BASIC FISHERIES TECHNOLOGY
for
Nigerian Schools and Colleges

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Dedication

This book is dedicated to my late mother Mrs. Avese Iorchor for laying my educational foundation

Acknowledgement

I wish to acknowledge the contributions of all those who contributed to my academic pursuits at various stages. I am grateful to Mr. Simon Omajawu, Mr. T.T. Nyam and Mr. Mough Ahire (late) for their kindness and encouragement in to the fisheries profession and career. I thank all my friends, colleagues and students who contributed in various ways to the success of this work.

I remain indebted to my wife Joy Member and my children Nguwasen, Luper, Ndernen, Suleiyol, Kulanen and Doonan for their inspirations.

Preface

Fisheries Technology is a relatively new area of study in Nigeria. The interest exhibited by prospective and practicing fish farmers will be inspired if related literature on fisheries is readily available to answer their curious questions concerning fish, fisheries and aquaculture.

The students of fisheries at various levels in different institutions of learning seem to have difficulties in relating or marrying easily, the differences in fisheries science and fisheries technology. This book will expose its readers to information about the aquatic animal (fin fish) and its basic biological requirements, like habitat, food and feeding habit, water chemistry and the techniques for establishing and managing fish holding structures. Other sections of the book are on fish harvest and preservation techniques.

Critics and comments on this first edition are needed for subsequent improvement.

CHAPTER 1

INTRODUCTION

Fishing is one of man's most ancient food gathering endeavours, it may be defined as the exertion of those activities, which with the aid of appropriate tools aim at the catching of fish. The term fish in this text is used to include not only the fin fish which are poikilothermic (cold blooded) aquatic vertebrates that breathe by means of gills and move by means of fins but also other aquatic vertebrates such as crocodiles and sea turtles (which are reptiles), whales, porpoises, dolphins and seals (which are mammals). Other aquatic invertebrates like shrimps, crabs, lobsters (mollusks) and crustaceans like Oysters clams, winkles and cuttlefish are also included here.

The terms **fishery** and **fisheries** are often used interchangeably in many texts however, fishery may be used to describe: (a) part or type of water body where fishing is carried out e.g. Lake fishery, inshore fishery. (b) Fishing in which definite types or craft or catching methods are applied with some regularity e.g. gillnet fishery, canoe fishery and (c) Fishing in which a particular species or a group of species of fish are selectively exploited with some regularity e.g. tilapia or tuna fishery. It therefore includes fishing, handling, preservation, processing, distribution and marketing of the products.

The term fisheries, is used to denote a number of different types of fishery viewed together in a given area or country. In order for fisheries to include aquaculture, it may be viewed or considered, in two perspectives viz, capture fisheries and culture fisheries. The former refers to the hunting of fish food and other valuable resources from bodies of water by man while the later is restricted to rearing of fish and other organisms in captivity of aquatic environment for food. The major characteristic of capture fisheries is that there is no recourse to recruitment of the stock population, culture fisheries is generally referred to as aquaculture (rearing of animals in aquatic environment). It may also be regarded as an aspect or agriculture since it has to do with production of fish seeds and rearing them to adult food fish and hence suitable course of study for agricultural students.
Fish farming (aquaculture), as originally practiced involves capturing and propagation of immature specimens and then raising them under optimal conditions in which they are well fed and protected.

Fisheries Technology is a general term that is used to describe a combination of activities that lead to the production of fish and fisheries products either as food for human and other animals, medicine, cosmetics etc. these activities cuts across Arts, Engineering, Science and Technology. The four areas can be summarized thus; the art of making wooden canoes and fish nets, the engineering designs for fishing vessels, fish ponds and dams, the science of understanding the fish as an animal with the water chemistry and the technology of hatching, growing, preserving/processing fish.

What fishes are

Fishes are cold blooded animals, typically with backbones, gills and fins and are primarily dependent on water as a medium in which to survive and live. The study of the life of fish may be referred to as the Biology of fishes but the pure and applied aspect of their study is known as **Ichthyology**. Fishes are the most numerous of

all the vertebrates on the earth surface water i.e. about 20,000 recent species are known to exist but these could be more, thus, not only are they many but they exist in many different shapes and sizes i. e. from the smallest e.g. percid least darta *(Etheostoma microperca)* which mature at the length of 27 mm. and a dwarf pygmy goby *(Erista)* of the pacific ocean which breeds at sizes less than 15 mm. There are giants too, such as the Whale shark *(Rhincodon),* which attain length of near 21m and weight of 25 tones or more, most fishes are torpedo shaped (streamed lined) but some are round, others are flat and still others are angular.
Fish also serve as one of the earliest links in the evolution of man and since more than 70% of the earth surface is covered with water, it may not be surprising why fishes are so numerous and varied. They occupy all waters from Antarctic waters below freezing point (0^o C) to hot springs of more than 40^oC and from soft and fresh waters to waters saltier than the seas (35ppm).
The percentage composition of some 41, 600 species of recent vertebrates discovered as occupying the Earth surface shows that Fishes are 48. 10% Mammals 10.80% Reptiles 14.40% Amphibian 6.0% Birds 20.70%s

Water is almost everything to the fish as a medium of survival, from birth to death. All of the fish vital functions of feeding, digestion, assimilation, responses to stimuli and reproduction are dependent on water. For the fish, the most important aspects of water are dissolved oxygen, dissolved salts, light penetration, temperature, toxic substances, concentration of disease organisms and opportunity to escape enemies. Most fishes including those with lungs depend mainly upon gills to extract oxygen ($O_{2)}$ dissolved in water and will not survive in any environment devoid of oxygen.
The ultimate food requirements of the fish depend upon small plants collection known as phytoplankton, which are also dependent on light for food production (Photosynthesis). Besides providing energy for food production in water, light is also known to trigger mechanisms of production growth and many kinds of behaviors, including that of feeding fish and other organisms. Unwanted materials such as toxins produced in nature and pollution from human activities are serious menaces to fish life, as they hardly escape such toxins. Like all animals, fishes also have diseases that worry them both externally and internally, these diseases are caused by many agents like viruses, fungi, bacteria worms, crustaceans and lampreys. Natural disorders e.g. blindness e.t.c also affect fishes. Apart from the above, fishes also suffer from predators and the capturing devices of fishers.

There are many reasons why we study fishes and these may include; to classify them, know their anatomy, evolution and genetics; their natural history and ecology, physiology and biochemistry as well as to find ways for their conservation which is the wise utilization/ management of fisheries resources for the benefit of man (Fisheries Biology and Management). Knowledge on fish stock manipulation through genetics, culture and rearing as well as preservation/processing (Aquaculture) is gained through the study of fisheries.

Major Branches of Fisheries Study
Fisheries, is a scientific and technical area of study and has the following branches: Aquaculture, Fisheries biology, Limnology, Oceanography, Gear technology, Preservation/Processing, distribution and marketing. One of the newest areas is aquatic toxicology which is mostly aimed at understanding the pollution of aquatic habitats and its effects on the fish.

Aquaculture; is the organized production of a crop in the aquatic medium. The crop may be that of an animal or plant, the organism cultured has to be ordained by nature as aquatic. Common organisms cultured in aquatic medium include; fin fish and other resources like crabs, prawns, frogs, crocodile, water hyacinth etc.

Fisheries Biology; is the study of life of fishes which may include reproduction, feeding, growth, response to stimulus, excretion, ecology and zoo-geography. Fish metabolism and the biochemical relationships between the animal and the environment (Ecosystem) are key areas. The pure and applied aspect of this study is known as ichthyology.

Limnology; Is the scientific study of the formation and characteristics of fresh water bodies (springs, streams, rivers, ponds and lakes).

Oceanography; is the study of the physical, chemical and biological characteristics of the oceans.

Gear Technology; Fishing gear deals with equipment and techniques (methods) employed in the exploitation of the fisheries resources of the inland, brackish, coastal waters and high seas. Construction and the principles of gear operations are core to this area.

Fish Processing, Preservation and Marketing; are fisheries support service activities that ensure the prolongation of fish products shelf lives and their distribution from the areas of abundance to areas of scarcity in good hygienic condition.

THE FISH

As earlier stated, fish is a cold-blooded water vertebrate animal that lives in water and depend on it for all its life activities. It typically has jaws, fins, scales, and slender body. It is described as cold blooded (poikilothermic) because it does not regulate its body temperature i.e. its body temperature varies with that of the water environment in which it lives but at a limited range. Fishes occupy almost all natural water bodies that exist on the earth surface with few limiting factors like pollution, altitude, draught etc. Many fish species exist with peculiar
adaptations to suit their preferred habitat, The main habitats of fish include; marine, brackish and fresh waters with the major differences among them being salt content (salinity). The fresh waters are sub-divided into running (lotic) and stagnant (lentic) waters.

Since we cannot talk about animals until they have names, the aspect of nomenclature is very important in the course of fisheries, the art and science of identifying, grouping and giving names to animals is referred to as S**ystematics** in biology**.** Knowing the correct name of a fish is very important when one chooses to work with it, and it will be easier to group the fishes before one could determine the differences in their body features. Any group of fish whose members are similar in structure and appearance and are capable of breeding among themselves are said to belong to the same species. A group of species which closely resemble one another in

structure but which do not interbreed, are said to constitute a genus (genera for plural) and when naming a fish, the genetic and specific names must are important as the major difference in their names is the species (specific). To appreciate how fishes are classified one has to be conversant with the terms used for describing the various parts of the body i.e. the different fins and appendages, scales, teeth, nostrils, lateral line, colour and sexual differences. Measurements of the different parts of the body and how they relate to each other also help us in classifying fishes. Most fishes can be identified correctly by examining their visible external parts (features) but this is not always so as sometimes it requires the examination of such parts as gills, rakers, air bladder or the inner harder parts.

Fish fins are the first structures to be examined when identifying a fish, their types, sizes, situations on the body and positions in relation to each other are important. The unpaired fins (dorsal, caudal and anal) are more important in classification compared to their paired ones (the pectorals, pelvics and ventrals). The caudal fin or tail of most fishes is lobed (forked), but in some fishes it is rounded, pointed or truncate. The number of spines and/ or rays in the dorsal and anal fins is generally the most consistent character in a species and is seldom the same in two different species. Each fin is made up of a number of rays, which are usually bony and flexible and are either simple or branched. The numbers of simple and branched rays are given separately in a description. In many fishes, some or all of the rays especially of the dorsal fin, are replaced by strong and sharp spines. The size and shape of this fin is often given as a clue to the identity of a species.

FOOD AND FEEDING

Fishes require adequate nutrition in order to grow and survive. Nature offers a great diversity of foods to fishes including nutrients in solution and a host of other different plants and animals. Sources of fish food come from many groups of plants and animals that inhabit waters, as well as from others that do not. Chemical elements like calcium are absorbed from the water itself (as through the gills) or are swallowed with food and then absorbed in the digestive tract. Different kinds and types of fish are adapted to a wide variety of foods: Some fishes feed exclusively on plants (Herbivorous), others feed only on animals (carnivorous), where as a third and larger group derives its proteins, CHO_2 and fats, as well as vitamins and most minerals necessary for growth and up keep, from both plant and animal sources (omnivorous), some specialized parasitic fishes live on the blood and the tissue fluids of other fishes. Many young fishes with tiny mouths and often still with yolk in their yolk sacs, begin to feed on plankton, (the microscopic plant and animal life in water, including bacteria). The earliest animal foods to be consumed are animal plankton organisms or zooplankton zooplanktons these include many different kinds of protozoans, microcrusteceans, other microscopic invertebrates and the eggs and larvae of many animals including those of fishes themselves. Other important fish food among the larger invertebrate animals are: annelid worms, snail's mussels, clams and crustaceans and insects. All classes of vertebrates are prey for fishes – birds, mammals, Reptiles, Amphibians and of course fishes themselves, not even humans escape as they are attacked by several fishes. Below is a diagram showing the external anatomy of a bony fish all the external features have their peculiar functions for the fish.

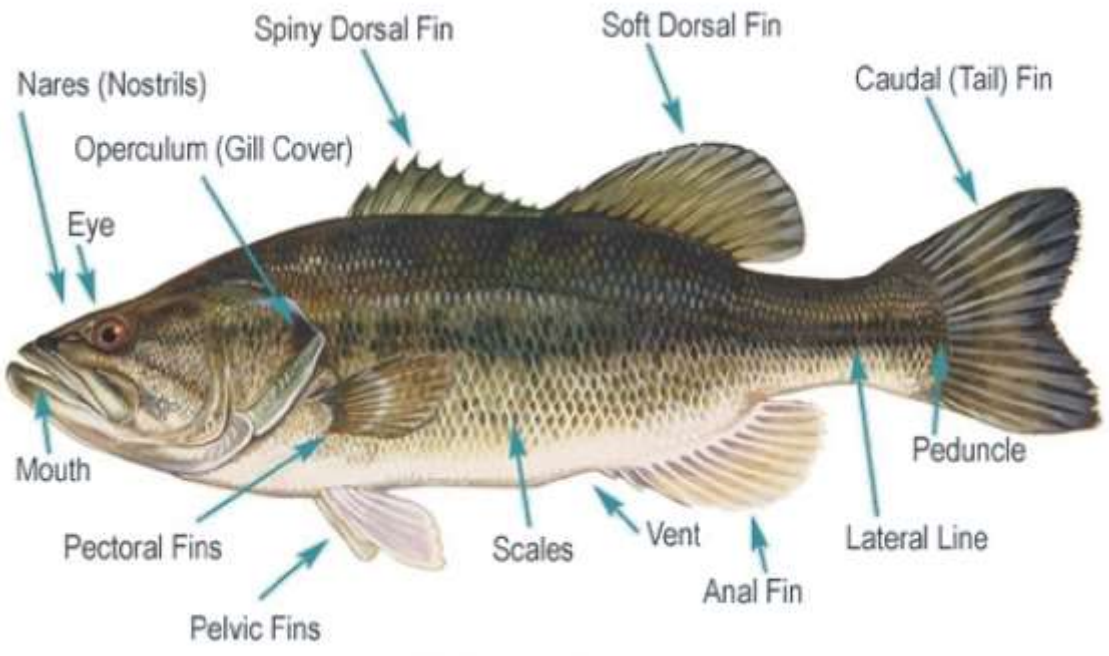


Fig1. External anatomy of a bony fish

CHAPTER 2
HISTORY AND DEVELOPMENT OF FISHERIES

Fishing dates back to when people of ancient times began fishing for food, and pieces of bone were used as hooks and lengths of vine as line. The oldest known painting of an angler using a rod or staff comes from Egypt circa 2000 B C. Greek philosophers Plato and Aristotle mentioned angling in their writings, and another Greek writer, Plutarch, gave tips about fishing lines. In the 2nd and 3rd centuries A D, Roman rhetorician Claudius Aelian wrote about Macedonian trout anglers using artificial flies as lures. Since then methods and tackles have evolved slowly so it is difficult to know when fishing began as an act or where it began from but it may be assumed, that people who lived near water (stream, river, lake and sea) learned to catch fish, at about the same time as man began to hunt for wild animals on land.

Devices for catching fish may have been simple tools or even hand picking of draught finfish and crabs. Later implements more specific for catching fish were made thus, hooks were made progressively from wood, then bone and finally metals; plants fibers were woven into nets and used to trap, entangle, or surround a school of fish. Much of the fishing gear in use today has been well known for some centuries B.C. Nowadays, however, the fishing gear has generally undergone a lot of modifications and improvements in consonance with advances in modern technology although the basic principle of wounding, hooking, trapping (by the gills, fins and spines), encircling, scooping and filtering can still be detected.

The development of fishing gear was accompanied by that of the fishing craft. Fishing had to be carried out beyond the banks and shorelines, and so arose the necessity for some craft or vessel with which the fishers could move into deeper waters. The early fishing crafts were simple devices such as floating logs, bamboo, papyrus rafts and calabash craft; canoes probably came later as an improvement on these. Most of these ancient crafts are still seen today particularly in the developing countries of the tropics but, as in the case of the fishing gear, modern fishing craft have generally undergone great changes in size, quality and sophistication made possible only through modern technology. Sails on fishing vessels were replaced by steam engines and later by petrol and diesel engines. Today, Japanese, American, Polish, Russian and Korean fishers fish in all oceans of the world using factory-type vessels of up to 5,000 gross tonnage displacement.

The development of the rather sophisticated fishing gear and the improvement in vessel design and size were followed by the improvement in fish detection methods or the invention of new fish finding and detection equipment such as echo-sounders and sonars. All these developments necessarily brought about increased catches per unit effort and this in turn required good and efficient method of preservation of the catch to reach the consumer or the processing plant in good condition. It was discovered that a simple way of doing this was to carry ice on board the fishing vessel to chill the fish. Further improvement on this was to have the fish holds refrigerated so that the catches were hard frozen at sea and so were landed in the original fresh condition. Concomitant to all these developments has been the improvement of shore-based facilities-berths for the vessel, slipways for dry-docking of vessels, cold stores into which the catch is off-loaded and good roads linking such fishing port complexes to facilitate the movement and distribution of the fish inland.

Another aspect of fisheries development is the raising of fin fish and other aquatic organisms in ponds or other artificial enclosures. The activity, now popularly known as aquaculture, has been in practice for over 4,000

years. The application of modern science and technology to aquaculture has raised the production from this type of fishery up to 10 tones or more per hectare. Generally, the past 80 years or so have seen greater progress in the fisheries industry than the previous 2,000 years

Evolution of Fish Culture in Nigeria

The practice of fish culture is very old. Huet (1972) traced the art of fish culture in ponds to the Egyptians, the Romans, people from Indo- Pacific regions, and the Chinese. However, the first written account of fish culture in ponds was by Fan Lai, a Chinese fish farmer in 475 B.C. (Chackroff 1976).

In Nigeria, the first trace of fish farming (aquaculture) was the practice by some missionaries in the early 1920's in IIora, Oyo State, where fish was raised to supplement the protein intake of pregnant women. Conventional fish farming in Nigeria, however, falls into two distinct periods; between 1950-1970 and 1970-1992. the first period popularized fish farming while the second phase concentrated on expansion and establishment of demonstration fish farms in addition to bold attempts at reducing the major constraints for rapid aquaculture development.

Between 1951 and 1953, the federal government of Nigeria, under the auspices of the federal ministry of Trade and Industries, built the first pilot fish farm (about 20ha) in Panyam, plateau State. It was intended that, this farm should be operated as a quasi-commercial enterprise serving as a model and providing information for other farms to be built in other parts of the country (Satia 1990). In 1954, due to disappointing results obtained from the culture of tilapia, common carp (Cyprinus carpio) was introduced probably from Israel and Australia (Welcome 1988). The production recorded in the first year of Panyam fish farm was less than 800kg/ha, however, the trials had generated sufficient interest such that both the then western and eastern region governments built fish farms in their respective areas.

In 1953, the Agodi fish farm was established by the western region government and common carp was introduced from Israel. In 1967, the federal government started additional pilot fish farms: the Ikoyi fish farm project in Lagos and another in the East which was short-lived due to the civil war.

Fish seed multiplication and training centres were also set up by the federal government between 1978-1980 in different parts of the country to facilitate fish production in Oyo (South West), Umuna Okigwe (South East), Panyam (North East) and Mando, Kaduna (North West), eleven River Basin Development Authorities (RDBA) were also established between 1977 and 1980 to accelerate agricultural development. The RDBAs were encouraged by the Federal Government to build commercial fish farms and to demonstrate the economic viability of aquaculture.

In 1986, the Directorate of foods, Roads and Rural Infrastructure (DFRRI) also popularized fish farming through its activities. There was an increased participation of the private sector in fisheries activities with the establishment of viable and functional commercial fish farms. Today, there are several fish farms in Nigeria ranging from small homestead fish ponds either in concrete tanks or earthen ponds to commercial fish ponds

covering several hectares. Production records from these farms range from as low as 50-100kg/ha/yr to as high as 31,500kg/ha/yr (in very few farms).

Fisheries Development in Nigeria

In 1941, the fisheries development branch was established in the Head quarters of the colonial office. In 1945 fisheries was upgraded to a division of the Department of Commerce and Industry. Between 1945 and 1950, the first five-year development plan was formulated, while in 1954, the Lyttletoris Constitution put fisheries research in the concurrent legislative list. The development oriented federal Department of fisheries (FDF) was established and in 1975, the research functions of FDF were transferred to two research institutes namely; Nigerian institute for Oceanography and Marine Research (NIOMR) and Kainji lake Research Institute – now, National Institute for Freshwater Fisheries Research (NIFFR). In 1999, the national constitution included fisheries and fishing other than in rivers; waterways, ponds and inland waters within a state, on the exclusive legislative list.

