COURSE GUIDE

AFM 505
AQUATIC BIODIVERSITY

Course Team Dr. A. E. Olatunji (Course Writer) - Cross River University of Technology
Prof. J. Ogunji (Course Editor) - Ebonyi State University
R. M. Bashir (Course Coordinator) - NOUN
Prof. G. E. Jokthan (Programme Leader) - NOUN

NATIONAL OPEN UNIVERSITY OF NIGERIA

National Open University of Nigeria
Headquarters
University Village
Plot 91, Cadastral Zone,
Nnamdi Azikwe Express way
Jabi-Abuja

Lagos Office
14/16 Ahmadu Bello Way
Victoria Island, Lagos

e-mail: centralinfo@nou.edu.ng
URL: www.nou.edu.ng

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CONTENTS **PAGE**

INTRODUCTION

Biodiversity or biological diversity is a sum of all the different species of animals, plants, fungi, and microbial organisms living on earth and the variety of habitats in which they live. Each species is adapted to its unique niche in the environment, from the peaks of mountains to the depths of deep-sea hydrothermal vents, and from polar ice caps to tropical rain forests. According to the definition of the Convention on Biological Diversity, biodiversity is the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Aquatic biodiversity can be defined as the variety of life and the ecosystems that make up the freshwater, tidal, and marine regions of the world and their interactions. Aquatic biodiversity encompasses freshwater ecosystems, including lakes, ponds, reservoirs, rivers, streams, groundwater, and wetlands. It also consists of marine ecosystems, including oceans, estuaries, salt marshes, sea grass beds, coral reefs, kelp beds, and mangrove forests. Aquatic biodiversity includes all unique species, their habitats and interaction between them. It consists of phytoplankton, zooplankton, aquatic plants, insects, fish, birds, mammals, and others. Biodiversity is essential for maintaining the ecological functions, including stabilising of the water cycle, maintenance. Conservation of aquatic biological diversity leads to conservation of essential ecological diversity to preserve the continuity of food chains. Biodiversity provides the base for the livelihoods, cultures and economies of several hundred millions of people, including farmers, fisher folk, forest dwellers and artisans. It provides raw material for a diverse medicinal and health care systems. It also provides the genetic base for the continuous up-gradation of agriculture, fisheries, and for critical discoveries in scientific, industrial and other sectors. The rapid erosion of biodiversity in the last few decades has impacted on the health of the land, water bodies and people. Biodiversity is a wealth to which no value can be put. In the final analysis, the very survival of the human race is dependent on conservation of biodiversity.

THE COURSE

This Course Guide tells you briefly what to expect from reading this material which bothers on aquatic biodiversity management and conservation. The study of aquatic biodiversity is of imperative importance to a nation’s economy. Biodiversity is critical to the maintenance of a healthy environment. Its role in meeting human needs directly while maintaining the ecological process upon which our

survival depends is enormous. Biodiversity not only provides direct benefits such as food, medicines, and energy; it also affords us a "life support system." Biodiversity is required for the recycling of essential elements, such as carbon, oxygen, and nitrogen. It is also responsible for mitigating pollution, protecting watersheds, and combating soil erosion. Because biodiversity acts as a buffer against excessive variations in weather and climate, it protects us from catastrophic events beyond human control. In a fundamental sense, experiencing and increasing our knowledge about biodiversity transforms our values and beliefs. Knowledge about biodiversity is valuable in stimulating technological innovation and providing the framework for sustainable development.

Inland water ecosystems, including lakes, rivers, estuaries, wetlands and aquifers, provide numerous services upon which human activities depend. Such services include, for example, the maintenance of fish-stocks, water purification for human consumption, energy supply, and even climate regulation. The services provided by inland water ecosystems are greatly undervalued. Also often neglected is the role of water availability, in adequate quantity and quality, for sustaining inland water ecosystem functions and maintaining their capacity to provide those valuable services. Changes in water availability affect the functionality of aquatic ecosystems, thereby compromising the delivery of ecosystem services.

If the functions of inland water ecosystems depend upon the availability of water, it is simple to conclude that moving water away from "natural" inland water ecosystems causes changes in those systems. Usually such changes are negative and can result in the loss of species and of related services supplying local populations and dependent water uses. Those changes may also affect river estuaries and coastal regions. Reductions in freshwater flows, or changes in flow regimes, usually accompanied by increased pollution, eutrophication and sedimentation, can lead to significant loss of estuarine/coastal ecological functions and related ecosystem services.

COURSE AIM

The aim of this course is to provide the basic background information on Aquatic Biodiversity management and conservation and also to integrate it with recent developments in vital areas of aquatic ecosystem.

COURSE OBJECTIVES

Besides the aforementioned aims, at the end of this course, you should be able to explain the:

- meaning of aquatic biodiversity
- different ecosystem species and genetic diversity
- term endemic species
- effect of habitat loss
- effect of aquatic pollution on biodiversity
  effect climate change on aquatic biodiversity
- basic methods of aquatic biodiversity monitoring and assessment
- uses of aquatic biodiversity
- different treat to aquatic biodiversity
- vulnerable trans-boundary aquatic system
- aquatic biodiversity conservation and management measures
- total aquatic biodiversity-value index
- knowledge of legislation or legislative framework for aquatic biodiversity
- meaning of national biodiversity action plan
- international law and administration.

WORKING THROUGH THE COURSE

A great effort was put into this course thereby enriching it with a lot of useful information. This accounts for why you find it an irresistible companion both in the class and for field purposes. However, it requires that concerted effort is made in reading through these materials for appreciating the effort in a commensurable manner so you will be required to spend a lot of time to read it. You are also encouraged to work through and practice all assignments contained in this materials.

COURSE MATERIALS

You will be provided with the following materials; course guide and study units. In addition, the course comes with a list of recommended textbooks which though are not compulsory for you to acquire or indeed read, are necessary as supplements to the course material.

ASSESSMENT

There are two components of assessment for this course. The Tutor-Marked Assignment and the end-of-course examination

TUTOR- MARKED ASSIGNMENT (TMA)

The TMA is the continuous assessment component of your course. It accounts for 30% of the total score. You will be given 4 TMAs to answer. Three of these must be answered before you are allowed to sit

for the end-of course examination. The TMA's will be given to you by your facilitators and returned after you have done the assignment.

FINAL EXAMINATION AND GRADING

This examination concludes the assessment for the course. You will be informed of the time for this examination.

MAIN COURSE

CONTENTS **PAGE**

MODULE 1 THE CONCEPT OF AQUATIC BIODIVERSITY

UNIT 1 AQUATIC BIODIVERSITY

CONTENTS

1.0 INTRODUCTION

Nigeria is endowed with a diversity of freshwater resources, including seasonal and permanent rivers, lakes, and wetlands. However, these are all under varying degrees of threat.

Nigeria has two major rivers — the Niger and the Benue — which meet in a series of tributaries and channels to form the Niger Delta. Further north, other rivers flow into the Niger and Benue rivers and into Lake Chad. Other rivers — including the Cross, Imo, Ogun, and Osun Benin — also flow into the Atlantic Ocean. All told, there are eight main river basins in Nigeria (Ita, 1993). A number of these have been dammed, diverted, polluted, or otherwise disturbed, along with their aquatic flora and fauna. Riparian marsh and swamps along river courses are also under threat. For instance, by 1990, the natural freshwater marsh and swamps along the Niger, Benue, and Hadejia rivers had nearly disappeared due to floodplain agriculture. Freshwater swamp forests are extensive in the south, adjacent to mangrove areas. Two large lakes are found in Nigeria: Lake Chad in the northeast and man-made Kainji Lake in the west. Nigeria also has many natural and man-made lakes, reservoirs, fish ponds, abandoned mine pits, and other freshwater

sources throughout the country. Many of these water features provide important breeding and feeding habitats for a diversity of bird species (Eleazor, 2002).

The coastline of Nigeria is approximately 853 km long, stretching from the western border with the Republic of Benin to the eastern border with Cameroon. The coastal shore consists of barrier islands, sandy beaches, lagoons, estuaries, mud beaches, and creeks and includes the Niger Delta. Mangroves and estuaries extend from 10-150 km inland. Further inland are freshwater swamp forests and other low-lying habitats, which are all considered to be part of the coast. The coastal area is heavily populated, with about 20 percent of Nigeria's residents living in one of the nine coastal states. Offshore, the continental shelf extends from 15 km off Lagos to more than 85 km off Calabar. The Exclusive Economic Zone, established in 1978, extends to 200 nautical miles offshore (PKL *et al.*, 2011).

The aquatic and coastal environment of Nigeria is rich in resources and species diversity. The mangroves found here are the largest remaining tract in Africa — and the third largest in the world — covering an area of about 9,723 km^2. The mangrove ecosystem provides a nursery and breeding ground for many of the commercial fishery species taken in the Gulf of Guinea. Nigeria's coast is said to have about 199 species of finfish and shellfish, a number of which are used commercially. The Nigerian shrimp fishery is especially strong, and shrimp are now being exported to other countries, including the United States. Artisanal fisher folk harvest a large variety of fish, crustaceans, and molluscs from the estuaries and channels and utilise mangrove and swamp forest products for a variety of domestic uses. A variety of birds, mammals, and reptiles inhabit the mangroves and swamp forests of the coast, including a few endemic species like the Sclater's guenon and the Nile Delta red colobus monkey. Although a few species of sea turtles lay eggs on Nigerian beaches, they are rare and under threat from human predation (Wilson, 1992).

Three patterns of marine biodiversity are:

1. The greatest marine biodiversity occurs in coral reefs, estuaries, and on the deep-sea ocean floor.
2. Biodiversity is higher near the coasts because of great variety of producers, habitats and nursery areas.
3. Biodiversity is higher in the bottom region than in the surface region of the ocean because of the greater variety of habitats and food sources.
4. Scientific investigation of poorly understood marine and freshwater aquatic systems is a research frontier.

B. Marine systems provide a variety of ecological and economic services. Conservative estimates value their ecological services at $21 trillion per year with at least 3.5 billion people—more than half of the world's human population, dependent on seas for their primary source of food.

1. Antibiotic and anticancer chemicals have also been extracted from a variety of algae, sea anemones, sponges, mollusks and several species of fish.
2. Freshwater systems important ecological and economic services as well.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the meaning of aquatic biodiversity
- list the types of aquatic biodiversity.

3.0 MAIN CONTENTS

3.1 Meaning of Aquatic Biodiversity

Aquatic biodiversity can be defined as the variety of life and the ecosystems that make up the freshwater, tidal, and marine regions of the World and their interactions. Aquatic biodiversity encompasses freshwater ecosystems, including lakes, ponds, reservoirs, rivers, streams, groundwater, and wetlands. It also consists of marine ecosystems, including oceans, estuaries, salt marshes, sea grass beds, coral reefs, kelp beds, and mangrove forests. Aquatic biodiversity includes all unique species, their habitats and interaction between them Hickman *et al.,* 1992). It consists of phytoplankton, zooplankton, aquatic plants, insects, fish, birds, mammals, and others. Today's biodiversity is the result of billions of years of evolution, natural processes, and in more recent years, human activity. Before the advent of *Homo sapiens*, the Earth's biodiversity was much greater than it is today. Human activity has had a tremendous impact on biodiversity due to use of Earth's resources and exponential population growth. There are 3 distinct levels of biodiversity:

3.2 Types of Biodiversity

3.2.1 Species Diversit*y*

The species is the basic unit of classification in biology. Although a species might be defined as a group of similar organisms that interbreed

or share a common lineage of descent, there is no universal agreement on how to define a species. Even when the species is the basic unit, it represents only one level of a complex phylogenetic hierarchy: related species are grouped in genera, related genera in families, families in orders, and so on, up to the highest level, the kingdom, of which five are generally recognised at present (animals, plants, fungi, bacteria and protoctists). Species richness measures the number of species within a given area, giving equal weight to each one. This measure can be used at different geographical levels (a given area, a country and, ultimately, the world). It is still the most straightforward and, in many ways, the most useful measure of biodiversity.

The number or richness of species is obviously a most incomplete measure of biodiversity. It is complemented by:

(a) Species diversity, which measures the species in an area, adjusting for both sampling effects and species abundance.
(b) Taxic (taxonomic) diversity, which measures the taxonomic dispersion of species, thus emphasising isolated evolutionary species. The basic idea behind this measure is that biodiversity might be better measured at higher taxonomic levels (e.g. genera or families).
(c) Functional diversity, which assesses the richness of functional features and interrelations in an area, identifying food webs along with keystone species and guilds. However, not only diversity is of importance.
(d) Species endemism, that is whether a species is restricted to ("endemic to") an area under discussion, is equally vital. For example, islands typically have fewer species than equivalent-sized continental areas. They also usually have a higher percentage of species found nowhere else. In other words, they have lower species richness and higher species endemism.

3.2.2 Genetic Diversity

Genetic diversity is the variation of the set of genes carried by different organisms: it occurs on a small scale among organisms of the same species, among closely related species such as those in the same genus, and among more distantly related species, in different families, orders, or kingdoms. Genetic diversity might be characterised by a range of techniques: by observation of inherited genetic traits, by studying the chromosomes and their species specific karyotype, and by analysing the DNA information using molecular technology. Global genetic diversity is extremely large. It has been estimated that there are some 109 different genes present in the world's biota. The number of possible

combinations of gene-sequence variants in a population is so great that it cannot even be expressed in a meaningful way.

3.2.3 Ecosystem Diversity

Species exist in natural settings, within functioning communities and ecosystems, interacting with other species and the abiotic environment. Ecosystems function as entities with system-wide properties. Care about diversity must, therefore, also focus on system-wide aspects, such as dying coral reefs. Different classification systems exist to describe ecosystem diversity. On a world scale, bio-geographic zones, biomes, eco-regions, and oceanic realms are used. On a smaller scale, one deals with landscapes, ecosystems and communities

4.0 CONCLUSION

Biodiversity is critical to the maintenance of a healthy environment. Its role in meeting human needs directly while maintaining the ecological process upon which our survival depends is enormous. Biodiversity not only provides direct benefits such as food, medicines, and energy; it also affords us a "life support system." Biodiversity is required for the recycling of essential elements, such as carbon, oxygen, and nitrogen. It is also responsible for mitigating pollution, protecting watersheds, and combating soil erosion. Because biodiversity acts as a buffer against excessive variations in weather and climate, it protects us from catastrophic events beyond human control. In a fundamental sense, experiencing and increasing our knowledge about biodiversity transforms our values and beliefs. Knowledge about biodiversity is valuable in stimulating technological innovation and providing the framework for sustainable development.

5.0 SUMMARY

- Aquatic biodiversity encompasses freshwater ecosystems, including lakes, ponds, reservoirs, rivers, streams, groundwater, and wetlands.
- Species might be defined as a group of similar organisms that interbreed or share a common lineage of descent, there is no universal agreement on how to define a species.
- Genetic diversity is the variation of the set of genes carried by different organisms: it occurs on a small scale among organisms of the same species, among closely related species such as those in the same genus, and among more distantly related species, in different families, orders, or kingdoms.

- Species exist in natural settings, within functioning communities and ecosystems, interacting with other species and the abiotic environment.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the meaning of aquatic biodiversity.
2. Explain the types of aquatic biodiversity.

7.0 REFERENCES/FURTHER READING

Hickman, Jr C.P., Roberts L.S., Keen, S., *et el,* (2012). *Integrated Principles of Zoology*. (15th ed.). McGraw-Hill.

PKL Ng, Corlett RT, Tan HTW (Eds.) (2011), *Singapore Biodiversity: An Encyclopedia of the Natural Environment and Sustainable Development*. Editions Didier Millet.

Wilson, E.O. (1992). *The Diversity of Life*. W.W. New York: Norton & Co.

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UNIT 2 IMPORTANCE OF BIODIVERSITY IN NIGERIA

CONTENTS

1.0 INTRODUCTION

Aquatic biodiversity has enormous economic and aesthetic value and is largely responsible for maintaining and supporting overall environmental health. Humans have long depended on aquatic resources for food, medicines, and materials as well as for recreational and commercial purposes such as fishing and tourism. Aquatic organisms also rely upon the great diversity of aquatic habitats and resources for food, materials, and breeding grounds.

Factors including overexploitation of species, the introduction of exotic species, pollution from urban, industrial, and agricultural areas, as well as habitat loss and alteration through damming and water diversion all contribute to the declining levels of aquatic biodiversity in both freshwater and marine environments. As a result, valuable aquatic resources are becoming increasingly susceptible to both natural and artificial environmental changes. Thus, conservation strategies to protect and conserve aquatic life are necessary to maintain the balance of nature and support the availability of resources for future generations. We know very little about the earth's aquatic biodiversity because there has been so little exploration of the water on this 'water planet.'

Aquatic biodiversity has enormous economic and aesthetic value and is largely responsible for maintaining and supporting overall environmental health. Humans have long depended on aquatic resources for food, medicines, and materials as well as for recreational and commercial purposes such as fishing and tourism. Aquatic organisms also rely upon the great diversity of aquatic habitats and resources for food, materials, and breeding grounds.

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2.0 OBJECTIVES

At the end of this unit, you should be able to:

- discuss the value of biodiversity
- explain the importance of biodiversity in Nigeria.

3.0 MAIN CONTENT

3.1 The Value of Biodiversity

Each aquatic species from a tiny bacterium to a blue whale is unique. It is not size, but the genetic composition of plants and animals that makes all life forms special. Each species has its own inherent genetic library that codes its ability to survive in changing environments. The huge variety of species and genes represents a living library of options to adapt to change, to develop immunity to disease, and to pass improved fitness on to future generations.
Sustaining biodiversity is essential to the health of our environment and to the quality of human life. We depend on many aquatic plants and animals, and their ecological functions, for our survival. For example, we use surface waters and their inhabitants to help process our waste products. Each day, aquatic organisms (bacteria and fungi) continually break down harmful toxins and nutrients that we flush into our sewage systems or discard directly into our rivers and streams.

Aquatic biodiversity are sources of medicine, food, energy, shelter, and the raw materials that we use and need. Although we seldom recognise them, each aquatic species has an important role in making our lives easier, healthier, and more productive. Every living organism has an important role to play, and many are indispensable. Our aquatic wildlife are important sources of food, energy, jobs, atmospheric oxygen, buffers against new diseases, pests, and predators, and protection against food shortages and global climate change.

3.2 Importance of Biodiversity in Nigeria

i. **Food** - Fishes, crocodile and antelope are hunted for their meat and eggs. Proteins and other nutrients are mostly supplied through these forest animals, fishes and birds providing up to 70% of their protein diet. Children collect termites, snails and caterpillars of several insects for food. Ripe fruits, vegetables, mushrooms and different kinds of leaves come from forest as diet supplement, while bees supplies us with honey and other bee products. Biodiversity provides us with varieties of food. About 80% of our food supply comes from just 20 kinds of plant and humans use at least 40, 000 species of plants and animals a day.

ii. **Medicine -**A significant proportion of drugs are derived directly or indirectly from aquatic biological sources. About 40% of the pharmaceuticals used in the US are manufactured using natural compounds found in plants and animals. Medicinal drugs derived from natural sources make an important global contribution to health care. An estimated 80% of people in less developed countries rely on traditional medicine for primary health care. Some 120 chemicals extracted in pure form from around 90 species of plants are used in medicines throughout the world (Kate and Laird 1999). Many of these natural chemical cannot be manufactured synthetically.

iii. **Industrial Material** -A wide range of industrial materials are derived directly from aquatic biodiversity.

iv. **Benefit in Area of Agriculture** -Aquatic biodiversity is the medium through which air, water, gases and chemical are moderated and exchanged to create environmental services that are not readily visible. It plays a part in regulating the chemistry of our atmosphere and water supply. It is potentially of use to agriculture particularly with the emerging biotechnology as well as genetically modified organisms. Much of the world population depends on the livelihood derived from natural resources such as land, forests water and the air we breathe.

v. **Leisure, Cultural and Aesthetic Value -** Many people derived value from biodiversity through leisure activities such as hiking in the country side, swimming, bird watching or natural history study. Biodiversity has inspired musicians, painters, sculptors, writers and other artists. Many cultural groups view themselves as an integral part of the natural world and show respect for other living organisms. Popular activities such as gardening caring for

aquariums and collecting butterflies are all strongly dependent on biodiversity.

4.0 CONCLUSION

Biodiversity refers to the number and variety of species, of ecosystems, and of the genetic variation contained within species. Roughly 1.4 million species are known to science, but because many species are un-described, an estimated 10-30 million species likely exists at present. The immense economic value of biodiversity is well established. Many people visit forests, beaches, mountains, grasslands, lakes, ponds, estuaries and streams for extended vacations or short periods of relaxation. Around the world, the number of eco-tourists, people travelling to enjoy nature and various cultures, is increasing. All of these bring in large amounts of money each year. For example, medicine from wild products generates some $40 billion each year while nature tourism generates some $12 billion worldwide in annual revenues. Exports of agricultural products represent a very high proportion of foreign exchange.

5.0 SUMMARY

- Aquatic biodiversity are sources of medicine, food, energy, shelter, and the raw materials that we use and need.
- aquatic wildlife are important sources of food, energy, jobs, atmospheric oxygen, buffers against new diseases, pests, and predators, and protection against food shortages and global climate change.
- Medical researchers constantly are hunting for organisms that produce special chemicals that may cure cancer and other diseases.
- Biodiversity is important to science because it helps us understand how life evolved and continues to evolve.
- It also provides an understanding on how ecosystems work and how we can help maintain them for our own benefit.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the value of biodiversity.
2. Explain the importance of biodiversity in Nigeria.
3. Describe the ecological services provided by aquatic systems.

7.0 REFERENCES/FURTHER READING

Hendrik S. & K. Martens (2005). *Aquatic Biodiversity: The Diversity of Aquatic Ecosystems*. (Developments in Hydrobiology). *Springer Publi*.

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Ormond, R. F. G., John, D. G. & Martin V. A. (Eds). (1997). *Marine Biodiversity: Patterns and Processes*. New York: Cambridge University Press.

UNIT 3 THREAT TO AQUATIC BIODIVERSITY

CONTENTS

1.0 INTRODUCTION

The threats to global freshwater biodiversity can be grouped under five interacting categories overexploitation, water pollution, flow modification, destruction or degradation of habitat, and invasion by exotic species Revenga *et al.* (2005). Environmental changes occurring at the global scale, such as nitrogen deposition, warming, and shifts in precipitation and runoff patterns are superimposed upon all of these threat categories. Over-exploitation primarily affects vertebrates, mainly fishes, reptiles and some amphibians; whereas the other four threat categories have consequences for all freshwater biodiversity from microbes to mega fauna. Pollution problems are pandemic, and although some industrialised countries have made considerable progress in reducing water pollution from domestic and industrial point sources, threats from excessive nutrient enrichment and other chemicals such as endocrine disrupters are growing. Habitat degradation is brought about by an array of interacting factors. It may involve direct effects on the aquatic environment (such as excavation of river sand) or indirect impacts that result from changes within the drainage basin. For example, forest clearance is usually associated with changes in surface runoff and increased river sediment loads that can lead to habitat alterations such as shoreline erosion, smothering of littoral habitats, clogging of river bottoms or floodplain aggradations.

Widespread invasion and deliberate introduction of exotic species adds to the physical and chemical impacts of humans on fresh waters, in part because exotics are most likely to successfully invade fresh waters already modified or degraded by humans (e.g. Bunn & Arthington, 2002; Koehn, 2004). There are many examples of large scale and dramatic effects of exotics on indigenous species (e.g. Nile perch, *Lates niloticus*, in Lake Victoria, the crayfish plague in Europe, salmonids in Southern Hemisphere lakes and streams: and impacts are projected to increase further (Sala *et al.*, 2000). Indirect impacts can arise from exotic terrestrial plants such as *Tamarix spp*. (Tamaricaceae), which

alter the water regime of riparian soils and affect stream flows in Australia and North America (Tickner *et al.*, 2001). The particular vulnerability of freshwater biodiversity also reflects the fact that fresh water is a resource for humans that may be extracted, diverted, contained or contaminated in ways that compromise its value as a habitat for organisms. In some instances, impacts have been sustained over centuries and, in the case of many of the major rivers of China, they have persisted for more than 4000 years (Dudgeon, 2000). Indeed, some authors now believe it unlikely that there remain a substantial number of water bodies that have not been irreversibly altered from their original state by human activities (Le´veˆque and Balian, 2005).

2.0 OBJECTIVE

At the end of this unit, you should be able to:

- mention the various threats to aquatic biodiversity.

3.0 MAIN CONTENT

3.1 Major Causes of Threat to Aquatic Biodiversity

These factors affect the aquatic biodiversity directly or indirectly. Excessive mortality of organisms due to any of these factors may lead to two types of effects – i) extinction of the species / populations ii) reduction of population size.

1. **Overexploitation of species —** Overexploitation of species affects the loss of genetic diversity and the loss in the relative species abundance of both individual and /or groups of interacting species. The population size gets reduced because of disturbances in age structure and sex composition. Efficient gears remove quick growing larger individuals. Consequently, the proportion of slow growing ones increases and the average size of individuals in a population decreases. Over-fishing causes change in the genetic structure of fish populations due to loss of some alleles. Thus, genetic diversity gets reduced.

2. **Habitat modification —** Physical modification of habitat may lead to species extinction. This is mainly caused due to damming, deforestation, diversion of water for irrigation and conversion of marshy land and small water bodies for other purposes. Construction of dams on river impedes upstream migration of fishes and displaces populations from their normal spawning grounds and separates the population in two smaller groups. Deforestation leads to catchment area degradation due to soil

erosion which results into sedimentation and siltation. This not only affect the breeding ground of aquatic organisms but cause gill clogging of small fishes also.

3. **Pollution load —** Four forms of pollutants can be distinguished-

   i **Poisonous pollutants —** Agrochemicals, metals, acids and phenol cause mortality, if present in a high concentration and affect the reproductive functionality of fish (Kime, 1995).
   ii **Suspended solids —** it affects the respiratory processes and secretion of protective mucus making the fish susceptible to infection of various pathogens.
   iii **Sewage and organic pollutants —** They cause deoxygenation due to eutrophication causing mortality in fishes.
   iv **Thermal pollution-** it cause increase in ambient temperature and reduce dissolved oxygen concentration leading to death of some sensitive species.

Others includes

i. Other threats to aquatic biodiversity include urban development and resource-based industries, such as mining and forestry that destroy or reduce natural habitats. In addition, air and water pollution, sedimentation and erosion, and climate change also pose threats to aquatic biodiversity.

ii. Pollution of coastal waters. The main sources of pollution include industrial waste, raw/untreated sewage and pesticides.

iii. Hydrocarbon production contributes about 95% of the country's Gross National Product (GNP).

iv. Oil exploration, exploitation and transportation have a significant effect on the environment. Crude and refined oil spills incidents are very frequent in the coastal and aquatic environment, especially during periods of very strong ocean currents when it can spread to cover the entire 853 km coastline.

v. The area where frequent spillages occur is categorised as ecologically sensitive or critical (mangrove ecosystems). Efforts to reduce the flaring of associated gas have not been very successful as low technology does not permit the exploitation of natural gas. Flaring impacts on the quality of the coastal

atmosphere and affects coastal vegetation and human habitation. The mixture of flared gas and precipitation causes acid rain, with harmful effects on the mangrove biota and Aquatic organisms. These impacts are yet to be studied and fully understood.

