

COURSE CODE:	FIS318
COURSE TITLE:	Fisheries Stock Assessment
NUMBER OF UNITS:	2 Units
COURSE DURATION:	Two hours per week

COURSE DETAILS:

Course Coordinator:	Dr. W.O. Abdul
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Office Location:	Room D206, COLERM
Other Lecturers:	Dr. I.T. Omoniyi and Dr. (Mrs.) N.B. Ikenweiwe

COURSE CONTENT:

Methods of stock management in fisheries. Capture- Recapture techniques, tagging and marking. Age group and year class determination. Catch per unit effort method. Practical evaluation of fisheries resources of selected project areas. Echo method in stock assessment.

COURSE REQUIREMENTS:

This is a compulsory course for all students in Department of Aquaculture & Fisheries Management. In view of this, students are expected to participate in all the course activities and have minimum of 75% attendance to be eligible to write the final examination.

READING LIST:

- Adrian Smith (1999): " Marking/Tagging Procedures for fish – The Norwegian Reference. American Littoral Society (2005): Why Tag Fish. www.littoralsociety.org
- Beverton, R. J. H., and Bedford, B. C. (1963): The Effects of the Return Rate of Condition of Fish when Tagged. *International Commission for the Northwest Atlantic Fisheries, Special Publication*, 4: 106-116.
- Cooke S.J. & Wagner G. (2004): Recent advances in the use of telemetry and tracking applied to freshwater fishes. *Feature* Vol. 29(12): 10-18.
- Fowler, G. M., and Stobo, W. T. (1999): Effects of release parameters on recovery rates of tagged ground fish species. *Canadian Journal of Fisheries and Aquatic Sciences*, 56 (10): 1732-1751.
- Jakobsson, J. (1970): On fish tags and tagging. *Oceanography and Marine Biology*, 8: 457-499.
- Mueller, A., Degan, D.J., Kieser, R. and T. Milligan (2006). Estimating Sockeye Salmon smolt flux and abundance with side-looking sonar. *North American journal of fisheries management*, 26(3): 523-534

LECTURE NOTES

INTRODUCTION TO FISH STOCK ASSESSMENT

Briefly, a fish stock assessment is an evaluation of the state of the stock as relating to changes in the abundance or composition of the stock to changes in the amount of fishing. It involves the use of theories, laws, models and methods propagated by various scientists.

There are two general approaches used which are:

The population model (typified by works of Schaefer, 1954, 1957) in which the stock is treated as a single entity subject to simple laws of population growth and the Analytic

approach (typified by works of Ricker, (1958, 1975) which considers the abundance of the population as determined by the net effect of the growth, reproduction and mortality of individual members of the stock.

Stock assessment has been in use for over a century in temperate countries to evaluate fisheries resources in their waters while it is a relatively recent application in the tropical waters. Nowadays, stock assessment has been enhanced by the use of special computer software packages to solve problems associated with fisheries management.

The basic purpose/use of stock assessment is to provide information or advice on the optimum exploitation, utilization and conservation of the fish (as resources) living in water. It involves conducting research work into knowledge of biological characteristics of particular fish species, taking length and weight frequencies, its reproductive biology, food and feeding habits, the age and growth parameters and other conditions of the fish in relation to its aquatic environment. Stock assessment is used to know maximum sustainable yield (MSY), fish mortality, the input and output into the fisheries. The various environmental changes as they affect biological and physical features of a fish species, family or the group need to be assessed by using a model for its stock assessment. To conduct fish assessment study, a scientist embarks on investigation involving a Survey. Firstly, the site must be defined whether it is a marine or freshwater environment or whether it is a small or large water body. The survey could be a Research or Commercial survey.

Research survey involves a detailed investigation of the fish based on the objectives. It involves taking the bio-data of the fish (length, weight, sex etc), the food of the fish including the percentage composition. Other factors include the environmental features such as time, weather, position of catch, physico-chemical parameters of the water body. Commercial

survey involves taking note of basic and important information of commercial usefulness e.g length-weight frequencies, percentage composition etc which are strictly for economic purpose. For example as it is done by fishing companies. This survey is biased because most vital information are 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 may be used as indication of taxation and to avoid rivalry with other fishing companies.