Fisheries Department as we know it today was an exigency of World War II in 1942. During the 2nd World war, there was a ban on the importation of food items including fish. Nigeria was then under the Colonial Rule of Britain. The British people were not used to Nigerian diets and so had to import their food items. When the ban on importation of food items came into force in 1942, it became necessary to look inwards to replace those food items that were hither to imported. The idea to establish a fisheries Department was then, transformed to practice but on small-scale fishing for consumption by the Colonial Masters. They also carried out trawling surveys from Lagos to the Cameroon. This delayed development because there was lack of manpower in this area. This arrangement continued until 1953 when a constitution was adopted dividing the country into three regions (Northern, Eastern and Mid-western). These regions had no proper connection with the Federal Government, although each region established a fisheries Department in its areas of operation.

In 1975, the Research Institution establishment order was enacted and 22 Research institutes were established. Three are concerned with Fisheries Research. They included:

i. Nigeria Institute for Oceanography and Marine Research (NIOMR), Lagos
ii. Kainji lake Research Institute (KLRI)
iii. Lake Chad Research Institute (LCRI)

KLRI and LCRI now National Institutes for Fresh water Resaerch (NIFFER) New-Bussa, Kainji and Baga near Lake Chad. The establishment of the research institutes has witnessed a lot of progress in research and development of fisheries resources.

In 1979, the Military Administration under General Gowon created 12 States. There were lot of problems of imbalance in natural resources and manpower. The activities and operations of fisheries department were then placed under the Ministry of Agriculture and Natural Resources in each state. Research and development in fisheries matters became the joint responsibility of the State and Federal Government so there was a great stride in development. In 1979 also, the Federal Department of Fisheries (FDF) established a planning division to safeguard the department. The functions of the planning unit included:

(a) The development of a national fisheries plan, which could take the various needs and aspirations of the states into account. It was also to ensure harmonious progress and coordinated efforts towards achieving planned national objectives.
(b) The establishment of Data Bank to provide information for established and new investors in the fisheries industry.
(c) To plan and execute the training of manpower required for fishery development in the public and private sectors of the economy.

In 1980, the National Science and Technology Development Agency (NSTDA), was formed to coordinate the activities of the research Institutes (RI) also in 1980 the Ministry of science and Technology was established to take charge of NSTDA. In the decade of 1980 to the 90s there was considerable or remarkable progress in research and development of fisheries as many people engaged in high technology fishing for target species and expanded aquaculture establishments.

The 2000 millineum is characterized by increased awareness of aquaculture and the needed human protein requirements. Presently, the depleting fish stocks from the wild due to fishing pressure and other ecosystem disasters like pollution, ageing of water bodies compounded by Global warming. The increased protein need for human body due to population growth and other uses of fisheries products has made fisheries a lucrative area of commercial business for entrepreneurship development and expansion. The trend is demanding for more efforts in research development and publication as well as training of manpower for sustained commercial fish production.

CHAPTER 3

DEVELOPMENT OF FISHERIES RESOURCES IN NIGERIA

Nigeria lies between Lat. 4^0 16' 13^0 52' N and Long 2^0 49' 14^0 37' E and has a coastline of about 850 km which borders the Atlantic Ocean in the Gulf of Guinea. The limits of Nigeria's territorial waters and Exclusive Economic Zone (EEZ) are 12 NMI and 200 NMI respectively (i.e. 22. 24 km and 370.40 km). The total area of the continental shelf is approximately 41000km^2 (Doy 1980), but flats are interrupted coast-wide by unburied fossil corals at about 40-120m depth (Allen and Wells 1962; Awosika, 1990); Canyons off Lagos, Mahin and Calabar also interrupt the shelf (Allen, 1964). Apart from these interruptions and some off shore oil prospecting installations, which now constitute a kind of obstacle for trawling, there are sanctuaries for some finfish resources on the shelf off the East coast of Lagos to between Kwa Iboe and Cross River (Tobor, 1995). There are two major rivers and many others, with Nigeria's portion of the Lake Chad that provide for the fisheries. The vast swampy areas that abound from south to north are great potentials for fisheries aquaculture. The distinctively marked dry and wet seasons which are associated with a prominent hydrologic cycle supports natural and artificial fish production.

Fishes exhibit enormous diversity in size, shape, biology and in the habitats they occupy. There are 798 species of fish recorded in Nigeria of which 316 are found in freshwater and 482 species in brackish/marine water (FishBase, 2010). Freshwater fish species of Nigeria is the richest in West Africa and its river basins have the highest number of endemism in the region. These fishes belong to three of the ten recognized ichthyofaunal provinces in Africa. Most of them are found in the Nilo-Sudan province (Niger-Benue, western coastal rivers and lake Chad), while the lower Guinean species and few species from the Zairean ichthyofaunal provinces are limited mainly to Cross River and part of Niger Delta (Olaosebikan et al 2013).

Hydrologic Cycle is the water balance on the earth surface. It is the principal science dealing with continental water on and under the earth's surface and in the atmosphere. The constant circulation of water from land and sea through the biosphere and atmosphere by evaporation, evapo-transpiration (loss of water from the soil by evaporation and transpiration by plants), and precipitation and runoff constitutes the so-called hydrologic cycle **Encarta ® 2009.**

All available water on the earth may be seen as constituting a closed cyclic system whose pattern is so largely determined by solar radiations, condensation and gravity. In this cycle, large amounts of water moves from the earth's surface into the atmosphere by evaporation; back to the earth by precipitation and then back to the atmosphere by many paths. A lot of water from the earth surface is returned to the atmosphere by evaporation and plant respiration or animal respiration. Some however infiltrates into the ground to become pan of the subsurface water, which gets into the cycle via lakes, streams and the bodies of living organisms. The hydrologic cycle phenomenon is the sole determinant of dry and wet seasons which influence seasonal variation in fish distribution and abundance.

Nigeria's fisheries resources may be summarized in quantity to include :

i. The South-coast, about 800km long of Atlantic Ocean and over 1 million hectres of lagoon.
ii. To the North-East there is the Nigeria portion of Lake Chad.
iii. Within the country there are the two major rivers i.e River Niger and Benue and several other rivers and Dams Viz Kainji lake, Rivers Sokoto, Kashimbila dam to mention a few.
iv. Nigeria has territorial water of 30 nautical miles and an EEZ (exclusive economic zone) of 200 nautical miles in the Atlantic Ocean.
v. Over 1,000,000 Nigerian households are engaged in fishing.
vi. About 1000 fishing trawlers (Licensed and unlicensed) operate in the Atlantic Ocean for fish exploitation.
vii. In the Aquacultural sector there is a driving interest, Fish Farms/ponds belonging to schools, colleges, individuals, government and communities are all contributing to the total fish production.

It is however, not easy to quantify all the fisheries resources for some of the following reasons;
i. Fish are seldom seen, since they are hidden under a mass of water unlike cattle, goats, birds etc.
ii. Fish are not evenly distributed in a water body. Their distribution is dependent on factors such as nature of the bottom, availability of food and other hydrographic and chemical factors (salinity, water Temp, depth and tide).
iii. Rate of recruitment, mortality and yield are not easy to estimate because of factors such as fishing gear, pollution etc.

In spite of the above, the estimation of fishery resources is done through:
a. Trends in statistical returns from both artisanal and industrial sector.
b. Degree of interest exhibited by entrepreneurs.
c. New fishing grounds opened through the declaration by Nigeria of a 200 nautical miles EEZ in the Atlantic Ocean.
d. New projects development especially in the areas of aquaculture.

For now there is scanty statistics about fish production figures in the country due to lack of well coordinated data collection system, efforts made by individuals or research groups fall short of wide coverage and available data in most cases do not cover the entire sub-sectors involved in fish production. The first nation-wide census to collect information on total production in the fishery sector was done by the Federal Department of Fisheries in 1975/76 therefore, is hardly a consistent survey result since then.

Development of Fisheries Resources

In Nigeria today, fisheries development programmes are made to suit the needs of each state and such programmes depend on the location of the state. Inland states depend on inland fisheries (River Fishing and Pond Culture), whereas emphasis is laid on marine fisheries in the coastal states.

Available data shows clearly that Nigeria is richly endowed with water resources, and in these waters, are found various species of fish that are commercially important and if properly harnessed can help to meet the ever-increasing demand for fish and foreign exchange.

The current population of **Nigeria** is **192,883,305** as of Sunday, November 26, 2017, based on the latest United Nations estimation, Nigeria population is equivalent to **2.53%** of the total world population. The estimated domestic fish demand is 2,121,716 metric tons (MT). The present domestic fish supply is less than 40 percent of the total demand, there is thus a wide gap between fish demand and production. Nigeria spends over 200 million US$ annually on importation of frozen fish to augment the short fall. Even with such high expenditure of scarce foreign exchange on importation of fish, the gap can only be narrowed and not closed.

Development Objectives

From the on-shelf information gathered so far, there is scarcity of information on the management of Nigerian freshwater bodies, information available indicates that there is the traditional fisheries management and the Government legal approach in form of fisheries Laws and Regulations and there exist development plans in the fisheries sector The current policy thrust of the Federal Government is aimed at ensuring sustainable development of Nigerian fisheries for National Food Security, for self-sufficiency in fish production, optimum resource utilization and conservation. The policy focuses on employment generation, wealth creation, poverty alleviation and reduction in rural-urban migration among others in line with the National Economic and Empowerment Development Strategy (NEEDS) of the Federal Government and the New Partnership for Africa's Development NEPAD) initiatives. The Nigeria Government strategies which are private-sector driven in developing fisheries are expected to sustain the;

- Achievement of self-sufficiency in fish production
- Development and modernization of the means of production, processing, storage, marketing and resources conservation;
- Promotion of export of shrimps and fish products as a means of earning foreign exchange from non-oil sector;
- Improvement on the quality of life in fishing villages;
- Provision and improvement of employment opportunities in the rural fishing communities thereby - reducing rural - urban drift, crime and criminalities;
- Acceleration of Research and Technology dissemination and adoption in all aspects of fisheries by ensuring rational exploitation of the nation's marine fisheries resources;
- Human capacity development through improvement and development of training Institutions and facilities
- Promotion of fisheries curricula in the institutions of higher learning;
- Encouragement of private entrepreneurship in all aspects of fisheries;
- Ensuring total compliance with the FAO's Code of Conduct for Responsible Fisheries(CCRF).
  To develop and utilize Nigeria’s fishery resources which have been exploited for long by foreign owned fishing trawlers

Initiate the local production of fish products e.g. fishmeal, fish oil, fish flakes, fish sausages, fishcakes, dehydrated fish etc., which are at present imported thereby helping to conserve foreign exchange.

Fish and Fisheries

The Nigerian industrial inshore fishing activities consist of trawling for dermersal finfish and shellfish, principally penaeid shrimps, they also catch crabs and others. The finfish species are heterogeneous and occur down to 50-m depth. They belong to supra-thermocline and sub-thermocline communities. Tobor (1990) recorded 71 families comprising 157 species most of which are small in size. The major target families/species of the supra-thermocline community i.e sciaenids include; Sciaenidae, (croakers), P. *seudotolithus, typus, P. senegensis, P. elongates and P. brachynathus (4 species).* Cynoglossidae (Tongue Sole), *Cynoglossus cynoglossus, C. Cararіensis, C. Mondi and C. brown.*Aridae (Catfish), *Arius heudeloti, A. gigas, A. Latiscutatus, A. parki.*Polynemidae (Shrinynose or Threadfins), *Polydactylus quadrifilis, Galeoides decadectylus.* Haemulidae (grunters); *pomadasys jubelini, P. suillus; P. incisus, P. peroteti. Syhyraenidae* (barracudas), *Sphyraena barracuda, S. afra, S. guachancho.*

The small scale fishermen operate dug-out or improved canoes and they are 2 to 10 men on board according to the type of fishery engaged in, most fishes caught belongs to the scieaenid community including croakers and bonga, shell, catfish, sardines, soles, shinynose, etc. *Polydaclylus spp*. (Polynemidae) as well as members of the Sphraenidae, Lutjanidae, Elopidae, Serranidae, and Carangidae families. The small-scale fishermen also catch sharks, sail, saw fishes as well as penaeid, palaemonid. and penaeid shrimps. They exploit mostly the same with motorized fishing vessels known locally as “Motor Fishing Vessels” which are licensed to trawl for fish.

Ita (1993) listed 230 fish species as occurring in the inland waters of Nigeria. Fish base (2013) recorded 316 fish species as belonging to the fresh or inland waters of Nigeria, and Nigeria is known to be the richest in fisheries resources of Africa. The National Institute for Freshwater Fisheries Research of Nigeria lists some of the following fish species as commercially important, they include ; *Lates niloticus, Bagrus domac, Malapterurus electricus, Heterotis niloticus, hemisynodontis membraneceus, hydrocynus forskalii, bagus bayad, gymnarchus niloticus, heterbranchus bidorsalis, chrysichthys nigrodigitatus, mormyrops deliciousus, citharinus citharus, clarias anguilaris, clarotes laticeps, distichodus rostratus, orechromis niloticus, synodontis nigrita*.

Exploitation of Fisheries Resources

There are three sectors involved in fisheries exploitation in the Country, they include;

1. The Artisanal fisheries sector
2. The industrial or commercial fisheries
3. The small-scale fisheries enterprises

Artisanal Fisheries Sector

Artisanal fisheries is a term recognized by international agencies such as the FAO refers to small scale fisheries that involved in a diverse continuum of activities.
The fishers in this sector are more or less peasant fishermen at the subsistence level. This sector is characterized by low technology and is labour intensive, they use less sophisticated craft and gear and because of these factors, they cannot go out far into the sea (because they are small and cannot withstand strong wave action) and so carry out fishing around the shores, rivers and streams. Small fish pond owners may be included in this group.

Okorie (2003), highlighted the current states of fishery industry in Nigeria and described the artisanal fishing sub sector as largely labour intensive and often characterized by low productivity. According to Okorie (2003), four categories of artisanal fishing include coastal canoe fishery, brackish water canoe fishery, fresh water fishing and aquaculture. He stated that, "By far, the bulk of Nigerian's fish production is contributed by this sector." Moses(1992) added that the gear employed are generally simple and hand operated. They also lack credit backing from banks and other financial houses.

According to the 1998 record of fish production by the F. A. O, this sector accounted for (46.6%) of total fish output in Nigeria. With demand for fish increasing as a result of a fast increase in human population. It would have been wonderful if there is a corresponding increase in capture fisheries. This has not been the case. The records of 1984-1998 tend to suggest that the output is stagnating.

Industrial or Commercial Fisheries Sector
Industrial or commercial fishing is distinguished form other types by the high level of technology employed and is therefore capital intensive. This type of fishing is usually found in what is commonly called deepsea fisheries. In this sector, they use sophisticated fishing crafts like trawlers, fish finders, echosounders, purse seiners etc. Fishing in this category is carried out in the high seas and catch is processed offshore and sold.

The Small- scale fisheries Enterprises
The sector is made up of fishing companies and medium to large scale fish farm enterprises. Most of these companies are located or operate close to river line areas where the fisheries potential is high.

Problems of the sectors involved in fisheries; all the sectors mentioned above have common problems which may include;

(a) Inadequate funds to operate effectively
(b) Lac k of good transportation and marketing infrastructure
(c) Lack of trained manpower to efficiently man the operations to a large extent
(d) Inadequate information on recent technological break-throughs to be applied for effective operation
(e) Low or no application of budgetary allocation to the fisheries sub-sector of the economy

Despite the above problems, the artisanal sector contributes about 75% of the total fish demand in the country today as more people are involved.

Between 1994 and 1997 the numbers of inshore trawlers, artisanal canoes (powered and non powered) and fishers remained relatively stable, suggesting that productivity and number of fishers it can accommodate. The Nigerian Trawler Owners Association (NITOA) in 1996 claimed that about 56 fishing companies owned 271 Nigerian flag-registered vessels, some of them were built in USA and Poland. However, not all vessels are operational. Their ownership is either fully Nigerian or joint venture ship between Nigerians and Foreigners. Government Policy currently permits 100% foreign ownership but the number fishing vessels operational in Nigeria's territorial waters can not be ascertained up till date. Other fishing boats operated within the country mostly by Ghanian and Camerounian porchers are hardly detected. The double- rigged/outrigger refrigerated vessels operate day and night using their booms to pull either two or four otter shrimp trawl nets with tickler chains. Turtle Excluder Device (TED) regulation came into force in 1996 to protect the sea turtles. The towing speed is between 2.5-3.0 knots and trawling time is about 3 hours. The vessels are crewed with about 3000 foreign and Nigerian crew, the later being mostly home- trained Mate certificate holders and 2nd class Engineers. The skippers and chief engineers are mostly Asian and Ghanaian nationals.

CHAPTER 4

FISHERIES MANAGEMENT STRATAGIES IN NIGERIA

Management may be defined as the handling and controlling of something successfully, or the application of principles for positive and sustainable utilization of resources. Generally, management of natural resources is the efficient exploitation and utilization of the products in such a manner that will allow for fair distribution and continuity. Fisheries management is the exercising of prudent foresight to avoid unacceptable or undesirable situations, taking into account that changes in fisheries systems are only slowly reversible, difficult to control, not well understood and subject to change in the environment and human values.

Fisheries management should protect the food security and livelihood of dependent communities and try to ensure that benefits from the surplus production of domestic and wild stocks are brought into economics in ways that are appropriate to the political, social and development of the environment in which they occur. Such management activities should protect the resources from going extinct so as to provide for younger generations.

Fisheries management is subject to environmental variability and also to long-term changes that may be human induced particularly pollution and climate change. There is thus far more uncertainty and risks in fisheries management than there is in the management of almost any other food sector or industry. Like in terrestrial agriculture which started with food gathering and hunting for wild animals by man, fishing is one of man's most ancient food gathering endeavours, it is the exertion of those activities, which with the aid of appropriate tools aim at the catching of fish. Agriculture has it main fields like; crops, tree crops (annual and biennial) and livestock, they all deal with nursery and rearing of seeds to maturity. Wild agricultural harvesting of timber and non-timber products (logging, firewood, medicinal plants, edible fruits and leaves) is another aspect of agriculture with bias to forestry. Capture fisheries is closely related to wild agricultural harvesting while aquaculture is the direct counterpart of production agriculture.
For effective monitoring and management of fisheries it may be subdivided into the areas earlier stated in the introduction (Aquaculture, Fish biology, Limnology, Oceanography, Gear and Craft technology, Preservation and Processing, distribution and marketing). One of the newest areas is Aquatic toxicology which is mostly aimed at understanding pollution and its effects on the fish.

A good understanding of the above areas of fisheries is a prerequisite for optimum exploitation and utilization of fisheries resources and if properly harnessed they may support conservation and enhance management tools and objectives. Management of fisheries resources is necessitated by the fact that it is a limited resource against the increase in human population with higher values and well developed technology for its exploitation.

Management Objectives
The main objective of fisheries management has been the conservation of fish stocks. In modern fisheries management, this limited aim has been extended to address additional economic, social and environmental objectives such as fisher's welfare, economic efficiency, the allocation of resources and environmental

protection. The broad objectives of fisheries management may therefore, include the conservation of fisheries resources and their environment, the maximization of economic returns from the fishery, the payment of fees to the community from profits made by the exploitation of a public resource.

Management Strategies

Fisheries Legislation and Regulations are evolved from time to time by various governments of individual countries and at different levels to manage fisheries resources. The laws enacted by the countries are governed by the United Nations (UN) through the Food and Agricultural Organization (FAO). In Nigeria the regulatory law is the Fisheries Act 2014 Federal Republic of Nigeria. ENACTED by the National Assembly of the Federal Republic of Nigeria, the act provide for the conservation, management and development of sea fisheries, inland fisheries and aquaculture and related matters. The main objectives are to promote optimum utilization and long term conservation, management and sustainable development of fisheries resources and ecosystems while recognizing the needs of present and future generations to utilize those resources in order to achieve food and nutritional security, economic growth, human resource development and employment creation. The act is explicit on the roles of government, Organizations and Individuals in fish exploitation, conservation and management as well as associated punishments for contraventions.

