LECTURE NOTE

ON

FISHERIES STOCK ASSESSMENT (2 UNITS)

FIS 318

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FISHERIES RESOURCE

Nigeria has an 853km coastline and an maritime water of 210,900km^2 including the Exclusive Economic Zone (EEZ). The continental shelve is narrow, extending, for only about 15km in the western area and ranges from 60 – 80km in the eastern tip. This conditions limits the trawlable grounds to 3200nm^2 of the 1147nm^2 continental shelf area. The inshore waters (0 – 50m) are characterized by a variety of small fish species varying from 25 to 50cm in total length. The most predominant is the Pseudotolihus. Estimated potential yield of the inshore waters is about 16620mt for finfish and between 3500 – 4020mt for shellfish resources, which are exploited by both the artisanal and industrial operators, the potential fisheries resources are estimated at about 9460mt, and consists of mostly tuna and tuna-like fishes.

More than 90 percent of recorded fish production in Nigeria emanates from the artisanal fisheries sector (marine, brackish and inland or fresh water). The principal pelargic fishes in inshore artisanal catches are bonga (Ethmalosa fimbriata) and sardine (Sardinella Maderensis) while the most common semi-pelagic is the shad (Ilisha Africana). Maximum sustainable yiels (msy) for pelagic fishes at sea in Nigeria was put at 60,000 tonnes while Ajayi and Talabi (1984) Summed up the yield of the fishery in coastal and brackish waters to be 70,000 – 90,000 tonnes. Although, an annual landing of 40,000 tonnes was projected for the fishery at sea during 1975 – 1980, far less catches were made.

PRODUCTIVITY AND FISHERIES

A brief examination of the basic structure and production of life at both inland and coastal water is necessary precursors to an understanding of the distribution of fisheries resources and to a study of the population dynamics of the exploited species of fish.

Between the various groups of animals, there is a flow of material through predator – prey relationship. All animals including fishes, act as predator to some species and prey to others, and as, in terrestrial ecosystems, life in the sea is dependent on plants.

In shallow coastal areas marine plants may include large algae and flowering plants such as sea grasses, but in the sea primary productivity is carried out by microscopic plants, coccolithophores, diatoms, dinoflagellates, collectively called phytoplankton. The phytoplankton, the largest individuals of which are less 1mm in length, float and drift in the photic zone, the sunlight surface layers of the sea. Here photosynthesis involves the taking of CO_2 and the nutrients, particularly phosphates and nitrates.

The resources of Nigeria can be grouped into finfish and shellfish resources, which is divided into the coastal fish stock and fresh water fish stocks. The coastal fish can however be sub-divided into two geographical strata such as coastal demersal (seawater) and brackish water fish stock (Coastal Fringe Zone) (Akegbejo – Samson, 1997).

COASTAL DEMERSAL FISH STOCK

Coastal demersal fish stock are found not to be location specific but residing within and outside offshore and inshore coastal areal of Nigeria with respect to where they occupy, these resources can be divided into three groups: - Sciaenid community, Sparid community and Slope community. Generally, about 30 percent of landed fish in Nigeria coastal area from sciaenid community, most especially the croaker (Pseudotolithus Senegalensis and Ptypus) the clupeid, (Ilisha Africana), the big eye (Brachy deuterus aurita); the silver fish (Trichurus lepturus) e.t.c.

BRACKISH WATER FISH STOCK

The main brackish water areas in Nigeria are found along the coastal zone, which are characterized by, expansive estuarine, Lagoon and Mangrove swamp fronted by beach ridges barriers. This extends from the Lagos Lagoon through Mahin in Ondo State to the Niger – Delta in the South – East of Nigeria. The common species found here include: Mugil SPP (Mullet), Tilapia SPP, Chrysichthys nigrodigitatus Ethmalosa fimbriata (bonga), Sarotherodon melanotheron. e.t.c.

FRESH WATER FISH STOCK

The Niger – Benue cycle of rivers with adjoining flood plains, the Kainji and Chad lakes and the numerous ponds, reservoir and dams constitute Nigeria fresh water environments. Major commercial fish species in the Kainji lake include the following: - Sarotherodon niloticus, Tilapia, zilli, Clarias SPP, Chrysichthys auritus, bagrus Bayad, e.t.c. while in the Nigeria sector of the CHAD, species of commercial valued include: Lates niloticus, Clarias lazera, Hydrocyanus brevis Hyperopsis bebe (Akegbejo – Samson, 1997)

SHELL FISH RESOURCES

The shellfish resources of Nigeria coastal and marine water includes: Prawn and shrimps (e.g. Penaeus duorarum (pink shrimp), para penaeus longirostries, palaemon hestatus, panulirus regius e.t.c.) crabs, lobters dan mollusks [gastropods bivalves and cephalopods].

