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AGE DETERMINATION OF FISHES (REVISED)

Scale From A 7-Year-Old Haddock

Fishery
Leaflet
637

UNITED STATES DEPARTMENT OF COMMERCE
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Age Determination of Fishes (Revised)

By

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Introduction

Span of life in fishes, like size, covers an extremely wide range, depending upon species. A tiny European goby that matures at little over an inch in length is an example of an "annual" vertebrate, running the course of its life within a single year. Other fishes are known to pass the century mark. Canadian biologists in 1953 determined the age of a 215-pound sturgeon, caught by a Lake of the Woods fisherman, to be 152 years.

Aside from its value in filling gaps in our scientific knowledge of fishes and satisfying human curiosity concerning them, age and accompanying growth-rate information is of vital importance for the management of fishery resources. For instance, where fish are caught commercially, growth rate must be known in order to learn the size and age at which the fish may be most efficiently harvested. A further use of age information is in judging the results of management practices. Knowledge of the average size and age of fish before and after management measures are put into effect can sometimes show whether or not such plans are achieving desired ends.

Age Determination

Three basic methods have been used for age and growth determination of fishes: (1) observation of the growth of fishes of known age, (2) study of fish size-frequencies, and (3) study of seasonal ring formation in hard body parts such as scales and bones. The method used usually depends upon special problems encountered in age determination of a given species.

Observation of the Growth of Fish of Known Age

Fish of known age are held in a pond or aquarium for a number of years so that length for a given age may be determined by simply catching and measuring the fish periodically. While the method is direct, it has limited use since it requires raising fish under artificial conditions where growth rate may differ from that in their normal surroundings and where maintaining certain species may be difficult. The technique probably has its greatest use in verifying ages that have been determined by other means that are discussed later.

As an extension of this technique, fish of known age may be marked and released in their normal environment and then measured when they are recaught to learn size for the known age. Some small fish may be marked by the removal of certain fins so they can be identified upon capture. Larger fish usually are marked with small numbered tags of plastic or noncorrosive metal. A major drawback to this method is that the tag or mark may slow down growth, as has been shown for many fishes. To use the method effectively, one must therefore either demonstrate that the tag has no effect or correct for its effect. Neither of these is easily accomplished.

Study of Fish Size-Frequencies

The size-frequency method of age determination depends on the reproductive and growth characteristics of fish. Most fishes breed during a restricted period and only once a year so that sizes within a given brood year are fairly uniform and distinct from sizes from other brood years. Haddock, for example,

[1] This publication is a revision of Lux, Fred E., *Age Determination of Fishes,* U.S. Fish Wild. Serv., Fish. Leaflet No. 488.

spawn only during the late winter and spring. Baby fish from this spawning are 4 to 8 inches long by the summer and fall, and their length marks them as young of the current year. Haddock spawned in the previous year would be 10 or 12 inches long by this time and clearly separable, by size, from the baby fish.

To illustrate the technique, suppose we use a net, such as an otter trawl, and obtain a large catch of one kind of fish in which all sizes, young to adult, are represented. Let us measure the lengths of all fish in the catch and count the number of fish in each length span of, say, one-half inch for the entire range of sizes. If we now plot the numbers of fish in each of these length intervals on graph paper, it is likely that more than one peak will be evident in our graph because fish of certain lengths occur more frequently than others. It may be suspected that each clear-cut peak represents the average length in a separate age-group because of the restricted range of lengths within each age-group.

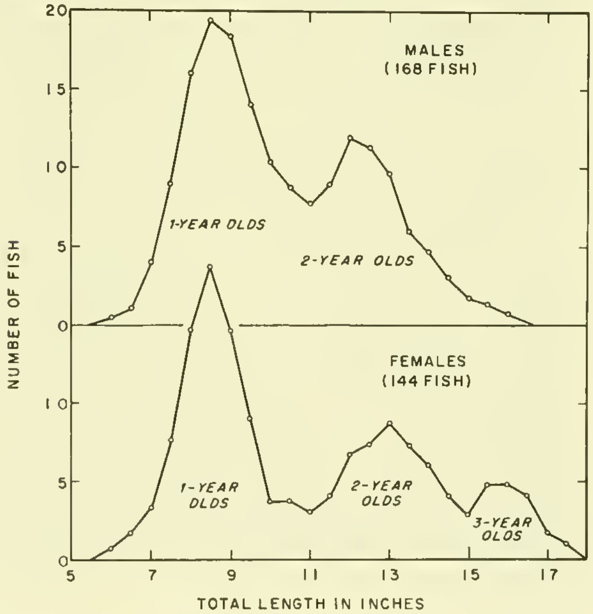

Figure 1.—The length-frequencies of a catch of yellowtail flounder, showing how fish age may be determined from fish size.

