Using Community and Food-Web Approaches to Inform Marsh Restoration in Coastal Louisiana

M. Polito[1], A. Engel[2], L. Hooper-Bui[1], O. Jensen[3], K. Lamb[1], P. Lopez-Duarte[4], C. Martin[5], J. Olin[6], B. Roberts[7], N. Rabalais[1,7], E. Swenson[1]

[1]Louisiana State University, [2]University of Tennessee-Knoxville, [3]University of Wisconsin-Madison, [4]University of North Carolina-Charlotte, [5]University of Florida/IFAS Nature Coast Biological Station, [6]Michigan Technological University, [7]Louisiana Universities Marine Consortium

RESTORE SCIENCE PROGRAM

OneNOAA Webinar: Wed, Oct 28, 2020 11:00 PM - 12:00 PM CDT

http://restorefoodweb.lumcon.edu/

Project PI Team

Mike Polito

Annette Engel

Linda Hooper-Bui

Olaf Jensen

Paola Lopez-Duarte

Charlie Martin

Jill Olin

Brian Roberts

Nancy Rabalais

Erick Swenson

More information: http://restorefoodweb.lumcon.edu/about/team-members/

End-Users & Technical Monitors

End-User Advisory Panel

- **Stuart Brown,** LA Coastal Protection and Restoration Authority
- **Jim Pahl,** LA Coastal Protection and Restoration Authority
- **Sharon Osowski,** US EPA Region 6
- **Kevin Roy,** U.S. Fish and Wildlife Service
- **Robert Spears,** Plaquemines Parish Coastal Zone Management Office
- **Pat Williams,** NOAA Restoration Center

COASTAL WETLANDS PLANNING, PROTECTION AND RESTORATION ACT

RESTORING COASTAL LOUISIANA SINCE 1990

MANAGING AGENCIES:

Program Officer & Technical Monitors

- **Frank Parker III**, NOAA RESTORE Science Program
- **Melissa Carle,** NOAA Restoration Center
- **Shannon Martin,** NOAA Cooperative Institute for Marine and Atmospheric Studies

Project Introduction

Marsh Food Web Research Informs Coastal Land Restoration Efforts in Louisiana (Video)

Published on: 09/21/2020

Research Area(s): Coastal Change / Natural and Nature-based Features, Restoration, Sea Level Rise, Vulnerability and Risk Assessment

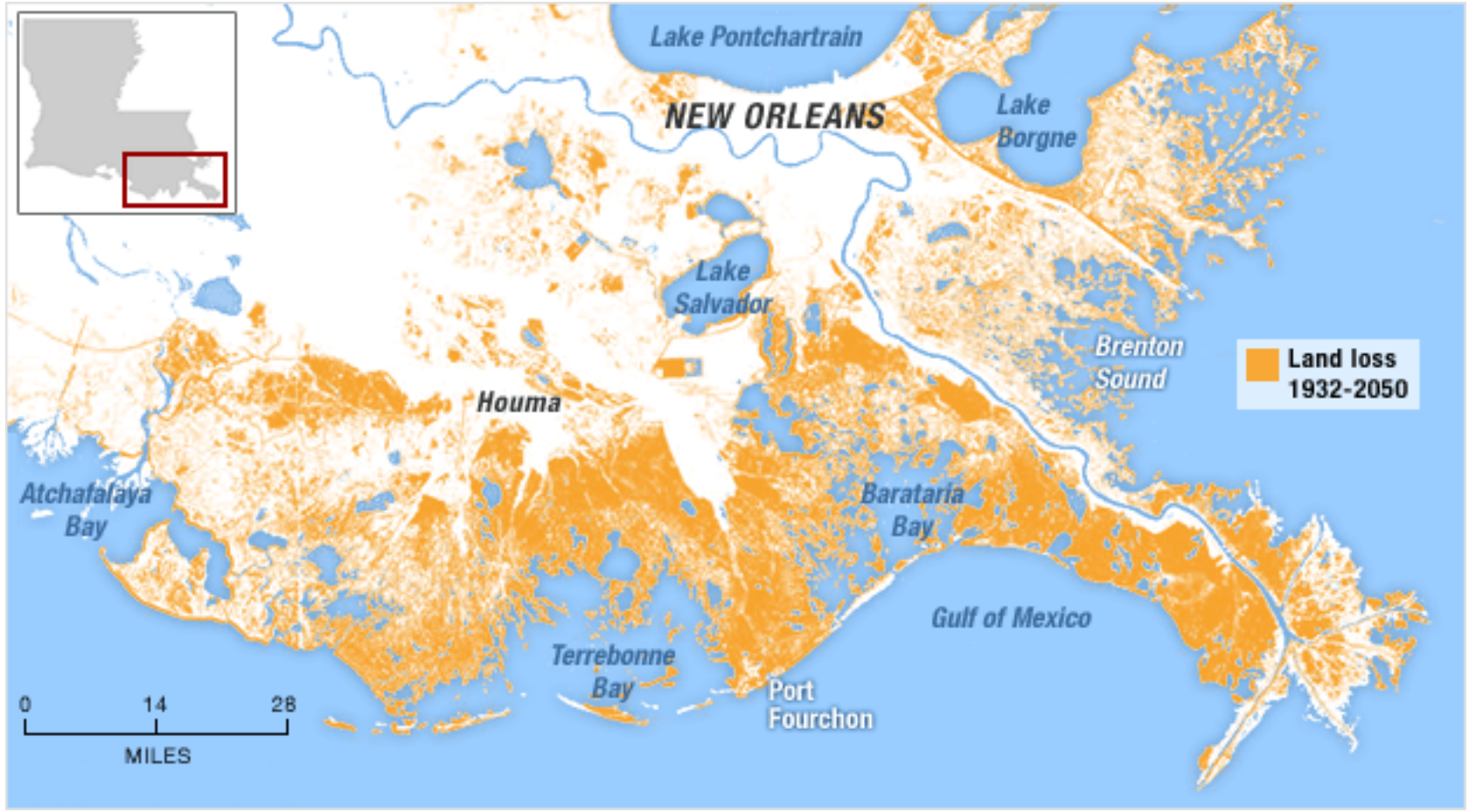
Region(s) of Study: U.S. States and Territories / Louisiana

Primary Contact(s): frank.parker@noaa.gov

More information: https://coastalscience.noaa.gov/news/marsh-food-web-research-informs-coastal-land-restoration-efforts-in-louisiana-video/

