

UNIVERSITY OF PORT HARCOURT

“FISHES IN NIGERIAN WATERS:
NO PLACE TO HIDE”

An Inaugural Lecture

by

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FISHES IN NIGERIAN WATERS: NO PLACE TO HIDE

“When we can drain the ocean into mill-ponds, and bottle up the Force of Gravity, to be sold by retail, in gas jars; then we may hope to comprehend the infinitudes of man’s soul under formulas of Profit and Loss; and rule over this too, as over a patent engine, by checks, and valves, and balances.

- Thomas Carlyle (1795 – 1881), Scottish essayist and Historian.

1.0 PREAMBLE

It is a real honour to be asked to give the 100th Inaugural Lecture of this great University which incidentally is also the first in the series of Inaugural Lectures slated for this year. I share in the view that an inaugural lecture is a debt a Professor owes the University Community and which must be paid at some point during his career. The lecture is intended to provide an insight into the current state of knowledge, thereby contributing to the history of the discipline and the professional/academic contributions of the lecturer. I commend the University administration and in particular the Vice Chancellor, Prof J.A. Ajiienka for institutionalizing this culture in the University of Port Harcourt. It is therefore my hope and prayer that this diverse and august audience would benefit from this lecture which I have titled: “Fishes in Nigerian Waters: No Place to Hide”

Permit me Mr Chairman to use this opportunity to acknowledge and thank all those who have contributed in various ways to the actualization of my academic dreams. Let me particularly acknowledge Prof Karl L. Lagler, Prof of Zoology and Fisheries at the University of Michigan, who supervised both my BSc and MSc Theses; thereby laying the foundation for my academic career. Let me also single out Prof Chinyewite Ejike, former Pro – Chancellor of the Enugu State University and former Dean of the Faculty of Science at the University of Jos who

supervised my PhD Thesis with Prof Larry Curtis of the Oregon State University serving as external supervisor. I'll continue to cherish the interest and love he showed me and his exemplary life style which have impacted positively in me.

Let me acknowledge my numerous research associates and former and present post-graduate students for their immense contributions to my research achievements. Let me also place on record my appreciation for the love, support and kindness shown to me by many of my colleagues in the University of Port Harcourt in general, and the Faculty of Science in particular. In this regard, I want to specially thank Professors Okoro, Alagoa, Okiwelu, Arene, Okoli, Oti, Amajor and Efebo among others for their friendship, support and encouragement.

I also thank my numerous guests, friends and family members who have come from far and near to honour my invitation. I appreciate your coming and hope that the time spent here would be a fulfilling experience. May I also thank in a very special way, my brother, friend and colleague Professor Nelson Brambaifa who graciously accepted to serve as my orator.

Finally, and most importantly let me thank my wife, Mrs Bondan Sikoki who had to put up with my frequent periods of absence from home on account of my work. I appreciate all your sacrifices and would continue to admire your patience and understanding.

In order to make my presentation easy to follow, I have divided it into three broad components as follows:

- (i) Historical perspectives;
- (ii) Present status; and
- (iii) Research Contributions/Recommendations.

2.0 INTRODUCTION

2.1 History of Human/Fish Relationship

Among vertebrates, fish has the closest relationship with humans. The relationship between humans and fish is not only phylogenetic but also religious, cultural and socio-economic. Phylogenetically, the subclass of ancient fishes, Sarcopterygii appeared in the fossil record during the Devonian period of the Paleozoic era and were from the start divided into two orders, Dipnoi – lungfish; and Crossopterygii – loperfined fishes.

The Crossopterygii were divided into two groups, Rhipidistii and the Coelacanthini. The Rhipidistii gave rise in the very late Devonian to the first amphibians, and thus are the common ancestors of all tetrapods including man (Figure 1.).

2.1.1 Religion

In **Christianity** and other **religions**, fish is a symbol of abundance and faith. Christ and his disciples were described as “fishers of men.” Here man is presented as the transformational fish and the ocean, a symbol of the abyss of sin in which man lives.

Fish is also given symbolic meaning in the **Gospels**. Several of Jesus 12 disciples were fishermen. Jesus commissioned them as fishers of men and when Jesus fed 5,000 people, it was with fish and bread Matthew 14:15-21; Luke 9:12-17.

Even before the birth of Christianity, fish may have been used as symbols representing several goddesses. Barbara Walker in her book, “The Woman’s Dictionary of Symbols and Sacred Objects, suggested that Ichthy, Greek word for fish was the son of the sea goddess, Atargatis.

In **Buddhism**, fish symbolizes happiness and freedom and is one of the eight sacred symbols of the Buddha. Some pagan traditions also recognized fish as a feminine symbol of fertility and attribute of the goddess. Here, water is regarded as a natural

emblem of the flow of the Divine Mother Principal, and as a consequence, all creatures of the water are regarded as components of the fertility and power of the female deity.

Ancient Celts believed that the Salmon, a fish, derived its wisdom from consuming the sacred hazel nuts from the well of knowledge (Segais). They therefore believed that if one eat the salmon, he would gain the wisdom of the well too. Here, fish symbolically meant wisdom, knowledge inspiration and prophesy.

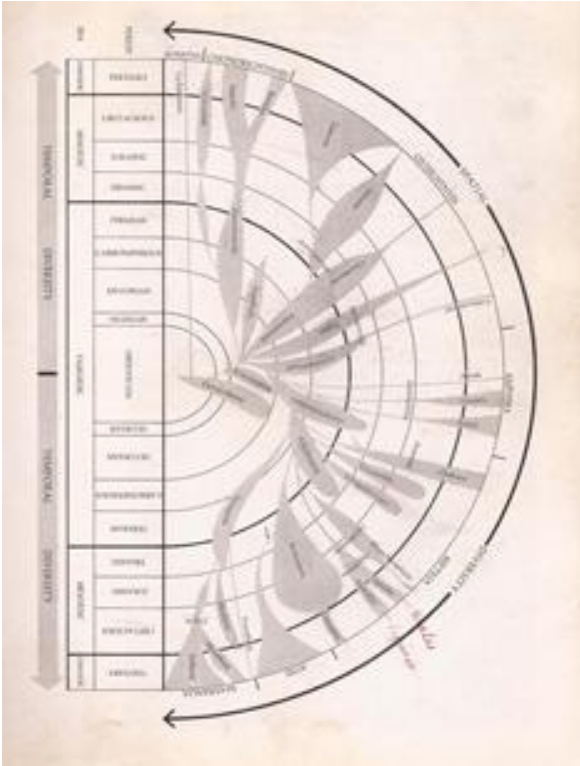


Fig 1: Vertebrate phylogeny

Similarly, ancient **Eastern Indian** mythology regarded the fish as a symbol of transformation and creation. We see this in an ancient flood myth in which Vishnu transformed himself into a fish (Matsya) to save the world from a great flood.

In **China**, fish is regarded as a symbol of unity and fidelity. It derives from the fact that the fish (particularly Koi) swim in pairs. For this reason, fishes are often given as wedding presents in the form of charms to newly-wed couples since they represent fertility and abundance due to their high reproductive potential (speed and volume).

Many **ancient European cultures** gave symbolic meanings of adaptability determination and flow of life to fish. Salmon were particularly revered for their determination in their annual spawning migrations usually against the water current.

There are also **ancient African** creation myths that talk of mangala, the creator, planting seeds in the cosmic womb from which two fish erupted and set forth into the cosmos upon the waters of creation.

2.1.2 Early Uses of Fish (Place of Fish in human Society).

From archeological records, fishes have occupied important places in human societies for several thousands of years. The earliest documented human communities that engaged in fishing occurred near lake Mungo, Australia, some 30,000 BP followed by Crete in 8,000 BP. However, archeological records documenting the use of fish spears for fishing date back to 90,000 BP. This was followed by nets in 40,000 while fish hooks appeared 35,000 BP.

Fishing for leisure was first reported among the Egyptian aristocracy as far back as 4000 BP. However, it was not until the middle ages, when better preservation techniques, particularly drying, smoking and salting and improved transportation, that fishing activity shifted from local, small scale operations to large scale, commercial enterprises.

2.1.3 Current Uses of Fisheries Resources.

At present, some 4,000 species of fish are harvested worldwide totaling approximately 120 metric tons of fish annually. The harvest from capture fisheries quadrupled between 1950 and 1990 but has since leveled off and even declined. However, aquaculture production has continued to increase and is expected to continue to play a key role in bridging the gap between supply and demand. Five countries are the leading world producers of fish (capture and culture) with China leading the pack with 32.5% of total world production. The others are Japan, 5.1%; India, 4.5%; U.S.A. 4.4% and Russia 3.9%.

Similarly, per caput consumption of fish has nearly doubled since the 1960s. The highest per caput consumption is among Europeans and Asians. Worldwide, per caput consumption of fish and shellfish is put at approximately 15kg but the value varies among the various regions of the world and countries. In the United States, per caput consumption is approximately 7kg with Tuna, shrimp, Pollock, salmon and catfish being the most favoured.

Aside its meat, fish is used for a variety of purposes. First, it can be used for aesthetic purposes such as in aquaria or stuffed and placed on display for people to admire. In fact, ornamental fish trade is a big business worldwide and Nigeria has great potential to participate. Approximately 10 million marine ornamental fish are imported annually worldwide. The freshwater species involved are over 5000 and the value of US retail in ornamental fish market is USD 3 billion. Secondly, several useful substances can be extracted from fish. An impotence curing medicine produced by sharks and cod liver oil are among the best known. Thirdly, fishes are used for certain exotic purposes including sending a fish by post to a member of a gang to alert

him or her that they have fallen out of favour with the gang and may soon be killed.

In addition to the above, many useful products are produced from fish. Some of these include:

- (i) **Fish Glue:** made by boiling the skin, bones and swim bladder of fish. The glue is highly valued for its use in many products such as illuminated manuscripts and Mongolian war bow.
- (ii) **Fish Oil:** Fish oils are highly recommended for their Omega - 3 fatty acid content, aicosapentaenoic acid (EPA) and docosahexaenotic acid (DHA) precursors to eicosanoids which are known to reduce inflammation in the body.
- (iii) **Fish Emulsion:** This is a fertilizer emulsion that is produced from the fluid remains of processed fish for fish oil and fish meal.
- (iv) **Fish Hydrolysate:** This is the ground up fish remains after the edible portion has been removed.
- (v) **Fish Meal:** Used as a high protein feed supplement in fish culture.

2.2 Evolution of Fisheries Management Concepts.

The fishing profession is one of the world's oldest but fisheries management is still in its infant stage owing to a number of reasons:

- (i) Prior to 1850, the fisheries of the Oceans and large lakes were essentially considered inexhaustible and in fact this notion persists in some areas up to the present day.
- (ii) For centuries, fishing activities had been carried out in coastal areas and in inland lakes, and the supply of fish seemed infinite.
- (iii) Owing to this supposed infinity, Hugo Grocius in 1608 founded the principle of the “freedom of the seas.” His reasoning was that if fishes and other resources could be exploited without limit, maintaining exclusive rights to oceanic resources was unnecessary (Christy and Scott, 1965).

It should however be noted that not all fisheries were considered inexhaustible. Restrictive regulations existed in the British Isles since at least 1278 and were enacted in North America shortly after the arrival of the pilgrims (Nielsen, 1976). The first to question the inexhaustibility of coastal fisheries were British fishermen, who complained of stock depletion even before 1850. They accused competing types of fishing gear particularly “trawling” as being responsible for the depletion.

It is now widely recognized that overfishing and improper fishing methods are responsible for depletion of marine fisheries. In freshwater systems, a wider variety of causes including overfishing, improper fishing methods, habitat degradation and pollution are implicated.

However, the rationale for regulating fisheries had evolved even before any dramatic scientific investigations. The realization that depletion had occurred as fishing effort increased provided empirical evidence that instead of infinite effort generating infinite yields, there was some intermediate effort which yielded the

greatest amount of fish. This thinking brought about two general principles:

- (i) that an adequate supply of eggs was needed for future generations of fish and as such fish should not be caught until they have at least spawned once;
- (ii) that small fish would continue to grow if allowed to live longer and the yield in weight could be sustained only if small fish are not captured.

This approach suggested the need for length limits for landed fish and minimum mesh size restrictions on fishing nets to guarantee sustainable fisheries.

A British Select Committee in 1893 recommended these regulations and they have since become the standard methods for fishery regulation. However, a more direct approach is to limit the total annual catch by means of a quota system. This way, the harvest would not exceed the production capacity, and in instances where rebuilding the stock was imperative, some production could be reinvested to provide for increased future yields.

An empirical evidence that regulated fishing allowed recuperation of stocks was seen during world war I. The catch of plaice in the North Sea increased for some years after war as the recuperated stocks from the war years were again exploited (fig 3). (Russel, 1942).

Alongside these explanations were developing other logical and empirical ideas. During the 1930, E.S. Russell developed a mathematic equation relating stock abundance to additions through growth and recruitment and losses via natural and fishing mortality (Russel, 1942).

The outcome of both empirical and theoretical principles was the generalization that for a stock of fish, there exists a Maximum Sustainable Yield, MSY and an associated fishing level to achieve that yield. Unfortunately, as a theoretical objective, MSY does not consider the SOCIAL, POLITICAL and ECONOMIC problems.

Michael Graham (1943) in his book, “The Fish Gate” stated the Great Law of Fishing which essentially opined that unregulated fisheries becomes unprofitable.

In the early 1950s a large body of economic literature had portrayed fisheries as a classical example of “Common Property Resources.” The essential features of such a resource are that:

- (i) no one pays for its use; and
- (ii) no one assesses the yields derived from additional units
of effort.

Consequently, as long as any profit is being made, additional effort will be expended either by more fishing per fisherfolk or by more fisherfolks until profits decline to zero. This essentially is the situation in Nigerian waters. Therefore, to properly manage, regulations must be directed at harvest and effort to achieve maximum net economic revenue.

Unfortunately, the application of economic principles in fisheries management is faced with difficulties relating to property rights. Property rights encounter social and political problems concerning:

- (i) proper allocation of the resource among fisheries; and
- (ii) the displacement and compensation of those denied access.