The data collection depends on the size of water body. If it is a small pond, total cropping can be done which involves the removal of all the fish in the water. But for a large water body e.g lakes, reservoirs, randomized samplings can be carried out which involve taking samples in random locations.

METHODS/TECHNIQUES OF STOCK MANAGEMENT IN FISHERIES

Usually, a scientist needs to have the problems of management in mind when carrying out an appraisal of a fishery stock and in presenting the results. There are three aspects of management to be considered:

- The type of objectives i.e what ultimately is to be achieved
- Choice of the policies (what characteristic of the fishery are to be altered and to what

value)

- The techniques (what practical form the regulations should take)

The basic objectives in managing a fishery resource include the general social and economic objectives e.g as more food, a better living for the individual fishermen, more employment and a more pleasant environment and fishing as a sport especially as noted in rich countries.

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However, these diverse objectives are not easily realized. For instance, the total supply of food is unlikely to be obtained by taking the maximum possible yield from a stock but by using appreciably less effort, accepting some reduction in yield from the stock and using the effort and resources saved to produce a more than equivalent increase in yield from some other less heavily exploited fishery.

To fulfill these objectives, a desired situation is brought about by a variety of techniques of regulations which include:

- Closed area and closed seasons
- Limitation of total catch
- Limitation of the total amount of fishing (i.e amount of gears used or length of time they are in use)
- Restrictions on types of gears used
- Restrictions on the sizes of fishes that are landed.

Attend classes for full discussion on each of the above techniques of regulation in fisheries management.

For example, size limits. Limiting the size of fishes retained is one of the oldest of all regulations applied to fisheries. This involves returning captured individuals smaller than a prescribed minimum size to the water body. Restriction of gear sizes theoretically achieve the same goal as size limits but prevents the fish being caught in the first instance.

Traditionally, the reason for the application of a size limited is to prevent the marketing of fish considered too small and to allow individual fish to spawn before being caught. This reason is related to growth rate over fishing and whether or not size limits are effective in this

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respect. It depends on the growth and mortality rates of the target species. If the growth rates are relatively high to mortality, then the economical value of the catch may be increased by delaying the size at capture. Also, closely associated with this method of management is rejection of spawning females. This needs to be considered in stock recruitment relationship because of the biological benefits of the females in fast growing species with high fecundity. Note that this regulation of protecting female only be applied sensibly to species in which the sexes can be distinguished easily by fishers and for which catching method does not harm the individual caught. Since it is not easy to determine sex of most fish by external examination, this method achieves a better result if the application of closed season during spawning period is considered along or as an alternative.

Attend lecture hours to enjoy the critical review/discussion on other techniques at managing fisheries resources.

AGE AND GROWTH IN FISHES

Age is defined as duration of existence measured in seconds, minutes, hours or years. Age data in conjunction with length and weight measurement can give information on stock composition, length at maturity, life span, mortality rate. The knowledge of age and length provides growth pattern in a given population. Age in fish species is usually determined by interpretation and counting of growth checks or growth zones which appear on the hard parts of the fish. When such zones or checks are formed once a year they are known by various names-year marks, annual rings, annual marks, annuli (annulus-singular). These growth zones/checks are formed during alternative period of fast and slow growth or period of no growth at all. Such growth zones reflect changes in environmental and internal factors.

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In temperate region of the World, the period of little or no growth usually occurs in a year beginning in winter and extending to spring or early summer. A general rule which may apply is that the more widely the seasons differ with respect to temperature, the more sharply

the annual marks/checks may be indicated. In the tropics, marked variations in temperatures do not occur during the year. Therefore tropical fishes exhibit a continuous growth throughout the year, nonetheless, growth marks have been shown to form on the hard parts of many tropical fishes.

