Habitat Restoration and Living Shoreline Oyster Reefs at Naval Weapons Station Yorktown and Penniman Spit, York River

Project Site Visit

1 May 2024

<u>PIs</u>: Rom Lipcius[1], Russ Burke[2], Rochelle Seitz[1], Scott Hardaway[1], Donna Milligan[1]

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Partnerships/Funding

VIMS | William & Mary
Virginia Institute of Marine Science

Department of Defense
United States of America

The PEW Charitable Trusts

Christopher Newport University

National Fish and Wildlife Foundation
NFWF

National Oceanic and Atmospheric Administration
NOAA
U.S. Department of Commerce

US Army Corps of Engineers
Norfolk District

National Park Service
Department of the Interior

CBTRUST
Chesapeake Bay Trust

Virginia
Marine Resources Commission

Agenda

Andrews Hall room 326

1. Introduction and Overview (Lipcius)

2. Update on NWSY subtidal reefs (Lipcius)

3. Update on VIMS subtidal reefs (Seitz)

4. Update on living shoreline intertidal reefs (Burke)

5. Update on Penniman Spit construction (Milligan)

Field demonstrations - Drive to sites

6. Demonstration of VIMS subtidal reefs (VIMS Beach)

7. View of restoration sites at NWSY

LAND RESTORATION, SHORELINE PROTECTION AND BASE RESILIENCE AT REPI SITE NAVAL WEAPONS STATION YORKTOWN

Goals: 2020 - 2026

1. Prepare engineer design plans for all phases. ✅

2. Acquire all Federal and State permits and Navy site approvals for all phases. ✅

3a. Construct subtidal living shoreline structures at VIMS. ✅

3b. Monitor subtidal living shoreline structures at VIMS (year 1). ✅

3c. Monitor subtidal living shoreline structures at VIMS (year 2/3).

4a. Construct intertidal and subtidal living shoreline structures at NWSY R3 and Penniman Spit. ✅

4b. Monitor intertidal and subtidal living shoreline structures at NWSY R3 and Penniman Spit.

5. Construct shoreline erosion structures and restore eroded sections of Penniman Spit.

6. Perform baseline surveys at Penniman Spit and control sites (BACI design). ✅

6. Perform monitoring surveys at Penniman Spit and control sites (BACI design).

7. Conduct year 2/3 monitoring surveys at R3 Pier and Penniman Spit.

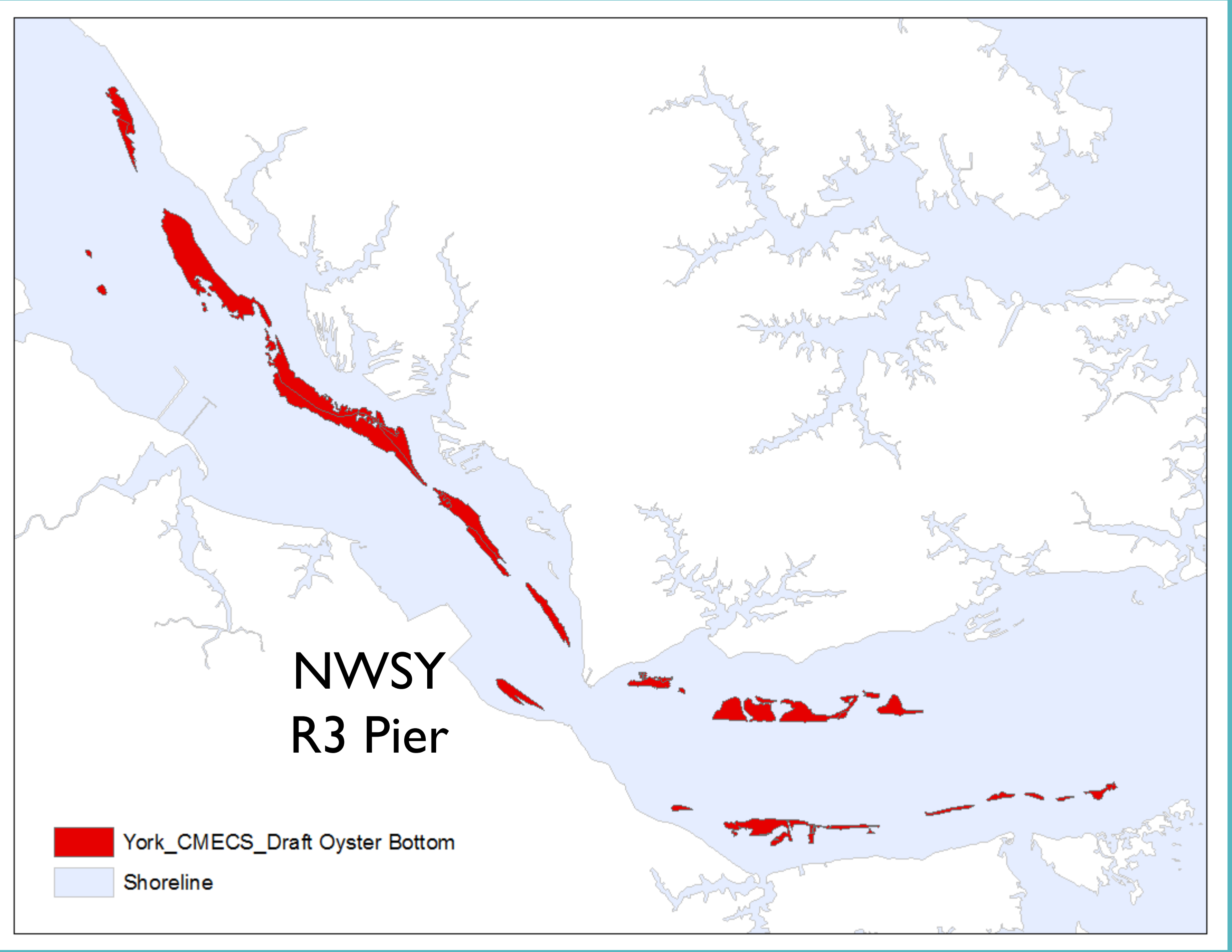
Location: Naval Weapons Station Yorktown, York River

Figure 1. Shore change at Penniman Spit on the York River (Milligan et al., 2010; Milligan et al., 2018).

BACI DESIGN; PRE-CONSTRUCTION MONITORING OF AN ECOTONE

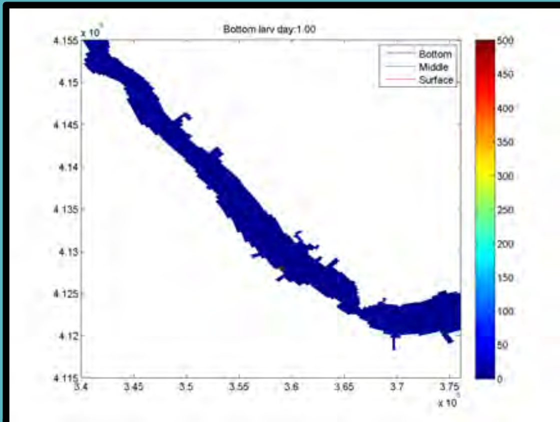
- **Salt marsh/shoreline erosion under high wave energy conditions and sea level rise**
- **Loss of protection for lower energy, productive ecotone--inner cove and creek systems**
- **Loss of nursery habitat for blue crab, white shrimp, and finfish**
- **Loss of trophic subsidies from marsh, cove and creek residents (e.g. clams, mummichogs, silversides, crabs, shrimp) to higher trophic levels**
- **Loss of oyster reefs and habitat important for ecosystem and tourism**

CMECS OYSTER SUBSTRATE

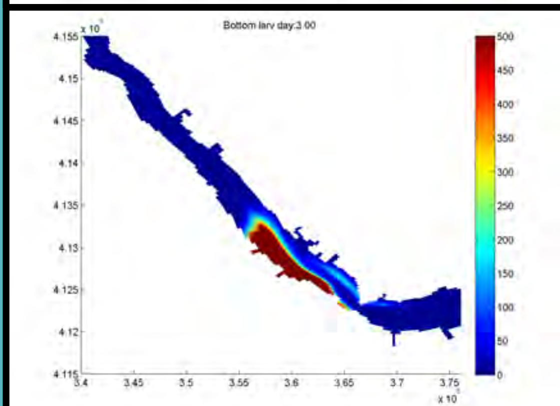


Structures benefitting oyster restoration in York River

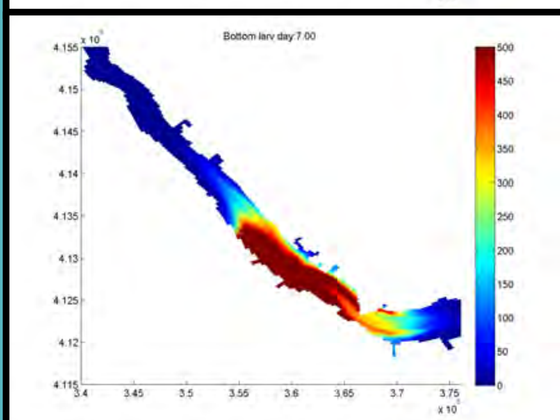
Day 1



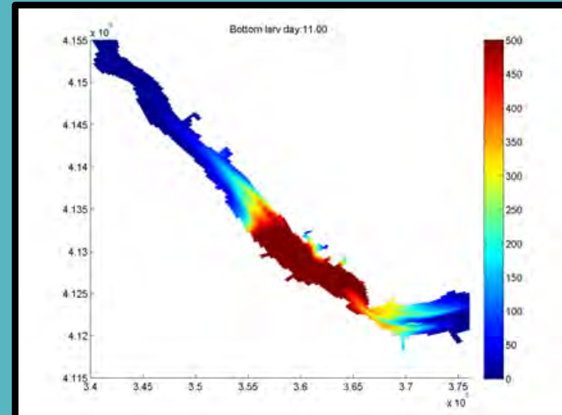
Day 3



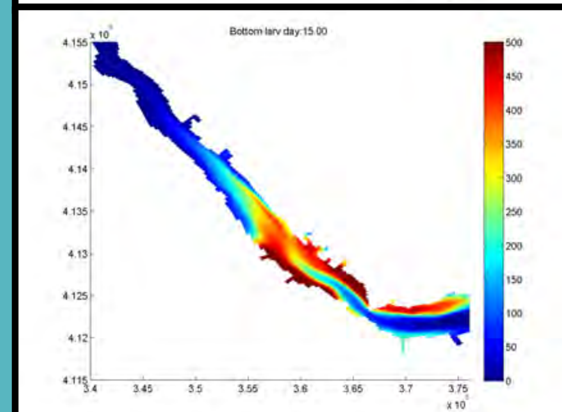
Day 7



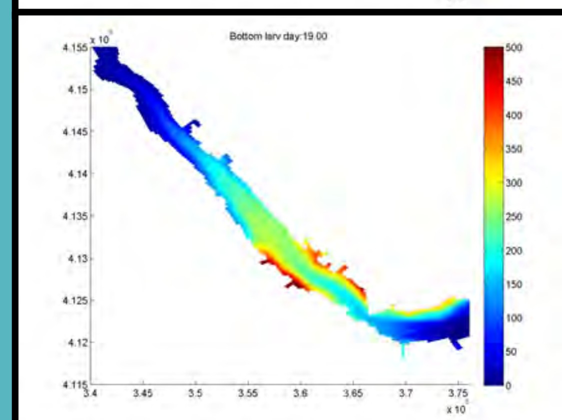
Day 11



Day 15

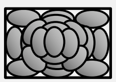


Day 19

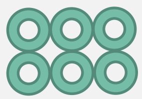


Subtidal Reef Legend

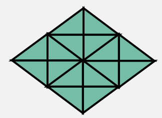
Each reef is on ~12 square feet of river bottom.



