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The Formation and Growth of Otoliths from Redfish (*Sebastes* spp.) Larvae from the Flemish Cap (Division 3M)

by

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ABSTRACT

Through the use of daily otolith increments it was possible to age redfish (*Sebastes* spp.) larvae and to resolve their growth rates. This technique increased our ability to interpret the age and growth structure of larval fish populations. The ability to perceive the structure and composition of larval fish otoliths was enhanced through the use of Scanning Electron Microscope methods.

INTRODUCTION

The ageing of larval fish is an important technique in understanding their ecology. Recently, methods have been used that utilize otoliths to determine the age of fish larvae. Daily growth increments were first postulated by Pannella (1971, 1974) when he used daily increment counts to confirm annual growth in the sagittae (the otolith most often used for age determinations). Subsequent work by Brothers et al. (1976), Ralston (1976), Struhsaker and Uchiyama (1976), Taubert and Coble (1977), Radtke (1978), Methot and Kramer (1979) and Radtke and Waiwood (1980) have shown that many fish species do indeed have daily growth increments.

The formation of daily increments in fish otoliths can be a record of the fish's life. That the layers appear to be deposited in a rhythmic fashion points to the fact that they are possible markers of a daily event, possibly growth. Taubert and Coble (1977) studied freshwater sunfish and postulated that daily increments in otoliths resulted from a twenty-four hour light cycle that entrained an internal, diurnal clock. Evidence of this was added by Radtke (1978). A composite of external factors might be responsible for increment formation. Consequently, otoliths possess the capability to record a fish's past life history.

In the present study, the formation and growth of otoliths were investigated in redfish larvae (*Sebastes* *spp*.) from the Flemish Cap in the Northwest Atlantic.

METHODS AND MATERIALS

Laboratory redfish larvae were acquired by stripping adults that were ready to extrude their young on board ship while on cruises at the Flemish Cap in 1979. These larvae were kept on a 12/12 light cycle in order to determine the time of first increment formation.

Field specimens were collected from the Flemish Cap in 1978 by oblique bongo tows (505 and 333 mm mesh). The captured larvae were preserved in 95% ethanol. (Formalin and lesser concentrations of ethanol can cause dissolution of the otoliths). Later the otoliths were teased from the larvae and viewed under the light and electron microscope.

After total length and weight measurements, an individual larva was immersed in glycerol which cleared the specimen and made the otoliths visable. All three otoliths (sagitta, lapillus, asteriscus; Fig. 1) were removed from every fish where possible and the sagitta, the largest of the otoliths was used for increment determinations. The otoliths were teased from the cranial area of the larva by the use of the fine insect needles and mounted on glass slides with Flo-Texx (Lerner Laboratory, Stanford, Conn.). The mounted otoliths were viewed with a compound microscope and photomicrographs were taken in order to determine increment counts and otolith diameters.

A number of otoliths were sampled in pairs with one of the sagittae to be viewed by the use of Scanning Electron Microscope (SEM) procedures. The otoliths were glued to viewing stubs with 5-min epoxy and were then ground with one-micron diamond polishing compound (Buehler Ltd., Evanston, Ill., U.S.A.). They were then etched with 7% EDTA (pH 7.4) for 1-5 min after which they were gold-coated in an Edwards vacuum evaporator with continual rotation on a planetary specimen holder. The coated otoliths were viewed in a Cambridge Steroscan Mark 2A SEM.

RESULTS AND DISCUSSION

Otoliths were found to be present at hatching in redfish (Sebastes spp) larvae and from laboratory study they appeared to form daily increments beginning from the time of spawning. At spawning the larvae were 6.0 ± 0.5 mm in total length, weighed .0009 ± .0001 gm, and showed no increments. Increments began forming after spawning and occurred on a daily basis.

The studies by Brothers et al. (1976) and Radtke (1978) have shown that daily increments form at different times in different fish species. Some species can hatch with increments already formed while others might not form until yolk absorption. In redfish it appeared that the increments began forming at spawning and gave us an indication of the time of spawning without any correction.

Age and growth data (Table 1) of individual larvae exhibit differences in growth rates with age. The younger larvae had a slower growth rate than the older larvae both in weight and length. The data demonstrate exponental growth which could easily occur in fish larvae. It appears that the larvae begin with slow growth with much of their energy being utilized for elongation and increase somatic growth with age. The increments present (Fig. 2) in the sagitta of larval redfish produce an estimation of age and growth that would be difficult to obtain by other means.

The fine structure of larval otoliths was clearly visable through the use of SEM techniques (Fig. 3). The increments are produced by a rhythmic deposition of protein with subsequent crystallization of calcium carbonate in the aragonite form. The width of the increments can be measured more accurately on SEM photographs than light micrographs, since there was no diffraction. Differences in increment width were seen which could conceivably be records of the amount of growth experienced by the first larvae on a daily occurrence. Struhsaker and Uchiyama (1977) postulated that back calculations of growth could be resolved from the width of the daily increments. Observations from this study corroberate with these claims.