Methods used in determining the age of fish

Ages of fishes can be determined either directly or indirectly. In the direct method, growth marks present on the hard parts are interpreted to provide information on the ages of different fishes. Hard parts used include:

Scales

Otoliths

Opercula bones

Vertebrae

Spines

Attend class on the discussion of each hard part to determine age of fishes.

In an analysis of age and growth, an unbiased sample of the fish population is required. Such sample must indicate date of capture, the gear used and place of catch. Sample is then subjected to a length and weight analysis. The sex and stage of gonads are recorded. The material to be used for age determination is extracted. From the data, the growth in relation to many factors e.g sex can be determined to understand growth pattern between sexes.

Age of fish can be determined by length-frequency distribution as used by Peterson. It is called Peterson method where standard length of each fish is taken. When a large sample is available, a frequency distribution is made and the modes obtained give the age distribution/year-class. The method gives uni-modal sizes distribution to depict all fish of same age group. The method can be easily used if there is no large overlap in the size of individuals of the adjacent age group. In general term, the method is quite useful but suffers from restriction to a short period of the year.

Illustrate during lecture hours.

Growth is defined as a phenomenon of the end product of a net balance between anabolic and catabolic processes going on within the body of an organism. It results in increase in cell differentiation, tissue multiplication and general increase in biomass. It is expressed physically as an increase in length, size, weight etc. Growth rate can be positive or negative. There are many methods used in fisheries growth studies. These include:

i Direct observation

ii By tagging and marking, both of which are direct methods of measuring fish growth.

iii. Back calculation is an indirect method.

Discussions on all these methods would be made during lecture hours. You are not studying in the University through correspondence. Attend classes regularly and punctually.

INTRODUCTION TO MARKING AND TAGGING

Tagging and marking are important techniques fisheries biologists use to study individual aquatic animals or populations. They will tag or mark aquatic animals to obtain information necessary for research or management. Certain marking techniques allow fish to be tracked giving biologists a better understanding of movement and migration patterns. Other mark and recapture methods provide population estimates, fish growth, and estimates of fish and natural mortality.

When marking fish, it is important for a fish biologist to think about the following reasons for marking

- Is it important to be able to identify an individual fish or a group of fish?
- Will the mark affect the fish's behaviour or increase mortality?
- What are the chances that the tag will be lost or misidentified?

FACTORS TO BE CONSIDERED DURING TAGGING AND MARKING STUDY

A researcher must carefully consider many different factors:

- Fish size
- Tag size and color
- Number of fishes to mark
- Area of the study
- Effects to the fish
- Cost
- Ability to detect by e.g transmitter, x-ray etc

- Retention time of tag/mark
- Ability to differentiate individuals

HISTORICAL BACKGROUND

Historical ledgers of fish tagging dated back to the early 1900's. They primarily focused on the movements of cod, haddock and pollock, but there are also occasional entries of other species such as monkfish and sharks. Since that time scientists have refined their methods and an entire industry of tagging related products has been established. Many of the products available to researchers originated in other industries and were modified to fit the needs of fishery biologists.

NECESSARY INFORMATION OBTAINED FROM TAGGING FISH

- Stock identification
- Migrations
- Behaviour
- Age
- Mortality rates
- Abundance
- Stocking success

METHODS AND TYPES OF MARKING AND TAGGING

Below is a list of various tagging and marking methods with a description of each method. The list is separated into three separate categories: biological, chemical, and physical marks.

BIOLOGICAL (NATURAL METHODS)

1. PARASITIC MARKS

Used to identify stocked fish and determining movement or migration patterns.

Advantages: they have low survey costs, can be used on large bodies of water, and are natural.

Disadvantages: Time to determine if parasite can be a mark, identification of individuals is not always possible, trained personnels are required, and mathematical errors can occur.

2. MORPHOLOGICAL MARKS

Used to differentiate stocked fish and for mark recapture studies. Some examples are meristic counts, pigmentation, shape, size, age marks on otoliths or scales.

Advantage: low cost

Disadvantage: markings are subject to environmental conditions.

3. GENETIC MARKS

Used to identify fish stock.

