



**LIVING SHORELINES IN THE GALVESTON BAY SYSTEM:  
STATUS, CONSIDERATIONS, AND LONG-TERM RESULTS**

# *Our panel*



Jeffery Fato, M.S.



Cindy Howard, Ph.D.



Lydia Thurman, B.S.



Jim Dobberstine, M.S., M.Sc.



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**UHCL**  
University of Houston  
Clear Lake



Environmental Institute of Houston

  
**LEE COLLEGE**

A coastal scene featuring a body of water in the background. On the left, a small boat is docked at a pier made of wooden posts. A person is visible in the water near the posts. In the foreground, there is a dense field of green marsh grasses with some brown seed heads. The sky is overcast and grey.

# Session outline:

- Jeffrey Fato (GBF): Living Shorelines in Galveston Bay – an overview of the approach, GBF’s program, and our study
- Cindy Howard (UHCL): Study findings on biological community comparisons between living shorelines and reference sites
- Lydia Thurman (EIH/UHCL): Evaluating salt marshes as a nature-based solution to microplastic pollution
- Jim Dobberstine (Lee College): Physical and chemicals stressors, shoreline stability, and tying it all together.
- Q&A

# Jeffrey Fato - Habitat Restoration Manager - Galveston Bay Foundation

## Presentation Outline:

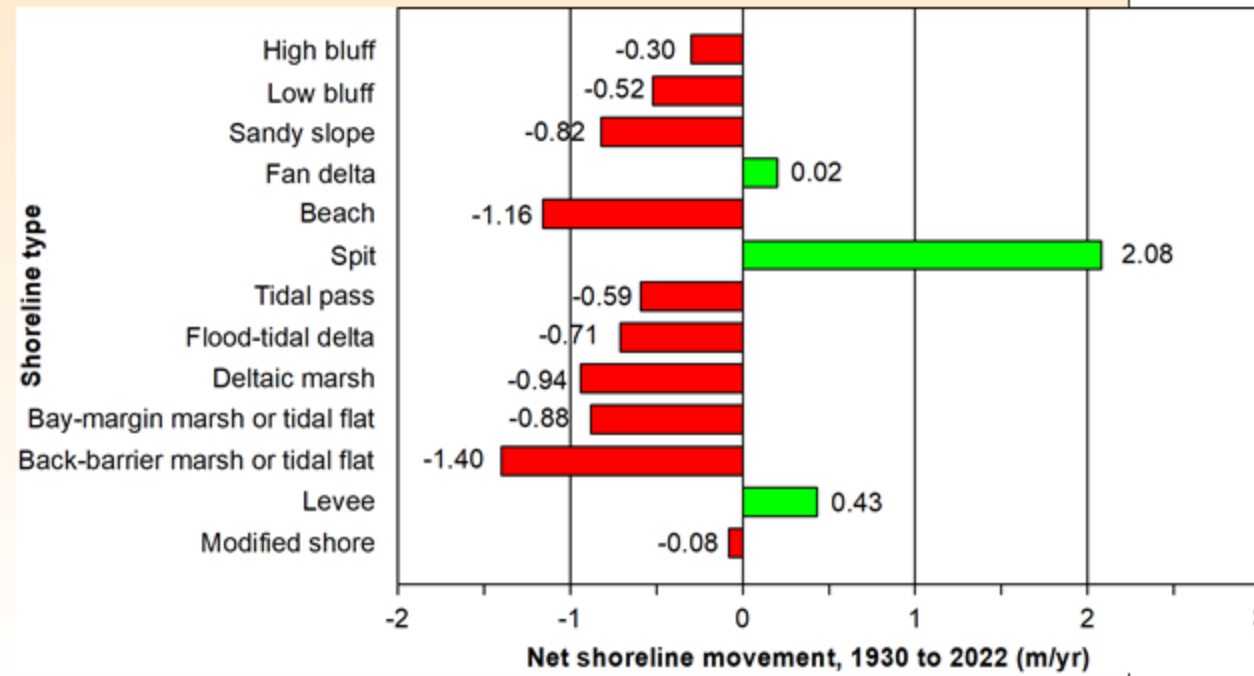
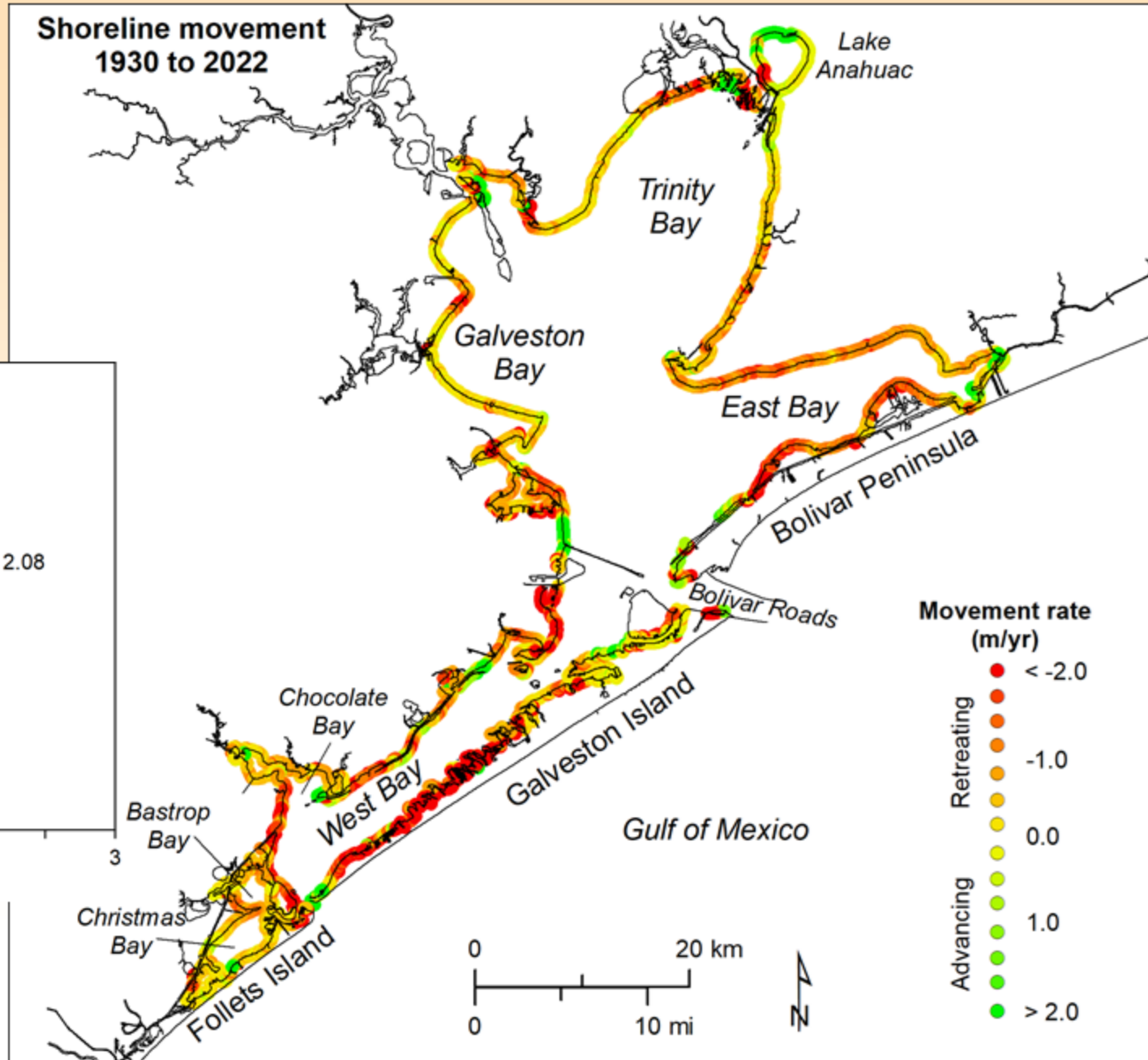
- Shoreline Protection
- Efforts of the Galveston Bay Foundation
- Long-term Monitoring of LVS
  - Hypothesis
  - Methods
    - Study Sites



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# Shoreline Movement 1930-2022

Number of sites: 9312  
 Average rate of movement: -0.78 m/yr  
 Range: -16 to +10 m/yr  
 17% of sites Advancing  
 83% of sites Retreating



# Armored Shorelines: An Imperfect Defense

May increase erosion on adjacent shorelines (Gittman et al., 2015)

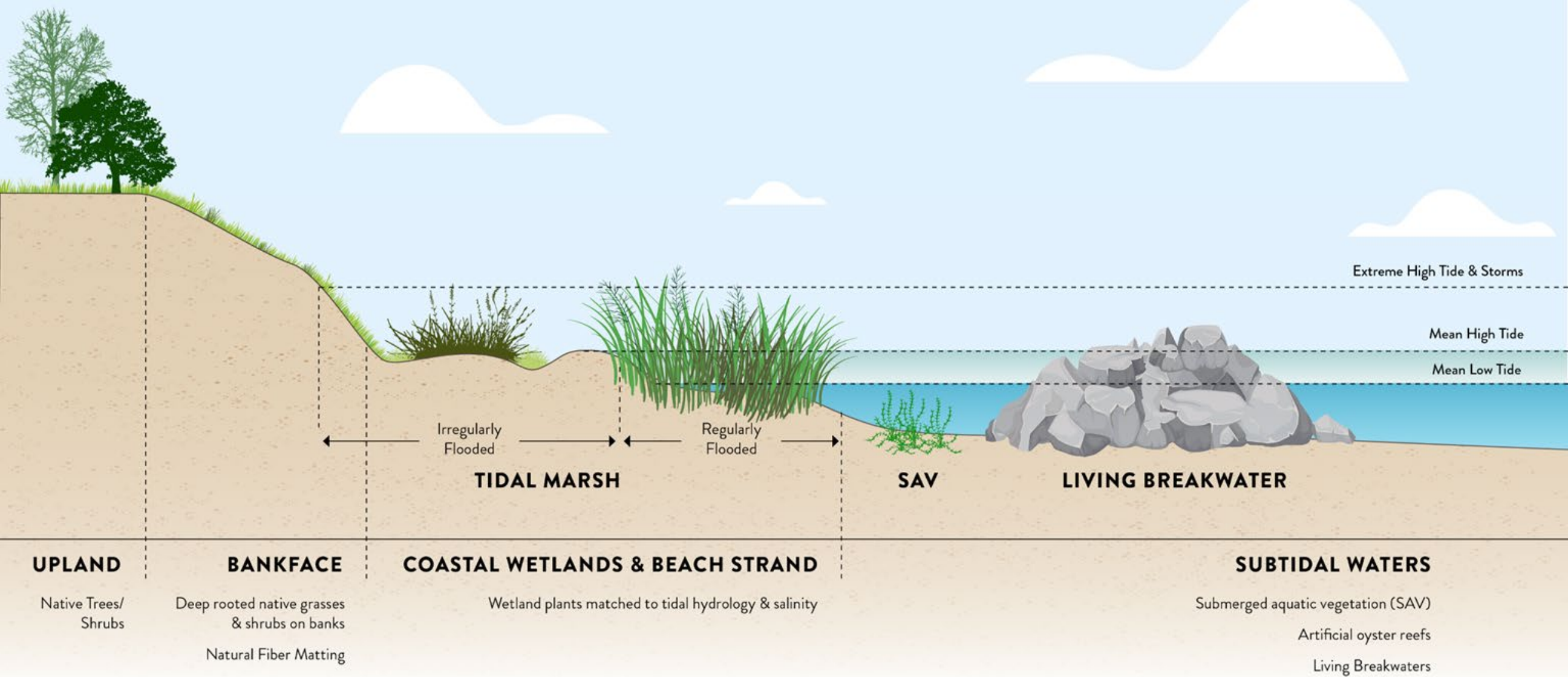
Lose stability due to undermining wave energy (Gittman et al., 2015; Rella & Miller, 2012)

Reduced biologic function relative to natural marshes (Seitz et al., 2006; Gittman et al., 2016)

Changes water quality, sediment distribution, & wave energy distribution (Seitz et al., 2006; Gittman et al., 2016)



As of 2013, ~19% of the Galveston Bay shorelines and tributary streams were classified as developed (HARC 2020; NOAA, 2013).



What is a *Living Shoreline*?



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# 30+ Living Shorelines

*15 Landowner  
Partnerships*



# GBF's Role in Living Shorelines

## Past

Funding Opportunities for Small-scale projects  
Cost-Sharing with Landowners  
Pursuit of Landowner Partnerships  
Partner Support: USFWS (\$50K); CIAP (\$71K)

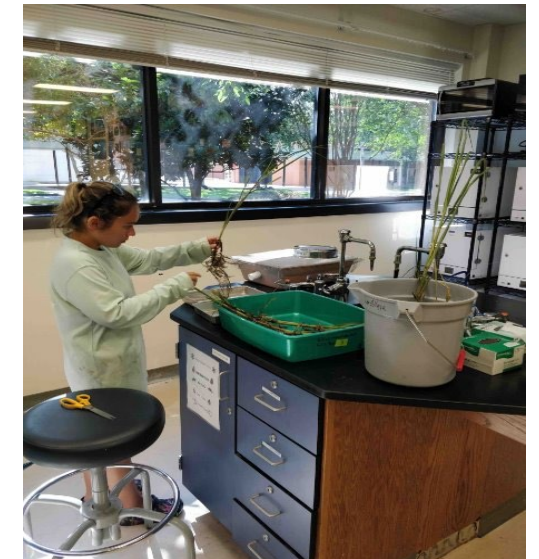
## Present

Funders want larger impacts; will NOT fund projects on private land  
Costs too high & timeframe too long for landowners  
Reduced landowner interest  
**GBF serving as a resource hub & outreach partner**  
[Galveston Bay Shoreline Protection Map Viewer](#)

## Future

Funding?  
Landowner incentives?  
Regulation changes?  
[More Research](#) – importance of living shorelines

# Restoration without *Data* is Fleeting!



## NEED

- Shorelines are retreating, and marshes are disappearing
- Most of the TX coast is privately-owned and small in scale relative to publicly-owned sites
- Lacking data to support the need and effectiveness of small-scale living shorelines

## HYPOTHESIS

- Living Shorelines will exhibit ecologic function and shoreline stability function...
  - SUPERIOR to armored shorelines
  - SIMILAR to natural, unrestored shorelines

## PARAMETERS

- Sediment texture
- Plant community
- Benthic community (*macro* & *micro*)
- Shoreline stability



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# Lee College & UHCL Study

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*Assessment of 3 living shorelines in comparison to natural and armored reference sites*

**Sullivan Living Shoreline**  
Trinity Bay Site

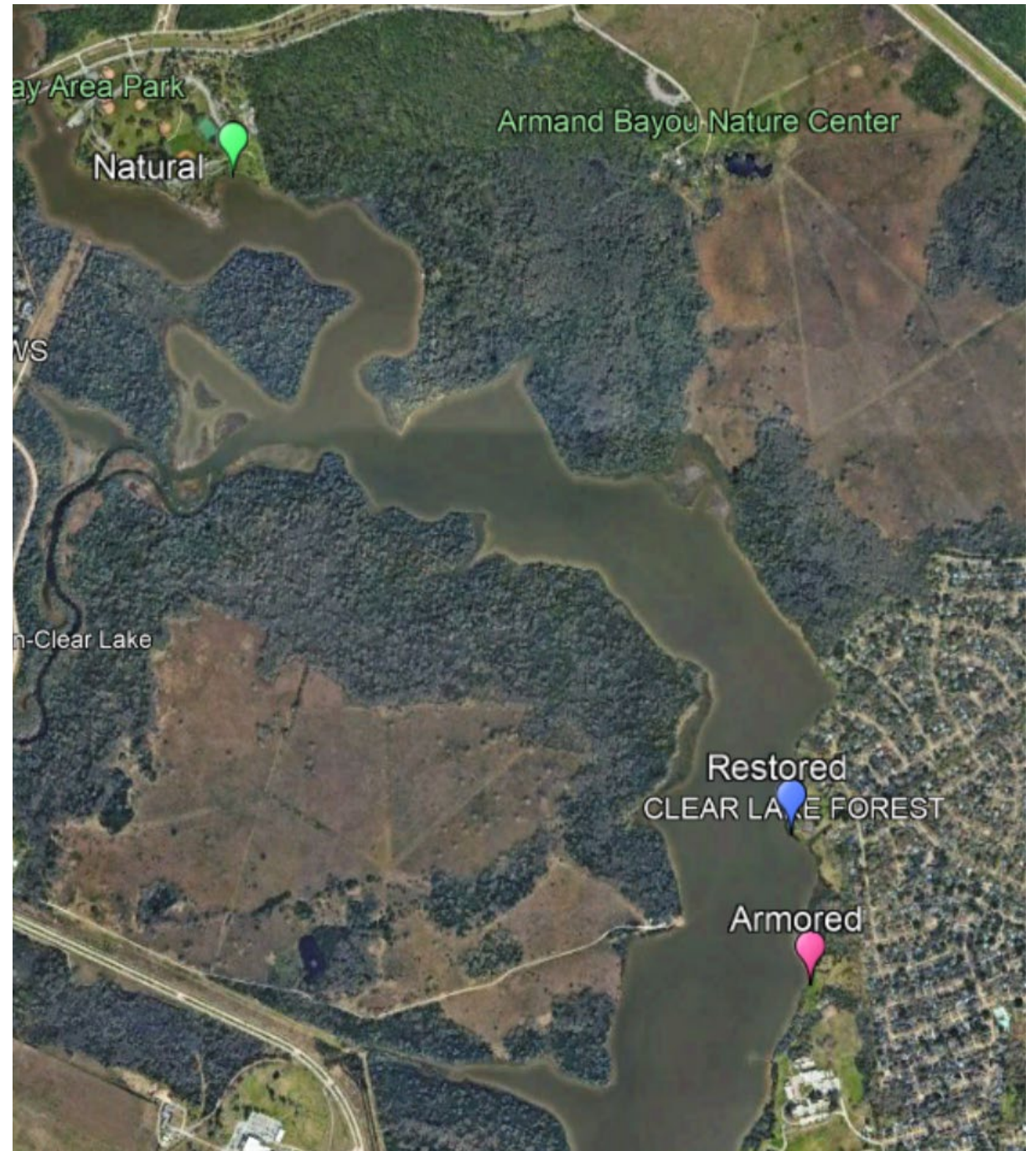
**Clear Lake Forest Park Living Shoreline**  
Armand Bayou Site