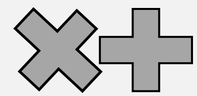
Granite/Class 1A Riprap



Concrete Domes

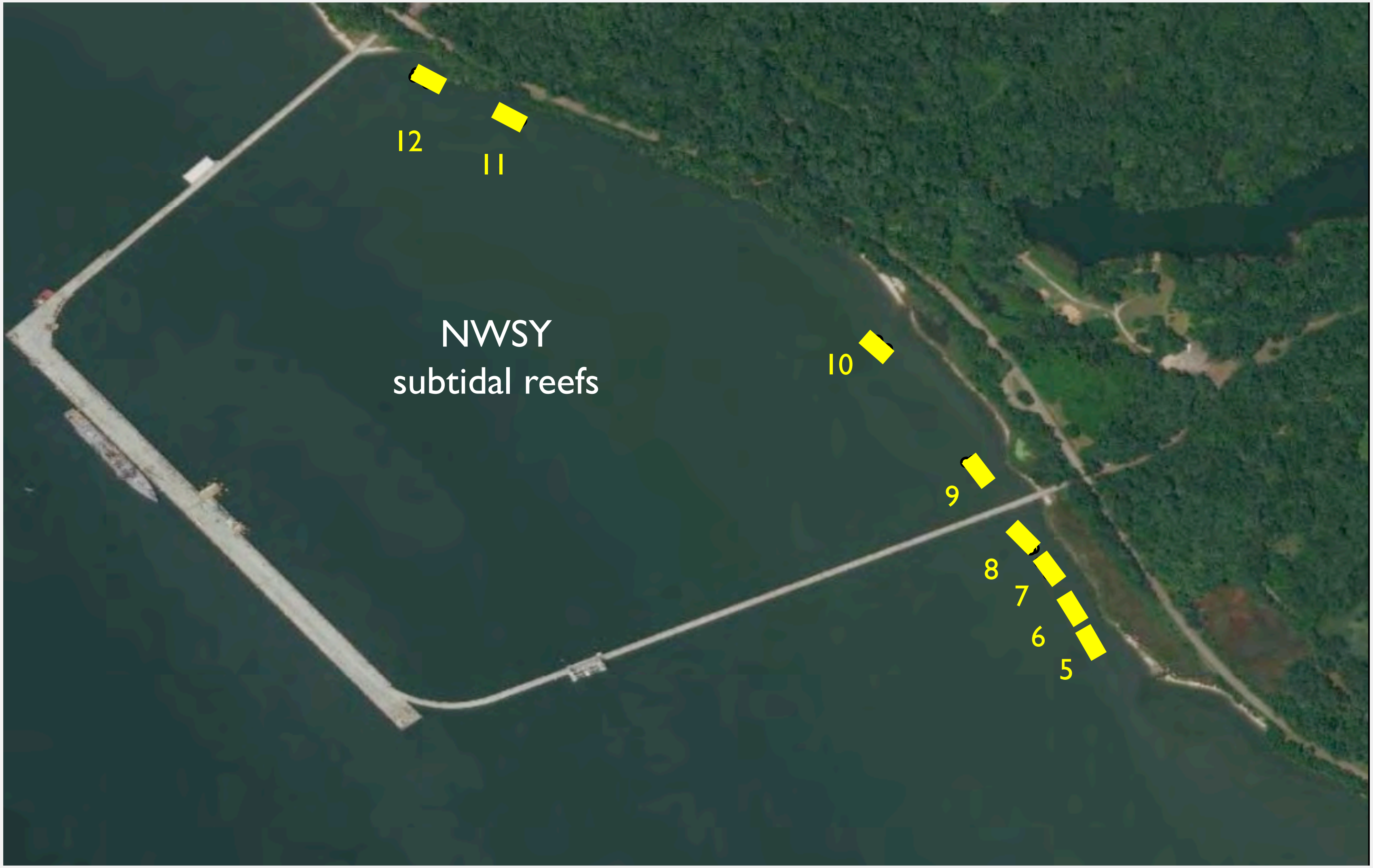


Diamond Reefs



X-Reefs

4 Reef Types Per Polygon


NWSY
subtidal reefs
12
11
10
9
8
7
6
5


VIMS
R/V SCOTER

SUBTIDAL REEF PERFORMANCE

SUBTIDAL REEF PERFORMANCE

SUBTIDAL REEF PERFORMANCE

SUBTIDAL REEF PERFORMANCE

INTERTIDAL REEF PERFORMANCE

VIMS subtidal reefs and secondary production

Rochelle Seitz,

Jainita Patel, Rom Lipcius, Russ Burke, Kathleen Knick, Gabrielle Saluta, Alison Smith, Michael Seebo

REPI Meeting 1 May 2024

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Virginia Institute of Marine Science

Marine Conservation Biology
Community Ecology Labs

Introduction

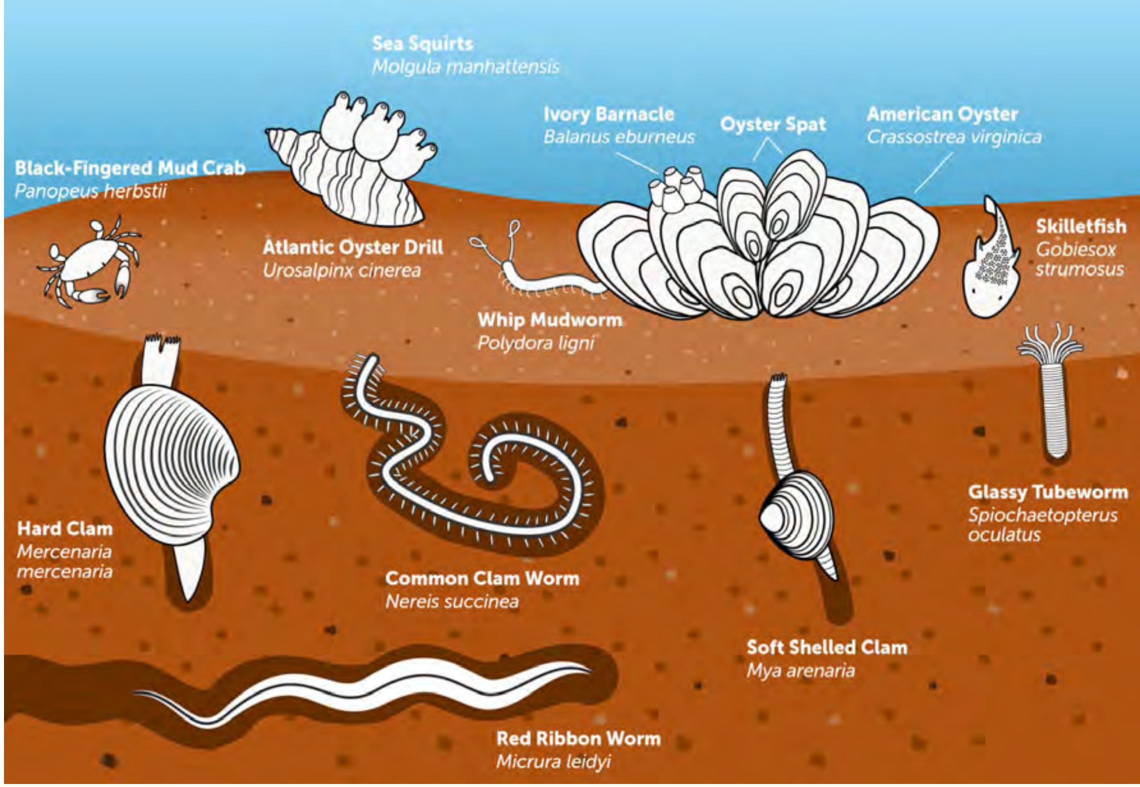
- **Natural shell – limited resource**
- **Success of riprap and concrete**
- **Engineered reefs – new structures**

Theuerkauf et al. (2015), Lipcius & Burke (2016), Lipcius & Burke (2018), Fan et al. (2020)

VIMS – CCRM

Community benefits of oyster reefs

- **Benefits and drawbacks of restoration**
  - **Unstructured sediment has infauna**
- **Community structure on hard substrate vs soft sediment**
- **Success measured as diversity of species, biomass, or secondary production**



Chesapeake Bay Program

Objectives – Part I

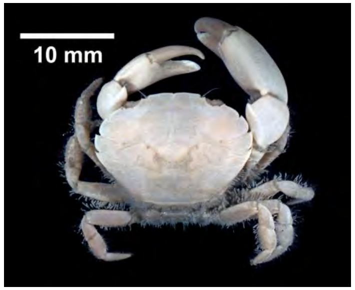
Of 6 structures, which is optimal to promote oyster recruitment?

Hypothesis: Angular structures will have higher recruitment and settlement.

