CAUTION IN THE USE OF otolith microstructure" during which a main effort

BEATRIZ MORALES-NIN
Instituto de Ciencias del Mar, Paseo Nacional s/n 08003 Barcelona Spain

Since Pannella's discovery of the daily growth rhythms present in fish otoliths (1971), caused by the episodic accretion of microscopic layers of calcium carbonate and protein, these increments in the otoliths have been used extensively in a wide range of studies of age and growth of fishes (Campana and Neilson 1985).

Ring formation in fish otoliths is closely related to physiological and environmental cycles. Daily increments are influenced by day/night cycles while annual rings are seasonal (summer/winter) cycles (Campana and Neilson 1985). The relative environmental stability on tropical areas causes the lack of clear seasonal rings in many tropical fishes, consequently most tropical fish growth studies have been relying mostly on length-frequency based methods. The discovery of the occurrence of daily increments in the otoliths of tropical fishes afforded the opportunity of developing novel approaches for ageing tropical fish (Brothers (1979).

based techniques at macro-structural (annual rings) and micro-structural (daily increment) levels were employed to study the otoliths of 14 species of tropical and subtropical areas (Table 1).

The microstructure of the otoliths was studied by means of light microscopy and scanning electron microscopy (SEM). The micro-structural otolith analyses demonstrated the presence of daily increments in all the species studied. The thickness of the increments laid down in a single otolith can be very variable. This variability shows irregular growth periods during the life span.

It has been shown that the species studied experience periods of reduced growth which are subsequently reflected as thin increments laid down in the otoliths. In almost all the species studied, these thin increments were below the detection power of light microscopy (Table 1). Consequently, when light microscopy techniques are employed for daily ring determination there is a high probability that the age may be underestimated. For instance, in *Engraulis ringens* after the first year of life the thin increments laid down in slow growth periods produced errors in the age determination (Fig. 1). Similarly, the thin increments detected in the otoliths of the oil sardine, *Sardinella longiceps*, may have caused the underestimation of age and the high growth

Table 1. Studied species by area and the average increment thickness in their otoliths determined with scanning electron microscope observations. (*samples with increment thickness under the detection power of the light microscope).

Family	Species	Sampling Area	Increment Thickness (µm)
Acanthuridae	*Acanthurus nigricauda*	Papua New Guinea	0.5-1.2*
Clupeidae	*Sardinella longiceps*	Philippines	0.1-2.5*
	Sardinops sagax	Ecuador	0.4-1*
Engraulidae	*Engraulis ringens*	Peru	0.7-1.4*
	Stolephorus heterolobus	Philippines	0.5-1.8*
Lethrinidae	*Lethrinus nebulosus*	New Caledonia	0.7-1.2
	Lethrinus choerorynchus	Australia	1.2-3
Lutjanidae	*Lutjanus vivarius*	Brasil	0.8-1.5*
	Lutjanus kasmira	Hawaii	0.2-1.8*
Nemipteridae	*Nemipterus furcosus*	Australia	0.8-1.4*
Scianidae	*Stellifer rastrifer*	Brazil	0.2-3.8*
Scombridae	*Scomber japonicus*	Ecuador	1.1-3.1
	Scomberomorus brasiliensis	Brasil	1.1-2.1
	Scomberomorus cavalla	Brasil	1.1-2.3

The most commonly increment-based methods employed in tropical fishes are the enumeration of all the increments present in an otolith, using the number obtained as an estimate of the age in days (Uchiyama and Struhsaker 1981), and the use of the increment width, which is function of fish growth, to assess growth rate and then interpolate fish age (Ralston and Miyamoto 1983).

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parameters obtained by Dayaratne and J. Gjøsaeter (1986) (L_∞ = 14.5, K = 5.62). These authors employed daily growth increments and light microscopy for growth determination. When SEM is used much lower growth rates are found (L_∞ = 19.3, K = 1.22 for oil sardine caught in Philippine waters; Morales-Nin, unpublished data).

