Annex 7/2: Anatomical, Features, and Terms and Methods of Counting and Measuring

052

ANATOMICAL FEATURES, AND TERMS AND METHODS OF COUNTING AND MEASURING

(Figs. 3–7)

There has been much variation in the methods of counting scales, fin rays and other serial parts and in the methods of measuring body lengths and other dimensions. Workers have altered procedures to suit investigational needs, the nature of the material or personal whims, but have seldom stated how the methods employed by them differ from more standard ones. The methods here given are widely used but do not invariably conform with past practices or with those in use by all other workers. Notes are provided which permit coördination. Several of the procedures described are not employed in the keys that appear later in this book. They are included, however, because they afford means for describing and comparing differences among fishes. Also given are salient features of external and internal anatomy, a knowledge of which is necessary for making identifications.

Methods of Counting Fin Rays

Number of Fin Rays (Fig. 3, below)—In specifying the number of fin rays, "dorsal rays," "anal rays," etc. are either written out of the following nomenclature and abbreviations are used:

Dorsal fin rays—D	Pectoral fin rays—P_1
Anal fin rays—A	Pelvic (ventral) fin rays—P_2
Caudal fin rays—C	

For paired fins the counts are made on the left side of the body unless otherwise specified.

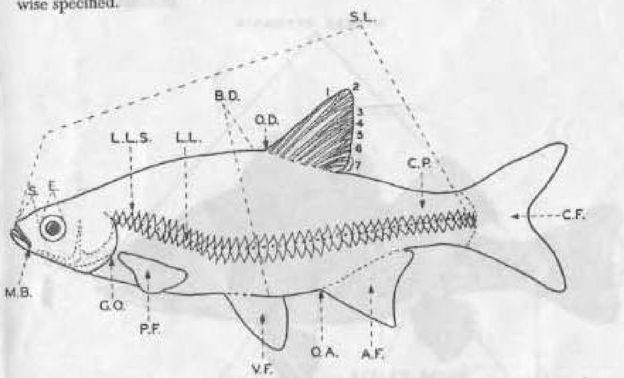

Fig. 3. Topography of a hypothetical soft-rayed fish (from Hubbs and Cooper, 1936). A. F., anal fin; B. D., body depth; C. F., caudal fin; C. P., caudal peduncle; E., length of eye; G. O., gill-opening; L. L., lateral line; L. L. S., lateral line scales; M. B., maxillary barbel (in terminal position); O. A., origin of anal fin; O. D., origin of dorsal fin; P. F., pectoral fin; S. length of snout; S. L., standard length; V. F., pelvic fin; 1 to 7, dorsal fin rays; (note that two very small rays at the front end of this fin are not counted and that the last fin ray is divided through its base).

Spines. All true spines (Fig. 4, D_1, below) are designated by Roman numerals no matter how rudimentary or how flexible (Figs. 14, p. 28 and 50, p. 118) they may be. It is desirable to treat numerically as spines the morphologically hardened soft-rays, whether these be simple rays as in the carp (*Cyprinus carpio*—Fig. 11) or the consolidated product of branching as in catfishes (Ictaluridae). True spines are median (unpaired) structures, without segmentation.

Soft-rays, designated by Arabic numerals, are usually though not always branched and flexible, and are bilaterally paired and segmented (Figs. 3, p. 19 and 37, p. 71).

Spines and soft-rays in one fin. In a fin containing both spines and soft-rays (Figs. 16 and 17, p. 28) the count for the spines is separated from the soft-ray count by a dash, if the two sections of the fin are separated. If the two sections are conjoined, a comma is used to separate the counts.

Ray. The term "ray" designates spines as well as soft-rays (and the latter term may be hyphenated to give it technical significance).

Principal and branched rays (Fig. 3, p. 19). In certain fishes, particularly the Cyprinidae and Catostomidae, the count is of principal rays, to accord with general practice and because the rudimentary rays are difficult to ascertain or are variable. Almost without exception in these families, the principal rays include the branched rays plus one unbranched ray, since only one unbranched ray reaches to near the tip of the fin. If it is desired to give the count as of the number of branched rays, the term "branched rays" is employed, but the principal ray count is recommended for use.

