Virtual Living Shoreline Public Education Session

LIVING SHORELINES

Wednesday, December 10, 2025
6:00 PM - 7:30 PM

Funding provided to the City of Cambridge for the Make Cambridge Resilient Initiative by the National Fish & Wildlife Foundation.

MAKE CAMBRIDGE RESILIENT
WWW.MAKECAMBRIDGERESILIENT.ORG

AGENDA

- 6:00-6:05 WELCOME
- 6:05-6:30 LIVING SHORELINES IN MARYLAND: PRACTICE, POLICY, AND PROGRESS
  - SAMUEL ECKERT & LAURA EXAR , MARYLAND DEPARTMENT OF NATURAL RESOURCES
- 6:30-6:55 LIVING SHORELINES RESEARCH IN THE PALINKAS LAB
  - CINDY PALINKAS, UNIVERSITY OF MARYLAND CENTER FOR ENVIRONMENTAL SCIENCE
- 6:55-7:05 ASSESSING HABITAT FUNCTION AS A CO-BENEFIT OF LIVING SHORELINES
  - KENNY ROSE, UNIVERSITY OF MARYLAND CENTER FOR ENVIRONMENTAL SCIENCE
- 7:05-7:15 LIVING SHORELINES
  - ANNA JOHNSON, BAYLAND CONSULTANTS & DESIGNERS, INC
- 7:15-7:30 PM Q&A SESSION

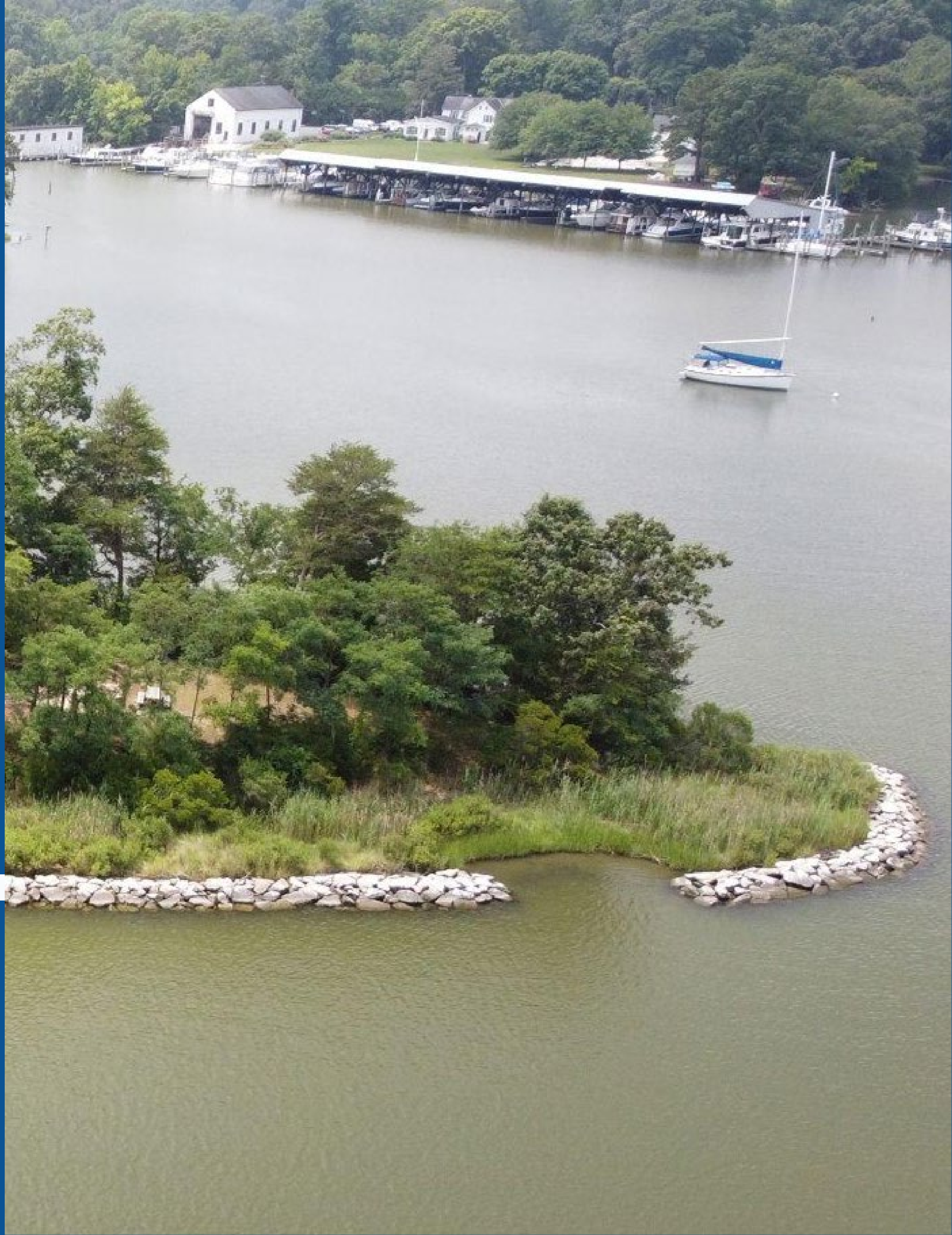
Sam Eckert
Coastal Restoration Specialist

Laura Exar
Coastal Restoration Specialist

Sam and Laura are Coastal Restoration Specialists at the Maryland Department of Natural Resources, working as part of the Shoreline Conservation Service (SCS) to provide property owners with technical and financial assistance to implement living shorelines. The SCS team manages the Shoreline Erosion Loan Program which provides communities, non-profits, local governments, and private property owners access to an interest-free loan to install living shorelines.

Living Shorelines in Maryland: Practice, Policy, and Progress

Sam Eckert and Laura Exar, Coastal Restoration Specialists
Maryland Department of Natural Resources
Shoreline Conservation Service



Outline

I. Who We Are: Shoreline Conservation Service
II. Introduction to Shorelines and Erosion in Maryland
III. Traditional Approach to Shoreline Stabilization & When They Fail
IV. What is a Living Shoreline? (Green Vs. Grey)
V. Benefits of Living Shorelines
VI. Living Shoreline Act of 2008
VII. Living Shoreline Waiver Process
VIII. Conclusion

Shoreline Conservation Service

Program History

Shore Erosion Control Program established in 1968 through legislation

Program provides technical & financial assistance to waterfront property owners experiencing erosion

Technical Assistance

Provided through site evaluations, assessments, and recommended solutions

Financial Assistance

Provided through zero-interest loan program

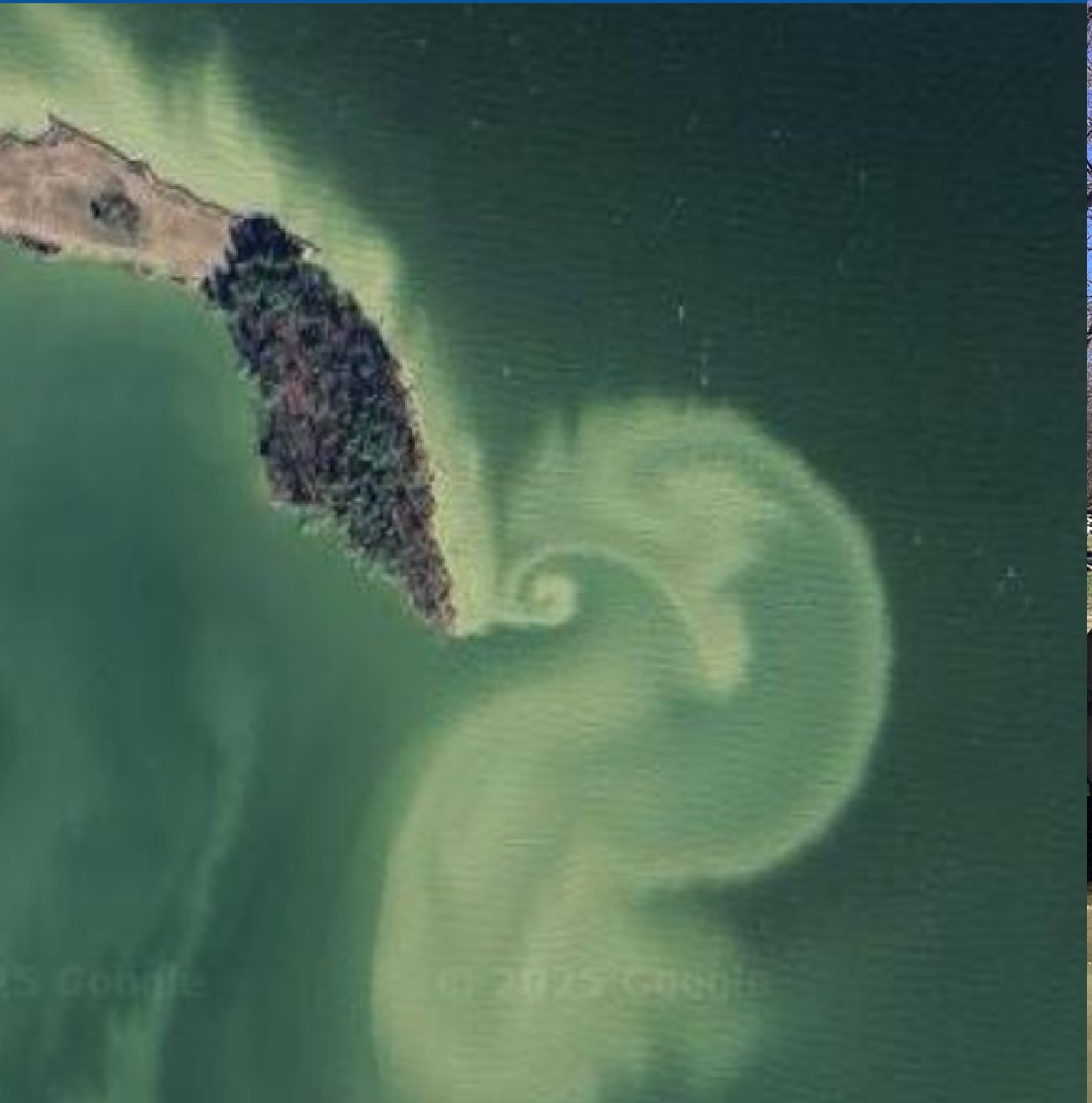
1968

Since 2008

Shorelines in Maryland: Current Status

- 6,776 miles bordering the Bay
- 85-95% privately owned
- Erosion affects all 16 coastal counties and Baltimore City
- Exacerbated by
  - Sea level rise
  - Human activities (large boats and hardened adjacent shorelines)
- 18% of Bay shorelines hardened as of 2016
  - Up to 80% in some Bay tributaries

Is Erosion Good or Bad?



Traditional Approach

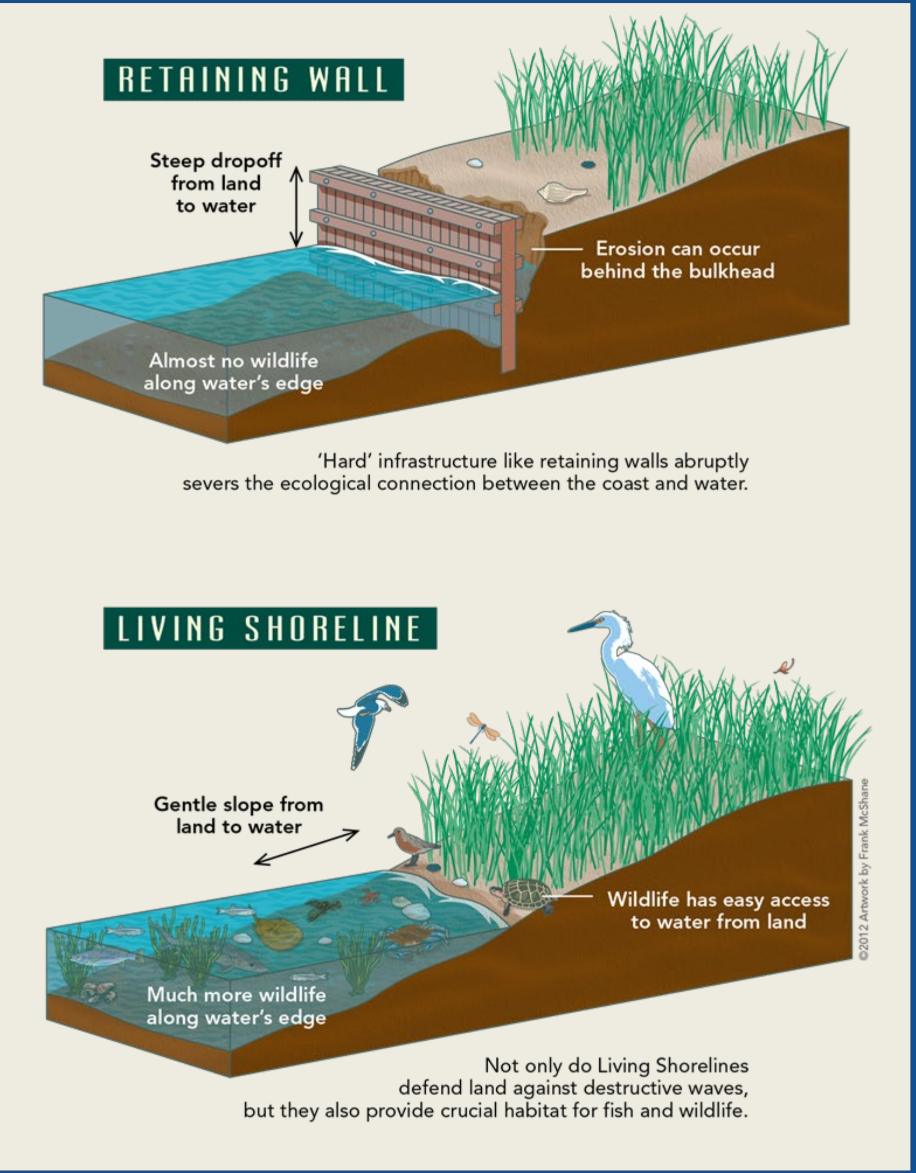
Revetment

Wooden Bulkhead

Problems Associated with a Structural Approach

These approaches *fight* nature instead of working with it.

Gray vs Green Infrastructure



Structural Solutions

Strongest day is the first day after construction – becomes **weaker over time**

Nature-based Solutions

If designed and built correctly, the weakest day is the first day after construction - becomes **stronger over time**

Hurricane Irene and Florence

- Hurricane Irene (2011) damage in the Outer Banks:
  - 76% of bulkheads
  - None of the coastal habitats that were studied
- Hurricane Florence (2018) damage:
  - Areas that had “hard structures” had significant damage and erosion
- Areas that had “soft solutions” like oyster reefs and living shorelines/marshes did much better
- NOAA reported on Beaufort Living Shoreline: “intact after the storm, with minimal erosion”

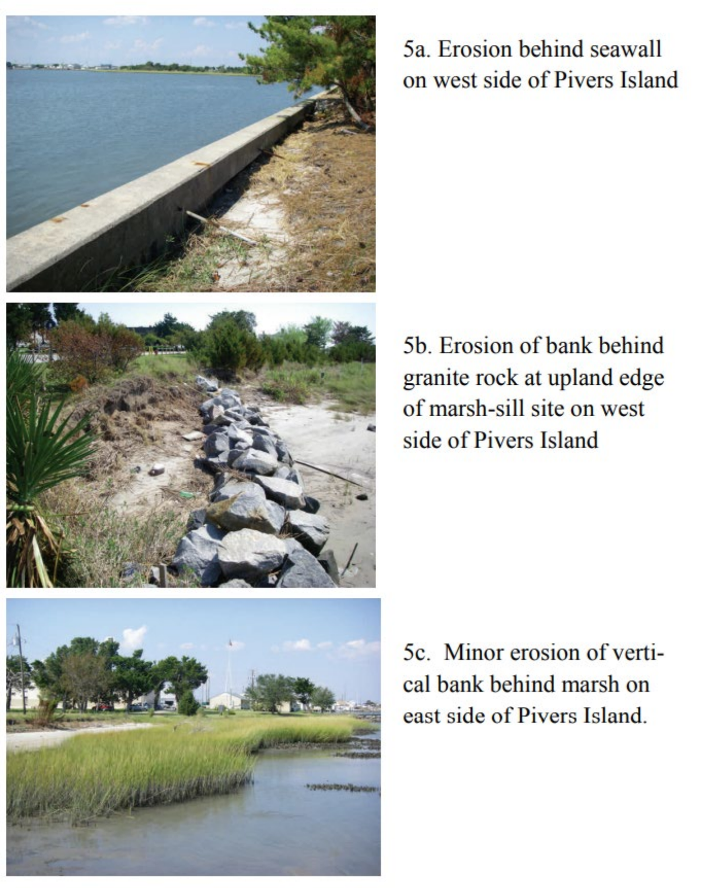


Diagram from NC DEQ

WHAT IS A LIVING SHORELINE?

