



Benthic Infaunal Responses to Shoreline Restoration

Revealing Recovery from the Bottom Up

→ Jessica Cline, Research Coordinator, MRC
Chris Bogdan, Ferguson Waterworks





A. succinea



A. lacustre



P. vibex



O. smithi

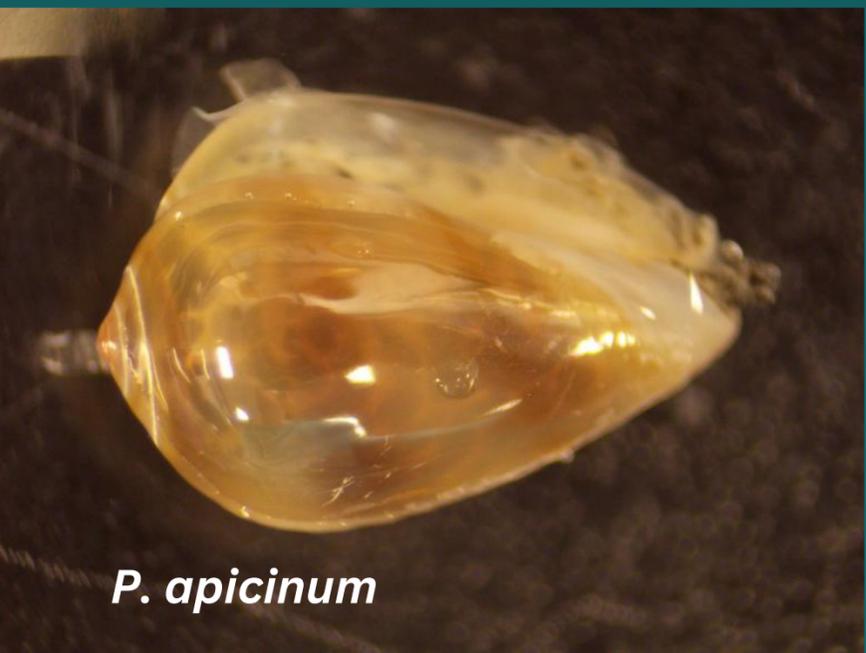


Order
Mysida

Benthic Infauna



Order
Tanaidacea



P. apicinum



P. setipunctata



A. cunemeris



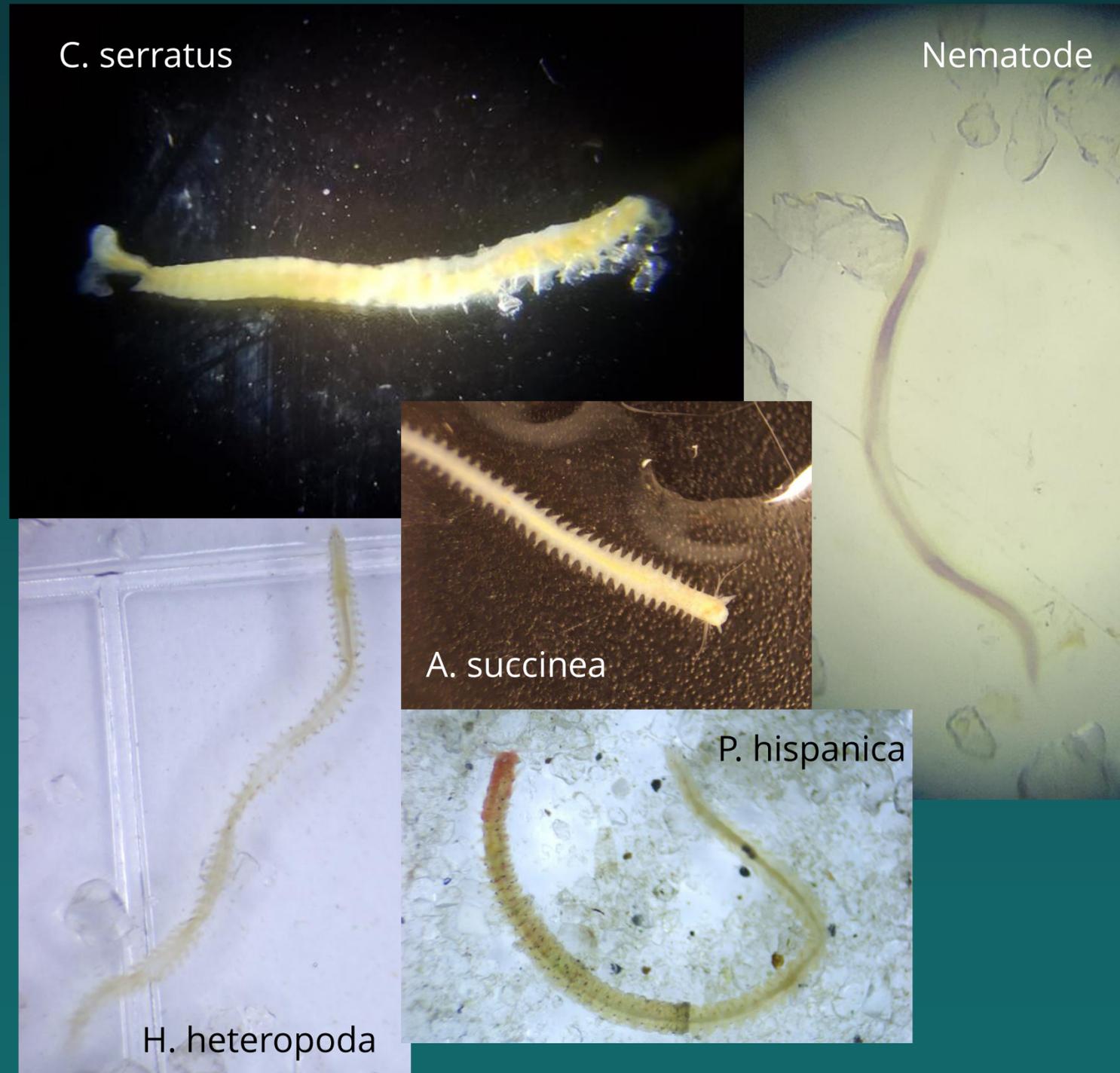
P. gouldii

Infauna as Bioindicators

Unhealthy Environments

- Worm Dominated
- Pollution Tolerant
- Detritivores
- Tolerate low dissolved oxygen

These animals are not bad!