Rudimentary rays. In groups of fishes such as Ictaluridae, Esocidae and Salmonidae, in which the "rudimentary" rays grade into the developed ones, both in length and degree of branching, the total count is given. And when the principal rays are enumerated, this is done by adding one to the count of the number of branched rays, including as branched any ray that is at all forked. The maximum total count is given for all fins in which few or no rays are branched.

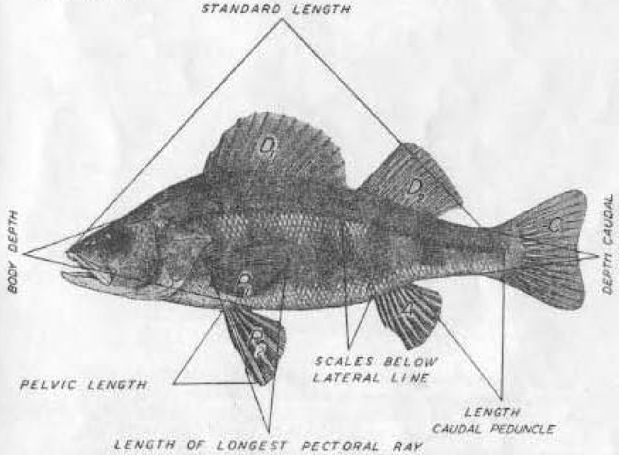

Fig. 4. Topography of a spiny-rayed fish (yellow perch, *Perca flavescens*), showing how certain measurements are made and locating structures and regions used in identification.

Last ray of dorsal and anal fins (Fig. 3, p. 19). In the dorsal and anal fins the last ray, for the purpose of the count, is defined as consisting of two ray elements that are separated (even though serially approximated) at the very base of the fin. In other words, the last two bases are counted as one ray. (This has been the general custom for counting fins in which the rays are well branched; there has been little consistency in this regard in the counts for fishes having the rays unbranched; no single, simple definition other than that given above would seem sufficient to designate the last dorsal and anal fin element that is to be counted as one ray.) In some special studies it has proved advantageous to compare the numbers of branched and unbranched rays.

Caudal rays (Fig. 10, p. 28). Ordinarily the caudal fin count as given is that of the principal rays. In fishes having branched caudal rays, the number of principal rays is defined as the number of branched rays plus two (for this is the obvious count).

Rays in paired fins. In the paired fins, all rays are counted, including the smallest one at the lower or inner end of the fin base. Very often good magnification is needed in this count. Frequently a small ray (counted in the pectoral but not in the pelvic fin) precedes the first well developed ray and may be bound very closely to it so as to require dissection to be seen.

In certain fishes with reduced pelvics, such as the Cottidae, the spine may be represented by a mere bony splint bound into the investing membrane of the first soft-ray (Fig. 50, p. 118), which can be recognized as such under the microscope by the articulations and by the bilateral structure.

