Manual for age determination of Baltic herring

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Standardised terminology

Accuracy: the closeness of a measured or computed value (e.g., age) to its true value. Accuracy can be proven or estimated: estimates of accuracy are less valuable, but in some cases only an estimate is possible.

Age estimation, age determination: these terms are preferred when discussing the process of assigning ages to fish. The term 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.

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

Annulus (pl. annuli): (winter zone) A translucent growth zone that forms once a year representing a time of slower growth.

Annual growth ring: A part of otolith that consists of one opaque zone (summer zone) and annulus (winter zone).

Bias: A lack of precision that is not normally distributed around the mean: it is skewed to one side or the other. For age reading it may apply to one reader's interpretations which are predominantly more or less than those of another for all ages: or it may apply to a portion of the age range.

Birth date: Based on the internationally accepted standard all Baltic herring are assumed to have a birth date of January 1.

Check: Translucent zone that forms within the opaque (summer) zone representing a slowing of growth. Such a zone is not usually as prominent as annuli and should not be included in the age estimate.

Cohort: A group of fish that were born during the same year (1 January–31 December).

Edge (marginal) growth: The amount and type of growth (opaque and translucent) on an otolith's margin or edge. The amount and type of growth on the edge must be related to the time of year the fish was caught and the internationally accepted and standard January 1 birthday. New opaque growth forming on the margin of the otolith is often referred to as plus growth or incremental growth.

False ring: Synonym of check. Translucent zone that forms within the opaque (summer) zone representing a slowing of growth. Such a zone is not usually as prominent as annuli and should not be included in the age estimate.

Nucleus: The central area of the otolith formed during the larval stage.

Opaque zone: (summer zone) A growth zone that restricts the passage of light. In untreated otoliths under transmitted light, the opaque zone appears dark. Under reflected light it appears bright.

Precision: A process that measures the closeness of repeated independent age estimates. Precision relates to reproducibility and is not a measure of accuracy. The degree of agreement among readers is a measure of precision of the determinations and not the accuracy of the technique.

Reflected light: Light that shines onto the surface of an otolith from above or from the side if the surface is not shadowed.

Sagitta (pl. sagittae): The largest of three otolith pairs found in Baltic Herring. The sagitta is the otolith used most frequently in otolith studies.

Summer zone: Opaque growth that is normally deposited during summer and autumn seasons when fish are growing relatively quickly.

Transition zone: A region of change in an otolith growth pattern between two similar or dissimilar regions. It is recognized as a region of significant change in the form (e.g., width, clarity or colour) of the annual growth zones. In some cases the formation of the transition zone is connected with the change from juvenile to mature growth. However, in the Baltic Sea the transition zone is more often observed on otoliths of herring from the north-eastern Baltic Sea and the gulfs where the formation of the transition zone is related to unfavourable feeding conditions or to significant changes of growth rate. In the transition zones the annual growth rings become very narrow and dark, and the distinction of them is troublesome.

Translucent zone: (Hyaline zone, annulus, check) A growth zone that allows a better passage of light. In untreated otoliths under transmitted light, the translucent zone appears bright. Under reflected light it appears dark.

Transmitted light: Light that is passed through the otolith from below (e.g., sections).

Validation: the process of estimating the accuracy of an age estimating method, etc.

Winter zone: translucent growth (annulus; not check) that is normally deposited during the late autumn and winter seasons when fish are growing relatively slowly.

Year-class: The cohort of fish that were in a given year (1 January – 31 December) (e.g., the 1990-year class).

Zone: Region of similar structure or optical density (opaque or translucent).

Age Determination Criteria and the Main Reasons for differences in age determination

Age determination

The age determination of herring is based on otoliths. Both sagitta otoliths should be taken. The otoliths are investigated using binocular microscope. The otoliths are put on a black background and examined under reflecting light. Opaque zones are then visible as white and hyaline zones dark (Figure 1). A 1 January birth date is used. The date of capture must always be available. One year's growth ring consists of one opaque zone and one hyaline zone. For younger fish the winter zones are usually well visible on the whole otolith, while for older herring they are best seen on the rostrum and this part of otolith should be preferred for age determination. Herring is aged by counting of hyaline winter zones. The winter zone is convincingly seen when it is situated between two opaque zones, while it is hardly visible when it is on the edge of the otolith. Therefore, the main task of the age reader would be to determine whether the last opaque zone has been formed during the previous or the current year. If it is considered that the last opaque zone has been formed during the previous year, then this opaque zone should be followed by a hyaline zone even if it is not visible and this hyaline zone should be counted. Such situation takes place in the first half of the year when the formation of the new opaque zone has not started yet. After the new opaque zone has started to grow the age of herring is obtained by counting visible hyaline zones and all of them are situated between opaque zones.