Living shorelines are a **suite of techniques** used to reduce erosion and enhance habitat by restoring and/or enhancing natural features while maintaining coastal processes.

Typical features may include:

- Marsh
- Beach Strand
- Headlands
- Groin
- Sill
- Offshore breakwater
- Tombolo
- Cobble/Shingle Beach
- Woody Vegetation/Debris

2008 Living Shorelines Protection Act

Potential Restoration Techniques - Living Shorelines

Headland Breakwater

Vegetated Headland Breakwater

Sill

Groin

Shingle Beach

Coir Fiber Log

Living Shoreline Benefits

- Erosion control
- Storm protection
- Shoreline stabilization and adaptation
- Water quality improvements
- Habitat creation and connectivity
- Carbon sequestration
- Enhancing fisheries
- Recreational and aesthetic value

Photo: DNREC

Living Shoreline Act of 2008

- First state-wide effort to promote living shorelines!
- Established living shorelines as the preferred method, unless:
  - A waiver is obtained from MDE
  - The project is mapped as appropriate for structural stabilization by MDE
- When issued a waiver, living shoreline approaches should be incorporated where possible

Ch. 304

CHAPTER 304

(House Bill 973)

AN ACT concerning

Water Management Administration – Living Shoreline Protection Act of 2008

Living Shoreline Waiver Process

In making the feasibility determination, several factors are considered by MDE:

B. When evaluating a person's request for a waiver, the Department shall determine whether the site is suitable to support a nonstructural shoreline stabilization measure by considering:

(1) The width of the waterway;

(2) The bottom elevation and slope at mean low water;

(3) The bottom substrate:

(4) The fetch;

(5) The bank elevation and orientation;

(6) The degree of erosion;

(7) The height and regularity of tides;

(8) Any other physical constraints that would impede or prevent successful establishment of a nonstructural shoreline stabilization measure; and

LIVING SHORELINE WAIVER WORKSHEET

Project Site Address:			
City, State, Zip:			
	Existing Structure	Is the proposed project a replacement of a previously authorized, functional structure i.e. replacement bulkhead? If yes, then check the yes box and do not fill out the rest of the form.	☐ Yes (Waiver) ☐ No
	Mapped Shoreline	Is the applicant's proposed project's shoreline mapped by MDE as an area appropriate for structural shoreline stabilization measures? If unknown, leave this section blank. If yes, then check the yes box and do not fill out the rest of the form.	☐ Yes (Waiver) ☐ No
1	**Navigation**	Distance in feet from the Mean High Water Line to the centerline of the closest mapped or unmapped navigable channel.	
2	**Width of Waterway**	Distance in feet from Mean High Water Line of proposed project's shoreline perpendicular across the waterway to the Mean High Water Line on the opposite shoreline.	
3	**Depth at Toe of Bank**	Depth of the water in feet from the Mean Low Water Line to the bottom or toe of the shoreline bank.	
4	**Depth of Waterway**	Depth of water in feet relative to the Mean Low Water Line at 20-feet and 40-feet channelward of the Mean High Water Line at the proposed project's shoreline.	At 20 Ft. / At 40 Ft.
5	**Shoreline Orientation**	A. Provide a compass direction perpendicular to the line of the proposed project's shoreline. Direction can be given as NE, SW, etc. or as a compass heading (i.e., 45°, 225°).	
		B. Is Bank grading or tree trimming required to provide at least six hours of daily sunlight.	
6	**Fetch**	Provide four measurements (in feet) of maximum unobstructed distance over open water for each compass quadrant (i.e., NE, SE, SW, NW) centered on the proposed project's location on the applicant's shoreline.	NW / NE SW / SE
7	**Bottom Material**	Firmness of bottom material in the proposed project's area of impact.	☐ Hard ☐ Soft
		Type of bottom material in the proposed project's area of impact.	☐ Muck ☐ Silt ☐ Sand ☐ Clay
	Sensitive Species	Will project construction adversely impact fish, plant, underwater vegetation, marsh, shellfish, wildlife habitat, or the area within 100 feet landward of the proposed project's shoreline? If unknown, leave this section blank.	☐ Yes (provide explanation and attach to this form) ☐ No
	Site Access	A. Can the proposed project be constructed from the water?	☐ Yes ☐ No
		B. Does the access to the site require any grading or trimming of vegetation?	☐ Yes ☐ No

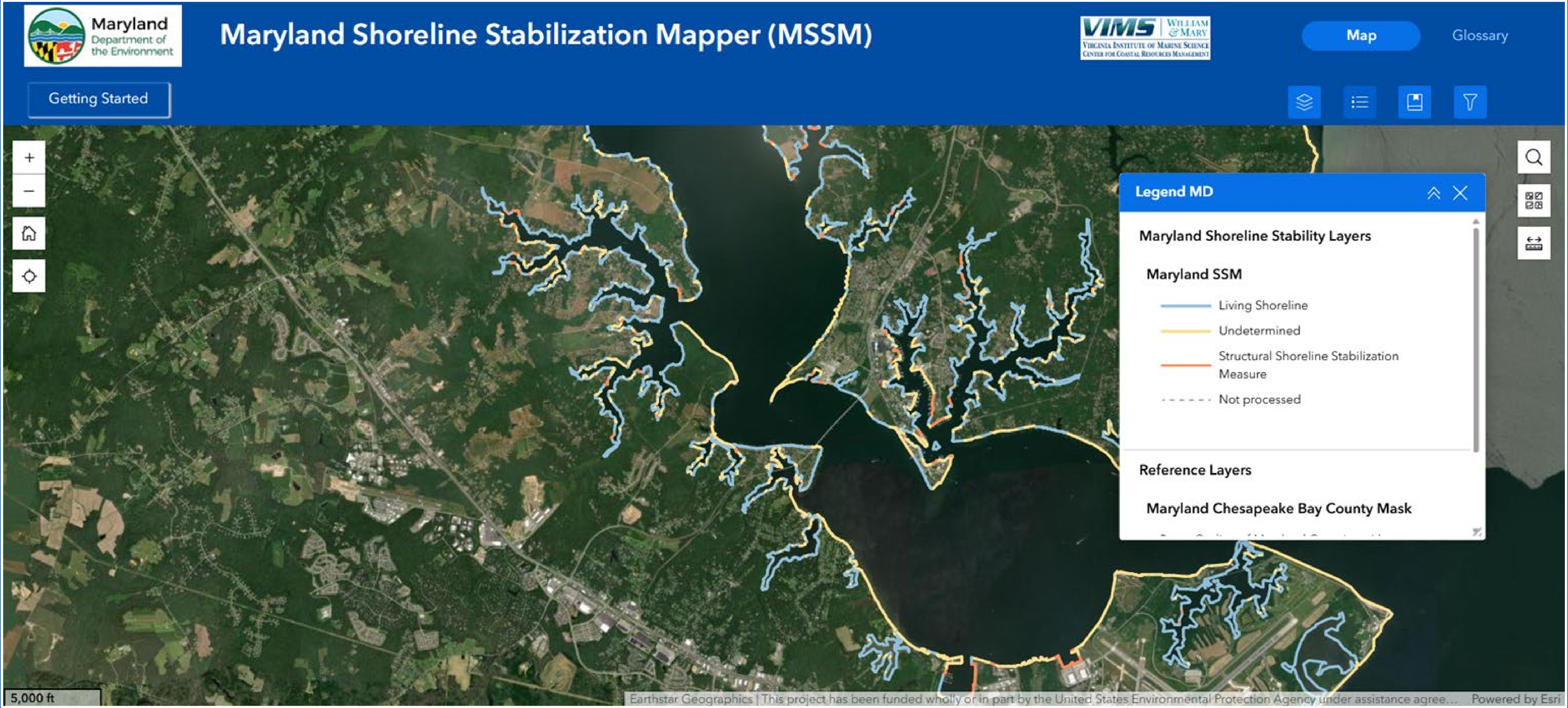
I certify that the information on this form is true and accurate to the best of my knowledge and belief.

RIPARIAN PROPERTY OWNER SIGNATURE: ______________________ DATE: __________

RIPARIAN PROPERTY OWNER NAME (PRINT): ______________________

VER. 2023.06

Living Shoreline Mapper



Thank you!

Questions?

Sam Eckert: samuel.eckert@maryland.gov

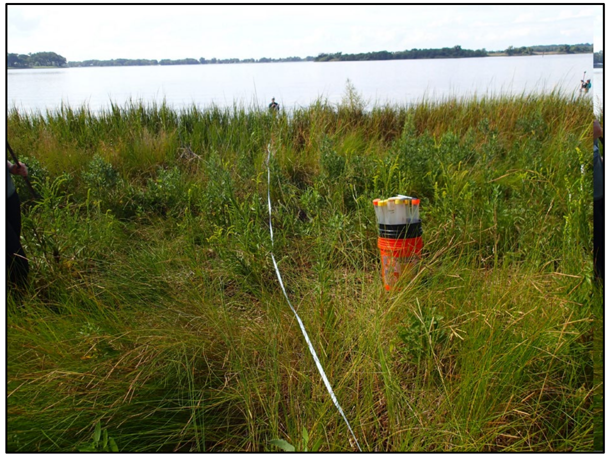
Laura Exar: laura.exar@maryland.gov

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Living Shoreline Research in the Palinkas lab

Cindy Palinkas, Associate Professor
University of Maryland Center for Environmental Science
Horn Point Lab
In collaboration with Lorie Staver
and many other Horn Point faculty, staff, and students!

BA, Earth and Planetary Science, Johns Hopkins University
MS and PhD, Geological Oceanography, University of Washington
2005-2013: Assistant Professor, UMCES
2013-present: Associate Professor, UMCES



What my students and I do: study **MUD** in and around Chesapeake Bay; aka playing in marshes and shallow water

Our big questions:

1. How does mud and sand (sediment) from land get into adjacent waters, and where does it end up?
2. How do people influence its supply via land and shoreline uses and/or management?
3. How does it interact with plants like SAV* and marshes?