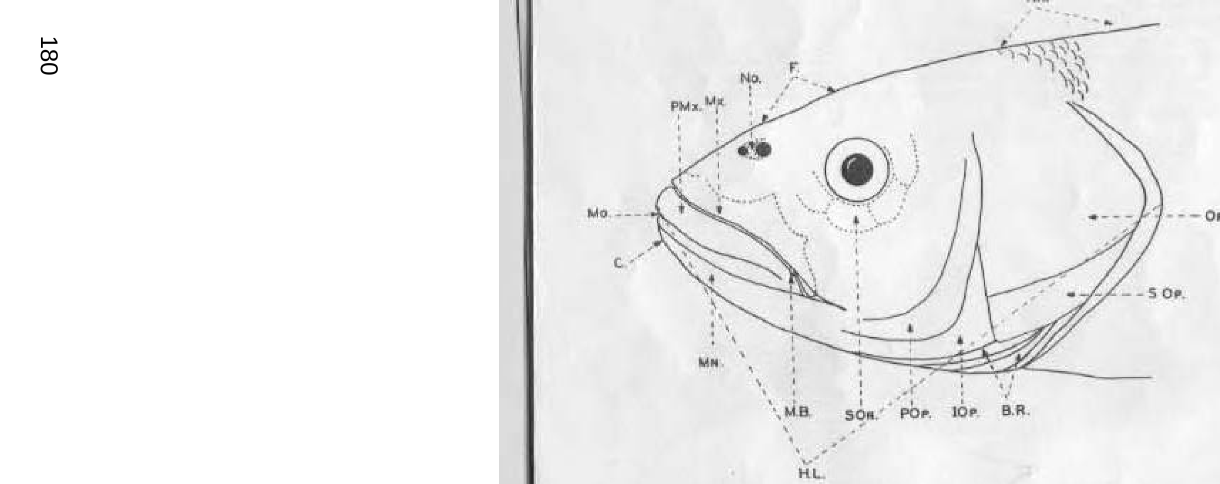

Fig. 5. Head of a soft-rayed fish (northern creek chub, *Semotilus a. atromaculatus*), showing structures and regions used in identification (after Hubbs and Cooper, 1936). B. R., branchiostegal rays; C., chin; F., forehead; H. L., length of head; IOP., interopercle; M. B., maxillary barbel (set forward on maxillary); MN., mandible; Mo., mouth; Mx., maxillary; NA., nape; No., nostrils; OP., opercle; PMx., premaxillary; POP., preopercle; SOP., subopercle; SOR., suborbitals.

Scale Counts

In general, the maximum possible scale count is stated, including small interpolated scales in the lateral line and the scales of reduced size near the origins of the vertical fins, but not including the scales on the fin bases or on the basal sheaths.

Lateral line scale count (Figs. 3, p. 19 and 4, p. 20) represents the number of pores in the lateral line or the number of scales along the line in the position which would normally be occupied by a typical lateral line. Count terminates at the structural caudal base or end of the hypural plate, as determined without dissection by moving the caudal fin from side to side. If the crease between the caudal fin joint and the body underlies a scale, the question of inclusion or exclusion is determined by the test of whether the crease appears to lie behind or in front of the middle of the exposed field of that scale. The scales wholly on the caudal fin base are not included in the count, even when they are well developed and pored. Sometimes referred to as "scales in lateral line" or as "scale rows along side of body."

The most anterior scale enumerated is that one which is in contact with the shoulder girdle but is followed by one which is definitely separated by another scale from the shoulder girdle. That is, in counting forward, the last scale counted is the first one to touch the shoulder girdle.

Scales above lateral line (Figs. 4, p. 20 and 6, p. 22). Unless otherwise indicated the count of scale rows above the lateral line is taken from the origin of the dorsal fin (or from the origin of the first dorsal fin if there is more than one), including the small scales, and counting downward and backward following the natural scale row to, but not including, the lateral line scale.

Scales below lateral line (Fig. 4, p. 20). The count of scale rows below the lateral line is taken similarly to that for rows above the lateral line. The

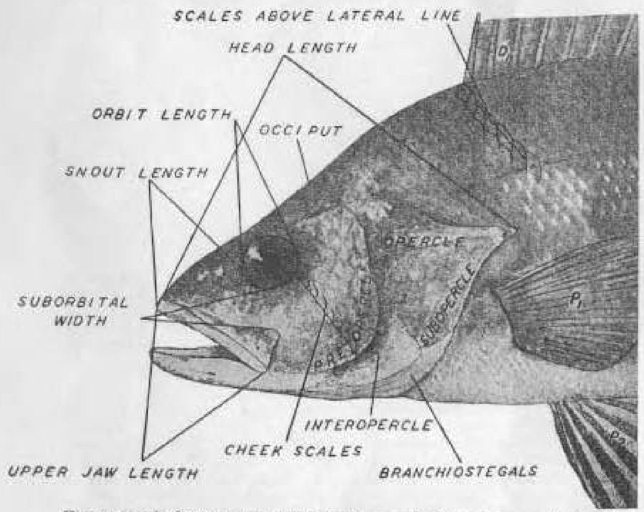

Fig. 6. Head of a spiny-rayed fish (yellow perch, *Perca flavescens*), showing topographical features and how certain measurements are made in identification.