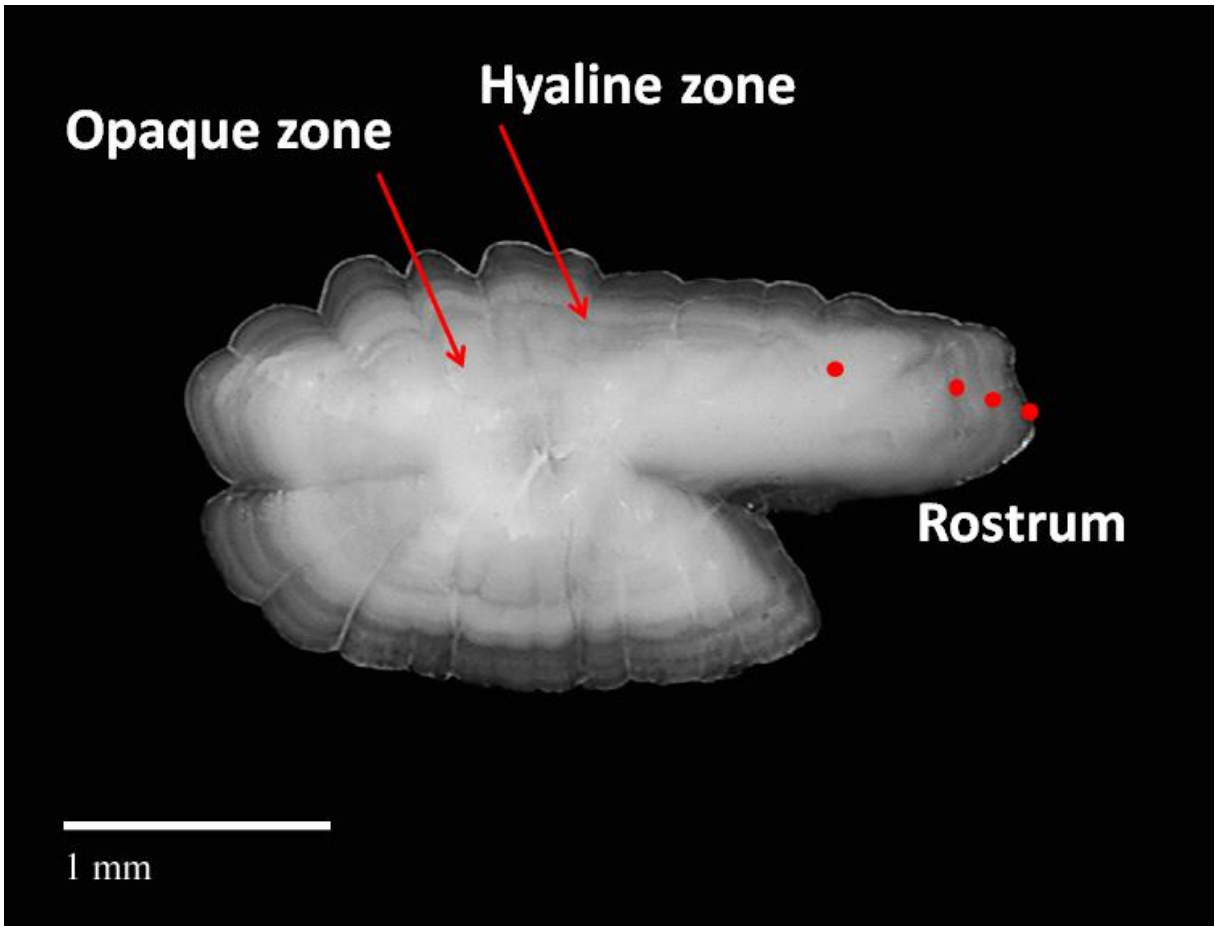

Figure 1. Baltic herring otolith (4 years old captured at early spring in the Gulf of Riga when the formation of the new opaque zone had not started).