Land reclamation

a. Land reclamation of swamps adjoining the coast for the increasing human population and other development activities destroys the nursery, breeding and feeding grounds of Aquatic organisms. It also restricts the distribution of organisms and leads to considerable loss of biodiversity.
b. Coastal erosion. Coastline erosion is prevalent in Nigeria and has been closely associated with ocean front constructions such as ports and harbours. Ibe (1988) reported that the Nigerian coastline experiences some of the fastest erosion rates in the world averaging about 20-30 metres per year in some locations.
c. Over fishing. The coastal and aquatic resources are either over fished, or fished close to, or beyond their maximum sustainable yield. The heterogeneity of species of different sizes poses a problem in mesh size regulation in the fishery sub-sector.
d. Deforestation. Deforestation of the coastal mangrove vegetation exposes the coast to storm surges, coastal erosion and loss of land. The mangrove swamp is the spawning, breeding, nursery and feeding ground for fish and shellfish for both brackish and aquatic organisms.
e. Construction of canals and channels. Construction of canals/channels contributes to land loss as craft movement generates strong waves that impact on the banks of these waterways.
f. Mining of sand. Mining activities on the foreshore and seabed are a very common feature in Nigeria and they impact negatively on the bottom communities. Mining of sand affects the environmental sediment balance and has major impacts on the associated bottom dwelling organisms.

4.0 CONCLUSION

The threats to Aquatic biodiversity arising from over-exploitation of aquatic resources by fisheries within 200 mile limits and from degradation of coastal ecosystems by pollution are common to many countries at all latitudes. They are, however, of greater significance in tropical developing countries where the sensitive coastal ecosystems, because of the richness of their biodiversity, are of relatively great importance to the national economy and the livelihoods of poor people aquatic biodiversity decline is characterised not only by extinctions, but

by invasions and hybridisations, populations of species reduced in number, habitats that have been diminished or removed, and ecosystem processes (e.g. cycling of water, nutrients and energy) that have been disrupted. Habitat loss presents the single greatest threat to world biodiversity, and the magnitude of this threat can be approximated from species-area curves and rates of habitat loss. The spread of non-native species threatens many local species with extinction, and pushes the world's biota toward a more homogeneous and widely distributed sub-set of survivors. Climate change threatens to force species and ecosystems to migrate toward higher latitudes, with no guarantee of suitable habitat or access routes. These three factors thus are of special concern.

5.0 SUMMARY

- The threats to global freshwater biodiversity can be grouped under five interacting categories overexploitation ; water pollution ; flow modification ; destruction or degradation of habitat ; and invasion by exotic species
- Widespread invasion and deliberate introduction of exotic species adds to the physical and chemical impacts of humans on fresh waters, in part because exotics are most likely to successfully invade fresh waters already modified or degraded by humans
- Human activities are causing species to disappear at an alarming rate. Aquatic species are at a higher risk of extinction than mammals and birds.
- Overexploitation of aquatic organisms for various purposes is the greatest threat to marine environments, thus the need for sustainable exploitation has been identified by the environmental defense.
- Excessive mortality of organisms due to any of these factors may lead to two types of effects – i) extinction of the species / populations ii) reduction of population size. Pollution of coastal waters.

6.0 TUTOR-MARKED ASSIGNMENT

1. List the causes of threat to aquatic biodiversity.
2. Explain three factors that could cause change in aquatic biodiversity, and describe *how* and *why* these factors affect change.

7.0 REFERENCES/FURTHER READING

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MODULE 2 THE DIFFERENT ECOSYSTEM SPECIES AND GENETIC DIVERSITY

Unit 1 Aquatic Ecosystem
Unit 2 Endemic Species
Unit 3 Aquatic Loss

UNIT 1 AQUATIC ECOSYSTEM

CONTENTS

1.0 INTRODUCTION

An aquatic ecosystem is a group of interacting organisms dependent on one another and their water environment for nutrients (e.g., nitrogen and phosphorus) and shelter. Familiar examples are lakes and rivers, but aquatic ecosystems also include areas such as floodplains and wetlands, which are flooded with water for all or only parts of the year (Dudgeon, 2000).

In aquatic ecosystems, the characters and extent of community succession in a given area depends on climate and soil condition. The climax community is achieved only if environmental factors permit a fish sequence of serial stages. All ecosystems resemble each other in the sense that all have same components, i.e. autotrophic and heterotrophic, interacting upon each other thus bringing about circulation of materials. In one ecosystem, the climate and soil conditions are relatively uniform and they favour the growth of a certain kind of climax community.

Aquatic ecosystems are usually, divided into fresh water, marine water, estuarine water.

There are two categories of fresh water ecosystems (a) lentic or standing or stagnant water including ponds, lakes and reservoirs (b) lotic or running Water are those which occur in fast running streams, springs, rivers and brooks. Fresh water ecosystems have low percentage of dissolved salts. They have fluctuating physical and chemical factors affecting the flora and
fauna.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- discuss the fresh water ecosystems
- identify the estuarine water ecosystem.

3.0 MAIN CONTENT

3.0 Types of Aquatic Ecosystem

The types of aquatic ecosystems commonly used by capture fisheries and aquaculture are the following:

3.1 Fresh Water Ecosystem

Very small proportion of earth's area that is only 0.8 percent of the earth's surface is covered by freshwater. Primary production in a fresh-water ecosystem is controlled by light and nutrient availability. Fresh water can be defined as the water that contains a relatively small amount of dissolved chemical compounds. It includes: Standing Water:- lakes and ponds; Moving Water :- rivers and streams.

3.1.1 Standing and Moving Water

Standing water- lakes and ponds: Standing water ecosystems are known as lentic ecosystems such as lakes and ponds. The organisms in lentic ecosystem includes algae, rooted and floating-leaved plants, invertebrates such as crabs, shrimps, crayfish, clams etc, amphibians such as frogs and salamanders; and reptiles like alligators and water snakes.

Moving Water - rivers and streams: flowing-water ecosystems are known as lotic ecosystems with water flowing in uniform direction and in a unidirectional way. Examples are rivers and streams, which harbour

several species of insects and fishes. Crustaceans like crayfish and crabs; and molluscs such as clams and limpets.

3.1.2 Lake

Lakes are inland bodies of standing water. Although millions of lakes are scattered over Earth's surface, most are located in higher latitudes and mountainous areas. Lakes can be formed by glaciers, tectonic plate movements, river and wind currents, and volcanic or meteorite activity. Some lakes are only seasonal, drying up during parts of the year. The study of lakes, ponds, and other freshwater bodies is called limnology. Based on primary productivity lakes may be classified into two broad categories –

3.1.3 Pond

A pond is an earthen container for storing water. The surface area of the stored water will normally vary from a fraction of an acre to tens of acres. The depth of the water will normally vary from two feet in the shallowest portion up to 1.5m in the deeper portions. Size range of ponds is from 0.05 to 25 acres, and depth from 2 m. to 20 m.

Although ponds are considered small, shallow lakes, there is one important difference between the two bodies of water: temperature. Many ponds are seasonal, lasting just a couple of months (such as sessile pools) while lakes may exist for hundreds of years or more. Ponds and lakes may have limited species diversity since they are often isolated from one another and from other water sources like rivers and oceans.

3.1.4 Lotic Streams and Rivers

These are bodies of flowing water moving in one direction. Streams and rivers can be found everywhere — they get their starts at headwaters, which may be springs, snowmelt or even lakes, and then travel all the way to their mouths, usually another water channel or the ocean. The characteristics of a river or stream change during the journey from the source to the mouth. The temperature is cooler at the source than it is at the mouth. The water is also clearer, has higher oxygen levels, and freshwater fish such as fish and heterotrophy can be found there. Organisms of lotic waters show adaptations for maintaining position in swift water. Some of these important adaptations are:-

i. **Permanent attachment to a firm substrate** – In fast running water, the plants and animals are permanently attached to substratum such as rocks, stones and logs.

ii. **Presence of hooks and suckers** – Certain animals have hooks and suckers to grip the substratum. Larvae of *Simulium* and *Blepharocerca* have well developed suckers to gain firm hold on substratum that prevent them from drifting away with current.

iii. **Sticky undersurface** – Snails and flatworms have sticky undersurfaces with the help of which they adhere to submerged objects.

iv. **Streamlined body** – Nearly all stream animals have streamlined body (broadly rounded in front and tapering posteriorly) that offer little resistance to water flowing over it.

v. **Fllatened body** – Many animals living in streams have flattened bodies which help them to take shelter and refuge under stones and in crevices. This is especially seen in the nymphs of mayfly and stonefly.

vi. **Positive rheotaxis** – Stream animals are invariably positively rheotactic i.e. they orient themselves upstream and move against water current.

vii. **Positive thigmotaxis** – Many stream animals exhibit positive thigmotaxis i.e. they have an inherent tendency to cling close to a surface or to keep the body in close contact with the surface.

River Continuum. The lotic ecosystem is essentially a continuum of physical and biological conditions from the headwaters to the river's mouth.

3.2 Estuarine Ecosystem

Estuaries are the areas where the freshwaters of streams and rivers meet the saltwater of ocean. It is a semi enclosed coastal body of water such as a river mouth or a coastal bay, which has a free connection with the open sea and which is strongly influenced by tidal action. An estuary is usually defined as a semi-enclosed coastal body of water having free connection with open sea. Thus, it comprises of both sea water and fresh water and occurs, usually nor the river mouths, coastal bays and tidal marshes. Primarily it is a passage or inlet where tidal water comes in contact with a river current. In other words, it may be designated as a confined arm of the sea situated at the lower and / or mouth of a river. Generally, estuaries may be thought as transition zones (or ecotones) between fresh water habitat and marine habitat. They consist of brackish water which may be oligohaline, mesohaline or polyhaline on the basis of degree of salinity. They undergo seasonal organismal changes and thus belong to "fluctuating water-level ecosystem".

3.2.1 Kinds of Estuaries

On the basis of geomorphology, the estuaries are broadly classified into four categories. They are:

Drowned river valleys

These are very common along the coastlines and are characterised by low and wide coastal planes, e.g., Chesapeake Bay of the United States.

Fjord type estuaries

They are deep, U-shaped coastal formations usually formed by glaciers, e.g., Norwegian fjords.

Bar built estuaries

These are shallow basins along the seashores being partly exposed at low tide and surrounded by a discontinuous chain of barrier islands. The inlets between these barriers connect various estuaries with the sea, e.g., 'sea islands', salt marsh estuaries from Georgia.

Tectonic estuaries

These are formed as a result of local subsidence (sinking) of land or by some geological faulting along the coasts, e.g., San Francisco Bay.

3.2.2 Features of Estuaries

i. The salinity of estuary is intermediate between that of seawater (salinity is about 35‰) and freshwater (salinity ranges from 0.065‰ to 0.3‰).
ii. Estuary is, thus, a transition zone or ecotone between freshwater and marine ecosystems.
iii. Estuaries differ in sise, shape and volume of water flow, all influenced by the geology of the region in which they occur.
iv. They normally have high silt content. As the river approaches the sea, the stream-carried sediments are dropped in the quiet water.
v. They accumulate to form deltas in the upper reaches of the mouth and shorten the estuary. In some estuaries silt and mud accumulations become so high that they are exposed at low tides, thereby forming tidal flat, which divide and braid the original channel of estuary.
vi. On the seaward side of estuary, ocean currents and tides erode the coast line and deposit material, further shortening the mouth. If

more material is deposited than is carried away barrier beaches and brackish lagoons appear.

4.0 CONCLUSION

Life on earth depends on water. Water comprises 99 per cent of the human body and covers 71 per cent of the earth's surface. Too often, however, the life within water is forgotten. The biological diversity of aquatic ecosystems is neglected in developed countries and developing countries alike, even in coral reefs that rival tropical rain forests in extraordinary diversity of life. Over 20 000 species of fish make up more than half of all vertebrate biodiversity; over 8 000 of these live in freshwater. The major difference between the fresh water and the sea is that the latter is highly saline, and organisms found here are not only adapted, but also use this characteristic to their own benefit. Some, such as the Dead Sea are so salty that no plants or animals can live in it.

5.0 SUMMARY

- Freshwater is defined as having a low salt concentration — usually less than 1%.
- Lakes are inland bodies of standing water. Although millions of lakes are scattered over Earth's surface, most are located in higher latitudes and mountainous areas.
- A pond is an earthen container for storing water.
- Streams and rivers are bodies of flowing water moving in one direction.
- Wetlands are areas where the soil is inundated by surface or ground water often enough that the prevalent vegetation community there is one adapted for life in saturated soils.
- Estuaries are the areas where the freshwaters of streams and rivers meet the saltwater of ocean.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the fresh water ecosystems
2. Explain the estuarine water ecosystem.

7.0 REFERENCES/FURTHER READING

Dudgeon, D. (2000). *Riverine Wetlands and Biodiversity Conservation in Tropical Asia. In Biodiversity in Wetlands: Assessment, Function and Conservation*. (Eds.) B. Gopal, W. J. Junk and J. A. Davis), pp. 35–60. Netherlands: The Hague Backhuys Publishers.

UNIT 2 ENDEMIC SPECIES

CONTENTS

1.0 INTRODUCTION

Endemism is the ecological state of a species being unique to a defined geographic location, such as an island, nation, country or other defined zone, or habitat type; organisms that are indigenous to a place are not endemic to it if they are also found elsewhere. The extreme opposite of endemism is cosmopolitan distribution. Another term for a species that is endemic, is precinctive - which applies to species (and sub-specific categories) that is restricted to a defined geographical area. Indigenous is a species which occurs naturally in a given area while Endemic species is an indigenous species which has a restricted home range.

Nigeria is rich in endemics. This is partly attributable to the country's ecosystem diversity. From the marine to the semi-desert, varied species of mammals, reptiles, birds, marine and freshwater fishes etc are solely recorded by science to exist in Nigeria. The endemism associated with Nigeria in Biodiversity underscores the significant role that biodiversity management plays in maintaining the world's natural heritage, apart from the implication that biodiversity has on livelihoods, health and food of generations of people.

2.0 OBJECTIVES

At the end of this unit, student should be able to:

- discuss invasions in water dependent ecosystems
- explain the different between endemic species and invasive species
- explain the management of invasions.

3.0 MAIN CONTENT

A native species is a species, subspecies or lower taxon occurring within its natural range and dispersal potential (i.e., within the range it occupies naturally or could occupy without direct or indirect introduction or care by humans). An alien species or alien genotype (introduced, non-indigenous, exotic) is a species, subspecies or lower taxon occurring as a result of human agency in an area or ecosystem in which it is not native. A domesticated or genetically altered native species may become an alien genotype. An invasive species is a species which colonises natural or semi-natural ecosystems. It is an agent of change and threatens native biodiversity (species, populations and/or ecosystems).

3.1 Invasions in Water-Dependent Ecosystems

Invasions in lakes, rivers, floodplains, and wetlands are especially problematic because they are difficult to manage. This is because they are hard to detect (especially the submerged species). One reason is because the water they invade is often part of other ecosystems of value. Another reason is because the affected ecosystem or habitat is linked to others through the water sources or drainage systems - both upstream and downstream (Howard 2001; Kasulo 2001). There are sometimes significant benefits from invasions such as increased fisheries yields from some invasive fish and crustaceans, and the by-products of invasive water-weeds like water hyacinth. Thus it is not possible to provide a prescription for wetland invasive management; rather it is useful to consider why we want to prevent or control invasions and what is the desired state of an ecosystem after management has succeeded. Note that in this approach, the impacts of aquatic invasive species are seen primarily as impacts on the invaded ecosystem as well as the possible long-term influences on people's uses of that ecosystem. Water-dependent ecosystems are frequently linked via watersheds, streams, and rivers to downstream systems so it is especially important to consider invasions in the upper catchments of a river basin or lake since these are likely to have the furthest-reaching impact in the long run.

3.1.1 Effects of Invasions

Invasions in water-dependent ecosystems may also have some of the following effects on the
water of an ecosystem:

i. Alteration (often impediment) of flow and changes in natural cycles of flow;

ii. Alteration (mostly reduction) of quantity and sometimes also in timing (seasonality);
iii. Alteration (usually lowering of acceptable standards) of quality in its broadest sense
iv. (including eutrophication, de-oxygenation, fouling, poisoning, and reduction of nutrients);
v. Reduction or loss of hydrological benefits of wetland function; and
vi. Alteration of wetland functions downstream of invasions and across national and international borders.

While these are not necessarily the primary effects of the introduction of (say) alien fish, they may become the secondary impacts of such introductions if the fish concerned becomes invasive.

3.2 Management of Invasions

The best form of management for invasive species is prevention. This requires that potential pathways for invasions are known and that the identity of potential invasive species can be determined. Both are possible in many cases since the necessary information is becoming widely available through local and global databases of invasive species and because experiences are exchanged and lessons learnt are shared around the world. While this is necessary to protect ecosystems from unintentional introductions, there is a more defined process for intentional introductions. It is possible to ascertain if a species proposed for introduction has been shown to be invasive in other situations or at other times and to then make an assessment of the risk that introduction will lead to invasion. This is the process of risk assessment in relation to the proposed introduction of alien species that has its own well-defined logic and procedure (Groves et al., 2001 and Wittenberg and Cock 2001). If the assessment shows that the risk is too great, a sensible decision is often to prevent the introduction or to ensure that it does not lead to invasion, if that is possible and feasible. Prevention of introduction of potentially invasive species is widely seen as the best and most effective way to avoid the consequences of invasions by alien and non-alien species.

4.0 CONCLUSION

A native species is a species, subspecies or lower taxon occurring within its natural range and dispersal potential (i.e., within the range it occupies naturally or could occupy without direct or indirect introduction or care by humans). Invasions in lakes, rivers, floodplains, and wetlands are especially problematic because they are difficult to manage. This is because they are hard to detect (especially the submerged species). An

alien species or alien genotype (introduced, non-indigenous, exotic) is a species, subspecies or lower taxon occurring as a result of human agency in an area or ecosystem in which it is not native. A domesticated or genetically altered native species may become an alien genotype. The best form of management for invasive species is prevention. This requires that potential pathways for invasions are known and that the identity of potential invasive species can be determined. Invasions in lakes, rivers, floodplains, and wetlands are especially problematic because they are difficult to manage. This is because they are hard to detect (especially the submerged species.

5.0 SUMMARY

- Endemism is the ecological state of a species being unique to a defined geographic location
- An alien species or alien genotype (introduced, non-indigenous, exotic) is a species, subspecies or lower taxon occurring as a result of human agency in an area or ecosystem in which it is not native
- Invasions in lakes, rivers, floodplains, and wetlands are especially problematic because they are difficult to manage.
- The best form of management for invasive species is prevention. This requires that potential pathways for invasions are known and that the identity of potential invasive species can be determined.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the concept of invasions on aquatic ecosystems.
2. Outline the effects of invasions on aquatic ecosystems.
3. Explain the different between endemic species and invasive species.
4. Explain the management of invasions.

4.0 REFERENCES/FURTHER READING

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UNIT 3 HABITAT LOSS

CONTENTS

1.0 INTRODUCTION

Virtually all the earth's ecosystems have been dramatically transformed through human actions and ecosystems continue to be converted for agricultural land and other uses. The current loss of biodiversity and the related changes in the environment are now faster than ever before in human history and there is no sign of this process slowing down. Many animal and plant populations have been declined in numbers, geographical spread, or both, species extinction is a natural part of the earth's history. Human activities have increased the extinction rate by at least 100 times compared to natural rate.

Aquatic resources are vulnerable to the effects of human activities catchment-wide, and many of the landscape changes humans routinely induce cause irreversible damage (e.g., some species introductions, extinctions of ecotypes and species) or give rise to cumulative, long-term, large-scale biological and cultural consequences (e.g., accelerated erosion and sedimentation, deforestation, toxic contamination of sediments). In aquatic ecosystems, biotic impoverishment and environmental disruption caused by past management and natural events profoundly constrain the ability of future management to maintain biodiversity and restore historical ecosystem functions and values. To provide for rational, adaptive progress in ecosystem management and to reduce the risk of irreversible and unanticipated consequences, managers and scientists must identify catchments and aquatic networks where ecological integrity has been least damaged by prior management, and jointly develop means to ensure their protection as reservoirs of natural biodiversity, keystones for regional restoration, management models, monitoring benchmarks, and resources for ecological research.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- identify the impact of human on aquatic ecosystem biodiversity
- mention the priority actions proposed to achieve sustainable resource use.

3.0 MAIN CONTENT

3.1 Human Impacts on Aquatic Biodiversity

A. The greatest threat to the biodiversity of oceans is loss and degradation of habitats

i. Twenty percent of the world's coral reefs have been destroyed and another 20% have been damaged.
ii. Rising sea levels, 10-25 centimetres during the past 2100 years and 9-88 cm over the next century.
iii. We have removed more than ½ of the world's ecologically important mangrove forests.
iv. More than half of the world's coastal wetlands have disappeared.
v. Many sea bottoms are degraded and destroyed by dredging and trawler fishing boats which drive huge and heavy nets over the seafloor.
vi. The amount of water held behind dams is 3-6 times the amount that flows in natural rivers.

B. Harmful invasive species increasingly threaten marine biodiversity.

C. About 45% of the human population lives along coastal zones and 80% of ocean pollution come from land-based human activities and similar pressures are growing in freshwater systems and more people seek homes and recreation areas around rivers and lakes.

D. About 75% of the world's commercially valuable fisheries have been over fished and many have surpassed their sustainable limits.

i. Modern industrial fishing can deplete 80% of target fish species in just 10-15 years.

ii. Over fishing can lead to commercial extinction, which occurs when it is no longer profitable to continue fishing the affected species.
iii. Ninety percent of the large, open-ocean fish like tuna, swordfish, and marlin have disappeared since 1950.
iv. More than 1/4th of annual fish catch consists of bycatch—non-target species that are thrown overboard dead or dying

E. Rapidly increasing human impact, invisibility of problems, citisen unawareness, and lack of legal jurisdiction hinder protection of aquatic biodiversity.

Protecting and Sustaining Marine Biodiversity

3.2 The Following Priority Actions are proposed to Achieve Sustainable Resource Use

Progressive efforts to ensure the ecological sustainability of Nigeria's fisheries including:

i. investigate options and mechanisms to extend the ecological risk analysis of fisheries (and associated revisions to management approaches) to all developed and active Nigerian fisheries including recreational fisheries;
ii. ensure that ecological sustainability assessments for fisheries pay particular attention to managing impacts on top-order predators;
iii. promote national standards for fisheries monitoring and reporting (commercial, recreational and Indigenous harvests);
iv. develop management arrangements for all fisheries based on ecologically sustainable development principles;
v. develop and expand plans that address the impacts of fishing on Aquatic biodiversity (e.g. bycatch action plans, recovery plans, threat abatement plans and national plans of action);
vi. continue to implement the National Recreational Fishing Policy; and
vii. continue to implement the National Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing.
viii. develop a national network of baseline/reference sites by establishing the National Representative System of Aquatic Protected Areas including highly protected areas and providing periodic monitoring.
ix. develop high-level links between industry, government, conservation organisations and other relevant stakeholders to identify the most cost-effective and environmentally beneficial approaches to conserving biodiversity assets and Aquatic resources, while minimising disruption to industry.

x. progress further development of national fisheries databases, at ecologically relevant scales, where necessary for enhanced reporting and management purposes, and develop national protocols to maximise data sharing between agencies.
xi. build capacity in Indigenous communities for sustainable management of Indigenous fishing.
xii. promote effective institutional arrangements for managing Aquatic resources and habitats, both within Nigeria and with our neighbours, including improved fisheries management and monitoring, and control and surveillance of remote areas of the EEZ.
xiii. increase seafood consumer education to promote purchase of sustainably harvested local species and to readily identify at-risk species or fisheries. Adopt a national seafood eco-labelling scheme for all seafood sold in Nigeria (domestic and imported) and promote the reporting of inappropriately and illegally labelled seafood products.

4.0 CONCLUSION

Habitat loss presents the single greatest threat to world biodiversity, and the magnitude of this threat can be approximated from species-area curves and rates of habitat loss. The spread of non-native species threatens many local species with extinction, and pushes the world's biota toward a more homogeneous and widely distributed sub-set of survivors. Climate change threatens to force species and ecosystems to migrate toward higher latitudes.

5.0 SUMMARY

- Aquatic resources are vulnerable to the effects of human activities catchment-wide, and many of the landscape changes humans routinely induce cause irreversible damage (e.g., some species introductions, extinctions of ecotypes and species) or give rise to cumulative, long-term, large-scale biological and cultural consequences (e.g., accelerated erosion and sedimentation, deforestation, toxic contamination of sediments).
- The greatest threat to the biodiversity of oceans is loss and degradation of habitats
- About 45% of the human population lives along coastal zones and 80% of ocean pollution come from land-based human activities and similar pressures are growing in freshwater systems and more people seek homes and recreation areas around rivers and lakes.

- About 75% of the world's commercially valuable fisheries have been over fished and many have surpassed their sustainable limits.

6.0 TUTOR-MARKED ASSIGNMENT

1. Outline the impact of human on aquatic ecosystem biodiversity
2. Outline the priority actions proposed to achieve sustainable resource of aquatic biodiversity

7.0 REFERENCES/FURTHER READING

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MODULE 3 AQUATIC POLLUTION ON BIODIVERSITY

UNIT 1 AQUATIC POLLUTION ON BIODIVERSITY

CONTENTS

1.0 INTRODUCTION

According to the 1982 United Nations Convention on the Law of the Sea, pollution of the marine means “the introduction by man, directly or indirectly, substances or energy into the aquatic environment (including estuaries) which results or is likely to result in such deleterious effects as

harm to living resources and marine life, hazard to human health, hindrance to marine activities including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities". The discharge of pollutants into the marine environment must therefore be controlled effectively as they are hazardous to marine life, the marine ecosystem and human health (Clark *et al.,* 2004).

Environmental problems have increased in geometric proportion over the last three decades with improper management practices being largely responsible for the gross pollution of the aquatic environment with concomitant increase in water borne diseases. Aquatic pollution is a worldwide phenomenon the practice and extend varies from one country to another. Pollution of water bodies is a phenomenon of concern in the developing nations of the world. Pollution of aquatic environment refers to the introduction of substances or energy directly or indirectly into water bodies by man, resulting in deleterious effects to living resources, hazards to human health, hindrance to aquatic activities such as fishing, impairment of water quality and reduction of amenities. Pollution had always been misused for contamination which can be defined as the presence of elevated concentrations of a substance in the air, water, soil or any other such thing not necessarily resulting in a deleterious effect. Aquatic pollution, therefore, is the direct or indirect human introduction of substances into the aquatic environment such as to harm living resources, affect human health and water quality.

Pollution is not merely the addition of a substance to the aquatic ecosystem, but its addition at rate faster than the ecosystem can accommodate it. There are natural levels of chemicals such as arsenic and mercury in the environment but only if these levels exceed critical values can they be considered as pollutants. Pollutants are not only chemicals. To be a pollutant, a material has to be potentially harmful to life. Chemicals released into the rivers and seas such as Pb, Cu, Zn, Hg, and CN will cause the death of fish, algae and lesions in human beings even at very low concentrations.

