TEMPERATURE-DEPENDENT OTOLITH GROWTH IN HERRING (*CLUPEA HARENGUS*) LARVAE

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Introduction

Otolith microstructure analysis is a powerful technique that can provide information about previous growth history in fish larvae (Campana, 1992). Knowledge about the growth of the otoliths at different and varying temperatures is important to enable accurate and precise characterisations of growth in the field. Temperature is a confounding effect in many biological processes, and it has been shown to influence larval growth in a variety of fish species (Houde, 1989). We therefore set up a laboratory experiment with herring (*Clupea harengus* L.) larvae with the aim of determining the effect of different and changing temperatures on the increment rate and width formation.

Materials and methods

Eggs from Norwegian spring-spawning herring caught off south-western Norway, March 31 1995, were incubated at 8°C. Two days after hatching, on April 18, 400 larvae were transferred to each of four 500 l tanks, two with 4°C and two with 12°C water temperature. They were fed natural zooplankton (mainly rotifers and nauplii) in excess (densities above 1000 l^{-1}). The rearing temperatures were maintained at respective levels until day 16, when the temperature in two of the tanks was shifted to 8°C (Figure 1). The larvae were subject to an alizarin complexone immersion marking (50 mg l^{-1} for 12 h) on day 16 immediately prior to the temperature change. Following a second alizarin marking on day 30, the temperature in the two tanks was shifted back to the original temperature.

Larval sampling was carried out weekly and were length measured live. Both sagittae were extracted and mounted in clear nail varnish on glass slides. Otoliths were read along the longest possible radius from the core to the outer edge of the otolith under a light microscope at 1000X (Andersen & Moksness, 1988). The radial distances of the alizarin marks were measured using a calibrated fluorescence microscope. In total 316 larvae were analysed.

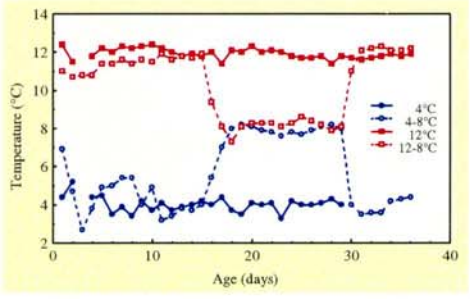

Figure 1. Temperature (°C) in larval rearing tanks.

References

Andersen, T. & Moksness, E. (1988). Manual for reading daily increments by the use of a computer programme. *Flødevigen Meldinger* **4**, 1-37.

Campana, S. E. (1992). Measurement and interpretation of the microstructure of fish otoliths. In *Otolith microstructure examination and analysis, Canadian Special Publications of Fisheries and Aquatic Sciences No. 117* (Stevenson, D. K. & Campana, S. E., Editors), pp. 59-71.

Houde, E. D. (1989). Comparative growth, mortality, and energetics of marine fish larvae: temperature and latitudinal effects. *Fishery Bulletin U.S.* **87**, 471-495.

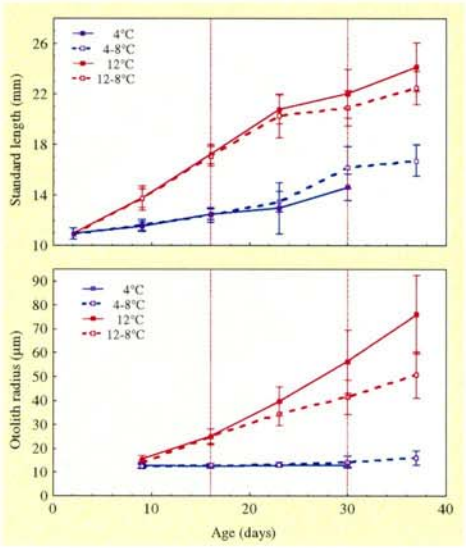

Figure 2. Standard length (mm) and otolith radius (µm) versus age for herring larvae (whiskers represent SD). Vertical lines indicate time of alizarin marking and temperature change.