**O'Donell Living Shoreline**  
West Galveston Bay Site



# Armand Bayou Site

- Constructed in 2011
- Low-profile Breakwater (rock)
- Fill + Marsh Planting



2006 - Before

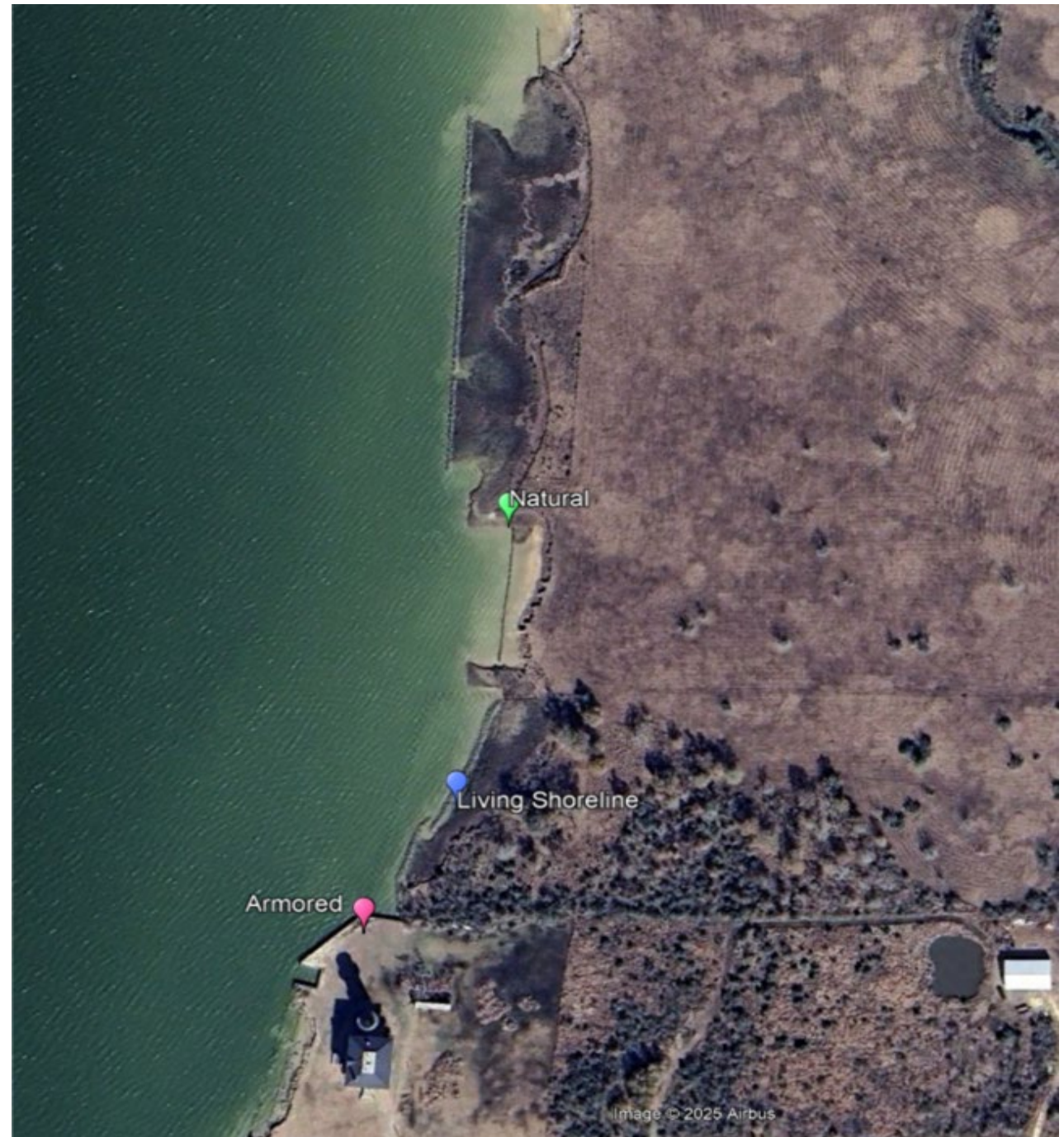


2019 - After



# Trinity Bay Site

- Constructed in 2011 & 2013
- High-profile Breakwater (rock)
- Marsh Planting behind



Before

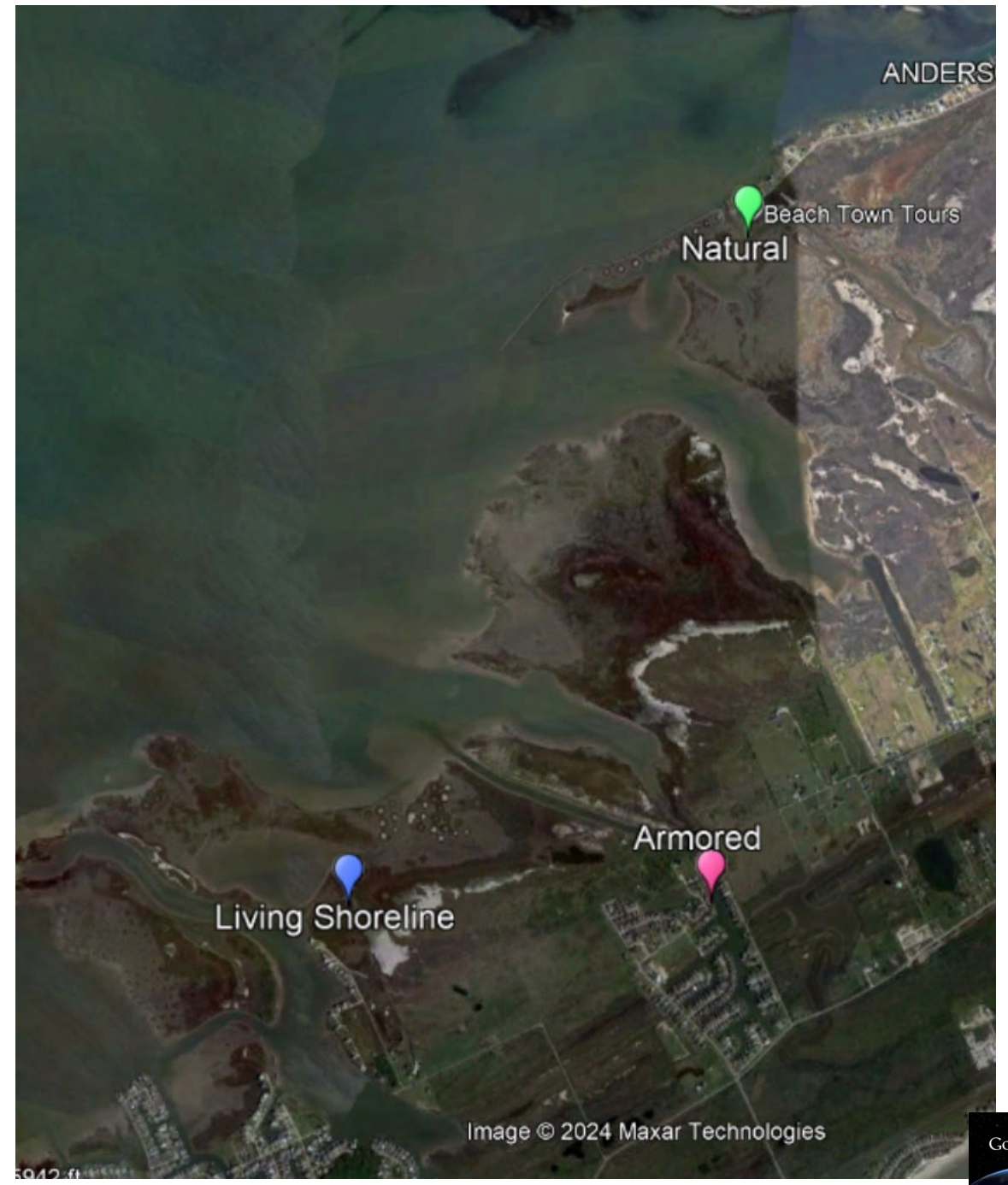


After



# West Bay Site

- Constructed in 2005
- Low-profile Breakwater (sacrete)
- Marsh Planting





# Cindy Howard, Department Chair, Environmental Sciences, UHCL

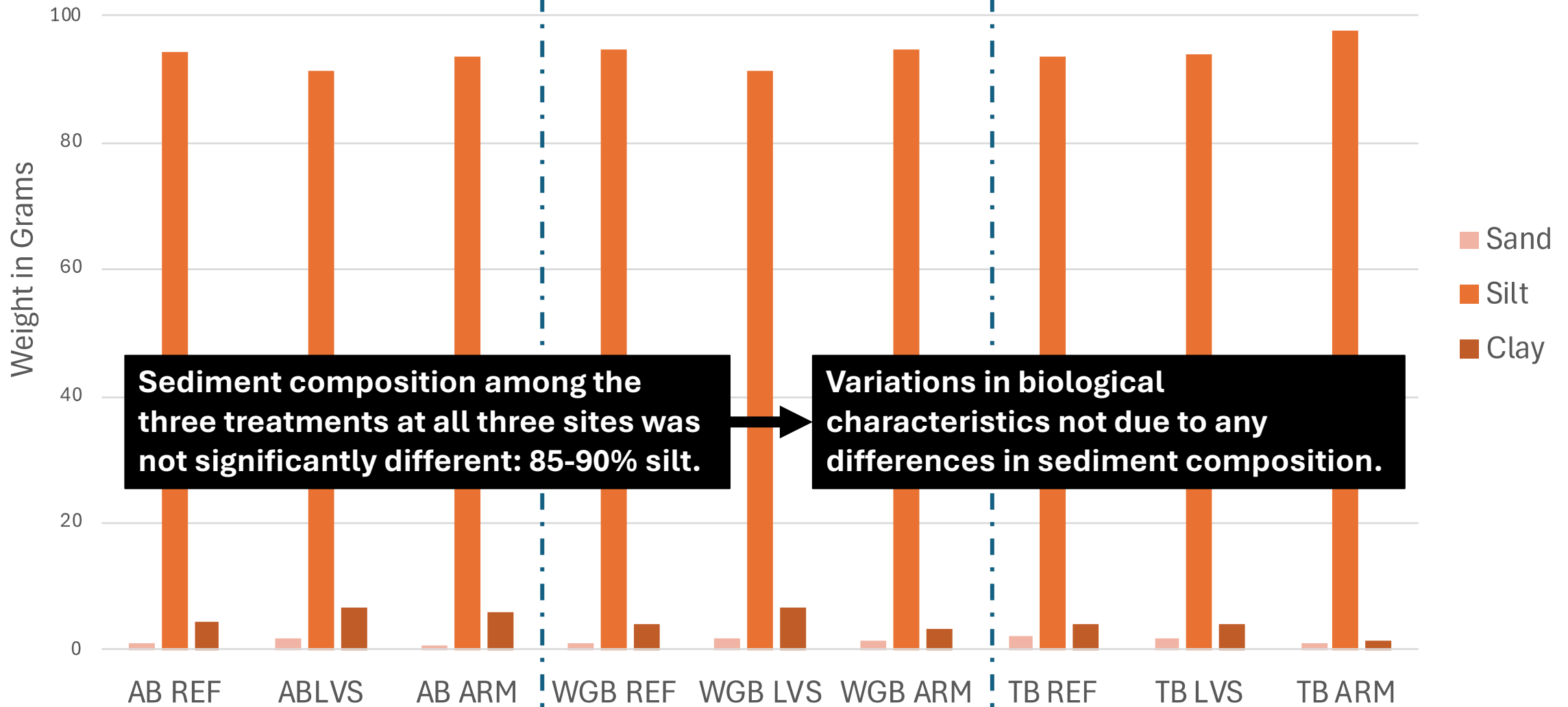
## Presentation Outline:

- Sediment Texture
- Plant community
- Benthic macroinvertebrate community
- Benthic microbial community



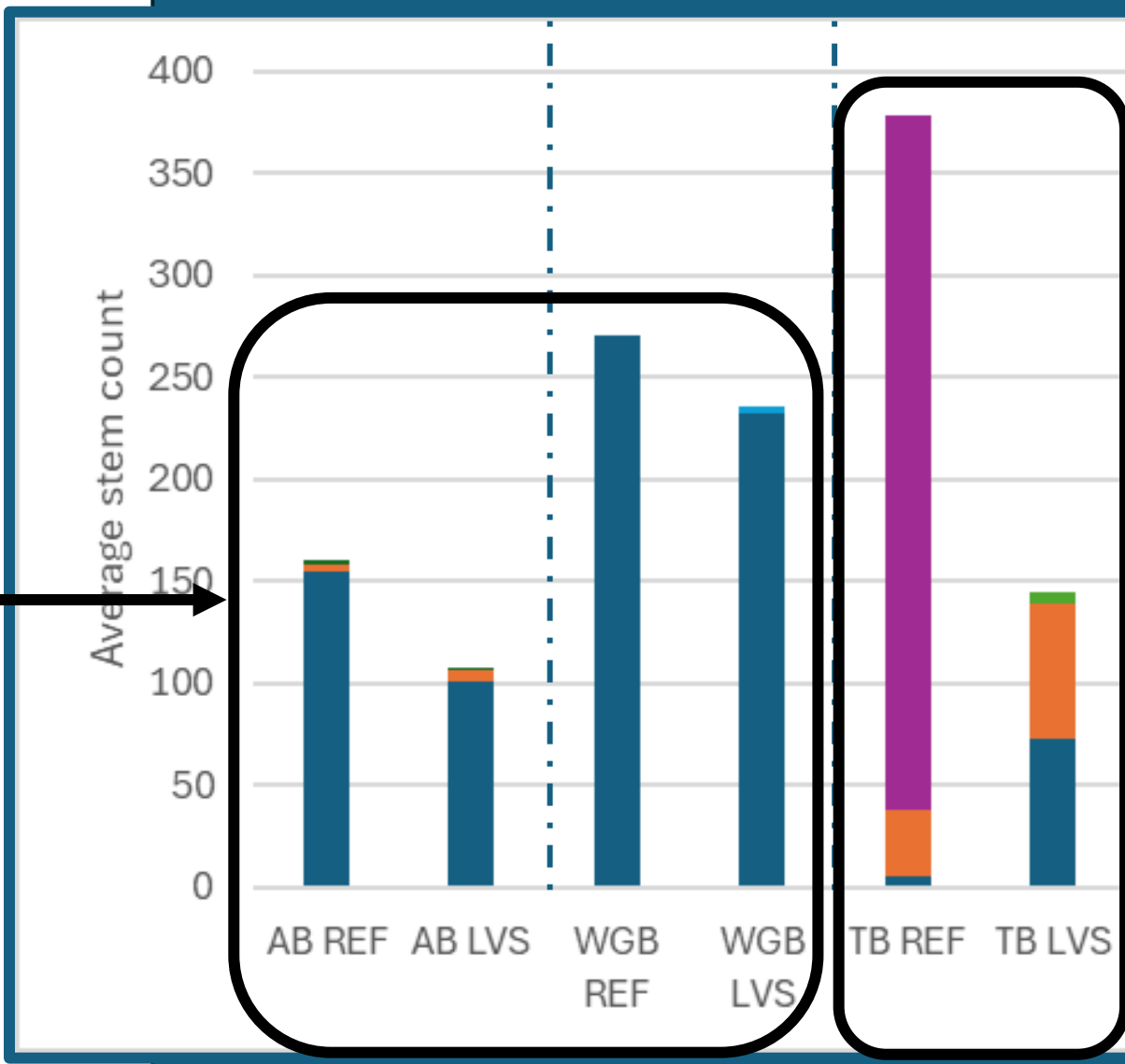
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# Comparison of sediment texture among sites



# Stem densities of plant communities

**AB and WGB dominated by *S. alterniflorus*.**  
**REF > LVS at both sites.**



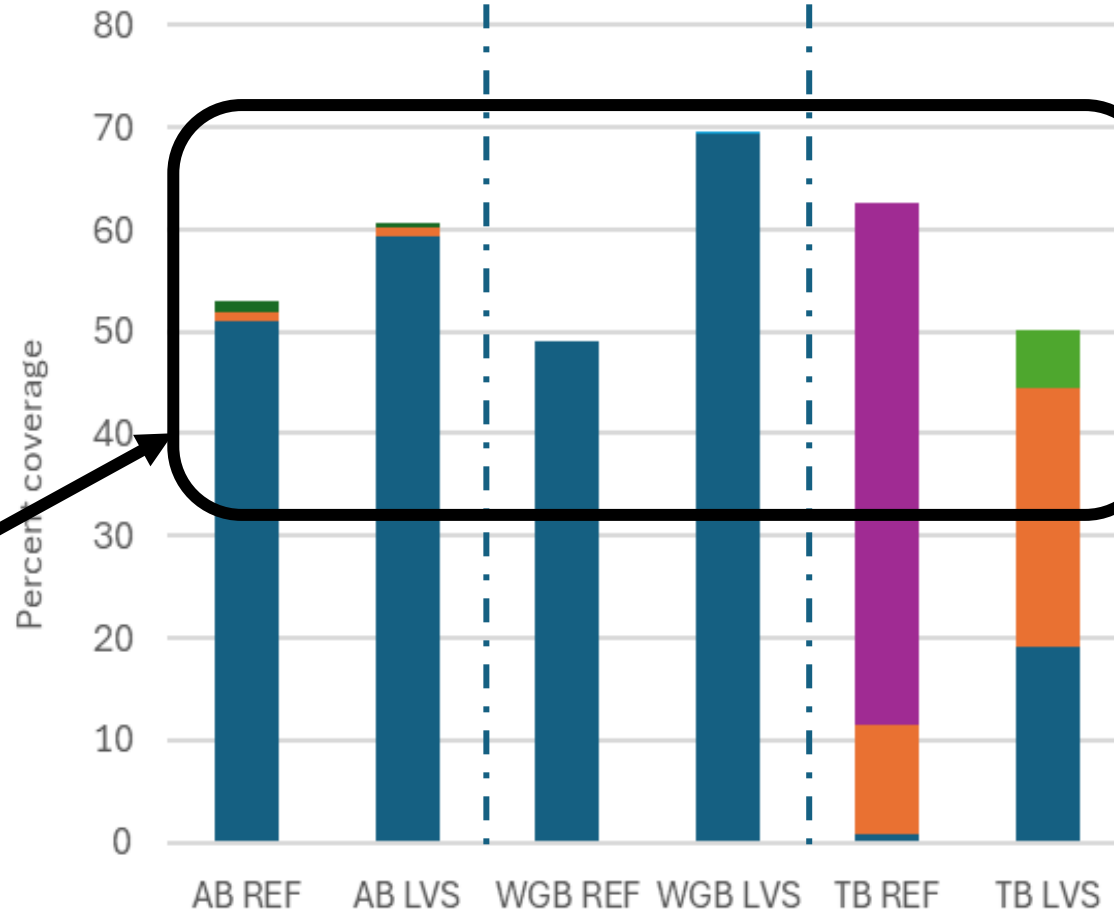
**TB dominated by two bullrush species.**  
**REF >> LVS.**

- Suaeda linearis*
- Schoenoplectus pungens*
- Salicornia virginica*
- Achyranthes philoxeroides*
- Bolboschoenus maritimus*
- Sporobolus alterniflorus*

# Percent coverage of plant species

Although stem densities varied among the sites and treatments, percent coverage was more similar.

LVS > REF at AB and WGB.



- Suaeda linearis*
- Schoenoplectus pungens*
- Salicornia virginica*
- Achyranthes philoxeroides*
- Bolboschoenus maritimus*
- Sporobolus alterniflorus*

Shannon Index is a measure of species richness and relative abundance of each species.

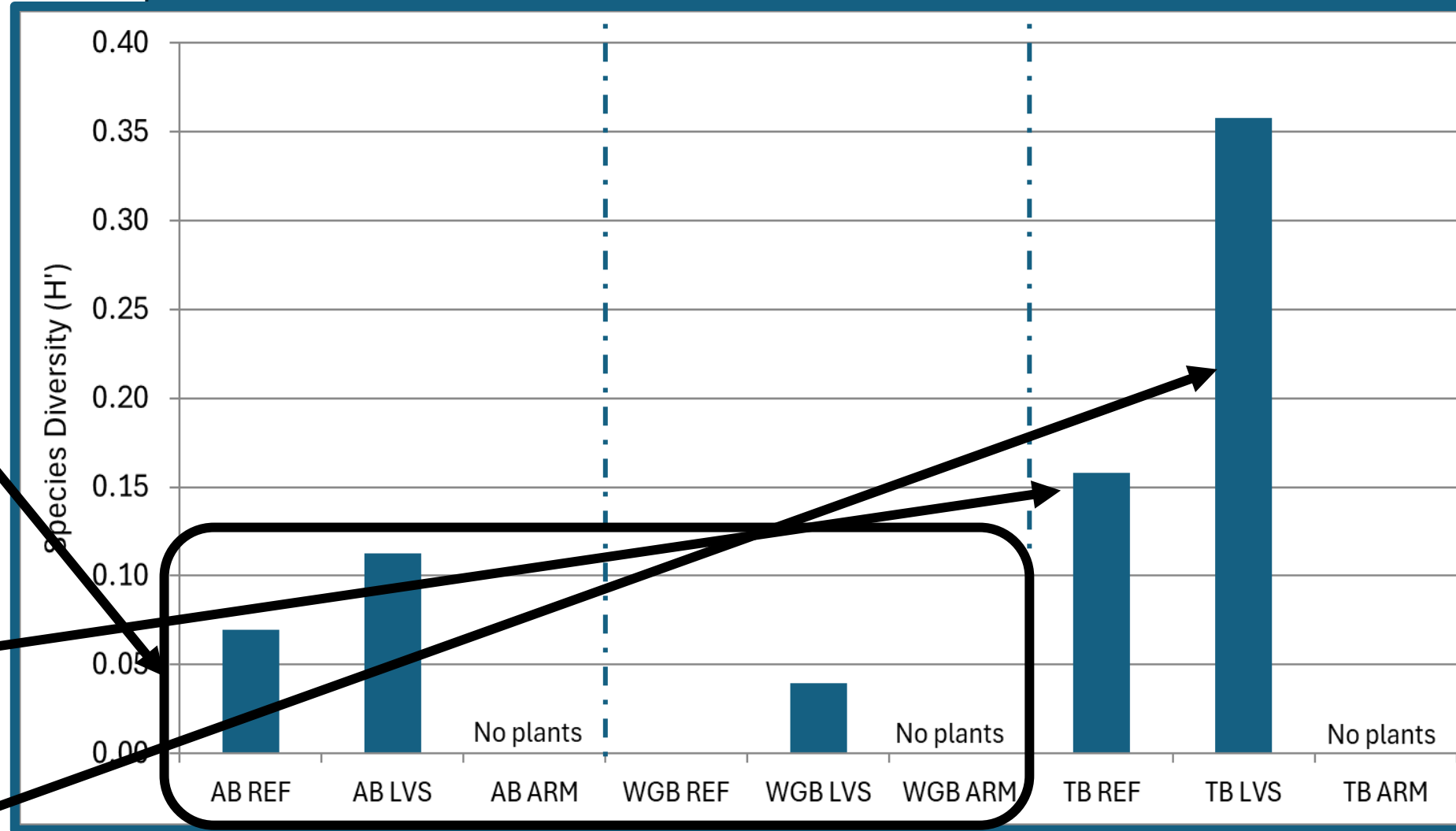
# Plant species diversity

All of these values are low.