In Nigeria, pollution of river water takes place at various centers of industrialisation, chiefly at Lagos, Abeokuta, Ibadan, Warri, Port Harcourt, Aba, Kano etc (Rainbow 2007). Industries generate a significant quantity of wastewater and discharge it into rivers and lake. Industrial discharges generally contain organic substances, solids and mineral acids. Pulp and paper, dairy and textile industries generate putrifiable organic waste, while industries manufacturing organic-chemicals, pesticides, fertilizers, dyes and pigments, non-ferrous metals, steel and chloroalkali generate hazardous and toxic inorganic waste (heavy metals).

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define the concept of aquatic pollution and causes
- explain the meaning and classification of pollutants
- identify the main Sources of water pollution
- discuss the effect of water pollution on fish
- point out the implication of aquatic pollution
- demonstrate the method of preventing pollutants from aquatic environment.

3.0 MAIN CONTENT

3.1 Aquatic Pollution

Thus pollution is generally defined as "the addition of the constituents to water, air or land, which adversely alter the natural quality of the environment". The word 'Pollution' derived from the Latin word 'Pollutionem' (meaning to defile or make dirty). The term pollution is defined in various ways, like Pollution means the addition of any foreign material such as inorganic, organic, biological or radiological or any physical change occurring in nature which may harm or affect living organisms directly (or) indirectly, immediately (or) after a long-time.

3.1.1 Pollutant

In general, pollutants are residues of substances made by us, used by us and even thrown away by us as waste products, which pollute the environment in one way or the other. The pollutants can be classified in a number of ways. Either they may be classified on the basis of their forms they exist in the environment after their release or from ecosystem point of view.

1) *Basing up on the basis of their forms of existence in the environment*, they are:
   a) Primary pollutants: Those substances emitted directly from an identifiable source
   b) Secondary pollutants: These are the substances, derived by primary pollutants by chemical reactions.
2) *Basing on the ecosystem point of view*,
   a) Biodegradable pollutants: It includes domestic sewage, heat etc. that can be readily decomposed under natural circumstances. However, if the rate of production of such waste is higher than the rate of breakdown of these

materials, they tend to accumulate in the system, disturbing the balance between natural cycles, which intern give rise to pollution.

b) Non - biodegradable pollutants: The substances that are not degraded by micro organisms.

These include substances like heavy metals, aluminium cans, plastics, synthetic compounds such as pesticides, detergents and others.

3.2 Aquatic/Water Pollution

Modern civilisation with its rapidly growing industrial units and an increase in the population has led to an accelerated degradation of the freshwater resources. The water bodies are subjected to a wide variety of human activities such as washing, Swimming, bathing and waste disposal, disposal of industrial effluents etc., these modifies the environment of the natural waters, in a way that leads to a potential health hazard. Water resources are said to be polluted, when because of man's activity in adding or causing the addition of matter to the water or altering the temperature, the physical, chemical (or) biological characteristics of the water are changed such an extent that its utility for any reasonable purpose or its environmental value is demonstrably depreciated.

3.2.1 Types of Pollution

Kendeigh (1975) classified the pollution of aquatic bodies into four main types. they are:

a) Natural - Pollution brought about by naturally.
b) Silting - resulting from excessive erosion of the surrounding upland.
c) Industrial - Produced by inorganic chemical wastes from tarmeries, breweries, paper and pulp mills, gas plants, mines, metal industries, petroleum industries etc., d) Organic - Principally municipal sewage and drainage of agriculture land.
e) Thermal - As hot water effluent from industries and atomic power plants.

3.3 Main Sources of Water Pollution

Discharge of solid or liquid waste products containing pollutants into surface or coastal waters, or on to the land surface is the main cause of water pollution. Main sources are identified as follows:

Sewage and Domestic Wastes

About 75% of water pollution is caused by sewage and domestic wastes. *Organic pollution* originates from incompletely digested sewage, which usually has some remaining biochemical oxygen demand (BOD) when it is released. Swage originates from domestic and commercial premises, land drains, some industrial plants, and agricultural site.

Industrial Wastes

All industrial plants produce some organic or inorganic chemical wastes, which cause water pollution. Sometime major part of the industrial waste is discharged directly into rivers, canals, and the sea, and not into the sewerage system. The largest volume *of* discharged waste is in the form of an "effluent", which may be any solid, liquid, or gaseous product, in a treated or untreated condition. Industrial effluents may contain water, origanic solvents, oils, suspended solids, and dissolved chemical compounds.

Pesticides, Fertilizers and Detergents

The major source of pesticides in the rivers, streams and lakes is run-off from agricultural fields. The optimum condition for run-off is when there is heavy rainfall soon after the pesticide application. Pesticides also reach aquatic systems from discharge of industrial effluents into water. Pesticides can reach water in such effluents, either as waste from pesticide factories, or as discharge from factories.
The use of organic synthetic detergents has been responsible for considerable increase in the phosphorus released in sewage effluents. Detergents are composed of complex phosphates (alky 1 benzene sulfonate or alkylate sulfonates) which eventually breakdown into phosphates usable by aquatic plants. Several studies also indicate the toxic effects of detergent to fish. Fish exposed to household detergents exhibit abnormal behavior like frequent surfacing, air engulfing, jerking movement and loss of body balance.

Toxic Metals

Toxic metals are often described as the heavy metals**,** and these includes iron, lead, mercury, cadmimum, zinc, copper, nickel and arsenic. Very small quantities or traces of some metals are required for normal growth and metabolism, for example, copper, iron, nickel and zinc. However, if the threshold limit value (TLV) is exceeded, these metals may cause variable deleterious effect on plants and animals.

Thermal Pollution

Thermal pollution may be defined as the warming up of an aquatic ecosystem to the point where desirable organisms are adversely affected. A large number of industrial plants (electric power, steel and chemical industries) use cold water from the rivers and discharge it hot. A single 1000 MW power plant may use one- half million gallons of cooling water per minute. At some places atomic energy plants have become a major source of thermal pollution, which is harmful to fishes and aquatic invertebrates.

3.4 Effects of Water Pollution on Fish

Effects of water pollution on the different components of the biosphere are too many as are the sources of water pollution. The effects of water pollution may be considered under the following six headings. However, many factors including the quantity and composition of the effluent, the value of water, and weather conditions govern the overall effects of pollution.

3.4.1 Turbidity

Various types of suspended solid particles, discharged into water bodies, cause water turbidity and reduction of the dissolved oxygen in water. The natural turbidities are seldom, directly lethal to fish. But the turbidity may affect the productivity of an aquatic ecosystem and also hampers spawning and growth of fish. Fish and some invertebrates suffer from such pollution because their gill surfaces are clogged with suspended matter.

3.5.2 Heat

Other physical effects of water pollution include cooling water discharge from power stations, causing a rise in water temperature or the so-called thermal pollution. The rise in water temperature will lower the dissolved oxygen content, and speedup the biodegradation of pollutant organic matter. The biological effects of thermal pollution depend upon how much the temperature is raised, for the metabolic rate of physiological processes is speeded up by heat. Since each species has its own metabolic rate, most aquatic animals can only exist within a specific temperature range. For example, trout are killed by temperature of over 25^0C and their eggs will not develop in water above 14^0C. Rivers affected by thermal pollution support only coarse fish and raised water temperature increase vulnerability of fish to disease.

3.5.3 Oxidation Effects

Oxidation effects are caused by (a) *bacterial action upon organic pollutants,* and (b) *through chemical oxidation of inorganic and organic substances present in industrial wastes.* Both types of oxidation require the use of dissolved oxygen, thereby producing an increased BOD and oxygen deficit in water bodies. Fishes are usually eliminated for long distances by severe organic pollution. Obviously, toxic substances, particularly ammonia, sulphides and cyanides, kill them, as do very low oxygen tensions which enhance the toxicity of most poisons.

3.5 Toxic Chemical Effects

Toxic chemical effects are caused by a range of substances that cause immediate or cumulative physiological changes in plants, animals and humans. Toxins are absorbed into the tissues from polluted water, and their effect varies with the type of chemical substance, the concentration in the tissues, and the metabolism of the organism. Chemical toxins can be broadly described as (i) metals and salts, (ii) pesticides, (iii) acids and alkalies, and (iv) other *organic compounds such as polychlorinated biphenyls orPCBs, phenols and cyanides.*

3.5.1 Metallic Pollution

One of the most significant effect of metallic pollution is that aquatic organisms can absorb and accumulate concentrations in their tissues. The heavy metals affect the fish tissues concerned with digestion, absorption, respiration, and excretion. Their haematological and pathological effects are well known. They also cause changes in tissue lipid and cholesterol content in fish and their acute toxicity leads to fish mortality.

3.5.2 Pesticidal Pollution

Pesticides also cause water pollution which is considered to be the most harmful. For example, DDT in rivers has an average half-life of 2.5 to 5 years, but it can persist for up to 25 years. Such non-degradable pesticides can accumulate in food chains through biological magnification, and it is known that shrimps and fish can concentrate some pesticides. Pesticide affect all the vital tissues of the fish body and their effects may be histopathological, biochemical and ecophysiological. Juvenile stages of fish are worst hit by pesticides.

3.5.3 Pollution by Acids, Alkalies and Other Organic Compounds

As acids and alkalie lower or raise the pH value of water, they are considered to be hazardous. Most animals and plants will not survive in water with a pH value below 5 (acid), or above 9 (alkaline). Changes in the pH can also affect the action of other toxins. A number of water pollution toxins such as chromates an chromic acid, beryllium, selenium, cadmium, chlorinated hydracarbons, some rganophosphorus pesticides, and polyvinyl eholoride, have been designated by the WHO. as potential carcinogens, capable of causing cancer in the long term to fish (Vlachogianni and Vlachgianni 2004).

3.6 Chemical Nutrient Effects

In water pollution, the two most important nutrients are nitrogen and phosphorus, usually present in all natural waters as nitrates and phosphates. The natural process of lake-ageing characterised by nutrient enrichment over a long period of time is called eutrophication. When the process of eutrophication is speeded up by human activity, it is called cultural eutrophication. About 80% of the nitrogen and 75% of the phosphorus added to lakes and streams in developed and developing countries have its source in human activities. When the average concentration of soluble inorganic nitrogen exceeds 0.30 ppm, and the soluble inorganic phosphorus content exceeds 0.01 ppm, algal blooms may appear.

During the summer, the algal bloom problem usually become more intense with adverse effects on the whole biota of the lake. Dense algal blooms at the lake surface reduce penetration of sunlight to the lake bottom. As a result, the deeper waters contain less amount of dissolved oxygen, which is further reduced by decomposing algal and organic matter accumulated at the lake bottom. The oxygen depletion is often responsible for the winter kill of fish in many lakes.

3.7 Pathogenic Effects Caused by Micro-Organisms

Inland coastal waters that receive sewage discharges and other wastes are a potential health hazard, as they contain pathogenic organisms. At present, sewage effluent is tested only for the presence of *E.coli*, which is a non-pathogenic intestinal bacterium. The so-called colifonu test of water purity is carried out to indicate the presence of absence of faecal matter present in water. This test does not show the presence of pathogenic bacteria and viruses.

Although drinking water supplies from rivers are given pre-water supply chlorination treatment, it is not possible to carry out chlorination of sewage effluent before it is discharged into water. This is because some free chlorine would enter rivers, and very low concentrations, such as 0.03mg/I, are lethal to fish and interfere with bio degradation, which is essential for resilience of rivers. Fish diseases caused by bacteria are - fin and tail rot, ulcer disease, dropsy, and eye disease. Fish are more prone to diseases in polluted waters and the incidence of diseases in polluted waters and the incidence of disease can be minimised by improving sanitary conditions prevalent in the water and by good pond management.

3.8 Effects Caused by Accumulation of Radioactive Substances

Radio-nuclides ultimately become concentrated in bottom living food organisms and produce deleterious effects on human body. However, close monitoring of radioactive pollution in necessary in order to assess their build up and harmful effects in fish, shell fish and crustaceans, which are used as food.

3.9 Industrial Pollution and Fisheries

At present, all the major rivers of Nigeria are polluted by a vast array of industrial effluents. Since these effluents have very low DO, high BOD and many types of toxic substances, causing various effects on the aquatic communities, including sudden fish kills and other ecological problems, All river systems of Nigeria are polluted by tanneries, textile, wood and jute mill wastes, besides effluents from sugar mills, distilleries, pulp and paper factories, synthetic rubber industry, fry ash from coal washeries and DDT factories. Industrial wastes from oil refineries, steel plants, paint and varnish manufacture plants, and cement and pesticide factories also pollute the inland waters. The distillery wastes of low pH and high oxygen demand created problems causing asphyxiation and mortality of fish. The industrial pollution not only degrades the natural water quality of streams and rivers, it also causes heavy losses of fishery.

Studies on the ecology and pollution states of the Nigerian rivers indicate that direct disposal of industrial wastes poses serious problem. Since most of the industrial units do not have satisfactorily waste disposal systems or treatment plants, the waste is indiscriminately discharged into nearby water bodies, leading to pollution.

3.10 Use of Fish as Biological Indicators of Water Pollution

Besides algae, macro-phytes, and benthie macro-invertebrates, fish are considered excellent indicators of the water quality. The presence of a species indicates that the habitat is suitable, and since some of the environmental requirements are known for many species, their presence indicates something about the nature of the environment in which they are found. Thus, the absence of a particular species is less useful as an indication of environmental conditions than the presence of a species. Based on these criteria several schemes of river zonation have been proposed indicating the presence of one or more dominant fish species usually present in a particular zone. From the headwaters to the mouth, these fish species indicate the unpolluted, less polluted, polluted and intensely polluted zones of the streams. Several other parameters such as fish population size, growth rate, condition factor and diversity are also indicative of the overall health of water and prevailing environmental conditions. Fish populations in polluted environments are subjected to a long-term contaminant stress which might affect them in several ways, including modification of reproductive ability, reduced longevity, reduced growth rate, and increased rate of tumor or lesion development.

Pollution of any kind usually affects both abiotic and biotic environment of fishery waters. The interrelationships between the fish and the elements of its abiotic and biotic environment are interdependent; any changes in one system of relationships inevitably produce changes in the other. The interaction of fish with any particular elements of its environment / total environment / the effect of total environment is greatly depends upon the condition of the fish itself. The topic of water pollution and fish will continue to be a subject of zero interest and inquiry for future generations of fish biologists, fishery scientists and limnologists.

3.11 Implication of Aquatic Pollution

The implications of Aquatic pollution for Aquatic biodiversity include, but are not limited to:

a. degradation or loss of seafloor habitats and poorer water quality;
b. displacement of Aquatic species and changes in their distribution and density;
c. increased concentrations of contaminants in Aquatic organisms and resultant morphological or other effects; and
d. reduction in relative abundance of top-order predators in Aquatic ecosystems. The major types of Aquatic pollutants are oil, sewage, Aquatic debris, pesticides, nutrients (e.g. agricultural fertilisers and nutrients from finfish farming), residues in

industrial wastewater, antifoulants, antibiotics, metals, radioactive waste and thermal pollution. The activities that cause Aquatic pollution generally include shipping, boating (e.g. vessel maintenance activities and littering), oil and gas exploration, mineral resource extraction, storm water run-off and poor land management practices.

3.12 Methods of Preventing Pollutant from Aquatic Environment

a. Whenever possible the chemical fertilizer may be replaced by biofertilizer. Similarly biodegradable insecticides should replace the nonbiodegradable ones and biological control should replace the chemical control as much as possible.
b. Indiscriminate use of fertilizer should be stopped.
c. Proper sanitation both in urban and rural area should be ensured.
d. Adequate measures should be taken by the industries to dispose off all types of wastes in a proper manner i.e. following the environmental quality standard.
e. All necessary steps to be taken for reutilisation of agricultural residues through bio-conversion to industrial products.
f. To promote research on waste utilisation and waste recovery process.
g. Attempts to be taken to control insect pests through biological, microbial or genetically process instead of using toxic chemicals.
h. Appropriate legislation of oil spill in the coastal area to be established and implemented as early as possible to minimise marine pollution.
i. To minimise the obstruction of water flow being created by the construction of dams, embankment and other water structures.

4.0 CONCLUSION

Pollution is generally defined as “the addition of the constituents to water, air or land, which adversely alter the natural quality of the environment”. In general, pollutants are residues of substances made by us, used by us and even thrown away by us as waste products, which pollute the environment in one way or the other. The pollutants can be classified in a number of ways: either they may be classified on the basis of their forms they exist in the environment after their release or from ecosystem point of view, basing up on the basis of their forms of existence in the environment, Basing on the ecosystem point of view. Discharge of solid or liquid waste products containing pollutants into surface or coastal waters, or on to the land surface is the main cause of water pollution. Effects of water pollution on the different components of the biosphere are too many as are the sources of water pollution. The

effects of water pollution fully discussed. However, many factors including the quantity and composition of the effluent, the value of water, and weather conditions govern the overall effects of pollution.

5.0 SUMMARY

- Pollution means "the introduction by man, directly or indirectly, substances or energy into the aquatic environment (including estuaries) which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazard to human health, hindrance to marine activities including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities".

- Pollutants are residues of substances made by us, used by us and even thrown away by us as waste products, which pollute the environment in one way or the other.

- Discharge of solid or liquid waste products containing pollutants into surface or coastal waters, or on to the land surface is the main cause of water pollution
- Effects of water pollution on the different components of the biosphere include, Turbidity: Heat: Oxidation Effects etc

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the concept of aquatic pollution and causes.
2. Explain the meaning and classification of pollutants.
3. Explain the main Sources of water pollution.
4. Explain the effect of water pollution on fish.
5. Explain the implication of aquatic pollution.
6. Explain the method of preventing pollutants from aquatic environment.

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MODULE 4 CLIMATE CHANGE ON AQUATIC BIODIVERSITY

UNIT 1 CLIMATE CHANGES AND AQUATIC BIODIVERSITY

CONTENTS

1.0 INTRODUCTION

Climate change has been defined as any change in climate over time, whether due to natural variability or as a result of human activity. Current global concern is focused on climate change resulting from human activity, and specifically from the release of carbon dioxide and other greenhouse gases to the atmosphere. The burning of fossil fuels, clearing of forests, and certain other human activities are major sources of greenhouse gas emissions.

Climate change will affect the nature and characteristics of the freshwater resources on which Nigerians depend. The impacts will vary

between eco-zones, exacerbating existing problems of too much water (floods), too little water (droughts) and reduced water quality (e.g. salt water intrusion). Climate change impacts, including sea level rise and extreme weather, will also affect Nigeria's coastal and marine areas, home to 25% of the country's population and to Nigeria's economically important petroleum industry. These impacts on freshwater and coastal water resources will also affect fisheries, a main source of livelihoods and protein for riverside and coastal rural communities

2.0 OBJECTIVES

At the end of this unit, you should be able to explain the:

- concept of climate change and its effect on aquatic environment
- fish food production and climate change in Africa adaptation strategies climate change for Africa
- evidence of climate change on the aquatic environment
- effect of climate change on aquatic environment
- priority action for the management of climate change on aquatic biodiversity

3.0 MAIN CONTENT

Water resources are inextricably linked with climate, so the prospect of global climate change has serious implications for water resources and regional development (IPCC, 2001). Efforts to provide adequate water resources for most developing countries will confront a number of challenges, including population pressure, land use related problems such as erosion/siltation, and possible ecological consequences on the hydrological cycle. Climate change will make addressing these problems more complex. The human population explosion, largely concentrated in and around the coastal belt is now earth's most significant environmental phenomenon. Over 90% of the earth living and non living resources are found within a few kilometres of the coast (Ahove, 2001), where more than 4 billion people live and this proposition according to prediction will rise to 75% by 2030. The coastal populations are growing at a rate of about 1 million people per day and 80% of the world biodiversity is concentrated within the coastal region, much of it undiscovered (IYO, 1998).

3.1 Impacts of Climate Change on Freshwater (Land-Water) Fisheries and Aquaculture

3.1.1 Higher Inland Water Temperatures

Higher inland water temperature will impact on fish stocks in diverse ways. Increased stratification of water in lakes will lead to reduction in productivity and reduction in fish population. This phenomenon could possibly enhance fish stocks for capture fisheries or else there will be reduced growth where the food supply does not increase sufficiently in line with temperature. Where the fish species experience raised metabolic changes, potential productivity will be affected. Most of the species and communities in rivers have a limited range of temperature tolerance. An increase of 2-3 degrees Celsius in temperature, along with changes in flow, could see some species, such as larval insects like stoneflies or mayflies, change distribution, decline in population or even become extinct by the 2080's. Fish, including shellfish, respond directly to climate fluctuations, as well as to changes in their biological environment (predators, prey, species interactions, disease) and fishing pressures.

All species are adapted for life over a relatively moderate range of temperatures compared with the extremes experienced form the poles to the tropics. Temperatures below the optimal range slow the rate of metabolism and, if too low, can become lethal. Temperatures above the optimal range increase metabolism and, because warmer water contains less dissolved oxygen, a thermal threshold is reached where respiratory demand exceeds the capacity for oxygen uptake, sometimes referred to as the “temperature-oxygen squeeze” (Portner and Knust 2007). Hence, temperature is one of the primary environmental factors that determine the geographic range of a species. Minimum winter temperatures often determine the high-latitude boundary (the northern boundary in the northern hemisphere) while summer maximums determine the low-latitude limit of a species. Even within the normal range of a species, the dynamics of populations often show strong correlations with temperature trends (Conover, 2007).

3.1.2 Changes in Precipitation

Changes in precipitation quantity, location and timing that alter water availability will collective alter abundance and composition of wild stock, and impact on seed availability for recruitment. Changes in lake water level will alter spawning and recruitment of endemic fish species. Lower water level will lead to low water quality due to reduced productivity capacity of photosynthetic balance. Fish often seek optimal temperature or salinity regimes or avoid suboptimal conditions. Thus,

ocean and freshwater changes as a result of projected climate change can lead to distributional changes. In suboptimal conditions, performance is reduced, leading to starvation or increased predation. The biology and ecology of fish in large rivers are strongly linked to the hydrological regime in the main channel and the regular flooding of their adjacent floodplains. The absolute and relative abundance and biomass of species of fish inhabiting large rivers are predicted to change in response to both natural intra-annual variations in flooding regimes as well as long-term climatic shifts. Changes in precipitation averages and potential increases in seasonal and annual variability and extremes are likely to be the most significant drivers of change in inland aquaculture and fisheries. While a relationship exists between greater flooding extent and higher production in capture fisheries, potential benefits may be offset by a range of factors including reduced success of pelagic river spawners arising from higher river flows, reduced fish survival in lower dry season flows, and loss of habitat to new hydraulic engineering projects and other human responses. Damage to other livelihood and food production resources may also occur. In many African lakes, water level determines stock fluctuations more than any other factor. This is especially true of lakes that periodically go completely dry, such as Mweru Wa Ntipa, Chilwa/Chiuta and Liambezi. In Lake Mweru and Lake Turkana, for example, catch rates decline when the lake level is low (World Fish Centre, 2007). Understanding how fisherfolks have adapted to variability through, for example, mixed livelihood strategies and the absence of barriers to entering fisheries, and how fisheries interact with other economic sectors may usefully guide responses to future climate variation and trends. Flexible management is the key to ensuring benefits flow from an unstable and uncertain resource. Reduced annual rainfall, dry season rainfall, and growing season length are likely to have implications for aquaculture and create greater potential for conflict with other agricultural, industrial and domestic users in water-scarce areas (World Fish Centre, 2007).

3.1.3 Impacts on Land-Water Interface on Lakes

Over 90 per cent of lakes in the developing countries harbour important fisheries that contribute to employment, food security, government tax revenues, domestic markets and exports. The production systems of these lakes are known to be climate-sensitive. Livelihoods around these lakes combine farming and fishing, and with both negatively affected by rainfall reduction, if regional climate forecasts are accurate, it seems likely that rural livelihoods in lakeshore regions will become more precarious and less viable over time. Migration from lake to lake, and from lakeshore regions to cities and other areas of economic opportunity is already common in the region.

For the extensive shallow lake-wetland complexes such as Lakes Chad, Kyoga and Chilwa, analyses of links between rainfall variation, lake levels and fish catches indicate that predicted reductions in rainfall in some regions are likely to result in significant reduction of lake and wetland area, with resulting large reductions in fish production and supply, particularly in the case of wetlands in arid and semi-arid areas. With the resilience of these production systems partly dependent on the existence of dry season refugia for fish, increasing duration of the dry seasons and increased number of drought years, forecast in some regional climate models, is likely to result in reduced resilience of these lakes and increased pressure on dry season refugia (Allison *et al*, 2005).

3.1.4 Impacts on Coastal (land-water) Fisheries

Coastal and marine ecosystems are intimately linked to climate. Thus, climate change will exacerbate the problems already occurring in these vulnerable ecosystems due to increasing coastal populations, habitat loss, nutrient pollution and invasive species. Climate induced environmental changes on estuarine and marine ecosystems include: Temperature changes that alter ecological processes and species interactions; Increase in frequency of extreme ocean warming events, with implications for coral reef bleaching; changes in precipitation that alter freshwater run-off of nutrients, sediment, and contaminants; accelerated rates of sea level rise; alteration of oceanic wind and water circulation patterns; continued losses of sea ice over large areas of the Arctic basin; ocean acidification caused by reaction of increasing CO2 with seawater (NCCOS,2007).

3.1.5 Sea Level Rise and Coastal Erosion

The IPCC Fourth Assessment Report (2007) reports that global sea level is expected to rise between 18 and 59 cm by the end of this century, not accounting for changes in ice flows in Antarctica and Greenland, which could boost that figure. Local rates of sea level change depend not only on the overall global warming and ice melt, but on regional changes in ocean and wind circulation patterns. With strong growth in coastal populations worldwide, sea level rise has strong and direct impacts on low-lying areas through increased coastal flooding and erosion, contamination of groundwater supplies, and increased vulnerability to storm surges. Sea level rise will lead to reduced area available for mariculture and aquaculture. Changes to estuaries' ecosystems, salt water infusion have the tendency to influence shift in species abundance, distribution and composition of fish stocks. In some coastal areas, damage to freshwater capture fisheries and reduced freshwater availability for aquaculture and a shift to brackish water species could be

negatively predicted. Loss of coastal forest ecosystem will alter the ecosystem balance between the riparian and freshwater interaction.

3.1.6 Impacts of Extreme Events and Worsening Risk

Extreme events such as cyclones and their associated storm surges and inland flooding can wreak sudden and severe havoc on fisheries, and particularly on aquaculture, through damage or loss of stock, facilities and infrastructure. Institutional responses such as constructing artificial flood defences and maintaining natural ones can provide protection that is significant but incomplete. (ICLARM, 2006). Poor communities in exposed areas are unlikely to be able to build substantial defences, so the most realistic and economic strategy will be to roll with the punches. In countries where floods are common, short culture periods and minimal capital investment in aquaculture help reduce stock loss and its cost. Building greater adaptive capacity will entail considering means, such as mixed livelihood strategies and access to credit, by which aqua culturists can cope financially with sudden losses of investment and income. Other considerations for coping strategies in high-risk areas include monitoring and assessing risk and promoting aquaculture species, fish strains, and techniques that maximise production and profit during successful cycles.

