Radiometric Ageing — New Age Validation Technique Established in Resource Ecology and Fisheries Management Division

Information about the age structure of a fish stock is important for accurate stock assessment. Age data are used to estimate fish growth and mortality rates and to generate age-structured stock assessment models. Because inaccurate age data can lead to the over- or underharvesting of an exploited fish stock, accurate age data are critical to determining appropriate harvest and management strategies. To examine and improve the accuracy of age data, a new facility for the radiometric ageing of marine organisms has been established as part of the Age and Growth Task of the Resource Ecology and Fisheries Management (REFM) Division at the Alaska Fisheries Science Center (AFSC).

The conventional method of determining the ages of North Pacific groundfish is to analyze the yearly growth rings (annuli) in the fishes' otoliths (ear bones). The otoliths, composed of calcium carbonate (aragonite crystals) in a protein matrix, contain growth rings which appear as concentric circles laid down in a fashion similar to that seen in tree rings. In fishes from the North Pacific Ocean, the otoliths reflect the seasonality of growth, showing one period of fast growth and one period of slow growth each year. Thus, an otolith provides a record in an annular pattern of a fish's growth over time.

The REFM Division's Age and Growth Task predominantly uses otoliths to estimate the ages of North Pacific groundfish. However, different hard parts, such as scales, fin spines, vertebrae, or other bones also can be used for reading the ages of certain fish species. The Age and Growth Task reads 20,000 to 30,000 otoliths annually. Each otolith is viewed individually under a dissecting microscope, and the growth rings are counted (Fig. 1).

The patterns of concentric rings formed in the otoliths are often difficult to decipher. The seasonality of the growth patterns can be masked or disturbed by environmental or behavioral factors affecting the fish. Only in the best otoliths is there a clear pattern providing an easy ring count. Otoliths are three-dimensional structures, not always growing equally in all dimensions. Therefore, a number of interpretative options often exist when counting the growth rings, increasing in proportion to the age of the fish (Figs. 2 and 3).

Additional complexities occur due to a choice of sample preparation methods. Growth rings may be counted microscopically from the exterior of the otoliths using specialized lighting equipment. Rings also may be counted from the interior of the otolith using several methods of cutting or cross-sectioning the otoliths. Usually, a consistent method is used for each species. Depending on the method of sample preparation, all of the rings may not be visible in the otoliths, especially if the fish are old (Fig. 3). Therefore, the science of counting otolith rings is not exact but relies heavily on the interpretation made by individual otolith readers. For example, what one otolith reader may interpret as 10 supposed annuli, another reader may interpret as 30.

To ensure the best possible age data available, a conventional age estimated by interpretation of otolith growth rings must be confirmed for accuracy. Hence, the goal of age validation research is to

