AGING LONG-LIVED TROPICAL FISH USING DAILY GROWTH INCREMENTS[a)]

by

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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 wide variety of marine and freshwater fishes has now been shown in temperate and tropical environments.

The occurence 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 difficulties when attempts are made to age long-lived fish using daily growth increments.

I have devised a simple method which can overcome some of these difficulties. 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 indicated 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 fish, 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. Usually, fish growth slows with age and approaches zero at an asymptotic size with increasing time. The same is true of otoliths. It is well known that the size of a fish is well correlated to the size of its otoliths.

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 subregions. I have found that within regions of about 500 microns the growth rate of the otolith is essentially uniform. The time it takes to grow through

a) Abbreviated from "A novel approach to aging tropical fish", by the same author, ICLARM Newsletter, January 1985.

each one of these subregions is calculated exactly as outlined above. The average widths of daily increments within subregions (e.g., 0-500 microns, 500-1,000 microns, 1,000-1,500 microns, etc.) are determined by examining a number of preparations. Average increment width is then equated directly to the average growth rate of the otolith, measured in units of microns per day.

Typically, areas in which up to 25-30 increments are plainly visible are analyzed in detail. The total length of a short segment containing the increments is measured with an ocular micrometer and the total number of increments within the short segment is counted. The ratio of segment length to included increments provides an estimate of the average width of increments within the short segment. If one computes a number of such ratios, categorized by subregion, their mean values will provide an estimate of the average growth rate of the otolith in the subregion of interest. Once the relationship between otolith growth rate and otolith length has been determined, one calculates the length of time it takes to grow through each subregion by simple division. Next, the time intervals necessary for growth through each of the subregions are added together sequentially to estimate the total amount of time necessary for the otolith to reach a given size. It is then possible to convert otolith lengths to fish lengths with a regression equation of these variables. Ultimately one is left with a series of age at length determinations which can be fitted to any growth model desired.

The accompanying Table summarizes data obtained in this fashion for one of the many Hawaiian deepwater snappers, *Pristipomoides auricilla*. Note that, like the whole fish, the growth rate of the otolith declines as the size of the otolith increases. One can consider increment width (microns/increment) equal to otolith growth rate (microns/day) because there is a one to one correspondence between days and increments, at least as long as increments are deposited daily.

The data presented in the table were gathered after examining 220 short segments in 51 separate *P. auricilla* otolith preparations. These 220 segments contained an average of 14.25 daily increments each (s.d. = 5.6) so that a total of 3,135 increments were counted and measured in all. Furthermore, the average length of each short segment was 67.4 microns (s.d. = 43.8).

The results in the table summarize the method as applied to the available data. 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.

Summary of increment width and otolith growth rate analysis for *Pristipomoides auricilla.*

Otolith length interval (micron)	Mean otolith growth rate (micron/day)	Time for interval growth (day)	Cumulative age through interval (day)	Length of fish-fork (cm)
0-500	29.04	17.22	17.22	3.4
500-1,000	20.05	24.94	42.16	6.4
1,000-1,500	18.88	26.48	68.64	9.3
1,500-2,000	7.99	62.56	131.20	12.1
2,000-2,500	5.55	90.04	221.24	14.9
2,500-3,000	4.92	101.57	322.81	17.6
3,000-3,500	3.92	127.42	450.23	20.3
3,500-4,000	3.41	146.74	596.97	23.0
4,000-4,500	2.28	219.35	816.32	25.6
5,000-5,500	1.64	303.95	1,401.88	30.9
5,500-6,000	1.53	326.53	1,728.41	33.4

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.

This simple method of aging tropical fish by estimating the widths of daily otolith increments is currently being evaluated at the Honolulu Laboratory. Results to date are encouraging.