Political considerations in fisheries management also run counter to those of biologists and economists. Thus, when a

British Commission saw the need for management in 1893, Parliament ignored their recommendations. Similarly, the recommendations of the plaice Committee of the International Council for the Exploration of the Sea were embroiled in political problems. Even the 1958 Law of the Sea Conference which accepted MSY in a formal resolution has not been ratified by all participating nations.

These actions are essentially at the core of current fisheries managements policies. The idea that regulation is impractical gave rise to several year of Laissez faire – policy of none interference and importance attached to personal liberty of fisherfolks which have inhibited necessary changes in the fishery sector.

2.3 Evolution of Nigerian Fisheries

A formal fisheries service was established in Nigeria by the British Colonial Government in the early 40s with a vision for fisheries research. Later, the department was split into two – the Federal Department of Fisheries (FDF) with responsibility for development activities and the Nigerian Institute for Oceanography and Marine Research, (NIOMR) for marine fisheries research.

Fisheries administration started in 1942 in earnest in response to wide spread protein shortages occasioned by world war II. It is generally believed that fisheries sub – sector lagged behind other sectors because during periods of food shortages, carbohydrate supply is given priority over protein supply. This probably explains why even when it was established it was placed in the Agriculture department of the colonial office. However, it received greater attention following the creation of the 12 state structure in 1967. During this period the Federal Fisheries performed mainly coordination functions among the states. Later, in 1975, the Federal Military Government created 22 Research Institutes including two new fisheries Institutes at Maiduguri –

Lake Chad Research Institute and at New Bussa – Kainji Lake Research Institute, now National Institute for Freshwater Fisheries Research (NIFFR).

2.4 Fish Vs Fisheries

Fish and Fisheries have several meanings but as traditionally used in Fisheries Management, fish typically includes the entire array of aquatic animals that are harvested (for example – tuna, tilapia, sea turtles, seals, whales, clams squid and frogs. A fishery on the other hand is generically defined as a system composed of three interacting components namely:

- the aquatic biota
- the aquatic habitat; and
- the human users of the resources.

There are many kinds of fisheries which may be classified in several ways: For example, on the basis of:

- (i) **Type of Environment:** - freshwater habitats such as lakes, reservoirs, rivers; or salt – water habitats such as estuarine, brackish, Coastal and open ocean.
- (ii) **Method of Harvest:-** (Seining, trawling, hook and line etc.)
- (iii) **Type of Access:** Open access, open access with regulation, limited or purchased, private property.
- iv) **Organism Targeted:** (e.g. salmon, catfish, shrimp, turtle, whale, tilapia etc)
- v) **Type of Fishing:** commercial/industrial, artisanal, or

recreation.

- vi) **Degree of wildness of organism concerned:**
e.g.
totally wild, captive, etc.

In biology per se, the term fish is strictly used to describe any animal with backbone that has gills throughout life and has limbs, if any, in the form of fins. In fisheries however, fish is used as a collective term to include – Cruteceans, mollusks, and other aquatic animals that are harvested. The true fish, the strict biological definition is referred to as finfish and are distinguished from other animals such as the crustaceans and molluscs which are called shellfish.

3.0 FISHERIES RESOURCES OF NIGERIA.

Nigeria is highly endowed with both fresh and marine fishery resources. It is generally believed that if these resources are rationally managed and exploited, the country can attain self sufficiency in fish production.

There are an estimated 12,478,818 hectares of inland water bodies made up of reservoirs, lakes, rivers, ponds and perennial swarms (Ita et al., 1985) and some 741,509 ha of brackish waters, most of which are suitable for aquaculture. At present only about 5,476 ha of these waters are utilized for fish culture (Sikoki and Oyero, 1994). In addition to the above, the nation's 200 nautical mile Exclusive Economic Zone (EEZ) within which she has absolute jurisdiction over all the living resources spans 853km of coastline and covers 192,000 km² in area. Bayagbona (1979) estimated that the shellfish potential of the country is approximately 3,500 tonnes; of which she harvests only 2,000 tonnes losing the rest to poachers.

There is, however, very little room for expansion in this area as recent data seem to suggest that operations are approaching their maximum sustainable yield.

In the fin fish fishery sub-sector, the biomass of the Nigerian continental shelf is estimated at 37,700 metric tons (Williams, 1968). Given that maximum sustainable yield (MSY) is 37 percent of the biomass, Fox (1970) estimated a potential yield of about 12,950 tonnes of tuna. At present, some 10,000 tonnes of tuna and other fishes are said to be harvested yearly.

In the inland waters, artisanal and culture fisheries operations are the predominant activities and account for over 90 percent of domestic fish production. These operations cover small – Scale canoe fisheries, and aquaculture activities.

3.1 Marine Fishes

Our coastal zone is home to some 104 species of fish belonging to 50 families. Some of the species of commercial importance include: Croaker, *Pseudotolithus typus*, *P. senegalensis*, *P. elongatus*; soles, *Cynoglossus spp*; Shinnose, *Polydactylus quadrifilis*; Sea catfish, *Arius spp*; Grouper, *Epinephelus spp*; large tarpons, *Megalops atlantica* and various sparids (breams). Other commercially important species include: moonfishes, *Vomer setapinnis*, *Trichiurus lepturus*; Jack fish, *Carranx spp* and Bigeye, *Brachydeuterus auritus* (Plate 1).

3.2 Freshwater Fishes

Commercially important freshwater fish families in Nigerian waters include the mormyridae (43 species); Cyprinidae (32); Mochokidae (27); characidae (25) and Cichlidae (19). However, the catfishes appear to be more commercially important. (Plate 2). In all some 196 species belonging to 105 genera representing 46 families have been recovered in the freshwater sector (Leveque et al., 1991).

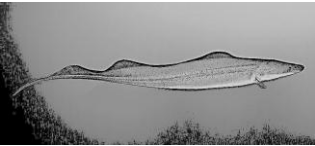
3.3 Endangered Species

The 2006 International Union for the Conservation of Nature, IUCN Red List names 1,173 fish species world wide that are threatened with extinction. The list includes the Atlantic cod, Devils Hole pup fish, the coelacanths and the great white shark. Many freshwater fish are particularly threatened because they live in smaller water bodies that are more prone to pollution and habitat degradation.

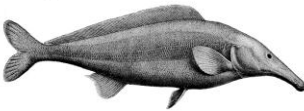
The mudskipper, *Periothalmus papilio* in our coastal areas has probably suffered more in this regard. This fish is not only of great evolutionary significance but of great biological value. Its pectoral fins are modified to enable it skip through the mud flats and from jumping from one tree branch to another in the coastal zone. According to Egborge (1992), in the 1960s and 70s, it was extremely abundant in many lagoon beaches and other water bodies but is currently being threatened by activities such as land reclamation, dredging and oil spills.



Oreochromis niloticus (Tilapia)



Gymnarchus niloticus



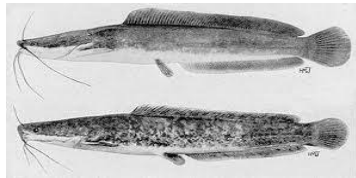
Mormyrus rume (Trunk fish)



Polypterus senegalus



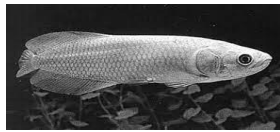
Protopterus annectens



Arias species



Citharinus citharus

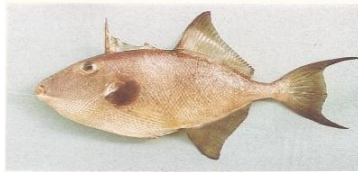


Heterotis niloticus

Plate 1. Representative Freshwater Fishes.



(1) ACANTHURIDAE: *Acanthurus monroviae* 230mm SL
(Ph: Bianchi)



(2) BALISTIDAE: *Balistes capricus*
(Ph: Bellemans)



(3) BALISTIDAE: *Balistes punctatus*
(Ph: Bellemans)



(4) BOTHIDAE: *Bothus podas africanus*
(Ph: Bellemans)



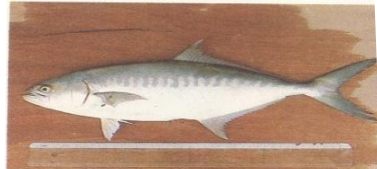
(5) CARANGIDAE: *Brachistegus semifasciatus*
(Ph: Bellemans)



(6) CARANGIDAE: *Alectis alexandrinus* (Juvenile)
230mm SL (Ph: Bianchi)



(7) CARANGIDAE: *Alectis alexandrinus* (adult)
(Ph: Bellemans)



(8) CARANGIDAE: *Campogramma glycos*
(Ph: Bellemans)

Plate 2. Representative Marine Fishes.

P. papilio and some other families among marine fishes contain only one species. These include *Gerridae*, *lobotidae*, *Liognathidae*, *oxynotidae* and *scombrescidae* which require special protection on account of this fact.

Freshwater fish families having only one species include:

- (i) *Albula vulpes* (Albulidae) – Warri River
- (ii) *Phractura clauseni* (Amphillidae) – Ogun River
- (iii) *Lates niloticus* (Centropomidae) – widely distributed
- (iv) *Gymnarchus niloticus* (Gymnarchidae) – do –
- (v) *Cromeria niloticus occidentalis* (kneridae) -Northern Nigeria
- (vi) *Protopterus annectens* (Lepidoserenidae) - Fairly dist.
- (vii) *Malapterurus electricus* (Malapteruridae) – Widely dist
- (viii) *Mastercemblus loennbergi* (Mastacemblidae) – Fairly dist
- (ix) *Polycentropsis abbreviate* (Ophiocephalidae) – Oguta Lake
- (x) *Heterotis niloticus* (Osteoglossidae) – widely dist
- (xi) *Pantodon bucholzi* (Pantodontidae) – fairly dist
- (xii) *Phractolaemis ansorgei* (Phractolaemidae) – do –
- (xiii) *Synbranchus afer* (Synbranchidae) – Fairly dist
- (xiv) *Trigon margarita* (Trigonidae) – do –

Source: Egborge, 1992.

According to Tobor (1990) the estimated maximum sustainable yield of the Nigerian fishery resources is 240,000 metric tons but official catch figures have consistently exceeded this value. The consequences therefore of fishing at the current level are grave as this would undoubtedly lead to a decline not only in catch volume but to a total disappearance of some of the most valuable fish species.

Other factors responsible for the decline in fish production include:

- Changing climatic and limnological factors;
- Habitat disruption;
- Pollution; and

- Improper or irrational fishing methods.

3.4 Climate Change

Globally, the period 2000 to 2009 is said to be the warmest decade since records began in 1850. The average temperature near the earth's surface has risen by about 0.750°C since 1900. Most scientists believe that if we continue to emit green house gases at current rates, global temperatures may rise by between 1.1° and 1.40°C above 1980 to 1999 levels by the end of this century.

This phenomenon could cause floods, droughts and tropical storms. Nigeria has already witnessed several such disasters as shown below in the last 30 years or so:

• No. of events	94
• No. of people killed	21,002
• Average killed per year	677
• Average affected per year	203,434
• Economic damage (USD)	188,025,000 =

Similarly, a number of natural disasters have been witnessed in the country each year including:

• Drought	0.03
• Epidemic	1.58
• Extreme temperature	0.06
• Flooding	1.13
• Storm	0.06

Furthermore, changes in rainfall patterns induced by climate change would adversely affect many plants and animals. Those species which may not be able to adapt may become extinct. It is estimated that if global temperatures increase by 2°C, 30 percent of all land animals and plants may be threatened by increased risk of extinction.

In fact, the International Union for the Conservation of Nature, IUCN reported that:

- One out of eight birds;
- One out of four mammals;
- One out of four conifers;
- One out of three amphibious; and
- Six marine turtles out of seven are threatened with extinction.

In addition, the report stated that:

- 75% of genetic diversity of agricultural crops has been lost;
- 75% of the worlds fisheries are fully or over exploited;
- Up to 70% of the world's known species risk extinction if global temperatures rise by more than 3.5°C;
- One third of reef – building corals are threatened with extinction; and
- A parcel of rainforest, the size of a football field disappears every second.

3.5 Habitat Disruption

It has been estimated that some 50 percent of mangrove trees in the coastal zone have been felled (World Resources, 1990). The result of this action has been increased erosion and flooding. Furthermore, the mangrove ecosystem provides a conducive environment for the spawning of various kinds of fish and as nursery ground. Its removal therefore results in loss of habitat, biodiversity and breeding/nursery grounds for fish.

Similarly, sand mining and dredging had adverse effects on the hydro – dynamics of the affected areas. These include increased depth and wave action, and altered hydrodynamics.

These processes could adversely affect living resources such as the benthic organisms which would lose their substrates.

Furthermore, the dredging of harbours and channels has deleterious effects on coastal environments to which bottom materials are carried in suspension. While in suspension, such materials cause waters to be turbid, reduce light penetration which may restrict photosynthetic activity of plants and the vision of animals (Sikoki, 1979). Finely divided materials at high concentrations are known to interfere with feeding of animals that obtain their food by filtration. They may also be abrasive to sensitive structures such as gills of fish.

On settling to the bottom, solid materials often alter the aquatic habitat making the substrate unsuitable for several bottom dwelling animals such as oysters. Rocky bottoms providing habitat for some animals may be buried as well.

3.5.1 Industrial Activities

Industries are a major source of environmental pollution and degradation. Their infrastructures modify the environment and their effluents and emissions adversely affect the environment. In this regard, the oil industry is a major contributor to resource depletion and environmental degradation. Its exploration and exploitation involve many steps – Exploration, drilling, flowlines and flowstations (Figure 2). The major environmental impacts of oil activities from extraction to its arrival at an oil terminal or refinery include:

- physical impacts on the environment;
- air emissions;
- water effluents; and
- waste materials.

(i) **Exploration:** This process begins by creating a subsurface “picture” through the generation of sound waves and recording their reflection from underground layers. It involves setting off small explosive charges along a grid of narrow paths or lines over the area to be surveyed. These surveys require a large number of people to cut lines through the area to collect exploration data. Although the environmental impacts are largely temporary, they cover thousands of kilometers and many of the older lines are still visible on the land scape.

(ii) **Drilling:** When seismic survey has been completed, the presence of oil can only be confirmed by drilling a well. The process involves the circulation of clay mud down a drill pipe and back to the surface to balance:

- Underground pressure;
- Cool the drill bit; and
- Flush out rock cuttings.

