OTOLITH GROWTH OF AUTUMN SPAWNED NORTH SEA HERRING (*CLUPEA HARENGUS* L.) LARVAE REARED AT DIFFERENT DAY LENGTH AND PREY DENSITY

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Introduction

Herring (*Clupea harengus* L.) larvae are visual feeders, and thus growth can be limited by hours of daylight available for feeding, which varies between seasons (Blaxter, 1966). Slower otolith growth in autumn spawned North Sea vs. Norwegian spring spawned herring larvae (Moksness and Fossum, 1991; Fossum and Moksness, 1993)) have been documented, but it is not clear to what extent this is due to seasonal differences in day length. In order to be best fit for survival in the winter, autumn spawned larvae with relatively short pre-winter larval growth period should improve their length specific energy content. A controlled laboratory experiment was performed to investigate the effect of progressively increasing and decreasing day length on somatic and otolith growth of autumn-spawned North Sea herring larvae.

Materials and methods

Autumn spawning North Sea herring (*Clupea harengus* L.) caught on August 13, 1998, outside Peterhead, Scotland (57°29'N, 1°40'W), were used as parental fish. Eggs were fertilised artificial in the laboratory and incubated at 10° C (± 0,1 SD) for 11 days. One hundred and fifty larvae were then transferred to each of eight rearing tanks (each 180 l). The experiment was performed applying two different light regimes (autumn (A) and spring (S)) similar to natural light conditions in Bergen (60°23'N, 5°20'E) (Fig.1). Within each light regime larvae were reared with (0 prey l^{-1} (S, starvation) and 40 prey l^{-1} (L, low)) and without food limitation (1200 prey l^{-1} (H, high)) (Fig. 3). Each prey density treatment was replicated. Temperature (10° C) and density level of natural zooplankton were monitored every morning and kept constant during the experiment (56 days). Once a week 20 larvae were sampled from each tank and standard length (SL, mm) and dry weight (DW, µg) measured. Both sagitta were extracted and mounted on glass slides and the individual increment widths (IW) and total radius of the otoliths (OR, µm) of 494 individuals were measured in a light microscope (1000 X) (Fig. 3). Increment structures were for some specimens also investigated using SEM (Fig. 2)

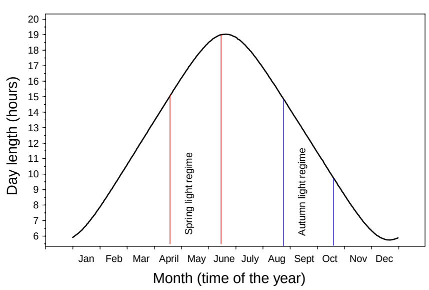


Figure 1 Simulated day lengths throughout the year (1998) at 60°23'N, 5°20'E. Experimental periods in spring (April 21 to June 16, red lines) and autumn (August 25 to October 20, blue lines) are shown in the figure. The black line shows numbers of hours when the sun is above the horizon.

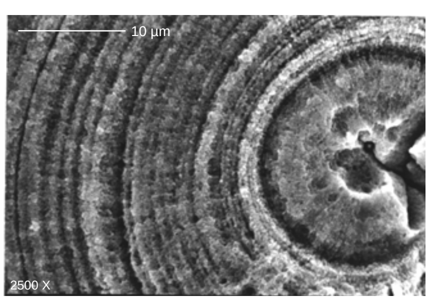


Figure 2 SEM image of a sagitta of a 56 day old herring larva from the autumn high prey density group.

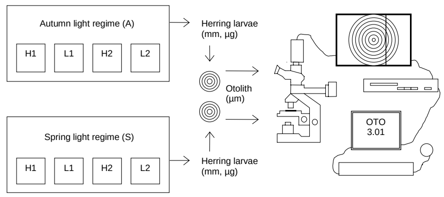
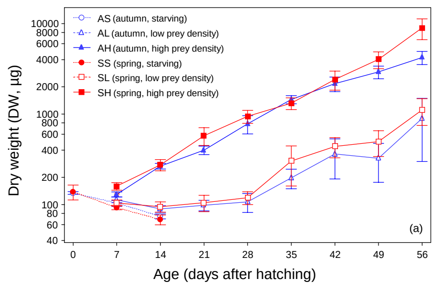


Figure 3 Schematic drawing of the experimental set up (H is high prey density, L is low prey density and each prey density treatment was replicated (1 and 2)), and tools for analysing the otoliths include computer, light microscope, digitizer and black-white monitor.

Results

Significant differences in SL and DW were observed between prey density groups (DW, Fig. 4a). The H-groups grew linearly in length (0.29 mm d^{-1} (AH) and 0.32 mm d^{-1} (SH)) up to 24.2 mm (AH) and 27.3 mm (SH) on day 56. Larvae in the S-groups were on average 5 % heavier than larvae in the A-groups at a given length (ANCOVA, $p < 0.05$).