Advantage:

I. effectiveness in identifying fish stocks

Disadvantages:

I. Is in preserving blood samples and developing reagents and equipment.

II. The analysis can be costly.

Two examples are electrophoresis and serological methods.

CHEMICAL METHODS

Advantages:- Low cost, decreased handling time, large numbers can be marked, and possible to mark smaller species.

Disadvantages: - Individual organisms not being recognized and retention tends to be brief because growth can disperse the marker and differs between species as well as between methods.

1. INJECTION

Consideration should be taken with diffusion of the substance, concentration of substance, and location of injection.

2. FEEDING

Works well in laboratory and hatchery settings where fish can be monitored and feed on the dyes. Various dyes and chemicals have been used with a varying degree of success.

3. IMMERSION

Staining by this technique allows a large number of fish to be marked. Retention of the mark can become a problem depending on age, size, water chemistry, temperature, concentrations of chemical, and duration of immersion.

Fish submerged in an Oxytetracycline chemical bath.

Chemicals used include

- **Alizarin (ALC)**

Advantages:

- I. Low mortality rate.
- II. Very effective way to mark fish but more costly than OTC.

Disadvantage:

- I. Cost of the chemical.

- **Calcein**

Disadvantages:

- I. Less reliable in producing marks on fish and has a higher mortality rate.

- **Oxytetracycline (OTC):**

Advantages:

- I. less costly,
- II. marks are reliably produced
- III. few if any mortalities
- IV. Can be used on salt water fish.

Disadvantages:

- I. Takes time to produce the mark and the sophisticated equipment needed to identify the mark.

Otolith with an Oxytetracycline (OTC) mark

PHYSICAL (MUTILATION OR TAGS) METHOD

Commonly used tag types and their attachment sites

1. INTERNAL TAGS

Advantages:

- I. They can be inexpensive
- II. Non-toxic
- III. Put less stress on the fish compared to some other tagging methods.

Disadvantages:

- I. Trained personnel are necessary at times
- II. Recovery is extremely difficult.

TYPES

a) **Body Cavity tags:** - First used in flounders during the 1930s, metal anchors were placed in body cavities to later identify.

b) **Subcutaneous tags:** - Inexpensive plastic discs imprinted with serial numbers and legends in order to identify individual fish.

c) **Microtags:** - Originally used to identify explosives, microtags are microscopic plastic chips which contain seven layers of plastic that can be colour coded to identify groups of fish much like coded wire tags.

d) **Coded Wire tags:** - A small piece of wire injected into a fish using small applicators or by hand. They are placed in the snout, necks, caudal fins, and any other muscular area. Tags detected with a sensitive metal detector or an x-ray, which can show colour-coded wires or notches that are used to identify specific groups of fish.

Coded wire tag in nose of fish.

e) **Passive Integrated Transponder tags (PIT):** - Many researchers use PIT tags to study migration habits and movement to and from specified areas. A PIT tag is a radio frequency device that transmits a unique individual code to a reader where it is displayed in a numeric or alphanumeric form.

Two PIT tags next to a penny.

f) **Thermal marks:** - Thermal marking is an efficient means of marking 100% of the fish at the hatchery. Therefore, we can take fish that have been thermal marked, remove its otoliths or ear bones and tell whether or not it is a hatchery fish

Image of a thermally marked otolith with a pattern of five dark bands (near center).

g) **Radio tags:** - tags that transmit radio signals to a receiver.

h) **Surgically implanted radio tag.**

- **Sonar tags:** - hydrostatic tag in which detailed instruction are placed inside a plastic capsule that is attached by a wire to the fish.

- **DST GPS Fish Tag, Fish Positioning Sounder and Simrad GPS Sonar** Data Storage tag (DST) Global Positioning System (GPS) can be attached externally or implanted into fish. DST GPS can receive information about geographic position.

Advantages

- I. The GPS Fish Positioning System will increase knowledge on fish migratory routes
- II. Provides major contribution to sustainable management of fish resources. Data for

improving stock assessment and management, for stock models, accessibility and availability of fish resources, behaviour analysis, migration and distribution, coastal migration.