Background

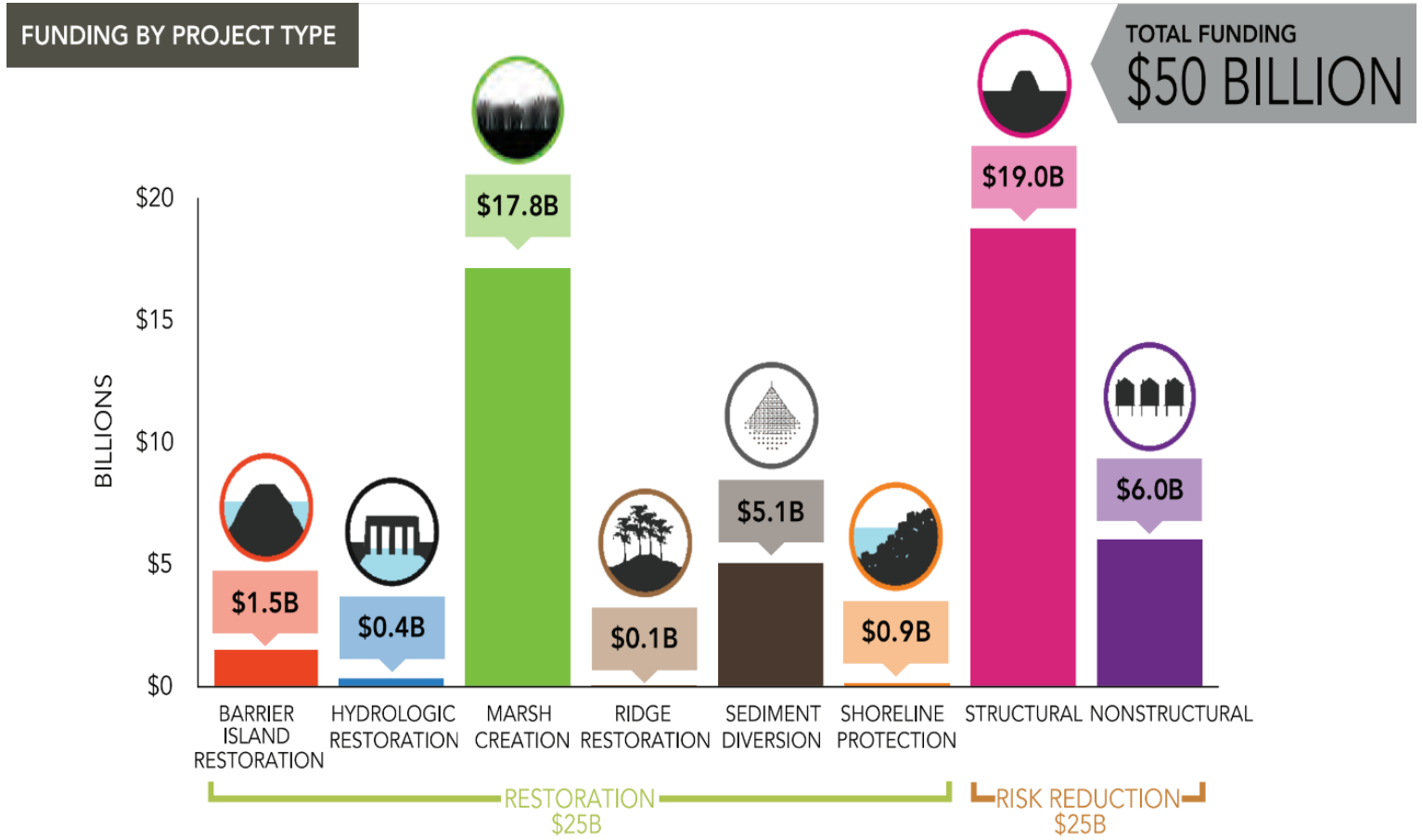
Louisiana is losing its boot



From the early 1930s to 2000, Louisiana lost an area close to the size of Delaware.

Marsh creation & river diversions are used to combat land loss

2017 Louisiana Coastal Master Plan Project Budget



Are created marshes ecologically equivalent existing marshes?

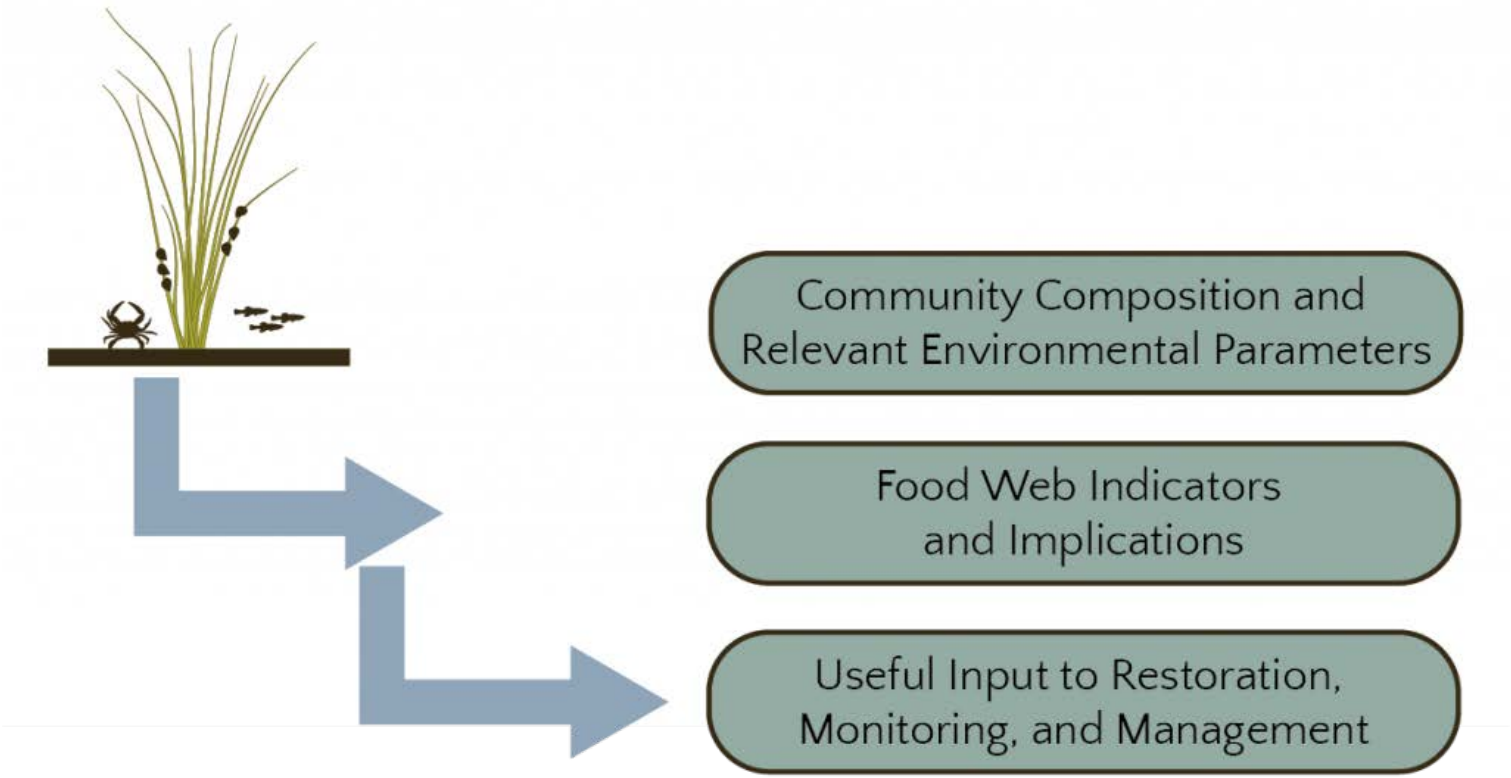
Most monitoring efforts evaluate:

- Dominant vegetation
- Elevation / Hydroperiod
- Soil and water chemistry

Limitation:

Does not directly examine functional qualities like community dynamics & the flow of energy and nutrients through the food web.

Our goal is guide restoration effort by integrating community and food-webs approaches into restoration monitoring and planning



Objectives

1. Examine community composition & food web structure at created vs. natural marshes.

2. Examine community composition & food web structure in natural marshes along a salinity gradient.

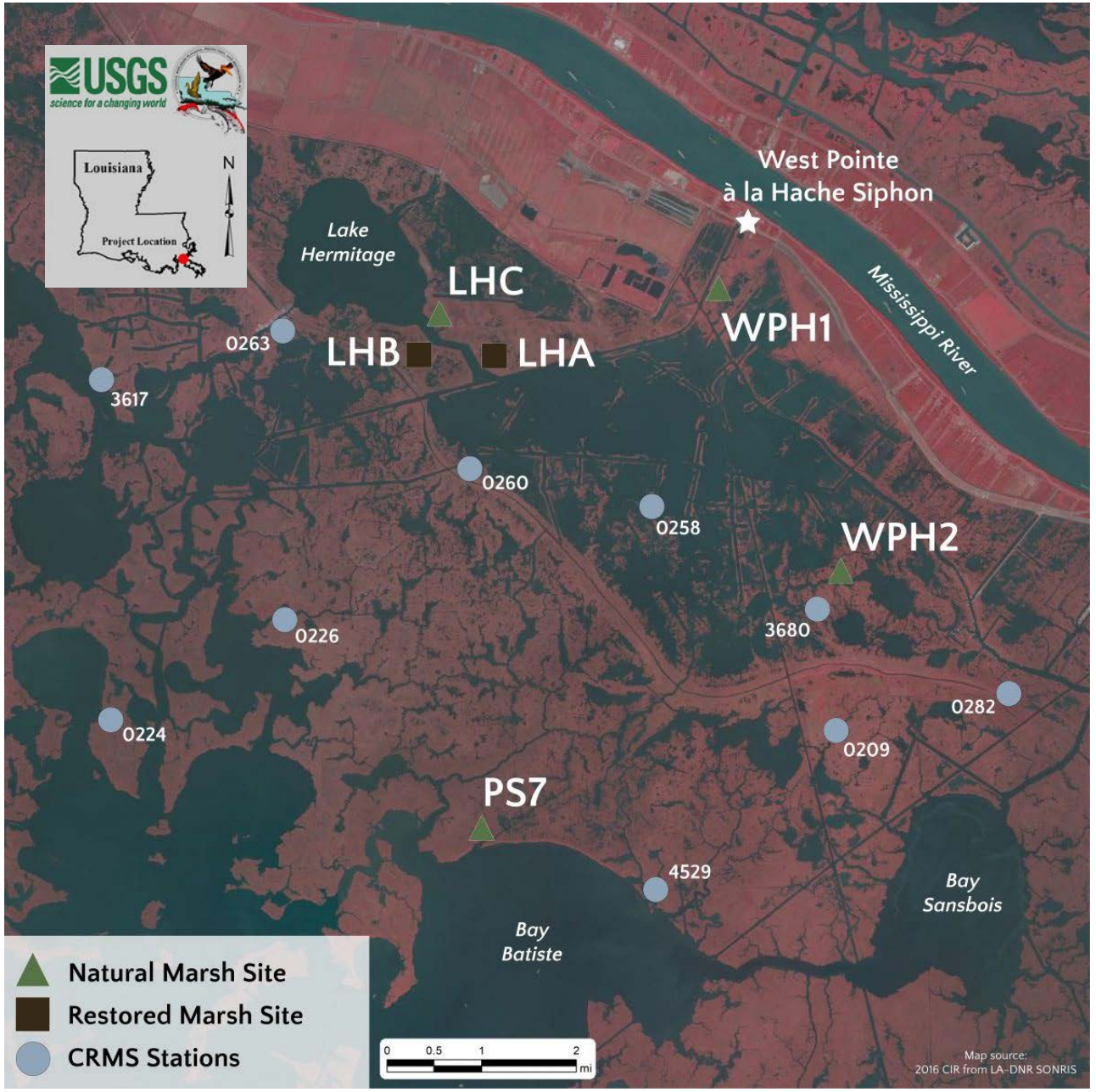
3. Develop an ecosystem model to predict the outcome of habitat restoration efforts on food web structure, function and resilience.

