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Living Shorelines Achieve Functional Equivalence to Natural Fringe Marshes Across Multiple Ecological Metrics

Robert E. Isdell

Donna Marie Bilkovic

Amanda G. Guthrie

Molly M. Mitchell

Randolph M. Chambers

See next page for additional authors

Authors

Robert E. Isdell, Donna Marie Bilkovic, Amanda G. Guthrie, Molly M. Mitchell, Randolph M. Chambers, Matthias Leu, and Carl Hershner

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risdell@vims.edu

VIMS | William & Mary
Virginia Institute of Marine Science

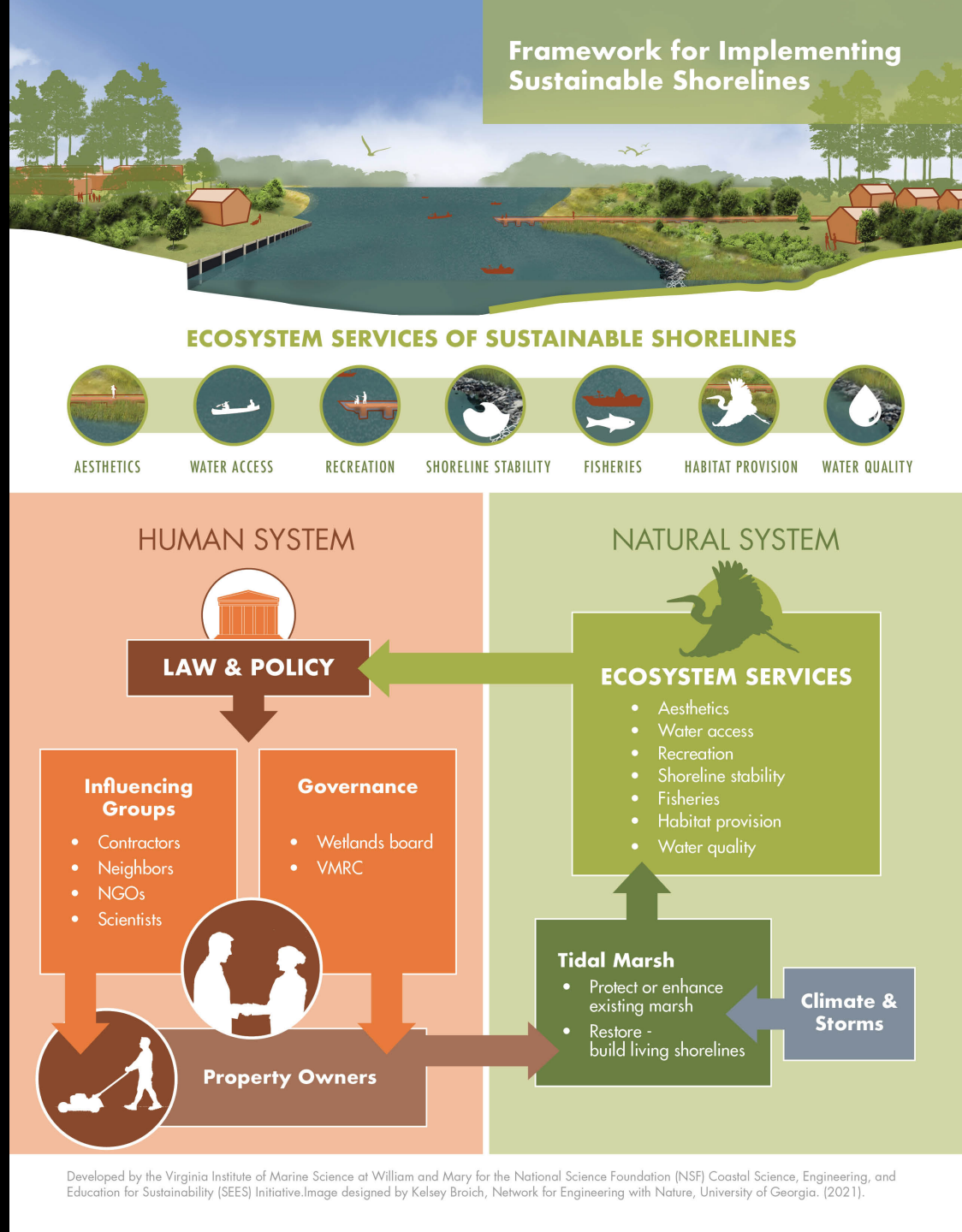
Center for Coastal Resources Management
Virginia Institute of Marine Science

NSF

What was the NSF Coastal SEES project?