Drilling operations require the acquisition of land for access roads. The construction of roads (on land) and canals (in swamps) involve land clearing, dredging and sandfilling. The environmental consequences of these activities include:

- increased turbidity of surface waters;
- loss of vegetation due to acidic slurry;
- accidental oil spills; and
- noise.

(iii) **Flowlines:** Oil from each producing well is carried to the nearest flowstation in small diameter pipelines. The land acquired for this purpose ranges from 10 to 15 metres in width.

(iv) **Flowstations:** The oil, water and gas produced together in a mixture from each well is transported to central production facilities called flowstations. At the flowstation, the gas is separated from the fluids. Most of the separated gas is flared while the oil and water mixture is pumped through delivery pipelines to oil terminals. At the terminals, the water is separated from the oil and discharged.

These operations have destroyed substantial areas vegetation, particularly mangrove. According to the IEOD – WCAD (1995) SPDC alone has removed about one percent of mangrove forest in Rivers State alone. (table 1).

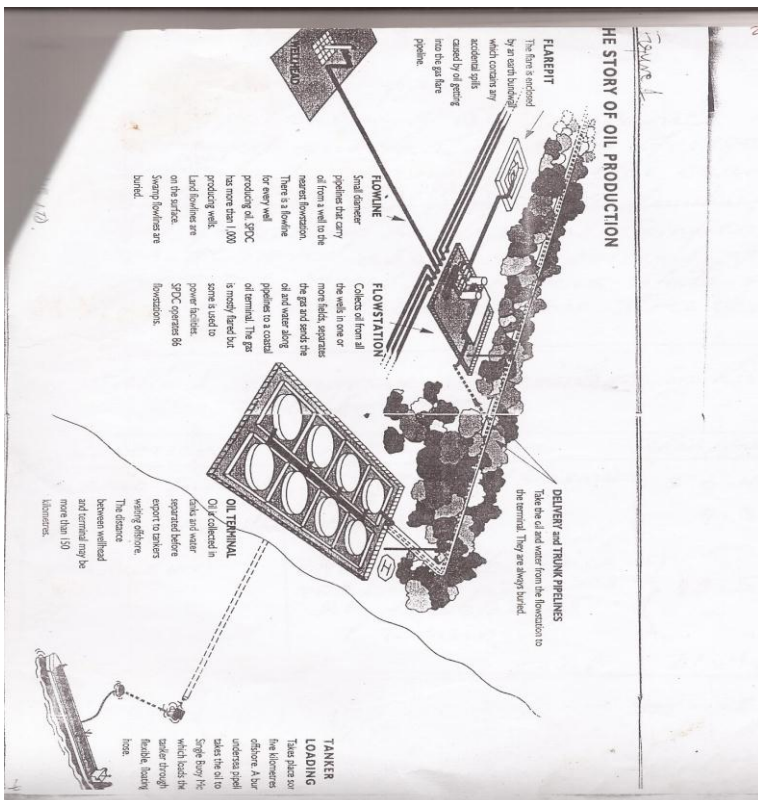


Fig 2: Oil Production Process: Source, SPDC

Table 1: Mangrove conversion in Rivers State (source, IEOD – WACD, 1995

S/N	Operation	Facility	Area Converted (km ²)
1.	Seismic Surveys	56,000km of seismic lines	56.4
2.	Drilling Operations	349 sites	4.5
3.	Production	700km of flowlines 400km of pipelines 22 flowstations 1 terminal	10.5
Total			<u>71.40km²</u>

In addition, the construction of oil facilities and transportation canals create a wide range of environmental problems including:

- destruction of fishing grounds;
- alteration of salinity;
- alteration of flow regime leading to erosion and sedimentation;
- temporary increase in turbidity;
- decrease in dissolved oxygen;
- increase in acidity;

- reduce agricultural yields resulting from run – off of dredge spoil; and
- water logging of fields.

3.5.2 Oil Spills

Each year, some 2,300 m³ of oil are spilled in about 300 incidents in Rivers, Bayelsa and Delta States (table 2)

Table 2: Oil spill in three states in the Niger Delta between 1991-1993

Year	No. of spills	Vol. (Barrels)	Spilled
1991	176	6,053	
1992	352	34,064	
1993	348	9,010	
Total	875	43,770	
Mean/Year	292	14,590	

It is widely believed that the actual figures may be higher as the reported ones do not include small spills that occur frequently.

Crude oil contains water soluble toxic materials (Sikoki and Enajekpo, 2001). Powell (1994) reported that oil spills cause mortality of fish and bivalves such as oysters.

Gunderlach (1981) developed a sensitivity index for various ecosystems and reported that sheltered tidal flats, salt marshes and mangroves are the most sensitive ecosystems.

3.5.3 Ballast Water

Powell (1986) reported that discharge of ballast water from oil tankers is responsible for the introduction of exotic species of marine organisms into Nigerian waters. The Indopacific sea urchin, *Temnopleuras toreumaticus*, previously unknown in Nigerian waters was probably introduced through this source. The animals presently constitute a major nuisance to artisanal fishers in some estuaries where they remove bait from long – line hooks, eat fish caught in nets and entangle set and cast nets. They also injure fishfolk with their spines.

4.0 PRESENT STATUS OF FISHERIES

Fish has been an important source of protein throughout recorded history. The modern English word for **fish** comes from the old English word *fisc* (plural: *fiscas* pronounced as it is today. More than 32,000 species of fish have been described, making them the most diverse group of vertebrates.

Approximately 90% of world fish catches come from oceans and seas, these catches have remained relatively constraint since the mid 1990s at between 80 and 86million tonnes. This is primarily because most marine fisheries are based in the coastal waters which are easier to exploit on account of:

- their being shallow;
- fish being more abundant near the continental shelf; and
- abundance of nutrients from coastal upwelling and land runoff.

The primary production operations in the fisheries sector provide direct employment for some 38 million people worldwide. It is also estimated that over 200 million people, mostly those living in landless communities depend on fisheries for their livelihood. It is also a source of income for millions of women and children, who engage in processing, marketing and transportation of fish and fish products.

Fish is the principal animal protein consumed by about one billion people worldwide (figure 3). In many coastal rural communities, fishing is the occupation of last resort; a situation that makes rational exploitation of the resource difficult.

4.1 World Fish Trade

The food and Agriculture Organization, FAO, 2012 estimated that total fish imports exceeded USD 100 billion in 2008. The value of exports was placed a little lower at USD 99.5 million. Of this figure, approximately half originated in developing countries while approximately 80% of world imports went to the developed countries. Nigeria's share of exports was placed at 0.10% while imports were 0.5% (Table 3)

Some 38% of world fish production is exported.

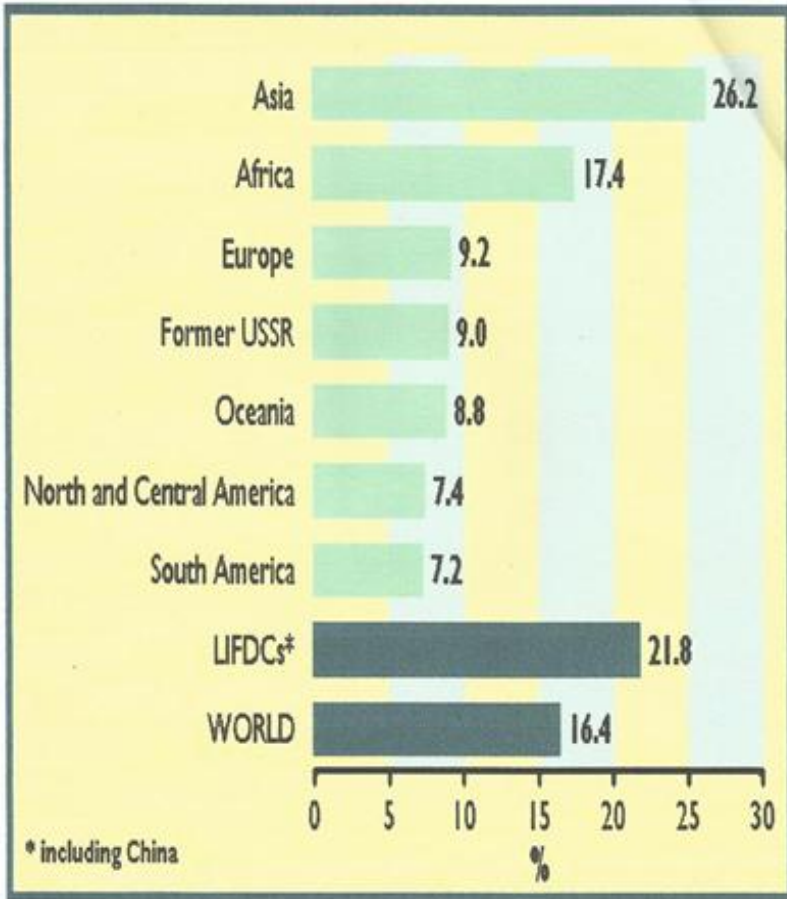


Fig. 3: Contribution of fish to human diet: fish as a percentage of total animal protein intake 1995 (Source: FAO, 2003)

Table 3: World fish trade

	Exports			Imports		
	2006	2007	2008	2006	2007	2008
			Estim.			Estim.
			US\$ billion			US\$ billion
ASIA	29.0	30.9	34.0	28.5	29.5	32.6
China of which	10.8	10.9	12.2	6.7	7.4	8.4
Hong Kong						
SAR	0.4	0.4	0.5	2.0	2.2	2.4
& Taiwan PC	1.4	1.2	1.5	0.5	0.6	0.7
India	1.8	1.7	1.7	0.0	0.0	0.0
Indonesia	2.0	2.1	2.5	0.1	0.1	0.2
Japan	1.4	1.7	1.6	14.0	13.2	14.5
Korea, Rep. of	0.9	1.1	1.3	2.8	3.1	2.9
Philippines	0.4	0.5	0.5	0.1	0.1	0.1
Thailand	5.2	5.7	6.5	1.5	1.7	2.4
Viet Nam	3.4	3.8	4.0	0.3	0.4	0.4
AFRICA	4.1	4.5	4.8	2.0	2.4	2.8
Ghana	0.1	0.1	0.0	0.1	0.2	0.1
Morocco	1.2	1.4	1.7	0.1	0.1	0.1
Namibia	0.5	0.5	0.5	0.0	0.0	0.0
Nigeria	0.1	0.1	0.1	0.5	0.5	0.5
Senegal	0.3	0.3	0.2	0.0	0.0	0.0
South Africa	0.4	0.5	0.5	0.2	0.2	0.2
CENTRAL AMERICA	1.8	2.1	2.2	0.9	1.1	1.2
Mexico	0.7	0.8	0.9	0.4	0.5	0.6
Panama	0.4	0.4	0.4	0.0	0.0	0.0

SOUTH AMERICA	8.8	9.0	9.7	1.0	1.4	1.7
Argentina	1.3	1.1	1.0	0.1	0.1	0.1
Brazil	0.4	0.3	0.3	0.5	0.6	0.7
Chile	3.6	3.7	3.9	0.2	0.2	0.2
Ecuador	1.3	1.4	1.8	0.0	0.1	0.2
Peru	1.8	2.0	2.1	0.0	0.0	0.0
NORTH AMERICA	8.2	8.4	8.5	15.1	15.6	16.2
Canada	3.7	3.7	3.8	1.8	2.0	2.0
United State of America	4.1	4.4	4.5	13.3	13.6	14.1
EUROPE	31.9	35.7	38.0	41.3	46.7	49.0
European Union	21.6	24.2	25.5	37.4	41.8	43.2
Iceland	1.8	2.0	1.7	0.1	0.1	0.1
Norway	5.5	6.2	7.4	0.8	1.1	1.3
Russian Federation	2.1	2.4	2.5	1.4	2.0	2.3
OCEANIA	2.1	2.2	2.3	1.1	1.3	1.3
Australia	0.9	0.9	0.9	0.9	1.1	1.1
New Zealand	0.9	0.9	1.0	0.1	0.1	0.1
WORLD 3	85.9	92.8	99.5	89.9	98.0	104.7
Developing Countries	42.6	45.1	49.5	18.6	21.3	23.9
Developed countries	43.3	47.6	50.0	71.3	76.7	80.9
LIFDCs	17.1	18.0	19.8	6.2	6.9	7.9
LDCs	2.3	2.5	2.4	0.6	0.9	1.0
NFIDCs	6.9	7.6	8.2	1.9	2.5	3.0

Source: FAO-FIES

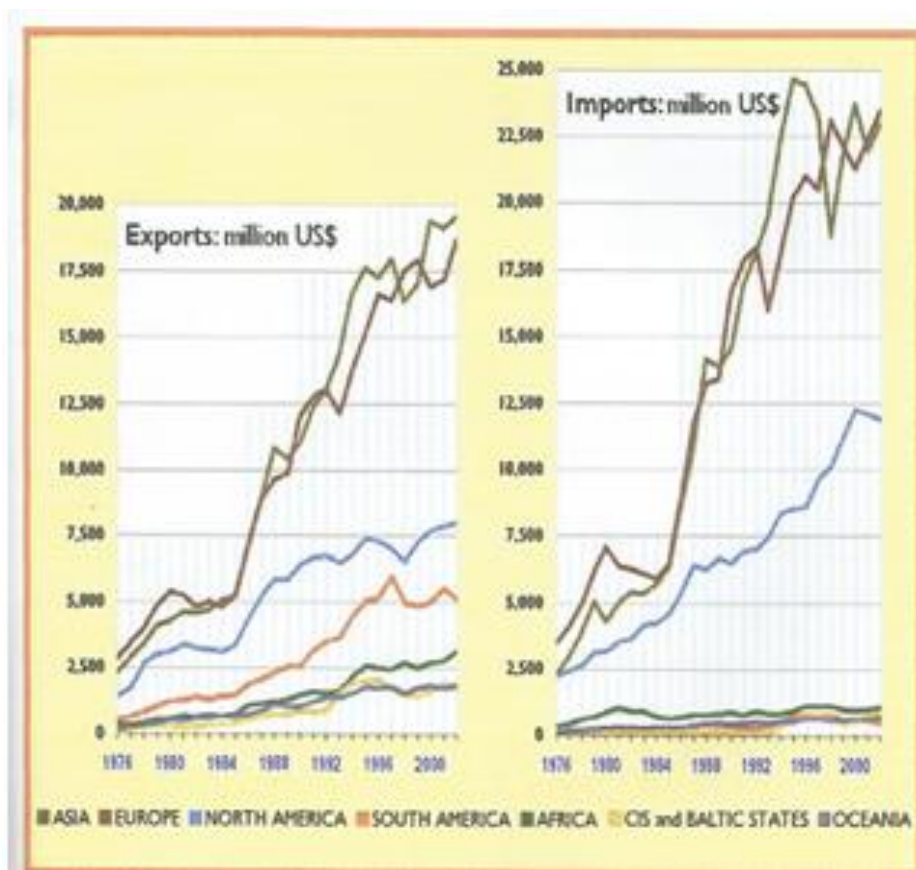


Fig. 4: Value of fish export and import 1986-2002

In 2002, the value of net fish exports from developing countries was reported to be higher than the combined value of coffee, cocoa, bananas, rubber, rice and tea. Although the expanding

global fish creates opportunities for developing countries, it also encourages overfishing and places fish beyond the reach of the poor.

