E-NOTE TEMPLATE

COURSE CODE:	FIS303
COURSE TITLE:	Ichthyology (Systematics of Fish)
NUMBER OF UNITS:	2 Units
COURSE DURATION:	Two hours per week

COURSE DETAILS:

Course Coordinator:	Dr. D.O. Odulate
Email:	oduolaniyi@yahoo.com
Office Location:	Room D203, COLERM
Other Lecturers:	Dr. A.A. Akinyemi

COURSE CONTENT:

Principles of systematics. Taxonomy and detailed study of principal commercial species of Nigeria fresh, inland, estuarian and ocean water, invertebrates and reptiles. Identification of species using keys and monographs. Important world species e.g sardine, tuna, anchorvies etc. Biological attributes of fish populations. Phylogenetic relationships.

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.

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READING LIST:

References
• Balogun, J. K. (2006) Basic fisheries biology and management . Pp 88
• Lowe-McConnel (1978) Identification of freshwater fishes, In the biological basis of freshwater fish production eds Shelby D. Gerking and E. David Le Cren. Pp 305

LECTURE NOTES

EXTERNAL FEATURES AND INTERNAL ANATOMY
GENERAL EXTERNAL FEATURES
• The overall structure of a fish is arranged to present a more or less streamlined shape [Fig.

l] consisting of the head, trunk and tail regions.

The Head

• The mouth, the snout, the nostril, the chin, the upper jaw [premaxilla and maxilla], the lower jaw, sub-orbital plate, the eye.

• The pre–opercle, sub-opercle, opercular membrane all constitute the external parts of the head. .

• When barbells are present as in cat fishes they take the designation of the structure that bears them such as maxillary, mandibular or nasal barbells.

• Barbels are sensory structures which carry tactile and chemical receptors.

• Most fishes have two nostrils on each side of the hand in front of the eyes.

• Fishes' nostrils are usually connected to olfactory organ and have no respiratory functions.

• Lungfishes have internal opening nostrils.

• Head spines are commonly found on the preopercle or opercle and make some fish such as Biger perch (*Lates niloticus*) difficults to handle.

The Trunk

• The regions of the trunk include the nuchal on the dorsal part, the breast and the belly on the ventral (Fig. 1).

• The conspicuous features on the trunk are the fins (unpaired and paired), the scales and the lateral line.

• Most fish have their body regions (head, trunk and tail) covered by scales and the lateral line
runs along the midlines of each side of the body and also a times on the head.

• Pelvic appendages are generally smaller than the pectorals, more restricted in function and subjected to greater variation in placement.

• Pelvic fins usually function in stabilizing and braking and are of very little use in locomotion.

• The dorsal fin(s) may extend the length of the back, be divided into two or three separate fins
or be single and small.

• The usual function appears to be stabilization with the caudal and anal in braking. The anal fin
is generally short-based.

• The scales are embedded below the skin.

• There are four types of scales namely cycloid, ctenoid, ganoid (rhomboid) and placoid (in marine species).

• Scales are termed cycloid when the exposed margin are evenly rounded giving the skin a smooth surface.

• The ctenoid scales have their exposed edges ciliated or toothed which give the surface of skin a rough texture.

• Ganoid or rhomboid scales are usually interlocked and cannot be removed singly.

• The most primitive type of scale is the placoid which consists of a basal plate that is buried in the skin with a raised portion exposed

The Tail

• The tail region consists of the caudal peduncle and caudal fin.

• The caudal fins appear in a variety of shapes, sizes and kinds and often reflect evolutionary levels and relationships more than other fins.

• Those fishes with lunate caudal and a narrow caudal peduncle are generally among the speediest of fishes and are capable of rapid sustained motion.

General Body Form

• The body forms of fishes can be used in quick appraisal of the fish's way of life.

• The ultra-streamlined configuration with elliptical cross-section and narrow caudal peduncle is called fusiform.

