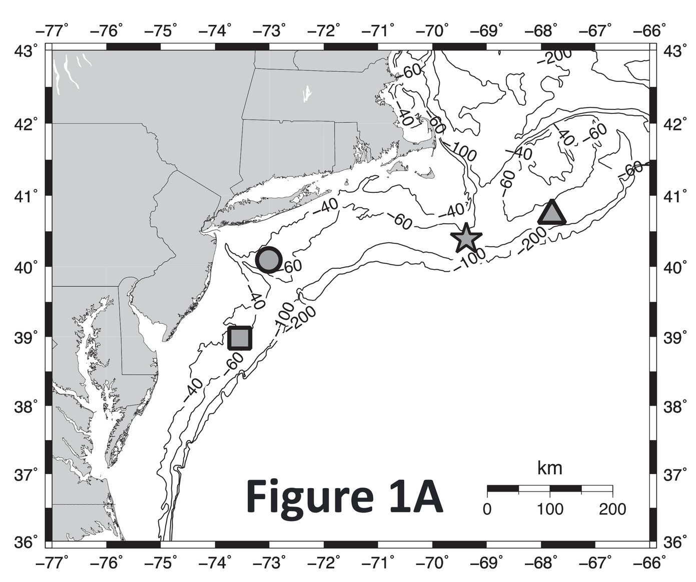
Reconstructing Bottom Water Temperature from Bivalves on the Continental Shelf: Holocene History as a Window to the Future of the Mid-Atlantic

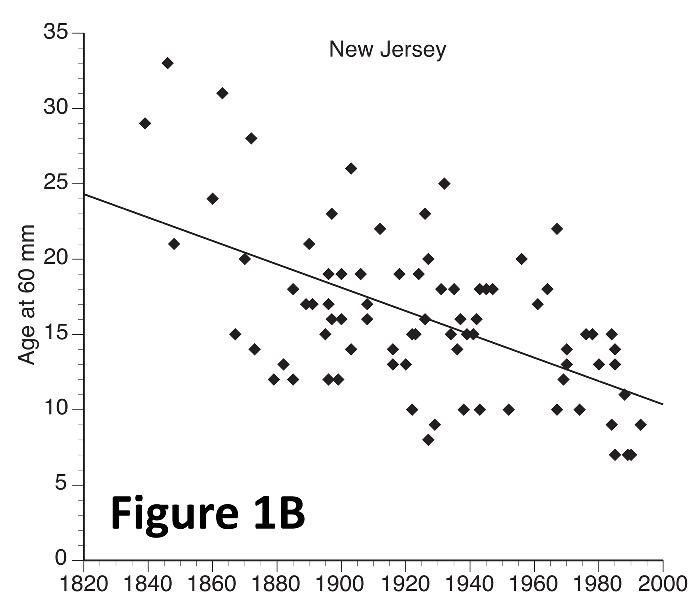
Roger Mann[1], Nina M. Whitney[2], Eric N. Powell[3], Caroline Ummenhofer[4], John M. Klinck[5], Sönke Dangendorf[6], Eileen E. Hofmann[5]

[1]Virginia Institute of Marine Science, [2]Western Washington University, [3]University of Southern Mississippi, [4]Woods Hole Oceanographic Institution, [5]Old Dominion University, [6]Tulane University

Motivation

- The Cold Pool, a large volume of cold bottom water on the Mid-Atlantic continental shelf, allows extension of the temperate-boreal boundary over a large geographic region
- The Cold Pool supports the existence of the long-lived ocean quahog (*Arctic islandica*) on the Mid-Atlantic shelf and constrains the geographic range of Atlantic surfclams (*Spisula solidissima*)
- Ranges and growth rates of these two species are affected by changes in bottom water temperature (BWT)
- Growth is recorded in the bivalve shells, and can be examined through sclerochronology – sectioning the shells and examination of annuli frequency and size.
- Ocean quahogs collected off New Jersey (●) (Pace *et al* 2017, https://doi.org/10.3354/meps12384, Fig. 1A below) show a gradually increasing growth rate over the past 200 years as decreasing Age at 60 mm versus Birth Year (Fig. 1B)





