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Distinguishing between spring and autumn spawned herring from daily increments, a preliminary report.

By

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ABSTRACT

Otoliths from Norwegian Spring Spawning herring larvae, collected on a cruise in May 1985 and North Sea Autumn Spawned herring larvae, collected on a cruise in Desember 1987, were examined for daily increments. A greater distance from the otolith nucleus to the first observed increment was seen in Norwegian Spring Spawning herring larvae (14.0 ± 3.4 µm) than in North Sea Autumn Spawned herring larvae (5.0 ± 1.6 µm). In addition the results indicate that species from autumn and spring spawning stocks can be separated by a comparition of the increment widths in the otoliths. In a distance between 40 and 60 µm from the nucleus, the increments in the North Sea Autumn Spawned herring larvae had a width less than 1.5 µm, while the corresponding widths in spring spawners were greater than 2.0 µm.

INTRODUCTION

The complexity of herring stocks in the Skagerrak - Kattegat area has been described by Rosenberg and Palmen (1981). One of the problems in this area has been separation problems between outbursts of spring and autumn spawning herring. Several metods has been suggested and are in use, like combined analysis of meristic characters, total fish length, scale length and otolith length (Rosenberg and Palmen, 1981), the size of the first winter zone (Otterlind, 1987) and length frequency distribution differences between the two subspecies. This paper looks at the position of the first daily increment, and the width of the increments in the otoliths as possible parameters to distinguish between larvae of the two different stocks. The regularity of ring deposition and the dependance of growth-rate of the increment width has been verified by the enclosure experiments reported by Moksness and Wespestad (in press). The growth rate of the larvae reflect the feeding condition and the temperature in the sea. A herring larvae that hatch in the spring experience good feeding conditions, while in the autumn the prey density is very much reduced. This is printed in the otoliths and therefore daily increment width is proposed as an useful parameter to distinguise between spring and autumn spawners.

MATERIAL AND METHODS

The materials were sampled on two different cruises. Larvae of Norwegian Spring Spawning herring were collected on a cruise with F/F " Eldjarn" on the Norwegian continental shelf north of 62 N, in May 1985. The larvae were sampled with a large midwater trawl and frozen onboard. The larvae used in this study (N =11) were sampled west of the Sklinna bank (Fig. 1).

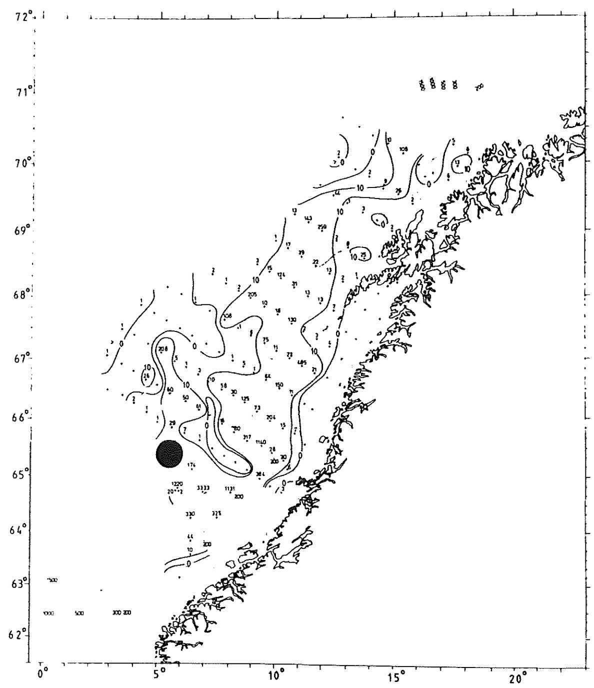

Figure 1. The herring larvae distribution, May 1985 (after Nedreaas 86).
● - Station 236 where the present larvae were sampled

Larvae from North Sea Autumn Spawners were collected on a cruise covering two transects between Denmark and Norway 9-13 Desember 1987 (Moksness and Johannessen 1988). All larvae were stored in 80% buffered ethanol and otoliths from a sample of these larvae were mounted on glass slides for later examination of daily increments.