*SAV = submersed aquatic vegetation

Our motivation: coastal resiliency, healthy Bay ecosystems

What it looks like in the field and lab



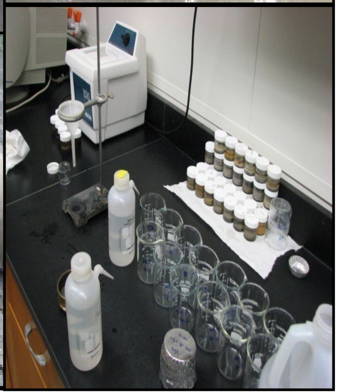










Our living shoreline research questions

1. Do living shorelines "work" – reduce erosion?

2. What happens to adjacent SAV beds after installation?

3. How do sediment and plant characteristics change as living shorelines age?

4. Does design matter?

Funding, management, and outreach partners

MARYLAND DEPARTMENT OF NATURAL RESOURCES

NSF National Science Foundation

GBKF

USCRP US COASTAL RESEARCH PROGRAM

Sea Grant Maryland

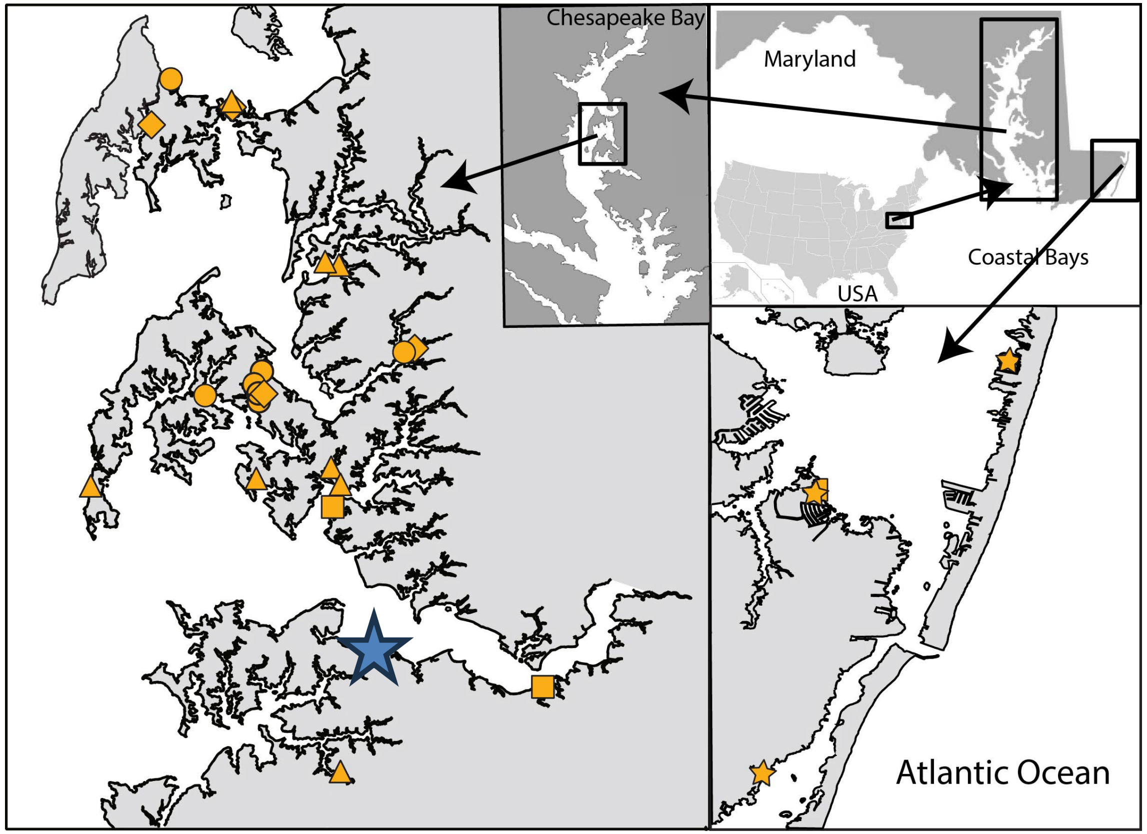
CHESAPEAKE BAY TRUST

SHORERIVERS

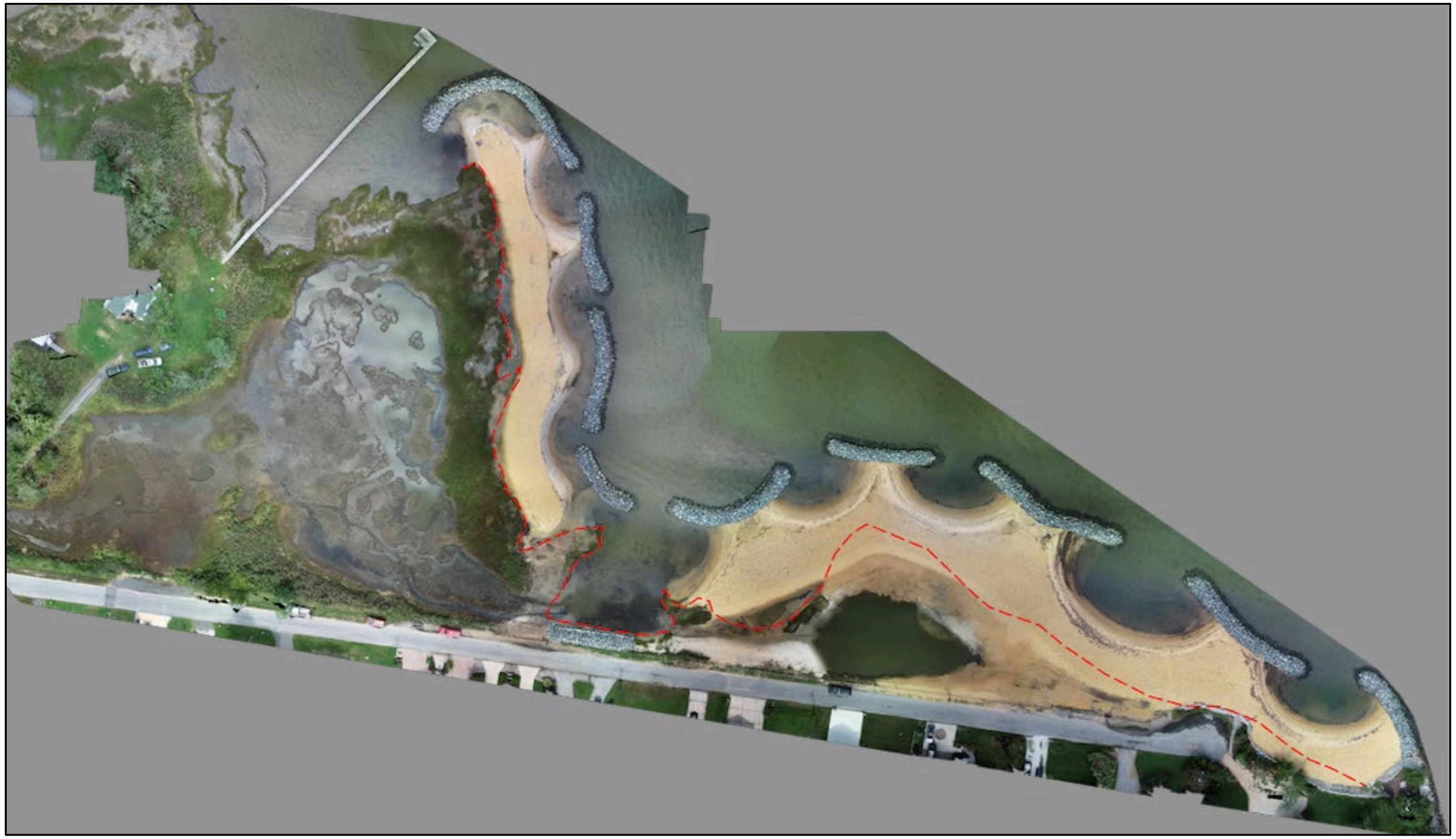
Maryland Department of the Environment

unity design/build landscape

Study sites across multiple projects



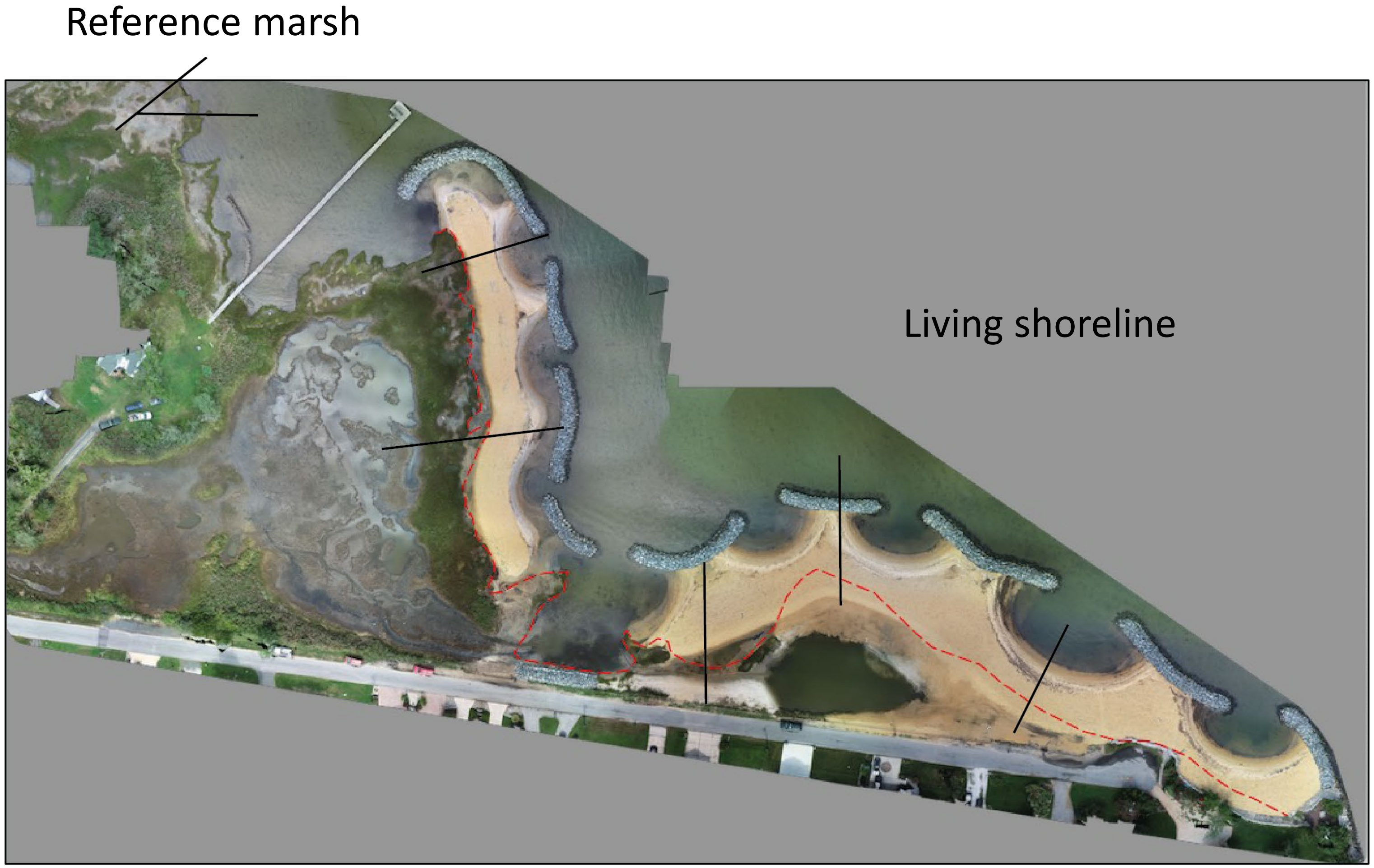
Living shoreline installation builds shorelines seaward into adjacent shallow-water habitat.



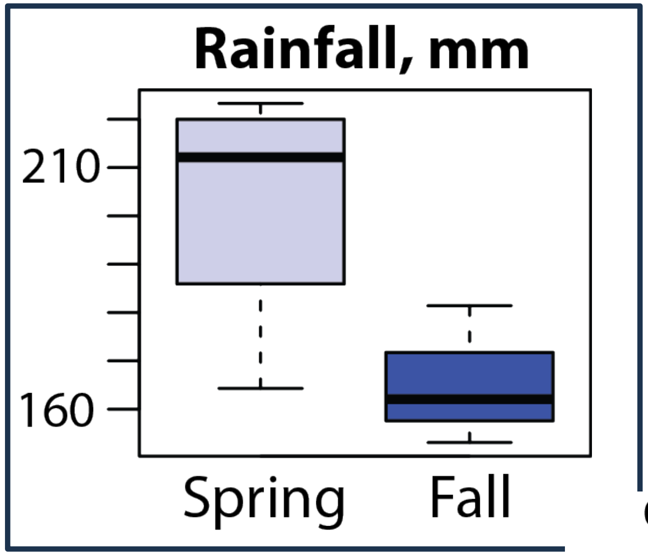
Selsey Rd, West Ocean City

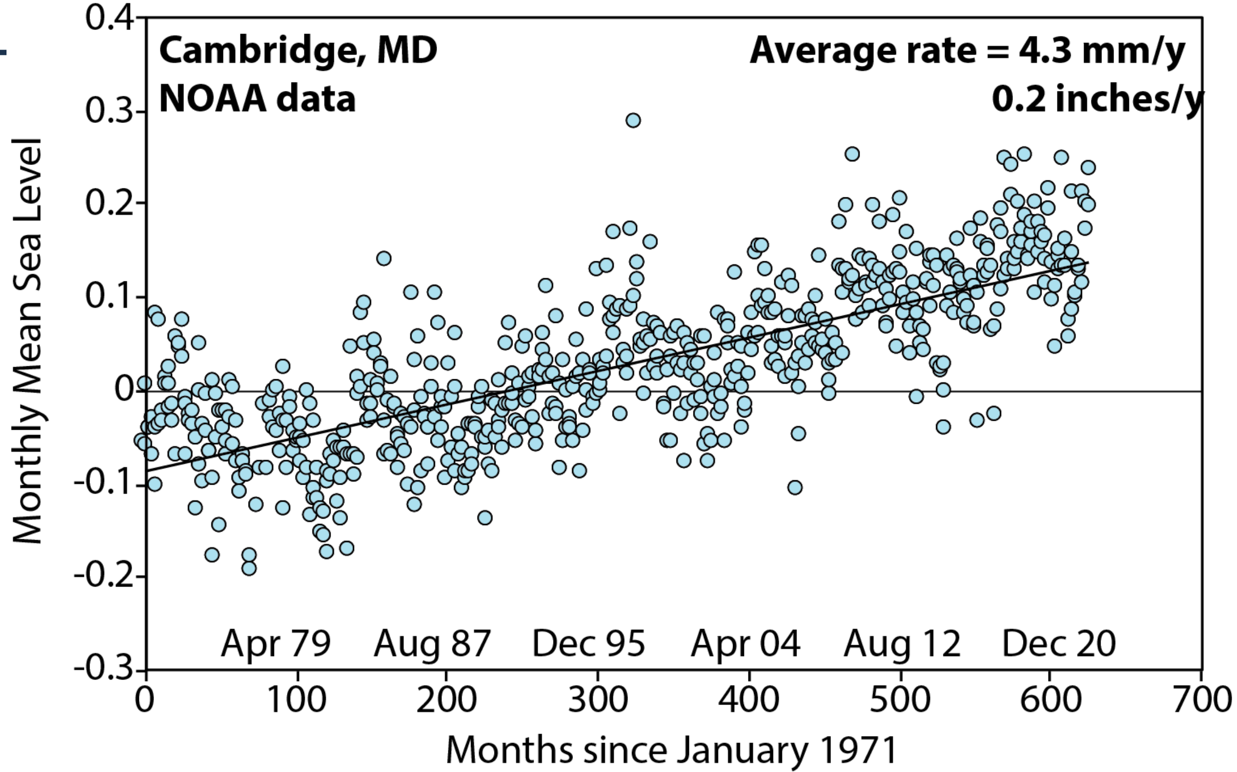
BACI*-inspired monitoring design

*BACI – before, after, control, impact



Why? Weather and other drivers vary over time

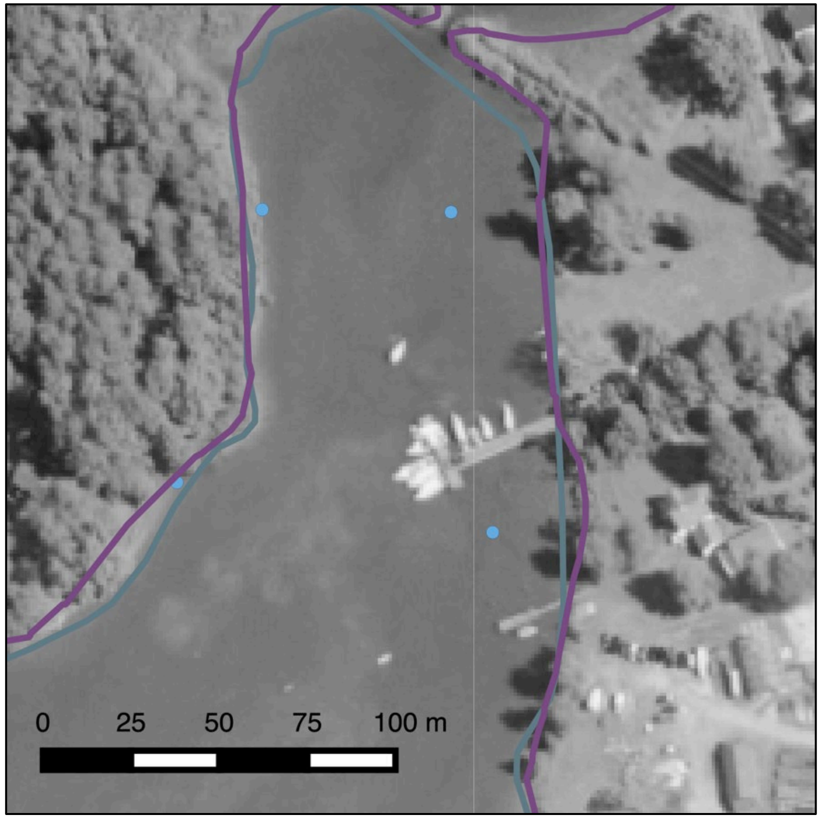




1) Do living shorelines "work" (reduce erosion)?

Compare erosion rates:
Historical: change from 1942 to 1994

Current: change from 2003 (before any installation) and 2017 (field survey)

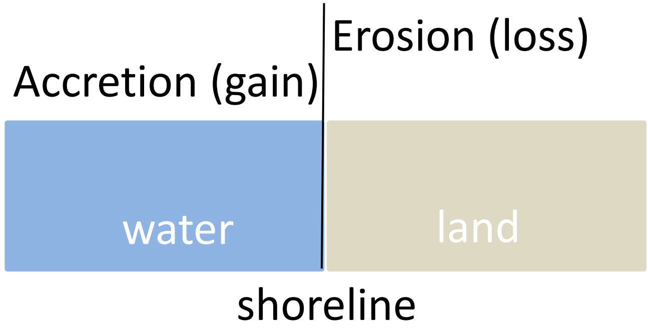


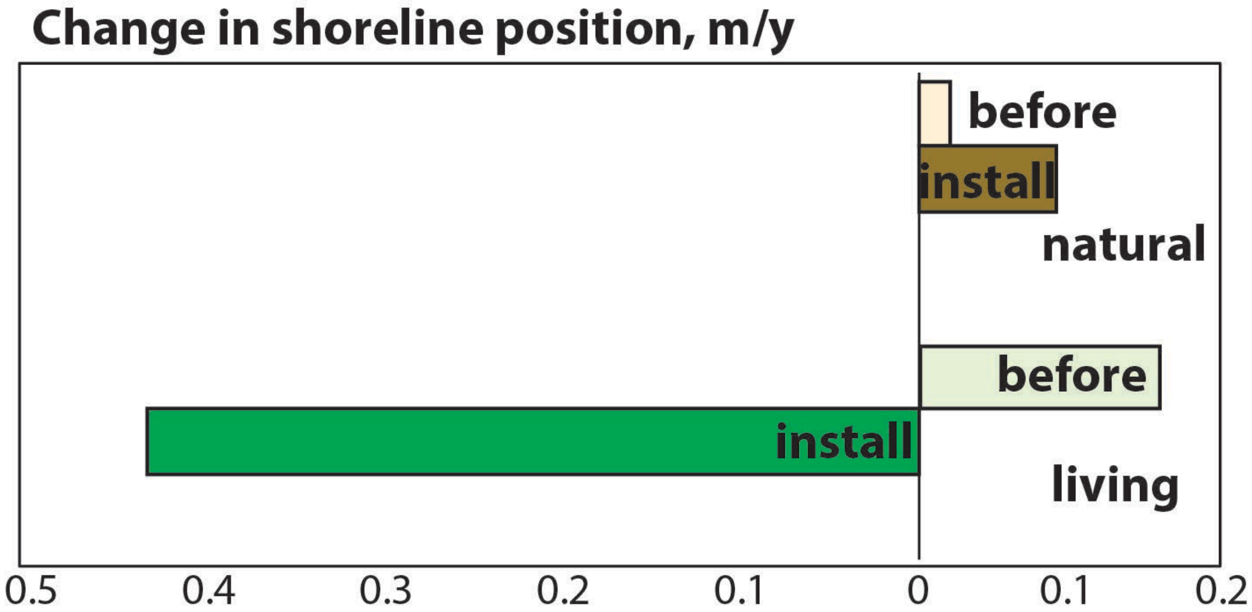
Purple = 1994 shoreline
Blue = 1942 shoreline
Maryland Coastal Atlas