Table 4: Presents key fisheries facts.

Table 4: Key Fisheries facts.

1. Total value of world trade in fisheries	USD 58.2 billion
2. Percent of global fish production from aquaculture	4% and 30%
3. Net receipts from fish by developing countries	USD 17.4 billion
4. Fish exports from developing countries	22 million tons
5. Value of global fish imports	USD 61 billion – 80% accounted for by dev. Countries
6. Status of capture fisheries stock	24% over exploited/depleted or recovering;
	52% fully exploited;
	24% under or moderately exploited.

Table 4 (cont'd)

7. No. of people for whom fish is the principal animal protein	>1 billion worldwide
8. No. of livelihoods supported by fisheries	38 million
9. No. of decked vessels in the global fishing fleet	1.3 Million
10. No. of undecked vessels in the global fishing fleet	2.8 million, 65% without power.
11. Global per capita supply of fisheries products	Declined by 2.5kg/person/year since mid 1980 (from 11.8kg in 1986 to 9.3kg in 1999).

Source – FAO, 2004, Delgado et al., 2003.

4.1.1. Fish as Food

Fish plays an important role in global food supplies and its demand is expected to increase considerably as living standards increase in Asia and population grows in Africa.

Global fish consumption has doubled since 1973 with China, India and Southeast Asia accounting for nearly all the increase. On the other hand, global per capita supply of fish products has declined by 2.5kg since the mid 1980 (from 11.8 kg in 1986 to 9.3 kg in 1999) essentially on account of fish production not keeping pace with population growth.

It is widely believed that capture fisheries would not be able to meet global demand and aquaculture holds the promise to bridge the supply demand gap. It is estimated that by 2020, 90% of fish consumed in sub - Saharan Africa would be low - value food fish, mainly small pelagic fish. Furthermore, by this date, increasing fish prices driven population growth and declining incomes would reduce per capita fish consumption in Africa from 7.6 to 6.6 (FAO; 2004).

These statistics are highly worrisome because fish provides a good source of high quality protein and several minerals and vitamins. It is classified as either whitefish, oily or shellfish. Whitefish is low in fat (<1%) while oily fish such as sardines contain between 10 and 25% fat. The fatty fish contain a wide range of fat soluble vitamins (A, D, E & K) and essential fatty acids which are needed for healthy functioning of the body.

Recent studies suggest that the amount of fatty acids in the diet of a pregnant woman affects her child's intelligence, fine motor skills and the propensity for antisocial behavior. For instance, children born to women who consume little amounts of Omega - 3 fatty acids during their pregnancies had verbal IQ 8 points lower than average. Therefore, widespread deficiencies within a country would have serious implications for its human resource potential.

4.1.2. Sustainability.

Despite the existence of several international conventions which provide framework for the rational management of fisheries resources among which are:

- the United Nations, UN Convention on the Law of the Sea (UNCLOS); and
- UN fish stocks Agreement, there are serious concerns over the sustainability of many capture fisheries. This is due to the “common property” and “open access” nature of many fish resources. A fishery without limits to access will attract more and more fishers until the aggregate cost of fishing approaches the aggregate value of the catch.

On account of these concerns, FAO member states in 1995 adopted the Code – of Conduct for Responsible Fisheries. The objectives of the code are to:

- (i) establish principles in accordance with the relevant rules of International Law for responsible fishing and fisheries activities;
- (ii) establish principles and criteria for the elaboration and implementation of national policies for responsible conservation of fisheries resources and fisheries management and development;
- (iii) serve as an instrument of reference to help states establish or improve the legal and institutional framework required for the exercise of responsible fisheries;
- (iv) Provide guidance that may be used where appropriate in formulating international agreements and other legal instruments;

- (v) facilitate and promote technical, financial and other cooperation in the conservation of fisheries resources;
- (vi) promote the contribution of fisheries to food security and food quality;
- (vii) promote protection of living aquatic resources and their environment;
- (viii) promote trade in fish and fishery products in conformity with relevant international rules;
- (ix) promote research on fisheries; and
- (x) Provide standards of conduct for all persons involved in the fisheries sector.

Mr. Vice Chancellor distinguished guests, Ladies and Gentlemen; the realization of the lofty ideas embodied in this code is the major challenge facing the Nigerian Fisheries Sector. The key issues therefore that require urgent attention are:

- access limitation to fisheries resources;
- allocation of the resources in an equitable manner between competing interest groups; and
- ensuring rational exploitation of the living aquatic resources in a manner that is compatible with ecosystem integrity and conservation of biodiversity.

4.2. STATUS OF NIGERIAN FISHERIES

Despite its high potential for fish production, (37,934 km² continental shelf area 853 km coastline, 210, 900km² EEZ, 14m ha

of inland water surface area and an estimated 2.5m tones aquaculture potential) Nigeria produces only 0.62m mt of fish annually as against a demand of 2.66m mt and yield potential of 3.2m mt i.e. only 23% of demand is met. (table 5). This inadequate supply situation resulted in increased efforts to boost animal production. These efforts are particularly directed at fish production which is traditionally regarded as a cheap source of animal protein.

These efforts were intensified in the mid – 1970s due to the 1973 Sahelian drought in the northern parts of the country which produce most of the beef locally consumed.

As a source of animal protein, fish and fish products locally provide nearly 10kg of fish per capita per annum; an equivalent of 40% of all animal protein consumed in the country.

The contribution of the fisheries sub – sector to the nation’s Gross Domestic Product (GDP) currently stands at 4.0 percent. Its contribution to national development cuts across such activities as:

Table 5: Nigeria’s fin and shell fish yield potential (Source: FDF, 2008)

S/N	Resource Category	Potential yield Per annum (mt)
1.	Coastal/Inshore (finfish)	
	• Coastal resources	142,000
	• Inshore resources	16,620
2.	Offshore (Finfish)	
	• Demersal resources	6,370
	• Tuna and other pelagic fish	15,000
3.	Coastal artisanal (shell fish)	48,000
4.	Industrial (Shell fish)	3,760

5.	Fresh – Water Resources	
	• Rivers and flood plains	226,550
	• Lake Chad	160,000
	• Kainji Lake	30,000
6.	Aquaculture	2,500,000

employment generation, income generation and household food security (Plate 3). The sector is also a high foreign exchange earner, generating about US 38.3 million dollars annually the rough export of fisheries products. In addition the sector, provides 8.23m direct and 18.27 million indirect employment opportunities for Nigerians.

4.2.1. Fish and Protein Food Demand in Nigeria.

Between 1970 and 1974, the Nigerian cattle, Sheep and Goat industry was heavily affected by drought. In the Northern parts of the country, about 90% of the cattle and 70% of the sheep and goat populations were adversely affected by the drought.

The **rinderpest** outbreak of 1983/84 further reduce the cattle population in Nigeria which resulted in massive importation of frozen meat, fish and chicken in order to meet the demand for protein foods. Efforts were also made to increase the country's fish and poultry production to bridge the gap between supply and demand. Some of the programmes directed at increasing fish production include:



Plate 3: Contribution of fisheries to the Nation's GDP.

- In-shore fisheries development project to enhance fish production and generate employment opportunities;
- National Accelerated Fish Production project (NAFPP) and Canoe Mechanization Scheme (CMS)
- Special Fisheries Development Project; and
- Processing and Marketing Project among others.



The implementation of these projects initially brought about increased fish production but owing to policy shifts and unsustainable implementation, fish supply has declined steadily over the years. Nevertheless, fishing and related occupations remain the mainstay of most rural coastal economics.

In these communities, fishing is the occupation of last resort; a situation that prevents rational management and sustainability. Coincidentally, small scale fisheries which include some of the poorest members of our society are also the most neglected groups. It is common knowledge that the level of poverty in these fishing communities is most pathetic and is often compounded by geographic isolation and a lack of social amenities.

Left with no alternatives, most fisherfolk feel obliged to exploit these resources irrespective of any consequences to satisfy their basic needs. It is therefore, no surprise that today overfishing is probably the most serious environmental problem on fisheries; causing changes in the composition of fish populations and ultimately entire ecosystems.

For these reasons, Mr Chairman, the sustainable development of our fisheries resources has become imperative. It is my considered opinion that this goal can be achieved if we reconcile economic growth with environmental protection and address poverty – induced causes of environmental degradation.

The question we need to ask ourselves is: for how long can the current rate of fish utilization continue without causing irreversible damage to the resource base and limiting long – term economic development? At many international fora such as the 20th session of the FAO Committee on fisheries in 1993 and the International Conference on Responsible fishing in 1992, concern have been raised about the overexploitation and economic losses being incurred by world fisheries.

It is now widely recognized that over – exploitation undermines fisheries conservation and management efforts, threatens the long – term sustainability of fisheries and harms the contribution of fisheries to food security.

These concerns were instrumental in the adoption of five fisheries resolutions at the 49th session of the United Nations General Assembly (UNGA) in 1994. They are:

- (i) The continuing use of large – scale pelagic driftnets in some countries;
- (ii) The continuation of the UN Conference on straddling fish stocks and highly migratory fish stocks in 1995;
- (iii) The implementation of the 1982 UN Convention on the Law of the Sea;
- (iv) Fisheries by-catch and discards; and
- (v) Unauthorized fishing in zones of national jurisdiction.

Agriculture in general and fisheries in particular are the sectors for sustainable development because hunger is the most visible manifestation of poverty in any society. Hence, any effort in these sectors is not only a fight against hunger but a necessary ingredient for economic development as well. In Nigeria, fish plays an important part in the diet of many communities and a large number of families earn a living from fishing, fish processing and marketing.

As a source of protein, fish and fish products provide 9.68kg of fish per person per year; an equivalent of approximately 49 percent of all animal protein consumed in the country. The importance of fish in the human diet therefore cannot be over – emphasized. Apart from being a cheap source of highly nutritive

protein, it also contains other essential nutrients required by the body.

The FAO recommends that minimum protein intake by the average person should be 65/day of which 35 should come from animal sources. In our country, per caput intake of protein is only 51.70gm and only 4.0 gm are of animal origin; a sharp contrast with the situation in developed countries where the figures are 90 and 65gm respectively (Sikoki and Otobotekere, 1995).

4.2.2. Contribution to National Economy

The contribution of the fisheries sub – sector to the Agricultural Gross Domestic Product, (GDP) is 4.0% (FDF, 2008). Furthermore, the sector is a high foreign exchange earner, generating about USD 38.3 million annually. It also provides direct and indirect employment to 8.23 and 18.27 million Nigerians (table 6).

Table 6: Contribution of Fisheries to National economy. Source: FDF, 2008

(i)	Contribution to Agricultural GDP (2007)	4.0%
(ii)	Total fish Demand	2.66m mt
(iii)	Domestic Production	0.62m mt
(iv)	Per caput fish consumption	9.68kg/person/yr
(v)	Est. Employment, Primary Sector	8.23m
(vi)	Est. Employment, Secondary Sector (Male, 7.16m; Female, 19.34m)	18.27m
(vii)	Total Import (2007)	0.74m mt
(viii)	Total Exports (2007)	0.005m mt
(ix)	Value of fish Imports (2007)	USD 596.4 million
(x)	Value of Exports (2007)	USD 38.3 million
(xi)	Estimated Aquaculture potential	2.5m mt
(xii)	Min. Fingerling requirement	4.3 billion
(xiii)	Total fingerling supply (all sources)	55.8 million

4.2.3. Fish Production in Nigeria

Despite its high potential for fish production, the demand for fish in Nigeria is yet to be met through domestic production. The fishing industry in Nigeria comprises both artisanal and industrial or commercial fisheries. The more labour intensive artisanal fishery employs simple gear crafts, and is carried out in coastal, brackish and inland waters. Table 7 below shows fish supply by sector between 1995 and 2007.

Although the total landings have increased gradually from 371,053 in 1995 to 615,507 tonnes in 2007, Table 7. The industrial sector has witness a decline 33,479 to 26,193 mt during the same period. In addition, the average catch per trawler has dropped considerably. For example, the average catch per trawler dropped from 170.38 in 1980 to 76.47 mt in 1989 (table 8).

From the foregoing, it can be seen that the catch per unit effort (C.P.U.E.) has drastically reduced because when more fish are removed from a body of water than can be replaced, the water body is being overfished (figure 5). This is due to the fact that as effort increases, catches also increase until a point is reached when increase in effort will no longer increase the catch.

Table 7: Fish supply by sector (mt) between 1995 and 2007 in Nigeria. Source : FDF, 2008.

Subsector/ Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Artisanal	320,955	309,200	360,219	433,070	426,736	418,069	433,537	450,965	446,203	434,830	490,594	518,537	504,227
%	86.5	86.9	87.2	89.6	89.0	89.5	89.1	88.1	87.4	85.4	84.7	81.4	81.9
Aquaculture	16,619	19,490	25,265	20,458	21,738	25,720	24,398	30,664	30,677	43,950	56,355	84,533	85,087
%	4.5	5.5	6.0	4.2	4.5	5.5	5.0	6.0	6.0	8.6	9.7	13.3	13.8
Industrial	33,479	27,244	27,703	29,955	31,139	23,309	28,378	30,091	33,882	30,421	32,595	33,778	26,193
%	9.0	7.7	6.7	6.2	6.5	5.0	5.8	5.9	6.6	6.0	5.6	5.3	4.3
Grand Total	371,053	355,934	413,188	483,482	479,663	467,098	436,313	511,720	510,762	509,201	579,544	636,848	615,507

Table 8: Fish Production from inshore fishing and shrimping (mt) from 1980 to 1989

Source: FDF, 1990.