3.1.7 Impacts on Coral Reefs

Coral reefs are a major source of ecosystem goods and services, particularly for small island developing states. Tens of millions of people in over 100 countries are likely to depend on coral reefs for part of their livelihood or for part of their protein intake. Thermal bleaching along with fisheries exploitation, pollution and disease are the greatest threats to coral reefs. The indirect effects of acidification on fisheries will include loss of reef habitat constructed by marine calcifiers. Many fishes depend on the physical structure provided by coral skeletons or shell-building organisms such as oyster reefs as essential habitat for one or more life stages. In addition, food web alterations will likely affect harvested species through bottom-up effects on the food chain resulting from pH-induced shifts in the plankton community.

3.1.8 Fisheries and Ecosystem Impacts

Marine organisms will be influenced by changes in circulation, ventilation, and stratification through changes in temperature, light, and nutrient supply. Alterations of any of these drivers may lead to changes in species abundance and composition, possibly leading to large-scale regime shifts and species migrations. Such changes will affect marine organisms higher up on the food chain in ways that are not yet fully

understood. Habitat loss, resulting from sea level rise and invasion by non-native species will also perturb marine ecosystems, including marine mammals and sea birds, affecting the health and biodiversity of marine ecosystems.

3.1.9 Implications for Management

Resource managers need to recognise that local populations of species near the limits of their distributional ranges will need additional precautionary measures to protect them from extinction. Warming and acidification represent additional stresses that make populations less resilient to the effects of harvest. We may need to reduce harvest of some species in certain areas to enable them to withstand the additional stress. Transitional regions are where the impact of climate change will first be evident. These regions are also conduits for species exchange. The certainty of climate change and its potential impacts on ocean ecosystems underscore the need for a comprehensive ocean observation system. Our ability to unravel the causes and consequences of ecosystem change is directly dependent on the availability of a continuous time series of many different kinds of environmental data. Gradual trends in highly variable environmental parameters like temperature, oxygen, salinity, pH, chlorophyll, wind, circulation patterns, and others become evident only after many years.

3.2 Fish Food Production and Climate Change in Africa

Over the years, different views and discussions have shown that there is considerable uncertainty about the physical changes and response of the various freshwater and marine species; however, it is possible to suggest how certain species may respond to projected climate changes over the next 50-100 years. The uncertainties highlight the importance of research to separate the impacts of changing climate from natural population fluctuations and fishing effects. Many commercial finfish populations already are under pressure (e.g., overexploited), and global change may be of minor concern compared with the impacts of ongoing and future commercial fishing and human use or impacts on the coastal zone.

Further, changes in the variability of climate may have more serious consequences on the abundance and distribution of fisheries than changes in mean conditions alone and changes in future climate variability are poorly understood at this time. The impacts of physical and biological changes on fisheries communities will be as varied as the changes themselves. Both negative and positive impacts could be foreseen, their strength depending on the vulnerability of each community, the combination of potential impacts (sensitivity and

exposure) and adaptive capacity. This phenomenon will carry a high risk in Africa. Impacts would be felt through changes in capture, production and marketing costs, changes in sales prices, and possible increases in risks of damage or loss of infrastructure, fishing tools and housing. Fishery-dependent communities abound in Africa and may also face increased vulnerability in terms of less stable livelihoods, decreases in availability or quality of fish for food.

3.3 Adaptation Strategies for Africa

The extent to which people and systems are affected by climate change (their vulnerability) is determined by three factors: their exposure to specific change, their sensitivity to that change, and their ability to respond to impacts or take advantage of opportunities. Coastal adaptation for developing countries will be more challenging than for developed countries, due to constraints on adaptive capacity. The non-linear interactions of these factors mean that vulnerability is unevenly distributed, sometimes in surprising ways. It is important to understand patterns of vulnerability to specify and prioritise adaptation interventions. It is a general opinion that more needs to be known about Africa's climate, impact of climate change on ground water and energy systems. Above all, there is a need to support more regional strategies for adaptation and at the same time mainstreaming climate change concern into developmental policies and plans by all the African governments.

It is a known fact that the impact of climate change on coasts is exacerbated by increasing human-induced pressures. Most African coasts are experiencing the adverse consequences of hazards related to climate and sea level. African governments need to do the following: (a) enhance social capital and reduce the vulnerability of developing countries; (b) increasing income levels, education and technical skills of its citizenry; (c) promote good governance including responsible policy and decision making and communities empowerment; (d) increase agriculture adaptive capacity and at the same time modifying farming practices and (e) massive restoration and re-establishment of vegetation.

3.4 Evidence of Climate Change on the Aquatic Environment

Evidence of climate change impacts on aquatic systems is mounting from the world's oceans. A number of examples include:

i. coral bleaching associated with prolonged high sea surface temperatures;

ii. shifts or range extensions polewards in species distributions, linked to warming temperatures, in all trophic levels including demersal and pelagic fish, intertidal fauna, macroalgae, plankton and seabirds; and
iii. alteration of the timing of biological events, such as the peak spring phytoplankton bloom and the migration and breeding periods of Aquatic animals. Variations in species adaptability and the different responses of species to changes in climate may have severe consequences that could lead to a mismatch between trophic links, mistiming of critical life history events and, ultimately, a loss of biodiversity.

3.5 Effect of Climate Change on Aquatic Environment

The likely implications of climate change for the Aquatic environment include, but are not limited to:

i loss, degradation of habitat or changes in its distribution and density;
ii changes in ocean currents, upwellings and productivity;
iii displacement, distributional and abundance changes of Aquatic species;
iv loss of synchronisation between essential climate/weather/seasonal events affecting biota (such as a mismatch between phytoplankton blooms and zooplankton growth);
v lower ocean productivity and disrupted/changed food chains; and
vi ocean acidification (changing the ability of calcium carbonate-producing organisms to construct shells).

3.6 Priority Action for the Management of Climate Change on Aquatic Biodiversity

The following priority actions are proposed to achieve a greater understanding of climate change impacts on Aquatic biodiversity and adaptive management approaches:

i. improve our understanding of the vulnerability of aquatic biodiversity to climate change and prioritise future activities:
ii. identify species and systems at particular risk from climate change (such as local endemics restricted to a small area of suitable habitat like the spotted handfish) or unique ecosystems with unique evolutionary origins unlikely to be replicated in another area (e.g. Bathurst Harbour, southwest Tasmania);
iii. identify processes threatened by climate change (e.g. tightly coupled processes that become decoupled due to changes in

timing; chemical changes in the oceans caused by acidification; and coral bleaching caused by increased temperature maxima); and

iv. develop regional climate models and scenario modelling, to assess the potential effects of major regional climate change on Aquatic activities (particularly fisheries and aquaculture) and biodiversity.

v. adapt management approaches to the impacts of global climate change on Nigeria's Aquatic biodiversity:

vi. develop regional Aquatic climate adaptation plans that identify climate risks and vulnerabilities and also Aquatic management scenarios and adaptations for Aquatic industries and activities (fisheries, aquaculture, coastal development);

vii. integrate current knowledge of regional climate change risks and vulnerability into current large-scale bioregional planning and decision making processes; and

viii. develop a national governance framework to assess and review the integration of current understanding of Aquatic climate change into Aquatic management frameworks and directions.

4.0 CONCLUSION

Climate change is environmental change, but given that human societies are affected directly and indirectly by the climate system – and given that human activities are driving climate change – it is fundamentally a human problem. Climate change cuts across boundaries. The impacts of climate change are expected to seriously (and disproportionately) affect the livelihoods, health, and educational opportunities of people living in poverty, as well as their chances of survival, both locally in specific areas and globally in general. A wide range of adaptations is possible, either carried out in anticipation of future effects or in response to impacts once they have occurred. In general, responses to direct impacts of extreme events on fisheries infrastructure and communities are likely to be more effective if they are anticipatory, as part of long-term integrated management planning. However, preparation should be commensurate with risk, as excessive protective measures could themselves have negative social and economic impacts FAO, 2008).

A changing global climate threatens species and ecosystems. The distribution of species (biogeography) is largely determined by climate, as is the distribution of ecosystems and plant vegetation zones (biomes). Climate change may simply shift these distributions but, for a number of reasons, plants and animals may not be able to adjust.

5.0 SUMMARY

- Climate change is environmental change, but given that human societies are affected directly and indirectly by the climate system – and given that human activities are driving climate change – it is fundamentally a human problem. Climate change cuts across boundaries.
- Higher inland water temperature will impact on fish stocks in diverse ways. Increased stratification of water in lakes will lead to reduction in productivity and reduction in fish population.
- Changes in lake water level will alter spawning and recruitment of endemic fish species.
- Coastal and marine ecosystems are intimately linked to climate. Thus, climate change will exacerbate the problems already occurring in these vulnerable ecosystems due to increasing coastal populations, habitat loss, nutrient pollution and invasive species.
- Global sea level is expected to rise between 18 and 59 cm by the end of this century, not accounting for changes in ice flows in Antarctica and Greenland.
- 7 Marine organisms will be influenced by changes in circulation, ventilation, and stratification through changes in temperature, light, and nutrient supply.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the concept of climate change and discuss its effect on aquatic environment.
2. Explain the fish food production and climate change in Africa..
3. Explain the adaptation strategies climate change for Africa.
4. Outline the evidence of climate change on the aquatic environment.
5. Outline the effect of climate change on aquatic environment.
6. Outline the priority action for the management of climate change on aquatic biodiversity.

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MODULE 5 AQUATIC BIODIVERSITY MONITORING, ASSESSMENT, CONSERVATION AND MANAGEMENT MEASURES

UNIT 1 QUATIC BIODIVERSITY MONITORING

CONTENTS

1.0 INTRODUCTION

Fish are an important component of aquatic ecosystems through their role as consumers of other organisms and they can have a significant influence on the structure and function of these ecosystems. Because of this, adverse effects on fish can have adverse flow–on effects on other aquatic organisms even if they are not directly affected by those changes in water quality. Monitoring of fish communities can, therefore, provide a useful indicator of the ecological health of natural waters.

Fish are sensitive to many changes in water quality and habitat structure caused by human activities and by natural causes. Common adverse anthropogenic effects on fish can result from many factors including: contamination of water by waste metal pollution, pesticides, salinity and organic wastes and nutrients causing either direct effects on fish health or indirect effects on the oxygen climate in the water through eutrophication; and physical habitat changes such as thermal pollution, changes in stream flow regime, stream bed aggradations, de-snagging,

and land clearance, especially in riparian zones. Consequently, as well as their intrinsic biodiversity value and the human food value of some species, fish can be useful indicators of the impact of many different human activities on the environmental health of a water body.

The use of fish community structure in environmental monitoring programs of freshwater systems (as opposed to fishery management programs) has increased in recent years. This is due in part to increasing public concerns about loss of natural biodiversity resulting from human activities and the higher public profile of fish in comparison to smaller invertebrates that are more widely used in assessment of the health of stream ecosystems. Also, as well as concern for the health of fish and the aquatic environment, there is often concern about the risk to humans from the consumption of fish from contaminated waters.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- discuss the methods of aquatic biodiversity monitoring
- list the advantages and disadvantages of monitoring fish
- explain the design considerations for a fish monitoring program.

3.0 MAIN CONTENT

Monitoring is technically defined as systematically checking or scrutinising something for the purpose of collecting specified categories of data. In ecology it generally refers to sampling something in an effort to detect a change in a physical, chemical, or biological parameter. The common types of monitoring used to examine changes in aquatic habitat and biota include: baseline, trend, implementation, effectiveness, and validation monitoring there are several logical steps that should be taken when designing any monitoring and evaluation programme. These include establishing project goals and objectives, defining clear hypotheses, selecting the monitoring design, selecting monitoring parameters, spatial and temporal replication, selecting a sampling scheme for collecting parameters, implementing the programme, and finally, analysing and communicating results. Many of these steps are interrelated and some steps could occur simultaneously or in a different order than presented here. For example, monitoring design depends on hypotheses and spatial scale, just as the number of sites or years to monitor depends in part on the parameters selected. The first steps are critical for designing an effective monitoring and evaluation programme and we focus our discussion on these.

3.1 Biodiversity Monitoring

3.1.1 Biodiversity Monitoring Will Include the Following Elements:

- **Monitoring of Poverty-Natural Resource Indicators:** that affect income, security and vulnerability of the poor. This recognises the cause and effect relationship between poverty and biodiversity loss. This will include monitoring of rural poverty levels, annual household consumption from common lands and forest products, distance walked by household members to collect fuel wood and water.
- **Monitoring of Habitats:** The Department of fisheries will continue to periodically monitor changes in aquatic environments, throughout the country, to elucidate and document the dynamics of habitat change in Nigeria.
- **Monitoring of Indicator Species:** Some key species shall be periodically monitored in wetlands through surveys to be conducted by the Federal Ministries of Environment, Agriculture, and Water Resources, in collaboration with other relevant government and non-government organisations and academic institutions.
- **Monitoring of Benefit Sharing:** Periodic Assessments (PA) will be carried out to find out the kinds of products and services used by various stakeholders. Individual projects will have a strong component on the monitoring of products/services and the actual benefits shared by different sub-groups of stakeholders.
- **Monitoring of Management:** The effectiveness of the PA and conservation programme management regimes will be monitored to ensure that natural resource use is sustainable. Each management plan will include a monitoring component whereby management procedures will be monitored and periodically evaluated.
- **Monitoring of Physical Parameters:** The Federal Ministry of Environment will monitor the level of soil and water erosion in the different agro-climatic zones. The Ministry will also monitor indicators such as air pollution and assess parameters such as water pollution, and levels of carbon dioxide and greenhouse gases.

3.2 Advantages and Disadvantages of Monitoring Fish Advantages

Compared to invertebrates and algae there are relatively few fish species to be considered in biodiversity measures in freshwater. Although some

species are difficult, or impossible, to distinguish in the field, most species are relatively easy to identify. This makes collection of data on numbers of fish of different species quite rapid once the fish have been captured. Training of staff to identify fish is relatively easy with only about thirty species likely to occur at any one location (usually much less) and around fifty species possible in an entire catchment in the Top End.

Disadvantages

The mobility of fish is a major disadvantage for monitoring programs since unless there are barriers to fish movement, different sites on a river system cannot be strictly regarded as independent. In Top End Rivers there is extensive dispersal of fish along river channels and across wetlands during the wet season (Bishop & Forbes 1991; Bishop et al. 1994). This makes it invalid to use sites upstream from a known point source of pollution as a control site for changes that may occur downstream. Control sites then should ideally be on different stream systems.

The mobility of fish also makes them difficult to sample and many different capture techniques have been devised for different habitats and types of fish behaviour. Unfortunately, each capture method has its own bias towards certain species and sizes of fish making this aspect an important consideration in the design of monitoring programmes and interpretation of results.

3.3 Design Considerations for a Fish Monitoring Programmes

There are many factors that must be considered in designing any environmental monitoring program. The design of a fish monitoring program is very much dependant on the management objectives and the parameters to be measured. For the objective of environmental protection the common parameters used are measures of biodiversity and measures of levels of contaminants of interest in fish tissues. Various indicators of fish health can also be measured. In some situations toxicity studies of water on fish (and other organisms) may be particularly useful, especially where adverse effects of known contaminants cannot be predicted and where chemical monitoring cannot explain observed adverse biological effects.
Where there are species of conservation significance, population studies similar to those used by fisheries managers may be warranted.

Preliminary literature and field pilot studies should be undertaken to provide information on the following:

1. Risk assessment of potential environmental impacts to decide on habitats and locations of concern, if any.
2. The array of fish species likely to be encountered

The risk assessment allows the decisions on what habitats and number of stream or wetland locations is required to test hypotheses involved in achieving management objectives.

The information on the possible fish assemblage allows the determination of the following:

1. Behaviour of different fish species to determine likely habitats and times to sample for them.
2. Appropriate sampling methods must then be selected considering their effectiveness in different habitats, biases for fish species and sizes, cost, time and effort involved in their use, OH&S issues and training.
3. The time and frequency of sampling taking staff resources and the seasonal behaviour of the fish into account.

The final experimental design will consider these parameters in a model that can test the hypotheses posed. Power analysis can be used to evaluate the level of effects that can be detected by the model.

4.0 CONCLUSION

Fish are sensitive to many changes in water quality and habitat structure caused by human activities and by natural causes. Common adverse anthropogenic effects on fish can result from many factors including: contamination of water by waste metal pollution, pesticides, salinity and organic wastes and nutrients causing either direct effects on fish health or indirect effects on the oxygen climate in the water through eutrophication; and physical habitat changes such as thermal pollution, changes in stream flow regime, stream bed aggradations, de-snagging, and land clearance, especially in riparian zones. The use of fish community structure in environmental monitoring programs of freshwater systems (as opposed to fishery management programs) has increased in recent years. This is due in part to increasing public concerns about loss of natural biodiversity resulting from human activities and the higher public profile of fish in comparison to smaller invertebrates that are more widely used in assessment of the health of stream ecosystems. Also, as well as concern for the health of fish and the aquatic environment, there is often concern about the risk to humans from the consumption of fish from contaminated waters.

5.0 SUMMARY

- Fish are sensitive to many changes in water quality and habitat structure caused by human activities and by natural causes.
- The use of fish community structure in environmental monitoring programs of freshwater systems (as opposed to fishery management programs) has increased in recent years.
- Monitoring is technically defined as systematically checking or scrutinising something for the purpose of collecting specified categories of data.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the methods of aquatic biodiversity monitoring.
2. Explain the advantages and disadvantages of monitoring fish.
3. Explain the design considerations for a fish monitoring programme.

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UNIT 2 AQUATIC BIODIVERSITY ASSESSMENT

CONTENTS

1.0 INTRODUCTION

The assessment of the size and state of the stocks exploited by fisheries is one of the pillars of modern management. Direct observation of fish populations over a wide area is impossible without specialised remote sensing electronic instruments (such as echo sounders and echo integrators used in acoustic surveys). Fisheries scientists have also developed techniques to estimate the nature, abundance, distribution, structure and population dynamics of fishery resources from catch data.

In most fully developed fisheries, a sizeable part of the fishable stock, often close to half of it, may be available for sampling, identification and measurement at the place of landing. This may not be possible when the catch is processed on board (e.g. on factory ships) and is particularly difficult for dispersed small-scale fisheries. When the age of

fish can be easily determined, e.g. from the fish hard parts (e.g. otholiths or vertebrae) or analysis of size frequency, growth and death rates (resulting from both fishing and natural causes) can be readily estimated and fed into models. When this is not possible, tagging methods can be used to obtain the same result plus information on migration).

A complete stock assessment is a stepwise process. Steps include; defining biological and geographic extent of the stock(s) in question; choosing data collection methods and collecting he data; choosing an assessment model and its parameters and conducting the assessment; specifying performance indicators and performing alternative action evaluations; presentation of findings (NRC, 1998). Stock assessment models attempt to predict changes in biomass and productivity based on yield data collected from a target fishery. Stock assessment relies on the estimation of many parameters, which require a lot of data from historical fishery and independent biomass surveys (Pitcher and Preikshot, 2001). Fundamentally, stock assessment models are based on rates, which imply time, which is why an estimate of fish age is required. Conventional stock assessment techniques employed in tropical lotic systems often use length-based data because the technology necessary for direct age determination i.e. otolith/scale preparation and analysis is unreliable, expensive or not available. Length-based analyses require a lot of data, and length is not a desirable variable, as its relationship to age is non-linear, but length data is easily taken in the field, with simple measuring boards and recording forms.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- demonstrate the method of assessing fish stock
- explain the sampling methods of stock under exploitation
- list the methods for measures of biodiversity
- identify the main problems with aquatic biodiversity assessment.

3.0 MAIN CONTENT

3.1 Assessing Stocks

Stocks are assessed using two alternative approaches (sometimes simultaneously), depending on data available. Synthetic methods use the theoretical relationship between the level of fishing intensity and the total catch. Analytical methods use the relation between recruitment, growth and mortality.

With both approaches, the starting point for assessing the state of a fish stock is to determine the size of the total catch. Ideally, data must be collected on all the age classes of fish removed from the stocks concerned. Apart from commercial landings, any subsistence catches or fish discarded at sea by fishers in pursuit of other species ought to be recorded or estimated. Statistics from commercial fisheries are easiest to obtain in the form of the landed weight of fresh, frozen, gutted or filleted fish. These landed weights are converted back to the equivalent of live weights to give the nominal catch. This figure, in turn, is converted to the gross catch by adding estimates of fish lost, consumed or discarded at sea.

Fishing reduces the abundance of the virgin stock, causing the catch per unit effort to fall. It also reduces the lifespan and the average size and age in the population, increasing however its biological productivity (production per unit of biomass). According to the synthetic models theory, for a large range of fishing levels, losses through fishing and natural mortality can be balanced by gains through growth and recruitment in the population, maintaining the population in equilibrium. At some intermediate level of fishing, the population is "fully exploited", i.e. exploited at the maximum level of productivity.

3.1.1 Effort, Catch Rate and Abundance

The gross catch per se is usually not a good indicator of the size or health of an exploited stock as it depends both on stock size and fishing intensity. Therefore, catch information must be combined with that of its corresponding fishing effort to generate a catch per unit of effort (or catch rate)..Unfortunately, fishing effort is not a simple variable as the vessel effectiveness in catching fish depends on a wide range of factors known to influence the capacity of a vessel to catch fish. These include the behaviour of the target fish (e.g. shoaling behaviour, dial and seasonal migration, vertical distribution), as well as the characteristics of the vessel (e.g. type, engine power, age, storage capacity), the characteristics of the gear (length or area, mesh size, material, gear-borne instrumentation) and the way it is used (fishing practices), the size and skill of the crew and the use of technical aids (sounders, global positioning systems, helicopters and aeroplanes).

3.1.2 Standardising Fishing Effort

Some of these characteristics cannot be measured directly and their effects on fishing power and fishing capacity are complex. Nevertheless, it has proved possible to compare and standardise the relative fishing power of different vessels (e.g. using vessel length, engine power, or

other relevant indicator as an index of power), combining it with fishing time to calculate standardised fishing effort, with some problems.

For example, for a given stock size, the catch by a trawler depends almost entirely on the time that the gear is towed on the bottom, The catch of a purse seiner, however, fishing on visible surface shoals, may depend more on the time and effectiveness of its searching, detecting, and approaching a shoa, than on the time it takes for encircling and hauling it on board. As a result, the relation between vessels characteristics, fishing time and fishing power is not simple. While the number of days at sea or on the fishing ground is an indication of fishing effort for any fishing vessel, measures of effective fishing time will be "soaking time" for vessels using fixed nets, pots or longlines, total duration of hauls for trawlers, searching time for purse seiners, etc. All of these have a complex relation with fishing power and fishing effort.

As a consequence, fishing effort needs to be standardised (across vessels and fleets) so that one unit of standard fishing effort removes a fixed proportion of the stock, i.e. generates a fixed and known amount of fishing mortality. The parameter that relates standard fishing effort and fishing mortality is known as the catchability coefficient. After standardisation, the catch per unit of effort (also called catch rate) provide an indirect measure of stock abundance. Because of the many assumptions needed in the computations, this measure is affected by statistical variance, and possibly by bias, that need to be accounted for in the stock assessment process.

Nevertheless, with a standardised measure of the magnitude of fishing on the stock, the final part of the assessment puzzle can be completed using a synthetic (production) model to establish the trend in the stock and the fishery, their present state, the stock potential, and the catch and effort regulations needed to maintain the stock at a high level of productivity.

3.1.3 Analytical Methods

Length-frequency distributions are a first step in determining the numbers and sizes of different ages or year classes in the catch that are needed for an analytical assessment of a stock. These measurements, based on samples taken regularly over a number of years, can be used to establish the age structure of the population, the growth of the fish, the age at which the fish become liable to capture, and how quickly the population is reduced as a result of fishing and natural mortality. Samples of the catch are obtained on landing sites and are sometimes supplemented by information from scientific surveys concerning abundance, size and age structure, spawning biomass, egg and larvae

abundance). The ratios of the numbers in various classes in successive years indicate the rate at which the fish die, due to natural reasons (e.g. predation) or due to fishing. Together with independent calculations of natural mortality, this information provides a basis for calculating the population available for capture and the effects of fishing. It is then possible to proceed to using analytical models to reach similar conclusions regarding catch and effort regulations as well as other interventions regarding mesh size, minimum landing size, closed seasons, etc.

3.1.4 Modern Approaches

Modern approaches forming the basis for multispecies assessments are now taking into account the feeding patterns of, and interactions between target and associated (or dependent) species, in addition to possible interactions between fishing gears and/or fisheries. The ecosystem-based management of fisheries as now being required by most modern fisheries agreement imply an even broader basis for resources assessment including the analysis of the state of the environment, critical habitats, ecosystem variability, climate change, impacts from land-based activities, and impacts on species composition (including trophic chains) and biodiversity (including genetic diversity). In addition, the growing requirement for a more systemic approach to fisheries assessment, including an assessment of its natural, human and governance components, call for more integrated processes of assessment and elaboration of advice, with a more active participation of stakeholders, and the collaboration of many more disciplines that those involved in conventional management.

3.2 Sampling Methods

3.2.1 Passive Methods

These are methods that rely on the movement of fish to capture them.

Gill nets

Lengths of netting stretched out vertically in water by weights and floats. Swimming fish collide with net and get caught while trying to pass through. Different mesh sizes catch fish of different sizes.

Advantages

Easy to use and commercially available. Very effective on many larger bodied fish. Can operate in deep open water as well as shallow open waters.

Disadvantages

Very small mesh sizes are not very effective on smaller fish sizes biasing method towards larger fish species. Meshing of fish can cause damage to fish. Some species such as banded grunter and bony bream can be difficult to remove without significant damage to the fish. Great care is needed if repetitive sampling is to be carried out so that the sampling does not affect numbers available at subsequent sample times. Mortality can be minimised by operators staying near nets and removing fish soon after they are captured. Holding released fish in fine mesh pens can prevent them re-entering nets and allows evaluation of short-term mortality.

Provides only CPUE measures of abundance.

Trammel nets are similar to gill nets but have rows of pockets along the net for fish to get wrapped in. May have advantages in shallow tidal situations

Fish traps: (Bait fish/minnow traps, Fyke nets, Trap nets)

Mesh enclosures with funnel shaped entrances to allow fish to enter and inhibit their exit. There are many different designs. Fyke nets and trap nets have panels of “lead” net to direct the fish into the trap.

Advantages

Can operate in most habitats except very dense vegetation. Size and species bias differs greatly between types of trap. Less bias with finer mesh size on fyke and trap-nets (Hayes 1989) and these have less size bias than gill nets. Mortality rate is very low making it easy to identify and return fish.

They can be left in place for prolonged period if required. This enables the sample to encompass are range of diurnal patterns of fish movement and can allow more than one site to be sampled at one time. Access to the surface for air breathing fauna should be provided. This is easier to do in shallower water.

Disadvantages

Gear for larger traps is bulky and cumbersome and labour intensive to set up. It is generally not commercially available. It provides only CPUE measures of abundance. It is based towards most active fish and some species less trappable than others. Minnow traps are readily available commercially but they are highly selective and variable in effectiveness even when baited.

3.2.2 Active Methods

These are methods that somehow seek out the fish and employ a device to capture them. They are not reliant on the natural movement of fish to effect the capture.

Seine (Drag) nets

Length of netting weighted at the bottom and supported by floats at the top which is set to enclose an area and then dragged to the shore. On larger nets there is often a deep pocket (purse) built into the centre for fish to collect in and minimise their escape.

