6 ; The government monetary policy guideline stipulates that a minimum of 6 per cent of Commercial Banks' sectoral allocation should go to the Agricultural Sector. The Fisheries Sub-sector of the Agricultural sector has been neglected over the years. To ensure that

the Fisheries Sub-sector is properly catered for, the government policy guideline should further stipulate that at least 2 per cent of the Commercial Banks' Sectoral allocation should go to the Fisheries Sub-Sector.

7) At the national level, man-power training essential for increasing fish production and providing gainful self-employment should be given topmost priority up to University level.

8) On the environment, FEPA should immediately organise a broad-based study of the Nigerian aquatic environment — rivers, lakes, lagoons and the sea to document their existing situation. In the process, major sources of chemical, biological and radiological pollutants in the aquatic environment should be identified.

9) Nigerian establishments dealing with the environment and its resources -- Ministries of Agriculture, Water Resources, Science and Technology, The Navy, Federal Department of Fisheries, Research Institutes and Universities should actively collaborate in solving Nigerian environmental problems. FEPA should make a serious effort to collate all available information and serve as data bank on matters relating to the Nigerian environment.

10) Education is the key to sustainable environment. Environmental Science should immediately be introduced as a core subject in primary and secondary schools in Nigeria to enable our children have a full appreciation of environmental protection and conservation.

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