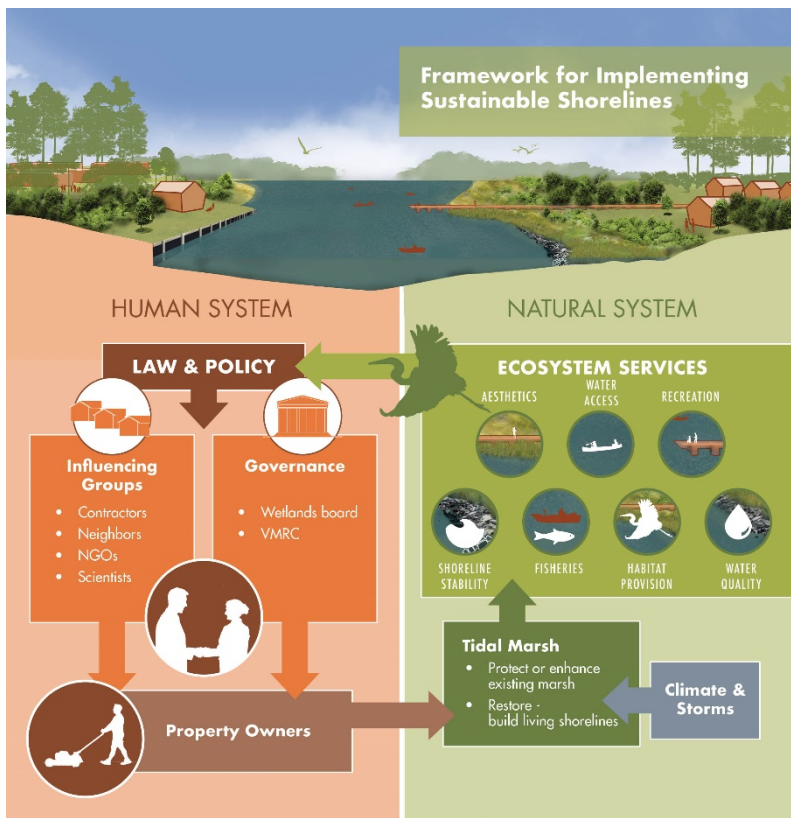


SUSTAINABILITY IN CHESAPEAKE BAY SHORESCAPES: CLIMATE CHANGE, MANAGEMENT DECISIONS, AND ECOLOGICAL FUNCTIONS

Worldwide, rising seas threaten coastal community economic vitality, lifestyles and livelihoods, and wellbeing. As climate change pressures intensify, short-sighted shoreline management policies and practices will have environmental consequences on the larger Bay system, cumulating over space and time to affect the benefits society derives from the system. Natural and nature-based approaches to shoreline protection, henceforth living shorelines, are being encouraged through various government policies as alternatives to armoring that not only provide protective services but also can adapt to rising seas and provide numerous non-protective societal and ecosystem benefits. These approaches include both conserving and restoring tidal marshes. While implementation of these practices has increased over the past decade, armoring is still the most common choice of property owners. We provide insights into the possible futures of Chesapeake Bay shorescapes under climate change and different shoreline management strategies, and identify social intervention points that may foster more sustainable shoreline decision making and policies to enhance short- and long-term ecosystem service provisions and benefits.

GOAL: Characterize the Shorescape Social-Ecological System (SES) to determine what elements have the greatest influence on attainment of sustainable outcomes (namely maximizing ecosystem services in Virginia moving forward)



This cross-disciplinary project engaged social scientists, economists, sociologists, demographers, physical and geospatial modelers, ecologists, biogeochemists and legal scholars to apply an SES approach to describe the relative importance of various interactions between the **Bay system**, **shoreline resources** (marshes and the ecosystem services they provide), **law & policy** (shoreline and marsh protection), **resource users** (property owners), **influencing groups** (NGOs, marine contractors), and **governance of resource usage** (local and state policy makers and resource managers) to inform decision-making for sustainability and enhancement of ecosystem services.

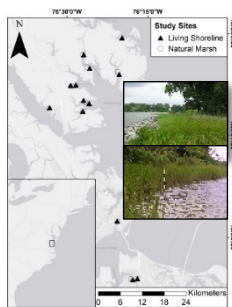
Developed by the Virginia Institute of Marine Science at William and Mary for the National Science Foundation (NSF) Coastal Science, Engineering, and Education for Sustainability (SEES) Initiative. Image designed by Kelsey Braich, Network for Engineering with Nature, University of Georgia. (2021).

