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4-15-2014

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Recommended Citation

Bilkovic, D., & Mitchell, M. (2014) Composition, distribution, and dynamics of intertidal epibiota on coastal defense structures. Virginia Institute of Marine Science, William & Mary. <https://doi.org/10.21220/V53F0S>

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Composition, distribution, and dynamics of intertidal epibiota on coastal defense structures



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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-Dec2012-3-01

15 APRIL 2014

INTRODUCTION

Proliferation of artificial structures to protect shorelines has introduced novel habitat to most coastal environments and fragmented natural habitats. These changes can result in disrupted connectivity, habitat homogenization, and altered estuarine landscapes, with uncertain implications for estuarine and marine faunal community structure and function. In estuaries, such as Chesapeake Bay, where soft-bottom habitat dominates and rocky shorelines are rare, the introduction of artificial rocky structure may enhance recruitment of species that are limited by the availability of suitable substrate including native and introduced species (*Bilkovic & Mitchell 2013*). There is a significant lack of empirical data on the types of epibiotic assemblages that colonize artificial structures, including information on seasonal changes in species composition and abundance and the prevalence of non-native species on offshore breakwaters. Breakwater are shore-parallel structures designed to reduce wave effects. They are typically high-crested rock features that remain partially emerged during all tides. These structures alter the hydrodynamics and physical conditions around them, likely affecting the distribution of epibiota which have planktonic larvae that rely on currents to transport them to suitable substrate for settlement. Considering the extensive and ongoing practice of hardening coastlines, it is imperative to understand the ecological consequences of converting existing coastal habitat to artificial substrate.

The SEED funding provided by the WISE Initiative supported the collection of pilot data on the seasonal composition and distribution of colonizing epibiota (oysters, mussels, barnacles, algae) on artificial hard structures (breakwaters). The intent is that research conducted in this SEED grant would support the development of a more extensive proposal to complete a regional project within East Coast estuaries that assesses the implications of introducing artificial structures for erosion control on estuarine species distribution and composition.

Our study objective was to document the seasonal composition and distribution of colonizing epibiota on artificial hard structures over the course of a year.

METHODS

Offshore breakwater systems provide shoreline protection by using large, gapped stone structures strategically placed offshore to intercept incoming waves and creating stable pocket beaches between the fixed stone structures, or "headlands". The system is enhanced through beach nourishment and planting beach and dune vegetation. Two breakwater systems with different wave and wind exposures were surveyed in the lower York River of Chesapeake Bay (**Fig. 1**). Each system consists of 3-4 offshore fixed stone structures with beach nourishment to create stable pocket beaches. The sand fill connected to the stone breakwaters is called a "tombolo".

The abundance of conspicuous intertidal epibiota on breakwater structures was quantified as a function of time and position around the structures. Sampling occurred monthly from April – October on the seaward and landward sides of 2 breakwaters from each location. In each position (landward, seaward) of each breakwater, epibiota in randomly placed 5 replicate plots of (0.25m²) were identified and percent cover of each sessile species estimated. Oysters, mussels, and mobile species (e.g. crabs) within plots were also counted. Algae and animals that cannot be identified to species or genus in the field, or that could be confused with other species, were grouped into larger taxonomic complexes or into morphologic groups. In this manner, data at multiple spatial scales was obtained (meters among replicate plots, hundreds of meters-among breakwaters at one location, thousands of meters-between locations). Environmental parameters (temperature, salinity, turbidity, dissolved oxygen, nutrient

concentrations) that may influence biological communities were measured during sampling events with a handheld YSI sonde. To assess seston (chlorophyll *a*) removal by the suspension feeding populations of the epibiota (e.g., oysters, mussels, barnacles) on each breakwater system (an indication of the potential for water clarity improvement), water samples upriver and downriver of each breakwater system were collected monthly on an ebbing tide. Water samples were filtered and chlorophyll *a* concentration determined.