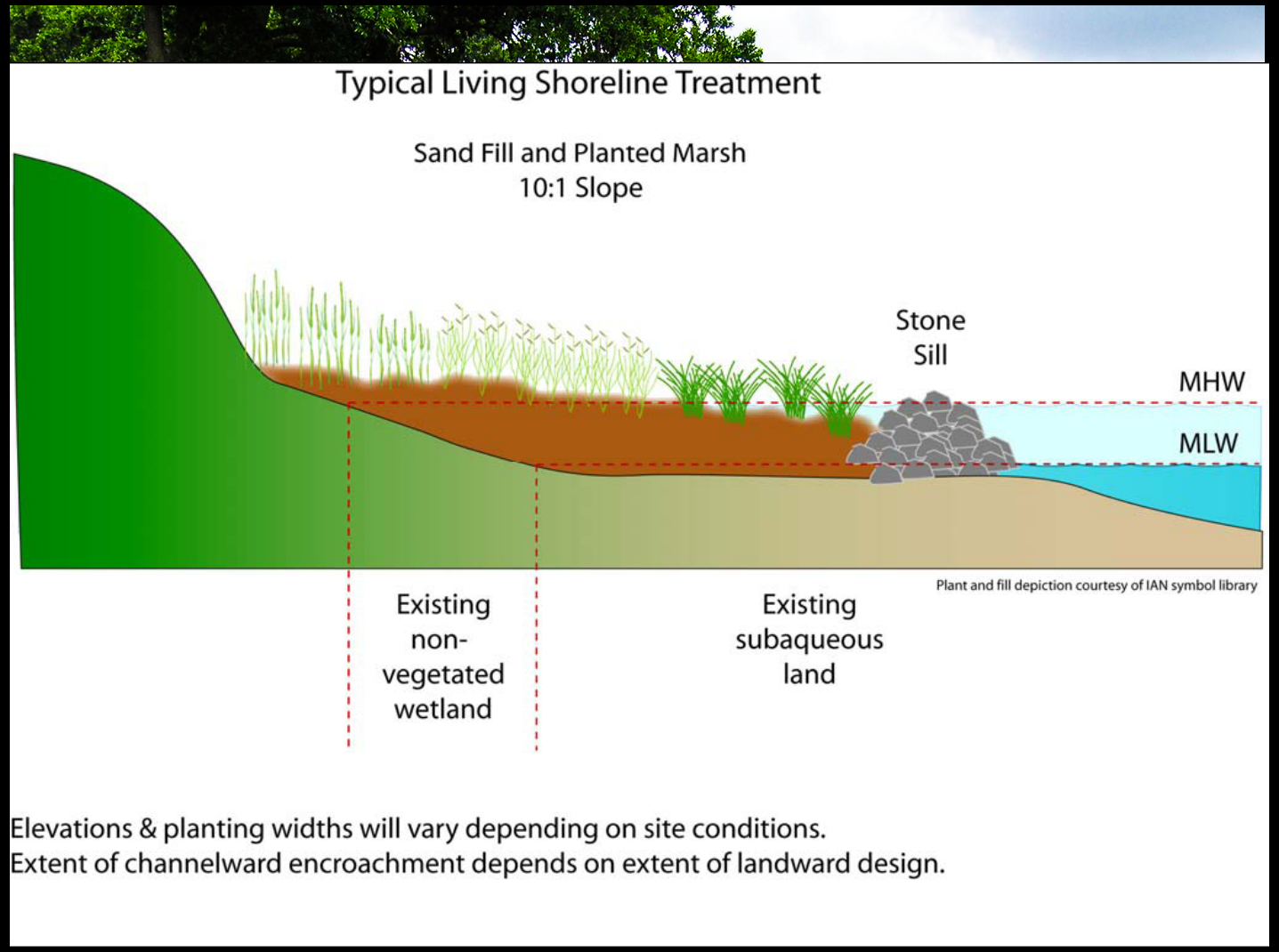
- 5-year effort to integrate the social and ecological systems of living shorelines.

- Ecological question: How do living shorelines compare to natural fringing marshes?



How did we define living shoreline?

- Marsh sills
  - Stone sill
  - Clean sand backfill and grading
  - Planted *Spartina alterniflora* in the low marsh and *S. patens* in the high marsh

