Living shorelines achieve functional equivalence to natural fringe marshes across multiple ecological metrics

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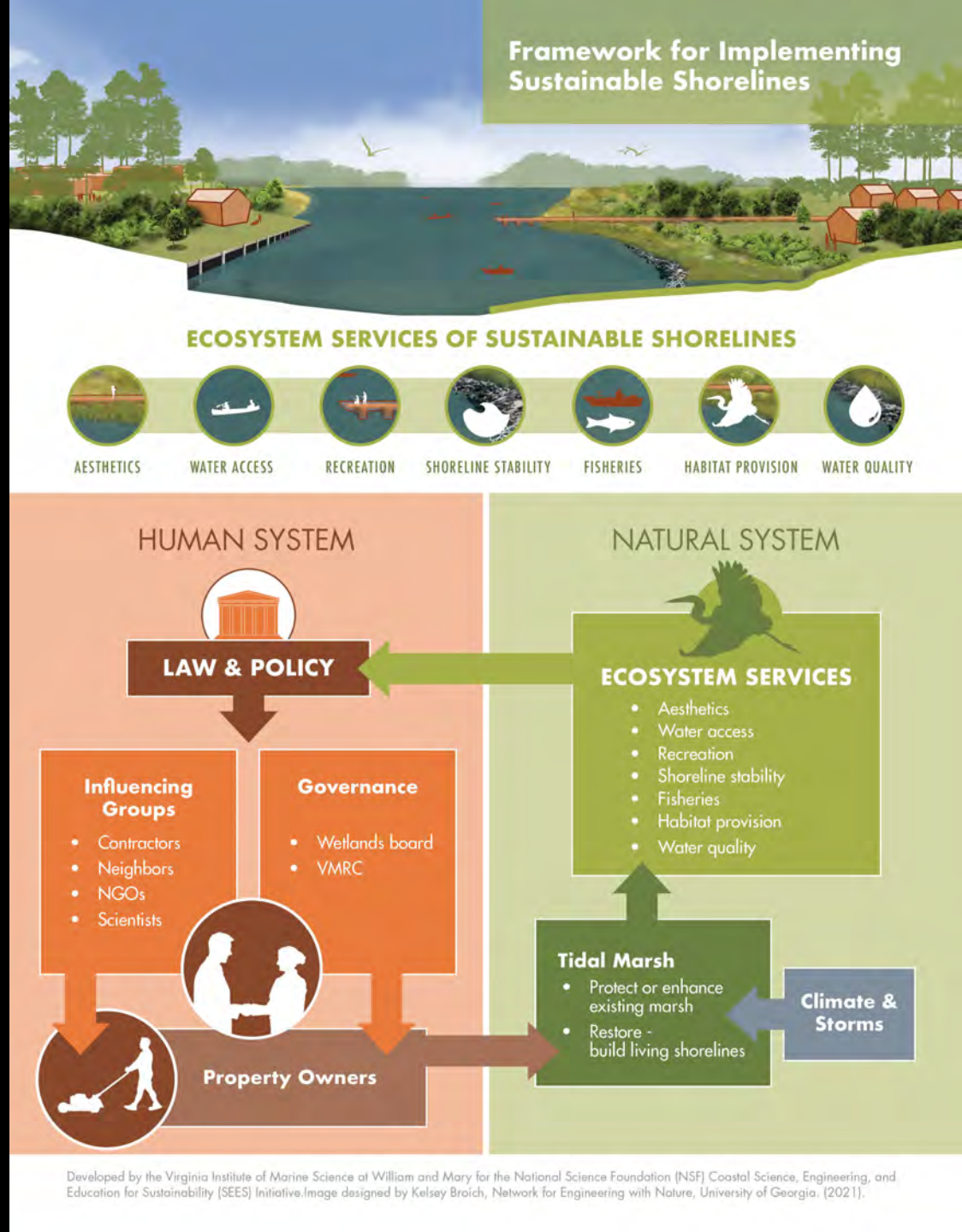
NSF

What was the NSF Coastal SEES project?