Advantages

Short sampling time. Low fish mortality. Some nets are commercially available and any design is easy to obtain from net makers. Low cost.

Disadvantages

Not very effective in even moderately vegetated sites. Catch is dependent on mesh size but is also biased towards smaller/slower fish that are less able to avoid the net. Provides only CPUE measures of abundance because of difficulty in standardising the area fished. Typically involves operators entering water and exposure to crocodile risk. Shorelines are often not suitable for beaching the seine.

Trawls

Cones of netting that are dragged through the water behind a boat, usually at or close to the bottom with devices to keep the entrance funnel extended and the trawl net at the required depth.

Advantages

Easy to use. Can sample large areas of habitat. Low mortality with short trawls.

Disadvantages

Can operate only in open water with a relatively clear bottom Limited use in freshwater streams and wetlands because of bottom structure. Ineffective in vegetation. Small beam trawls can be effective in tidal reaches with clear bottoms. Not commercially available. Bias in fish size related to mesh size which affects minimum size retained and speed of tow and hence ability of fish to avoid trawl. Provides only CPUE measures of abundance.

3.2.3 Electro Fishing

Electrofishing is now one the most widely used methods for sampling freshwater fish for both biodiversity and population measurements. It involves the use of pulsed electric current to temporarily immobilise fish enabling their capture with a hand net as they come to the surface, or to cause fish to swim along a directional field towards one electrode (galvanotaxis) where they can be captured by a hand net.

Advantages

Can provide estimates of density. Can capture a wide range of fish sizes but catch biased towards larger fish. Relatively short sampling time. Easy to target specific habitats and times. Commercially available

Disadvantages

The impact on fish is unclear. Variation in pulse structure is required to sample different size fish. The higher frequency required for smaller fish can kill larger fish. Multiple passes through fished areas using different pulse settings can reduce this risk (Pusey et al 1998).

The equipment can be very expensive ($30,000 -$50,000 for a large boat mounted unit) but small back-pack units are less expensive and can be hired. Difficult to use in dense emergent vegetation.

Effectiveness is reduced at very low temperatures and in high and low conductivity waters. Also it is less effective in turbid waters where stunned fish under the surface cannot be seen.

Boat based units powered by generators are useful only in larger streams and open water lagoons and billabongs. In smaller streams back-pack battery operated units are generally used but this involves entering the water and exposing operators to crocodile risk. Operators need to be well trained in use and safety procedures. High risk of electric shock. The need to wear insulating gloves and waders has the potential to cause rapid weight loss in operators in the tropics.

3.2.4 Fish Poisoning

The use of fish poisons is widely used in fish surveys by taxonomic researchers in situations where rapid dilution by tidal movement can occur eg in inter-tidal rock pools. Whilst fish poisons are used by indigenous peoples in northern Australia for gathering food in freshwater pools they are not widely used by scientists in fish surveys

because of the difficulty of either diluting the toxin or neutralising it. Rotenone, the active ingredient of derris root powder, is the most common commercially available product used for this purpose. This acts on the gill membranes blocking the uptake of oxygen by affected fish. There are a number of native Australian trees whose bark produces extracts that can induce fish kills (Bishop et al 1982).

Advantages

Can sample all species, especially more cryptic species and mobile species that are difficult to capture when alive. No species or size bias.

Disadvantages

It kills every fish in pool or reach of stream or lagoon. Risk of killing fish in non-target areas. Cannot be used where repeat sampling is required.

3.2.5 Visual Census

This involves counting fish by observation without capturing them. Various counting techniques have been used such as transects, fixed plots, random point observation in a manner similar to visual census of large terrestrial fauna. Widely used in marine situations such as coral reefs where visibility underwater is very good. Visibility in freshwater is generally not good enough and large predators can be a deterrent in the tropics. Clear flowing water in Top End streams at the end of the wet season provides some opportunity for this technique. Used effectively in some situations in Kakadu.

Advantages

Does not harm fish and is ideal for repeated sampling which is desirable in some politically sensitive situations. No size or species bias. Can provide density measurements.

Disadvantages

Visibility and water depth. Discrimination of physically similar species often difficult or impossible.

Pop-net traps

Bottomless enclosures of netting that can be placed in aquatic vegetation to be later triggered to rise and trap fish within the enclosure. Vegetation

is subsequently removed and then the fish are removed by dip nets or small seines.

Advantages

It is one of few methods that work in dense vegetation. No species bias. Little bias in fish size. However, when very small enclosures are used larger fish are difficult to trap. Provides measurements of fish density.

Disadvantages

Depth limitation to water <1 m deep. Vegetation damage. Larger nets can be heavy and labour intensive to set and clear. Not commercially available. Cost is dependent on chosen size and design. Wading in water is required and provides risk of exposure to crocodiles (may require expensive safety nets).

Drop net traps and throw traps

These are devices that enclose areas of aquatic vegetation in shallow waters by dropping from above. Drop nets are netting enclosures dropped from a supporting frame standing above the water. Throw traps are heavy metal enclosures that are thrown from a boat to cut through vegetation to surround fish. Fish are removed from traps using dip nets or small seines, as with pop-nets.

Advantages

No species bias. Little bias in fish size. However, when very small enclosures are used (throw traps) larger fish are difficult to trap. Provides measurements of fish density.

Disadvantages

Similar to pop –nets. Depth limitation to water <1 m deep and vegetation damage. Not commercially available. Cost is dependent on chosen size and design. Wading in water is required and provides risk of exposure to crocodiles (may require expensive safety nets). Do net penetrate very dense vegetation very well.

Cast nets

Weighted circular pieces of netting that are thrown by hand to extend over water surface and drop to surround fish and trap them inside the net or entangle them in the mesh. Widely used around the world in artisanal fisheries and in recreational bait fish capture.

Advantages

Commercially available and relatively inexpensive: Once operators are trained they are easy to use from boats or shore where substrates are suitable.

Disadvantages

Difficult to quantify area sampled. Not effective in deep water, dense vegetation or areas with rough bottoms or locations with snags. Very low capture efficiency.

3.3 Measures of Biodiversity

The most common measures of biodiversity are species richness, Simpson's index and Shannon-Wiener index.

- **Species Richness**

This is the simplest of all the measures of species diversity. All you do is count of the number of species found in a community (e.g., the number of the species found on a bio film plate).

However, this does not indicate how the diversity of the population is distributed or organised among those particular species. For example, if there were 4 different species on a plate from the Marina and a plate from Pier 4 the richness would be equal. This does not indicate what % of each species there were of the 4 species identified. At the Marina 80% of the total number of species could have been stentor while at Pier 4 there could have been an even 25% of each species.

- **Simpson's Index**

A measure that accounts for both richness and proportion (percent) of each species is the Simpson's diversity index. It has been a useful tool to terrestrial and aquatic ecologists for many years and will help us understand the profile of biofilm organisms and their colonisation pattern in the Inner Harbor.

The index, first developed by Simpson in 1949, has been defined three different way in published ecological research. The first step for all three is to calculate P_i, which is the number of a given species divided by the total number of organisms observed.

1. **Simpson's index: D = sum(P_i^2):** The probability that two randomly selected individuals in the community belong to the same category (e.g., species).

2. **Simpson's index of diversity: 1 - D**
   The probability that two randomly selected individuals in a community belong to different categories (e.g., species).

3. **Simpson's reciprocal index: 1/D**
   The number of equally common categories (e.g., species) that will produce the observed Simpson's index.

   D is influenced by two parameters - the equitability of percent of each species present and richness. For a given species richness, D will decrease as the percent of the species becomes more equitable. The example illustrates how these three indices are influenced by these two parameters. The researcher must observe the species patterns carefully to interpret the values effectively.

3.4 The Main Problems with Aquatic Biodiversity Assessment

Several weaknesses are apparent in the existing inland water statistics. Some of these are listed below.

3.4.1 Inadequate Data-Collection Systems

Many countries do not have the financial or manpower resources to establish adequate sampling systems. Moreover, many fishery landing sites are so dispersed that they defy conventional catch-recording methods, so require altogether different approaches or proxy indicators. As a consequence, the data are absent, fragmented, underreported, or misreported.

3.4.2 Selective Data Collection

Data are only collected from commercially important sites such as major landing places or markets or from commercial fishing operations. This is often linked to some sort of revenue collection, however, so may be subject to misreporting. Focusing on these sites means that whole sectors, such as subsistence, artisanal, and recreational fisheries, are frequently excluded from national estimates. In addition, most reporting is limited to finfish, whereas other incidental or targeted species such as crustaceans, molluscs, amphibians, and aquatic insects and plants go unrecorded.

3.4.3 Double Counting of Landings

This may arise when the same fish are presented at a number of landing sites or markets and is a special problem in international lakes and rivers such as Lake Victoria, Lake Chad, or the interface between the Brazilian and Colombian Amazon, where the same fish may be recorded in more than one country. There is also a problem with preserved fish which, if not sold, are reprocessed and returned to the next market.

3.4.4 Confusion with Aquaculture

The distinction between capture fisheries in the wild, culture-based fisheries, and aquaculture is not clear, but it hinges largely on the ownership of the waters fished. This is a problem, especially with regard to stocked, enhanced, or culture-based fisheries in water bodies without clear ownership.

3.4.5 Political Pressure

There are often political pressures to inflate catch estimates, either to meet centrally dictated quotas or to raise the profile of the sector. Further, deliberate underreporting to conceal the true value of a fishery to evade taxes and levies is also a widespread phenomenon. This is particularly the case in concessionary or leased fisheries.

3.4.6 Piracy and Unrecorded Catches

In addition to the probably enormous quantity of unrecorded fish caught for home consumption or local markets by the artisanal and subsistence sectors, fish may be caught and sold illegally in unregulated markets. For example, Egyptian authorities estimate that about half the catch from Lake Nasser is illegal and unrecorded, and Cowx (2005) estimated that some 30% of the catch of Nile perch in Lake Victoria was unreported and passed through informal markets.

3.4 Other Problems

These arise because some national statistics do not distinguish between the different lake and river basins, or between “inland” and “coastal marine” catches, despite the latter often being from inland estuaries or freshwater coastal lagoons. Furthermore, catches are not usually reported by species or species-group in a comprehensive manner.

4.0 CONCLUSION

Stock assessment models attempt to predict changes in biomass and productivity based on yield data collected from a target fishery. Stock

assessment relies on the estimation of many parameters, which require a lot of data from historical fishery and independent biomass surveys (Pitcher and Preikshot, 2001). Fundamentally, stock assessment models are based on rates, which imply time, which is why an estimate of fish age is required. Conventional stock assessment techniques employed in tropical lotic systems often use length-based data because the technology necessary for direct age determination i.e. otolith/scale preparation and analysis is unreliable, expensive or not available. Length-based analyses require a lot of data, and length is not a desirable variable, as its relationship to age is non-linear, but length data is easily taken in the field, with simple measuring boards and recording forms. A relationship between length (size) and age is required (Kolding references in Mosepele and Kolding 2003). Length-based assessments are valid over a narrow time frame and if measured parameters are relatively constant. NRC, 1998 conclude that stock assessments do not always provide enough information

5.0 SUMMARY

- The assessment of the size and state of the stocks exploited by fisheries is one of the pillars of modern management.
- Length-frequency distributions are a first step in determining the numbers and sizes of different ages or year classes in the catch that are needed for an analytical assessment of a stock
- Fish sampling methods for assessment include passive methods and active methods
- Electro-fishing is now one the most widely used methods for sampling freshwater fish for both biodiversity and population measurements
- The use of fish poisons is widely used in fish surveys by taxonomic researchers in situations where rapid dilution by tidal movement can occur eg in inter-tidal rock pools.
- Problems with Aquatic Biodiversity Assessment include double counting etc

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the method of assessing fish stock.
2. Explain the sampling methods of stock under exploitation
3. Explain the methods for measures of biodiversity
4. Explain the main problems with aquatic biodiversity assessment

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UNIT 3 TOTAL AQUATIC BIODIVERSITY-VALUE INDEX

CONTENTS

1.0 INTRODUCTION

There are mainly three reasons why biodiversity should be studied. First, the need has come as many countries are signatories to the Convention on Biological Diversity. For various reasons the mangrove forests have been ruthlessly exploited and cleared. Coral reefs have been indiscriminately mined. The fishery resources have been overexploited. Many other organisms have been exterminated for ornamental and medicinal purposes. There has been widespread degradation of the habitats. Due to industrial development and large scale use of pesticides and insecticides in agriculture, the pollution load has increased in the estuaries, mangroves backwaters and seas. Measures of diversity are

frequently seen as indicators of the wellbeing of ecological systems. Secondly, despite changing fashions and preoccupations, diversity has remained the central theme of ecology. The well documented patterns of spatial and temporal variation in diversity which intrigued the early investigators of the natural world continue to stimulate the minds of ecologists today. Thirdly, considerable debate surrounds the measurement of diversity. It is mainly due to the fact that ecologists have devised a huge range of indices and models for measuring diversity. So for the various environments, habitats and situations the species abundance models and diversity indices should be used and the suitability evaluated.

2.0 OBJECTIVES

At the end of this unit, you should be able to discuss the:

- biodiversity indices
- species richness indices
- species diversity indices
- species evenness indices

3.0 MAIN CONTENT

3.1 Biodiversity Indices

Given the large number of indices, it is often difficult to decide which the best method of measuring diversity is. One good way to get a feel for diversity measures is to test their performance with one's own data. A rather more scientific method of selecting a diversity index is on the basis of whether it fulfils certain functions criteria-ability to discriminate between sites, dependence on sample size, what component of diversity is being measured, and whether the index is widely used and understood. The various diversity measures are given below.

3.2 Species Richness Indices

3.2.1 Simpson's Index

Simpson gave the probability of any two individuals drawn at random from an infinitely large community belonging to different species. The Simpson index is therefore expressed as 1-D or 1/D. Simpson's index is heavily weighed towards the most abundant species in the sample while being less sensitive to species richness. It has been shown that once the number of species exceeds 10 the underlying species abundance distribution is important in determining whether the index has a high or

low value. The D value which is standing for the dominance index is used in pollution monitoring studies. As D increases, diversity decreases. That way it is effectively used in Environmental Impact Assessment to identify perturbation.

3.2.2 Margalef Index

It is having a very good discriminating ability. However it is sensitive to sample size. It is a measure of the number of species present for a given number of individuals. However it is weighed towards species richness. The advantage of this index over the Simpson index is that the values can come more than 1 unlike in the other index where the values will be varying from 0 to 1. This way comparing the species richness between different samples collected from various habitats is easy.

3.2.3 Berger-Parker Index

This simple intrinsic index expresses the proportional importance of the most abundant species. As with the Simpson index, the reciprocal form of the Berger-Parker index is usually adopted so that an increase in the value of the index accompanies an increase in diversity and a reduction in dominance.

3.2.4 Rarefaction Index

Even though it is used for standardising the sample size, it is also used an index (Hsieh and Li, 1998). This index relates sample size (number of organisms) with numbers of species. This is very much helpful in comparing the diversity of organisms living in healthy and degraded environments.

3.3 Species Diversity Indices

3.3.1 Shannon-Wiener Index

Shannon and Wiener independently derived the function which has become known as Shannon index of diversity. This indeed assumes that individuals are randomly sampled from an independently large population. The index also assumes that all the species are represented in the sample. Log2 is often used for calculating this diversity index but any log base may be used. It is of course essential to be consistent in the choice of log base when comparing diversity between samples or estimating evenness. The value of Shannon diversity is usually found to fall between 1.5 and 3.5 and only rarely it surpasses 4.5. It has been reported that under log normal distribution, 105 species will be needed to produce a value of Shannon diversity more than 5. Expected Shannon

diversity is also used (Exp H') as an alternative to H'. Exp H' is equivalent to the number of equally common species required to
Produce the value of H' given by the sample. The observed diversity (H') is always compared with maximum Shannon diversity (Hmax) which could possibly occur in a situation where all species were equally abundant. Shannon diversity is the very widely used index for comparing diversity between various habitats (Clarke and Warwick, 2001).

3.3.2 Brillouin Index

The Brillouin index is used instead of the Shannon index when diversity of non-random samples or collections is being estimated. For instance, fishes collected using the light produce biased samples since not all the fishes are attracted by the light. The Brillouin index is used here to calculate the diversity of fishes collected by gears which use light for fishing.

3.3.3 Log Series Index

This popular method is very widely used because of its good discriminant ability and the fact that, it is not unduly influenced by sample size. It is reported to be a satisfactory measure of diversity, even when the underlying species abundances do not follow a log series distribution and it is less affected by the abundances of the commonest species.

3.3.4 Log Normal Diversity

It is reported to be independent of the sample size and that way very efficient for comparing the biodiversity of one habitat from another. However it can not be accurately estimated when the sample size is small. Therefore it can be used when the sample size is large. It is also used as a measure of evenness.

3.3.5 McIntosh's Measure of Diversity

Mcintosh proposed that a community could be envisaged as a point in an S dimensional hyper volume and that the Euclidian distance of the assemblage from the origin could be used as a measure of diversity.

3.3.6 Jackknife Index

It is a technique which allows the estimate of virtually any statistic to be improved. The beauty of this method is that it makes no assumption about the underlying distribution. Instead a series of Jack-knife

estimates and pseudo values are produced. The pseudo values are normally distributed and their mean forms the best estimate of the statistic. Confidence limits can also be attached to the estimate.

3.3.7 Q Statistic

An interesting approach to the measurements of diversity which takes into account the distribution of species abundances but does not actually entail fitting a model is the Q statistic. This index is the measure of the inter-quartile slope of the cumulative species abundance curve and provides an indication of the diversity of the community with no weighting either towards very abundant or very rare species.

3.4 Species Evenness Indices

Evenness index is also an important component of the diversity indices. This expresses how evenly the individuals are distributed among the different species. Pielou's evenness index is commonly used. Heip evenness index is also there but comparatively less used.

3.4.1 Hill Numbers

Hill (1973) proposed a unification of several diversity measures in a single statistic. While N1 is the equivalent of Shannon diversity, N2 the reciprocal of Simpson's ¥ë and N¡Ä is the evenness index. The advantage is that instead of calculating various indices for diversity, richness and evenness, it can be used to calculate all these measures.

That is its advantage.

3.4.2 Caswell Neutral Model /'V' Statistics

This is helpful in comparing the observed diversity with the diversity provided by the neutral model (Caswell, 1976). This model constructs an ecologically neutral community with the same number of species and individuals as the observed community assuming certain community assembly rules (random birth/deaths and random immigration/emigrations and no interactions between species).

3.4.3 Newly Introduced Indices

Taking into consideration the demerits of the routinely used conventional indices, new indices have been recently introduced. Conventional indices are heavily dependent on sample size effort. Indices with similar effort only can be compared. But with respect to the

conventional indices, the effort is not mentioned. Also the old indices do not reflect the phylogenetic diversity.

3.4.4 Taxonomic Diversity Index

It is defined as the average taxonomic distance between any two individuals (conditional that they must belong to two different species) chosen at random along the taxonomic tree drawn following the Linnaean classification. When the sample has many species, the values are on the higher side reflecting the taxonomic breadth.

3.4.5 Taxonomic Distinctness Index

It is defined as the average path length between any two individuals (conditional that these must belong to two different species) chosen at random along the taxonomic tree drawn using the Linnaean classification. Here also the higher values reflect the higher diversity of samples. Another advantage of this index is that making use of the average taxonomic distinctness and variation in taxonomic distinctness index, biodiversity between healthy, moderately degraded and heavily degraded habitats could be compared using the 95% histogram, 95% funnel and ellipse plot. Another feature of this index is that in the absence of quantitative data, the above could be accomplished based on qualitative data.

3.4.6 Phylogenetic Diversity Index

The total phylogenetic diversity index denotes the taxonomic breadth/ total taxonomic path length and the average phylogenetic index is obtained by dividing the total phylogenetic diversity index by the number of species. In healthy environment due to rich faunal assemblages, (taxonomic breadth) the total phylogenetic diversity and average phylogenetic diversity are always more.

4.0 CONCLUSION

Measures of diversity are frequently seen as indicators of the wellbeing of ecological systems. Secondly, despite changing fashions and preoccupations, diversity has remained the central theme of ecology. The well documented patterns of spatial and temporal variation in diversity which intrigued the early investigators of the natural world continue to stimulate the minds of ecologists today. Thirdly, considerable debate surrounds the measurement of diversity. It is mainly due to the fact that ecologists have devised a huge range of indices and models for measuring diversity. So for the various environments,

habitats and situations the species abundance models and diversity indices should be used and the suitability evaluated.

5.0 SUMMARY

- Measures of diversity are frequently seen as indicators of the wellbeing of ecological systems.
- A rather more scientific method of selecting a diversity index is on the basis of whether it fulfils certain functions criteria-ability to discriminate between sites, dependence on sample size, what component of diversity is being measured, and whether the index is widely used and understood.
- The various diversity measurement include species richness indices such as Simpson's Index

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the biodiversity indices.
2. Explain the species richness indices.
3. Explain the species diversity indices.
4. Explain the species evenness indices.

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UNIT 4 AQUATIC BIODIVERSITY CONSERVATION

CONTENTS

1.0 INTRODUCTION

Conservation is defined as the management of human use of biosphere so that it may yield the greatest sustainable benefit to present generation while maintaining or potential to meet the needs and aspiration of future generation. Thus, conservation is positive embracing preservation, maintenance, sustainable utilisation, restoration, and enhancement of the natural environment. Wildlife resources conservation is specifically concerned with plants, animals and micro- organism and with those non-living elements of the environment on which they depend. Living resources have two important properties, the combination of which distinguishes them from non- living resource, they are renewable if conservation is to process to be applied cross sectorially not an activity sector that own right conservation is that aspect of management which ensures that utilisation is sustainable and which is safeguards by ecological process and genetic diversity essential for the maintenance of the resource concern.

2.0 OBJECTIVES

At the end of this unit, you should be able todescribe the biodiversity conservation:

- methods
- strategic Directions

- approaches
- fishery regulations
- actions for fish and development (Inland Fisheries Sub-sector).

3.0 MAIN CONTENT

3.1 Biodiversity Conservation Methods

3.1.1 In-situ Biodiversity Conservation

In-situ conservation means the conservation of species within their natural habitats, this way of conserving biodiversity is the most appropriate method for biodiversity conservation. In this strategy you have to find out the area with high biodiversity means the area in which number of plants and animals are present. After that this high biodiversity area should be covered in the form of natural park/ sanctuary/biosphere reserve etc. In this way biodiversity can be conserved in their natural habitat from human activities.

3.1.2 Ex-Situ Conservation Methods

Ex-situ conservation involves the conservation of biological diversity outside of their natural habitats. This involves conservation of genetic resources, as well as wild and cultivated or species, and draws on a diverse body of techniques and facilities. Ex-situ Biodiversity conservation can be done as following:

i. By forming Gene banks: In this store seeds, sperm and ova at extremely low temperature and humidity.
ii. It is very helpful to save large variety of species of plants & animals in a very small space. E.g. sperm and ova banks, seed banks.
iii. Forming Zoo and botanical garden: for research purpose and to increase public awareness collecting living organisms for aquaria, zoos and botanic gardens.
iv. Collections of In vitro plant tissue and microbial culture.
v. Captive breeding of animals and artificial propagation of plants, with possible reintroduction into the wild.

Ex-situ biodiversity conservation strategy also plays an important role in recovery programmes for endangered species. The Kew Seed Bank in England has 1.5 per cent of the world’s flora - about 4,000 species - on deposit.

In agriculture, ex-situ conservation measures maintain domesticated plants which cannot survive in nature unaided.

3.2 Strategic Directions

a. Promote and enhance measures for both in-situ and ex-situ conservation through identification, evaluation, monitoring, research, education, public awareness and training.
b. Increase understanding of the status, genetic diversity and ecological relationships of species and populations.
c. Expand and strengthen the network of protected areas to include all the major ecosystems: Savannah, High forests, Wetlands, Mangrove, Montane, Coastal and Marine vegetations.
d. Protect watersheds along all intra and interstate watercourses to protect the water bodies and aquatic biodiversity.
e. Establish migratory corridors where practicable for isolated species and populations.
f. Establish reserves to conserve freshwater, brackish water and marine biodiversity
g. Establish and maintain gene and clone banks for plants and animals genetic diversity.
h. Implement measures to eliminate or reduce environmental pollution that adversely affect biodiversity
i. Monitor the effects of climate change on ecosystems, species and genetic diversity
j. Encourage community participation in Biodiversity conservation.

3.3 Conservation Approaches

Aquatic conservation strategies support sustainable development by protecting biological resources in ways that will preserve habitats and ecosystems. In order for biodiversity conservation to be effective, management measures must be broad based.

a. Aquatic areas that have been damaged or suffered habitat loss or degradation can be restored. Even species populations that have suffered a decline can be targeted for restoration.
b. An aquatic bio- reserve is a defined space within a water body in which fishing is banned or other restrictions are placed in an effort to protect plants, animals, and habitats, ultimately conserving biodiversity. These bio-reserves can also be used for educational purposes, recreation, and tourism as well as potentially increasing fisheries yields by enhancing the declining fish populations. These bio-reserves are also very similar to marine protected areas, fishery reserves, sanctuaries, and parks.

c. Bioregional management is a total ecosystem strategy, which regulates factors affecting aquatic biodiversity by balancing conservation, economic, and social needs within an area. This consists of both small-scale biosphere reserves and larger reserves.
d. Watershed management is an important approach towards aquatic diversity conservation. Rivers and streams, regardless of their condition, often go unprotected since they often pass through more than one political jurisdiction, making it difficult to enforce conservation and management of resources. However, in recent years, the protection of lakes and small portions of watersheds organised by local watershed groups has helped this situation.
e. Plantation of trees in the catchment area of water body prevent soil erosion and subsequently reduce the problem of slitation in water body resulting in better survival of aquatic organisms.
f. Avoid the establishment of industries, chemical plants and thermal power plants near the water resources as their discharge affect the ecology of water body resulted in loss of biodiversity.
g. Various organisations and conferences that research biodiversity and associated conservation strategies help to identify areas of future research, analyse current trends in aquatic biodiversity.

3.4 Fishery Regulations

a. Set catch limits well below the maximum sustainable yield
b. Improve monitoring and enforcement of regulations
c. Economic Approaches
d. Sharply reduce or eliminate fishing subsidies
e. Charge fees for harvesting fish and shellfish from publicly owned offshore waters
f. Certify sustainable fisheries
g. Protected Areas
h. Establish no-fishing areas
i. Establish more marine protected areas
j. Rely more on integrated coastal management.

3.5 Actions for Fish Biodiversity Conservation and Development (Inland Fisheries Sub-sector)

1. Protection of the inland aquatic environment from pollution by oil exploration, agro-chemicals, and pesticides, industrial domestic wastes
2. Enforcement of appropriate countrywide fishery laws and edicts for the inland fisheries, their conservation and sustainable development and management.