Figure 1 shows the lengths of a catch of yellowtail flounder graphed in this way. Males and females have been plotted separately because females of this species are known to grow faster than males. One-year-olds outnumber fish of older age-groups because deaths from various causes take a continuous toll.

There are two peaks in the graph of males, one at about 8½ inches, representing the approximate average length of 1-year-old fish, and a second at 12 inches, marking average length for 2-year-olds. For females, peaks are shown at 8½, 13, and 15½ inches, representing average lengths of 1-, 2-, and 3-year-olds, respectively. The graphs indicate that few fish older than these age-groups were present on the fishing ground. Also, no fish in their first year (0-year-olds) were caught here, for during the summer when this catch was made the baby yellowtail have not yet begun to school with older ones.

The size-frequency method works best for young fish, generally less than 3 or 4 years old. As fish grow older, the spread of sizes within an age-group becomes more variable. The peaks representing ages of older fish in the length-frequency graph tend to blend together, and it may be impossible to identify them. The peaks for 2- and 3-year-old females in Figure 1 already show signs of flattening out and blending together.

This disappearance of peaks with age is more apparent in the length-frequency distribution of haddock in Figure 2. This catch was

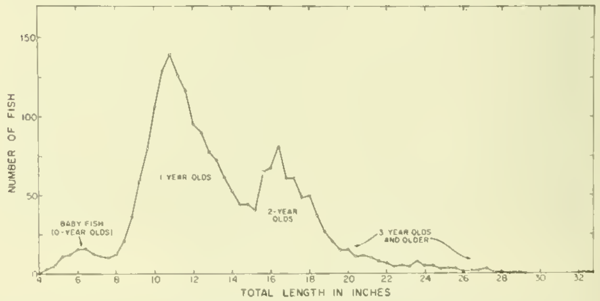

Figure 2.—The length-frequency distribution of a catch of haddock, showing the different size groups of fish caught.

obtained in the fall when baby fish are just beginning to appear in otter trawl catches. These averaged about 6 inches in length. One-year-olds averaged about 11 inches, while 2-year-olds were slightly over 16 inches in length. It is clear that the peak for 2-year-olds is not as sharply defined as that for 1-year-olds. This is because it undoubtedly also includes some

3-year-olds in the right-hand part. Beyond the 2-year-olds, no peaks are apparent because of the blending together of age-groups of older fish.

Study of Seasonal Ring Formation in Hard Body Parts of Fishes

Because fish are cold-blooded animals, their body processes are regulated by the temperature of the water in which they live. Growth is rapid during the warm season and slows greatly or stops in winter. The technique of determining the age of a tree by counting annual rings in a cross-section through the base of the trunk is a familiar one. As in trees, seasonal changes in growth rate of fishes are often reflected in zones or bands in hard body structures such as scales, otoliths (ear stones), and bones.

Fish Scales.—Of the hard body parts used for age determination in fishes, scales are most useful. They are easy to collect and prepare for study. Of importance is the fact that a few can be removed with little or no injury to the animal since fishes have the ability to regrow lost scales within a short time. A further advantage, that of permitting an estimation of the past growth history of a fish from its scale, will be discussed later.

Scales are of value for age determination in many of our "bony fishes," a broad grouping which includes most fishes of importance for food. Scales are formed when newly hatched fish complete their larval stages, and soon cover the entire body, with the exception of head and fins. In most species they lie in an overlapping pattern much like shingles on a roof and serve as a protective coat.

Scale growth begins with the formation of the scale center or focus, and growth is outward from this focus, though it is greatest toward the forward margin of the scale. Fine ridges called circuli are laid down in a circular pattern around the focus as growth proceeds. Many circuli are added to the scale each year.

Most food and game fishes have either cycloid or ctenoid scales. These two scale types are illustrated in Figure 3. Cycloid scales, found on trout, minnows, whitefish, pike, cod, and most other soft-finned fishes, have circuli which pass entirely around the scale margin as growth is added. In ctenoid scales, found on bass, perch, some flounders, and most spiny-finned fishes, the focus is near the rear edge of the scale, and circuli here are obscured by the tiny spines or ctenii which give these scales their name. It is the ctenii which give the bodies of such fish a rough sandpapery feeling.

As stated earlier, fish growth is reflected in scale growth. Circuli are widely spaced in warm seasons when fish growth is rapid and closely spaced in cold seasons when it is slow. In some northern climates, especially in ice-covered lakes, fish growth stops in winter. The growth of a fish during 1 year, therefore, is shown on its scale as a series of widely spaced spring and summer circuli followed by a series of closely spaced fall and winter circuli. Since fishes continue to grow throughout their lives, this pattern is repeated each year. The outer edge of a series of closely spaced circuli is generally taken to be the end of growth for that year, and this point is referred to as the year-mark or annulus (see whitefish and haddock scales in Figures 3 and 5). The age of a fish is determined by counting the number of annuli or year-marks.

In some cycloid scales, such as those on trout, there may be no clear seasonal difference in spacing between circuli. On these scales the year-mark is sometimes shown as a discontinuous or broken circulus following a series of complete circuli.

In ctenoid scales, like those of sunfish and bass, there is often no detectable difference in the seasonal spacing of circuli. Here another feature of scale circuli is relied upon to identify the end of growth for a given year. On these scales the last few circuli laid down in a year are often incomplete in that they do not continue all the way around to the spiny area of the scale. When fast growth resumes in spring, the circuli are again complete and cut across the ends of the incomplete circuli inside of them. The first complete circulus of the growth for the new year is considered to be the year-mark. This cutting over of circuli is illustrated in the sunfish scale in Figure 3.

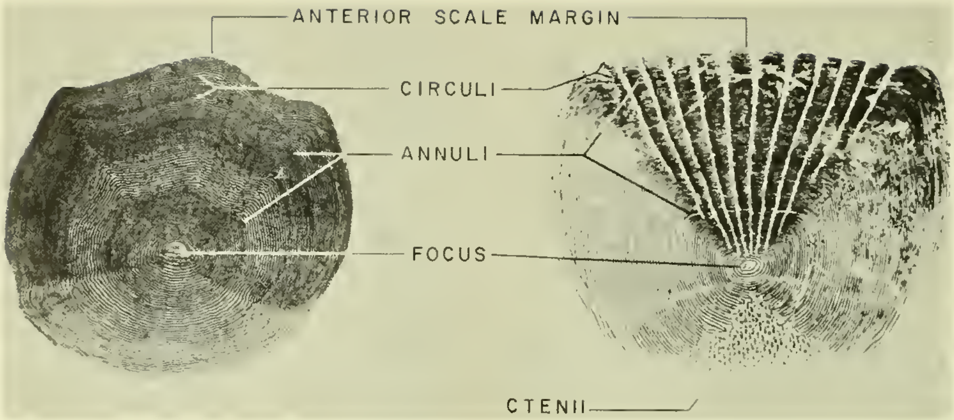

Figure 3.—The cycloid scale of a whitefish (left) and the ctenoid scale of a sunfish, showing year-marks (annuli) and general scale features. Both fish were 2 years old.

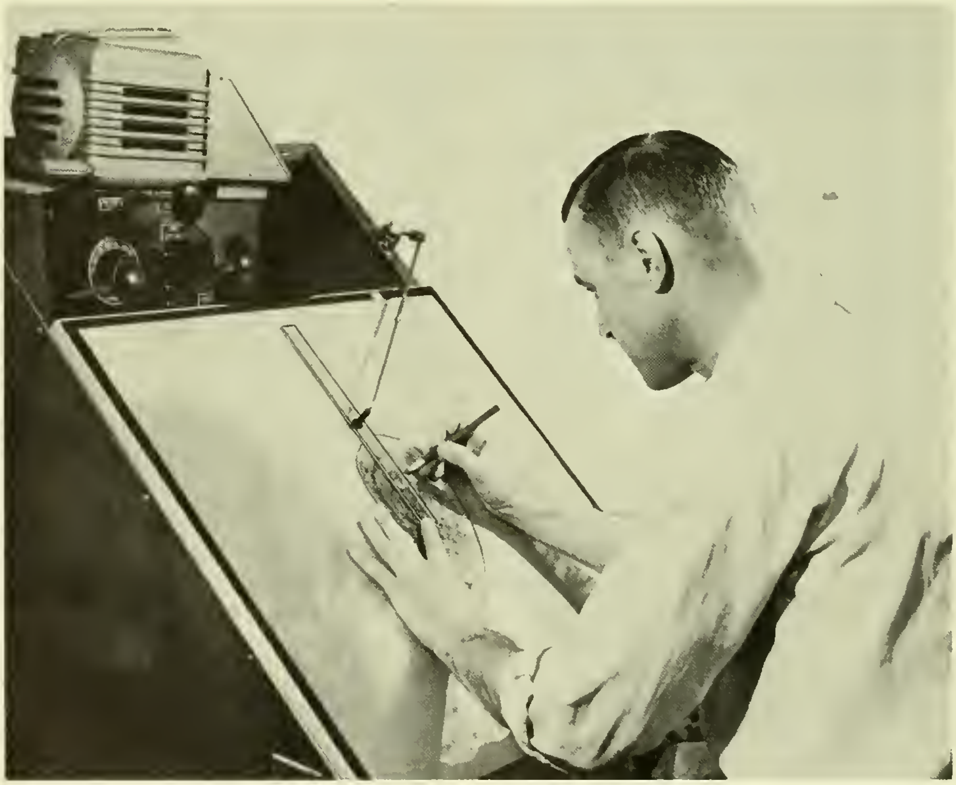

Figure 4.—A microprojector designed for the study of fish scales. The magnified scale image is projected on the frosted glass screen.

Scales may be prepared for study by mounting the whole scales on glass slides or, more commonly, by pressing imprints of the scale circuli into transparent plastic. The scale photographs shown are of these plastic impressions. Scales or scale impressions are examined under a low-power microscope or by use of a microprojector like the one shown in Figure 4.

As fish grow older and growth slows down, with a consequent narrowing of the band of circuli added to the scale each year, it becomes increasingly difficult to identify year-marks. This causes a greater amount of error in the determination of age of older fish.

A slowdown in fish growth may occur during a growing season, and the resulting check in scale growth sometimes resembles a year-mark. Where such checks are counted as year-marks, the age determined from the scale will be greater than the true age. These false year-marks are sometimes associated with reduced growth-rate at spawning time or with shock, such as injury or disease.

Growth in length of a fish scale is proportional to the growth in length of the fish itself. Because this is true, the past growth history of a fish can often be worked out from its scale through a technique called back-calculation. If the length of a fish at capture is known, it is possible to calculate length at earlier ages from measurements of the scale at each year-mark. The increase in length of a haddock in each year, in relation to increase in scale length, is illustrated in Figure 5. Lengths at each of the three year-marks were determined from back-calculations.

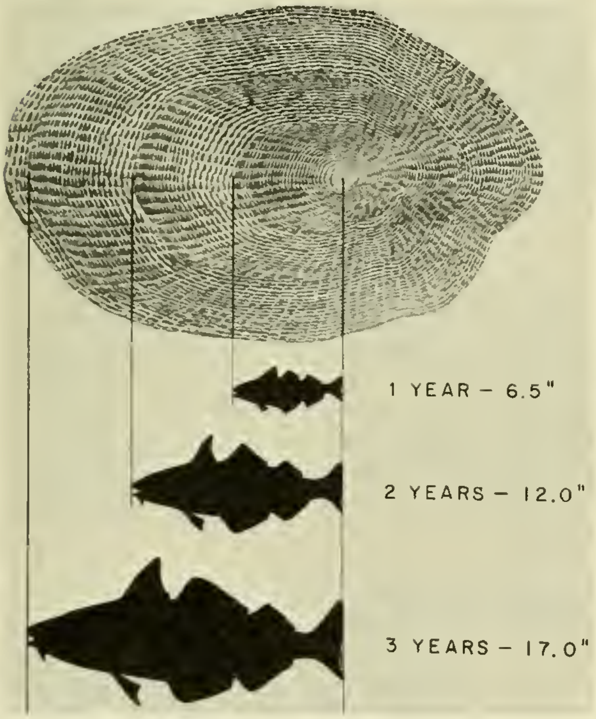

Figure 5.—Illustration showing how the past growth history of a fish may be determined from its scale. The 18½-inch haddock was in its fourth season since it has three year-marks on its scale and the beginnings of fourth-year growth on the scale edge.