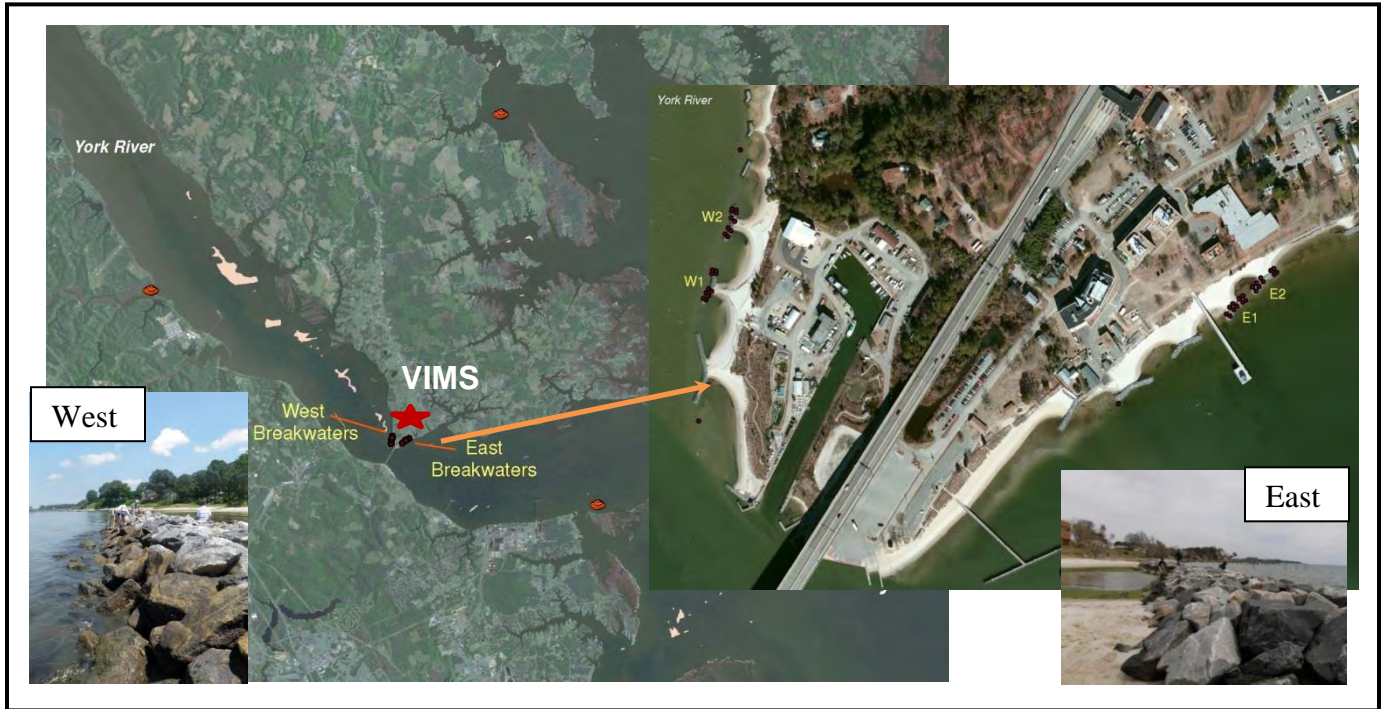
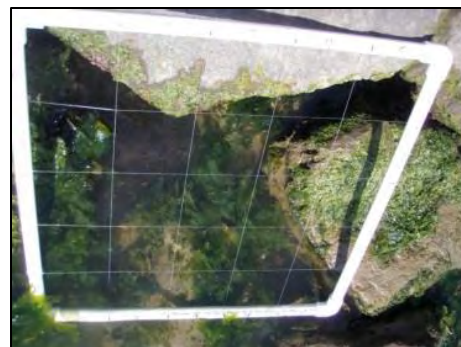


Figure 1. Location of two breakwater systems at Gloucester Point, Virginia. One system is East-facing and exposed to Chesapeake Bay winds and waves and the other system is West-facing with primary exposure from South-Easterly winds along the York River. The inset image illustrates the sampled breakwaters in each location (E1, E2, W1, W2) with samples collected landward and seaward of each structure.



RESULTS & DISCUSSION

Colonization of epibiota on breakwater rock structures

Breakwater structures were colonized by Eastern oyster *Crassostrea virginica*, ribbed mussels *Geukensia demissa*, barnacles, and macroalgae on both landward and seaward sides of the structures. When mean water temperatures exceeded 26°C in August and September, macroalgae declined (**Figure 2**).

There were differences in the assemblages observed landward versus seaward. A lower percent cover of barnacles, oysters, and ribbed mussels on the landward side, particularly in the East system, contributed to the differences in community composition (**Figure 3**). Further, the East system had significantly lower oyster and ribbed mussel abundance (individual/m²) on landward compared to seaward, while the West system supported similar densities of both species on either side of the breakwater (**Figure 4**). The breakwaters of the East system possess much wider tombolos mainly because of engineering constraints. These were placed closer together to accommodate outfalls and this location experiences higher fetch/exposure (see images below). Additional sand was placed following construction as well. As a result of these design features, the sand behind the rocks was at a higher elevation that prevented extensive recruitment of oysters or mussels. There was also evidence of elevated water temperatures landward of the East breakwater system (**Figure 5**). Market sized oysters (3 inches) and spat (newly settled young oysters) were present on all breakwaters. However, there was evidence of mortality at this site, and the question remains whether the structure will support a reproductively successful population.



