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Recommended Citation

Bilkovic, D., & Mitchell, M. (2014) Biofiltration potential of ribbed mussel populations. Virginia Institute of Marine Science, College of William and Mary. <https://doi.org/10.21220/V5ZQ6K>

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Biofiltration potential of ribbed mussel populations



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Final Report to the Women in Science and Engineering (WISE), National Science
Foundation, College of William & Mary

NSF Prime Award: HRD-1107147, Women in Scientific Education (WISE)
Subrecipient Grant No. WISE-April2013-3-02

18 JULY 2014

INTRODUCTION

Bivalves (oysters, mussels, clams) can provide a variety of ecosystem services including stabilizing shorelines, decreasing suspended particulates and nutrients, and increasing water clarity. Ribbed mussels (*Geukensia demissa*) are commonly found from low to high intertidal marsh elevations attached with strong byssal threads to the roots, rhizomes, and stems of *Spartina alterniflora* (Lutz and Castagna 1980). Ribbed mussels play important ecological roles in a tidal marsh by affecting nutrient dynamics of the marsh and estuary (Kuenzler, 1961; Jordan and Valiela 1982), altering the physical structure of the marsh through sediment accretion and stabilization (Bertness 1984), and facilitating marsh grass *Spartina alterniflora* growth (Bertness 1984).

The potential for ribbed mussels to process water in a system, which removes sediments and nutrients, can be estimated on the basis of population surveys, clearance rates, and available suitable tidal marsh habitat. Preliminary experiments suggested that ribbed mussels have the potential to improve water clarity to a similar extent as oysters (*Crassostrea virginica*). Clearance rates have been reported to be approximately $5.1 \text{ L h}^{-1} \text{ g}^{-1}$ for ribbed mussels (Kreeger unpublished data) and $6.5 \text{ L h}^{-1} \text{ g}^{-1}$ for oysters (Newell et al 2005).

The use of bivalves to alleviate eutrophication effects in Chesapeake Bay is being explored as a potential management practice to meet total maximum daily load (TMDL) requirements. To date, focus has been on the native oyster in part because of the extensive available data on the species, commercial interests, and established cultivation practices. Ribbed mussels not only have the potential to contribute to the overall filtration capacity of a system, but also are natural marsh residents supporting plant growth and resilience. Because ribbed mussels are considered to have an unpleasant taste, no fishery exists for this species. Subsequently, there is limited information on the extent and distribution of historic and existing ribbed mussel populations in Virginia.

The SEED funding provided by the WISE Initiative supported the collection of data on ribbed mussel population distribution and characteristics along the York River in relation to marsh areal extent to provide first estimates of their water processing potential. The intent is that research conducted in this SEED grant would support ongoing long-term monitoring evaluating the effects of climate change and human activities on marsh systems as well as the development of an external proposal to evaluate the potential of ribbed mussels to enhance tidal marsh resilience and nutrient reduction.

Our primary study objective was to characterize the ribbed mussel population and estimate their water processing potential along the York River, Virginia.

METHODS

Mussel Population Characteristics – York River

To estimate the size of the mussel population on the York River, we conducted transect surveys at 20 marshes that are included in a long-term monitoring program of representative marshes and within ribbed mussel salinity preferences (~8-30ppt) during the summer (June –July) (**Figure 1**). Marshes were categorized as fringing (n=10) or embayed/extensive (n=10) and further distinguished as being present on the mainstem of the York River (n=13) or within tidal creeks of the York River (n=7). Because mussel density varies with tidal elevation, we determined mussel abundance within 0.25 m^2 quadrats along replicate transects that ran perpendicular to the shore from the edge of the marsh to the high marsh habitat. Quadrats were placed along each transect at 1-m intervals from the marsh edge representing

distances of 0-1m, 1-2m, 2-3m, and 3-4m from the marsh-estuary edge. When present, a representative sample of mussels was collected in each marsh to document the size and biomass distribution of the community. Mussel length, width, and height were measured with calipers. To obtain mussel biomass, we quantified ash free dry matter (AFDM); animals were shucked, dried to a constant weight (typically for 48 h) at 60°C, and ashed at 550°C for 4 h.