Objectives

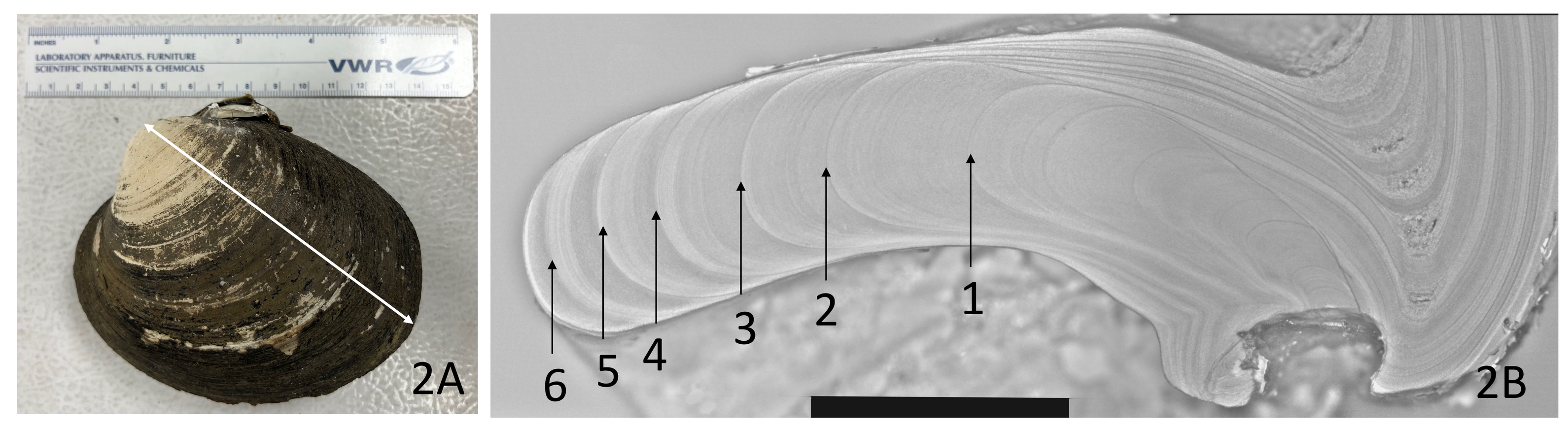
- Reconstruct the history of bottom water temperature (BWT) over past 5000 years from data recorded in ocean quahog and Atlantic surfclam shells
- Determine timing of and BWT conditions resulting in climate-related range shifts of ocean quahogs and Atlantic surfclams on the Mid-Atlantic shelf

Research Questions

- What are the large-scale climatic changes in the mid-to-late Holocene in the Mid-Atlantic Cold Pool, as revealed by estimates of BWT?
- Can climatic changes reconstructed in the Cold Pool be linked to known climatic parameters and/or large-scale climatic changes, particularly in more recent periods where better estimates of birthdates and individual clam growth descriptors exist?
- How does the record of habitation of surfclams and ocean quahogs relate to BWT reconstructions?

Approach: Age and Growth

- Ocean quahog and Atlantic surfclam aging and dating, based on birth year, are used to provide database for assessing growth and bottom water temperature relationship.
- Clams are sectioned along the hinge to the growing edge axis (Fig. 2A below), the exposed face polished and annuli in the hinge identified (Fig. 2B below). Age is estimated by counting annuli (arrows in 2B). Growth is estimated by inter annuli distance.



Figures 2A and 2B.