Identification and location of false rings

False rings are translucent zones which form within the opaque (summer) zone representing a slowing of growth. Such a zone is not usually as prominent as annuli and could be seen only on some parts of the otoliths (usually it is not seen on the rostrum!). Besides, false rings tend to be discontinuous, weak or diffuse, and inconsistent with the general pattern of true winter zones. Therefore, it is recommended to compare the pattern of a questionable zone with normal winter zones to decide whether the questionable zone is a true winter zone or not. False rings should not be included in the age estimate. Most often false rings could be seen inside the opaque zones which have formed during the first years of herring life. Thus, in the southern Baltic false ring could be seen in the first opaque zone. This false ring usually has a circular form and is situated close to the nucleus. On some otoliths the second opaque zone (forming when herring is 1-year-old) is much narrower than the following opaque zone. Since at the age of 1 year herring is not spawning and its feeding season is very long, even bad feeding conditions should not result in formation of such narrow zone. Therefore, it should be considered that one of the hyaline (winter) zones which border the second opaque zone is false and should not be counted. The exception could be the case when the reader has evidenced the formation of such narrow zone by previous otolith sampling.

Identification of the first winter zone

In some cases, especially in older herring, the first winter zone may be overgrown by the opaque material, and therefore the first winter zone may be visible only in the dorsal and ventral area of the otolith. In the cases when the second summer zone is very narrow in comparison with the first summer zone it could be an indication that the first winter zone is hardly visible, and the reader should try to identify the possible first winter zone from both sides of the otolith.

Formation of summer zones

The formation of summer zone depends on the area, hydrometeorological conditions and age of fish. In the western Baltic the growth in young age groups may start already in March. Due to climate differences, the growth starts later in more northern areas. In the northern Baltic the yearly growth in young age groups may start as late as in July. The formation of growth zone in adult fish depends on spawning time and feeding conditions. At first the new opaque zone could be noticed on 1 and 2 years old herring otoliths and later on older herring otoliths. In the central and northern parts of the Baltic Sea the growth of otoliths in old age groups may start as late as in September-October therefore in late summer-early autumn it may be difficult to determine whether the outermost opaque zone has formed in the current feeding season or the previous year. It would be important for old fish to determine whether the last opaque zone is followed by the hyaline zone or not. For old fish the presence of a hyaline zone on the edge of the otolith in late summer and early autumn should be considered as the winter zone of the previous year and should be counted when estimating the age. It also means that the formation of the new opaque (summer) zone has not started yet. To detect the beginning of summer zone formation regular monthly sampling during summer months is desirable. Usually early appearance of the new summer zone indicates favourable feeding conditions and often results in a formation of a relatively wider summer zone while late appearance could result in opposite. Very wide or narrow summer growth zones can be used as markers for the age determination in the next years. Especially it could be helpful in the age determination of older fish.

Differences in various parts of the otolith

In general, the width of annual growth rings is gradually decreasing, and every next growth ring is narrower than the previous one. If the next growth ring is broader than the previous one it could

indicate very good feeding conditions in this year. If this has a general pattern it could be useful for the age determination. The first two winter zones are mostly not visible on the rostrum of older fish but are visible on other parts of the otolith. The third and next winter zones are usually visible in the whole otolith. In old fish the last winter zones can be distinguished only in rostrum. In the transition zones of otolith the annual growth rings usually become significantly narrower than the growth rings before the transition zone. Besides the growth rings in the transition zones become darker and the distinction of separate growth rings is more difficult. Therefore, it should be taken into account that in the transition zones the darkening of the growth rings indicates a lower growth rate and narrower growth rings in comparison with growth rings before the transition zone.

Transparency of otoliths

Crystallised otoliths should be recorded and then discarded from the sample. Partly crystallised otoliths which are readable should be recorded and the age should be determined. At present it is not clear if the phenomenon of crystallisation is a feature of particular year classes.

Other available information for age determination

Usually the otolith readers are provided with information on length, weight and often also sex and maturity of the aged fish. An experienced reader is not much influenced by the information on the length of the fish. It would be desirable that otolith readers are provided with information on hydrometeorological and herring feeding conditions in the area of investigations. It can help the reader to estimate the formation of the summer zone in the current year.