The ability to age larval fish accurately is very important to the study of fish ecology. If the mechanism by which the otolith increments are formed is understood,then the otolith would be a calendar of the life history of each fish. This would greatly facilitate the understanding of growth and age structure of larval fish populations.

The ability to collect and read a long term record of a fish's growth history under different field conditions is very intriguing and would add a new dimension to fish ecology studies. By understanding how the otoliths grow, it should be possible to correlate increment growth to fish growth.

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Table 1. Growth information on larval redfish collected on July 19, 1978 at 48°00'N, 45°00'W.

Total Length mm	Weight (gm)	Otolith Increments	Otolith Diameter (mm)	Daily Growth Length (mm)	Daily Growth Weight (gm x 10^{-4})
19	.040	88	.173	.15	4.4
23	.067	103	.205	.17	6.4
20	.032	88	.169	.16	3.5
21	.043	93	.173	.16	4.5
11	.005	31	.068	.16	1.3
21	.043	90	.184	.17	4.7
22	.047	98	.189	.16	4.7
15	.011	63	.135	.14	1.6
24.5	.077	108	.215	.17	7.1
21	.048	96	.185	.16	4.9
18	.038	86	.167	.14	4.3
21.5	.047	96	.187	.16	4.8
19	.046	91	.175	.14	5.0
17	.019	75	.149	.15	2.4
22	.055	99	.193	.16	5.5
15	.012	65	.136	.14	1.7
18	.022	79	.158	.15	2.7

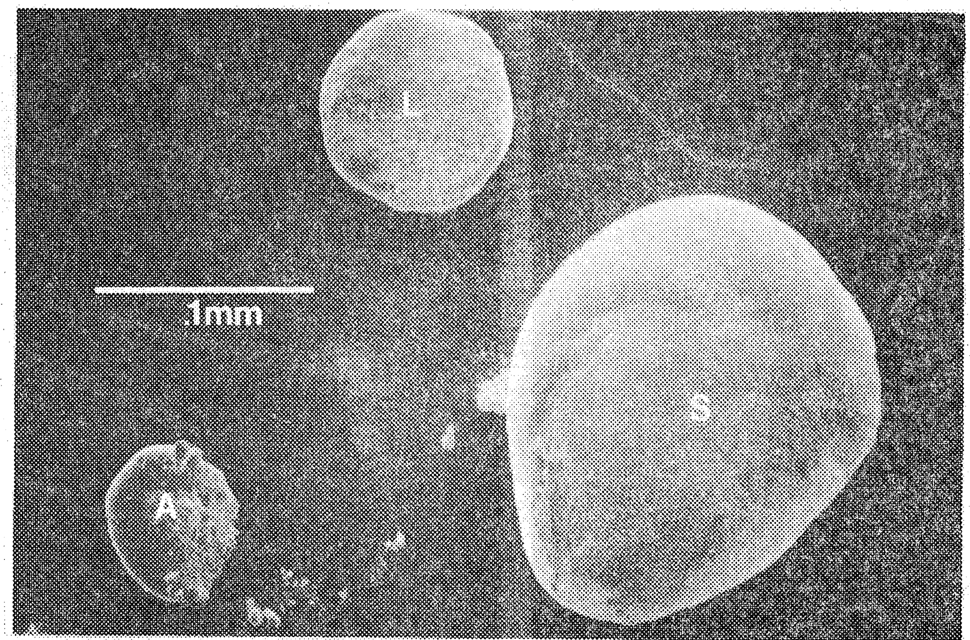

Fig. 1. Otoliths from redfish larvae. S-sagitta; L-lapillus; A-asteriscus.