• These are fast swimming open water fishes.

• Those that are constantly moving are capable of quick bursts of speed are markedly compressed

laterally and are called compressiform.

• depressiform fish are dorsoventrally compressed and are botton dwellers e.g rays, Eel-shaped fishes are called anguiliform whilem filiform are threadlike in shapes.

• Taeniform have ribbon-like shape while sagittiform have arrow-like shape.

• Other shape include the globiform e.g Tetraodon fahaka.

INTERNAL ANATOMY

• The alimentary canal and associated structures are considered.

Mouth

• Different mouths are adapted for various feeding groups.

• Adaptations involve the size and placement of the mouth.

• Many fish are equipped with large mouth and big sharp teeth, some with large mouth with or without teeth or weak teeth but may be equipped with other structures that can hold prey or strain plankton out of water.

• Pods of small conical or cardiform teeth are seen in many species that are opportunistic in capturing a variety of animal prey.

Gills

• The gills lie behind the cavity in the pharynx.

• Commonly, the gills are 4 pairs but shark and ray may have 5-7 pairs of arches.

• Gill arches may be equipped with projections called rakers which vary from few numbers in predators (which may have rough prominences or denticles that aid in holding
and swallowing) to extensive slender gill rakers in plankton feeders.

Teeth

• Teeth are borne on several of the head and face bones.

• Those in the upper jaw include the premaxillary, the maxillary, vomerine and platines while those in the lower jaw are called dentaries, glossohyal (on the tongue) and basibranchials (between the gills).

• Teeth are also borne on pharyngeal bones (upper and lower) which vary, ranging from small conical points to grinding plates.

Oesophagus

• The oesophagus in fish is short and distensible so that relatively large objects can be swallowed but microphagus fishes have less distensible tubes that those of predatory fishes.

• The oesophageal wall equipped with circular and longitudinal layers of striated muscles and column epithelium with mucous cells.

• Other features of oesophageal wall are taste but and gastric glands (in some fishes).

• There are modifications of oesophageal walls.

• Butter fishes have sac connecting to the oesophagus while in other fishes the oesophageal sacs are line with teeth (e.g *Pampus sp.*) which are attached to thin bone in the walls of the sacs.

• The sacs serve various functions in various species i.e production mucous, storage of
food, modified for respiratory purposes Stomach

• The stomach is lacking in lampreys, hagfishes and some bony fishes including minnows (Cyprinidae).

• Also gastric glands are lacking and oesophagus empties directly into the intestines.

• The stomachs of fishes vary shapes such as U or V being essentially a bent muscular tube.

• Other common stomach shapes are bag-shaped, gizzard-like (mullets) and heavy-walled.

Intestines

• The intestines are long tubes and coiled or folded into distinct patterns in herbivorous fishes but
short guts are obtained in carnivores while omnivore have guts of intermediate lengths.

• Lungfishes, polypterids, some primitive bony fishes as well as shark or related cartilaginous fishes posses spiral intestine.

• Jawless fish (parasitic lampreys feed on blood or juices of its prey. Such fishes have extremely thin walled and distended intestines.

• The associated organs attached to intestines are the pyloric caeca, liver, pancrease and air bladder

Taxonomy

• Use skeletal preparations prepared by dissection, by dermestid beetles, ants ot other organisms, or clearing of tissues and subsequent staining of bone by alizarin;

• Use soft X-ray to disclose skeletal features without destroying the whole fish specimen;

• Use chromosome numbers and morphology for which careful histological peparations must be

made, often of developing gonad cells;

• Employ differences in behaviour, which demand quantification and careful analysis;

• Obtain accurate identification of parasites, for some of these are host-specific and thus may assist in identification of their hosts (when host-parasites relations and faunas are

adequately known);

• Measures physiological differences among species and varieties, including those of biochemical nature such as protein analysis is by elecrophoresis.