Butler (1945)

VIMS – Flickr

Objectives – Part II

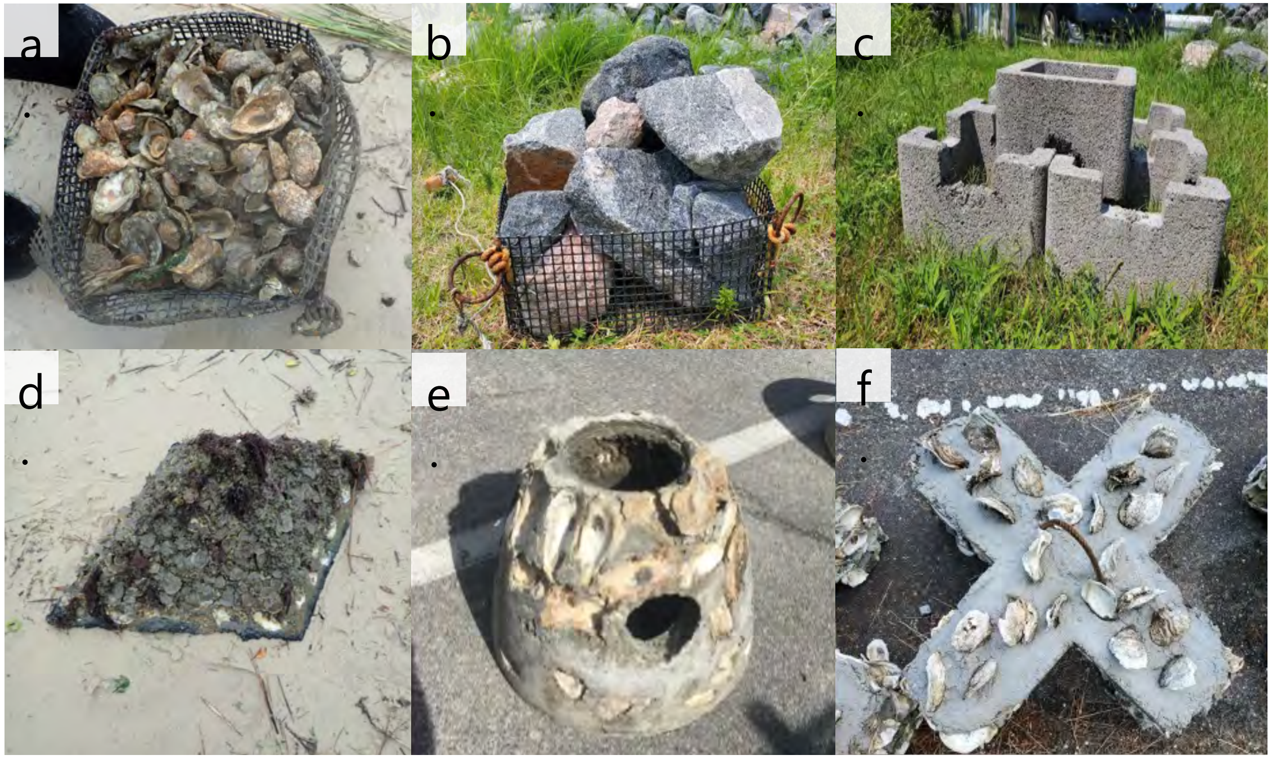


How does artificial reef presence impact benthic community macrofauna and secondary productivity?

Hypothesis: Artificial substrate will promote benthic community growth with greater density, diversity, and productivity than bare sediment

Grabowski & Peterson (2007)

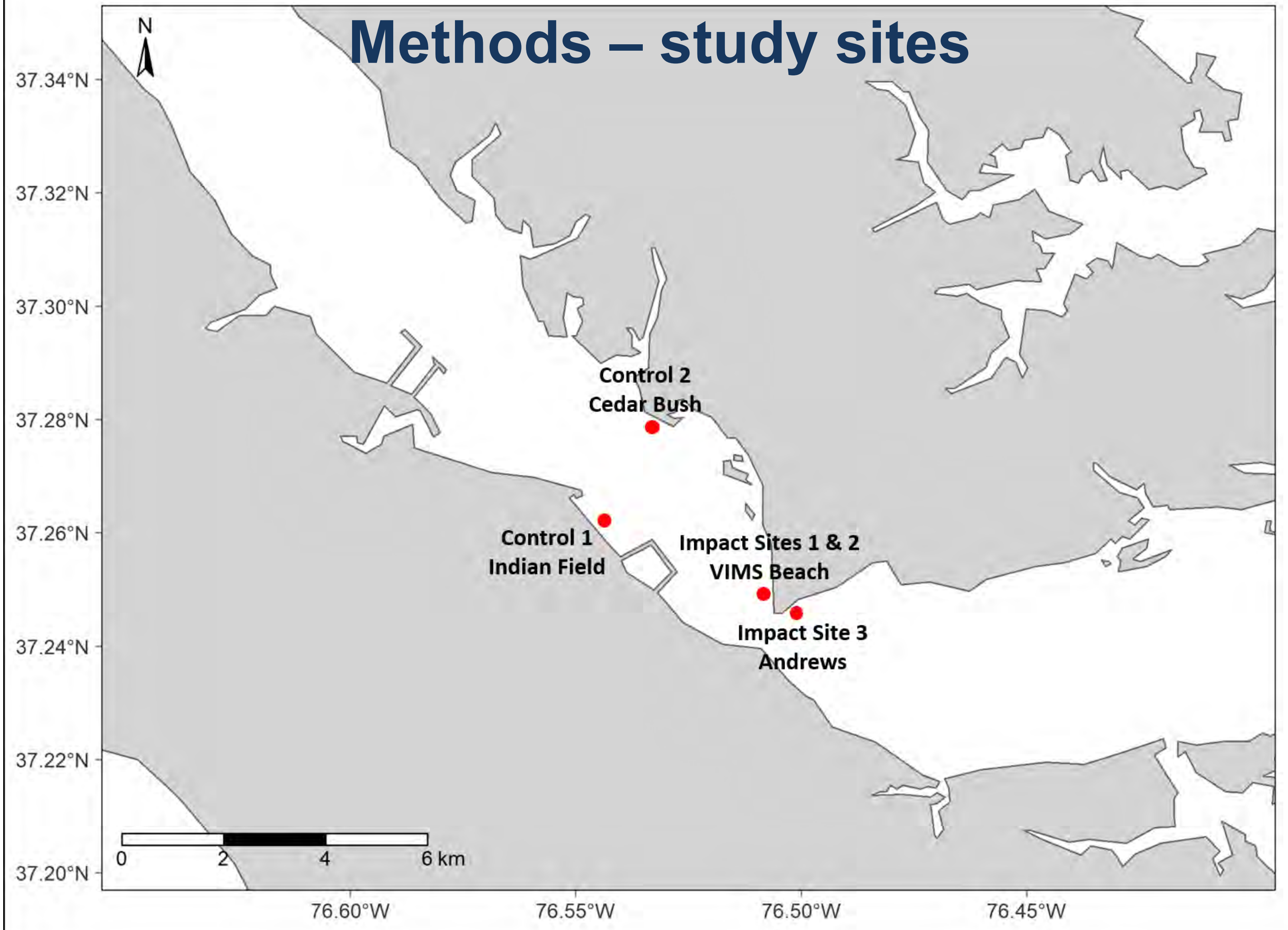
Methods – Reef types and experimental design



6 Reef types
(depl. June 2021)
a. shell basket
b. granite basket
c. oyster castle
d. diamond
e. c-dome
f. x-reef

Design
5 sites (2 control, 3 experimental)
Experimental:
2 transects/site
2 reps/reef type/transect

Methods – study sites



Methods

Sampling

- **Summer 2021**
  - Sampled bare sediment
  - Deployed reef structures
- **Fall 2021**
  - Structures lifted out of water
  - Measured and counted oysters
- **Summer 2022**
  - Structures lifted out of water
  - Physically sampled ¼ structure for oysters and macrofauna

Field sampling 2022

Lab Analysis

Part I

- Oyster density

Part II

- Macrofaunal community
  - biomass
  - secondary production

Results – oyster growth on all substrates






Part I - Oyster Density: 1 year post-deployment

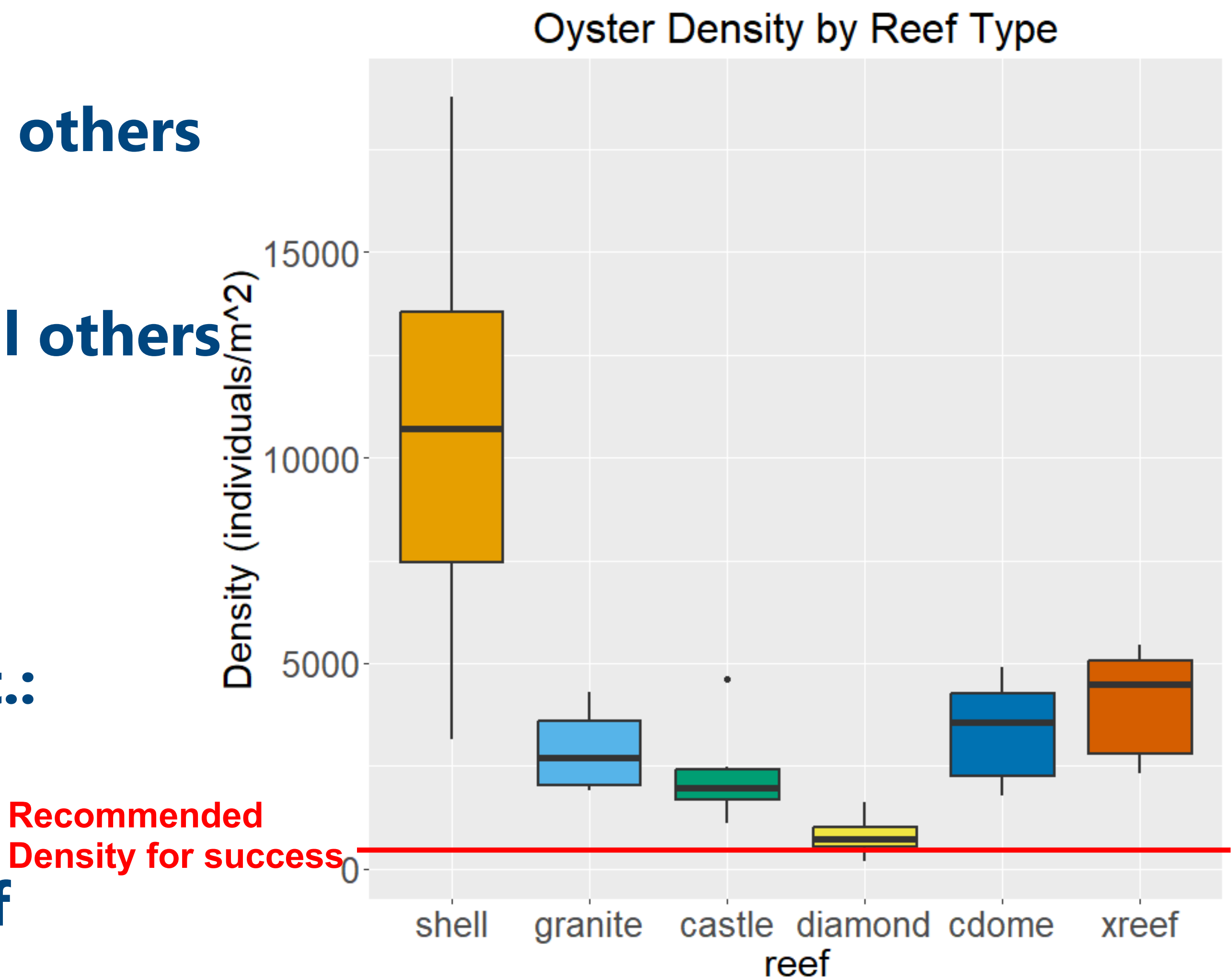
shell greater than all others
($p < 0.01$)

