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**Aging manual for Pacific halibut:  
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Commission**

by

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## Abstract

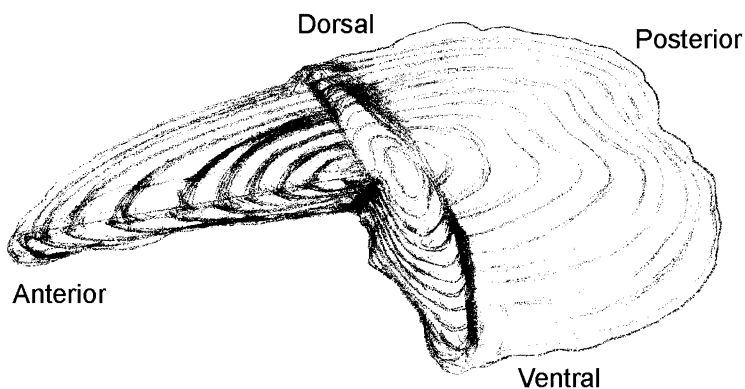
Since its inception, the International Pacific Halibut Commission (IPHC) has collected Pacific halibut otoliths for use in age determination. This manual provides an overview of generalized age determination procedures for fish otoliths as well as detailing otolith preparation, storage, and aging techniques used at the IPHC.

## General background on otoliths and age determination

In fisheries management or research, accurate age determinations for the fish species in question are critical for estimating growth and mortality rates as well as population age structure (Pentilla and Dery 1988, Chilton and Beamish 1982). Otoliths were first used for age determination by a researcher named Reibisch in 1899. Otoliths, also called “ear-bones” or “ear-stones”, are calcareous structures found in the head of most fish. All teleost fishes have three pairs of otoliths: the *asteriscae*, *lapillae* and *sagittae*. The sagittae are much larger in size than the other otoliths and are the pair most often used in age determination. Each sagittal otolith is enclosed in a fluid-filled sac called the *sacculus* within the otic capsule of the head. The otic capsules are situated on either side of the posterior portion of the brain. Otoliths are not true bone; they are acellular and avascular, unlike skeletal bone. Rather, otoliths are composed of calcium carbonate in the crystalline form of *aragonite*, in a protein matrix. Otoliths act as sound receptors and also play a role in balance and orientation. Otolith size and shape, particularly of the sagittae, varies greatly among species. Size and shape of the sagittae are related to their function, namely sound detection in the fish (Popper and Lu 2000).

As the fish grows, so does the otolith. The otolith begins as a very small spherical body in the ear of the larval fish and with the growth of the fish, increases in size by the deposition of concentric *lamellae* or layers of material around the outside. Deposition is much greater in two planes than in the third, producing a flattened structure in the adult (Fig. 1).

In addition, seasonal changes in the fish’s growth rate are reflected in the otolith. Material is deposited on the otolith from the *endolymph*, the fluid that surrounds the otolith. The deposits are formed in bands of alternating optical density, which appear either opaque or translucent under reflected light. The alternating zones on the otolith are due to differences in the amount of protein (called *otolin*) in the zones and shape of the aragonite crystals; aragonite crystals form longer and narrower at higher temperatures, shorter and



**Figure 1. Cutaway three-dimensional illustration of a halibut otolith showing deposition of concentric lamellae.**

wider at lower temperatures (Hagen 1997). A year's growth consists of both an opaque and translucent zone. The opaque zone is formed during the period of faster growth, which typically occurs in the summer and is made up of longer aragonite crystals. The translucent zone is formed during slower growth, which typically occurs in the winter, and is composed of shorter crystals of aragonite and contains comparatively more protein. The opaque and translucent zones are also often referred to as the summer and winter zones respectively. Winter-spawning fish such as halibut are assigned an arbitrary January 1 "birth date" by international convention. Therefore, the translucent or winter zones of halibut otoliths are counted to determine the age of the fish in years. The winter growth zones are also referred to as *annuli* (singular: *annulus*) or *hyaline zones*.

Within the opaque (summer) and translucent (winter) zones on the otolith are *daily rings*. Daily rings are, as the name implies, laid down daily and are composed of two alternating zones with different optical properties, as in annual zones. The differing appearances of the two zones in daily increments are due to the orientation of organic fibers in relation to the aragonite crystals and the relative widths of the zones. The alternating deposition of zones of different appearance and composition is related to both external (temperature, food, light, salinity, etc.) and internal (e.g., calcium metabolism and interaction of various hormone feedback systems) factors (Simkiss, 1974). Daily rings are only visible under high magnification and are not used in the production aging of Pacific halibut. In most species, daily rings are legible only through the first year. After the first year, daily growth rings are too compressed to differentiate. Weekly, bi-weekly and monthly patterns (as well as daily and annual) can also be seen in some species.