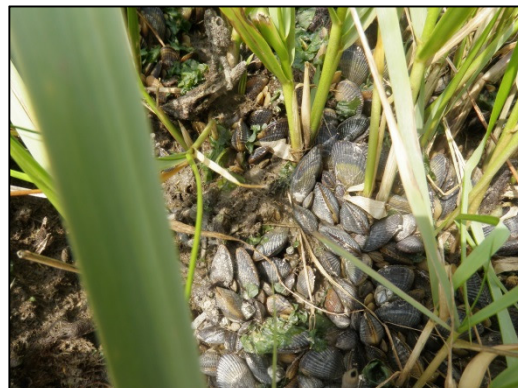
We calculated mussel abundance for each marsh within each 1-m interval from the marsh edge and then estimated the average abundance per interval for each marsh category: Mainstem fringing, mainstem embayed, tidal creek fringing, and tidal creek embayed. We then calculated the potential total area of marsh habitat per each 1-m interval available to mussels along the York River (constrained by areas with salinity >8, and within 4-m of the marsh-estuary edge) using wetlands spatial data (National Wetlands Inventory) in ArcGIS.

Water processing Estimate – York River

Using mean density of mussels/hectare, total hectares of available suitable marsh habitat, clearance rate estimates (liters water filtered/hour/grams dry weight of mussels) from the scientific literature, and the average dry weight of mussels, we estimated the liters per hour water processing rate for mussels in the York River.



Depiction of 1-m intervals along marsh edge used in mussel surveys and areal estimates of marsh habitat



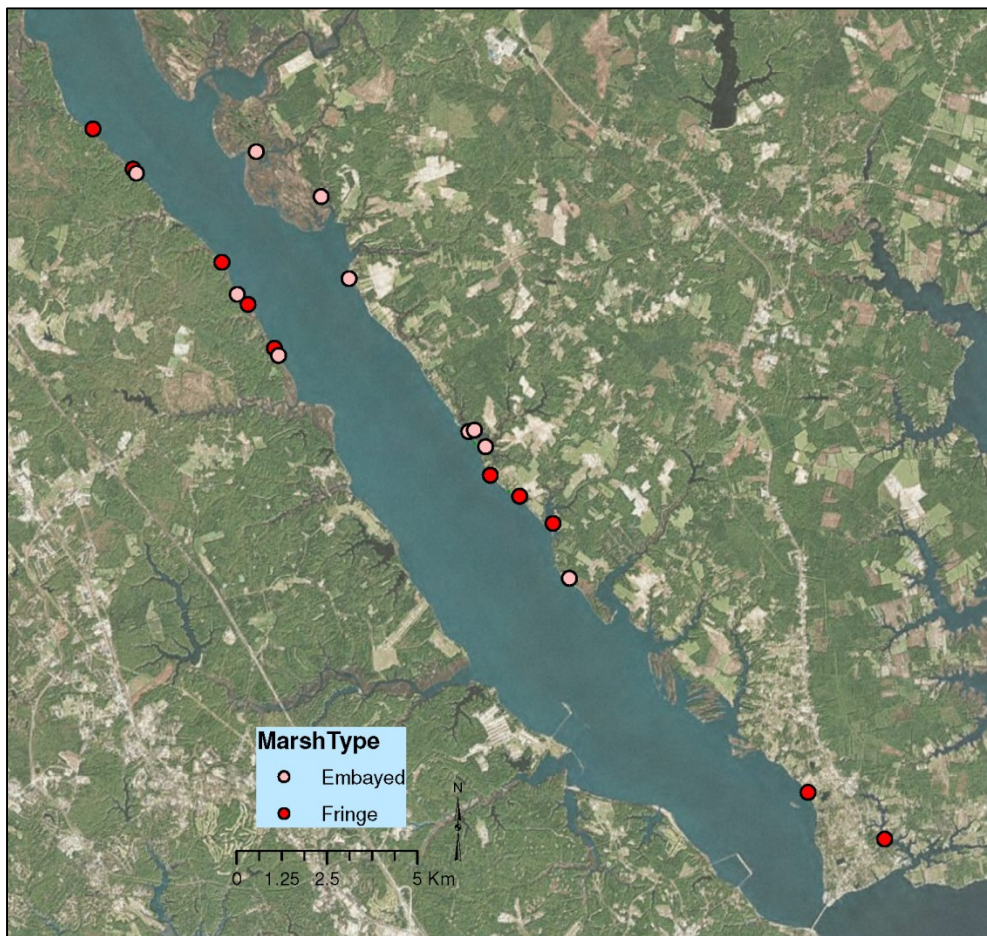


Figure 1. Location of 20 marshes surveyed along the York River, Virginia.