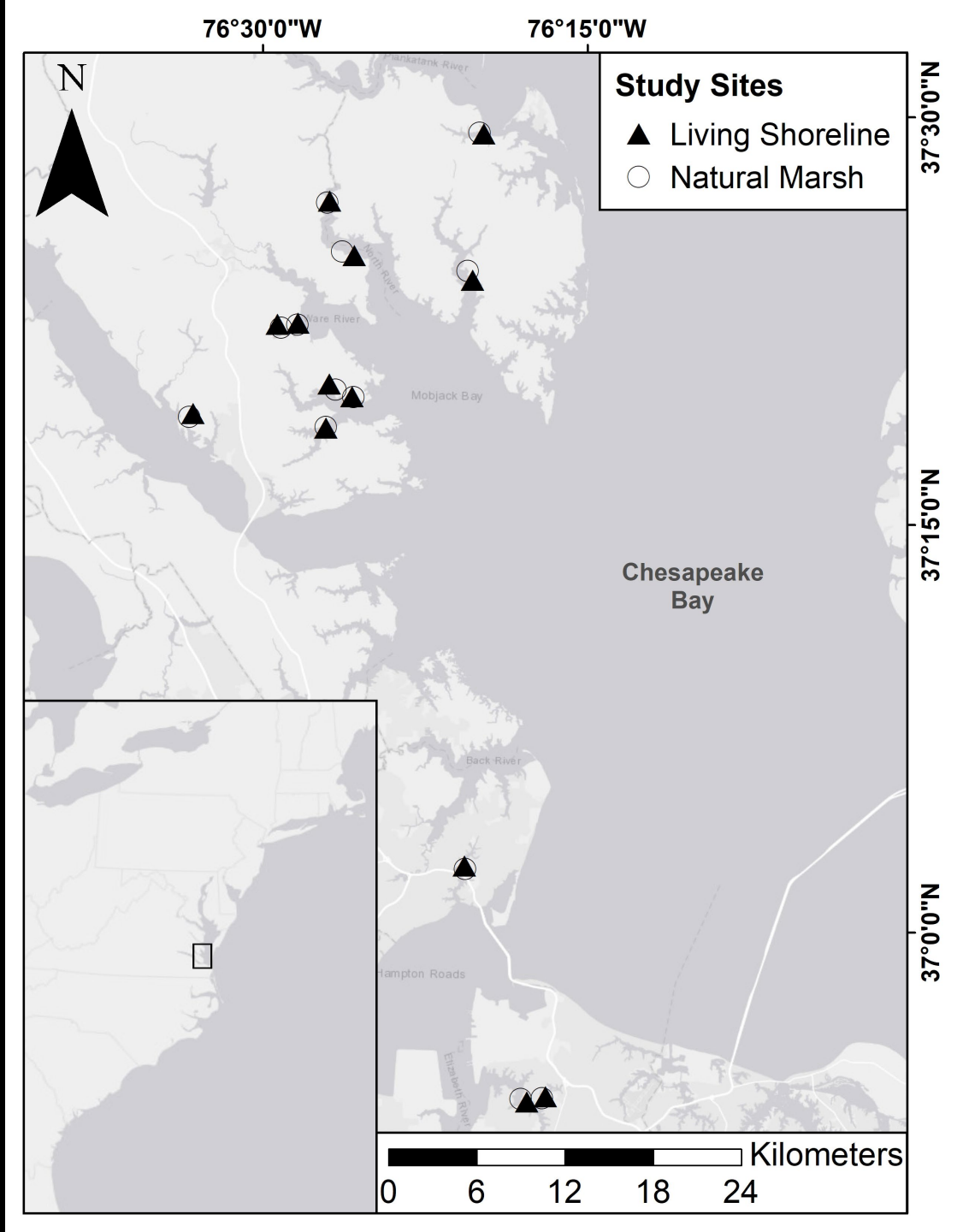


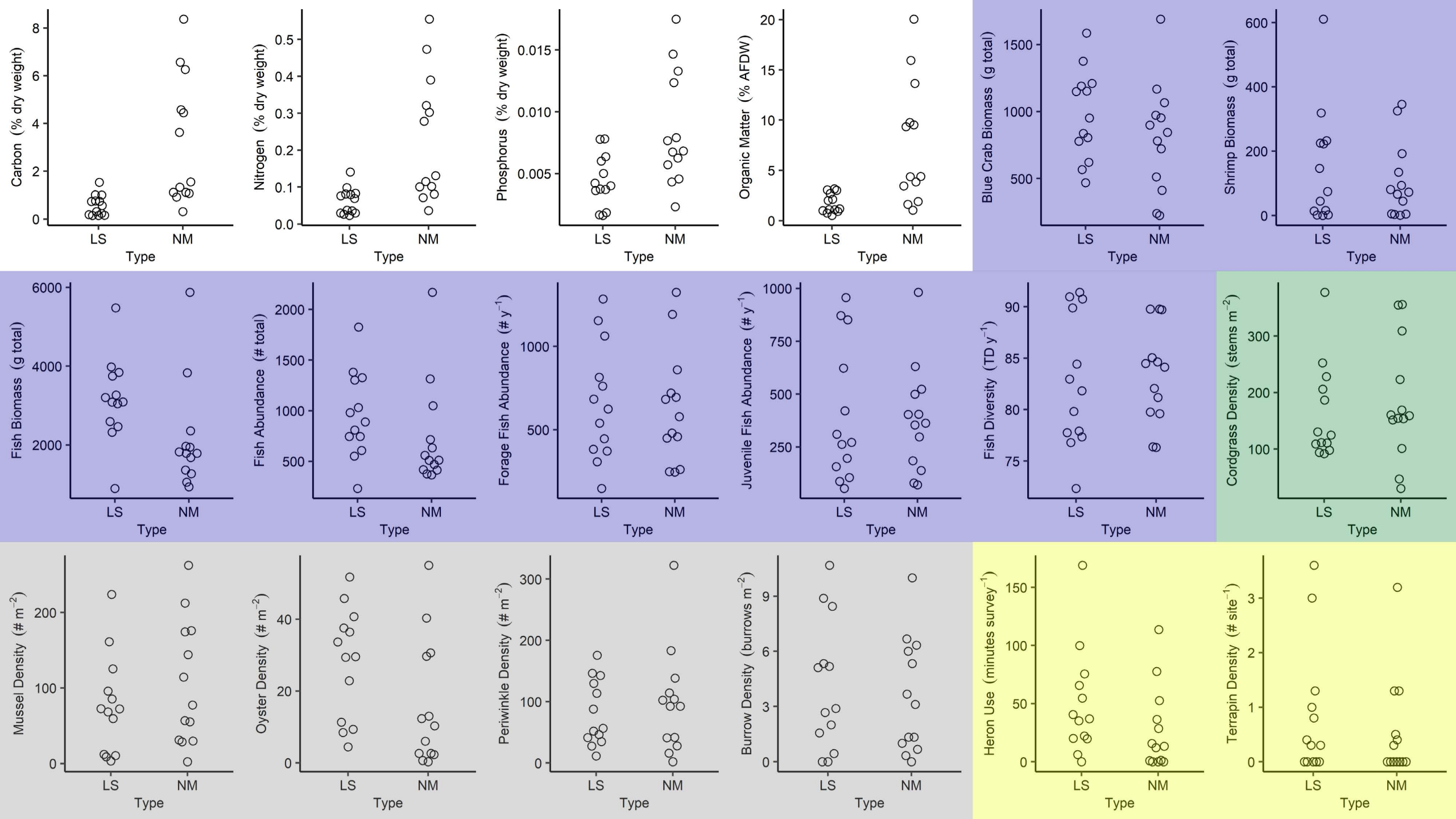
What did we measure?