Last ray of dorsal and anal fins (Fig. 3, p. 19). In the dorsal and anal fins the last ray, for the purpose of the count, is defined as consisting of two ray elements that are separated (even though serially approximated) at the very base of the fin. In other words, the last two bases are counted as one ray. (This has been the general custom for counting fins in which the rays are well branched; there has been little consistency in this regard in the counts for fishes having the rays unbranched; no single, simple definition other than that given above would seem sufficient to designate the last dorsal and anal fin element that is to be counted as one ray.) In some special studies it has proved advantageous to compare the numbers of branched and unbranched rays.

Caudal rays (Fig. 10, p. 28). Ordinarily the caudal fin count as given is that of the principal rays. In fishes having branched caudal rays, the number of principal rays is defined as the number of branched rays plus two (for this is the obvious count).

Rays in paired fins. In the paired fins, all rays are counted, including the smallest one at the lower or inner end of the fin base. Very often good magnification is needed in this count. Frequently a small ray (counted in the pectoral but not in the pelvic fin) precedes the first well developed ray and may be bound very closely to it so as to require dissection to be seen.

In certain fishes with reduced pelvics, such as the Cottidae, the spine may be represented by a mere bony splint bound into the investing membrane of the first soft-ray (Fig. 50, p. 118), which can be recognized as such under the microscope by the articulations and by the bilateral structure.

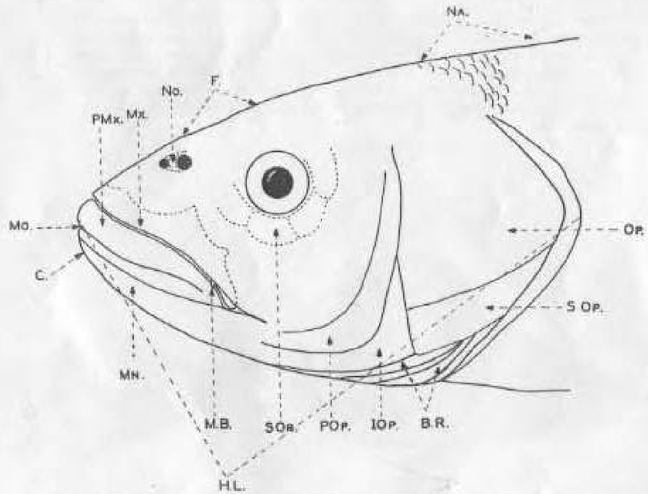

Fig. 5. Head of a soft-rayed fish (northern creek chub, *Semotilus a. atromaculatus*), showing structures and regions used in identification (after Hubbs and Cooper, 1936). B. R., branchiostegal rays; C., chin; F., forehead; H. L., length of head; IOp., interopercle; M. B., maxillary barbel (set forward on maxillary); Mn., mandible; Mo., mouth; Mx., maxillary; Na., nape; No., nostrils; Op., opercle; PMx., premaxillary; POp., preopercle; SOp., subopercle; SOr., suborbitals.

[21]

Scale Counts

In general, the maximum possible scale count is stated, including small interpolated scales in the lateral line and the scales of reduced size near the origins of the vertical fins, but not including the scales on the fin bases or on the basal sheaths.

Lateral line scale count (Figs. 3, p. 19 and 4, p. 20) represents the number of pores in the lateral line or the number of scales along the line in the position which would normally be occupied by a typical lateral line. Count terminates at the structural caudal base or end of the hypural plate, as determined without dissection by moving the caudal fin from side to side. If the crease between the caudal fin joint and the body underlies a scale, the question of inclusion or exclusion is determined by the test of whether the crease appears to lie behind or in front of the middle of the exposed field of that scale. The scales wholly on the caudal fin base are not included in the count, even when they are well developed and pored. Sometimes referred to as "scales in lateral line" or as "scale rows along side of body."