Feb 2007 Google Earth

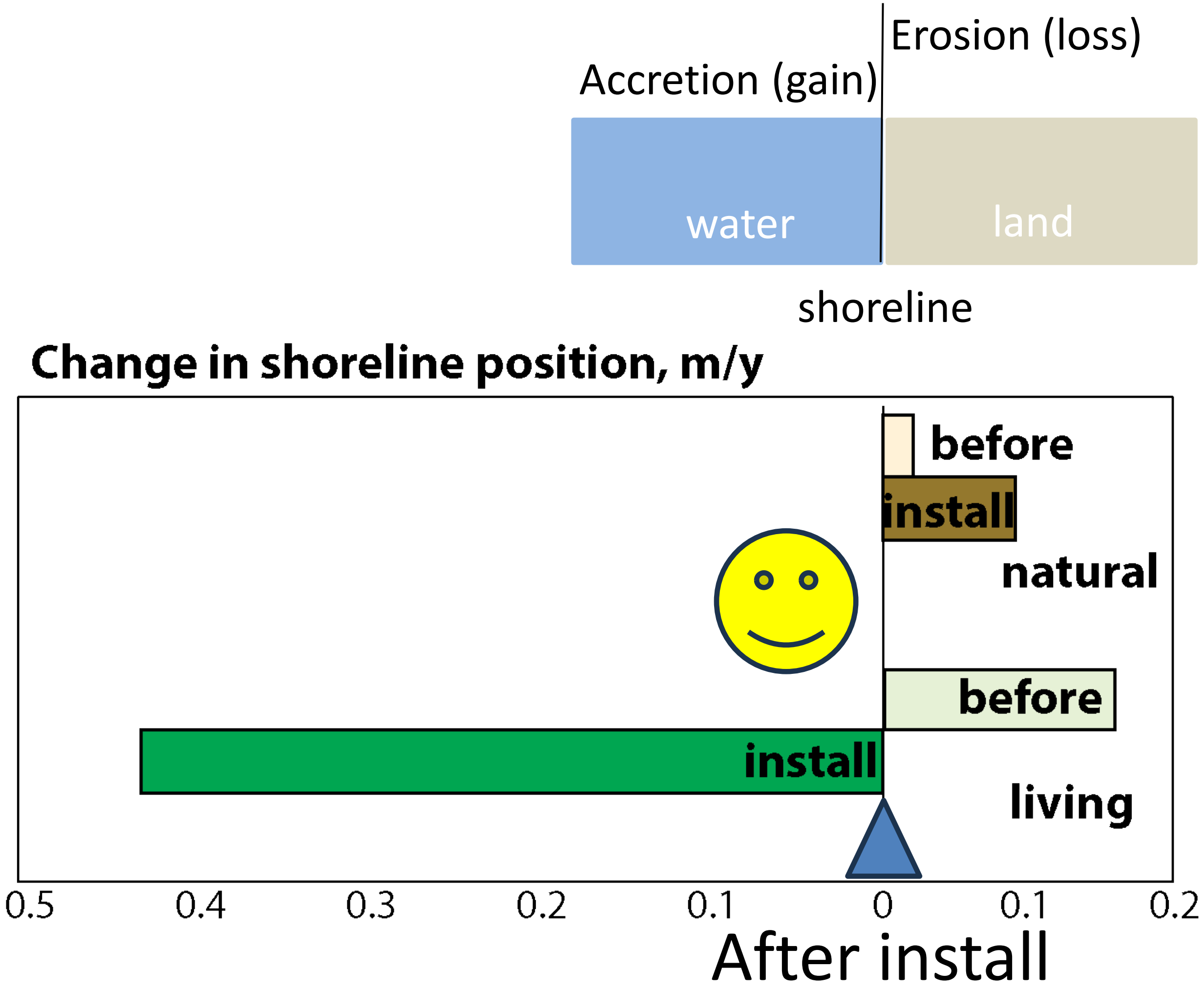
LS
natural

Erosion continues at natural shorelines; shorelines move seaward with living shoreline installation

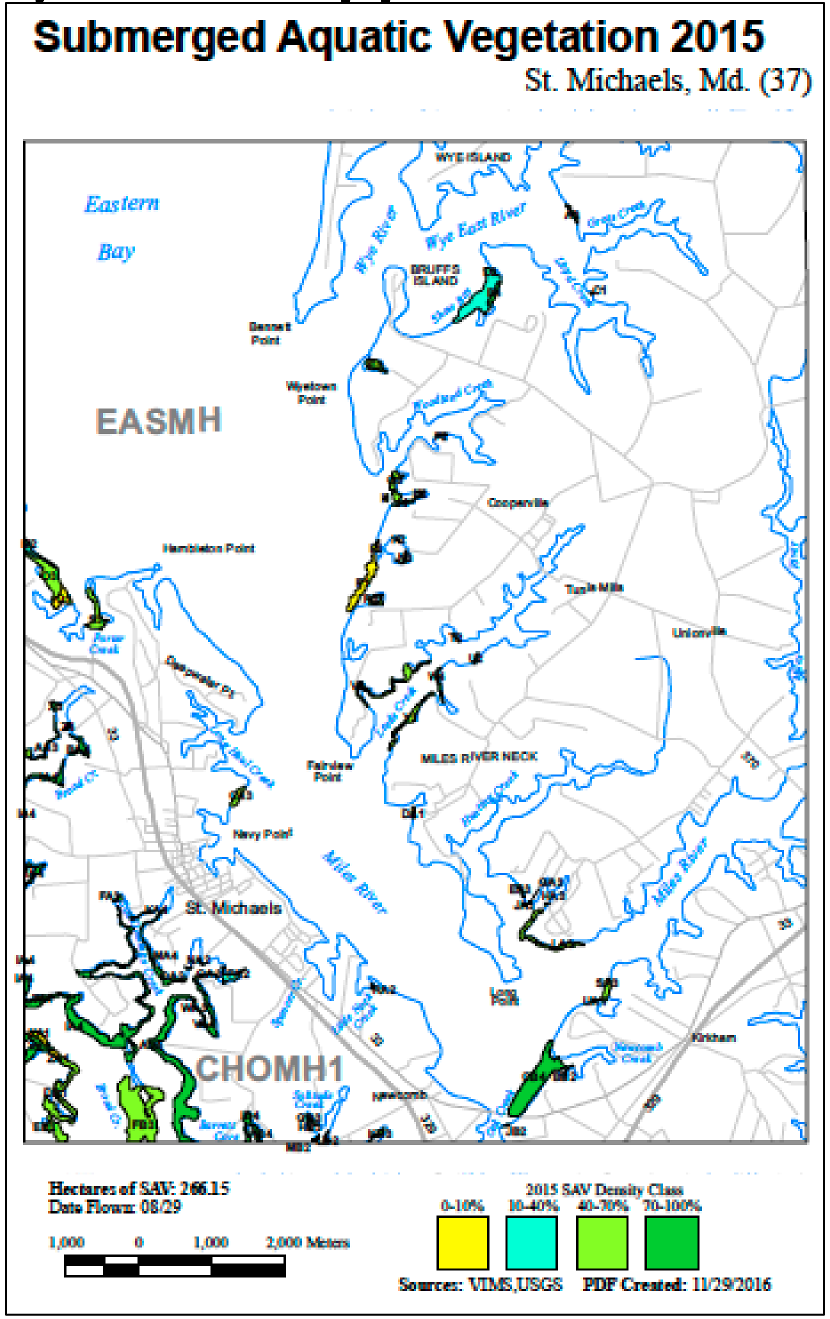




Erosion continues at natural shorelines; shorelines move seaward with living shoreline installation then stabilize



2) What happens to SAV after installation?

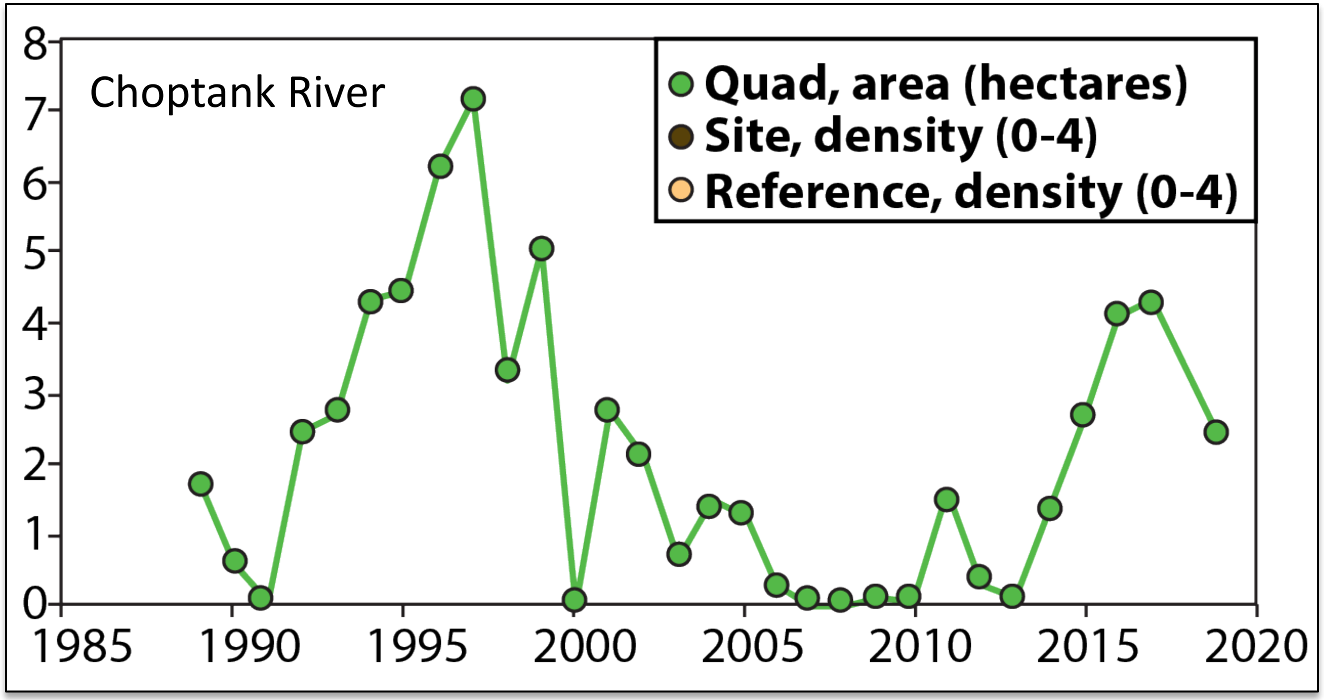


Aerial photos from VIMS* 1978, 1984-present w/ground surveys

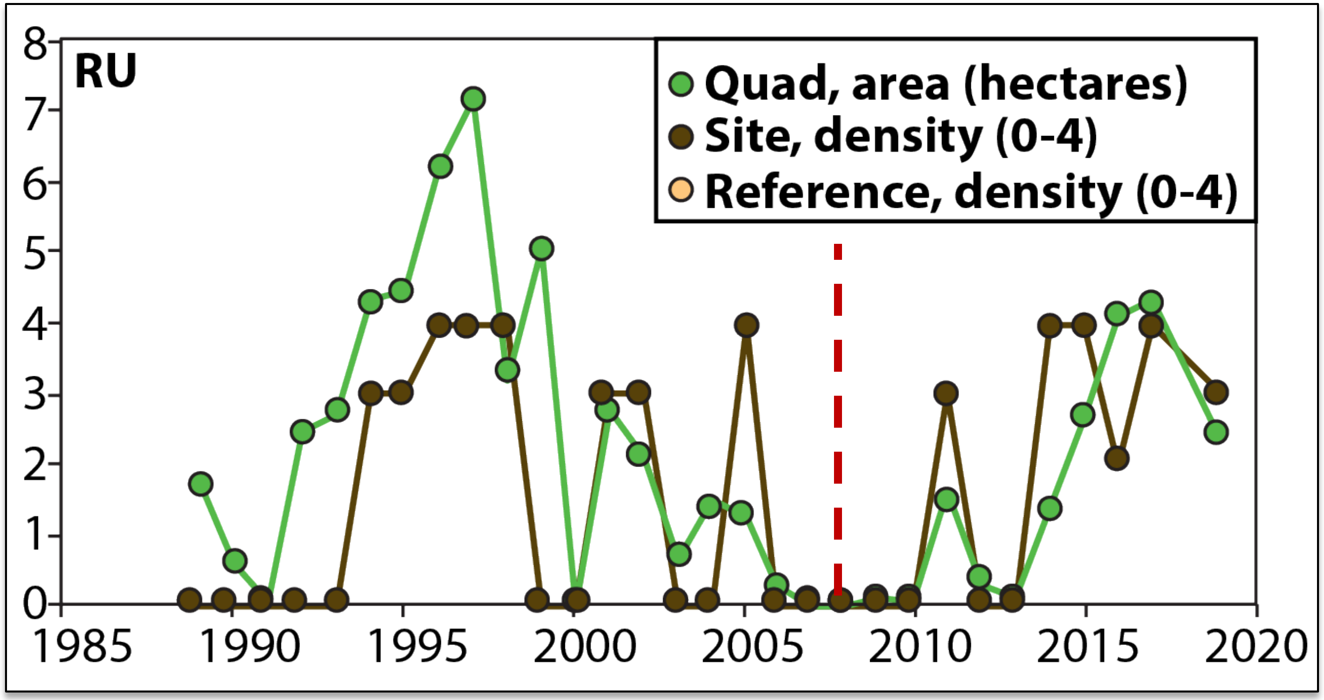
Photographs, data on VIMS SAV website (http://web.vims.edu/bio/sav)

*VIMS – Virginia Institute of Marine Science

SAV in the region varies a lot!

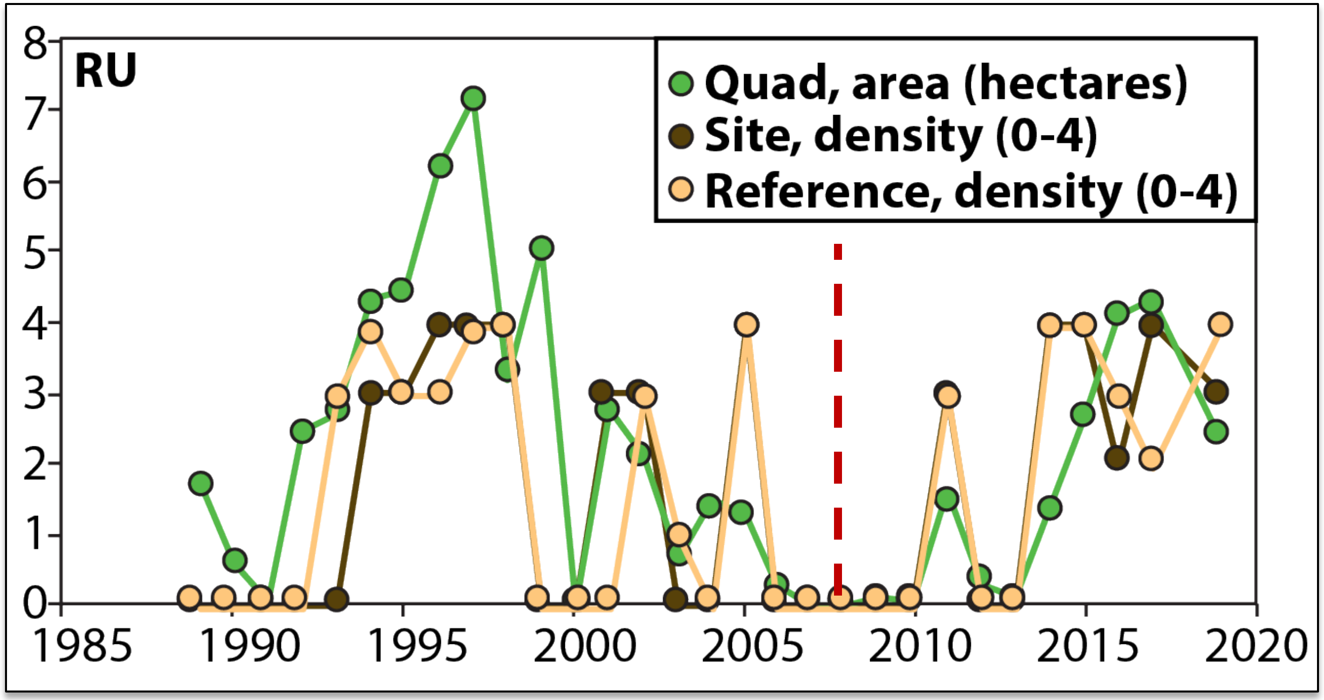


SAV offshore the living shoreline follows the region



Install 2008 (red line)

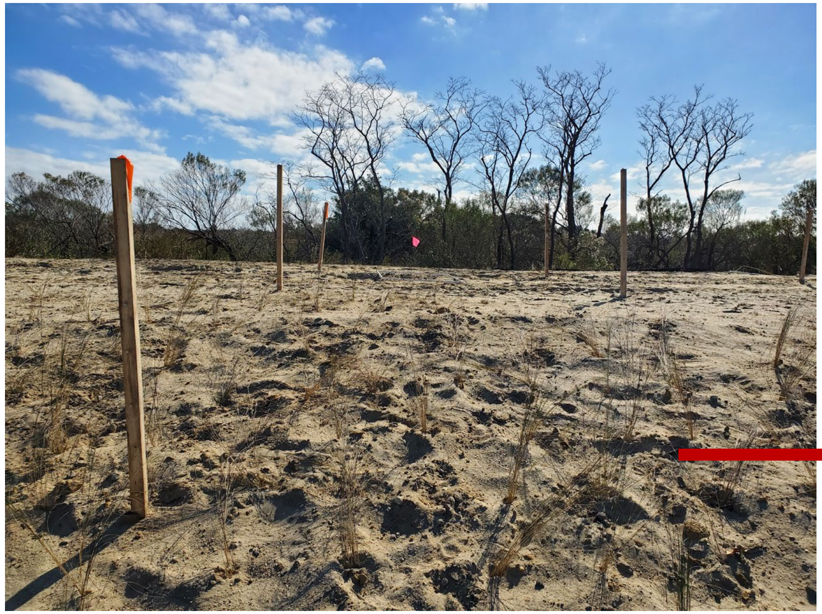
SAV at the reference shoreline also follows the general trend



Install 2008 (red line)

SAV offshore of all shorelines seems to follow the trend in the larger area, with no obvious impact of living shoreline installation.