YEAR	Total Landing	No. of Trawlers	Average Landing
1980	13,631	80	170.38
81	9,611	81	118.65
82	18,861	86	219.31
83	19,245	120	160.37
84	25,650	133	192.85
85	26,142	163	160.37
86	25,650	250	100.16
87	24,900	252	98.80
88	35,608	372	95.72
89	33,645	440	76.46

Table 9: Fish Catch from inshore fishing and shrimping (mt) 1995 – 2007. Source: FDF, 2008.

YEAR	INSHORE SHRIMPING	INSHORE FISHING
1995	26,755.0	6,688.0
1996	19,333.0	5,642.7
1997	20,919.2	5,214.2
1998	24,124.1	4,539.8
1999	26,981.0	2,448.5
2000	21,043.7	3,889.5
2001	21,810.5	6,361.0
2002	23,004.50	5,857.6
2003	23,118.31	5,840.08
2004	23,391.45	5,140.66
2005	26,420.03	4,250.90
2006	27,278.71	5,617.06
2007	20,630.14	3,405.16

In the figure 5, the fishing effort; measured by number of fishing vessels at effort “B” is twice that at A and half that at C. The catch at the peak of the yield curve represents the Maximum Sustainable Yield (MSY). A level of fishing higher than that at point “B” is

considered as overflowing but at point “D” the stock would go into extinction.

Unfortunately, most fishermen in our country, unaware of these basic principles, employ obnoxious and irrational/illegal practices to maximize their catch. Some of these practices are:

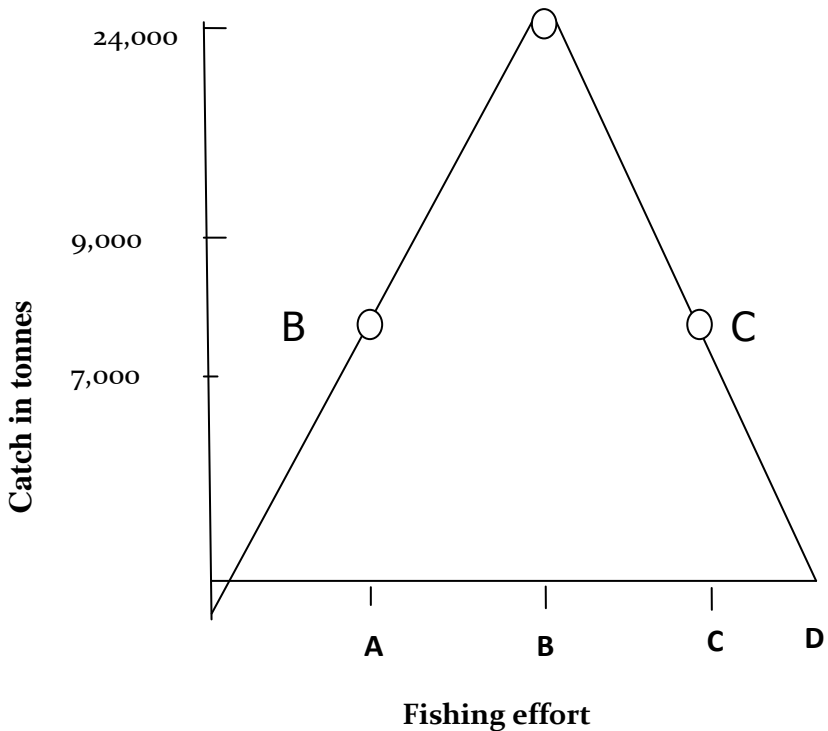


Fig. 5: A typical fish production function for a fish stock.

- (i) **Use of Poisonous Chemicals:** These include – Gamalin 20 Adrex 40 and Didimac 25. These poisons when introduced into a water body are not selective in their actions - killing fish, shellfish and plankton. The poisons

also pollute the water and contaminate fish muscles making them unsafe for human consumption.

(ii) **Ichthyotoxic plants:** These are plants which contain chemicals that can narcotize or kill fish and shellfish. Their roots, leaves or bark are grinded up with tobacco or lime to form a paste which is introduced into the water body. Hot pepper is also used with clay in some cases to produce the above effects. Ichthyotoxic plants commonly used include:

- *Accacia pen* - leaves or bark
- *Baillonella toxisperma* - leaves
- *Mundulea sericea* - - do -
- *Tephrosia vogelli* - - do -
- *Tetrapleura tetraptera* - - do -

(iii) **Dynamites, Hand Grenades and Bombs:** These explosives also narcotize fish making them easy to capture by hand, net or spear. They are especially destructive when used in areas where fish breed as they kill both the adults and young.

(iv) **Castnets with Small Meshes:** These nets with stretched mesh size less than 25mm catch both the old and young of several fish species such as the croakers, *Pseudotolithus* spp and *Polydactylus quadrifilis* in river mouths. It is recommended that the ideal mesh size for castnets should be 40mm stretched but many fisherfolk use much smaller mesh sizes.

(v) **Beach Seines:** These are commonly used in lagoons and creeks where they cause great havoc to immature

fishes on account of their small mesh sizes – typically 10 – 20 mm. The recommend mesh sizes are 44 and 51mm for cod-end and wings respectively.

- (vi) **Stow Nets:** These are also commonly used in lagoons and and estuaries. The conical bags made from multifilament nylon fibres having mesh sizes of 10 to 30mm with the cod – end mesh size measuring 10mm. They are particularly efficient in catching juvenile shrimps.
- (vii) **Traps:** Traps are commonly used in fresh water bodies. They are equipped with non-return valves which capture all sizes of fish including the immature ones.
- (viii) **Trawl Nets:** Some fisherfolks employ trawl nets with cod-end mesh size smaller than the legal cod-end mesh size of 44mm for shrimping. These Nets catch large numbers of immature fish which some estimates put at about 45 percent of the total catch. Such practices are highly destructive and are capable of destroying the inshore demersal trawl fishery. Unfortunately, no laws exist in Nigeria for the prohibition of the landing of juveline fish.
- (ix) **Poaching:** Illegal fishing by foreign vessels in Nigerian waters is a serious problem making management and conservation of marine resources in our waters extremely difficult.

Mr Chairman, distinguished ladies and gentlemen, there is general consensus today that:

- Knowledge of the state of fish stocks; and
- Knowledge of the aquatic environment or fundamental to rational management of fisheries resources as advocated by the World Summit on Sustainable Development in 2002. Further more, poor sector governance is a primary cause of the crisis in world fisheries in general and Nigerian fisheries in particular.

Policies and institutional frameworks are often deficient because overfishing and economic losses generate stymied fiscal measures constrain financing of compliance measures and undermine enforcement of regulations.

Awareness of the social and economic drivers of overfishing and aquatic environmental degradation is also required to design solutions. The application of solutions similarly requires building stakeholder knowledge, creating awareness and reaching consensus on best practices and approvals.

Finally, it is generally believed that capture fisheries cannot meet future demands for fish and major expansion of aquaculture production is needed to fill the gap between supply and demand. I recognized these facts early in my academic career and my research activities have been directed at these areas right from my doctoral Thesis which examined the hormonal and environmental control of reproductive cycling in the common carp, *Cyprinus carpio*. Subsequently, I and my collaborating scientists/students directed our attention at examining exploitation patterns of the living aquatic resources and their compatibility with ecosystem integrity and conservation measures

5. MY CONTRIBUTIONS TO KNOWLEDGE OF FISHERIES

5.1. Contributions of my PhD Thesis.

In many countries the world over, an increasing population without a corresponding increase in the production from capture fisheries has led to an increased interest in the development of aquaculture. This practice dates back as far as 2,500 B.C. in Egypt where pictorial engravings of an ancient Egyptian tomb showing tilapia being fished out from an artificial pond were found. However, the earliest form of fish culture appears to be of common carp, *Cyprinus carpio*, a native of China. It was introduced into several countries of Asia and the far East by Chinese immigrants, and to Europe during the middle Ages for culture in monastic ponds.

In Nigeria, experimental studies for the culture of common carp by the colonial government started only in 1944. Between 1948 and 1954, the Panyam Fish Farm was established in Panyam, Plateau State by the then Northern Regional Government for the production of commercial carp. Thereafter, similar farms were established in other areas. For instance, in the old Western Region, an experimental 100 acre farm was established in Ibadan. In the East, a small experimental facility was built for carp culture at Okigwe, while in the Niger Delta area, a 14 acre brackish farm was established at Buguma in present day Rivers State.

Today, the importance of fish farming is gradually being recognized by many Nigerians. Unfortunately, inadequate supply of fingerlings for stocking of ponds and the failure of some valuable species such as the common carp to reproduce spontaneously under captivity in small bodies of water have greatly hampered the expansion of aquaculture.

This informed the choice of my PhD research work which was aimed at solving the later problem. I worked on "Endocrine

and Environmental Control of Reproductive Cycling in the common carp, *Cyprinus carpio* and published four papers from it.

In the first paper, we demonstrated that under confinement, there were no simple relationships between plasma sex steroid hormone concentrations and the activity of hepatic microsomal UDP-glucuronyltransferase activity in the common carp. However, injection of pituitary extract induced final gonadal maturation and transient elevation of (within 24 hours) of both plasma sex steroid concentrations and UDPGT activity (Sikoki et al, 1989). In rats, pregnancy is associated with impaired hepatic xenobiotic biotransformation and biliary excretion and inhibited biotransformation occurred during gonadal maturation in rainbow trout (Curtis, 1983).

In the second paper, we examined the relationship between reproductive state and UDP-glucuronic transferase activity. It was found that in either sex, gonadal development was facilitated by elevated plasma sex steroids and reduced hepatic UDP-GT activity (Sikoki et al, 1990). The correlation between these parameters was stronger in male specimens than females. Endogenous periodicities of physiological processes are said to be responsible in part for seasonal reproductive patterns (Sundararaj, 1978). Some proximate environmental factors that act as cues for the approaching favourable season for reproduction impinge on the exteroceptors, and through them the central nervous system, pituitary and the gonads are affected.

Thus, in the males, during the months of March and April when the majority of the fish were in mid recrudescence, UDP-GT activity levels were relatively low. The pattern was similar in females except that the activity levels were relatively lower.

The third paper reported on the role of environmental factors on gonadal recrudescence maturation and spawning. We discovered that both gonadal and breeding activity in the common carp were closely attuned to changes in environmental variables (Sikoki and

Ejike, 1997). As temperature and mean hours of sunshine increased, a rise in spermatogenic activity was observed. Spawning occurred in March as the temperature of the water attained its maximum value of 24.75°C, and the rains commenced.

During the second breeding period in July, maximum temperature was still sustained but rainfall values had just attained their maximum level. Although the roles of temperature and sunshine in reproductive cycling is relatively clear, the influence of rainfall on peak reproductive activity is not so clear. However, Swingle (1965) suggested that the mechanism by which rainfall induces spawning may be related to the dilution of certain inhibitory factors in the water.

The final paper from my PhD thesis was an invited paper presented to the Annual Meeting of the American Society of Toxicology (New Orleans, LA) 1986. It examined the mechanisms by which hepatic UDP-Glucuronyl Transferase (UDP-GT) is inhibited during gonadal maturation. We found inhibition of the activity of this enzyme in the presence of elevated plasma sex steroid concentrations (Sikoki et. al, 1986).

Taken together, our work showed that biotransformation activity in the liver varies not only between the seasons (environment) but with the reproductive status of the animal. While the seasonal oscillations act as time signal in fish for reproduction, the biotransformation enzymes carryout reactions which control the levels of many endogenous compounds including the sex steroids.

5.2. Post Doctoral Contributions

Upon my return to the country, I identified three major areas of research in respect of fisheries production and stock management/conservation. These are:

- Enhancement of Aquacultural Production;
- Environmental Pollution and Degradation; and

- Assessment of fish stocks.

Consequently, most of my research efforts in collaboration with my research associates and PhD students have been directed at these areas.

5.2.1. Enhancement of Aquacultural Production

Current aquacultural practices in Nigeria emphasize the catfishes and tilapias. However, while catfishes do not breed all year round and so fingerling supply is largely restricted to the rainy season months, tilapia has the opposite problem of uncontrolled reproduction; leading to stunted growth. In order to solve these problems, we designed research projects aimed at:

- (i) ensuring year-round production of catfish fingerlings;
- (ii) controlling uncontrolled reproduction of tilapia using anabolic hormones;
- (iii) enhancement of growth through breeding experiments; and
- (iv) studies on the biology of potential aquacultural fish species.

5.2.1.1. Year-round Production of Catfish Fingerlings.

The catfishes, *Claria gariepinus* and *Heterobranchus* spp are the most popular candidates for aquaculture today in Nigeria. Unfortunately, inadequate supply on account of their seasonal breeding pattern has severely hampered their culture. My PhD student and I, worked on this problem using a combination of nutritional, environmental manipulation and brood stock management practices to produce off-season fingerlings.

In our nutrition experiments using *Claria gariepinus*, we demonstrated that feeding/maintaining the broodstock on a high protein diet and mimicking the environmental conditions

prevalent during their breeding season under controlled conditions ensured natural spawning of the fish off season (Ibim and Sikoki, 2009).

The spawning act can be further enhanced when pituitary extract is administered to ripe females. Unfortunately, this practice is not standardized and various fish farmers hitherto administered the extract half hazardly. Again, my research associates and I worked on the standardization of the practice and reported our results at the Triennial Conference of the World Aquaculture Society in Buena Vista, Florida, USA (Omozusi et al., 2001). Our work showed that a priming dose of the extract, half the decisive dose given 12 hours prior gave the best results.

5.2.1.2. Use of Anabolic Hormones for Production of All-male Tilapia and Growth Enhancement in Catfish.

The tilapia, *Oreochromis niloticus* has a high fecundity; breeding at least once every 4 to 6 weeks and a high degree of parental care which ensures survival of the progeny. This efficiency of reproduction precipitates overcrowding, competition for food, stunted growth and ultimately poor yield.