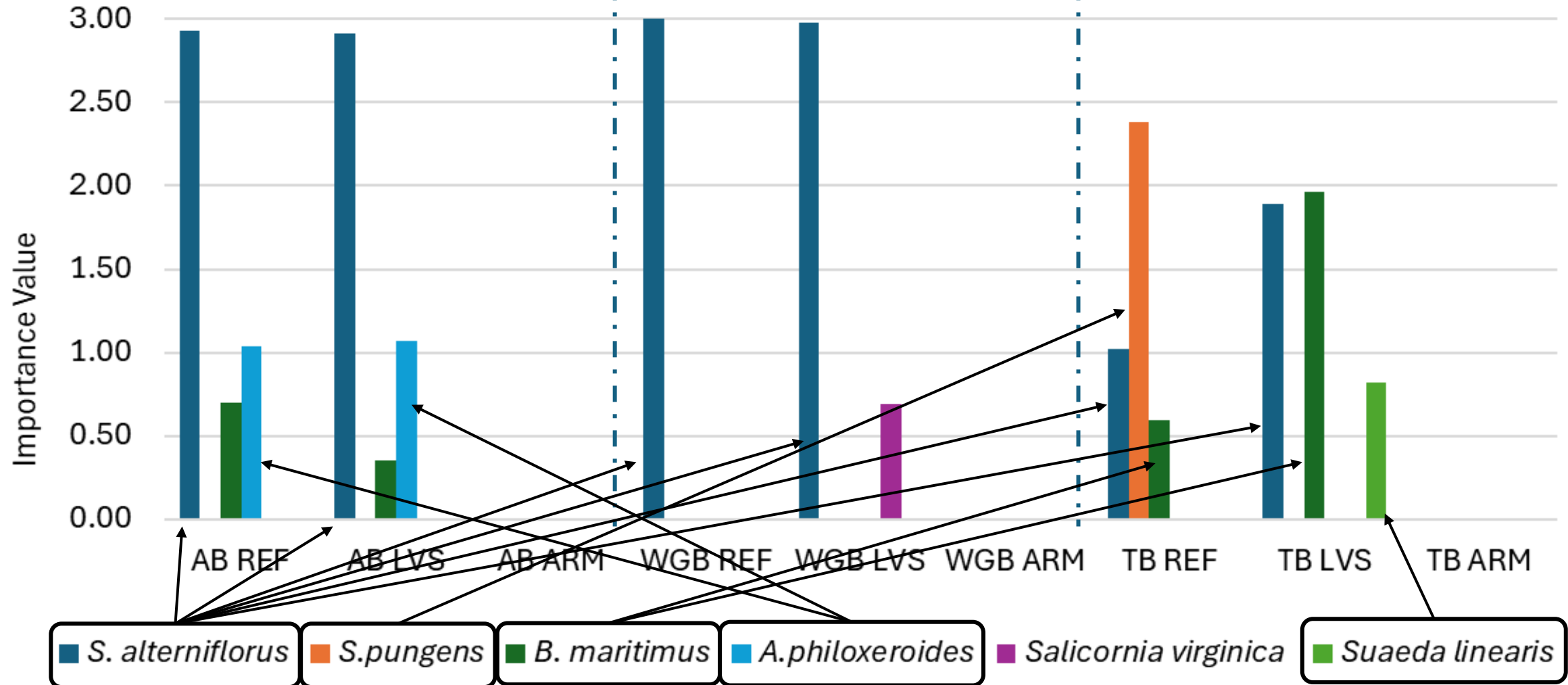
AB and WGB REF and LVS extremely low due to dominance of *S. alterniflorus*.

TB REF low due to dominance of *S. pungens*.

TB LVS higher because species present are more evenly distributed.



# Plant species Importance Values (2021-2023)



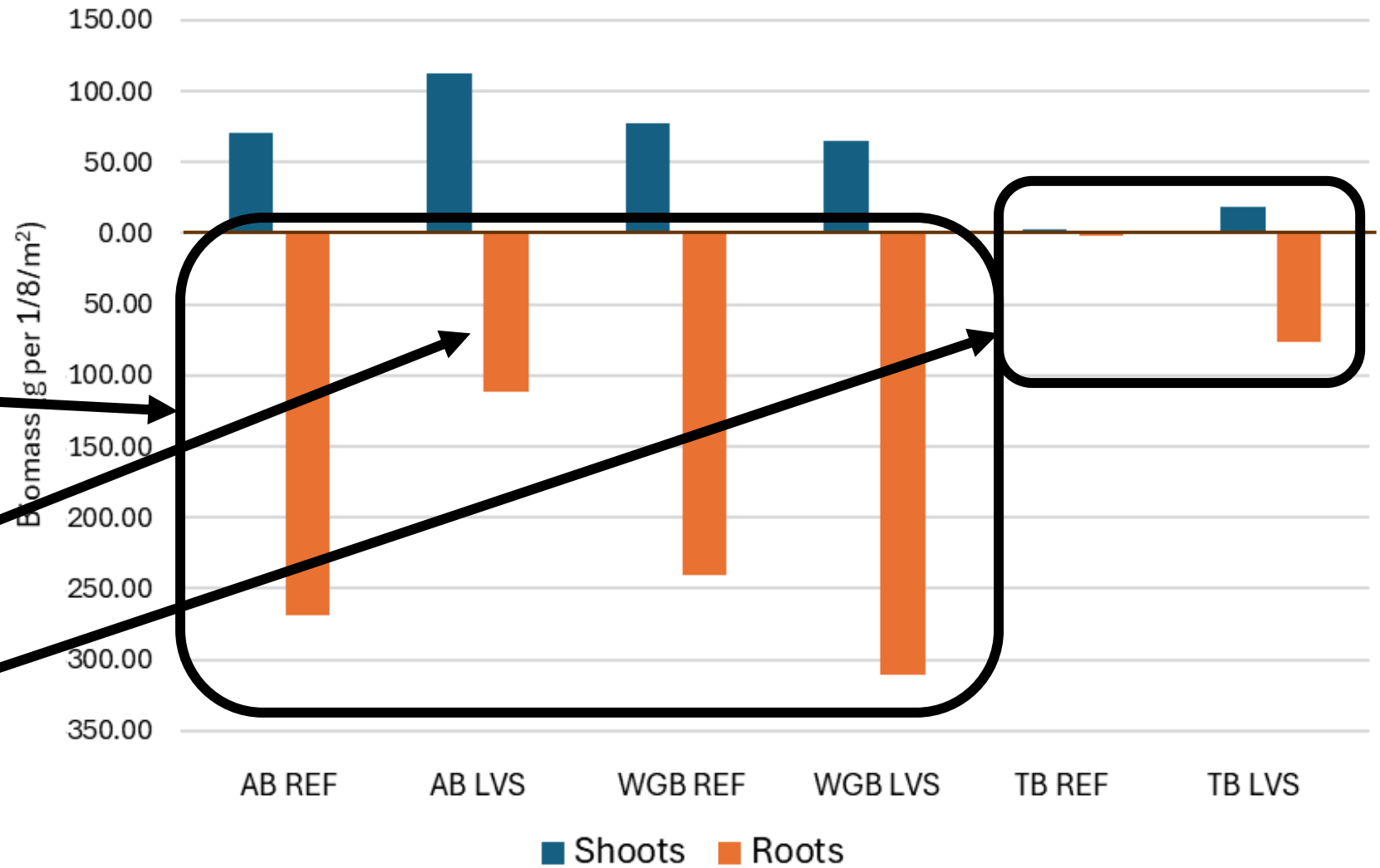


# *Sporobolus* root and shoot biomass

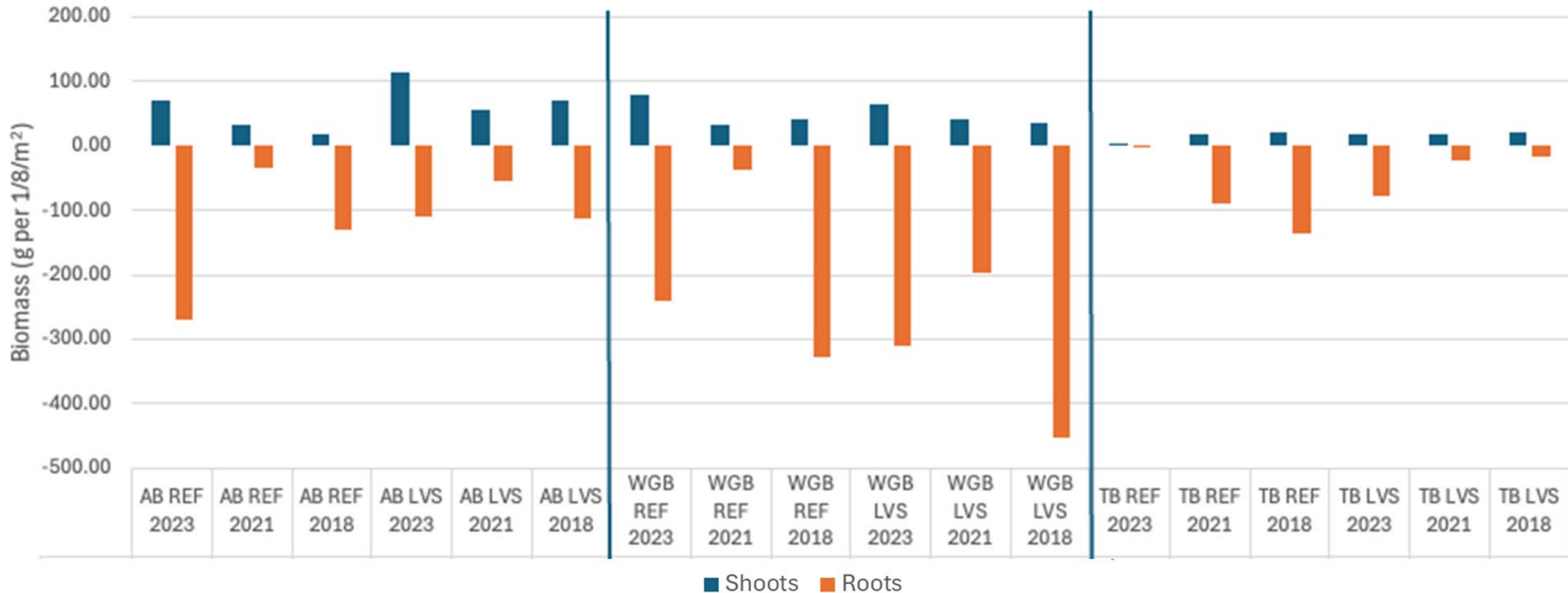
Increased root biomass in  
more stable salt marsh plant  
communities.

AB REF > LVS factor of  
disturbance?

TB REF area significantly  
eroded.



# Comparison of *Sporobolus* biomass by year

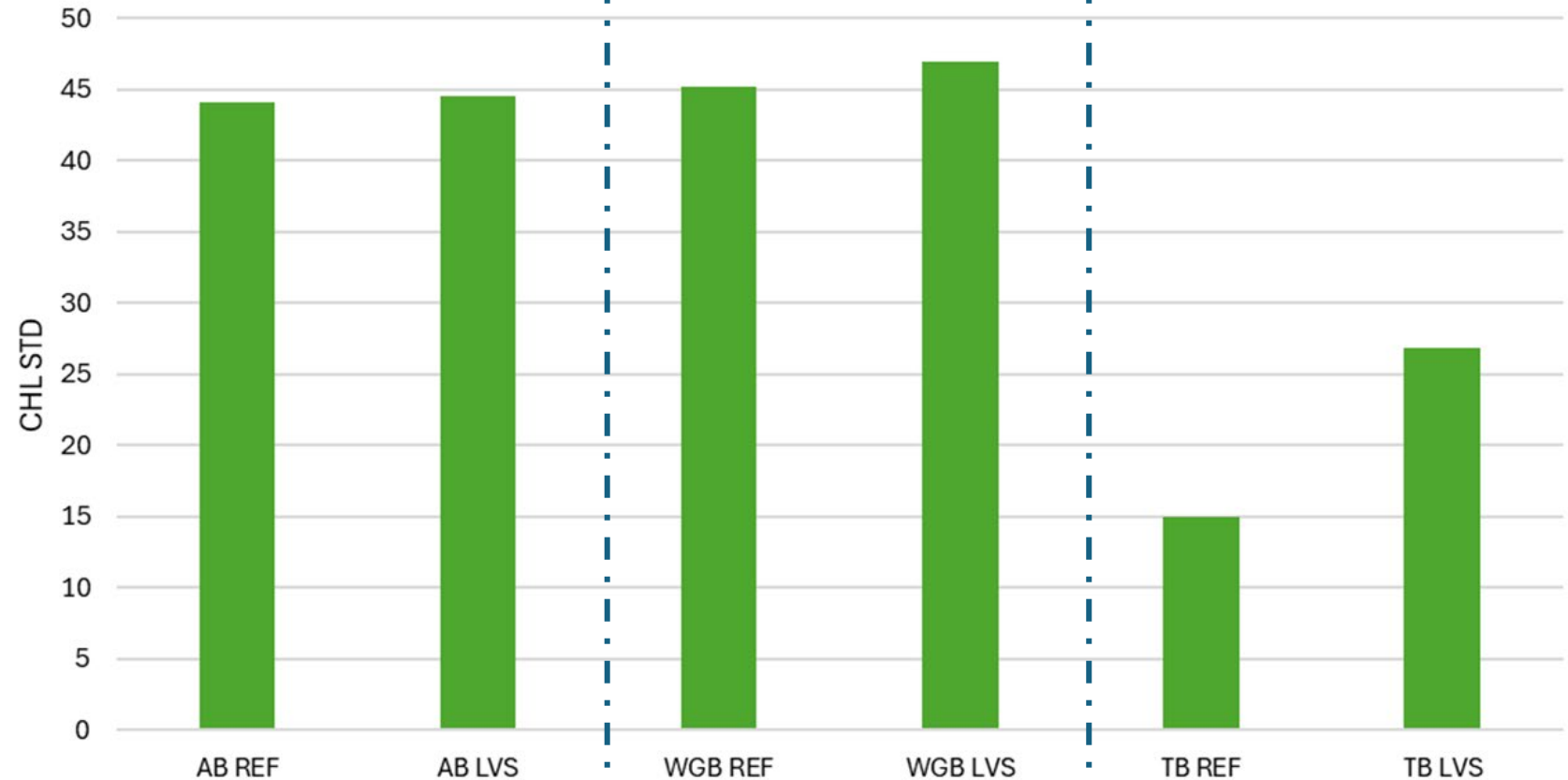


# *Sporobolus* chlorophyll (per leaf)

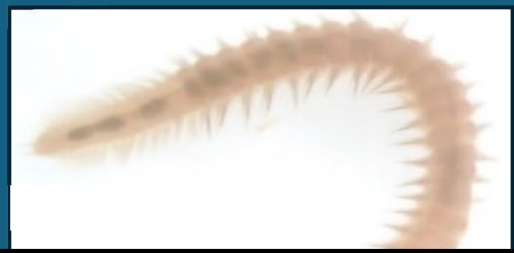
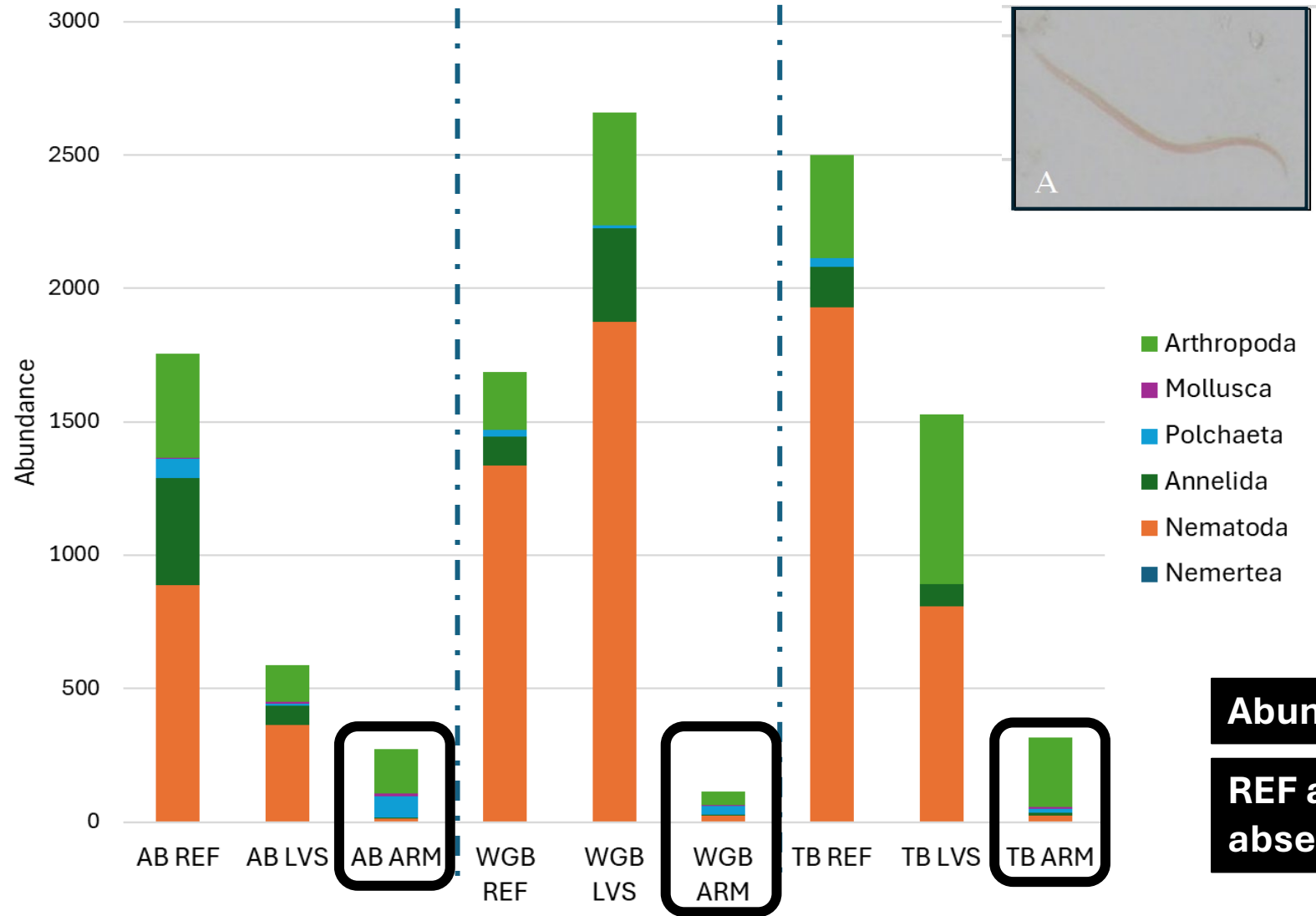
**Measure of community  
productivity.**

