What are the impacts of rotational harvest areas and replenishment on oysters and the fishery? Evidence from the Rappahannock River.

Key Findings and Recommendations

- Current management strategies enhance oyster reefs *and* the oyster fishery
- Shell replenishment supports oyster reef structure and provides juvenile oyster habitat
- A 3-year harvest area rotation increases market sized oyster density
- Focus replenishment efforts on reefs with low shell volume (<10 L m^{-2}) to maximize benefits
- Future fine scale harvest report monitoring will help target replenishment efforts

BACKGROUND

Eastern oysters (*Crassostrea virginica*) create critical habitat and are a valuable fishery species in the Chesapeake Bay; however, oyster populations collapsed in the Chesapeake Bay in the mid-1980s leading to extensive restoration efforts. The Virginia Marine Resources Commission (VMRC) manages the public oyster fishery and coordinates oyster restoration efforts in the Virginia portion of the Chesapeake Bay. Oyster restoration in Virginia and throughout the Chesapeake Bay focuses on shell replenishment, where clean oyster shells are added to reefs to increase reef height and provide habitat for juvenile oysters. Shell for replenishment is a limited and expensive resource, which limits how much and where replenishment can occur. Further, prior research on oyster replenishment focuses on marine protected areas, where fishing is not allowed. There is a critical need to evaluate the best way to apply limited shell to maximize the benefits to the overall oyster population and support a successful fishery.

The Rappahannock River is a major oyster producer in Virginia. VMRC manages the Rappahannock using a combination of rotational harvest areas and shell replenishment. Since the 2007-2008 harvest season, over 500,000 bushels of oysters worth over $24 million (2023 USD) in dockside value were harvested in the Rappahannock River alone. Since 2000, VMRC has invested over $14 million (2023 USD) towards replenishment in the Rappahannock. Long term monitoring data in the Rappahannock was used to evaluate how current management strategies impact oyster reefs and fisheries success.

METHODS

The analyses presented in this document incorporated data collected and maintained by the VMRC and Virginia Institute of Marine Science (VIMS). Data sources included the annual fisheries independent oyster patent tong survey (2003-2021), daily oyster harvest records (2007-2008 to 2020-2021 seasons), and shell replenishment records (2000-2021) from the Rappahannock River. Using generalized linear mixed effects models, this project examined how **rotational harvest area timing**, **marine protected areas (MPAs)**, and the **volume of shell** used for replenishment impacts oyster reefs and the oyster fishery. To understand the broad impacts from current management strategies, analyses considered four metrics: brown shell volume (L m^{-2}), spat density (m^{-2}), market oyster density (m^{-2}), and fisheries efficiency (meeting the daily bushel limit or not).

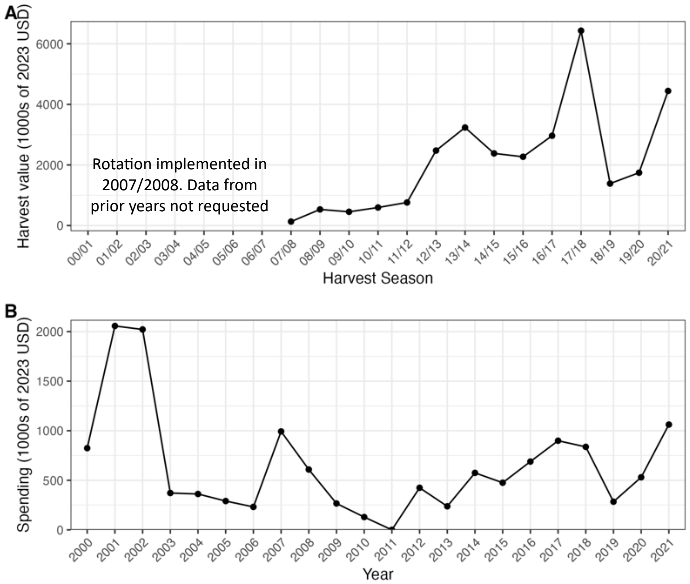

Fig. 1. Dockside value for harvest (A) and amount spent on replenishment efforts (B) in the Rappahannock.

RESULTS

Our results demonstrate that the combination of shell replenishment, harvest area rotation, and marine protected areas enhance oyster reefs and the oyster fishery in the Rappahannock River.