The most anterior scale enumerated is that one which is in contact with the shoulder girdle but is followed by one which is definitely separated by another scale from the shoulder girdle. That is, in counting forward, the last scale counted is the first one to touch the shoulder girdle.

Scales above lateral line (Figs. 4, p. 20 and 6, p. 22). Unless otherwise indicated the count of scale rows above the lateral line is taken from the origin of the dorsal fin (or from the origin of the first dorsal fin if there is more than one), including the small scales, and counting downward and backward following the natural scale row to, but not including, the lateral line scale.

Scales below lateral line (Fig. 4, p. 20). The count of scale rows below the lateral line is taken similarly to that for rows above the lateral line. The

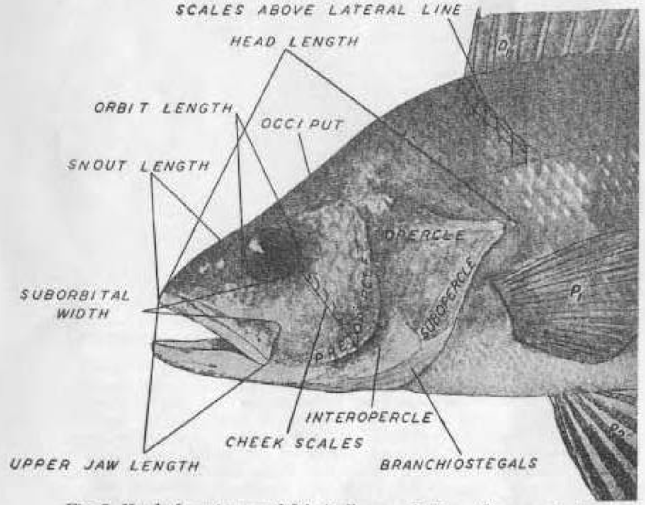

Fig. 6. Head of a spiny-rayed fish (yellow perch, *Perca flavescens*), showing topographical features and how certain measurements are made in identification.

[22]

count is made upward and forward from the origin of the anal fin. In this count, as in the one above the line, the small scales are included. If in continuing upward and forward the series can with equal propriety be regarded as jogging backward or forward the backward shift is accepted. The scale nearest the fin is counted as one-half only when this is very definitely an evident characteristic.

Scales before the dorsal fin. The number of scales before the dorsal fin is determined by counting all scales, the exposed surfaces of which wholly or partly intercept the straight midline running from the occiput to the origin of the dorsal fin. Ordinarily this count is made in fishes in which the transverse occipital line very sharply separates the scaly nape from the scaleless head. The "number of scale rows before the dorsal" (commonly fewer than the number of predorsal scales) is made to one side of the midline.

Check scales. This count represents the number of scale rows crossing an imaginary line from the eye to the preopercular angle. (Fig. 6, p. 22)

Circumference scale count (particularly valuable in the Cyprinidae) represents the number of scale rows crossing a line around the body immediately in advance of the dorsal fin.

Caudal peduncle scale count is taken similarly to the circumference scale count but is made around the part of the peduncle where the count is lowest.

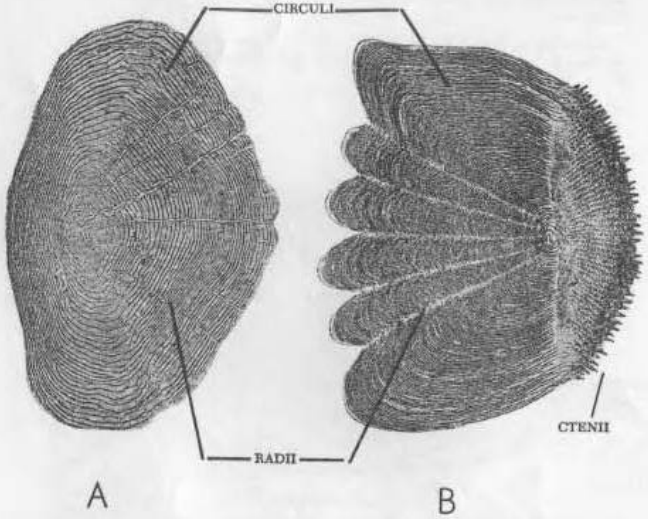

Fig. 7. Two common types of fish scales, with embedded portions to the left, and the posterior, exposed margin to the right. A. Cycloid scale (northern mimic shiner, *Notropis v. volucellus*). B. Ctenoid scale (yellow perch, *Perca flavescens*).