Study Methods

Study Area & Timing

- Lake Hermitage Marsh Creation Project within Barataria Bay, in Plaquemines Parish, Louisiana.

- Spring 2018 (Siphon off) ✓
- Spring 2019 (Siphon off) ✓
- Spring 2019 (COVID) ✗
- Spring 2021 (Siphon on)



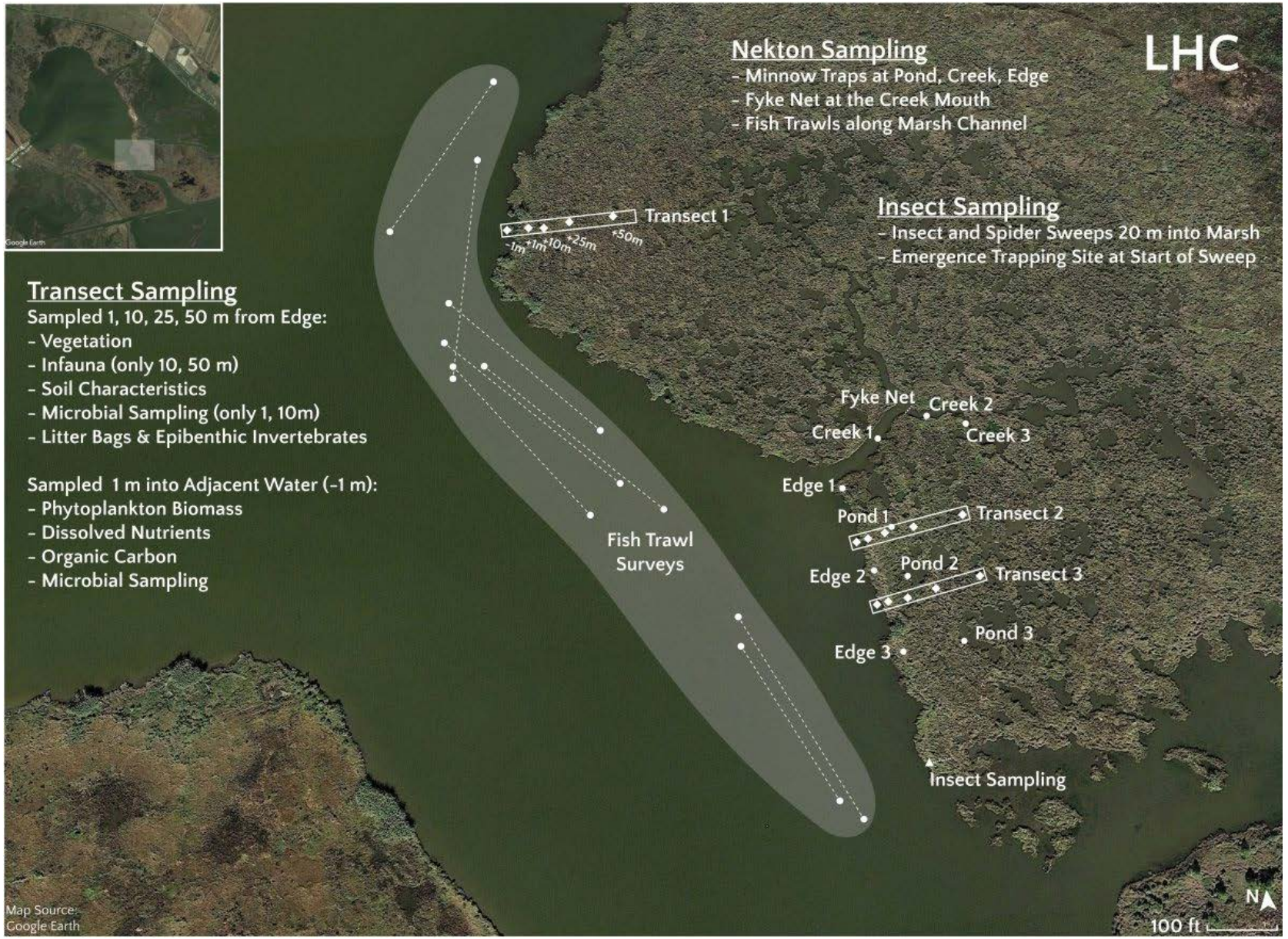
Study Design

2 created & 2 reference marshes

3 reference marshes

Data Collection

- Hydrology & Elevation
- Soils Characteristics
- Vegetation
- Microbes
- Infauna
- Insects
- Nekton
- Food Web (isotopes)



Created vs. Reference Marshes

Are created marshes ecologically equivalent to reference marshes?