Encouragement of the private sector to invest in the Distant Water Fishery through:

i. Preferential reduction of costs of lubricants and Automotive Gas Oil (AGO) used by licensed fishing trawlers to bring down the cost of fishing operation
ii. Reduction of duty on imported fishing materials, outboard motor engines, used trawlers canoes etc. in the inshore waters.
iii. Promotion of export of high quality shrimps.
iv. Enforcement of penalties to curb pilferage and exportation of fish and shrimps from trawlers in the high seas.
v. Creation of specialised funds kept with a bank for lending at special concessions to fishermen.
vi. Training of fish farmers
vii. Provision of simple fish feed pelleting machine to fish farmers and fish feed millers.
viii. Provision of fingerling through research centres, government-sponsored fish hatcheries and the private sector.
ix. Establishment of at least 10ha fish farm (with its support hatchery and fish seed service) by all local governments.
x. Establishment of strong machinery for enforcing of regulations and monitoring catch data.
xi. Assistance to artisanal fishermen to organise themselves into viable co-operatives.
xii. Establishment of industries for the manufacture of
xiii. Fishing gears (gill nets, lipats, twines, etc.) in Nigeria.
xiv. 10. (b) Construction and maintenance of fishery boat yards. Training of fishermen to upgrade their proficiency in catching, handling and processing of fish.

4.0 CONCLUSION

The overall strategy employed by the Government of Nigeria to pursue the fisheries conservation and management objectives are Regulation and Enforcement. It is aimed at resource conservation, food security, economic efficiency, employment and income distribution, foreign exchange earnings and socio-political stability. The measures to achieve them will be described in the following section under the major fisheries.

5.0 SUMMARY

- Conservation is defined as the management of human use of biosphere so that it may yield the greatest sustainable benefit to present generation while maintaining or potential to meet the needs and aspiration of future generation.

- In-situ conservation means the conservation of species within their natural habitats, this way of conserving biodiversity is the most appropriate method for biodiversity conservation.
- Ex-situ conservation involves the conservation of biological diversity outside of their natural habitats.
- Aquatic conservation strategies support sustainable development by protecting biological resources in ways that will preserve habitats and ecosystems. In order for biodiversity conservation to be effective, management measures must be broad based.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the biodiversity conservation methods.
2. Explain the biodiversity conservation strategic directions.
3. Explain the biodiversity conservation approaches.
4. Explain the biodiversity conservation fishery regulations.
5. Explain the actions for fish biodiversity conservation and development (Inland Fisheries Sub-sector.

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UNIT 5 AQUATIC BIODIVERSITY MANAGEMENT CONTENTS

1.0 INTRODUCTION

Fisheries management is a term that has come to mean many different things to different people. Characteristically, those undertaking fish stock assessment have used it to describe the process of determining how much fish resources are available and, and what amount of catches should be permitted from the different stocks. Equivalently, it may be considered as the task of determining the amount of fishing effort, or fishing mortality (**F**), that should be allowed on a stock basis. Those responsible for economic and social analyses, and policy formulation and appraisal, also describe their activities as fisheries management while departments undertaking market analysis and product development may also claim that the term describes their activities.

Management is the integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and the accomplishment of other fisheries objectives.

Planning is an essential part of the management process regardless of whether one deals with the management of a fishery or the management of a car assembly line. The management plan is the main instrument that specifies how management is to be conducted in the future. In many fisheries, fishery management plans (FMP) are often also instruments not just for planning but also for operational management. These plans don't just document the way to reach management goals in the future (strategic), but also describe how to manage the fishery in the present (tactical). This dual purpose of fishery management plans is not recognised universally.

Long-term management objectives should be translated into management actions, formulated as a fishery management plan or other management framework". However, clarify that FMPs have a tactical component to them that defines day to day management: "The management plan provides detail on how the fishery is to be managed and by whom. It should include a management procedure which gives details on how management decisions are to be made in accordance to developments within the fishery.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the meaning of aquatic biodiversity management
- discuss the guiding principles for developing the fisheries management plan
- describe the process of managing and sustaining marine fisheries

3.0 MAIN CONTENT

A fisheries management plan is a formal or informal arrangement between a fishery management authority and interested parties which identifies the partners in the fishery and their respective roles, details the agreed objectives for the fishery and specifies the management rules and regulations which apply to it and provides other details about the fishery which are relevant to the task of the management authority

3.1 Guiding Principles for Developing the Fisheries Management Plan

The following guiding principles provide direction for the development of fisheries management goals, objective and actions.

Ecological Approach: An ecological approach to fisheries management will be followed to ensure conservation and use of the resource in a sustainable manner.

Landscape Level Management: Fisheries will be managed on a landscape scale. However, in some limited cases, components of the resource within a FMZ may need to be managed differently.

Balanced Resource Management: Strategies and actions will consider the ecological, economic, social and cultural benefits and costs to society, both present and future.

Sustainable Development: The finite capacity of the resource is recognised in planning strategies and management actions within a FMZ. Only natural resources over and above those essential for long-term sustainability requirements are available for use, enjoyment and development.

Biodiversity: Fisheries management will ensure the conservation of biodiversity by committing to healthy ecosystems, protecting our native and naturalised species and sustaining the genetic diversity of fisheries in the FMZ. All species in the FMZ including non-sport fish and Species at Risk must be considered.

Natural Reproduction: Priority will be placed on native, naturally reproducing fish populations that provide predictable and sustainable benefits with minimal long-term cost to society. Hatchery-dependent fisheries will also play a role in providing fishing opportunities.

Habitat Protection: The natural productive capacity of fish habitats will be protected and habitat will be enhanced where possible.

Valuing the Resource: Stakeholders and other users will be invited to understand and appreciate the value of fisheries resources. They will be encouraged to participate in decisions made by MNR that may directly or indirectly affect aquatic ecosystem health.

Responsibility: Local, regional, provincial and federal cooperation and sharing of knowledge, costs and benefits will be sought to manage fisheries at a FMZ level.

Multi-Party Involvement: A wide range of stakeholders, Aboriginal peoples and interested parties will provide fisheries management advice to ensure an open and transparent process that acknowledges their valuable role in the process.

Aboriginal Interests: Ontario is committed to building better relationships with Aboriginal peoples and in involving them in decisions that affect them.

Direct Action: All possible options must be considered and evolve to implementation actions that are feasible.

Knowledge: The best available information will be used for FMZ-based objective setting and strategy development and implementation.

Adaptive Management: FMZs will be managed using an adaptive management approach. Objectives will be set, monitoring will occur,

results will be compared against objectives and management regimes adjusted as necessary and where possible to ensure attainment of objectives.

Precautionary Principle: When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically.

3.2 Managing and Sustaining Marine Fisheries

(a). Over fishing is a serious threat to biodiversity in coastal waters and to some marine species of open-ocean waters.

(b). One way to prevent over fishing is to develop better means to project fish populations. The maximum sustained yield mathematical model is used, but indications are that it has hastened the collapse of most commercially valuable stocks for several reasons:

- i. Populations and growth rates are difficult to measure
- ii. Sizes of fish stocks are often based on unreliable/underreported catch figures
- iii. Harvesting a species at maximum sustainable yield can affect other target and non target fish species
- iv. Fishing quotas are difficult to enforce

(c). Optimum sustained yield is a concept that takes into account interactions with other species and allows more room for error. Another approach is multi-species management of a number of interaction species, which accounts for competition and predator-prey interactions.

(d). There has been limited management of several large marine systems, such as the Mediterranean Sea.

(e). Many fisheries scientists and environmentalists are interested in using the precautionary principle for management of fisheries and marine systems.

(f). Some fishing communities regulate fish harvests on their own and others work with the government to regulate them. Influx of large modern fishing boats and fleets has weakened the ability to regulate and sustain local fisheries. Many community management systems are now co-managed, where community and government work together to manage fisheries.

- i. Central government sets quotas for various species, divides the quotas among communities
- ii. Government may also limit fishing seasons and regulate gear to be used.
- iii. Each community then allocates its quota among members.

(g). Individual transfer quotas (ITQs) are assigned to each fisherman, and these can then be bought, sold or leased, like private property. This has resulted in some reduction of over fishing, but it is hard to enforce, and wasteful bycatch has not been reduced.

(h). Four problems with the ITQ system are:

i. It transfers public ownership to private fishers, but still makes the public responsible for cost of management and enforcement. Remedy this by collecting fees form quota holders to pay costs of enforcement.

ii. Small fishing vessels and companies may be squeezed out if they can't afford to buy ITQs from others

iii. Poaching may increase. Remedy this by strict record keeping and observers on all vessels with quotas.

iv. Fishing quotas often set too high, so leave 10-50% of the estimated MSY as a buffer to protect the fishery from decline.

Protecting, Sustaining, and Restoring Wetlands

a. Coastal and inland wetlands are important reservoirs of aquatic biodiversity; they provide ecological and economic services.

b. Despite their ecological value, the U.S. has lost more than half of its coastal and inland wetlands since 1900

c. Wetland loss in the U.S. will get worse as global warming leads to rising sea levels which will put many coastal wetlands under water.

d. In the U.S., a federal permit is required to fill or deposit dredge material into many wetlands

e. The U.S. federal policy is a zero net loss goal; mitigation banking allows destruction of some wetlands as long as same type of wetland is created elsewhere.

f. An ambitious restoration project is trying to undo the human damage in South Florida's Everglades. The natural Everglades is half its original size and is drying out, leaving it vulnerable to fire and invasion by non native species

Protecting, Sustaining and Restoring Lakes and Rivers

a. Invasions by non native species have upset the ecological functioning of the Great Lakes for decades with more invaders coming.

- At least 162 non native species have invaded the Great Lakes since the 1920's.
- Measures have been taken to control a number of these species.

- Sea lampreys are one of the biggest threats and have depleted a number of the sport fish species in the lakes.

b. Zebra mussels were brought into the lakes in ballast and have become very aggressive pests since they have no known natural enemies. They have displaced native mussel species, clogged pipes, piers, and fouled beaches and have spread to other parts of the U.S.

c. Quagga mussels invaded the Great Lakes in 1991 and Asian Carp may be the next invader.

d. Rivers/streams are important ecological and economic resources, but they can be degraded by over fishing, pollution, dams and water withdrawal.

e. The Columbia River has been altered by 119 dams and withdrawal of water for agriculture.

f. Sustainable management of freshwater fish involves encouraging populations of commercial/sport fish species, prevents over fishing, and reduces or eliminated less desirable fish populations.

- Regulate fishing seasons and the number and size of fish taken.
- Improve habitats, breed genetically resistant fish varieties, and judicious use of antibiotics and disinfectants to control predators, parasites and diseases are methods suggested.
- Some individuals have worked to restore degraded streams.

f. The national Wild and Scenic Rivers Act was passed in 1968 to protect rivers and river segments with outstanding scenic, recreational, geological, wildlife, historical or cultural values.

g. Congress established a three-tiered classification scheme:

- Wild rivers are relatively inaccessible; they are not permitted to be widened, straightened, dredges, filled or dammed.
- Scenic rivers are free from dams, mostly undeveloped, of great scenic value, and accessible in some places by roads.
- Recreational rivers are readily accessible by roads and may have some dams or development along their shores.
- Only 0.2% of the 3.5 million miles of rivers are protected under the Act, and 17% of the total river length has dams and reservoirs on them.
- Environmentalists want to add 1,500 additional river segments for a total of 2% of the total river systems. There is opposition from several groups.

h. Threats to aquatic biodiversity are real and growing. We must greatly increase research and expand efforts to protect and restore aquatic biodiversity and promote integrated ecological management.

4.0 CONCLUSION

The main objective of aquatic biodiversity management is to manage the aquatic resources and provide for sustainable exploitation of the same. Equitable allocation among users and Biodiversity control are also important. A useful feature of inland fisheries management is that it is localised, permitting the participation of resource owners, which in turn enhances the ability to monitor and enforce regulations. The provisions of the national legislation are de-centralised to Regional and State edicts, community acts and by-laws, as may be appropriate.

A fisheries management plan is a formal or informal arrangement between a fishery management authority and interested parties which identifies the partners in the fishery and their respective roles, details the agreed objectives for the fishery and specifies the management rules and regulations which apply to it and provides other details about the fishery which are relevant to the task of the management authority.

5.0 SUMMARY

1. Management is the integrated process of information gathering, analysis, planning, consultation, and decision-making.
2. Planning is an essential part of the management process regardless of whether one deals with the management of a fishery.
3. A fisheries management plan is a formal or informal arrangement between a fishery management authority and interested parties.
4. Over fishing is a serious threat to biodiversity in coastal waters and to some marine species of open-ocean waters.
5. Coastal and inland wetlands are important reservoirs of aquatic biodiversity; they provide ecological and economic services.
6. Sustainable management of freshwater fish involves encouraging populations of commercial/sport fish species, prevents over fishing, and reduces or eliminated less desirable fish populations.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the meaning of aquatic biodiversity management.
2. Explain the guiding principles for developing the fisheries management plan.
3. Explain the process of managing and sustaining marine fisheries.

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MODULE 6 VULNERABLE TRANS-BOUNDARY AQUATIC SYSTEM AND LEGISLATIVE FRAMEWORK FOR AQUATIC BIODIVERSITY

Unit 1 Vulnerable Trans-boundary Aquatic System
Unit 2 Legislation or Legislative Framework for Aquatic

UNIT 1 VULNERABLE TRANSBOUNDARY AQUATIC SYSTEM

CONTENTS

1.0 INTRODUCTION

Trans-boundary aquatic area is an area of water that straddles one or more boundaries between states, sub-national units such as provinces and regions, autonomous areas and/or areas beyond the limits of national sovereignty or jurisdiction, whose constituting parts are especially dedicated to the protection and maintenance of biological biodiversity, and of natural and associated cultural resources, and managed co-

operatively through legal Trans-boundary water of 263 international rivers in the world constitutes 60% of the water around the globe (Wolf et al., 2005). 40% of the river basins around the world are transboundary water-ways shared by two or more countries worldwide (Wolf, 1999). Most of these rivers have many problems that may result in international disputes. The rivers that may cause disputes spread over five continents of the world and most of them are in Asia and Africa where developing countries are located and where there are few international treaties on the development and utilisation of trans-boundary waters signed between the states. Historical records showed that more than 400 water treaties and water related agreements were signed between 1820-2002. 60% of these treaties and agreements were concluded in Europe and North America whereas Asia and Africa, with nearly 75% of global population and more than 40% of international rivers, have only 30% of the treaties due to lag in legal system development and cross border cooperation. Therefore, the shared water vulnerability is much more prominent in Asia and Africa than in North America and Europe. (Yan et al., 2008)

Water in border setting is a regional public good that is non-excludable but rival in consumption. Asymmetries over time and space between the countries are important to determine sustainable outcomes for water resources. (Fernandez, 2000). The border region between United States and Mexico shares its surface water resources between Colorado River and Rio Grande river basin. The boundary between the two states is 3300 kilometres. In 1944, water treaty was signed between United States and Mexico for resolving the water sharing issues but it did not do so. The problem was the groundwater withdrawal on both sides of the borders and the deteriorating water quality. This requires bi-national cooperation that addresses water quantity and quality issues simultaneously. The variation in water bodies spans the variation elsewhere on earth in terms of some surface waterways flowing north to south, some flowing south to north, deep and shallow groundwater aquifers along the borders.

China is one of the most important upstream countries in terms of trans-boundary waters in the world, especially in Asia. China’s terrestrial boundary measures approximately 220,000 km and borders 14 countries, making trans-boundary water issues as a key component in China’s international relations. The shared water among the borders has the problems of variability in water demand due to social and economic development.

Pakistan shares most of its water resources with Nigeria. Major River, river Indus enters to Pakistan from Nigeria. Water pollution is the major problem in Pakistan by the water resources entering from Nigeria.

Hudiara drain entering to Pakistan from Amritsar carries a lot of pollution and ultimately pollutes the rivers and streams of the country.

2.0 OBJECTIVES

At the end of this unit, you should be able to explain the:

- instability in water availability
- problem of trans-boundary water
- regional cooperation and shared water
- cross-border water pollution management
- trans-boundary marine protected areas.

3.0 MAIN CONTENT

3.1 Instability in Water Availability

Instability in availability of water is a major problem of trans-boundary waters. The variability and availability of water greatly affects the regional, social and economic development of the country. The availability of water is greatly affected by the conditions of the surrounding water resources such as the effects of global warming, human activities and water regulation by dam operations. (Yan *et al*., 2008). Past results verifies that the natural environment is subject to the influences of a changing climate. Most of the international rivers were fed by melting glaciers, which were affected by global climate change. For example, the Himalayan glaciers were receding at an average speed of 10 to 15 m per year due to global warming. The rivers' flow would, therefore, notably increase in short term because of the increase in glacial melt, but over the long term, glacial shrinkage would likely result in greater problems, including floods, wetland drying, and unstable river systems. Instability of water is also brought forth from the social aspect, including population growth, immigration, and trans-boundary management of water resources. (Wolf *et al.*, 2005). Availability of water also varies with different seasons. Most of the East Asian region is subject to the monsoon climate, the warm and wet winds in spring and summer times bring most of the annual precipitation. However, in the winter seasons, the climate tends to be cold and dry. The water problems become worsened when climate change brings higher temperatures reducing amount of precipitation but increasing the rate of evaporation. (Jayakumar et al., 2008). These conditions make the region vulnerable to floods, water logging, droughts, storms, hurricanes, wetland drying and unstable river systems. (Yan et al., 2008)

3.2 Problem of Trans-Boundary Water

3.2.1 Decreasing Outflow of Rivers

Decreasing outflow of rivers is the major problem of trans-boundary water across the globe. Riparian states are paying greater attention to water shortages in dry regions after the increase in demand, growth in population and economic development. In the northwest region of China, it was a great problem of international rivers that the use of water is over 40% of the total water resources in 1980-2006 (Liu and Chen, 2001). In the face of water shortages in all the riparian states of this region, there were great differences in trans-boundary water utilisation among the riparian states. For example, the Kapchagay Reservoir, capable of multi-year water storage, is located in Kazakhstan on the downstream of Ili River. The discharge regulation ratio of the reservoir is 56%. On the downstream of the Irtysh River, where a series of large-scale hydraulic projects were constructed, the runoff regulation ratio of Bykhtarmo Reservoir among these projects was 170%. All of these reservoirs control the entire outflow from the related rivers of China (Chen et al., 2005).

3.2.2 Eco-System Vulnerability

Ecosystem security and river basin health has many factors, including limited water flow and its time-space distribution; water quality and its maintenance; land use and soil erosion. Trans-boundary waters on ecosystem vulnerability and security are mainly reflected by the floods, droughts, species invasion and loss of habitat. In most parts of the world, drought, decreasing outflow, and degraded ecology and natural environment resulting from competition for water between humans and ecosystem are the major issues (Yan et al., 2008). China is facing a serious trans-boundary water pollution problem in the northeast region because more than 60% of river reaches were polluted, and it is getting worse day by day. In the southwest of China, especially in Tibet, glacial lakes resulting from rivers blocked by landslides have released floods into international rivers in recent years when their natural dams have broken. These disasters caused significant harm to the downstream countries (in this case, Nigeria, Nepal) and affected the relationships among China and its neighbouring countries. Pakistan also experiences water pollution problems as it receives waste water from its neighbouring country Nigeria (Swaran, 2005). Water species are very much affected by the quality of water and it is a threat to the aquatic ecosystem. But this also affects other activities as thick mats of the plant reduce oxygen content, degrading water quality for aquatic species and curtail recreational activity such as boating and fishing and clog water intakes for irrigation (Fernandez, 2000). During the past two decades,

the rapid economic boom and growing agricultural, industrial and municipal development in the region leads to substantial accumulation of toxic organic compounds and a significant environmental impact has been imposed on the ambient conditions. Untreated sewage is discharged in an expeditious rate and large quantities of various pollutants have been released which is more threatening to the ecosystem (Chau, 2005).

3.2.3 Water Scarcity and Water Quality Deterioration

The vast amount of trans-boundary water in the world is facing the problem of increasing water scarcity and aggravation through competitive utilisation for growing populations and has produced headlines warning of "water wars." In the arid Middle East, water is the prime driver for military strategies and territorial conquests, particularly in the ongoing conflicts between Arabs and Israelis. Headlines surrounding the trans-boundary water issues in China have, in recent years, been alarmist at times as the regional security is implicated by water development projects (Yan et al., 2008). Pakistan and Nigeria are also facing water problems as Nigeria is constructing dams on the rivers which are coming towards Pakistan and this will cause water scarcity in the region in the coming years.

With untreated sewage and salinity travelling across the border, there are serious water quality problems in most of the surface waterways along the border. Urbanisation in border cities next to rivers leads to urban runoff and sedimentation that is causing serious water quality problems. (Yan et al., 2008) The Tijuana River Watershed that is shared border with the upstream 2 / 3 of the watershed in Mexico and the remaining in the U.S. is threatened by degradation water quality. The wetlands of this watershed is an asylum for endangered and threatened bird, fish, and plant species and it was recently named as a Ramsar site of international importance. The three most significant aquifers include the Hueco, Bolson extending 3000 square miles in the Ciudad Juarez-El Paso region, the Mesilla Bolson extending 7450 square miles between Chihuahua and New Mexico, and the Mesa de San Luis aquifer extending 3000 square miles across Arizona and California in the U.S. and Sonora and Baja California in Mexico (Frisvold and Caswell, 2002).

3.2.4 Physical Changes and Socio-Economic Conditions Affecting Water Availability

Climate change has the potential to make a significant impact on both the availability of and requirements for water in most part of the world. Rising temperatures and increasing variability of rainfall generally affects surface waters, increasing drought in some regions and causing

floods in others, as well as influencing groundwater recharge. The probable effect is greater evapo-transpiration and more stress on arid and marginal zones.

Runoff is highly dependent upon changes in rainfall, and groundwater recharge even more so. Parts of Africa could experience reductions in runoff and/or stream flow of up to 10%, which could be evident in the western parts of the country in as soon as 2015. The decrease in runoff would move progressively from west to east, and could be expected to reach the east coast by 2060. Even if the average rainfall were to remain the same, increased variability of stream flow would result in reduced natural yields and reliability, and an increase in the unit cost of water from dams.

From 1980 to 2006, the total water resources in the northeast region of China changed greatly compared with the normal years, causing the most serious recorded flooding in a century (1998), which was then followed by severe drought for four consecutive years. Water resources are becoming even scarcer, as population and development pressures grow, and it is increasing tensions regarding water utilisation and degradation of aquatic environments. In China, water resources are over-exploited. The construction of large number of hydraulic projects interrupted the flows of some rivers; it decreased outflow and results in the destruction of the riverine ecological systems. (Sergei Blagov, 2005).

3.2.5 Poor Emergency Response

Sound administrative institutions and emergency response is necessary for the shared waters. Due to lack of understanding of the international rules, duties and obligations of states set forth in international laws, have led to serious shortcomings in emergency response mechanisms. This creates tension in relations of the countries with the other countries who shared international rivers with it. There should be proper institutions for the control and management of shared water resources.

3.3 Regional Cooperation on Shared Waters

Trans-boundary waters include any surface or groundwater that mark, cross or located on the boundaries between two or more states. By the year 2006, 263 trans-boundary waters were identified in the world and the number has increased by emergence of the newly independent states after the breakup of the former Soviet Union. Europe alone has 100 trans-boundary groundwater aquifers and more are expected to be identified in the future (United Nations Development Programme, 2006). Due to the increasing pressure of economic development and

competition for scarce resources, many international water basins have to suffer serious environmental, social and political problems. The United Nations Conference on efforts among European, South-American and Middle-East countries for cooperation on trans-boundary water between neighbouring countries, East Asia has relatively low number of trans-boundary waters and thus less cooperative work regarding sharing waters. China shares 12 main rivers with six neighbouring countries, including Mongolia, Pakistan, Nigeria, Kazakhstan, the Kyrgyz Republic, Myanmar, Lao People's Democratic Republic and Vietnam. Pakistan shares its water resources with Nigeria and Kashmir, United States with Mexico and Bangladesh shares its water resources with Bhutan. And to promote regional cooperation between these cross-border water resources, Environment and Development (UNCED) in Rio de Janeiro in 1992 adopted Agenda 21, recognising the multi-sectoral nature of water resources development as well as the diverse interests in their utilisation (United Nations University, 1990).

3.4 Cross-Border Water Pollution Management

Over the past half a century, Western academic communities accumulated substantive literatures on trans-boundary water pollution management, such as industrialised countries successfully engaged in controlling water pollution of rivers. Trans-boundary cooperation was the core component of these studies since trans-boundary water pollution had to be addressed through trans-boundary cooperation, and specific institutional arrangements might result in wider and sustainable water cooperation. Focusing on the cooperation between countries or regions, Western scholars carried out multidisciplinary studies from such aspects as economics, law, politics, management, and empirical methodology, which involved a wide range of contents, including extensive discussions on institutional and system arrangements for trans-boundary cooperation. They developed a number of models for the design of water pollution management systems, probed into various influencing factors on institutional choices and changes, and summarised international experience in the institutional arrangements for the water quality management of Trans-boundary Rivers.

3.5 Trans-boundary Marine Protected Areas

While marine protected areas are contiguous across many international boundaries and collaboration takes place between them, some have gone further to seek the designation of trans-boundary marine protected areas. Lubombo TFCA, the first marine trans-frontier conservation area in Africa was established in 2007 by Mozambique, South Africa, and Swaziland, focusing on marine turtle conservation. The Pelagos

Sanctuary for Cetaceans in the Ligurian Sea of the Mediterranean involves cooperation among France, Italy, and Monaco.

Three trans-boundary marine sites have been inscribed on the World Heritage List. These include Kluane/Wrangell-St Elias/ Glacier Bay/ Tatshenshini-Alsek between Canada and the U.S., the High Coast/ Kvarken Archipelago between Finland and Sweden, and the Wadden Sea between Germany and the Netherlands, with Denmark also participating. The World Heritage Marine Program has also focused attention on trans-boundary marine conservation in the central Pacific islands and atolls of Kiribati, Cook Islands, French Polynesia, and U.S. territories.

3.5.1 Marine Peace Parks

Trans-boundary marine conservation has also been used to contribute to peace-building and improving relations between countries through the concept of Marine Peace Parks. The Red Sea Marine Peace Park between Jordan and Israel was established as part of the 1994 peace treaty. It promotes collaboration between the countries to protect trans-boundary coral reefs and tourism. Although not contiguous, the two MPAs in each country's waters share common species and environmental stresses.

Marine peace parks have also been proposed for several regions where maritime boundaries are still in dispute or peace-building is needed. South Korea has proposed a Korean marine peace park to jointly promote both conservation and peaceful resolution of unresolved boundary disputes. Other marine peace parks have been proposed for the Eastern Caribbean Island states; Gaza/Jordan/Israel on the Mediterranean coast; Pakistan and Nigeria near the Indus River delta region; the Former republics of Yugoslavia on the Adriatic Sea; Greece and Turkey on Cyprus; and the Pratas/Spratly Islands region of the South China Sea and between Japan and Russia in the Kuril Islands.

3.5.2 Trans-boundary to Regional Marine Conservation

Often marine conservation is necessary at a larger, regional scale, involving multiple countries and boundaries. As early as 1974, the UNEP Regional Seas Agreements began to promoting environmental cooperation, although they were initially more focused on preventing pollution than on conservation. Today, they cover 18 regional seas around the world and address conservation issues as well. The Pelagos Cetacean Sanctuary was established under the aegis of the Mediterranean Sea Agreement (aka The Barcelona Convention.) Members of two regional seas agreements, OSPAR and HELCOM in

the Northeast Atlantic today collaborate with the Northeast Atlantic Fisheries Commission to develop and manage a network of MPAs in the region. This is a model likely to be replicated between other regional seas and fisheries management organisations.