In our studies using two strains, red and grey tilapia, we were able to achieve 97% and 96% males respectively through feeding the fish with the androgen, 1700 – methyltestosterone (Ekwu & Sikoki, 2001). This work has therefore eliminated the problem of undesirable reproduction, thereby controlling over – population and ultimately increased yield.

In a similar work, Sikoki and Eneh (1993) used the same androgenic hormone, 1700-methyltestosterone to enhance growth and food utilization in the African catfish, *Claria gariepinus*. Methyl-testosterone and other anabolic hormones generally speed up metabolic reactions and increase growth rate and feed conversion efficiency in treated fish.

We have also used non – conventional feeds such as *Mucuna* spp (Sikoki and Komi, 2012) with a view to sparing animal protein for human consumption and reduce the cost of feeding fish. The results obtained were quite encouraging, as the growth rates in the test and control groups were comparable.

5.2.1.3. Breeding Experiments for Selection of Growth Enhancement Traits.

Through genetic selection, useful traits in a fish can be selected for either to enhance growth, general appearance or hardness. We therefore first determined sources of variation in growth parameters in *Tilapia guineensis* (table 10). Using this information we were able to demonstrate that heritability of total length (0.35) was moderate and hence can be improved through mass selection experiments (Sikoki and Uka, 2012). Body weight however, had a very low heritability value (0.03) and so cannot be improved through mass selection.

As a follow up of the above study, we looked at the effects of salinity of larval dimensions of *T. guineensis* and found that the heaviest and largest larvae were hatched in 12 ppt saline water. This finding is of significant practical importance as it can be used for the efficient and economic production of *T. guineensis* seeds.

5.2.1.4. Studies on Environmental Contamination and Degradation.

When I transferred my services to the University of Port Harcourt, my interest shifted to issues relating to fisheries depletion on account of industrial activities, particularly oil. Consequently, my PhD students and I devoted considerable attention to:

- direct effects of oil spills;
- the effects of drilling muds and dredge spoils;
- the effects of dispersants on fish communities; and

- exploration activities involving dredging.

Table 10: Sources of variation in growth parameters of *T. guineensis*.

Parameter/Components	Total Length		Body Weight	
	Value	%	Value	%
Genetic Variance (VG)	0.655	55.3	0.023	3.3
Environmental Variance (VE)	0.53	44.7	0.67	96.7
Genetic effect	P<0.01		P<0.05	
Variance due to Dam (VD)	0.41	62.6	0.012	52.2
Variance due to Sire (VS)	0.21	37.4	0.011	47.8
Total variance (VT)	1.185	100	0.693	100
h^2 (Dam)	0.55	55	0.03	3.0
h^2 (Sire)	0.69	69	0.04	4.0
H^2	0.35	35	0.03	3.0

The direct effects of oil spills are largely known but details of their effects on various stages of fish, bioaccumulation patterns and pathology have been the thrust of our work.

Sikoki and Enajekpo, (2000) found that the red blood cell count (RBC) and haematocrit values of oil exposed fish were significantly lower than those of control fish. Furthermore, moisture content and percentage protein of the carcasses of exposed fish were also significantly lower.

However, the adverse effects of dredge spoils and drilling fluids are even of greater concern as these are produced/used regularly in oil exploitation activities. Before now, oil based drilling fluids were commonly used but they were replaced with

water based ones which the oil companies claimed were not harmful to the environment. Vincent – Akpu, my former PhD student and I investigated this claim by the oil companies and found that at high concentrations, the drilling fluid – XP – 07 caused fish mortality and damaged their gills (Vincent – Akpu et. al, 2010).

The use of chemicals for dispersing spilled oil is another widely used method which has not been properly investigated. We therefore set out to determine the environmental effects of a dispersant, Goldcrew commonly employed in the Niger Delta. We discovered that this dispersant increased the toxicity of Bonny light crude oil by as much as 57 times, thereby causing increased fish kills. In addition, fish exposed to the dispersant showed varying degrees of histopathological changes in their gills, liver, muscles and brain tissues (Sikoki and Lelei, 2012).

Dredging of river basins is another widespread practice employed by oil companies and others either to enable them to transport materials or for the mining of sand. My PhD student and I studied the impact of dredging on the fisheries and water qualities variables in the upper Nun River between 2009 and 2011. Aside the obvious changes this activity caused on the hydrodynamics of the river – flow regime and depth profile, it resulted in increased turbidity and the values of NO_3 , NO_2 , SO_4^{2-} and BOD_5 .

With respect to the fisheries only 23 species were recovered from the dredged site as against 29 from the undredged area. In addition, the growth patterns and condition factors of fish species were generally lower than those from the undredged (Sikoki and Seiyaboh, Unpublished).

Sikoki and Babatunde (2010) reviewed trace metal contamination of marine resources following dredging of the Warri River in Delta State. The data revealed that dredging caused several hundred fold increase in Lead, Zinc, Copper, Iron,

Chromium, Maganese and Cadmium concentrations in the water. In the biota, both fin and shellfish tissues accumulated considerable amounts of the above metals with values higher than FEPA limits.

5.2.1.5. Limnological and Stock Assessment Studies.

I have devoted the greater part of my academic career to studies on the limnological characteristics and assessment of fish stocks in various water bodies. This is because knowledge of the state of fish stocks and the aquatic environment is fundamental to sustainable exploitation of a fishery. The over – exploitation of a particular fish species or particular size group will lead to serious depletion of stock. On the other hand, under – exploitation may cause depletion of food organisms due to high population density, resulting in migration of a large number of individuals to other suitable sites.

Thus, for management purposes, a fish biologist is concerned with two major factors, viz:

- (i) the size of the stock, that is the number of individuals in a given area; and
- (ii) assessment of optimal fishing activity, that is the maximum number of fishes that can be harvested without affecting the population size.

Given the dearth of information in the two factors in many of our numerous water bodies, I secured a research grant from the Dutch government (International Cooperation) in 1991 to undertake an assessment of Shiroro lake, in Niger State. Later in 1997, I secured World Bank assistance for the same purpose in the Niger Delta Basin. I was appointed the same year as the Joint National Coordinator, South of the Nationally Coordinated

Research Project of the National Agricultural Research Project (NARP).

In the course of these studies, I have undertaken Limnological/stock assessment exercises in the following 17 water bodies nation – wide and elsewhere.

- (i) Shiroro Lake, Niger State, Nigeria.
- (ii) River Jamieson, Delta State, Nigeria.
- (iii) Burrow Pits, Rivers State, Nigeria.
- (iv) Brass River Estuary, Bayelsa State.
- (v) Umuoseriche Lake, Abia State.
- (vi) Onu-Iyi Ukwu Stream, Imo State.
- (vii) Oguta Lake, Imo State (on-going)
- (viii) Andoni River, Rivers State.
- (ix) New Calabar River, Rivers State.
- (x) Nun River, Bayelsa State.
- (xi) Orashi River, Rivers State (on-going)
- (xii) Bonny River Estuary, Rivers State.
- (xiii) Epie Creek flood plains, Bayelsa State.
- (xiv) Cross River Estuary, Cross River State.
- (xv) Imo River, Imo State.
- (xvi) Andoni Mud flats, Rivers State.
- (xvii) Lake Michigan, USA.

A general feature of most of the lakes and rivers that we have studied is their high productivity but most of them face increasing problems of pollution, dams that restrict fish spawning migrations and poor management (Sikoki and Veen, 2003; Ekwu and Sikoki, 2010; Sikoki et. al, 2009. Yakubu et. al, 1998). Figure 6

shows water quality parameters in Shiroro Lake with desirable levels for fish production in the tropics (Sikoki and Veen, 2003).

Similarly our studies on plankton densities showed ranges of 67 to 26,000 org/L for phytoplank and 67-733 org/L for zooplankton in lower reaches of the Nun River (Yakubu et. al, 1998).

In the Cross River Estuary, Ekwu and Sikoki (2010) reported temporal variations but rated the system as being high in primary productivity.

1.	TOTAL HARDNESS (mg/L CaCO ₃) Shiroro Lake Desirable Range	5 - 30 20 - 30
2.	ALKALINITY (mg/L HCO ₃) Shiroro Lake Desirable Range –	22 - 83 20 - 300
3.	DISSOLVED OXYGEN (mg/L) Shiroro Lake Desirable range	22 - 120 5 and above
4.	CONDUCTIVITY (μ mhom/cm) Shiroro Lake Desirable range	3.8 – 10.0 Variable
5.	TEMPERATURE (°C) Shiroro Lake Desirable range	20.1 – 34.0 25 – 32
6.	NITRATE NITROGEN Shiroro Lake Desirable range	9.0 – 86.0 9.8 – 49
7.	PHOSPHATE – PHOSPHORUS (mg/L) Shiroro Lake Desirable range	5 - 212 3.2 – 630
8.	pH Shiroro Lake Desirable range	5.9 - 7.0 6.5 - 90

Fig 6: Comparison of some water quality parameters in Shiroro Lake with desirable levels for fish production in tropical lakes.

Unfortunately, the results of our studies on the fisheries of the various water bodies indicated over-exploitation and consequent stock depletion. We provide below summary of our stock assessment results.

- (i) **Shiroro Lake:** Data regarding the estimated total standing crop of fish using the Morpho - Edaphic Index (MEI) approach revealed that some 293 mt of fish are produced in the lake each year. The total fish catch per year based on a survey of fishermen/canoes and the average fish caught per fisherman/canoe gave approximately 298 mt.

Theoretically therefore, it can be concluded that all the fish produced in the lake are taken each year (Sikoki et. al; 1997). However, this is not the case as fish migrate from the numerous tributaries flowing into the lake. However, the results clearly indicate that the fish populations are severely over exploited.

- (ii) **The Nun and the Andoni River Systems:** Our work in these two systems emphasized natural and fishing mortality, and exploitation ratios. The exploitation ration (Eopt) assesses whether or not a stock is overfished on the assumption that the optimal value of E is 0.5. The use of this value itself is based on the assumption that the sustainable yield is optimized when F (fishing mortality) = m (Natural mortality). In the Nun River, we found three species, *Synodontis clarias* (0.54), *sphraena*

barracuda (0.54) and *Schilbe mystus* (0.67) exceeding the optimal value for sustainable yield (Sikoki and Abowei, 2002). These populations therefore stand the risk of over exploitation if urgent measures are not taken to protect the fishery (Table 11).

Data from our work in Andoni River presented in table 12 show a much more worrisome picture. Out of eleven species we evaluated in this River, a total of five showed exploitation rates exceeding the optimal for sustainable yield (Francis et. al; 2007). When the values were expressed as percentages, death due to fishing operations ranged between 46 and 68% (8 fishes) while three fishes recorded values between 20 and 30 percent.

Table 11: Estimated exploitation rates and ratios from total natural and fishing mortality data in the Nun River.

Fish Species	Z(yr ⁻¹)	M(yr ⁻¹)	F(yr ⁻¹)	E	U(yr ⁻¹)	E%
1. <i>Clarotes laticeps</i>	1.2	0.87	0.33	0.27	0.29	27
2. <i>Alestes baremose</i>	1.6	1.43	0.17	0.11	0.04	11
3. <i>Alestes dentex</i>	1.1	0.63	0.49	0.43	0.43	43
4. <i>Distichodus rostratus</i>	1.5	0.97	0.52	0.35	0.19	35
5. <i>Synodontis schall</i>	2.1	1.82	0.30	0.14	0.28	14
6. <i>Synodontis clarias</i>	1.2	0.57	0.67	0.54	0.29	54 *
7. <i>Synodontis membranaceus</i>	1.5	1.28	0.22	0.15	0.09	15
8. <i>Grathonemus tamandua</i>	1.3	0.93	0.40	0.30	0.31	30
9. <i>Schilbe mystus</i>	1.4	0.55	0.87	0.67	0.58	67 *

10. *Sphyraena barracuda*

1.6	0.79	0.81	0.54	0.69	54 *
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Key: Z = Total mortality; m = Natural mortality,

E = Exploitation Ratio; U = Rate of Exploitation

F = Fishing mortality; E% = Exploitation Ratio

Table 12: Exploitation ratios of fish species from the Andoni River System in 1999.

S/N	Fish Species	Exploitation Ratio (E)	Exploitation rate %
1.	<i>Chrysichthys nigrodigitatus</i>	0.250	25.00
2.	<i>Ethmalosa fimbriata</i>	0.524	52.40
3.	<i>Eucinostomus melanopterus</i>	0.459	46.00
4.	<i>Galeoides decadactylus</i>	0.200	20.00
5.	<i>Uisha africana</i>	0.554	55.40
6.	<i>Liza grandisquamis</i>	0.456	46.00
7.	<i>Lutjanus goreensis</i>	0.514	51.40
8.	<i>Pamadasys jubelini</i>	0.529	52.90
9.	<i>Pseudotolithus elongatus</i>	0.681	* 68.14
10.	<i>Sarotherodon melanotheron</i>	0.315	32.00
11.	<i>Tilapia guinensis</i>	0.482	48.20

- (iii) **The Brass and Bonny Estuaries:** These two estuaries located in Bayelsa and Rivers State respectively are centres of high anthropogenic activities including oil and gas operations and fishing. In the Brass estuary, Sikoki and Hart (1999) carried out a frame survey of fishing communities and fish stock assessment. We recorded 22 species of fish belonging to eleven families.

The estimated mean catch per boat was 160.40kg of fish with clupeids accounting for 52.62% of the catch. The estimated annual fish production was 610.93 mt or 1.19 metric tons per km². The fisherman density was 9 persons per square kilometer; nearly five times the recommended density of two persons per square kilometer. This situation clearly indicates that the area is being over – exploited.

Although our stock assessment work at the Bonny estuary is ongoing, we studied aspects of the reproductive Biology of *Mugil cephalus*. The fish attained first sexual maturity at 17.0cm TL at age 0.5 yr. The maturation ratios were: males (0.697) and females (0.646). These values indicate that the fish is not stunted in this estuary as low values are indicative of stunted growth. Consequently, if well managed and exploited, this estuary can support sustainable fisheries.

- (iv) **Epie Creek flood plains and River Jamieson:** In these systems, we elucidated the composition and aspects of the biology of selected fish species of commercial importance.