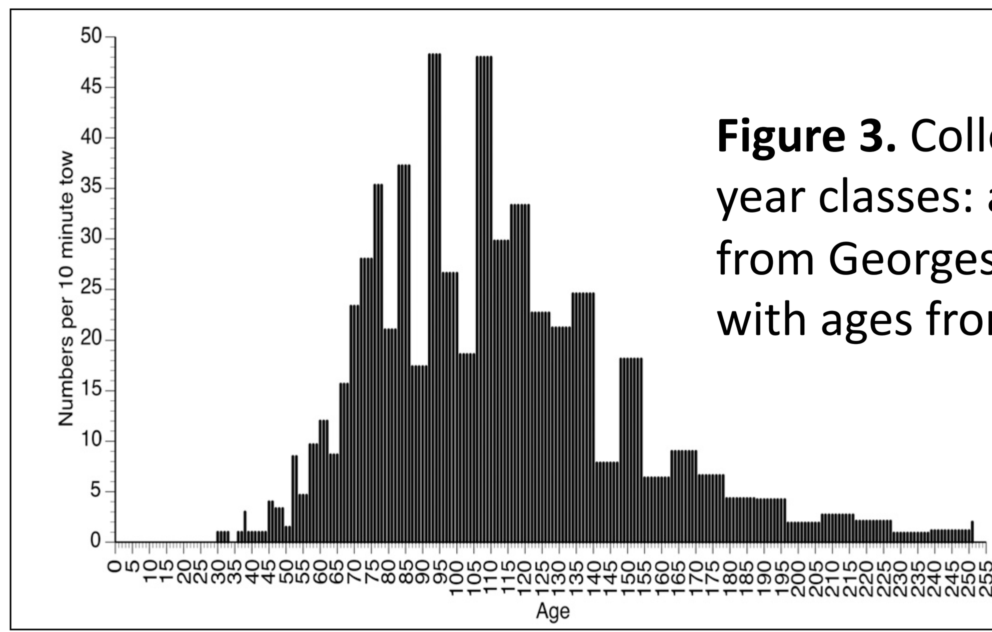


Figure 3. Collections include multiple year classes: an ocean quahog example from Georges Bank (▲ in Figure 1) with ages from <30 to 250y.

Approach: Oxygen Isotopes

- Oxygen isotopes in ocean quahogs provide estimates of temperature to evaluate growth dependency and enable temperature reconstructions based on growth rates

