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Disentangling *Arctica islandica*'s environmental archive

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Summary

In these times of global and fast climate change, there is a need to further develop the research field of sclerochronology. This relatively new discipline uses the annual banding in the shells of long-lived mollusks to develop long timelines or chronologies. These chronologies can be coupled with local environmental records, in the same way as growth rings of trees are used in dendrochronology (Jones, 1980; Witbaard et al., 1994; Karney et al., 2011). As such they provide insight into past and present ocean climatic conditions (Schöne et al., 2003; Witbaard et al., 2003; Butler et al., 2013; Mette et al., 2016). Continuous long-term (>50 years) instrumental records of environmental conditions are sparse in the marine environment. Thus, proxy-based environmental reconstructions are needed to improve regional and temporal coverage and to understand past marine climate variability (Jones et al. 2009; Wanamaker et al., 2011; Mette et al., 2016; Steinhardt et al., 2016).

The boreal species *Arctica islandica* (Mollusca, Bivalvia) is an example of a great marine bioarchive due to its wide distribution and extreme long-life (up to five centuries). This species' shell presents annual growth increments (or growth bands) which provides dated environmental information by way of variable growth increments, and microstructural and geochemical properties. However, the duration, timing, and main environmental forces regulating *A. islandica*'s growing season still needed further study. The combined role of temperature and food in regulating activity patterns and shell growth of this bivalve had to be disentangled.

Chapter 1 of this thesis describes the main characteristics of the species and the aim of my research. Chapter 2 reports about a fieldwork *in situ* experiment where we discovered that *A. islandica* gaping activity in northern Norway has an eight months long active season in which valve movements are mainly regulated by food availability. Active gaping periods appear to coincide with periods of growth, indicating that *A. islandica* records their environment when its valves are open.

A series of food and temperature experiments (Chapter 3 and Chapter 4), where the microstructural properties of *A. islandica* shells were studied, showed that temperature, but not food, induced a change in the crystallographic orientation of the biomineral units, indicating that this microstructural property may be a potential proxy for seawater temperature. This change in crystallographic orientation was only detected by confocal Raman microscopy (CRM), not by scanning electron microscopy (SEM).

Chapter 4 explores the combined effects of temperature and food availability on the shell and tissue growth of *A. islandica* under laboratory conditions. It appeared that the concentration of algal food is the main factor driving siphon activity and with that shell and tissue growth. Thus, these experimental outcomes support the results from Chapter 2, where *in situ* gaping activity was most closely correlated with the concentration of chlorophyll-a and to a lesser degree with the seawater temperature.

We used a subsample of specimens from above laboratory growth experiment (Chapter 4) to study the role of environmental and biological controls on trace elemental incorporation of *A. islandica* shells (Chapter 5). We found that all trace element-to-calcium ratios (Mg, Sr, Na, and Ba) were significantly affected by growth rate. This indicates that physiological processes seem to dominate the controls of element incorporation into *A. islandica* shells.

Chapter 6 describes the energy use of *A. islandica* based on a Dynamic Energy Budget model. Our results indicate that *A. islandica*'s extreme longevity arises from its low somatic maintenance cost [\dot{p}_M] and low ageing acceleration \dot{h}_a . We could not find a direct relationship between food availability and lifespan (theory of caloric restriction) in the eight North Atlantic populations studied. Nevertheless, food estimates based on the DEB's scaled functional response can be a good food indicator, sometimes the only one, of the benthic food conditions at *A. islandica* localities.

The main conclusions of this thesis are that (1) *A. islandica* gaping and growing season seems to be limited to 8 months of the year, and that food availability and not temperature is the main driver of this gaping and growth behavior, (2) some microstructural and geochemical properties of *A. islandica* shell contain environmental information, but further study still need to be done to use them as a reliable environmental proxy, and (3) the extreme longevity of the species is due to its low somatic maintenance cost and low accumulation of waste that provokes ageing.