Fisheries Management Activities

The activities carried in the field that control and provide information for decision making and policy formulation include statistical data collection. Fisheries statistics include all statistical information on the business activities of Artisinal fishermen, aqua culturists, commercial in-shore trawler operators and importers of fish. In addition to landings of different species of fishes, the sector's statistics also include quantity and price data on inputs, equipment and facilities in fish production as well as prices of different categories of fish. As a result of the ubiquitous nature of fishing activity, spatial coverage is not as easily defined as in the case of crop and livestock statistics. Nevertheless, fisheries data are also reported on State and National bases. The items of data and the scope of coverage are segregated according Local Government Areas, states and the Federal jurisdiction areas like the Atlantic Ocean and the Nigeria's portion of Lake Chad. The attributes of fisheries and fishing activities covered include: socioeconomic information about fishermen and other manpower in fish production and distribution; commercial fishing practices and characteristics; fish production and imports infrastructure, equipment and inputs in fish production; education, extension services, research and development. Uses and Users of Agricultural Statistics are useful for planning, monitoring and evaluation purposes as well as research and development.

CHAPTER 5

ENVIRONMENTAL FACTORS FOR FISH

WATER PARAMETERS

Fish can only live and survive in water, water is scientifically referred to as **Aqua** so the water environment is generally known as aquatic environment or aquatic habitat hence all plants and animals including fish that makes water their habitat are classified as aquatic organisms.

The aquatic habitat is categorized into three major groups which may include fresh water, marine water and brackish water. This grouping is based on the amount of salt dissolved in water which occurs at different locations on the earth surface. Fresh waters are mostly rivers, streams and lakes which have salt content of about 10% or 10ppm. Marine waters are the seas and the oceans which have dissolved salt content of 35% or 35ppm and above. The brackish water habitat is the inter-phase between marine and fresh waters especially at the points where fresh waters empty into the ocean or in lagoons and lakes which sometimes receive marine waters during tides (low or high).The major characteristic of this habitat is the high level of fluctuation in the salt content which may alternate between 10% and 40%. Different species of fish and organisms prefer or adapt to one of the above habitats, they sometimes migrate for specific live activities but still return to the most preferred habitat.

The three different habitats are influenced by chemical, biological and physical factors that determine the occurrence /existence of individual species of organisms in each of them, these factors are commonly known as water parameters. For one to understand fisheries for any purpose, one needs the basic knowledge of the parameters. The mutual interactions among living organisms and the none living organisms in a particular water body is referred to as an ecosystem.

The parameters of water in both natural and artificial environments are major determining factors for fish survival, growth, reproduction and distribution. They are categorized into physical, chemical and biological parameters and they all interrelate to function in an ecosystem. Small water bodies like fish ponds (earthen and concrete), tanks and other containers are all affected by the parameters, individual species of fish and other organisms have their various scales of comfort and lethargy.

PHYSICAL PARAMETERS

The physical parameters include Temperature, Turbidity and colour, Density, Hydrology, odour.

Temperature: Fish species are adapted to a scale of temperatures including minimum and maximum temperatures outside which they cannot live. There is also a scale of intermediate temperature, which corresponds to the maximum growth of fish within supportable limits, temperature affect dissolution of oxygen(DO) in water i.e. the higher the temperature the lower the DO, in some fresh water bodies for example; DO will be as follows

24.62mg/l at O^0C
11.33mg/l at 10^0C

9.117mg/l at 20^0C
7.63mg/l at 30^0C,

DO is the amount of oxygen dissolved in water, it is treated under chemical parameters below.

Temperature also affect reproduction in fishes, different species of fish have various temperature ranges at which they prefer to eat, reproduce and even remain active e.g. for tilapias the optimum reproduction temperature in the tropics is 21^0-23^0C. Mercury (Hg) thermometers calibrated in degrees celcius (^{0}C) or Fahrenheit (^{0}F) are used for measuring water temperatures.

Turbidity; The term turbidity refers to the decreased ability of water to transit light caused by suspended particulate matter ranging in sizes from colloidal to coarse dispersions. In ponds, turbidity and colour may result from:

(a) Colloidal clay particles entering with run-off
(b) Colloidal organic matter originating from the decay of vegetation or
(c) From abundance of plankton

High turbidity restricts light penetration and limits photosynthesis. Sedimentation of soil particles may smother fish eggs and destroy community of bottom organisms. Turbidities in natural waters seldom exceed 200mg/litre and even muddy waters usually have less than 2,000mg/1 (Irwin, 1945). Turbidity from plankton is not harmful to fish except in extreme conditions. Turbidity sometimes determines the colour of a water body to look muddy, brown, greenish, yellow or dark. Water colouration indicates changes in a water body, greenish or bluish waters are generally good, muddy yellowish or brownish waters are not very good as they tend to be acidic, they sometimes arise from Mooreland or marshy ground. The colour of natural water results from the unabsorbed light rays remaining from the incident sunlight. Greenish colour may be due to the presence of green plants (phytoplankton) and is a source of primary food for fishes as well as provide oxygen in the ecosystem through photosynthesis.

Sechi disc is a simple apparatus used for the measurement of depth visibility, the greater the turbidity of water, the lesser the sechi disc visibility. A secchi disc is a weighted disc usually 20 cm in diameter and painted with alternate black and white quadrants. The average of the depths at which the disk disappears and reappears is the secchi disc visibility. The unit of measurement for turbidity is Nephelometri Turbidity Units (NTU).

Density is expressed physically in kilograms per cubic metre of water, this is the amount or volume of water molecules that lay over others, the amount of overlay is closely associated with depth i.e. the higher the depth the higher the volume of water and subsequently the greater density. Some fishes can not live at high depths as they do not tolerate high densities, some would prefer to remain at the surface or edges of the water body while other fishes prefer shallow water bodies, in some species this may depend on the age and size of the fish. Based on these densities fishes are grouped into pelagic (surface), dermersal (mid column) and benthic (bottom) fishes. In fish culture water volumes are adjusted to suit the species and age of fish under culture.

Hydrology is the movement of water. It is influenced by gravitational force incident upon topography, wind action and percolation, other internal and external turbulence forces like (animals including fish, earth movement and rainfall). Currents and waves are hydrological characteristics. Velocity is the speed at which water move in streams and rivers or the speed of waves and currents in lakes, ponds and the oceans. Based on hydrology water bodies are classified into **Lotic** (running) and **Lentic** (stagnant) waters. Water movement determines fish species distribution, some species would prefer fast or moderate running waters while others will prefer stagnant waters. Research has proved that most fishes suitable for aquaculture or pond culture prefer stagnant waters but other species may be cultured by modifying the culture systems like re-circulatory systems and raceways.

Odour is any kind of smell being perceived from any water body, naturally water is adourless but certain factors like pollution, decomposing organic materials and excess ammonia and body slime from the fish under culture may cause water to smell. Odour may be described as pleasant, unpleasant, choky and offensive and in whatever category odour may create environmental discomfort for humans and the fish itself but the harmful on the fish may be from the cause of the smell. So in fish ponds, odour is a symptom of deteriorating water condition.

CHEMICAL PARAMETERS

Water is a universal chemical substance with the formula H_2O and its composition is always affected by such chemical factors like Dissolved oxygen level, P^H, Hardness, Salinity, alkalinity, conductivity and total ammonia. The most favorable conditions that will enhance the biotic potential (the ability of a population to grow maximally in an ecosystem) of fish in a pond is/are obtained by adjusting the levels of these chemical indices to the optimum.

Dissolved Oxygen (DO)

All animals including fish inhale oxygen (O_2) and exhale cabondioxide (CO_2) in their metabolic process of respiration, for the fish, the oxygen must be dissolved in water and is referred to as Dissolved Oxygen. In running waters, the water molecules are in constant motion thus mixing oxygen from the atmosphere down to the bottom so DO fluctuation is not significant but in stagnant waters like artificial ponds, it is a limiting factor for fish growth especially in densely populated ponds because there has to be a proper means of increasing dissolution in them. There is a lot of literature on the DO requirements of freshwater fish species but generally, tropical fishes have a high tolerance to low oxygen. There are some cases where fishes are known to survive in complete absence of oxygen. It is also important to note that fluctuating dissolved oxygen concentrations affect fish growth. Usually dissolved oxygen values reach its peak in the afternoons, and values close to zero towards dawn. The effect of constant cloudy weather days will cause more serious low oxygen problem. Super saturation also causes problem of gas embolism. Tsadic (1984), observed that the effect of fluctuating dissolved oxygen on *Oreochromis nilocticus* was a reduction of growth rate almost close to that caused by low dissolved oxygen itself.

pH of water

The water used in fish cultivation is not chemically pure but contains in solution, different substances which give it an acid, neutral or alkaline reaction. pH at which a water is just saturated with calcium carbonate($cacO_3$) is known as the pH of saturation, a negative index indicates a tendency to dissolve $cacO_3$ and a positive index indicates tendency to deposit $cacO_3$. Since it is not only possible to determine the nature of these reactions and also to measure intensity by determining the pH it is done by measuring the exact quantity of H^+ ions and ^-H anions. Hydrogen molecule content of + and – ions determine shifts in water pH so pH may simply be defined as the power of hydrogen.

P^H values range between 0 and 14 scales with its neutral point at 7, so if the pH is equal to 7.0 the water is said to be neutral. If it is higher than 7.0 the reaction is alkaline; it is acidic if the pH is lower than 7.0. The stability or variability of p^H value affects different organisms including fish. Since all organisms including fish have tolerance limits, some fishes do not easily withstand sudden or strong variations in pH. Biological conditions are better when the p^H is quite constant rather than in water undergoing considerable variation. Variations in water pH values are caused by dissolution of natural salts from the substratum, pollution and decaying organic matter. The optimum pH values for fish growth in culture systems is between 6.0 – 9.0.

Alkalinity refers to the capability of water to neutralize acid. This is really an expression of buffering capacity. A buffer is a solution to which an acid can be added without changing the concentration of available H^+ ions (without changing the pH) appreciably.

Hard Water

It is water that has high mineral content, hard water is formed when water percolates through deposits of limestone and chalk which are largely made up of calcium and magnesium carbonates. Water's hardness is determined by the concentration of multivalent cations that are positively charged metal complexes with a charge greater than 1^+ usually, the cations have the charge of 2^+. Common cations found in hard water include Ca^{2+} and mg^{2+}. These ions enter a water supply by leaching from minerals within an aquifer. Common calcium containing minerals are calcite and gypsum. A common magnesium mineral is dolomite (which also contains calcium). **Total hardness** is the mineral content in a water sample that is irreversible.

Water hardness has a major effect on pH and pH stability. It will affect the toxicity of many common substances including some fish disease treatments, it also has major effect on fish osmoregulation.

Salinity

Is the saltiness or amount of salt dissolved in a body of water, marine waters contain higher salts than fresh waters and different fish species are adopted these deferent environments, saltwater fishes require a delicately balanced environment to thrive, this is why fresh water fishes must be cultured in fresh water A hyposalinic environment can cause a variety of health related issues (both negative and positive). Salinity is usually measured in milligrams/litre.

Conductivity is a measure of water's capability to pass electrical current flow. This ability is directly related to the concentration of ions in the water. These conductive ions come from dissolved salts and inorganic materials

such as alkalis, chlorides, sulfides and carbonate compounds. High conductivity of water facilitates the effects of other factors on the fish wellbeing.

Ammonia

Ammonia or azane is a compound with the formula nh3 the simplest pnictogen hydride, ammonia is an odourless gas with a characteristic pungent smell. Fish digest the protein in their feed and excrete ammonia through their gills and in their feaces. Ammonia also enters the pond from bacterial decomposition of organic matter such as uneaten feed or dead algae and aquatic plants. Excess concentration of ammonia in stagnant water bodies reduce fish growth and cause death.

BIOLOGICAL FACTORS

Biological factors in water bodies are living organisms in the aquatic environment including various fish species, plankton, aquatic insects, reptiles, benthic worms and aquatic weeds that occupy different strata and trophic levels in the aquatic environment. Since they occur at different trophic levels and interact with each other either positively or negatively Bigger fishes eat smaller ones, other organisms including man also eat the fish a well as some other organisms serve as food for the fish so a judicious control of these various components is important in maintaining the integrity of the aquatic environment. Biological factors therefore, determines an ecosystem and its various components.

CHAPTER 6
HYDROGRAPHY AND ZOOGOEGRAPHY

Hydrography is a science that deals with water and the physical factors for its movement and stability, it can be subdivided into oceanography (which deals with the study of the oceans) and limnology (which deals with the study of freshwaters). The distribution and abundance of fish in both marine and freshwaters are influenced, not only by hydrographic conditions but also by geography and climate of the land mass. A third division of water as an aquatic environment is discussed when environmental conditions for fish occurrence are considered between the marine and fresh waters (brackish water). Brackish water occur mostly at river mouths where such a river empties into the ocean or at the inter-phase of marine and fresh waters (lakes, bogs), the major distinguishing factor for brackish water and others is the high fluctuation in salinity(salt content)

Fisheries and Oceanography

Covering a little over 362 million square kilometers (or 71 per cent) of the 510 million square kilometers of the earth's surface is a sheet of saltwater, which constitutes the marine environment. It is divided into several portions by the land mass; the more extensive portions are called oceans and there are five of these, namely; the Arctic, Indian, Atlantic, North and South Pacific oceans. Enclosed by land, are called sea (e.g., the Mediterranean Sea, the Caspian Sea, the Red Sea). However, in popular language the word 'sea' is applied to all the great masses of saltwater on the earth's surface.

The sea has great potentials as a source of renewable and-renewable natural resources for mankind. From time immemorial, the sea has been used by man for transportation, and for food production. Nowadays the sea is also yielding valuable minerals, particularly oil (petroleum), and there are possibilities of harnessing the different water movements as direct energy sources. But the use of sea for fish production and for transportation far transcends its uses for other economic activities. The sea as a source of fish is our concern. It yields approximately 82 per cent of the total world yearly fish output, the remaining 18 per cent comes from the inland waters including production from aquaculture. Marine fisheries is very important, it is therefore necessary to outline the main oceanographic features that influence the productivity of the oceans.

The continental Shelf

The continental shelf is the shallow water zone, which adjoins the land and surrounds all the continents. The average maximum depth of the continental shelf is about 200m, the width of the shelf varies from one sea area to another, width of the continental shelf is formed mainly through the deposition of eroded materials brought in by rivers and surface run-offs, subsidence of coastal land mass and the tectonic movements of the ocean floor.

The seashore (or littoral zone), is the junction of land and water and is affected by tidal rise and fall, it is considered as the outer part of the continental shelf since the shelf itself is generally regarded as an extension of the land mass below water. The continental shelf is of great economic importance with regard to marine fish production. Although forming about 8 per cent of the total ocean area (and 18 per cent of the earth's total surface area), over 80% of the word's sea fisheries production comes from it. One of the important factors

which contribute to this is the shallowness of the shelf which allows light to penetrate a good part of the water. Light is necessary for the photosynthetic activity of phytoplankton which is the basis of all organic production in the sea. Furthermore, these shallow areas are rich in nutrients brought in by rivers and surface run-offs. The tidal flow at the seashore above the continental shelf causes turbulence, which is useful in keeping the water of the shelf to some extent mixed and well oxygenated and brings nutrients which have sunk into deeper layers up to the euphotic zone to become available for organic production.

The nature of the bottom of the shelf (topography and bottom deposits) affects fisheries in two main ways. The nature of the bottom may determine the type of gear suitable for use in the fishery. For example in the shallow waters of the Central American coast and along the chain of islands in the Caribbean Sea, the bottom of the shelf contains a high proportion of rough grounds which make the area unsuitable for extensive trawling; but potentially the area can be suitably fished with hand-line. Similarly, lack of success in the trawl fishery along the East African coast (off Kenya, Tanzania Mozambique) has been attributed to the extensive coral outcroppings in this area as well as to the narrowness of the shelf itself. The nature of the bottom deposit may similarly influence the distribution and abundance of some species of fish.

Often the distribution of fish in the continental shelf is the result of not one, but several factors acting together. A typical example is the distribution of demersal fishes in the Gulf of Guinea (Tropical West Africa) which has been worked out by several fisheries scientists. It has been shown that demersal fishes in the Gulf of Guinea appear in two distinct assemblages or fauna. One assemblage consists of silvery fishes typified by the croakers, grunters, threadfins and groupers. This is labeled “the Croaker fauna”. The other assemblage consists of red fishes typified by the red snappers, sea breams or sparids (Sparidae) and Letherenidae. The second group “the snapper fauna”. The two faunas do not mingle. The croaker fauna appears in shallow water only above the thermocline only on soft mud and muddy deposits. The snapper fauna is distributed both above and below the thermocline: above thermocline it is found only on relatively clean sand and hard deposits (corals, gravel, stones, shells, etc.). Below the thermocline, because it is no longer in competition with the croaker fauna, the snapper spreads out on all types of bottom. Clearly, the distribution of demersal stocks of fish in the Gulf of Guinea is influenced not only by the type of bottom deposit of the shelf but also by temperature gradient as well as the interaction or competition for space and food by the two groups or faunas.

The presence of a permanent thermocline between the tropical surface water and the underlying South Atlantic central water is a characteristic feature of the tropical West African continental shelf, in this phenomenon heat absorption at the sea surface produces a warm light surface layer of water overlying the cold dense deeper layer. Between the two layers of water is a mixed zone or discontinuity zone where the temperature gradient is very steep (up to 1^0C/m average 0.5^0 C/m in West Africa). In the Gulf of Guinea, above the thermocline the water temperature is greater than 25^0C and surface mixing maintains a warm, fairly even temperature. Below the thermocline the temperature is less than 19^0 C, while the upper limit of the thermocline is 20-35m over most of the region. The thickness of the mixed zone varies between 30-40m as in most tropical regions, the thermocline in West Africa gradually inclines down-wards offshore.

The Continental Slope

At the seaward end of the continental shelf, the slope steepens greatly and descends to about 3,350m. Some demersal fishing have been carried out on the continental slope down to a depth of about 500m, but by and large commercial fishing for demersal stocks are undertaken mainly in the shallow waters of the shelf.

The Deep Sea Plain (Abyssal)

The deep sea plain forms about two thirds of the total ocean floor and has a mean depth of 3,600m, here the ocean basin is rather similar to the land surface: there are submarine ridges, valleys (or deeps), plateaus and plains –with the plains forming the major portion. Demersal fishing are not undertaken in the abyssal plain, however some pelagic stocks (e.g. tuna) may occur near the surface in tropical seas, particularly where there are convergences, boundary currents and other hydrographic disturbances which cause the enrichment of the surface water.

Ocean Currents

Ocean currents are circulating masses of water moving in regular patterns round the oceans. They are caused mainly by the combined effects of the prevailing winds, pressure gradients (resulting from an uneven heating of the water masses in different parts of the sea as well as from differences in salinity), geostrophic (or Coriolis) force due to earth's rotation, and the gravitational attraction of the sun and moon (especially in confined waters where this can give rise to tidal currents). The most important factors that set the currents in motion are wind and pressure gradient; the other factors act mainly in modifying the direction of the current. The circulation of the main ocean currents between the equatorial and temperate regions is clockwise in the Northern Hemisphere and anticlockwise in the Southern Hemisphere, the deflection being caused by the earth's rotation (or Coriolis Force). The term "cold" and "warm" currents denote the temperature of the moving masses of water relative to the atmospheric temperature of the area. In general, currents moving from the equatorial region towards the poles or higher latitudes are warm compared with the general atmospheric temperature while the currents moving towards the equator or lower latitudes are cold.

Main Characteristics of Ocean Currents

The main features of the ocean surface currents which are of major ecological importance in relation to fisheries are outlined as follows:

(a) In the tropical belt and near the equator both the north equatorial currents and the south equatorial currents which convey cold masses of water (because they come from higher latitudes) flow westward. Warm equatorial counter currents flow eastward at the equator and separate the masses of cold water.

(b) Between the warm counter current and cold equatorial current are zones of convergences (approximately 5^0N and 5^0S) where the two different masses of water "converge, the warmer, lighter water flows over the more dense and cooler water and the homogeneous surface layer becomes thicker. Areas of convergences are usually rich in planktonic food organisms and small fish which are carried into them rather passively or mechanically by the currents. Because of this, large pelagic

fishes such as the yellowfin tuna are also found here and such areas form potentially rich fishing grounds. A convergence zone may also be an area of big plankton production besides the plankton aggregating there through the action of the currents.