**AB and WGB REF and LVS  
areas equally productive.**

**TB REF productivity < LVS  
(due to erosion stress).**



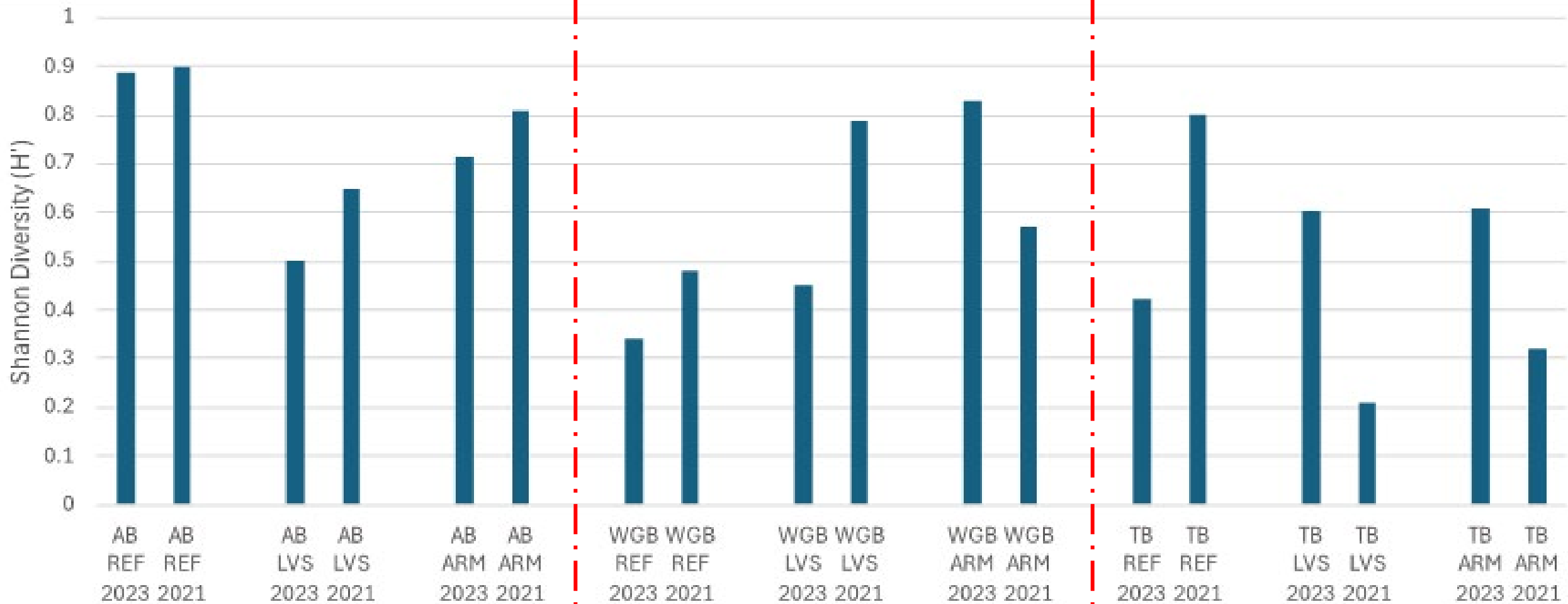
# Benthic macroinvertebrate taxa abundance



**Abundance significantly lower at ARM.**

**REF and LVS dominated by Nematoda, virtually absent from ARM.**

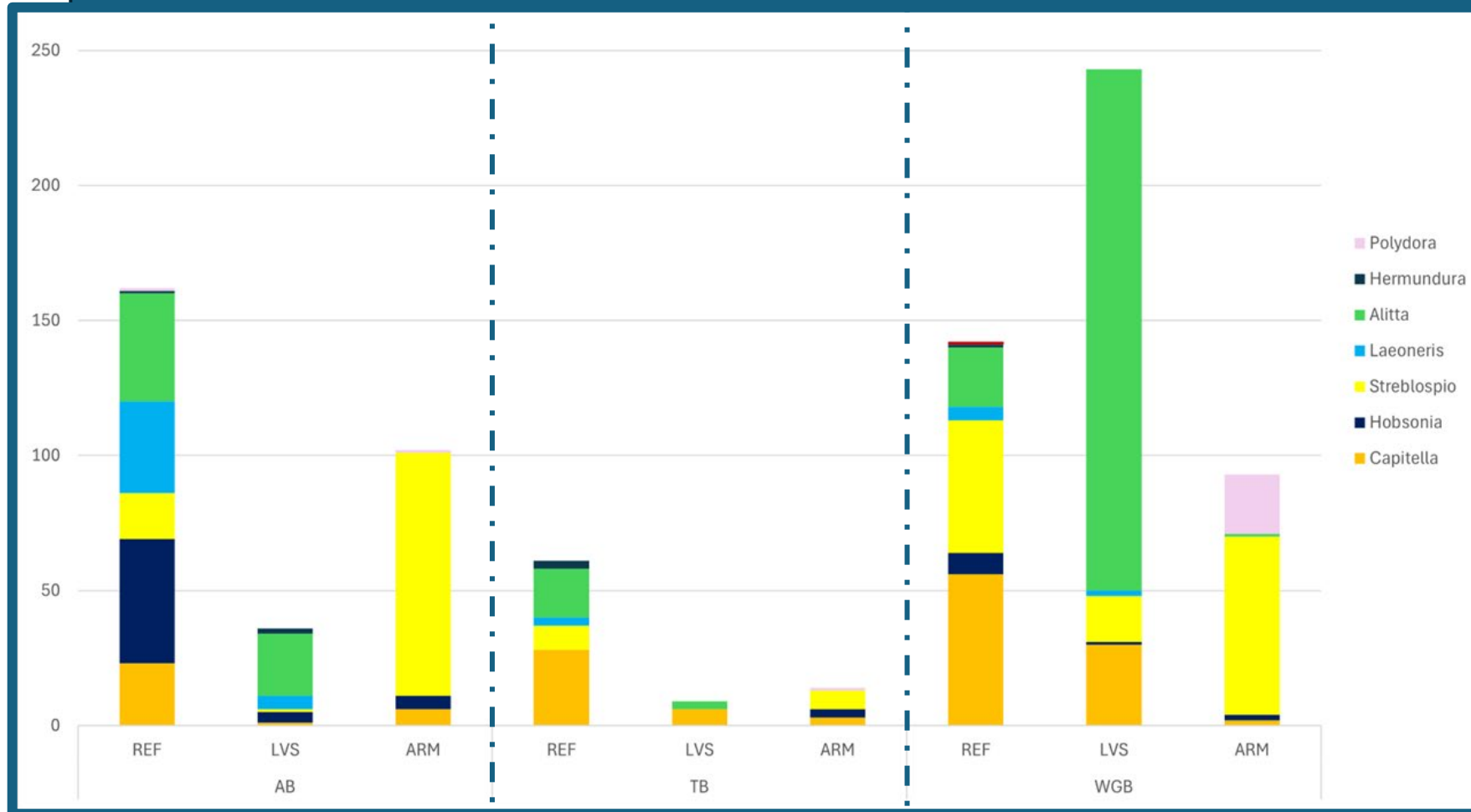
# Comparison of benthic macroinvertebrate diversity



# Abundance of benthic polychaete worm taxa

***Alitta*** is a positive indicator, found in REF and LVS at all three sites; none in ARM

***Streblospio*** is an indicator of moderate disturbance, dominates ARM



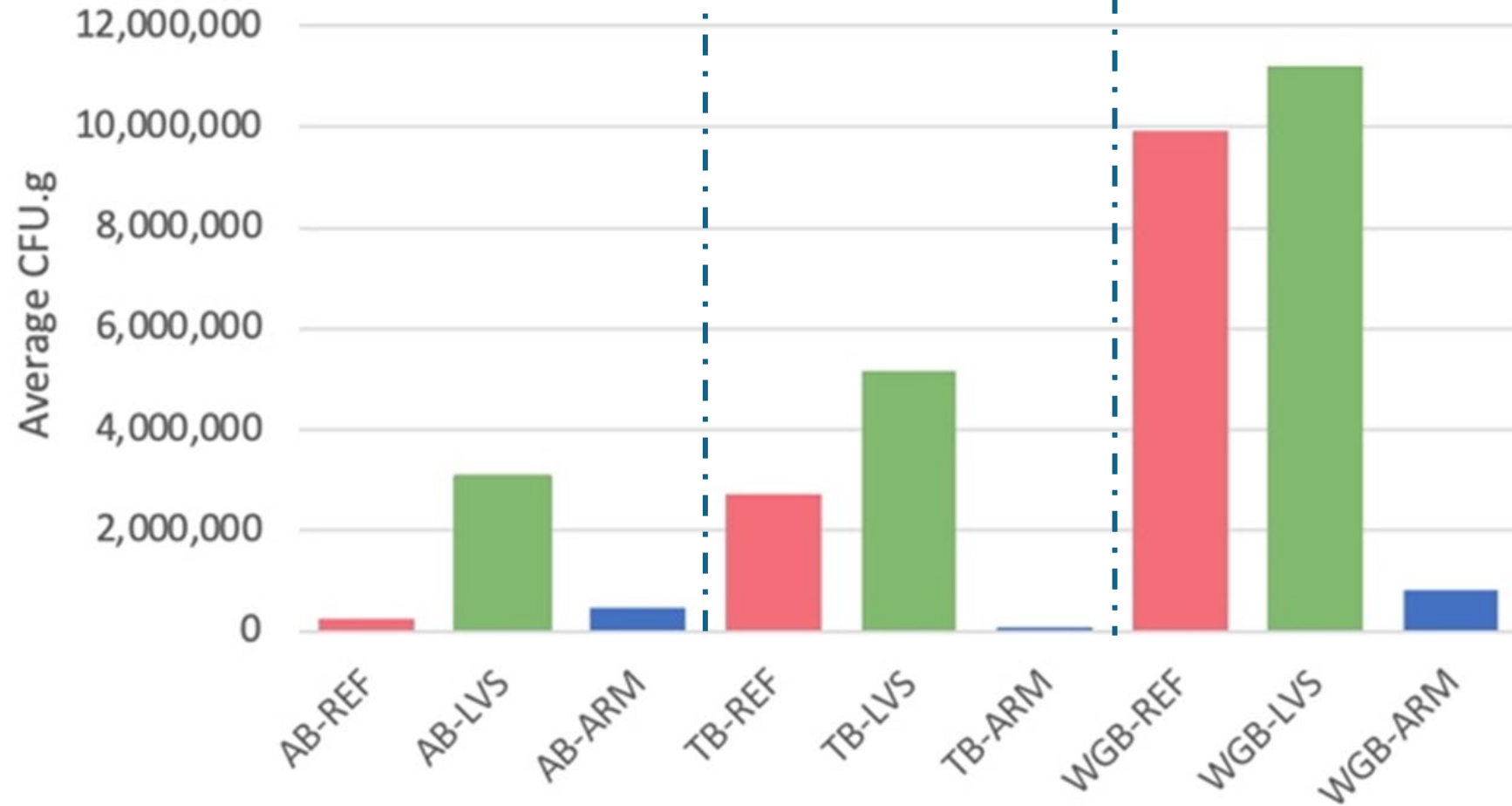
Presence/activity of microbes important for nutrient cycling, decomposition and overall ecosystem function.

# Viabile microbial counts

Low counts may lead to nutrient accumulation and sediment degradation.

Highest CFUs at each site: LVS.

All sites low CFUs at ARM.

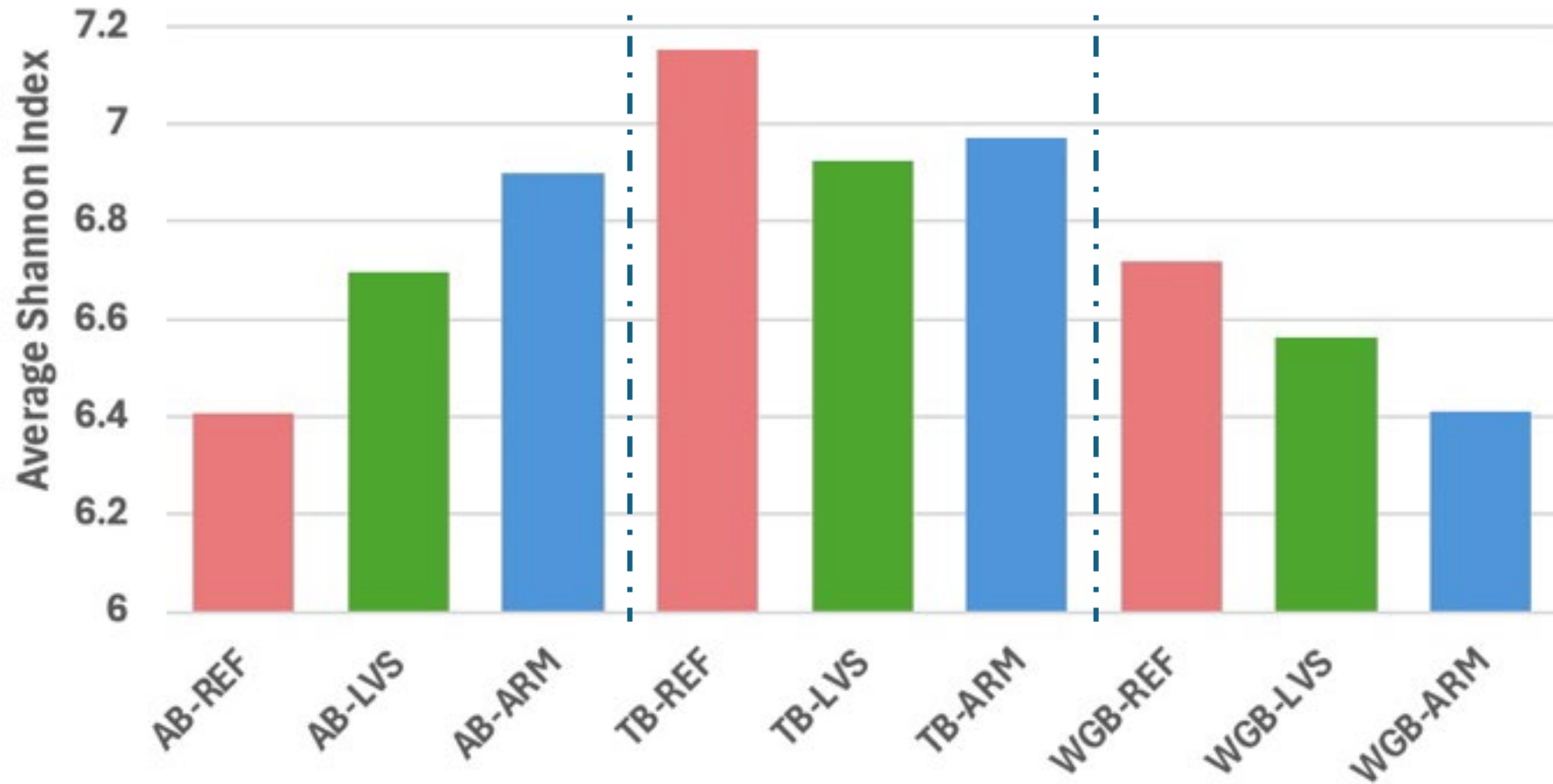




# Bacterial taxa diversity

Highest bacterial taxa  
diversity at TB

Although the CFUs were  
low at ARM sites, the  
taxa diversity was high.



# Evaluating Saltmarshes as a Nature-based Solution to Microplastic Pollution

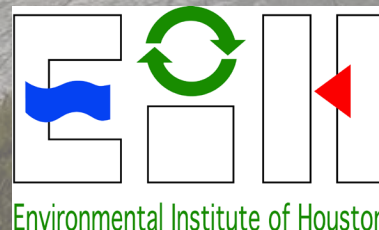
Lydia Thurman<sup>1,2\*</sup>, Marc Mokrech<sup>1,2</sup>, Gabrielle Hammerbach<sup>1,2</sup>, Mandi Gordon<sup>2</sup>, Kathleen Garland<sup>3</sup>, Cynthia Howard<sup>1</sup>

<sup>1</sup>College of Science and Engineering, University of Houston–Clear Lake, Houston, Texas

<sup>2</sup>Environmental Institute of Houston, University of Houston–Clear Lake, Houston, Texas

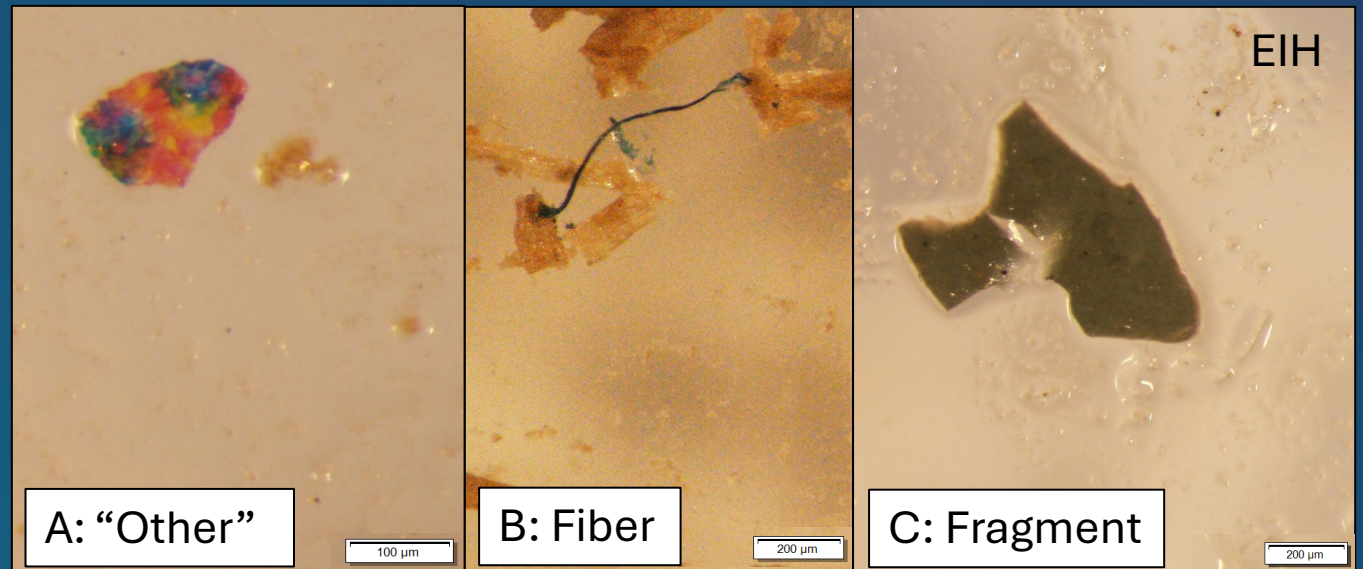
<sup>3</sup>College of Business, University of Houston–Clear Lake

\*Corresponding and presenting author; [thurmanl@uhcl.edu](mailto:thurmanl@uhcl.edu)



# Microplastics

- <5mm
- Shapes, surface-area, properties
- Density separation (Song et al. 2022, Lavoy and Crossman 2021)
  - Likely influence dispersion in environment



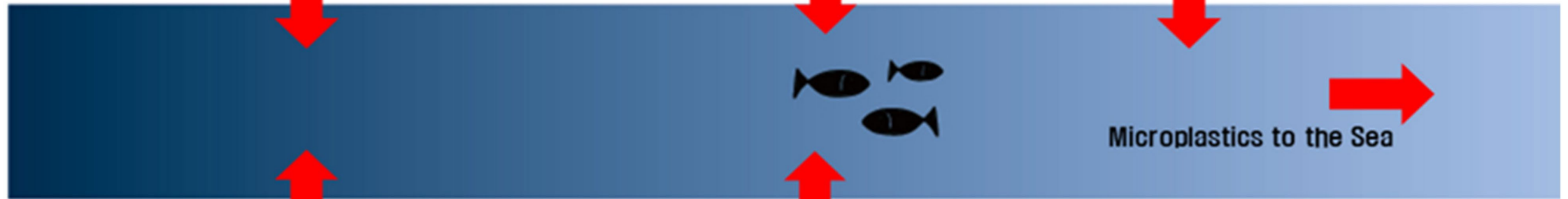
**Microplastic from Agriculture**  
Sources: Vinyl, styrofoam, pipe, fertilizer, etc.