The examination of the otoliths followed the same prosedure as given in Andersen and Moksness (1988). An example of an otolith from larvae of spring spawning herring is given in fig. 2.

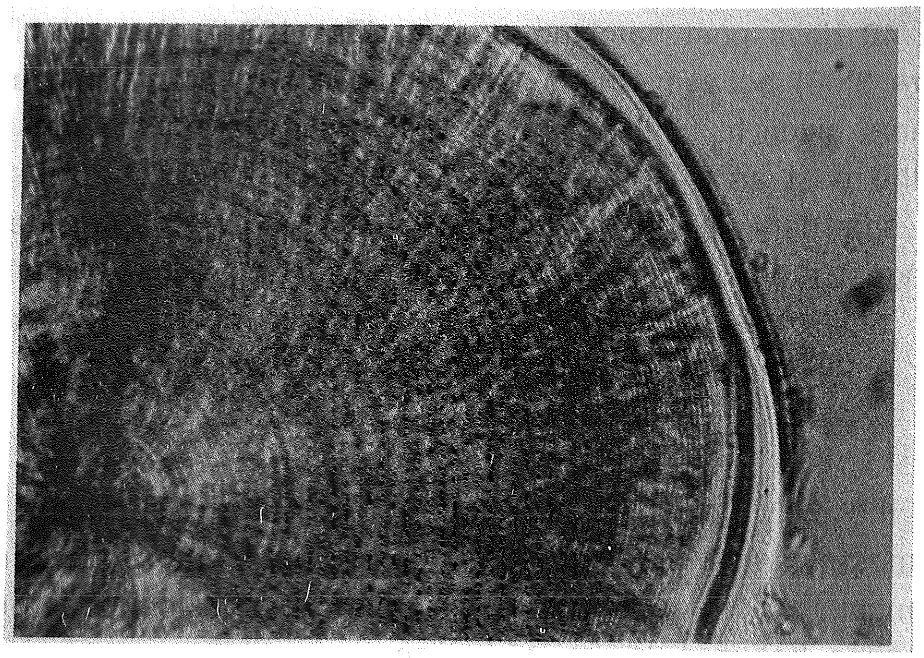

Fig. 2. Otolith of a 2 month old larvae of spring spawning herring. 200x magnification.

RESULTS

The distance observed from the nucleus to the first increment (Table 1) was 5 ±1.6 μm and 14 ± 3.4 μm in the otoliths of larvae from autumn and spring spawning herring respectively. The reason for the difference in distance between the otolith nucleus and the first increment in spring and autumn spawners can be the reduced hatching-weight of larvae of autumn compaired to larvae of spring spawners 100-120 μg compaired to 180-200 μg (Blaxter and Hempel 1963).

Table 1. Mean distance between nucleus and first increment

Spring - spawners	SD	Autumn- spawners	SD
14.0 µm	3.4	5.0 µm	1.6

From figs. 3 and 4 it can be seen that the increment width in autumn spawners is persistant below 1.5 µm, with a mean about 1.0 µm in the whole period. In spring spawners, however, the increment width is above 2.0 µm from 40 days post hatching. A test, (Zar 1974) gives significant differences (t= 3.06) between the slopes of the curves of autumn and spring spawners given in figs. 3 and 4. It is evident from the present results that the best area in the otolith to separate larvae from spring and autumn spawners, is the area between 40 and 60 µm from the center, along the longest radius of the otolith. The reason for somewhat more variability in the results with spring spawners, may be due to that some of the larvae are approaching metamorphosis and then the growth is reduced.

Fig. 5. show the daily growth in the otoliths . In Autumn spawners this growth is almost linear,while the otolith growth in spring spawners is more exponential. All three figures (3-5) gives impression of large growth-differences between larvae of spring and autumn spawners.