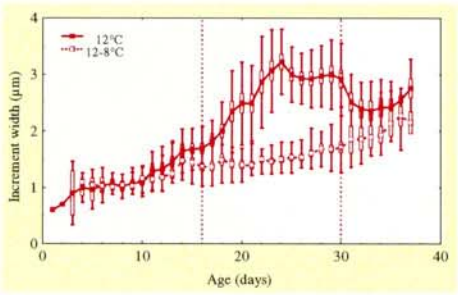

Figure 3. Mean otolith increment width (µm) versus age for herring larvae (boxes represent SE and whiskers SD). Vertical lines indicate time of alizarin marking and temperature change.

Results

Larval growth was clearly temperature dependent (Figure 2). The group reared at 12°C grew around 0.4 mm day^{-1}, compared to 0.15 mm day^{-1} for the 4°C group. An uncoupling of otolith growth and somatic growth was observed at the 4°C group and no significant otolith growth was observed between the markings. Otoliths of larvae from the 4°C groups were also smaller than those from the 12°C groups at comparable larval length (Figure 2). The 12-8°C group had a daily deposition rate of 0.9 between the markings compared to 0.1 in the 4-8°C group. Both these groups had a daily length increase of 0.29 mm during the same time interval. The double alizarin marking confirmed a daily increment deposition rate of 1 day^{-1} in the 12°C group. The increment growth pattern in the 12°C and 12-8°C groups diverged rapidly after the temperature change (Figure 3). The differences in otolith growth between the markings were also noticable when comparing the size ratios of the two marks (Figure 4 and 5). Large overlap in length of larvae at termination of the experiment between the 12°C and the 12-8°C groups made it impossible to seperate these groups on length alone.

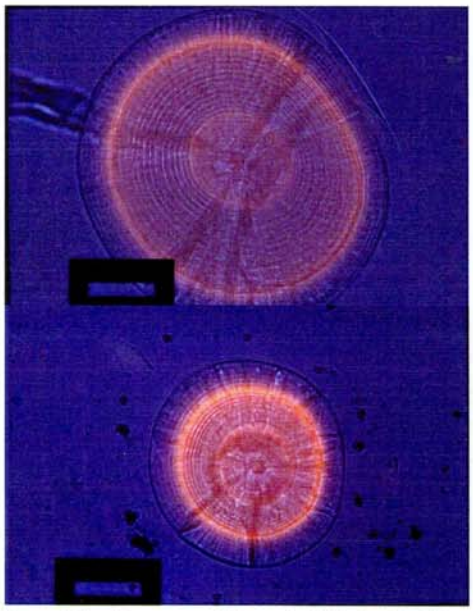

Figure 4. Double exposure pictures of otoliths (sagittae) from 37 day old herring larvae from 12°C group (upper), and 12-8 °C group (lower) showing the two alizarin marks (in red). Bar in picture is 30 µm.

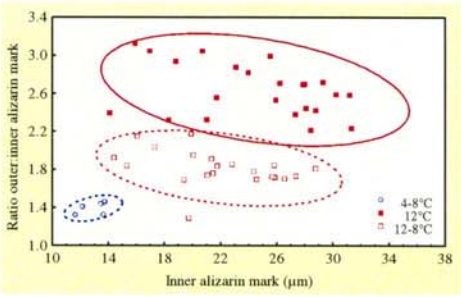

Figure 5. Ratio of outer alizarin mark to inner alizarin mark versus size of inner alizarin mark of herring larvae sampled at day 37. Confidence ellipses (0.9) are included.

Conclusions

- Alizarin complexone marking produced clear marks in sagittae of growing herring larvae
- Length growth did not change dramatically following a sudden temperature increase or decrease, whereas otolith growth responded rapidly following a temperature decrease from 12 to 8°C
- Herring larvae reared at 4°C had low length growth rate (0.15 mm day^{-1}), and no detectable otolith growth rate (less than 0.2 µm day^{-1})
- Increment deposition rate of 1 was confirmed for herring larvae growing at 0.4 mm day^{-1}
- Otolith growth pattern was a better indicator of previous environmental history than larval size

Acknowledgements

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