Compare 4 sites in 2018-19

- LHA: ~4.5 years old
- LHB: ~4.0 years old
- LHC: Reference
- WPH2 Reference

Community & Food Web Comparisons

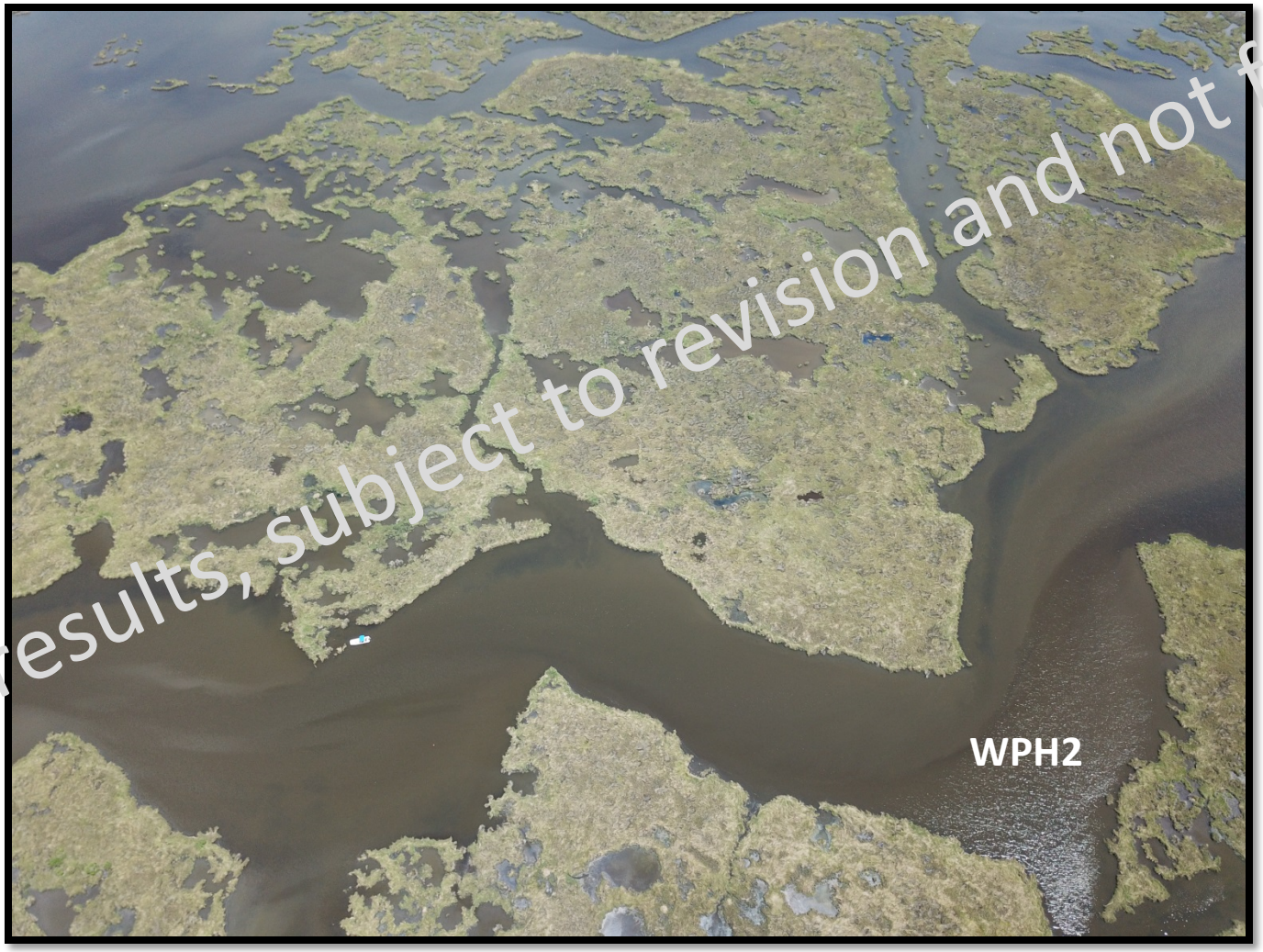
- Shannon-Wiener index
  - increases as both the richness and evenness of the community increase

$$H' = -\sum p_i \ln p_i$$

- Sørensen–Dice index
  - An estimate of community similarity based on species presence / absence

$$S_{SD} = \quad 2a/2a+b+c$$

Results



Created vs. Reference Marshes

- Hydrology & Elevation
- Soils Characteristics & Decomposition
- Vegetation
- Bacteria, Archaea, Fungi
- Infauna
- Insects
- Nekton
- Food Web Structure

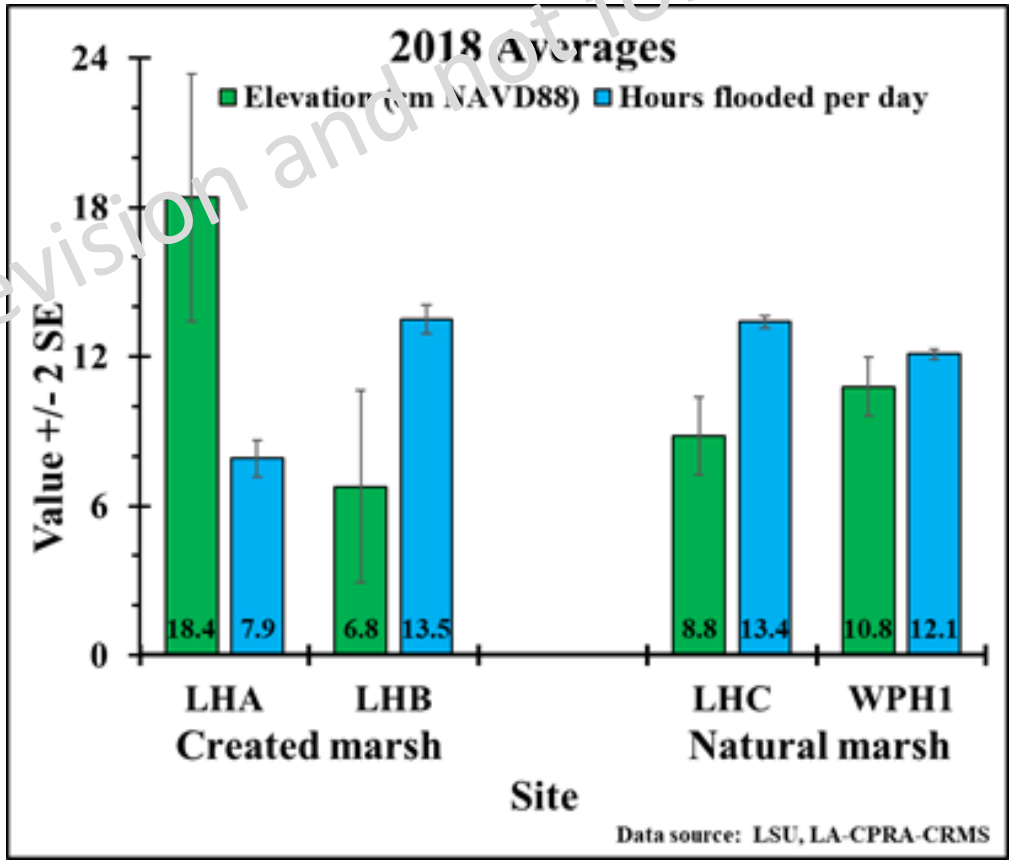
Hydrology & Elevation

Elevation

- LHA (created) = highest elevation; other sites are all similar.
- Reference marshes have a more uniform surface (lower SE).

Flooding

- LHA (created) = least flooded; other sites are similar.
- Reference marshes have more uniform flooding (lower SE).



Soils & Decomposition



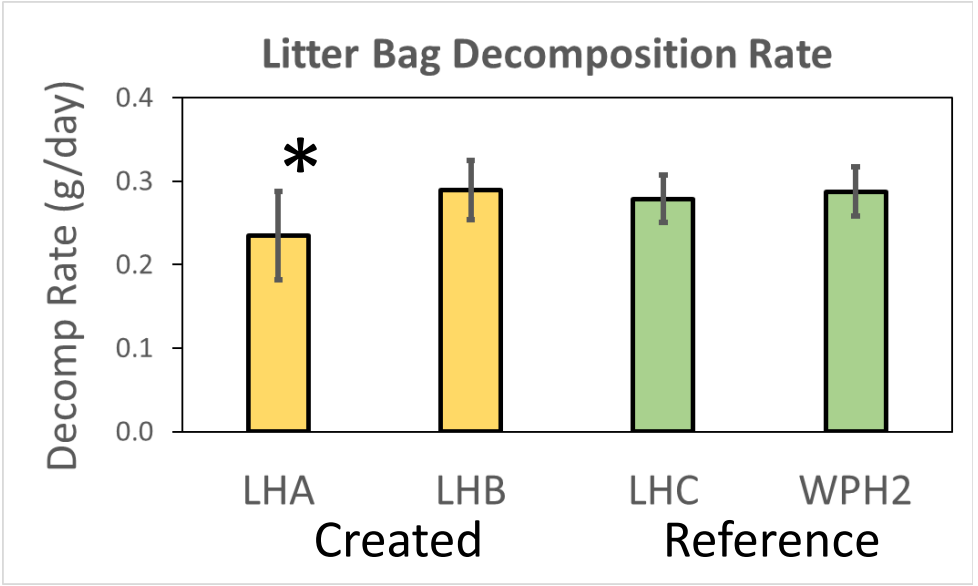
Soil Organic Matter (SOM) Content

- Created sites (LHA &LHB) have lower soil organic matter content than reference marshes.

