A Novel Approach to Aging Tropical Fish

Research has been underway for several years at the Southwest Fisheries Center Honolulu Laboratory of the National Marine Fisheries Service (NMFS) to improve upon existing methods of aging tropical fishes. Most people familiar with the subject are now aware that the otoliths of virtually all the fishes that have been studied to date grow by means of a daily episodic accretion of calcium carbonate. The episodic nature of the growth process leaves microscopic daily check marks which are commonly called "daily increments." The existence of daily increments in the otoliths of a wide variety of marine and freshwater fishes has now been shown in temperate and tropical environments.

The occurrence of daily increments in the otoliths of tropical fishes affords the opportunity of developing novel approaches to aging. Perhaps the simplest method used so far is to count all the increments present in an otolith, and to use the number obtained as an estimate of the age, in days, of the sample specimen. Although simple on theoretical grounds, there are a number of reasons why this particular approach is not always the most effective. First, for slow growing species characterized by long life spans, this method may entail counts to several thousands of increments. Work of this type is tedious, exhausting, and time-consuming. Second, it is very difficult to obtain preparations of otoliths which show the complete development of increments extending all the way from the otolith focus to the outer margin. Obscure areas such as these not uncommonly account for half of the visual field in a preparation. Because otoliths without a fully visible complement of increments are useless for this type of approach, undue time is spent working on sample preparations, i.e., in trying to develop perfect specimens.

Faced with these realities, I have devised a simple method which can overcome some of the difficulties which arise with daily increments. The method takes advantage of the fact that it is possible to measure the growth rate of the otolith by studying daily increments. A wide space between adjacent increments is interpreted to mean that the otolith grew rapidly in the intervening time interval. Conversely, a narrow space between adjacent increments indicates slow growth. The basic approach is to estimate the average width of daily increments at various points in the otolith. If the otolith were to grow at a constant rate, independent of the size of the otolith, then increment widths would be uniform at all points in the otolith from focus to margin. If one could estimate this rate and the total length of the otolith, then the age of the specimen could simply be estimated by dividing the otolith length by its rate of growth.

Of course, otoliths do not grow at a constant rate and neither do whole fish. Nevertheless, this same process works well if one takes into account otolith and fish size. According to the von Bertalanffy growth model, fish growth slows with age and approaches zero at an asymptotic size with increasing time. The same is true of the otolith. It is well known that the size of a fish is well correlated to the size of its otoliths. The relationship is often nonlinear but it is nonetheless relatively easy to obtain and describe statistically.

In my method, the otolith is subdivided into regions which are small enough so that the growth of the otolith can be considered constant within a subregion. I have found that within regions of about 500 microns the growth rate of the otolith is essentially uniform. Usually there are areas in which increment microstructure becomes unclear. Obscure areas such as these not uncommonly account for half of the visual field in a preparation. Because otoliths without a fully visible complement of increments are useless for this type of approach, undue time is spent working on sample preparations, i.e., in trying to develop perfect specimens.

Typically, areas in which up to 25-30 increments are plainly visible are analyzed in detail. The total length of a short
The relationship between increment width (otolith growth rate) and otolith size for *Pristipomoides auricilla*. The circles are mean values which are bracketed by standard deviations. Individual sub-region sample sizes are presented above each mean.

The results in the accompanying table summarize the method as applied to the data presented in the figure. The amount of time necessary to grow through a length interval is simply the interval length divided by the average growth rate during the interval. Fish lengths were estimated from an independently derived regression on otolith length.

It is apparent from the data that *P. auricilla* is relatively fast growing for members of this genus, reaching 50% of its maximum size of 42 cm in roughly 1.3 years. This fast growth is not surprising in light of its small adult size. *Pristipomoides filamentosus*, one of several larger species also under study, is known to exceed 80 cm, but does not reach 50% of its maximum size until well after three years of growth.

The whole fish, the growth rate of the otolith declines as the size of the otolith increases. One can consider increment width (microns/segment) equal to otolith growth rate (microns/day) because there is a one-to-one correspondence.

Results to date are certainly encouraging. One of the problems with using daily increments to age fishes, as some published studies show, is that increment deposition can break down from its daily periodicity, and there are longer intervals of arrested accretion in larger (older) fish. This particular problem hinders any method using daily increments for aging purposes. Nevertheless, a head start has been made towards developing a reliable and economical technique for studying the growth dynamics of a wide variety of tropical species.

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