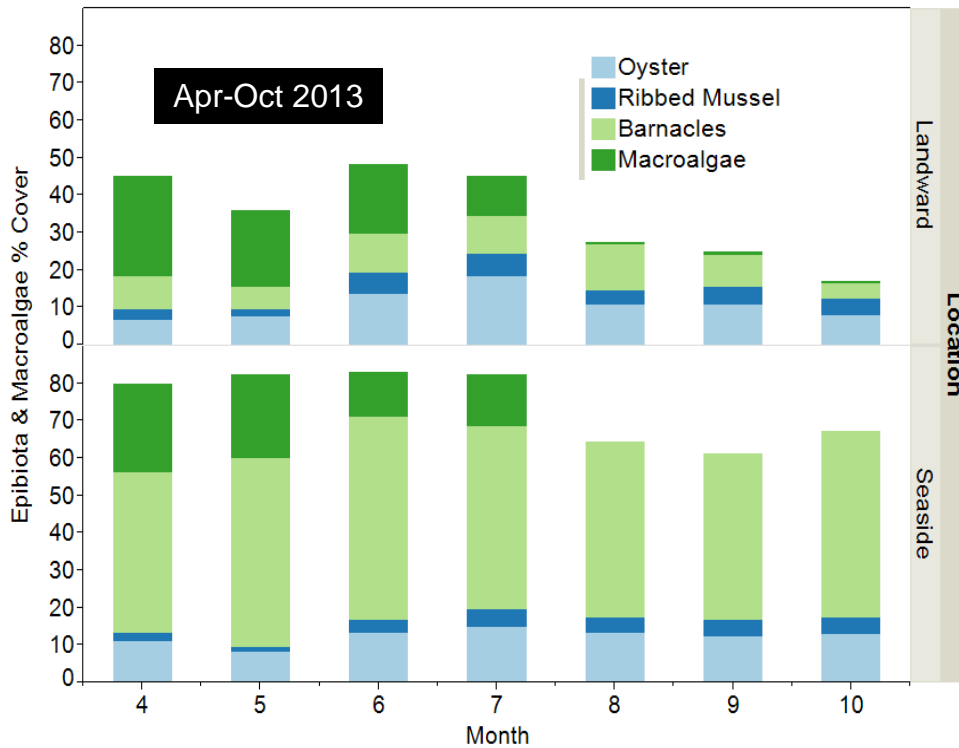


Figure 2. Changes in epibiota assemblage percent cover over time (April – October 2013) on landward and seaward sides of breakwater structures. A sharp decline in macroalgae is apparent in August.

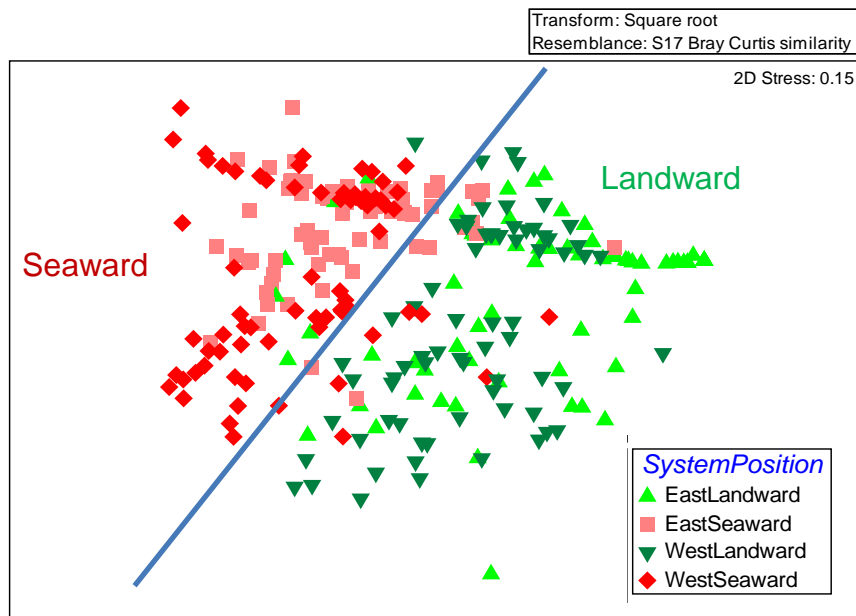


Figure 3. Distinct epibiota assemblages were present in landward and seaward positions of the breakwaters. Nonmetric multidimensional scaling (MDS) analysis used to compare similarity in percent cover of taxa groups.