At the Epie Creek flood plain, we recovered twenty six fish families containing 63 species from the creek, 43 from a lake in the flood plains and 36 from the swamps. A significant contribution from this study was the discovery for the first time in the Niger Delta, the presence of the catfish, *Clarias albopunctatus*, sub genus *Clarias* (Clariodes), (Tengels, 1986) (Elakhame and Sikoki, 1996).

Similarly, at the River Jamieson, we recovered fifty five species (Ikomi and Sikoki, 1998). Our work here also elucidated aspects of the biology and ecology of *Brycinus nurse* (Ikomi and Sikoki, 2001) *Brycinus nurse* (Ikomi and Sikoki, 2001) and *Brycinus longipimis* (Ikomi and Sikoki, 2003).

- (v) **Umuoseriche Lake and Onu – Iyi Ukwu Stream:** Our contributions in these two systems were in the areas of the biology of selected fish species and fish communities respectively.

At the Umuoseriche Lake, where we studied the biology of *Labeo senegalensis*, we obtained three age groups – 0+, 1+ and 2+ with length-at-relative age of 195, 265 and 310mm respectively. (Anene and Sikoki, 1996). These results were at variance with data from Kainji lake where Blake and Blake (1978) reported six age groups. The implication of these findings is that this species does not live as long as their counterparts in Kainji Lake.

In the Onu – Iyi Ukwu stream, we produced a checklist of fish assemblages (Sikoki et. al; 2009) and the spatial and temporal variation of physico-chemical variables of the water (Sikoki and Anyanwu, 2010).

- (vi) **Imo New Calabar and Cross Rivers:** In these river and systems, our major contributions have been in

areas of establishing seasonal variations in plankton, benthic communities and physico-chemical variables. In the Imo River, Sikoki and Zabbey (2006) recorded poor benthic community with only 14 representative species and low margalef diversity values of 0.362 to 1.086.

Similarly, in the Cross River system, we recorded substantial algal blooms during the dry season months which coincided with massive mortality of *Heterotis niloticus* (Ekwu and Sikoki, 2010). Ekeh and Sikoki (2002 and 2004) reported on the status and seasonal variability of phytoplankton and physico-chemical parameters in the New Calabar River.

- (vii) **Lake Michigan:** My work in this lake was undertaken during my MSc programme in the late 1970s and it is highly significant in my academic career as it introduced me into the subject of environmental studies. We investigated the effects of depth on the temporal and spatial distribution of a burrowing and deposit – feeding macrobenthic invertebrate, *Pontoporeia hoyi*. Among amphipods, it believed to be exceptional because it migrates extensively into the pelagic zone at night and is stenothermally restricted to only cold, deep and oligotrophic temperate lakes.

We discovered that this animal was most abundant at the interval 30 – 40m depth interval (Sikoki and Lagler, 1986). A possible explanation for its low densities at shallow waters (10 – 20m) in the lake is probably due to proximity to sources of organic enrichment.

6.0 CURRENT RESEARCH

My current research is centered on:

- ✚ evaluation of pollution trends in the coastal waters of Nigeria;
- ✚ assessment of aquatic ecosystem integrity in the Niger Delta basin; and
- ✚ studies on utilization of nuisance aquatic resources for wealth creation.

For the evaluation of pollution trends in the coastal waters, we secured a grant from the INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA for the deployment of nuclear techniques for the assessment of contamination of coastal waters. I am also the National Coordinator of this project, RAF/7008 and 7009 in Nigeria. Under it we have four aquatic monitoring stations along the Nigerian Coastline as follows:

- (i) South – Central I Station – Centre for Marine Pollution Monitoring and Seafood Safety University of Port Harcourt.
- (ii) South – Central II Station – Koluama, Bayelsa State.
- (iii) South – West Station – Nigerian Institute of Oceanography and Marine Research, (NIOMR), Lagos.
- (iv) South – East Station – Institute of Oceanography, University of Calabar, Calabar.

At the Centre for Marine Pollution Monitoring and Seafood Safety at this university where I am also the Director, we are currently undertaking the following activities:

- Reconstruction of pollution data dating back more than 70 years;
- taking of pollution stocks of radionuclides, trace metals, organochlorines and nutrients; and
- determination and mapping of pollution “hot-spots” in the coastal waters.

We have already trained two of my PhD students each in Radiometry and Sediment core dating in off-shore institutions in Germany, Brazil, Morocco and Egypt in trace metal and organochlorine pollution analysis in Egypt and Spain under the IAEA – FGN Projects RAF/7008 and 7009.

6.1 Pollution Trends

Following these developments, we now have preliminary data on radioactivity concentrations in the sediment and selected seafoods from the Niger Delta basin.

In the sediment of the Bonny estuary, radioactivity levels ranged from below detection levels to 812 Bq kg⁻¹ for ²³⁸U; 370 to 849 Bq Kg⁻¹ for ²³²Th; 175 to 484 Bq Kg⁻¹ for ²²⁶Ra; 1032 to 9800 Bq Kg⁻¹ for ⁴⁰K and <39 Bq Kg⁻¹ to 67 Bq kg⁻¹ for ¹³⁷Cs. The ²²⁶Ra/²³⁸U ratio was less than one in all the locations, indicating that there were anthropogenic inputs of ²³⁸U (Babatunde and Sikoki, 2012). Furthermore, the activity levels of radionuclides we measured were higher than those reported elsewhere in the Niger Delta and global averages.

The sediment ages determined through ²¹⁰Pb Constant Rate of Supply (CRS) and Constant Initial Concentration models revealed that average annual sediment mass accumulation rate in the

Bonny estuary was influenced by environmental perturbations in 1971, 1975, 1979, 1987, 1995, 2003, 2005 and 2008 Fig 7. These periods correspond to increased oil and urbanization activities in the Niger Delta.

The average sedimentation rate in the Bonny estuary was 0.16cm yr^{-1} . However, while sedimentation rate increased by only 5 percent between 1952 and 1957, it increased by 40 percent between 2006 and 2008. It is predicted that sediment rates as high as 4.226 cm yr^{-1} are likely by 2020 resulting in complete reclamation of shallow areas in the next 100 years (Babatunde & Sikoki, 2012) Fig 7.

Our data also showed steady increases in pH values and heavy metal contamination of the sediment of Bonny estuary from 1971 with peak values occurring in 1979, 1987, 1995, 2005 and 2008 a period corresponding to heightened oil and gas production and urbanization in the Niger Delta Fig 8.

We have also analysed organic matter (OM) content in the inter-layers of the sediment profile in the Bonny estuary. Two peaks corresponding to increased OM in 1940 and 1971 as a result of high decompositional activities were observed. The 1940 peak may have been as a result of organic matter input from early developmental activities in the Niger Delta area and the second peak in 1971 corresponds to the oil boom period which may have resulted to increased input of organic matter from oil production activities (Omos and Sikoki, 2012).

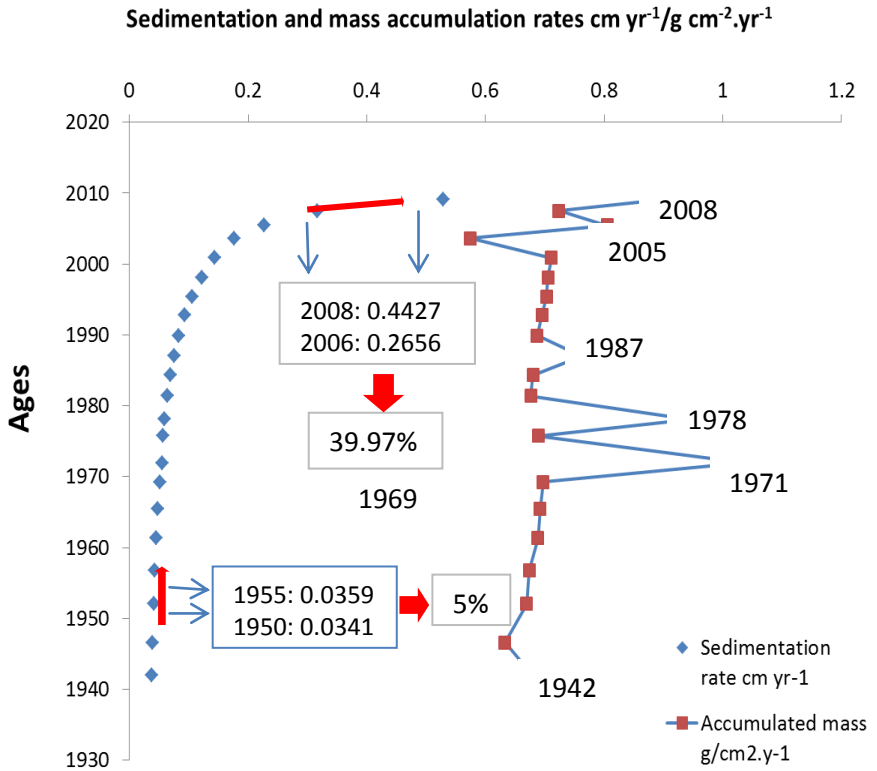


Fig. 7: Sediment accumulation rates and sedimentation rates in the Bonny estuary of the last 66 years.

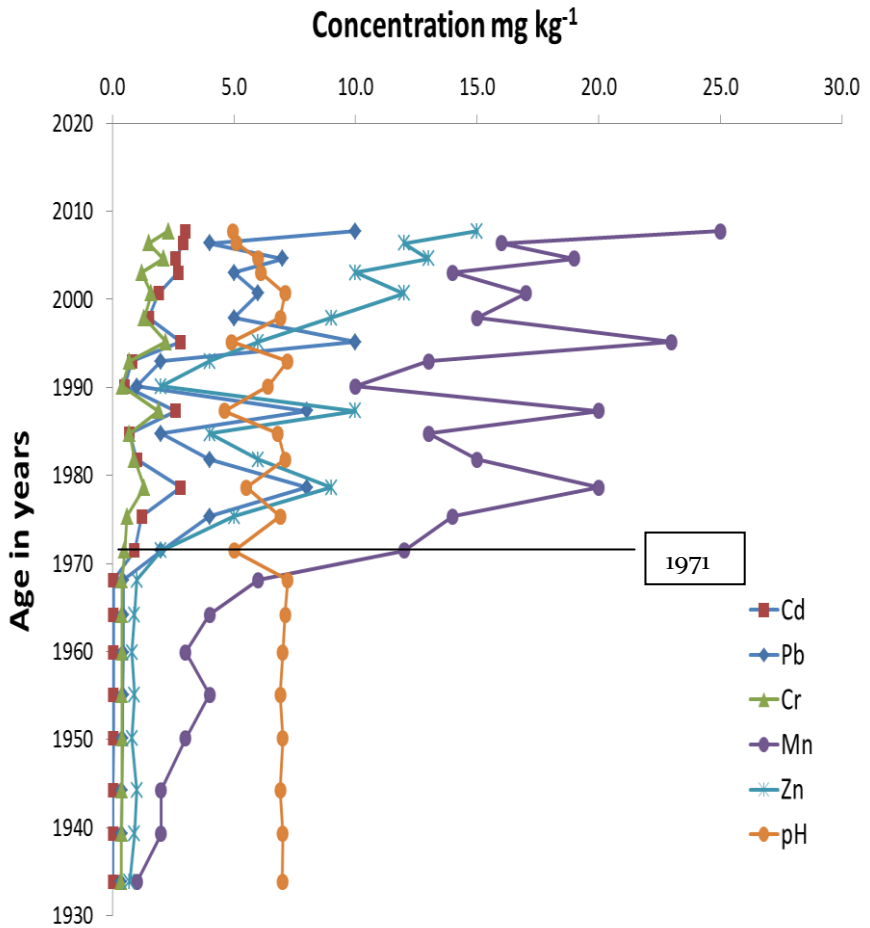


Fig. 8: Heavy metals profile and pH of core sample from Bonny estuary over 74 years.

6.1.1 Seafood Safety

Radioactive doses received by humans from consuming fish showed that highest and least effective doses of $1757\mu\text{Sv yr}^{-1}$ and $656\mu\text{Sv yr}^{-1}$ can be delivered by the water snail, *Ergeria radiata* and *macrobrachium spp* (shrimp) respectively. These doses are higher than those recommended as safe by the ICRP and UNSCEAR (Babatunde and Sikoki, 2012) Table 13.

Table 13: Effective dose to the adult public due to consumption of selected seafood from the Bonny estuary.

Samples	Common name	Consumption rate (kg y ⁻¹)	% contribution by seafood	Effective dose (μSv y ⁻¹)		
				Low	Upper	limi limit
Mollusc						
<i>T.fuscatus</i> <i>var.radula</i>	periwinkle		25	12.1	744	1203
<i>T.fuscatus</i> <i>var.fuscatus</i>	periwinkle		25	12.8	772	1266
<i>Ergeria radiata</i>	clam		25	17.9	113	1787
<i>Thais sp</i>	dog whelk		25	10.5	661	1085
<i>G. gasar</i>	oyster		25	9.3	579	927
Crustaceans				6.2		
<i>Macrobrachium sp</i>	shrimp		25	9.2	431	656
<i>Penaeus notialis</i>	cray fish		25	6.6	571	947
<i>Portonus sp</i>	crab		25	15.4	431	691
Fin fish						
<i>Ethmalosa fimbriata</i>	bonga fish		25	28.3±1.5	845	1532

6.2 Aquatic Ecosystem Integrity (Health)

This study is born out of the realization that 48 percent of fish species in the IUCN Red List are freshwater inhabitants. The continued degradation therefore and persisting claims by fishers of declining catches informed the work.

Consequently, my research associate, Mr Osunkpe and I have designed a project to evaluate the ecological integrity of the Lower Orashi River employing bioassessment techniques. It is hoped that the results of the study would empirically determine the claims of environmental in this and other water bodies in the Niger Delta.

6.2.1 Utilization of Nuisance Aquatic Resources for Wealth Creation.

Water hyacinth, *Eichhornia crassipes* is a free floating aquatic that constitutes a nuisance to fishing and transportation activities in many river communities. Due to its high growth rate, the plant outpaces all efforts directed at containing it.

Consequently, my research associates and I have designed a programme for utilizing it to produce crafts and furniture. Our major research effort in this regard concerns efficient and cost effective means of harvesting and processing the plant. We have already made an assortment of crafts from the plant and are exploring ways of commercializing it for youth empowerment through job creation.