WHAT IS FISH STOCK ASSESSMENT?

By definition, a fisheries stock assessment is an evaluation of the state of stock as relating to changes in the abundances or composition of the stock to the changes in the amount of fishing. This involves the use of theories, laws, models and methods propagated by various scientists. There are various terms used in describing the state of fish stock in water. These include:-

1. Steady state: If the stock is the same year in, year out or year after year.
2. Cyclical state: If the stock is varied but catches are predictable.
3. Irregular state: If the catches are unpredictable
4. Sparrmodic State: In this case, the stock develops, collapses and reappears some other times.

There are various models or approaches used in conducting FSA

1) Analytical models / approach
2) Holistic models.

TYPES OF MODELS / APPROACH USED IN CONDUCTING FISH STOCK ASSESSMENT

ANALYTICAL MODELS

These models required to age composition of catches to be known e.g. the number of one year old fish caught, the numbers of 2 years old fish caught, e.t.c. The basic idea of the model may be expressed as follows:

a) If there are too few old fish, the stock is over fished, fishing pressure on the stocks should be reduced.
b) If there are very many old fish, the stock is under fished and more fish should be caught in other to maximize the yield.

Therefore, one can say, analytical models are agestructured model working with concept such as mortality rate and individual body grown rate. But, the basis concept in age-structured models is

that of Cohort. A Cohort of a fish is a group of fish all of the same age belonging to the same stock.

HOSISTIC MODEL

These are less data demanding methods of assessing fish stock. These methods disregard many of the details of the analytical models. They do not use age or length structures in the description of the stock but consider the stock has a homogeneous biomass.

Types of Holistic Model

- Swept are method
- Surplus production model

Swept Area Method: this method is based on research trawl survey catches per unit of area, from the densities of fish observed (the weight of fish caught in the area swept by the trawl), we obtain an estimate of the biomass in the sea from which an estimate of Msy is obtained.

Surplus Production Model: this uses catch per unit effort i.e. weight of fish caught per hour per trawl. The data usually represent the series of years.

WHY FISH STOCK ASSESSMENT?

The basic purpose of stock assessment is to provide information or advice on the optimum exploitation, utilization and conservation of fish as aquatic resources living in waters. It involves conducting research work into knowing Biological characteristics of particular fish species taken length, weight, frequencies, reproductive Biology, food and feeding habit, the age and growth parameters and other conditions of fish in relation to its aquatic environment.

It is also used to know the Maximum Sustainable Yield (MSY), fish morality, the input and output into the fisheries.

To conduct fish stock assessment, scientists embark on investigation, involving survey. First, the site must be defined whether marine or fresh water environment or whether it is a small or large water bodies. The various survey carried out are: Research survey, Commercial survey and Frame survey.

TYPES OF SURVEY IN FISH STOCK ASSESSMENT

RESEARCH SURVEY

This involves a detail investigation of the fish-based on the objective. These may involve taking the bio data of the fish (length, weight, sex, age e.t.c.). The food of fish including percentage composition which includes: environmental features like weather, time, position of catch, physio-chemical parameters of the water body.

COMMERCIAL SURVEY

This involves taking note of basic and important information of commercial usefulness e.g. length, weight, frequency, percentage composition of spp, which strictly for economic purpose e.g. has done by fishing company. This method is biased because most vital information regarding either missing or deliberately not investigated e.g. most commercial data are devoid of information on actual composition, landing and position. It is believed that such information bay be used as indication for taxation and to avoid rivalry with other company.

The data collection also depends on the size of the water body. If it is small body of water i.e. pond, total cropping can be done which involves the removal of all individual fishes in the water but for a large body of water e.g. lakes or reservoir, randomized sampling can be done which involves taking sample in random location.

DATA COLLECTION PROGRAMMES.

The need for regular review of assessment programmed is imperative. Lake and reservoir fisheries may change rapidly, through changes in the stocks, the quality of the water, the population in the catchment area, or introduction of new fishing technologies. Managements objectives must be regularly evaluated and re-defined and assessment programmes altered to account for changes, if required. In Lake Malawi, for example, assessment programmes designed in the 1970's focused on large, commercially important species such as the cyprinids (Labeo mesops). This species is now absent from commercial catches, which are presently dominated by small cichlids, many of which are not recorded by genera or functional group and have not been studied (Tweddle and Magasa 1989). The fisheries data collection programmes must now re-allocate resources to emphasis the study of these more important fisheries.

DISSEMINATION OF STOCK ASSESSMENT RESULTS

Scientists engaged in stock assessment studies should make every effort to ensure that their work is published in a form available to others. While not every study is of sufficient general interest to be published in primary scientific journals, all well documented studies carried out competently are likely to be acceptable for publication in natural and regional journals, regional and international workshop proceedings, or as experience papers in international departmental reports, where results remain unavailable to others. Both FAO and ICLARM are supportive of publications in tropical fisheries, and may provide assistance in publication and distribution of reports.

