Glossary

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From Francillon-Vieillot *et al.*, 1990; Kalish *et al.*, 1995.

Legend: *(O)*, terminology reserved for otoliths; *(S)*, terminology reserved for scales; *(Sk)*, terminology reserved for skeleton.

Accessory growth centre (O): A growth centre 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 centres are often referred to as accessory *primordia*; however, the term accessory growth centre is preferred because these features are different structurally from *primordia* (e.g., they do not contain primordial granules). The term "secondary growth centre" has also been used. See figure II.A.8.

Accuracy: The closeness of a quantity estimation (measured or computed value) to its true value.

Age estimation: This term is 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 the composition, structure, and function of an organism over time. The term "age estimation" is preferable to "age determination" due to the uncertainty in assigning ages.

Age-group: The cohort of fish of 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. In some cases, an *annulus* may not be continuous or obviously concentric. The optical appearance of these marks depends on the calcified structure and the species and should be defined in terms of specific characteristics of 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. For otoliths, the variations in microstructure that make an *annulus* a distinctive region of an otolith are not well understood. See figures II.A.9, II.A.10 and II.C.9.

Anterostrum (O): see *Antirostrum.*

Antirostrum (O): Anterior and dorsal projection of the *sagitta*. Generally shorter than the *rostrum*. See figure II.A.4.

Asteriscus (pl. asterisci) (O): 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 Ostariophysi the *asteriscus* is roughly circular and laterally compressed and is considerably larger than the *sagitta*. See figure II.A.1.

Axis of measurement: A line along which growth increments are numbered and measured.

Band: See zone.

Bone remodelling (Sk): The process of reshaping of the bone tissue which occurs internally or at the edge of the bone. It can affect primary or secondary bone and every type of tissue. It is due to morphogenesis during the early life, or to physiological demand or mechanical constraints.

Bone resorption (Sk): The action of the erosion of the bone surface by osteoclasts or osteocytes at their own periphery.

Calcification: The process of deposition of calcium carbonate crystals in otoliths and calcium phosphate crystals in bones and scales.

Canaliculus (pl. canaliculi) (Sk): The thin space of the bone tissue including the cytoplasmic extension of the osteocysts and osteoblasts. See figure II.C.2.

Cementing line of resorption (Sk): There are two kinds of cementing lines: resorption lines (reversal lines) that occur on irregular resorbed surfaces and resting lines (rest line) that occur on unresorbed surfaces. Both are thin chromophilic lines that show a greater degree of mineralisation than the surrounding bone tissue. The resorption line separates the secondary bone from the primary bone. The resting line is a line of discontinuity within the bone tissue which corresponds to temporary but complete cessation of growth. See figure II.C.8.

Check (O): A discontinuity (e.g., a stress-induced mark) in an otolith zone, 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. See figure II.A.11.

Circulus (pl. circuli) (S): A concentric crest on the external face of elasmoid scales caused by tissue elevation of the superficial layer of the scale.

Cohort: A 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.

Compact bone (Sk): A kind of bone architecture in which the tissue volume is greater than that of the vascular cavities. Compact bone can be avascular.

Core (O): The area or areas surrounding one or more *primordia* and bounded by the first prominent D-zone. See figure II.A.5. Some fish (e.g., Salmonids) possess multiple *primordia* and multiple cores.

Corroboration: A measure of the consistency or repeatability of an age estimation 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.

Ctenius (pl. ctenii) (S): The outgrowth (spine) on the external face of the ctenoid scales, mainly deposited in the posterior field, particularly on the posterior edge. See figure II.B.2.

D-zone (O): That portion of an otolith microincrement that appears dark when viewed under transmitted light, and 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 the discontinuous or matrix-rich zone in earlier works on daily increments; "D-zone" is the preferred term. See L-zone and figure II.A.5.

Daily increment (O): An increment formed over a 24-hour period. In its general form, a daily increment consists of a D-zone and a 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 and figure II.A.5.

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.

Discontinuity (O): See check.

Double zone (or ring or mark): Two zones/rings that are close together relative to the size of the calcified structure and the distance between two *annuli*, which are considered as one *annulus*. As such a double zone includes both a secondary zone and an *annulus*. This structure has also been termed a "split ring".

Excisura major (O): The cleft separating *rostrum* and *antirostrum*.