diamond less than all others
($p < 0.01$)

cdome = xreef

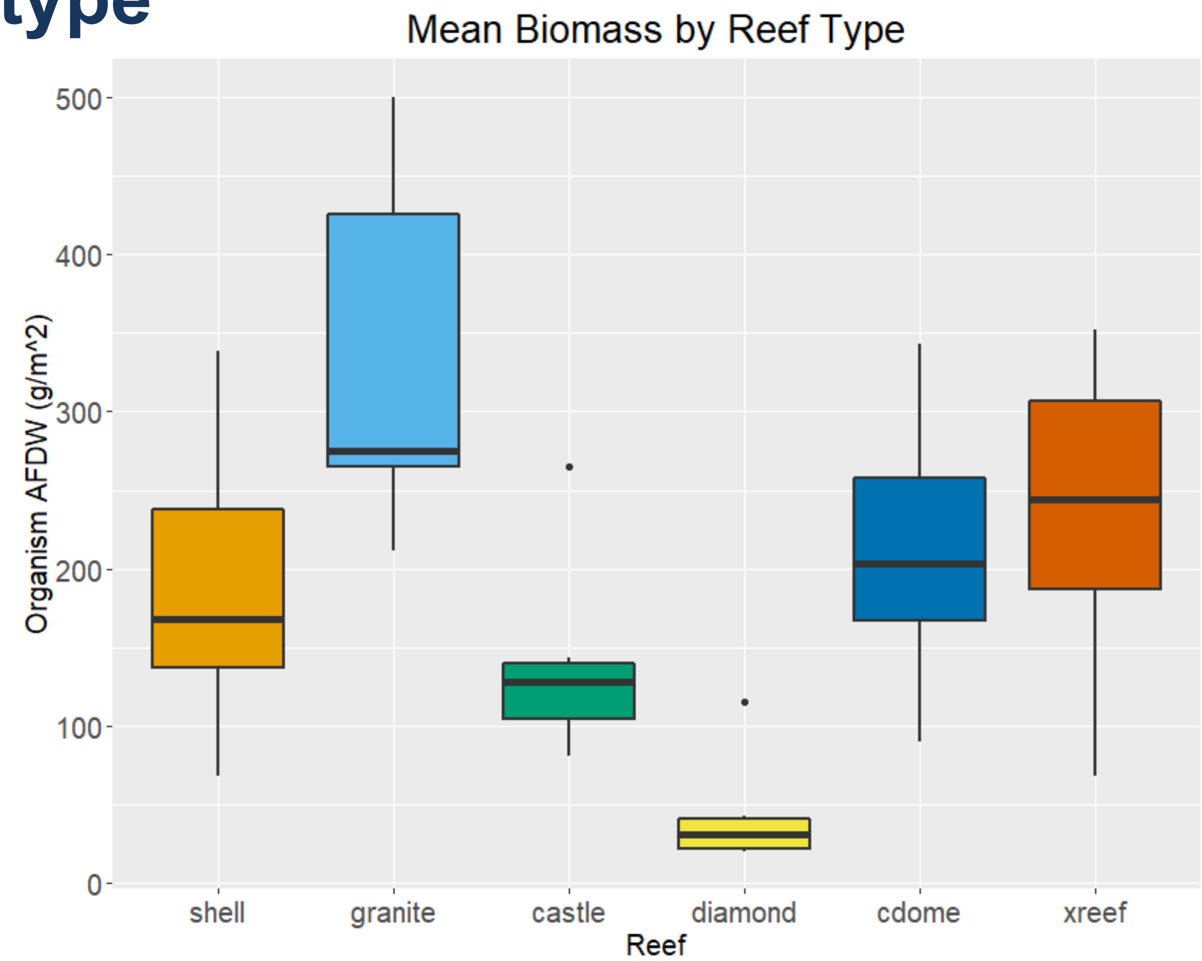
High densities on alt.: 715-3,800 indiv./m^2

Also high biomass of 50-513 g AFDW

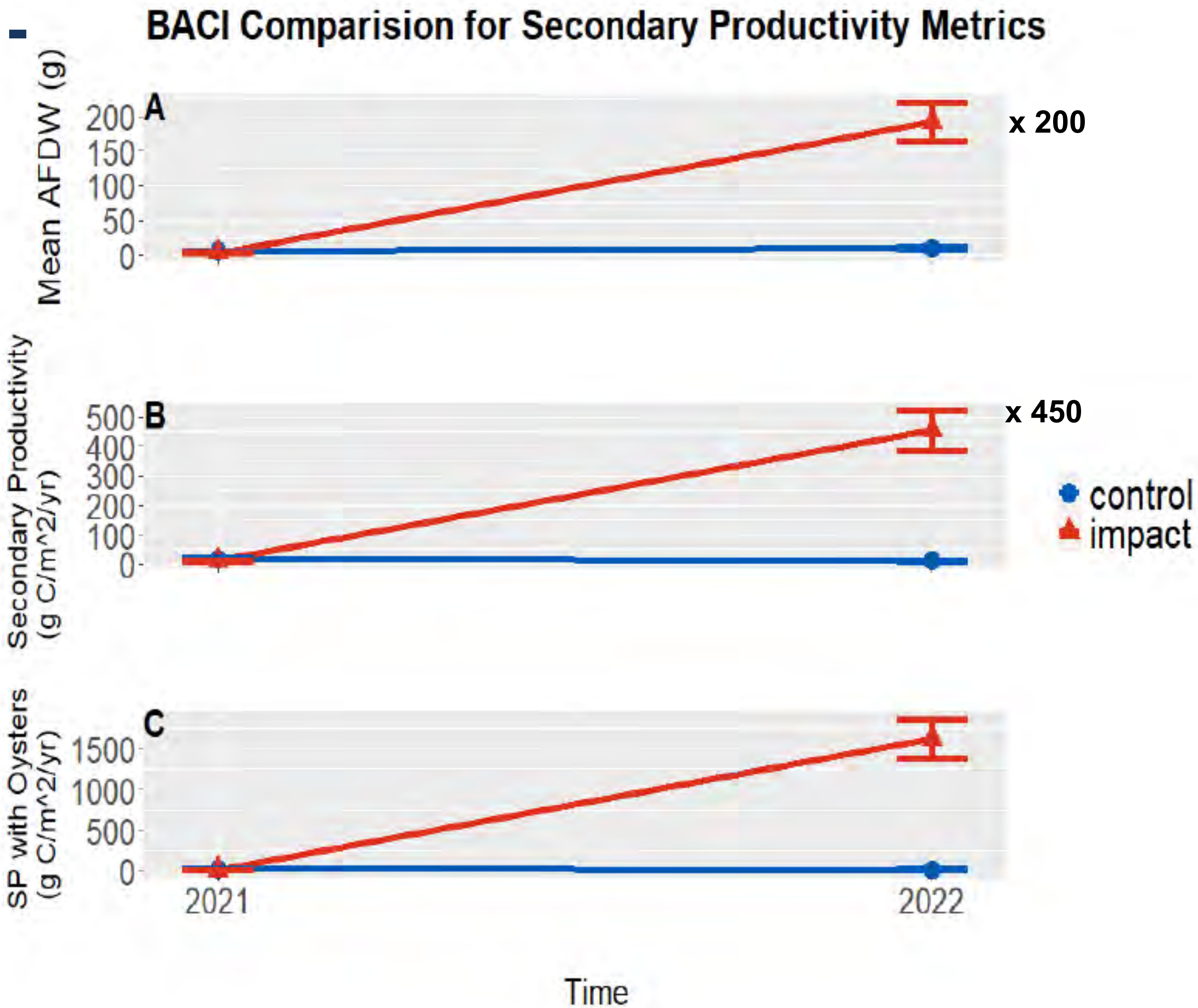


Part II -Benthic Community Biomass by reef type

- **Granite has highest biomass and similar to cdome and xreef**
- **Diamond significantly lower than all reefs**

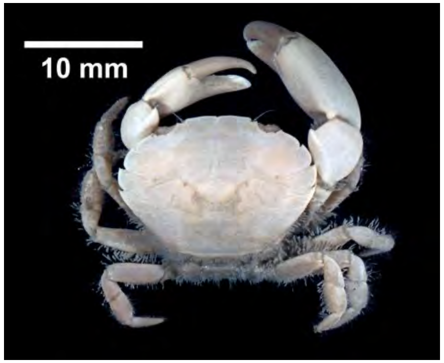


Part II -


BACI Comparision for Secondary Productivity Metrics
A
Mean AFDW (g)
200
150
100
50
0
x 200
B
Secondary Productivity (g C/m^2/yr)
500
400
300
200
100
0
x 450
control
impact
C
SP with Oysters (g C/m^2/yr)
1500
1000
500
0
2021
2022
Time

Key Findings after one year

- Shell reefs had higher oyster densities and biomass than all structures
- Concrete structures -- high recruitment
  - Densities 715 – 3,800 per m^2
- Macrofauna recruited well
  - Shell, cdomes and xreefs: high biomass



- Secondary Productivity: All reefs had > macrofaunal biomass than soft sediment
- **Oyster reefs made of alternative structures are highly successful**

Jainita Patel thesis: https://dx.doi.org/10.25773/v5-gayz-s420

Thanks to field crews and funding from NFWF, the Navy and others
Questions?