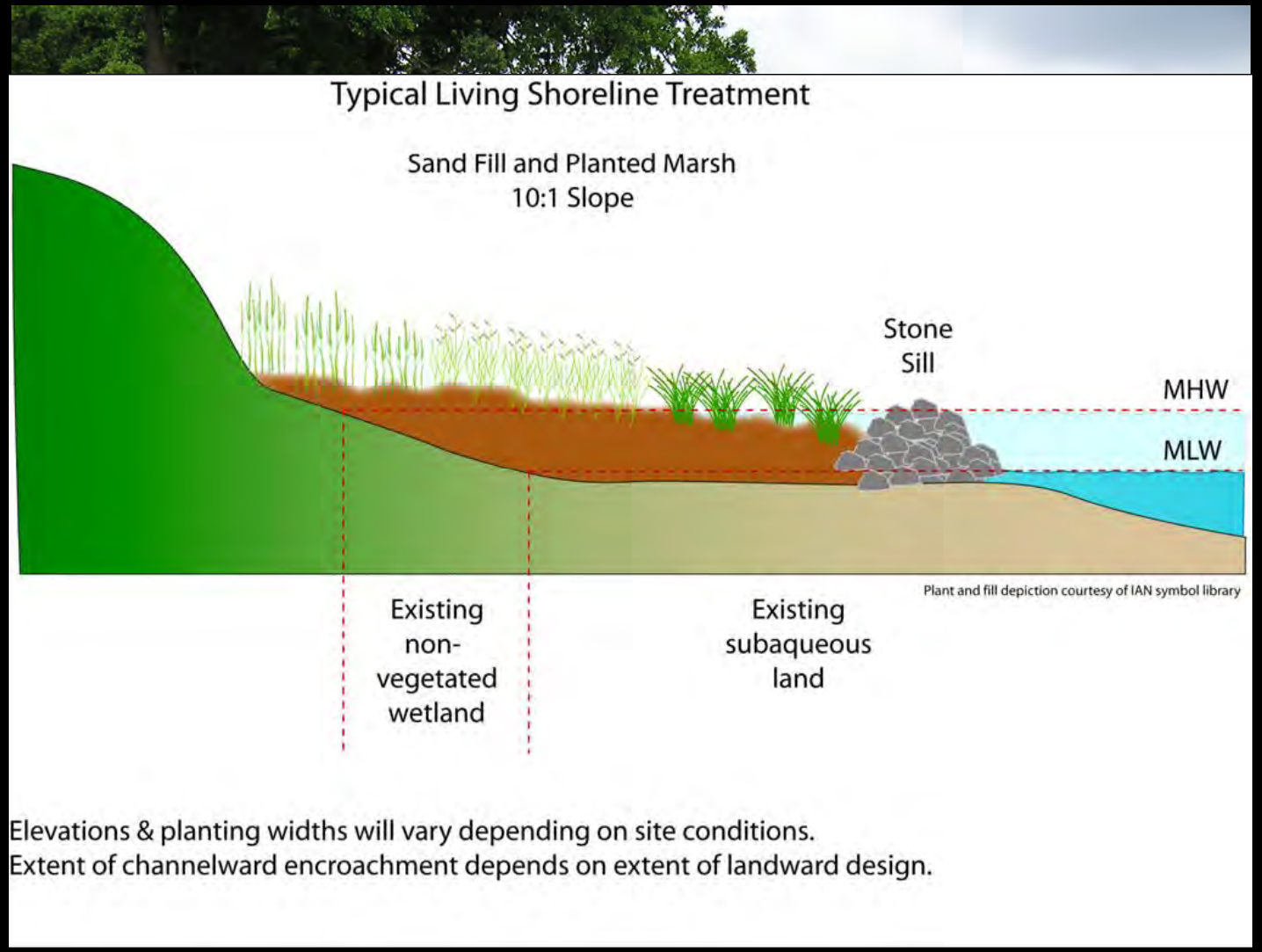
- 5-year effort to integrate the social and ecological systems of living shorelines.