(c) In mid-latitudes (approximately between 20^0-40^0N and 20^0-40^0S) the currents produce rather huge anticyclonic circulatory systems (or gyres) which are clockwise in the 3Northern Hemisphere and anticlockwise in the Southern Hemisphere.

(d) The currents along the western boundaries of the gyres, (the eastern coasts of continents) in Gulf Stream, in the Western Central Atlantic and the Kuroshio Current off Japan in the North Western Pacific.

(e) The southward northward flows of the current along the eastern boundaries of the gyres, (along the western coasts of continents) are generally broad, slow moving and shallow (the Canary Current and Benguela Current in the north eastern central and south eastern Atlantic respectively and the California current and Peruvian (or Humboldt) current in the north eastern central and south eastern Pacific respectively).

(f) Eastern boundary currents flow towards the equator from high latitudes, the waters are therefore at lower temperatures than those of comparable latitudes in the central regions of the ocean.

Effects of Ocean Currents on Fish and Fisheries

Ocean currents affect fish and fisheries either directly or indirectly. Thus, fishes may respond directly to the water movement; or they may react indirectly to the current system through the changes in the physical, chemical and biological conditions of the water.

Direct Effects of Currents

(i) Some adult fishes use the direction of the current to orientate themselves to swim in the right direction (usually against the direction of the current) to reach the spawning grounds. Alteration in the direction of the current flow may result in the fish spawning in an unusual area, and this may affect the survival of the young for that year.

(ii) After spawning the eggs planktonic larvae and fry drift with the current to the nursery grounds and from there to the feeding grounds. Departure from the normal pattern of current system may affect this movement and the survival of the given yearn year class.

(iii) Variation in current distribution may cause large scale mortality not only of fish but of other organisms in the water. For example in December-February, warm tropical water (an extension of the equatorial counter current) extends southward along the coast of Peru. In an abnormal summer in the Southern Hemisphere this warm water may go much farther south than 5^0 S, and result in surface water temperature rising about 7^0 C higher than normal. When this happens the upwelling off Peru ceases and the strip of cool coastal water vanishes. This phenomenon is called El Nino and is characterized by unusually high surface temperature, northerly winds and heavy rainfall.

Indirect Effect of Currents

Ocean currents have an important effect on the productivity of the sea and hence on the fisheries. They do this by keeping the water mixed, thus influencing the distribution of heat and salinity and in areas of upwelling by bringing nutrients and oxygen from subsurface layers to the euphotic zone. Under normal circumstance there is a large amount of upwelling associated with the edge of this current. This provides enough nutrients for a large crop of phytoplankton which supports the largest anchovy population in the world. At convergences, planktonic organisms and small fish may accumulate. This attracts large predators to such areas.

Upwelling

In certain rather restricted areas of the world, particularly along the western coasts of continents at mid (or subtropical) latitudes, prevailing winds blowing parallel or almost parallel to the coastline cause the movement of surface water from the coast offshore. To compensate for the water so driven away, water from subsurface layers rise up to replenish the so driven away, water from subsurface layers rise up to replenish the surface flow. The slow circulation set up by process is known as upwelling. The effect of upwelling is to bring the rich nutrients in deep layers of ocean water to the surface, thus causing the enrichment of the euphotic zone (zone of high productivity)

The Fresh Water Habitat

Fresh water habitats are described in limnology as Rivers, Streams, Lakes, ponds and bogs, the habitats are classified in to two; (a) Lotic for running waters and (b) Lentic for stagnant waters.

The environmental characteristics of the above habitats determine species distributions that can be found at a variety of spatial and temporal scales. At regional scales, the seasonal variations in water temperature can explain annual variations in the distribution of fishes. Within regions, temporally stable associations of species have been found and tend to follow isotherms and isobaths. Species groups are sometimes seasonal and may split or show changes in composition that correlate with temperature patterns. Nested within regional scale patterns are small-scale variations in abundance and distribution of demersal fishes which can be partially attributed to variation in topographic structure. In contrast, habitat associations for lotic and lentic water species, as well as sandy bottom, muddy bottoms preferred habitats for fishes are relatively clear. Habitat has been defined as "the structural component of the environment that attracts organisms and serves as a center of biological activity. Habitat in this case includes the range of sediment types (i.e., mud through boulders), bed forms (e.g., sand waves and ripples, flat mud) as well as the co-occurring biological structures (e.g., shell, burrows, sponges, seagrass, macroalgae, coral).

The behavior of fishes is characterized by three special features that are used in controlling their environment, they have three main orientations that make up for the special features, these include:

i. Direction finding i.e. (reception of signals from the outer world).
ii. Location (emitting signals and receiving their reflections).
iii. Signaling (emission of signals by some individuals and their reception by others).

In fish of different ecological groups different sets of receptors may function, and different sense organs may be the most important.

The principal sense organ of the pelagic fish is sight. In predatory fish that hunt their prey at dusk and at night, the most developed organs are the lateral line and olfactory organs. Orientation by sight and hearing is most wide spread; orientation by smell is of effect only at smaller distances, and only at contact with the object is it noticeable. Fishes use the above senses to escape their enemies look for and locate their food, adjust themselves to environmental factors, migrate to suitable grounds for feeding and spawning. Fishes, just like other higher vertebrates live together and move in groups. These groups are referred to as shoals, school or aggregation. **Shoaling** is the grouping of fish at littoral zones of lakes and shores of the sea, mainly for the purpose of feeding and spawning. A **school** of fish is a group of individual fishes that move in the same direction, at the same speed and at the same distance from each other, it may be migration in search of food or escape from enemies.

Fish aggregation is the collection of different species of fish from different families in a specific location. Their collection may be influenced by environment conditions like draught, pollution, food availability, shelter, and temperature changes. Other artificial methods for purposes of fishing may cause aggregation of fishes, e.g. electric fishing.

Fish migration is generally defined as the movement of organisms, form one place to another. In fishes this movement has to do with growth, age differences, feeding, spawning and over wintering, this may be horizontally or vertically. Migration could be on long distances or short distances and may involve movement from one ecological habitat to another i.e. fresh water, brackish and marine habitats.

Vertical migration is the movement from the surface to the bottom or vise versa of the same water body and in the same location. Factors controlling such migration pattern may be quest for food, aeration and photophoby, escape from enemies and environmental changes. Horizontal migration is the movement on long distances from one ecological location to another or one ecological habitat to another. Factors responsible for this kind of migration may include; search for food from places of none availability to areas of abundance, this may be on short or long distances. Over wintering i.e. escape form draught areas to flooded areas. Spawning, fishes may leave their main habitats to lay eggs I suitable sites that guarantee survival of their eggs and young. Currents, waves and tidal actions could induce migration of fishes. Thus the major types of horizontal migration are; feeding, spawning and over wintering migrations which in most cases are controlled by the hydrologic cycle.
Fishes are also classified on the basis of migration as;

a. Anadromous fish; these are fishes that move from marine waters to fresh waters.
b. Catadromous fishes; those fishes that move from fresh water to marine waters.
c. Amphidromous; these are diadromous fishes that alternate from marine to fresh waters or from fresh waters to the marine waters at various stages of their life circle, such movement is not influenced by feeding or spawning.
d. Petamodromous fish; these are fishes that move from one fresh water environment to another.
e. Oceanodromous; those moving from one geographical location to another within the marine habitat.

CHAPTER 7

VALUE OF FISH IN HUMAN NUTRITION AND OTHER USES

Fish is among the healthiest foods on the earth planet. It contains important nutrients, such as protein and vitamin D. Fish is also the world's best source of omega-3 fatty acids, which are incredibly important for human body and the brain. Fish is high in many nutrients that most people are not getting enough like; high-quality protein, iodine and various vitamins and minerals, some fish are better than others, and the **fatty** types of fish are considered the healthiest, this is because fatty fish (cat fish, sardines, tuna mackerel etc) are higher in fat-based nutrients. Fat-soluble vitamin D is a nutrient that most people are deficient in and it functions like a steroid hormone in the body. Fatty fishes are also much higher in omega-3 fatty acids. These fatty acids are crucial for the body and brain to function optimally, and are strongly linked to reduced risk of many diseases. To meet one's omega-3 requirements, eating fatty fish at least 12 kg in a year is recommended for adults but higher quantities are recommended for children and pregnant women. Other advantages of eating fish include;

1. Fish may lower the risk of heart attacks and strokes, heart attacks and strokes are the two most common causes of premature death in the world today**.**

2. Fish Contains Omega-3 fatty acids which is absolutely essential for growth and development. Omega-3 fatty acid Docosahexaenoic acid (DHA) is especially important, because it accumulates in the developing brain and eye, it is often recommended that expecting and nursing mothers eat high quantities of omega-3 fatty acids. Fish from contaminated and polluted waters are not safe for human consumption. Pregnant women should also avoid raw and uncooked fish because it may contain microorganisms that can harm the fetus.

3. Fish may increase grey matter in the brain and protect it from age-related deterioration. One of the consequences of ageing is that brain function often deteriorates (referred to as age-related cognitive decline), many observational studies have shown that people who eat more fish have slower rates of cognitive decline.

4. Fish may help prevent and treat depression, making you a happier person; Depression is a serious and incredibly common mental disorder which is characterized by low mood, sadness, decreased energy and loss of interest in life and activities. Depression is currently one of the world's biggest health challenges.

5. Fish is the best dietary source of vitamin D, **i**f one does not get much sun and doesn't eat fatty fish regularly then, such a person should consider taking a vitamin D supplement.

6. Fish consumption is linked to reduced risk of autoimmune diseases, including type 1- diabetes. Autoimmune disease occurs when the immune system mistakenly attacks and destroys healthy body tissues.

7. Fish may help prevent asthma in children. Asthma is a common disease that is characterized by chronic inflammation in the respiratory airways. Studies have shown that regular fish consumption is linked to a 24% lower risk of asthma in children, and that children who eat more fish have a lower risk of developing asthma.

8. Fish may protect your vision in old age: A disease called macular degeneration is a leading cause of vision impairment and blindness, and mostly affects older individuals. There is some evidence that fish and omega-3 fatty acids may provide protection against this disease. People who eat more fish have a much lower risk of developing macular degeneration, a leading cause of vision impairment and blindness.

10. Fish may improve sleep quality: Sleep disorders have become incredibly common worldwide. There is preliminary evidence that eating fatty fish like salmon may lead to improved sleep.

Fish is considered mainly as a source of protein, appreciable amounts of fat can be found in some species. Fish also contain large quantities of all important dietary minerals, but if only the flesh is eaten, most of the minerals are lost because nearly all of them are located in the skeleton. However, the mineral content is not wasted if small fish are eaten whole. The softened bones of canned fish are usually eaten with the flesh as well.

ENERGY

Although fish and fish products are considered mainly as sources of protein, a basic understanding of energy requirements is also useful. In humans, energy (i.e. the ability to do work) is necessary to maintain life, initiate voluntary activity, and promote processes such as growth. The amount of energy the body needs to maintain itself in a functional resting state. e. g. when lying down, it is called energy which must be provided to maintain life.

The unit used to measure energy is the kilocalorie (kcal)or kilojoule (k); I kilocalorie is the amount of heat needed to heat 1liter of water by 1◦C, and 1 joule is the energy expended when 1kg is moved through 1m by a force of 1N.A KJ=10^3J and 1kcal = 4.184 KJ (usually taken as 4.2kj). The BMR is approximately 1 kcal/kg body weight /h. therefore, a man weigh 70kg needs 70×24 = 1680 kcal/day in order to survive without

undertaking any activity. The BMR varies with age, sex and body weight, and if any activity is to be undertaken, such as walking, sitting or writing, more energy is required. The amount of energy needed will depend on the type of activity; physical labour requires more energy than sedentary activities. Extra energy is also required for special purposes such as growth, and during pregnancy. The amount of energy which a person uses can be determined either by measuring oxygen uptake and carbon dioxide production, or by measuring the energy content of the food eaten.

Energy is supplied mostly by dietary fat and carbohydrate, although protein may be used when the total energy intake is low. The energy provided by 1g of fat is 9 kcal (37 kJ) ; 1 g of carbohydrate provides 3.75kcal (16kJ), 1g of protein is 4 kcal (17 kJ) and1g of alcohol is 7 kcal (21kJ). Small amounts of energy may also be derived from organic acids as acetic acid in vinegar and citric in fruit.

PROTEIN

All proteins are made up of carbon, hydrogen oxygen and nitrogen; many also contain sulphur, and some contain phosphorus. Proteins are essential constituents of all living organisms in which they provide structure and as the basic components of enzymes, regulate the processes of living. They must be provided in the diet for body growth and repair; any excess can be used for energy. Proteins consist of chains of hundreds or thousands of amino acids. Although only about twenty amino acids exist, they can be arranged in an almost infinite number of combinations. It is the specific and unique sequence of these units which gives each protein its characteristic structural and enzymatic properties.

The amino acids can be classified as essential or non- essential. Essential amino acids cannot be manufactured in the body. In adults, these are isoleucine, leucine. Methionine, phenylanlanine, thereonine, tryptophan and valine; children also require hsitidine.the remaining amino acids commonly in proteins are alamine. Arginine. Asparticacid, eysteine, gutamie acid glycine, proline, serine and tyrosine. It should be remembered that these are the sophisticated, more exotic amino acids have been found but these appear to have a limited distribution.

The quality of a protein depends on its ability to supply all the essential amino acids in the amounts required

Fats

Fats are found in the muscles of fish and are soluble in water. It is a good source of energy roughly twice as good as carbohydrates. It also occurs as structural fats being of supreme importance in the structure of all animal tissues. Foods rich in fats are also rich in fat solauble vitamins A,D,E &K vitamins D&E are never found in foods of plant origin. Fish flesh and liver are however rich sources of vitamins D&E.

Vit A - is necessary for good sight, lack of it impairs eye sight.

Vit D - is essential for health production of bones. Deficiency leads to rickets

Vit K - is necessary for the clotting of blood.

Minerals

Fish is a fair good source of calcium and phosphorus, w----------+hich are essential for bone formation. Iron blood and a whole range of others for general good health.

Others are involved in the proper functioning of enzymes are mostly present in fish. Canned fish with bones are a rich source of these minerals. Iodine is often lacking in vegetables and fish tends to accumulate these minerals present in water. Small quantities of carbohydrates are present in fish but of no nutritional value. Lack of lodine causes GOITRE

Other uses of fish

1. Parts of the fish are used for various purposes, thus:
   (a) The skin of some cartilaginous fishes (Chondrichtyes) makes useful leather and polishing materials.
   (b) The scales of some fishes yield a substance that when coated on the inside of glass beads makes artificial pearls.
   (c) The lining of the airbladder of sturgeons is used to make isinglass, a shiny powder used as an absorbent in the wine industry.
   (d) Fish oils, besides being used as food, are used in the manufacture of soap.

2. Whole fish, especially those of small size like the Tilapias, barbus clupeids and other species not readily acceptable for direct consumption, are converted into fish meal for the manufacture of animal feeds.

Fish is therefore, a good food, the consumption of which deserves to be encouraged to promote the level of nutrition in the whole world. It is however, a highly perishable material which undergoes decomposition quite easily and unless technological methods are employed for making fish and fish products available to the people without deterioration, and without considerable loss of its nutritive values, its consumption cannot be increased to the extent, which may be desired.

CHAPTER 8

FISH FARMING AND REQUIREMENTS FOR FARM ESTABLISHMENT

Fish Farming

Fish farming or pisciculture involves raising fish commercially in enclosures, such enclosures include fish pond (earthen or concrete), Cages, raceways, tanks (steel, plastic, tarpaulin aquarium) and happa. The act if fish farming is commonly referred to as aquaculture. Many literatures have defined aquaculture in various ways like;

a. Aquaculture is literarily defined, as the cultivation of plant and animal organisms in aquatic environments.
b. From the biological view point, aquaculture can be regarded as man's attempt through the inputs of labour and energy to improve the yields
c. The Japanese Resource Council for science and Technology has defined aquaculture as "An industrial process of raising aquatic organisms up to final commercial factors and administering the life history of the organism positively.

Aquaculture may simply be regarded as the organized production of a crop in the aquatic medium. The crop may be that of an animal or plant, the organism cultured has to be ordained by nature as aquatic. Some of the aquatic organisms that are cultured for now include; Crabs, Crocodiles, Fish, Frogs, Snails and hosts of aquatic plants. Fish culture is an aspect of aquaculture concerned mainly with the rearing of fish and shell fish in controllable water environments.

Man, while he domesticated many plants and animals, left the fish out, the neglect was perhaps, mainly owing to the unfamiliarity of man with the watery environment, since what is under water is not easily seen as well. Man could commune with his terrestrial cohabitants and make them his pets and beasts of burden. He could watch his land livestock and easily recognize a sick cow or chicken but when an attempt was made to learn how the fish performed, he could not comprehend easily, from the foregoing, it is clear that man has been more conversant with the terrestrial environment. The major task for one to become an aqua-culturist therefore, is to narrow this gap in knowledge to know his animal before he can really succeed in rearing it to his own advantage. He has to know the biological characteristics and potentials of the aquatic organism he wants to grow and also the nature of its environment i.e. the physics, chemistry and biology of its host medium (water).

Look at the fish in the wild and try to capture them it is difficult, but much easier to rear them to adult size and make them reproduce under controlled conditions. Fish pond, race way, cage or pen are only an artificial extension of the aquatic environment concept but the problems become more complex and poses some questions like:

(i) How does the fish respond behaviour wise in captivity?
(ii) How many of what size and species could be put together to live happily and be induced to produce protein economically?

(iii) What are the optimal requirements for nutrition and growth which could change with the age and kind of fish?

It is therefore obvious that the skills needed in aquaculture are multidisciplinary:

- Biology of the fish is the beginning.
- Biochemistry and water chemistry must thoroughly be known.
- The economic ways of constructing ponds and enclosures should be known.
- The need for fertilizers and feeds applications should be precisely known.
- Propagation of fish in captivity is an elementary necessity in aquaculture because it is difficult to always obtain sufficient seeds (fish fry and fingerlings) from the wild to meet culture demands.
- The whole process of breeding and nursing fish according to nutritional requirements should be known.
- The lessons from the well-trodden paths of the production of improved strains and hybrids should also be known.

For effective aquaculture practice therefore, one has to;

(a) Gain familiarity and control water quality to enhance its biological productivity

(b) Understand fish nutrition so as to be able to formulate nutritionally balanced diets

(c) Develop deep into fish genetics so as to be able to evolve new varieties and strains, which bestow commercial advantage to the product in terms of superior growth rate, nutritive value, boneless ness, taste, colour etc.

(d) Prevent incidence of fish infections and diseases through prophylactic and therapeutics methods.

Aquaculture is the aquatic counterpart of agriculture because the principles and many of the problems are the same, though there are unique characteristics associated with the aquatic medium, and the entirely different set of organisms involved. Fish culture has the same objective as agriculture and stock breeding, namely; to increase by all possible means the production of food far above the level which could be produced naturally. Like agriculture therefore, fish culture includes the elimination of unwanted plants and animals, their replacement by desirable species, the improvement of these species by crossbreeding and selection, and improvement of the substratum by the use of fertilizers.

Though the idea of fish farming is relatively new to many people, it is really a form of land and water usage and the land so used must find its proper competition with agriculture, stock raising and irrigation.

Objectives of aquaculture

Having defined aquaculture, it is proper to state its objectives which include the following:-

- The production of protein rich, nutritive, palatable and easily digestible human food benefiting the whole society through plentiful supply of food at reasonable cost.
- Providing new species and strengthening stocks of existing fish in natural and man-made water bodies through artificial means and propagation;
- Production of sport fish and support to recreational fishing;

- Production of baitfish for commercial and sport fishery;

REQUIREMENTS FOR FARM ESTABLISHMENT

A fish pond is a drainable body of water constructed for the purpose of raising fish with inlet and outlet for easy entry and out flow of water. A fish farm refers to a number of ponds intergraded economically into a production unit. Such a farm would have a hatchery, nursery, production/ holding ponds and would be properly secured. Fish farms are mostly located where the conditions permit this may be the source of water, availability of landed space and other social factors. The level and structure of management depends on the number of facilities and their capacity for production of fish and other fisheries products. The recent and relatively new practice of integrated farming systems is becoming very popular due to increase in human population against limited land space, various land tenure systems and cost of land as well as the increased awareness of waste recirculation for efficient resources management gives enough reasons for careful selection of sites for farming.