7 FUTURE RESEARCH

Our plans for the future include:

- the development of a web-based GEORAD for the archiving of pollution stocks; and
- the establishment of a Coastal Resources Centre at the University of Port Harcourt.

The Nigerian Information Technology Development Centre has shown interest in the GEORAD project and we have already submitted a proposal to it for funding.

With regard to the Coastal Resource Centre, the National Action Plan (NAP) Committee of the Guinea Current Large Marine Ecosystem Project has invited us to submit Concept Notes. The main objectives of this project are to establish a Centre that would continuously monitor coastal resource status, identify possible marine Protection Areas (MPAs) and establish a Coastal Resource Park for the benefit of host communities.

8 RECOMMENDATIONS

The key to a healthy fisheries sector is establishing good fisheries governance which involves:

- Control over fishing fleets;
- Enforcing limits on catches;
- Stakeholder participation;
- Technology transfer; and
- Community awareness.

At a cross – sector level, it also involves the promotion of economic diversification, and alternative livelihoods for fishers and fishing communities to reduce pressure on over-exploited

resources. Without limiting access, the economic rents and benefits from a fishery would be dissipated among increasing numbers of fishers which would lead to increase in fishing effort and result in increased resource depletion.

Furthermore, there is need to protect inshore and coastal fisheries on which the poor and subsistence fisher depend. There is also the need to eliminate subsidies which contribute to over – capacity and subsequent depletion of fish stocks. Based on the above, the following specific recommendations are made.

8.2 Fisheries monitoring, Control and Surveillance.

Appropriate monitoring, control and surveillance are necessary for effective fisheries conservation and management. Such programmes should ensure that government policies and laws are implemented, and appropriate enforcement measures taken to ensure compliance.

8.3 Protection of Fish Stocks from Environmental Degradation.

There is need for stricter monitoring of pollution, protection of nursery and feeding grounds, and general habitat improvement schemes.

8.4 Adoption of Traditional Approaches to Fisheries Conservation and Management.

In many traditional communities, communal control of fishery resources with a wide range of conservation and management oriented measures are practiced. Considering the mixed results that have accompanied the introduction of other measures, it is opined that these traditional approaches hold greater promise for voluntary regulation and sustainable exploitation of fisheries resources.

It is therefore suggested that government should transfer the custody of fisheries resources to indigenous communities through the insurance of a special permit which would allow the affected community to allocate fishing rights to its members for a fee during designated seasons.

8.5 Allocation of Resources by Government.

In order to stem the rapid depletion of fishery resources, it would be necessary in some situations for government intervention to allocate the resources. However, one possible fallout from such an approach would be the fisher who would be displaced.

Some developing countries have successfully adapted compensation schemes to assist such fishers but in the long term, such a scheme would require programmes that would provide alternative employment opportunities for fishers.

8.6 Reduction of Waste.

On a world – wide basis, only about 20 percent of fish caught is lost due to spoilage and poor handling practices. In Nigeria, some estimates indicate up to 50 percent loss due to these factors. Suggested strategies to reduce losses include:

- research, education and improved extension services in post-harvest technology; and
- introduction of more practical and economic post-harvest technologies for artisanal fishers.

8.7 Introduction of Value added Products

Adding value to fishery products intended for export purposes have the potential of creating employment and earning more foreign exchange. These measures would impact positively on protecting fishery resources.

8.8 Enhancement of Extension Services.

Extension services are severely limited in the Agricultural sector in general. Consequently, extension workers are not only poorly paid but transportation facilities are also grossly inadequate.

In Asia, where extension services are said to be most successful, it is observed that technical services available and educational standards are generally high (FAO, 1995). The provision therefore of a special revolving fund to ensure basic extension programmes is highly recommended.

9.0 CONCLUSIONS

Mr. Chairman, distinguished guests, Ladies and gentlemen, I have spent the last 90 minutes or so describing my modest contributions to fisheries research in Nigeria which informed the University of Port Harcourt to elevate me to the rank of Professor in Fishery Biology back in 2001. I am indeed profoundly grateful to the authorities of the University for this honour.

However, let me conclude by saying that the recognition of the concept of exhaustibility was not the direct outcome of either theoretical or scientific investigations. Instead, they represent the forced acceptance of new ideas after established ones had collapsed.

Finally, fisheries Biologists and managers should see themselves as evaluators of knowledge from diverse disciplines and sources including

- Sociology;
- Economics;
- Politicians; and
- Interest groups/individuals and adopt an integrated approach to fisheries management/conservation practices.

THANK YOU

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CITATION ON



Professor Francis David Sikoki,
FFs, UPF Ambassador of Peace
100th Inaugural Lecturer of the
University of Port Harcourt

Mr Vice Chancellor Sir, distinguished guests, Ladies and Gentlemen. It is my honour and privilege to read the citation of my colleague, friend and brother with whom I have associated closely for some 30 years now. During this period, I have had the opportunity of relating with him both professionally and socially.

Professor Francis D. Sikoki became a great scholar and teacher of international repute not by accident but by a conscious desire and painstaking determination to pursue a career in teaching, which he has been doing for the past 31 years now. This is because in 1973, after completing his Advanced School Certificate Course at the Baptist High School, Port Harcourt, he was one of three students selected by the Rivers State Government to undergo a course of study in Radiography in the United Kingdom. He turned down the offer on the grounds that he wanted to become a Teacher, not a Radiographer. His decision made the then Principal Medical Officer (PMO), Ministry of Health, Port Harcourt in utter disbelief of this young man's decision to remark thus: "I have not seen such manifestation of naivety all my life. May the good Lord bless you." With that determination, the young Francis set out to accomplish his goal of becoming a Teacher!

Born some 60 years ago to the family of Mr and Mrs David T. Sikoki of Angiama in Southern Ijaw Local Government Area of Bayelsa, Francis had his primary education in various schools in the old Eastern Region from 1957 to 1963 where his father served as a Court Registrar. From there, he proceeded to the Niger Grammar School and later to Baptist High School both in Port Harcourt for his Secondary and Higher School education.

Thereafter, he proceeded to the United States of America for his tertiary education. He attended Northland College, Wisconsin and the prestigious University of Michigan, Ann Arbor from 1974-1979. He later attended the University of Jos and the Oregon State University, Corvallis, Oregon, USA for his doctoral

degree from 1983 to 1987. During this period, he received several awards scholarships and fellowships including:

- Citation in the Dean's list for outstanding academic performance; 1975
- Academic Achievement award, Kiwanis of Grand Forks, USA 1980.
- Letter of commendation for maintenance of clean and healthy Environment, Unijos – 1986
- Academic Noble Award of the Institute of Administration in Nigeria. – 2008
- Fellow, Institute of Administration, Nigeria - 2008
- Fellow, Fisheries Society of Nigeria - 2010
- Rivers State Government Scholarship - 1974–1979
- Federal Government of Nigeria Scholarship – 1980
- University of Jos Study Fellowship - 1984–1985
- Member, Board of the American Biographic Institute- 2007 to date

Professor Sikoki returned to Nigeria in September in 1980 and after his National Youth Service, began his teaching career as an Assistant Lecturer in 1981 at the University of Jos. He left Unijos for the Federal University of Technology, Minna in 1988 but retained his position at the University of Jos as a Visiting Lecturer for two years. In August 1993, Professor Sikoki transferred his services to the University of Port Harcourt where he was elevated to the rank of Professor in 2001.

His well deserved elevation to this rank is the manifestation of an impressive scholarly career in the University system with an international perspective. First, from January, 1984 to May, 1985, he was visiting Assistant Professor at the Oregon State University. His research work while there elucidated the sequence of events (endocrine and enzymatic) leading to the spawning act in the common carp, *Cyprinus carpio*. The

significance of this work earned him an invitation to the annual conference of the American Society of Toxicology in 1986 to present a paper.

His other scholarly works include:

- Over eighty published works in reputable Journals and Conference Proceedings;
- Six books;
- Five chapters in books; and
- Several monographs/technical reports.

Professor Sikoki also successfully combined his research activities with a productive teaching/students supervision programme in the University. In the course of his 32 year career, he has produced 18 PhD holders among whom are two Professors – one being a Deputy Vice Chancellor in a Nigerian University. He has also supervised 32 MSc students and over 60 BSc holders. Many of his former students currently hold high positions of authority in Government and in the organized private sector.

Professor Sikoki has held several administrative positions in the Nigerian University system over the years.

- (i) Member, Governing Council, Federal University of Technology, Minna (1991–1993).
- (ii) Member, Governing Council of Niger Delta University, Wilberforce Island (2005–2012).
- (iii) Head, Department of Animal Production and Fisheries, FUT, Minna (1991 – 1993)
- (iv) Head, Department of Animal and Environmental Biology, Uniport (1997 – 1999)
- (v) Coordinator, Post Graduate Programmes in Fisheries and Hydrobiology (1999 – date)
- (vi) Member, Board of Institute of IAR & D, Uniport (2007 – 2009)

- (vii) Chairman, Department Laboratory Manuals Committee (2012 to date)
- (viii) Chairman, SLT, University of Jos (1986 – 1988)
- (ix) Director, Centre for Marine Pollution Monitoring and Seafood Safety (2012 to Date)
- (x) Chairman, Housing Committee, Uniport (2010 to date)
- (xi) Member, Council Committee on Honourary degrees (2003 to 2005)
- (xii) Chairman/Member of Several University-wide Ad-hoc Committees at FUT, Minna; Unijos and Uniport.
- (xiii) Faculty Coordinator, Community Service Programme (2000 – 2002)
- (xiv) Member Capital Projects Committees (1998 to 2000)
- (xiv) Member, World Bank Project Implementation Committee (FUT, Minna, 1990-1993)

His contributions to national development are equally very impressive. He has served as a member of four NUC Accreditation Panels including:

- University of Ibadan;
- Federal University of Technology, Akure;
- Tafawa Belewa University, Bauchi; and
- Usman Dan Fodio University, Sokoto.

He has also chaired two NUC Resource Verification Panels to:

- Anambra State University, Uli, and
- Federal University of Technology, Owerri.

Some of his other national and international assignments include:

- (i) Membership of a Fisheries Development Mission of the World Bank Assisted NS/ADP in 1991;
- (ii) Membership of a World Bank Review Mission of the National Agricultural Research Project (NARP) in 1995;

- (iii) Chairman/Member (FEPA/FMEnv) Review Panels for Oil Field Development Plans (from 1999 to Date);
- (iv) Member, National Agricultural Land Resources Development Committee (NALDAC) (1991 to 1998);
- (v) Member, Fisheries Sub-Committee, National Advisory Committee on Agricultural Research (NACAR), 1993-1999;
- (vi) Joint National Coordinator, (South), Nationally Coordinated Agric Research Programme (NCRP), 1996 to 1999;
- (vii) Member, Capital Market Bond Committee, Bayelsa State Govt., 2011.and
- (viii) National Cordinator, IAEA-FGN, project RAF/7009 on Marine Pollution Monitoring and Seafood Safety. (2009 to date).

While serving at the Federal University of Technology, Minna, Prof Sikoki attracted a grant from the Directorate of International Development of the Netherlands for the establishment of a Dutch- FUT training programme for Post-graduate Fisheries Research at FUT, Minna. He served as the local Coordinator for the programme which involved the exchange of Post Graduate Students between the Wageningen Agricultural University in the Netherlands and FUT, Minna from 1991 to 1993. Professor Sikoki has contributed to the development of other universities through his participation as External Examiner to:

- Federal College of Fisheries, New Bussa (1992)
- R/S University of Science and technology, (1993 to date)
- University of Uyo, Uyo, (1995 to date)
- University of Benin, Benin, (2000 to date)
- Federal University of Agriculture, Umudike, (2001-2010)
- Federal University of Agriculture, Markurdi (2009 to date)
- Federal University of Technology, Minna, (2010 to date).

Professor Sikoki also has considerable industry experience through sabbatical placement in the Shell Petroleum Development Company, SPDC in 1995 where he served as an Environmental Adviser. He was attached to the Special Studies Unit of the department of Health, Safety and Environment where he was involved in the design and execution of scientific investigations on Environmental issues. Since then, he has provided consultancy services to several other private companies.

Mr. Chairman, distinguished Ladies and Gentlemen, while most people would have felt satisfied and content with the above professional achievements, Prof Sikoki felt otherwise, saying that “pursuing a career in teaching cannot be complete with emancipating your people culturally, socially and economically. It is therefore no surprise that this erudite academic devoted considerable effort to community service. He served as chairman of the Southern Ijaw Consultative forum, SICOF from 1995 to 2007 and is currently a member of the National Representative Council of the Ijaw National Congress, INC.

Without question, his activities and contributions in these positions have touched the lives of several people, who in turn, have influenced the attitudes of others. It is therefore, no surprise that when the INC inaugurated the Action Committees for the Socio-economic development of Ijaw land, he was appointed to all important Wetlands Study Group.

Mr Chairman, Your Excellencies, distinguished Ladies and Gentlemen, permit me at this juncture to mention that the greatest attributes of Prof Sikoki are his exemplary Christian life and love for the under – privileged member of his community. He is a Licensed Lay Reader of the Anglican Communion. During visits to his home community, he regularly visits with the elderly and identifies with the youth; encouraging them to pay attention

to their studies and providing counseling for those who may be experiencing difficulties.

His love for the youth further manifested some five – years ago when he established a scholarship scheme under the auspices of his late father’s Foundation, the DAVID SIKOKI FOUNDATION through which some indigent students from his community in tertiary institutions receive limited financial support.

Prof Sikoki is happily married to Bondan Sikoki who has created a conducive environment for a stable family. A great researcher in her own right; she is currently engaged in an International study family life in Jarkata, Indonesia. They have one son, Miebi who is also resident in Jakarta.

Mr Chairman, distinguished Ladies and Gentlemen, I am delighted to present to you our 100th Inaugural Lecturer as a distinguished international fisheries expert, an apostle of fisheries conservation, a fighter for the elimination of hunger, a great teacher and a fine gentleman, Professor Francis David Sikoki.

Prof Nelson Bramaifa
Professor of Pharmacology,
University of Port Harcourt,
Port Harcourt.
ORATOR