Analysis on Eastern Oysters (*Crassostrea Virginica*) Recruitment and its Influence on Species Diversity and Water Quality in Rehoboth Bay, Delaware

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Abstract

Rehoboth Bay (38.6610° N, 75. 0962° W) is part of Delaware's Inland Bays system and is connected to the Atlantic Ocean and freshwater rivers. Eastern oysters (*Crassostrea virginica)* are a species of bivalve that are native to eastern North America and provide ecological benefits for wildlife. This project examined *C. virginica* ability to improve oyster recruitment, water quality, and support native aquatic wildlife in the Delaware Inland Bays. Data was collected through oyster shell bag surveying at restoration and aquaculture sites; Chemical and physical water quality was obtained through photometry and sonde practices. ANOVA results showed a significant increase in *C. virginica* recruitment and species abundance at artificial reefs and aquaculture sites ($p < 0.05$). Species diversity, dissolved oxygen and phosphate results showed no significant difference regarding *C. virginica* presence ($p > 0.05$).

Introduction

Eastern oysters (*Crassostrea virginica*) is a species of bivalve that are keystone species within the Delaware Inland Bay communities. They provide multiple benefits to the environment such as providing food and habitat for fish and crustaceans, improving species diversity, protecting coastal developments and habitats through reef formation, and improving water quality via filter feeding (Drexler 2011). A decline in *C. virginica* populations began in 1950 due to disease, habitat loss, and overexploitation. In Delaware, shellfish aquaculture was banned due rising concerns about diseased *C. virginica* affecting native wildlife. (Marenghi 2010; Ewart 1993). Since 2018, Delaware's Department of Natural Resources and Environmental Control (DNREC) began their Shellfish Program, providing acreage in the Inland Bays available for shellfish aquaculture (fig. 1) and Delaware Center for the Inland Bays (CIB) have implemented artificial restoration reefs to improve oyster recruitment and water quality.

Objectives:

1) Monitor and compare the effects that artificial oyster reefs and aquaculture sites have on oyster recruitment and native biodiversity.
2) Observe physical and chemical water quality parameters and how oyster reefs and aquaculture farms affect them.
3) Determine the effectiveness of CIB's pilot oyster reefs for improving water quality, species diversity, and oyster recruitment in Rehoboth Bay compared to natural sites and aquaculture farms.

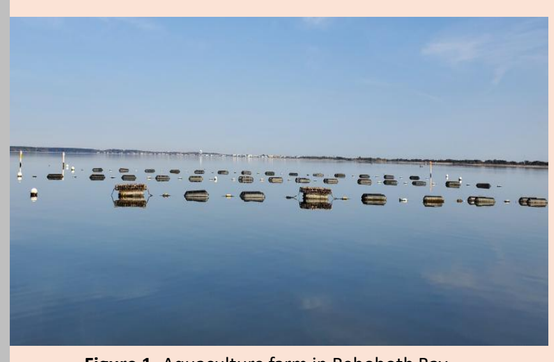

Figure 1. Aquaculture farm in Rehoboth Bay.

Figure 2. Formation of CIB restoration reef.