RESULTS & DISCUSSION

Mussel Population Characteristics – York River

Ribbed mussels were most abundant within the first meter of the marshes (**Table 1**). Mussel abundance was highly variable among marsh types/position and fringing marshes along the mainstem the river possess the highest average number of animals. Even though they were smaller in number, mussels in creek fringing marshes, had the highest average biomass (0.7 g dry weight of tissue) compared to other marsh types (0.24 g DW) (**Figure 2**).

Estimated potential ribbed mussel population size on the York River

We estimated that there is approximately 390 hectares of marsh habitat suitable for ribbed mussel occupancy along the York River. The mussel population on the York was estimated to be ~ 197 Million animals (range: 8.3 to 313 Million, 95% CI) (**Table 2**). The water filtration potential of mussels on the York River is between 111 and 464 Million liters per hour (mean: 286 Million L hr⁻¹) on the basis of observed biomass and previously estimated clearance rates (5.1 L h⁻¹ g⁻¹, Kreeger unpub. data). By comparison, the oyster biomass along the York has been estimated to be ~ 10,000 kg, a historically low population size. Using an estimated clearance rate of 6.5 L h⁻¹ g⁻¹ (Newell et al. 2005), oysters on the York River are potentially able to filter 65,000,000 liters per hour; significantly lower than the estimated mussel filtering potential.

Table 1. Average number of total mussels/m² in each distance contour from the marsh edge

Marsh type	Distance (m) from marsh edge moving landwards			
	0-1	1-2	2-3	3-4
Creek-embayed/extensive	0.3	0	0	0
Creek-fringing	167.1	34.2	11.1	8.4
Mainstem-Embayed/extensive	630.4	184.9	70.9	59.0
Mainstem-Fringing	1207.2	371.1	251.9	15.9
Marsh Island	1207.2	371.1	251.9	15.9

The same values for mainstem fringing marshes were applied to marsh islands which are expected to function in a similar manner as fringe marsh. Over 85% of the animals were found in < 2m from the marsh edge for every marsh category.

Table 2. Total potential number of mussels per marsh category for the York River in each distance contour from the marsh edge

Distance	Creek - Embayed	Creek - Fringe	Mainstem - Embayed	Mainstem - Fringe	Grand Total
1	0	15,164,538	23,565,213	95,222,425	133,952,176
2	240,358	2,802,525	6,716,561	28,458,996	38,218,440
3	0	782,270	2,490,948	18,227,805	21,501,024
4	0	501,052	1,998,715	1,074,423	35,74,190
Total	240,358	19,250,385	34,771,436	142,983,649	197,245,829

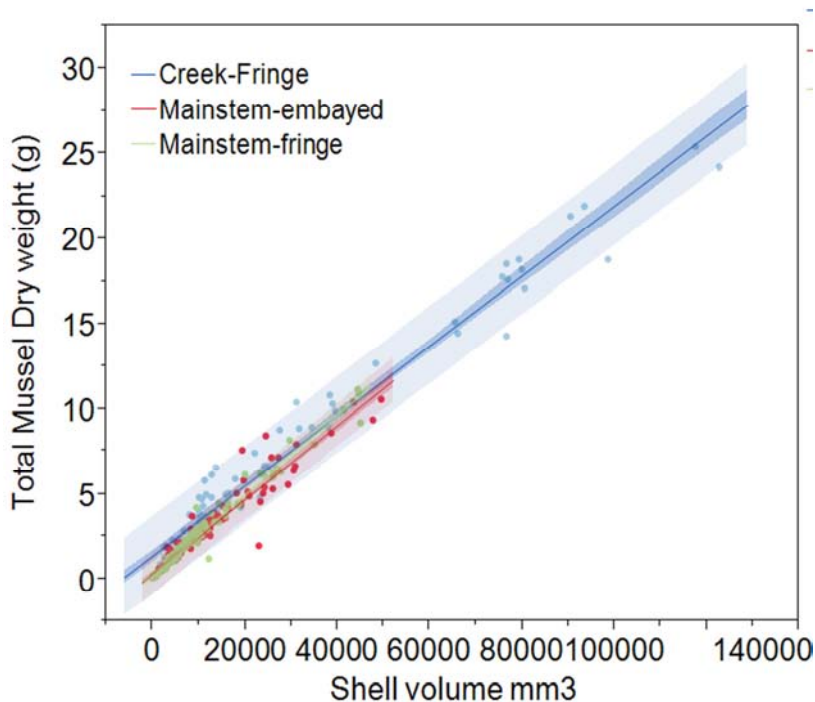


Figure 2. Relationship between ribbed mussel dry weight and shell volume. Mussels in fringing marshes within tidal creeks had a larger size distribution than mainstem marshes. The overall relationship between mussel dry weight and shell volume was strongly correlated ($R^2=0.965$, $n=324$). Line and confidence of prediction (95% CI) is expanded shaded area.

