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Oceanographic control on shell growth of *Arctica islandica* (Bivalvia) in surface waters of Northeast Iceland — Implications for paleoclimate reconstructions

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ABSTRACT

Absolutely dated, annually resolved sea surface temperature records from middle to higher latitudes covering long time intervals are crucial to better understand the climate system. Such data can potentially be obtained from variations in shell growth of long-lived bivalves such as *Arctica islandica*. This study presents the first statistically robust 178-yr long composite chronology (covering 1835–2012) based on sixteen live-collected and subfossil specimens of *A. islandica* from unpolluted, shallow waters of Northeast Iceland. Between 1875 and 1996, up to 43% of the variation in annual shell growth was explained by SST during February to September. Faster growth occurred when temperatures were warmer and food supply was elevated. However, the correlation was subject to strong temporal variations. Likewise, the inter-series correlation (synchrony among time series) was intermittently stronger and weaker. If more uniform environmental conditions prevailed over a longer time interval and the habitat was solely influenced by one of the major currents in this region – the warm, nutrient-rich Irminger Current or the cold, nutrient-poor East Iceland Current – the agreement between growth records of contemporaneous specimens broke down and the correlation between shell growth and SST was at minimum. However, when the habitat was under the alternating influence of both currents, the inter-annual variability of shell growth and synchrony in growth among the specimens were at maximum, and the correlation between SST and shell growth strengthened. As demonstrated here, the relationship between shell growth of *A. islandica* and environmental variables is highly complex and depends on oceanographic parameters. These findings should be taken into account in subsequent studies in order to reliably reconstruct SST and other environmental variables from shells of this species.

1. Introduction

Shells of the bivalve mollusk *Arctica islandica* (Linnaeus, 1767) serve as a novel ultra high-resolution archive of paleoclimate dynamics in the upper 500 m of the boreal North Atlantic Ocean (Nicol, 1951; Jones, 1980; Schöne, 2013). Like other mollusks, this species contains distinct growth patterns in its shell consisting of annual and daily growth lines and growth increments (Jones, 1980; Thompson et al., 1980; Schöne et al., 2005a). With these growth patterns, each increment can be placed in a temporal context. If the exact date of a particular growth increment is known, e.g., the date of death, it is also possible to assign precise calendar dates to the complete shell record. Changes of ambient environmental conditions (e.g., water temperature, food availability) are recorded by the shells in the form of variable increment widths (e.g., Witbaard et al., 1997) and variable geochemical properties (e.g., Schöne et al., 2011; Wanamaker et al., 2011; Holland et al., 2014a). Since annual growth line formation, i.e., the period of retarded or halted growth, occurs during late summer/fall (Weidman et al., 1994; Witbaard et al., 1994; Schöne, 2013), shells of *A. islandica* record the full seasonal amplitude of environmental variables (Schöne et al., 2005a). What makes this species special among other sclerochronological paleoclimate archives is the extraordinary longevity of up to 500 years (Schöne et al., 2005b; Wanamaker et al., 2008; Butler et al., 2013). Individual shells can thus provide subseasonally resolved environmental information over a coherent time interval of several hundred years. Furthermore, based on synchronous changes in relative shell growth rates, it is also possible to combine increment width chronologies from specimens with overlapping life spans to build so-called composite or master chronologies covering centuries to millennia (e.g., Marchitto et al., 2000; Butler et al., 2010; Lohmann and Schöne, 2013; Holland et al., 2014b).

A number of studies successfully constructed such composite or master chronologies from specimens of *A. islandica* that lived near or below the thermocline (Marchitto et al., 2000; Schöne et al., 2003; Butler et al., 2010, 2013; Matras, 2011). For example, Marchitto et al. (2000) presented a 154-yr long chronology from Georges Bank (Gulf of Maine) using three live-collected and four dead, single shells from

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