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VIRGINIA INSTITUTE OF MARINE SCIENCE

MARINE CONSERVATION BIOLOGY
COMMUNITY ECOLOGY LABS

The end

Contact me: seitz@vims.edu

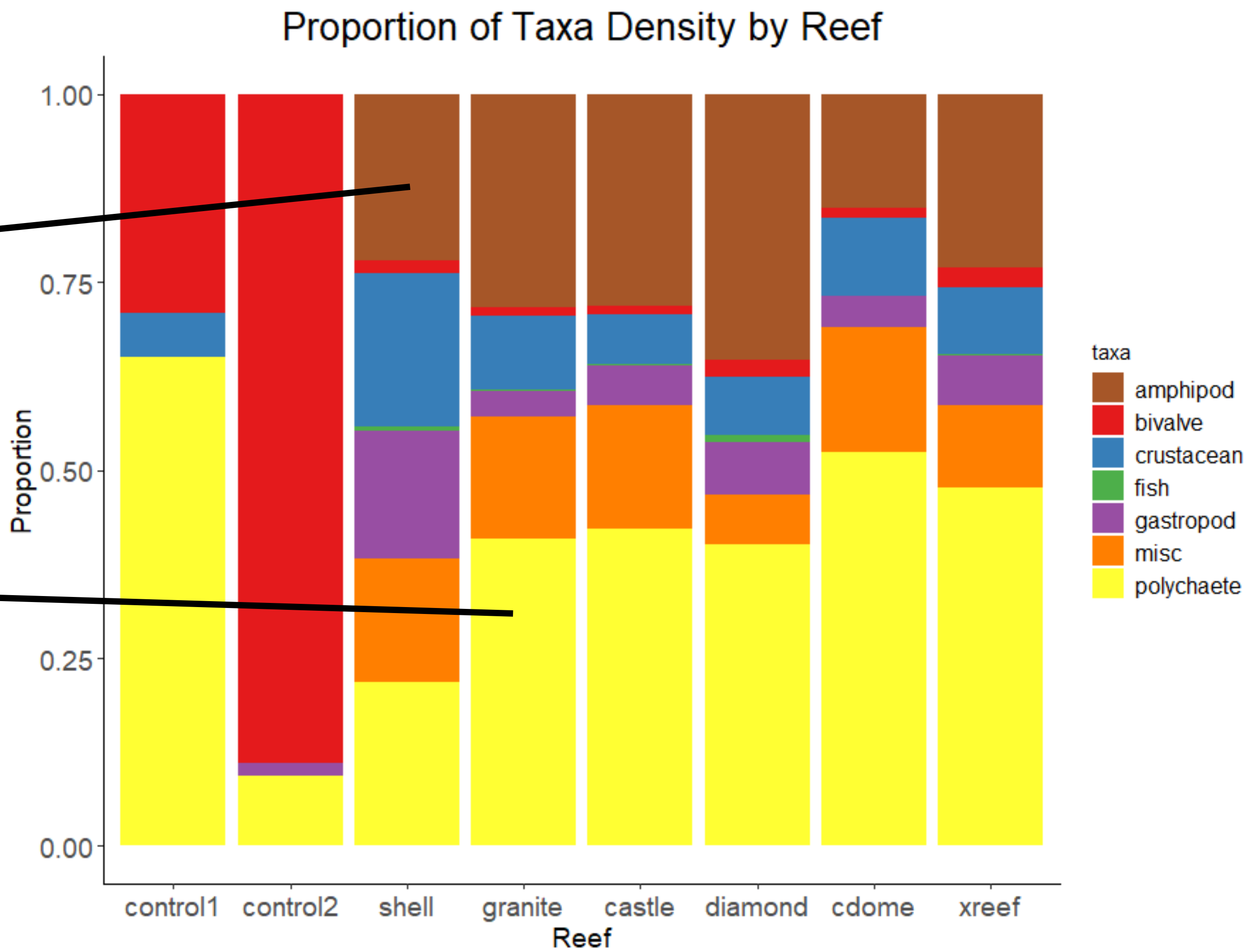
Methods

Reef Type	Reef Height (m)	Reef Width (m)	Reef Length (m)	Bottom area (m^2)	Surface Area (m^2)
Oyster Shell	0.30	0.30	0.30	0.09	NA
Granite	0.30	0.30	0.30	0.09	NA
Oyster Castle	0.61	0.61	0.61	0.37	1.78
Oyster Diamond	0.30	0.61	0.91	0.28	0.46
C-Dome	0.46	0.48	0.48	0.18	1.38
X-Reef	0.36	0.74	0.74	0.24	1.47

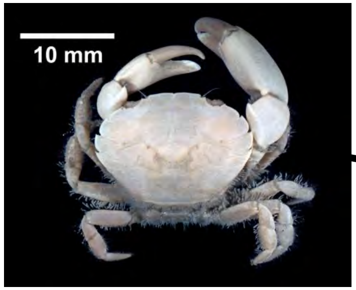
Community Composition – control & reef density

Amphipod
Caprellidae
WoRMS - Nozères, Claude

Polychaete
Potamilla neglecta
WoRMS – Drew, D. J.

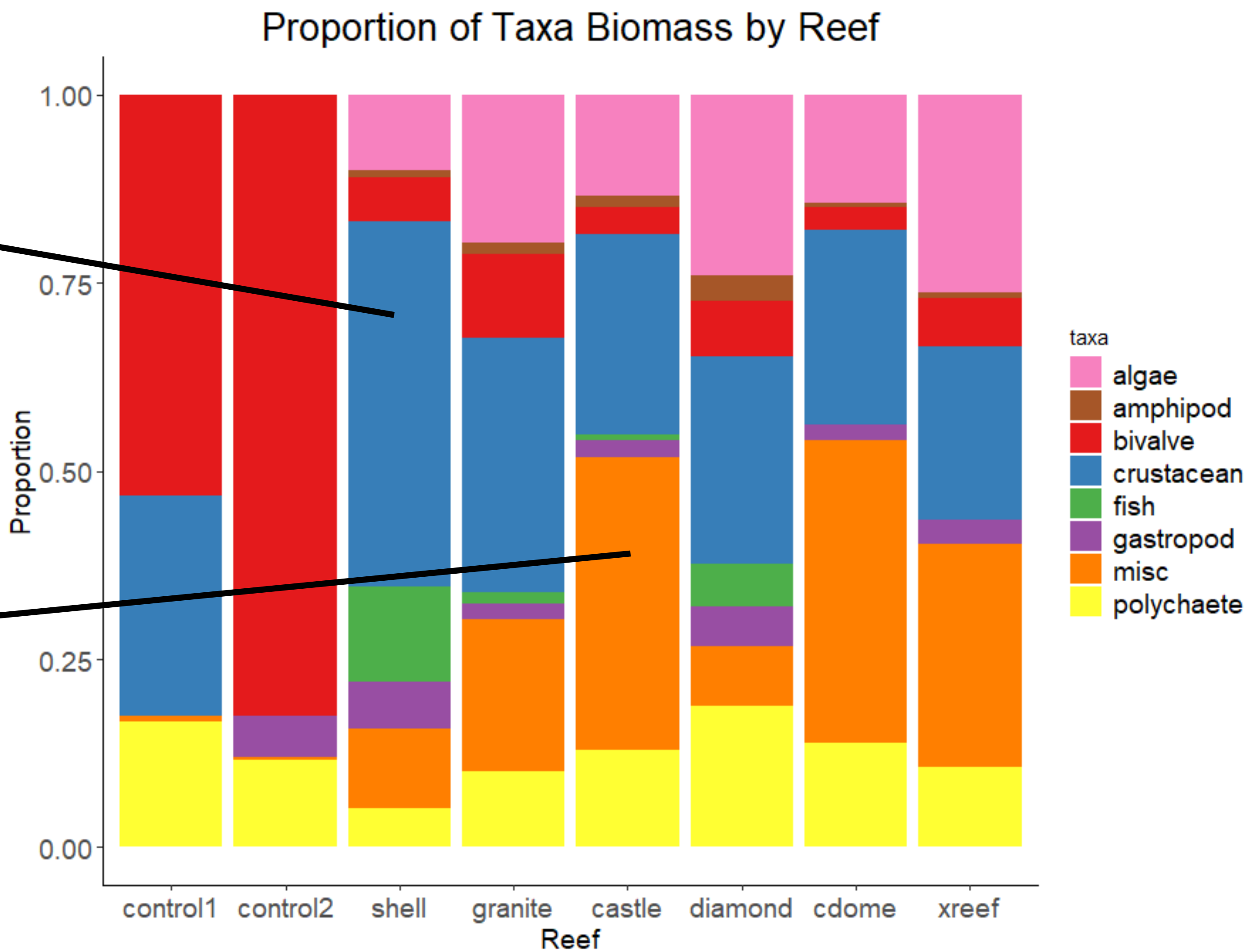


Community Composition–control & reef biomass



Xanthid crab
Eurypanoepus depressus
WoRMS - Lazo-Wasem, E. A

Tunicate
Molgula manhattensis
WoRMS - Decleer, Misjel



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Penniman Spit
Hybrid Living Shoreline Project
VMRC #2022-0565

Site Assessment and Plan Development

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Shoreline Studies Program VIMS