Other Counts

Branchiostegals or branchiostegal rays (Figs. 5, p. 21, 6, p. 22 and 40, p. 94). It is often desirable to separate by a plus sign (+) those branchiostegals which lie on the outer side of the hyoid arch from those that are inserted more anteriorly and more ventrally on the inner face of the arch. Care should be taken to include the most anterior branchiostegals which are apt to be very short, slender and concealed. The method of making this count has been described by Hubbs (1920).

Pharyngeal tooth counts (Fig. 36, p. 69). In minnows counts are made on the "throat-teeth" borne on two bones which are modified fifth gill arches and must be temporarily removed (with great care) and cleaned so that the count may be made. Each of these bones bears one or two rows of teeth (three rows in the introduced carp). The teeth in each row are counted and given in a formula in order from left to right; thus the formula 2, 5–4, 2 indicates that the pharyngeal bone of the left side has two teeth in the outer row and five in the inner, whereas the right bone has four teeth in the inner row and two in the outer. The formula 4–4 discloses that the fish has no teeth developed in the outer row. Pharyngeals of suckers are shown in Figs. 15, p. 28 and 32, p. 60.

Gill-rakers (Figs. 29, p. 51 and 49, p. 112). Unless otherwise stated, the count is that of the first arch. It is sometimes of value, however, to count the rakers on the other arches as well. A single gill-raker count indicates the number on the entire first arch, but has often been used for those on the lower limb only. If the numbers on the upper limb and lower limb are taken separately, the two figures are separated by a plus sign. If the count is taken along the lower limb only, the fact is stated. If a gill-raker straddles the angle of the arch, it is included in the count of the lower limb. All rudimentary rakers are to be included in the count (unless it is stated that the rudiments are excluded).

Pyloric caeca. In counting pyloric caeca all tips are enumerated unless the condition of branching is specifically described.

Vertebral counts. The typical hypural plate (Fig. 10, p. 28) of most teleosts is counted as a single vertebra. However, definite sutures along the vertebral axis are regarded as separating vertebrae, even though the suture or sutures lie within the hypural complex (this reservation applies particularly to the Salmonidae). In heterocercal (Fig. 8, p. 28) and abbreviate-heterocercal (Fig. 9, p. 28) tails, all elements are counted that are separated by definite sutures. Precaudal and caudal vertebrae are commonly distinguished. The first caudal vertebra is the first vertebra bearing a definite hemal spine. The last one to several precaudal (trunk) vertebrae may have complete hemal arches.

Methods of Measurements

Smoothly working dividers or dial-reading caliper should be used for measurements. Dividers should have one point flat at a right angle to the plane of operation and the other kept at a needle point. A steel ruler of good quality is recommended for precise readings. Great caution should be exercised in the way of accuracy. Measuring boards as commonly used in fishery investigations are hardly suitable for routine systematic work.

Unless otherwise stated, all measurements are taken in a straight line, from point to point rather than around the curve or as a projection. When the body or any part being measured has been curled, bloated, or otherwise distorted on death or in preservation, or when the head has been fixed in abnormal position, thrown upward and backward (in opisthotonus), with the gill-covers dilated, the part being measured is gently forced into as nearly the normal appearance as possible before being measured.