• X-ray and alizarin preparations can be made from formalinpreserved specimens. Chromosomes studies usually require special treatment of fresh materials, as do parasites

analyses. Biochemical differences also need fresh, even live, specimens. Sometimes sharp-frozen materials can be used, either as whole freezing dry ice and a suitable insulated container are useful in some field conditions.

Protein taxonomy

• Regarding protein taxonomy (Nyman, 1965a) or biochemical systematics (Tsuyuki and Roberts, 1966, the following summary was prepared by T.

D. Hes (Fisheries Research Station. St Andrews, New Brunswick):

• A type of protein, such as haemoglobin, which in different species has the same function, may

show specific differences in the rates at which is migrates through a gel medium under the influence of an electric current.

• These differences in electrophoretic mobility reflect differences in the fine structure of these proteins which have a generic basis, and they may also be to a large extent independent of environmental factors.

• These characteristics, together with the fact that such differences can exist between species whose gross morphology may be very similar, emphasize the potential value of protein analysis in taxonomy.

• In marine freshwater fishes the proteins which have been most intensively studied include the haemoglobins (Sick, 1961), serum and plasma proteins (Nyman 1965s, b), muscle myogens (Tsuyuki and Roberts 1965, 1966; Tsuyuki et al., 1965) and organ proteins (Nyman, 1965a).

• The result of electrophoresis is the production of a pattern of bands that are revealed by staining represents one (at least) specific protein.

• The shown to be species specific (Tsuyuki and Roberts 1966). It has also been possible to identify hybrid individuals between species of which the parent patterns are known, its geographical range by minor differences in the patterns (Child et al., 1976; Brassington & Ferguson 1976; Child & Solomon 19770.

• Individual variation in the band pattern is also well established.

• In a few instances the genetic mechanisms determining the inheritance of different patterns in the same species has been determined (Sick, 1961), allowing different populations of the same

species to be characterized by the gene frequency of the various alleles which, usually by a co-dominant effect, are responsible for the differences in band pattern.

• Although protein taxonomy requires facilities, techniques and some experience, there can be

little doubt that it will become established as a valuable tool in the elucidation of taxonomic problems. (Hawkins & Mawdesley-Thomas (1972) and the papers by Ligny (1971), Avise (1974), Utter et al (1974) and Market (1975).

Collection of fish for taxonomic work

• What to preserve?

• The days are gone when new species often described from one specimen.

• At least 20 to 30 specimens should be collected from each locality. These samples are best selected at random, avoid equally taking only what seem to be the most typical specimens, or concentrating on extremes of colour, form, etc. both sexes are needed, and gonads should be left

in the fish.

• As comprehensive a size range as possible is desirable.

• Extreme or aberrant specimens are of interest and should be collected, but they should be especially marked as atypical; often they will prove to belong to a different species.

• To find young stages, it is often necessary to fish in different places, as fish often change their habits and habitats as they grow.

• It does not matter how the fish are caught, provided that they are not damaged; long-spined species often have their dangerous spines broken off by fishermen, destroying most

of their values as specimens.

• Whole individuals should be kept whenever feasible.

Labeling and recording

• It is essential to label individual fish or lost of fish immediately on collection.

• Serial numbers, written on a strip of good waterproof paper (high rag content) using a soft pencil or waterproof ink, can generally be fixed under the gill cover or in the mouth of individual specimens, or in the containers of lots of specimens, to correspond with the notes recorded at the time of collection in field notebook.

• It is a good plan to give a serial number to each fishing operation, followed by a serial number denoted differently (say in a circle) for the specimen, together with the initials

of the collector.

How to preserve specimens?

• Formalin is generally a reliable preservative, after which they can be transferred to alcohol for lengthly preservation.

• Commercial formaldehyde (trade-name Formalin) is concentrated (about 40%) and must be diluted before use, I part formalin to 9 parts water (approximately a 10% solution of formalin) for most uses.

