Validation of annual growth ring formation in the statoliths of the common whelk, *Buccinum undatum*

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Overview

Fisheries for the common whelk, *Buccinum undatum*, throughout the North Atlantic have grown steadily in value since the mid-1990s [1]. In 2015, the UK fishery had a value of £18.7million which related to roughly 20,000 tonnes of whelks landed into UK ports alone [2]. With concerns about sustainability for this increasingly important fishery, new management strategies are being sought to monitor a species which has been historically difficult to assess. Due to highly variable growth rates between and within populations, standard size based estimations of age are ineffective, meaning that individual age assessments are a necessity for population age structure calculations. The current method of age determination using organic opercula has been shown in many studies to be ineffective due the poor readability of growth lines contained within this structure. This has led to extensive research into the calcium carbonate statoliths (which contain clear growth rings) as reliable analogues to the currently used opercula [3]. Initial chemical analysis of statolith growth rings using SIMS revealed clear cycles in the Mg/Ca ratio which related to the visible growth rings in statoliths from a range of specimens from several wild populations. A single clear cycle in Mg was also observed in the statoliths of 1 year old laboratory reared whelks. This report outlines further chemical analysis undertaken on the statoliths of 2 year old laboratory reared whelks from the same conditions as those analysed previously. 2 clear cycles of Mg were found in all sampled 2 year old specimens which corresponded to the visible growth rings. These finding support the validation of annual growth ring formation which has been outlined by laboratory based growth experiments [3].

Rationale for using SIMS

Due to the small size of the statoliths, their radial structure and the large time period covered by their growth a high sampling resolution was required. In the statoliths of the 2 year old whelks, a maximum growth axis of only ~100 μm was available in larger specimens. It would have been difficult to sample sub-annually using other conventional in-situ analytical techniques such as LA-ICP-MS. The detection limits for lighter target elements such as Na and Mg are also better when using SIMS.

Methods

Using the IMS-4F instrument, a line transect analysis profile was run across the midpoint of the polished central plane of each statolith. Firstly a 25μm high current beam was used with a step size of 10μm to pre-condition the surface, removing any contamination; along this 25μm track a low current 1 μm beam was used at a 2 μm step size to analyse the targeted trace elements (Ca, Na Mg, Sr and Al).

Results and discussion

A total of 8 statoliths were analysed from 2 year old laboratory reared specimens representing a range of fast growing (large) and slow growing (small) specimens. In the previous report, 1 year old animals were demonstrated to contain a single cycle of Mg within the year of growth. For the 2 year old animals, 2 clear cycles of Mg were found within each statolith, corresponding to the visible growth rings (**Figure 1**.)