Site Selection for Fish Farms

Usually a site is selected during the time a general and reconnaissance survey has been carried out after which a detailed survey is carried out, this is often referred to as feasibility assessment or study. The study considers and seeks to assess;

Physical environmental factors

Water Supply- Sites should be selected for fish farms only where water of the required volume and quality is available at the times needed for operating the farm. Preference should be given to sites where a gravity water supply to the farm is possible. The quality of the water available must be such that the desired fish can be raised, e.g. fresh, brackish or salt water.

Topography- Drainage of water from the ponds by gravity should be possible at the end of construction. For low construction costs, plain areas with slope less than one percent should not be selected (0.3 gradient) but gradients of 1.0 is ideal. The fish farm should be sited primarily in land areas unsuitable for other agricultural uses and the soil in the area selected should, if possible, be impervious. The ground elevation of the soil affects water supply quantity, its dynamics, physical and chemical parameters. Vegetation of a site apart from affecting (positively or negatively) the cost of initial construction may influence the biological parameters of the pond water especially if it is earthen ponds.

Weather Condition The geography of the area under consideration should be an important consideration as some areas are characterized by higher seasonal rainfall, such areas may be prone to flooding and heavy soil erosions. Desert and highland zones loose water by percolation, leeching, seepage and evaporation these may increase operational cost of the farm.

In each of the above factors considered reference should be made to the fish species intended for culture with specific structural set-up, as it will be the objective of the culturist to manipulate the species and the environment to obtain an optimum (if not maximum) yield, considering the economics of production.

Socio-Economic Considerations

Social Amenities

The site should be in the vicinity of transportation routes, or where the access road can be constructed economically. In the proximity of inhabited areas, considerations of public health and the necessity of guarding against poachers should be kept in mind. Fish farms need electrical power, so the possibility and cost of connection should be considered. Existing electric power lines should guard the positions of farm structures and facilities and if possible, must be excluded from the area envisaged for the fish farm. Consideration of other socio-economic aspects such as infrastructure facilities for post-harvest treatment of product including marketing, manpower (labour quality and quantity), even if the fish produced is for local consumption (same province/country) or export outside the country. Similarly relative merits or demerits of the specific site, with reference to availability and cost of materials and equipment for farm construction and subsequent needs for renewals in the farm structures and also for the maintenance of the farm, e.g. supplies of feed stuffs and fertilizers, should also be considered. Skilled operators are essential for operating major fish farms efficiently. An important consideration in site selection is, therefore, to provide an attractive environment and facilities for both professionals and other operators.

Social Factors

The aspects of social life such as religious customs, consumer preference, cultural values, norms and taboos, society civilization and cultural dynamics may frustrate or promote the project. Considering the social factors it is obvious that the objectives of producing fish in a culture system should be clearly spelt out while the acceptance or preference of the local community would be of prime interest in producing fish for local consumption, the acceptability of the target group to whom the fish are supplied, in some cases, even by export, is of major interest.

Political and Legal Considerations

Government acts, laws and guidelines for aquaculture project established should be consulted properly to fit into the national plan for development of industry and agriculture This is specially, needed when aquaculture is a part of rural development programme, as indeed most such projects are. It should specially help in sharing infrastructural facilities of public water supply, transportation (road), power supply and communications and also in judicious sharing of inputs and recycling outputs. Partisan politics is another good factor for

consideration as a very suitable site for a fish farm may be rejected by the entrepreneur, the key players in execution and or the host community based on political differences.

Legal aspects, such as security of landed property tenure, legal size limits with reference to the ponds/culture area, as well as the species under culture, and closed seasons, should also to be considered. Several countries already have certain regulations concerning these legal aspects, some of which are in force, much before aquaculture was thought of as an industry. In many cases these legal clauses cannot be easily modified, even though some attempts in this direction would be necessary, especially with reference to size-limits of fish and closed seasons. Some legal regulations have been included to protect the species survival under intensive capture systems of wild stock. While this protection may be necessary for such cases here in aquaculture, capture from the wild fish of certain size, when the season for capture is closed legally, the fish can only be transferred to the culture ponds - either as brood fish or as fry or fingerlings in grow-out ponds.

Maritime laws controlling coastal waters (in cases where sites are coastal) should be referred to, in some cases maritime areas through which navigational routes and certain other country priorities exist, cages and pens may not be allowed.

Environmental Impact Assessment

Environmental Impact Assessment (EIA) is a process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse.

Environmental Impact Assessment (EIA) as a tool should be used to identify the environmental, social and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers. By using EIA both environmental and economic benefits can be achieved, such as reduced cost and time of project implementation and design, avoided treatment/clean-up costs and impacts of laws and regulations.

Based on the above considerations for fish farm establishment, EIA would help in project establishment and profitable operations.

FISH CULTURE SYSTEMS

The objectives of aquaculture could be to produce whole-some nutritious food for local consumption through small scale rural farms or large vertically-integrated commercial systems. Alternatively the objective could be for the production of high-cost fish or shrimps for exports and earning foreign exchange for the countries concerned. As it would be obvious, no venture can sustain unless it is profitable. Sites suitable for aquaculture could be listed as; land-swamps, rivers, stream beds, coastal areas (bays, estuaries backwaters, lagoons, salt

marshes and mangrove swamps), lakes, reservoirs and other water bodies, including irrigation tanks and canals. Dry lands could be used to be provided with boreholes or public water supply sources.

The specific site to be chosen would be based on the requirement of the culture systems, static water ponds are the most common types, hence pond culture is the most important system for discussion in this text. Most of these are confined to freshwater areas, but brackishwater ponds are also becoming common. There is a variety of culture systems which can be developed in open waters - the stocking and management of open waters themselves being major occupation, e.g. extensive stocking of man-made reservoirs and lakes. In the larger freshwater bodies and coastal areas cage and pen culture can be developed. Site selection for these culture systems has to be carefully done, bearing in mind the species to be cultured and the structures to be erected for the culture. In the culture systems where closed systems are used, the inputs required can be costly and management very intensive. Thus there can be gradation of culture, systems based on the input costs and management strategy employed, from extensive, through semi-intensive to intensive.

Culture types (Systems)

The different culture systems in vogue are as follows:

- static water ponds, running water culture, culture in recirculation systems (closed or reconditioned water);
- culture in rice fields and integrated culture systems, as the duck-cum-fish and pig-cum-fish culture - or any fish-livestock-crop combination;
- culture in raceways, cages, pens and enclosures; also
- mollusc/oyster culture - hanging, on-bottom and stick methods (Happas)

CHAPTER 9

FISH CULTURE FACILITIES AND ESTABLISHMENT

Many culture facilities are in vogue these include; concrete pond, earthen pond, plastic tanks, cages, fibre glass reinforced tanks, tarpaulin and glass tanks (aquarium). Others are Cage, Race way and recirculatory systems. The choice for any one of them depends on the individual operator and purpose of culture which could be for aesthetic, hobby, commercial or game fishing, but One's desire, availability of space and financial strength could determine the choice and magnitude of establishment. Earthen and Concrete ponds are the most permanent unmovable structures that are used as fish culture facilities. They are also most suitable for commercial fish production, other facilities mentioned above are either, factory produced and transported or may be joined on site but higher technology and skillful knowledge for establishment and construction is required for the first two.

Once a suitable land site has been acquired, land surveying is a prerequisite for construction of a fish pond. The first step in preparing a site for pond construction should therefore, be a survey of each pond area, and the whole pond system if the ponds are to be built at once. Different kinds (shapes, depths and sizes) of fish ponds are established to serve for specific functions in fish farming and they may be constructed of different kinds of materials and methods and as such, fish ponds are described; according to the construction materials

- Earthen ponds are entirely constructed from soil materials. They are the most common and the best for fish production, this is because it provides the fish with a near natural environment
- Lined ponds are earthen ponds lined with an impervious water proof materials such as a plastic or rubber sheet.
- Concrete walled ponds are usually surrounded by blocks, brick or concrete walls. Sometimes wooden planking or corrugated metal is used to cast.
- Tarpaulin material or other waterproof material may be shaped to hold fish and may serve as fish pond

Earthen ponds are classified according to the construction methods

- **Dug-out ponds** are constructed by excavating soil from an area to form a hole which is then filled with water. They are usually partially drainable and are fed by rainfall, surface runoff or groundwater.
- **Embankment ponds** are formed without excavation but by building one or more dikes above ground level to impound water. They are usually drainable and fed by gravity flow of water or by pumping.
- **Cut-and-fill ponds** are built by a mix of excavation and embankment on sloping ground. They are drainable, and water, which is impounded within the dikes, is fed by gravity or by pumping.
- **Barrage ponds** are created by obstructing the flow of an existing stream or river water with a barrier to increase the cubic volume (depth) of the water. A spill way is always necessary for this type since it is practically impossible to completely stop a stream of water originating from a permanent source.



Methods of Surveying Fish Pond Sites

There are several ways to survey pond sites, small farmers may be able to determine relative topographical features of their sites by using strong stakes and a simple level. More sophisticated tools are used by Aquaculture engineers, especially when a large farm with many ponds is planned. Whatever the tools and the skills of the surveyor, the main aim of surveying fish pond sites is to determine the relationship of land topography and elevation to the source of water, land and other pond structures (gates, Canals walkways and weirs). Surveys will also show where earth should be removed and where it should be built up to result in strong dikes of uniform heights and a gently sloping and pond bottom.

The survey should result in a contour map of the site showing the highest ground as well as the lowest ground levels within the designated pond area. This map is very useful in determining where pond structures should be placed. There are generally two methods of surveying fish pond sites:-

The visual survey- this is the ordinary site inspection by moving round the area. After the visual survey, an "investigation" report is produced under the following headings;

Situation of the site, source of water supply, water quality and soil type, vegetation, climate and area limitations. A detailed survey may comprise- land survey and soil/water exploration, instruments may include the "Chain Survey" which entails use of the land chain or tape for measurement of dimensions and calculating perimeters and areas of ponds. Topographic Survey is carried out with the surveyor's level, staff, chain, ranging poles and field book for production of Contour Maps and costing of the fish farm project.



Pond Construction

The construction of ponds is the final stage of the process in which decisions were made on the use of ponds, types of ponds, species to be cultured and so on.

The first step in pond construction is the removal of all trees, rocks, stumps, bush etc. from the area to be flooded both to improve the appearance of the pond and to prevent later decay of large amounts of organic materials on the pond bottom. The top soil is removed until impervious soil is reached. Land clearing is also necessary to eliminate possible predators and facilitate compacting of dikes and pond bottom. If a large farm is being constructed, land clearing is done by machine. In this case, marking out of pond structures would be done after land clearing has been completed. In pond construction, the following structures deserve special mention; floor, dike (walls), and gates (inlets and outlets). The parts of a gate include:-

Floor – This forms the foundation for the whole gate, which lies below the pond bottom.

Apron – This is an erosion control attachment to the gate or wall. It gives support to the walls.

Flashboards – These are slabs or wooden boards inserted into the grooves of the gate, they control water flow through the gate.

Screens – are filtering mechanisms made of nylon or wire mesh netting mounted on frames, which can be slotted into the grooves. They are used to control exit of fish from the pond or entry of unwanted organisms. A pond gate may be a sluice gate or monk is mainly an outlet structure.



Dikes (Walls or Embankments)

Dikes are walls that enclose ponds in the fish farm and protect it from flooding and to hold water in ponds for the growing period. The main dike is also called the primary or perimeter dike. It divides the fish farm from the seas or river that serves as the water source, while secondary and tertiary dikes separate ponds from water supply canals and each other respectively. Usually the material to construct dikes is excavated from inside the pond or from the water supply canals, dikes must be compacted well to prevent erosion from fast flowing water.

Leveling the Pond Bottom: After the pond has been constructed, the pond bottom should be smoothed and any depression filled in. the pond should always slope towards the outlet for easy drainage. This could be done either by hand or by machine.

Construction of Dikes, Monks and Sluice Gates:

DIKES; parts of the dike include:- the crown of the crests or top, the base, the core and sides.

Steps in Dike construction:-

Clean the path or area where the dike is to be constructed to about 2- 4 metres wider than the base by removing all types of vegetation, stumps and debris.

Fill in all the low depressions in the area before construction

If blocks of mud are to be used for diking, they should be dug near the dike for ease of construction and lower cost. Sandy clay soils make one of the best diking materials.

Dike should not be built at once but in stages to allow for settlement before the next layer is added. The building of the dike in stages allows for foundation time to settle or consolidate so that dike can support the weight of soil above it.
Dike must have a free board (extra height) of 60cm – 100cm to check excess water level in the pond. Dikes may be built either by hand or by machine.
Dike made by machine tend to be loosed and usually depend upon the amount of soil to be moved in M^3.

Gates (monks and Sluice)
Monks are vertical concrete or wooden structures, with identical functions as the sluice gates and their constructions are similar. Both are operated in the same manner, i.e. by use of sluice boards and screens. The major difference between the two is that while the monk has the drainage pipe or culvert constructed under the dike, the sluice gate cuts through the dike.

Spill Way; The spill way acts as a safety device that takes care of excess water usually in reservoirs. The excess water may be due to floods especially when the reservoirs haves a river or stream as its sources of water supply. The spill way is usually located at the tail end of the dike or dam where the dam is paved to the high land. Common or general protection spillway may separate and convey land surface run-offs away from the entire farm.

Supporting Facilities and Equipment
After the ponds have been built and the water control systems completed, the supporting structures can be built. They include farm accommodation, office. Laboratories, workshops, stores and culvets on walkways, all fish farms need certain equipment to function properly. The equipment may include thermometers sechi-discs, hydrometers, field test kits, nets, aerators, pumps processing and preservation as well as fish feed mill. A fish hatchery is also a special farm unit with distinct equipment and tools

CHAPTER 10

POND PREPARATION, STOCKING AND MANAGMENT

POND PREPARATION

Pond preparation covers all the steps taken to get the completed pond ready for stocking, the techniques include liming and fertilization these are the two major management techniques employed to generate natural food production in pond fish culture. The two practices are geared towards increasing the productivity of biotic communities within the pond. This is achieved through the manipulation of the abiotic environment. The biotic community refers to plants and animals resident in the pond while the abiotic substances refer to the basic inorganic and organic compounds in the environment from which producers fix food.

The biotic communities in a pond can be classified as follows:-

(a) Producers (or autotrophs) mainly green plants (planktonic and benthic algae), which produce food (through photosynthesis) from inorganic substances.

(b) Consumers- These are mainly animals, which feed on other organisms or depend on producers for food. Examples are zooplankton, benthic invertebrates etc.

(c) Decomposers – are mainly bacteria and fungi which breakdown dead organic matter (of a and b), absorb some of the decomposed products and release inorganic substances like phosphates, nitrates etc. which are utilized by the producers during photosynthesis.

The above organisms make up the pond biota and are found either in the water column or pond bottom. Their abundance depends on water quality and soil condition. The fish depend on these organisms directly or indirectly for food and this is why it is important to increase their populations. These animals and plants make up the natural production of the pond.

As earlier stated, liming and fertilization are the two techniques used in management of fish ponds to increase natural production. The application of lime and fertilizer generally improves the pond condition through increased mineralization. Nutrients are made available in the pond water and growth of natural fish food such as plankton, periphytic and benthic organisms is stimulated.

Aims and Actions of Limes and fertilizers

LIMING; uses of lime in fish ponds include the following:

It increased the P^H of pond bottom mud and water. This enhances the availability of nutrients like phosphorus.

Through the increased nutrient availability benthic production becomes greater.

It increases the alkalinity of water thereby increasing the availability of carbon dioxide for phosynthesis.

Lime destroys bacteria as well as fish parasites in their various life history stages.

It removes humic stains of vegetative origin which restrict light penet4ation into the pond water.

Lime is also considered as fertilizer since it supplies calcium which is one of the essential nutrients.

Before a fish pond is limed, there should be a careful study of soil type and P^H. this is very vital because it determines the dosage of lime to be applied.

For example, more lime is required for clayed soils than sandy soils and acid sulphate soils have the greatest lime requirements.

Types of liming materials:-

a. Agricultural limestone ($C^a C^0_3$)
b. Slaked lime Ca $(0H)_2$
c. Quick lime Ca 0.

These liming materials differ in their ability to neutralize acid. 'in fact, agricultural limestone ($CaC0_3$) is used as a standard against which other liming materials are measured and because of this it ($CaC0_3$) is the most commonly used in fish ponds. The neutralizing value of $CaC0_3$ is 100%, $Ca(0H)_2$ =136% and Ca0 =179%. Therefore, when Ca(0H) and C_30 are used, enough time should be allowed before stocking of fish so as to allow enough time for a decrease in the P^H (raised by the lime, otherwise the fish would die.

Methods of Application of Lime and Dosage

For new ponds, lime is spread evenly on the pond bottom before they are filled with water.

In nursery ponds (for fry and fungus production) after each cropping they are limed to eradicate predatory organisms parasites and other disease causing organisms. Old ponds containing water can be limed by spreading lime over the entire pond surface.

For small ponds, lime can be broadcast from the dikes while in large ponds construction of plat forms or use of boats becomes necessary.

It is usually more desirable to leave the pond dry for at least 2 weeks after lime application. because of the residual effects of lime, subsequent application may not be necessary particularly in fresh water fish ponds.

Fertilization of Ponds

Apart from artificial feeding of fish, one of the best means of increasing fish production in ponds is by improving the substratum in which fish by through fertilization. The aim of fertilizing fish pond is to aid production of fish by increasing the quantity of natural food present. This is done by stepping up the production of both phyto and zooplankton organisms, which are the primary producers. The use of fertilizers is as important for fish cultivation as it is in agriculture. Experience has shown that inorganic nutrients responsible for vegetable production in ponds in very (phosphorous, potassium, Nitrogen) are generally found in very small amounts and it is because of this that it is necessary to use fertilizers containing these nutrients. These fertilizers don't act directly on water or organisms but the nutrients in the fertilizers are absorbed by mud, which returns little by little according to the needs of the plants. This explains the prolonged action of fertilizers fall under two categories:

a. Inorganic and
b. Organic fertilizers

Inorganic Fertilizers; The major fertilizer elements are phosphorous, nitrogen, potassium and calcium. Inorganic fertilizers are prepared with precise amounts of desired elements as they have a definite and

constant chemical composition of nutrients elements. They are usually expressed as percentage of available nitrogen (N) phosphoric and ($P^2$05) and potash (K). The commonly used ones are;- Phosphate fertilizers e.g. Ordinary superphosphate, Tripple superphosphate.
Nitrogenous fertilizers e.g. potassium nitrate, potassium suphate etc. phosphate fertilizers are commonly used in fish ponds because it is found that plankton grow this limited in ponds by inadequate phosphorous. Fertilizers are expressed as percentages of the constituent elements.
For example NPK 15-15-15,20-20-5 etc.

Dosage and Method of Application of Fertilizers in Fish Pond
Fertilizers are usually applied at least two weeks after flooding a limed pond. This is to prevent the reaction of phosphate (available in the fertilizer) with lime as this would make the phosphate unavailable.
In organic fertilizers are most effective when applied at short intervals e.g. for 2 weeks and in small amounts. In this way nutrients are more available to phytoplankton. Large doses at long intervals are wasteful because much of the phosphorous would be absorbed in the mud.
Application; inorganic fertilizers are applied by broadcasting over shallow area of the pond. It is advisable to dissolve the fertilizers pellets or grains in water before application so that the nutrients are made available to the plankton in the water column as they are being added otherwise the fertilizers would sink to the bottom mud and the nutrients would become absorbed.

b. Organic Fertilizers
They consist of various animal manures and plant wastes. The organic materials may serve as direct food source to the fish or when they decompose, the inorganic nutrients released would be used to generate plankton production.
Organic manures add detritus to the pond and this stimulates the heterotrophic food chains producing more bacteria and Zooplankton. They also do the following.

a. Enrich organic matter content of soil and water,
b. Release carbon dioxide on decomposing and sustain the fertility of the water.

Their disadvantage lies in the fact that they use up dissolved oxygen during decomposition and produce offensive odours in a pond. They can also transmit parasites and diseases.

Types of Organic Fertilizers:-

1. Cow dung.
2. Chicken dropping (Manure)
3. Pig manure
4. Sewage
5. Plant leaves
6. Oil cakes
7. House hold craps.

Method of Application:

They can be spread all over the pond surface or in heaps at the different corners of the ponds. It is good to put them near the inlet pipe so that nutrients can be washed into all parts of the pond by incoming water.