Specifically, regular **shell replenishment maintains the underlying reef structure** and reduces shell loss. Marine protected areas and harvest areas have comparable brown shell volume. **Spat density increased immediately after shell replenishment** was applied, suggesting that shell replenishment is providing additional habitat for young oysters. **Market oyster density peaked 3 years after shell replenishment** was applied. The current 3-year harvest area rotation allows oyster spat to grow to market size and is an optimal rotation interval in the Rappahannock. Additionally, harvest areas and marine protected areas had comparable reef structure (as brown shell volume, L m^{-2}), but marine protected areas had higher market oyster density on average. Marine protected areas offer protection to larger oysters, which may serve as valuable spawning stock. **Management practices directly enhanced harvester efficiency** (meeting the daily bushel limit or not), particularly in harvest areas with poor oyster reef condition. Low levels of shell replenishment (~1000 bushels $acre^{-1}$ on individual reefs with ~200-300 bushels suitable $acre^{-1}$ across a harvest area) provide benefits to oyster reefs and the oyster fishery. One challenge with this analysis is that harvest records are collected for harvest areas and not for individual reefs. The analysis cannot examine how the input of shell on an individual reef influences commercial harvest. Future efforts to collect harvest data at a finer spatial scale (e.g. individual reefs) would help optimize replenishment efforts and better understand the benefits (or drawbacks) to the oyster fishery.

Since shell replenishment and rotational harvest areas were implemented, oyster reefs have improved throughout the Rappahannock. Brown shell volume has steadily increased over time. Oyster spat density, though highly variable, was highest in recent years coinciding with higher brown shell volumes. Market oyster density has increased substantially since 2018. Oyster harvest has steadily increased as oyster reefs have improved in the Rappahannock.

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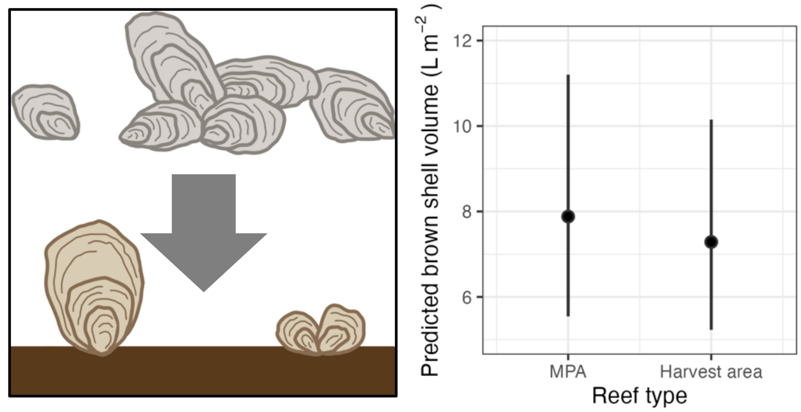
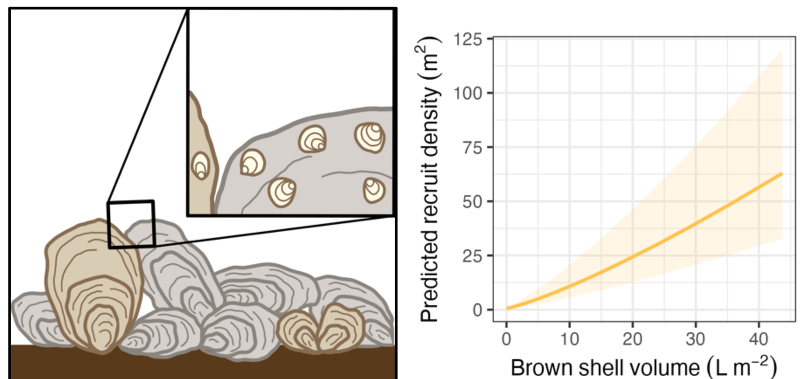
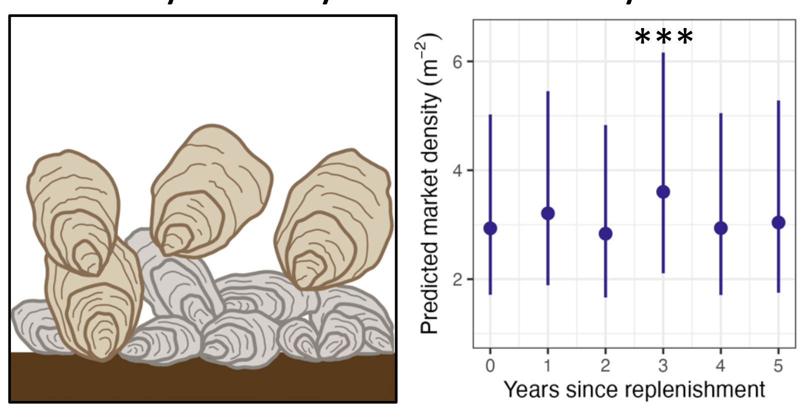
Shell replenishment maintains reef structure and habitat



Increased habitat improves spat density



Market oyster density is enhanced with a 3-yr rotation



Replenishment improves harvester success, especially in harvest areas with poor reef conditions