Treatment, Site		% SOM (0.5 cm depth)
Created	LHA	7.5 ± 4.5
	LHB	8.3 ± 4.0
Reference	LHC	31.1 ± 4.4
	WPH2	33.1 ± 5.1

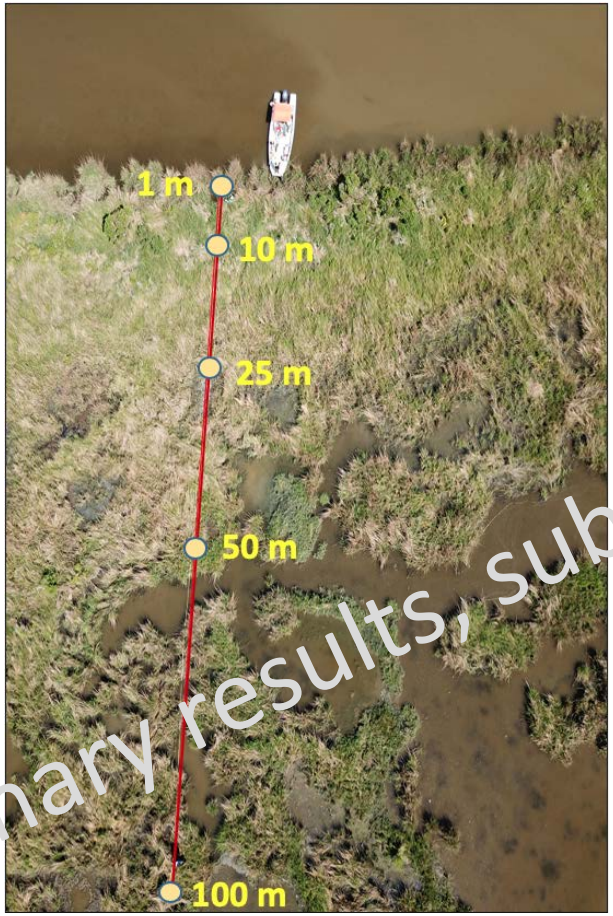
Litter Decomposition Rate

- LHA (created) has slower decomposition relative to LHB (created) & reference sites (LHC & WPH2)



More info: http://restorefoodweb.lumcon.edu/wp-content/uploads/2020/05/Winston-et-al.-2019-GoMOSES.pdf

Vegetation



Aboveground Biomass

- LHA (created) = lowest biomass
- LHB (created) = reference sites

Community Diversity (H')

- Higher diversity & species richness in created marshes.
- LHA (created) = Highest diversity; species not typical of wetlands

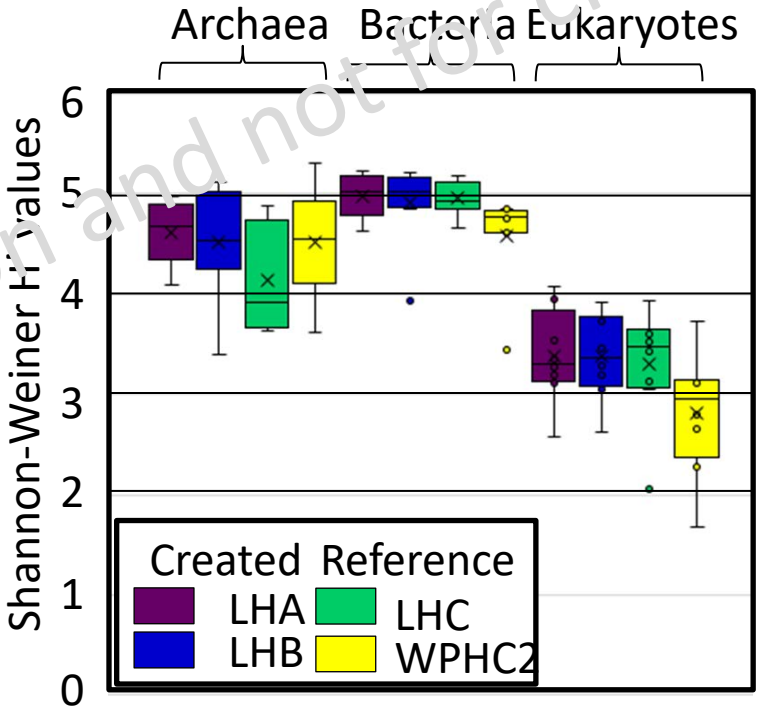
Community Similarity (SD)

- LHB (created) is more similar to the reference marshes (88-90%) than it is to other created marsh LHA (~66%).

Microbes (DNA & lipid-based approaches)

Community Diversity (H') & Similarity (SD)

- Similar diversity between created & reference sites (some exceptions).
- High community similarity across sites (~70-94%).
- Bacteria & archaea at created sites are slightly more like each other than reference sites



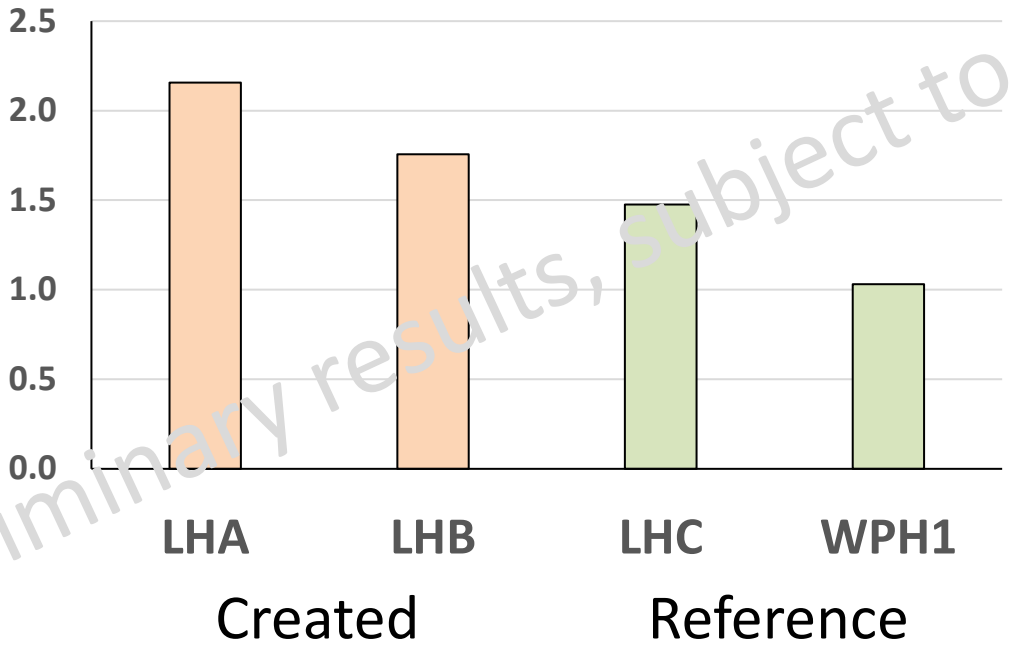
- Operational taxonomic units (genetic units) used for comparisons

More info: http://restorefoodweb.lumcon.edu/research/reports-presentations/#iLightbox[gallery_image_1]/0

Benthic Infauna

Community Diversity (H')

- Higher diversity (H') in created marshes



Community Similarity (SD)

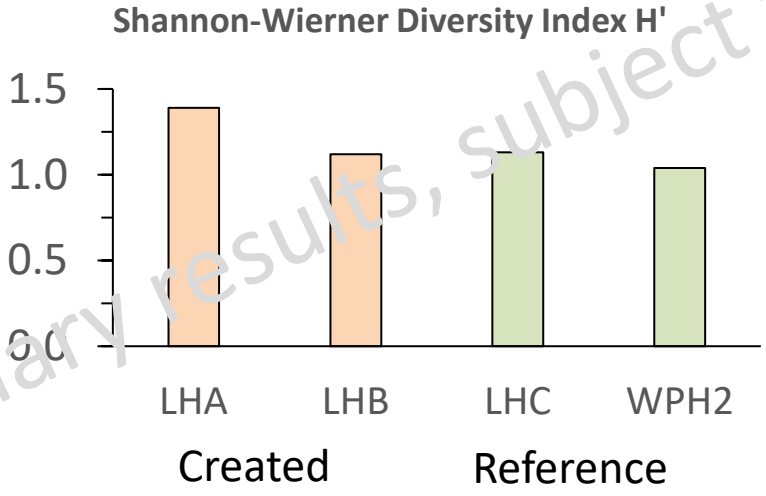
- ~50-60% community similarity between all sites, apart from LHB and LHC (~84.8%)

(Data for Two Created and Two Reference Sites – 2018 only, 10 m and 50 m combined)

Terrestrial Insects & Spiders

Species Diversity (H')

- Highest diversity (H') at LHA (created).
- Higher richness (78 morpho-species) in LHA and LHB (66) at LHB relative to reference sites (LHC: 50; WPH2: 48)



Community Similarity (SD)

- ~52-64% community similarity between all sites

More info: http://restorefoodweb.lumcon.edu/wp-content/uploads/2020/05/Bui-NOAA-Insects-and-Spiders-2019-CERF.pdf