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



What is a 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

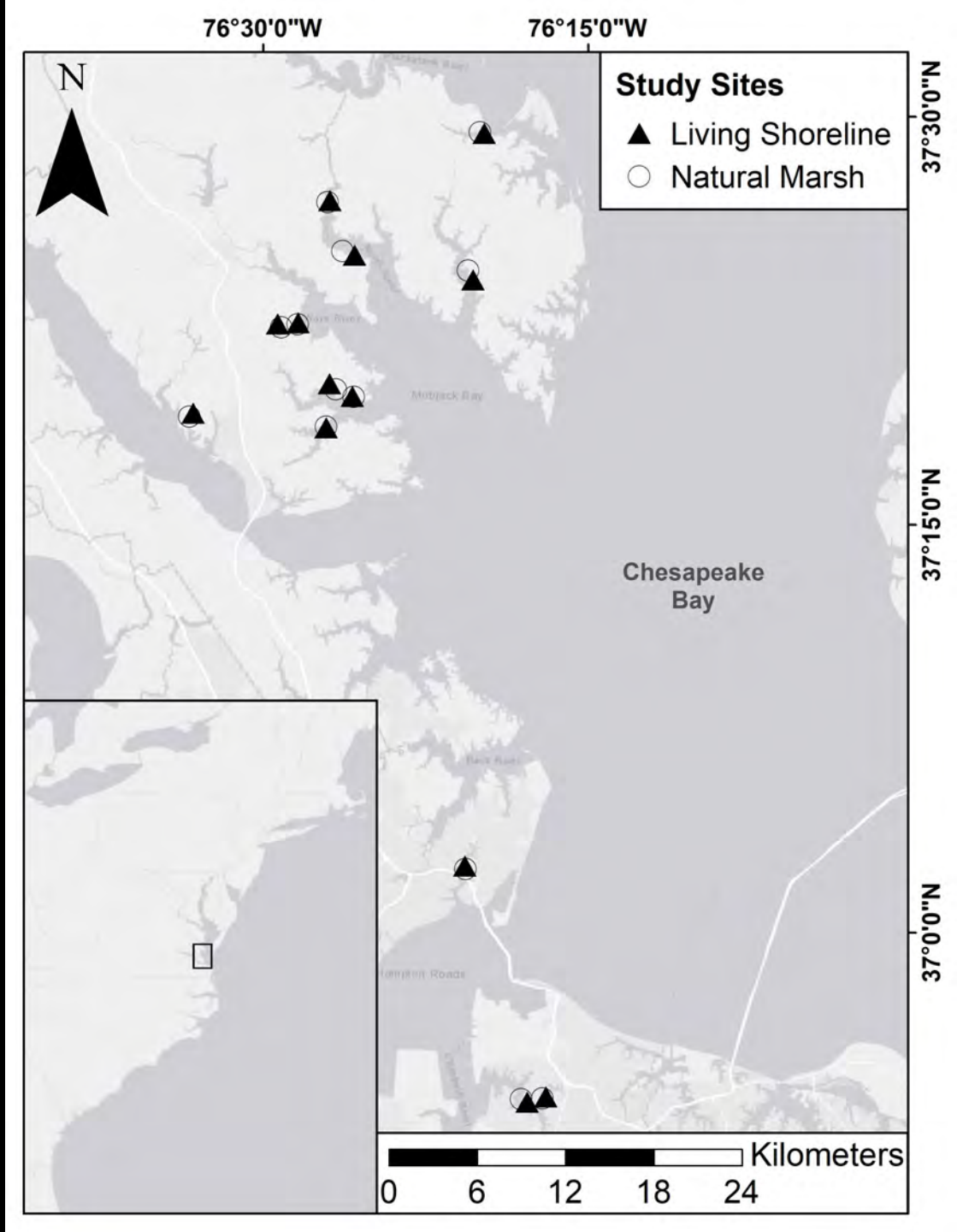


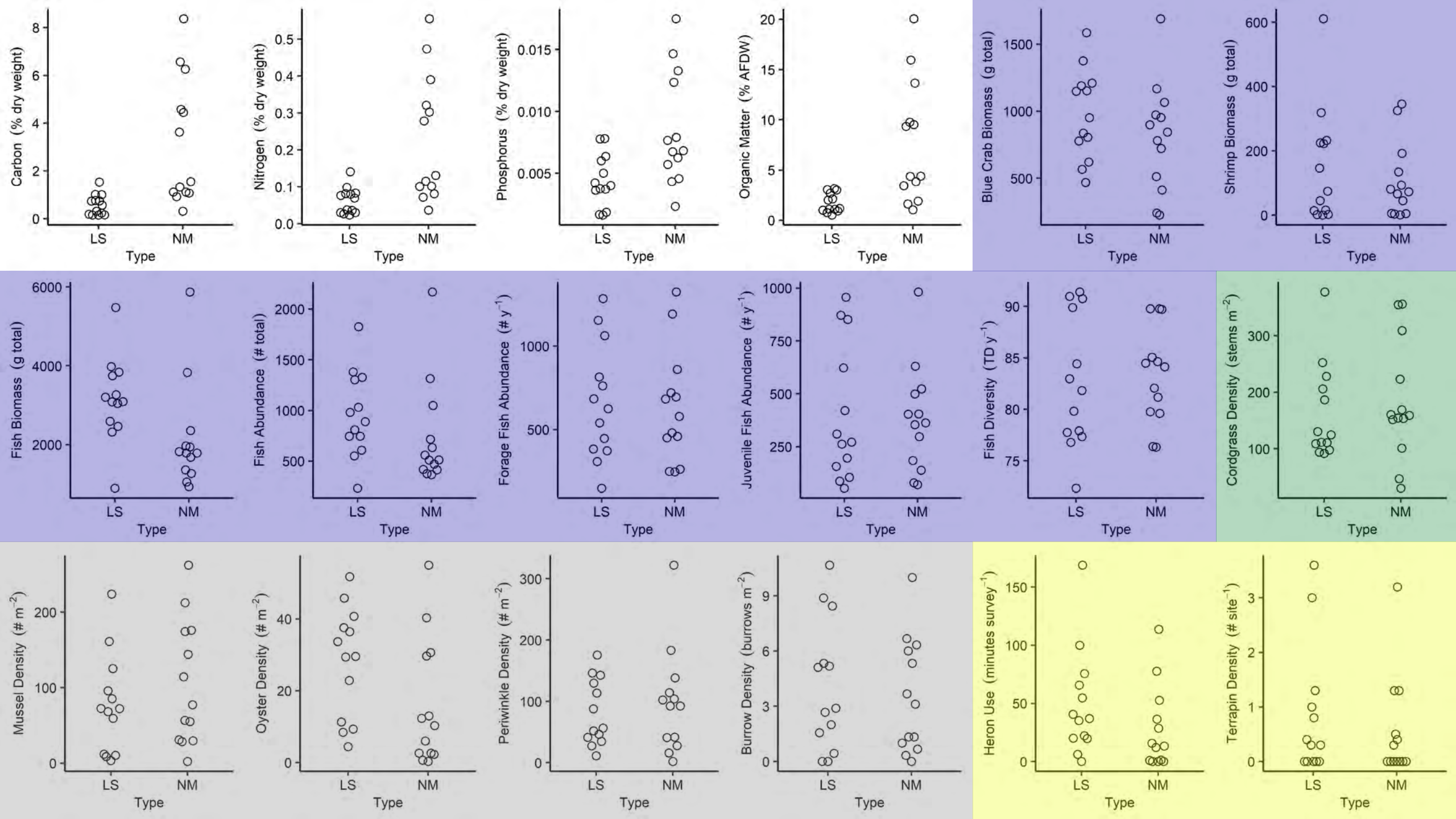
What did we measure?