APPROACH

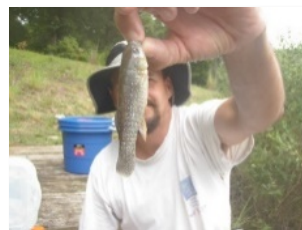
HUMAN SYSTEM: Identify decision factors influencing both property owners & the policy/management personnel governing shoreline property owners

We used multiple approaches to assess why people decide to modify their shoreline and the type of shoreline modification they choose. We surveyed current property owners to determine the factors that impacted their decisions. We also surveyed multiple groups to assess their level of influence and role in property owner decisions, including local Wetlands Boards, state Tidal Wetland Regulators (VMRC), local NGOs, and marine contractors. We examined historic patterns of shoreline modification decisions using wetlands permit data combined with cadastral and environmental data to assess the primary factors driving decisions on different shoreline modifications (i.e., armor, living shoreline, or do nothing). We evaluated shore and marsh protection laws from Florida to Delaware for commonalities and variation in the characteristics of the law that drive trends in shoreline modification.

NATURAL SYSTEM: Determine the environmental consequence of changes in Bay shorescapes through a series of field investigations describing the ecological functions provided by natural fringing marsh shorelines and those provided by living shorelines marshes.



We evaluated the differences in proxies of ecosystem functions related to marsh ecosystem services: **1)** habitat provision (invertebrate, fish, bird, terrapin; abundance, biomass, diversity), **2)** primary production (aboveground plant biomass), nutrient storage (aboveground plant and soil total N, P content), and **3)** carbon storage (aboveground plant and soil carbon content) for both natural marshes and a chronosequence (2 to 16 years from construction) of living shorelines, within shorescapes representing the continuum of marsh connectivity conditions.



Shorescapes, a shoreline zone which includes riparian, intertidal, and littoral areas, are ideal areas to investigate linkages between human and natural components of the ecosystem because they are significant and critical points of intense socio-ecological interactions, and climate change.

FINDINGS

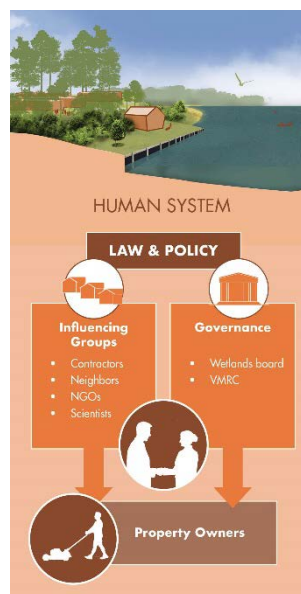


Shoreline development and armoring reduces the resiliency of natural marshes under sea level rise, leading to decreased marsh habitat and ecosystem services.

The more sustainable and ecologically sound alternative, living shorelines (i.e. created tidal marsh), provide similar marsh habitat for most estuarine fauna and had similar plant productivity as reference marshes within 2 years, suggesting that many ecosystem services will be sustained if living shorelines are used as shore protection.

As the living shoreline marsh matures, sediments become richer and store more nutrients, and mussel abundance increases. These ecosystem services will be enhanced over time (years to decades).

Living shorelines in urban and rural settings performed similarly to nearby natural marshes indicating that created, living shoreline marshes provide valuable services in both urban and rural locations.



Property owner shoreline modification decisions are primarily influenced by marine contractors, neighbors, and NGOs. Direct training and engagement of key influencing groups could enhance living shoreline use and integration into local and social norms.

Armored shorelines are held to a lesser standard in the law than living shorelines, limiting living shoreline use. To manage for sustained ecosystem services, regulations should be updated to have a shorescape perspective that accommodate shifting marsh boundaries with sea level rise and reflect current societal concerns and values.

Revised policies, in concert with enhanced communication by influencing groups to property owners on the societal value of ecosystem services provided by marshes and living shorelines, will likely result in more sustainable shorelines and coastal communities under a changing climate.

Project Investigators.

VIMS – Carl Hershner, Donna Marie Bilkovic, Molly Mitchell, Joseph Zhang, Karinna Nunez, Julie Herman, Jian Shen, Amanda Guthrie, Robert Isdell

W&M – Randy Chambers, Matthias Leu, Sarah Stafford, Bob Galvin, Sam Mason

ODU – Michelle Covi, Wie Yusuf

UGA – Shana Jones

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For more information, please contact Donna Bilkovic, donnab@vims.edu