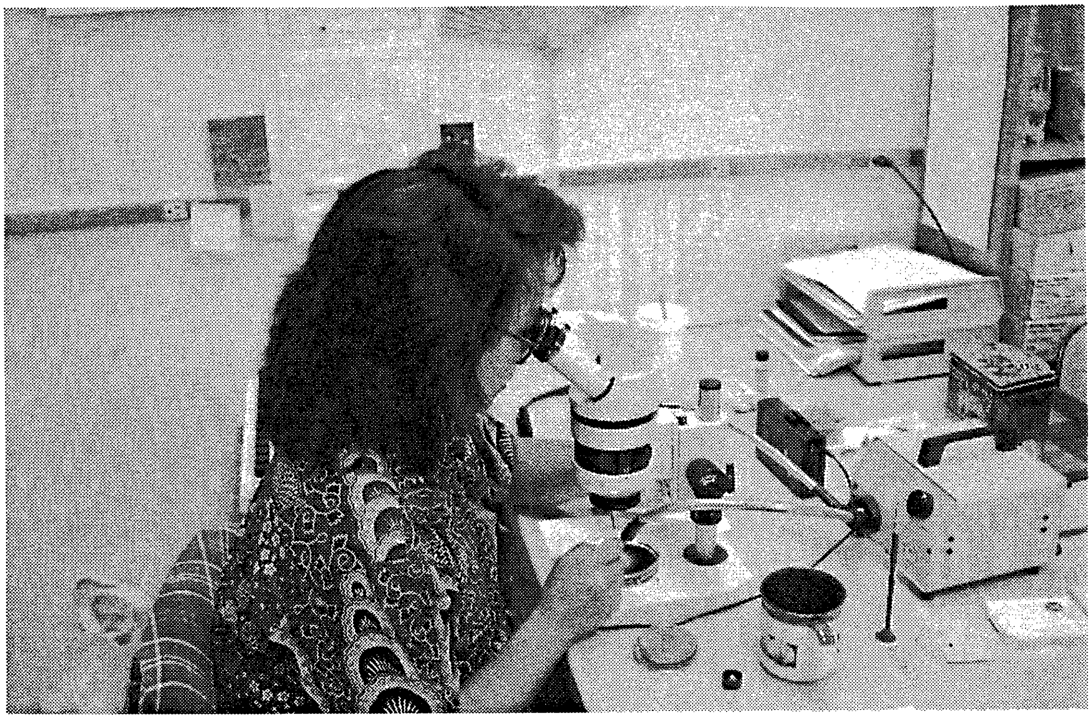

Figure 1. Biologist Delsa Anderl employs the conventional method of ageing fish by using a dissecting microscope with a special light source to read otolith growth rings.

confirm that the conventional methods used are generating accurate ages. This usually means finding another, independent (nonconventional) method of determining a fish's age. When the estimated age from an annular count agrees with the estimated age derived from an independent method, a degree of accuracy can be attributed to the annular count.

Fisheries science historically has used a number of age validation methods, often requiring a specialized collection of otoliths. Mark and recapture projects, which use external tags with an injection of a bone-marking chemical such as oxytetracycline, require large tagging efforts followed by even larger recovery efforts years later. In some species, those with a swim bladder for example, the survival rate is very poor after tagging. On rare occasions, a natural mark in the otolith from a known source such as El Niño can be used for age validation. However, such natural marks are not commonly seen in the large volumes of samples routinely collected by the AFSC. Otolith marginal incremental analysis can be used when samples can be collected frequently (every month) throughout a year. This method determines the time or season of otolith growth by studying periodic samples and looking for new deposition. Unfortunately, the cost of ship time prohibits this type of collection. The best validation is from reading otoliths of "known-age fish," but collections of known-age fish from their natural environment are extremely rare.

A new method of fish age validation and the focus of research at the Age and Growth Task's new radiometric facility uses the radionuclides Ra-226 and Pb-210, which are naturally occurring in seawater. These radionuclides can be measured in any sample routinely collected by the AFSC. This method is analogous to radiometric dating methods employed in geology and anthropology which use long-lived radionuclides. The major difference is that the half-lives of Ra-226 and Pb-210 are relatively short (Fig. 4), thereby allowing the dating of marine organisms 10-100 years old.

The radionuclides Ra-226 and Pb-210 are part of the natural decay chain of U-238 (Fig. 4). Each step in the chain has a specific half-life associated with it. Radium-226 is found in all seawater and thus is available to fish via food or by osmoregulation. In a fish's metabolism, the Ra-226 is a calcium