• Large fish need formalin of this strength or stronger (up to 20%), but small fish can be fixed in a more dilute solution (down to 5% formalin).

• The formalin bath can be reused but becomes diluted with use. Neutralized formalin is to be preferred, because ordinarily formalin will soften bones of fish after a time.

• It can be purchased ready neutralized or neutralized by adding about one level teaspoonful of household borax to each litre of preserving solution.

• The inconvenience of taking liquid formalin into remote field areas can be offset by carrying dry, powdered paraformaldehyde (e.g Trioxymethylene, Fisher Scientific Co, USA).

• One litre of neutralized 10% formalin is obtained by dissolving about 40g of the paraformaldehyde, together with about 8g of anhydrous sodium carbonate (Na_2CO_2) or other buffer and about a teaspoonful of ordinary powdered detergent (such as Tide) to aid in solution, with a litre of water, at room temperature.

• This mixture is then used as ordinary 10% formalin.

• **Caution:** Formaldehyde is a cumulative external poison. Different people vary greatly is susceptibility, but all becomes sensitized after repeated exposure. Avoid contact of formalin with the skin, for example by using rubber or plastic glove.

Use of keys for identifying fish

• Specialists vary slightly in their ways of taking certain measurements and counts.

• It is desirable to ascertain how these were made: this may be stated in the preamble to the key, or n the book where it is found.

• The sizes of specimens on which the key is based (the sizes of specimens available are often given in the species description), as the key may be based on fish of one size only and allometric growth changes will affect proportional measurements.

• The topography of a typical spiny rayed fish indicating how the various measurements are made.

• Fin ray counts,

• scale counts,

• morphometric measurements to define body shape, gill raker number, teeth, and colour patterns are characters commonly used for identifying fishes.

• Ordinarily counts and measurements needed for identification are made on the left side of the fish.

• **SPINES:** True spines are single-shafted and of entire composition. They are designated by Roman numerals, no matter how rudimentary or how flexible they may be. Morphologically hardened soft rays (spiny in character) may be treated as spines, whether these be simple rays as in carp, or the consolidated product of branching, as in some catfishes (Ictaluridae).

• **SOFT RAYS:** soft-rays ate bilaterally paired and segemented and are usually though not always, branched or flexible. They are designated by Arabic numerals. In certain fishes (e.g Cyprinidae and Catostomidae) the count is of the principal rays only, to accord with general practice and because the rudimentary rays are difficult to ascertain. In these families the principal rays generally include the branched rays reaches to near the tip of the fin. In fishes such

as Ictaluridae, Escocidae and Salmonidae, in which the rudimentary rays grade into fully developed ones, the total count is given. The last ray of the dorsal and anala fins, is often divided to the base, making it difficult to decide whether is should be 1 or 2 (it is better to yake it as 1, but record it as 1(-1) to see how it fits in with other people's keys).

• **CAUDAL FIN:** Count the number of branched rays and add 2 (for the 2 principal unbranched

rays, above and below).

• **PAIRED FINS:** All rays are counted, including the smallest one at the lower or inner end of

the fin base (good magnification is often needed). Sometimes a small ray (counted in pectoral but not pelvic) precedes the first well-developed ray (and may require dissection to be seen). In some fishes with reduced pelvics (e.g Cottidae) the spine may be a mere bony splint bound into the investing membrane of the first soft ray.

• Scale counts: The scales of most fishes have either a smooth exposed surface (cycloid scales) or a minutely denticulated surface (ctenoid scales) which is rough to the feel; the denticulations can be seen with a lens. In general the maximum possible scale count is stated (including small interpolated scales in the lateral line and scales of reduced size near the origins of vertical fins), but not including scales of fin bases or sheaths. Scale formulae are often written thus.

• Indicating the lateral line count and the scales above and below it.

