Do different bivalve mollusk species record their shared environment in the same way?

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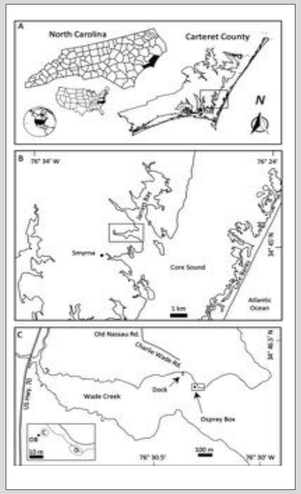
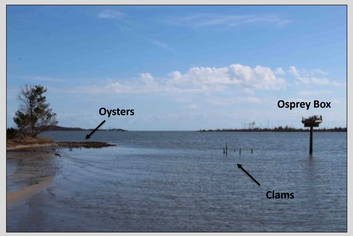
Abstract

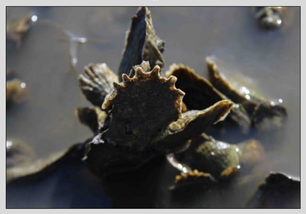
Bivalve mollusks record environmental variations experienced during shell growth. Paleoenvironmental reconstructions derived from these biogeochemical archives rely on the assumption that these animals faithfully recorded environmental conditions. It is generally accepted that bivalves precipitate oxygen isotopes ($\delta^{18}O$) in equilibrium with water, and carbonate $\delta^{18}O$ values reflect temperature and the oxygen isotope composition of the water. Less well understood, however, is the role of species-specific growth preferences. Variable growth patterns can obscure original environmental variation in the same way an antique windowpane blurs the view outside. Our previous work suggests that the clam, *Mercenaria mercenaria*, and the oyster, *Crassostrea virginica*, record slightly different aspects of their shared environment. $\delta^{18}O$ values from *M. mercenaria* reflect preferential growth during the warmest hours of the day, while *C. virginica* do not show this bias. To investigate this idea, we collected 22 clams and 36 oysters of various sizes living in the same locality (Jarrett Bay, Carteret County, North Carolina). All specimens were sectioned along the axis of maximum growth. A single ~75 µg carbonate sample was drilled from each specimen using a 300-µm drill bit. *M. mercenaria* specimens were drilled at the commissure, whereas *C. virginica* samples were drilled from the ventral margin of the resilifer. In all cases, carbonate samples represent the most recent growth prior to collection. Our preliminary results suggest $\delta^{18}O$ values from *M. mercenaria* shells have a lower mean, smaller standard deviation, and narrower range than those from *C. virginica*. In both clams and oysters, $\delta^{18}O$ values from smaller specimens showed less variability than from larger specimens. These patterns reflect a combination of species-specific preferential growth temperatures and sample time-averaging reflecting different growth rates through ontogeny. We also calculated water temperatures from all specimens using several aragonite (clam) and calcite (oyster) paleotemperature equations. Assuming a constant $\delta^{18}O$ water value, our reconstructed temperatures range over at least 5°C. Taken together, our results suggest reconstructed paleotemperatures are highly dependent on taxon, specimen size, and paleotemperature equation.

Study Site and Specimens





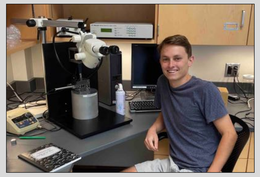
M. mercenaria *C. virginica*

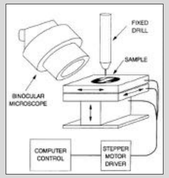


Sample Preparation, Drilling, and Analysis

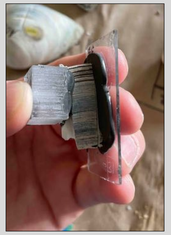
- Water temperatures recorded hourly (10/26/19 to 6/21/21) using Onset HOBO Water Temperature Pro v2 data loggers.
- Specimens collected from Wade Creek (6/21/21).
- *C. virginica* shell lengths and *M. mercenaria* shell height, inflation and lengths measured (6/23/21).
- Left valves of *C. virginica* and right valves of *M. mercenaria* were sectioned along the axis of maximum growth.
- Axes of maximum growth were molded to glass slides and then cut again along a parallel axis. This left each shell as a thick section attached to a glass slide.
- Shells point sampled using a microdrill. Shells were drilled at the area of most recent growth (red arrows) and samples had a mass of ~75 µg.
- Carbonate samples analyzed at the Union College Stable Isotope Laboratory with Thermo Delta Advantage isotope ratio mass spectrometer coupled to a GasBench II.