- 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

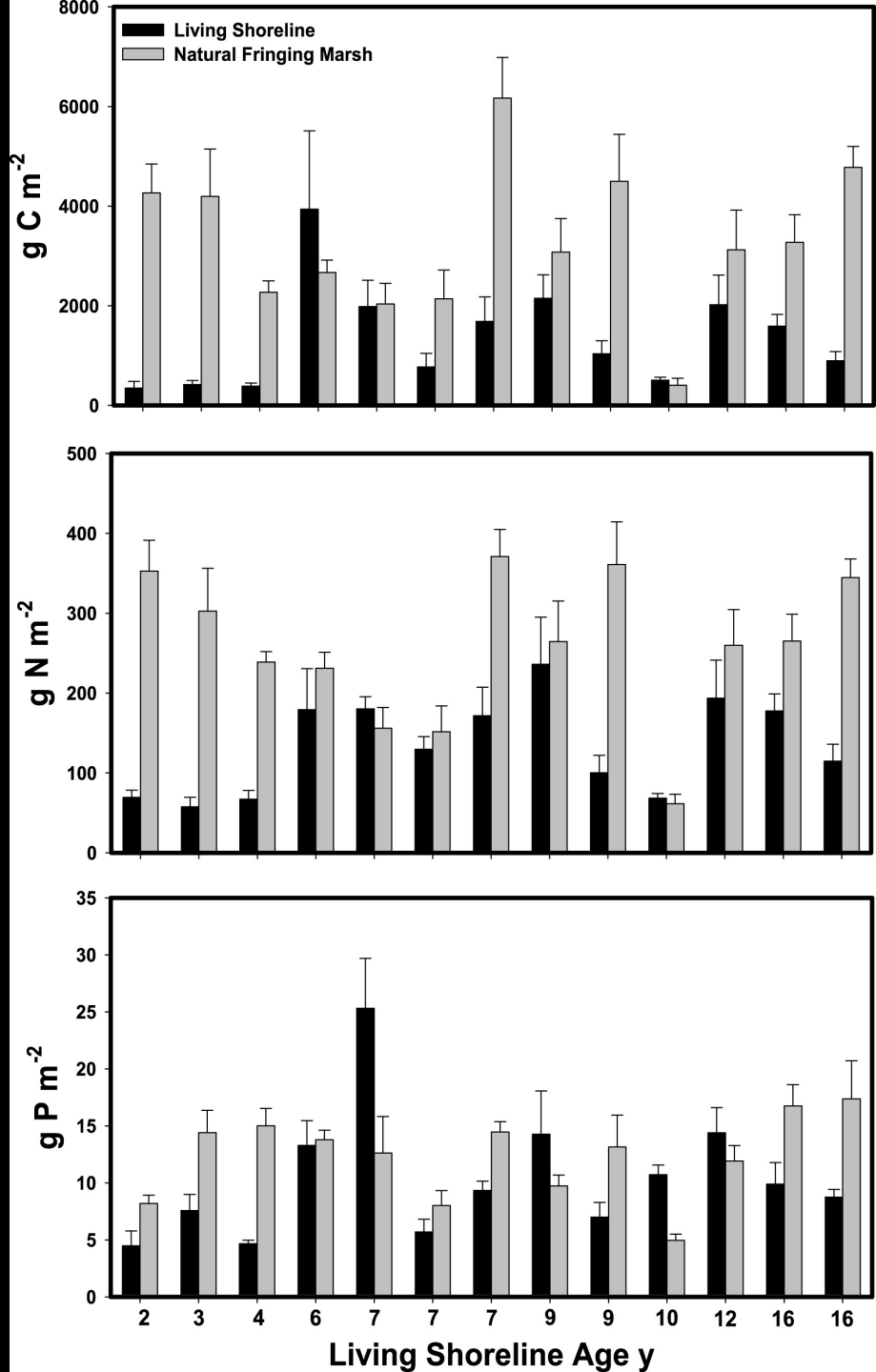
$$\sigma_{Local_i} = \sqrt{\frac{\sigma_{LS_i}^2 + \sigma_{NM_i}^2}{2}}$$