Excisura minor (O): The cleft separating *postrostrum* and *pararostrum*.

Field: An area of a calcified structure, defined on a side or a section, and delimited at least by the centre and the edges (e.g., anterior, posterior, dorsal, ventral fields). It has also been termed as "region".

Focus (pl. foci) (S): The central part and the centre of origin of the scale.

Growth mark (or ring or zone): See mark or zone.

Growth pattern: The notion of the relative growth of increments during a period of the life of the calcified structure (e.g. *annuli* or daily increments).

Hatch date (O): The date on which a fish has hatched, typically ascertained by counting daily increments from a presumed hatching check (see check) to the otolith edge.

Haversian system (Sk): See secondary osteon.

Hyaline zone: A zone that allows the passage of greater quantities of light than an opaque zone. The term should be avoided; the preferred term is "translucent zone". See 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 hard part formed over a specified time interval (e.g. sub-daily, daily, annual). Depending on the portion of the hard part being considered, the dimensions, chemistry, and period of formation may vary widely. A primary increment consists of a D-zone and an L-zone, whereas an annual increment comprises an opaque zone and a translucent zone. There may also be secondary structures such as sub-daily increments and false and double zones within annual increments.

Initium (Sk): The centre of origin of growth of the fin ray.

L-zone (O): That portion of a microincrement that appears light when viewed under transmitted light, and 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 and figure II.A.5.

Lapillus (pl. lapilli) (O): 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*. See figure II.A.1.

Lobes (O): The minor rounded protrusions of the *sagitta* along the dorsal and the ventral edge.

Macrocentric scale (or regenerated scale) (S): See regenerated scale.

Macroincrement: Increments that are typically more than 50 µm in width; the prefix "macro" serves to indicate that the object denoted is of relatively large size and that it can be seen with a binocular microscope. Often used to describe seasonal increments. See increment.

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.

Mark: A general expression describing an histomorphological mark of similar structure or optical density laid down during the growth of hard parts. See zone.

Medular cavity (Sk): The first vascular cavity in the median position in the long bones, for example in spiny rays of catfishes. See figure II.C.6.

Microcentric scale (S): A scale present since the early life of the individual, which has not been resorbed.

Microincrement (O): An increments that is less than 50 µm in width, typically from one to 20 µm; the prefix "micro" serves to indicate that the object denoted is of relatively small size and that it can only be observed with a compound or electron microscope. Often used to describe daily and sub-daily otolith increments. See increment.

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

Mineralisation: The biological process of the deposition of crystalline or amorphous mineral material in or on an organic matrix.

Multiple zone (or ring or mark): A number of closed zones, compared to the size of the calcified structure and the distance of the *annuli*, which are regarded as one *annulus*. See also false zone.

Nucleus, Kernel (O): Collective terms originally used to indicate the *primordia* and core of the otolith. These collective terms are ambiguous and should not be used in descriptions of microstructure. The preferred terms are "*primordium*" and "core" (see definitions). When viewed macroscopically, the term "*nucleus*" has been used to refer to the region around the core, although the precise extent of this area is generally ill defined. If the term is used in describing macrostructure, it requires precise definition.

Opaque zone: A zone that restricts the passage of light in comparison 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.

Optical focus plane (O): A plane at a certain depth in the 3D otolith structure where microincrements can be distinguished when viewed under a light microscope. The orientations of the radial growth directions at an optical focus plane are perpendicular to the direction of observation.

Ossification (Sk): All the processes involved in bone formation.

Osteoblast (Sk): A specific bone cell which synthesizes the bone matrix and is located on the inner (endost) or on the outer (periost) surfaces of the bone tissue.

Osteoclast (Sk): A specific bone cell which is involved in bone resorption, generally multinucleated in higher Vertebrates; they may also be mononucleated in fish.

Osteocyte (Sk): A specific type of bone cell embedded in the bone tissue and carrying out the trophic needs of the bone. It is an osteoblast incorporated in tissue.

Osteogenesis (Sk): The process of bone tissue formation by the specialized cells (osteoblasts).

Otolithometry (O): Age estimation from marks recorded in the otoliths of Teleost fish.

Pararostrum (O): The posterior and dorsal projection of the *sagitta*. Generally shorter than the *postrostrum* (used in connection with Clupeid otolith morphology).