**Microplastic from Landfill**  
Sources: Plastic wastes etc.



**Microplastic from Runoff**  
Sources: Tires, Paint, etc.



**Microplastic from Household**  
Sources: Personal by products, Textiles, Paint etc.



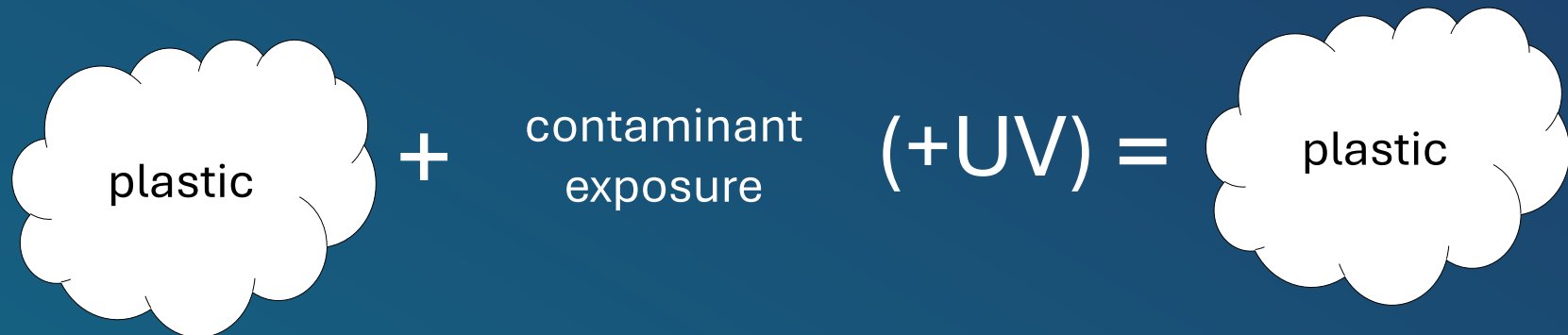
**Microplastic from Industry**  
Sources: Wastewater, Cosmetics, textiles etc.



## Microplastic Sources

# Impacts of Microplastics

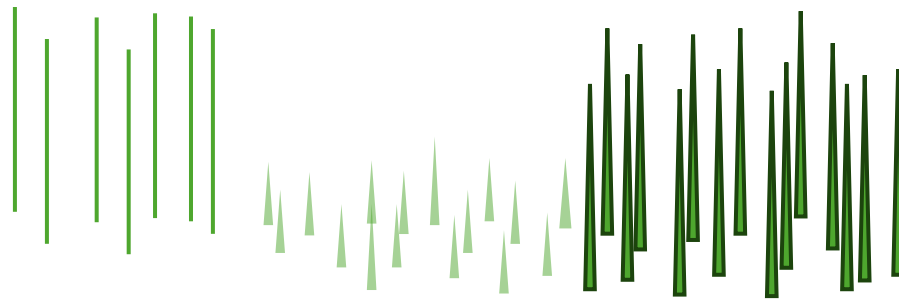
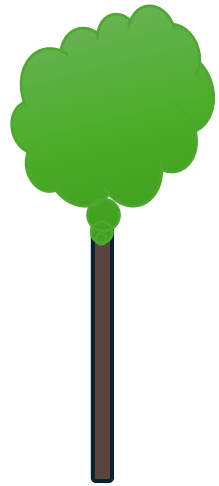
- Polychlorinated biphenyls (PCB's), organochlorine pesticides (OCP's), polycyclic aromatic hydrocarbons (PAH's) sorption (Campanale et al. 2020)
- UV-aging and adsorption, heavy metals (Mao et al. 2020)
- Bioconcentration (Miller et al. 2023) – uptake and concentration



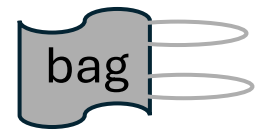
# Saltmarshes

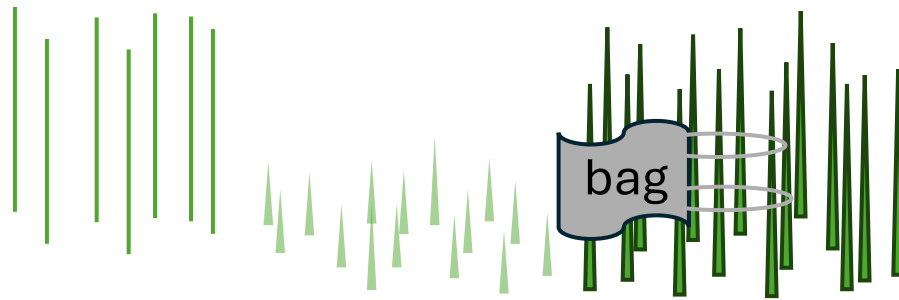
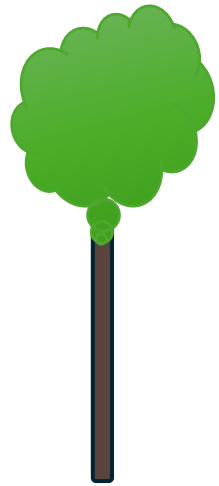
- Ecologically significant habitat
  - Fish nurseries
  - Bird rookeries
- Suspended particulate matter builds the marsh platform
- Filter contaminants
  - Uptake and sieve



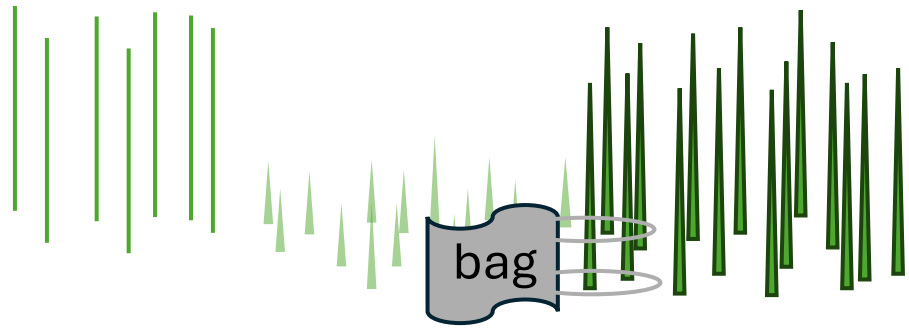
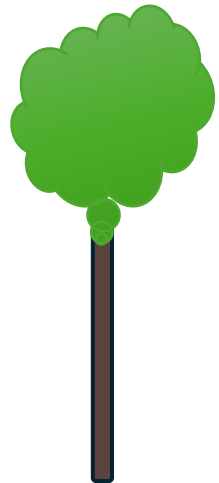


Low tide





High tide



Low tide

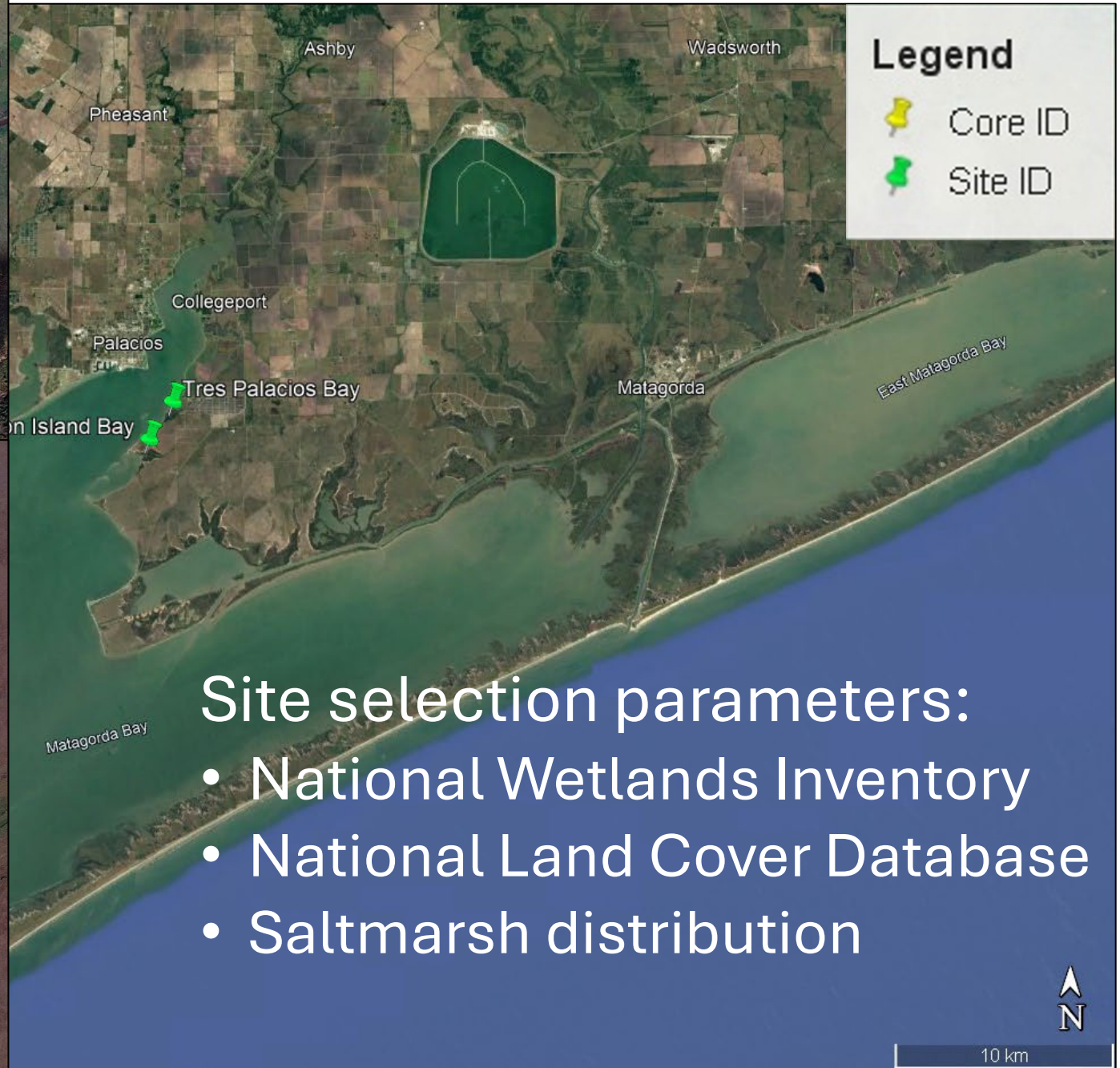
# Research Questions

- Do saltmarshes accumulate microplastics?
- Do different marsh zones accumulate different concentrations of microplastics?
- How have microplastic concentrations changed in the sediment profile over time?
- Is urban proximity correlated to microplastic concentrations in saltmarshes?

# Tres Palacios Bay (TPB)



# Coon Island Bay (CIB)





A



B



D



F



C



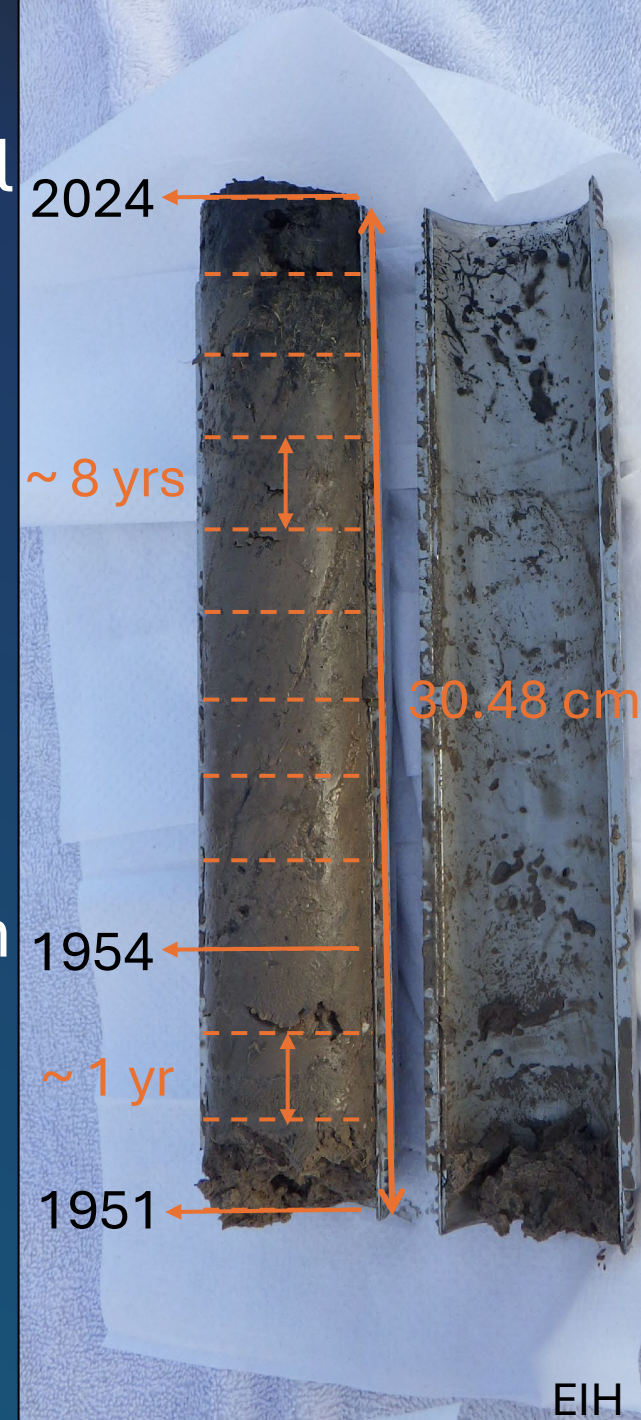
E



G

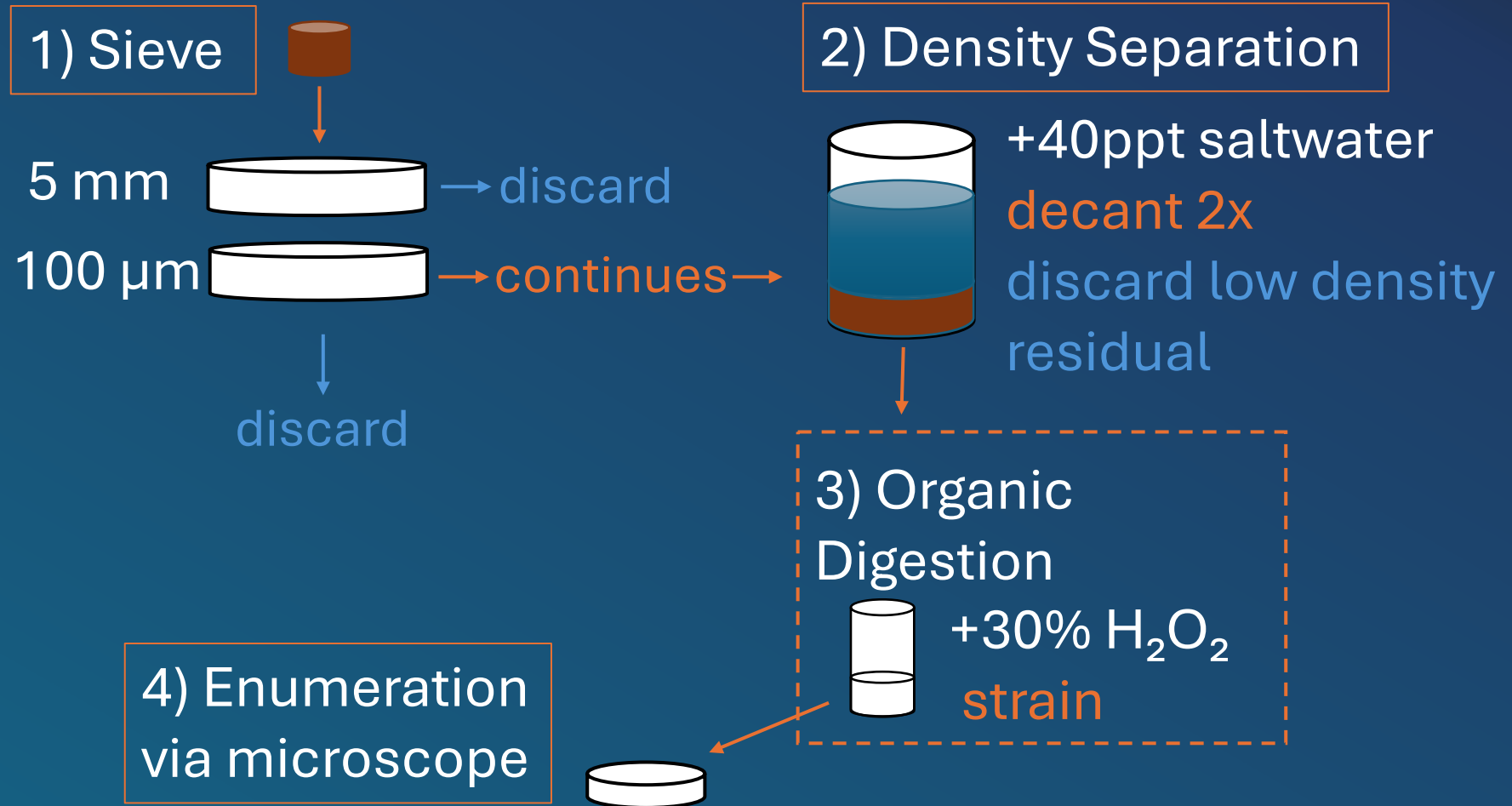
# Methods

- Sediment cores ~ 30.48cm
  - High marsh, low marsh, channel zones
- Sectioned based on standard time interval (Williams, 1995) into 12 segments
  - 0.32 cm/yr average between 1954-1994
    - => 1954=2024
    - ~ 8 years of sediment in 2.54cm
  - 2.4 cm/yr average between 1948-1954
    - =>1951-1954
    - ~ 3 years; ~1yr/2.54cm



# Methods

- Processed to isolate microplastics
  - Sieved, density separation, organic digestion ( $\text{H}_2\text{O}_2$ )
- Enumerated via stereomicroscope

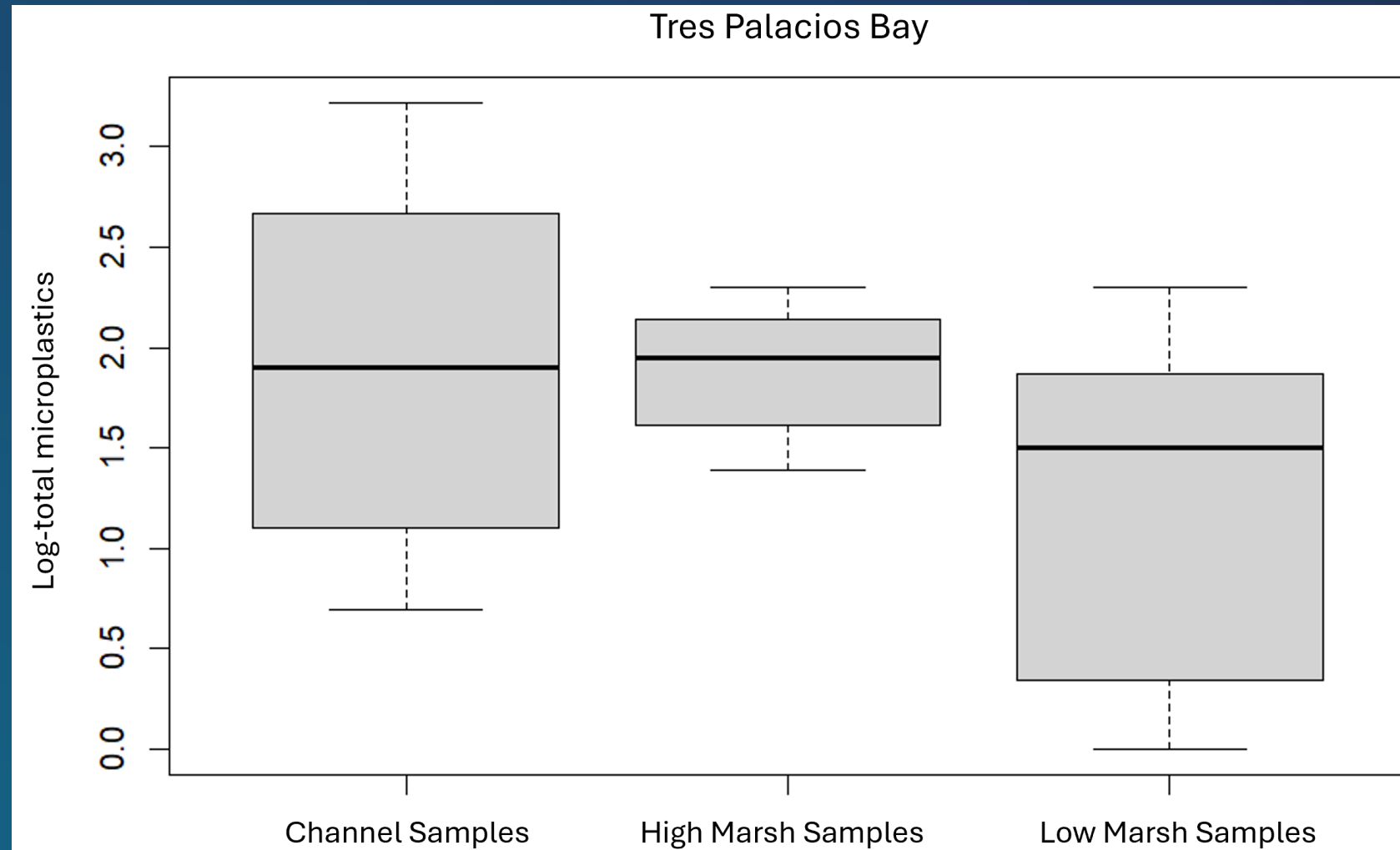


# Do saltmarshes accumulate microplastics?

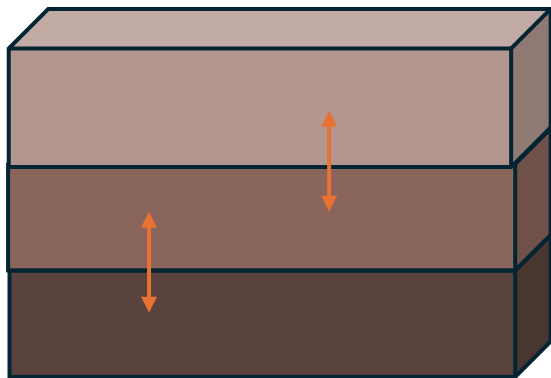
- Microplastics present in sediment
  - 63/72 slices had microplastics
    - 7 low marsh slices (between 2 sites) had 0 microplastics
  - Significant differences in microplastic type
    - CIB: between fibers and fragments, between fibers and “other” microplastics
    - TPB: between fibers and fragments

Do different marsh zones accumulate different concentrations microplastics?