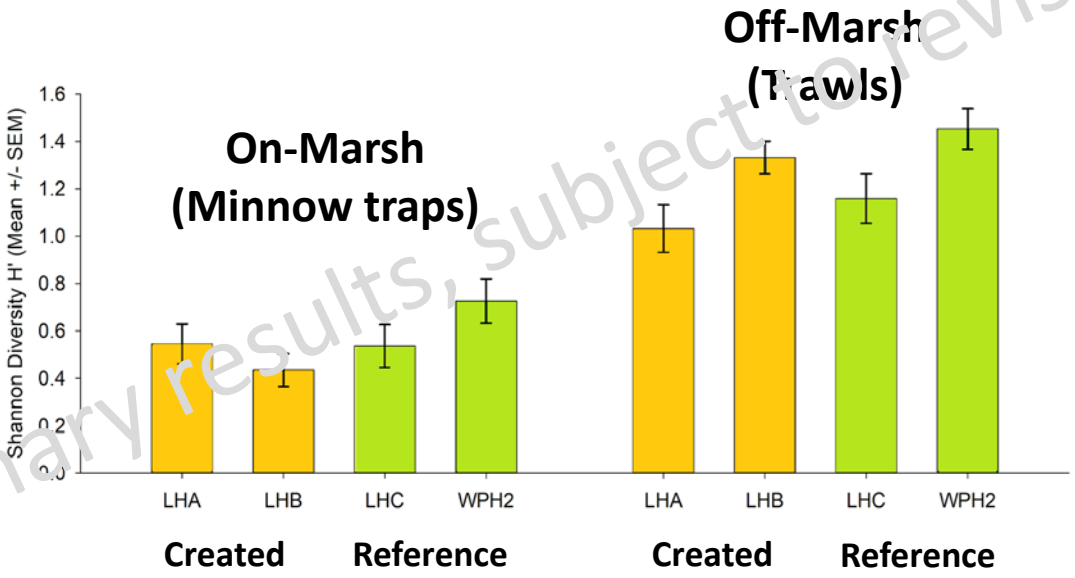
Fish & Nekton

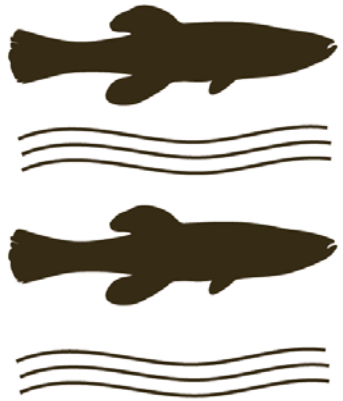
Community Diversity (H')

- Similar diversity across created & reference sites for both "on-marsh" & "off marsh" nekton communities

Community Similarity (SD)

- High similarity across both created and references sites (~71-96%).





More info: On Marsh

- http://restorefoodweb.lumcon.edu/wp-content/uploads/2020/05/Lopez-Duarte-et-al.-GOMOSES2019.pdf

More info: Off Marsh

- http://restorefoodweb.lumcon.edu/wp-content/uploads/2020/05/Martin-et-al.-GOMOSES-2019-poster.pdf

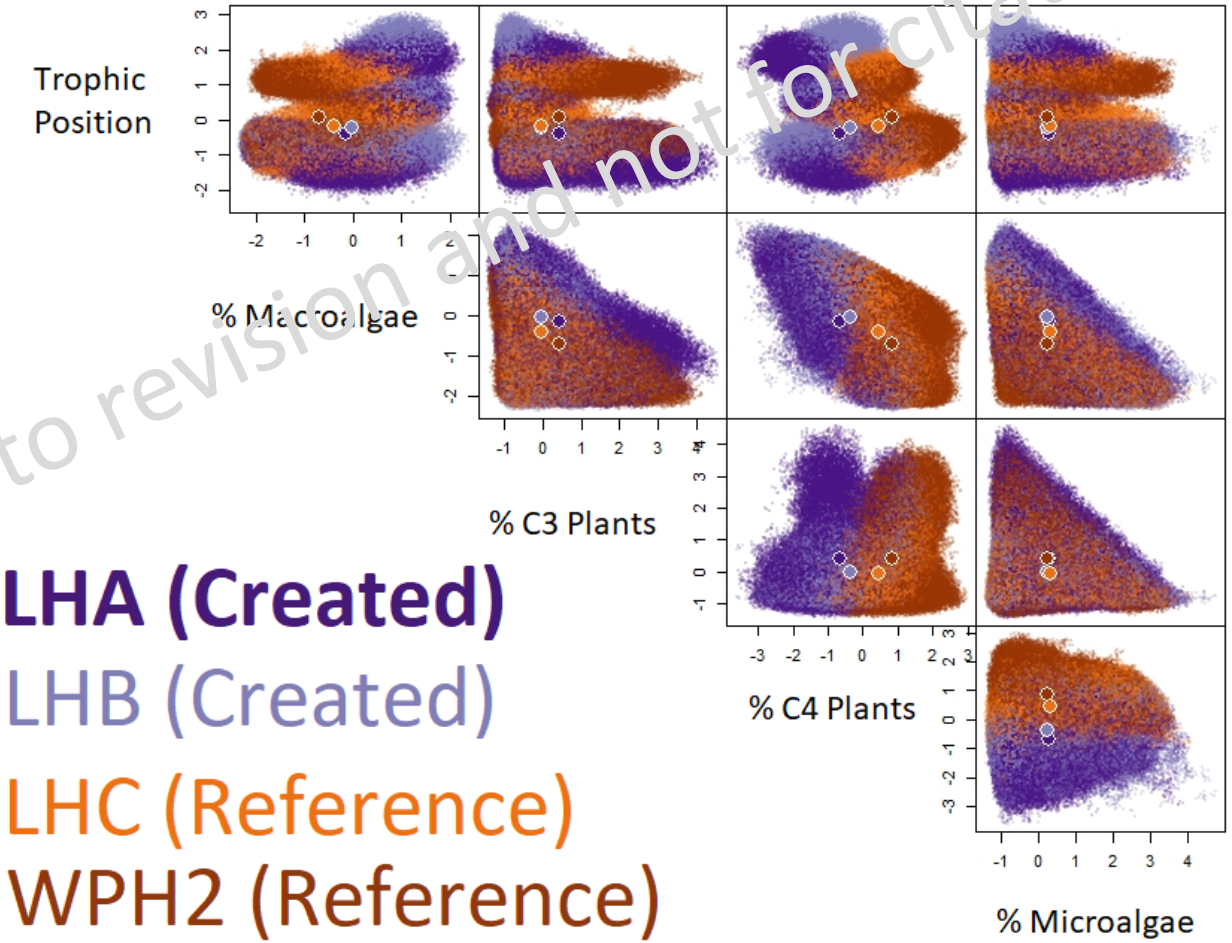
Food Web Structure (Stable Isotopes)

Trophic Diversity (Hypervolume Size*)

- Reference sites = smallest; LHA = largest; LHB = intermediate

Trophic Similarity (SD)

- LHA = 18-33% similar to reference sites
- LHB = 33-49% similar to reference sites
- Created marshes have wider trophic niches & lower C4 plant contribution



Larger hypervolume = broader resource use and/or longer food chain length.

More info: http://restorefoodweb.lumcon.edu/wp-content/uploads/2020/05/Lamb-et-al.-2019-CERF.pdf

Summary

2 created & 2 reference marshes

Characteristic at LHA(created) differ from reference sites while those at LHB(created) are more similar

Commonly Measured Marsh Characteristics

Parameter	LHA	LHB
Elevation	Higher	Similar
Flooding Duration	Lower	Similar
Soil Organic Matter	Lower	Lower
Decomposition Rate	Lower	Similar

Higher diversity & lower similarity at LHA(created) while the other LHB(created) is more similar to reference marshes

Community Diversity (H')

Parameter	LHA	LHB
Vegetation	++	+
Microbes	=	=
Infauna	++	+
Insects & Spiders	+	=
Nekton	=	=
Food Web Stucture	++	+

Community Similarity (SD)

Parameter	LHA	LHB
Vegetation	68%	89%
Microbes	80%	78%
Infauna	57%	70%
Insects & Spiders	64%	56%
Nekton	81%	84%
Food Web Stucture	26%	41%

Conclusions

What is driving ecological differences, or lack thereof, among created & reference marshes?