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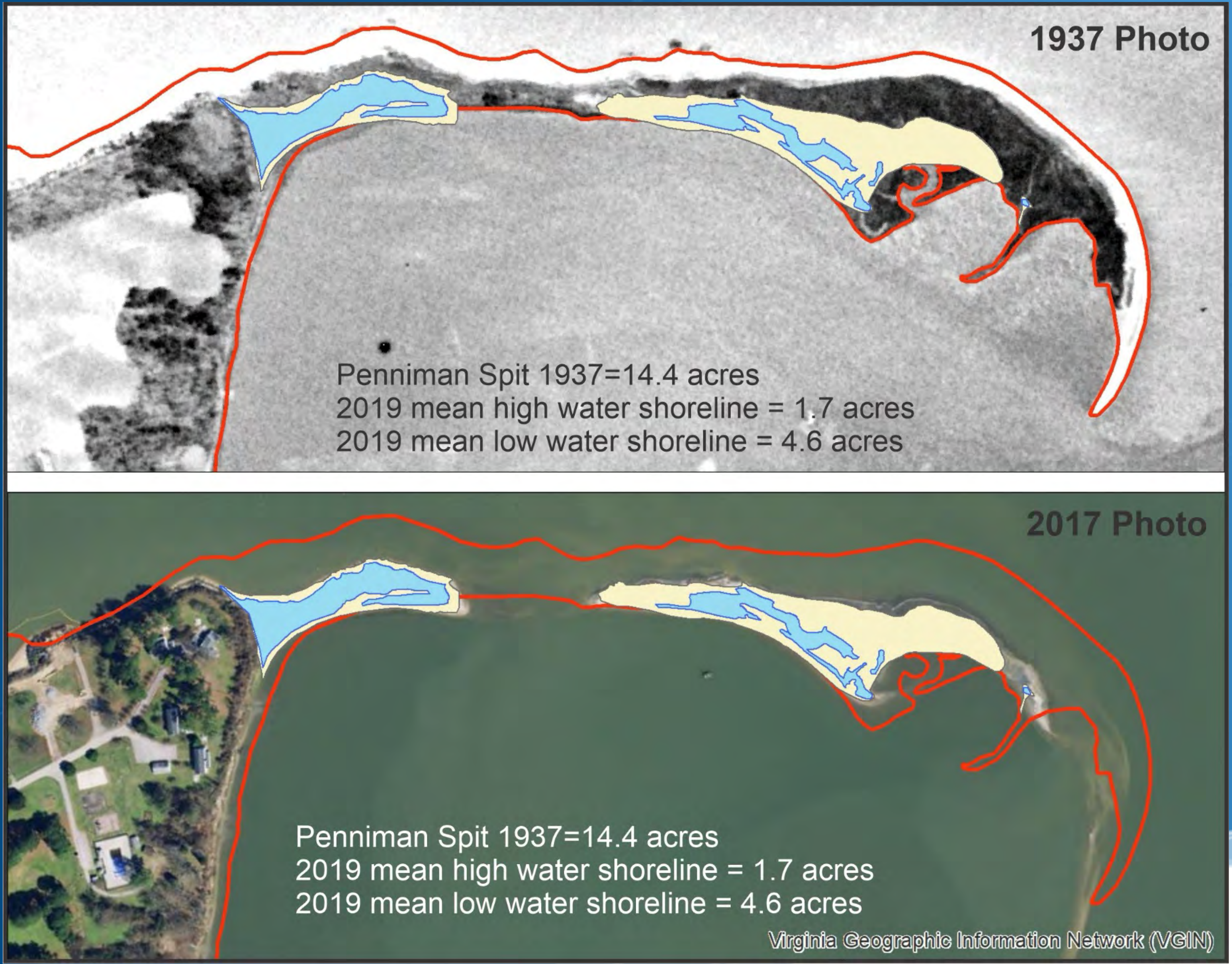
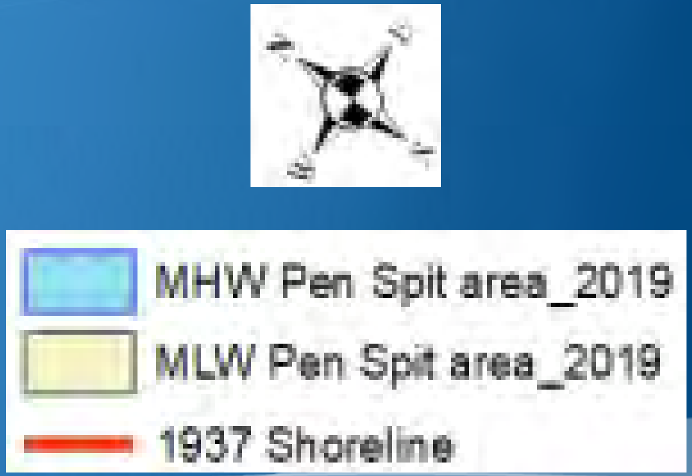
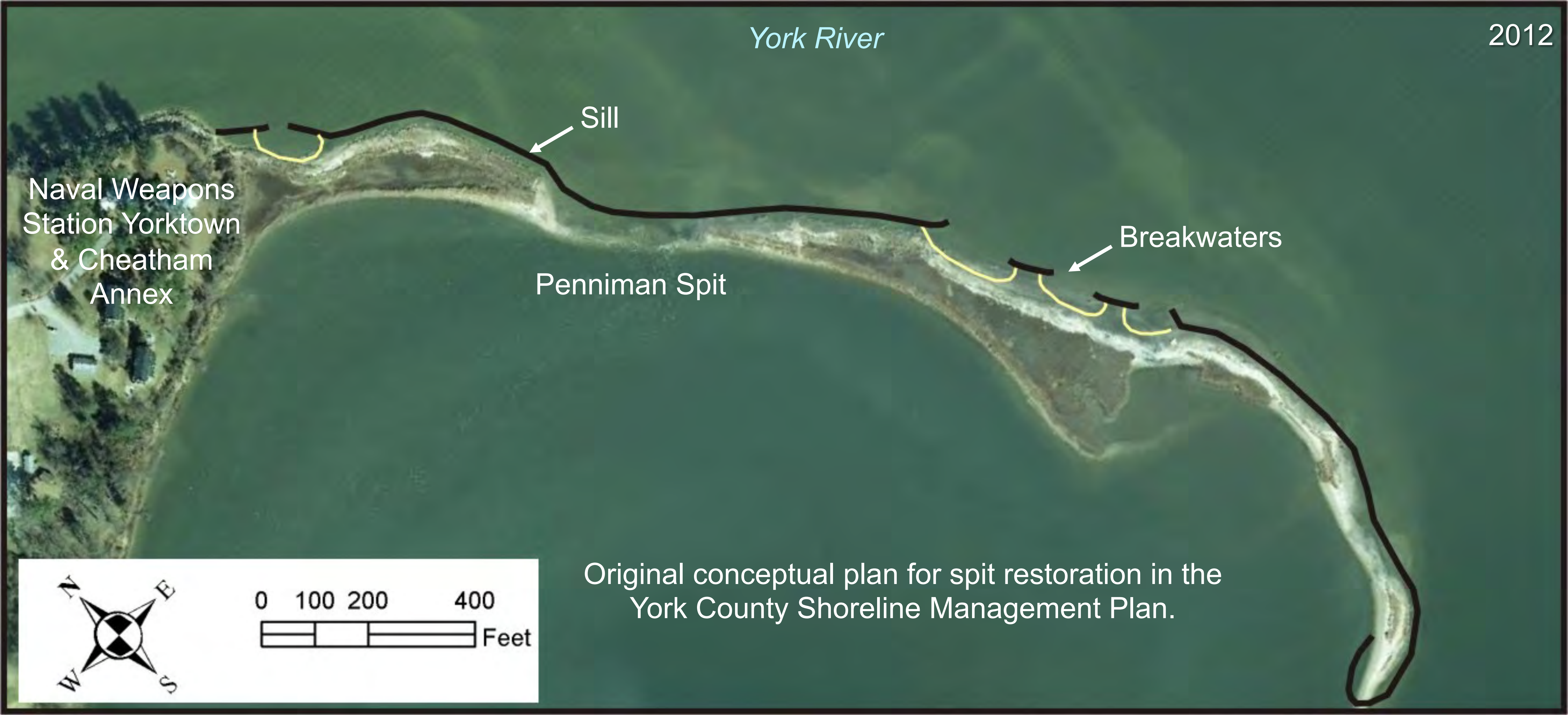
Location of Hybrid Living Shoreline Projects

Change in Spit Area



68% loss in area above MLW over 80 years





From: York County Shoreline Management Plan

Hardaway, C., Milligan, D. A., Wilcox, C. A., Berman, M., Rudnicky, T., Nunez, K., & Killeen, S. (2014) York County Shoreline Management Plan. Virginia Institute of Marine Science, William & Mary. https://doi.org/10.21220/V54C72

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Penniman Spit 2023

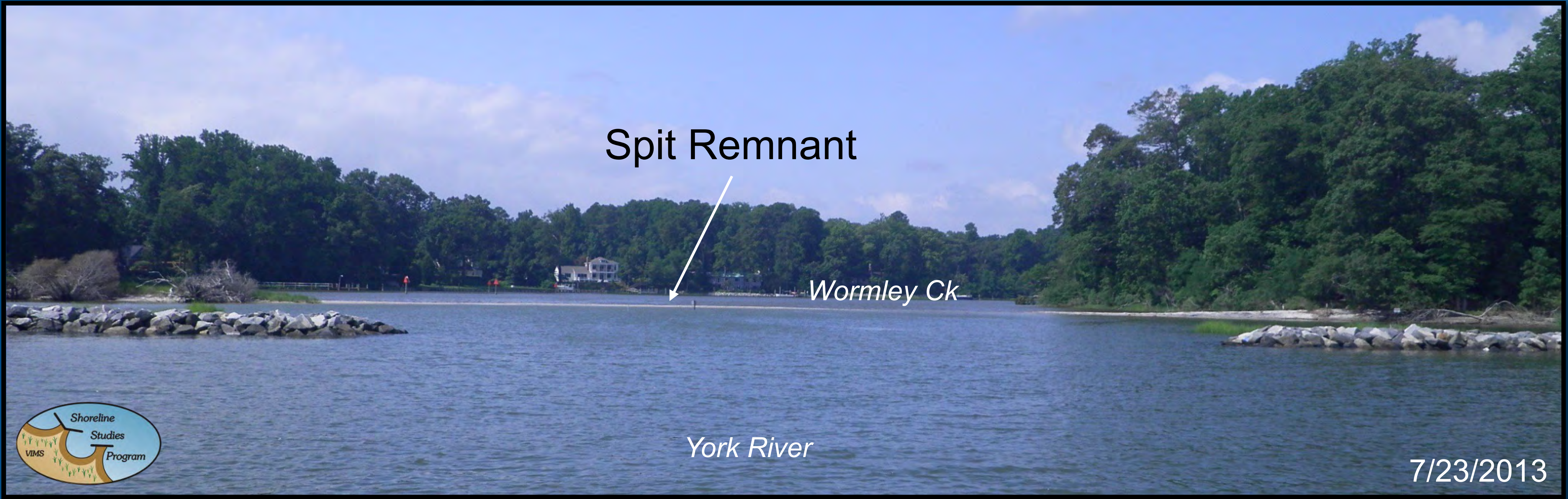
Site Assessments for Design

Physical: Elevation Survey , Aerial Photography, Shore Change

Hydrodynamics: Tide Range, Water Levels, Sea-Level Rise, Storm Surge

Existing Structures for Sizing: Wormley Creek, VIMS, Werowocomoco NP

Wormley Creek Breakwaters



Wormley Creek Breakwaters

The Wormley Creek shore protection project was an early breakwater project constructed by the US Army Corps of Engineers in Virginia and was a learning experience.