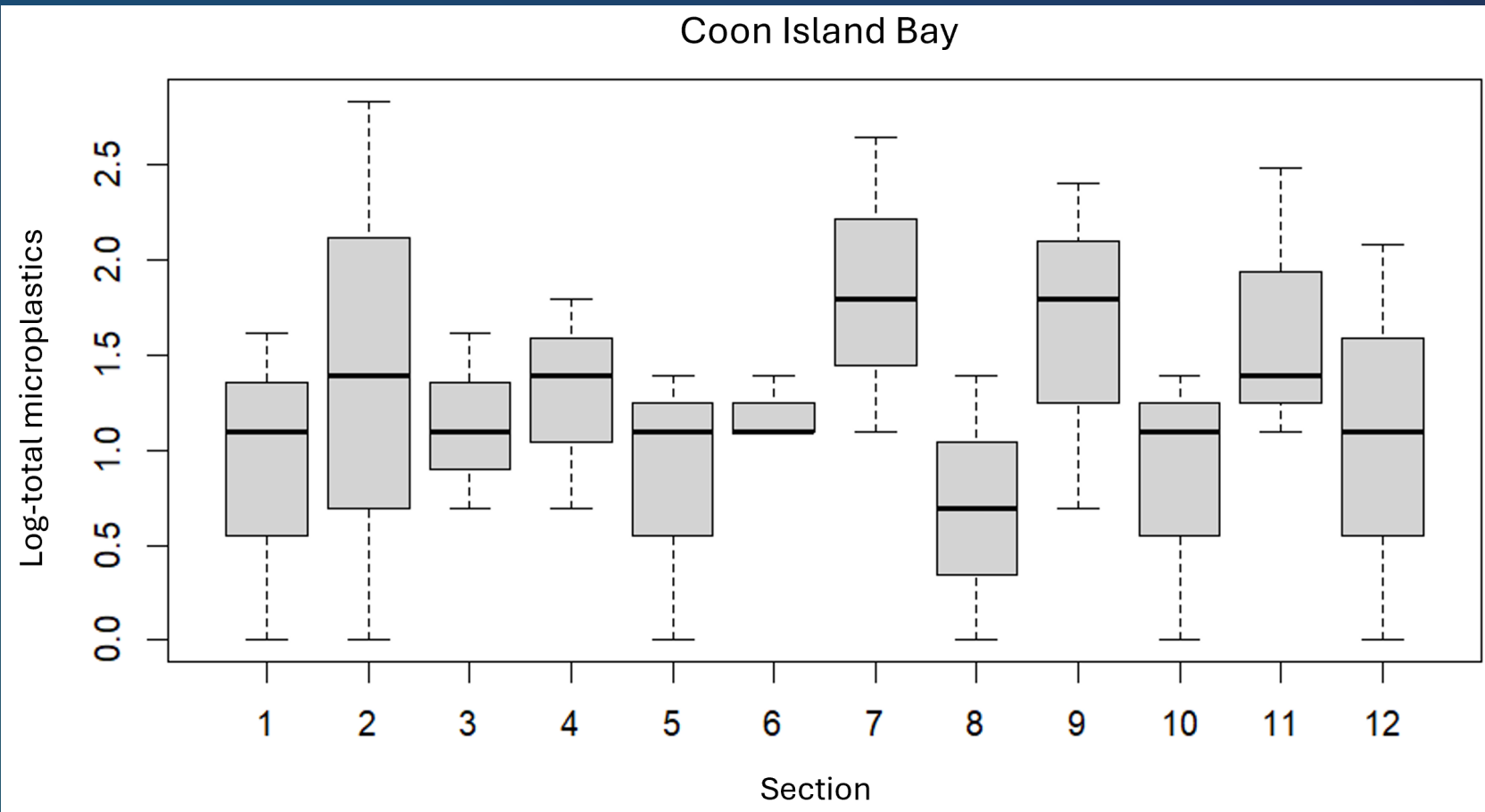
- No significant differences ( $\alpha = 0.05$ )
  - TPB (p-value: 0.06394;  $\log(y+1)$ ); CIB (p-value: 0.7974;  $\log(y+1)$ )
- Spatial variation in deposition (Cornacchia et al. 2024)



# How have microplastic concentrations changed in the sediment profile over time?



- No significant differences in total microplastics across depths at both sites
- Bioturbation – vertical mixing



Is urban  
proximity  
correlated to  
microplastic  
concentrations  
in saltmarshes?

- A negative correlation was observed between microplastic totals and urban proximity ( $\tau$ : -0.6; p-value: 0.1361)

# Limitations

- Small sample size
- Assumptions
  - Constant sedimentation rate – linear extrapolation
    - Additional variables
- Subjectivity
  - Bias in visual identification

# The Bigger Picture

- More sediment to process
  - Increase statistical power
  - Surficial sediment to incorporate
- Modeling
  - Sea-level rise
  - Change in marsh zone distribution
    - Impact microplastic loading?
    - Tidal inundation or habitat type?

Jim Dobberstine – Faculty, Environmental Science – Lee College

## Presentation Outline:

- Considerations and planning
- Study results
  - Stabilization
  - Other benefits
- Implications

# Well, what do you want to know?

About:

- Shoreline stabilization?
  - Design
  - Location
    - Soil parameters
    - Wave energy
    - Water table/subsidence
- Biologic function?
  - Single parameter: aerial coverage of plant species
  - Multi-parameter:
    - Plant community
    - Nekton community
    - Benthic community
    - Trophic interaction
- Physical functions/risk profile?
  - Water and sediment quality
  - Sediment contaminants
    - POPs
    - Heavy metals
    - Microplastics



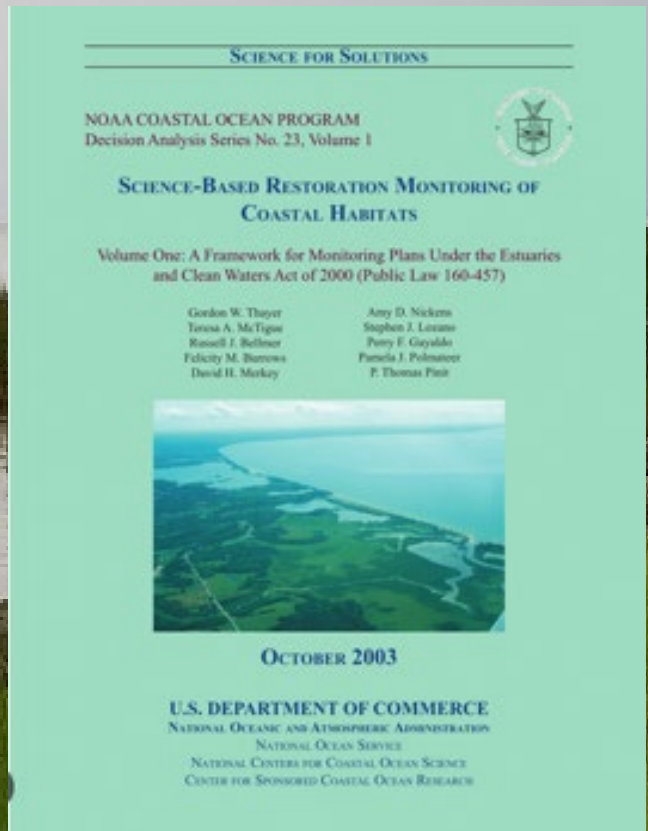
Houston, we  
have a problem.



- Single parameter, short-term monitoring is not informative toward understanding:
  - Biologic or physical function
  - Persistence and resiliency
  - Emerging challenges
- Multi-year, multiparameter monitoring can be informative to all of the above, but is often\* cost prohibitive

\*dang near *always*

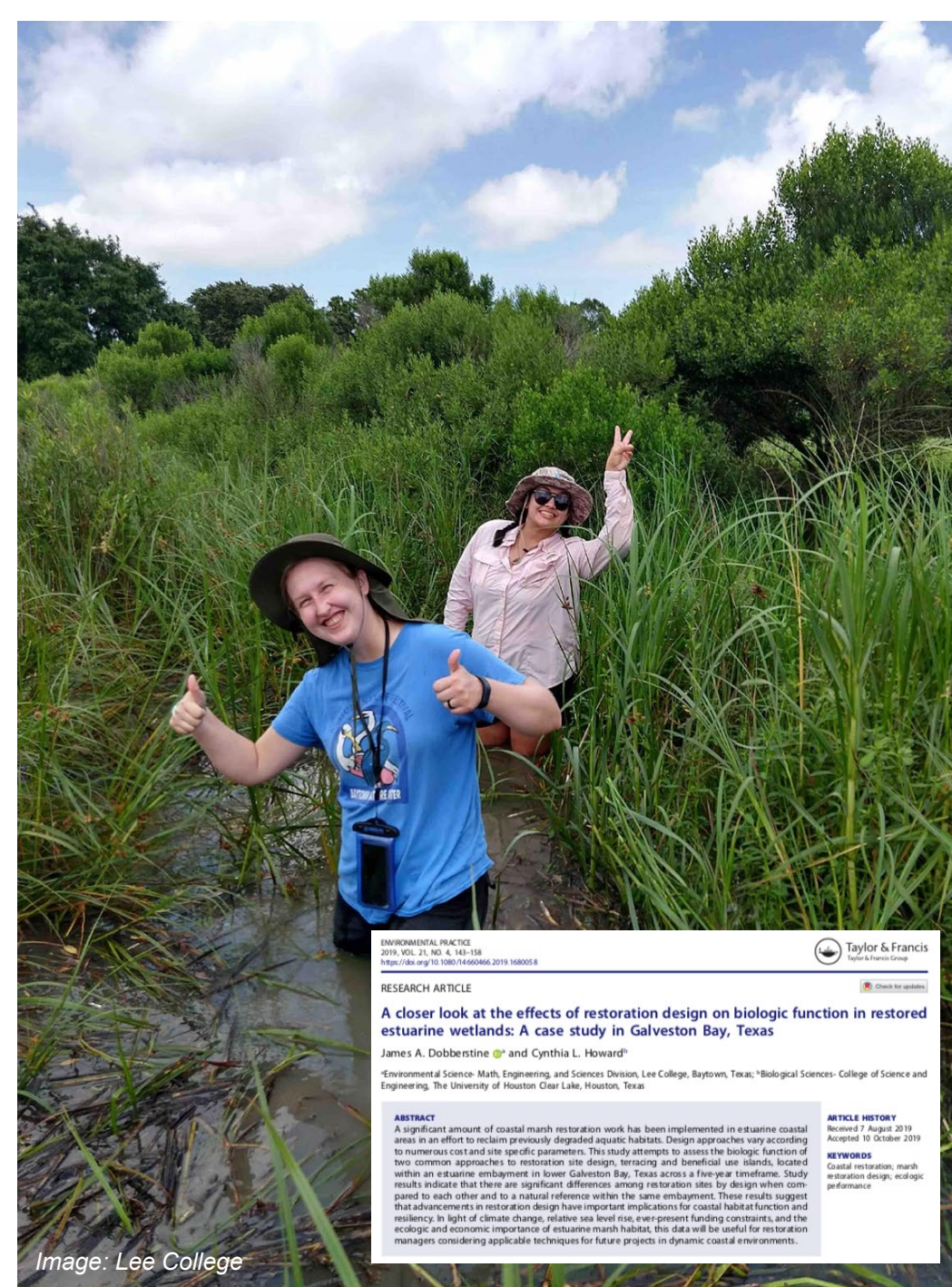




The purpose\* of science is to inform decision making for good outcomes

- ✓ Carefully selected and gathered data
- ✓ Valuable, applicable information
- ✓ Sound decisions
- ✓ Good outcomes





ENVIRONMENTAL PRACTICE  
2019, VOL. 21, NO. 4, 143-158  
<https://doi.org/10.1080/14660466.2019.1680058>

Taylor & Francis  
Taylor & Francis Group

RESEARCH ARTICLE

**A closer look at the effects of restoration design on biologic function in restored estuarine wetlands: A case study in Galveston Bay, Texas**

James A. Dobberstine and Cynthia L. Howard\*

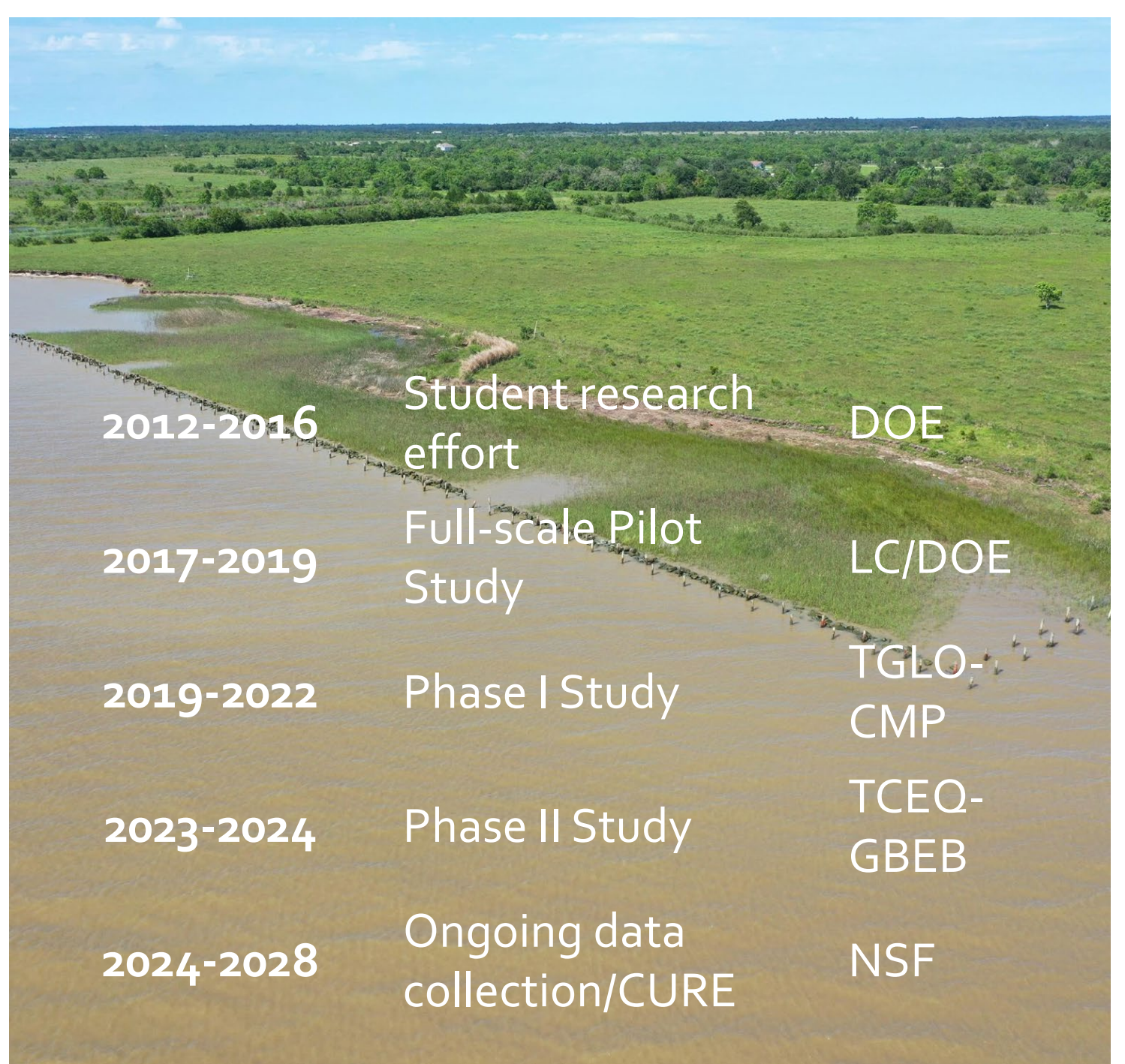
\*Environmental Science- Math, Engineering, and Sciences Division, Lee College, Baytown, Texas; \*Biological Sciences- College of Science and Engineering, The University of Houston Clear Lake, Houston, Texas

**ABSTRACT**  
A significant amount of coastal marsh restoration work has been implemented in estuarine coastal areas in an effort to reclaim previously degraded aquatic habitats. Design approaches vary according to numerous cost and site specific parameters. This study attempts to assess the biologic function of two common approaches to restoration site design, terracing and beneficial use islands, located within an estuarine embayment in lower Galveston Bay, Texas across a five-year timeframe. Study results indicate that there are significant differences among restoration sites by design when compared to each other and to a natural reference within the same embayment. These results suggest that advancements in restoration design have important implications for coastal habitat function and resiliency. In light of climate change, relative sea level rise, ever-present funding constraints, and the ecologic and economic importance of estuarine marsh habitat, this data will be useful for restoration managers considering applicable techniques for future projects in dynamic coastal environments.