- Soils
  - Carbon
  - Nitrogen
  - Phosphorus
  - Organic Matter
- Plants
  - *S. alterniflora* Density
- Invertebrates
  - Ribbed Mussels
  - Oysters
  - Periwinkles
  - Burrowing Crabs
- Nekton
  - Fish Biomass
  - Crab Biomass
  - Shrimp Biomass
  - Fish Abundance
  - Juvenile Fish Abundance
  - Forage Fish Abundance
  - Fish Diversity
- Herons
  - Use
- Terrapin
  - Density

Where did we measure it?

- 13 Paired Living Shoreline and Natural Fringe Marshes
- Ages 2 – 16 (c. 2018)
- A variety of shorescape settings, from urban to rural




Carbon (% dry weight)
Nitrogen (% dry weight)
Phosphorus (% dry weight)
Organic Matter (% AFDW)
Blue Crab Biomass (g total)
Shrimp Biomass (g total)
Fish Biomass (g total)
Fish Abundance (# total)
Forage Fish Abundance (# y^{-1})
Juvenile Fish Abundance (# y^{-1})
Fish Diversity (TD y^{-1})
Cordgrass Density (stems m^{-2})
Mussel Density (# m^{-2})
Oyster Density (# m^{-2})
Periwinkle Density (# m^{-2})
Burrow Density (burrows m^{-2})
Heron Use (minutes survey^{-1})
Terrapin Density (# site^{-1})
LS
NM
Type

How did we analyze the data?

- We used a Z-score approach: $\frac{\bar{\mu}_{LS_i} - \bar{\mu}_{NM_i}}{\sigma_{LS,NM*}}$