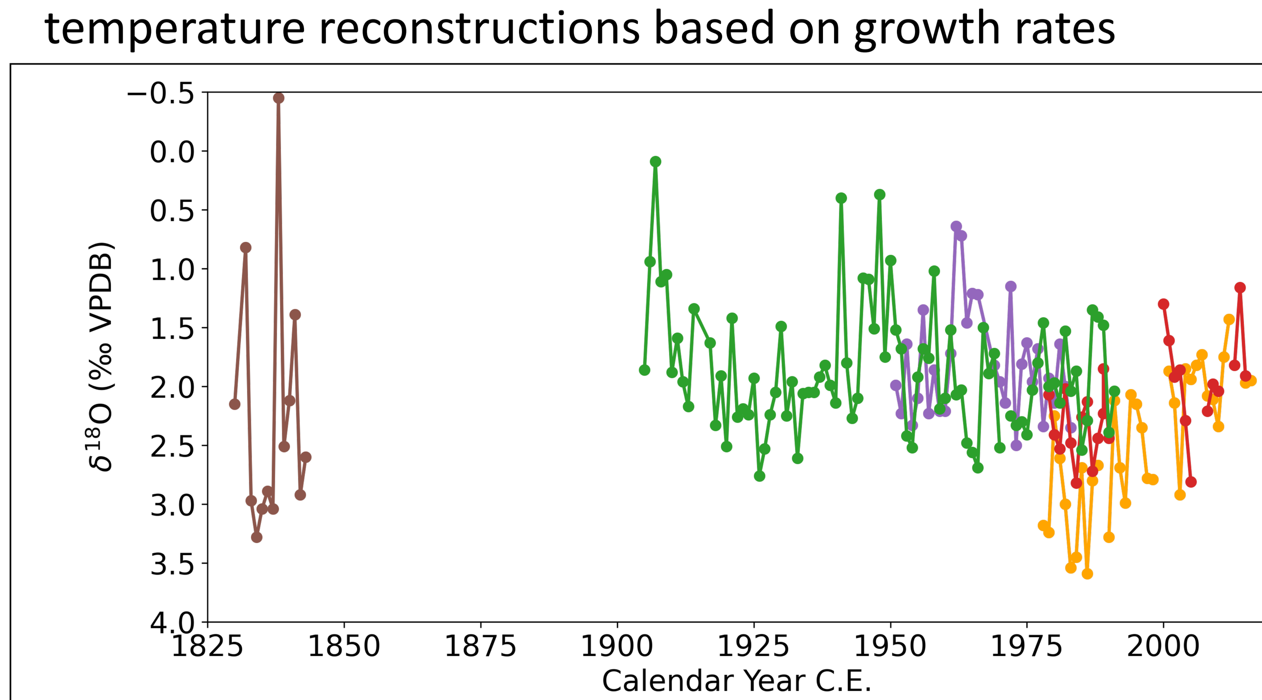
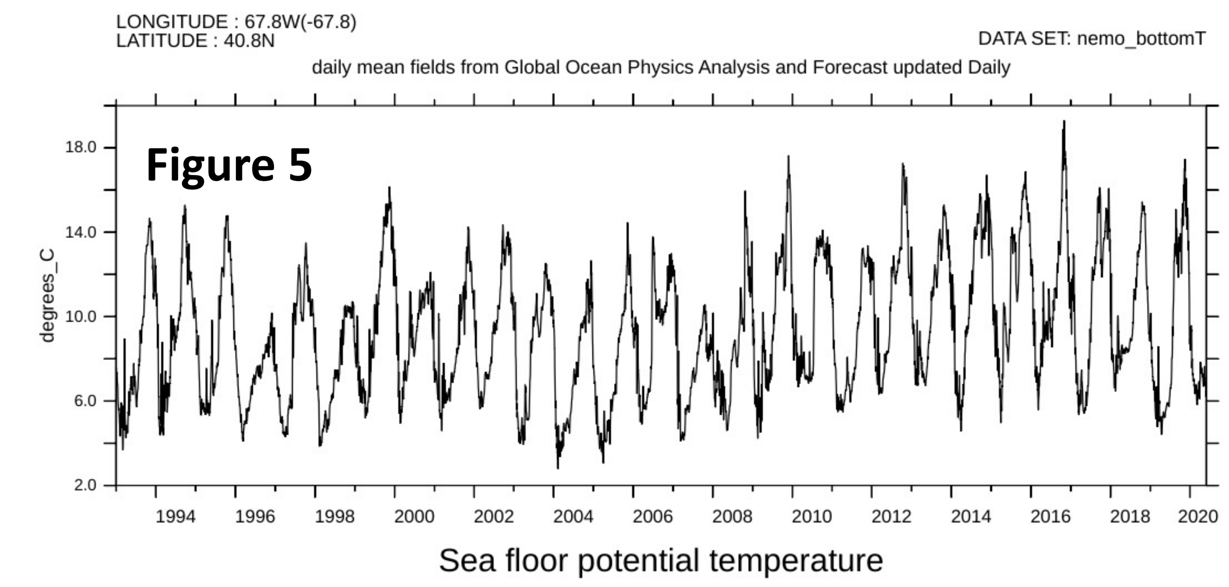
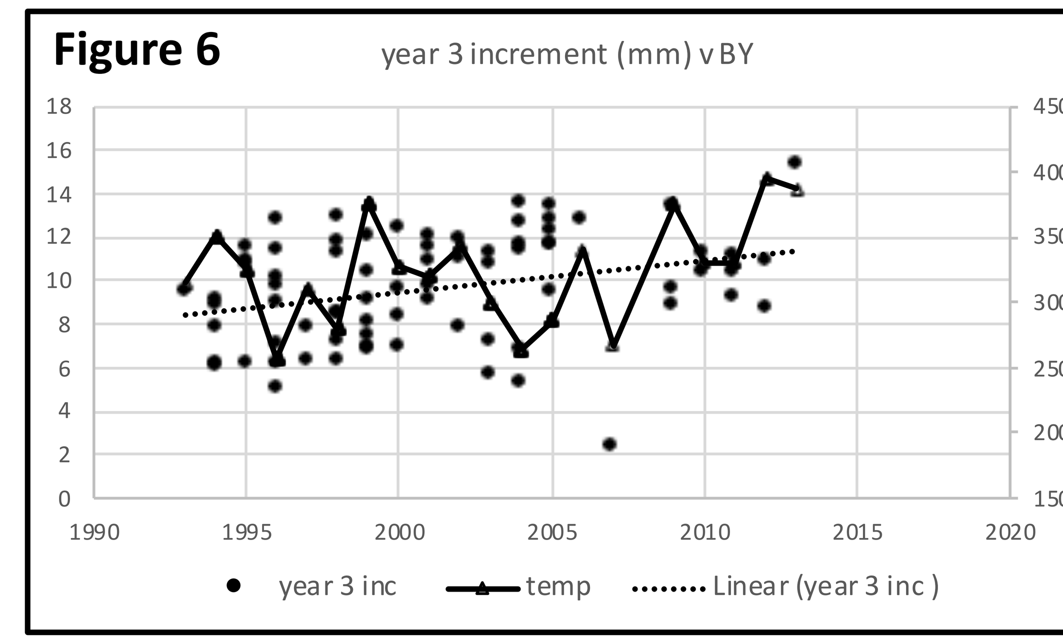


