Reconstructing past Gulf of Maine sea temperatures from clam shells

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Paleoceanography, or the study of past ocean conditions, is a crucial contributor to our current understanding of climate. By comparing past climate reconstructions to contemporary trends, we can better contextualize the climate patterns we observe today. These comparisons contribute greatly to our understanding of current environmental issues such as ocean warming and acidification.

For my Honors Project, I conducted a paleoceanography research project aimed at reconstructing past Gulf of Maine temperatures from shell of the long-lived bivalve *Arctica islandica*. I initially focused on developing a more accurate calibration process for the temperature-$\delta^{18}O$ relationship for mollusks. I then used that process to construct a time series of temperature in the Gulf of Maine using oxygen isotopes from *Arctica islandica.*

The initial stage of my research focused on improving the accuracy of the calibration process for mollusks by assessing the need for species-specific calibrations. Mollusk shells are important climate archives because oxygen isotope ratios from the calcium carbonate in the shells can help reconstruct past temperatures. However, the current process for extracting data from these shells may not be the most accurate means of calculating temperature. In the process of using calculations to establish the relationship between oxygen isotopes and temperature, scientists operate under the assumption that one equation can be sufficiently applied to the calibration process for all mollusks, but it has never been determined whether species record temperature differently enough to warrant species-specific calibration equations. My research this summer focused on testing this assumption by developing species-specific equations for three species of clams (*Mya arenaria, A. islandica, Mercenaria mercenaria)* found in the Gulf of Maine (GOM) and comparing the calibration results to results calculated using the equation for all mollusks developed by Grossman and Ku (1986). The comparison suggested that calculated temperatures from *M. arenaria* and *M. mercenaria* using the equation determined by Grossman and Ku (1986) differed significantly from measured tank temperatures. Temperatures calculated from *A. islandica* using the Grossman and Ku equation generally agreed with measured temperatures for each treatment, validating the use of this equation in oxygen isotope-based reconstructions of sea temperature in the GOM.

The second part of my honors research involved the creation of a time series from the shells of *A. islandica.* The clam *A. islandica* can live up to 500 years and its calcium carbonate shell displays annual growth bands. This makes *A. islandica* a valuable option for temperature reconstructions, because with only one shell, it is possible to look as far back as 500 years into the past. I used the shells of live caught *A. islandica* from Isle au Haut in the GOM to reconstruct annual sea temperature. This reconstruction allowed me to see how sea temperature has changed over the last century at Isle au Haut and compare those changes to other sea temperature records from the GOM. Differences between the Isle au Haut record and other sea temperature records from Boothbay Harbor, Jonesport, and Seguin suggest that recent warming in the GOM is occurring heterogeneously and is variable across space. Understanding these uneven warming rates, which may have been caused by currents, circulations, and fluvial influence, will be critical to improving our knowledge of GOM warming.

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References: Grossman, E.L. and Ku, T.L., 1986, Oxygen and carbon isotope fractionation in biogenic aragonite: Temperature effects: Chemical Geology: Isotope Geosciences Section, v. 59, p. 59-74.