Presentation of the assessment to manager must be concise simple but sufficiently comprehensive to allow them to make a decision based on the evidence, including an estimate of the risk attached to each decision, derived from the uncertainty in the data and assessment models.

METHODS OF FISH STOCK ASSESSMENTS.

There are various methods used in assessing the fisheries resources of our inland water i.e. fresh water which may include large lakes, reservoirs e.t.c.

These methods includes.

- ❖ Experimental gill – net method
- ❖ Standing crop method
- ❖ Estimation of abundance under which we have

I. Catch assessment survey
II. Abundance estimated by catch per unit effort.
III. Estimation by direct enumeration
IV. Change in ratio estimation
V. Mark recaptured methods / marketing and tagging

EXPERIMENTAL GILL – NET MEHTOD

Experimental gill – net survey using a standard fleet of gill nets with graded mesh sizes comprising 25.4, 50.8, 63.5, 76.2, 88.9, 101.6, 127.0, and 177.8mm stretched mesh sizes. The 25.4mm mesh et was added to the traditional sampling fleet of seven mesh sizes (2, 2 ½, 3, 3 ½, 4, 5 and 7 inch stretched mesh sizes) each measuring 30meters long and 3meters deep giving a total fleet surface area of $630m^2$. The catch per fleet was usually extrapolated to catch per $1{,}000m^2$ of net surface area for the purpose of standardization of the catch per unit effort (catch per night). The 25.4mm (1 inch) mesh was added for the purpose of compiling a complete list of species in the reservoir including the small adult species not usually captured in 50.8mm (2 inch) stretched mesh size.

STANDING CROP METHOD.

Cove rotenones sampling using fish toxicant were usually conducted in the larger reservoirs in the country not utilized, for drinking water. The survey involved the blocking of unit areas of the littoral zone preferably coves or inlets and applying the requisite amount of fish toxicants to kill

all the fish in the blocked area. The total number and weight of fish collected in the blocked areas were then scaled up to biomass or standing crop per hectare of the shoreline sampled.

Often, the station chosen in most lakes for rotenone survey corresponded with the stations sampled with the gillnet fleets. In most cases, the two surveys were conducted simultaneously for purposes of direct comparison.

The comparison was also intended to save cost and labour in the field surveys if it become possible to extrapolate one from the other. As a matter of caution it is not advisable to conduct cove rotenone survey in a small drinking water reservoir.

ESTIMATION OF ABUNDANCE

Estimation of abundance is one of the most interesting aspect of fish Biology. The mobility of fishes couple with their invisibility due to cover (water), habitat preferences that can only be survey on a piece meal business presents an enormous challenge to the Biologist who must know how many fishes are present in a given population. Because direct enumeration is rarely possibly, Biologist generally use estimation of population catch based upon some kinds of survey procedure rather than a census.

General method of Estimation Numeric Abundance of fish are:

- Estimation from catch statistics / catch assessment survey
- Estimation by direct enumeration
- Change in ratio method
- Mark recaptured method

ESTIMATION FROM CATCH STATISTICS / CATCH ASSESSMENT SURVEY

Statistical catch assessment survey of the commercial fisheries were usually conducted simultaneously with the experimental gill net survey in order to determine the total number of artisanal fishermen exploiting the fisheries of the small lakes and their mean catch per boat. The

objective of such a comparison was to establish some relationship between the catch per boat in commercial landing the catch per 1,000m^2 of graded fleet of net in experimental surveys.

This was intended to cut down expenditure in field surveys by using one to extrapolate the other.

ABUNDANCE ESTIMATED BY CATCH PER UNIT OF EFFORT (CPUE)

The CPUE is the number or the weight of fish caught per a unit of effort. This is usually a measure of quantity such as wet weight of fishes, the number of or number of baskets. When the CPUE is then combined with he appropriate activities level, the answer gives us the yield. If the length of the gill net used is low, CPUE could be recorded in units such as Kilogram per 100 meters of nets per day, Lobster caught per trap per day or at 24hrs and demersal fish caught per hour of trawling. CPUE is also fishing efforts required to yield a certain catch in Kg/day. The mean average of this is then calculated for the whole lake or each stratum (this means that the river is divided into different layers) the sum of that weight of all the fishes gives the catch in Kilogram.

$$\text{CPUE} = \frac{\text{Sum of the weight of all species or number of species}}{\text{Types of gear used}}$$

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ESTIMATION BY DIRECT ENUMERATION