In descriptions it is customary to express the size of each part as a proportion of the standard length or of the head length, or occasionally of some other base. For routine descriptions the smaller part is conventionally divided into the larger, as head (length) 4.2 in standard length, or eye

(length) 3.5 in head (length). These values are usually obtained by stepping the length of the part into the base length over the curve of the latter, and this is our recommendation. Some, however, make the division arithmetically; when that is done, the practice should be so stated. In variation studies and for precise descriptions, the size of the parts is expressed in hundredths, or, better, as thousandths of the standard length. The divisions are most readily performed on a calculating machine.

Total length is the greatest dimension between the most anteriorly projecting part of the head and the farthest tip of the caudal fin when the caudal rays are squeezed together. The measurement is a straight line and is not taken over the curve of the body.

Standard length. In fishery work, as a result of the use of the measuring board, the standard length is taken as the distance from the most anterior part of the head (whether the lower jaw or the upper jaw projects) backward to the end of the vertebral column (structural base of the caudal rays).

In systematic work the standard length (Figs. 3, p. 19, and 4, p. 20) is properly the distance from the most anterior part of the snout or upper lip to the caudal base (although this has not been universal practice). Since the measurement is a straight line it is not taken over the curve of the body.

Body depth (Figs. 3, p. 19 and 4, p. 20) is the greatest dimension, exclusive of the fleshy or scaly structures which pertain to the fin bases.

Depth of caudal peduncle (Fig. 4, p. 20) is the least depth of that part.

Length of caudal peduncle (Fig. 4, p. 20) is the oblique distance between the end of the anal base and the hidden base of the middle caudal ray.

Predorsal length is the distance from the tip of the snout or upper lip to the structural base of the first dorsal ray.

Length of dorsal or of anal base is the greatest overall basal length, extending from the structural base of the first ray to the point where the membrane behind the last ray contacts the body.

Height of dorsal or of anal fin is taken from the origin of the fin to the tip of the anterior lobe.

Length of depressed dorsal or anal is the distance from the base of the first ray to the farthermost point when the fin is flattened down.

Length of longest dorsal or anal ray is measured from the structural base of the longest ray to its tip.

Length of pectoral or of pelvic fin (Figs. 4, p. 20). The length of the paired fins is the distance from the extreme base of the uppermost, outermost or anteriormost ray to the farthest tip of the fin, filaments, if any, included. For the pectoral fin this measurement is used when the fin is asymmetrical.

Length of longest pectoral ray (when this ray is at or near the middle of the fin) is measured from the middle of the base of the fin (Fig. 4, p. 20).

Spine and soft-ray lengths. When a spine is being measured, especial care is required to make sure that one tip of the dividers is inserted at the very base of the spine. Soft-rays are measured to their most extreme tip, but spines are measured only to the tip of the spine proper, not including filaments or soft-rayed extensions (as on the false pectoral spine of catfishes).

Head length is the distance from the most anterior point on the snout or upper lip to the most distant point of the opercular membrane (Figs. 5, p. 21 and 6, p. 22). Many authors, however, have excluded the membrane from the measurement.

Depth of head is measured from the midline at the occiput *vertically* downward to the ventral contour of the head or breast. If the cross-line of the isthmus is distinctly removed from this vertical, then a measurement "occiput to isthmus" may be taken.

Head width is the greatest dimension when the opercles, if dilated, are forced into a reasonably normal position.

Snout length (Figs. 3, p. 19 and 6, p. 22) is taken from the most anterior point on the snout or upper lip to the front margin of the orbit.

Postorbital length of head is the greatest distance between the orbit and the membranous opercular margin.

Suborbital width (Fig. 5, p. 21) is the least measurement from the orbit to the suborbital or preorbital margin.

Height of cheek is the least distance from the orbit downward to the lower edge of the anterior arm of the preopercle.

Length of cheek is the distance from the most posterior point of the preorbital (lachrymal) horizontally backward to the caudal margin of the preopercle, including spines if present approximately along this horizontal.

Orbit to angle of preopercle. The distance from the orbit to the angle of the preopercle is taken to include any spine at the angle.

Interorbital widths. In determining the *least fleshy width* of the interorbital, the dividers are not squeezed at all, but in measuring the *least bony width*, the points are pressed tightly against the bone so as to eliminate so far as practicable the thickness of the flesh overlying the bony rims.