In 1984, the concept of Large Marine Ecosystems (LMEs) was introduced to identify 64 coastal ecosystems globally. The Global Environmental Facility has used LMEs since 1994 as a means for facilitating integration across sectors and geographies in marine and coastal regions. In many cases, these provided the basis for trans-boundary, regional scale marine projects involving multiple countries. One example is the Guinea Current LME off the west coast of Africa, where sixteen countries have formed the Guinea Current Commission. The Benguela Current Commission, comprised of Namibia, Angola and South Africa provides for collective management of all trans-boundary marine ecosystem issues among these three countries.

Some of the most significant regional marine conservation in recent years is taking place under the Coral Triangle Initiative (CTI), a collaboration of six countries - Indonesia, Malaysia, Papua New Guinea, the Philippines, the Solomon Islands and Timor L'este to protect and manage sustainable use of the richest marine biodiversity on earth. Built on the foundation of previous trans-boundary collaborations in the Sulu-Sulawesi and Bismarck-Solomon Seas marine ecoregions, the CTI countries have committed to cooperating in managing this rich marine region. Other governments, international organisations and NGOs have partnered with the CT governments to provide over $120 million USD in funding to support the goals of the CTI.

3.5.3 Trans-boundary MPA Networks

Often single marine protected areas (MPAs), even large ones, are not adequate to protect the vast migratory ranges of many marine species. As on land, connecting several MPAs within corridors can improve their effectiveness for species conservation. Recognising this need for ecological connectivity, the Convention on Biological Diversity calls for networks of MPAs to be established. This need for connectivity was behind the formation of the Eastern Tropical Pacific Corridor initiative in 2004 by Colombia, Costa Rica, Ecuador, and Panama. These countries agreed to protect 2.1 million sq. km of their islands and marine areas and to collaborate in marine conservation. It led to two new marine UNESCO World Heritage sites in Panama and Colombia. The Commission for Environmental Cooperation under the North American Free Trade Agreement collaborates on a virtual North American MPAs Network (NAMPAN) to address tri-national and trans-boundary marine conservation along the Pacific coast, contributing to the proposed "Baja

to Bering Initiative." Other collaboration is taking place on the Meso-American Reef among Belize, Guatemala, Honduras and Mexico.

3.5.4 Marine Cooperation beyond National Jurisdiction

While much trans-boundary marine conservation takes place between neighbouring countries, some also involves boundaries between the waters under the jurisdiction of coastal states and the areas beyond national jurisdiction, or the high seas. The UN Fish Stocks Agreement requires that conservation measures for straddling fish stocks be complementary in these regions. A grander scale of trans-boundary conservation is underway in the Ross Sea in the Southern Ocean surrounding Antarctica. Parties to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) are seeking to establish a network of MPAs or even a single giant MPA to protect the Ross Sea, one of the worlds's last remaining pristine marine areas, which under the Antarctic Treaty System is considered high seas.

While protected areas feature prominently in most trans-boundary marine conservation, much additional collaboration also takes place outside of MPAs. This international cooperation addresses issues such as migratory species, trans-boundary fisheries, marine pollution, and the myriad other human uses of the oceans from land-sourced pollution to mineral resource extraction to shipping to discarded fishing gear and climate change, all of which can threaten marine ecosystems. Out of necessity, trans-boundary conservation may be even more critical in marine realms than it is on land.

4.0 CONCLUSION

At the dawn of the new millennium water is becoming a strategic, limited resource that needs our concern and protection. Water related problems and concerns are not new, but now they are becoming more and more obvious and materialisation of the international concern should be applied in this field. There should be integrated river basin management which will represent a unified approach towards water management and includes all stakeholders within the basin. Special attention needs the trans-boundary river basins in which some specific problems have to be overcome: legal and political discrepancies, communication problems, social, cultural, historical differences and economic issues. Public participation is very important for the river basin management. There is a dire need to properly monitor the instability in water availability.

5.0 SUMMARY

- Trans-boundary aquatic area is an area of water that straddles one or more boundaries between states, sub-national units such as provinces and regions, autonomous areas and/or areas beyond the limits of national sovereignty or jurisdiction.
- Instability in availability of water is a major problem of trans-boundary waters. The variability and availability of water greatly affects the regional, social and economic development of the country.
- Trans-boundary waters include any surface or groundwater that mark, cross or located on the boundaries between two or more states.
- Trans-boundary marine conservation has also been used to contribute to peace-building and improving relations between countries through the concept of Marine Peace Parks.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the instability in water availability.
2. Explain the problems of trans-boundary water.
3. Explain the regional cooperation on shared waters among states.
4. Explain the cross-border water pollution management.
5. Explain the trans-boundary marine protected areas.

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UNIT 2 LEGISLATION OR LEGISLATIVE FRAMEWORK FOR AQUATIC BIODIVERSITY

CONTENTS

1.0 INTRODUCTION

Nigeria has measures in place which are robust enough to effectively combat Illegal Unreported and Unregulated fisheries activities in their EEZ. Many of the National Fisheries Laws Acts and regulations need to be reviewed to enable enforcement as an effective deterrent to IUU fishing. Nigeria is a maritime country with a coastline of 853km. The surface area of its continental shelf is 46,300km2 while the Exclusive Economic Zone (EEZ) covers an area of 210,900km2, within which Nigeria exercises sovereign rights for the purpose of exploitation, conservation and the managing its fisheries resources. The wide expanse of sea is endowed with abundant fish and shrimp resources. The marine fisheries resources made up of demersal, pelagic and shellfish stocks are of economic importance. The total annual value of the known resources is estimated as US $233.57m--$531.64m. The known shrimp fisheries (with a total annual value of US $29.6m-- $46.6m) are export oriented. There are other marine resources yet to be identified and exploited. The principal commercial species comprising the Nigerian marine fisheries resource are at serious risk from over-exploitation by both foreign and domestic fishing vessels. There are no coordinated national fisheries management plans in place yet to arrest this decline or restore the stocks to the equilibrium necessary to allow for the sustainable development of Nigeria’s fisheries for the benefit of future generations.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the Legal framework conservation of biological diversity
- discuss the environment related international conventions and protocol signed and ratified by Nigeria
- explain the environment related national legislations enacted by Nigeria.

3.0 MAIN CONTENT

3.1 Legal Framework

Nigeria was a party to the signing of the Convention on Biological Diversity. Nigeria, thus assumes obligations under the provision of the treaty in accordance with customary international law.

The Nigerian constitution makes fundamental provision for environmental protection and clearly identifies important components of environment. Section 20 of the constitution of the Federal Republic of Nigeria contains the country's environmental objectives that are meant, "to protect and improve the environment and safeguard the water, air, land, forest and wildlife".

In recognition of the need to protect her biological resources, Nigeria has put in place a number of legislations including the Forestry Ordinance the National Parks Decree, the Federal Environmental Impact Assessment Decree, and the Environmental Impact Assessment among others

An indicative list of laws and international signatories are shown below:

3.2 Environment Related International Conventions and Protocol signed and Ratified by Nigeria

i. African Convention on the Conservation of Nature and Natural Resources, (Algiers)**,** 1968
ii. International Convention for the Prevention of Pollution of the Sea by Oil, 1954-62
iii. Convention on Fishing and Conservation of the living resources of the High Seas, 1985
iv. Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters, 1972
v. United Nations Convention on the Law of the Sea, 1982

vi. The RAMSAR Convention on the Conservation of Wetlands of International Importance, especially as Waterfowl Habitat, 1971
vii. The Convention Concerning the Protection of the World Culture and Natural Heritage, 1972
viii. Convention on International Trade in Endangered Species of Fauna and Flora, (CITES) 1973
ix. Convention on the Conservation of Migratory Species of Wild Animals, 1973
x. Framework Convention on Climate Change, 1992
xi. Convention to Combat Desertification, 19.

3.3 Environment Related National Legislations Enacted by Nigeria

i. Exclusive Economic Zone Decree 1978;
ii. The Forestry Ordinance, 1937
iii. Wild Animal Preservation laws of 19
iv. Oil in Navigable Waters, Decree 1968;
v. FEPA Decree no. 58 of 1988, 59 of 1992
vi. FEPA Decree no. 59 of 1992
vii. EIA Decree (1992)
viii. National Parks Decree no 1979, 1991, and 1999
ix. Sea Fisheries Decree 1971 and listing regulation of 1972;
x. National Parks Decree, 1991 and revised in 1999; and
xi. The Endangered Species (Control of International Traffic) Decree. No. 11 of 1983

1. Regulations

Fishing in territorial waters is reserved for Nigerian-flag vessels. A Nigerian vessel is defined as one belonging to a company whose capital is no less than 50-percent African ownership. Theoretically, foreign fishing is allowed only for joint ventures with at least a 51 -percent Nigerian interest, though in practice this requirement is waived when there is substantial Nigerian interest in the company. Foreign flag vessels may be licensed to fish only outside the Nigerian Exclusive Economic Zone (EEZ), but they may land fish in Nigeria.

Business permits and fishing licenses are required for all companies operating within Nigeria's 200-mile EEZ. To obtain a fishing license, a company must first secure approval from the Industrial Development Coordinating Committee of the Ministry of Industries in Abuja. The applicant must then apply to the Ministry of Transport for registration of fishing vessels. Finally, all approvals and documents must be submitted to the Department of Fisheries, Ministry of Agriculture, for granting of the license.

2. Reflagging

Reflagging, registering a vessel in another country, is a growing concern for fishery managers around the world. By reflagging a vessel with a country that is not a signatory to an agreement designed to manage and/or conserve living marine resources, a vessel may avoid the regulations/conservation measures for a regional area. The problem is compounded by the fact that many of the countries frequently used for reflagging simply do not have the staff to monitor the fishing operations of their flagged vessels throughout the world. The issue of reflagging is gaining international attention and is the subject of the proposed Agreement to Promote Compliance with International Conservation and Management Measures for Fishing Vessels on the High Seas approved by the Food and Agriculture Organisation of the United Nations in November 1993 for ratification by interested States.

Reflagging is done for many reasons

i. The simplest case is a vessel owner in one country selling a vessel to a new owner in a different country.
ii. In other cases, local requirements may require all joint venture fisheries' vessels to fly the flag of one particular country.
iii. In some instances, and particularly for older and less efficient vessels, fishermen may not be able to operate profitably in one country and may reflag their vessel in another where taxes, fuel costs, and crew salaries are less onerous.
iv. To avoid internationally agreed measures for the conservation and management of living marine resources.

3. International Agreements

Nigeria is a member of the Commission for the Eastern Central Atlantic Fisheries (CECAF). Nigeria also has fishing agreements with three African countries, Equatorial Guinea, Angola, and Sierra Leone which allow Nigerian vessels to register to fish in the participating country's national waters.

Equatorial Guinea: An agreement, renewed with Equatorial Guinea, allows 17 Nigerian trawlers to fish in its waters in exchange for 50 tons of fish per year per vessel given to the Equatorial Guinean government. The Government of Equatorial Guinea negotiated this requirement to provide fish for its local market, as it does not have an offshore fishing industry of its own.

Sierra Leone: Nigeria's agreement with Sierra Leone, allowing for 12 Nigerian vessels to fish the Sierra Leonean waters is a reciprocal

agreement though Sierra Leone is not currently exercising its right to fish Nigerian waters

Angola: Nigeria's 1989 agreement with Angola allows the licensing of four Nigerian vessels with a minimum length of 50 meters. This requirement virtually nullifies the agreement since Nigeria does not currently operate trawlers of this size.

Currently, Nigerian vessels are only fishing in Equatorial Guinea's waters, as well as in local waters. Federal Department of Fisheries (FDF) officials say that no negotiations over reciprocal fishing agreements have taken place with any of the major fishing powers (i.e. Japan, Russia, Norway, or the EC).

4. Fleet Background

The Nigerian commercial fishing sector is dominated by five large companies. Together they own approximately 60 percent of the majority of all other companies, which own fewer than five trawlers each. Most companies are located in Lagos, but several operate from Port-Harcourt, Warri, and Calabar.

The Federal Department of Fisheries (FDF) reports that registration of the inshore and deepwater trawlers peaked in the late 1980's and has been declining since then. The drop in the inshore fish supply caused by overfishing and the high cost of vessel maintenance and licensing fees contributed to this drop. Rising operational cost and smaller catches force many operators to retire older vessels and not replace them. At any given time, 30 to 40 percent of registered vessels are not in service because of breakdowns or maintenance problems. Spare parts, mostly imported from the United States, are so expensive that retiring and cannibalising older vessels for spare parts is more economical than ordering new ones.

5. Enforcement

The government considers illegal fishing a major problem though estimates on the number of illegal vessels in operation are unavailable. Frequent violations include use of illegal undersized mesh nets, fishing without a license, pilferage (black market sale of a percentage of the legal catch transacted at sea by fishing crews), and infringement of a 5-mile, no- trawler zone. Most of these infractions contribute to Nigeria's larger problems of depletion of native fish stocks and degradation of the environment for traditional fishermen. Fishing without a permit in Nigerian waters is punishable with forfeiture of the vessel and detention of the captain, or a fine of about $4,550) payable in foreign currency.

While the FDF has the primary responsibility for enforcement of fishing regulations, it does not have the resources necessary to patrol the waters or apprehend violators. Currently, the FDF must rely on the Nigerian Navy for patrolling the coast and must coordinate with Ministry of Justice in the prosecution of cases. Though the fishing laws were revised in 1992 to require stiffer fines and longer prison terms for fishing violators, a lack of resources prevents the FDF from enforcing the laws effectively. A World Bank loan was granted to the FDF for the procurement of four new patrol vessels, but the vessels have not yet been delivered and, in any case, the FDF lacks the trained personnel necessary to man them.

The national policy on conservation and sustainable use of biological diversity is an integral part of the national policy on environment. The policy was first developed in 1989 following the promulgation of the Federal Environmental Protection Agency (FEPA) decree no 58 of 1988 and revised in 1999. The decree provides the legal framework for the implementation of the policies on environmental protection, natural resources conservation and sustainable development. The national policy on conservation of biological diversity is aimed at:

(i) Integrating Biological Diversity considerations into national planning, policy and decision making; and
(ii) Conserving and enhancing the sustainable use of the nation's biological diversity.

With the creation of the Federal Ministry of Environment (FME) in 1999, FEPA was absorbed and the ministry became the highest policy making body responsible for addressing environmental issues in Nigeria, including conservation of biodiversity.

In pursuit of the policy objectives as enunciated, an overriding concern is to alleviate poverty and increase the per capita income of Nigerians. Consequently, the country has developed strategies and programmes for sound and sustainable management of biodiversity involving the most vulnerable groups particularly women and children. The strategies have been designed to promote sustainable and adequate levels of funding and focus on integrated human development programmes, including income generation, increased local control of resources, strengthening of local institutions and capacity building including greater involvement of community–based and non-governmental organisations, as well as the lower tiers of government as delivery mechanisms.

4.0 CONCLUSION

The national policy on conservation and sustainable use of biological diversity is an integral part of the national policy on environment. The policy was first developed in 1989 following the promulgation of the Federal Environmental Protection Agency (FEPA) decree no 58 of 1988 and revised in 1999. The decree provides the legal framework for the implementation of the policies on environmental protection, natural resources conservation and sustainable development.

Nigeria is a maritime country with a coastline of 853km. The surface area of its continental shelf is 46,300km^2 while the Exclusive Economic Zone (EEZ) covers an area of 210,900km^2, within which Nigeria exercises sovereign rights for the purpose of exploitation, conservation and the managing its fisheries resources. The wide expanse of sea is endowed with abundant fish and shrimp resources. The Nigerian constitution makes fundamental provision for environmental protection and clearly identifies important components of environment

5.0 SUMMARY

- Fish habitat is defined as a spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly to carry out their life processes."
- Fish are defined in the Act (Section 2) as: "(a) parts of fish, (b) shellfish, crustaceans, marine animals, and any parts of shellfish, crustaceans or marine animals, and (c) the eggs, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals
- Fishing in territorial waters is reserved for Nigerian-flag vessels. A Nigerian vessel is defined as one belonging to a company whose capital is no less than 50-percent African ownership.
- Nigeria is a member of the Commission for the Eastern Central Atlantic Fisheries (CECAF). Nigeria also has fishing agreements with three African countries, Equatorial Guinea, Angola, and Sierra Leone which allow Nigerian vessels to register to fish in the participating country's national waters.
- The government considers illegal fishing a major problem though estimates on the number of illegal vessels in operation are unavailable.
- The United Nations Law of the Sea says that all coastal nations have responsibility over the waters up to 19 kilometres (12 miles) from the shore. Also, they have jurisdiction over their Exclusive Economic Zone which extends 320 kilometres (200 miles) offshore.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the Legal framework for conservation of biological diversity.
2. Explain the environment related international conventions and protocol signed and ratified by Nigeria.
3. Explain the environment related national legislations enacted by Nigeria.
4. Explain clearly on the role of environmental law on aquatic biodiversity management.

7.0 REFERENCES/FURTHER READING

Pollutec Nigeria Limited, (1996*). Proceedings of the First Consensus Workshop on the Preparation of Rivers and Bayelsa State Environmental Action Plan.* Port Harcourt, Nigerian Federal Environmental Protection Agency and World Bank.

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MODULE 7 NATIONAL BIODIVERSITY ACTION PLAN AND INTERNATIONAL LAW CUM ADMINISTRATION

UNIT 1 NATIONAL BIODIVERSITY ACTION PLAN

CONTENTS

1.0 INTRODUCTION

Nigeria started the process of preparing her own Biodiversity Strategy and Action Plan (BSAP) in 1995. The World Bank funded it as part of an Environmental Management Programme. The current draft is a result of a series of consultation with stakeholders through workshops at national and zonal levels. The goal of the plan is to conserve and enhance the sustainable use of the nation's biodiversity and to integrate biodiversity-planning considerations into national policy and decision-making. It identified the biggest threat to conservation of biological diversity as poverty.

In the plan, emphasis is placed on in situ conservation through protected areas such as Forest Reserves, Game Reserves, National Parks and Wildlife Sanctuaries. Priority attention is placed on conservation of samples of ecological characteristics (montane, mangrove, wetland and rain forest, and endemic species across the country.

BSAP also contains specific priority actions for ex situ conservation of various species of plants and animals of distinct economic importance, including the re-introduction or rehabilitation of endangered species of

plants and animals and the conservation of threatened and endangered species. The administrative and policy reforms contained in the plan provide a vehicle for achieving its conservation goal and objectives. It emphasises the values inherent in individual, community and NGOs activities in Nigeria.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the fishery management plan
- explain the objective of the national fishery policy
- explain the constraints and opportunities of National Biodiversity Strategy and Action Plan (NBSAP).

3.0 MAIN CONTENT

3.1 Fishery Management Plans

A Fishery Management Plans specify how a particular fishery (fish stocks and fishing for such stocks) will be managed. And identifies important problems or issues in the fishery and specifies conservation and management measures to address them. One of the primary objectives of FMPs/ is to achieve and maintain, on a continuing basis, the optimum yield from each fishery. The optimum yield is that amount of fish from the fishery that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems.

3.1.1 National Standards for Fishery Conservation and Management

The National Standards are as follows:

(1) Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery.
(2) Conservation and management measures shall be based upon the best scientific information available.
(3) To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit in close coordination.
(4) Conservation and management measures shall not discriminate between residents of different states.

(5) Conservation and management measures shall, where practicable, consider efficiency in the utilisation of the resources; except that no such measure shall have economic allocation as its sole purpose.
(6) Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

3.2 Objective of the National Fishery Policy

The main objective of the national fishery policy is to achieve self-sufficiency in fish production. Others include:

i development and modernisation of the means of production and handling;
ii promotion of export trade in fish and fish products;
iii provision and improvement of employment opportunities in rural communities;
iv improvement of the quality of life in fishing villages;
v provision of opportunities for training of operators in the fishing industry;
vi acceleration of research to provide required information for development and resource management.

The overall strategy employed by the Government of Nigeria to pursue the fisheries management objective is Regulation and Enforcement. It is aimed at resource conservation, food security, economic efficiency, employment and income distribution, foreign exchange earnings and socio-political stability. The measures to achieve these fall under the major fisheries sectors.

Finally, the Action Plan makes concrete provision for a programme of research, extension and education that will enhance the sustainable development of Nigeria's new legal instruments, institutional collaboration and responsive financial mechanism.

(i) Sustainable use of components of biological diversity especially the aspects concerning the protection and encouragement of customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation and sustainable use requirements.
(ii) Incentive measures for the conservation and sustainable use of components of biological diversity.
(iii) Access to genetic resources.
(iv) Access to and transfer of technology.
(v) Handling of biotechnology and distribution of its benefits.

In addition, adequate strategies are yet to be identified and plans developed to address the gaps in the draft National Biodiversity Strategy and Action Plan (NBSAP). The gaps arose as a result of some constraints encountered in the course of preparing the document.

3.3 Constraints and Opportunities

The major constraint to the production of a comprehensive NBSAP in Nigeria is financial. However, the country recently sought and obtained assistance from GEF to update and complete the preparation of the plan. The purpose of the GEF support is to enable Nigeria address all the provisions of the Convention in the NBSAP. The actual implementation of the NBSAP may also be limited by finance. Other perceived constraints include inadequate capacity, lack of database and poor understanding of the importance of biological diversity in the national economy. Support from international partners will go a long way in addressing these constraints.

Nigeria has a lot of opportunities for international investors, multilateral and bilateral donor agencies, the private sector and NGOs to participate in biodiversity activities. Among some of the activities identified in the NBSAP are:

(i) Wetland Conservation and Management;
(ii) Bio-prospecting;
(iii) Rehabilitation of degraded ecosystems;
(iv) Development of Biodiversity Centre in each Ecological zone;
(v) Support Zone Development of Protected Areas;
(vi) Management of National Parks;
(vii) Sustainable Fisheries management;
(viii) Agro-biodiversity;
(ix) Medicinal Plants Conservation;
(x) Captive breeding of a variety of animal species; and
(xi) Plantations of indigenous tree crops.

4.0 CONCLUSION

A Fishery Management Plans specify how a particular fishery (fish stocks and fishing for such stocks) will be managed. And identifies important problems or issues in the fishery and specifies conservation and management measures to address them. One of the primary objectives of FMPs/ is to achieve and maintain, on a continuing basis, the optimum yield from each fishery. The optimum yield is that amount of fish from the fishery that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational

opportunities, and taking into account the protection of marine ecosystems.

The major constraint to the production of a comprehensive NBSAP in Nigeria is financial. However, the country recently sought and obtained assistance from GEF to update and complete the preparation of the plan. The purpose of the GEF support is to enable Nigeria address all the provisions of the Convention in the NBSAP.

5.0 SUMMARY

1. The goal of the plan is to conserve and enhance the sustainable use of the nation's biodiversity and to integrate biodiversity-planning considerations into national policy and decision-making.
2. The biggest threat to conservation of biological diversity as poverty.
3. Action Plan makes concrete provision for a programme of research, extension and education
4. The major constraint to the production of a comprehensive NBSAP in Nigeria is financial.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the fishery management plan.
2. Outline the National Standards for Fishery Conservation and Management.
3. Explain the objective of the national fishery policy.
4. Outline the constraints and opportunities of National Biodiversity Strategy and Action Plan (NBSAP).
5. Appraise the role of national biodiversity action plan on biodiversity management.

7.0 REFERENCES/FURTHER READING

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UNIT 2 INTERNATIONAL LAW AND ADMINISTRATION

CONTENTS

1.0 INTRODUCTION

The Sea Fisheries Decree makes it illegal for anyone to operate or navigate any motor fishing boat within the Nigerian territorial waters and the EEZ without licence. It stipulates the penalties and vests the enforcement in the Minister of Agriculture. The Licensing supplement stipulates the requirements and procedure for licensing and penalties for default. The Fishing supplement puts a restriction on trawling in the first five nautical miles area of the coast and prescribes cod-end mesh sizes for trawl nets. The Inspectorate and Quality Assurance supplement regulates all fish handling procedures, subjects operators to inspection and prescribes the requirement of a quality assurance certificate issued by the Federal Department of Fisheries.

The Exclusive Economic Zone Decree delimits the extent of the zone under the Nigerian government jurisdiction, in accordance with the United Nations Convention on the Law of the Sea. Its supplement, the EEZ Fishing Regulation, states the conditions for exploitation of the resources by Nigerian-owned boats or partnerships as may be permitted; and for conservation with penalties attached to default.

The Inland Fisheries Decree regulates capture and culture fishing activities in the inland waters. Its provisions include licensing of fishing crafts, identification mark on crafts, restriction on use of certain gear, prohibition of obnoxious fishing methods, declaration of catch, control of international trade in live fish and other aquatic animals/weeds,

declaration of closed areas and seasons, construction of dams, weirs and barriers and protection of fish and fish products against contamination and infection. In accordance with the constitutional provisions on power sharing, the decree clearly spells out the respective responsibilities of the Federal Minister and State Commissioner of Agriculture in the enforcement of above provisions. Its supplement of 1995 prescribes methods for fish handling, processing and preservation, prohibits the harvest or culture of fish in contaminated waters and the sale of poisonous fish species.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the types of fisheries laws/regulation
- state the laws guiding licensing of motor fishing boats
- discuss the law of Sea Exclusive Economic Zone (EEZ)
- point out the sea fisheries decrees
- apply the inland fisheries act.

3.0 MAIN CONTENT

3.1 Types of Fisheries Laws/Regulation

Four sets of fisheries laws regulate fishing activities within the territorial waters and the EEZ of Nigeria.

1. These are the Sea Fisheries Decree (ACT) No. 71 of 1992
2. The Sea Fisheries (Licensing), Regulations 1992
3. The Sea Fisheries (Fishing), Regulations of 1992 the Turtle Excluder Device (TED), Regulations of 1992
4. The Exclusive Economic Zone Decree (ACT) 1978.

3.1.1 The Sea Fisheries Decree (ACT) No. 71 of 1992

A typical State Fisheries Edict in Nigeria reads:

a. No fisherman shall:

   a. Catch any of the freshwater fish species below the size specified in Schedule I of this Edict.
   b. Fix stationary fishing structures across the river for the purpose of cultivating, culturing or propagating fish.

b. No person shall take from or destroy any fish within the water bodies by any of the following methods:

- The use of any explosive substance or electricity
- The use of any poisonous or noxious matter
- The use of gillnet or drawnet of less than 3 inches or 7.62 cm mesh size
- The use of clapnet, castnet or any webbing traps of less than 2 inches or 5.1 cm mesh size
- Lift net of not less than 1.5 inches or 3.8 cm mesh size.

c. No person shall:

- Preserve fish by use of insecticide or other toxic chemical
- Transport, display or sell fish under unhygienic conditions.

d. No person shall fish within the territorial waters of the State unless he obtains a licence so to do.

3.2 Licensing of Motor Fishing Boats

1. Subject to the provisions of this section no person shall operate or navigate any motor fishing boat for the purpose of fishing or a reefer vessel for the purpose of discharging frozen fish within the territorial waters of Nigeria or its exclusive economic zone, unless that boat or reefer vessel has been dully registered and licensed.