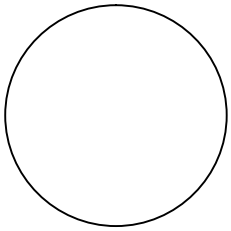
In this method, suppose we know the boundary of the total population space but we do not know how the population is distributed in this space, we arbitrarily divided the space into "A" equal spaces and select "a" of these to enumerate completely. The experiment yields error free numbers N_1, N_2, N_3 …..... Na for the spaces up to a 1, 2, 3, …… (a). Then, if this is the population of the samples, we now have

$$N = \sum_{i=1}^{A} Ni \quad \text{and then our estimate of N becomes } \hat{N} = A \sum_{\substack{i=1 \\ a}}^{A} Ni$$

The whole population divide by 3 i.e No. of As and multiply by (a) gives the total population.

$$\tilde{N} = A \sum_{i=1}^{a} Ni$$

This estimate is valid whether the population is randomly dispersed in space or contagious by distributed, (over dispersed) or uniformly distributed, (under dispersed).



CHANGE IN RATIO ESTIMATION

Method of this type has been variously known as change of compositions, survey removal or dichotomy method. The basis for this method is an obscene change in the relative abundance of 2 classes of animals within a population. The chases may be naturally occurring group such as age, species or sex classes or they may be artificial constructed classes such as market fish. The nature of the change in ratio of the classes allows us to estimate population abundance on survival e.g. in a situation where males of females might be selectively removed is evident in the equation:

$$\frac{\text{(No. of males before removal) – (No. of males removed)}}{\text{(population size before removal) – (Total No. of animal removed)}}$$

Note that, the signs in the word equation depends upon whether fish are entering or leaving the population.

MARK RECAPTURED METHOD MARKING AND TAGGING.

A mark is defined as any factor or feature that makes a fish identifiable either as an individual or as a member of a batch. It could be artificial e.g. mutilation of fins, addition of tags or naturals e.g. genetic maker or DNA in the body of parasite.

Tagging involves the use of a tag to identify an individual fish. A tag can bear a serial number, which converse an advantage for its use. Marketing fish enable scientist to estimate their number in directly and to monitor the growth or fate of the labeled individual fish.

The main uses of tagging involves:

1. Studies on population parameters e.g. in densities, mortality rate, rate of exploitation, rate of recruitment e.t.c.
2. Studies on movement and migration
3. Age determination and growth
4. Behavioural work and other studies for recognition of individual involved. Effective and ideal marking method should permanently and unmistakably recognized the fish and the method should be in expensive, easy to apply infield condition and have no effect on the fish growth, mortality, behaviour, liability to rapture by predators or fishing gears or its commercial value.

MARK AND RECAPTURE

Mark and recapture is a method commonly used in ecology to estimate population size and population vital rates (i.e. survival, movement, and growth). This method is most valuable when a researcher fails to detect all individuals present within a population of interest every time that researcher visits the study area. Other names for this method, or closely related methods, include **capture-recapture, capture-mark-recapture, mark-recapture, sight-resight, mark-release-recapture** and **band recovery.**

Another major application for these methods is in epidemiology, where they are used to estimate the completeness of ascertainment of disease registers. Typical applications include estimating the number of people needing particular services, say services for children with learning disabilities, services for frail elderly living in the community, or with particular conditions, say illegal drug addicts, people infected with HIV, e.t.c.

Field work related to mark-recapture

Typically a researcher visits a study area and uses traps to capture a group of individuals alive. Each of these individuals is marked with a unique identifier (e.g., a numbered tag or band)., and then is released unharmed back into the environment. This technique was originally used by Meiron, Naaim Salam and Nick Darling in 1894.

Sufficient time is allowed to pass for the marked individuals to redistribute themselves among the unmarked population.

Next, the researcher returns and captures another sample of individuals. Some of the individuals in this second sample will have been marked during the initial visit and are now known as recaptures. Other animals captured during the second visit will not have been captured during the first visit to the study area. These unmarked animals usually are given a tag or band during the second visit and then are released.

Population size can be estimated from as few as two visits to the study area. Commonly, more than two visits are made, particularly if estimates of survival or movement are desired. Regardless of the total number of visits, the researcher simply records the date of mathematically to estimate population size, survival, or movement.

Population estimates using a mark-recapture technique in Aquaculture

Background: Quadrat counts are a typical method for estimating the abundance of a sessile organism, but many ecologists study organisms that move. To estimate the population size of mobile organisms, one commonly used method is the mark-recapture technique. This involves

first capturing and marking a sample of organisms and then recapturing them and counting the number that have marked. As discussed in lecture, there are many variations on the basic technique as well as many assumptions involved in each specific method. In this lab, we will use the Petersen method to estimate the population size of the common water strider, *Gerris remigis,* at two locations along a small in Tilden Park.