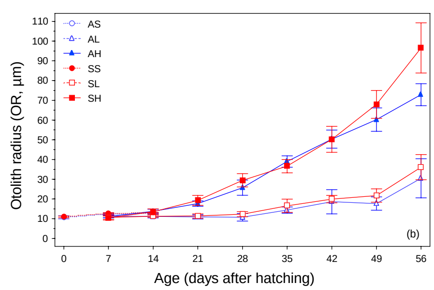


Figure 4 Size development, dry weight (DW, µg) (a) and otolith radius (OR, µm) (b) at age of autumn-spawned herring larvae at autumn (A) and spring (S) light regime. The larvae in each light regime had 0 (S), 40 (L) and 1200 (H) prey l^{-1} from day 3 - 56. Mean and 2x SE are given.

The DW estimated growth rate decreased from 8.8 % d^{-1} to approximately 6.4 % d^{-1} after four weeks in both H-groups, then decreased further to 4.7 % d^{-1} for AH-larvae, but increased to 9.2 % d^{-1} for SH-larvae (Fig. 5). After seven weeks a larger size difference between the SH- and AH-group than between the SL- and AL-group was observed (Fig. 4).

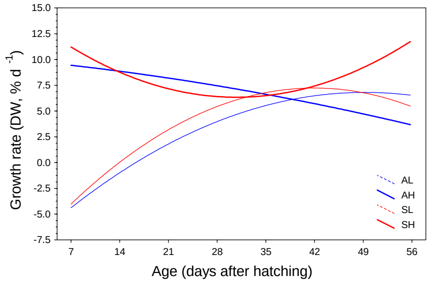
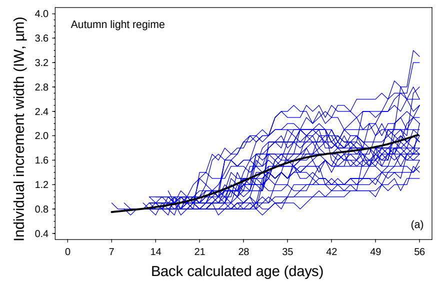


Figure 5 Weight specific growth rate (DW, % d^{-1}) at age of autumn-spawned herring larvae reared at low (L) and high (H) prey density both with autumn (A) and spring (S) light regime. The estimated DW growth rates were obtained by using the time derivative of the third degree polynomial fits to the size-at-age data of the respective treatment groups.

Significant differences in OR were observed between prey density groups. Average OR was larger in the SH-group than in the AH-group from day 49 (67.9 µm v. 60.2 µm) and onwards (Fig. 4b). Average IW in the AH-group and the SH-group was approximately the same the first month (Fig. 6). During the second month the average IW in the AH-group was 1.8 – 1.9 µm d^{-1}, but in the SH-group they became progressively wider, approaching 3.0 µm d^{-1} (Fig. 6).



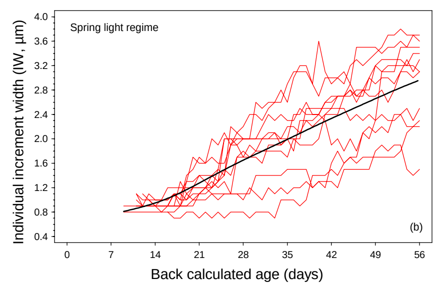


Figure 6 Individual otolith growth trajectories of autumn-spawned herring larvae reared without food limitation (1200 prey l^{-1}) in autumn light regime (n = 27) (thin blue lines) (a) and spring light regime (n = 11) (thin red lines) (b). Thick solid black lines (*Distance weighted least square*) are superimposed the trajectories to indicate general trends in otolith growth.

Conclusions

- The size difference between the AH- and SH-group after seven weeks implies that the SH-group benefited from longer days when food was not limiting. The small size difference between the AL- and SL-group indicates that food quantity is more limiting than day length to sustain growth at low food levels.
- Higher length-specific DW in the S-group larvae than in the A-group larvae indicates that decreasing day length is insufficient as a signal for predicting unfavorable growth conditions in the coming winter. Increasing weight-specific growth rate for SH-larvae and decreasing for AH-larvae the last three weeks may also be a result of rather than an adaptation to the prevailing light regime.
- Different IW trajectories between the seasonal groups of larvae sampled on day 56 confirmed day length specific growth of otolith. Since this is not found for larvae collected on day 49 the effect of day length is considered to be weak.

References

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This work was supported by a EU-FAIR CT-96-1371 project: Precision and Accuracy of tools in Recruitment Studies (PARS).