Infauna as Bioindicators

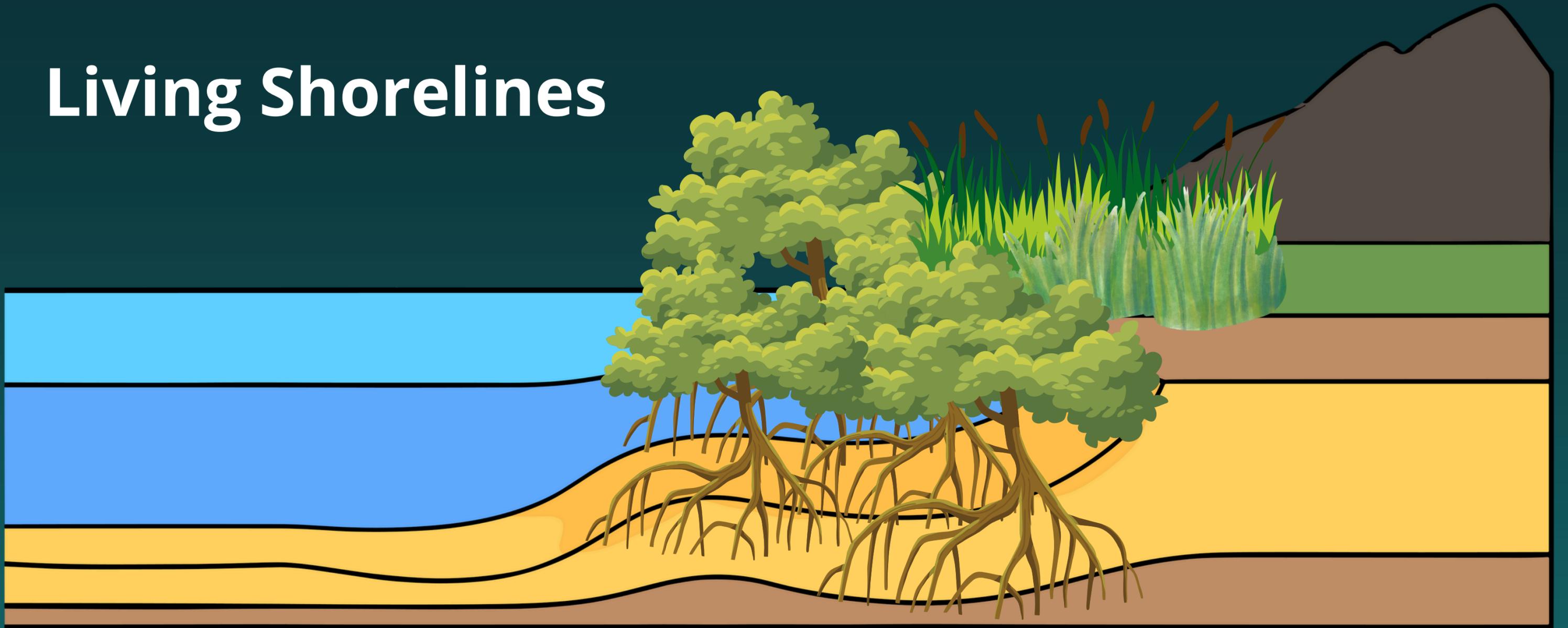
Healthy Environments

- Higher species diversity
 - more arthropods, mollusks
- Not pollution tolerant
- Need higher dissolved oxygen
- Clearer waters
- Stable sediments

All taxa, including worms, are needed to perform ecosystem services!

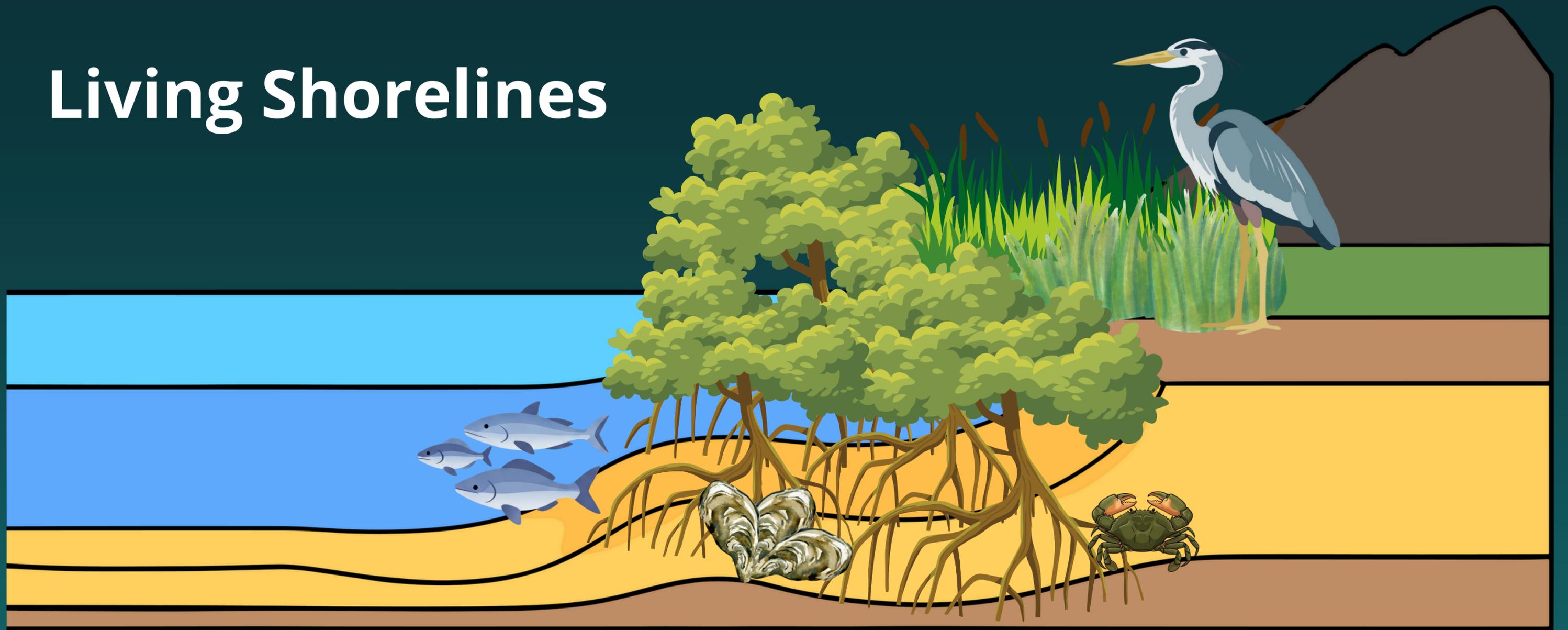


Living Shorelines



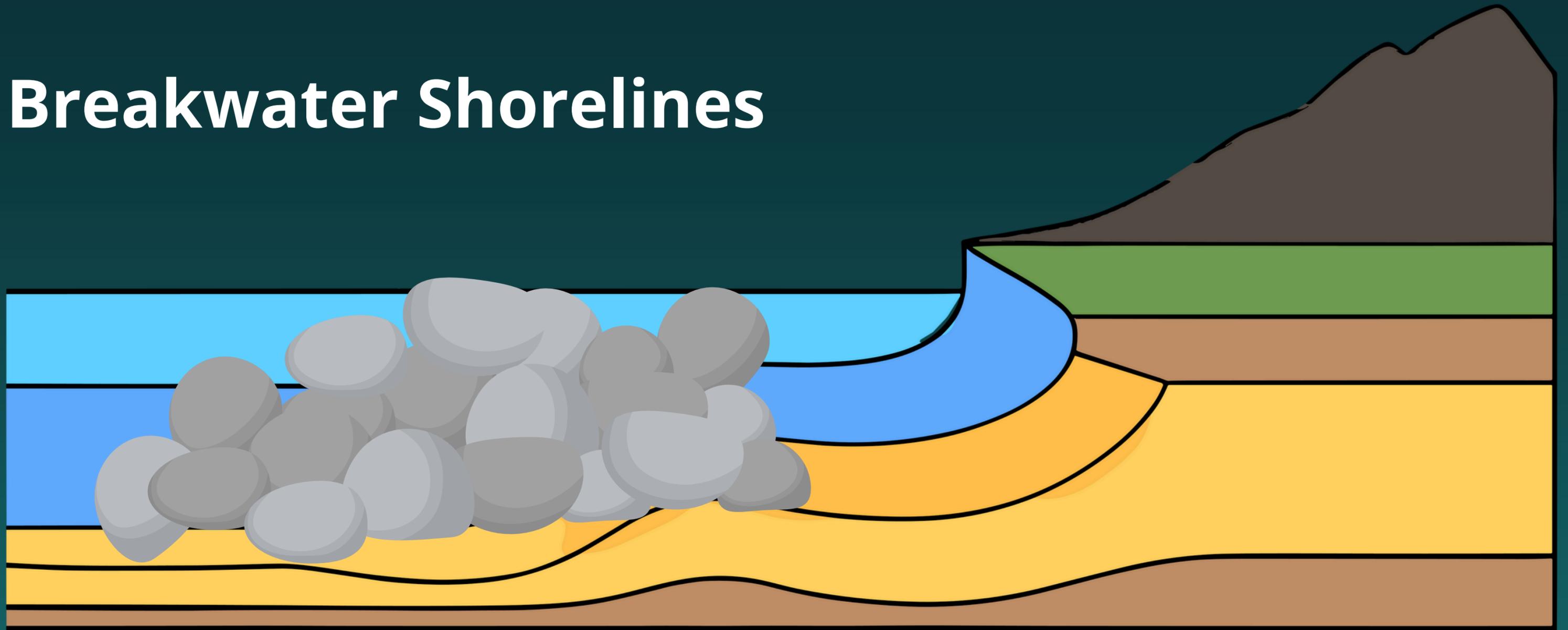
- Uses natural materials like **native plants and shellfish**
- Reduce erosion while **maintaining natural processes and habitat spaces**
- Buffer waves, storm surges, and wind forces
- More adaptable to sea-level rise

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Breakwater Shorelines



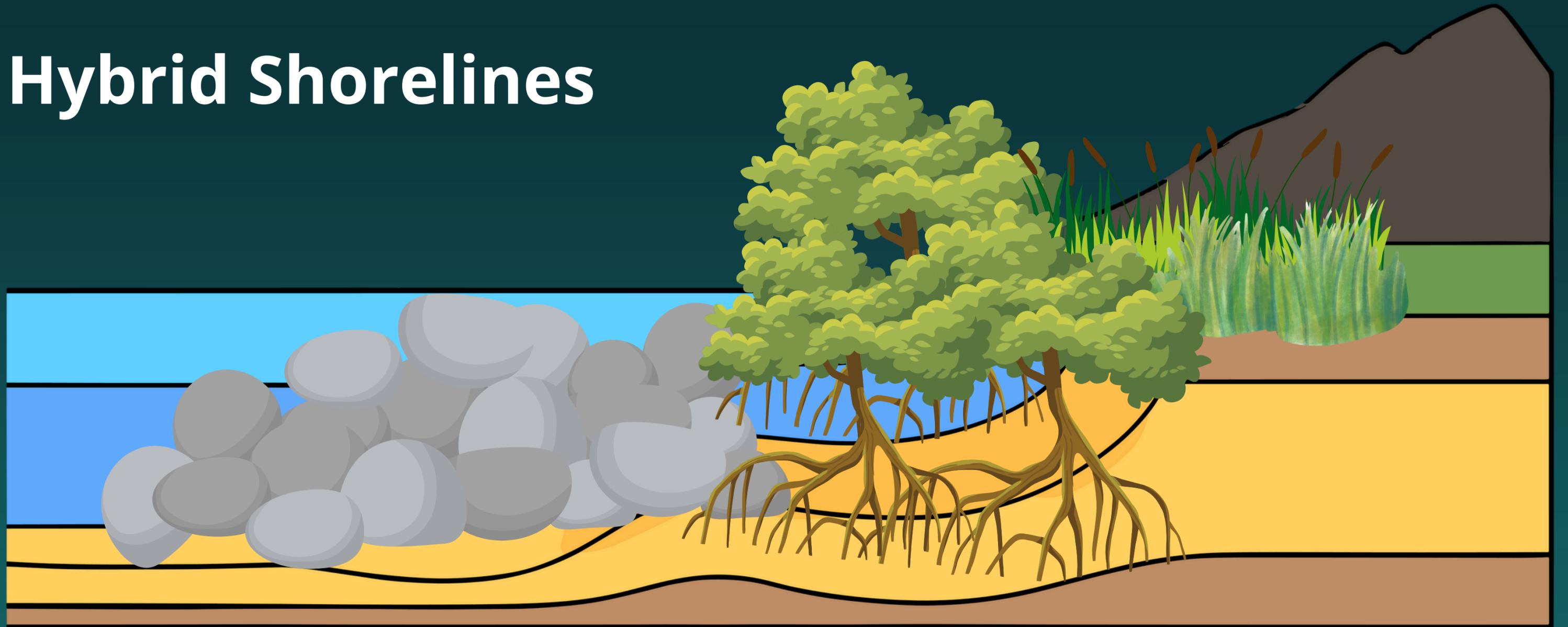
- An offshore installation of **rocks or concrete** structures
- Reduces erosion by slowing waves
 - Can lead to **sediment accretion behind**
- **More intense but more durable** solution for areas with high wave energy

Breakwater Shorelines



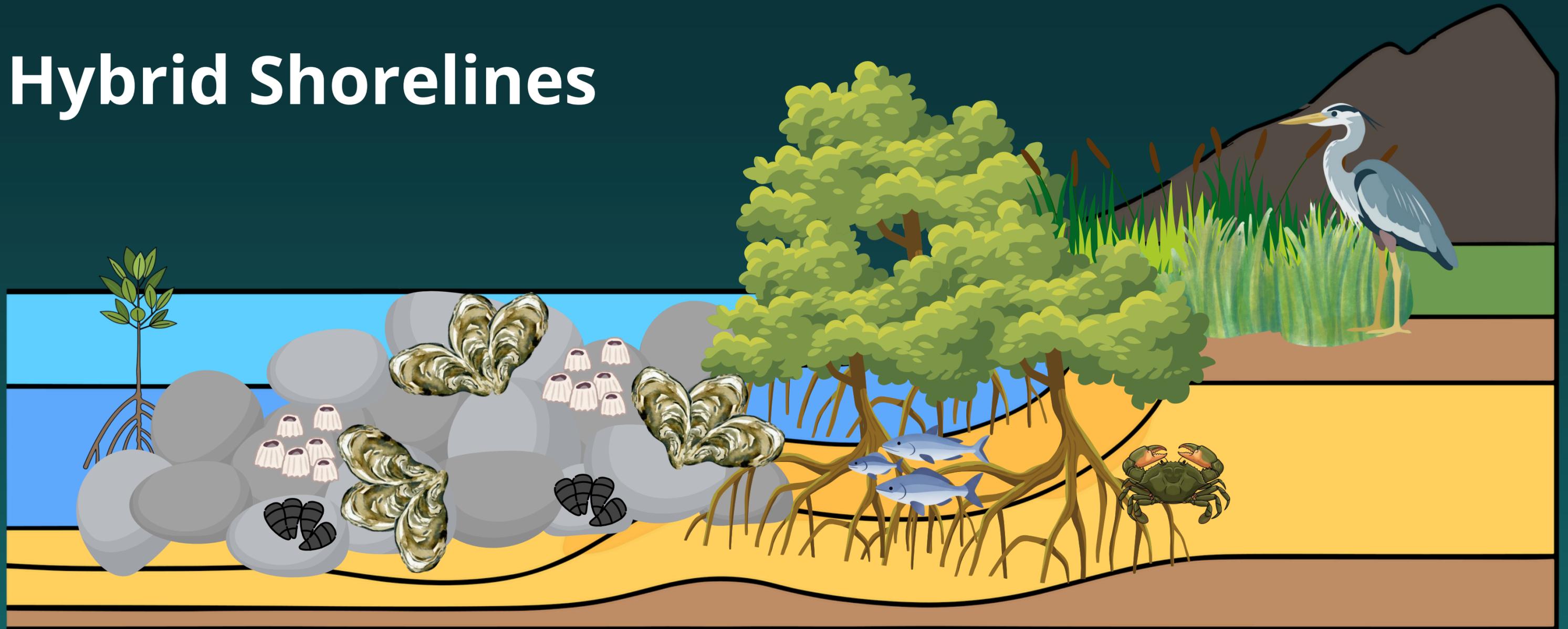
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Hybrid Shorelines



- Uses **native plants** and installed rock/concrete **breakwaters**
- Breakwaters **provide stability** while new plants establish
- Gives natural habitat and settlement spaces
- More protection than plantings or breakwaters alone

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Before Restoration

Adult Mangroves



Facing South

Facing North



Why Reef Arches

Deployment method

Product availability

We needed a project

Met MRC project goals



Reef Arches

Breakwaters, slow wave energy

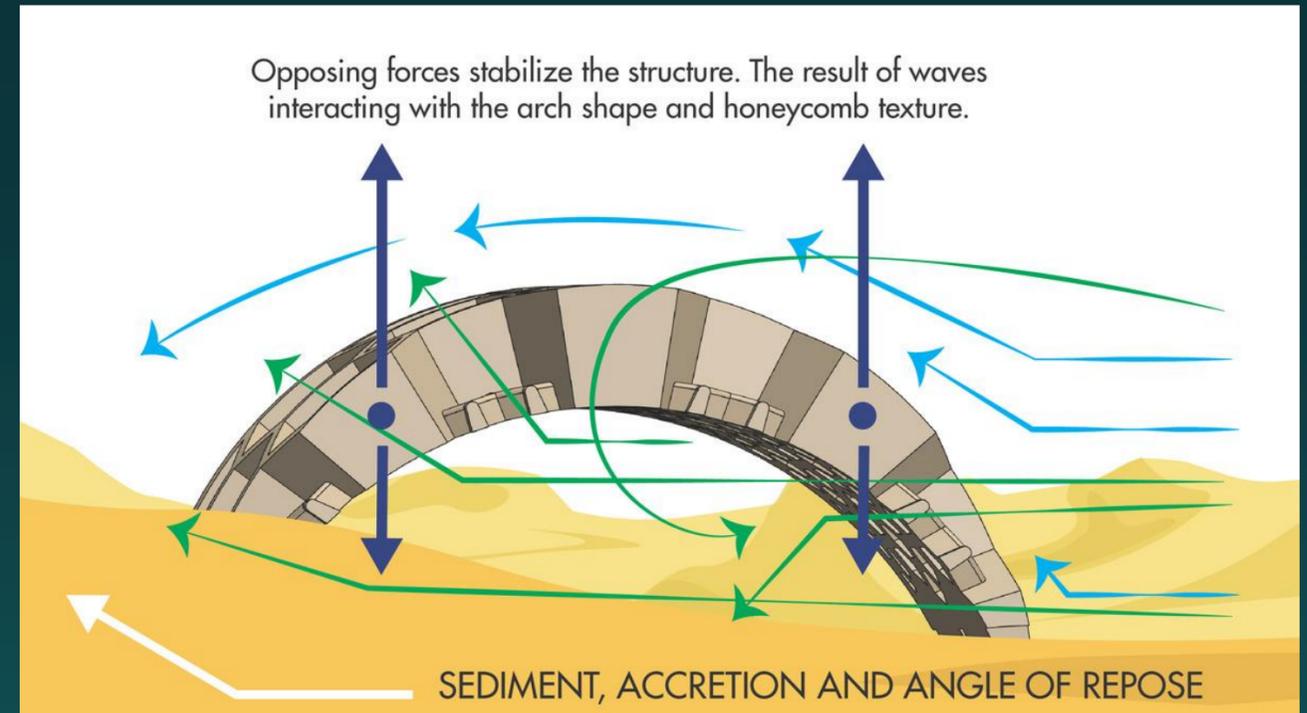
Promote sediment accretion

CSA, marine-safe concrete

Don't cause habitat fragmentation

Multiple deployment methods

Efficient to transport and store



Restoration Performed at MRC's Palm Bay Campus

- **Permitting for Restoration**
(January 2024)
- **Breakwater Installation**
(March 2024)
- **Mangrove Planting**
(July 2024)
- **Continuous Monitoring**
(Ongoing, monthly/quarterly)



FDEP: ERP_0446061-001 EE
USACE: SAJ-2019-00252



Mangrove Planting July 2024

Over 30 volunteers
Planted 128 trees in 2 hours

3-4 feet tall
Had at least one prop root forming
Treated for CNP pathogens

Shoreline Restoration at Ais Lookout Point



Project Objective

To quantify a potential relationship between infaunal abundances and organic matter content where shoreline restoration treatments are employed



Hypothesis Testing

Restoration treatments will significantly change sediment movement

Infaunal Biodiversity will increase over time following shoreline restoration

Restoration treatments will significantly change the sediment's organic content

Restoration treatments will have significantly different effects on the infaunal community composition



Monthly Monitoring

Water
Quality



Horiba U-50 series,
multi-parameter
water quality checker

Sediment
Movement



USGS
Sediment Pins

Quarterly Sampling

Sediment Collection



Organic Matter %
Water Content %

Infauna Collection



Petite PONAR grabber



Infauna Identification



Stereo-microscope and
camera attachment



**Has been monitored for 2 years for this study
Monitoring and research will be ongoing through MRC**

February 2024

- Pre-restoration

May 2024

- Post-breakwaters

August 2024

- Post-mangrove
planting

December 2024

February 2025

May 2025

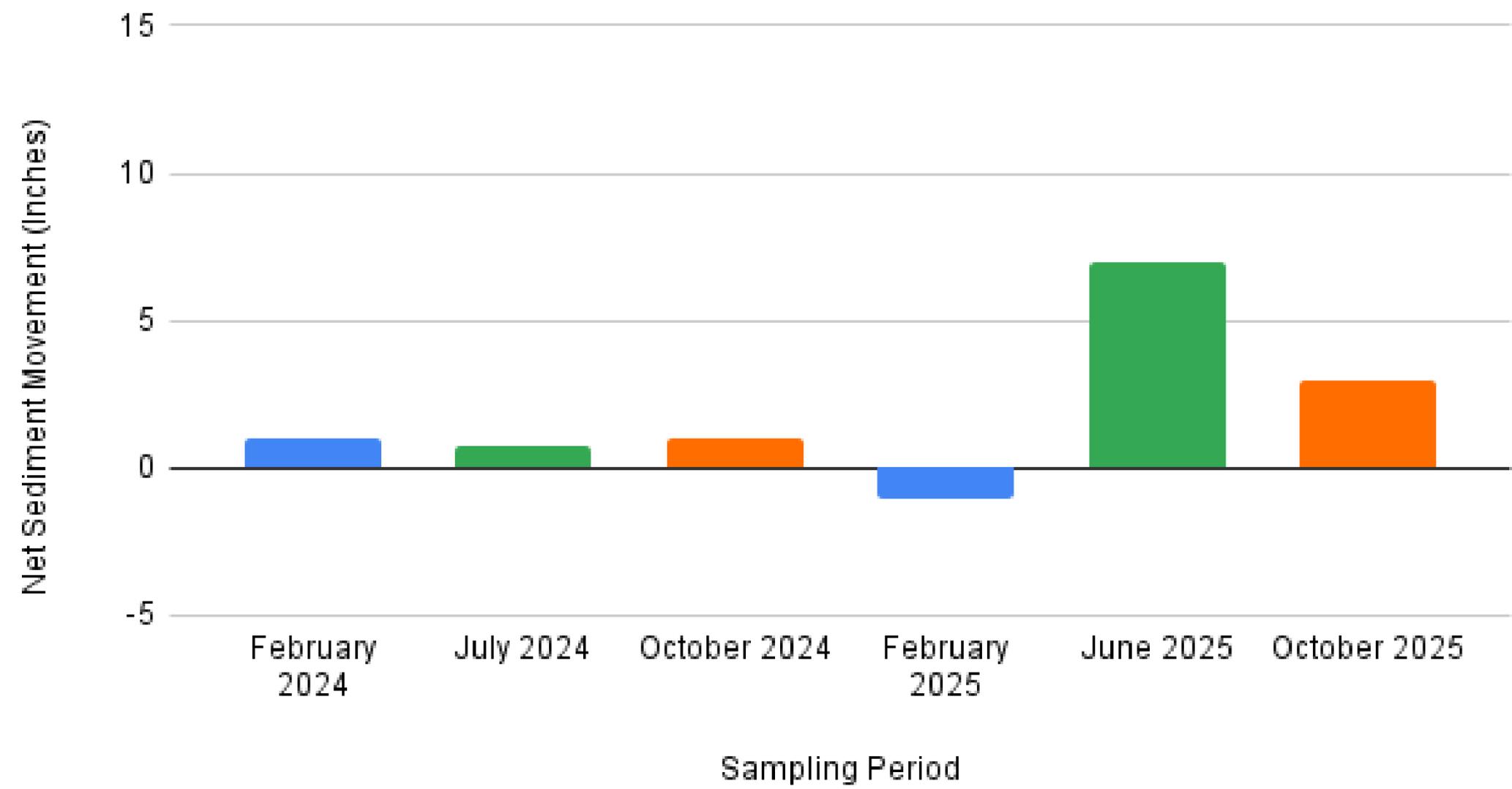
August 2025

December 2025

February 2026

Sediment Movement- Living Shoreline

Living Shoreline (Site 2)



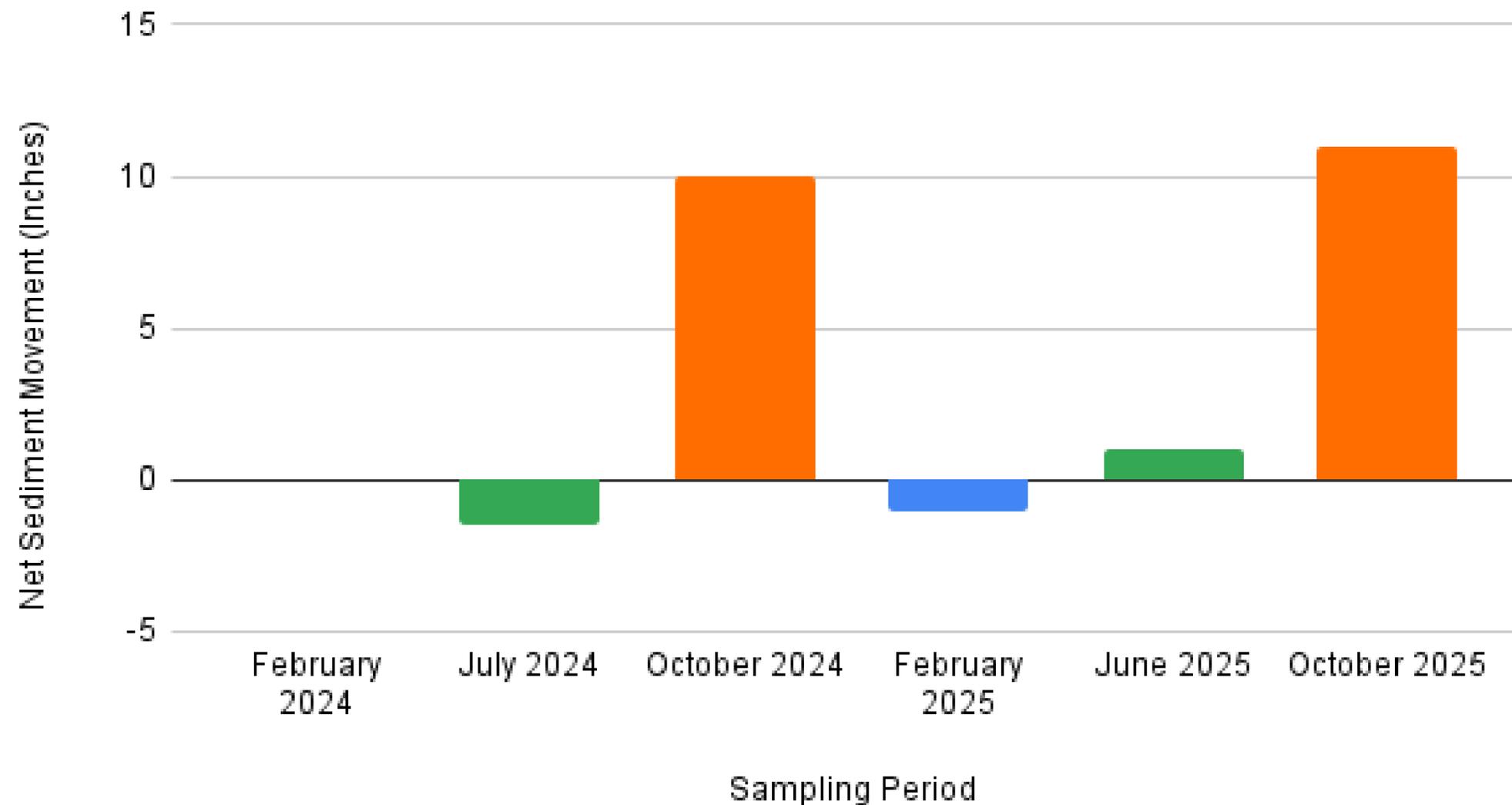
Red Mangroves Only

Minimal movement for the first year

Some accretion during the second summer to a maximum of 7 inches

Sediment Movement- Breakwater Shoreline

Breakwater Shoreline (Site 6)



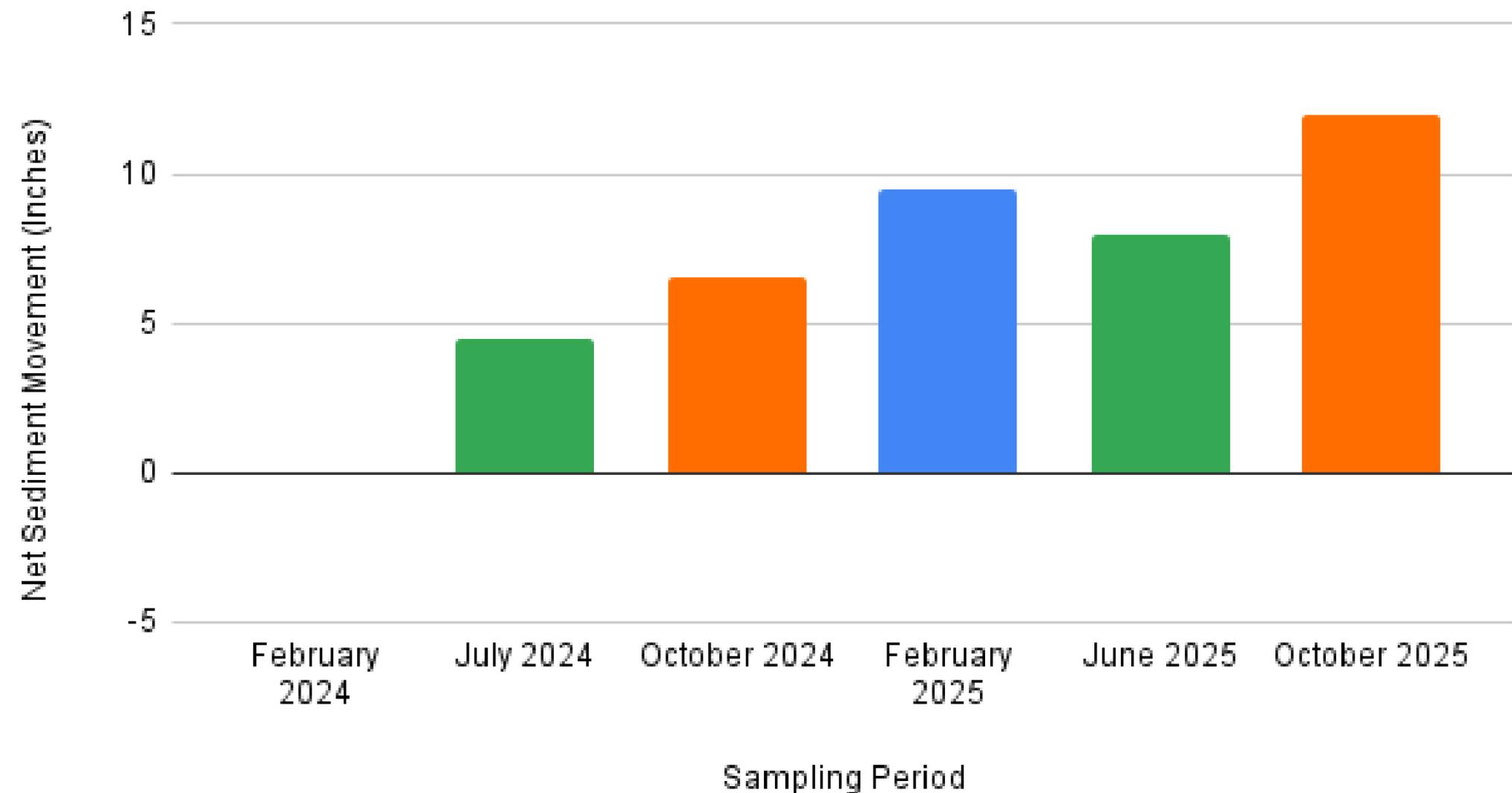
**Reef Arches
Breakwater Only**

**Angled Breakwater,
not parallel to the
shoreline**

**Accretion occurs
most during storms
and high water
season**

Sediment Movement- Hybrid Shoreline

Hybrid Shoreline (Site 5)



**Red Mangroves and
Reef Arches
Breakwaters**

**Consistently
increasing accretion
over time**

**Best Retention
Values**

**Accretion maximum
of 12 inches**

Breakwaters and Beach Growth



Aerial Imagery
Provided by Reef
Arches and Ferguson
Waterworks

Breakwaters and Beach Growth



June 2025

Sediments Summary

Living Shoreline:

- Took longer to establish
- Accretion Maximum of 5–7 inches

Breakwater Shoreline:

- Very dependent on water levels
- Accretion Maximum of 11 inches

Hybrid Shoreline:

- Steady Increase in accretion
- Best Retention
- Accretion Maximum of 12 inches

Kruskal-Wallis Results

Interaction Restoration
Type*Sediment Movement
Significant (p<0.001)

Interaction Restoration
Type*Organic Content
Not Significant (p=0.827)

Shannon-Wiener Diversity Index



- Diversity score that considers **species richness and evenness** of the populations
- A “typical ecosystem” ranges from **1.5 to 3.5** on this scale
- Best to **compare within like seasons** to account for reproductive trends
 - Compare February 2024 to February 2025

Infauna- Living Shoreline

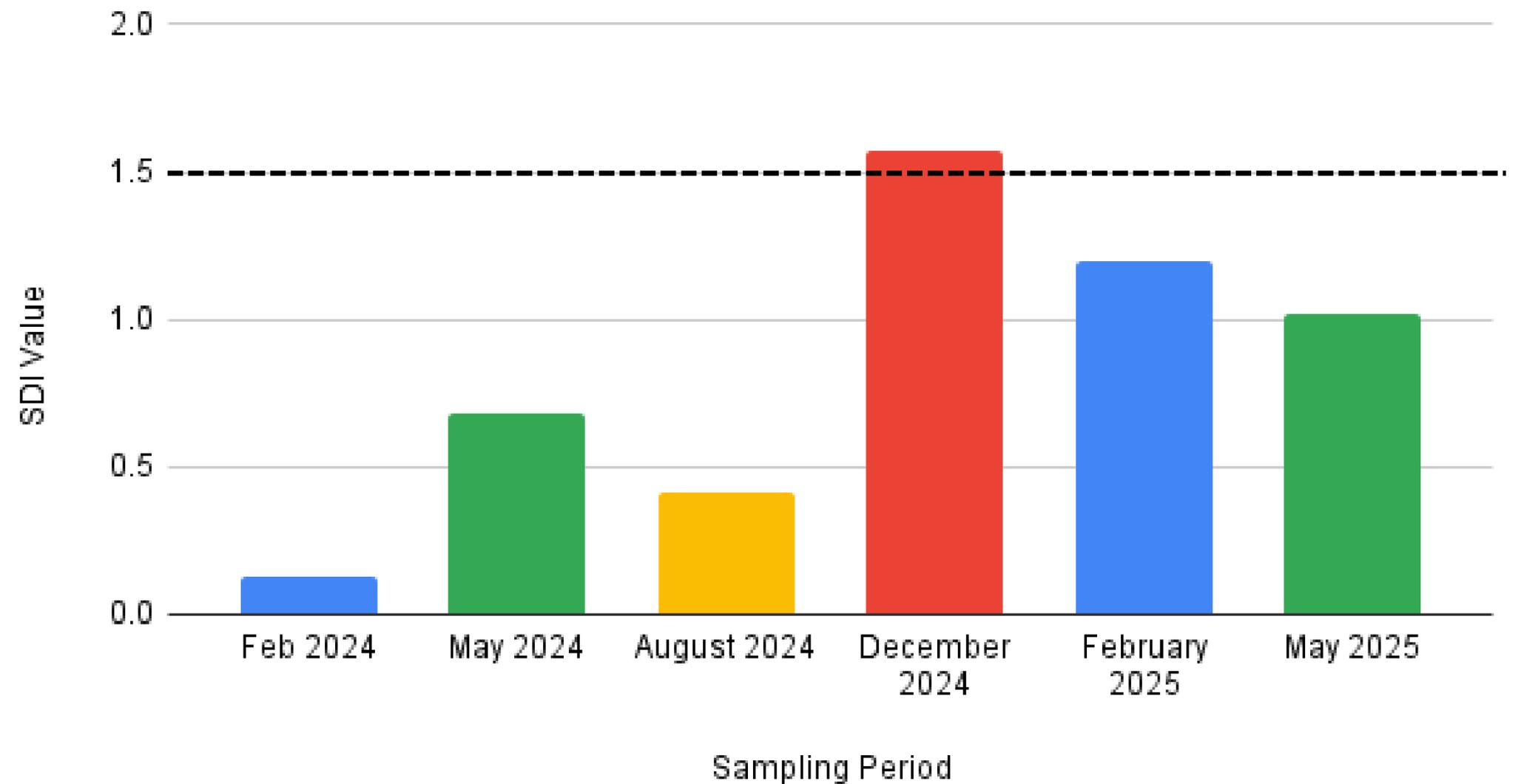
February 2024-2025:

Increase of 1.06 points

May 2024-2025

Increase of 0.35 points

Living Shoreline (Site 2)



Infauna- Breakwater Shoreline

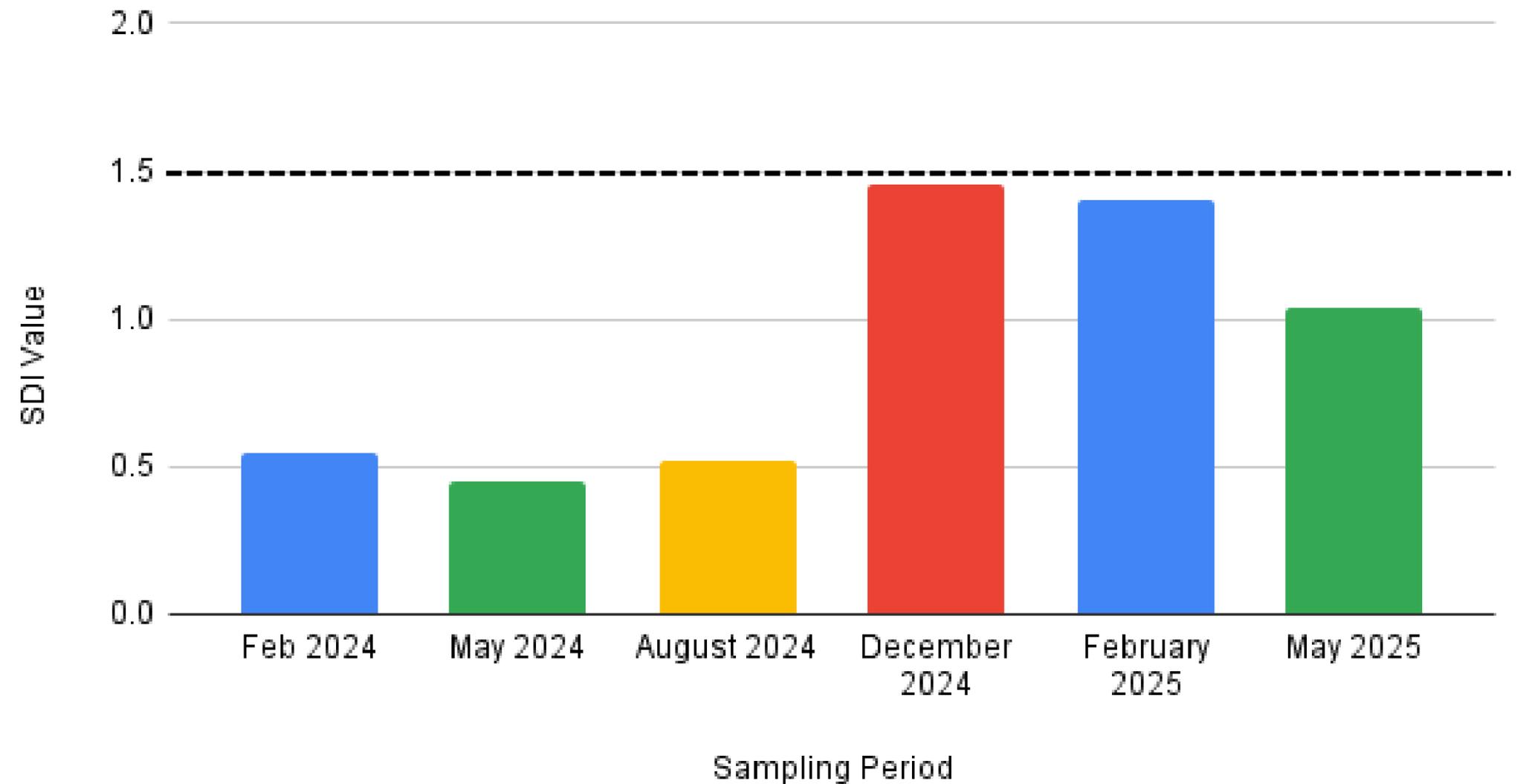
February 2024-2025:

Increase of 0.86 points

May 2024-2025

Increase of 0.59 points

Breakwater Shoreline (Site 6)



Infauna- Hybrid Shoreline

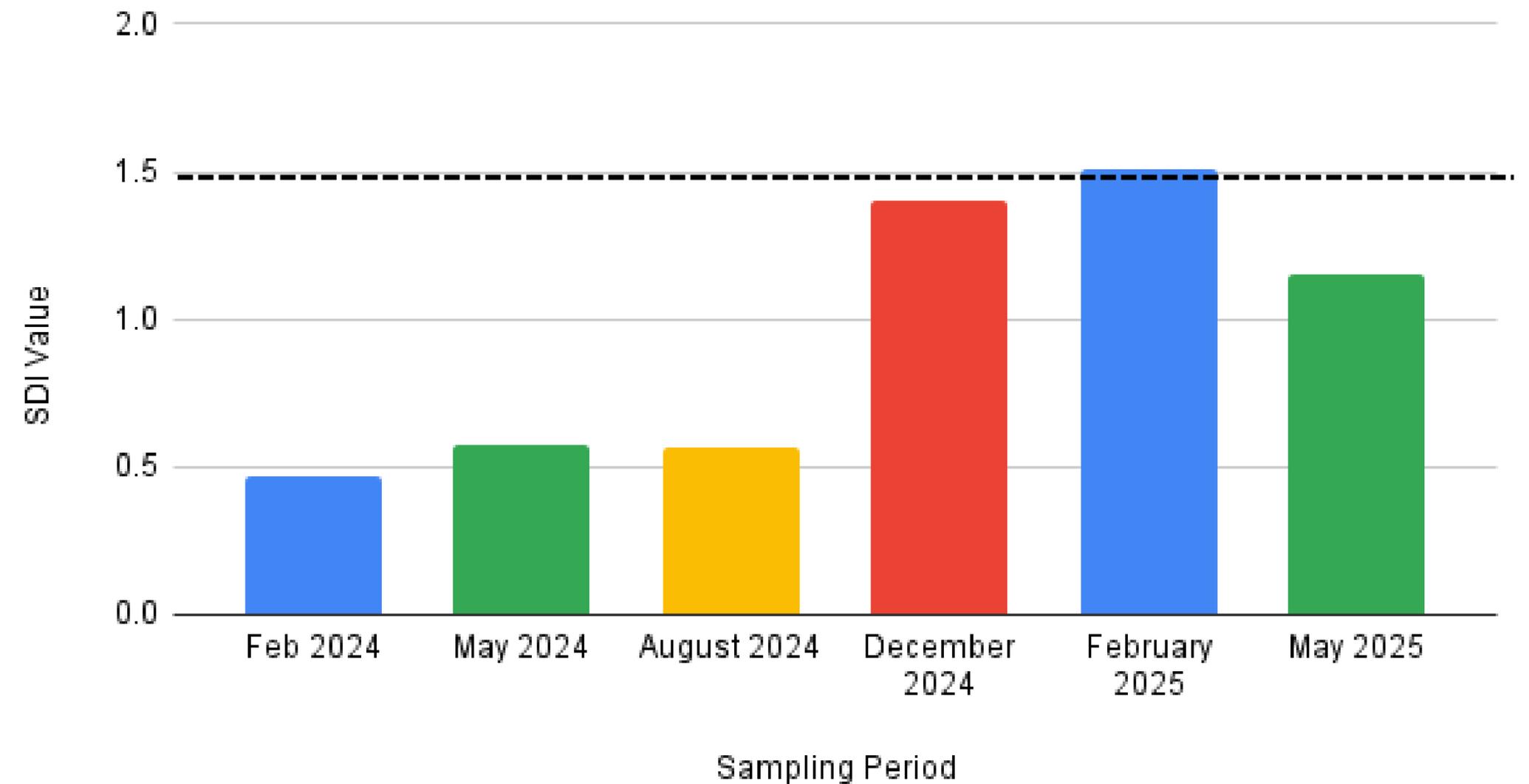
February 2024-2025:

Increase of 1.03 points

May 2024-2025

Increase of 0.57 points

Hybrid Shoreline (Site 5)



Biodiversity Summary

The Living Shoreline demonstrated the **largest increase in biodiversity over time** (1.06 points, Feb. 2024-2025)

Only the Living and Hybrid Shorelines reached the minimum threshold for a “**typical ecosystem**” at any point during the study

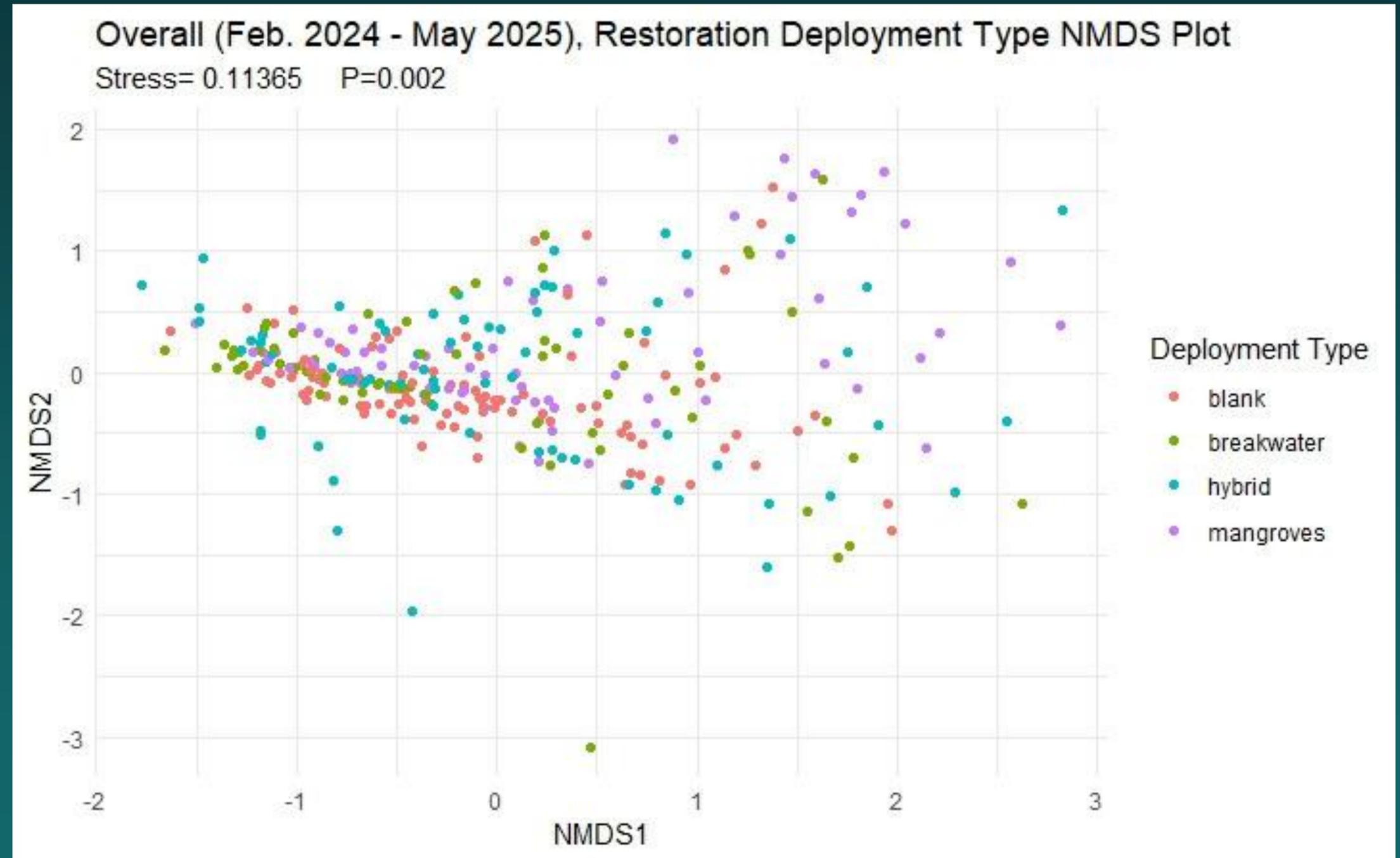
Biodiversity increases were still happening in the Breakwater Shoreline, just to a **lesser extent** compared to the areas with mangroves

Wilcoxon Results

Significant differences in diversity scores from 2024 to 2025 (February and May) (**p=0.033**)

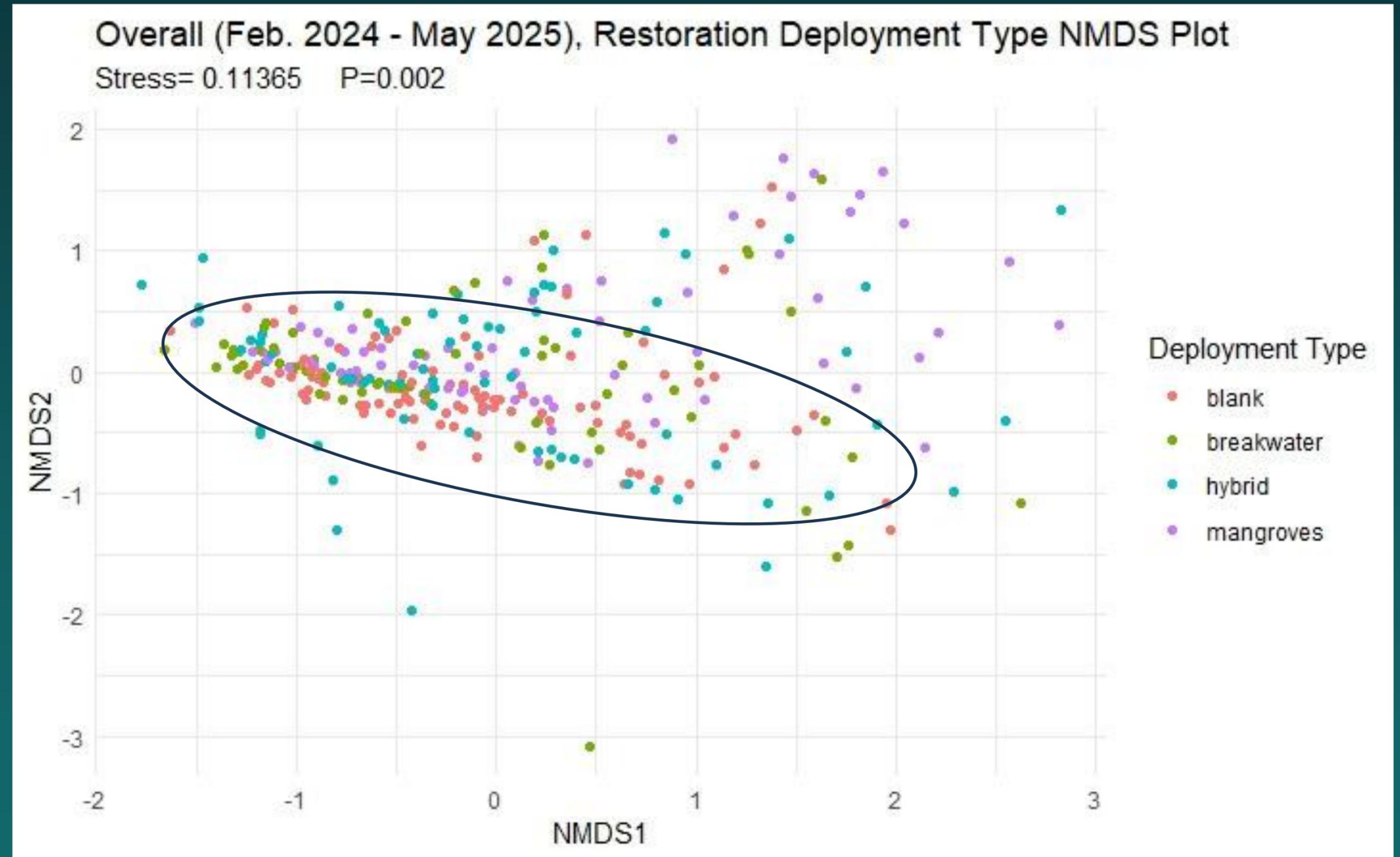
Overall PERMANOVA Results

Season ($p < 0.001$)
Grab Distance From Shore
($p < 0.001$)
Restoration Treatment
($p = 0.002$)
Water Temperature ($p < 0.001$)
Dissolved Oxygen ($p = 0.026$)
Salinity ($p = 0.342$)
pH ($p = 0.247$)
Organic Content ($p = 0.228$)
Water Content ($p = 0.002$)



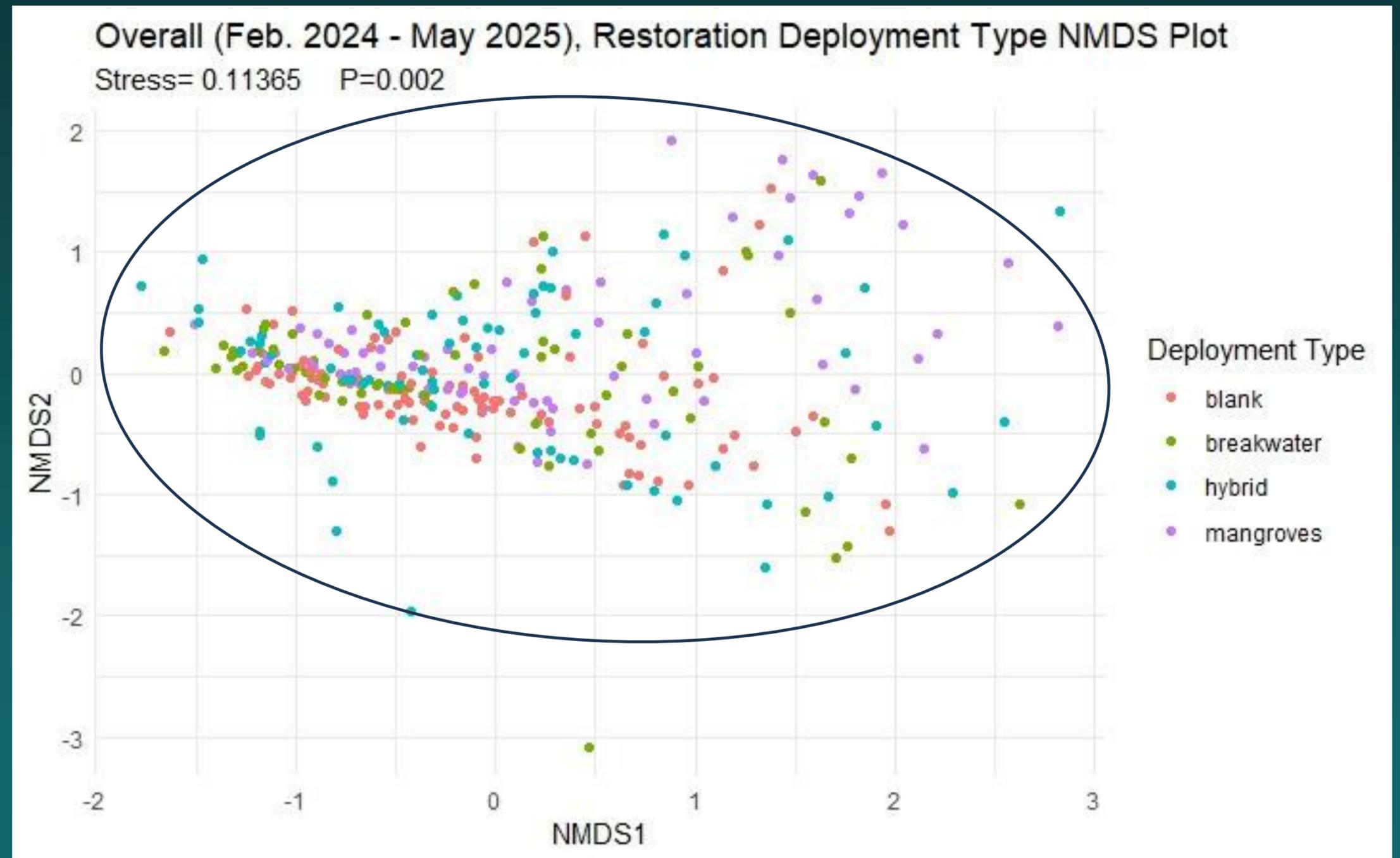
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Key Takeaways

Until further monitoring/research is completed, all results should be **interpreted as a case study**

The infaunal community overall has begun to even out with **fewer nematodes and more arthropods and mollusks**

Hybrid Living shorelines yield the best results for promoting sediment accretion and increasing beach growth

Mangrove Living shorelines yield the best results for increasing infaunal biodiversity



Thank You!

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