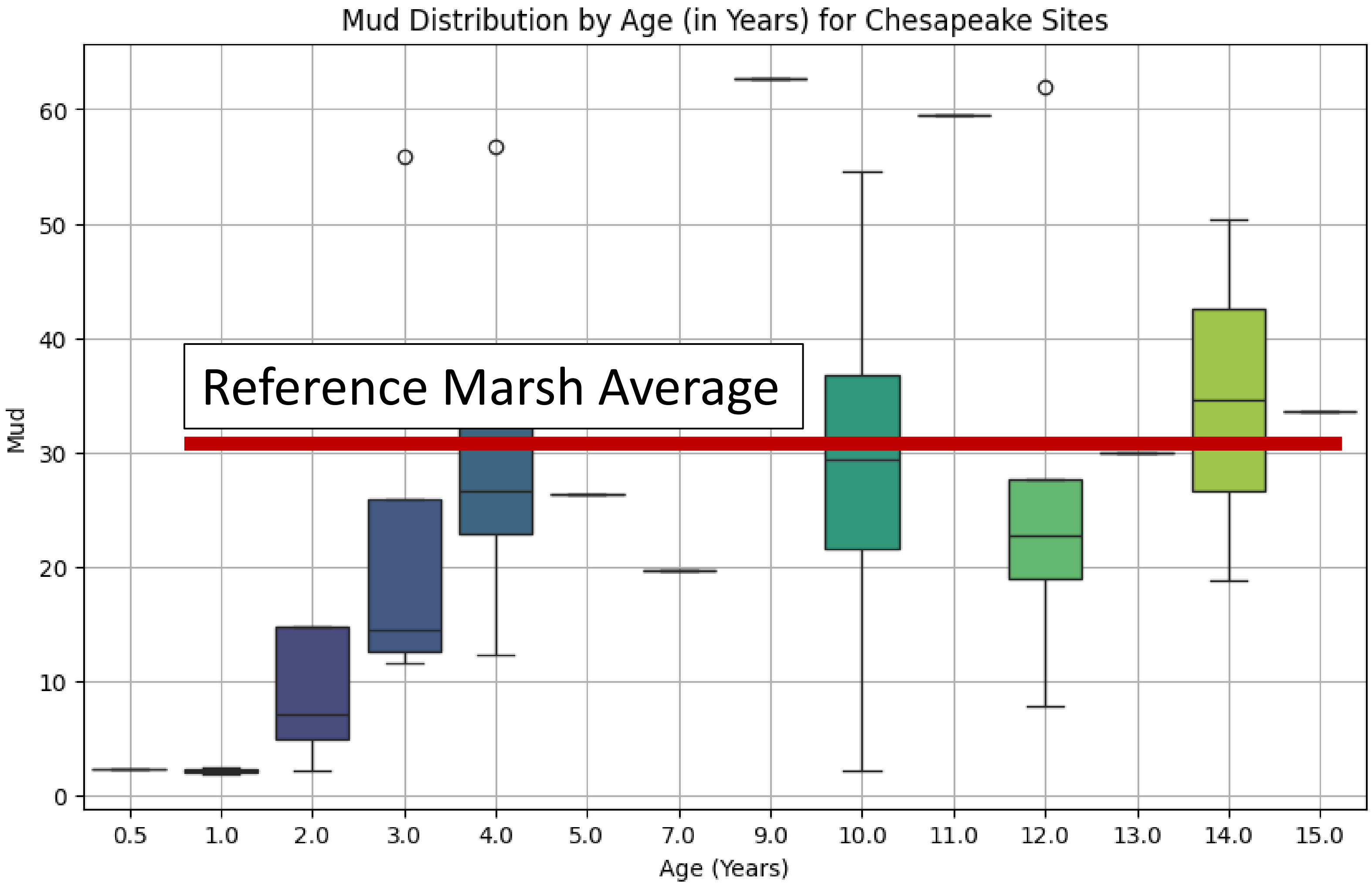
3) How do sediment and plant characteristics change as living shorelines age?



Hurst Creek – October 2022
After initial planting

Hurst Creek – natural marsh

How do sediment and plant characteristics change as living shorelines age?



4) Does design matter?

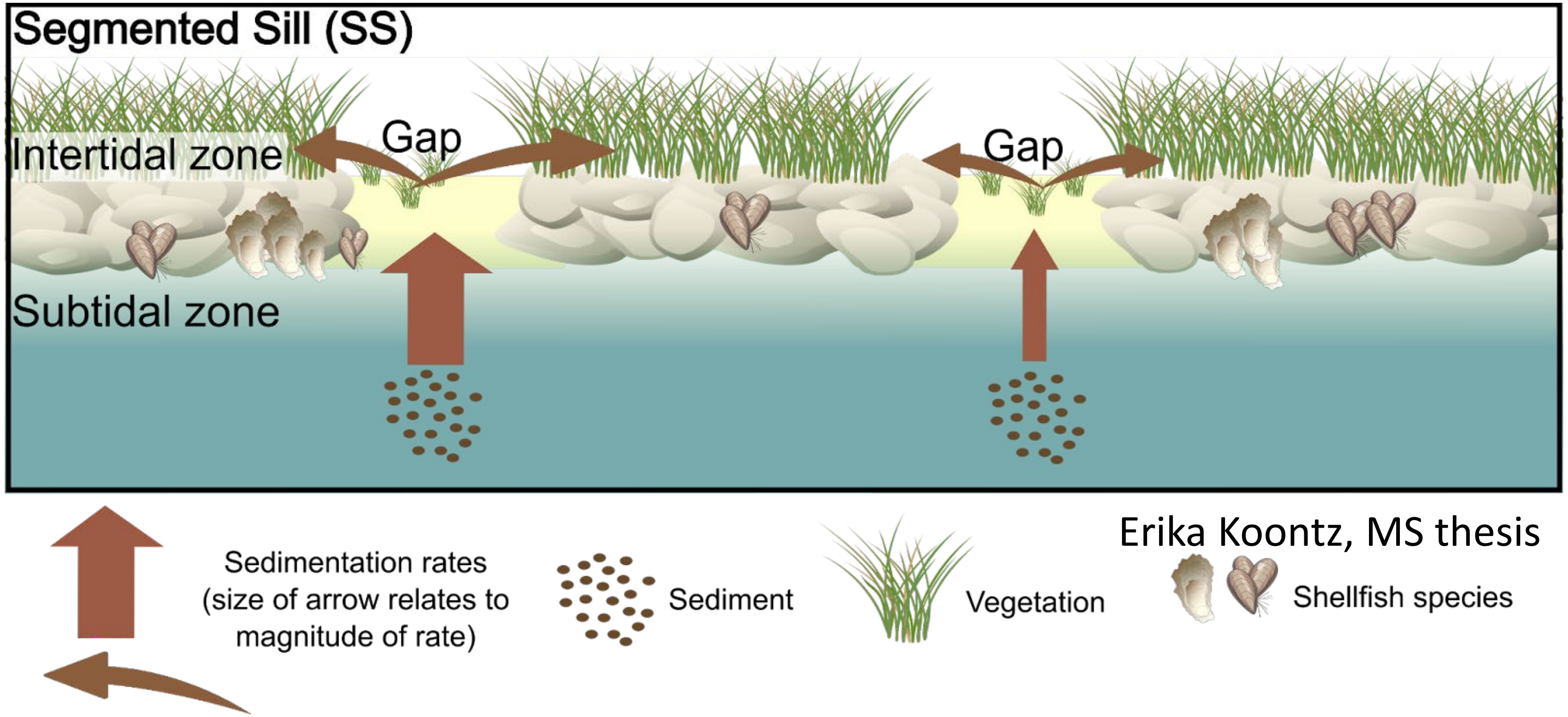
OP – continuous sill

Oxford Park – segmented sill

Gaps connect land and water, similar to natural shorelines

Artwork by Talia Mastalski; MD Sea Grant

Erosion and fewer plants in the gaps, healthy marshes behind the rocks



Erika Koontz, MS thesis

But overall performance is (about) the same!

Our answers so far…

1. Do living shorelines “work” – reduce erosion?
Yes! Erosion continues at reference shorelines, installation builds living shorelines out into the water, after which shorelines stabilize

2. What happens to SAV* after installation? (*offshore of project footprint)
Nothing; SAV mainly follows regional trends before and after installation

3. How do sediment and plant characteristics change as living shorelines age?
Sediment gets muddier and plants get denser, becoming more like a natural marsh; stabilize ~8-10 years after installation

4. Does design matter?
Segmented sill designs have erosion hotpots in the gaps, but overall performance (stable shoreline position and created marsh area) is similar to continuous sills

Assessing Habitat Function as a Co-Benefit of Living Shorelines

Kenneth Rose
France-Merrick Professor in Sustainable Ecosystem Restoration
Horn Point Laboratory
University of Maryland Center for Environmental Science

BS, Mathematics and Biology, SUNY at Albany
MS and PhD, Fisheries, University of Washington
Research Scientist, Environmental Sciences, Oak Ridge National Laboratory
Professor/Associate Dean, College of the Coast and Environment, Louisiana State University
France-Merrick Professor in Sustainable Ecosystem Restoration, Horn Point Lab, UMCES

Introduction

- Co-benefits
  - Win-win
- Focus on habitat
  - Flood protection
  - Reducing shoreline erosion
  - Hybrid structures
- Quick view of methods

ANNUAL REVIEW OF MARINE SCIENCE

Performance Evaluation of Natural and Nature-Based Features for Coastal Protection and Co-Benefits

Matthew A. Reidenbach,[1] Ming Li,[2] Kenneth A. Rose,[2] Tori Tomiczek,[3] James Morris,[4] Cindy M. Palinkas,[2] Lorie W. Staver,[2] William Nardin,[2] Matthew W. Gray,[2] Serena B. Lee,[5] Ariana E. Sutton-Grier,[6] and Amy M. Hruska[7]

Table 2 Categories of ecosystem services or co-benefits and example metrics influenced by NNBF

Service/co-benefit	Source[a]	Example metric(s)[b]
Biodiversity	(*a*) Maintenance of wildlife (*b*) +, ecological functionality (*c*) Ecosystem resilience (*d*) + (*e*) + (*f*) +, habitat connectivity	■ Species richness, evenness, and diversity at different trophic levels ■ Presence of bird species within project ■ Annual coverage area by vegetation ■ Modeling and telemetry for connectivity ■ Use of project by special-status species
Raw materials	(*b*) +	■ Annual biomass harvested by vegetation type for external uses
Food production	(*a*) Fisheries (*c*) + (*d*) Harvested fish and wildlife	■ Quantify enhancement of habitats for economically important fish/shellfish ■ Presence of forage within project area ■ Ease of access to fishing locations
Habitat	(*b*) Natural resources preservation (*d*) +, TES species (*e*) +, invasive species, reduced conflicts over resources	■ Percentage of marsh that is native species ■ Shoot density of marsh vegetation ■ Quality and quantity of habitat added by project using suitability models ■ Percentage of day habitats are inundated ■ Oyster reef area and height
Nutrient and sediment cycling	(*a*) Nutrient cycling (*b*) Hydrologic regulation (*c*) Erosion control (*d*) Erosion control, nutrient sequestration or conversion (*e*) Erosion control	■ Nitrogen, phosphorus, and sediment concentrations entering/exiting project ■ Retention rates of forms of nutrients and sediments by the project ■ Changes in shoreline-change rates and Relative Exposure Index
Water quality	(*a*) Water purification (*c*) + (*d*) Maintenance of suspended sediments, reduction of toxic materials, clean water provisioning (*e*) +, algal blooms, sewage and storm water management (*f*) +, soil/sediment health	■ Dollars saved by stormwater management reducing treatment ■ Reduction in annual loadings of nutrients to local receiving waters due to project ■ Bulk density of bottom soils within project

Table 2 (*Continued*)

Service/co-benefit	Source[a]	Example metric(s)[b]
Tourism	(*a*) + (*c*) + (*d*) + (*f*) +	■ Dollars from visitation of businesses ■ Annual number of out-of-area visitors ■ Use of Recreational Opportunity Spectrum to, e.g., assess project naturalness
Recreation	(*a*) + (*c*) +, recreation, health and well-being, noise reduction (*d*) + (*e*) +, public access, healthy living and well-being, leisure and nature views (*f*) +, health and well-being, noise reduction	■ Number of visitors to project ■ Number of recreational activity events ■ Number and activity levels of visitors ■ Catch rates of fish by visitors ■ Annual number of kayaks rented ■ Noise attenuation potential based on leaf biomass and canopy area
Education	(*a*) +, research (*c*)+ (*d*) + scientific opportunities (*e*) +	■ Annual number of students who use project through their school activities ■ Scientific products from research at project
Aesthetics	(*c*) +, amenity (*d*) + cultural heritage and identity (*e*) Heritage and culture	■ Ratio of green spaces to built structures ■ Conservation of historical or culturally important buildings or features

Achieving Water Quality Goals in the Chesapeake Bay: A Comprehensive Evaluation of System Response

An Independent Repor
Advisory Committee (S
Chesapeake Bay Prog
Annapolis, MD

May 2023

Scientific and Technica

Scientific and Technical Advisory Committee:
A Proposed Framework for Analyzing Water Quality and Habitat Effects on the Living Resources of Chesapeake Bay

Kenneth Rose[1], Mark E. Monaco[2], Tom Ihde[3], Jason Hubbart[4], Eric Smith[5], Jay Stauffer[6], Kirk Havens[7]

[1]University of Maryland Center for Environmental Science, [2]National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, [3]Morgan State University, Patuxent Environmental and Aquatic Research Laboratory, [4]West Virginia University, [5]Virginia Tech, [6]Penn State University, [7]Virginia Institute of Marine Science

May 2023

stac

STAC Publication 23-005

JAWRA

JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION

OCTOBER 2023

AMERICAN WATER RESOURCES ASSOCIATION

Research Article

A Framework for Prioritization and Assessment of Restoration Actions Based on Living Resources: An Illustration Using the Chesapeake Bay

Kenneth A. Rose, Horn Point Lab, University of Maryland Center for Environmental Science, Cambridge, MD 21613 krose@umces.edu, https://orcid.org/0000-0002-9310-8410

Mark E Monaco, National Centers for Coastal Ocean Science, NOAA, Silver Spring, MD 20910, mark.monaco@noaa.gov

Thomas F. Ihde, Morgan State University, Patuxent Environmental and Aquatic Research Laboratory (PEARL), St. Leonard, MD 20685, thomas.ihde@morgan.edu

Eric P. Smith, Department of Statistics, Virginia Tech, Blacksburg, VA 24060, epsmith@vt.edu

Jay R. Stauffer Jr., Department of Ecosystem Science and Management, Penn State University, University Park, PA 16802 and Honorary Research Associate South African Institute for Aquatic Biodiversity, Makhanda, SA, vc5@psu.edu

Kirk J. Havens, Center for Coastal Resources Management, Virginia Institute of Marine Science, William & Mary, Gloucester Point, VA 23062, kirk@vims.edu