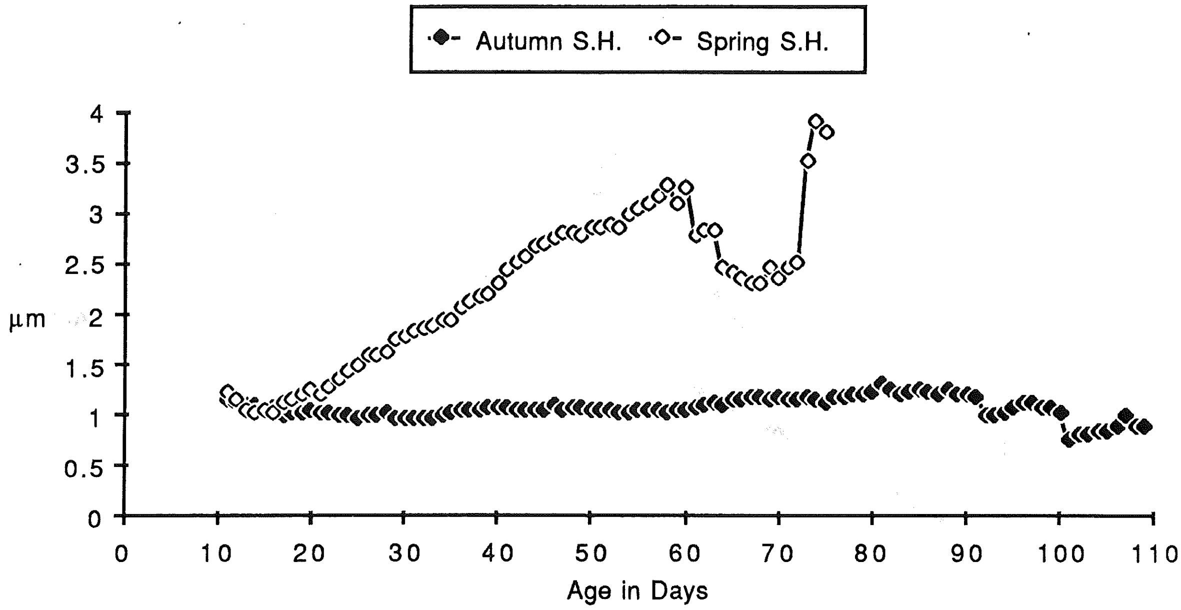

Fig. 3. Average increment widths in otoliths from North Sea Autumn Spawned herring (Autumn S.H.) (N=31) and Norwegian Spring Spawned herring (Spring S.H.) (N=11).