Precaution for Lime and Fertilizer Application in Fish Ponds

Watch phytoplankton blooms closely to avoid excessive production which leads to oxygen depletion. You can do this by visual observation or by proper plankton analysis. Sechi disc readings are also important.

When there is excessive production of phytoplankton the stocked fish come to the air –water interphase to obtain dissolved oxygen. This is because there is usually a reduction in the $^{0}2$ content of the water.

Fish behaviour is therefore an indication of the presence of stress factors in the pond. When this happens, part of the water is drained and new water is added.

After proper liming and fertilization programmes, there may be no change in the quality of the water. This could be as a result of low alkalinity, presence of humic acid in the water, low P^{H}, turbidity etc when this happens addition of lime may be necessary.

A proper fertilization is usually accompanied by a water quality assessment programme. This will help the fish pond owner to assess the impact of the fertilizers on the overall water quality.

When there is excessive phytoplankton bloom, fertilization should be discontinued.

When water P^{H} is high 7.5 use of ammonium fertilizers should be discouraged. This is because unionized ammonia is toxic to fish at high P^{H} levels.

You can use both organic and inorganic fertilizers together. This is particularly beneficial in polyculture i.e. a situation where different species of fish are cultured together. In this case the benthos and plankton would develop side by side and so the fish species would have different feeding opportunities exploit.

Finally, it is very important to point out that no fertilization application rate should be rigidly adhered to, rather adjustments based on environmental response should be made from time to time. This is to effect a proper enrichment of the fish ponds.

FISH STOCKING

Pond Stocking

This can be described as the introduction of culturable aquatic organisms into the pond for rearing or growing, such organisms include fish, crustacean mollusks frogs and others. Such organisms could be finfish or shell fish, with particular reference to fish stocking, different categories of fish sizes ranging from fry, fingerling juveniles and adults are used. Stocking of each category however is motivated by some factors like need and purpose.

Fish fry for instance are mostly stocked for experimental purposes while adult fish are stocked, either for sport fishing, fin fishing or are stocked for conditioning or fattening for subsequent use in induced breeding activities. Stocking of fish fingerling inter-alia may be for experimental purpose but it is the best choice of fish size for pond stocking aimed at commercialization or subsistence purpose.

Economically speaking stocking fry will attract more management expenses and ingenuity in the area of feeding up to desired fingerling size, and the ability to monitor properly all the bio-physicochemical parameters required for sustainable growth. In the same manner stocking adult fish for the purpose of rearing will not only bring about bio-economic diminishing returns but also amount to financial squandamania conversely, stocking of fish fingerlings might be found to be most economically viable, this is backed up by the fact that fingerlings will take less period of time to attain adult or marketing stage.

There are certain criterions that determine pond stocking these may include;

1. Size of pond; This refers to the total water surface area, in effect the bigger the pond is the more fish will be stocked and vise versa.
2. Type of fish spp:- Some fish spp are more commercially productive than others e.g. *Heterobrancus spp* and *Tilapia spp* both have 1-$1^1/_2$ yrs and ; 3-6 months as final harvesting period respectively. Although one gets quicker returns from tilapia the net gain from *Heterobrancus* is a lot more in terms of size, aesthetics and even all consumer preference.
3. Reproduction: Fish that reproduce during rearing often cause problems at times to the pond system. Tilapia for example is noted for its prolific, multiple and intermittent breeding habits with unavoidable results to ever crowding graduating to spatial distribution problem which automatically results in competition for inadequate food which can caused stunting or dwarfing and that would result in low yield and proportionate profit.
4. Size of fish:- The fish to be stocked should be measured and weighted this will in future help the fish farmer to up date the growth rate of the fish.
5. Bio-physicochemical qualities of pond water: The amount of feed to be given is to some extent determined by the amount of natural foods available especially in earthen pond ecosystem.

Fisheries Terminologies Used in Pond Stocking

Stocking rate is defined as the number of one particular spp stocked in the pond if for instance carp, tilapia clarias are stocked in a pond system, each of the fish has its own stocking rate. If however only one spp is stocked i.e. monoculture practice the stocking rate is equal to the stocking density. The stocking rate recommended in commercial fish culture ranges between 1-20 fish/ M^3 of pond water depending on the intensity of management.

Stocking density: This is defined as the aggregate no of different spp stocked per unit area of pond water Different species respond in a variety of ways to crowding. Some animals become aggressive at low densities whereas others may exhibit aggression or antagonistic or carnibalistic behaviours at high densities. The proper culture density must be determined for each spp in terms of no of animals per unit area or volume of water. Over stocking may lead to two pit fails

1. Carrying capacity may be reached and growth will seize entirely before the fish have attained market size.

2. When there is over stocking there is a decrease in the amount of food available in the pond hence there would be a proportionate decrease in the growth rate of the fish.

Under Stocking

Under stocking is a situation whereby the pond system is stocked with less proportionate no hence under utilization of available food resources and the spatial distribution are manifested.

Critical Standing Crop

Critical, in fish pond stocking is a term or terminology used to describe a situation whereby food deficit increases and growth rate decreases

Monoculture

On the assumption that facilities and the availability of fish for stocking are no limiting factors, a fish culturist may employ some management techniques for effective operation of its ponds. Such techniques include among others; Choice and combination of fish spp to be stocked in his pond hence has an option of either to go by monoculture or polyculture. Monoculture therefore is the simplest system which involves the culture of a single spp from fry or fingerling stage through to commercial size. For monoculture practice, stipulation must include that early maturation or excessive breeding will not occur. Therefore in the tilapia culture monoculture should only be carried out in non breeding (stock be mono sex).

Monoculture is the only culture method in running water system and in cages where the supply of natural food is limited under stocking is undoubtedly a draw back in monoculture because at low densities mono does not fully utilize natural pond productivity.

Poly-culture

Ideally, the polyculture system involves the growing of spp which by their different feeding habits do not compete with one another in other words the growing of more than one non competing or non competitive fish spp in the same culture system is termed polycultue. In order to achieve increased production the spp stocked must have different feeding habbits and occupy different trophic niches in the pond system obviously the ratio among the different spp and the stocking densities are of prime importance in polyculture this can be determined in 2 ways

1. If one knows feeding the feeding habit of a fish, and the unit of natural food in the pond, then the relationship among the species can be calculated.
2. Trial and error which is a way commonly used for the relationship.

Source of Water Supply

Sources of water supply to the system can be by municipal Tap water, Bore hole, deep well spring water etc, but provided the water is potable and free of contaminants like heavy metals and pollutants such water needs to be stored in overhead GRP Tanks (by lift pump)and given at least 24 hours to settle (if it is municipal tap water) in order to allow chlorine to evaporate before being introduced into the culture medium (fiberglalss tanks). The

overhead water storage tank will allow water to be supplied into the ponds as desired and can always be tasted for acidity or basity (Ph), DO and other parameters on a regular bases.

Culture Species

Catfish especially do very well in intensive fish- culture systems, tilapia also do well especially with monosex culture and can similarly be grown to big market size within a relatively short culture period (3-4 months). The species recommended for culture in the tropical waters especially Nigeria, are good strains of Clarias, Heterobranchus, tilapia, Gymnachus, Heterotis and Cap species), they all have good commercial values and can withstand considerable stress conditions. They could be cultured as desired by the farmer but monoculture with good feeding regimes utilizing high quality formulated feed that will ensure a very good feed conversion ratio for adequate will give profit margins. The source of fish should be from a reputable and certified hatchery to avoid problems of stunted growth or disease infestation.

Stocking

The best size of fish for stocking should be juveniles in order to avoid cannibalism especially with catfishes. If fry or fingerlings are stocked, some faster growing ones (jumpers)will cannibalize on the slow growing ones which will raise mortality rates in the culture system but with periodic sorting system to separate the fast and slow growing ones fingerlings will give better results as earlier stated this is because some stunted fish may be sold to farmers as juveniles. The recommended stocking density is usually 200 fingerlings per cubic metre of water (200/m3) but at later stages of grow out, the fish can be thinned out into holding tanks to ease constraints of space when their size becomes very large.

The best time to stock fish is early in the morning and evening between 7:00 am and 10am to between 5:00pm 9:00pm. Temperatures at these periods are at optimal levels for alteration.

The culture period for growing fish to market size from date of stocking is usually between 3-4 months provided that there is adequate management and a food feeding regime with high quality formulated feed.

CHAPTER 10

FISH NUTRITION IN AQUACULTURE

Fish, like all other living animals, need food for their daily activities, for maintenance of growth and repdtn there are 3 types of fish foods:-

(1) Primary foods:- They are plant/Animals and nutrient materials present in the water on which the fish feed. These include- (a) phytoplankton and other size plant materials like duck weeds and vegetation and zoo plankton bacteria protozoa, mineral community.

(2) Supplementary foods:- These are foods which are given to fish in addition to the natural nutrients in the environment of the fish these include:- (i) agricultural residue e.g. Ice straw sugar cake tuffs, brewing waste (ii) rejected whole fruits such as pineapple bananas pawpaw and other spoilt fruits (iii) plants such as leaves of bananas pawpaw, lattuce, spinach (iv) oil seeds: e.g. soya-bean, plants, bean seeds mellon seeds (v) waste from animal origin such as chicken dung, cow dung, silkmorm, blood meal, chicken waste (intestines feet and shanks feather) can be chopped mechanically (feather is hydrolysed) (vi) live insects/ worms such as termites, black ants and helmits worms (earth worm)

(3) Complete artificial food; artificial diets are compounded feeds or prepared diets containing all the essential nutrients prepared diets come in the form of dry or moist pellets, crucibles or flakes.

In order to further improve intensive culture of several fish spp, the composition of a complete diet is of the outmost importance and appropriate feed is well balanced to it respect to the major macro-nutrients such as proteins CHO, lipids and moisture and fortified with some basic micro nutrients such as vitamin and mineral premixes.

Protein (macronutrients)

Functions (i) It is essential for tissue growth and tissue replacement. (ii) it can be used as an energy source (iii) They are main nutritional elements in fish feeds (iv) It constitutes the major cost in fish feed formulation, (v) It constitutes amino acids limited is peptide bonds and cross linked between chorins with sulphul hydral and hydrogen bonds.

For fish 10 essential amino acids are mentioned (these amino acids can not be synthesized by fish themselves) and must be given by the feed. These EAA's are arginine, histedine, isoluirine, luicine, glycine, methionine, phenylalanine, thriowine, typtophan valine.

Non essential amino acids can be synthesized by the fishes themselves, stating from N & glucose.

(1) Protein synthesis, this occurs only when all essential and non essential amino acids needed for that specific protein are sufficiently present in the blood plasma. Im balance AAs or sulplus of some AAs in the blood plasma are caterbolised is ammonia excretion by the gills as the main final results

(2) CHO synthesis: carbohydrates is the so-cooled crude fibre nitrogen free extract (NFE); sugar starch cellulose etc. Cho are present in limited amt in natural diet of most fish species there is no nutritional requirement for crude fibre and no efficient conversion, cho is not a source for energy but used in fat

metabolism there is however no storage of cho exapt glycogen in the liver, carnivorous fish are deficient in insulin production and this physiological explains the how capacity to utilize cho.

(3) Lipids:- They are promisingly a source of (metabolic energy) and essential fatty acids (Efa) and are used for the formation of body fats, the content of which can in crease during the growth of some fish spp, lipids consist of essential of glyucerol and Fas. EEa requirement varies from spp to spp and are different for marine and fresh water fish. omega- 3 and omega-6 fatty acids must be included in the diet these f.a (0-3and 03) are incorporated in cell membrane and sub-cellular particles in other words they regulate bio-membrane fluidity

(4) Moisture: Defined as ambient water adsorbed by the organism.

(5) Micro nutrients: They include the minerals, fat soluble vitamins and trace metals.

Minerals

These include ca, ph, mg, fe, na, k, etc. trace metal, cabalt, I, celemum, zu mn co

Vitamins:- vitamins can not be syntheses by fish and are required in minor geaneties for growth, health and gen metabolisms. The ff units are classified to be essential vit A, Dz, E, K, & C and from the B-complex; B1, B2, Niacine, patothenic acid, B,B B12 choline, folic acid, Biotine and inositol. In conclusion a well balanced diet ensures that a max of the proteins are used for growth as a result, less excretion of toxic ammonia. In balanced diets the lipids and cho fulfill optimally the energy requirement, protein sparing action.

Prepared Diets

They are also referred to as artificial diet. They are either complete be containing all the required nutrients or supplements meant to provide additional protein, CHO & fats to animals already receiving some natural food, but not justified with vitamins and minerals. Prepared diets in most cases usually come in the form of pellets, crumbles or flakes. The size of the particles will depend on the age and specie being fed, its feeding habbits and the size. There are 3 basic types of prepared diets which are commonly used by aquaculturists.

(1) Practical diets
(2) Semi purified diets
(3) Purified diets

(1) A practical diet is one that is formulated from natural ingredients such as cereals, grains, oil seed meals fish meal and fish meat-b1- product (eg bone meal, blood meal) supplementary vitamin and minerals areusually added to for tif of the natural ingredients.

(2) Semi purified diets; It is mostly used in nutritional research hence it is more significantly much expensive than practical diet. A semi- purified diet may be described as that which may contain some natural ingredient in relatively pure form eg. Casein (milk protein) however, it is nearly purely protein source with a good amino balance, corn oil which might be used as lipid source balance it contains nearly 100% fat while the CHO source might be straight corn starch.

(3) Purified diet; This contains only ingredients of precisely known composition and for this reason such diets are very expensive and only rarely utilized even in aquaculture research. Irrespective of the type of feed formulated, it is always necessary to have it binded, such binding agents include starch Gelative,

cellulose and caroxymethyl carbonic (cmc) the essence of using them is to give the feed water stability thereby preventing immediate dissolution in water which invariably might increase the BOD level leading to 0_2 depletion.

Feeding Regime; For better management in fish farm the operational regime for feeding got to be well laid act this does not only help fish farmer in knowing precisely the amount of feed to be dispensed at a given time but also help in conserving feed thereby disallowing unnecessary wastage more also it enables the culturist to have an updated knowledge of the growth of the animal. This optimum rate of feeding can be determined by examination of the food conversion ratio (FCR).

Food conversion ratio (FCR) is the dry weight of the food administered:- net weight gained by an animal. FCR becomes lower as the efficiency in food utilization increases (FCR< as food utilization increase) A good FCR= 1 and below anything above 1 is not good.

Factors That Affect FCR

(a) physical environment – increase in water temp, increase in food consumption.

- Decreased dissolved 0_2 reduces food consumption eg. Tilapia will have reduced appetite of Do <1.5g/l
- Increase in water acidity reduces food consumption.

(b) Food; (i) size of food a finely divided / ground food has a better conversion rate than a coarsely ground or sieved are (ii) Amount of food: an unlimited supply of food may pass through the gut faster than a limited food and can only be partially digested. (iii) Composition of food; Food with higher water or woody tissue content eg. Leaves and potatoes will have a less favourable conversion rate.

Method of presentation; certain foods may provide a better conversion if they are mixed than when they are presented separately.

(c) Fish; (1) size of fish, a small fish grows fat because guts capacity is high relative to its body. The ratio decreases with increase in weight of fish be: the bigger the fish the smaller the gut capacity.(ii) sexual maturity; gonadal development reduces growth, for example male clarias will develop more than female clarias. (iii) stocking rate; excessively high rate will slow growth. (iv) Fish spp: herbivores utilize more food than carnivores.

FISH FEEDING

The type of fish feed that can ensure fast growth of fish with a good feed conversion ratio (FCR) is a nutritionally complete high quality formulated diet that contains 35-40% crude protein for table fish or 45% crude protein for brood stock.

The feeding frequency should be 4-6 times a day depending on age and culture system (fingerlings have higher feeding frequencies that adult fish, while the size of feed, preferably pelleted, should not be too large or too small for the fish to consume directly.

The quantity of feed to be applied to the fish in each pond/tank should be computed at 3-5% of the average body weight to minimize wastage. The quantity of feed required to feed the fish daily can be calculated based on the stocking density and average weight of the fish in each pond/tank which can be obtained by random sampling (stock assessments) carried out bi-weekly and adjusted accordingly to feed fish until harvest time.

Usually about 10% of the total number of fish stocked in each tank should be randomly sampled every two weeks to determine their average weight and compute quantity of feed to be applied daily with bi weekly adjustments as the fish grow in size. For this computation, the following equation can be applied;

$$F = \frac{W \times S \times P}{1000 \times 100} \text{ kg./tank/day}$$

Where, F=weight of feed to be applied per tank daily.
W =Average weight of fish obtained by random sampling.
S =Stocking rate (total number of fish stocked per tank).
P =percentage of body weight (3-5%).

Example: if a fish farmer has 1000 juvenile fish in on e fiberglass tank with an average weight of 10gms., then the quantity of feed to be fed to the fish daily at 5% body weight can be calculated thus:

$$F = \frac{10 \times 100 \times 5}{1000 \times 100} = O.5\text{kg/tank/day}$$

The above example shows that 500gm or half kilogram of feed can be applied to that tank each day and can be divided into two or three parts for that day.
The feeding table below may guide farmers on the daily feeding of pond fish

Daily Feed Quantities/1000 Fish

Fish size in grams	Feeding level % of feed of body weight	Amount of feed for 1,000 fish feed in KG per day
5	**9.2%**	**0.5**
10	**7.3%**	**0.7**
30	**5.3%**	**1.6**
50	**4.5%**	**2.25**
100	**3.6%**	**3.6**
200	**2.9%**	**5.8**
300	**2.6%**	**7.8**
400	**2.2%**	**8.8**
500	**2.1%**	**10.5**

600	**1.9%**	**11.4**
700	**1.5%**	**12**
800	**1.4%**	**12.3**
900	**1.3%**	**12.7**

Feed Formulation

Feed formulation is the science of combining selected dreaded feed ingredients in varying proportion such that the end product (balanced formulated diet) can comply with predetermined nutrient requirements for the specific type of fish under culture (By species; By feeding habit whether carnivore, herbivore, By age or size whether fry, fingerling, juvenile, table fish or broodstok etc).

Based on the established proximate composition of local feed ingredients required, they can be put together by weight to meet the desired levels of carbohydrates and protein using the person's square method.

In most formulated fish feeds, the critical requirement is protein: about 30-40% crude protein (CP) where all calculations are based on a total of 100% 100kgs.

It is often necessary to combine both plant and animal sources of protein in order to satisfy the profile of essential amino acids which are limiting in plant proteins.

Feed application will constantly affect water quality in the pond so special attention should be given to the kind and type of feed applied, fish nutrition and water quality management are treated in subsequent chapters.

Types of Feed Stuff Used in Fish Feed Formulation

Feed stuffs are ingredients used in formulating fish feeds. They can be of animal or plant origin. There are 3 type of feed stuff.

(1) CHO – rich-feed stuffs: examples include corn, starch, rice bran, wheat offal etc.
(2) Simple- feed-stuffs include CHO derived from area.
(3) Protein- rich feed stuffs; These include ingredient such as soyabeans, corn oil, fish real, chicken offal maggot. In considering the type of feed stuff to be applied, one has to know the feeding habbit of the cultured fishes (1) nutritional requirements (2) size of fish (3) feeding habit.

Nutritional requirement; some fish would require CHO or protein in their fingerling stage more than in their adult stage.

Size of fish; some fish in their fry stage would prefer feeding on crumbles; fingerlings would eat feed in crumbles, flakes or pellet depending on size while adult fish would eat pellet or flaked feeds. However, a domesticated fish have been found to accept crumbled or powered feeds.

Feeding habbit; if the fish is a surface feeder it would prefer floating feed. (powdered, flaked, pellet, crumbles) this is because of the anatomical placement or nature of the mouth parts (supraterminal) conversely, a dermersal fish would prefer sinking pellet. To prepare a floating pellet, one would need to add a lot of oil as a component of the moximate composition of the feed or in the alternative are would subject the prepared feed to high temp or pressure.

Advantages of Floating Pellets

(a) It afford the fish farmer the op0portunity to study the behavioral feeding pattern of the fish.
(b) It does not allow for feed wastage.

Disadvantages

(a) When one subject the feed to high tem & pressure the protein content tend to denature.
(b) Only pelagic fishes or surface feeders take advantage of the feed administered.

Sinking Pellets

(a) The major disadvantage is that the fish farmer does not know if the fishes are actually feeding on the feed or something else.
(b) The farmer is not opportuned to study the feeding habbits of fish cultured.