The structures were too short to effectively address the incoming wave climate and not enough sand was placed to connect the structures to the shore.

The adjacent marsh sill has performed well, but is it being flanked by erosion.

1994 shoreline shown in orange

VIMS Breakwaters

Shoreline Studies Program's Conceptual design for living shore protection at VIMS' east and west shoreline. 2008

VIMS West Breakwaters

Google Earth Image 4/6/2010
Pre-construction

SSP Image 9/20/2019
9 years post-installation

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VIMS Breakwater Habitats

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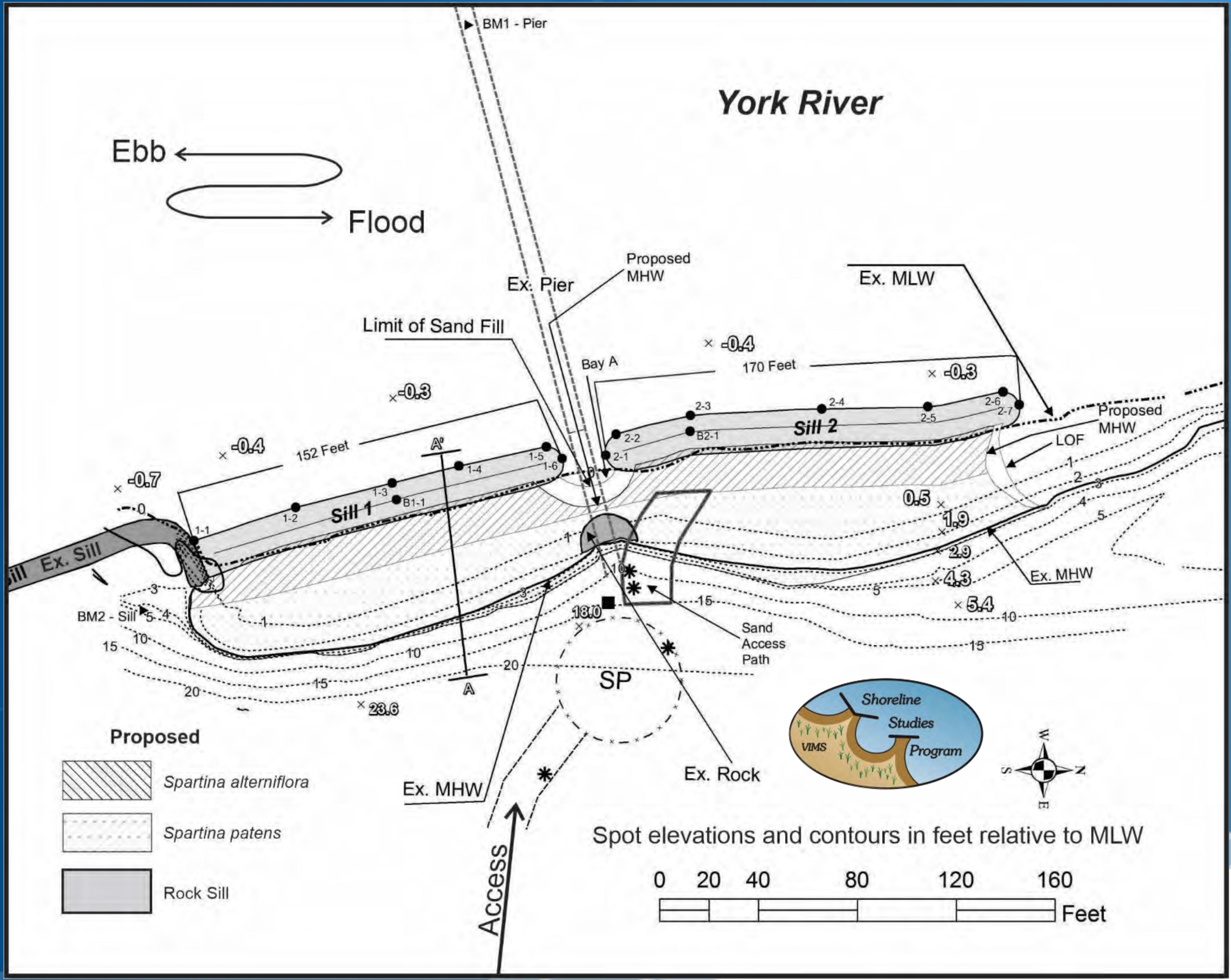
Werowocomoco Sills



Living Shoreline Design
2 rock sills with sand and marsh grass plantings

Milligan, D. A., Hardaway, C., & Wilcox, C. A. (2016) Werowocomoco Shoreline Management Plan. Virginia Institute of Marine Science, William & Mary. https://doi.org/10.25773/9YA3-DY74

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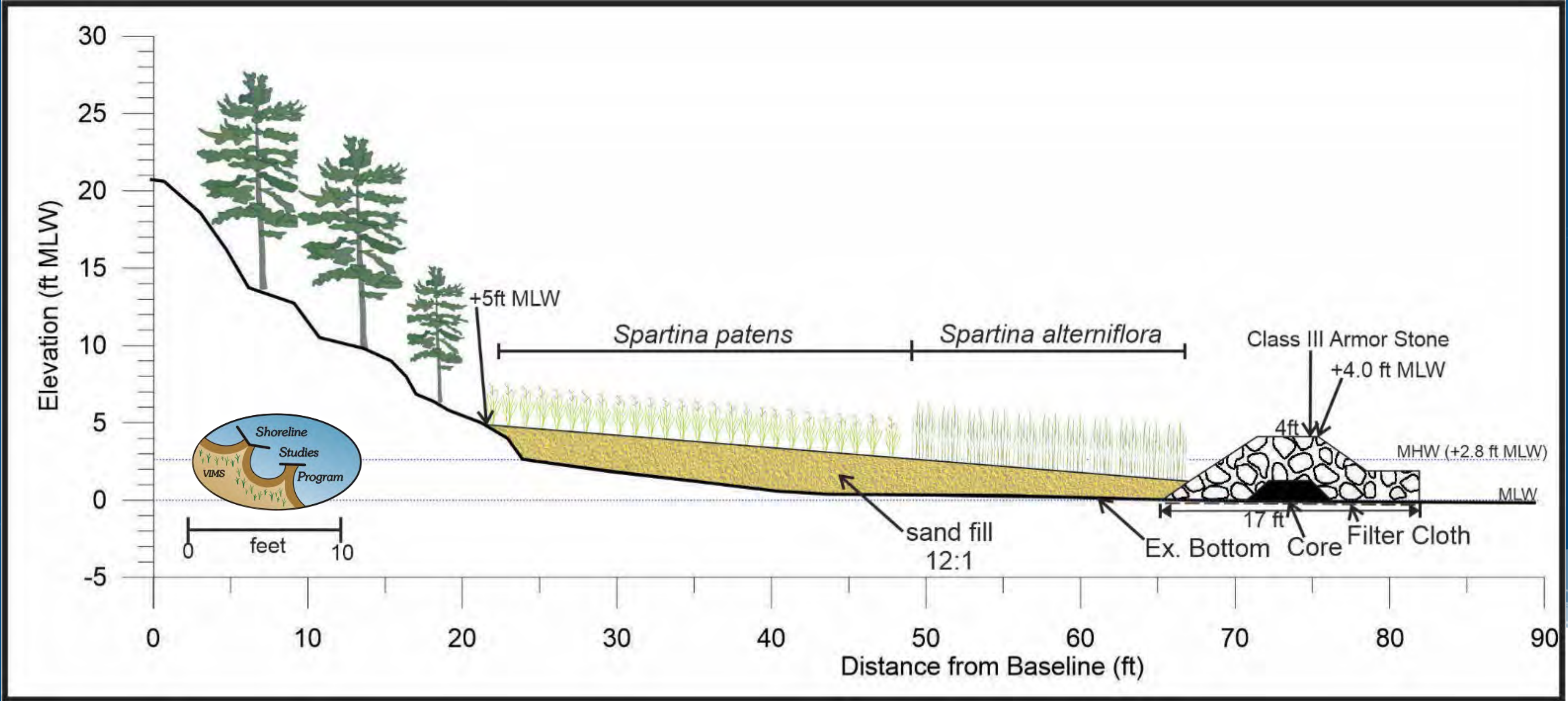
Werowocomoco Sills

Milligan, D. A., Hardaway, C., & Wilcox, C. A. (2016) Werowocomoco Shoreline Management Plan. Virginia Institute of Marine Science, William & Mary. https://doi.org/10.25773/9YA3-DY74