G.remigis (Order: Hemiptera; Suborder: Heteroptera (true bugs) is semi-aquatic, living on the surfaces of ponds, slow-moving streams, marshes, and other quiet waters. The front legs of water striders are short, modified for grasping and used strictly for capturing prey. The middle and hind legs are long and thin, allowing the water strider's weight to be supported by surface tension. It skates across the water by synchronous, oar-like movements of the middle legs, which are longer than the others, while steering with its hind legs. A water strider's legs are covered with thousands hairs that render them effectively non-wetting. This property allows it to freely remove its legs from the surface to row. A water strider's weight is balanced by a surface tension force more than ten times its weight. This large margin of safety allows the strider to freely lift its legs from the surface during rowing or to support the weight of a companion without falling through the surface.

Gerrids are predaceous, feeding mainly on insects and other organisms that fall on the water, but they can also catch aquatic insects (e.g. mosquito larvae) that swim near the surface. Adult *G.remigis* are 14-18mm long; females are approximately 50% larger than males. In breeding season, water striders communicate by sending ripples to each other on the surface of the water. Females lay eggs at the water's edge, usually on plant stems. When eggs hatch, nymphs must grow for over a month before molting to the adult stage. In central and northern California, gerrids overwinter as adults in leaf litter or protected vegetation along shores. Certain species exhibit wing dimorphism, with shorter-winged morphs occurring in more permanent aquatic habitats.

Field instructions: the goal is to mark and recapture as many water striders as possible. To facilitate this, we will divide into two groups of four with each group performing the same tasks, so as to increase our sample size.

Day 1: Marketing

At each of the two study reaches, we will collect, mark, sex, measure and release a large number of water striders. Use the following procedure:

1. Catch water striders with an aquarium dip net, and place them in a plastic box containing about an inch of stream water. To prevent the striders from escaping, be sure to keep the lid closed between captures.
2. When you have finished capturing the sample, transfer individuals to a second plastic box that is lined with paper towels. This will allow them to dry for marking.
3. First measure and then mark each individuals, placing them in a second paperlined box to insure that the marks dry. Measure the length of each individual tip of rostrum to tip of abdomen), determine its sex (see handout), and then mark the dorsum with a small dot of "whiteout". It is critical to avoid getting whiteout on the ventral plastron, as this will kill the gerrid. The length and sex of each individual should be recorded.
4. When the entire sample has been marked, release the striders in the pool where they were collected.
5. Using quadrants, estimate the area of pools occupied by the sampled population of striders.

Day 2: Recapturing

1. Using the aquarium nets, capture as many striders as possible from the sampled pools, placing them in plastic boxes containing about an inch of stream water.
2. Examine each striders for a whiteout mark, determine its sex, and measure its length as above.
3. When sampling is completed, return the striders to the sampled pools.

Data analysis: In the computer lab, use Excel and the Peterson method equations to answer the following questions:

1. What is the estimated density of striders in each study reach? Determine the 95% confidence intervals for these estimates following the procedures in Krebs.
2. What is the sex ratio of striders in each of the study reaches? Does it differ statistically from 50:50?

3. Plot a histogram of the size-distribution of strider at each site. What is the average and variance in length in each of the study reaches? Using 2-way ANOVA, determine if strider gender and / or site significantly affect average strider size.
4. Using a chi-squared test, determine if males and females were recaptured with equal frequency?

AIDS TO FRESH RESEARCHERS IN FISH BIOLOGY

Data collection in Fishes

This chapter is included for the benefit of readers (especially research officers and students) who may wish to undertake a study on fishes or fish biology. There are various aspects to investigate under the subject, for instance, fish physiology, parasitology, ecology, population studies, nutrition, genetics, e.t.c. are different aspects that can be studied. There are few items of basic information which are common to all these aspects and which are necessary in order to collect meaningful data. These are discussed below. A data chart, (Table 10.1) is necessary.

1. Size measurement

A measuring board graduated in centimeters or a long ruler fixed to a table is needed for size measurement. In the measurement of fish length, the standard length, fork length and total length are often measured (see fig 10.3). It is advisable to use the standard length because sometimes the tip of the tail might have been chopped off by predators or taken off by other means. Such tails will not give reliable results. Also one may wish to know the girth of the fish and the length of the head. Girth measurement is necessary in considering mesh sizes of fishing nets since the girth is the widest part of the body. The width of the mouth may be measured by opening up the mouth to its maximum width. This is important in estimating the possible size of preys.

