Reconstructing Guana River oyster filtration capacity of the recent past through geohistorical records: Methods for estimating past oyster density.

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Introduction

- Water quality is a concern within the Guana River Marsh Aquatic Preserve (GRMAP)[1]
- The Eastern Oyster, *Crassostrea virginica*, provides an ecosystem service of water filtration that might be a natural solution to improve water quality.[2,3]
- Oyster filtration capacity, or the amount of water filtered by an oyster population, can be calculated from oyster size, density, and reef area.[3,4]
- The Budgets & Bivalves project is working to quantify current oyster filtration capacity within Guana River (GR).[5]
- Understanding how GR oyster filtration capacity has changed over time could help inform if adding more oysters to GR as a management strategy could improve water quality. However, records are only available 2014-present.[6]
- Vibracore methods successfully piloted in 2022-2023 demonstrate oysters can be collected and body size measured from the buried geohistorical record beneath living oyster reefs.

Problem: How can we reconstruct GR oyster density from the past to calculate filtration capacity?

Lockwood & Mann (2019)[7]: A method for estimating density from the past

- Attempted to reconstruct oyster density for Mid-Late Pleistocene (500,000-11,700 years ago) fossil oyster samples from Chesapeake Bay, VA.
- Bulk samples were collected from fossil reefs; all left-valves and hinges were counted for density, and complete right-valves >35mm were measured for shell length.
- Live oyster density estimated from 1m^2 of living subtidal oyster reef sampled with hydraulic patent tongs (~50L of shells and sediment).
- All live oysters were counted, and the volume of live and dead oyster material (shells and sediment) was recorded.
- A conversion factor of 21.25 live oysters/L was calculated across monitoring samples, sites, and years to create a live-to-dead oyster ratio from the volumes of live and dead material. This ratio was applied to fossil abundances to estimate the density of live oysters from the Pleistocene.

Can this method be applied to reconstruct GR oyster density from the past?

References

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Methods

- 2 surface quadrat samples (25cm^2 x 15cm) were collected from 8 GR reefs.
- Live, boxed (recently dead, gaping oysters), and dead oyster left-valves >25mm (same as the GTMNERR monitoring program) or complete hinges were counted.
- **Expected:** a strong positive correlation between the number of live and dead oysters, implying the number of dead oysters could reasonably predict the number of live oysters.
- A regression would be applied to reef core intervals from the past to estimate live oyster density.
- Method validation is possible using dead shells from the surface quadrants and monitoring data for overlapping years (Figure 1).

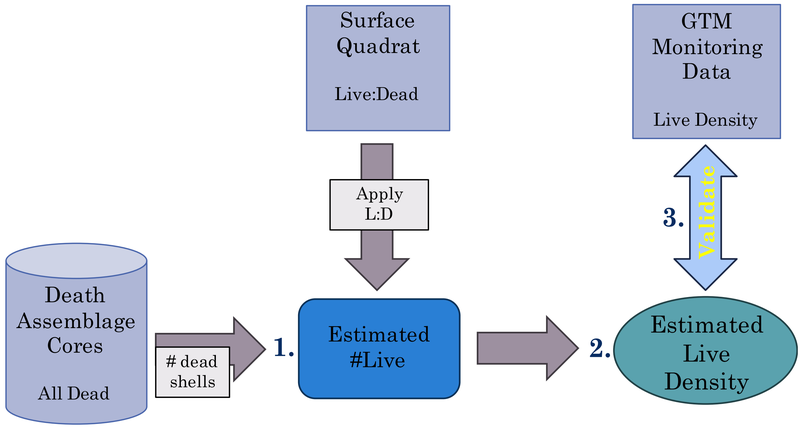

Figure 1. The conceptual figure for applying a live-to-dead (L:D) regression determined from surface quadrat samples to core interval samples to estimate living oyster density (# oysters/m^2) from the past.

Results & Discussion

- Improving the method still resulted in data too variable across samples and reefs to estimate live density from the past accurately.
- Weak relationship, explains only 5% of the variation (Figure 2).

