4-23-2020

Oxygen isotope variability in Crassostrea Virginica shell from the Chesapeake Bay: applications to regional paleoclimate

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Introduction

The Chesapeake Bay region is affected by anthropogenic climate change, particularly from extremes in precipitation events causing large swings in salinity (Najjar et al., 2010). To quantify recent changes in the hydroclimate in this region, we need a longer baseline of natural climate variability beyond the instrumental era. The common eastern oyster, (*Crassostrea Virginica*), is a promising natural archive of climate change using stable oxygen isotopes (δ^{18}Oshell) recorded in their calcium carbonate shell, which are indicators of both changes in temperature and the δ^{18}O of the water (δ^{18}Osw), which is typically a function of salinity. Before we can use the oyster shell for paleoclimate reconstruction, we must understand how the oyster incorporates the geochemistry of the water, particularly the δ^{18}O, into its shell.

The purpose of this project is to understand how the variability in δ^{18}O of the Crassostrea Virginica calcium carbonate shell reflects changes in sea surface temperature and salinity in the Chesapeake Bay in order to validate it as a paleoclimate archive.

Location of Study

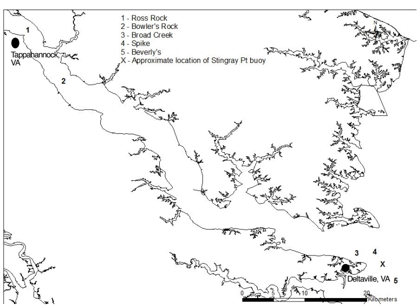

Fig. 1 Live oysters were collected at each of the marked oyster reefs by the Virginia Institute of Marine Science and transported to UMW. Stingray Point Buoy Data collected by USGS.

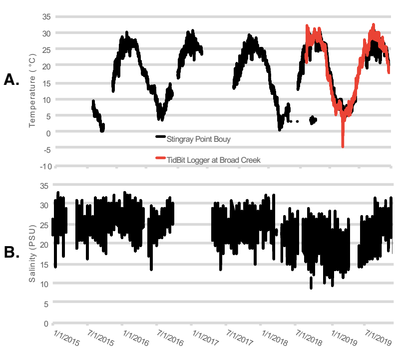

Fig. 2 (A) Temperature data from USGS Stingray Point Buoy paired with our HOBO temperature logger at Broad Creek reef. (B) Salinity (PSU) data from USGS Stingray Point Buoy.

Methods

- Collaborators at the Virginia Institute of Marine Science collected oysters from established reefs in the Rappahannock River.
- Viable oysters were slabbed using a band saw, exposing the best sampling path along the hinge, where the banded growth pattern is pronounced.
- Using at 0.8mm drill bit, carbonate shell powder was collected down the hinge, sampling a low resolution of the oysters growth through time.
- The oyster shell oxygen isotopic composition was established using mass spectrometry methods at the University of Saskatchewan.

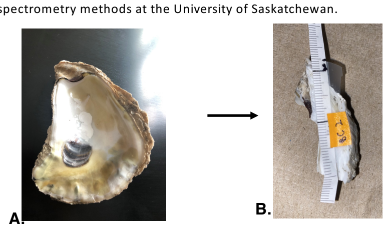

Fig. 3 Example sampling of oysters Oyster sample at Broad Creek Reef (A) Full left shell (B) Drilled oyster hinge.

Results

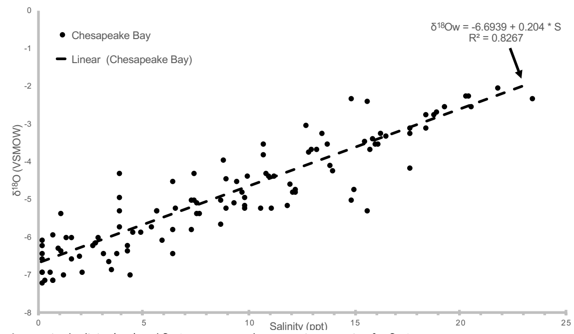

Fig. 4: Paired salinity (ppt) and δ^{18}O to compute the regression equation for δ^{18}Ow.

- This figure represents the linear mixing relationship between δ^{18}O and salinity throughout the Bay.
- The regression equation represents the relationship between salinity and δ^{18}O in a highly variable estuarine environment.
- Fig. 4 regression line falls close to similar studies conducted by Harding et al (2010) and Surge et al (2001). This concludes that oxygen isotopic compositions in the Chesapeake Bay and it's tributaries are consistent in different studies.

