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Interannual to decadal variability of summer sea surface temperature in the Sea of Okhotsk recorded in the shell growth history of Stimpson's hard clams (*Mercenaria stimpsoni*)

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ABSTRACT

Sclerochronological and shell stable oxygen isotopic analyses were conducted on live-caught specimens of Stimpson's hard clams, *Mercenaria stimpsoni*, from the southern Sea of Okhotsk, off northern Hokkaido, Japan. In this region, the main growing season of this species during early ontogeny (below the age of 12 years) lasts from mid-spring to mid-fall at sea surface temperatures (SST) between approximately 10 and 22 °C. Growth cessation begins between late fall and early spring at SST, below approximately 6 °C; however, shell growth was largely limited to the summer season later in life. Counting of annual increments indicated that this species had a relatively long life span of up to 100 years. Annual shell growth rates were high during early ontogeny and declined abruptly afterwards. Mean standardized shell growth indices (SGIs) of long-lived specimens were positively correlated to the mean summer SSTs near the sampling site and in the coastal waters off northern Hokkaido. The SGI chronology of the longest-lived specimen (99 years old) exhibited periodicities of approximately 10 and 5 years during the calendar years 1920–2011, possibly reflecting the quasi-decadal variability of summer SST in the southern Sea of Okhotsk. These findings indicate that *M. stimpsoni* could serve as an archive to reconstruct past marine climate changes in the Sea of Okhotsk.

1. Introduction

Long-term and annually resolved records of past environmental conditions from different geographic settings provide a reliable basis for predicting future state of the climate system. Of the various organisms that secrete a marginal growing skeleton, bivalve mollusks are best suited to analyze past aquatic environmental changes because (1) they exhibit a broad biogeographic, bathymetric, and environmental distribution ranging from tropical to polar realms, intertidal to deep-sea settings, and freshwater to marine environments; (2) their shells have a high preservation potential as fossils; and (3) they preserve sequences of daily and annual increments in the ventral shell margin and hinge plate (Richardson, 2001; Schöne and Surge, 2012).

In the past two decades, sclerochronological studies, specifically analyses of shell growth patterns, stable isotopes, and trace elements, have been conducted in several long-lived marine bivalve species to reconstruct past environmental conditions such as SST (sea surface temperature), salinity, nutrient sources, and daily light cycles over a wide range of different temporal resolutions ranging from seasons to millennia. Examples include the giant clams, *Hippopus hippopus* and *Tridacna gigas*, from the tropical to subtropical oceans (e.g., Watanabe et al., 2004; Elliot et al., 2009; Aubert et al., 2009; Sano et al., 2012; Hori et al., 2015), *Arctica islandica* (e.g., Witbaard et al., 1997; Schöne et al., 2004; Wanamaker et al., 2008; Butler et al., 2011; Schöne, 2013; Holland et al., 2014), and *Glycymeris glycymeris* (Brocas et al., 2013; Royer et al., 2013) from the northern North Atlantic, as well as *Panopea abrupta* from the Northeast Pacific (Strom et al., 2005; Black et al., 2009). These studies also demonstrated that age-detrended shell growth rate is coupled with decadal climate variabilities, such as the North Atlantic Oscillation (NAO), Pacific Decadal Oscillation (PDO), and El Niño-Southern Oscillations (ENSO).

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