- **Possible reasons:**
  - Didn't account for sedimentation rate: high sedimentation could result in fewer, larger oysters growing to reach the sediment-water interface.
  - The rate of shell loss (disintegration) could vary between sites.

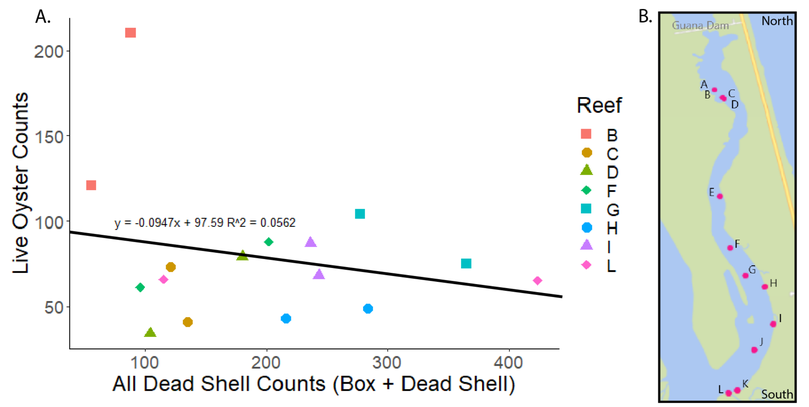

Figure 2. A) Live and dead oyster counts from Guana River oyster reef surface quadrats. Dead shell counts include both boxed (recently dead, gaping oysters) and loose dead oyster shells. Reef letters indicate which reefs quadrat samples were collected from. B) Map of Guana River reefs sampled with quadrats and cores.

Other Density Reconstruction Methods

- Other methods to reconstruct density from the past include stratigraphic unmixing models, which account for sedimentation rate and the rate of shell loss over time (Figure 3).[8]
- Preserved shell abundance within a core interval is a result of mixing between intervals, shell disintegration (loss), and burial due to sedimentation. Shell size reflects oyster age (lifespan).

Stratigraphic unmixing steps (Figure 3):

1. Estimate age-frequency distributions (AFDs) for individual core intervals based on the number of shells preserved.
2. Resample from AFDs and pool core intervals together of overlapping ages, determined with 14C radiocarbon dating.
3. Apply sedimentation and shell disintegration rates with a survival function to the entire core, providing core interval abundance estimates binned into age cohorts. Extrapolate to oysters/m^2 for density.

Stratigraphic Unmixing

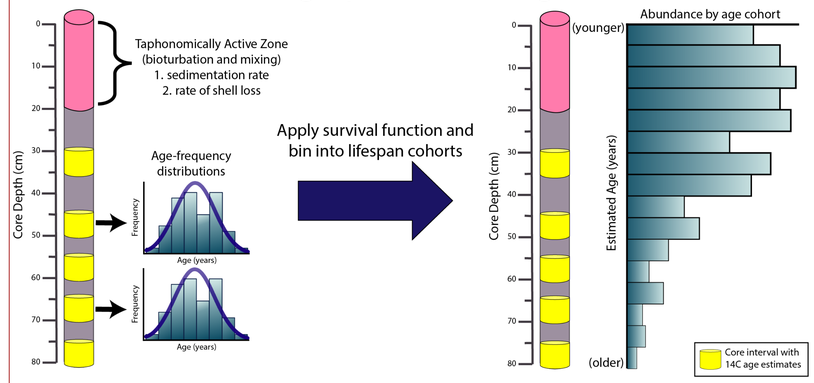

Figure 3. The process of stratigraphically unmixing shells over time from core samples to estimate abundance over time. Abundance can be extrapolated to density by converting to a meter-squared area. Total core depth corresponds to the total depth of oyster reef material.

Next Steps

- 16/33 cores still require processing to count oyster shells and radiocarbon date specimens. Preliminary age estimates ~2010s-1600s possible.
- GR reef sediment samples will be collected to determine the local sedimentation rate and unmixing models applied to core oyster counts.
- Density estimates will be cross-validated with available monitoring records from surface layers of the same exact reefs.
- Density estimates will be applied to calculate GR oyster filtration capacity from the past.

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