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High similarity likely due to high dispersal / connectivity

- *Nekton*

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Low similarity likely due to high spatial heterogeneity

- *Infauna / Insects*

What is driving ecological differences, or lack thereof, among created & reference marshes?

High similarity likely due to high dispersal / connectivity

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Low similarity likely due to high spatial heterogeneity

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Differences among sites related to elevation, hydrology, and soil characteristics

- *Vegetation / Microbes / Food Web Structure*

Soil stock, flooding, & vegetation drive consumer access to terrestrial carbon in created marshes

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1. Soil organic matter is lower at all created sites

2. Higher elevation leads to less flooding at some created sites (e.g. LHA)

3. Lower vegetation biomass & lower decomposition rates at higher elevation created sites

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- Lower terrestrial carbon use at created sites (higher aquatic carbon source use)

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2. Higher elevation leads to less flooding at some created sites (e.g. LHA)
3. Lower vegetation biomass & lower decomposition rates at higher elevation created sites

- Lower terrestrial carbon use at created sites (higher aquatic carbon source use)
- Created sites that are less flooded than reference sites have lower food web similarity (LHA = 18-33%), relative to those with more similar hydrology (LHB = 33-49%)

Take Away Points

1. Community “recovery” will differ among taxa relative to dispersal potential, spatial heterogeneity, and the importance of hydrological conditions.

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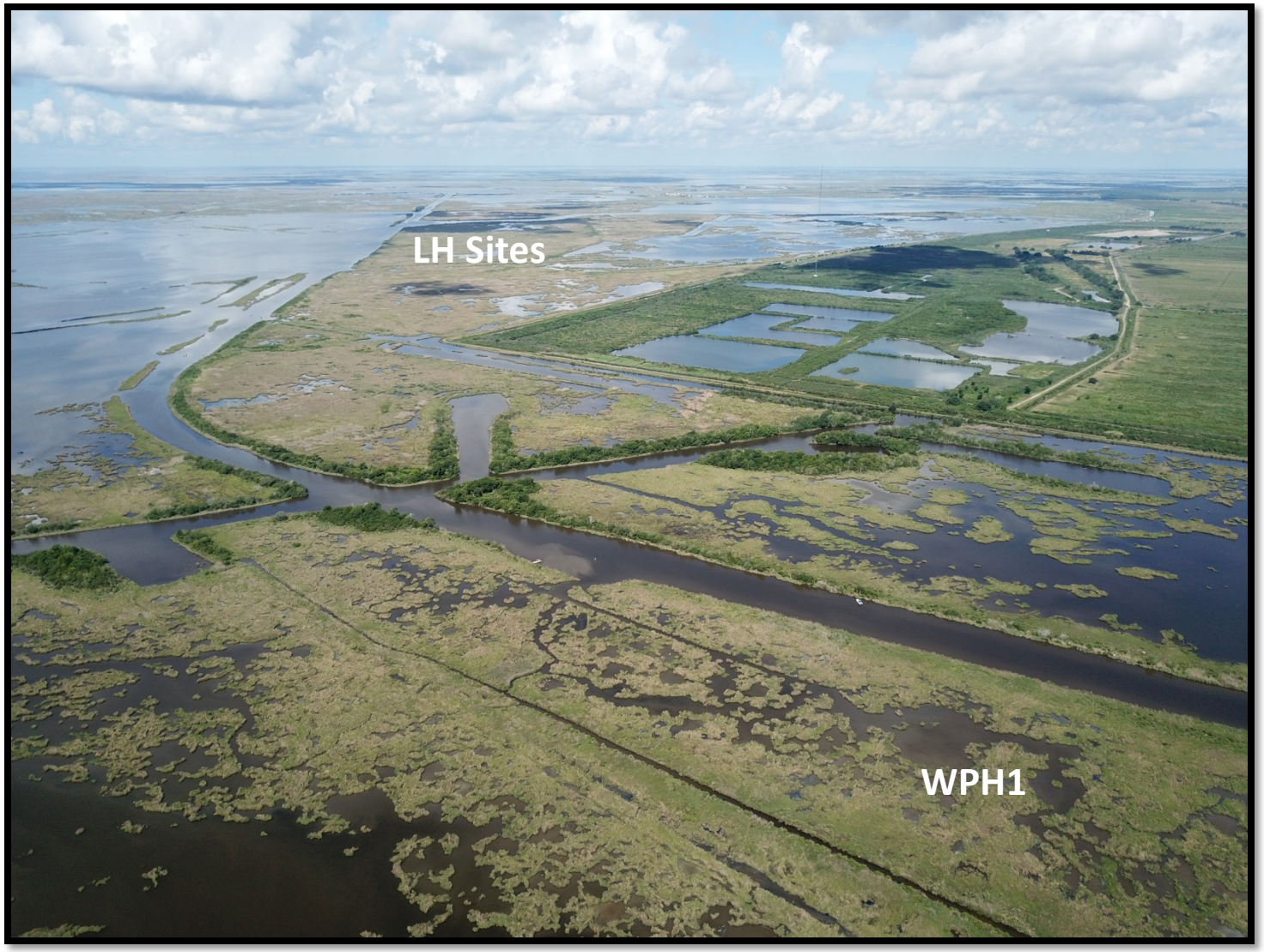
1. Community “recovery” will differ among taxa relative to dispersal potential, spatial heterogeneity, and the importance of hydrological conditions.

2. Post-construction hydroperiod, soil, and vegetation monitoring can provide proxies of community and food web dynamics.

Next Steps



Siphon Opening in 2021

1. Examine community composition & food web structure at created vs. natural marshes.

2. Examine community composition & food web structure in natural marshes along a salinity gradient.

3. Develop an ecosystem model to predict the outcome of habitat restoration efforts on food web structure, function and resilience.