2. Any person operating or navigating or causing to be operated or navigated a motor fishing boat or a reefer vessel in contravention of subsection (d) of this section shall be guilty of an offence under this Decree and on conviction shall be liable to imprisonment for five years or to a fine of $250,000, or both such fine and imprisonment and in addition forfeiture of the motor fishing boat and the fish or shrimp catch onboard

3. The provisions of this section shall not apply to any motor fishing boat or a reefer vessel entering the territorial waters of Nigeria not for fishing or disposal the disposal of fish, but solely for re-fuelling at any port or for shelter or solely because the motor fishing boat or reefer vessel is in distress or there is any other emergency.

4. Every unlicensed motor fishing boat in transit or enjoying the right of innocent passage within Nigeria's territorial waters or its exclusive economic zone shall have its -

   (a) Fishing gear stowed wholly inboard;
   (b) Nets and trawl boards disconnected from towing warps or hauling ropes; and

(c) Fishing gear above deck firmly secured to the vessel's superstructure as it is customary when steaming to and from the fishing ground.

5. (1) Any person, being the owner of a motor fishing boat may apply to a licencing officer for a licence in respect of the motor fishing boat to -

(a) trawl for fish or shrimp in Nigeria's territorial waters or Nigeria's exclusive economic zone; or
(b) navigate for the purpose of discharging imported frozen fish in any Nigerian port; or
(c) navigate Nigerian or foreign waters for the purpose of processing or discharging wet fish caught from such waters in any Nigerian port.

(2) An application for a licence shall be in such form and manner as may be prescribed and shall:-

(a) contain the particulars and descriptions of the motor fishing boat in respect of which the application is made; and

(b) a statement in detail as to -

(i) the methods employed for taking fish,
(ii) the area within which it is proposed that the motor fishing boat shall operate;
(iii) the arrangements that are to be made for the preservation and marketing of the catch in Nigeria;
(iv) such particulars as may be required from time to time by regulations made under this Decree.

6. (1) On being satisfied that -

(a) an application for a licence has been made in the prescribed manner and contains all the information that is required under section 3 of this Decree;
(b) the prescribed fees have been paid;
(c) the applicant is the lawful owner of the motor fishing boat in respect of which the application is made, and that he is a fit and proper person to be granted a licence; and

(d) the operation of the motor fishing boat in the territorial waters of Nigeria or its exclusive economic zone is not likely to be prejudicial to the interests of sea fishing industry in Nigeria, the licensing officer shall issue a licence in respect of the motor fishing boat.

(2) Subject to the provisions of this Decree, a licence shall be in the prescribed form and may be issued subject to such conditions as the licencing officer may think fit to impose, and any conditions so imposed shall be endorsed on the licence.

(3) A licence shall be a yearly licence or a quarterly licence and -

(a) if the licence is a yearly licence, it shall expire on the 31st day of December in the year in which it is issued;

(b) if the licence is a quarterly licence, it shall expire on the 31st day of March, the 30th day of June, the 30th day of September or 31st day of December, which ever day falls next after the date of the issue of the licence.

(4) When the ownership of a motor fishing boat in respect of which a licence has been issued is transferred form one person to another person, the licence shall not be valid in respect of the new owner of the vessel, until such time as a licensing officer has approved the transfer of the ownership of the motor fishing boat and has endorsed the licence to that effect.

(5) A licensing officer may, without assigning any reason -

(a) cancel a licence; or

(b) suspend a licence for such period as he thinks fit.

(6). Any person who operates a motor fishing boat with an expired licence shall be guilty of an offence and liable on conviction to a fine of N 50,000 and forfeiture of catch.

7. The Provisions of this Decree relating to application for a licence and the issue of a licence shall apply in relation to an application for the renewal of the licence and to such renewal.

8. (1) Any person aggrieved by any refusal by a licensing officer to issue or renew a licence or by the cancellation or suspension of a licence or by any condition endorsed on a licence may within fourteen days of receiving notice of the refusal, cancellation, suspension or endorsement appeal to the Minister in respect thereof.

(2) After considering any appeal made under subsection (1) of this section the Minister shall take such decision thereon as he deems fit and the licensing officer shall give effect thereto, accordingly.

(3) The decision of the Minister on any appeal under this section shall be final.

9. The owner of a motor fishing boat in respect of which a licence has been issued shall -

(a) render to a licensing officer such periodical returns concerning the operation of the motor fishing boat as many be prescribed; and

(b) permit a licensing officer or any person authorised in writing by a licencing officer to inspect the catch of the motor fishing boat either before or after the catch has been landed and shall give the licensing officer or that person all reasonable facilities for the inspection of the catch.

10. (1) An authorised person may, within the territorial waters of Nigeria or its exclusive economic zone for the purpose of enforcing any provision of this Decree.

(a) require the owner or the person in charge of a motor fishing boat in respect of which a licence has been issued, to exhibit his licence fishing apparatus and catch;

(b) require the owner or the person in charge of any motor fishing boat .or any person engaged in fishing to exhibit his fishing apparatus and catch;

(c) go on board any motor fishing boat, search and examine the motor fishing boat and any fishing apparatus that may be therein;

(d) where there is reasonable suspicion that an offence under the Decree has been committed, take the alleged offender and the motor fishing boat fishing apparatus and catch to the most convenient port police station.

(2) The powers vested in an authorised person under subsection (1) of this section may be exercised by him without warrant summons or other process.

(3) Any motor fishing boat or apparatus taken from an alleged offender under the provisions of paragraph

(a) of subsection (1) of this section, may be detained or kept pending the trial of the alleged offender and the catch may be sold and the proceeds of the sale detained or kept pending such trial.

(4) Any motor fishing boat, apparatus or money detained or kept under subsection (3) of this section shall unless forfeited under the provisions of sections1(2) or 13 of this

Decree be returned to the person from whom the same was taken or the lawful owner thereof.

(5) If a motor fishing boat after detention under subsection (3) of this section proceeds to sea before it is released by an authorised person or a court, the master of the motor fishing boat and also the owner and any person who sends the motor fishing boat to sea, if the owner or person is privy to master's offence, shall be guilty of an offence under this Decree.

(6) In this section "an authorised" person means -

(a) a licensing officer;
(b) any commissioned officer in the Nigerian Army, Navy or Air force;
(c) a police officer not below the rank of assistant superintendent of police;
(d) a customs officer not below the rank of assistant preventive superintendent;
(e) a surveyor or examiner appointed under the provisions of the Merchant Shipping Act; and
(f) any other person authorised in writing by the Minister in that behalf.

11. (1) No person shall take or destroy or attempt to take or destroy any fish within the territorial waters of Nigeria or its exclusive economic zone by any of the following methods, that is -

(a) by the use of any explosive substance; or
(b) by the use of any noxious or poisonous matter.

(2) Any person, who contravenes the provisions of subsection (a) of this section, shall be guilty of an offence and liable on conviction to imprisonment for two years or a fine of ₦50,000.

12. Any person who -

(a) Contravenes or fails to comply with any of the provisions of this Decree; or
(b) Contravenes or fails to comply with any requirement made under this Decree: or
(c) Contravenes or fails to comply with any condition endorsed on a licence; or
(d) is in breach of any regulation made under this Decree. For which no penalty is prescribed shall be guilty of an offence under this Decree and liable on conviction to a fine of N 50,000.

13. If any person in furnishing any Information for purposes of procuring a licence, makes a false statement which he knows to be false in any material particular, that person shall be guilty of an offence under this Decree and liable on conviction to a fine of N50,000.

14. A court before which any person is convicted of an offence under this Decree may -

(a) order the forfeiture to the Government of the Federation of any fishing boat, apparatus or catch employed in the commission of or derived from any act in respect of which that person is so convicted.

(b) where the fishing boat employed in the Commission of the offence is a motor boat in respect of which a licence had been issued, cancel the licence or suspend the licence for such time as the court may think fit.

15. (1) The Minister may make regulations -

(a) for furthering the interests of sea fishing industry in Nigeria; and

(b) for giving effect to the provisions of this Decree.

(2) Without prejudice to the generality of the foregoing provisions of section, regulations under this section may -

(a) regulate, prohibit or restrict the taking of fish in any specific areas within the territorial waters of Nigeria

(b) prohibit or restrict the use of any fishing boat, apparatus or method of taking fish that is considered harmful to the sea fishing industry in Nigeria.

(c) prescribe limits to the size of nets or the mesh of nets that may be employed in the taking of fish within the territorial waters of Nigeria or in any specific area therein

(d) prescribe the form of a licence and the amount of fee to be paid in respect of a licence;

(e) provided for the inspection of buildings, and premises used for the curing, preservation, storage or sale of fresh, cured or preserved fish;

(f) provide for the seizure and destruction of any fresh, cured or preserved fish that is that is unfit for human or animal consumption.

(g) provide for the exemption of specified persons from any provision of this decree where such exemption is considered necessary for scientific or experimental purposes in connection with the sea fishing industry in Nigeria or otherwise for the furtherance of the national interest of the Federation;

(h) regulate any other matter relating to the conservation and protection of the stocks of sea fish.

16. In this Decree, unless the context otherwise requires - "exclusive economic zone" has the meaning assigned to it in the Exclusive Economic Zone Act. "fish" means any aquatic creature whether fish or not and includes shell fish, crustaceans, turtles and aquatic mammals; "fishing boat" means any ship, boat, canoe or other craft used for the taking of fish for sale or barter; licence" in relation to a motor fishing boat means a licence issues under section 4 of this Decree; "licensing officer" means the Minister of Agriculture, Water Resources, and Rural Development, or any persons appointed by him to carry out any of the provisions of this Decree; "Minister" means the Minister charged with responsibility for fisheries; "motor fishing boat" means any fishing boat propelled by means of steam, internal combustion or other machinery except one or more portable outboard engines; "port" includes a place and harbour; "prescribed" means prescribes by regulations under this Decree; "taking fish" includes any method of catching fish; "territorial waters of Nigeria" has the meaning as in section 1 of the Territorial Waters Act.

17. (1) The Sea Fisheries Act is hereby repealed.

(2) The repeal of the enactment mentioned in subsection (1) of this Decree shall not affect anything done under the repealed enactment prior to the commencement of this Decree.

(3) Accordingly any licence issued under the repealed Act being a licence that was in force immediately before the date of the commencement of this Decree shall from that date have effect as if it were a licence issued under this Decree.

(4) Any licence, which under subsection (2) of this section has effect as if it were a licence issued under this Decree, shall from the date of commencement of this Decree be read and construed with such adaptations and modifications as may be necessary for the purposes of this Decree, and subject to section 6 of this Decree, the licence may on or after that date be cancelled or suspended or be made subject to the new conditions, by a licensing officer.

18. This Decree may be cited as the Sea Fisheries Decree 1992.

3.3 Exclusive Economic Zone (EEZ)

Under the law of the sea **Exclusive Economic Zone** (**EEZ**) is a sea zone over which a state has special rights over the exploration and use of marine resources. It stretches from the edge of the state's territorial sea out to 200 nautical miles from its coast. In casual use, the term may include the territorial sea and even the continental shelf beyond the 200 mile limit.

Generally a state's EEZ extends to a distance of 200 nautical miles (370 km) out from its coast. The exception to this rule occurs when EEZs would overlap; that is, state coastal baselines are less than 400 nautical miles (740 km) apart. When an overlap occurs, it is up to the states to delineate the actual boundary. Generally, any point within an overlapping area defaults to the most proximate state.

The Exclusive Economic Zone starts at the seaward edge of the territorial sea and extends out into the sea to a distance 200 nautical miles (370 km) from the baseline. Thus, the EEZ overlap the contiguous zone. States also have rights to the seabed of the continental shelf up to 350 nautical miles (650 km) from the coast, where this extends beyond the EEZ, but this does not form part of their EEZ.

3.4 Sea Fisheries Decrees

The 1971 and 1972 Sea Fisheries Decrees

As interim measures pending the collection and collation of scientific information, the Federal Government through the Supreme Military Council and using advice from Federal Department of Fisheries, promulgated the Sea Fisheries Decrees of 1971, 1972 and 1992. These decrees were limited in scope and were directed at the following parameters:

i) Registration and licensing of fishing trawlers operating in the coastal waters of Nigeria. The number of trawlers to be registered required biological information on the Maximum Sustainable Yield (MSY) of the exploited stock and the yearly quota for each trawler. The catch quota for each boat was not included in the decree.
ii) The 1971 decree prohibited the use of explosives and poisons in catching fish. The damages caused by explosives and poisons to the fish stock were known and did not require additional information prior to its promulgation.
iii) The 1972 Sea Fisheries Decree restricted fishing trawlers from operating within the first two nautical miles of the continental

shelf. This was intended to prevent industrial vessels from competing with small-scale artisanal canoe fishers. This restriction was later extended to 5 nautical miles in 1992. This decree was based on complaints, by local fishers, of damages done to their fishing nets by industrial fishing trawlers.

iv) The 1972 decree also placed restriction on the codend of trawl nets used by industrial trawlers. The minimum codend mesh size of trawl nets was put at 3.5 inches (or 76mm) for finfish and 1.75 inches (or 44mm) for shrimping. This restriction was based on experience of trawling along the West African coast. It was lacking in details of the sizes of fish to be caught. Many undersized fishes were caught by shrimp trawlers initially and dumped in the sea for fear of being arrested. This resulted in the extension of the decree to include restriction on dumping of fish by-catch by shrimp trawlers.

v) The 1972 decree also restricted shrimp trawlers from operating within the inshore waters of the Lagos-West fishing grounds. This was intended to protect the juveniles of croakers common in the area. It was the only restricted fishing area for trawlers. There are many such areas along the Nigerian coast, particularly along the estuaries of major rivers, which constitute breeding and nursery grounds for different marine fish species.

These have to be identified and included in the revised law. As Neiland et al. (2002) pointed out, weak scientific data lead to incomplete information and knowledge, and policies based on such data will remain incomplete. Another crucial gap in Nigeria's fisheries policy is the complete absence of stakeholders' input during the policy formulation process. Experience shows that top-bottom approach to fisheries management does not yield the best of results. Local communities whose livelihoods derive from fisheries resources either directly or indirectly (e.g. artisanal fishers, women trading in fisheries products), local authorities where these resources domicile, commercial fishers, fishing equipment manufacturers and suppliers, should be given the chance to contribute to the policy formulation. Nigeria is now a democracy, so it is imperative to address these issues when the proposed revision of the laws takes effect.

The Exclusive Economic Zone (EEZ) Decree of 1978

By this law, Nigeria claimed 200 nautical miles as its EEZ, where it has sovereign rights over all natural resources, in concert with the provisions of the UN Convention on the Law of the Sea. The EEZ decree did not explicitly state the role that local research would play in the management and exploitation of the living resources, although that was

a requirement under the Law of the Sea. The decree however provided for the policing of the EEZ by law enforcement agents.

The 1992 Sea Fisheries Decree

The 1992 Sea Fisheries Decree consists of two segments namely:

The Sea Fisheries Licensing Regulation of 1992 which stipulates the conditions for granting fishing license for shrimping and fishing. This requires application for pre purchase assurance and submission of feasibility studies. The 1992 decree also re-emphasised the provision of regulations dealing with restriction of trawling within the first 5 nautical miles of the continental shelf. Trawl codend mesh size restriction was re-emphasised together with:

(i) Dumping of edible and marketable sea products and export thereof. Accordingly, fish landed by shrimp trawlers must not be less than 75% by weight of the total landing including the head on weight of the shrimp landed. This decree opens itself to wrong interpretation and has possibly resulted in the landing of more by-catch than shrimps. The rendering: “Fish landed by shrimp trawlers should not be less than 75% by weight...” This implies that the by-catch (fish) should not be more than 25% of the total catch.

(ii) Restriction on minimum sizes of fish to be caught was not available at the time. The decree did not supply any information on fish sizes but made provision for the Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos, to publish the sizes of different species (minimum total length of different species) to be caught during each year.

The provision of such information required special commissioned surveys by the Development Agency (Federal Department of Fisheries) on account of the costintensive nature of such surveys. In the absence of such commissioned study, the gap in knowledge exists up to the present, despite the fact that the decree has stipulated for such information.

The fixing of 3.5 inch codend was based only on the selectivity of croakers, the most dominant species at the time and lacked scientific information on the sizes of other species likely to be caught by the 3.5 inch codend of trawls. Because of this deficiency in the decree and the lucrative trade in the by-catch of cheap small fish, some shrimp trawlers became more interested in the by-catches than shrimps meant for export. Such action was dangerous to the survival and continuous recruitment of the fish stocks.

3.5 Inland Fisheries Act

An Act to provide for the licensing of fishing craft and the regulation of fishing on the inland waters of Nigeria and for matters connected therewith.

[1992 No. 108.] [28th December, 1992] [Commencement.]

1. Licensing of fishing craft

(1) As from the commencement of this Act no person shall operate a motor fishing craft (in this Act referred to as a "craft") within the inland waters of Nigeria unless a licence in respect of that craft has been issued to the owner or operator of the craft under this Act.

(2) A person who operates or causes to be operated a craft in contravention of sub-section (1) of this section commits an offence and is liable on conviction to a fine not exceeding ₦500 or imprisonment for a term of six months or to both such fine and imprisonment.

2. Application for a licence

(1) An application for a licence under this Act shall be made in a writing to the Commissioner in such form and manner as may be prescribed by the Commissioner and shall-

(a) contain the particulars and description of the craft in respect of which the application is made;
(b) state in sufficient details-
  (i) the method to be employed in fishing; and
  (ii) the area within which it is proposed that the craft is to be operated;
(c) be accompanied by such fee as the Commissioner may prescribe.

(2) The Commissioner may, before considering an application require the applicant-

(a) to satisfy him-
  (i) that the craft is properly constructed and equipped; and
  (ii) that the form and construction of the fishing nets, fishing gear and other equipment intended for use in fishing are adequate for the purpose of the fishing operation;

(b) enable him to reach a decision on the application.

3. Issuance and validity of licence

(1) The Commissioner shall issue to a successful applicant a licence for the craft subject to such conditions as he may deem necessary.
(2) A licence issued under this Act shall be valid for one year and expire on 31 December every year.
(3) Where the craft is to be operated in a body of water shared by two or more States, the owner or operator of the craft shall not be required to obtain more than one licence in a particular year.
(4) The holder of a licence under this Act shall, not later than one month before its expiration, apply to the Commissioner for a licence to take effect from the expiry of the current licence.

4. Identification mark on fishing craft

(1) The owner or operator of a craft shall exhibit the registration number of the craft on both sides of the craft in bold letters with a prefix reflecting the State of registration.
(2) A person who fails to exhibit a registration number on his craft as required under subsection (1) of this section commits an offence and is liable on conviction to a fine of ₦250or imprisonment for a term of three months or to both such fine and imprisonment.

5. Restriction on use of fishing gear, etc.

(1) No person shall fish with a gear constructed with net webbing of less than 76 millimetres except where the gear consists of-

(a) pelagic trawl nets used for freshwater sardines, that is, clupeids, which are used with outboard engines of not more than 25 horsepower capable of operating trawl net with three millimetres cod-end; or
(b) lift nets used for freshwater sardines constructed with three to five millimetres stretched mesh webbing.

(2) No single fishing unit shall operate with a single net or a combination of nets exceeding 500 metres of three millimetres mesh size and above.

(3) A person who contravenes a provision of subsection (1) or (2) of this section commits an offence and is liable on conviction to a fine of ₦500 or imprisonment for a term of six months or to both such fine and imprisonment and, in addition, the net and

catch shall be forfeited to the government of the State in which the offence was committed.

6. Prohibition of unorthodox fishing methods

(1) Except for electro-fishing and the use of chemicals for the purpose of research, no person shall take or destroy or attempt to take or destroy any fish within the inland waters of Nigeria by any of the following methods, that is the use of:

(a explosive substances;
(b) noxious or poisonous matter; or
(c) electricity.

(2) A person who contravenes a provision of subsection (1) of this section commits an offence and is liable on conviction to a fine of ₦3,000 or imprisonment for a term of two years or to both such fine and imprisonment.

7. Declaration of catch, etc.

(1) The operator of a craft in respect of which a licence has been issued under this Act shall-

(a) declare his catch to a nominated government agent when required to do so by the government agent;
(b) permit a Commissioner or a person authorised by him or a government agent to inspect the catch either before or after it has been landed; and
(c) give the Commissioner, person or government agent, as the case may be, all reasonable facilities in respect of the inspection of the catch.

(2) A person who contravenes a provision of subsection (1) of this section is guilty of an offence and is liable on conviction to a fine of ₦500 or imprisonment for a term of three months or both such fine and imprisonment.

8. Prohibition of export or import of live fish, etc.

(1) No person shall export or import a live fish or any other aquatic animal without the permission of the Minister.
(2) A person who contravenes a provision of subsection (1) of this section commits an offence and is liable on conviction to a fine of ₦25,000 or imprisonment for a term of five years or to both such

fine and imprisonment and, in addition, the fish or aquatic animal shall be forfeited to the Federal Government.

(3) Notwithstanding the provisions of subsection (1) of this section, the Minister may, from time to time, export or import a specialised species of fish or other aquatic animal for the purpose of exchange of fishery information or for research.

9. Closed areas and seasons

(1) A Commissioner may at his discretion declare as closed, for the purpose of fishing within the jurisdiction of a State, such area or season as he may deem fit and the Minister may at his discretion declare as closed, for the same purpose, a body of water shared by two or more States.

(2) A person who fishes in a closed area or during a closed season in contravention of subsection (1) of this section commits an offence and is liable on conviction to a fine of N3,000 or imprisonment for a term of two years or to both such fine and imprisonment.

10. Construction of dams, weirs, barriers, etc

(1) The appropriate authority shall regulate and control the building of dams, weirs or other fixed barriers or obstructions to ensure a free movement of fish, and where permission is granted to a person to build a dam, weir or other fixed barrier or obstruction, fish ladders shall be built to ensure free movement of fish.

(2) person who contravenes a provision of subsection (1) of this section commits an offence and is liable on conviction to a fine of ₦50,000 or imprisonment for a term of ten years or to both such fine and imprisonment and, in addition, the dam, weir or other fixed barrier or obstruction, if any, shall be destroyed.

(3) In this section**, "appropriate authority"** means the body charged with the responsibility for matters relating to the construction of dams and other fixed barriers.

11. Protection of fish or fish products against contamination and infection

(1) No person shall spray noxious chemicals on fish or fish products and no contaminated, infected or spoiled fish shall be sold or offered for sale.

(2) A person who contravenes a provision of subsection (1) of this section commits an offence and is liable on conviction to a fine of ₦200 or imprisonment for a term of two months or to both such

fine and imprisonment and, in addition, the contaminated, infected or spoiled fish or fish product shall be destroyed.

12. Offences by bodies corporate, etc.

Where an offence under this Act is committed by a body corporate or firm or other association of individuals-

(a) every director, manager, secretary or other similar officer of the body corporate; or
(b) every partner or officer of the firm; or
(c) every trustee of the body concerned; or
(d) every person concerned in the management of the affairs of the association; or
(e) every person who was purporting to act in a capacity referred to in paragraphs (a) to (d) of this section, is severally guilty of that offence and liable to be proceeded against and punished for that offence in the same manner as if he had himself committed the offence unless he proves that the act or omission constituting the offence took place without his knowledge, consent or connivance.

13. Enforcement

(1) The provisions of this Act shall be enforced by such officers as may be authorised by the Minister or Commissioner, as the case may be.

(2) An authorised officer may within the inland waters of Nigeria for the purposes of enforcing a provision of this Act-

(a) require the owner or operator of a craft in respect of which a licence has been issued to exhibit his licence, fishing apparatus and catch;
(b) go on board a craft to search and examine the craft and any fishing apparatus that may be there and collect statistical information; and
(c) where there is reason to suspect that an offence under this Act has been committed, take the alleged offender and the craft, fishing apparatus and catch to the most convenient post or police station.

(3) The power vested in an authorised officer under subsection (2) of this section may be exercised by him without warrant, summons or other legal process.

(4) A craft or fishing apparatus taken from an alleged offender under paragraph (c) of subsection (2) of this section may be detained pending the sale of the catch, and the proceeds of the sale shall be retained pending the trial.

14. Return of craft, apparatus, etc., to lawful owner

Any craft, fishing apparatus or money detained or retained under subsection (4) of section 13 of this Act shall, unless forfeited under the provisions of this Act, be returned to the person from whom it was taken or to its lawful owner.

15. Regulations

Subject to the provisions of this Act, the Minister may make regulations-

(a) to provide guidelines aimed at encouraging persons engaged in the fishing industry to make voluntary arrangements on a comparative or other basis for the selling of fish or the buying of equipment, supplies and other requisites for the fishing industry and to provide for financial or other assistance for bringing the arrangement into operation;

(b) to regulate the handling, processing and storage of fish or fish products on craft or on-shore and the times and places at and in which the landing of fish may be effected;

(c) for the registration of distributors and retailers of fish or fish products and of any premises used for the distribution or retailing and for the accounting and the records to be kept and the information to be furnished by them in relation to their business;

(d) for the maintenance of good order among the persons engaged in fishing and in the fishing industry and the regulation of any other matter or thing relating to the protection of fish and the administration of the fishing industry;

(e) generally for carrying into effect the provisions of this Act.

(2) The Minister or Commissioner, as the case may be, shall determine whether enclosures, including pens and cages used for fish, shall attract a license fee or not.

4.0 CONCLUSION

It is thus imperative that the existing Sea Fisheries Laws and Regulations should be updated with necessary scientific data previously not available, in light of the non-sustainable exploitation of fisheries resources in the coastal waters. It is in this regard that the fisheries sector of the national economy can be rescued from imminent collapse. Moreover, government's poverty alleviation measures in the rural coastal communities would suffer a great set back because of the fisheries resources-dependent livelihood of the population. In addition, health problems related to deficiency of protein, which is most cheaply derived from fish diet, would attain significant dimension with increasing fish scarcity and non-affordability. This paper is targeted at highlighting the crucial scientific data needed for an effective monitoring and control of the operation of the fishing industry to enhance sustainability of the resources.

5.0 SUMMARY

- The Sea Fisheries Decree makes it illegal for anyone to operate or navigate any motor fishing boat within the Nigerian territorial waters and the EEZ without licence.
- The Exclusive Economic Zone Decree delimits the extent of the zone under the Nigerian government jurisdiction, in accordance with the United Nations Convention on the Law of the Sea.
- The Inland Fisheries Decree regulates capture and culture fishing activities in the inland waters.
- Four sets of fisheries laws regulate fishing activities within the territorial waters and the EEZ of Nigeria.
- No person shall operate or navigate any motor fishing boat for the purpose of fishing or a reefer vessel for the purpose of discharging frozen fish within the territorial waters of Nigeria or its exclusive economic zone, unless that boat or reefer vessel has been dully registered and licensed.
- Under the law of the sea Exclusive Economic Zone (EEZ) there is a sea zone which a state has special rights over the exploration and use of marine resources.
- No person shall export or import a live fish or any other aquatic animal without the permission of the Minister.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the types of fisheries laws/regulation.
2. Explain the laws guiding licensing of motor fishing boats.
3. Explain the law of sea Exclusive Economic Zone (EEZ) and its implication for fisheries management.
4. Explain the sea fisheries decrees.
5. Explain the inland fisheries act.

7.0 REFERENCES/FURTHER READING

The Sea Fisheries Decree, (1992). *Sea Fisheries Decree No 71 of 1992* Laws of the Federation of Nigeria 30th day of November 1992.

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