Typical Cross-Section



Werowocomoco Sills

Through Time

7 years post- construction

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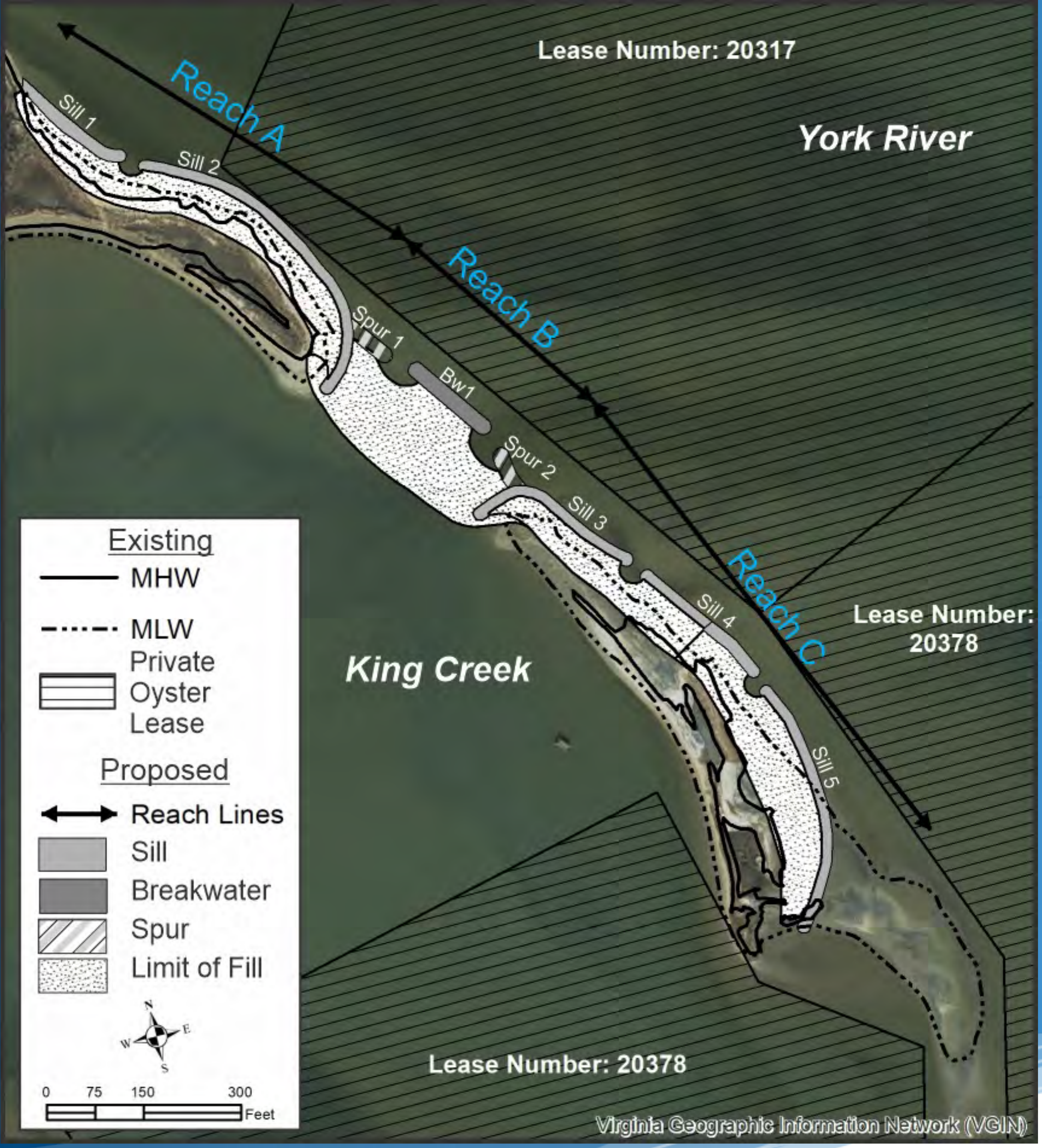
Penniman Spit

Proposed Structures



5 Rock Sills with 5 Gaps

1 Rock Breakwater

2 Rock Spurs

Sand Fill and Marsh Grass Plantings

Rock is Class III Armor Stone – 1,000 lbs per stone

Shoreline Studies Program VIMS

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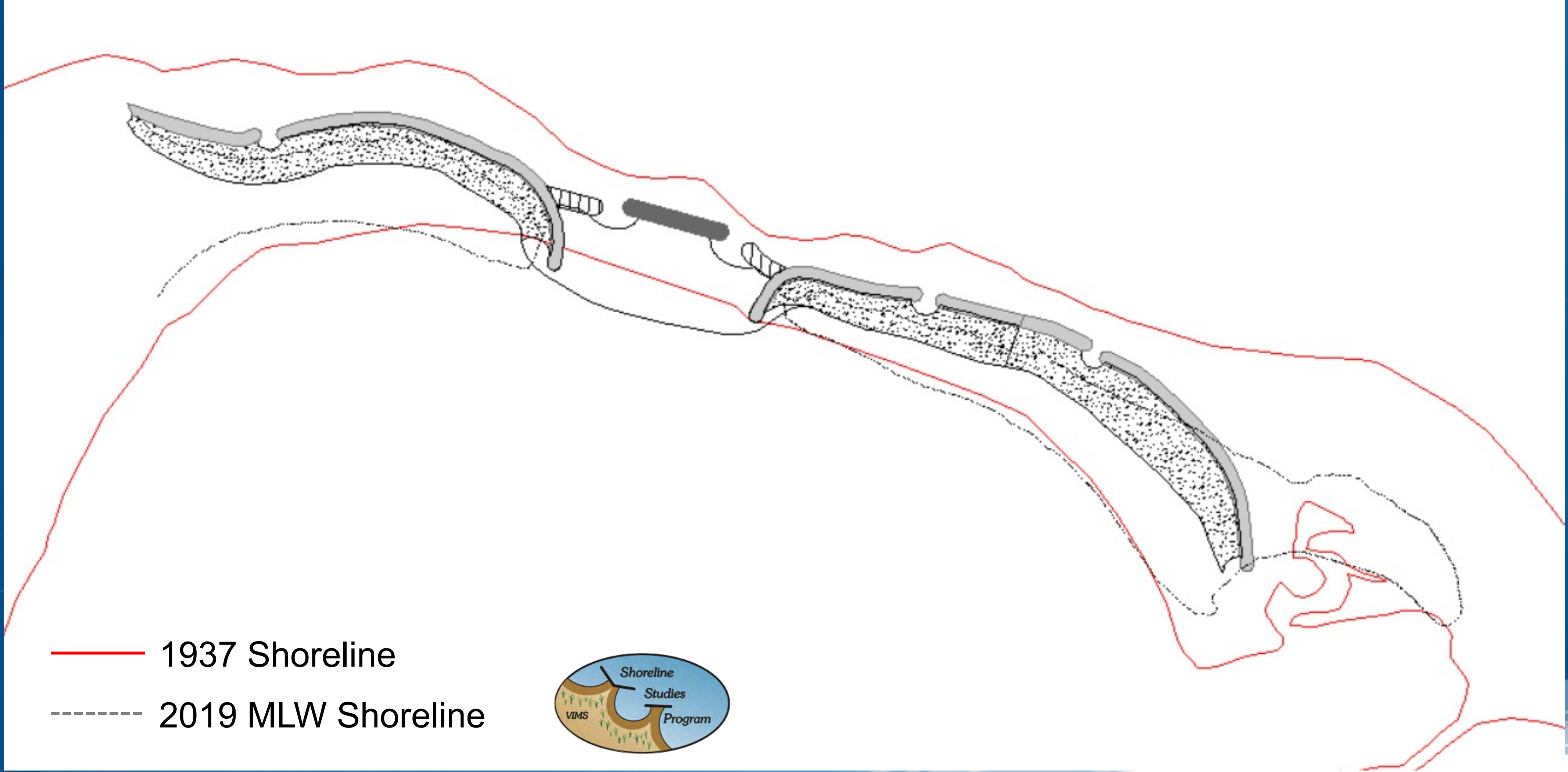
Proposed Structures & 1937 Spit Outline



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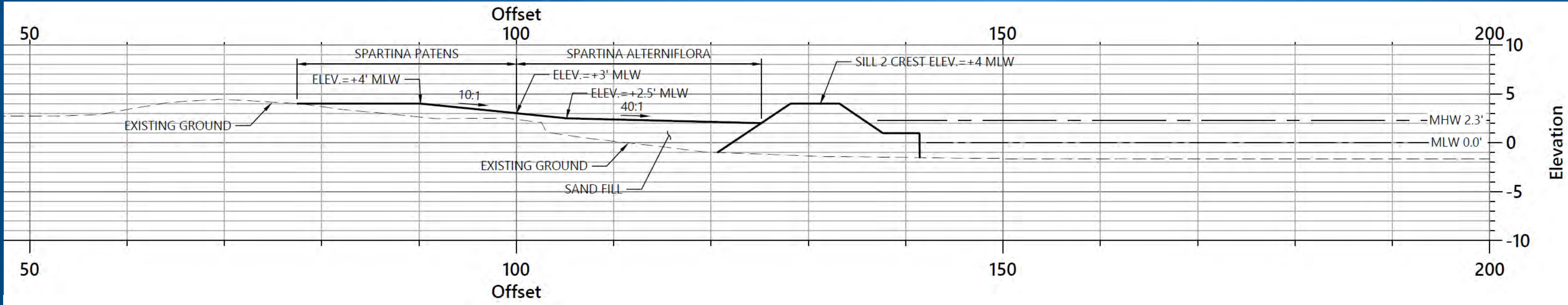
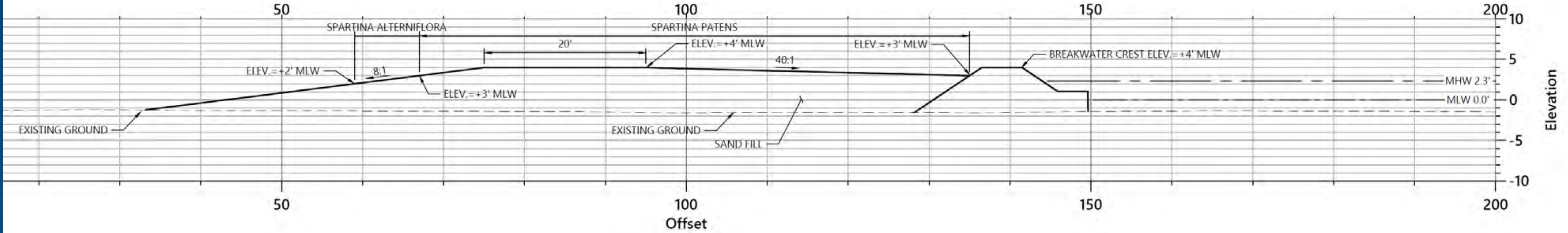
Final Design

Typical Cross-Sections





vhb
351 McLaws Circle
Suite 3
Williamsburg, VA 23185
757.220.0500

COASTAL
Design & Construction, Inc.

1,700 feet long
High Marsh: 41,000 sqft (0.9 acres)
Low Marsh: 57,000 sqft (1.3 acres)

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