Key

AB	-	Preorbital length
AD	-	Head length
BC	-	Eye
CD	-	Postorbital length
EF	-	Length of pectoral fin
GP	-	Depth of body
HI	-	Base of anal fin
JK	-	Caudal peduncle (length)
KL	-	Caudal fin length
MN	-	Length of rayed dorsal
MO	-	Depth of dorsal
MQ	-	Base of spined dorsal
AK	-	Standard length
AL	-	Total length
AL^{I}	-	Fork length

There is always a relationship between the gape of the mouth and the size of prey. Sometimes the distance between the fins and the tail or head and between one another is used in taxonomic study. The length of the gut is useful when placing fish in trophic groups. The diameter of the

eyes, the position of the anal opening in relation to the tail and the head are also of taxonomic importance. All measurement should be expressed in millimeter (mm) or centimeter (cm).

2. Weighing

The weight of the fishes should also be obtained in grammes or kilogrammes using a spring balance, either the hanging type or the top-loading type. Sometimes more sensitive electronic weighing balance (e.g mettle balance) is required when weighing balance (e.g mettle balance) is required when weighing small materials like stomach contents, gonads, tissues, e.t.c.

3. Sex of fish

Because the sex of fish affects a various aspects of the fish life-food, rate of growth, size at maturity, parasite infestation, e.t.c. – it is often necessary to determine it as well as the stage of gonad development, and the ratio of the gonad to the body (gonado-somatic ratio).

In some cases, the sex of fish can be determined by the examination of the external features. For example, male and female Tilapia, Sarotherodon and Oreochromis spp. can be identified by merely looking at the papillae: there are two orifices (openings) in the papillae of female and one in male. In most catfishes the male has an elongated papilla whereas the female has a short rounded vulval. Many other species do not show differences of this type. Colour difference is only reliable during breeding in some cichlids. The family Cyprinodontidae also shows marked sexual differences, in that male have larger fins than female. Besides these few examples, male and female can only be identified by examining the gonads and this involves the dissection of the fish.

In the very young specimens when eggs are not yet produced, the gonad can be differentiated by their shape. The female gonad can be differentiated by their shape. The female gonad (ovary) is wider posteriorly and tapers anteriorly, while the male gonad (testis) has the same width almost throughout its length. In bigger specimens, the female can be recognized by the swollen egg-filled lower part of the gonad, although the male gonad maintain the same width throughout its length, and upon gentle pressing, it may bring out a whitish yellowish milt. The gonad should be weighed always using a sensitive balance (analytical balance when available) and the weight

recorded. From the weight value, it is possible to calculate the gonado-somatic ration (G.S.R.) or gonado-somatic index (G.S.I.) both of which may be useful in the interpretation of data later.
The stages of gonad development identified by Nilkosky (1963) which have since been found useful are given below:

Gonadal Stage I – Immature
Young individuals which have not yet engaged in reproduction, gonads of very small size.

Gonadal Stage II – Resting Stage
Sexual products have not yet begun to develop, gonads of very small size, eggs not distinguishable to the naked eye.

Gonadal Stage III – Maturation
Eggs distinguishable to the naked eye, a very rapid increase in weight of the gonad is in progress; tests change from transparent to pale-rose colour.

Gonadal Stage IV – Maturity (Gravid)
Sexual products ripe, gonads have achieved their maximum weight, but the sexual products are still not extruded when light pressure is applied.

Gonadal Stage V – Reproduction (Running)
Sexual products are extruded in response to light pressure on the belly, weight of the gonad decreases rapidly from the start of spawning to its completion.

Gonadal Stage VI – Spent Condition
The sexual products have been discharged, genital aperture inflamed, gonads have the appearance of deflated sacs, the ovaries usually contain a few left-over eggs and the testes, some residual sperm.

Gonadal Stage II – Resting Stage

Sexual products have been discharged, inflammation around the genital has subsided, gonads of very small size, eggs not distinguishable to the naked eye.
This second “Stage II” occurs when the fish has just spawned while the first “Stage II” occurs when the fish is getting ready to enter into maturation.

4. Reproduction

As regards reproduction, one may want to know when a fish reproduces for the first time, size at maturity, where fish reproduces, what stimulates fish to reproduce, how many eggs are laid per fish per annum, and so on. Even for these, one needs to fill data sheets from where one can obtain most of this information later. From the data, one will be able to know the months of the year when maturing, mature or spent fishes are caught. When a student wants to know about breeding sites, he has to move round the water to look for fry of fish and notice the environment where fry are present. He will need to study some physical things like nest construction. Conditions prevailing in water during the time the fish is spawning should be noted and this will be useful when deciding the stimuli for reproduction.

The mature ovaries should be preserved in Gilson’s fluid which helps to:

(i) harden the eggs; and
(ii) separate the eggs from the ovaries wall and from one another.

The composition of Gilson’s fluid is:
100ml 60% alcohol
880ml water
15ml 80% nitric acid
18ml glacial acetic acid
20g mercuric chloride.