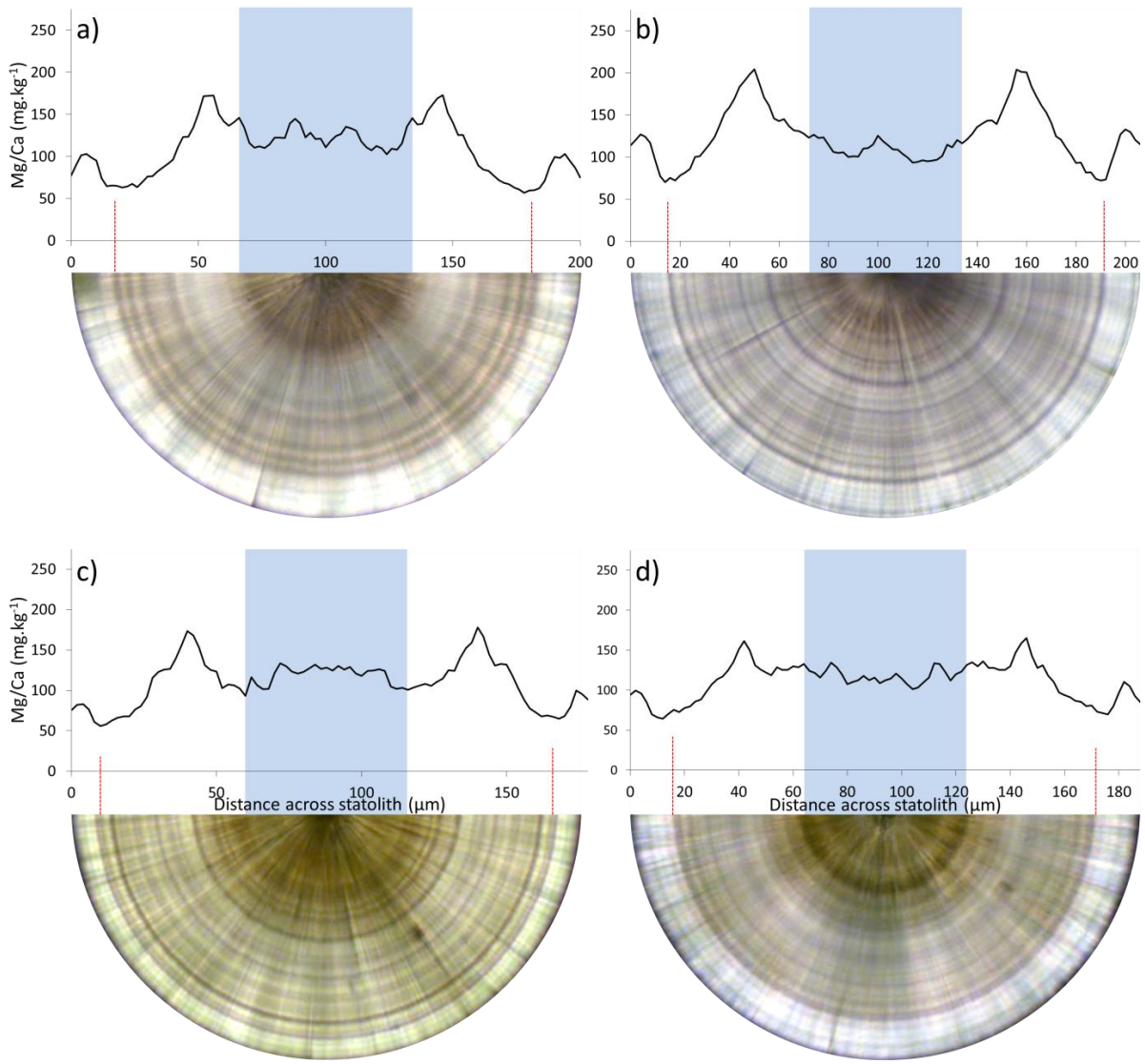

Figure 1. Cycles in the Mg/Ca ratio (mg.kg^{-1}) across statoliths overlaid on photomicrographs from large specimens (~50 mm shell length a) & b)) and small specimens (~35 mm shell length c) & d)). Red dotted lines represent growth rings with matching Mg/Ca cycles, blue boxes indicate larval growth (to be discounted).

Summary and Impact

SIMS was used to highlight two clear cycles in Mg/Ca ratios along growth axes in all sampled statoliths from 2 year old animals, coinciding with visible growth rings. This suggests an annual periodicity inherent in their growth. This information has been used to develop aging techniques which are currently being adopted by CEFAS (Centre for Environment, Fisheries and Aquaculture Science) for UK based fisheries policy and management. Additionally, it will also be presented at a dedicated workshop for North American fisheries scientists in Newfoundland, Canada this coming May. The study is currently being written up for a special issue of the Chemical Geology journal, arising from the 4th International Sclerochronology conference where it was given as an oral presentation. This work was also presented at the ICES annual science conference in a theme section organised by Phil Hollyman and several colleagues titled 'Innovative use of sclerochronology in marine resource management'.

References

[1] C. Heude-Berthelin et al. (2005) Aquatic living resources, **24**, 317-327
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[4] P.R. Hollyman et al. (accepted pending minor corrections). Marine Ecology Progress Series.