* The SD could either be local or regional

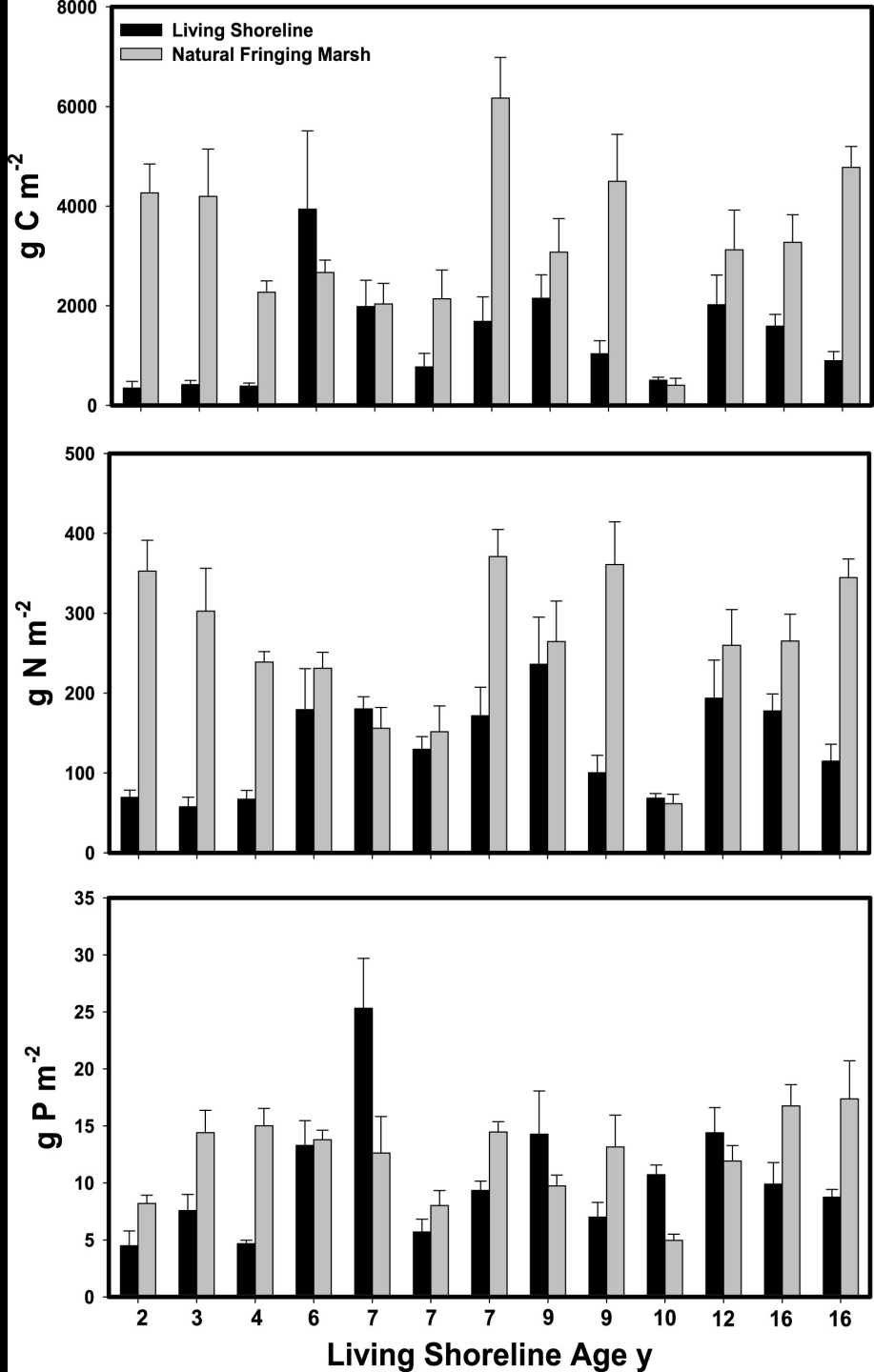
$$\sigma_{Local_i} = \sqrt{\frac{\sigma_{LS_i}^2 + \sigma_{NM_i}^2}{2}}$$

$$\sigma_{Regional} = \sqrt{\frac{\sigma_{LS}^2 + \sigma_{NM}^2}{2}}$$

What did we find? - Soils

- Soils at our living shoreline sites are still not the same as those at natural marshes, even after 16 years.
  - Carbon: Z = -2.61; 0 – 63 years to equivalence
  - Nitrogen: Z = -2.60; 0 – 31 years to equivalence
  - Phosporus: Z = -1.76; 0 – 23 years to equivalence
  - Organic Matter: Z = -1.86

Chambers et al. 2021



What did we find? - Nekton

- There was no observable difference between LS and NM.

Metric	Z-score
Fish biomass	0.85
Crab biomass	0.46
Shrimp biomass	0.28
Fish Abundance	0.48
Juvenile Fish Abundance	0.09
Forage Fish Abundance	0.09
Fish Diversity	-0.12

