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Late Holocene seasonal temperature variability of the western Scottish shelf (St Kilda) recorded in fossil shells of the bivalve *Glycymeris glycymeris*

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ABSTRACT

The North Atlantic Ocean and adjacent shelf seas play a crucial role in global climate. To better constrain long-term natural variability and marine-terrestrial linkages in this region, a network of highly resolved marine archives from the open ocean and continental shelves is needed. In recent decades, bivalve sclerochronology has emerged as a field providing such records from the mid- to high latitudes. In May 2014, dead valves and young live specimens of the bivalve *Glycymeris glycymeris* were collected at St Kilda, Scotland. A floating chronology spanning 187 years was constructed with fossil shells and radiocarbon dated to 3910–3340 cal yr before present (BP), with a probability density cluster at ca. 3700–3500 cal yr BP. Sub-annual $\delta^{18}O$ data were obtained from five fossil and three modern specimens and showed a strong seasonal signal in both time intervals. The growth season of *G. glycymeris* at this location today lasts from May to October, with most growth occurring before the temperature peak in August. Thus, the modern specimens and the fossil chronology represent late-spring and summer sea surface temperatures (SST). The annual temperature range was 4.4 °C in the fossil shells, which is similar to the range observed today (3.8 °C). Average SSTs reconstructed from the fossil shells were 1 °C cooler than in 2003–2013 CE and similar to the early 20th century CE. The radiocarbon age of the floating chronology coincides with a climatic shift to wetter conditions on the British Isles and with a cold interval observed in palaeoceanographic records from south of Iceland. However, our data do not provide evidence of a cold interval on the Scottish shelf. The similarity in growth season and temperature range between the fossil and modern specimens are attributed to similar boundary conditions in the fourth millennium BP compared to today.

1. Introduction

The North Atlantic is a key region in the global climate system. The Atlantic Meridional Overturning Circulation (AMOC) plays a crucial role in the global redistribution of heat, carbon, and nutrients, and has been implicated in abrupt climatic shifts (Buckley and Marshall, 2015). In addition to the main North Atlantic basin, shelf seas are an integral part of the North Atlantic region. Shelf seas are in exchange with the open ocean, and disproportionately important for primary production and the sequestration of atmospheric carbon (Chen et al., 2013). Thus, understanding the dynamics and natural variability of the Atlantic circulation and adjacent shelf seas is crucial to understanding past and future climate changes.

North Atlantic sea surface temperatures (SST) have been decreasing since 5700 years before present (yr BP), which is generally linked to an orbitally forced decrease in solar irradiance (e.g. Marchal et al., 2002). However, SST trends and variability in the late Holocene are temporally and spatially heterogenous, due to processes in the different limbs of the AMOC and regional ocean-atmosphere feedbacks (e.g. Moffa-Sánchez et al., 2014; Solignac et al., 2008). In the fourth millennium BP, solar activity was relatively low, with a strong negative excursion noted at ca. 3.4 kyr BP (Steinhilber et al., 2012, 2009). The atmospheric conditions in the fourth millennium BP are thought to have been dominated by a weakly positive North Atlantic Oscillation (NAO) with several negative

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