Length of orbit (Fig. 6, p. 22) is the greatest distance between the free orbital rims, and is often oblique.

Length of eye (Fig. 3, p. 19), as contrasted with length of orbit, is the greatest distance across the cornea, that is, between the margins of the cartilaginous eye-ball. The location of the margin can be determined rather accurately by close examination, and by touching the eye surface with the points of the dividers, thereby causing the margins to become more visible, since the cornea is thinner and softer than the eye-ball.

Length of upper jaw (Fig. 6, p. 22) is the term that now replaces "length of maxillary," which is not truly descriptive since the measurement is taken from the anteriormost point of the premaxillary to the posteriormost point of the maxillary.

Length of mandible. In measuring the mandible, one tip of the dividers is inserted in the posterior mandibular joint, so as to give the maximum possible dimension.

Width of gape is the greatest transverse distance across the opening of the mouth.

Fish Names

Throughout this book, great care has been taken to give the user the most accurate, acceptable and up-to-date names for the many fishes treated. Two sets of names are involved, technical (scientific) and lay (common). Unhappily, there is only moderate stability in both; as new information is gained and as new concepts form, changes inevitably come about. Fish students, acquainted with earlier editions of this bulletin, will be aware of many of the changes that we have incorporated and will also know of many others that are pending. Although distressing to one who must continually re-learn names, or to one who must look under several names, when bibliographing a fish, change is the very essence of progress, and also the very clear manifestation that the science of ichthyology is a live one. Furthermore, the fact that there is change may be taken as encouragement by students. Even in such a circumscribed and much-investigated fauna as this, far from all of the taxonomic problems have been solved. Future works on Great Lakes fishes will always have in them some differences in naming (and classification) from those presented herein.

Each scientific name of a fish is composed of two parts and is latin or in latinized form. One of these names, the first, is the genus or generic name. The other, the second, is the species name. Thus, each of the families of fishes in the Great Lakes has one or more genera in it. Similarly, each genus has one, but may have more than one species in it. And species are divisible into groupings of close relatives called subspecies. When subspecies names are used, the scientific name is of three parts, or tri-nomial. An example follows for the northern smallmouth bass:

Genus	Species	Subspecies
Micropterus	*dolomieui*	*dolomieui*

When a scientific name of a fish is written, as in the keys and statements of ranges in this book, it is followed by the name of the person who first properly ascribed the scientific species (or subspecies, for tri-nomials) name to that kind of fish. Subsequent workers may have technical ground for moving this species to a genus other than that in which it was originally described. When this is done, the name of the first describer accompanies the species designation to the new generic location but is placed in parentheses to call attention to the fact that a shift has been made.

Alterations in the usage of scientific names, including shifts of species from one genus to another, are sometimes the result of painstaking study—research in greater detail and thoroughness than has been done or has been possible in previous time. Such emendations are welcome and tend to be durable. At other times, changes are made on a subjective basis and are less likely to be true and, therefore, acceptable. Our tendency has been to be conservative regarding change in this edition, with the full realization that certain proposals which we have deigned to follow may in the future be strengthened to the point of acceptability through additional study.

Alterations in scientific names and their assignment and usage follows established rules of the International Zoological Congress. Unfortunately, there is no such set procedure regarding common names. It is not surprising, therefore, that the beginning student and informal fisherman may be confused greatly by the profusion of common names that are applied to one and the same fish at different points in the Great Lakes basin and elsewhere. A classical example is that of the yellow walleye (*Stizostedion v. vitreum*) which is reputedly known by more than 80 common appellations throughout its range in chosen parts of the United States and Canada. Considerable effort is going into standardization of common names for use in print (even though highly localized names will continue their provincial existence). Most active and cooperating in this regard are the Outdoor Writers of America, the American Society of Ichthyologists and Herpetologists, and the American Fisheries Society. Most of the changes in common names in this edition, compared to the previous ones, result in our desire to conform with the printed results of the efforts of these groups.