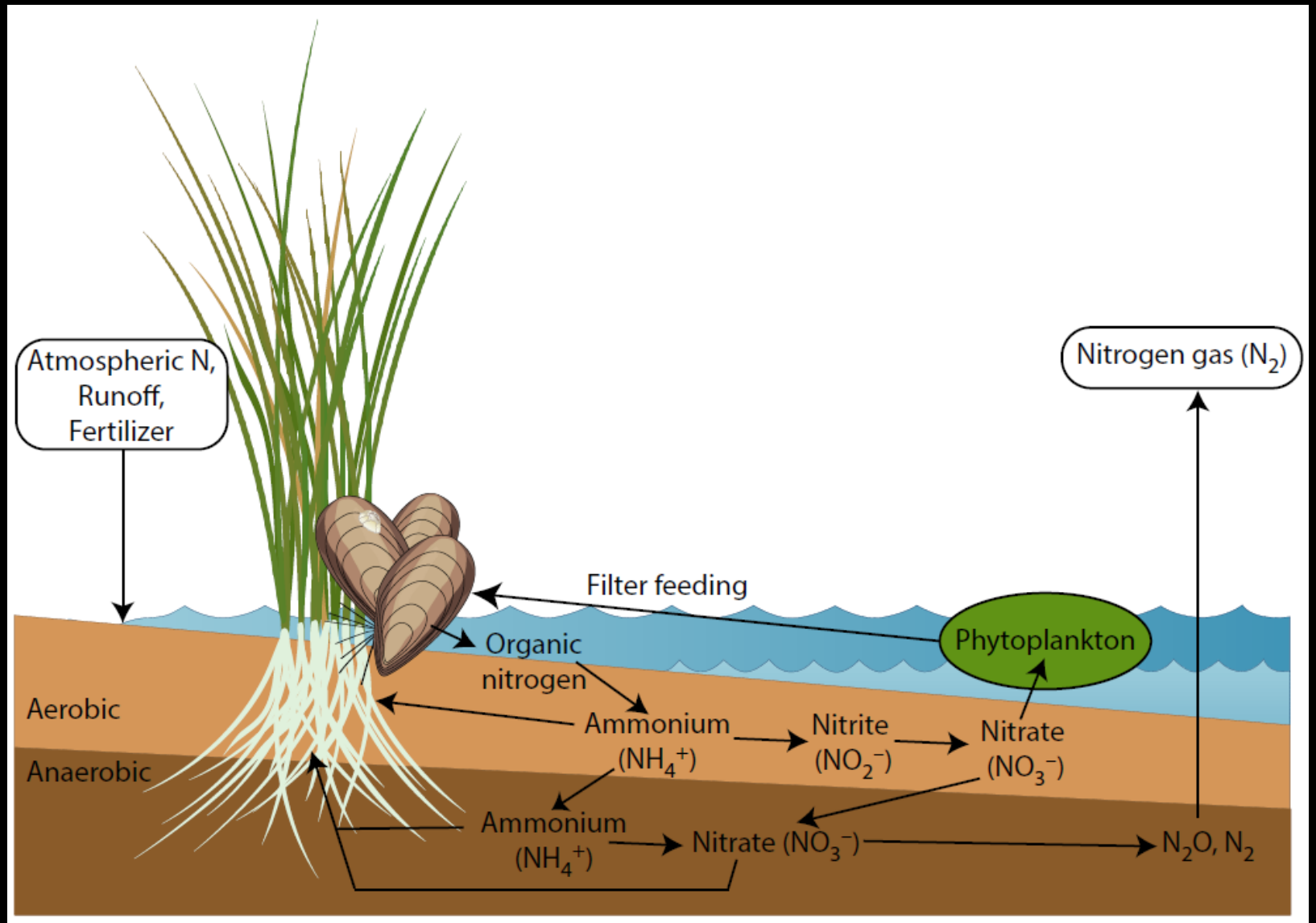
What did we find? – Herons and Terrapin

- They use both types equally
  - Herons: 0.55
  - Terrapin: 0.27

What did we find? – Plants and Inverts

- Plants and Inverts were basically the same*
  - *Spartina*: Z = - 0.14
  - Mussels: Z = - 0.80
  - Oysters: Z = 0.28
  - Periwinkles: Z = -0.12
  - Burrows: Z = 0.01