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

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	0.06
Forage Fish Abundance	0.09
Fish Diversity	-0.12

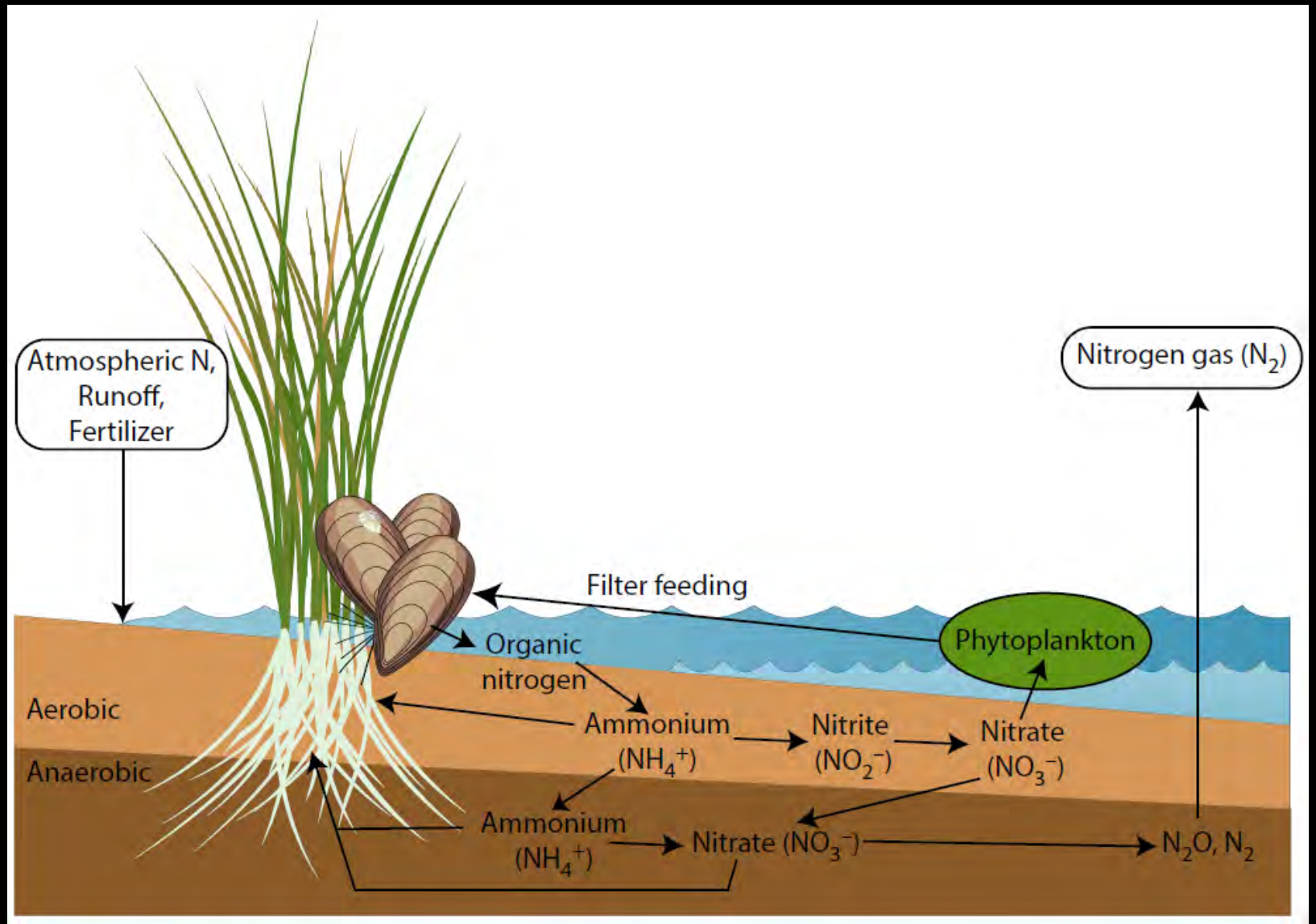
What did we find? – Herons and Terrapin

- 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

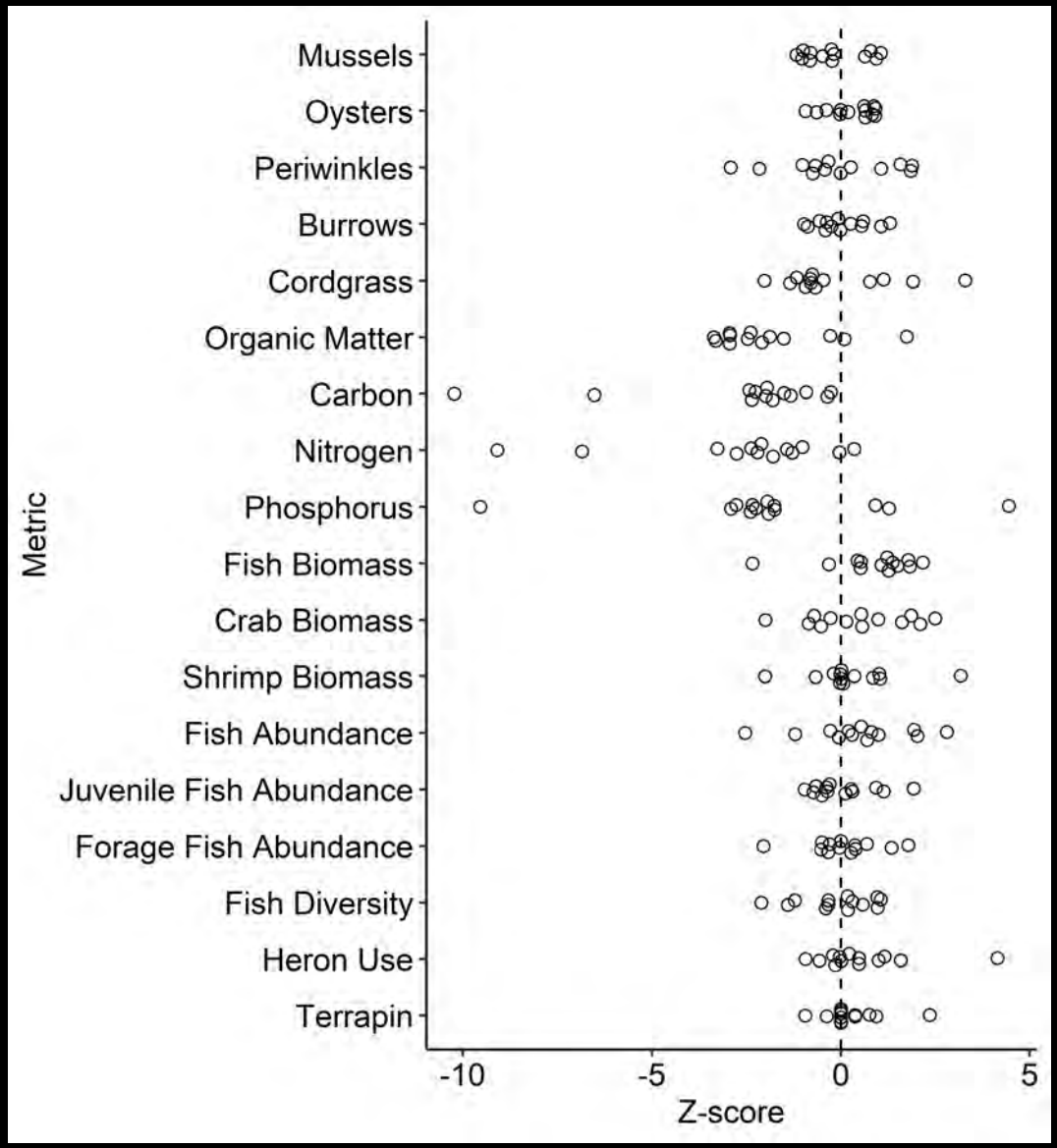