The otolith reflects growth rate changes over the years as well as seasons within a year. As the fish grows older, the relative width of the otolith zones decreases. In the first few years, otolith growth is rapid, resulting in broad opaque zones. As the fish ages, the opaque zones become narrower until they are almost the same width as the translucent zones.

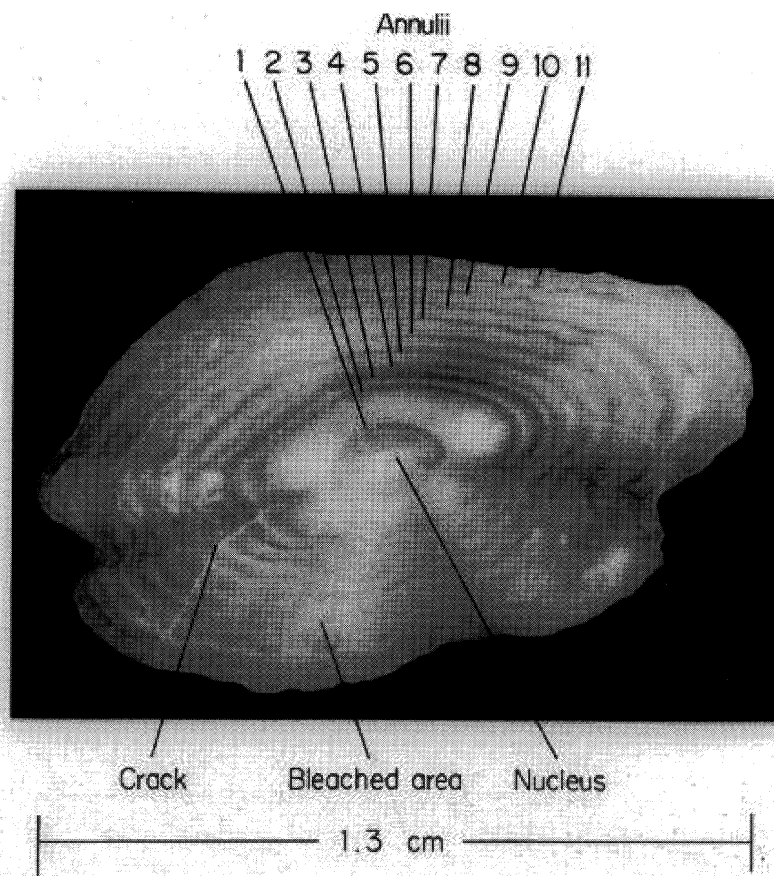
Otolith terminology can be confusing; different agencies or researchers can use different terms for the same structures. The terms "opaque" and "translucent" are a particular problem, since the optical properties of these zones depend on whether illumination is reflected or transmitted. The opaque zone appears white under reflected light, but dark with transmitted light, since light doesn't pass through it. The translucent

zone appears dark under reflected light but since light passes through it, it appears bright with transmitted light. Since reflected light is used in Pacific halibut aging techniques, in this manual *translucent* refers to the zone of slow growth and *opaque* to the zone of faster growth. See glossary in Appendix I for complete list of terms.

Other hard structures in fish have similar alternating patterns caused by seasonal changes in growth rates and may be used for age determination along with or instead of otoliths. These other structures include vertebrae, scales, fin rays, opercular bones, and cleithra. Certain structures show growth patterns more clearly in a given species. One advantage to using otoliths is their stability. Scales can be lost and replaced; a regenerated scale has fewer annual rings than the total age of the fish. Moreover, calcium can be resorbed from scales and other calcareous deposits in the body under certain physiological conditions, resulting in the loss of some previously deposited growth rings. On the other hand, calcium is not resorbed from otoliths, so otoliths provide a “permanent” record of growth.

Some additional sources of information on general aging procedures are listed in Appendix II.

The International Pacific Halibut Commission (IPHC) has used sagittal otoliths for aging halibut since 1914 (Fig. 2). Otoliths can provide other information as well as age; at one time, otolith radius, length, and weight (Table 1) were used to estimate the size of individual halibut (Clark et al. 2000). Other properties such as shape have been used to distinguish between stocks of fish in other species. At IPHC, otolith shape and a combination



**Figure 2. A left (blind) side halibut otolith with annuli marked.**