Lee McDonnell, U.S. EPA Chesapeake Bay Program Office, Environmental Protection Agency Region 3, 1750 Forest Drive, Suite 130, Annapolis, MD 21401, McDonnell.Lee@epa.gov

Lewis C. Linker, U.S. EPA Chesapeake Bay Program Office, Environmental Protection Agency Region 3, 1750 Forest Drive, Suite 130, Annapolis, MD 21401, linker.lewis@epa.gov

Kaylyn S. Gootman, U.S. EPA Chesapeake Bay Program Office, Environmental Protection Agency Region 3, 1750 Forest Drive, Suite 130, Annapolis, MD 21401, Gootman.Kaylyn@epa.gov

Ecological Modelling 300 (2015) 12–29

Contents lists available at ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel

ELSEVIER

Proposed best modeling practices for assessing the effects of ecosystem restoration on fish

CrossMark

Kenneth A. Rose[a,*], Shaye Sable[b], Donald L. DeAngelis[c], Simeon Yurek[d], Joel C. Trexler[e], William Graf[f], Denise J. Reed[g]

Climate-Resilient Restoration and Mitigation Strategies for Columbia River Basin Fish and Wildlife

INDEPENDENT SCIENTIFIC ADVISORY BOARD

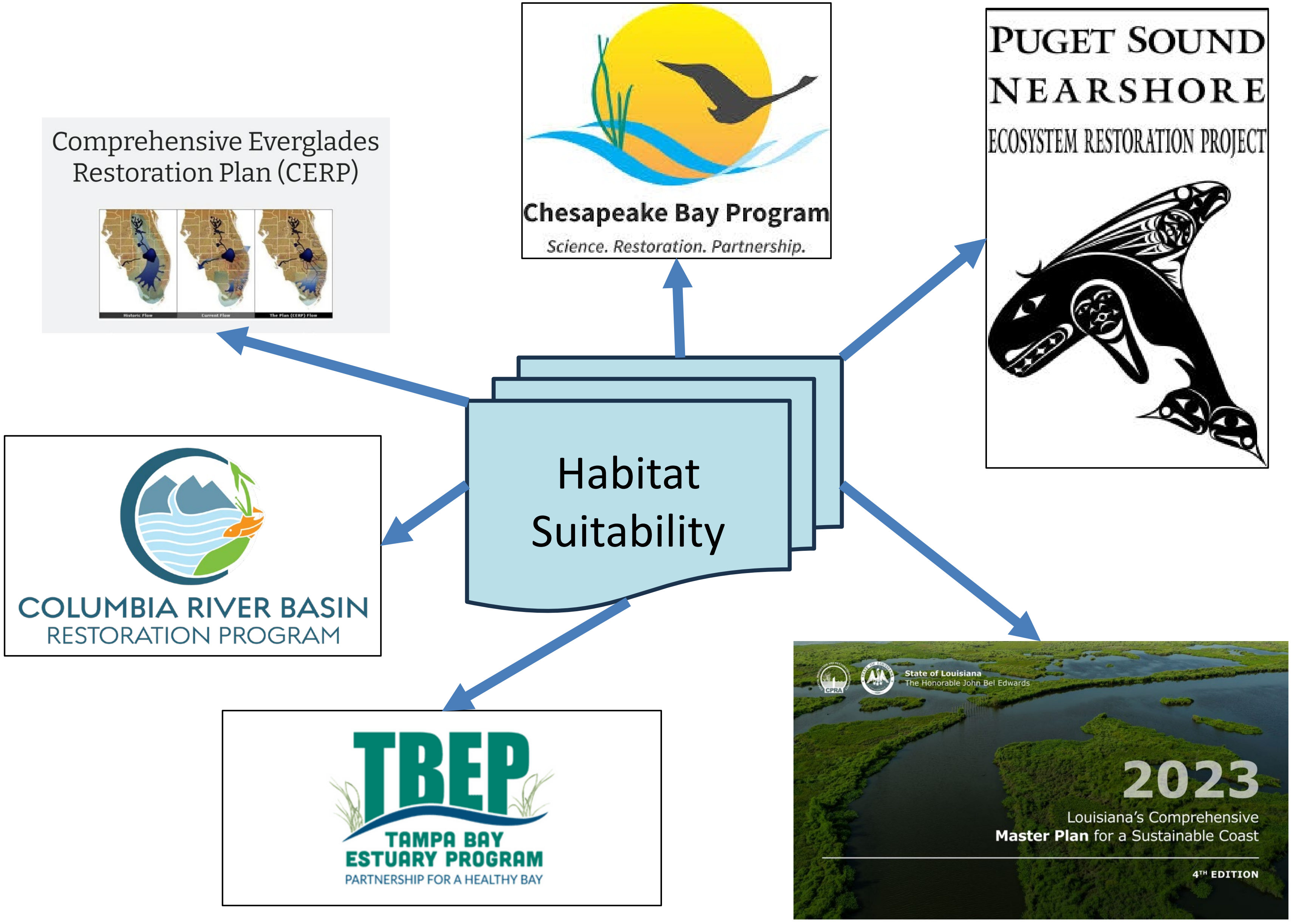
ISAB 2025-2 SEPTEMBER 30, 2025

ICES CIEM

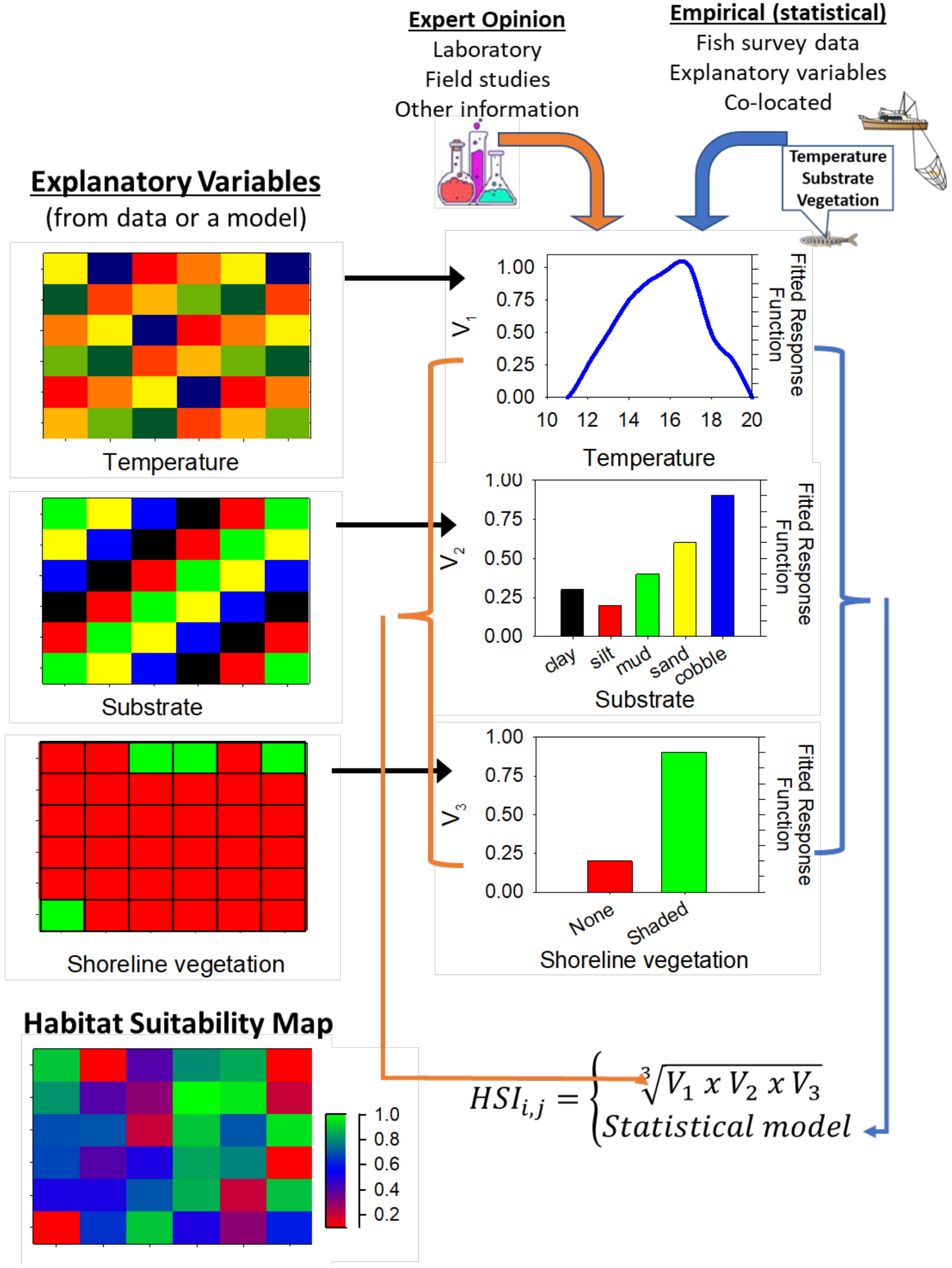
WORKING GROUP ON THE VALUE OF COASTAL HABITATS FOR EXPLOITED SPECIES (WGVHES; outputs from 2024 meeting)

NSF U.S. National Science Foundation

Advancing Interdisciplinary Research to Build Resilient Communities and Infrastructure in the Nation's Estuaries and Bays



Comprehensive Everglades Restoration Plan (CERP)
Chesapeake Bay Program
Science. Restoration. Partnership.
PUGET SOUND NEARSHORE
ECOSYSTEM RESTORATION PROJECT
Habitat Suitability
COLUMBIA RIVER BASIN
RESTORATION PROGRAM
TBEP
TAMPA BAY ESTUARY PROGRAM
PARTNERSHIP FOR A HEALTHY BAY
State of Louisiana
The Honorable John Bel Edwards
2023
Louisiana's Comprehensive
Master Plan for a Sustainable Coast
4TH EDITION

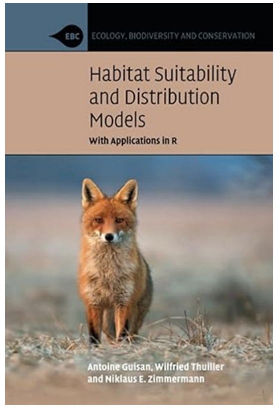



River Research and Applications

SPECIAL ISSUE PAPER | Full Access

History and review of the habitat suitability criteria curve in applied aquatic ecology

John M. Nestler, Robert T. Milhous, Thomas R. Payne, David L. Smith



frontiers in Marine Science

ORIGINAL RESEARCH
published: 12 October 2021
doi: 10.3389/fmars.2021.706666

The Extent of Seasonally Suitable Habitats May Limit Forage Fish Production in a Temperate Estuary

Mary C. Fabrizio[1], Troy D. Tuckey[1], Aaron J. Bever[2] and Michael L. MacWilliams[2]*

[1] Department of Fisheries Science, Virginia Institute of Marine Science, William & Mary, Gloucester Point, VA, United States,
[2] Anchor QEA, LLC, San Francisco, CA, United States

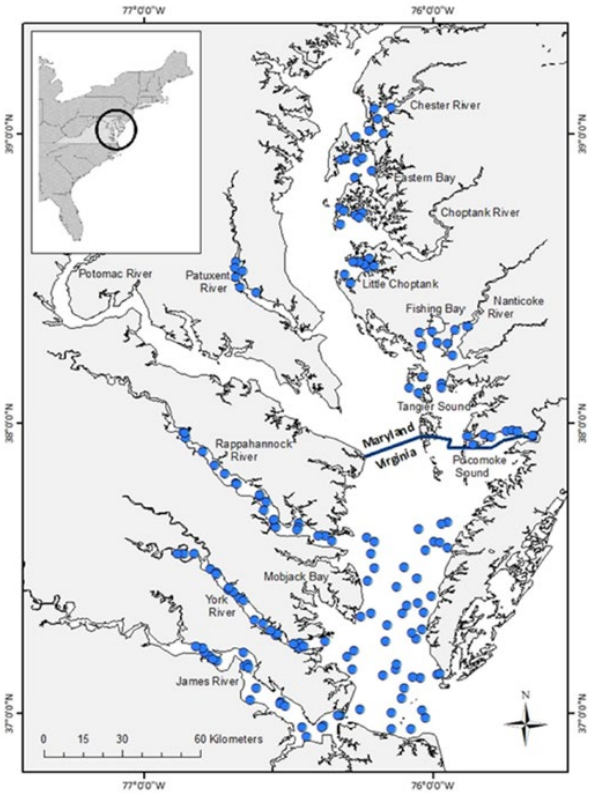


FIGURE 1 | Sites (filled circles) sampled to assess relative abundance of forage fishes in Chesapeake Bay, 2000–2016. Sites in Virginia waters were sampled monthly from a random stratified survey design; sites depicted in the figure are from a representative month and year (October 2020). Fixed sites were sampled monthly between May and October in Maryland waters of Chesapeake Bay.

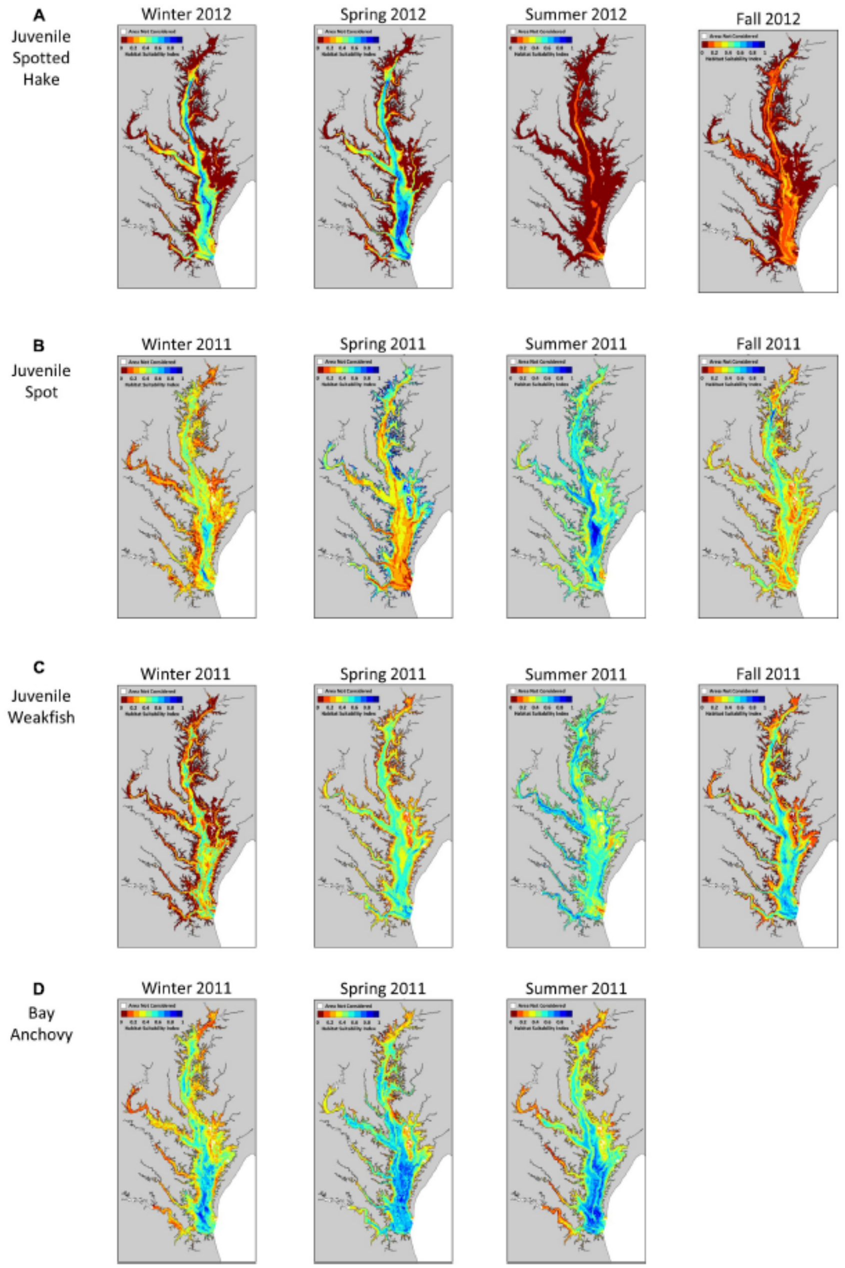


FIGURE 5 | Representative examples of seasonal variation in habitat suitability for **(A)** juvenile spotted hake, **(B)** juvenile spot, **(C)** juvenile weakfish, and **(D)** bay anchovy in Chesapeake Bay. The habitat suitability index ranges from 0 (red) indicating poor habitat to 1 (blue) indicating most suitable habitat.