**ARTICLE HISTORY**  
Received 7 August 2019  
Accepted 10 October 2019

**KEYWORDS**  
Coastal restoration; marsh restoration design; ecologic performance

Image: Lee College



2012-2016 Student research effort DOE

2017-2019 Full-scale Pilot Study LC/DOE

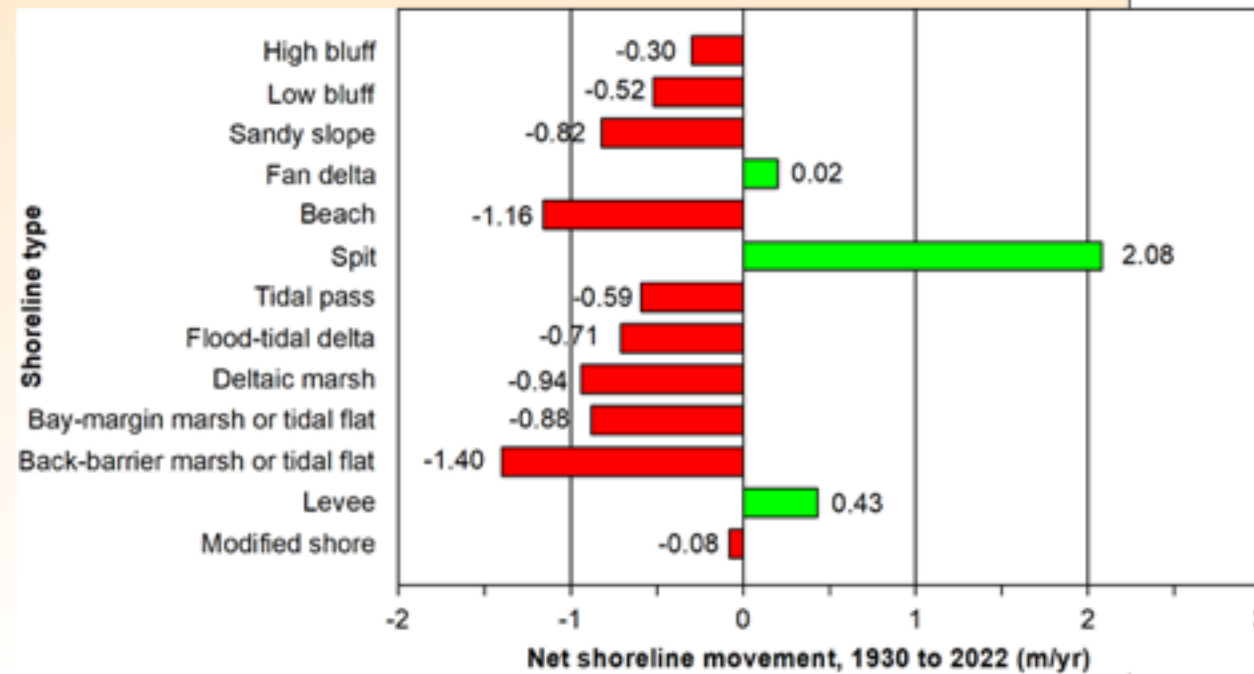
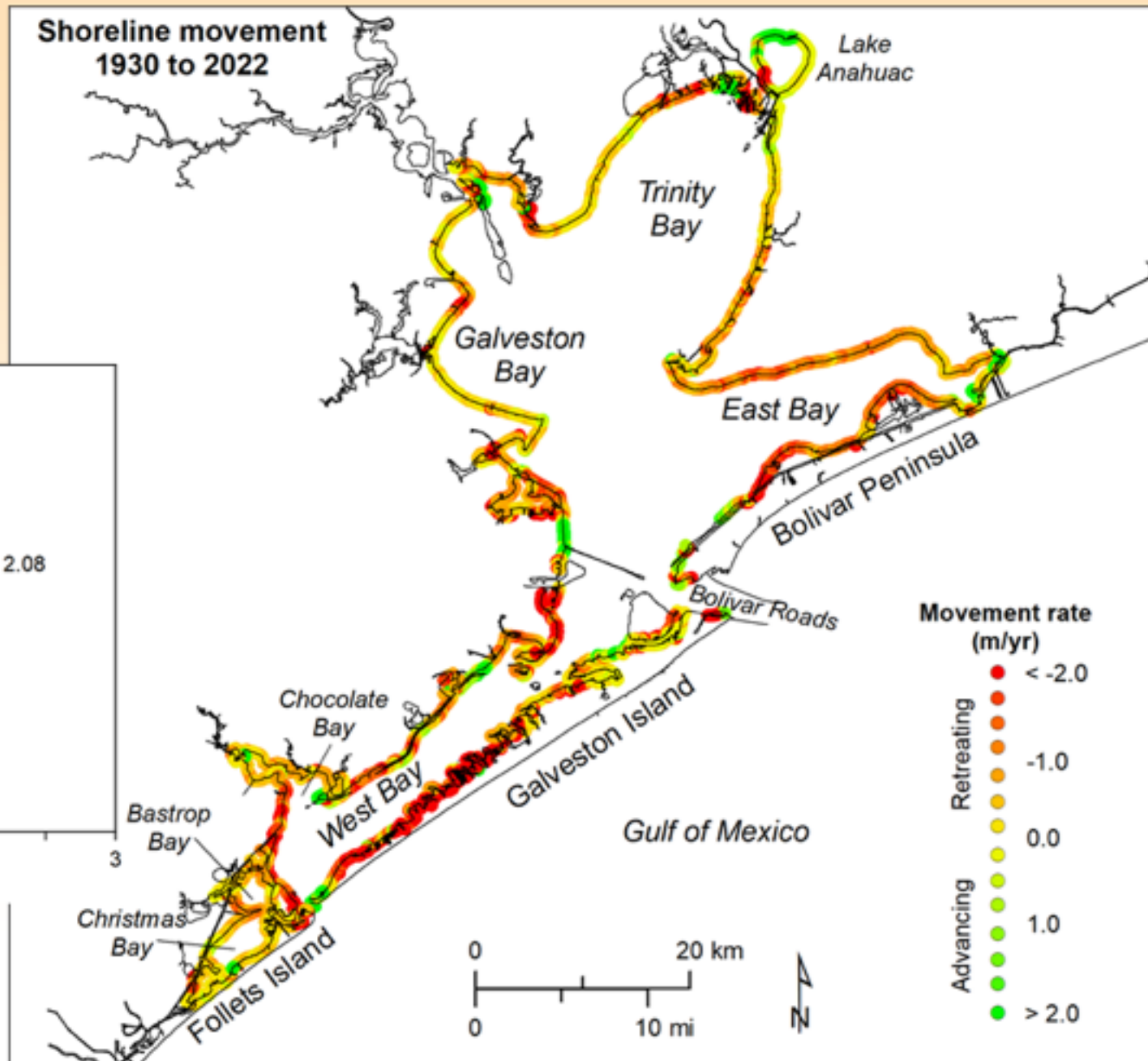
2019-2022 Phase I Study TGLO-CMP

2023-2024 Phase II Study TCEQ-GBEB

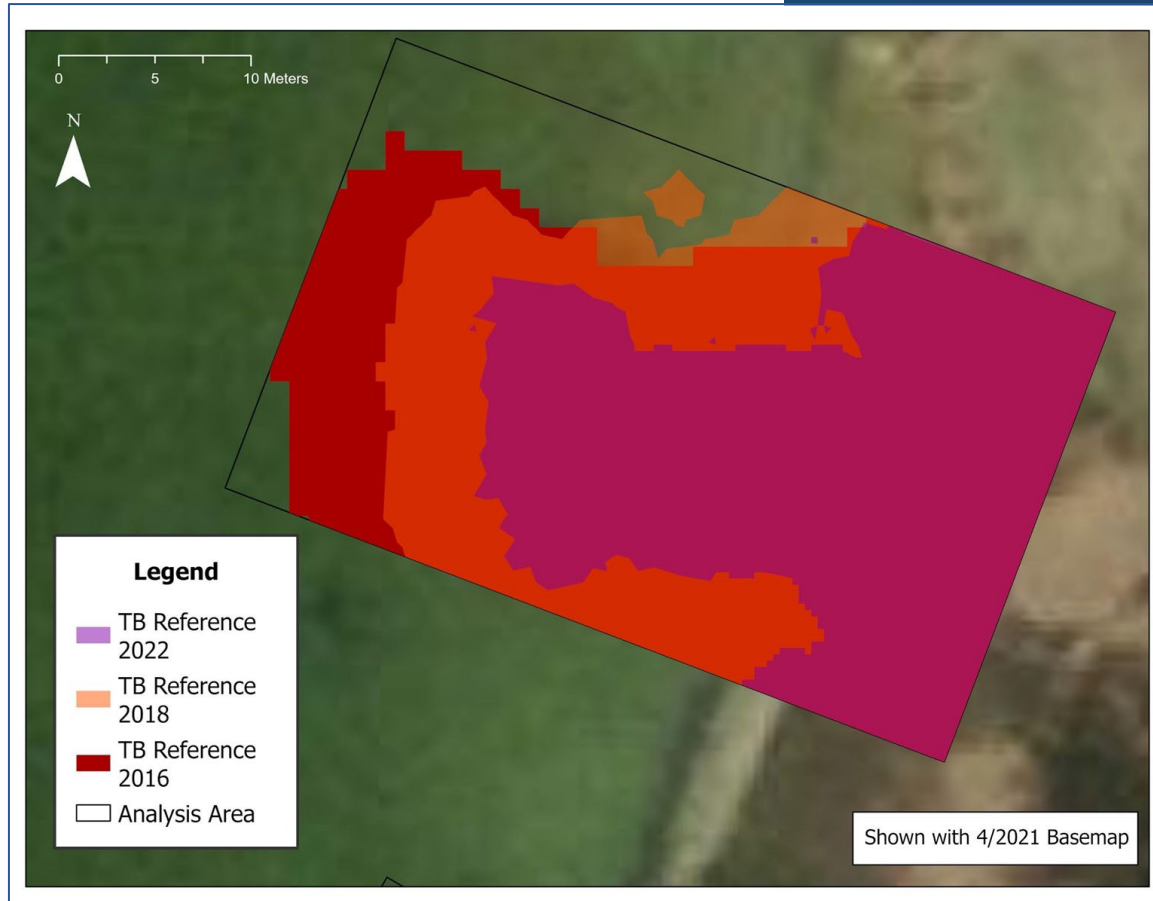
2024-2028 Ongoing data collection/CURE NSF

# Shoreline Movement 1930-2022

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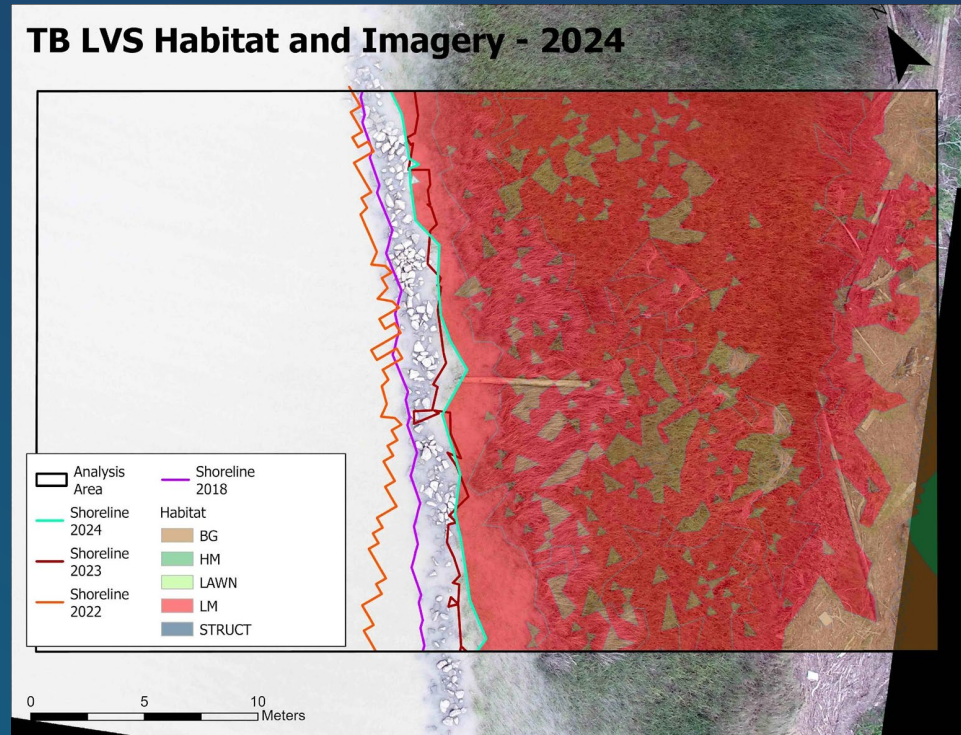
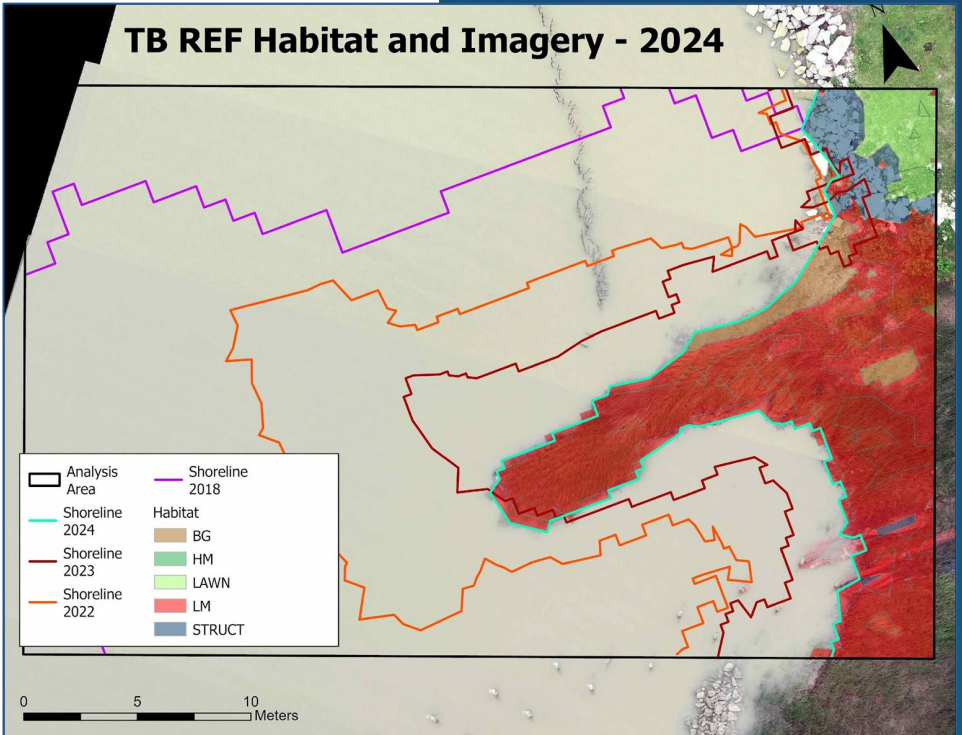


# Significant findings: shoreline stability



Shoreline change 2016-2022: TB REF (left) and TB LVS (right)

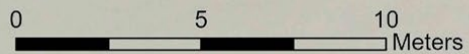
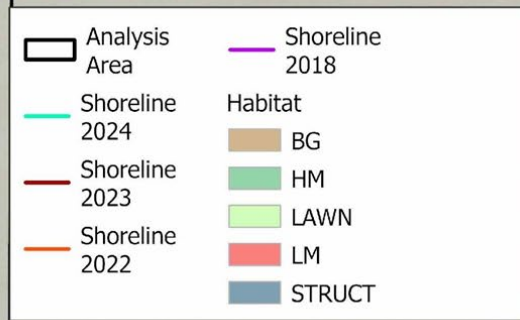
# Significant findings: shoreline stability



What it seems?

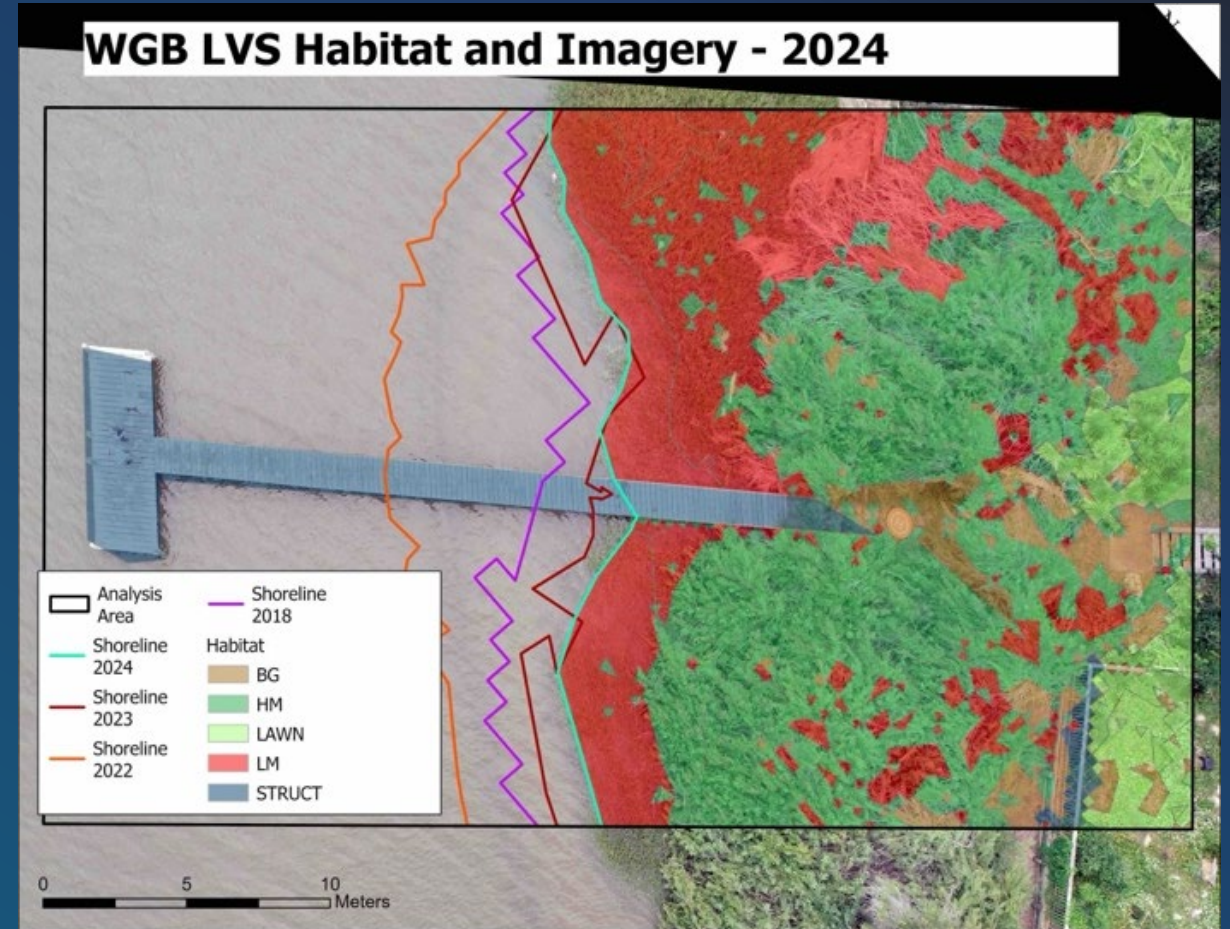
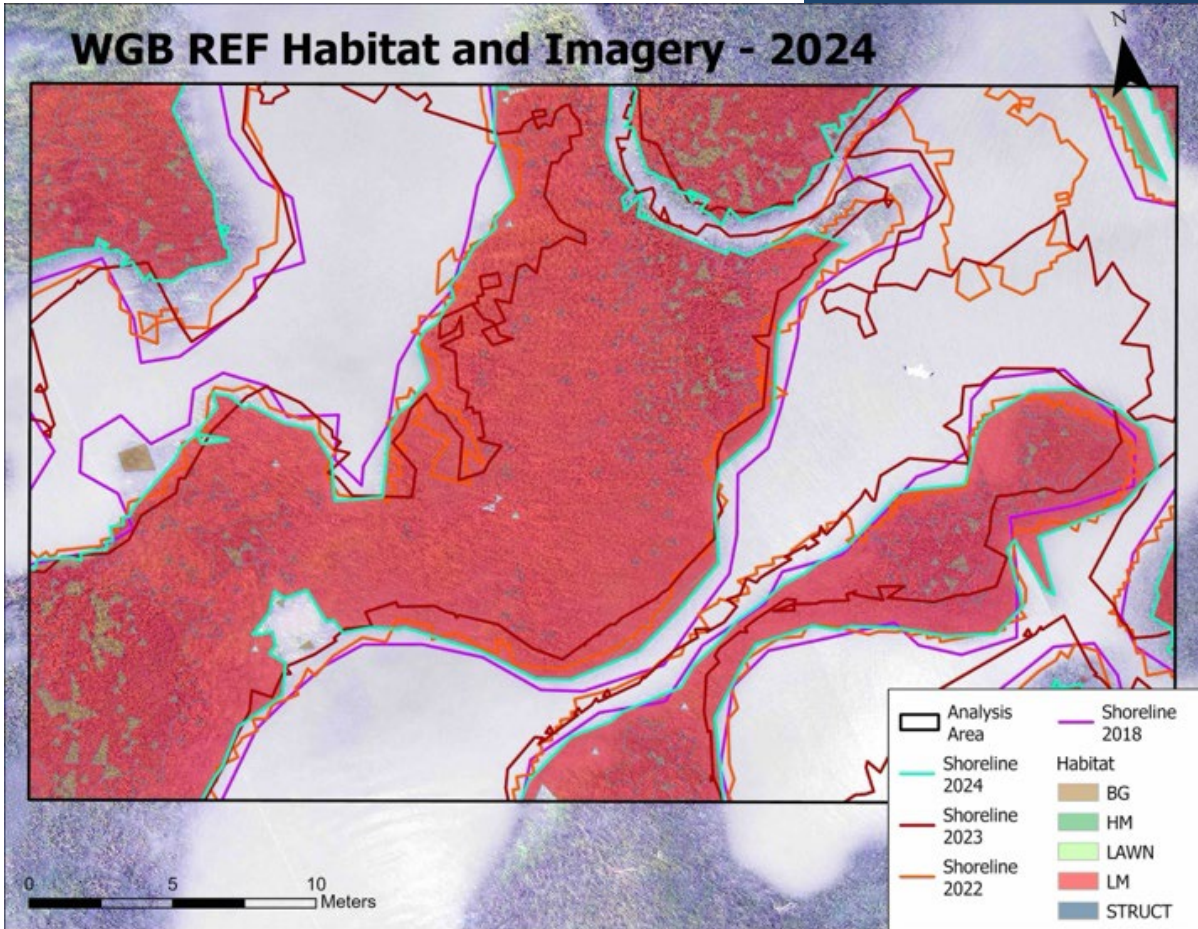
# TB ARM Habitat and Imagery - 2024