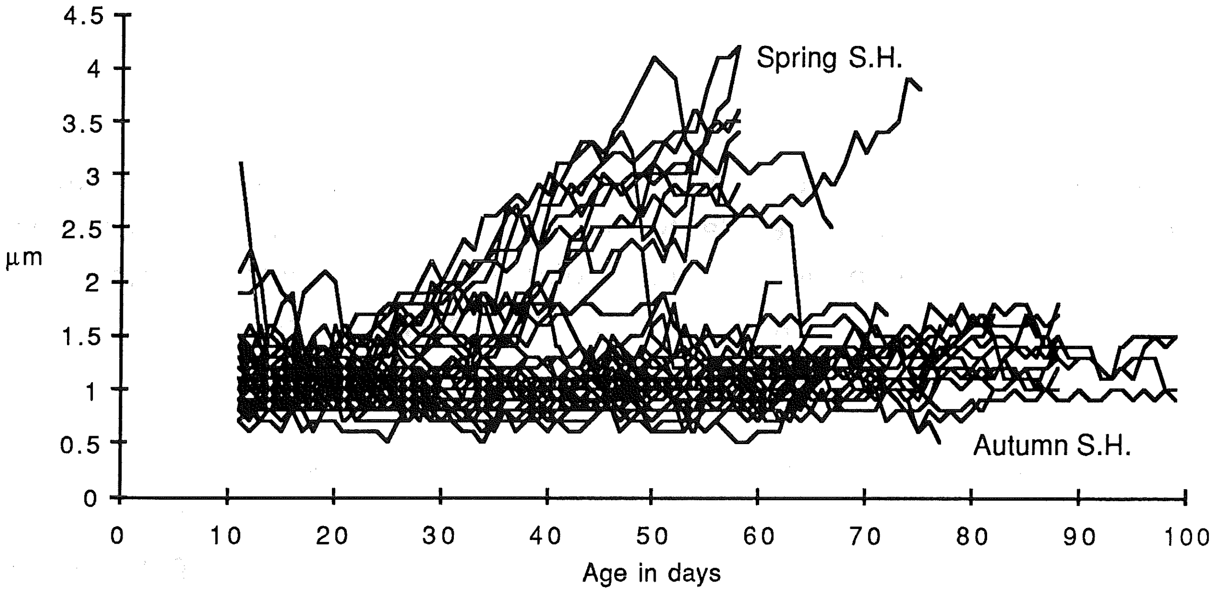

Fig. 4. Daily increment widths from each of the 31 North Sea Autumn Spawned herring (Autumn S.H.) and 11 Norwegian Spring Spawned herring (Spring S.H.).

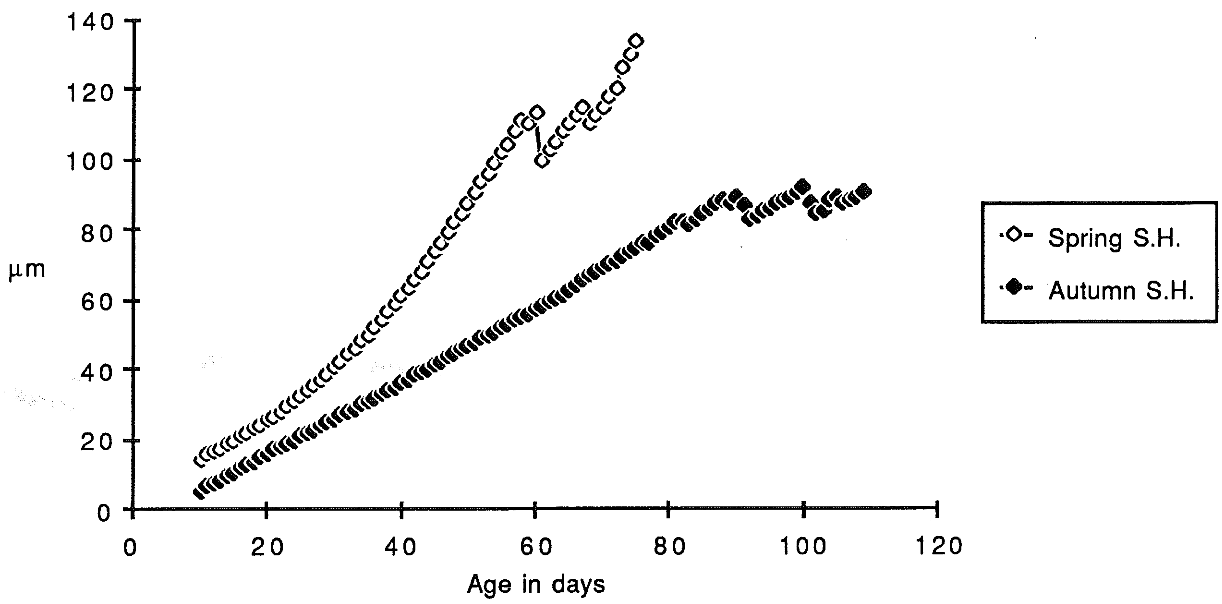

Fig. 5. Average distance from the otolith nucleus along the longest radius of the otolith as a function of age in the North Sea Autumn Spawned herring (Autumn S.H.) (N=31) and Norwegian Spring Spawned herring (Spring S.H.) (N=11).

DISCUSSION

Working with microstructure in otoliths, one is confronted with the crucial problem about regularity in ring deposition. Larvae exposed to cyclical stimuli experiences more distinct daily growth increment patterns than others (Pannella 1980). Such rythms can be vertical migration patterns, feeding regimes, light or temperature.