Disadvantages

- I. Requires expensive equipment for locating fish.
- II. Time Consuming on insertion of tag internally by surgery.
- III. Need skilled personnel for surgical procedure.
- IV. Fish need to be fairly big in size and in body cavity for tag to be inserted.

2. EXTERNAL TAGGING

Advantages: -

They can be seen without dissection of the fish. Also many external tags allow for individual recognition.

Disadvantages: -

- I. Main disadvantage is that they can cause higher mortality by attracting predators,
- II. interfere with locomotion by protruding
- III. Make the organism more susceptible to disease and infection.

TYPES

- Mutilation
- Branding
- Visible Implant Elastomer (VIE)
- Petersen discs
- Spaghetti tag
- Dart tags
- Anchor tag (Floy tags)
- Dangler tags
- Strap tags
- Paper fasteners
- Carlin tag

a) **Mutilation**: - clipping or punching fins or other body parts are a type of mutilation that can be used to later identify individuals. This is a simple and quick technique that is very inexpensive to use. Although some marks can remain permanent, others like fins can regenerate. Even though fins can regenerate they are often distorted and can be identified as marked. One problem with mutilation is the possibility of negatively affecting the fish's behaviour and ability to survive.

Example of a mutilation mark (adipose fin clip).

b) **Branding**: -The uses of hot or cold instruments on the body of a fish in order to produce an identifiable mark for recognition. One advantage of branding is that no changes are made to the body or fins of the fish. The main disadvantage over time is that the mark becomes unrecognizable. When branding it is important to consider the type of scales, age, temperature of the branding tool, total time the branding takes, and the cost of equipment.

VIE tag implanted behind eye of a coho salmon.

c) **Visible Implant Elastomer (VIE)**: - tags are injected as liquid that soon cure into a pliable, biocompatible solid. They are implanted beneath transparent tissue and remain externally visible.

d) **Paper fasteners**: - Paper fasteners can be used like strap tags for short-term marks. You can purchase these at an Office supply store and paint with fast-drying spray paint for easy detection. Paper fasteners are easy to apply and easy to remove. Paper fasteners work best on fish with bony opercula.

e) **Strap tags**: - strap tags are made of light-weight, noncorrosive metal, come in all different sizes and are serially numbered. Strap tags are easily attached to fish. Straps are attached to different locations of the fish body; opercula, fins, and caudal peduncles. Strap tags are used on a variety of species, are permanent tags on some fish. Best retention results are with fish with bony opercula.

f) **Dangler tags**: - consist of a dangling tag (with information on it) attached by wire to the fish. Dangler tags that are applied close to the body and are streamlined are retained well and can remain on fish for life. Dangler tags are best suited for small studies involving few fish because applying takes a great deal of time.

g) **Petersen discs**: - these tags were used during the first 60 years of tagging. Although tag construction has changed from different types of material to a less expensive in terms application but design of the tag have remained unchanged.

Peterson disc below the dorsal fin of a warmouth.

h) **Spaghetti tag:** -is a loop of vinyl tubing that passes through the fish. Information is printed directly on the tubing. Attachment for the tag is by threading tubing through the body of the fish with a hollow needle. Two variations of the tag are lock-on and cinch-up tags, which use special locking devices instead of a knot. The tag is retained well and inexpensive, but application is time-consuming.

i) **Dart tags:** - made of nylon shaft with a barbed end and a vinyl tube that fits over the upper end of the shaft. The barbed end of the shaft holds the tag in the fish and the tube contains the tag information.

j) **Anchor tag (Floy tags):** - applicable for long-term studies on migration on adult migratory species. This tag is a modified dart tag in which a nylon T-bar replaces the harpoon like head of the dart tag. These tags are exactly like tags used to attach prices to clothing. The tags are inserted with a gun which can be loaded with one or a clip of anchor tags, marking the tagging of individuals or hundreds of organisms quick and easy. Like dart tags it is important that anchor tags penetrate deep enough into the fish that the T-bar interlocks with the skeleton.

k) **Carlin tag:** - the disc carries individual identification of the fish and reporting instructions and can be used for short-term experiments, but is ideal for long-term experiments. Carlin tags are very common in monitoring and research work.