• **LATERAL LINE SCALE COUNT:** This represents the number of pored scales in the lateral line or number of scales in the position which would normally be occupied by such scales. In some sciaenid fishes, in which the lateral line scales are greatly enlarged, or are obscured by overlapping smaller scales, the number of 'transverse' (i.e olique) rows along the side

of the fish just above the lateral line is used, sometimes compared with number of scales with lateral line pores. The count is taken from the scale in contact with the shoulder girdle, to the structural caudal base (as determined without dissection by moving the caudal fin from side to side); the scales wholly on the caudal fin base are not included, even when they are well developed and pored.

• In the Cichlidae, where the lateral line is in two parts, this count is generally now made to the end of the upper lateral line, then by sliding downward and forward (without counting), to the scale in front of the lower line, and continuing the count along the lower lateral line; this may

give two extra scales over the count used by some earlier workers.

• **SCALES ABOVE LATERAL LINE:** Unless otherwise stated, these are counted from the origin of the dorsal fin (first dorsal if two), including the small scales, and counting downward and backward to, but not including, the lateral line scale.

• **SCALES BELOW LATERAL LINE:** These are counted similarly to those above but upward and forward from the origin of the anal fin (including the small scales). If,
in continuing upward and forward, the series can with equal propriety be regarded as jogging backward or forward, the backward shift is accepted. Scales between pelvic fin and lateral line are used by some authors.

• **SCALES BEFORE DORSAL FIN:** All those which wholly or partly intercept the straight midline from origin of dorsal to occiput (made in fishes in which the transverse occipital line very sharply separates the scaly nape from the scaleless head); 'the number of scales before the dorsal' (commonly fewer than the number of predorsal scales) is made to one side of the midline.

• CHEEK SCALES: The number of scales rows crossing an imaginary line from eye to preopercular angle, or at the deepest point of the cheek in some cases.

• **CIRCUMFERENCE SCALE COUNT**: Represents the number of scale rows crossing a line round the body immediately in front of the dorsal fin (particularly valuable in Cyprinidae).

• **CAUDAL PEDUNCLE SCALE COUNT:** The circumference count around the narrowest part of the caudal peduncle (very useful in Mormyridae and Cyprinidae).

• Morphometric measurements: Dividers or dial-reading calipers should be used, also a steel rule, the measuring boards commonly used in fishery investigations are generally not adaptable enough for systematic work.

• It is better to use bony rather than flesh measurements where possible (e.g from the bony rather than from the fleshy edge of the orbit), as museum keys have generally been prepared on preserved specimens in which there is less soft padding for flesh than in fresh fish.

• **TOTAL LENGTH AND FORK LENGTH:** These are not commonly used in systematic work.

• **STANDARD LENGTH:** In systematic work this is typically taken as the distance from the anterior part of the snout or upper lip (whichever extends farthest forward) to the caudal base (junction of hypural bone and caudal fin rays) in a straight line (not over body curve). Notice that the 'fishery' standard length is measured to the end of the fish with the jaw closed – hence often begins at the tip of the lower jaw.

• **RELATIONSHIP BETWEEN TOAL AND STANDARD LENGTHS:** To relate fisheries data and systematic data it is often necessary to know the relationship of these measurements in a particular species. Therefore, both should be recorded in early samples, over the whole size range, to enable a curve to be constructed for conversion of one to the other in later work.

• **BODY DEPTH:** This is taken at the deepest point, exclusive of fleshy or scaly structure at fin bases.

• **HEAD LENGTH:** This is measured, with the mouth closed, from the tip of the snout or upper lip (whichever extends farthest forward) to the posterior edge of the opercular bone or to the extremely of the membrane margining the bone (depending on the author), but excluding the opercular spines if these are present.

• **HEAD WIDTH:** This is the greatest dimension, with gill covers closed in normal position.

• **SNOUT LENGTH**: This is taken with dividers from the most anterior point on the snout or upper lip (whichever extends farthest forward) to the front margin of the orbit.