Growth dependant deposition have been shown to occure with herring larvae (Geffen 1983) kept in small volumes of water. Moksness et al.(1987) shows that herring larvae from Norwegian Spring spawners in a laboratory experiment, fail to deposit growth increments untill their growth rate exceeds 0.15 mm per day, but later the deposition was regulary. A recurring problem with lab. experiments may be that the larval growth are too low, or that the larvae lack a sort of calibrating mecanism. However, in experiments with herring larvae in mesocosms (Gjøsæter and Øiestad 1981 , Moksness and Wespestad in press) ring deposition was found to be daily, and Moksness and Wespestad (in press) concludes that the increment width is significantly correlated with the growth of the herring larvae. As the ring deposition rate is daily and increment widths depends on the growth rate, there is evident that the growth differences seen in situ, between larvae of spring and autumn spawners also are reflected in the otoliths.

The present paper deal with at least to separate stocks of herring , Norwegian Spring Spawning herring and North Sea Autumn Spawning herring, the latter one built up of several separate stock units spawning from August - Desember.

The growth rate of the larvae reflect the feeding condition and the temperature in the sea. A herring larvae that hatch in the spring is exposed to large environmental variations. The larvae experience a spring bloom with high densities of microzooplankton, and grow up with large cohorts of copepod nauplii and copepodites. The temperature is also improving through this period and everything is prepared for rapid growth and developement.

The relative success of herring stocks in different ecosystem is dependant of the size and productivity of the system (Iles and Sinclair 1982). If the productivety of the system is too low, spring hatced herring larvae are not able to metamorphose through the metamorphose-window in june-august . The herring living in such a system will through selection be forced against late summer and autumn spawning. In the autumn the abundance of zooplankton, the temperature and light intensity are decreasing and Jones (1985) used daily increment analyses of otoliths to distinguish between herring larvae that had hatched early and late in the hatching period. After a short period of rapid growth, the growth rate is heavily reduced, and in the winter period the larvae enters a sort of lethargic condition.

All this is printed in the otoliths and therefore daily increment width is proposed as an useful parameter to distinguise between spring and autumn spawners in the present paper.

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REFERENCES

Andersen, T and E. Moksness 1988. Manual for reading daily increments. *Flødevigen Meldinger, 2* :1-31. A Apple Macintosh software program, OTO 1.05 included.

Blaxter, J.H.S. and Hempel, G. 1963. The influence of egg size on herring larvae (*Clupea harengus* L.). *J. Cons. perm. int. Explor. Mer, 28* : 211-240.

Geffen, A.J. 1983. Otolith ring deposition in relation to growth rate in herring (*Clupea harengus*) and turbot (*Scophthalmus maximus*) larvae. *Mar.Biol.,71*:317-326.

Gjøsæter,H. and Øiestad, V. 1981. Growth patterns in otoliths as an indication of daily growth variations of herring larvae (*Clupea harengus*) from an experimental ecosystem. ICES CM 1981 (H:31), 1-7.

Iles, T.D. and M. Sinclaire 1982. Atlantic herring: Stock Discreteness and Abundance. *Science, 15*: 627-633.

Jones, C. 1985. Within- season differences in growth of larval Atlantic herring, *Clupea harengus harengus. Fish. Bull. U.S.,83* :289-298.

Moksness, E. and A. Johannessen 1988. Herring larvae (*Clupea harengus*) investigations in the Skagerrak area, December 1987- March 1988. A preliminary report. ICES CM 1988/H:20, 1-16.

Nedreaas, K. 1986. Abundance and Distribution of Postlarvae in the 0-group Saithe Survey in the North-East Arctic in 1985. *NAFO SCR Doc. 86/*117.

Otterlind, G. 1987. On the Öresund herring and related population problems. *Meddelande från Havsfisklaboratoriet nr. 232.* ISSN 0374-8030: 1-92.

Rosenberg, R and L.-E.Palmén 1981 Herring stock composition in the Skagerrak-Kattegat with reference to the North Sea and adjacent waters. ICES CM 1981/H:28, 1-25.

Panella, G. 1980. Growth patterns in fish sagittae. In : Skeletal growth in aquatic organisms: biological records of environmental change, edited by D.C. Rhoads and R.A. Lutz. New York, Plenum Press, 519-560.

Zar, J. H. 1974. Biostatistical Analysis. *Prentice - Hall, N. J.* : 228-229.