Bilkovic et al. 2017

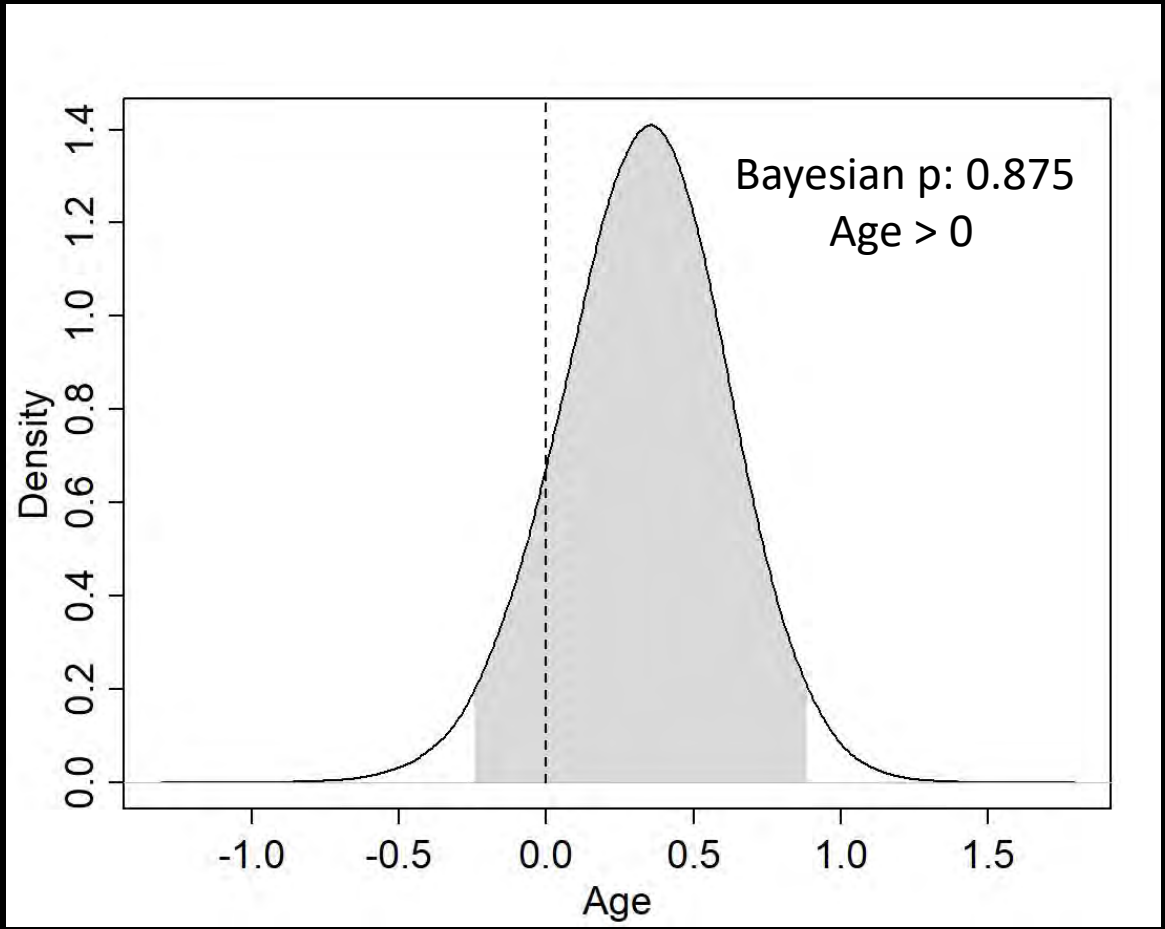
What did we find? - Overall

- 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