Mussels in living shorelines

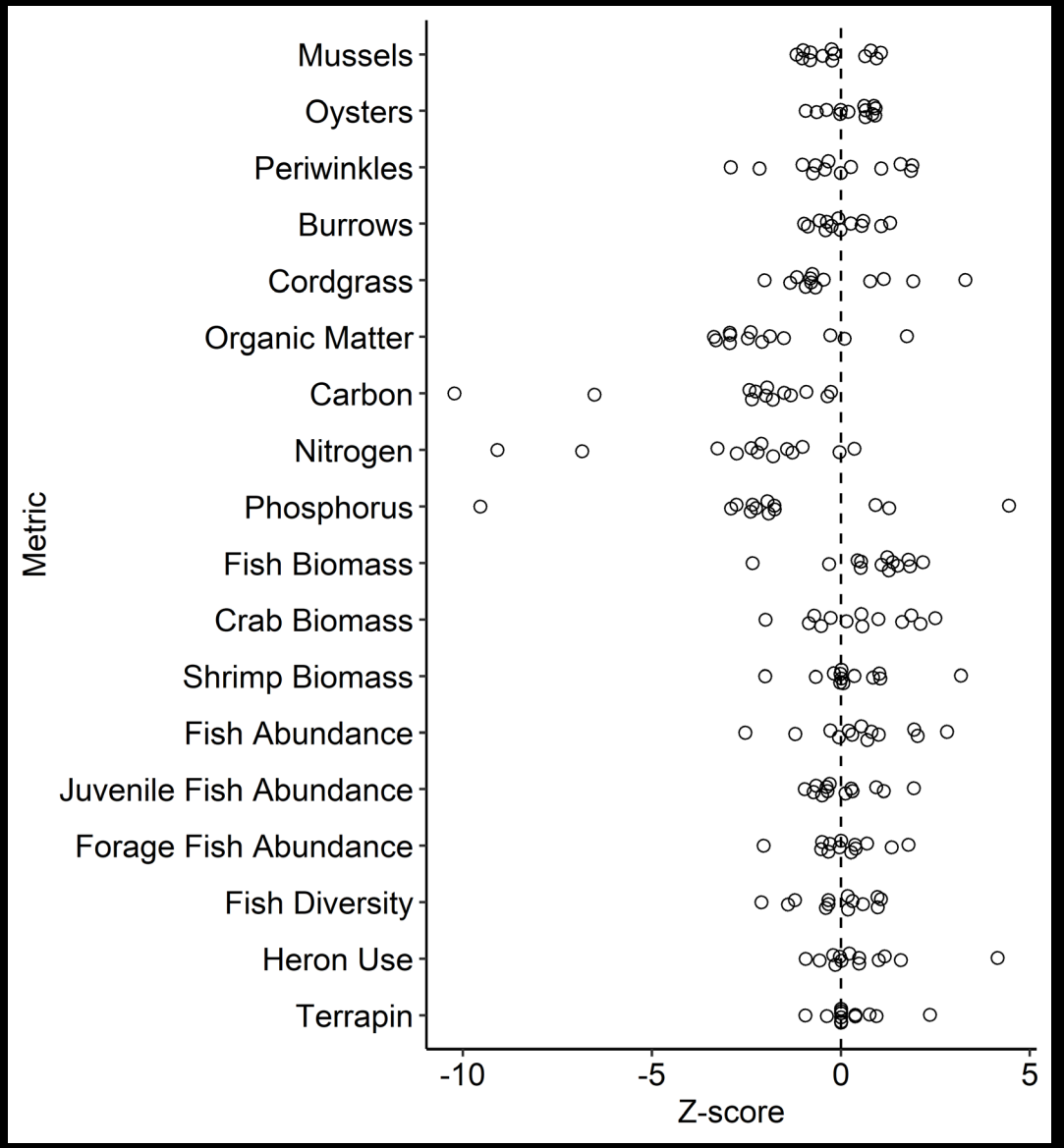


Bilkovic et al. 2017

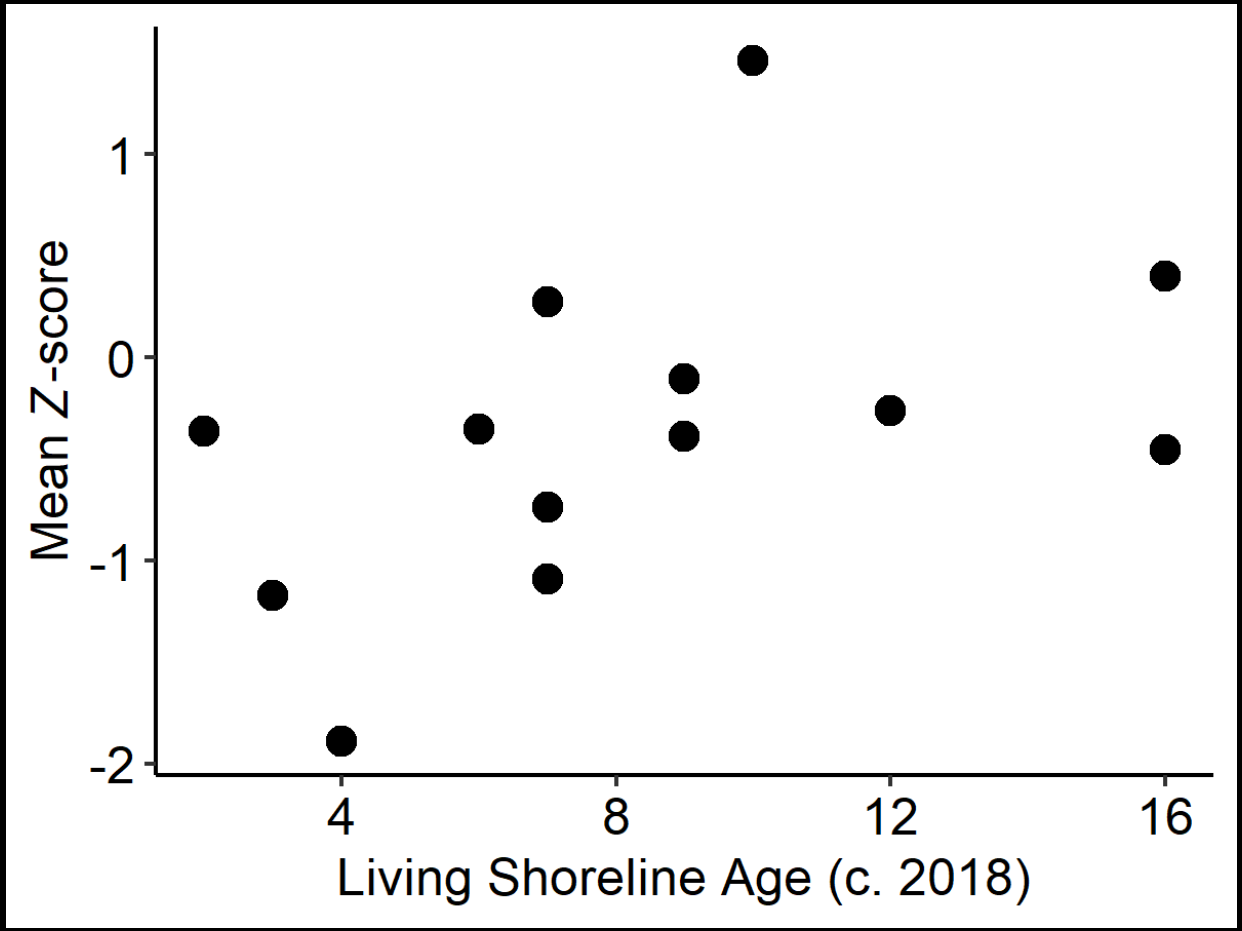
What did we find? - Overall

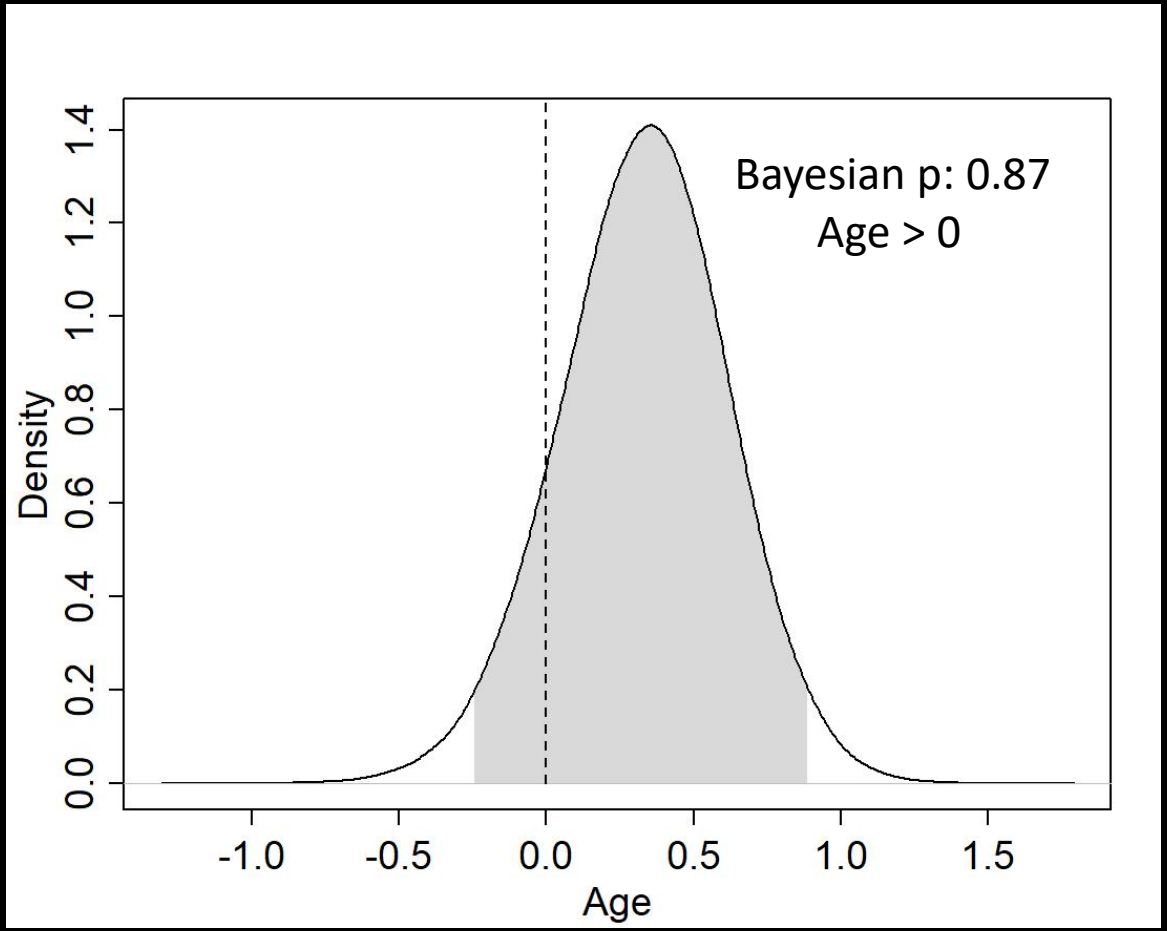
- Overall, living shorelines were functionally equivalent to natural fringing marshes.
  - Overall Z-score: **-0.36 ± 1.11**

- Neither all sites nor all metrics were equivalent at the pair-level
  - John's Point vs. Tolar scored -1.86 overall
  - Martin's vs. River Road scored 1.46 overall
  - The Wilson's Creek pairs: Fish abundance: 1.94; Carbon: -1.96



What about age?





What does it mean?

- Can living shorelines provide the same levels of ecological function as natural marshes?
  - YES
- Will every living shoreline provide the same levels of function?
  - NO
- How long will it take a newly constructed living shoreline to reach functional equivalence?
  - It depends…

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Robert E. Isdell[1], Donna Marie Bilkovic[1], Amanda G. Guthrie[1], Molly M. Mitchell[1], Randolph M. Chambers[2,3], Matthias Leu[2] and Carl Hershner[1]

Isdell RE, Bilkovic DM, Guthrie AG, Mitchell MM, Chambers RM, Leu M, Hershner C. 2021. Living shorelines achieve functional equivalence to natural fringe marshes across multiple ecological metrics. *PeerJ* **9**:e11815 http://doi.org/10.7717/peerj.11815