When the otolith increments in adult fishes are studied with light microscopy, areas with unclear increments are found. Ralston (1985) attributed these areas to imperfect sample preparations, and proposed the use of a method based on increment thick-

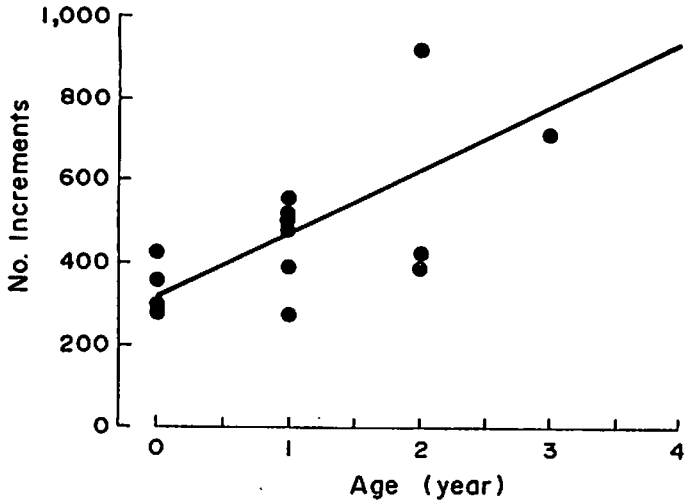

Fig. 1. Correspondence between the number of daily increments determined by means of light microscopy and the age in years for the same specimens of anchoveta *Engraulis ringens*.

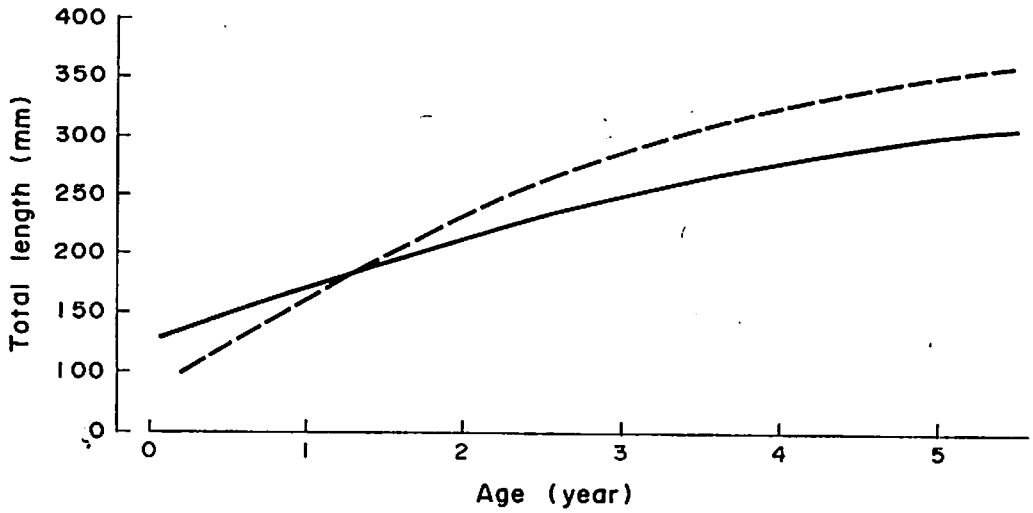

Fig. 2. *Lutjanus kasmira* growth curve determined by means of annual rings in the otoliths (continuous line) and by means of Ralston's method (discontinuous line).

ness to determine growth rate and interpolate age based on increment measurements. However, in *Lutjanus kasmira* from Hawaii, it has been shown that these areas are composed of very thin increments and are below the detection power of the light microscope. Thus, if growth is determined by Ralston's method, only the clearer and thicker increments, laid down in the periods of active growth, will be employed. Consequently, the growth parameters obtained were clearly overestimated (Morales-Nin and Ralston, in preparation) (Fig. 2).

In summary, the presence of these thin increments in most of the tropical species studied, and the methodological problems presented, strongly questioned the use of daily increments to age adult tropical fish when light microscopy is used. Based on the above mentioned results, the need for a careful study of some otoliths with SEM to assess the increment thickness prior to undertake any study with light microscopy is evident.

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