• **POSTORBITAL LENGTH OF HEAD:** This is the greatest distance between the hind margin of the orbit and the bony opercular margin (some authors use the membraneous opercular margin as the posterior extremity of measurement).

• **INFRAORBITAL DEPTH:** Generally taken from the bony edge of the orbit to the margin of the first infraorbital bone (preorbital = lachrymal) at its deepest point; sometimes taken as the 'least' measurement from orbits to infraorbital ring marging; usage varies with group of fish and author.

• **INTERORBITAL WIDTH:** Unless specified as least fleshy width, this is the least bony width, from orbit to orbits.

• **EYE DIAMETER** This is generally taken as length of orbit, the greatest distance between the free orbital rims, and is often oblique.

• **UPPER JAW:** Upper jaw length is taken from the anteriormost point of the premaxillary to posterior point of the maxillary.

• **LOWER JAW:** Lower jaw length is the length of the mandible, taken with one tip of the dividers inserted in the posterior mandibular joint to give the maximum possible dimension.

• **GAPE WIDTH:** This is the greatest transverse distance across the mouth opening, with the mouth closed.

• **Other characters: GILL RAKERS:** Unless otherwise stated, the count is that of the first arch, and often of the lower limb only, or of the two limbs separately. The junction of the two limbs can be felt with a divider point, and if a gill raker straddles the angle of the arch, this is generally included in the lower-limb count, as are all rudimentary gill rakers at the anterior end.

• **TEETH:** The numbers and kinds of jaw teeth, number of tooth rows, and (as in siluroids) the relative widths and shapes of vomerine and palatine tooth bands may be useful characters.

• **LOWER PHARYNGEAL BONES:** These represent the modified fifth gill arches. The bones may be more or less C-shaped and paired (as in Cyprinidae), but the two are sometimes united into a triangular median plate (as in Cichlidae). Their shape, toothed area, and the type and density of teeth on them, are very important characters for the identification of fish of these two families, among others. To remove the bone incichlids, lift the left gill cover, continue forward with scissors the slit between the fourth gill arch and the balde of the lower pharyngeal bone; then cut the membrane along the side of the bone and the muscles joining its hind corner to the shoulder girdle. Do the same on the other side, being careful not to cut the anterior blade. Cut the bone clean away from the oesophagus and from the tissues beneath it; remove bone, clean off soft tissues and let it dry. The teeth can then be examined with a lens, and the bone replaced if the specimen is to be kept (if not, a more drastic method of removal can be used).

• **PHARYNGEAL (THROAT) TEETH:** These often have to be

counted among cyprinids, for precisions in
identification. For this the pharyngeal bones have to be
temporarily removed (with great care) and cleaned.
Each bone bears 1 to 3 rows of teeth. Teeth in each row
are counted and given a formula in order from left to
right; thus '2,5-4,2' indicates that the left pharyngeal
has 2 teeth in an outer row and 5 in an inner one,
whereas the right has 4 in the inner and 2 in the outer
row; the formula 4-4 discloses that teeth are present in
one row only.

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• **BRANCHIOSTEGAL RAYS, PYLORIC CAECA, AND
VERTEBRAE**: These and certain other taxonomic characters
may be used for fish identification, but are less commonly
used under field conditions. Methods of making these
counts are given by Hubbs & Lagler (1947).

• **BARBELS:** The numbers and relatives lengths of barbells
(whiskers) are important in such fishes as the catfishes, as
in their branching in mochokidae. Tiny barbles are
sometimes well hidden in grooves at the sides of the head
in some cyprinids. Similarly the dorsal filaments present in
some gymnotoids are well hidden in the congealed mucous
cover of preserved specimens, necessistating probing them
out before they can be seen.

