

Glossary for Otolith Studies

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The rapid development of otolith studies has resulted in the need for standard terminology. Several glossaries have been produced (e.g., Jensen 1965; Chilton and Beamish 1982; Wilson et al. 1987), but either the terms or their definitions are not accepted universally. This has often led to confusion and incorrect interpretation of otolith structure. Furthermore, the rapid increase in the number of studies investigating daily increments and related otolith microstructure underscores the need to standardize terms relevant to this field of research.

The following glossary evolved from meetings held during the symposium "Fish Otolith Research and Application." It was not possible to reach consensus on most of the terms during the meetings and the majority of the glossary was compiled over several months following the conference. Therefore, authors of papers presented in the symposium volume may not have used the terminology or definitions presented here.

The glossary was produced for otolith studies only and is likely to evolve as this field of research develops. In many instances, similar terms and definitions would be applicable to scales, vertebrae, spines, cleithra, and other calcified tissues used in age estimation studies; however, the glossary has not been produced with this "universal" application in mind.

LITERATURE CITED

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Accessory growth center - a growth center formed beyond the otolith core that leads to a new plane of growth and from which a new series of growth increments appears to emanate. Formation of these structures is often associated with life-history transitions such as metamorphosis. Accessory growth centers are often referred to as accessory primordia; however, the term accessory growth center is preferred because these features are different structurally from primordia (e.g., they do not contain primordial granules).

Accuracy - the closeness of a measured or computed value to its true value.

Age estimation, age determination - these terms are preferred when discussing the process of assigning ages to fish. The term aging (ageing) should not be used as it refers to time-related processes and the alteration of an organism's composition, structure, and function over time. The term age estimation is preferred.

Age-group - the cohort of fish that have a given age (e.g., the 5-year-old age-group). The term is not synonymous with year-class or day-class.

Annulus (pl. annuli) - one of a series of concentric zones on a structure that may be interpreted in terms of age. The annulus is defined as either a continuous translucent or opaque zone that can be seen along the entire structure or as a ridge or a groove in or on the structure. In some cases, an annulus may not be continuous nor obviously concentric. The optical appearance of these marks depends on the otolith structure and the species and should be defined in terms of specific characteristics on the structure. This term has traditionally been used to designate year marks even though the term is derived from the Latin "anus" meaning ring, not from "annus," which means year. The variations in microstructure that make an annulus a distinctive region of an otolith are not well understood.

Antirostrum - anterior and dorsal projection of the sagitta. Generally shorter than the rostrum. See Fig. 1.

Asteriscus (pl. asterisci) - one of the three otolith pairs found in the membranous labyrinth of osteichthyan fishes. It lies within the lagena ("flask") of the pars inferior. In non-ostariophysan fishes the asteriscus is small and shaped like a flattened hemisphere or quarter moon. In the Ostario-physi the asteriscus is roughly circular and laterally compressed and is considerably larger than the sagitta.

Brood year - the year that eggs of salmonids are fertilized. The eggs hatch in the following year.

Check - a discontinuity (e.g., a stress-induced mark) in a zone, or in a pattern of opaque and translucent zones, or microincrements. Microstructural checks (e.g., hatching checks) often appear as high-contrast microincrements with a deeply etched D-zone or an abrupt change in the microstructural growth pattern. If the term is used, it requires precise definition.

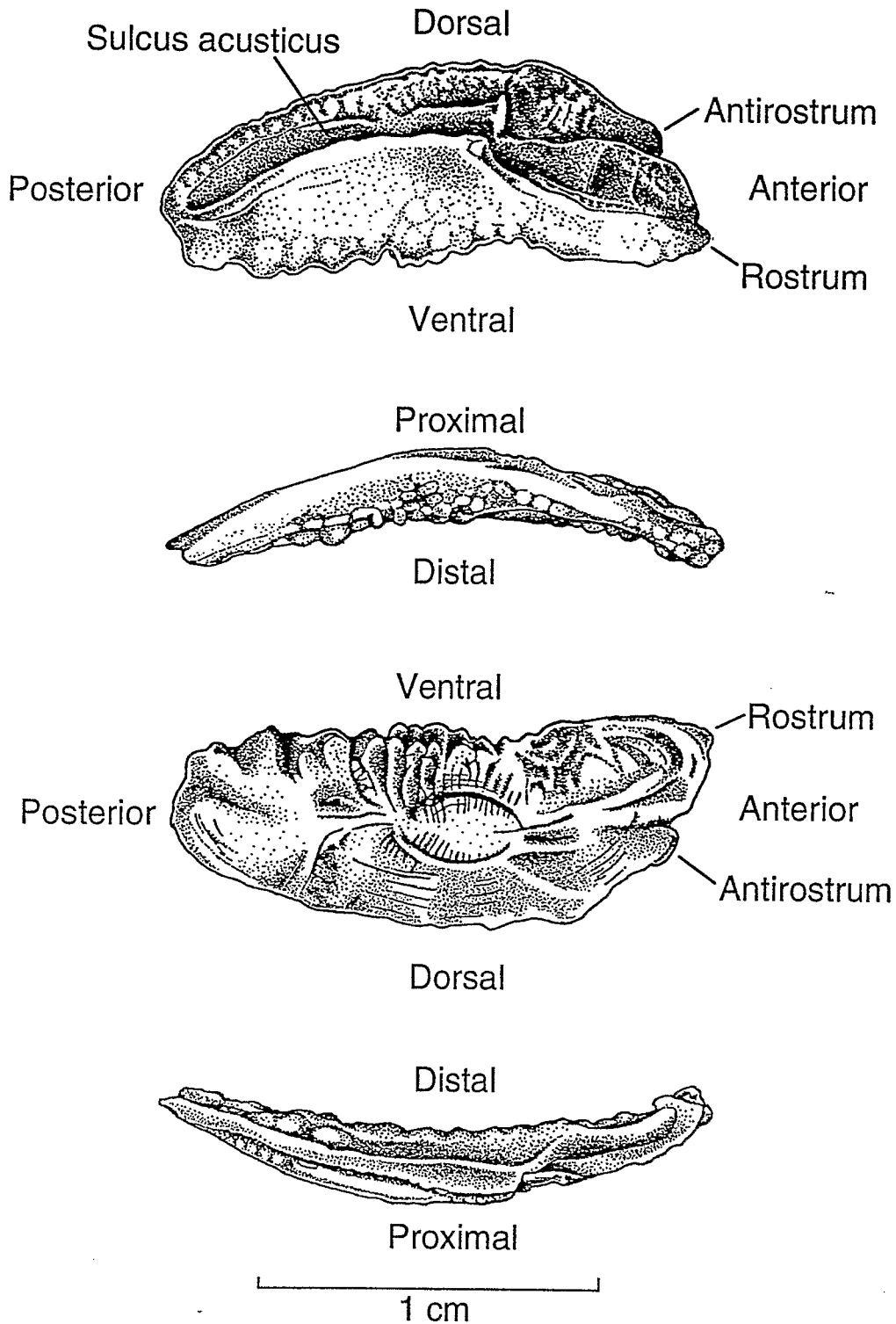


Fig. 1. Views of a left sagitta from *Arripis trutta* illustrate orientation and basic structure. A) the proximal surface, B) the ventral edge, C) the distal surface, D) the dorsal edge. (Drawing by Darren Stevens, New Zealand MAF Fisheries.)

Cohort - group of fish of a similar age that were spawned during the same time interval. Used with both age-group, year-class, and day-class.

Core - the area or areas surrounding one or more primordia and bounded by the first prominent D-zone. Some fishes (e.g., salmonids) possess multiple primordia and multiple cores.

Corroboration - a measure of the consistency or repeatability of an age determination method. For example, if two different readers agree on the number of zones present in a hard part, or if two different age estimation structures are interpreted as having the same number of zones, corroboration (but not validation) has been accomplished. The term verification has been used in a similar sense; however, the term corroboration is preferred as verification implies that the age estimates were confirmed as true.

D-zone - that portion of a microincrement that appears dark when viewed with transmitted light, and appears as a depressed region when acid-etched and viewed with a scanning electron microscope. This component of a microincrement contains a greater amount of organic matrix and a lesser amount of calcium carbonate than the L-zone. Referred to as discontinuous zone in earlier works on daily increments; D-zone is the preferred term. See L-zone.

Daily increment - an increment formed over a 24-hour period. In its general form, a daily increment consists of a D-zone and an L-zone. The term is synonymous with "daily growth increment" and "daily ring." The term daily ring is misleading and inaccurate and should not be used. The term daily increment is preferred. See increment.

Day-class - the cohort of fish spawned or hatched on a given date (e.g., the 22 September 1990 day-class). Whether this refers to the date of spawning or hatching must be specified.

Hatch date - the date a fish hatched; typically ascertained by counting daily increments from a presumed hatching check (see check) to the otolith edge.

Hyaline zone - a zone that allows the passage of greater quantities of light than an opaque zone. The term hyaline zone should be avoided; the preferred term is translucent zone.

Increment - a reference to the region between similar zones on a structure used for age estimation. The term refers to a structure, but it may be qualified to refer to portions of the otolith formed over a specified time interval (e.g. subdaily, daily, annual). Depending on the portion of the otolith considered, the dimensions, chemistry, and period of formation can vary widely. A daily increment consists of a D-zone and an L-zone, whereas an annual increment comprises an opaque zone and a translucent zone. Both daily and annual increments can be complex structures, comprising multiple D-zones and L-zones or opaque and translucent zones, respectively.

L-zone - that portion of a microincrement that appears light when viewed with transmitted light, and appears as an elevated region when acid etched and viewed with a scanning electron microscope. The component of a microincrement that contains a lesser amount of organic matrix and a greater amount of calcium carbonate than the D-zone. Referred to as incremental zone in earlier works on daily increments; L-zone is the preferred term. See D-zone.

Lapillus (pl. lapilli) - one of the three otolith pairs found in the membranous labyrinth of osteichthyan fishes. The most dorsal of the otoliths, it lies within the utriculus ("little pouch") of the pars superior. In most fishes, this otolith is shaped like an oblate sphere and it is smaller than the sagitta.

Marginal increment - the region beyond the last identifiable mark at the margin of a structure used for age estimation. Quantitatively, this increment is usually expressed in relative terms, that is, as a fraction or proportion of the last complete annual or daily increment.

Microincrement - increments that are typically less than 50 μm in width; the prefix "micro" serves to indicate that the object denoted is of relatively small size and that it may be observed only with a microscope. Often used to describe daily and subdaily increments. See increment.

Microstructural growth interruption - a discontinuity in crystallite growth marked by the deposition of an organic zone. It may be localized or a complete concentric feature. See check.

Nucleus, Kernel - collective terms originally used to indicate the primordia and core of the otolith. These collective terms are considered ambiguous and should not be used. The preferred terms are primordium and core (see definitions).

Opaque zone - a zone that restricts the passage of light when compared with a translucent zone. The term is a relative one because a zone is determined to be opaque on the basis of the appearance of adjacent zones in the otolith (see translucent zone). In untreated otoliths under transmitted light, the opaque zone appears dark and the translucent zone appears bright. Under reflected light the opaque zone appears bright and the translucent zone appears dark. An absolute value for the optical density of such a zone is not implied. See translucent zone.

Precision - the closeness of repeated measurements of the same quantity. For a measurement technique that is free of bias, precision implies accuracy.

Primordial granule - the primary or initial components of the primordium. There may be one or more primordial granules in each primordium. In sagittae the granules may be composed of vaterite, whereas the rest of the primordium is typically aragonite.

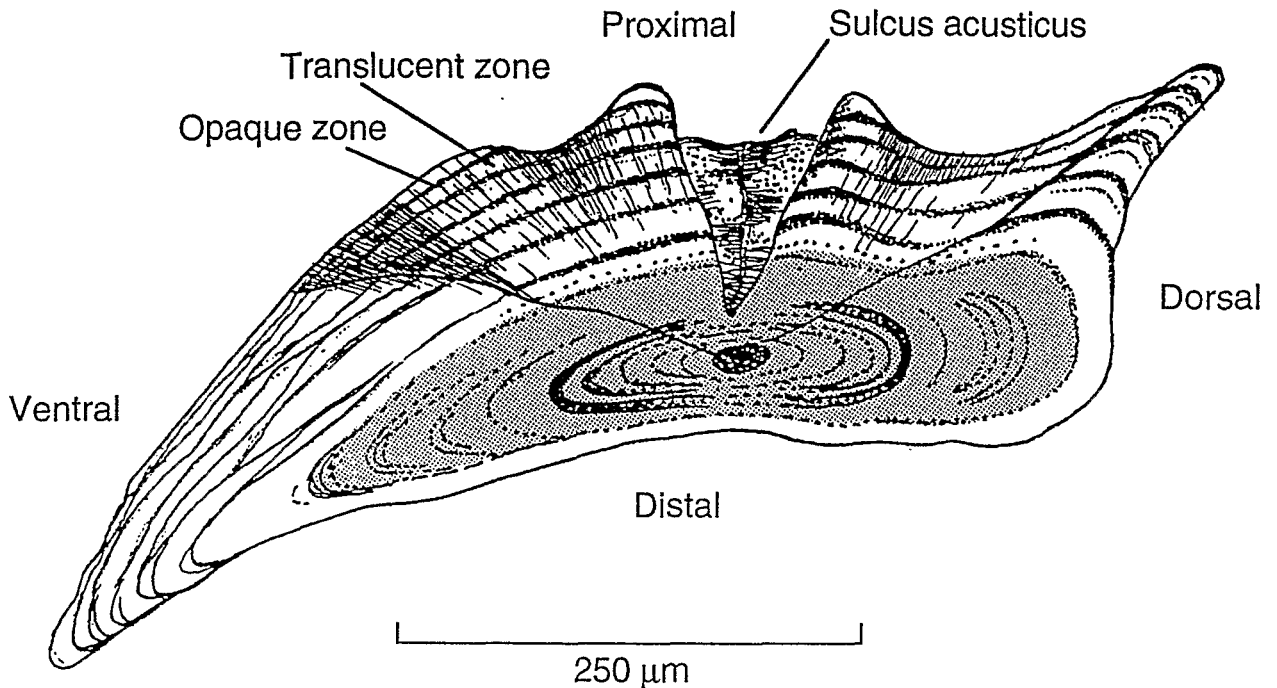


Fig. 2. Transverse thin section through a sagitta from *Arripis trutta* viewed with transmitted light illumination. The section is taken through the core. (Drawing by Darren Stevens, New Zealand MAF Fisheries.)

Primordium (pl. primordia) - the initial complex structure of an otolith, it consists of granular or fibrillar material surrounding one or more optically dense nuclei from $0.5\ \mu\text{m}$ to $1.0\ \mu\text{m}$ in diameter. In the early stages of otolith growth, if several primordia are present, they generally fuse to form the otolith core.

Rostrum - anterior and ventral projection of the sagitta. Generally longer than the antirostrum. See Fig. 1.

Sagitta (pl. sagittae) - one of the three otolith pairs found in the membranous labyrinth of osteichthyan fishes. It lies within the sacculus ("little sack") of the pars inferior. It is usually compressed laterally and is elliptical in shape; however, the shape of the sagitta varies considerably among species. In non-ostariophysan fishes, the sagitta is much larger than the asteriscus and lapillus. The sagitta is the otolith used most frequently in otolith studies. See Figs. 1 and 2.

Subdaily increment - an increment formed over a period of less than 24 hours. See increment.

Sulcus acusticus (commonly shortened to sulcus) - a groove along the medial surface of the sagitta. A thickened portion of the otolithic membrane lies within the sulcus acusticus. The sulcus acusticus is frequently referred to in otolith studies because of the clarity of increments near the sulcus in transverse sections of sagittae. See Figs. 1 and 2.

Transition zone - a region of change in otolith structure between two similar or dissimilar regions. In some cases, a transition zone is recognized due to its lack of structure or increments, or it may be recognized as a region of abrupt change in the form (e.g., width or contrast) of the increments. Transition zones are often formed in otoliths during metamorphosis from larval to juvenile stages or during significant habitat changes such as the movement from a pelagic to a demersal habitat or a marine to freshwater habitat. If the term is used, it requires precise definition.

Translucent zone - a zone that allows the passage of greater quantities of light than an opaque zone. The term is a relative one because a zone is determined to be translucent on the basis of the appearance of adjacent zones in the otolith (see opaque zone). An absolute value for the optical density of such a zone is not implied. In untreated otoliths under transmitted light, the translucent zone appears bright and the opaque zone appears dark. Under reflected light the translucent zone appears dark and the opaque zone appears bright. The term hyaline has been used, but translucent is the preferred term.

Validation - the process of estimating the accuracy of an age estimation method. The concept of validation is one of degree and should not be considered in absolute terms. If the method involves counting zones, then part of the validation process involves confirming the temporal meaning of the zones being counted. Validation of an age estimation procedure indicates that the method is sound and based on fact.

Verification - the process of establishing that something is true. Individual age estimates can be verified if a validated age estimation method has been employed. Verification implies the testing of something, such as an hypothesis, that can be determined in absolute terms to be either true or false.

Year-class - the cohort of fish that were spawned or hatched in a given year (e.g., the 1990 year-class). Whether this term is used to refer to the date of spawning or hatching must be specified as some high-latitude fish species have long developmental times prior to hatching.

Zone - region of similar structure or optical density. Synonymous with ring, band, and mark. The term zone is preferred.

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Recent Developments in Fish Otolith Research

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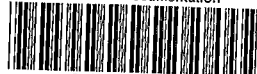
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