Study Sites

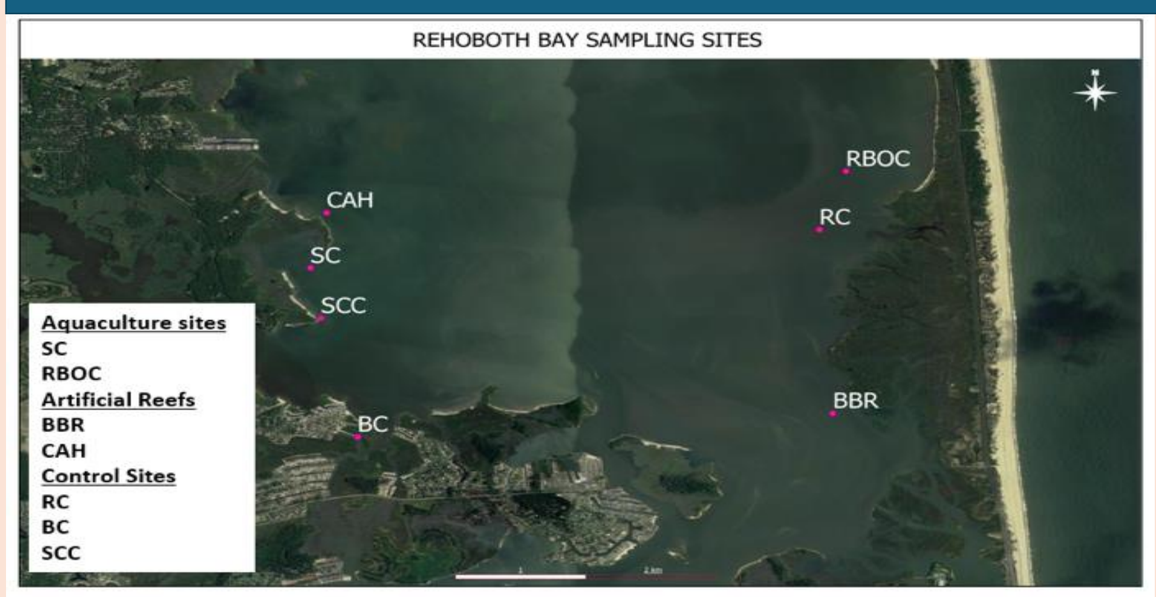

Figure 3. Location of study sites in Rehoboth Bay, Delaware.

Rehoboth Bay is a shallow inland bay that is connected to freshwater rivers Love Creek and Herring Creek, and to the Atlantic Ocean through the Indian River Inlet. Due to the limited access to freshwater and saltwater discharge, Rehoboth Bay has a low flushing rate, making it vulnerable to environmental changes such as eutrophication. The bay is home to salt-tolerant marsh grass and Native aquatic species include the naked goby (*Gobisoma bosc*), oyster toadfish (*Opsanus tau*), and blue crabs (*Callinectes sapidus*). Rehoboth Bay experiences high amount of boat traffic during the spring, summer, and fall months with tourism increasing during the summer. The bay is 4.5 miles from Rehoboth Beach and the Rehoboth Beach Boardwalk, and is directly across from Dewey Beach, separated by the Delaware Route 1 Highway. Because of the increase in activity in the summer, Rehoboth Bay is most susceptible to environmental changes between April and October due to anthropogenic factors. Likewise, *C. virginica* growth can be negatively affected by an increase in human activity, causing recruitment counts and overall wildlife survivability to be decreased.

Methodology

Seven sites around Rehoboth Bay were selected, categorized as aquaculture sites (Sally's Cove, Rehoboth Bay Oyster Company), control sites (Redefer Control, Bay City, Sally's Cove Control), and artificial restoration reefs (Big Bacon Reef, Camp Arrowhead) (fig. 3). Data collection was done during the 2021 and 2022 spawning seasons of *C. virginica*. All sites received four recycled oyster shell bag replicates over three intervals during the season (fig. 4a). Shell bags were retrieved and observed to record species and oyster recruitment counts. Three replicates of water quality samples were collected to monitor chemical water quality parameters (fig. 4b) using photometry instruments (fig. 4c). Physical water quality data was collected in situ through YSI EXO sondes (fig. 4d).

Figure 4 (a-d). Demonstrates a) deployment of oyster shell bags, b) chemical water quality testing, c) YSI 9500 Photometer, d) YSI EXO sonde deployment

Results

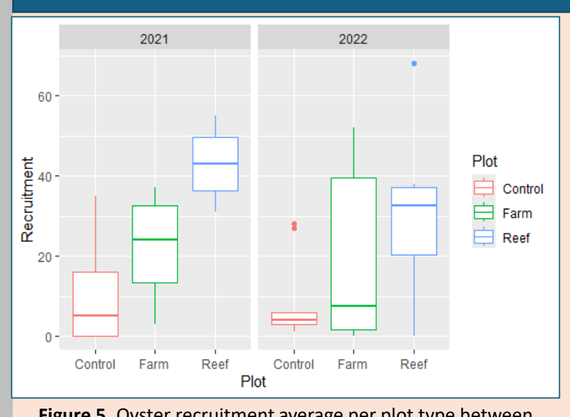

Figure 5. Oyster recruitment average per plot type between 2021 and 2022.

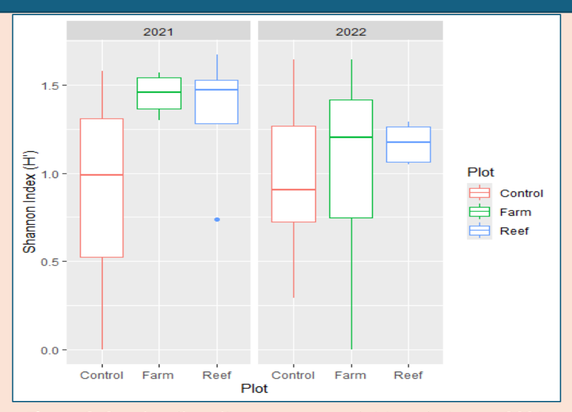

Figure 6. Species diversity average per plot type between 2021 and 2022.