Carlin darter tag attached to a fish

UNDERWATER TAGGING EQUIPMENT (UTE)

The UTE is located at the end of the belly section of a trawl net (both bottom and pelagic) and performs the whole tagging operation underwater, from the surface down to more than 1000 m. Since UTE prevents the need for hauling the fish to the surface for tagging and release (most deep water species do not survive being brought to the surface), the handling time for each fish is short. By tagging the fish in its natural environment, stress factors such as changes in pressure and temperature can be avoided, reducing tagging mortality.

The newly developed Underwater Tagging Equipment (UTE) for tagging of fish in situ, by Star-Oddi

(<http://www.star-oddi.com>, Iceland).

Deep-sea redfish (*Sebastes* sp.) tagged in situ. A small plastic tube hangs outside the fish to allow its identification (Star-Oddi, <http://www.star-oddi.com>, Iceland).

SUMMARY

TAGGING AND MARKING TECHNIQUES

BIOLOGICAL CHEMICAL PHYSICAL
PARASITIC
MARK
MORPHOLOGICAL
MARK
GENETIC
MARK
METHODS CHEMICALS
USED
IMMERSION INJECTION
FEEDING
EXTERNAL INTERNAL
ALZ OTC CALCEIN

ECHO SOUNDING

Echo sounding in this context is referred to as hydrostatic 'echo sounder' defined as active sound in water (sonar) used to study fish. Hydrostatic assessments have traditionally employed mobile surveys from boats to evaluate fish biomass and spatial distributions. Conversely, fixed location techniques use stationary transducers to monitor passing fish.

Echo sounding is commonly used for fishing. Variations in elevation often represent places where fish congregate. Most charted oceans depths use an average or standard sound speed. Where greater accuracy is required average and even seasonal standards may be applied to ocean regions. For high accuracy depths, usually restricted to special purpose or scientific surveys, a sensor may be used to observe the factors such as temperature, pressure and salinity used to calculate sound speed and thus determine the actual sound speed in the local water column.

This acoustic technique can be applied to sensing aquatic fish, zooplankton and physical and biological habitat characteristics.

Basic theory:

Biomass estimation is a method of detecting and quantifying fish and other aquatic organisms using sonar technology. An acoustic transducer emits a brief, focused pulse of sound into the water. If the

sound encounters objects that are of different density than the sounding medium, such as fish, they reflect some sound back toward the source. These echoes provide information on fish size, location, and abundance. The basic component of scientific echo sounder hardware function is to transmit the sound, receive, filter and amplify, record, and analyse the echoes. Quantitative analysis requires that measurements be made with calibrated echo sounder equipment, having high signal-to-noise ratios.

Techniques:

a. Fish counting

When individual targets are spaced far enough apart that they can be distinguished from one another, it is straight forward to estimate the number of targets. This type of analysis is called echo counting, and was historically the first to be used for biomass estimation.

b. Echo integration

If more than one target is located in the acoustic beam at the same depth, it is not usually possible to resolve them separately. This is often the case with schooling fish or aggregations of zooplankton. In these cases, echo integration is used to estimate biomass. Echo integration assumes that the total acoustic energy scattered by a group of targets is the sum of the energy scattered by each individual target. The total acoustic energy backscattered by the school or aggregation is integrated together, and this total is divided by the previously determined backscattering coefficient of a single animal, giving an estimate of the total number.

Instruments:

. Single-beam echo sounder

. Twin-beam echo sounder

. Split-beam echo sounder

Target strength (TS)

This is a measurement of how well a fish, zooplankton, or other target scatters sound back towards the transducer. In general, larger animals have larger target strengths, though other factors, such as the presence or absence of a gas-filled swim bladder in fishes, may have a much larger effect.