• **COLOUR:** Fish colours may changes diurnally, according to
habitat, with emotional displays, and on death; also
breeding colours, often brightest in bright colours fade,
basic colour patterns, such as dark stripes or spots, remain
in preserved fishes and are important characters in some
groups (e.g Cichlidae, Characidae). Differences in breeding
colours may also give important clues to species. 'For
example, in Lake Nyasa (now Malawi) two species of tilapia
are practically indistinguishable except by the colour of the
breeding male and differences in time of year and depth of
spawning. Such cases stress the importance of non
morphological characters and the need to relate field and
ecological data to the specimens kept for museum
examination.

• **Statistical analysis:** Since taxonomic conclusions are reached on the basis
of samples from large populations, it is incumbent upon a classifier of
fishes to be knowledgeable regarding the statistical treatment of data. He
should also, as far as possible, be careful to avoid bias, and should
evaluate statistically the conclusions that he reaches. For example, often
available statistically the conclusions that he reaches. For example, often
available samples of two kinds of fish will differ in respect to the mean
value of some count or measurement; in that event the degree of
confidence in the reality of this difference must be established statistically,
as well as the variation (standard deviation) of the count in both species,
and degree of overlap. Taxonomic hypotheses formulated in terms of
quantitative characteristics may be tested by means of the chi-square test,
Student's t-test, analysis of variance, multiple range or non-parametric
tests (Steel & Torrie 1960). The t-test has sometimes been misapplied in
taxonomy; Rothschild (1963) discuss this problem and suggests proper
procedures. Multivariate analysis may be useful when it is necessary to
combine information on several characters to obtain the best possible

discrimination between two groups (Sokal & Sneath, 1963; Royces, 1954).

• **Taxonomic references for different parts of the world**

• Only the main works can be listed here, those with keys where available, otherwise check lists, or papers with good bibliographies of the numerous short papers on the region concerned. Where no recent synoptic treatmemts exist, it is wise to consul a specialist about the literature. Contact a local museum, or see the list of taxonomists working on Pisces, pp. 79-85 in the Directory of Zoological Taxonomists of the World (compiled by Blackwelder, R.E. and R.M., 1961, for the Society of Zoology, Southern Illinois University Press, Carbonadale, Illinois); this gives the specialities and addresses of fish taxonomists. The Smithsonian Information Exchange, Washington, D.C., may also be able to help with such information.

• As the literature is growing rapidly, the Pisces Section of the Zoological Record should be consulted to keep up to date. The Zoological Record (Section 15, Pisces) is available, singly or by annual subscription, from the Publications Officer, Zoological Society of London, Reagent's Park, London, NWI. Many back issues are still available. Abstracting journals are another source of information especially Biological Abstracts (Philadelphia) and Referativnyi Zhurnal (Moscow).

References

• Balogun, J. K. (2006) Basic fisheries biology
and management . Pp 88

• Lowe-McConnel (1978) Identification of
freshwater fishes, In the biological basis of
freshwater fish production eds Shelby D.
Gerking and E. David Le Cren. Pp 305

1 **Identification of fish species:**
- Use of monographs to identify members of cichlids, clupeids and cynoglossids.

2. **Important world commercial species:**
- Commercial production of sardines, tuna, and anchovies.
- Methods of exploitation e.g. use of purse seine net

3. **Biological attributes of fish population:**
- Population (species composition, species abundance and relative composition)
- Population growth
- Population density
- Regulation of population size

4. Phylogenetic relationships:

Phylogeny: It defined as the history of organismal evolution. It generates diagram that resembles a tree commonly referred to as "the tree of life". Existing species as generally located at the terminal twigs while extinct species are located at the interior twigs.

The following shall be emphasized:
- The tree of life
- Systematics: the science of ordering or organizing the history of organismal evolution.
- Identification of species: Recognizing the place of an organism in a classification with the aid of keys and monographs.

Taxonomy: It is the assigning scientific names to organisms according to legal rules of International

Code of Zoological Nomenclature (ICZN).

Taxonomy of major commercial fish species in Nigeria.