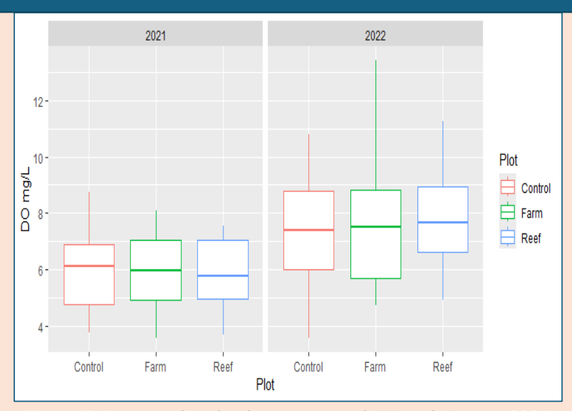

Figure 7. Average dissolved oxygen per plot type between 2021 and 2022.

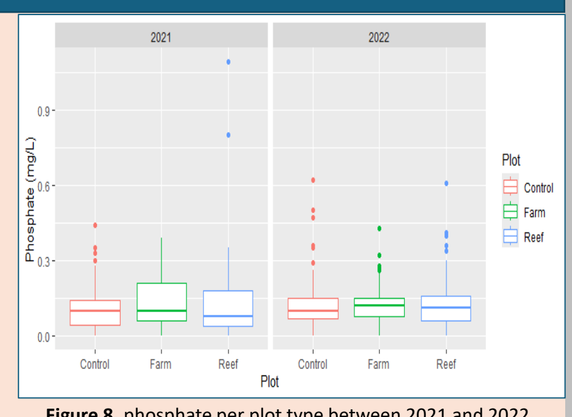

Figure 8. phosphate per plot type between 2021 and 2022.

- Oyster recruitment was the highest at restoration reef plots ($F(7.607), p < 0.05$) (fig. 5).
- Species diversity was not significant between the three plots ($F(1.66), p > 0.05$) (fig. 6).
- Dissolved oxygen was not significantly different between the three plots ($F(1.403), p > 0.05$) (fig. 7).
- Phosphate levels were not significantly different between the three plots ($F(2.059), p > 0.129$) (fig. 8).
- The most dominant species found were Harris mud crab (*Rhithropanopeus harrisii*), grass shrimp (*Palaemon paludosus*), and Atlantic oyster drill (*Urosalpinx cinera*).
- Dissolved oxygen and phosphate levels were ideal for *C. virginica* growth.
    - Days of high phosphate levels may be due to an increase in anthropogenic activities and agriculture waste finding its way into Rehoboth Bay

Discussion & Conclusion

- Rehoboth Bay's landscape and tidal shifts may influence oyster recruitment and wildlife movement.
    - Barrier structures and boat traffic may block wildlife from migrating, and an increase in human activity in Rehoboth Bay during the summer may increase turbidity.
- Proximity to coastal communities may have a negative impact on the performance of some sites.
    - The east of the bay is alongside Delaware's Route One Highway, and BC is next to a neighborhood.
- Due to the size of the bags, larger fish and crustacean were unable to be captured.

Artificial restoration reefs in Rehoboth Bay have been successful in facilitating oyster growth in Rehoboth Bay. To understand the compete impact that *C. virginica* has on species diversity and water quality, continued monitoring is required.

References

- Drexler, M., Parker, M. L., Geiger, S. P., Arnold, W. S., & Hallock, P. (2014). Biological assessment of eastern oysters (Crassostrea virginica) inhabiting reef, mangrove, seawall, and restoration substrates. *Estuaries and Coasts*, *37*(4), 962-972.
- Ewart, J. W., & Ford, S. E. (1993). *History and impact of MSX and Dermo diseases on oyster stocks in the northeast region*. Northeastern Regional Aquaculture Center, University of Massachusetts Dartmouth.
- Marenghi, F., Ozbay, G., Erbland, P., & Rossi-Snook, K. (2010). A comparison of the habitat value of sub-tidal and floating oyster (Crassostrea virginica) aquaculture gear with a created reef in Delaware's Inland Bays, USA. *Aquaculture International*, vol. 29 :889-900. Research gate.

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