The back-calculation method is of importance in fisheries studies since it permits an evaluation of growth rate of fish in all years of life.

Otoliths.—In fishes that do not have scales, or where annual zones are not clearly shown on scales, it is often possible to determine age from seasonal bands laid down in otoliths. Otoliths, or earstones, structures formed of calcium in the heads of bony fishes, function as organs of balance. Although there are three pairs of otoliths altogether, only one pair is large enough to be of use in age determination. Otolith form varies in different species from a flat oval to spindle shape. Growth, as in the scale, is concentric around a central kernel or nucleus (Figure 6). Factors, such as water

Figure 6.—An otolith from a 4-year-old yellowtail flounder. The fish grew most rapidly during its second year, and the otolith band in that year is therefore the broadest one.

temperature, that affect fish growth cause seasonal changes in the density of layers laid down in otoliths, and in some cases it is possible to determine fish age from the banding that results. When otoliths are viewed under a low-power microscope, the layers making up spring and summer growth appear as a white, opaque band. Layers laid down in the fall, and also in the winter in some fishes, appear as a dark translucent band. A light and a dark band together make up the annual growth, and age in years is determined by counting the number of dark bands. The otolith from a yellowtail flounder shown in Figure 6 illustrates the features described.

For many fishes otoliths show age more clearly than scales. They are often considered better than scales for determining age of older fish.

Preparation of otoliths for examination varies with the fish species under study. In some cases bands show clearly in dried otoliths, which may be examined whole or sectioned and polished. For other species, banding remains clear only if the otoliths are stored in some fluid such as glycerine or alcohol, upon removal from the fish.

Determination of fish age from otoliths is generally not difficult since little preparation time is required. Otolith extraction requires killing the fish, however, a disadvantage for some studies.

Bones.—Cross sections through the bases of fin rays, the thin bones that support fins, often show concentric banding that is related to fish age. The age of the 152-year-old sturgeon, mentioned earlier, was determined from a cross-section of the thick, spiny fin ray found at the base of one of the paired breast fins of this fish. Fin rays have been used for age determination in a number of species besides the sturgeon, such as catfish, bullheads, and suckers. Zonation is similar to that found in otoliths with a light band forming in the early part of the growing season followed by a narrow, dark band in fall and winter. The haddock fin ray cross-section shown in Figure 7 shows seven pairs of such bands. Age in years is determined by counting the dark bands.

Certain other bones of fishes may show seasonal zonation associated with age. Individual vertebrae and opercular bones (gill covers) are often well suited for age determination although other bones have been used in some cases. Annual bands, where present, are identified by differences in color shade between early and late season growth, as in fin rays. Zonation in vertebrae is concentric around the center line of the backbone. Opercular bones show banding along the growing edge.

Figure 7.—The cross-section of a fin ray from a 23-inch haddock, showing seven growth zones.

Bones may be cleaned by boiling in water. Most bones are then air dried to ready them for study, but fin rays must be cut into thin sections with a jeweler's saw or other suitable instrument. The sections are sometimes ground and polished for examination under a microscope.

References

The foregoing treatment of fish age determination is necessarily brief. For the reader who is interested in further pursuit of the subject, a short list of reference books containing sections on fish age and growth is given below. Some of the larger public libraries may be consulted for these as well as additional works.

CARLANDER, KENNETH D.
1950. Handbook of freshwater fishery biology. Wm. C. Brown Co., Dubuque, 281 pp. Summaries of age and growth data for most North American freshwater species, extracted from published reports.

CURTIS, BRIAN.
1948. The life story of the fish. Harcourt, Brace and Company, New York, 284 pp. A general work on fishes.

LAGLER, KARL F.
1952. Freshwater fishery biology. Wm. C. Brown Co., Dubuque, 360 pp.
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NORMAN, J. R.
1951. A history of fishes. A. A. Wyn, Inc., New York, 463 pp. (This is a 1951 reprint of the 1931 edition.)
Extensive work on the natural history of fishes of the world.

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1953. Fishery science, its methods and applications. John Wiley & Sons, Inc., New York, 444 pp.
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