Accurate increment identification and the spatial extent of the common signal in five *Arctica islandica* chronologies from the Fladen Ground, northern North Sea

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[1] The creation of networks of shell-based chronologies which can provide regionally extensive high-resolution proxies for the marine environment depends on the spatial extent of the common environmental signal preserved in the shell banding and on the reliability of the dating model. Here *Arctica islandica* chronologies from five neighboring sites in the North Sea are compared, and the strength of the common environmental signal across distances up to 80 km is analyzed using statistical techniques derived from dendrochronology. The signal is found to be coherent across these distances. In a linked study, chronologies based on one of the same sites but constructed by two different research teams are compared. Methodological differences in increment interpretation are found to lead to slippage in the dating models. Systematic inclusion or exclusion of intermittently occurring increments results in the two chronologies becoming misaligned by 4 years over a 70-year period. Comparisons with neighboring chronologies indicate that such increments can generally be regarded as genuine annual increments even if they are not visible in all shells.

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1. Introduction

[2] A number of recent studies have used the annually deposited growth increments in shells to demonstrate synchronized growth in populations of the bivalve mollusc *Arctica islandica* [*Butler et al.*, 2009; *Helama et al.*, 2006, 2007; *Marchitto et al.*, 2000; *Schöne et al.*, 2002, 2003; *Scourse et al.*, 2006; *Witbaard et al.*, 1997, 2003]. Synchronized growth represents prima facie evidence for the existence of a common environmental signal, that is, a suite of (usually climatic) forcing factors which affects the physical growth of all members of a population in the same way. Such factors may include seawater temperature [*Schöne et al.*, 2005a, 2005b], length of the growing season [*Weidman et al.*, 1994] or food supply [*Witbaard et al.*, 1999]. It has also been possible to link growth and variability in *A. islandica* with large-scale oceanographic and climatic features, including the hydrography of the northern North Sea [*Witbaard et al.*, 1997] and the winter North Atlantic Oscillation index [*Helama et al.*, 2007; *Schöne et al.*, 2003].

[3] The annual increments in the shell of *A. islandica* are discrete and well defined; in this sense they are similar to tree rings and can be used to fulfill the same function as a high-resolution climate proxy for the marine environment that tree rings fulfill for the terrestrial environment. In addition, the dendrochronological technique of cross-dating can be used to assign absolute calendar dates to dead-collected shells, enabling the proxy archive to be extended back in time before the lifetime of any living animals [*Briffa*, 1995]. In this way, a multicentennial high-resolution archive for the temperate marine environment can be constructed, analogous to the tropical marine archive preserved in coral banding [e.g., *McCulloch et al.*, 1999] and the terrestrial archive in tree rings [*Fritts*, 1976]. In particular, the geographical spread of *A. islandica* populations around the North Atlantic margins [*Dahlgren et al.*, 2000] highlights the utility of the species as a marine proxy in a region of critical importance to the role of ocean circulation as a climate driver [*Keenlyside et al.*, 2008; *Sutton and Hodson*, 2005]. Research into marine paleoclimates is substantially (and for some regions exclusively) based on proxy archives obtained from sediment cores. The dating control of any particular archive is therefore dependent on the accuracy and precision of the age-depth model of the sediment core

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