Some workers have tried to use 4% or 5% formalin to preserve eggs for counting, but this solution makes the whole ovary fix together in a hard mass which becomes difficult to separate. The sample bottles containing the eggs should be fully labeled. A label bearing the fish serial number, species, size, date of catch, should be firmly attached to the bottle and the fluid should completely cover the ovary in he bottle. The bottles should be shaken regularly and after a month the eggs can be washed and counted with the aid of an egg counter. The number of eggs in the ovaries is the fecundity of the fish. Sometimes it becomes necessary for the right and left ovaries to be preserved separately, for the purpose of comparing the fecundity of the two.

5. Age determination

To know the age of fish specimen, one has to collect information that will help to determine this during data collection. Age determination of fish is more difficult in the tropics than in the temperate regions where temperature changes are drastic. In the temperate regions, rings* laid on the scales, opercular bone or any other hard structure are due to temperature change and since winter comes once a year, a scale with one ring and two rings are automatically one and two years old respectively. In tropics, however, causes of ring formation may be one or more of the following factors:

(i) Food scarcity (Fagade 1974, Akintunde 1976).
(ii) Fluctuation in water-level (Akintunde 1976, Daget 1952).
(iii) Salt concentration of water (Akintunde 1976)
(iv) Rain (Daget 1950, 1952, 1956, Hopson 1972 Pickford and Atz 1957).
(v) Stress due to reproduction (Tweddle, 1975)

So, a scale with two rings does not actually indicate a two-year-old fish. One has to collect specimens every month of the year to obtain reasonable information. Before rings can be used to determine age and growth rate. One must know:

(i) The number of rings laid in one year.
(ii) The time of ring formation
(iii) The factors prevailing in the water during each ring formation, (i.e. the stimuli in ring formation). The youngest ring is at the edge of the scale or operculum.

(iv) The relationship between body length and the scale radius and also the opercular bone radius.

It is not enough to know the quantity of growth, it is important to know the quality as well. With regard to the quality of growth, the following should be determined:

(i) The length-weight relationship of the fish

(ii) Length frequently distribution.

(iii) Length-girth relationship.

(iv) Condition factor.

All these are easy and would be constructed from the general data records stated earlier.

* Rings are laid when fishes are not growing or when the rate of growth is very low.

From the length-weight relationship, it is possible to determine whether the growth is isometric (that is, whether the length and weight of the fish are increasing at the same rate) or heterometric. The relationship is often presented in a Log-log graph paper and quantified by the equation:

$$W = aL^b$$

Where "b" is the slope of the line of best fit whose value fluctuates between 2.5 and 4 most frequently near 3, "W" is the weight of the fish is gramme; and "L" the length in centimeters, and 'a' is the intercept of the curve with y axis. The equation can also be expressed as log W + log a + b logL. The log W is plotted against log L and value of 'a' calculated from the graph.

The length frequency relationship is obtained by plotting length against the number of times the same length occurs. This graph shows peaks, and the number of peaks shows the number of size groups or year classes in the population. It gives an idea of how many times recruitment occurs per annum in the population. The length-girth relationship shows the rate at which the length and the girth of the fish are growing. Information on this is important as it is the girth which determines whether or not the fish will be caught in a gill-net of a particular mesh size.

The condition factor describes the degree of fitness or well-being in fishes. The equation generally employed is

$$K^* = \frac{100W}{L^3}$$

Where:

K = Condition factor

W = Weight of fish in grammes

L = Length of fish in centimeters

3 = the regression value of the relationship between total length and weight

* A value below 1 indicates unhealthy fishes, while values of 1 and above (the higher the better) indicate that the fishes are healthy.

The value of K may be affected by the following:

(i) The time of the day which affect the amount of food in the stomach. Amount of food in the stomach automatically affects body weight.

(ii) Stage of Gonadal development.

(iii) Starvation.

In many instances there could be monthly fluctuations in condition factor as Adebisi (1978) found in the fishes of Upper Ogun river. Whatever is able to affect weight of fish will definitely affect the K values. The amount of food in the stomach and stage of egg development are known to be able to affect the weight of the body and therefore to affect the value of condition factor in fishes.