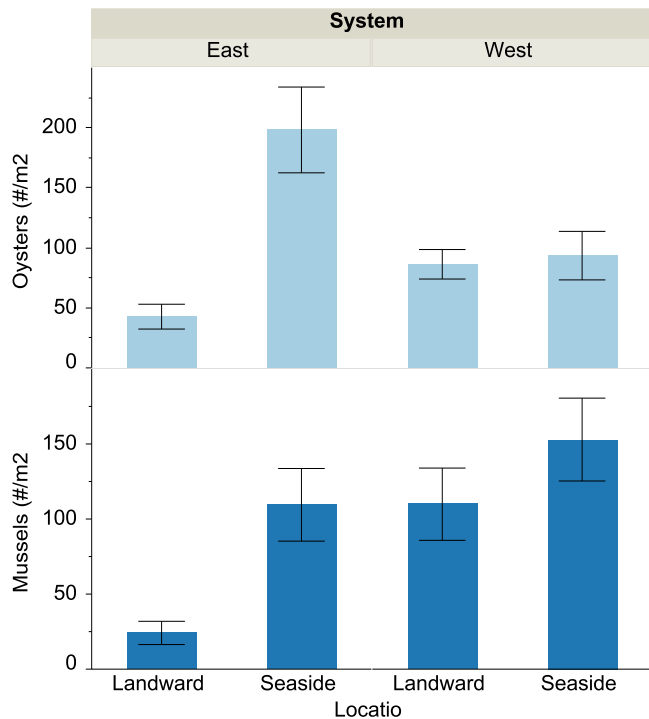


Figure 4. For the East system, oyster and mussel densities were significantly lower on the landward side in relation to the seaward side. West breakwaters system had similar densities of both species on either side due to lower landward elevations that allowed more inundation.

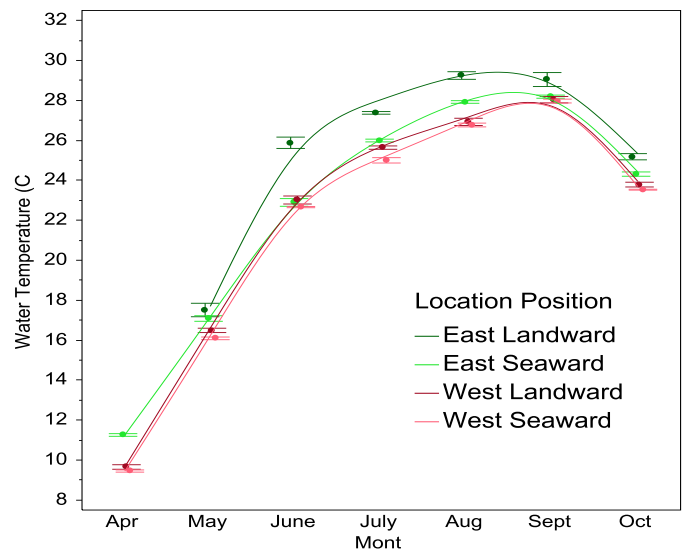


Figure 5. Water temperatures were relatively high in the summer months landward of the East breakwater system with potential implications on the biota.

SUMMARY

Species recruitment to breakwaters is expected to be highly variable because it is regulated by many factors such as species distribution, life history, distance from source populations, relative dominance of pioneer species, estuarine circulation patterns, physical conditions, and wave energy (Sutherland and Karlson, 1977; Bushek, 1988; Barnes et al., 2010). Even within a single breakwater system, we observed differing assemblages between individual breakwater structures that is likely related to the created elevations which effect inundation patterns and thus recruitment. This study illustrated the sensitivity of the biology to nuances in the design of shoreline protection approaches. If properly implemented, the addition of structural habitat could subsidize secondary productivity particularly in areas where loss of complex biogenic habitat (e.g., oyster reefs) has occurred. However, caution is warranted because the introduction of artificial substrates, even those used in combination with natural elements, to protect shorelines has the potential to act as an anthropogenic dispersal mechanism for opportunistic native, non-native, or invasive species. Additional larger questions to consider are whether the increasing amounts of artificial stone structures have the potential to influence the source/sink dynamics of shellfish, either positively or negatively, and in what ways the oyster assemblages on rock structures may differ from natural reefs in terms of ecosystem functioning and service provision.

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.

Acknowledgements

Many thanks to all the invaluable volunteers at the Center for Coastal Resources Management at VIMS who assisted in the monthly data collection and sample processing including Kory Angstadt, Julie Bradshaw, Karen Duhring, Emily Eggington, Dawn Fleming, Sharon Killeen, Karinna Nunez, Karen Reay, Alexander Renaud, David Stanhope, Christine Tombleson, Dave Weiss, Anna Whitmore, Fei Ye, and Joseph Zhang.

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