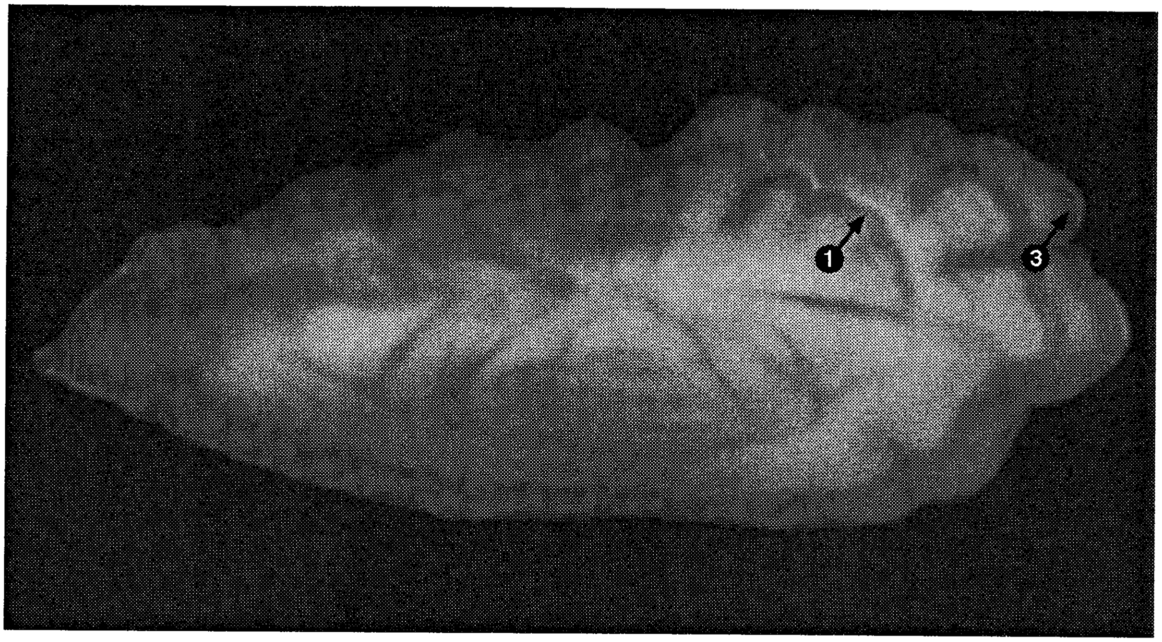

Figure 2. A three-year-old sablefish otolith. Arrows indicate the first and third yearly growth rings.

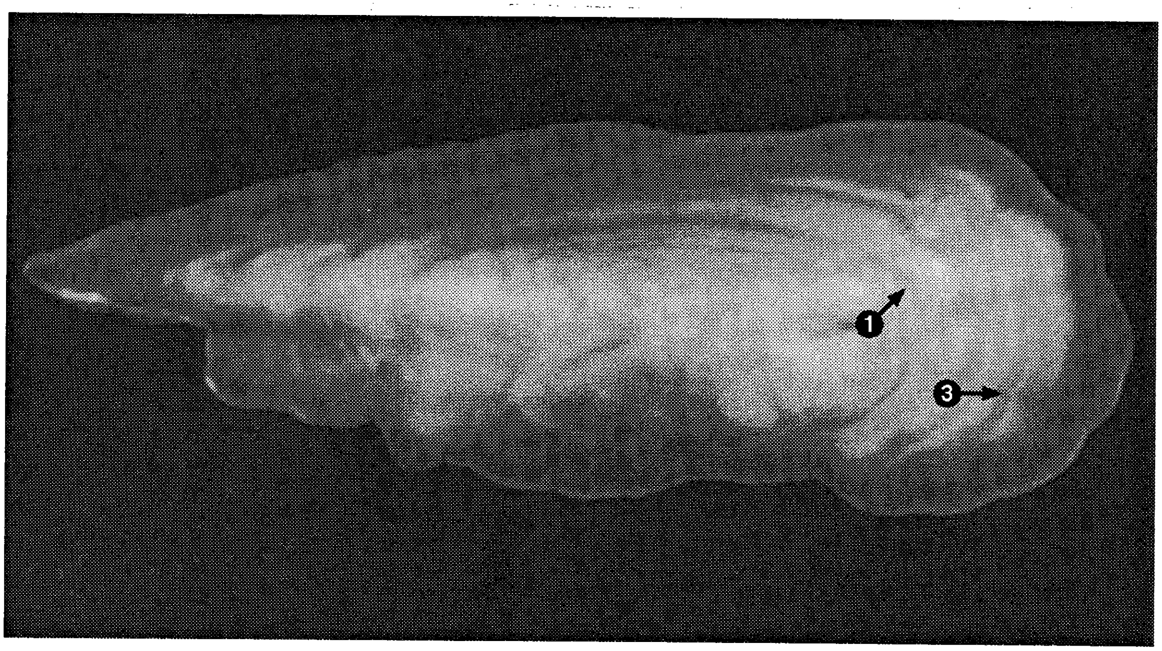

Figure 3. A twenty-year-old sablefish otolith. Arrows indicate the first and third yearly growth rings. Note the lack of clarity outside the third growth ring.