By the quantity of growth, a researcher wants to determine the rate at which he fish is growing, and wants to know what time of the year the fish is growing, what is the length increase for different years, after which year of their life does growth slow down, and a few other things. The student has to decide on what part of the fish to use if it is to be in *vitriol* study. Scales, opercular bones, otolith, vertebrae, spines, rays and cleithrum are hard parts of fish that can be used for these information. Any of these parts decide on (the use of more than one part gives better results) should be removed from the fish (after the data sheet ;has been filled (see table 10.1) cleaned and enveloped. When the rings are to be examined, the scales are soaked in 10% ammonia for a day or two and be mounted between 2 slides in case of the scales or sliced otolith, but mounting is not necessary in case of the opercular bone and vertebrae. A microscope or a binocular (in case of opercular bone and vertebrae) is necessary to examine the annuli on the hard parts. If the study is to be in *vivo* in approach, tagging or marking of live fish and later

releasing them into the water can be done. Tags are foreign objects (bearing numbers or codes) that are attached to the body of a live fish. Tagging is used to study population dynamic, migration, growth and age and other study that involves recognition of individuals (Ricker 1971). When a tagged fish recovered, a researcher will be able to compare it with what is was before it was tagged and answer questions on how it has moved, the increase in size, and again by calculating the percentage recovery, a researcher will also have idea of the mortality of the fish in that particular water body. For different types of tags methods of attaching them to fishes, a researcher is referred to Brian Stott (1971) in the *Method for Assessment of Fish Production in freshwaters" IBP Handbook No. 3. A tag hinder's the normal behaviours of fish and may therefore not give their correct rate of growth. Sydenham (1976) observed that tagging caused slight increase in mortality, reduction in growth rate, drop in weight and that the tag wound was usually infected to the extent that it formed a lesion. The same author also showed that the species of fish and the colour of tags are important factors in recovery rate. Jones (1968) listed the characteristics of ideal mark or tag to include the following:

(i) the tag or mark should stay in place indefinitely.
(ii) They should be readily spotted or recoverable when the fish is caught.
(iii) They should allow an individual fish to be identified if this is required
(iv) They should not harm or injure a fish or make it more liable to capture by predators or fishing gear.

6. Food studies

After the regular data collection, and the dissection of the fish, the whole length of the gut should be removed and measured and the contents of the stomach carefully removed and weighed. If the study involves only physical identification of the stomach contents, the contents should be preserved in 4% formalin (4ml of formaldehyde + 96ml of water) until analysis can be done, Preys which are not badly digested should be identified and measure immediately. For the identification of plankton and other microscopic organisms, a microscope, table lamp, glass slides, cover slips, a dropper, and atimes an ocular micrometer are needed. A key to the identification of plankton should be consulted regularly. All bottles containing the contents should be accurately labeled.

When the analysis is to be biochemical, the stomach contents should be kept in the labeled sampled bottles and frozen (no formalin or other preservative is needed). Separately preserved

contents from different regions of the gut are necessary when absorption is to be monitored. Duly clean gut tissues are required for enzymatic studies. Various sizes of fish are needed (preferably all the sizes in the water) for food study, because fishes change their food with their ages. Data collection should cover at least a whole year because seasonal variations do occur in the food of fishes.

7. Population studies

Numerical studies (census) in fishes is important in the understanding of the changes that occur in the population from time to time. This is an essential aspect of management strategies since the ability to estimate fish population numerically is essential in any attempt to determine the population dynamics, fish production and rate of mortality. Fishes cannot be subjected to the regular method of counting because they are under-water and are not exposed as other animals are.

Methods of carrying out populations studies

Robson and Regier (1968) listed various ways by which census can be done in fishery studies. These include:

(i) Marking and tagging fishes and subsequent recapture.

(ii) Monitoring of catch and fishing effort is often approximately and proportionally related to stock abundance.

(iii) Age composition of catch points to total mortality rate.

(iv) Estimation from estimates of the total number of eggs laid during a spawning season.

Nielsen and Johnson (1989) described various way of enumerating population. These include:

(i) Laying a transect line.

(ii) Direct observation by divers equipped with video camera and television.

Interested readers on this topic is referred to “Fisheries Techniques” by Nielsen and Johnson (1989).

Bennett (1970) gave a simple method of indirect enumeration of fish as follows;

In a randomly collected alive. Within a short period of time after the marked sample has had opportunity to mix with the unmarked population, another random sample is taken. In this

second sample some marked individuals appear. The proportion of recapture of the total number of fishes taken in the second sample should be the same as the proportion initially marked to the total population.

$$\text{Total population} = \frac{\text{total marked x total caught when recapturing}}{\text{recaptures}}$$

Table 10.1 Data Collection chart

Table 10.1 Data Collection chart

Fish Species

Date	Time	Fishing station	Description of station	Water level	Temp ^{0}C	Fishing mehtod	Mesh size (cm)	TL (cm)	SL (cm)	Wt (gm)	Girth (cm)	Sex	Gonadal Stage	Wt of gonad	Stomach condition	Wt of stomach content	Remarks

Key

Fishing station e.g station A

Description of station e.g. weedy, Inflows, open water etc.

Fishing method e.g. Castnetting, gillnetting, beach seining etc.

Stomach condition e.g empty, half full, one quarter full, etc.

Remark e.g. tail eaten, eye plucked out, colour faced, Ectoparasite seen etc.