Denison University Microdrill

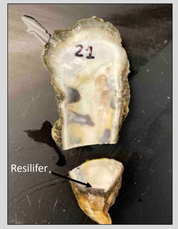


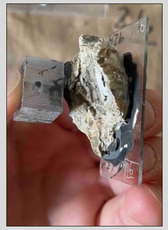


M. mercenaria

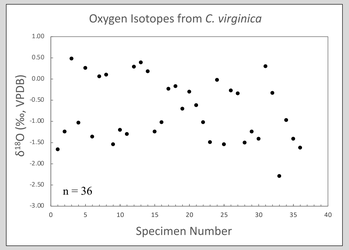


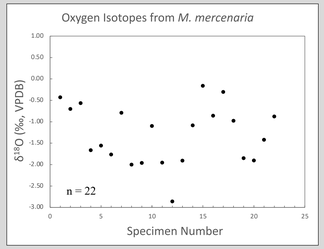
C. virginica

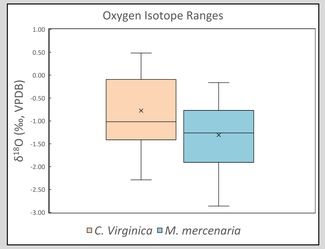




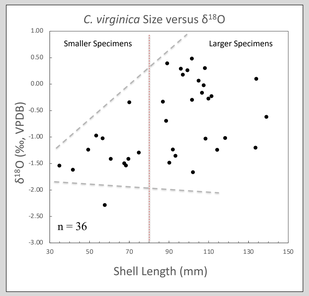
Comparison of Mollusk Species and Oxygen Isotopes

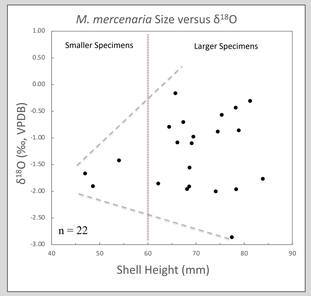


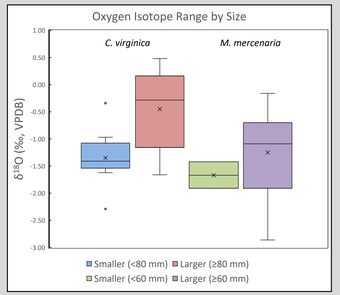




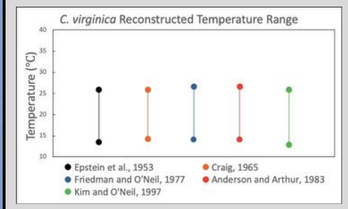
Comparison of Shell Size and Oxygen Isotopes

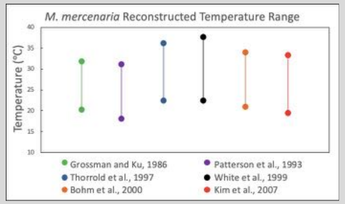






Paleotemperature Equation Significance





Temperatures were predicted using maximum and minimum $\delta^{18}O_c$ values with an assumed $\delta^{18}O_w$ of 0‰.

Findings

- Our findings suggest that $\delta^{18}O$ values from *M. mercenaria* are lower than from *C. virginica.* This suggests that oysters favor growing during the warm times of the day. These findings are consistent with previous studies.
- In both species, smaller specimens have lower $\delta^{18}O$ values than larger ones. We suspect that this is because of changing growth rates in individuals throughout ontogeny. Because smaller (and presumably younger) specimens grow their shells more quickly, the amount of growth contained in one sample represents less time than in larger specimens. Specimens were sacrificed in June of 2021, so samples from larger specimens likely contain growth further back into the cooler spring and winter of 2021, yielding higher $\delta^{18}O$ values.
- Smaller specimens have more consistent $\delta^{18}O$ values than larger specimens. This also reflects the differential growth rates in smaller and larger mollusks. Because growth rates are higher in smaller mollusks, the length of time representing a single sample should be more consistent in smaller shells.
- In shells for both species, reconstructed temperatures range over more than 13°C when using a single paleotemperature equation. Taking the various paleotemperature equations into account, reconstructed temperatures vary by almost 20°C for *M. mercenaria* and about 14 °C for *C. virginica.*
- Our findings are important for Sclerochronologists because they suggest that it is important to consider the species and size of mollusks used to reconstruct paleoenvironments. In particular, the shells of smaller mollusks record a completer and more consistent picture of their living environment.

Acknowledgements

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