Lee College,  
Baytown, TX





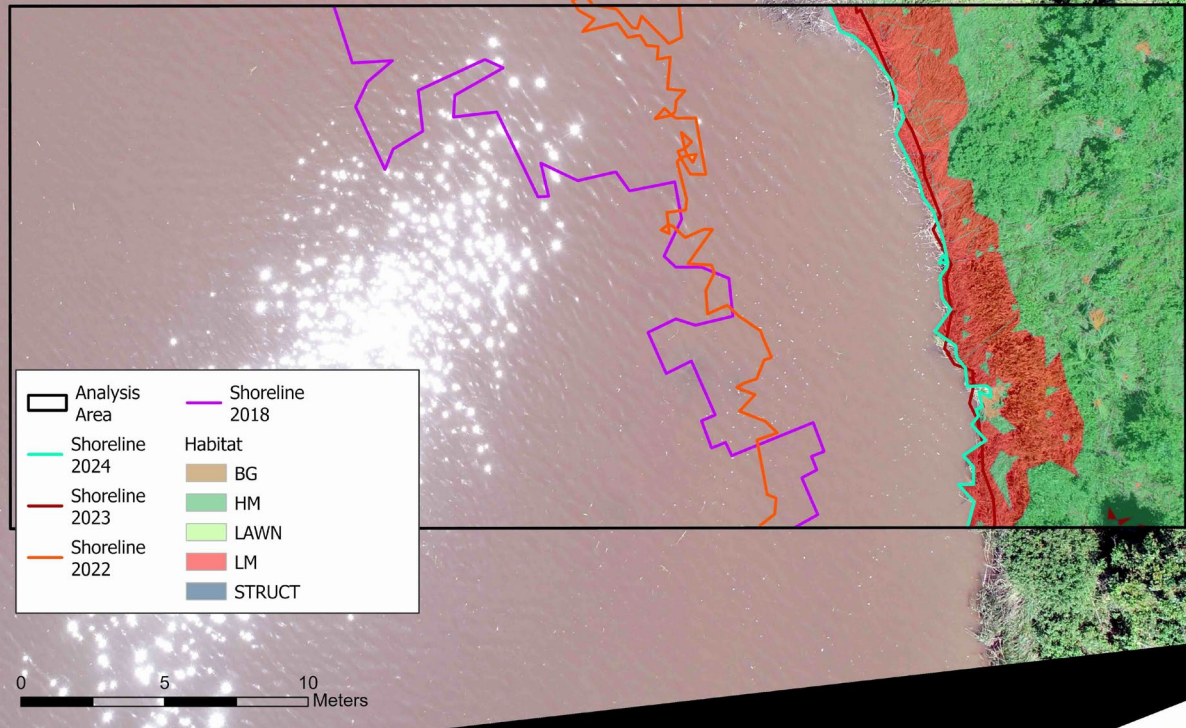
Failing sheet pile bulkhead at Trinity Bay. Inset A shows the damage from the ground, looking toward the south. The study boundary for TB ARM is immediately south of the damaged area (Inset B), on the same bulkhead, where undermining is also becoming evident.



Shoreline change 2018-2024: WGB REF (left) and WGB LVS (right)

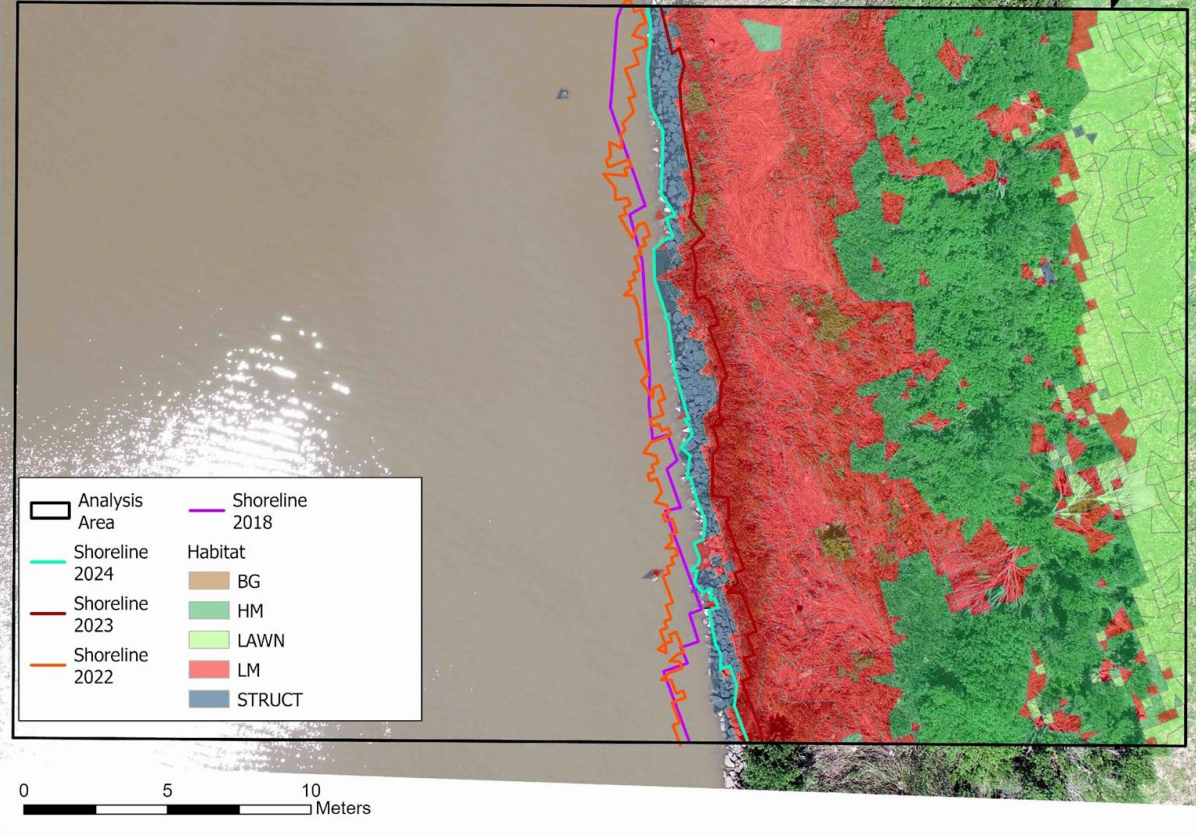
# AB REF Habitat and Imagery - 2024

Lee College,  
Baytown, TX



# AB LVS Habitat and Imagery - 2024

Lee College,  
Baytown, TX



Shoreline change 2018-2024: AB REF (left) and AB LVS (right)



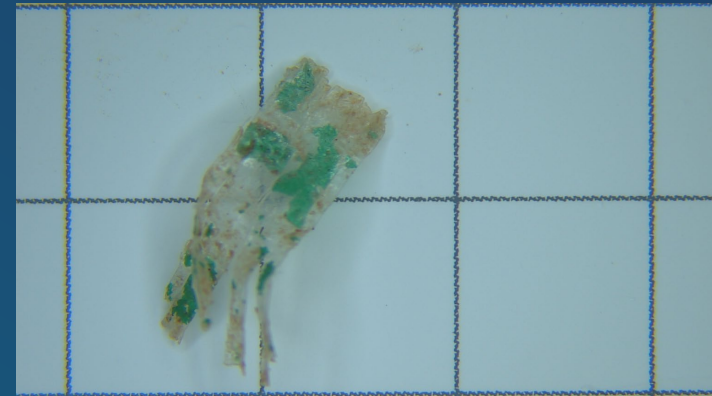
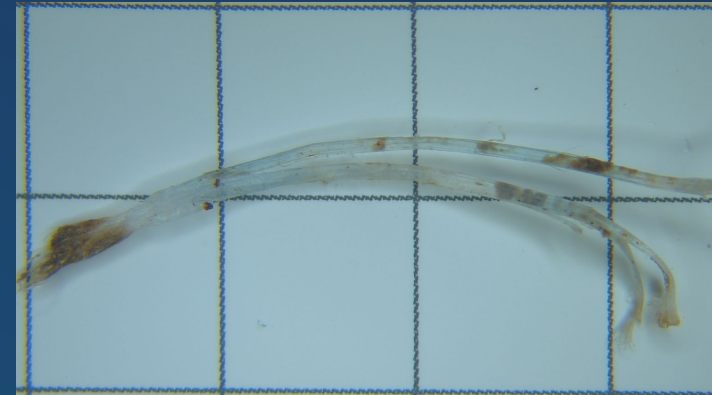
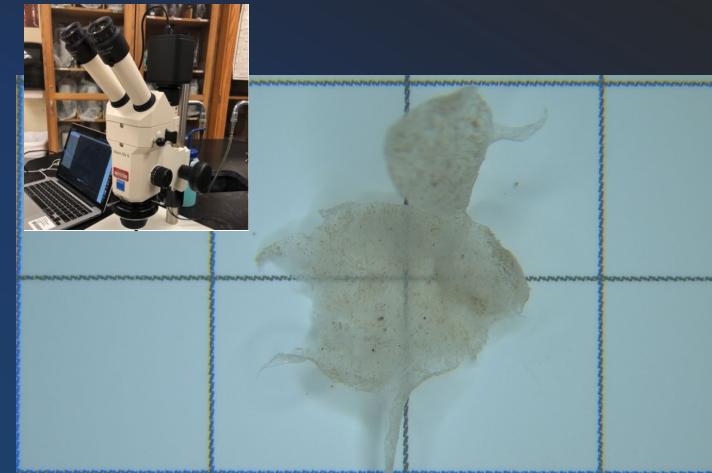
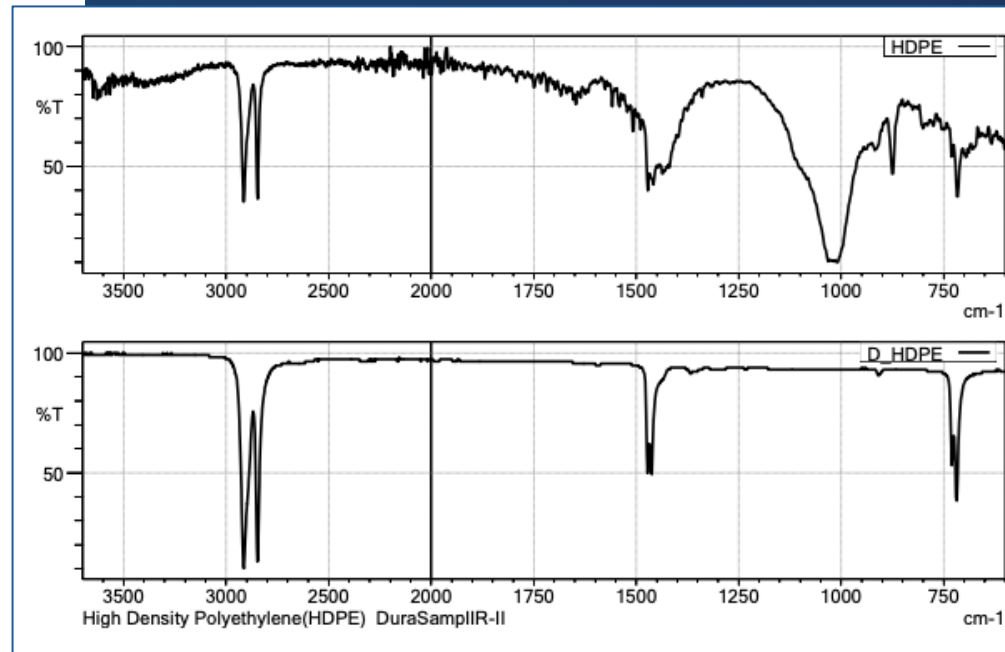
Image: The Galveston Bay Foundation (Haille Leija)

Extra benefits of LS: act now and get these free gifts!



# Sediment Microplastics

- Microplastics were detected in 12 out of 27 samples (44.4% recovery rate).
- Trinity Bay (TB) had the highest number of positive samples



## Plastic types include

- PET (Polyester film)
- PP (Polypropylene)
- HDPE (High-Density Polyethylene)
- Polyurethane fiber
- Acrylic
- Polyester film



	Score	Library	Name	Comment
1	790	23 - ATR-Polymer2	D_PE	Polyethylene(PE) DuraSamplIR
2	790	107 - ATR-Polymer2	D_HDPE	High Density Polyethylene(HDPE) DuraSamplIR-II
3	774	146 - ATR-Polymer2	D_Polyethylene_Oxidized	Polyethylene, Oxidized DuraSamplIR-II
4	770	16 - IRs Polymer2	IONOMER1	Ionomer (Na Type) Surlyn1601 Film
5	769	4 - ATR-Polymer2	D_EAA	Ethylene Acrylic Acid(EAA) DuraSamplIR-II
6	768	56 - A_FoodAdditives2	A_Microcrystalline Wax-4	Microcrystalline Wax(Product name:MW-0055CSales origin:MACHIDA CANDLE CO.,LTD.)@DuraSamplR2(diamond)
7	767	17 - IRs Polymer2	IONOMER2	Ionomer (Zn Type) surlyn1652 Film
8	763	38 - A_FoodAdditives2	A_Paraffin Wax-4	Paraffin Wax(Product name:PW-3501CSales origin:MACHIDA CANDLE CO.,LTD.)@DuraSamplR2(diamond)
9	758	21 - A_FoodAdditives2	A_Candelilla Wax-4	Candelilla Wax(Sales origin:MIKI CHEMICAL INDUSTRY & CO.,LTD.)@DuraSamplR2(diamond)
10	756	39 - T_FoodAdditives2	T_Paraffin Wax-4	Paraffin Wax(Product name:PW-3501CSales origin:MACHIDA CANDLE CO.,LTD.)@Film

# Implications



- *Our results suggest the efficacy of Living Shorelines applications can successfully promote the establishment of aquatic habitat replicative of natural habitat within the same system.*
- *In cases where more severe erosion of shoreline habitat is occurring, LS applications may also be a preferable approach to shoreline stabilization while also restoring habitat that is, or would be, lost because of erosion and/or relative sea level rise.*
- *In either case, the data show that habitat creation via this process may take some time to fully reach peak ecological function, as the processes of ecological succession unfold.*

# Implications



- Our data suggest that this approach is supported
- The “environment” is also moving in a favorable direction
- TAEP presentation (Gilbert & Dobberstine)
  - Potential on the Texas Coast
  - Easing (slightly) regulatory hurdles
  - Tools and support
- To see the full presentation, please visit:



# Implications



## Potential for Living Shorelines in Texas

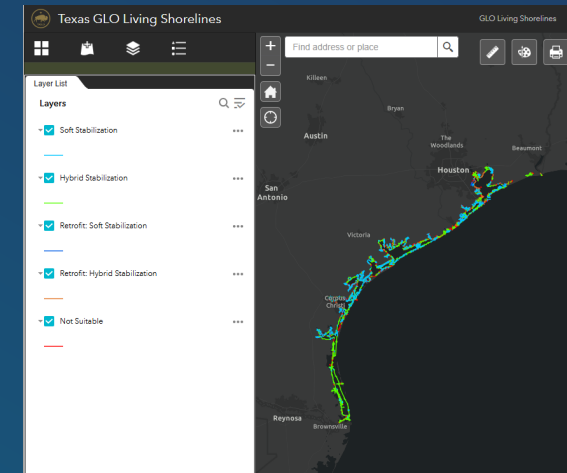
### Small-scale(individual property) level:

- Erosion protection
- Ecological value
- Stewardship



### Large scale (public/corporate) level:

- Coastal Resilience
- Generate Tidal Wetland Credits
- Mitigation Banking/Permittee Responsible Mitigation
- Blue Carbon
- Environmental pollutant remediation



- Landowners
  - Black Cat GIS & Biological
  - HARC
  - Moody Gardens
  - NRCS
  - USFWS
  - TCWP-TAMU
- Funding
- TCEQ-GBEP
  - TGLO-CMP
  - NSF-DUE

The Efficacy of Living Shorelines for Restoring Shoreline Habitat and Stability

Final Report

GLO Contract No. 20-040-000-B748  
September 2022

Prepared by:

Jim Dobberstine, Principal Investigator (PI) <sup>1</sup>  
Amanda Hackney, Co-PI <sup>1,3</sup>  
Cindy Howard, Co-PI <sup>2</sup>  
Christine Miller, Co-PI <sup>2</sup>  
Yihfen Yen, Co-PI <sup>1</sup>

and

Emily Blumentritt, Undergraduate Research Assistant <sup>1</sup>  
Ryan Gilbert, Graduate Research Assistant <sup>2</sup>

Technical and content contributions by:

Todd Cameron (Microbiome bioinformatics) <sup>4</sup>  
Myrah Urquidez (GIS Image analyses) <sup>1,2</sup>  
Ashley Van Wieren (GIS Image analyses) <sup>1,2</sup>

<sup>1</sup> Lee College, Baytown TX; <sup>2</sup> The University of Houston-Clear Lake, Houston, TX; <sup>3</sup> BlackCat GIS & Biological LLC, Houston TX; <sup>4</sup> The University of Texas Health Science Center, Houston, TX

Submitted to:

The Texas General Land Office  
1700 Congress Ave.  
Austin, TX 78701-1495



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# Thanks for your support!



Image: Lee College



A PROGRAM OF TCEQ



# Acknowledgements

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M. Mokrech, K. Garland, C. Howard

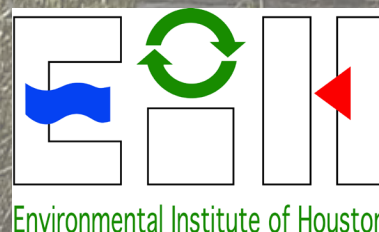
## UHCL Environmental Institute of Houston

M. Mokrech, G. Hammerbach, M. Gordon, D. DeChellis, A. Killgore, A. Flores, T. Pytlak, B. Steward, N. Santee, N. Reese, M. Sunshine, D. Holmes, A. Barajas, A. Castillo, T. Goldstein, C. Gonzalez

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Contact information: Lydia Thurman - [thurmanl@uhcl.edu](mailto:thurmanl@uhcl.edu)



Thank you!

Questions?

For literature cited, please visit:

