Characterizing composition and nutrients released by alternative restoration materials

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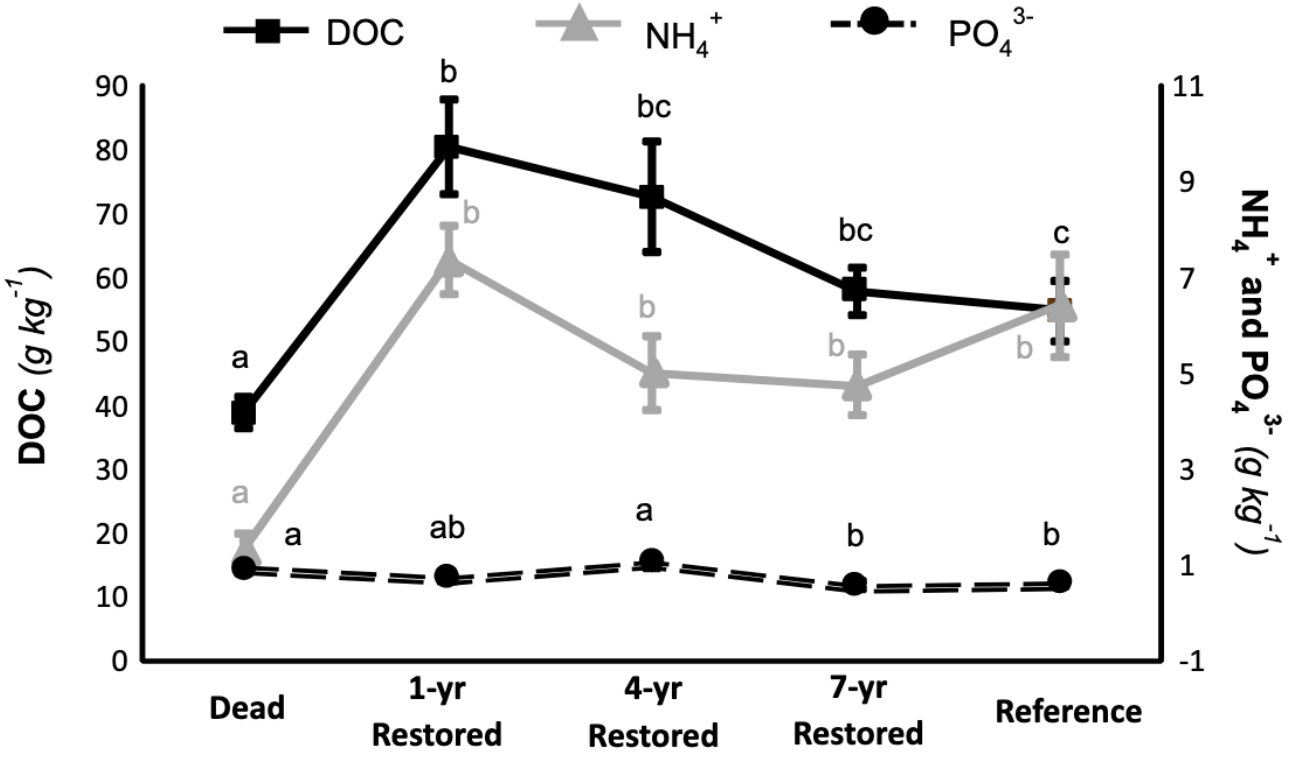
UNIVERSITY OF CENTRAL FLORIDA

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

Oyster Reefs are Biogeochemical Hotspots

- Nutrient pools of interest
  - Nitrogen (N)
  - Phosphorous (P)
  - Organic Carbon (DOC)
- Nitrogen (N) and Phosphorous (P) are limiting nutrients for plant and microbial growth
- Organic carbon is a source of energy and is released as CO_2 as it is mineralized by microorganisms



Source: Chambers et al 2018[1]

Oyster Reef Restoration


Source: Amy Sprinkle 2022

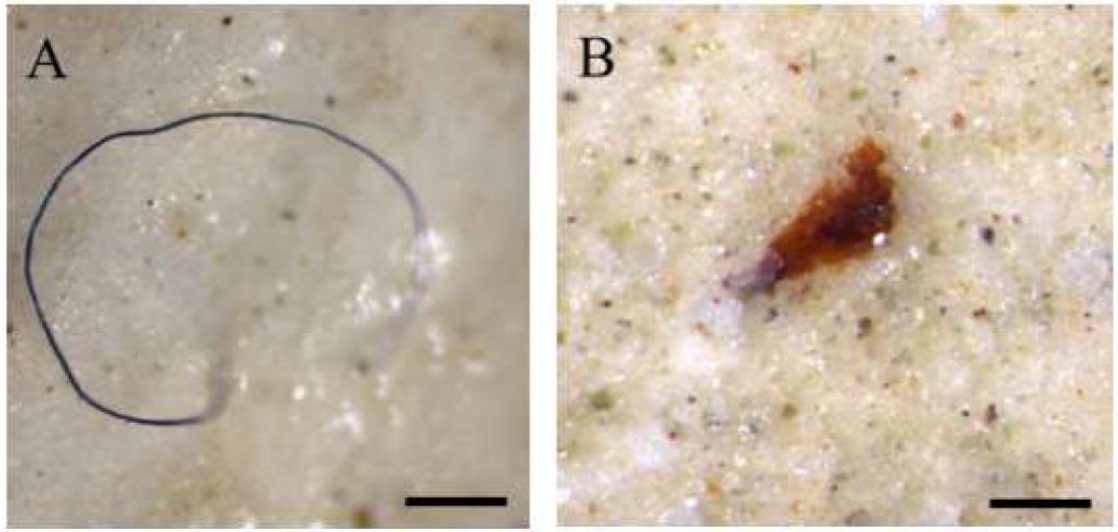

Source: Guy Busby 2026


Source: Dauphin Island Sea Lab 2022


Source: South Carolina ETV 2018

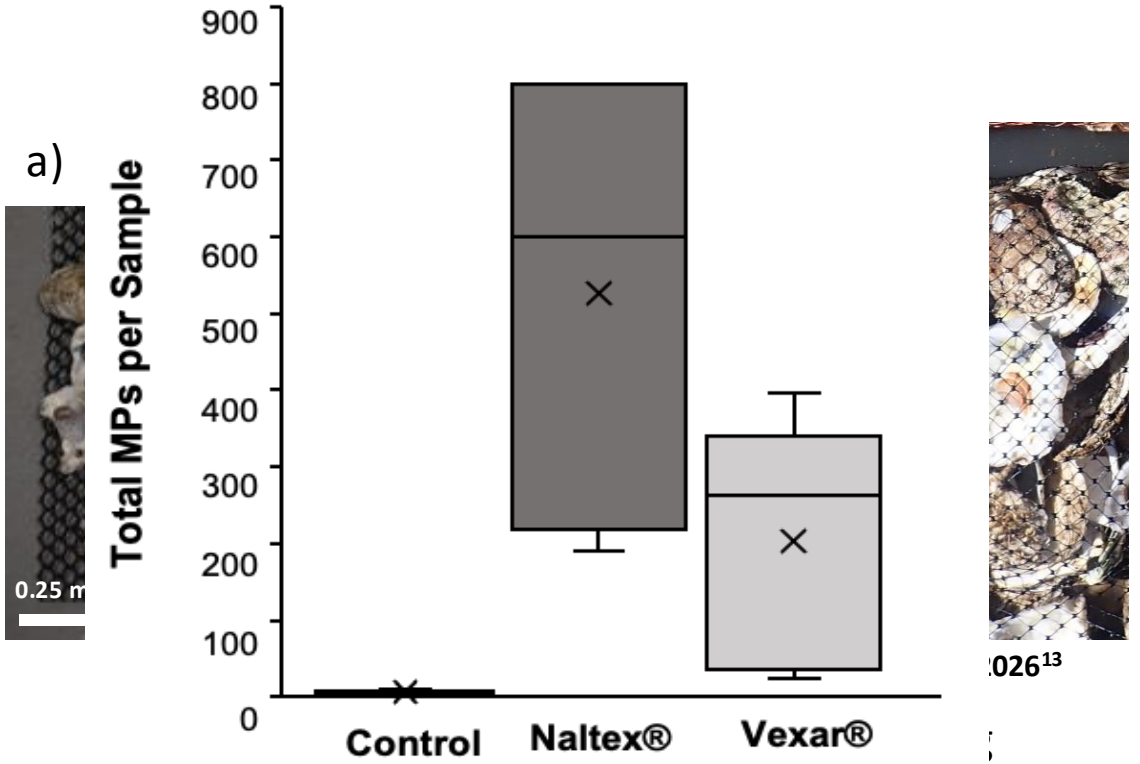
The Issue with Microplastics

- Act as vectors for parasites and pollutants and delay the growth of oyster larvae[2]
- Water and oyster tissues from Mosquito Lagoon contain high abundances of microplastics[3]



Source: Zhu et al 2020

Microplastics found in the tissues of Pacific oysters



Source: Chambers et al 2026[13]

Types of Alternative Materials

Bags made from beech trees

BESE-elements® oyster mats

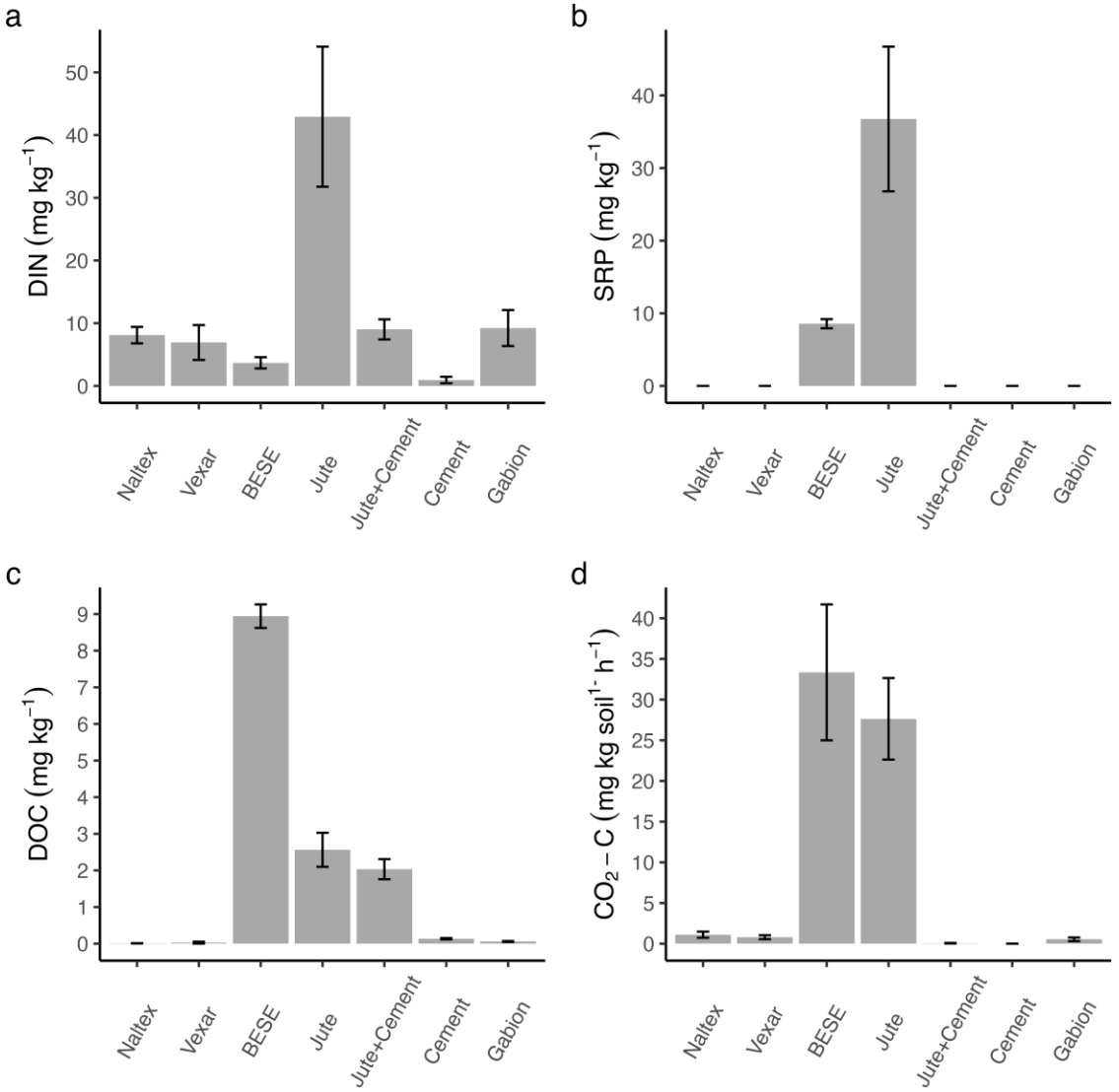
Wire gabions filled with shell

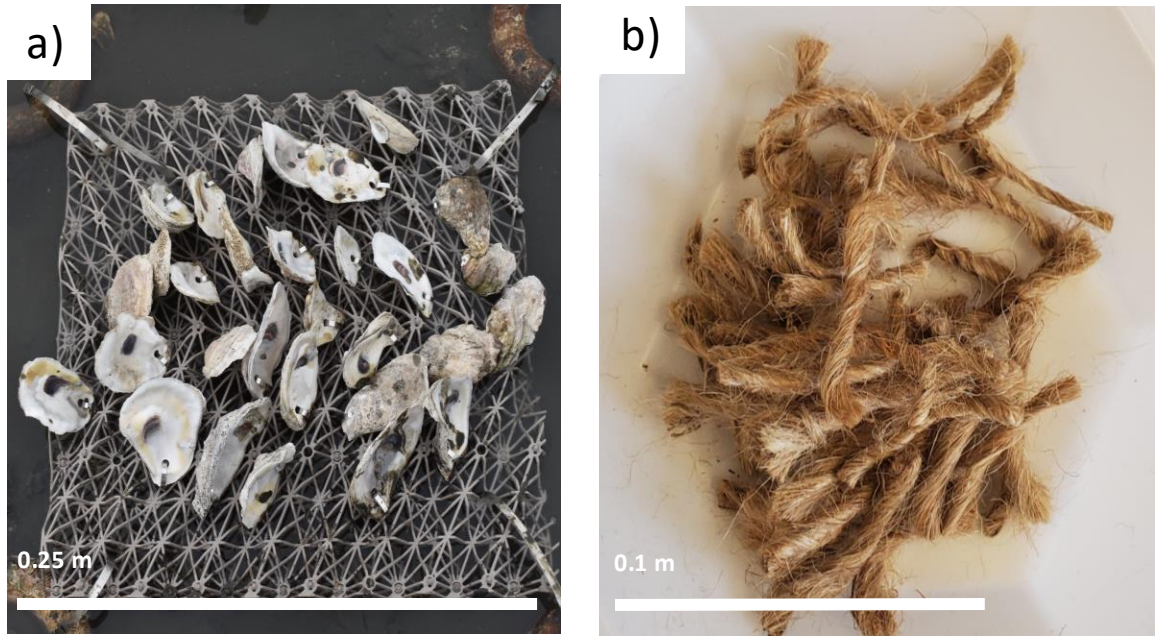
REEFBLK^{SM} Cages

Reef Balls^{TM}

Oyster castle barrier

Organic Materials Release Nutrients

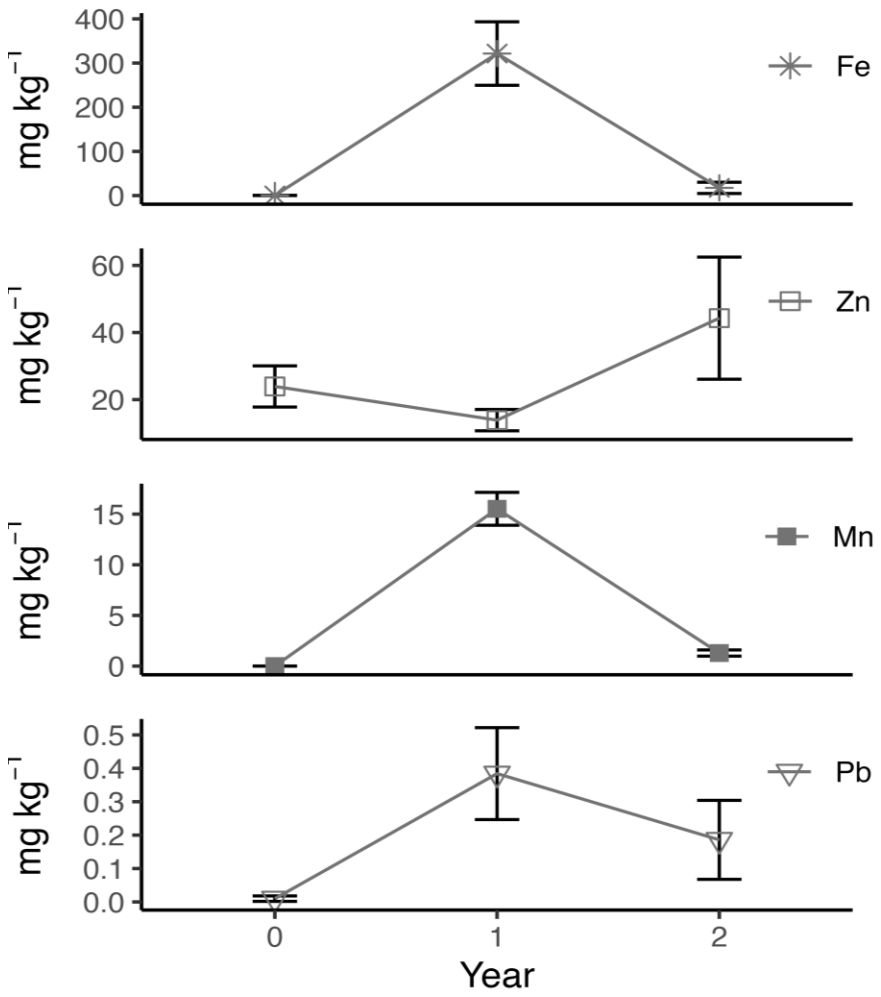




a) BESE-elements® mat and b) Jute fiber

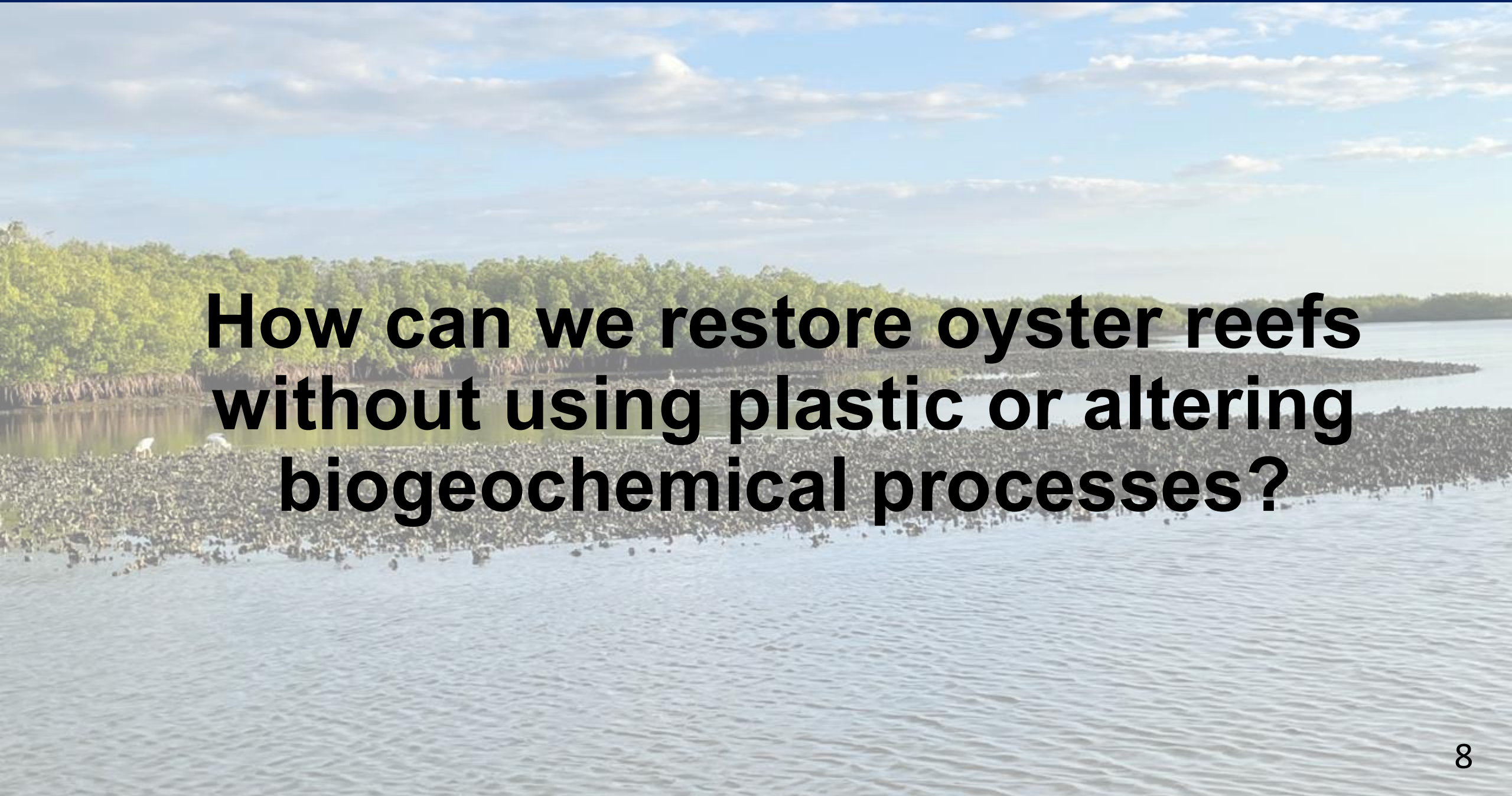
Source: Chambers et al 2026[4]

Metal Materials Release Iron and Zinc



Galvanized metal gabions

Source: Chambers et al 2026[4]



How can we restore oyster reefs without using plastic or altering biogeochemical processes?

Study Materials

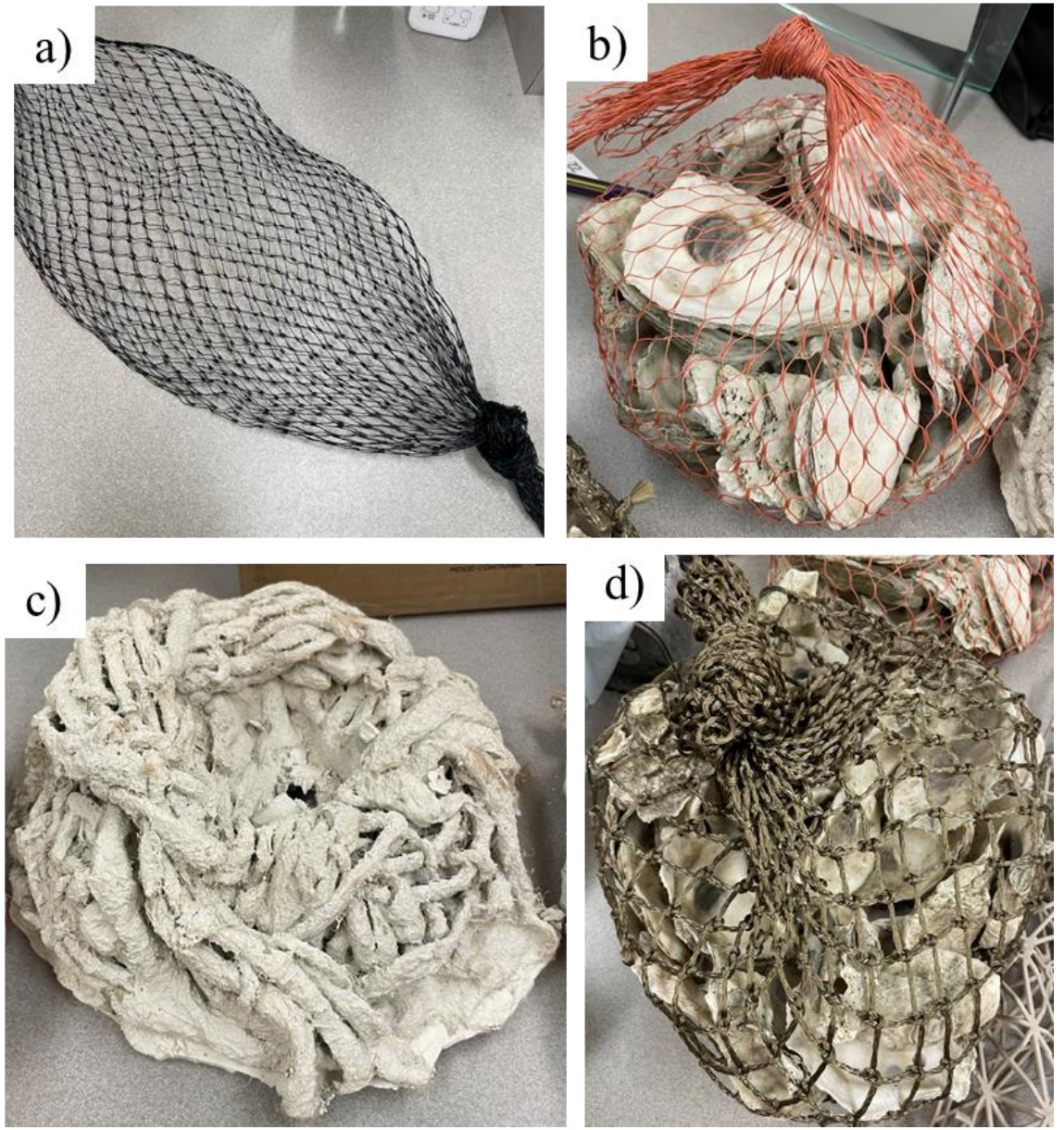
Restoration materials to be studied:

a) Naltex® plastic mesh

b) BESE-mesh biopolymer

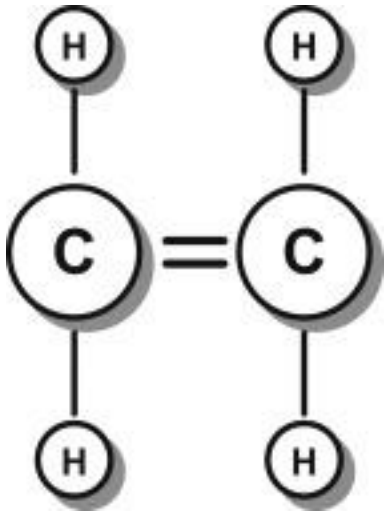
c) Cement-jute ring

d) Natrx® basalt fiber bag



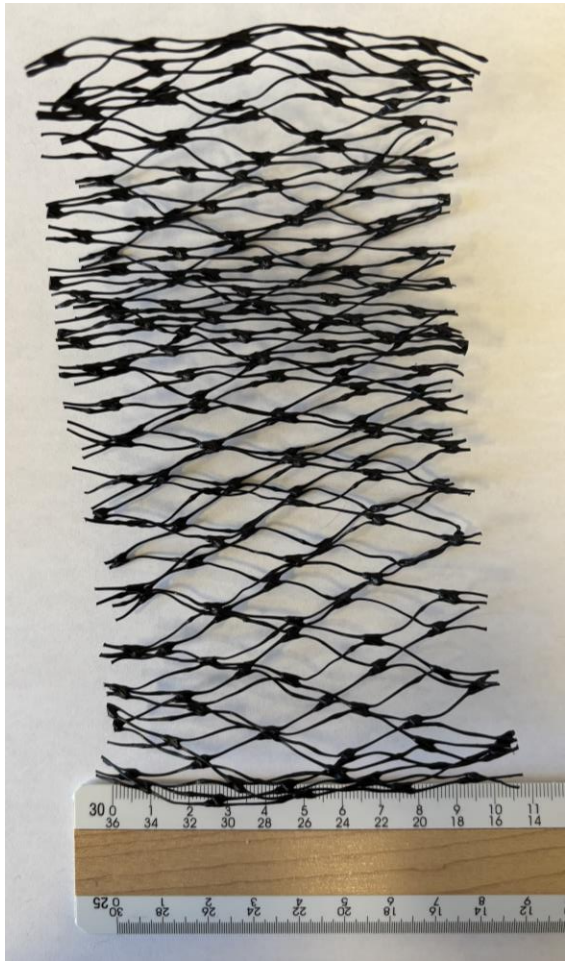
Naltex® Plastic Mesh

- Mesh made of polyethylene
- Ethelyne- made by breaking down ethane or naptha[5]
- Ethane and naptha- come from natural gas and oil hydrocarbons[6]



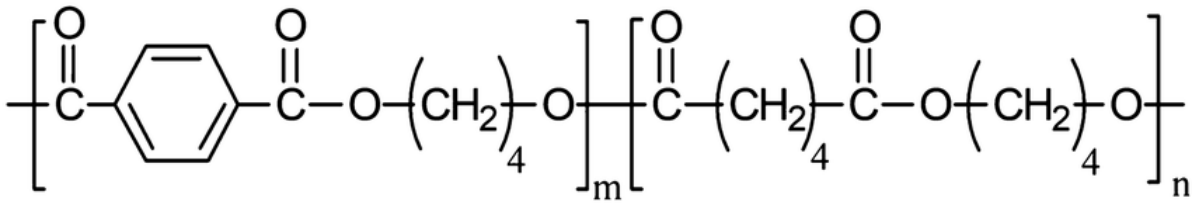
Ethylene molecule

Source: Patel 2016



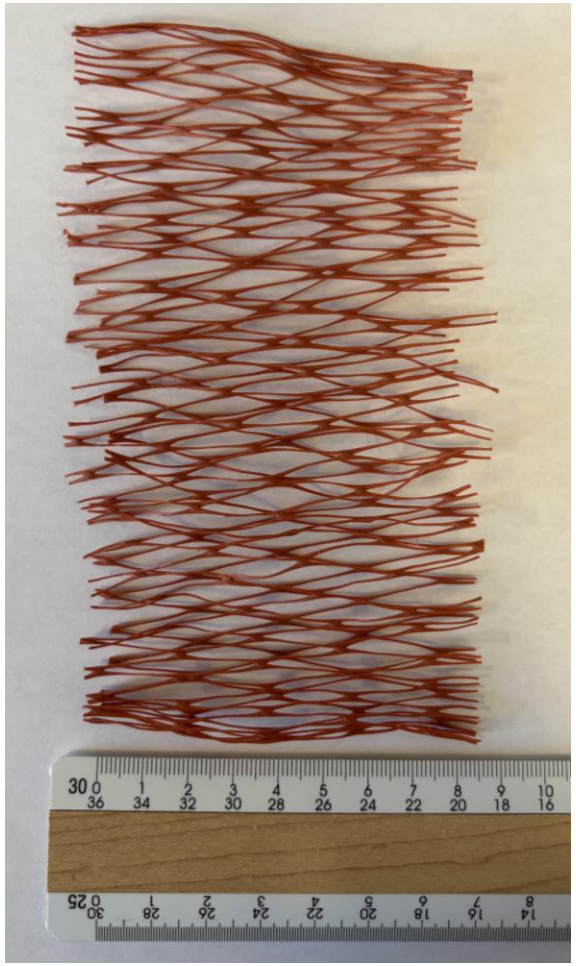
BESE-biopolymer Mesh (orange)

- Biodegradable EcoSystem Engineering Elements (BESE) made from potato waste
- Made of biodegradable polymer: poly (butylene adipate-*co*-terephthalate) (PBAT)[7]
- hydrophobic and has a semi-crystalline structure that contribute to its strength and water resistance



PBAT

Source: Wang et al. 2021



Cement-Jute

- Jute: plant made of α-cellulose, hemicellulose, lignin[8]
- Cement: calcium sulphoaluminate (CSA), mainly CaO, Al_2O_3, SO_3, SiO_2 and some Mg, Fe, and K[9]

Source: Malcolm Manners 2012

Source: ©CEMENTSY INC. 2026

Source: Shandong Senshine New Materials Co., Ltd. 2026

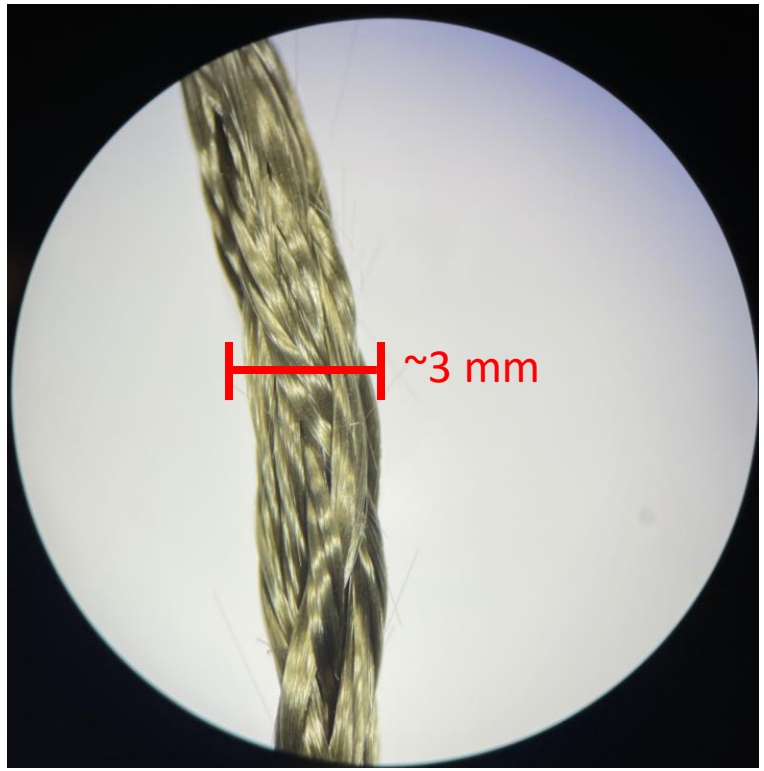
Source: Linda Walters 2025

Basalt Fiber

- Made of basalt, an igneous rock that makes up much of the Earth's crust[10, 11]
- Composed primarily of Si, Al, and Fe oxides, including trace amounts of Mg, Ca, Ti, Zn, K, and others[10, 11]
- Composition can vary based on where it was sourced and the manufacturer[10, 11]

Basalt rock

Source: Minerals Education Coalition



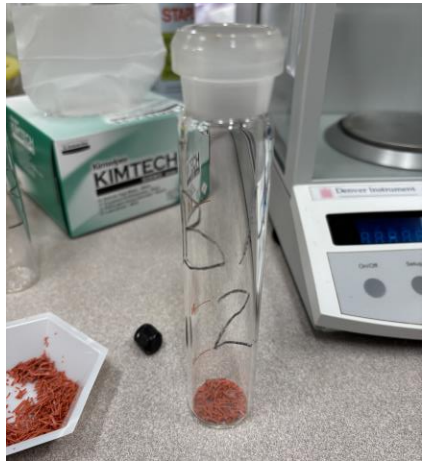
Close-up of basalt fiber strand

Knowledge Gaps

- What is the chemical composition of the study materials?
- Will they release nutrients into the environment?

- Determine the **total carbon**, **nitrogen**, **phosphorous** content of BESE-mesh, basalt fiber, and jute-cement rings, and **total metal content** of basalt fiber.

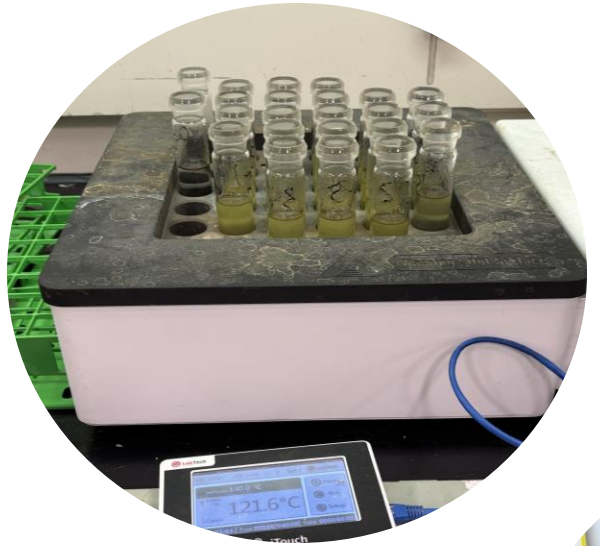
- Quantify **nutrients** released from Natryx® basalt fiber bags, BESE-mesh, cement-jute rings, and Naltex® plastic mesh when incubated for 5 weeks.



Material Composition Methods

Grind Material

Organic Matter (OM)



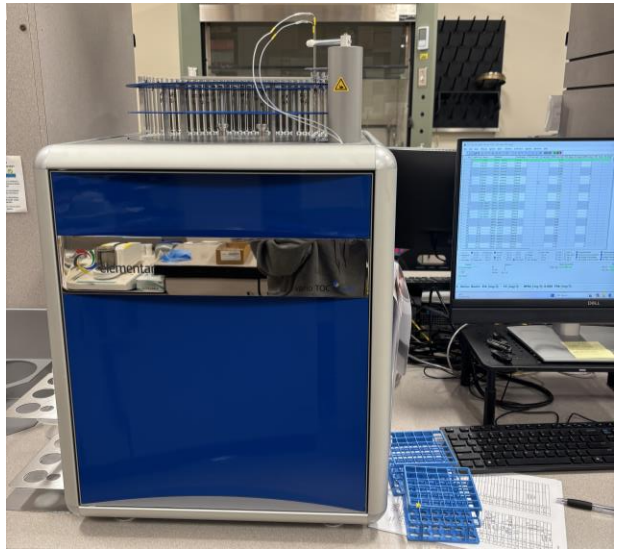
Total Phosphorous (TP)

Total Carbon and
Total Nitrogen
(TC/TN)

Total Metals
(Basalt Fiber only)

Nutrient Release Study

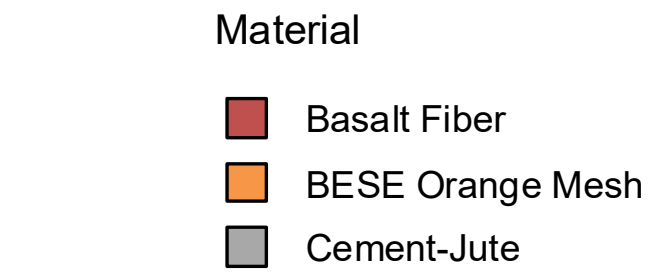
- 100 ml simulated site water (SSW), ~5g material except cement-jute
- 10 replicates of each material, controls only SSW
- 150 rpm at 30°C for 5 weeks

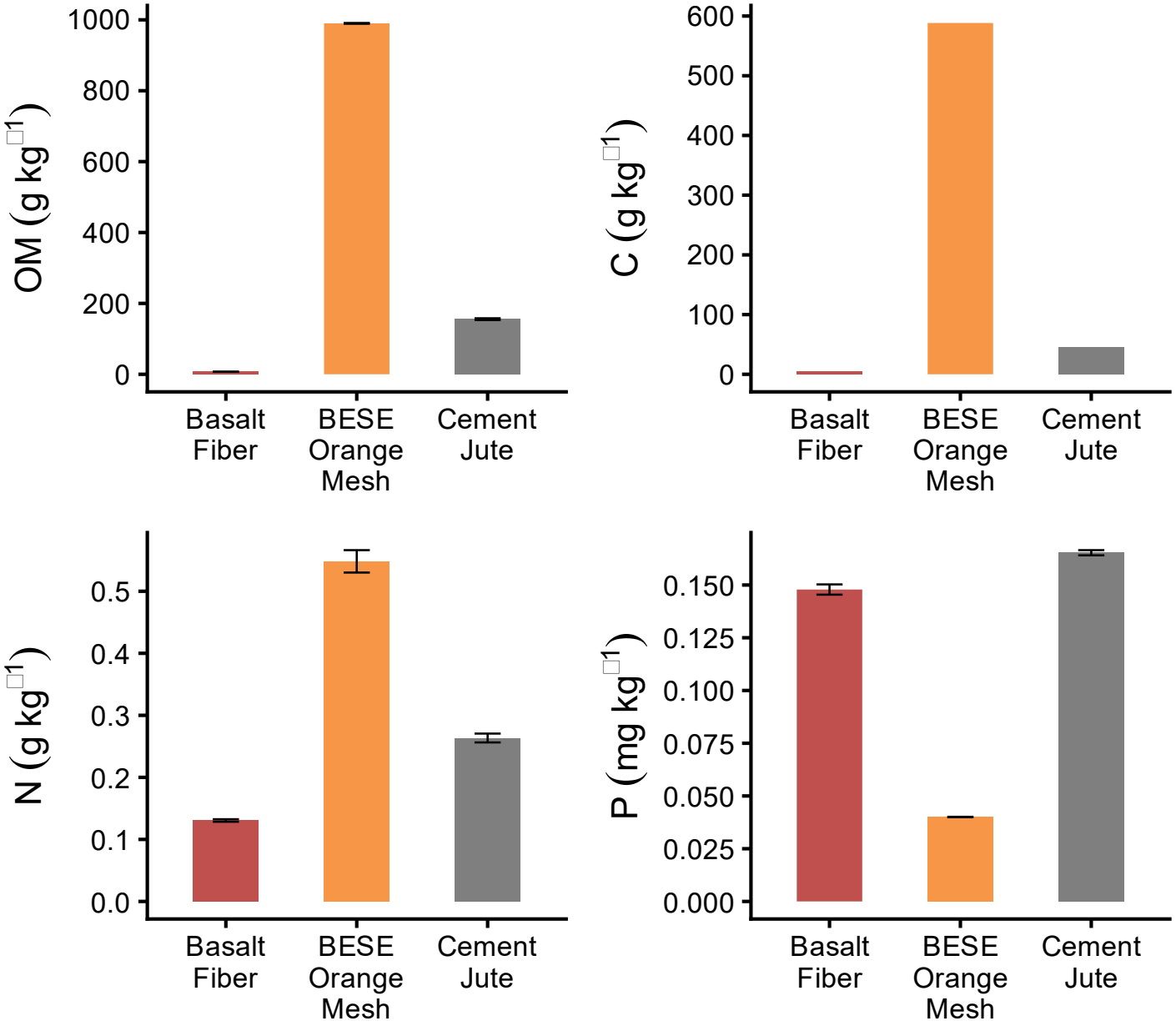


BESE mesh is 99% OM

Basalt fiber contains OM

Cement-Jute and Basalt Fiber contain P

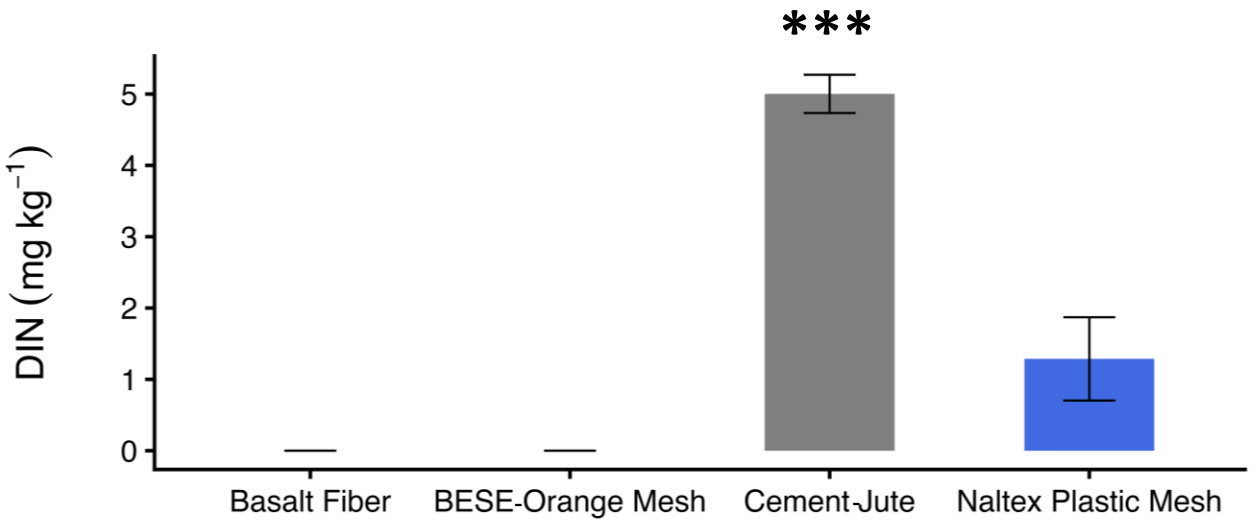




Basalt Fiber contains metals (Al, Fe, K, Mg) in high quantities

Element	mg kg^{-1}
Aluminum (Al)	12140.1 ± 103.4
Iron (Fe)	10390 ± 80.4
Potassium (K)	5129.1 ± 260.5
Magnesium (Mg)	4852.5 ± 47.5
Calcium (Ca)	748.4 ± 6.2
Manganese (Mn)	99.6± 0.8
Barium (Ba)	67.8 ± 0.6
Copper (Cu)	55.9 ± 0.4
Vanadium (V)	18.1± 0.2
Lead (Pb)	16.2 ± 0.2
Zinc (Zn)	13.4 ± 0.4
Chromium (Cr)	10.3 ± 0.2
Nickel (Ni)	3 ± 0.0
Cobalt (Co)	2 ± 0.0

Only cement-jute and plastic released nitrogen, SRP below detection for all materials



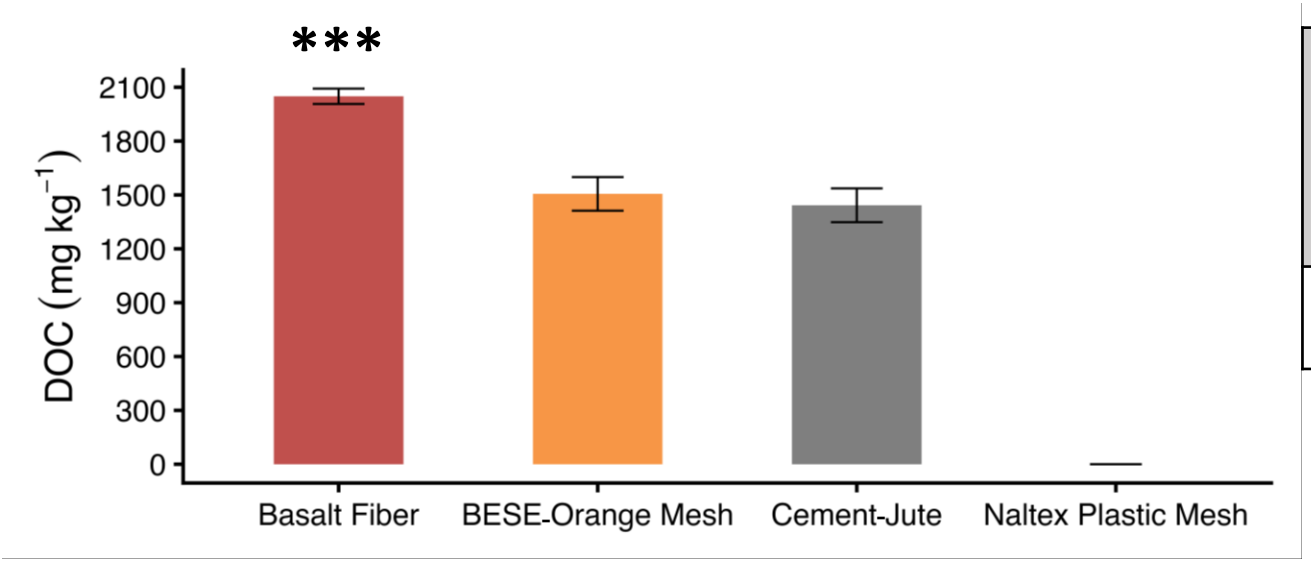
Parameter	Background IRL mg L $^{-1}$	Cement-Jute mg L^{-1}	Naltex Plastic Mesh mg L^{-1}
DIN*	0.19 ± 0.02	1.55 ± 0.05	0.06 ± 0.03
SRP*	0.03 ± 0.002	BD	BD

***Source: Chambers et al. 2018, Locher et al 2021**

Material Basalt Fiber BESE Orange Mesh Cement-Jute Naltex Plastic Mesh

Note: *** indicates $p < 0.0001$;
below detection (BD)

Basalt fiber released the most DOC in mg kg^{-1} compared to other materials



Parameter	Background IRL mg L^{-1}	Basalt Fiber mg L^{-1}	BESE Orange Mesh mg L^{-1}	Cement-Jute mg L^{-1}	Naltex Plastic Mesh mg L^{-1}
DOC*	9.2 ± 0.06	107.91 ± 2.21	76.61 ± 4.79	431.35 ± 13.54	BD

***Source: Chambers et al. 2018, Locher et al 2021**

Material Basalt Fiber BESE Orange Mesh Cement-Jute Naltex Plastic Mesh

Note: *** indicates $p < 0.0001$

Basalt Fiber released Mg after 7 days under simulated site conditions

Element	mg kg^{-1}	mg L^{-1}
Magnesium (Mg)	2158.61 ± 219.34	114.30 ± 11.74
Aluminum (Al)	1.58 ± 0.21	0.084 ± 0.011
Potassium (K)	906.41 ± 171.87	48.04 ± 9.21
Calcium (Ca)	14.97 ± 0.49	0.793 ± 0.027
Nickel (Ni)	1.30 ± 0.09	1.304 ± 0.085
Phosphorous (P)	0.74 ± 0.10	0.0392 ± 0.0053
Iron (Fe)	0.01 ± 0.01	0.0004 ± 0.0002
Barium (Ba)	0.28 ± 0.02	0.0148 ± 0.0008

Plastic Mesh

Source: Senior Airman Vernon L. Fowler Jr. 2015

- Releases DIN
- Not inert in terms of nutrients

Cement-Jute Rings

- Releases DIN and large concentrations of DOC

BESE-Orange Mesh

Source: ©BESE 2026

- No release of N and P
- Releases DOC

Basalt Fiber

- Contains metals
  - Fe, Mn, and Al are redox active
  - P, K, Fe, and Mg are micronutrients
  - Pb are Cr are toxic
- Releases DOC, Mg

Natural materials are not inert – all possible ecosystem effects should be considered

Source: Florida Department of Environmental Protection 2020

Acknowledgements

Graduate Students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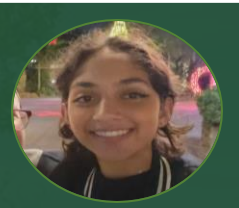
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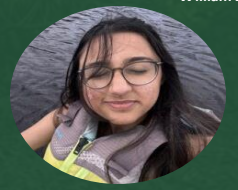
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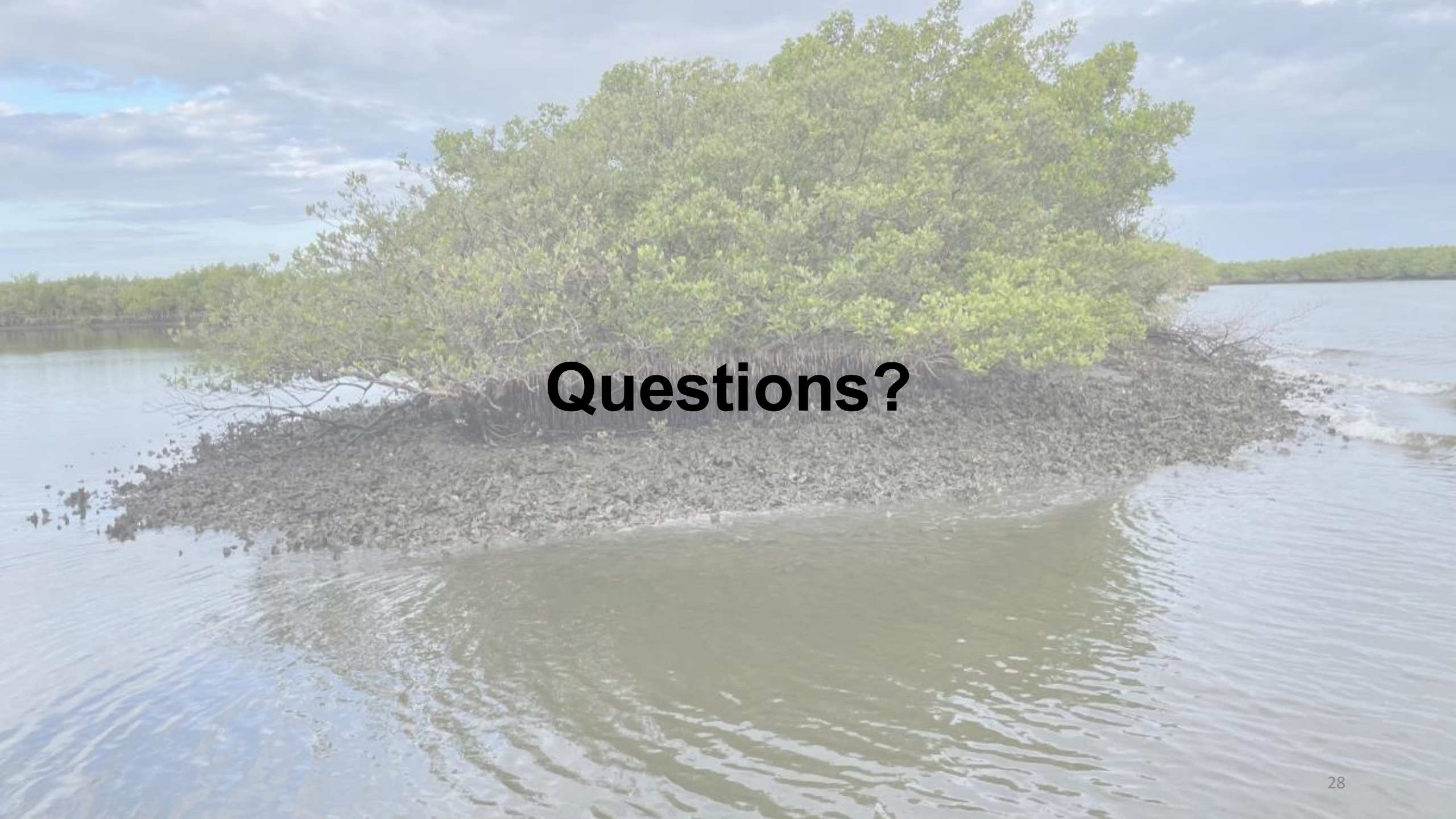
Questions?