Postrostrum (O): The posterior and ventral projection of the *sagitta*. Generally longer than the *pararostrum* (used in connection with Clupeid otolith morphology).

Precision: The closeness of repeated measurements of the same quantity. For a measurement technique that is free of bias, precision implies accuracy but the two terms are not equivalent.

Primary bone (Sk): The bony tissue which is deposited where antecedent bone does not exist.

Primary osteon (Sk): A vascular canal surrounded by concentric bone *lamellae* which are deposited centripetally and which does not depend on previous resorption.

Primordial granule (O): 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.

Primordium (pl. primordia) (O): The initial complex structure of an otolith; it consists of granular or fibrillar material surrounding one or more optically dense *nuclei* from 0.5 μm to 1.0 μm in diameter. In the early stages of otolith growth, if several *primordia* are present, they generally fuse to form the otolith core.

Pseudo-lamellar bone tissue (or parallel-fibred bone tissue) (Sk): A bone tissue which is composed of a matrix with parallel collagenous fibres from one to another bone layer.

Radius (pl. radii) (S): A radially oriented groove, generally starting from the scale focus, and corresponding to the absence of an superficial (external) layer of the scale. See figure II.B.1.

Read, Reader, Reading: Special terms used in the jargon of sclerochronologists. The reading of a calcified structure consists of interpreting its growth patterns. A reader is a person who tries to interpret the marks recorded in a given calcified structure.

Regenerated scale (or macrocentric scale) (S): A scale which has been rapidly regenerated after the removal of the original (microcentric) scale.

Resorption: The loss of the original material of a calcified structure through a physiological process (e.g. removed from its original place).

Rest line (or line of growth stop) (Sk): See cementing line.

Ring: See increment and zone.

Rostrum (O): Anterior and ventral projection of the *sagitta*. Generally longer than the *antirostrum*.

Sagitta (pl. sagittae) (O): 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 figure II.A.1.

Scalimetry (S): Age estimation using marks recorded in the scales of Teleost fish.

Sclerochronology: The method of estimating age and the duration of life history events (or temporally-based events), from marks recorded and conserved in calcified structures.

Secondary bone (Sk): Bony tissue which is deposited in an area where the primary bone has been resorbed (bone of substitution).

Secondary osteon (or Haversian system) (Sk): An erosional cavity initiated from a vascular canal and secondarily filled with concentric bone *lamellae* deposited centripetally.

Secondary structure: A term used for all macroscopic zonations that do not appear to conform to the opaque and translucent zones of an *annulus*. The main examples are false and split or double rings/zones.

Skeletochronology (Sk): Age estimation using marks recorded in the skeletal structures of Teleost fish.

Spongy bone (Sk): A type of bone atchitecture in which the tissue volume is very vascular. The volume of the vascular cavities is much larger than that of the tissue.

Stained ring (or line): A chromophilic/stainable ring or zone with a variable intensity.

Sub-daily increments (O): An increment formed over a period of less than 24 hours. See increment.

Sulcus acusticus (usually shortened to *sulcus) (O):* 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 often referred to in otolith studies because of the clarity of the increments near the *sulcus* in transverse sections of *sagittae*. See figure II.A.4.

Supernumerary mark (or ring or zone): A mark which is not accepted for age estimation or retained as an *annulus*. This mark is generally aperiodic.

Transition zone (O): 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 structure (see opaque zone). An absolute value for the optical density of such a zone is not implied. In untreated calcified structures 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 preferable.

Ultrastructure: The structure of a tissue observed at high levels of magnification (particularly with electron microscopy).

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 significance 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 a hypothesis, that can be determined in absolute terms to be either true or false. See corroboration.

Vertebral body (Sk): The circular and central part of a vertebra.

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 undergo a long period of development before hatching.

Zone: A region of similar structure or optical density. Synonymous with "ring", "band" and "mark". Where possible the use of this term should be illustrated.

Panfili Jacques, Meunier F.J., Mosegaard H., Troadec H., Wright P.J., Geffen A.J. (2002)

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In : Panfili Jacques (ed.), Pontual H. de (ed.), Troadec H. (ed.), Casselman J.M. (préf.), Moksness E. (préf.), Wright P.J. (ed.). *Manual of fish sclerochronology*

Paris (FRA) ; Brest : IRD ; IFREMER, p. 373-383

ISBN 2-7099-1490-5