Eq: δ^{18}Oc= δ^{18}Ow - 0.20 + (4.30 - (18.49 - 0.56 * (16.5 - T))^0.5) / 0.28

Equation 1: Harding et. Al (2010) equation for calculating S18Ocalcite (VPDB) from S18Owater (VSMOW) and temperature (C).

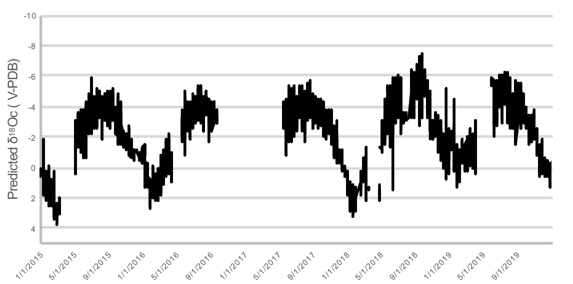

Fig. 5: Predicted δ^{18}Oc (V-PDB) using equation 1 for the past 5 years.

- Equation one takes the relationship between salinity and δ^{18}Ow, temperature and the VSMOW to V-PDB conversion into account to compute the predicted δ^{18}Oc value.
- Gaps within the model shell (Fig. 5) are a result of data gaps from the Stingray Point Buoy data.

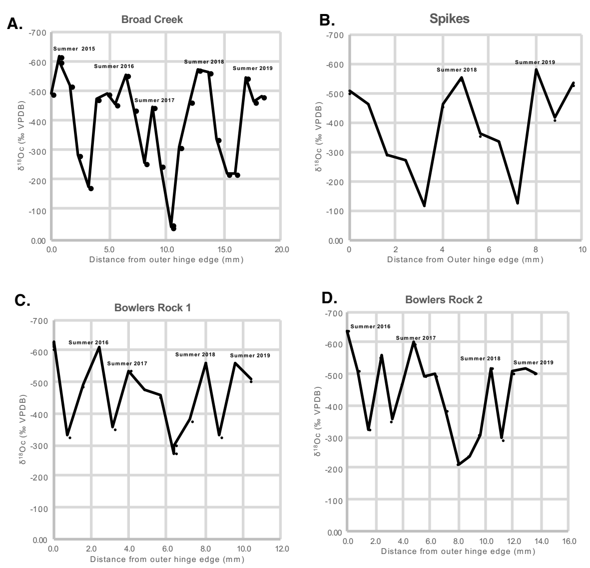

Fig. 6: Actual δ^{18}Oc (VPDB) paired with sample distance from outer hinge (mm) at (A) Broad Creek (B) Spikes (C) Bowlers Rock 1 and (D) Bowlers Rock 2.

Discussion

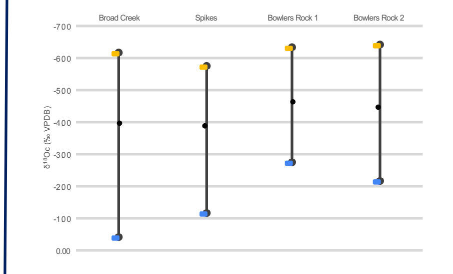

Fig. 7: Average, minimum and maximum δ^{18}Oc (VPDB) for each sample at established oyster reefs in the Rappahannock River, VA.

- The predicted shell model shows seasonality where the minimum δ^{18}Oc values peak between July and September, and maximum δ^{18}Oc values peak between January to March. The model supports warm and wet summers, and cool and dry winters. In estuaries, it is likely that higher δ^{18}O values correlate with drier conditions, due to increased evaporation of the lighter O^{16} isotopes first, leaving the heavier O^{18} still in the water. Inversely, a δ^{18}O that is more negative reflects wetter conditions due to the addition of the lighter O^{16} isotope back into the water via precipitation (Stuvier., 1970).
- It is important to note that due to a low resolution sampling path (0.8mm), we can see trends and estimate seasonality, but a higher resolution sampling path using micro milling techniques will give a more accurate reading on variability within the calcium carbonate shell.

Conclusions

Through low resolution sampling, we can conclude that samples of *Crassostrea Virginica* found in the Rappahannock River reflect similar trends from the Predicted shell model from equation 1, which is similar to previous work done in the Chesapeake Bay. The predicted shell model takes estuarine variability into account for analysis in the Chesapeake Bay.

Subsequent Research

•Future research will use the constructed shell model to assess fossil oyster shells in the Chesapeake Bay in hopes to quantify the change in climate over a longer time scale in the Region.

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Acknowledgements

I would like to thank the University of Mary Washington CAS Undergraduate Research Fund and Dr. Pamela Grothe for the continued support during this research. I would also like to thank Dr. Christopher Maupin at Texas A&M University for running our water isotope content and Dr. William Patterson at the University of Saskatchewan for running our oyster shell isotope content.