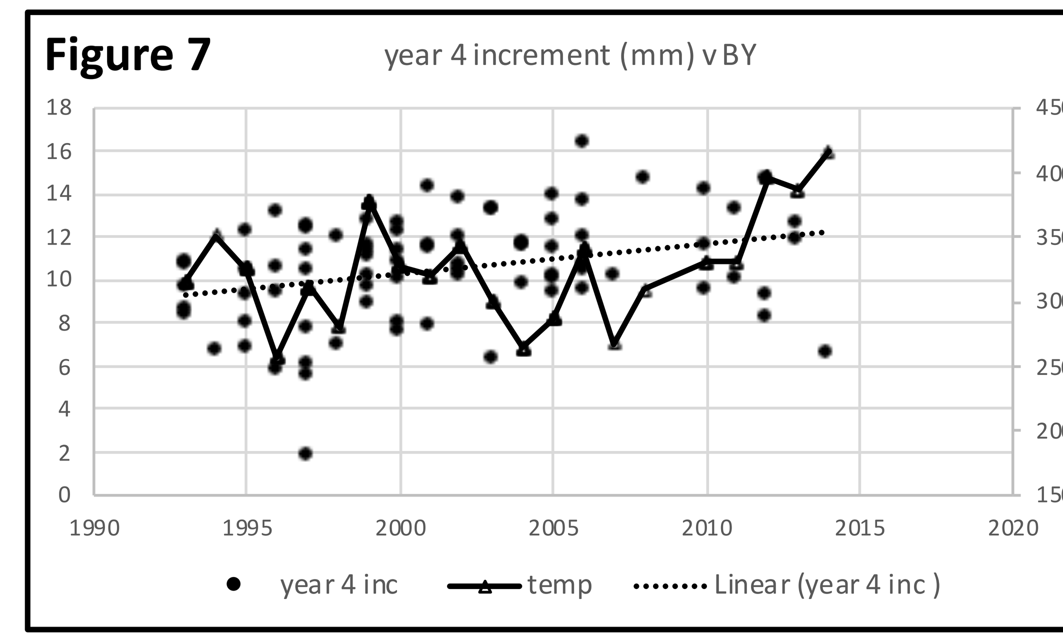
Figure 4. Oxygen isotopes measured in ocean quahogs collected off Long Island (see Fig 1). Different colors represent isotope values from different shells. Note inverted y-axis as lower δ^{18}O values correspond to warmer temperatures. Records from Georges Bank and Delmarva ocean quahogs will be analyzed to explore temperature changes throughout the cold pool.

- Statistical reconstructions of BWT based on growth-temperature relationships will examine estimates of Cold Pool location and intensity
- Observed and simulated BWT will be used to calibrate and verify estimates of bottom water temperatures

Growth-Temperature







- Relationships between growth increment at age and BWT are examined. Growth data for small ocean quahogs collected at the Georges Bank site in 2017 was compared to BWT estimates from the GLORYS reconstruction (duPontavice *et al* 2023, https://doi.org/10.1016/j.pocean.2022.102948, Fig. 5 above) for that location. Figs 6 and 7 (above) show the year 3 and year 4 growth increments (individual clam shell lengths, mm) versus Birth Year (BY). The solid line plots cumulative day degrees (range ~2500 to ~4300) from Fig 5 for the corresponding year. A linear trend line for the growth increment data shows gradually increasing values over the included period (1993-2014). Additional increment data sets will be explored in future work.

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