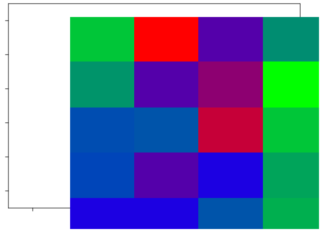
Habitat Suitability

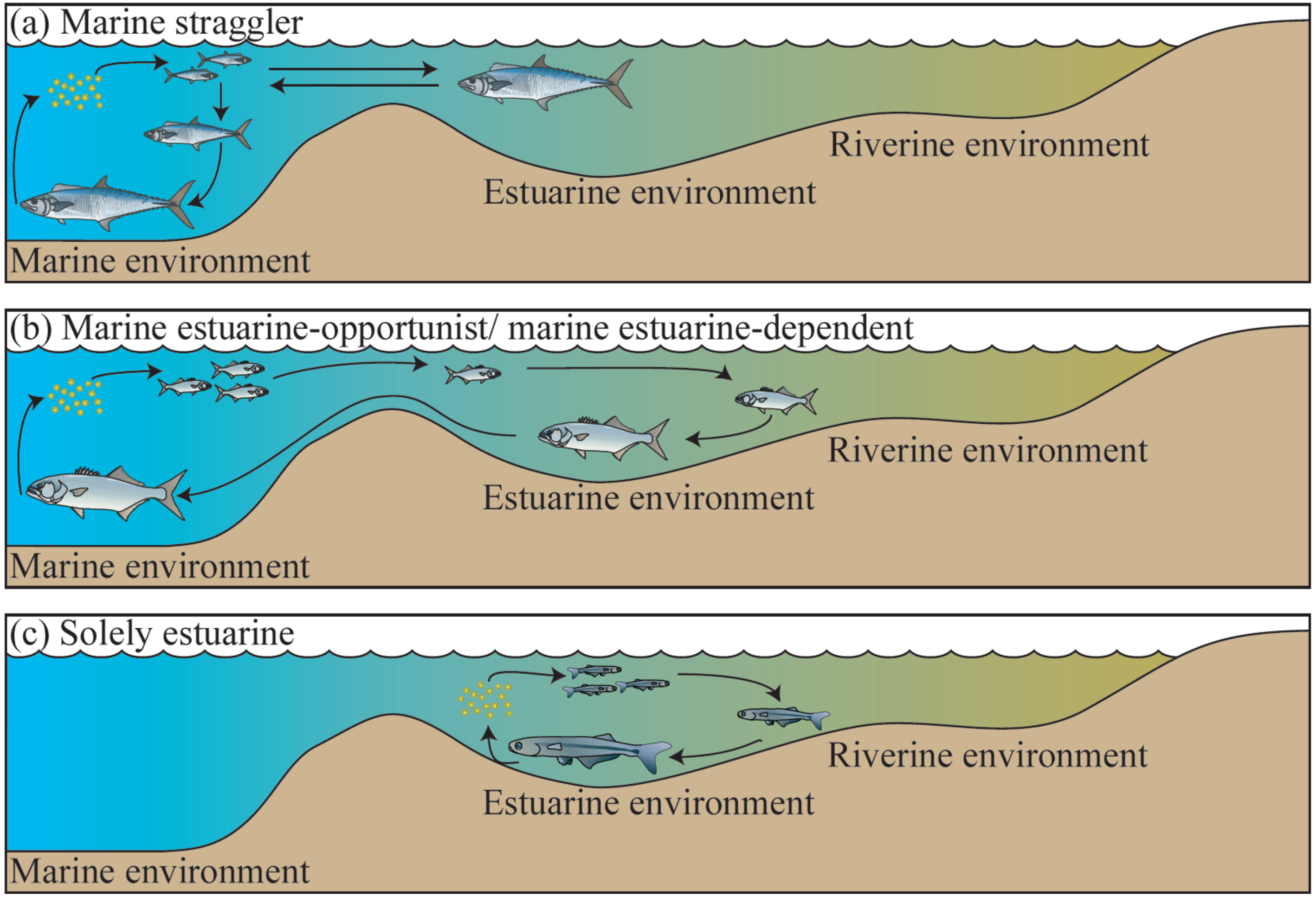
Advantages

- Information is available for Chesapeake Bay
- Habitat is recognized as important
- Essential Fish Habitat
- Relatively high confidence
- "Quick" and conceptually simple

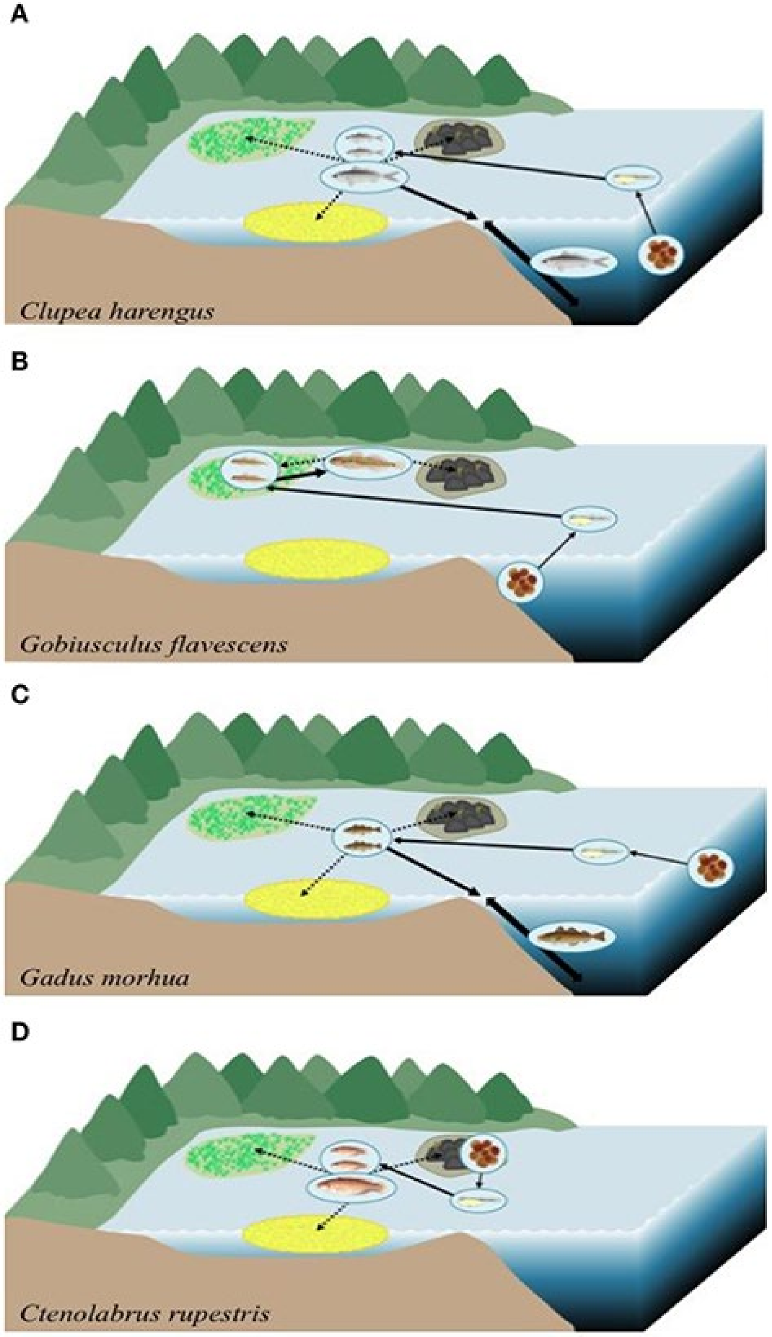
Limitations

- Some mismatch in scales
- Need ecological and management variables
- Challenged by novel situations
- Moderate relevance, acceptable for certain questions
- Capacity not biomass

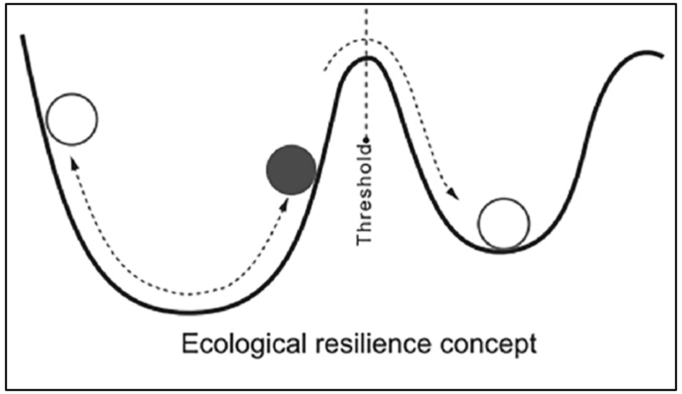


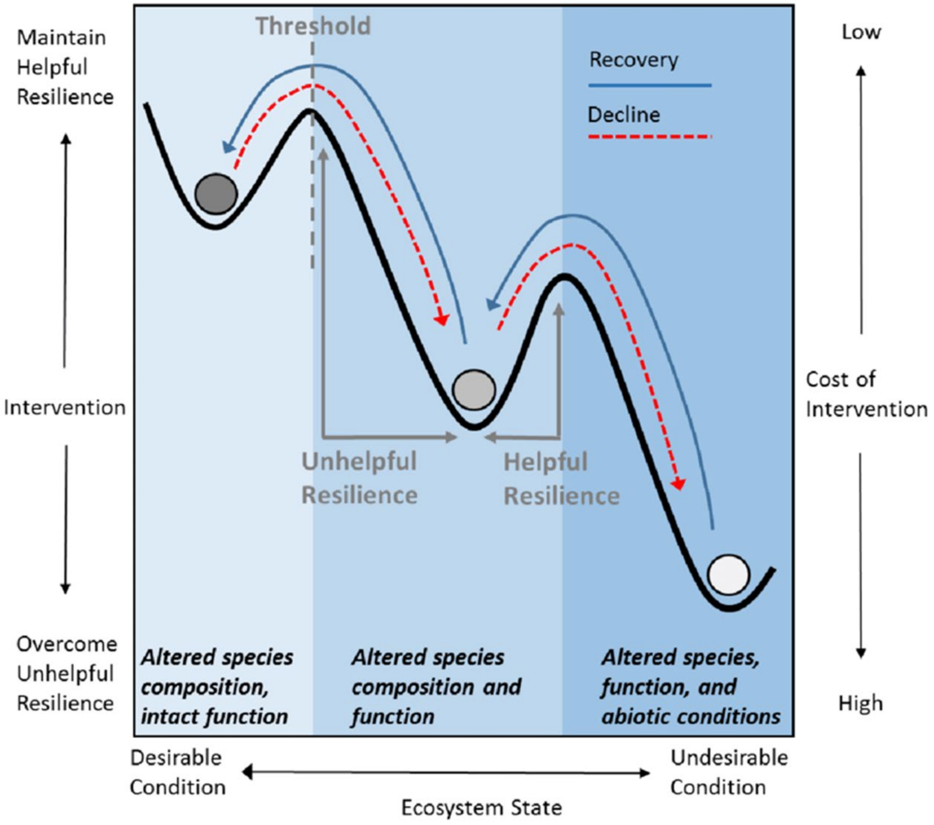


Potter, I.C., J.R. Tweedley, M. Elliott, and A.K. Whitfield (2015) The ways in which fish use estuaries: a refinement and expansion of the guild approach. *Fish and Fisheries* 16: 230-239.

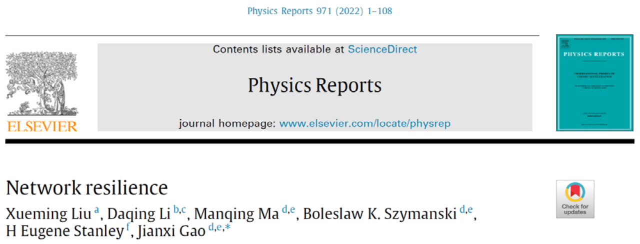


Perry, D., T.A.B. Stavely, and M. Gullstrom (2018) Habitat connectivity of fish in temperate shallow-water seascapes. *Frontiers in Marine Science* 4, article 440.





Holling, C.S. (1973) Resilience and stability of ecological systems. *Annual Review of Ecology, Evolution, and Systematics* 4: 1-23.


Physics Reports 971 (2022) 1–108

Contents lists available at ScienceDirect

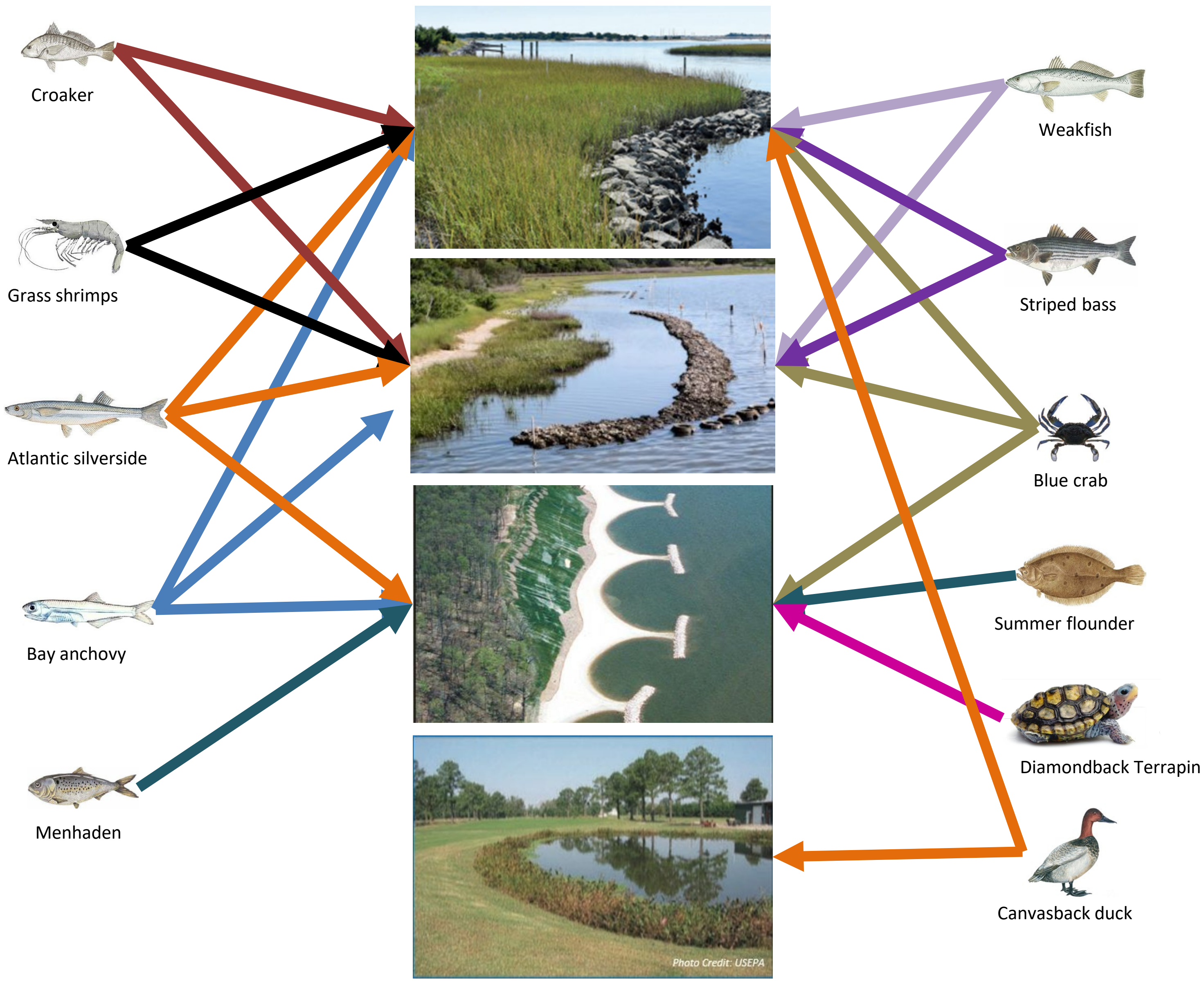
Physics Reports

journal homepage: www.elsevier.com/locate/physrep

Network resilience

Xueming Liu [a], Daqing Li [b,c], Manqing Ma [d,e], Boleslaw K. Szymanski [d,e], H Eugene Stanley [f], Jianxi Gao [d,e,*]

https://depositphotos.com/photo/moving-forward-street-sign-illustration-56325423.html



www.olentangywatershed.org

Bilovic & Mitchell. 2013. Mid-Atlantic Living Shorelines Summit.

coastalscience.noaa.gov/news/nccos-study-provides-evidence-better-fish-habitat-living-shoreline

Species	Stage	Now (Losses)				With Living Shoreline (Gains)					
		Open water	Bulk-head	Shore riprap	Bea ch	Protected open water	Marsh	Beach	Riprap wall	Tidal pond	Oyster reef

Square meters of suitability-weighted habitat

Species	Stage	Design A					
		Protected open water	Marsh	Beach	Riprap wall	Tidal pond	Oyster reef

Plus,

Screen for adequate connectivity

Assess resilience of the habitats

Anna Johnson
Senior Project Engineer

Anna Johnson is a Senior Project Engineer with 15 years of experience in coastal engineering analysis and design. She has gained technical expertise through working on a variety of projects along the Gulf of Mexico, the North American West Coast in California, Oregon, British Columbia, and Mexico and the Chesapeake Bay. She earned her MSc in Coastal Engineering and Management from Delft University of Technology in Delft, the Netherlands. She is an expert in coastal modeling and design and has applied her expertise to shoreline projects across the Chesapeake Bay for the last 7 years. She specializes in climate resiliency and has earned her credentials as a Climate Change Professional (CC-P®) through training at the Maryland Climate Academy. She is an expert in climate change adaptation measures and has assisted multiple public and private sector clients and non-profit organizations in developing and implementing coastal resiliency plans and projects.