SUMMARY

Ribbed mussel population characteristics (size distribution, biomass, density) varied among marsh types (fringing, embayed/extensive) and position in the landscape (tidal creek, mainstem river). Interestingly, the highest densities of mussels were observed within narrow fringing marshes and within the first meter of the marsh highlighting the significance of that edge habitat for mussels. Likely, the availability of food items and accessibility of the habitat during larval settlement periods contributes to the high densities observed in fringing environments. In tidal creek habitats, mussels were fewer in number, but larger in size which may suggest that predation pressure is lessened in those marsh settings. Along the York River, the mussel population was estimated to be significantly larger than the remaining oyster population and have the capacity to filter more water than oysters. Because oyster populations are low, the use of ribbed mussels and other bivalves in efforts to alleviate eutrophication effects in Chesapeake Bay should be investigated further.

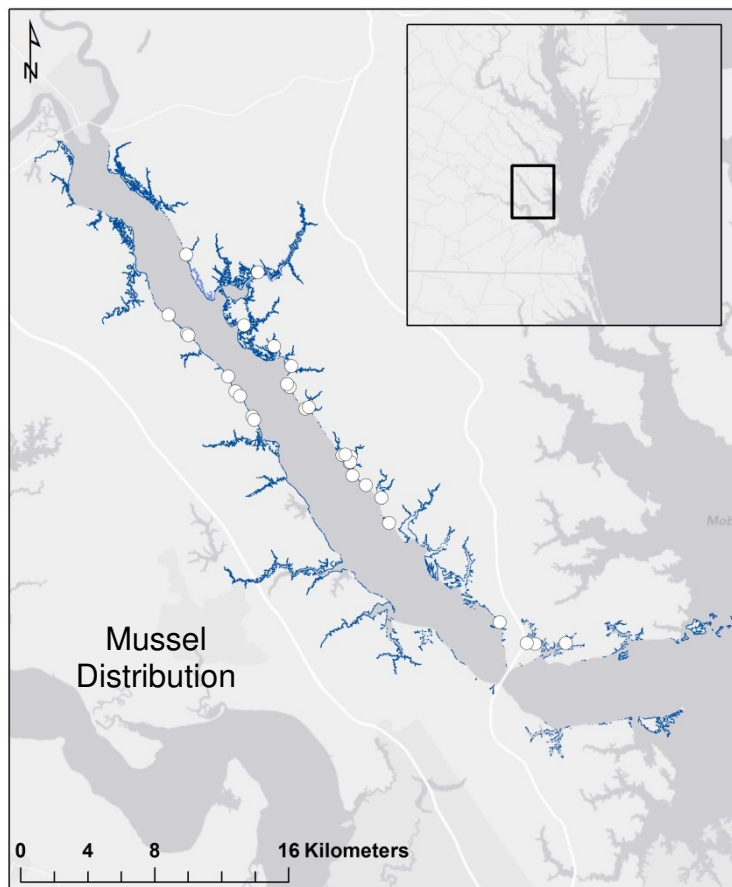


Figure 3. Potential ribbed mussel distribution along the York River.

Additional project products

Invited speaker – Bilkovic, D.M., M. Mitchell. March 30-April 2, 2014. Potential for living shorelines to augment biogenic habitat in soft-bottom estuaries. Invited speaker to the 106th Annual Meeting of the National Shellfisheries Association. Jacksonville, Florida

Invited speaker to the *CCRM Tidal Wetlands Workshop*, May 22, 2014, a forum targeting local and state government, planners, resource managers, wetlands boards, and the public.

Data from this research was integrated into a *NSF - Research Experience for Undergraduates (REU)* student project at Virginia Institute of Marine Science, College of William & Mary during Summer 2014.

Acknowledgements

Many thanks to all the invaluable volunteers at the Center for Coastal Resources Management at VIMS who assisted in data collection and sample processing including Kory Angstadt, Julie Bradshaw, Karen Duhring, Dawn Fleming, Sharon Killeen, Karinna Nunez, Karen Reay, David Stanhope, Christine Tombleson, and Carl Hershner.

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