Feeding Strategy

This can be described as the modus operandi of feed mgt act, in other words it is planned or an approach to dispersing fish feed in a fish farm set up. A farmer can have a precise time for feeding the fish eg. 6-30 – 7.30 coith this the cultured fish becomes accustomed to this timing. In the same way a particular spot or spots may be designated as feeding positions there by influencing the fish to reporting to this designated spot wherever it is time for feeding. Moreover the fish becomes accustomed to a particular person with tune and exhibit some traces of non-comfortability when a strange comes around. There are 2 types of feeding styles.

(1) manual style; This involves the dispersion of feed by hand as a means of broadcasting to the fish. This style is only applicable to small fish ponds but it would be labour intensive for more than I ha pond.
(2) Mechanical style; there are two techniques of devices
(1) Automatic devices; electrically powered (a) Demand feeder (b) Automatic feeder; is a device that feed is presented to the fish at precise time. It works with the aid of electric power.

Advantages of Automatic Feeder

(a) The system allows for proper dispensation of feed
(b) It affords the fish farmer the opportunity to disperse the right amount of feed at the right time thus disallowing for wastage.
(c) It is the right type of tool or equipment for an absentee farmer.

Disadvantages

(a) The efficiency of this devices only hinged on the availability of electricity.
(b) It practicability devoid awareness of the satisfaction of the fish.

Demand Feeder; It is an improved device with tripod stand housing a hopper, it is not electrically activated as in the case of automatic feeder rather it is speriodically activated as a result of the contact of the fish with the penditum suspended in the water column when the penditum is activated by the fish it swings to a side and an opening in the hopper is partially created hence the release of the feed. The efficiency of this device is a function of the force exerted by the fish and the angle of tiltation created by the pendulum.

Advantages

(a) It enables the fish farmer to conserve feed because the fish would only demand for feed when it is hungry.
(b) It is not electrically activated hence, a lot of money is saved in the area of operational cost.
(c) It can be simply constructed or manufactured because of the availability of the materials needed for it construction.

Disadvantages

(a) It can allow or pave room for wastage because any slight contact with the penditum will cause a release of feed.
(b) The fish farmer is not opportune to always feed the fish during the early hours of the day.

Guides to Good Feeding

Fish feeding is vitally important for efficient aquaculture because underfeeding can result in loss of production and overfeeding will cause wastage of expensive feed. It is a potential cause of water pollution, and may result in loss of animals which may require expensive corrective measures. Thus, both overfeeding and underfeeding have serious economic consequences which affect the viability of the farm.

Effective Methods of Feeding

- The most effective method of feeding may be with respect to
- location, time of the day and frequency varies from species to species as well as the age/size.
- Its cost effectiveness depends also on other factors such as the availability of feeding labour or automatic feeders, size of pond or tank, cost of labour, and the personal preference of the farm manager, based on observations and results.

Feeding frequency in Cat Fishes

-Catfish fry begin to feed 5-10 days after hatching, when the yolk sack reserves are used up.
-swim-up fry are best fed many times per day 8-10 feeds per day is recommended,
- It should be reduced quickly to 6 times per day by the time the fish are about 2.5 cm long.
Feeding frequency is further reduced to 3 times per day when the fish reach 7.6 cm in length
-Juvenile catfish grow best with two feeds per day, one at mid-morning and one late in the afternoon, seven days per week.

Feeding Rules for Observation

For optimum growth and feed conversion, each feed should ideally be only 1% of the body weight Thus,

- if 5% of biomass per day is being fed, there should be five feeds per day
- Survival rate is not significantly affected by feeding frequency once the initial feeding stage of the animals has been passed.
- Frequent feeding reduces starvation and stunting of small fish; thus the group has better uniformity.
-Infrequent feeding results in feed wastage, poor FCR, water quality problems, and the leaching out of water soluble nutrients.
- Dry feeds should be distributed more frequently than moist feeds

90% of the feed (for fish) should be consumed within 15 minutes or less of the feeding time.

Special Feeding frequencies

Feeding frequency in ponds may depend on water temperature.

-feed may be applied 6-7 times per week

At extreme temperatures, less frequent (4 or 5 times per week) feeding is suggested.

Feeding 6, instead of 7 days per week is said to encourage the fish to consume any surplus feed in the pond and lessen the chance of over-feeding.

Catfish in cages should be fed daily.

Feeding catfish twice per day, especially under raceway conditions, results in a faster growth rate.

Methods of Feed Application

In narrow or small ponds for fish, feed should be spread evenly around the perimeter.

- For larger ponds, other methods have to be used to give adequate distribution, especially for species which are territorial in nature.

- These methods include feeding from a boat, feed blowers towed by a tractor, and distribution by aeroplane for very large ponds. Boats are, of course, essential for the feeding of moored cages which are not connected to the shore by a walk-way.

Characteristics of Good Fish Feed

Fish feed should remain stable in water for at least 10 minutes,

-It should be completely dry during preparation

-Be attractive and acceptable to the fish,

-Not pollute the water medium in any way, -Be able to promote and assure fish growth,

-Be affordable and cost effective to the farmer

CHAPTER 11

WATER QUALITY MANAGEMENT AND FISH HEALTH

All aquatic organisms have optimal and lethargy levels at which they would survive, grow, reproduce and have normal metabolic functions. Shift to the extremes (negative or positive) hampers normal biological and to some extent chemical functioning of the ecosystem. Pollution refers to the excesses that bring about the negative impacts in the aquatic environments. Physical evaluation and monitoring of the aquatic environment is therefore necessary to check the effects and necessary changes brought about by feed application and other inputs in fish holding facilities. Colour plays an important role in physical assessment as it gives the first signal of change in water quality. Other parameters as earlier mentioned in chapter 1. will be reviewed here with respect to pond culture condition.

P^H of Pond water

P^H is the negative logarithm of hydrogen in concentration within the range of 0 to 14. The water used in fish cultivation is not chemically pure but contains different substances in solution, which give it acidic, neutral or alkaline reaction. It is possible to determine the nature of these reactions and also to measure the intensity by determining the exact quantity of hydrogenous (H^t) Quantities are always very small and expressed in very small numbers. P^H values range between 0 – 14, P^H of 7.0 is neutral. If it is higher than 7.0 the reaction is alkaline, if it is lower than 7.0 it is acidic. Fish grow best between 6.5 and 9.0

P^H determination - P^H is often measured using and electrodes which is automatically compensated for temperature change. The equipment is called a P^H metre. Litmus paper can also be used or colorimeters.

The importance of P^H in fish cultivation lies in its stability or variability. This is because most aquatic organisms are adapted to an average P^H value and do not easily withstand sudden and strong variations in P^H. Biological conditions are better when P^H is constant rather than in water undergoing considerable variations. The optimum P^H for fish growth is 6.5 - 9.0.

Control of P^H in pond water is achieved by liming.

Temperature

It is one of the most important among the external factors, which influence fish production. Temperature has a considerable influence on the principal and vital activities of fish notably, breathing, growth and reproduction. This is because the body temperature of the fish varies with and is almost the same as that of the environment.

Temperature is linked with dissolved oxygen, the higher the temperature, the less the dissolved oxygen content. Each fish spp is adapted to a scale of temperatures including minimum and maximum temperatures outside which they cannot live.

Mercury (Hg) thermometers calibrated in ^{0} Celcius or Fahrenheit are used for measuring water temperatures. The best way of controlling the temperature of pond waters is by increasing or reducing the quantity of water in the pond

Dissolved Oxygen (DO)

It is important for the fish producer to understand the factors effecting production and removal of DO in ponds because of the importance of this gas in respiration. Water in fish ponds is never 100% saturated with DO because temperatures are constantly changing, and physical, chemical and biological activities continuously use off and produce oxygen.
Oxygen in the water comes from several sources, some is absorbed directly from the atmosphere but most of it is produced by primary production through photosynthesis. This is the most important source of DO, and respiration by all plankton is the principal process of removing oxygen from ponds.

Oxygen Determination
The unmodified Winkler procedure is the most common method used. The procedure entails the oxidation of manganous hydroxide (MnOH) in a highly alkaline solution. On acidification in the presence of an iodide, the manganic hydroxide dissolve and free iodine is liberated in an amount equal to the oxygen originally dissolved in the sample. This iodine is titrated with a standard sodium thiosalphate solution, using starch as an indicator. Oxygen metres can also be used. There are many models.

Carbon Dioxide (CO_2)
Unlike O_2 it is highly soluble in water, one volume of water, solubility being higher at low temperature. $C0_2$ can be in dissolved or bound form i.e. (bicarbonate $HC0_2$ or carbonate) in water depending on the water P^H. CO_2 + H_20 H_2CO H_t + HC03 Ht +C03
Low P^H water (acidic waters) have high dissolved CO_2 and water with P^H above 8.36 are free from dissolved CO_2. CO_2 apart from being the end product of respiration and source of carbon fixation (photosynthesis) interferes with the building capacity of haemoglobin with oxygen, thus reducing the maximum blood oxygen capacity.

FISH HEALTH

The ill health of fish may be caused by diseased condition or stress factors.
Identification of diseased fish is based on physical appearance and behaviour. Fishing mortality is one of the factors that cause losses in fish. Ill health in fishes are caused by bacteria, virus, fungi as well as environmental factors (stress, poor water quality, oxygen depletion, high NH_3 content, low P^H, pollution etc.) and insufficient or inappropriate food supply.
If it is a protozoan attack, the fish will swim without a definite direction so as to avoid the attack, infection results in the feeding itchy and then rubbing its body against stomps or the walls of the pond or cage. If the attack is very heavy the result is that the fish remains stationary or moves sheepishly. Eventually the fish becomes weak and dies. If the infection is in the gills, it will damage the gills and impede respiration. This is easily recognized because the fish will surface for air and remain close to the water surface. The skin will become grey colour and sometimes the scales will fall of. If the fish are affected by Trematodes (worms), they show similar symptoms of fish with protozoan infection because the parasites also destroys the skin and gills. If they are affected by Nematodes (round worms), the fish lose weight appear pale and underfed, mortality is

sporadic. There is no satisfactory treatment, complete draining and liming of the pond after harvesting is important.

Bacteria diseases are found in water but will cause disease only when the fish are stressed. Chemical Symptoms- The body shows reddish colouration, hemorrhage and if not controlled, the hemorrhage will spread over the entire body and possibly become ulcers. The fish will stop feeding due to lack of appetite. The eyes and stomach may also swell. Prevention and control – since stress factors are the principal reasons behind bacteria infection: it is necessary to prevent the stress factors.

Stress Factors:-
Fish are cold blooded organisms where the body temperature are dependent on the water temperature. If there is a sudden change in the water temperature, it will result in shock to the fish and subsequently weakens the fish.

Water quality is also very important, a negative change in water quality will have a harmful effect on the fish e.g. low 0_2, high NH_3, acidic waters (low P^H)etc.
Agricultural and chemical pollution from factories and large scale farms can also cause changes in water quality. Tool large a population in a pond can also cause unpleasant circumstances.

Shortage of feed or unsuitable feed can also weaken and cause mortalities in fish. The feed must be given according to specific rates for age and size of the fish. A suitable feeding rate is 5 or 3% of the body weight (young and adult fish) with spread over several times a day.

General methods of Treatment of Fish
Preventive and control measures are much better than treatment. Treatment should be the last resort. It is done by dipping/ exposing the fish in water containing a specific dose of medicine for a specific period. This should be carried out in known volume capacities usually tanks or aquarium

CHAPTER 12

FISH HARVESTING AND FISHING GEAR

Fishing gear technology is a special area of science and technology in fisheries that requires Physics, chemistry, Engineering and biological knowledge to be able to understand Gear design, construction and operation. Catching fish in the wild demands that, fishers should be able to detect fish in water and at particular locations in order to operate their gears economically. In addition to the use fish finding devices that are fairly sophisticated equipment, the fishers ought to be conversant with the weather of the day, season of the year and climate of the fishing ground as these will enhance the selection of the type and kind of gear that will give the best result in catches. Fish behavior on contact with the gear and, in relation to the habitat also demand for skills of the fisher to catch.

Any device that could enhance fish catch other than hand picking is termed gear, the common fishing Gears used are the hook and line (which is familiar to everyone) the fishing nets which could be; gillnet or drift net (floating), encircling nets (e.g. purse seine, ring or lampera), trawl net, and cast net. Wounding gears include spears, arrows, knives and cutlass. Others include traps of various kinds. The hook and line is the traditional gear familiar to everyone the gillnet or drift net is a cut off of net hung from above with floats at the surface and sinkers at the bottom. It is set in position and fish swim into it and are caught by their gill covers. There are many variations of encircling nets by which a shoal of fish is surrounded and caught. The shoal is located near the surface and the net is closed with rings below them so that they cannot escape downwards, when the fish are contained within the ring, they are lifted from the water and are carried about the carrier. Ring nets and lampera are smaller and are used to catch fish at the surface quickly without pausing. There are so many fishing gears that one will need a special text to discuss.

Gear Classification

Fishing gears of the world are classified based on

(a) Mode of operation i.e.
   (i). Active gears; those gears that are actively operated using manual labour or motorized crafts with improved technology.
   (ii). Passive gears; stationary gears that are set and left in water to succeed based on the movement of fish.

(b) Materials used in their construction; they may be of metal substances, wooden materials. Textiles or none textile materials, they may be of synthetic or none synthetic fibres.

(c) International Standards Statistical Classification of Fishing Gears (ISSCFG) Recommended by Food and Agricultural Organization (F.A.O) and the Committee on World Fishing (C.W.F). The classification is based on numerical and prefix or suffix of the gear by indicating the numeration in the various grades and groups

Methods for Detecting Fish in Water

1. Visual sighting with naked eyes especially for pelagic fishes which stay at the surface through their oil sleak and schools of fish

2. Flying birds (when birds fly above the water in a particular zone)
3. AERIAL surveys / surveillance; Helicopters and aero planes are employed which may carry low light level television to show light from fish and aerial photo-graphs.
4. Scuba diving – self contained under water breathing apparatus
5. Use of Echo sounder and Sonar
6. Bioluminescence – where plankton reflect either the moonlight or either artificial light.
7. Experimental fishing (trial fishing etc.)
8. Porpoise fishing – closely associated with tuna because of the similarity in food requirement (food is supplied and observed for fish feed on it) gear is then applied.
9. Hydrological studies involving the use of simple equipment e.g. thermometers and salino meters to the use of sophisticated sate light equipment, usually this is done to conserve energy during fishing. Thermo cline and upwelling phenomenon are good features for the studies. In Africa, upwelling is common off the coast of Ghana.
10. Creation of conducive habitats like fish aggregation devices (FAD), fish are also fed artificially, use of light; different light intensities are applied or provided to attract fish.
    Bait – life bait or artificial baits are used to attract fish especially for the case fishes like tuna.

Methods of Catching Fish in Ponds

When fish have grown to marketable sizes, the goal of the farmer is to harvest them at the best possible time for maximum profit. The type of harvesting and time of harvesting depend to a great extent upon the market where the fish will be sold. Farmers must try and judge the desires of the market place as to the size or age of fish that are to be sold. In order to get the right size of fish, partial or selective harvesting is done. At other times a total harvest may be needed.
Catching fish by draining the pond water i.e. single or complete harvesting when the cultured fishes have grown to marketable size, the pond can be drained completely to catch all the fish at once. Modern fish ponds have a catching pond located near the outlet. This is a circular or rectangular construction or structure that is lower than the rest of the pond. A screen is placed over the outlet and the outlet is opened to allow the water to flush out. The fish follow the water and collect in the catching pond where they are either hand picked or scoped out.

In larger ponds that do not have a catching pond, the water level is reduced considerably and dragnets and scope nets are used to get rid of the fish.

Selective or partial harvesting/ cropping are done for several reasons:

(a) When there is no ready market to absorb all the fish at once
(b) When there is uneven growth of the fish and the bigger once have to be removed for sale.
(c) For sampling purposes
(d) When the farmer believes in supplying a moderate quantity to restaurants on a daily basis to spread his sales over a period of time.

In selective harvesting, gears like traps, cast nets, gill set nets, lift nets and hook and line are used. Which ever method that is used in harvesting fish from ponds fish are prone to injury, stress, and mal-handling during or after catching, so every care needs to be taken to safe guard the remaining stock after harvest, it is therefore advisable to construct separate selling ponds or tank on a farm where fish that is ready market could be stocked especially when sales are on daily bases, this will reduce destabilization of growing fish and also maintain proper feeding regime.

CHAPTER 13

FISH PRESERVATION, PROCESSING AND DISTRIBUTION

The rapid spoilage of fish after catch is well known to all fish consumers, it is also very clear that the supply of fish as food and other fisheries products are in short supply to the world population therefore the quality of any fish or fish products is dependent largely on the degree of freshness of the raw material and to obtain the best quality of the products, care has to be taken in handling the raw material so that it gets to the consumer in good condition.

Once fish is out of its natural environment and rigor mortis has passed off, various factors play upon it and cause it to spoil. Of these deteriorative factors (which include autolytic and oxidative reactions), the most important is bacterial decomposition. Shortly after fish are caught, the bacteria invade the tissues and multiply rapidly. However, the microbial condition of the fish remains subject to factors such as handling the fish at point of catch to the consumers in distant places. The sanitary condition of all surfaces that come in contact with the fresh fish; the extent of amount and type of initial infection and the temperature and time of storage matters. The intestines and surface slime of fresh fish contain high bacteria loads depending on the methods used in catching the fish. Most of these organisms produce highly potent exo-toxins present in food, and consequently are pathogenic for humans, their exclusion from fish products is therefore of vital importance.

Besides the normal inhabitants of the viscera of fish, there are also other forms of bacteria non-indigenous to fish they are collectively called feacal indicator organisms. They consist *of streptococcus faecalis* E. *Coli* and allied coliform bacteria. They occur very commonly on any material- soil, water, ice or even man that is feacally contaminated. Boat decks, fish holds and wooden boxes used to store fish on board have heavy bacteria loads unless they are properly cleaned and disinfected. It is therefore important to observe current practices in handling fresh fish and fish products as an answer to the problem of rapid spoilage of fresh fish so that fresh fish and subsequent fish products will reach consumers in acceptable forms.

The technologist's or processor's task is to make the best possible use of the raw materials available, ensuring that the consumer is supplied with the products required in the form desired. Therefore, the processor should understand both the science and the technology of the processes used so that he can modify them as needed. He should also understand market demand. Processors who can modify procedures through scientific understanding are usually called technologists; technicians, on the other hand, carry out routine processes but they are not trained to modify or improve on them. Now, and in the immediate future, there is a need to up-grade and improve many products so that they keep better, maintain nutritional value are more attractive to consumers, and are safer to eat. There is also a need to find ways of using animals not commonly eaten at present in order to devise new products.

Broad Aims of Preservation and Processing

There are two main ways by which spoilage can be slowed down or stopped: preservation and processing. Preservation methods keep the fish in a fresh state so that the changes in texture, taste and appearance, etc. are minimized. Processing methods usually change these properties so that the deterioration is slowed or halted, but the characteristics of the fish also alter according to the process used. In general, two different species of fish processed in the same way are more alike than the fresh (or preserved) and the processed product of the same species.

PRESERVATION METHODS

Bacterial and autolytic spoilage are biological systems which operate only under certain optimum conditions. Therefore, altering these conditions can prevent or reduce spoilage. As bacteria require water and are sensitive to heat, salt concentration and differential P^H values, a number of approaches can be used. Control of autolysis is effected by controlling enzyme activity. The most commonly used and practicable way of reducing autoltic action is to lower the temperature, but methods such as irradiation can be used but require high technology and costly.

Temperature control

The bacterial flora of the fish, and the enzymes present in the tissues, are adapted to the temperature at which the fish lives, i.e., about 5-10ºC in cold waters and 25-30ºC in the tropics. The bacterial and autolytic spoilage rates can therefore be reduced by lowering or raising the temperature. In broad terms, the lower the temperature the slower the bacterial and enzyme activity will be and consequently, the longer the storage life. A fish can therefore be chilled or frozen to preserve it.

1. Chilling: Chilling involves holding the fish at, or just above, its freezing point. In tropical climates, this would mean reducing the temperature of the fish from perhaps 25 ºC to 1 ºC, ice is an ideal medium for chilling and is now widely used. Wherever possible, fish should be stored in ice immediately after capture whether they are to be used fresh or dried etc. storage in ice is generally for short-term use although some species can be stored for up to one month.
2. Freezing: This is used for longer-term storage. The fish are held at temperatures below 0 ºC, though storage temperatures of - 30 ºC are usual. The much longer shelf-life is due to the following:

a. Autolytic and bacterial actions are almost completely halted at the recommended storage temperature of -30 ºC
b. Water is effectively removed by being ‘locked away’ as ice.

Freezing may be useful in a number of situations (particularly for high value products which are to be exported, or for storing excess amounts of fish in a seasonal fishery) but freezing plants are expensive and costly to run.

Use of radiation

Another method of fish preservation which has not been widely used but has been gaining in popularity is the use of ionizing radiation. Radiation in suitable does can kill the micro-organisms, insects and parasites which may be present in food and inhibit enzyme activity. Irradiation is not used commercially to any great extent because of the cost involved and consumer resistance.

PROCESSING METHODS

Raising the temperature

Generally, raising the temperature involves cooking the fish by canning, boiling or smoking, for example.

1. Canning; the fish are subjected to high temperatures to kill bacteria and inactivate enzymes. The product must then be protected from further bacterial contamination by being hermetically scaled within the can. The inside of the can must be resistant to its contents, and outside, to ambient conditions. Canned fish will keep for long periods but canning is often an expensive process. Canning operations are generally successful only on a large commercial scale for species such as tuna, sardines, etc.
2. Boiling; fish can be boiled with or without salt, to extend the shelf-life by several days under tropical conditions. Boiled fish are popular in southeast Asia. In some places, the fish are dried after boiling to give a longer shelf-life.

Removal of moisture

The moisture content of a fresh fish is about 80%. If this is reduced to about 25%, bacteria cannot survive and autolytic activity is greatly reduced. At moisture contents of 15% or less, moulds cease to grow. If stored under the right conditions, well dried fish can be kept for several months. Drying can be carried out either alone, or in combination with smoking or salting. Whether the fish are dried, smoke-dried, or salted and dried, the aim is to reduce moisture as quickly as possible, before spoilage can occur.

1. Natural drying : Fish can be dried in the sun by using the sun's energy to drive the moisture out. If the fish are very small they can be left whole but larger ones should be split to increase the surface area. The main advantage of sun drying is that the energy is free. Energy from the sun is also used in solar driers and black box drying, but these systems have so far only been used experimentally.

In colder climates, e.g. in Iceland and Norway, wind is the main drying agent. As air temperatures are low, spoilage is slower. The fish are headed and gutted (and split if large) and hung in the open air for about six weeks until they are hard and dry. This type of product is called stockfish.

2. Mechanical drying: Traditional drying by sun and wind can be slow and at the mercy of the weather. Mechanical drying allows the temperature, humidity and air flow to be controlled but the fuel, e.g. electricity or oil, required to run the heaters and fans is expensive in many countries.
3. Smoking: In many tropical countries, fish are smoked over open fires or in simple kilns to accelerate the drying process. If the relative humidity is high and salt is scarce (as is often the case in may African countries), hot-smoking, during which the fish are cooked (and often charred), is the only method of preservation available. Wood or some other local combustible product is used.

Cold-smoked products in which the flesh is not cooked are enjoyed in many industrialized areas of the world. Smoking is carried out as a means of imparting flavour to the fish rather than as a method of preservation. Refrigeration is necessary to keep these products for long periods. Cold-smoking is rarely carried out in the tropics.

Throughout the world, many different types of fish are smoked by many different methods. These range from traditional processes by which the fish are smoked over open fires or in simple smoking ovens, to improved processes using vertical kilns, and, particularly in industrialized countries, sophisticated mechanical kilns.

4. Salting: Salting is often used in conjunction with drying and smoking. If salt is rubbed into the flesh of the fish, or if the fish is placed in brine, water is removed and salt passes into the flesh. As most bacteria cannot grow in salt concentrations above 6%, salting will reduce bacterial action. There are, however, groups of bacteria which can survive in, or need a lot of, salt to develop, i.e., the halotolerant and halophilic bacteria; these can casue problems in salted fish.

Fish sauces and pastes

Fish sauces and pastes are very popular in southeast Asia. They are produced mainly by mixing fish and salt together and allowing them to ferment. This results in the formation of either a paste or a liquid which is separated from the fish solids and used for condiment purposes. Different types of fish and shrimp produce pastes/ sauces with their own characteristic flavour and odours.

Fish marinades

These are made by storing, fish in acid, with or without salt. The fish or the final product may or may not be heat-treated. The shelf-life will depend on the processing conditions; low P^H, higher salt content and heat will all tend to increase it.

Choice of processing method

The following factors need to be considered when deciding which processing method to use:

- The customer's requirements
- The suitability of the fish species for the different processing methods
- The climate
- The cost of the product
- The available facilities
- The available raw materials.

Consumer preference

The preferences of the consumer must be considered when preparing any product. This is especially important if low income groups are involved. Consumer preference can involve product type (e.g. whether the fish is salted and dried or just dried, form of presentation (whole, gutted, filleted or head-off), fish species (preferred species), and even packaging (loose or pre-packed).

It is therefore important to determine the preferences of new consumers before marketing any product. Normally, customers will only buy products which they like; at times they will even pay more money for them. However, after sufficient market research it should be possible to slowly introduce new products if they are priced competitively.

Suitability of processing method

Different fish may need to be processed in different ways. For example, large fish are usually split before salting, drying or smoking to increase their surface areas and improve the quality of the final product. Small fish, however, can be left whole. It is usually recommended that fatty fish should be salted by a method such as pickling or brine salting which excludes oxygen as this reduces fat rancidity; as white fish have less fat, they may be dry-salted.

Climate

The climate will influence the choice of processing method and may necessitate the use of ice. For example in tropical counties, fresh fish will spoil in a very short time if they are not iced, while in temperate climates, they may remain fresh for longer without the use of ice. Climate may also affect the suitability of different processes. In very humid climates it is difficult to dry fish and when the dried fish are stored, they may quickly absorb moisture from the atmosphere and spil. If a lot of salt is used, drying may be more difficult and absorption of moisture during storage may be encouraged. In this case, smoking may be more suitable than sun-drying.

Cost of the product

Different products/species are bought by different consumer groups because of differences in purchasing power. Higher income groups probably consume more fresh (fillets) or processed (frozen, canned) large fish, while lower income groups buy more salted /dried small fish because they are cheaper. The processor must therefore consider the target consumer group before deciding which process to use. A freezing plant will cost much more to build and run than a dried fish plant to frozen fish will usually be more expensive than dried fish.

Available facilities

The facilities needed to produced salted and/ or dried fish are relatively simple and are therefore available to a wide range of income groups. However, as it is much more costly to produce frozen or canned fish the number of producers is more restricted. As quality control and standards of hygiene are much stricter for high tech' products, facilities for regulating these requirements must be included. Also, a much higher degree of expertise is needed to product 'high tech' products than 'low tech' ones.

Raw materials available

The choice of processing method will also depend on the availability of fish in terms of both species and quantity. Large-volume plants will either need to own a fleet, or be sited near a large fishing harbor. If the target species is seasonal, storage facilities may be necessary to ensure supplies during down seasons; alternatively, the plant may need the capacity to produce a different product during these periods.

Guides to Good Handling of fresh fish

The following recommendations are important in handling fish that is meant for preservation, processing and storage:

(a) Fish should not be thrown aboard as tears and bruises accelerate the process of spoilage, careful handling should be exercised. Sufficient ice of high bacteriological quality should be used in the ratio of 1.1 (ice-fish) soon after fish are caught and washed.

(b) All materials and surfaces that come in contact with fish should be kept in good sanitary condition.
(c) Fish. Ice and materials for insulation should not be contaminated with soil, at all material stages of fishing, handling, transportation and marketing.
(d) Just as for meat, a fish inspectorate unit could be set up, aimed at preventing spoilt fish form being sold in the market.

The Distribution and Marketing Channels of Fish in Nigeria

Goods are produced where conditions are suitable for them i.e. Geographical specialization. e.g. specific crops are grown where climate is best suitable for them. Fish is produced only where there is water but there are consumers or middle men who may take these to persons who desire to purchase or use them regardless of where they are located. This general movement or distribution of goods is called marketing. A distribution or marketing channel is therefore the means through which goods are distributed until they reach the consumer.

Storage and Transportation

For long distance transportation, sufficient ice must be used to keep the temperature low. A layer of fish placed at the bottom of container and in between the layers of the fish. The containers should not be too deep to avoid crashing of the fish at the bottom.

Storage – is aimed at prolonging the keeping quality of the product no matter what method of processing is used. If the method used involves icing the temperature of the product must NEVER be allowed to exceed the initial one otherwise the fish will spoil.

If the method used is the one involving the removal of moisture. E.g. smoking or drying, the moisture content at storage should be kept as low as recommended (10%). Attack by beetles should also be avoided.

EXTRA CHAPTER (16)

CULTURE TECHNIQUES FOR TILAPIA FISH

Management of Fish Farms/Pond

This chapter treats the farm culture and management of tilapia species due to its unique characteristics. They are a conspicuous element in the fresh water fauna of Africa and Tropical America, it is highly successful in abundance of individuals and can live in a variety of habitats and their ways of life range from predator to plankton feeder and from pelagic to permanently bottom living fishes. The above qualities make it the easiest fish for aquaculture. The fish reproduces at interval of ninety days and can dominate any other species population within a short growing period. The fish is therefore cultured for sale and as food for other farmed fish.

The net effect of fishpond management is to increase fish production. This is done by creating an environment that is conducive for production e.g. making liming nutrients available in the pond through such practices as supplementary feeding, fertilization etc. making efficient use of energy sources e.g. through polyculture where the various trophic levels are utilized mainly for growth and not for struggling for food.
Generally, pond management techniques include pond, preparation, stocking, pond fertilization, supplementary feeding, stock manipulation, control of disease, weeds, predators and the control of water quality. In nature, the fish are left at the mercy of predators like snakes, etc. and there is a lot of competition for food from other organisms that inhabit the water column. The elimination of these enemies is important for healthy development of the pond system. The above therefore explains the need for management of farms/ponds.

Distribution/Occurrence:
From the point of view of human nutrition, Tilapia was already firmly entrenched as one of the worlds most important fish by the start of the twentieth century, but with greatly increased emphasis on fish culture in this century, plus the advent of modern transportation Tilapia became even more available to man. Today no fish, with the probable exception of the common carp (Cyprinus carpio) is more widely cultured than Tilapia. As early as the 1920's experiments, in Tilapia culture were being carried out in Kenya. Tilapia had become an inter- Continental traveler by 1939 when naturally propagating stocks of Tilapia Mossambica native to the streams of Africa's east coast, were discovered in Java. No one is quite sure how they got there, but it is likely that they were discovered by those who have long been intrigued by bizarre "Mouth brooding habits of this and most other Tilapia species, were implicated, however, Tilapia Mossambica arrived, they made themselves at home and abroad rapidly throughout the island. So prevalent did they become that, despite the geographical reference in the scientific name, the generally accepted common name for *Tilapia Mossanibica* is "Java". They were originally regarded as a nuisance but when facilities for the traditional Indonesian practice of milk fish (chances chanos) culture began to deteriorate under the Japanese occupation, the less demanding nature of Tilapia were not only too well established in the waters of Java but too deeply entrenched in Indonesian fish culture for anyone to consider control measures against them.

The Japanese, always a nation cognizant of the nutritional possibilities of fish, helped spread Tilapia throughout Indonesia, where today it is found in virtually everybody of water, including ditches stagnant pits where a few other fish of value can be grown. The Japanese also introduced Tilapia to other Malasiya, from where it spread throughout South East Asia, achieving considerable importance as a food fish in virtually every country.

Today due to the enthusiasm generated by the research of such men as H. S Swindly at the Aurbun university in Alabama and C. F. Heckling at the tropical fish. Culture Research Institute in Malaysia, plus the Missionary efforts of such organization as FAO and the peace Corps, the Java Tilapia and its congeners are cultured, at least experimentally, not only in South- East Asia, but in Japan, Asiatic Russia, the Indian sub-continent, the near east, virtually all of Africa, part of Europe, the United State and many of the Latin American Countries. Tilapia belongs to the group of fish in the families of Africa, part of Europe, the United States and many of the Latin American countries.
Tilapia belongs to the group of fish in the family Cichlidae. Cichilids are perch like fish which have produced an enormous variety of species in African waters. Many of them are characterized by extremely specialized feeding habits, which have enabled them to live in peculiar environments. Tilapia have very deep, laterally compressed bodies. Their scales are large, usually Cycloid and they have double lateral line: one starts near the head but instead of running continuously to the tail, it stops almost at the same level with the posterior end of the dorsal fin and a second lateral line begins underneath it and continues to the tail.

The dorsal fin consist a spiny first half which is followed without a break by the second half which has soft branches. At the base spot, which is more pronounced in some species than in other, and is they incudes: *Tilapia monody; Tilapia nilotica; Hermchromis bimaculatus; Tilapia zillii Tilapia melanopleura; tilapia mossambica and Oreochromis Niloticus*

Tilapia, for at least 6,000 years, have been kept in ponds as a source of human food many species show ideal characteristics for a domestic pets, they are easy to handle, they breed rapidly under controlled conditions, are tolerant to stagnant or salty water and there is no problem of getting fry for other ponds. Tilapia also has high quality flesh.
All tilapias are more or less herbivores, some prefer higher plants, whereas others are adapted to feed on plankton. Some Tilapia are relatively omnivorous and will benefit from artificial feeding with vegetable materials and in some cases even accept animals food if nothing else is available; others are obligate herbivores, some microphyte feeders are sufficiently veracious to function well as biological weed controls whereas others are useless in this capacity.

Spawning and Growth of the Young; Most forms of fish culture, obtaining spawn is one of the most difficult tasks. Tilapia present no such problem; indeed it is difficult to prevent them from spawning. The fact is that it takes no skill whatever to spawn tilapia in ponds, it is one of the reasons they have been promoted as a fish for sustenance culture.

Methods of controlling over-population in Farmed Tilapia; Mouth-brooders or not, over-population is the greatest problem encountered in raising any species of Tilapia. Some people argue that there is no need to acquire technical know-how in the culture of Tilapia. But since over-population results in stunted growth and size of real market value, it is necessary to acquire some technical know-how in order to raise tilapia to table size.

Classical methods of preventing over-population and stunting include:

(a) Separation of parents and young; this is done by making use of drainable spawning pond structures like the fry pond. When the eggs are hatched, the adults are disturbed so that they release the larvae, which drain into the fry pond. Different sizes of fry may then be cropped from the fry pond for further use in culture from time to time.

(b) Polyculture with predaceous fish- fish like lates niloticus at the ratio of 3000T: 3L has been found yield 6000kg/ ha. with 95% of the fish weighing 6kg. Control of population has also been found be effective by polyculture with G*ymnarchus nilotious, hepsotus odoe* etc.

Monosex Culture- Tilapia in ponds present problems which can be solved if the pond is stocked with only males. It is possible to sort out the different sexes by hand. (The structure of the genital papollae is indicative of sex. In males there is a single urogenital opening on the tip of the papilla; in females the genital opening is separate and located on the frontal wall of the papilla, close to the apex). This method has the disadvantage of being laborious and even experienced workers can only achieve 80-90% accuracy. Male tilapia grow bigger and faster than their female counterparts. This is why attempts to produce mono sex stocks of tilapia have generally concentrated on obtaining males. Unlike females, males continue to grow during breeding periods. The males however have one disadvantage; whether or not there are females present, they go ahead to construct nests at the base of the pond bank, and the nest-building activities of a great number of males may eventually undermine the bank.

Another simple technique is to use stock of tilapia spp. that are not allowed to mature quickly. In this way, before they become over-populated, the pond will be harvested.

Cage culture appears to offer a solution to the problem of controlling spawning in tilapia. Since all species dig nests at the bottom of ponds, and this is obviously not possible in cages the technology for this type of farming is relatively simple, since no hybridization of pond management would be needed in order. Even uneducated fish farmers can operate the system.

Tilapia has the following favourable qualities:

(a) It is the commonest and easiest fish obtainable in Nigeria, one does not need much money or technical know-how to set up a Tilapia hatchery.

(b) It is a hardy fish with a high reproductive rate, it can live on almost all kinds of organic matter be they from man, animal or plant.

(c) The nutritional value of Tilapia compares favourably with that of lean meat. Carlories protein

Tilapia 32Kals / g 2.9.7

Lean meat	38 Kal / g	20.6

Tilapia has high yield per hectre. Yield of 5000 kg/ha/yr or more can readily be obtained at minimum cost.

Stocking system in Tilapia Culture;

Monoculture- except for very primitive subsistence culture, or in waters that will not support other edible fish. Monoculture of tilapia for human consumption can hardly be defended. However monoculture is practiced on a small scale especially in rice fields (120-190) fingerlings/ ha where care should be taken to use plankton and algae feeding species, since marcrophyte feedings spp. might destroy the rice crop.

Polyculture- Tilapia produces no problem in polyculture with other fish communities. They are stocked with other fish and no case of education in the initial stocking rate has ever been reported.

Stocking Rate- Most of the reported stocking densities for tilapia are lower than necessary, at least where mono sex culture is employed. The problem of excess small fish in tilapia ponds is more closely allied to excess reproduction than to initial over stocking. Experiments show that, up to a weight of 50gm, fry did not suffer retarded growth at densities as high as 800/ha. Above that size it is necessary to transfer them to rearing ponds at much higher stocking densities at 20,000/ha and well fed gave a production of 2822kg/ha in 196 days.

Management of tilapia ponds

The practice of segregation of different ages of fish in nursing rearing. And growing ponds, so prevalent in culture of species where spawning is strictly controlled, is rare in tilapia culture. This is because it is difficult to control spawning in tilapia ponds. However, fry, may be nursed from 6 weeks to 2 months until they begin to breed, in 0.01 to 0.1 ha ponds. Pre practice of aggregating different ages of fish in nursing, rearing and growing ponds will become important in tilapia culture especially in mono sex culture.

Pond fertilization- Is important in Tilapia culture particular the plankton feeding species since fertilization promote the growth of phytoplantonic organism which forms the base for food production of these herbivorous fishes. 0-8-2 (NPK) has actually been found to more effective than mixtures containing nitrogen compounds.

Supplementary feeding – is important in Tilapia culture but it is little understood. It is particularly essential for success in large scale, culture of Tilapia among the feeds employed are rice brain, broken rice, oil cakes, flow, corn meal, kitchen refuse, rotten fruits and a variety of aquatic and terrestrial plants.

Harvesting and marketing – of Tilapia is usually done by seining or where feasible, pond draining. In most places where tilapia is cultured, it is marketed fresh or may be iced but it may also be sold frozen. In Africa the commercial value of tilapia largely depends on size. Tilapia too small to be marketed is usually employed as ingredients in livestock feeds or as bait in commercial fishing.

Diseases and parasites – Diseases and parasites are somewhat less of a problem with tilapia than with many cultured fishes. Among the parasites found in tilapia are *trichodina*. *Chilodon* and *asprolegna*. The only disease mentioned in the literature is bacterial fin rot. Tilapia also act as carriers of *catannal enteritis*.

The focus on Tilapia was because of its availability, prolific growth in population and easy management. Any beginner can start a fish farm with its culture and when a farmer get used to its culture one may find it easy to grow other fish species.

The techniques Available for fish seed production;

Fish seeds are fish of small sizes (fingerlings) that are used in stocking fish ponds. There are generally two main methods available for obtaining fish seeds ;

(a) Fish seeds (fry and fingerlings) can be collected from the wild (i.e. steams rivers, lagoons etc) where the fish spawn.

(b) Fish seeds are also produced in fish hatcheries but this method require adequate skills for the techniques. There are three techniques used in fish hatcheries they include:

- Natural spawning without inducement; in this case ripe breeders or spawners are brought together i.e. confine in tanks (concrete or plastic) to enhance the chances of survival of the hatchlings. Conducive conditions are created for this to happen. E.g. optimum temperature good quality feeding etc.
- Induced natural spawning; spawners are brought together as in above but they are not allowed to spawn naturally. Hormones responsible for the raising of the concentration of sex products in the blood stream of the recipients are injected into the fish to accelerate the process of spawning. This act induces the spawners to release their sex.
- In a healthy state. When the breeders are finally confirmed ripe, their sex products are stripped from them and mixed in clean containers and incubated at the right temperature to ensure a high degree of fertilization.

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