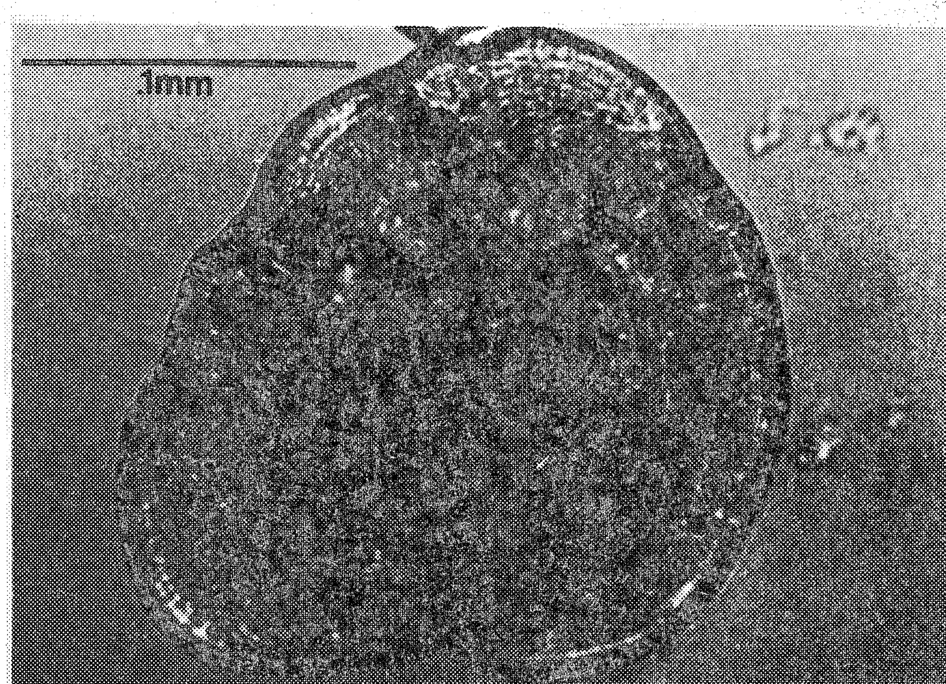

Fig. 2. Sagitta from a redfish larva captured from the Flemish Cap that had sixty-three increments.

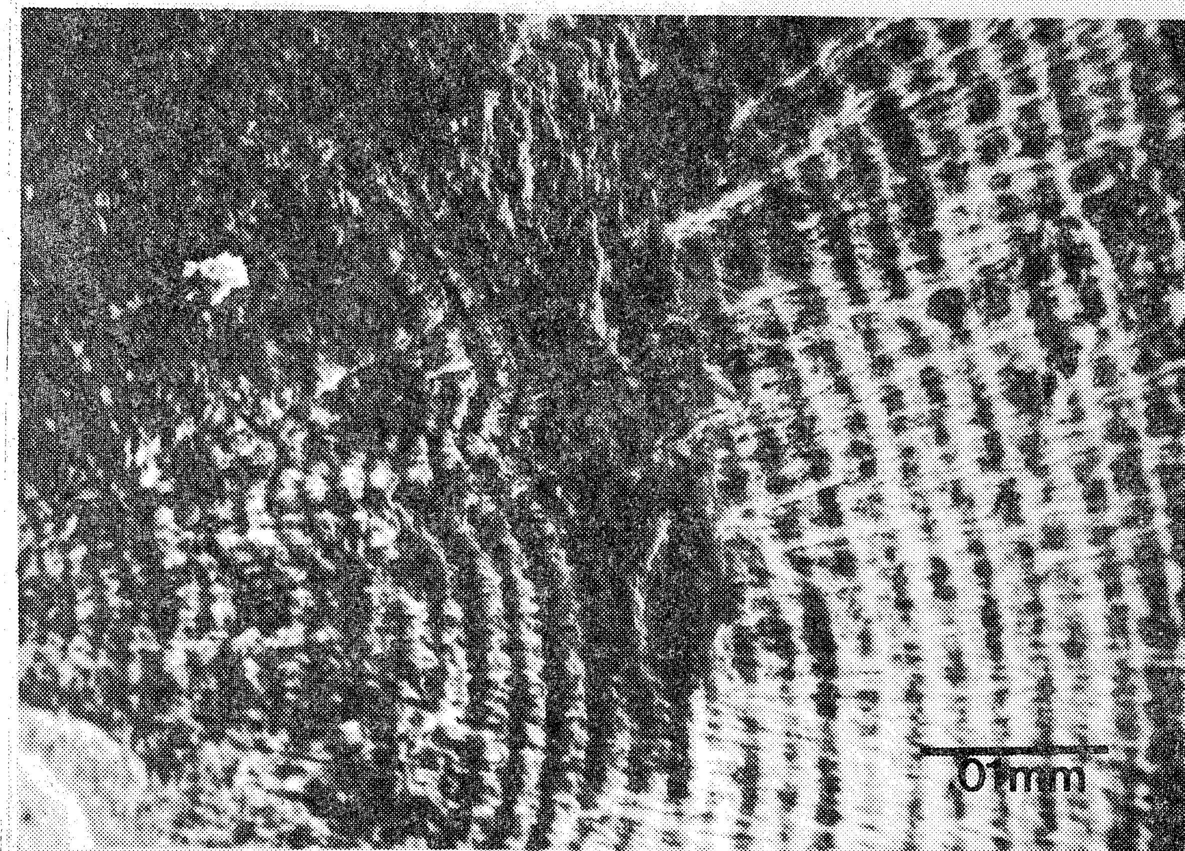

Fig. 3. Scanning Electron Micrograph with daily increments. The calcium (c) and protein (p) belts are visible.