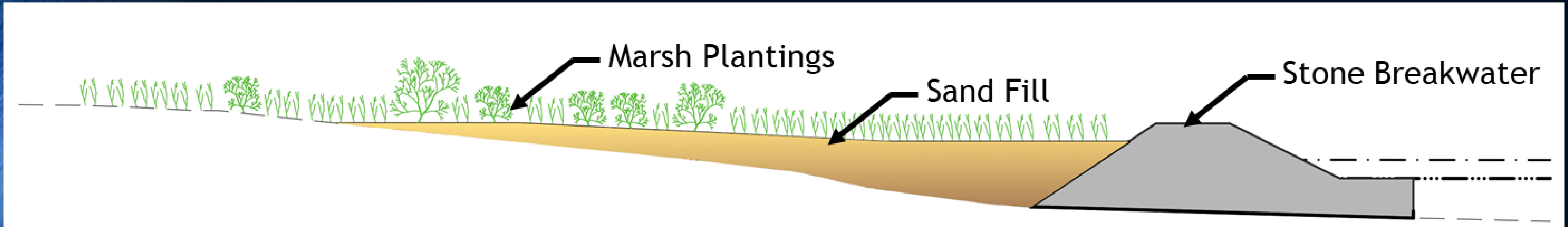
BayLand

Living Shorelines

BayLand Consultants & Designers, Inc.
"Integrating Engineering and Environment"
7455 New Ridge Road, Suite T
Hanover, Maryland 21076
Phone: (410) 694-9401
Fax: (410) 694-9405

Living Shoreline Materials

- Required:
  - Beach or Marsh Substrate – Sand
- Optional Components
  - Protection Structure – Stones, Reefs, Coir Logs, Dead Trees, Oyster Bags, Manufactured Modules
  - Vegetation – Marsh and Beach grasses



Protection Structures


Stones Sills/ Breakwaters


Woody Debris


Oyster Bags


Vegetated Headlands


Concrete Modules


Coir Logs

Shoreline Substrate

Dense Marsh Vegetation

Sandy Beach Area

Cobble/ Pebble Beach Area

Vegetated Cobble/ Pebble Beach Area

Mixed Habitat

Transitional Area

Living Shoreline Alignments


Continuous Sill along Shoreline

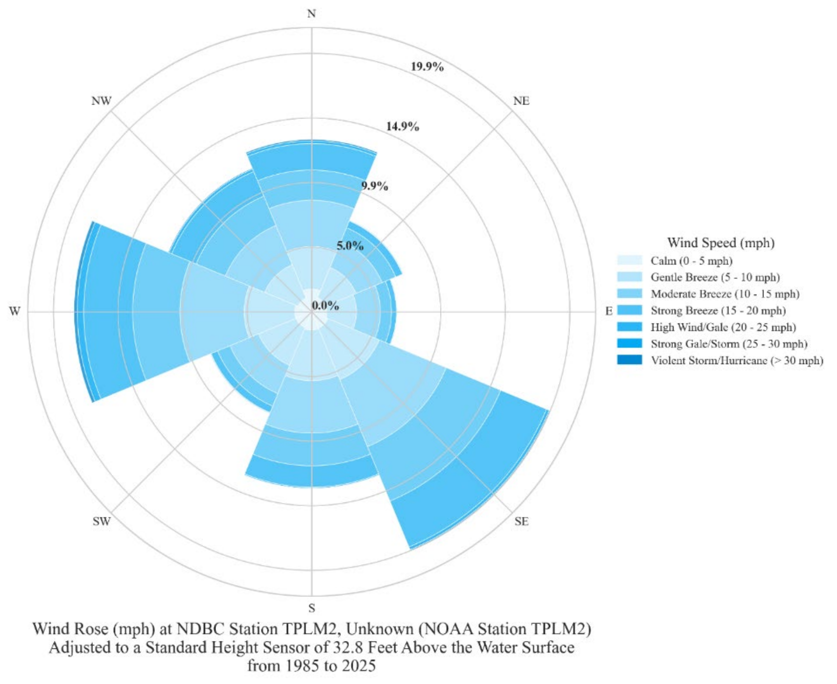

Segment Sill following Shoreline Alignment

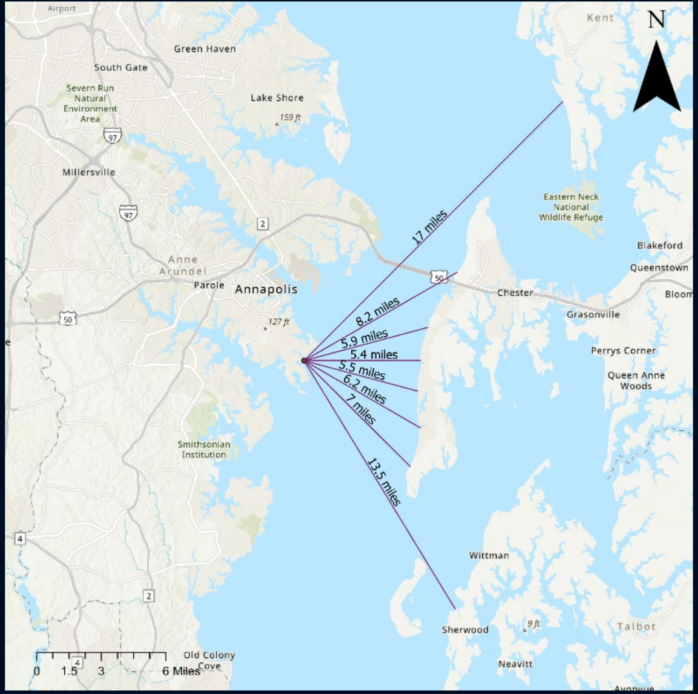

Straight Segment Sills

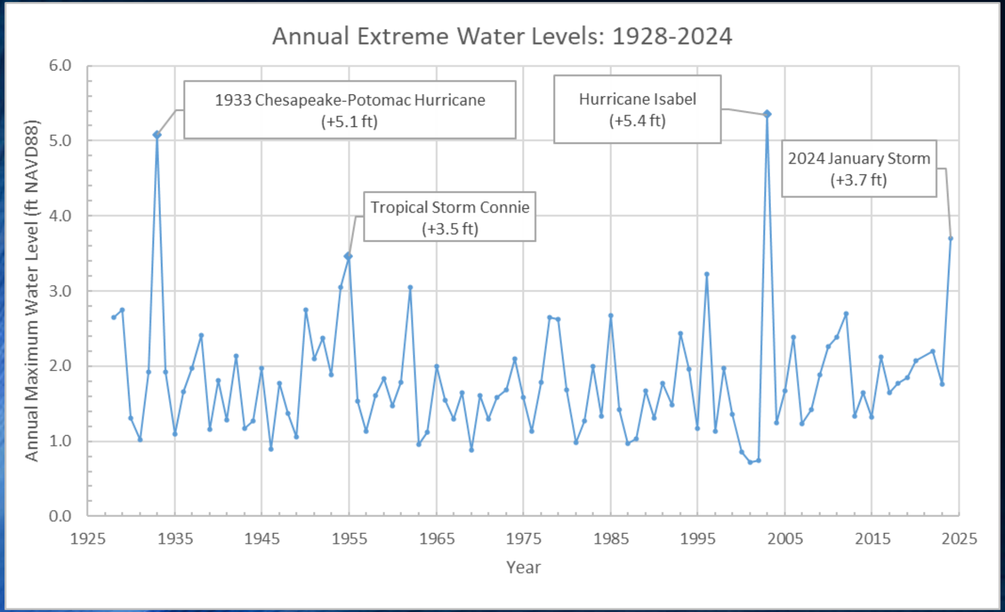

Offshore Breakwaters for More Shallow Water

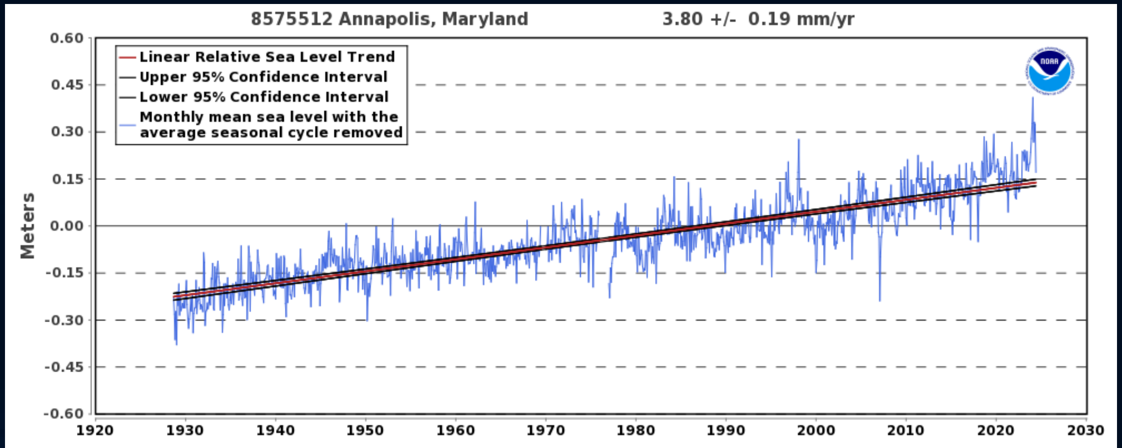
Coastal Analysis

- **Wind-generated waves along Longest Fetch**
- **Storm Surges (25-year)**
- **Sea Level Rise (2050)**









Engineering Analysis

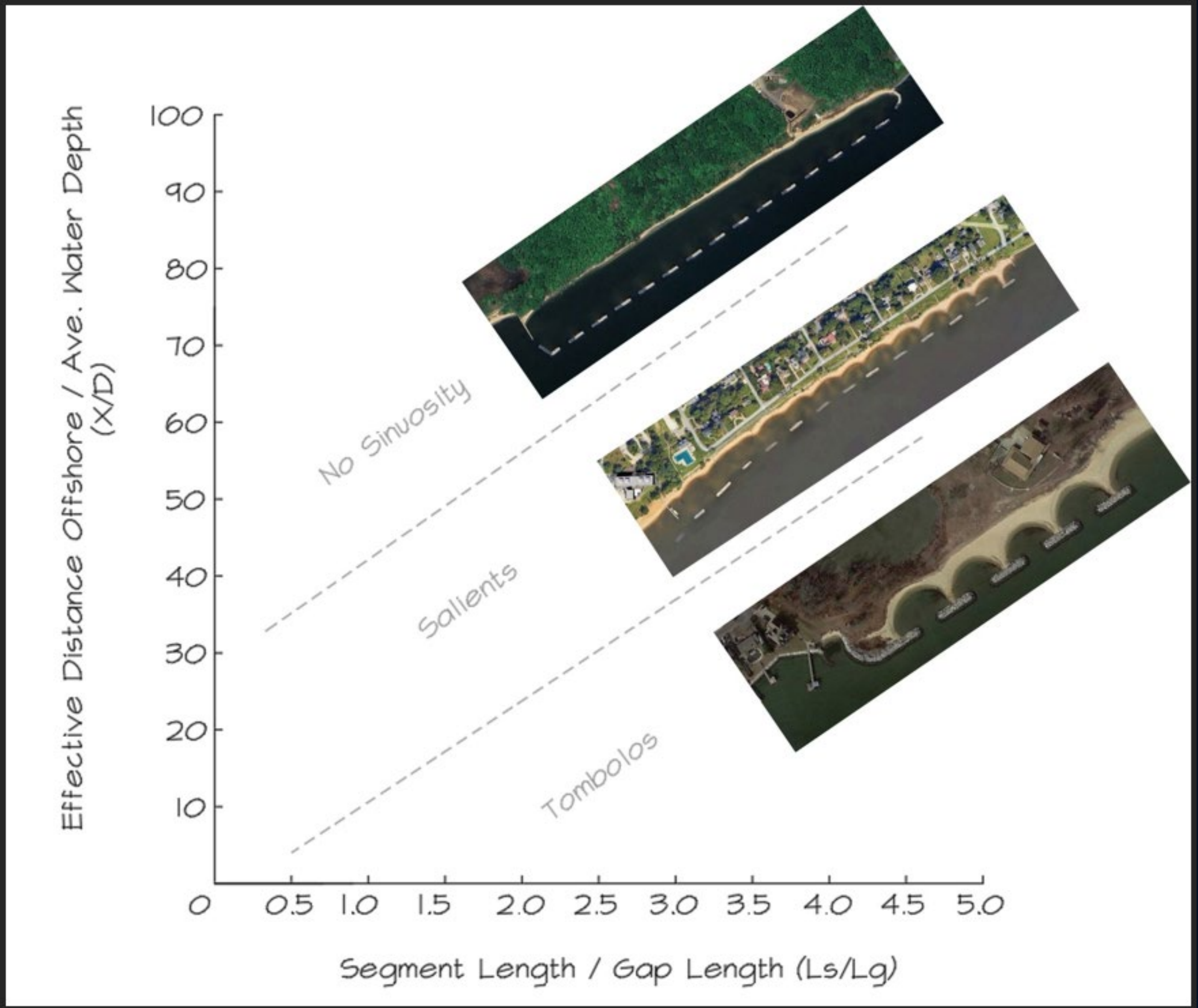


Figure 43 - Shoreline Response Relative to Breakwater Configuration after Pope and Dean (1986)

Ahrens and Cox (1990) proposed a beach response index (I_s) based on the ratio of breakwater length to breakwater distance from the original shoreline. The beach response index proposed the following classifications:

$$I_s = e^{\left(1.72 - 0.41 \times \frac{L_S}{X}\right)}$$

where:

$$L_S = Length\ of\ Structure$$
$$X = Distance\ to\ Shoreline$$

Response:

$$I_s = 1 \rightarrow Permanent\ tombolo\ formation$$
$$I_s = 2 \rightarrow Periodic\ tombolos$$
$$I_s = 3 \rightarrow Well - developed\ salients$$
$$I_s = 4 \rightarrow Subdued\ salient$$
$$I_s = 5 \rightarrow No\ sinuosity$$

Construction

- Access
  - Material and equipment by land or water
- Equipment
  - Excavator
  - Bulldozer for sand grading
  - Tug Boat
  - Supply Barge
  - Deck Barges
- Cost to Implement
  - Average $500 - $1200/foot

NEXT STEPS

- RECORDING AVAILABLE ON THE PROJECT WEBSITE

  WWW.MAKECAMBRIDGERESILIENT.ORG

- 2026 PUBLIC EDUCATION SESSION ARE BEING PLANNED

CONTACTS

PROJECT MANAGER

LARRY WHITE

LAWHITEPE@AOL.COM

PUBLIC OUTREACH LEAD

VIRGINIA SMITH

VSMITH@SMITHP-D.COM