EcoPath / EcoSim Modeling

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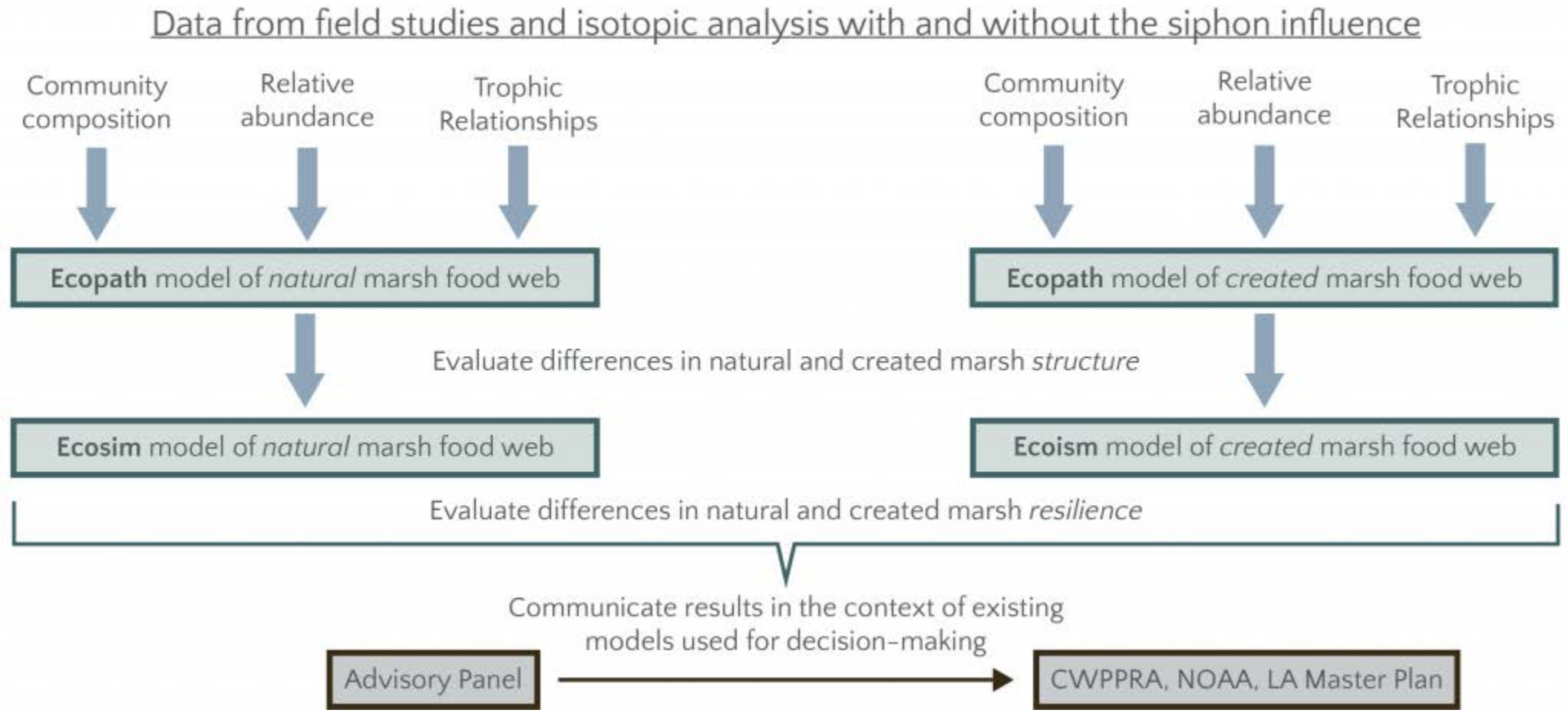
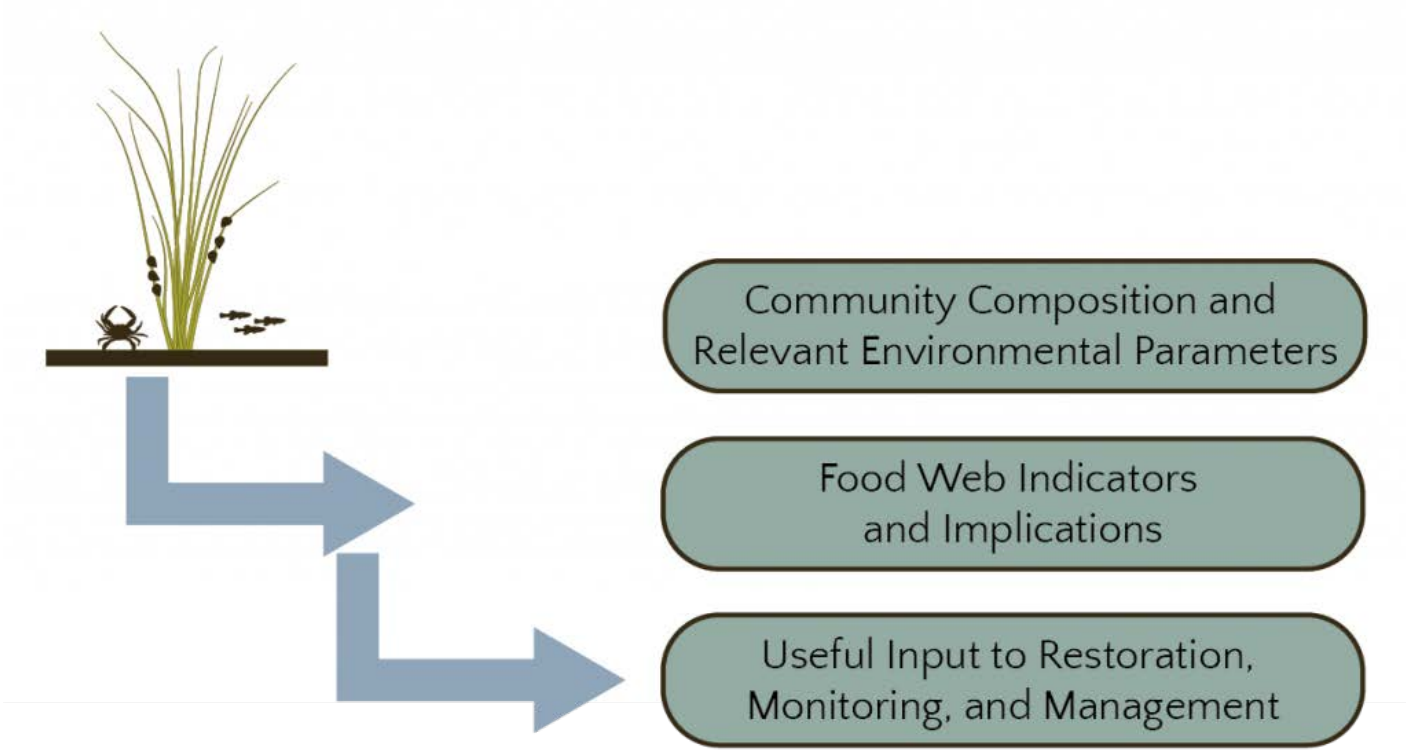
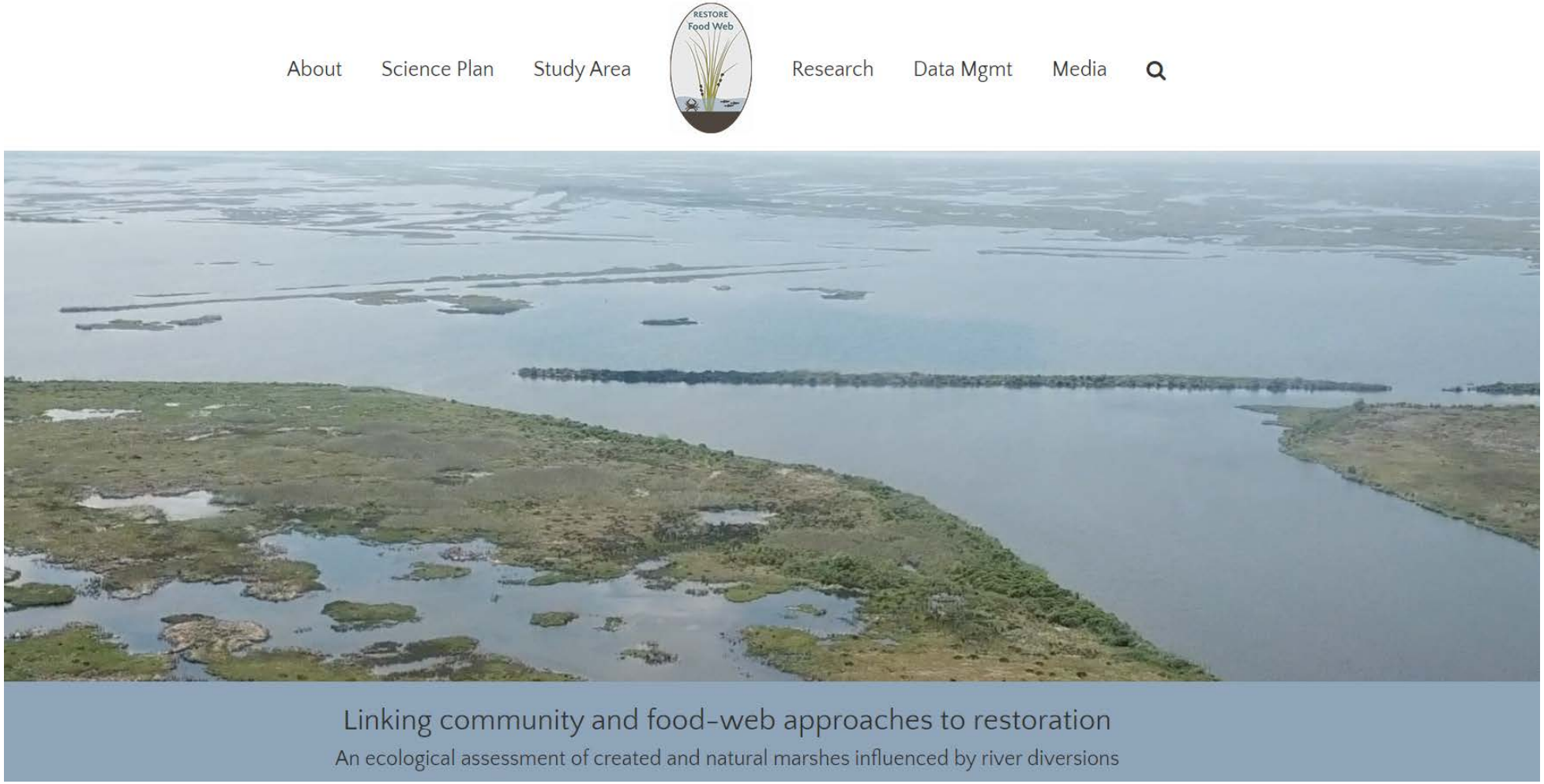
EcoPath / EcoSim Modeling



Inform restoration effort by integrating community and food-webs approaches into restoration monitoring and planning



To learn more visit: http://restorefoodweb.lumcon.edu/



Thank you!

Project Team:

End-Users:

Funding: