Morphometrics, Population Structure, and Spatial Distribution of Diamondback Terrapin in Texas Estuaries

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GBEP State of the Bay Symposium, Galveston, Texas; February 24-25, 2026

Acknowledgements

Field Personnel: countless graduate students, staff members, volunteers, project partners, and stakeholders

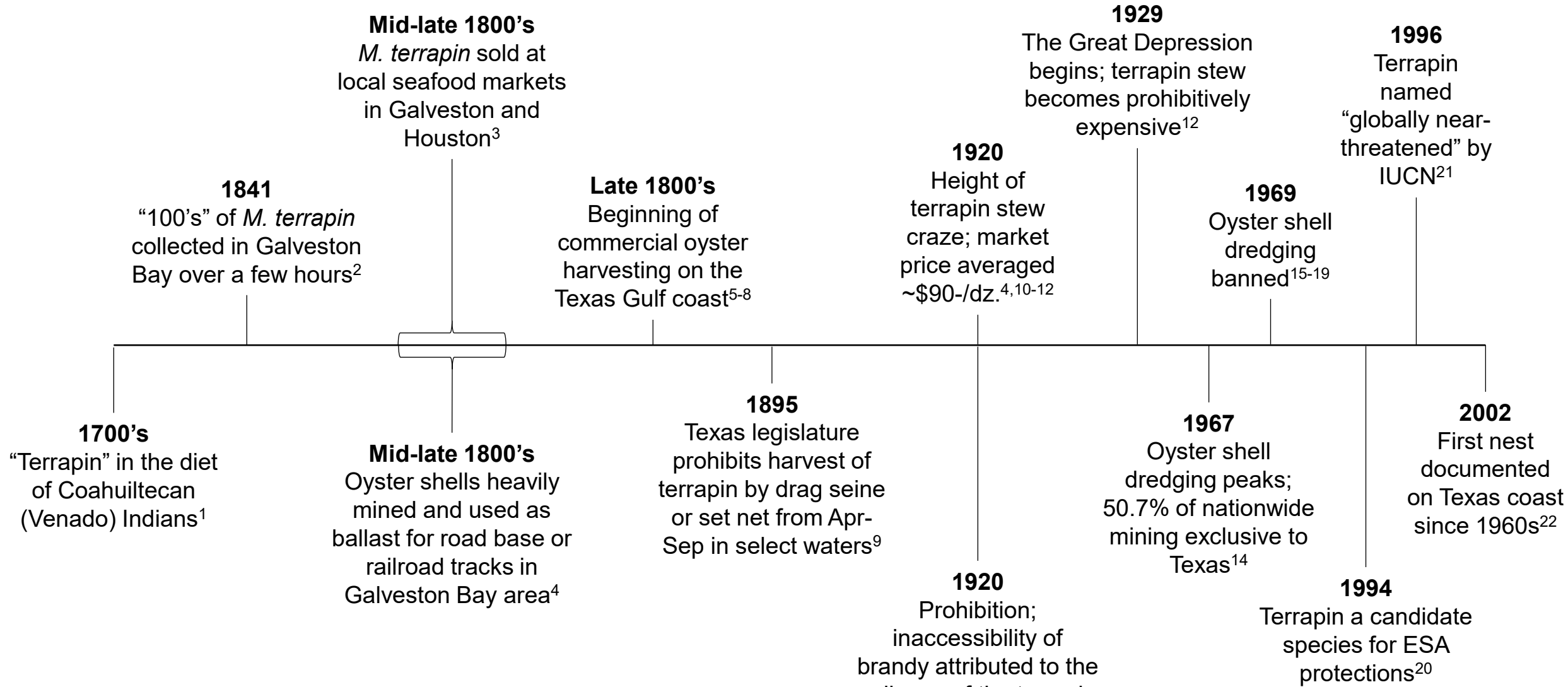
Funding Sources: Houston Zoo, U.S. Fish and Wildlife Service, Texas Parks and Wildlife, Texas SeaGrant, Texas Herpetological Society

Permitting & Site Access:

- TPWD permits SPR-0504-383 and SPR-0321-026
- Multiple IACUC protocols
- NWR Special Use permits
- The Nature Conservancy, Galveston Bay Foundation and other private landowners

What is a Terrapin?

A Timeline of Terrapin History (Galveston Bay)



[1]Kohout 2010
[2]Hooten 1847
[3]Shaffer et al. 2008
[4]Doran 1965
[5]Tucker 1929
[6]Galstoff 1931
[7]Hoffstetter 1977
[8]Henson 1993
[9]Texas Legislature 1895
[10]Coker 1920
[11]Martin1989
[12]Morise 2010
[13]TPWD 2007b
[14]Arndt 1976
[15]Hoffstetter 1960
[16]Benefield 1976
[17]Garcia 1979
[18]Crowe 1984
[19]Gallaway 2011
[20]Beattie 1994
[21]Outerbridge 2014
[22]Hogan 2003

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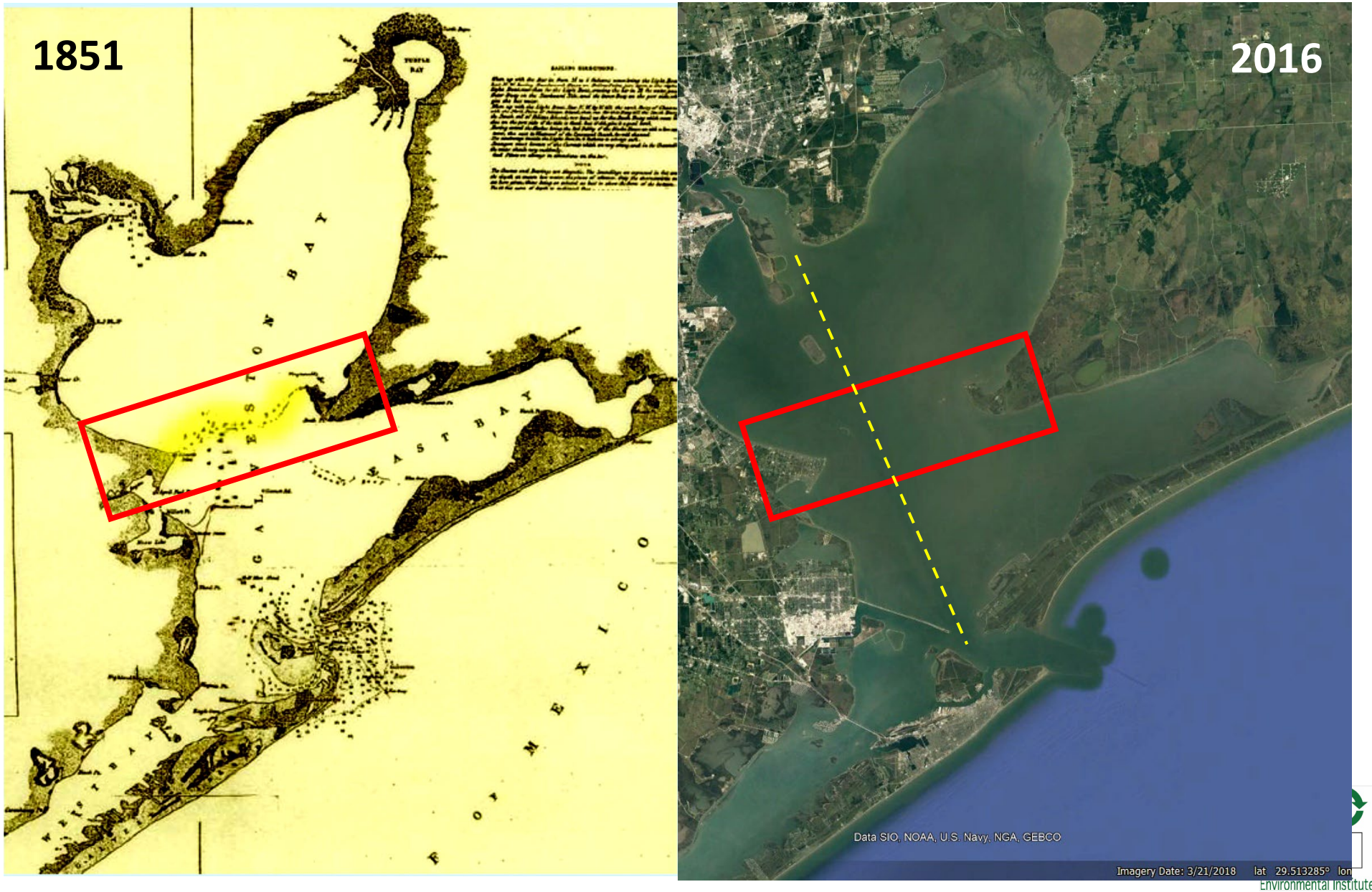
Effects of Oyster Harvesting in Galveston Bay



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UHCL-EIH Terrapin Monitoring Program

Environmental Institute of Houston

- Within our 17th year (2008-present)
- Covers 9 counties and 5 major bays
- Nearly 1,100 turtles state-wide
- 7 grant funded studies (2008-2015; 2016-2017; 2023-2027)
  - Population Study on Deer Island (HZA 2008)
  - Mid-Coast Complex Surveys (USFWS 2009)
  - Population Status & Demographics (Sea Grant 2010-2012)
  - By-Catch Study (TPWD & USFWS 2012-2014)
  - Mid- & Upper Texas Coast Surveys (TPWD SWG 2014)
  - Continued Monitoring (THS 2016-2017)
  - Microplastic Contaminants (MBMT 2023-2027)

MATAGORDA BAY MITIGATION TRUST

TEXAS HERPETOLOGICAL SOCIETY

Sea Grant Texas

TEXAS PARKS & WILDLIFE

U.S. FISH & WILDLIFE SERVICE

HOUSTON ZOO

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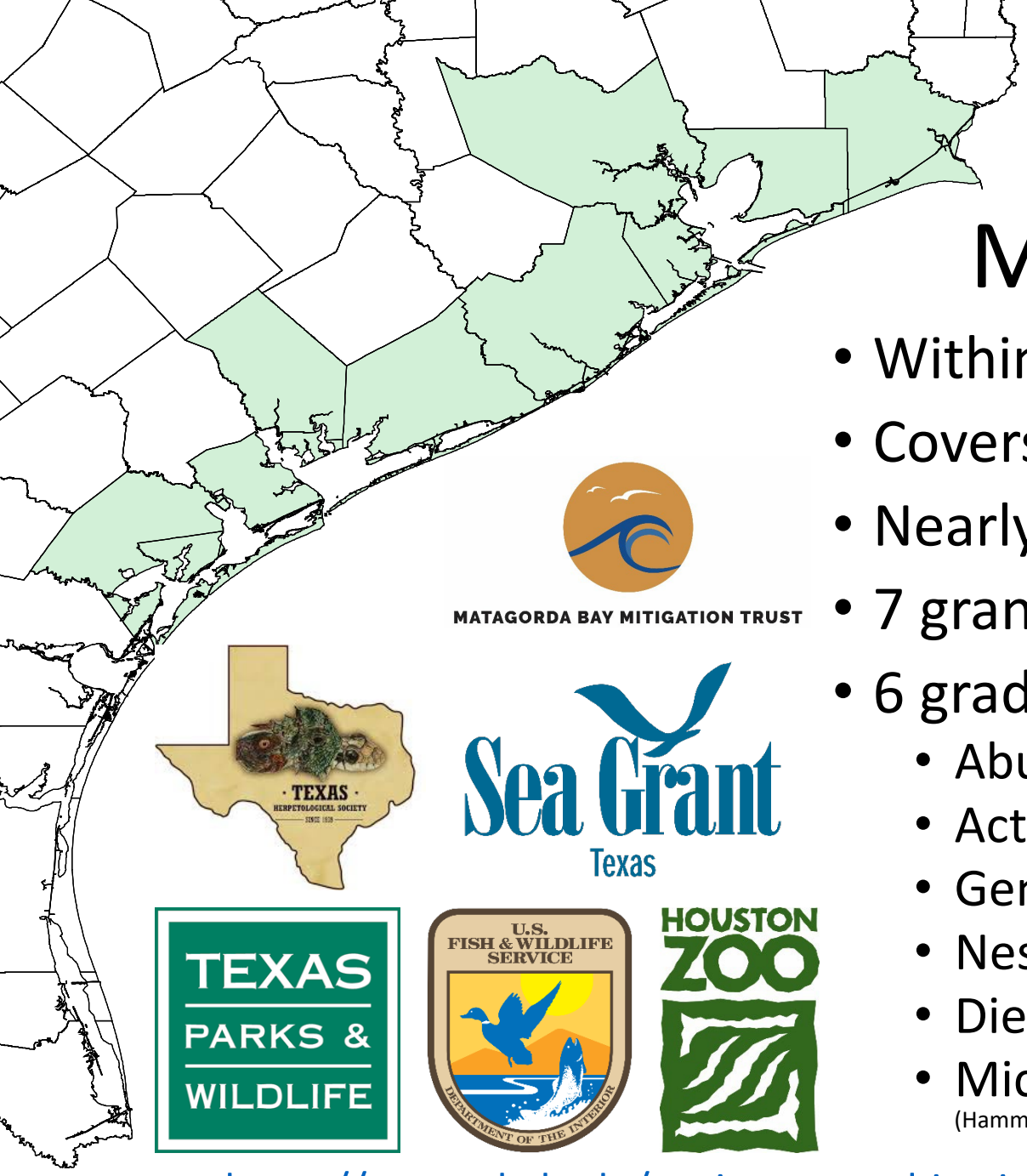
https://www.uhcl.edu/environmental-institute/research/current-projects/terrapin-life-history



UHCL-EIH Terrapin Monitoring Program

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- Within our 17th year (2008-present)
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- Nearly 1,100 turtles state-wide
- 7 grant funded studies (2008-2015; 2016-2017; 2023-2027)
- 6 graduate theses (2011-2015; Ongoing)
  - Abundance & Movement (Haskett [Ondracek] 2011)
  - Activity & Habitat Selection (Clarkson 2012)
  - Genetic Variation (Glenos [Gynego] 2013)
  - Nesting Ecology (George 2014)
  - Diet, Habitat, & Prey Availability (Alleman 2015)
  - Microplastic Accumulation in Habitats (Hammerbach 2025)

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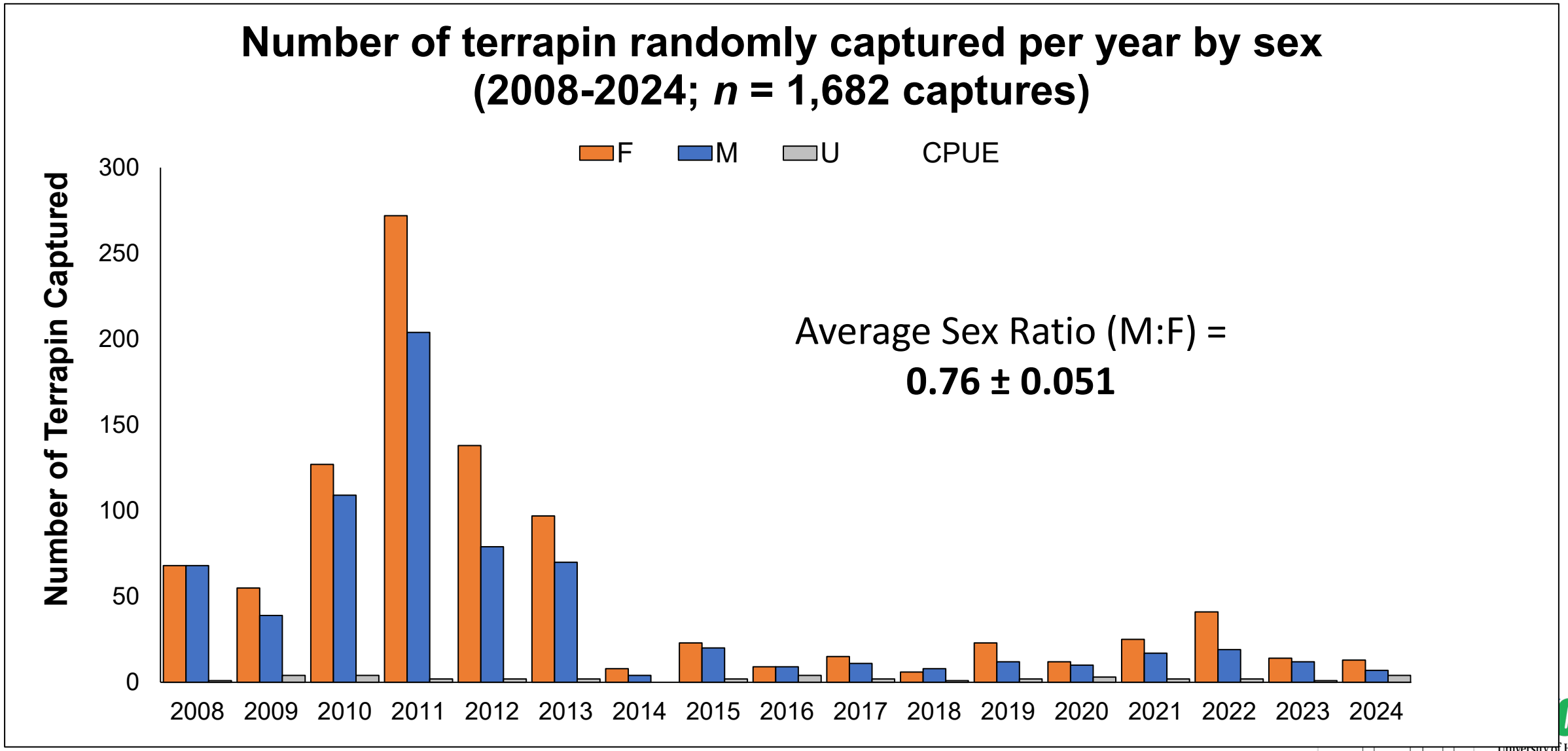
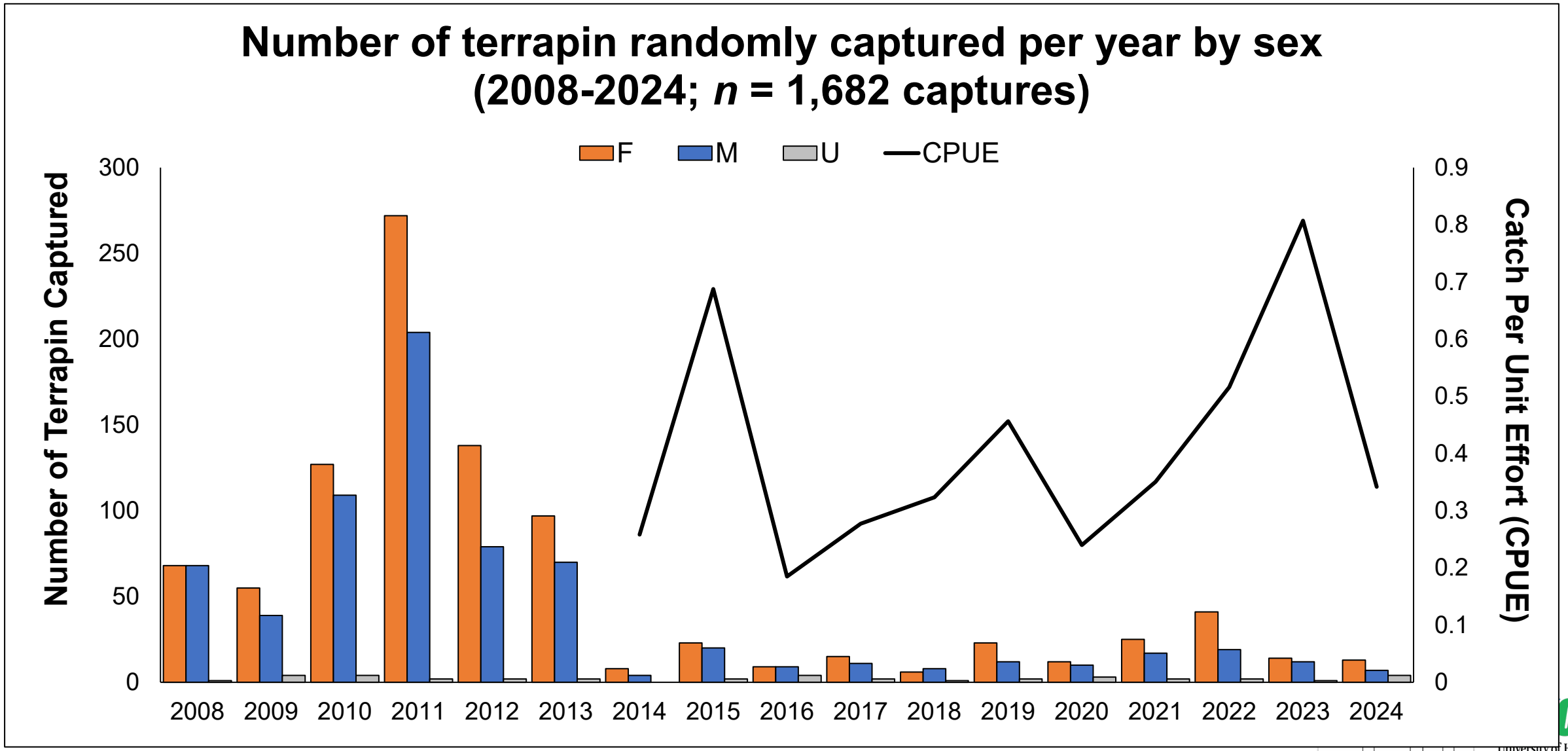
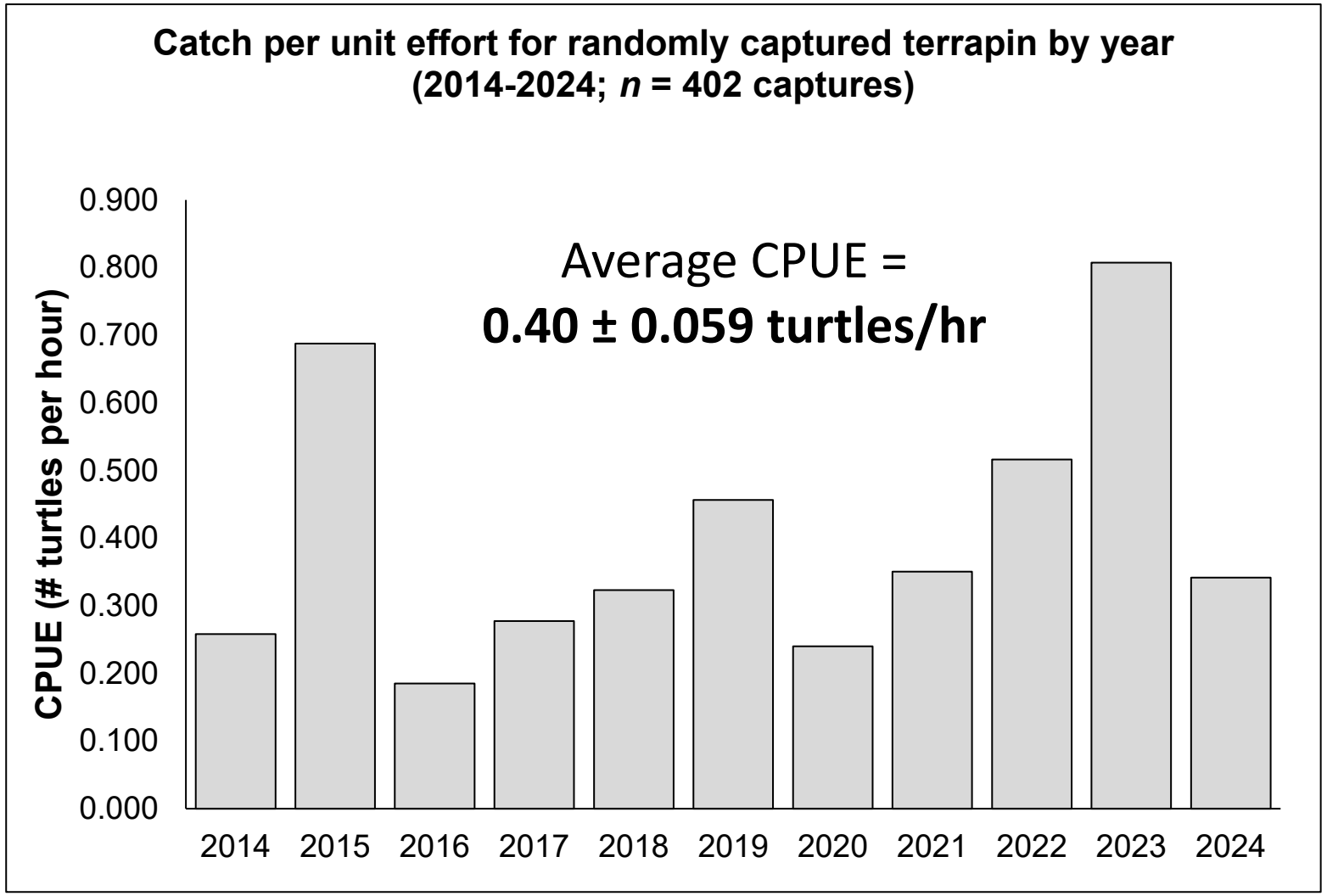
Current and Historic Capture Rates



Current and Historic Capture Rates



Current and Historic Capture Rates



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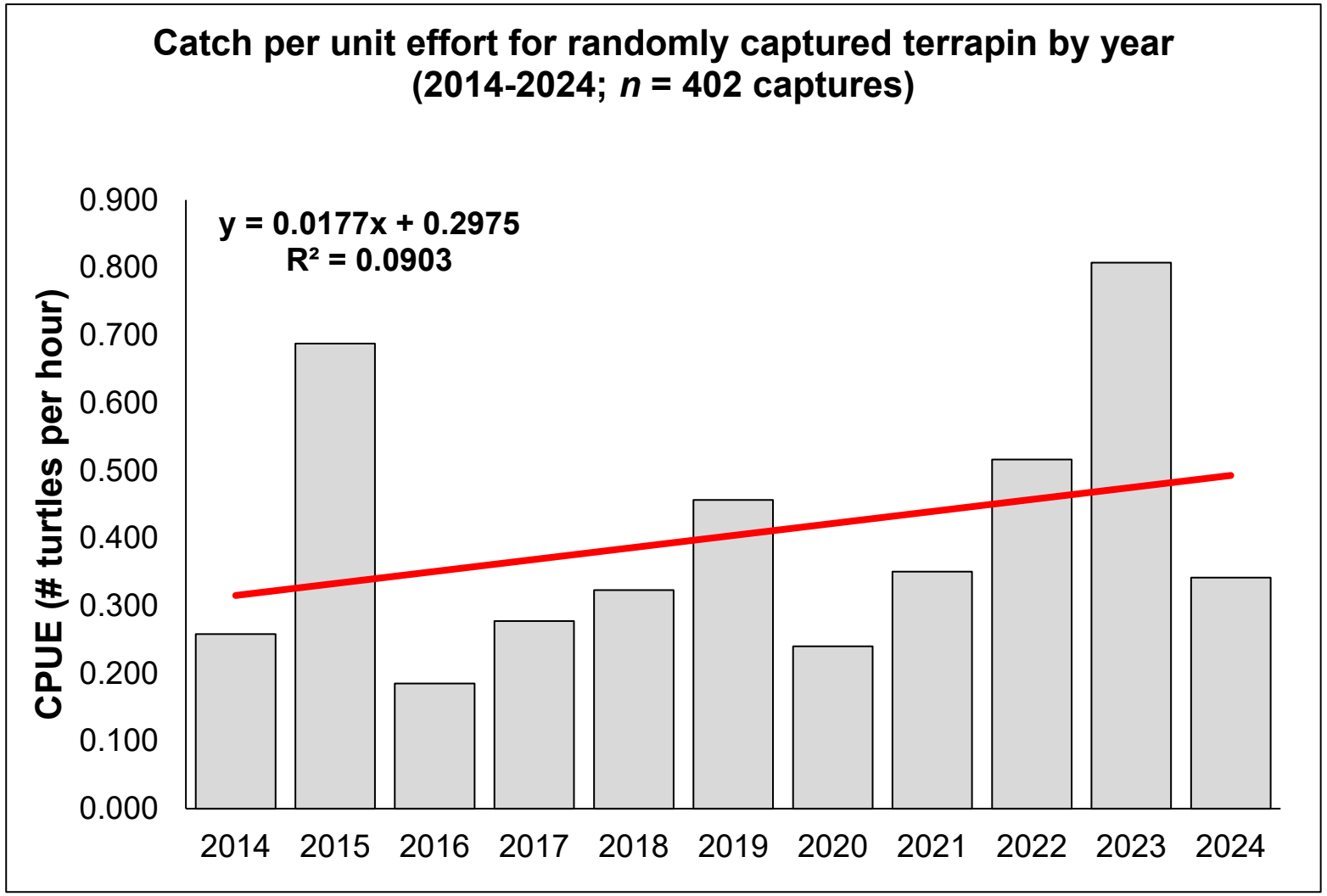
Current and Historic Capture Rates



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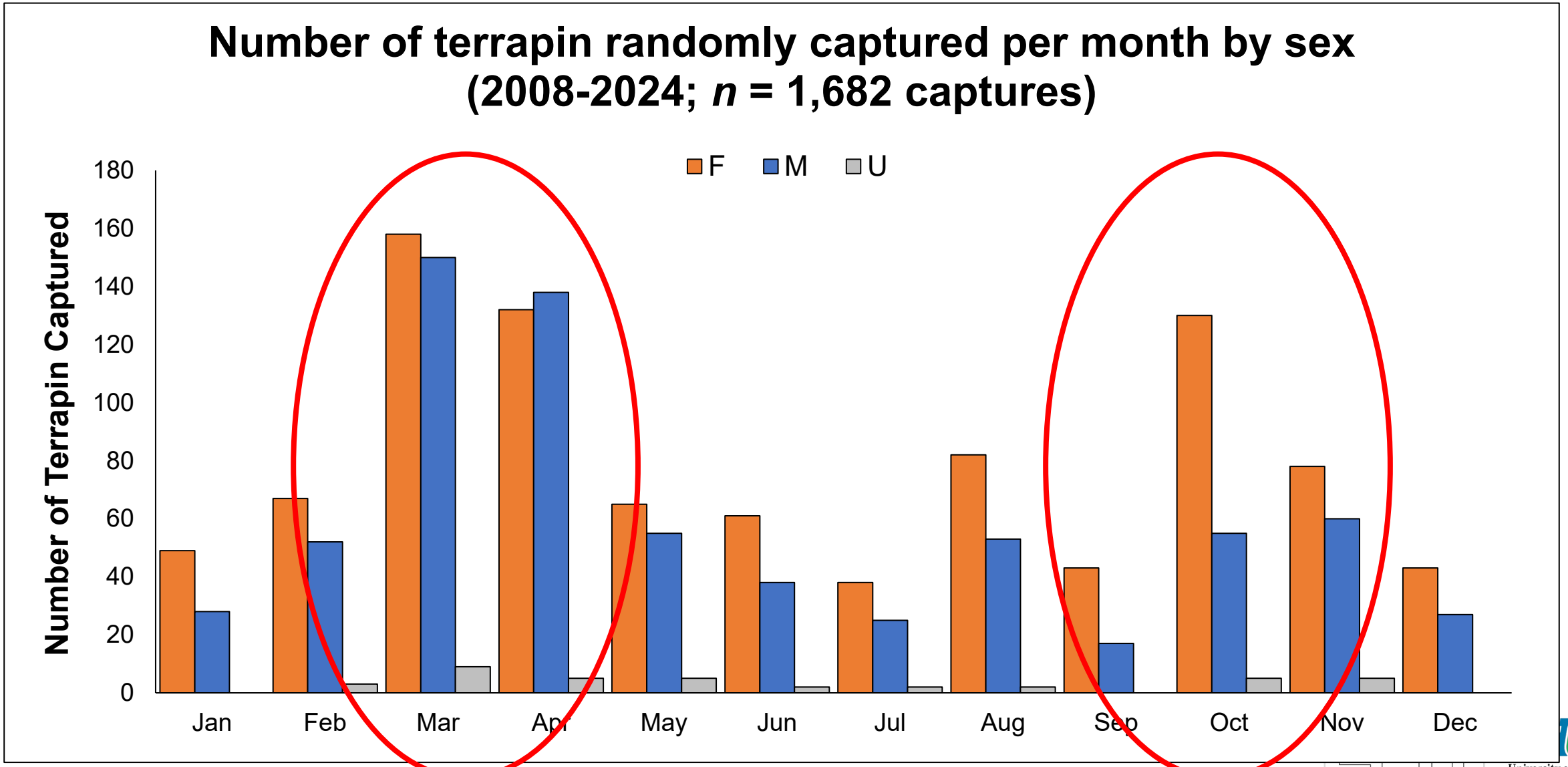
Current and Historic Capture Rates



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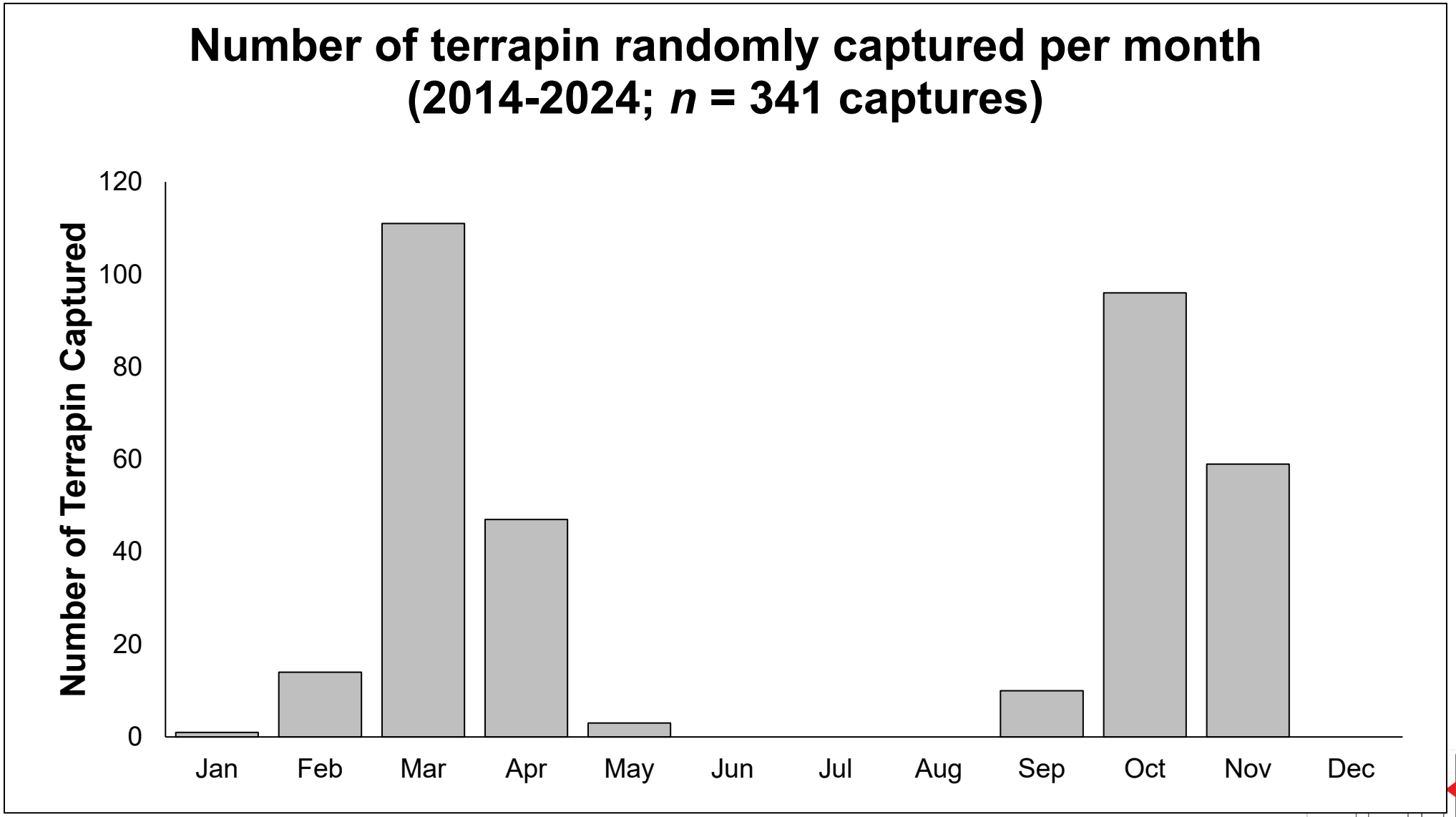
Current and Historic Capture Rates



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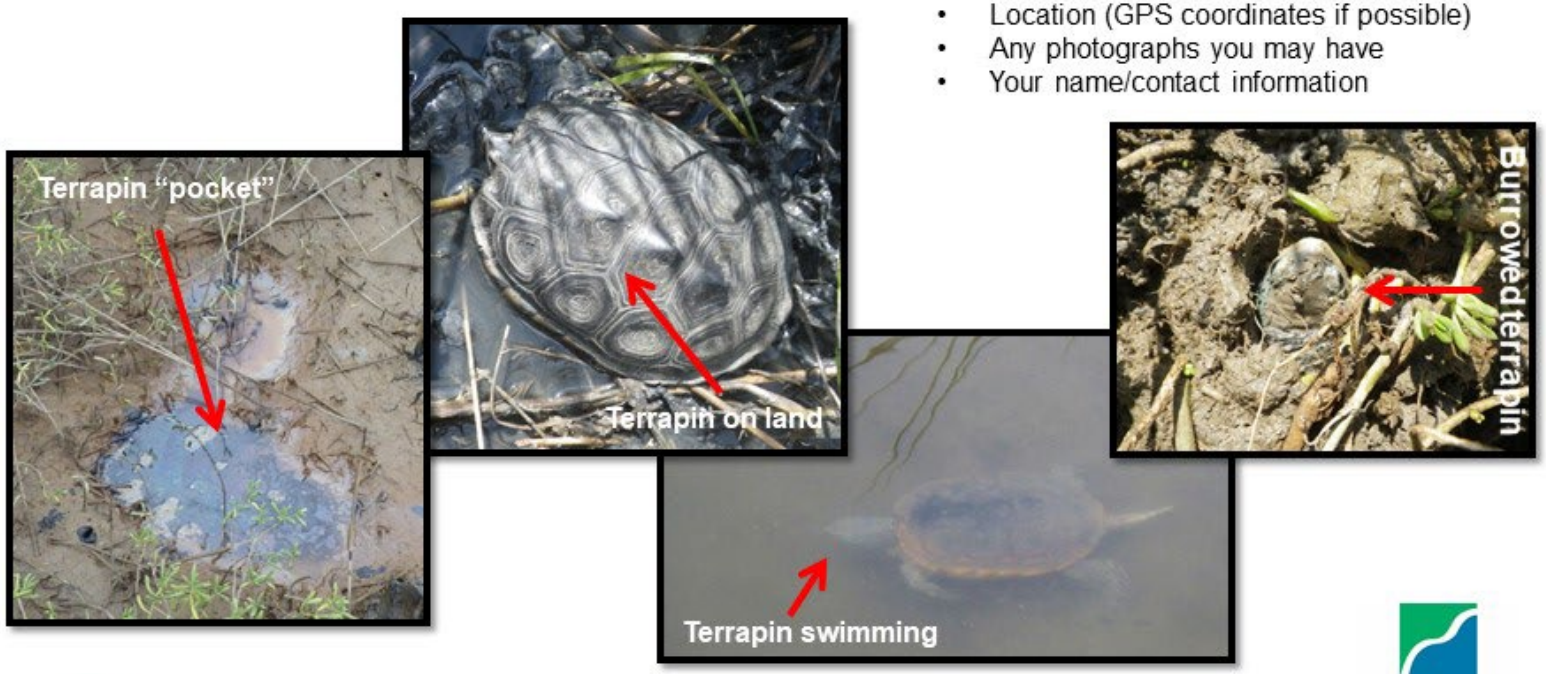
“Have You Seen Me?” Campaign

HAVE YOU SEEN ME?

The Environmental Institute of Houston (EIH) is researching Texas Diamondback Terrapins, in cooperation with Texas Parks and Wildlife and the US Fish and Wildlife Service. If you have seen one of these turtles, please call our main office at 281-283-3950 or email eih@uhcl.edu with the following information:

- Date and time
- Location (GPS coordinates if possible)
- Any photographs you may have
- Your name/contact information



Environmental Institute of Houston

Please do not pick up or disturb any of the terrapins you may see. Thank you!

For more information about this and other projects, please visit our website:
http://www.eih.uhcl.edu/research

University of Houston Clear Lake

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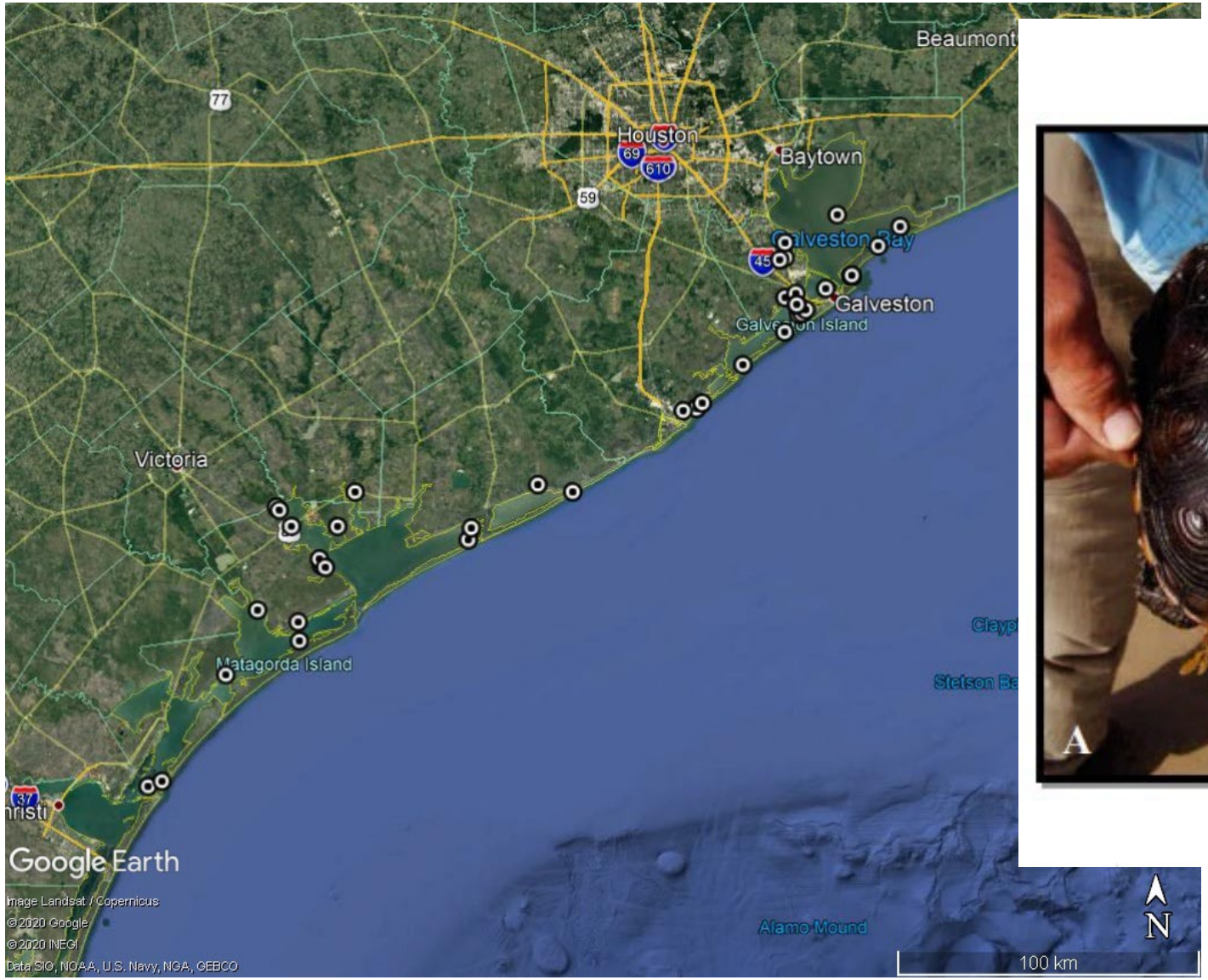
UHCL University of Houston Clear Lake

“Have You Seen Me?” Campaign



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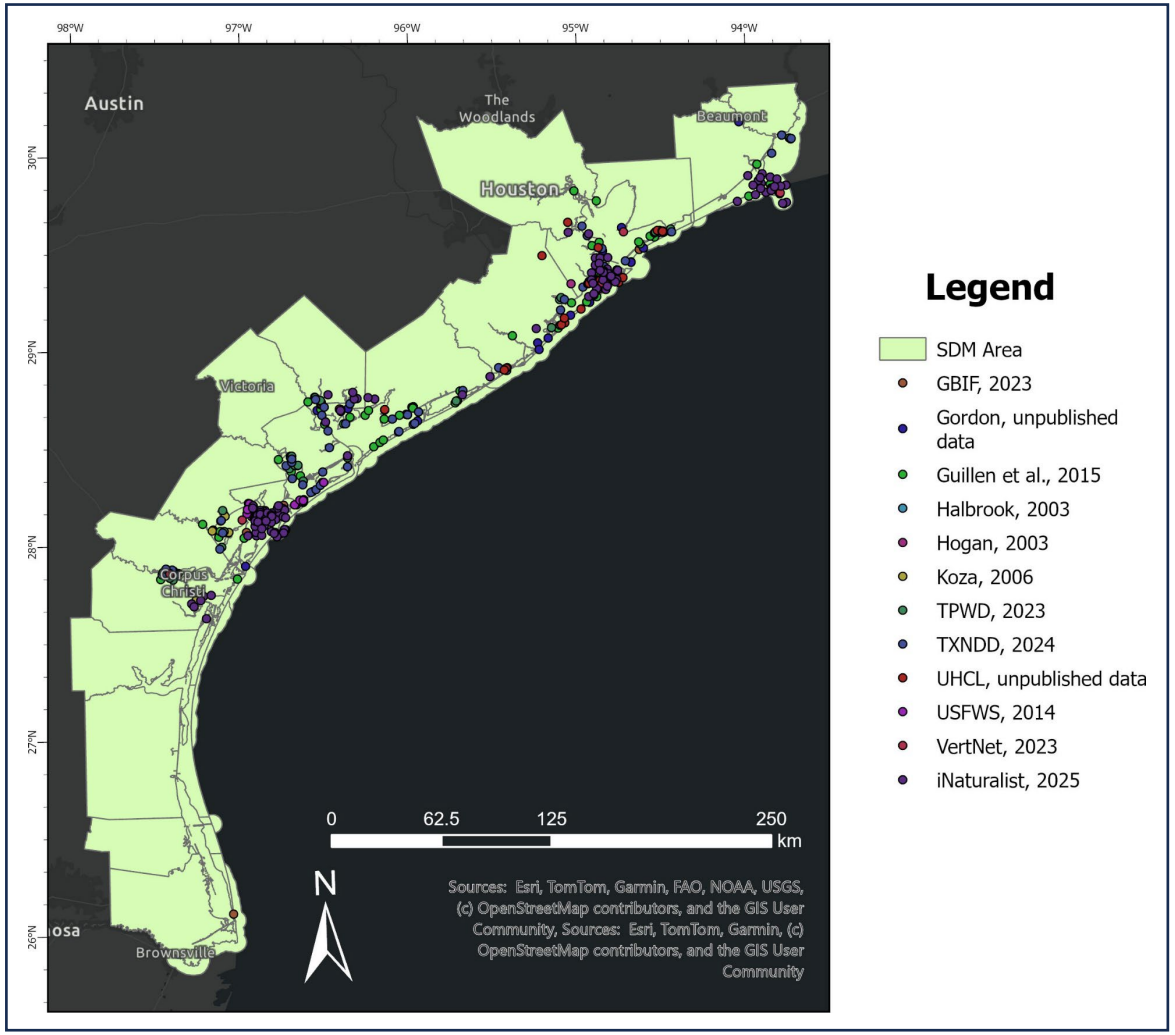
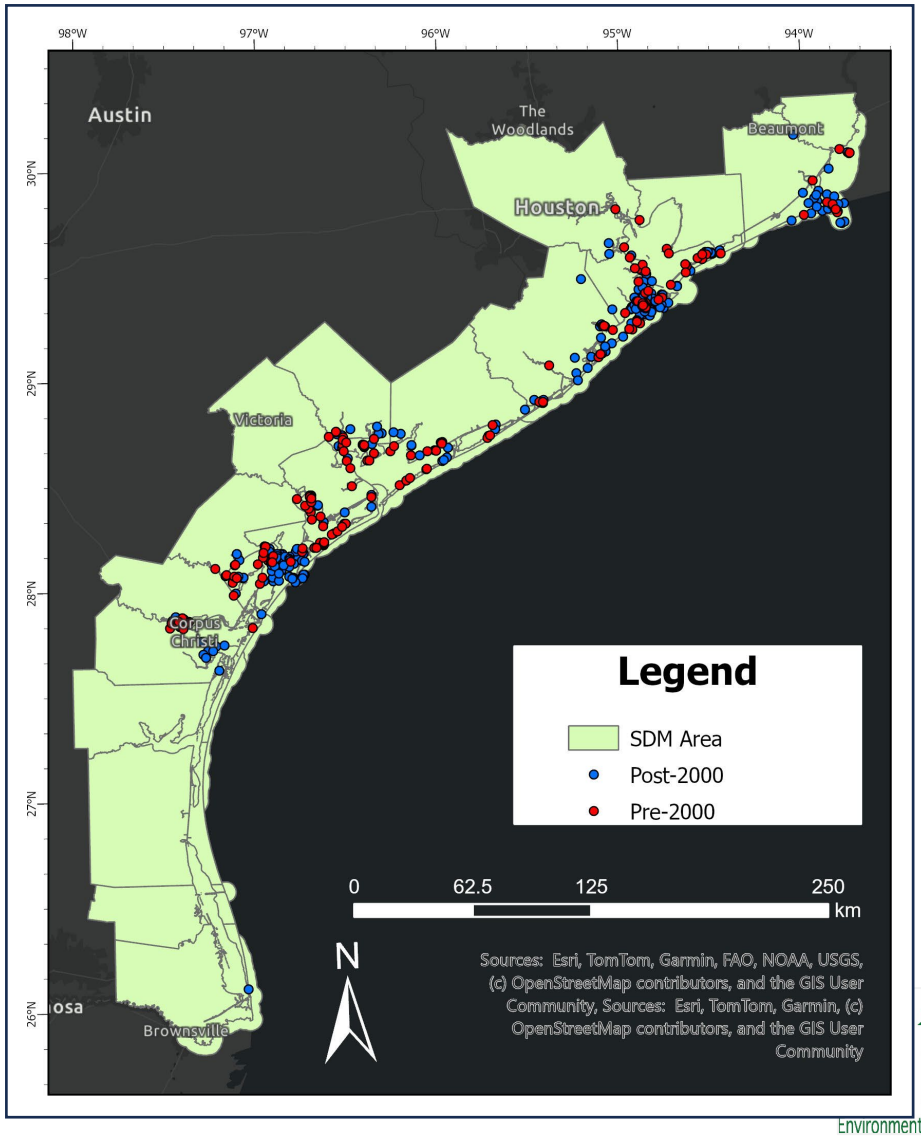
Distribution Modeling

Evaluate historic, current, and future coastal habitat availability utilizing species distribution models.





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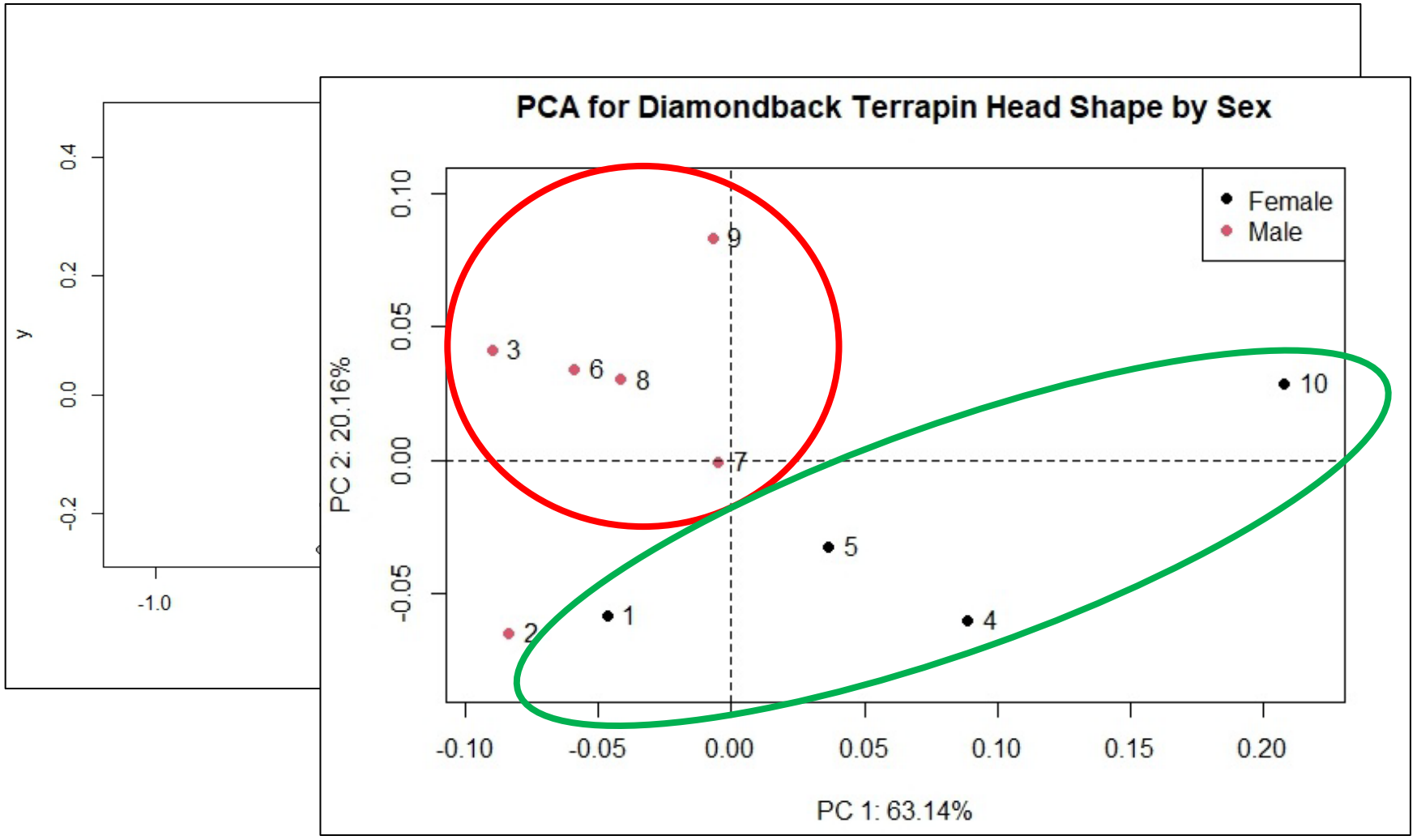
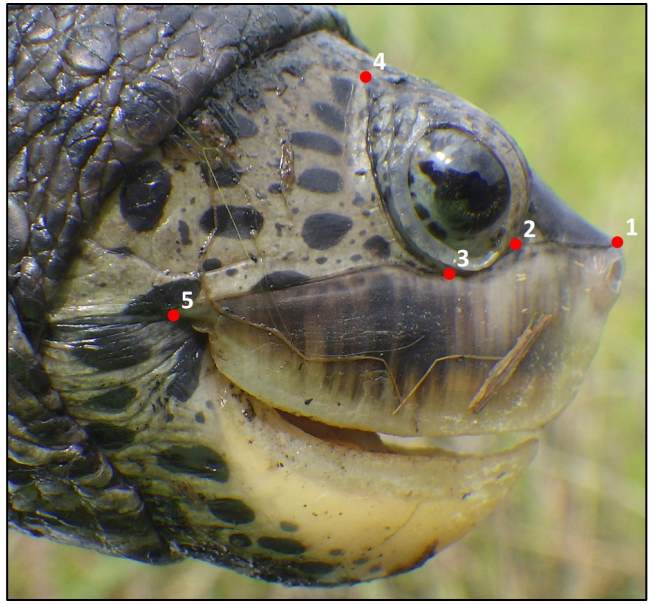
Geometric Morphometrics

Compare morphometric differences and evaluate implications for ecotoxin consumption or exposure.





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Shameless Plug

Environmental Institute of Houston

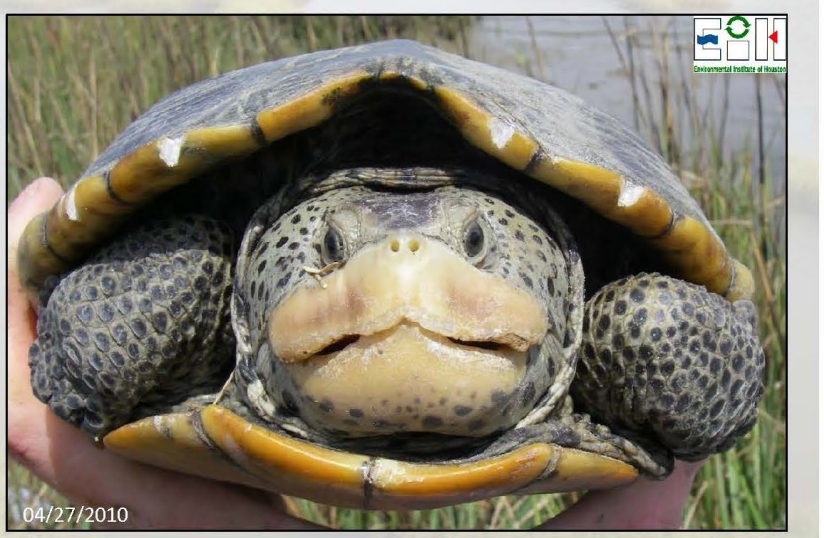
certifies that

John Smith

has adopted and named a Texas Diamondback Terrapin *(Malaclemys terrapin littoralis)*

Individual Terrapin Capture Data

Adopted Name:	**Chico**
Initial Capture Date:	04/27/2010
Last Seen On:	04/27/2010
Initial Capture Location:	Green's Lake
Initial Capture Habitat:	*Spartina* marsh
Carapace Notch ID:	N236
Pit Tag Number:	037 816 332
Sex:	Female
Weight:	1.19kg
Carapace Length (mid):	187mm
Carapace Width (max):	139mm
Carapace Depth (max):	85mm
Plastron Length (mid):	173mm
Plastron Width (min):	89mm
Head Width (max):	45mm



Chico was originally captured in 2010 and has not been seen by EIH since (as of December 2017)

Terrapin Adoption Program

- Funds our ongoing population monitoring
- Funds graduate research opportunities
- Allows volunteers to get out in the field with us!

Adopt by Dec. 11th
for delivery by Dec. 25th

https://www.uhcl.edu/environmental-institute/outreach/adopt-terrapin

Environmental Institute of Houston

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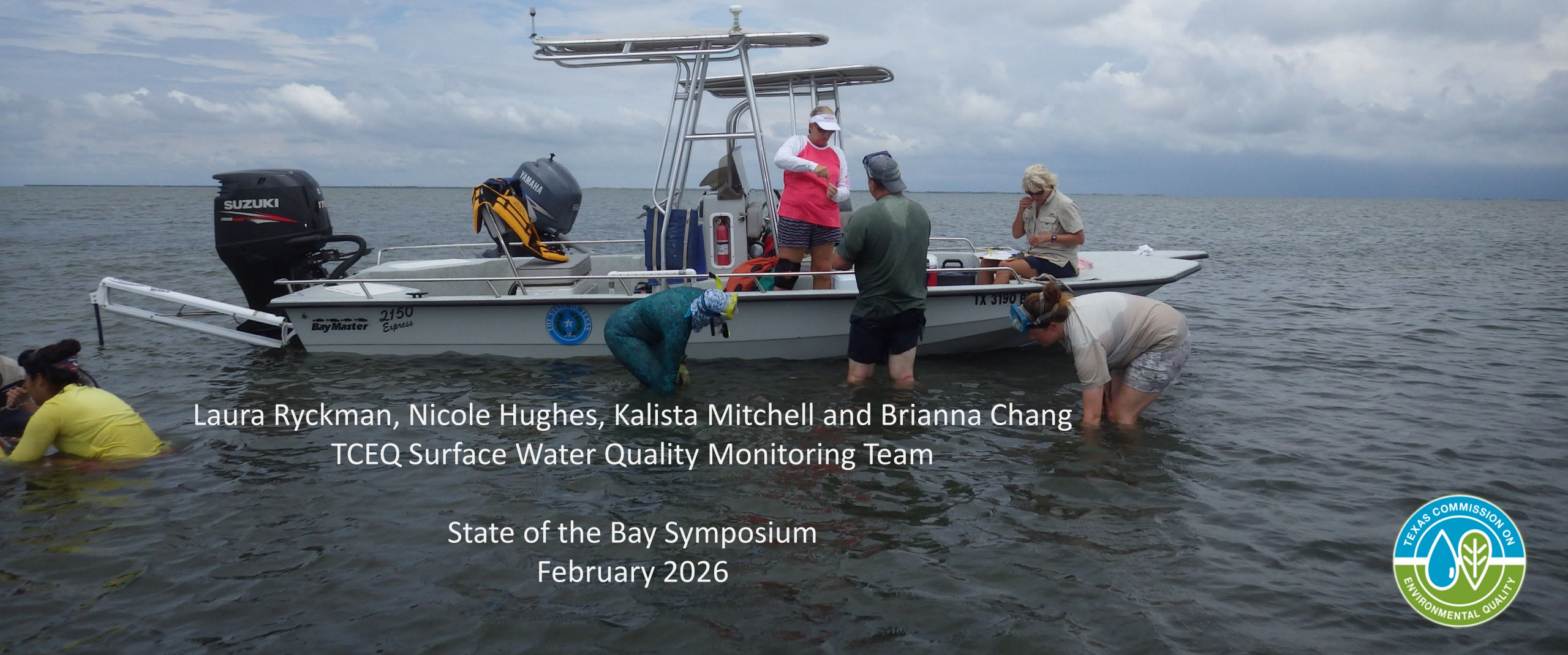
Seagrass Community in West Bay and Christmas Bay: Observations from 2016 - 2024



Laura Ryckman, Nicole Hughes, Kalista Mitchell and Brianna Chang
TCEQ Surface Water Quality Monitoring Team

State of the Bay Symposium
February 2026

Seagrass Conservation Plan for Texas

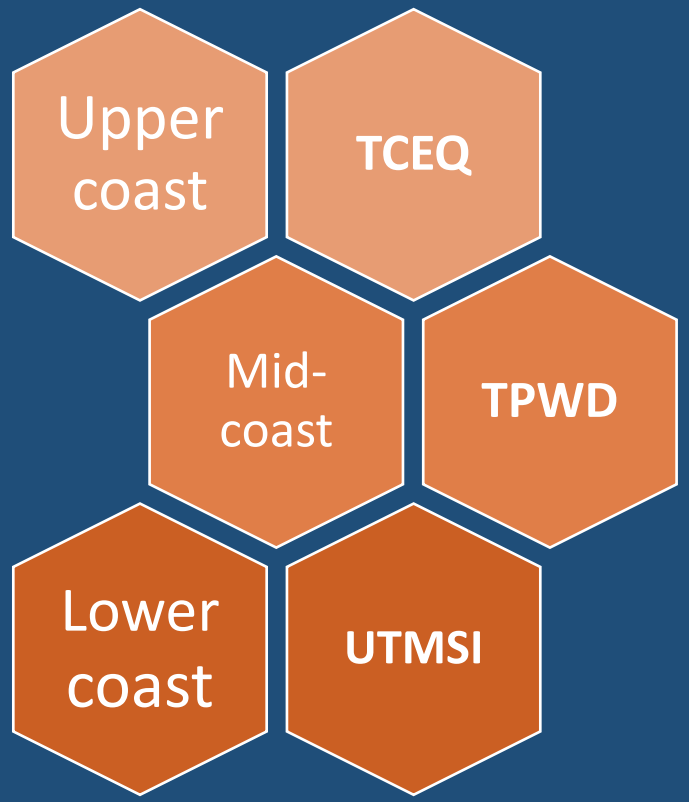
- 1999: TCEQ, TPWD, TGLO signed the Seagrass Conservation Plan for Texas

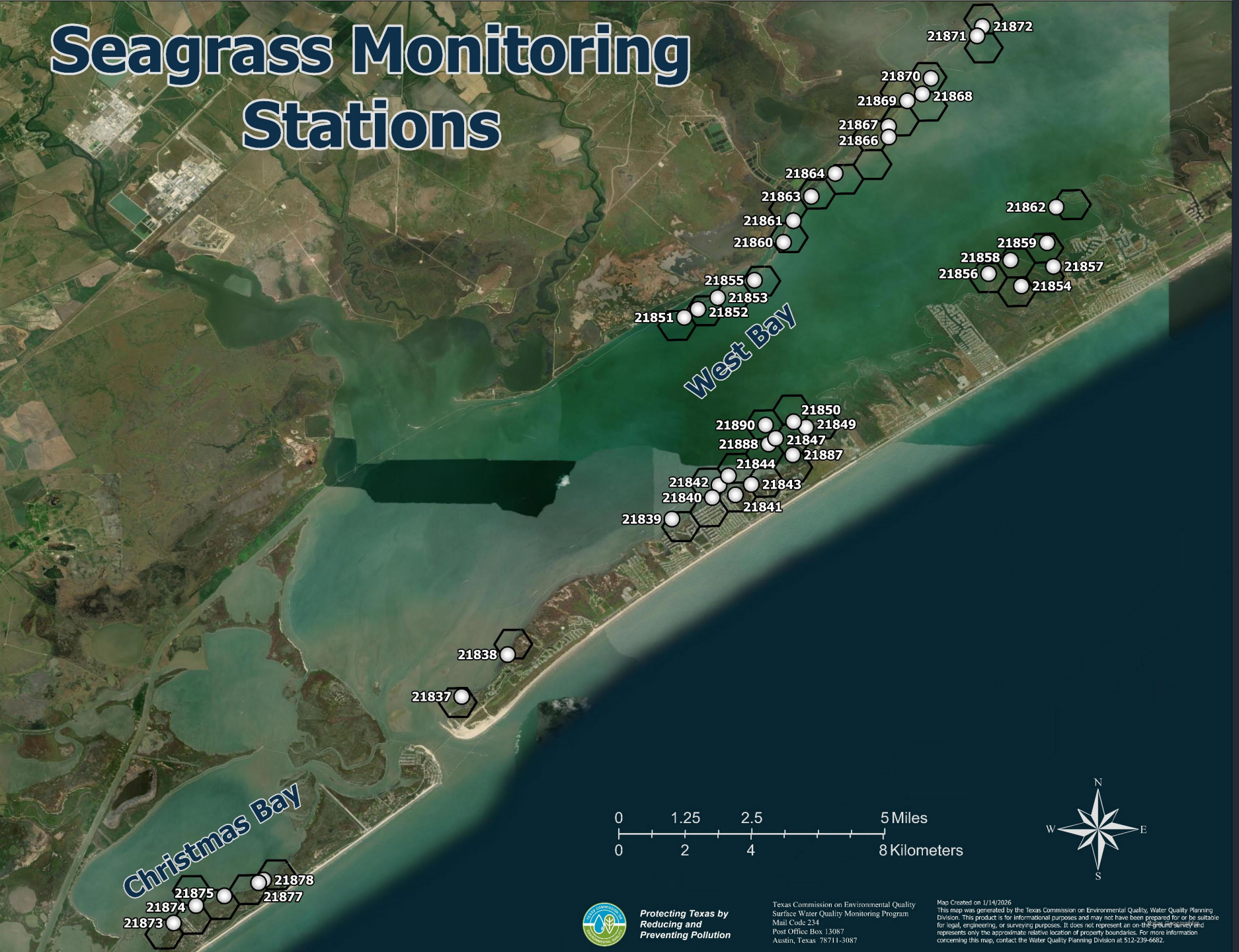
- 2000 Texas Surface Water Quality Standards revision:

  TCEQ adopted a seagrass propagation use which afforded protection to seagrass statewide


TCEQ & TPWD began Phase 1 Statewide Seagrass Monitoring Protocol Development
TPWD collected aerial imagery of seagrass in Galveston's West Bay & Christmas Bay
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Texas Statewide Seagrass Monitoring Program began collecting data along the lower and middle coast
Phase 2 Protocol Development in San Antonio and Redfish Bays
TCEQ monitored at established stations in West and Christmas Bays (Tier 2)
TX 3190 BE
In 2014, 2015 and 2025, TCEQ conducted monitoring at sites in San Antonio Bay.

A statewide strategy

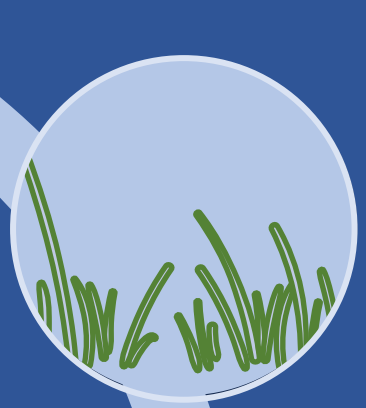




42 stations

Monitoring between August 1 – October 31

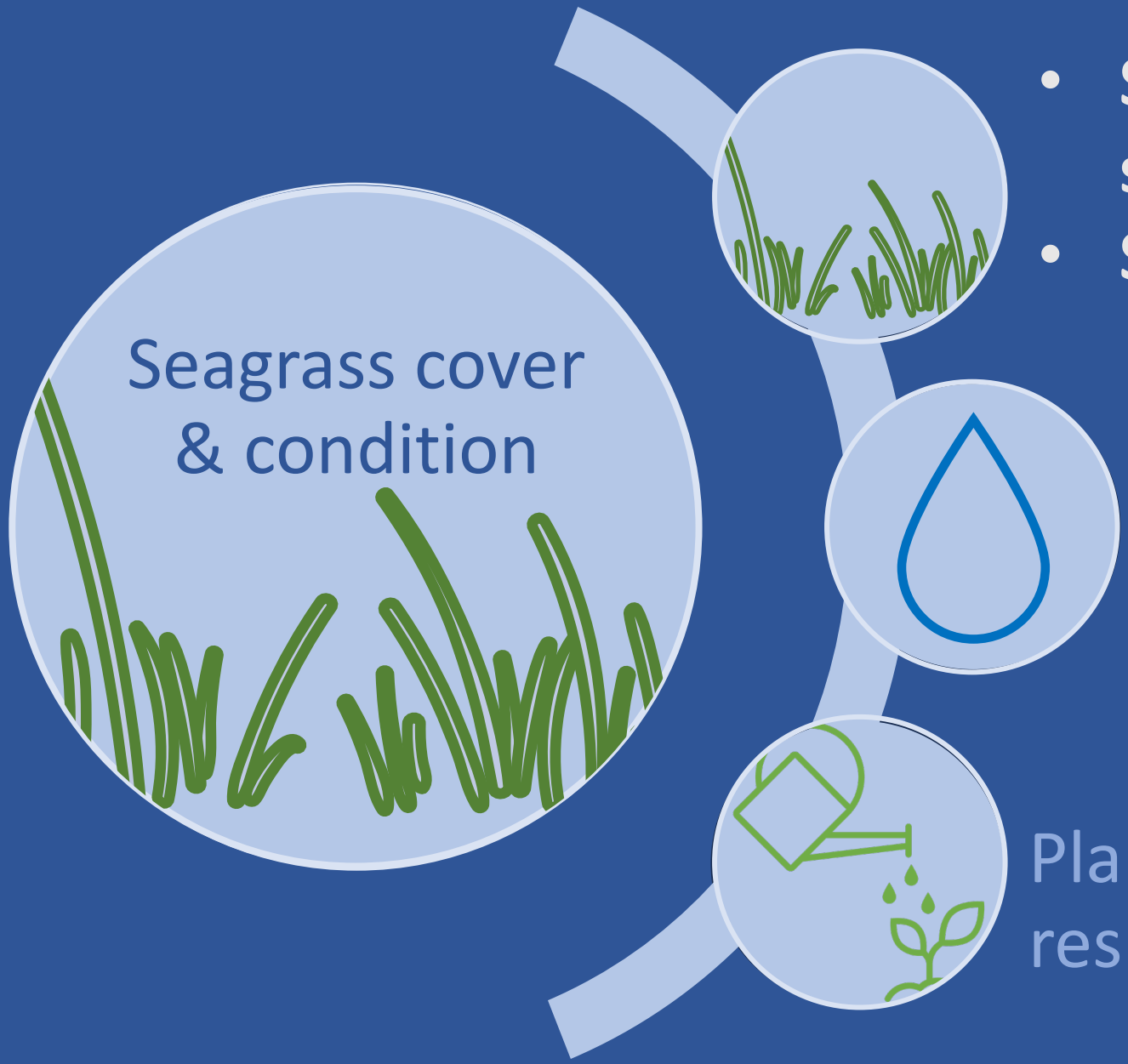
Rapid Assessment



Seagrass cover and condition

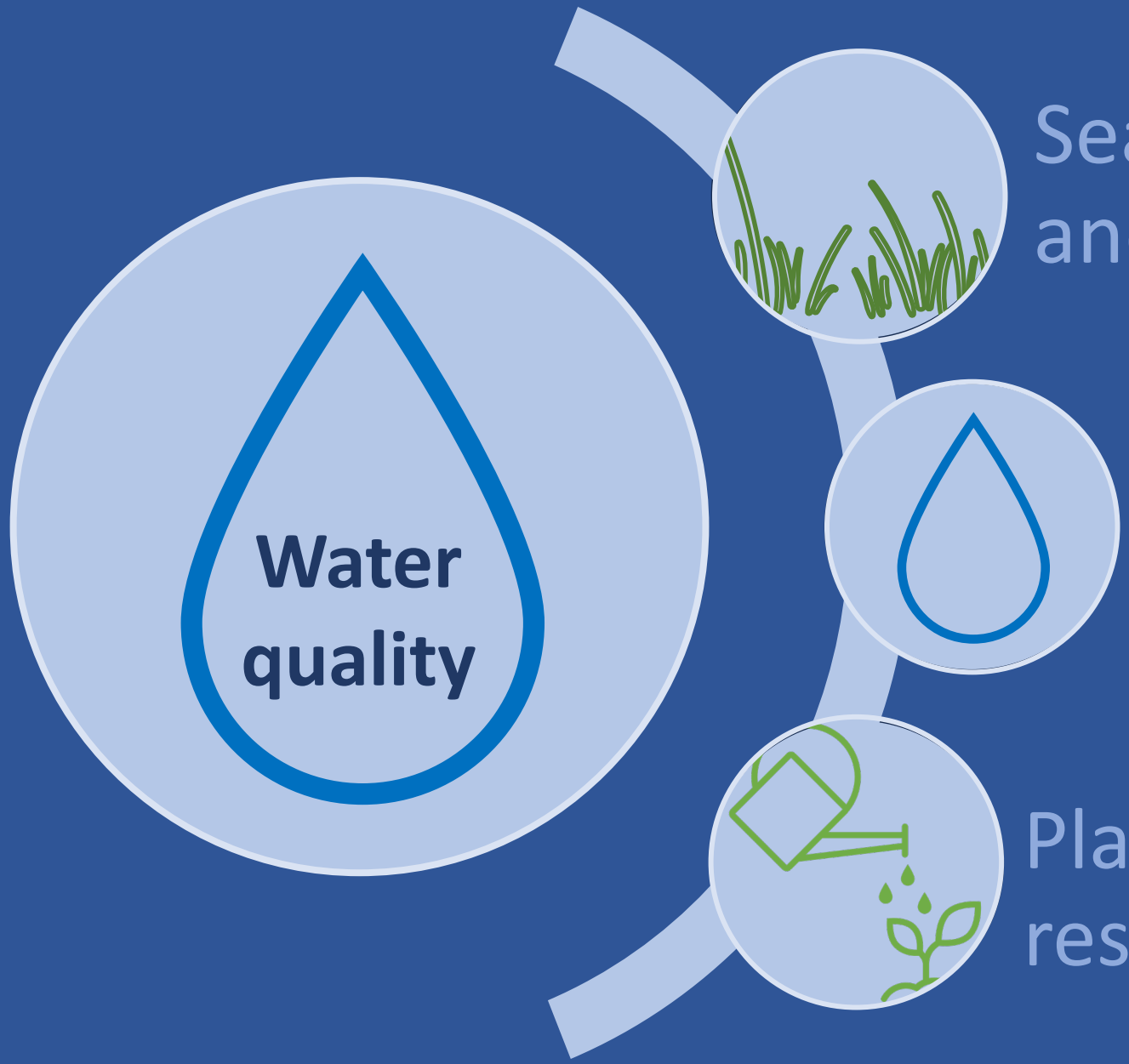
Water quality

Plant nutrient response



- **Seagrass percent cover by species**
- **Seagrass canopy height**

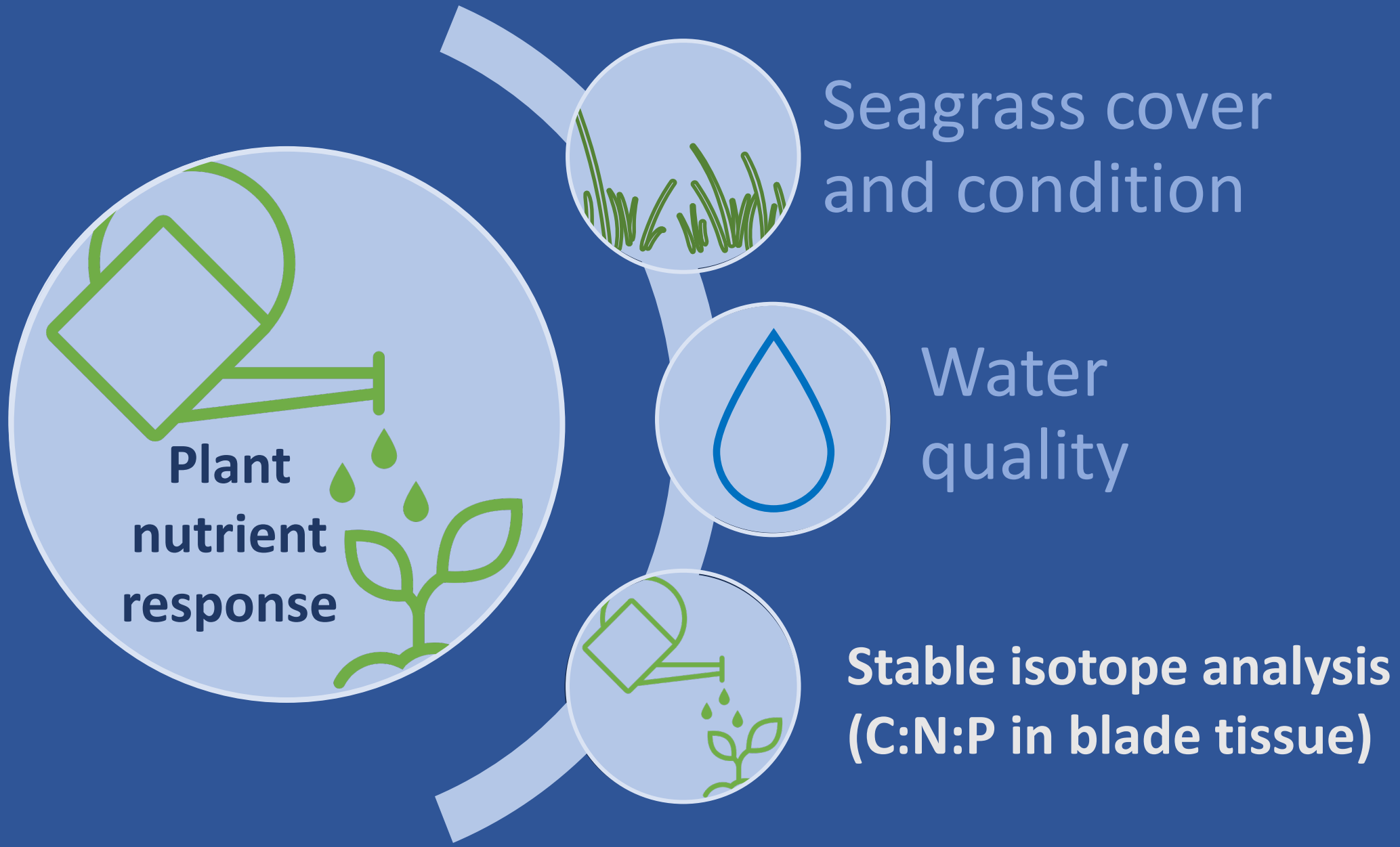
Plant nutrient response

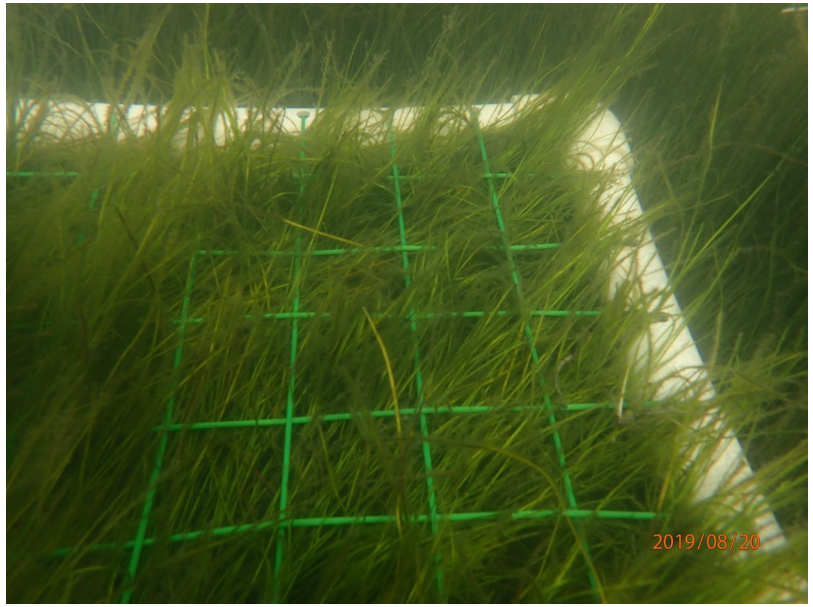


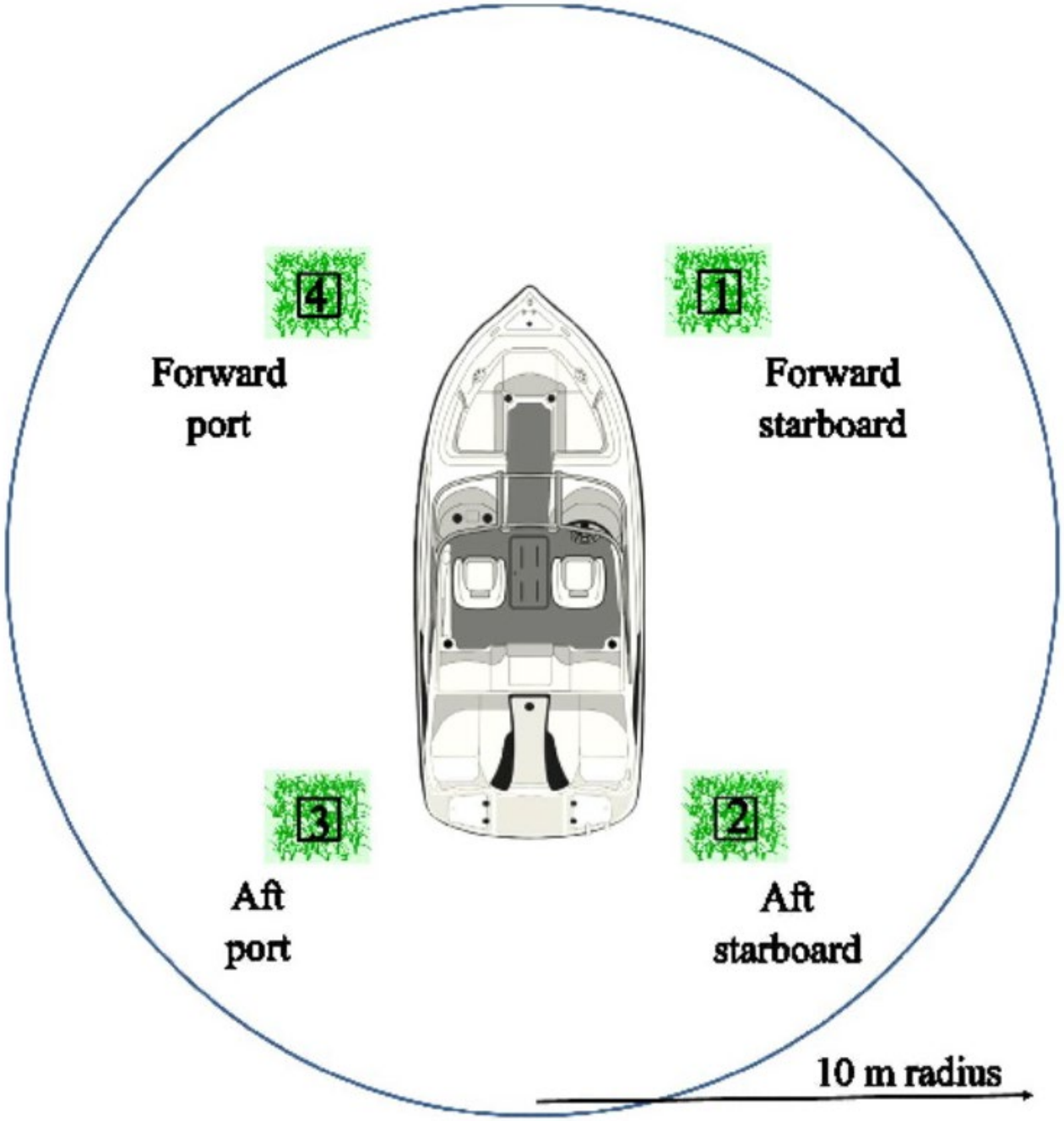
Seagrass cover and condition

- **Dissolved oxygen, pH, specific conductivity, temperature, salinity, chlorophyll-a**
- **Total suspended solids**
- **Secchi**
- **Light attenuation and Photosynthetically Active Radiation**

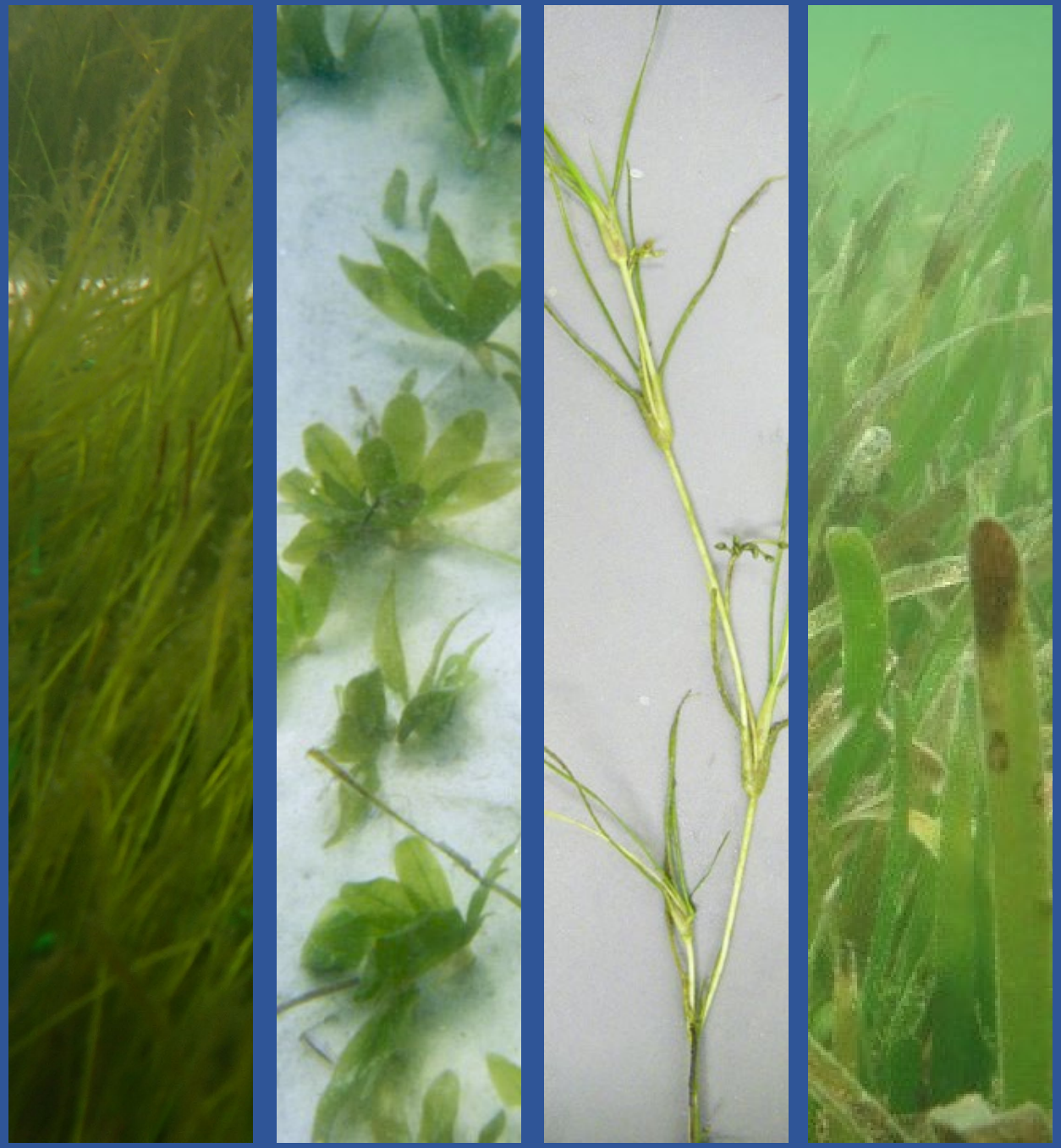
Plant nutrient response


Plant
nutrient
response
Seagrass cover
and condition
Water
quality
Stable isotope analysis
(C:N:P in blade tissue)

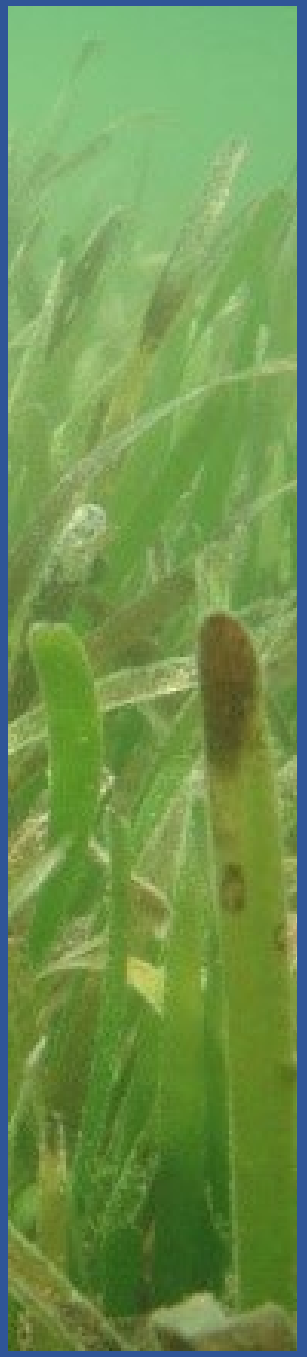

2019/08/20

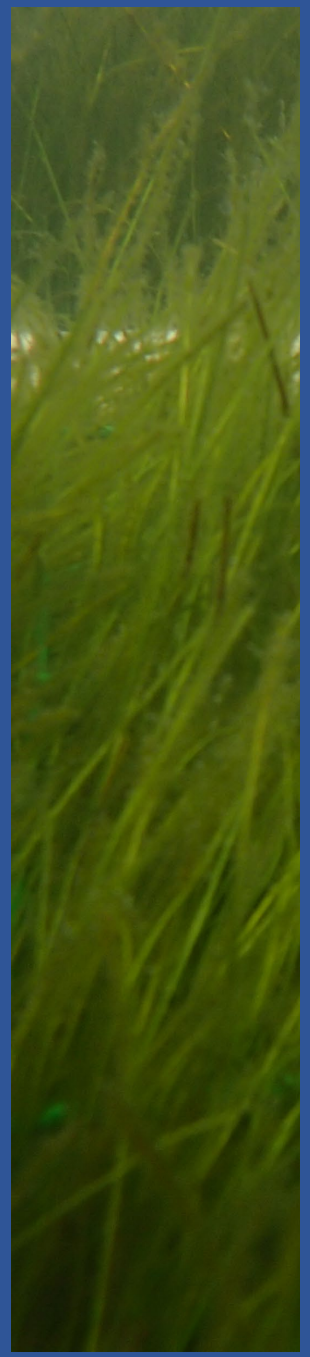

4
Forward
port
1
Forward
starboard
3
Aft
port
2
Aft
starboard
10 m radius

Galveston Bay Seagrasses

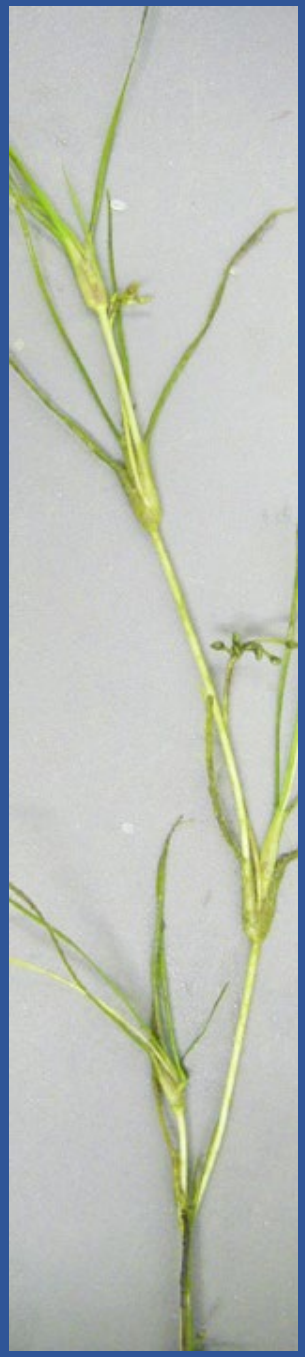
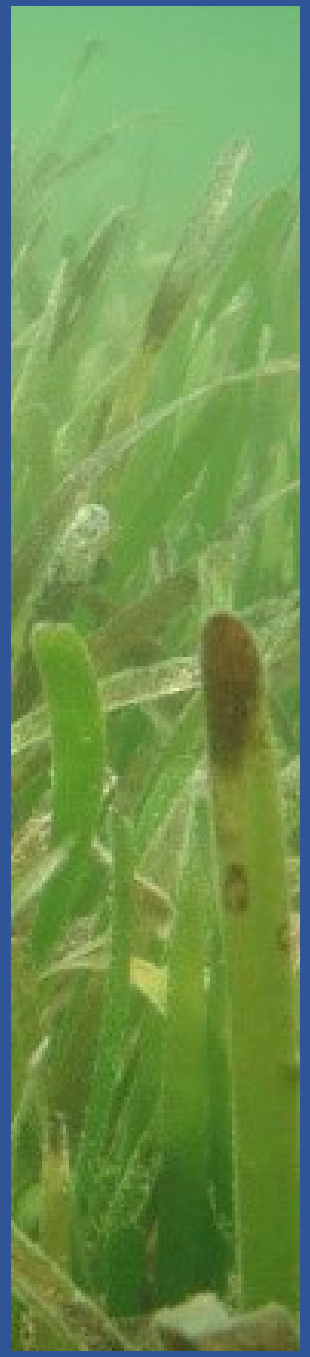


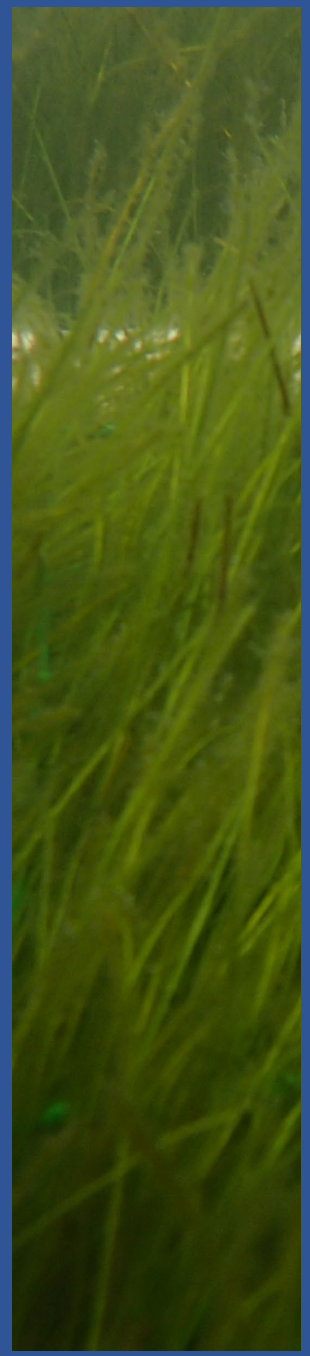
Halodule wrightii



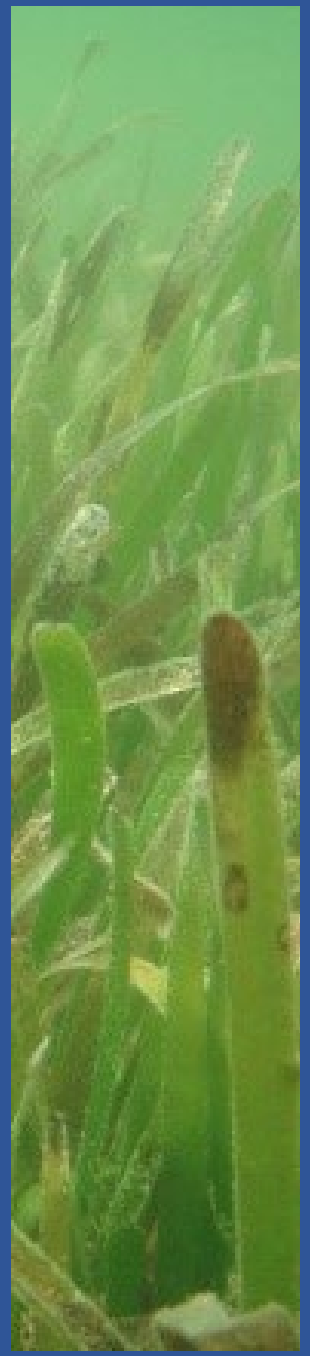


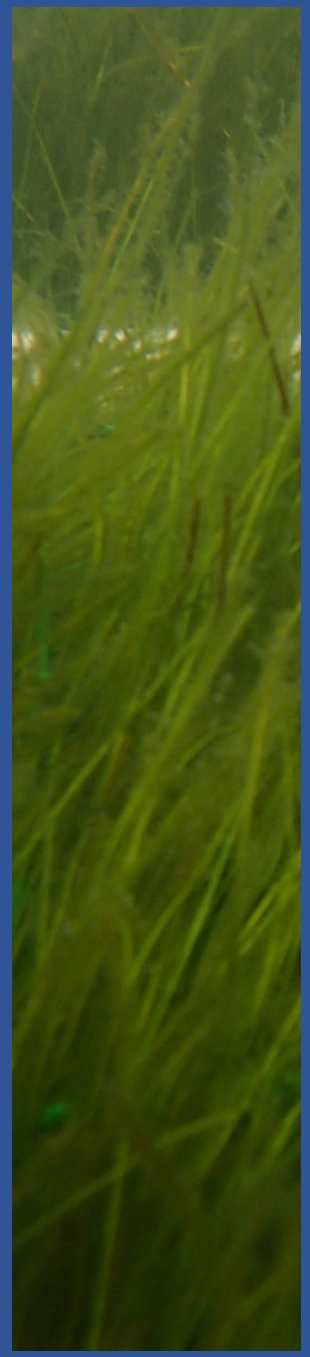

Halophila engelmannii

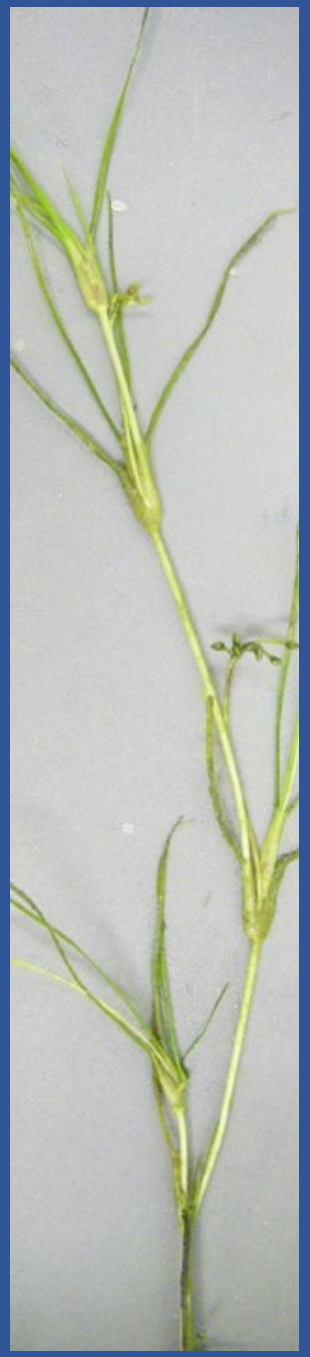





Ruppia maritima

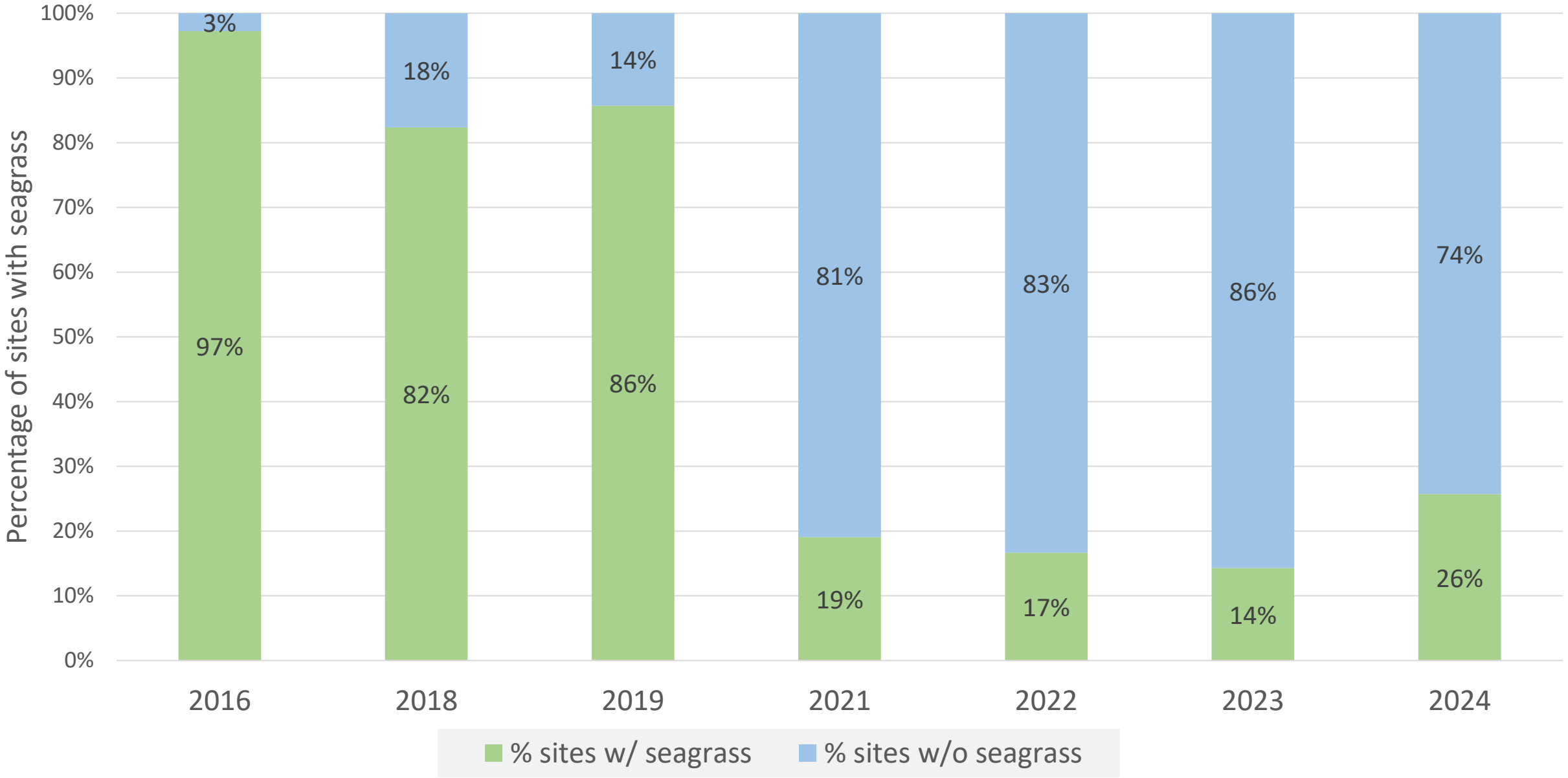


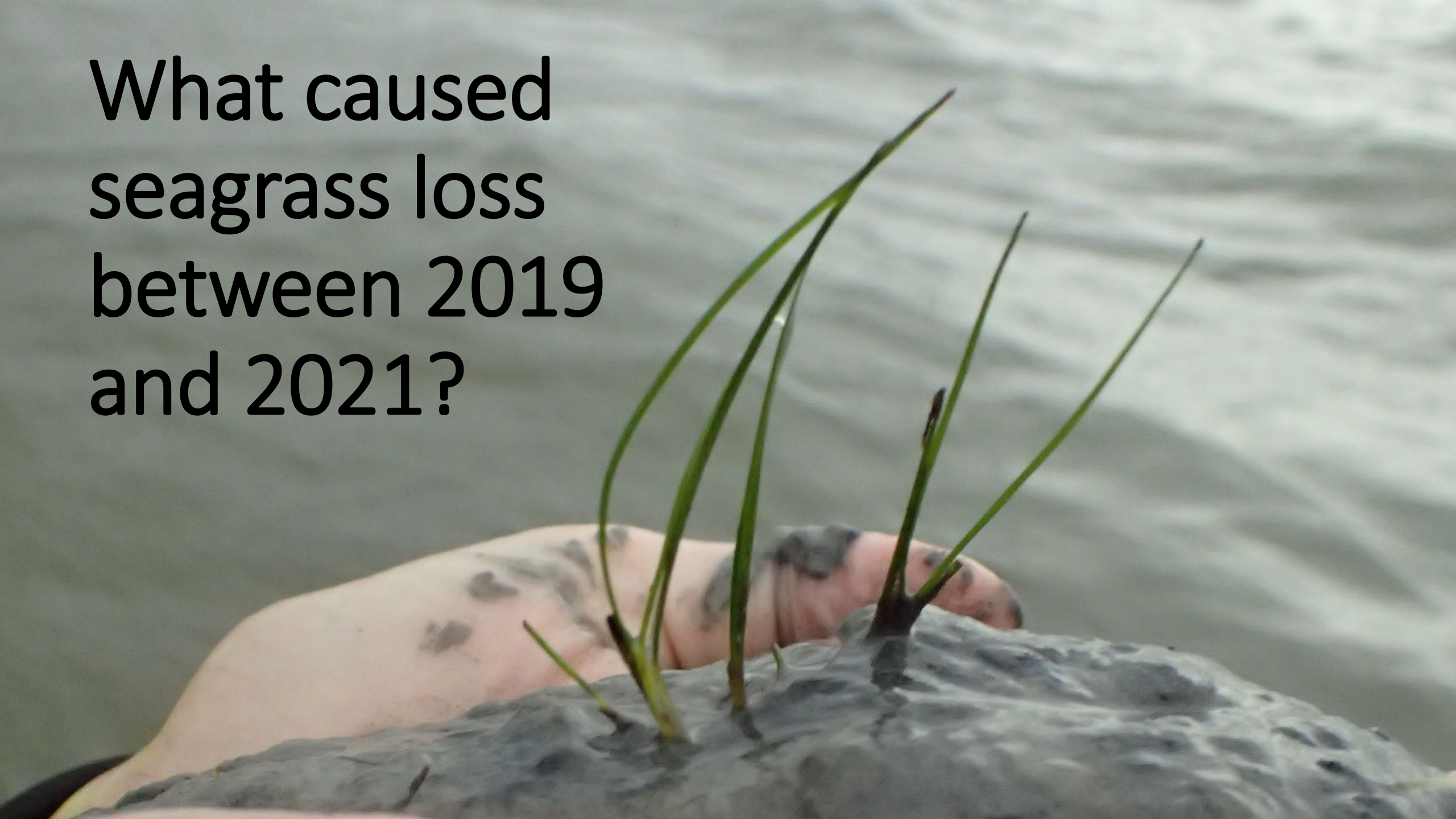




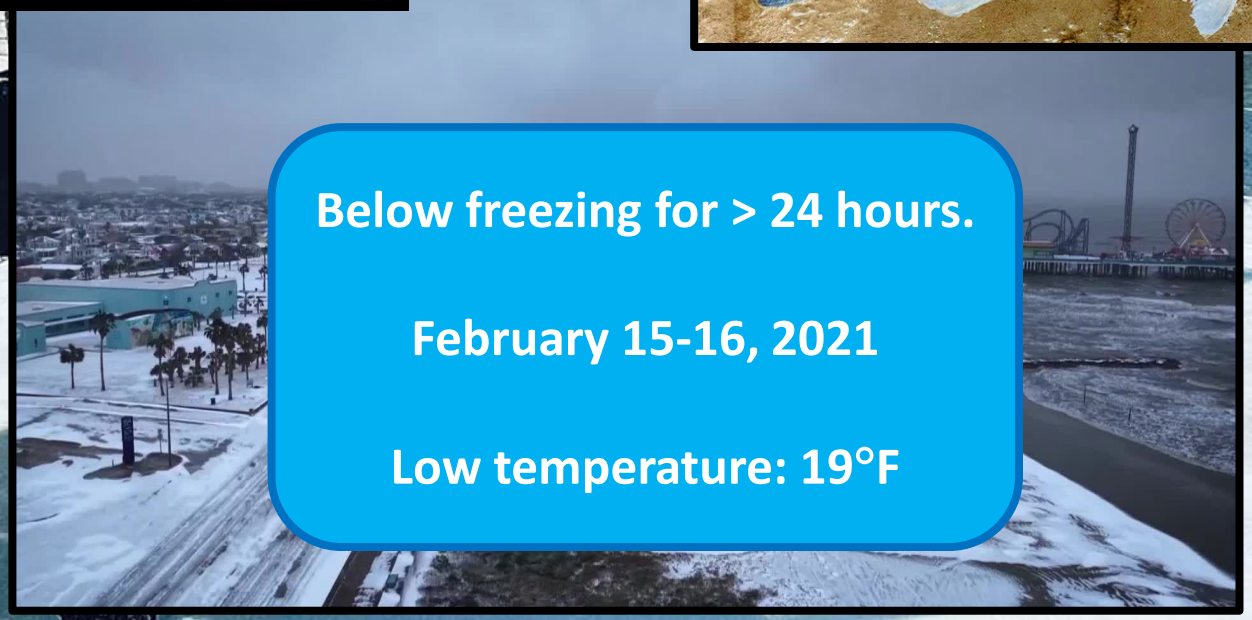

Thalassia testudinum

Seagrass presence in West and Christmas Bays




What caused seagrass loss between 2019 and 2021?

February 2021



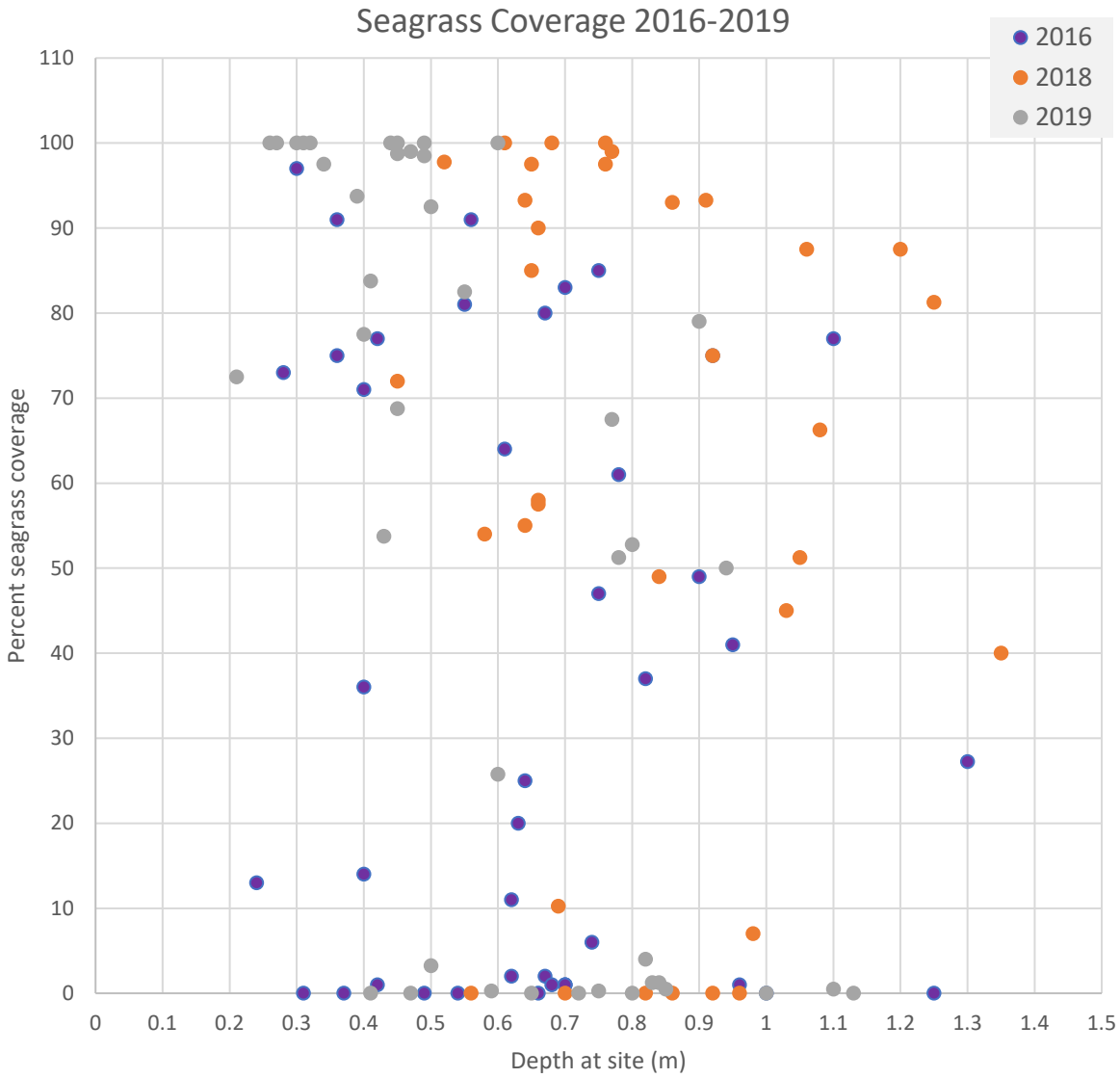
Below freezing for > 24 hours.

February 15-16, 2021

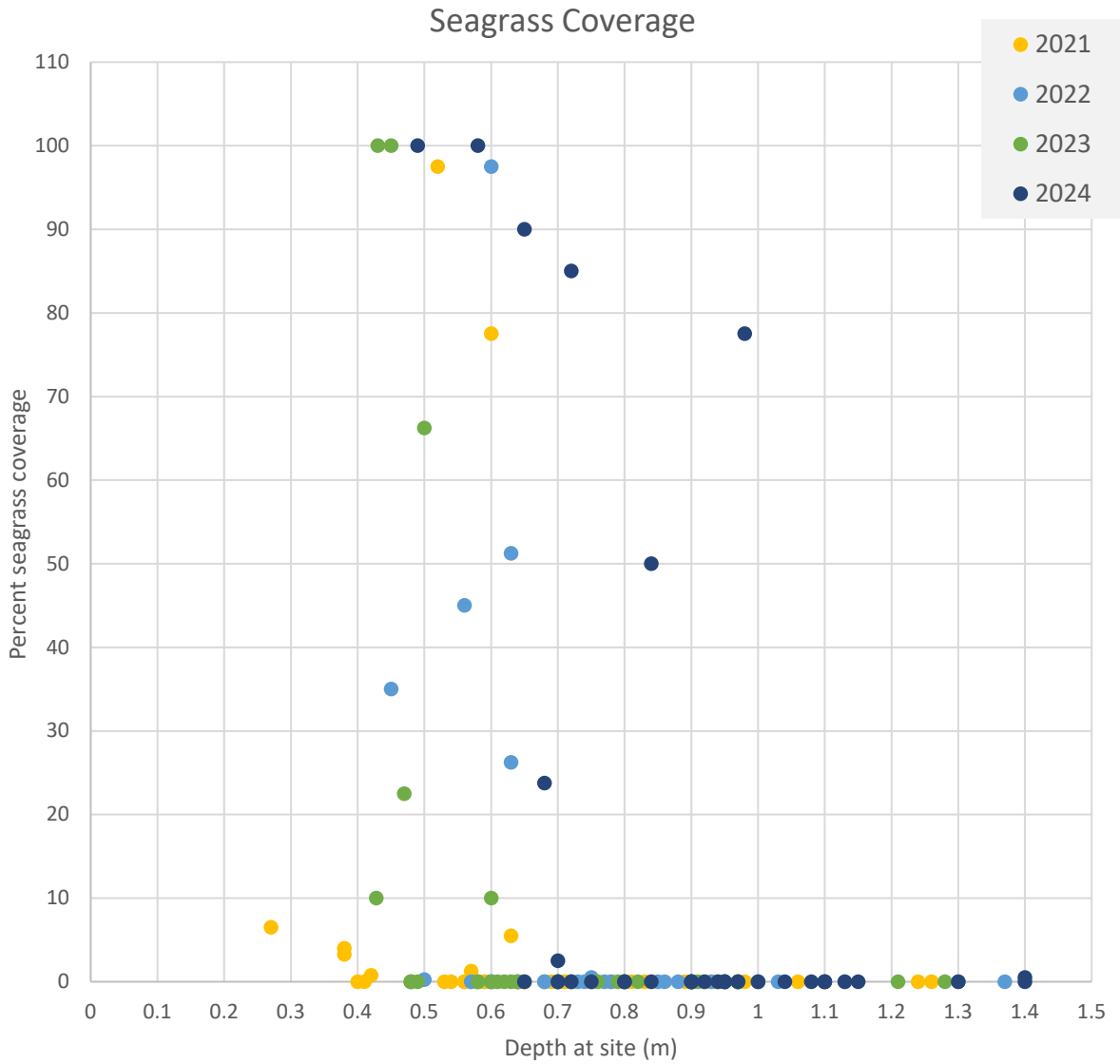
Low temperature: 19°F

Photo credits: TPWD

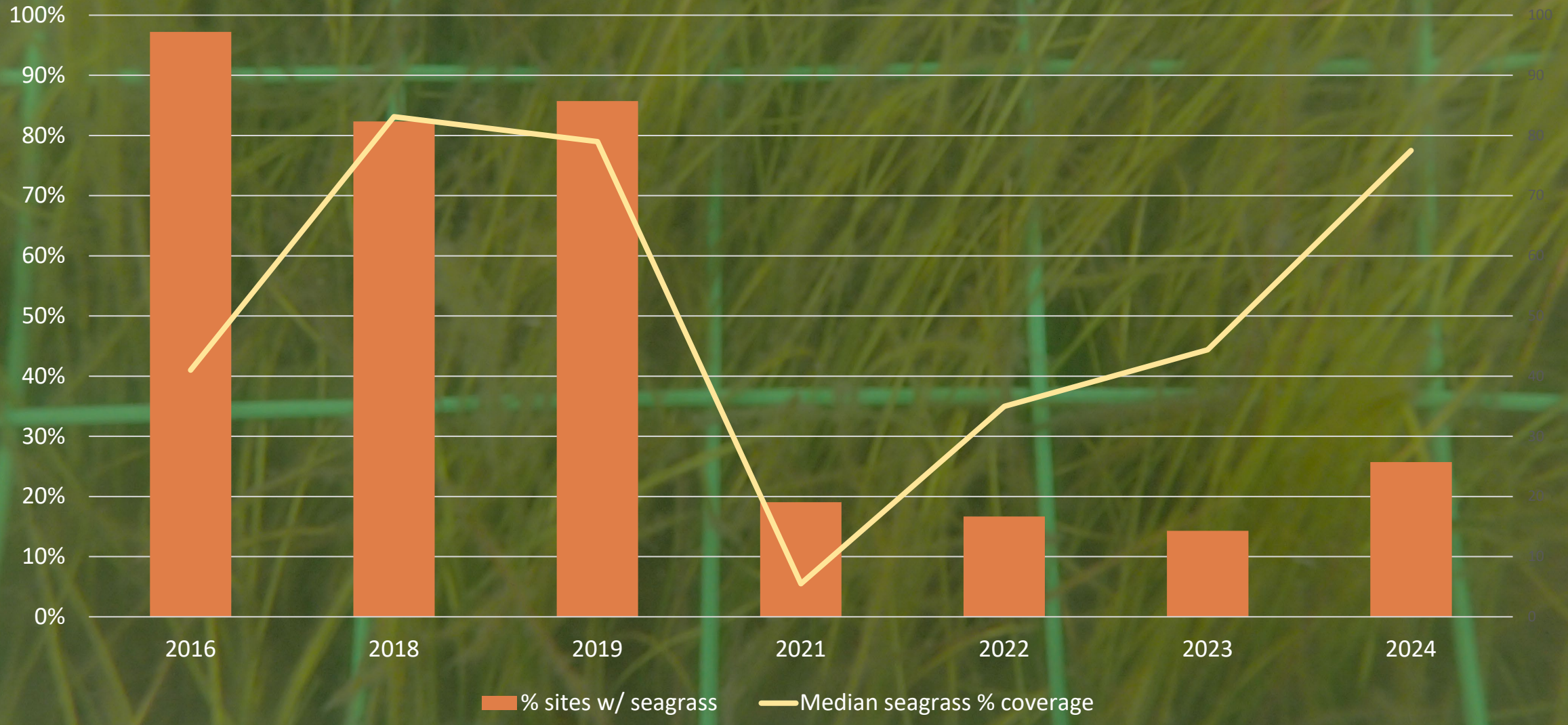
Before

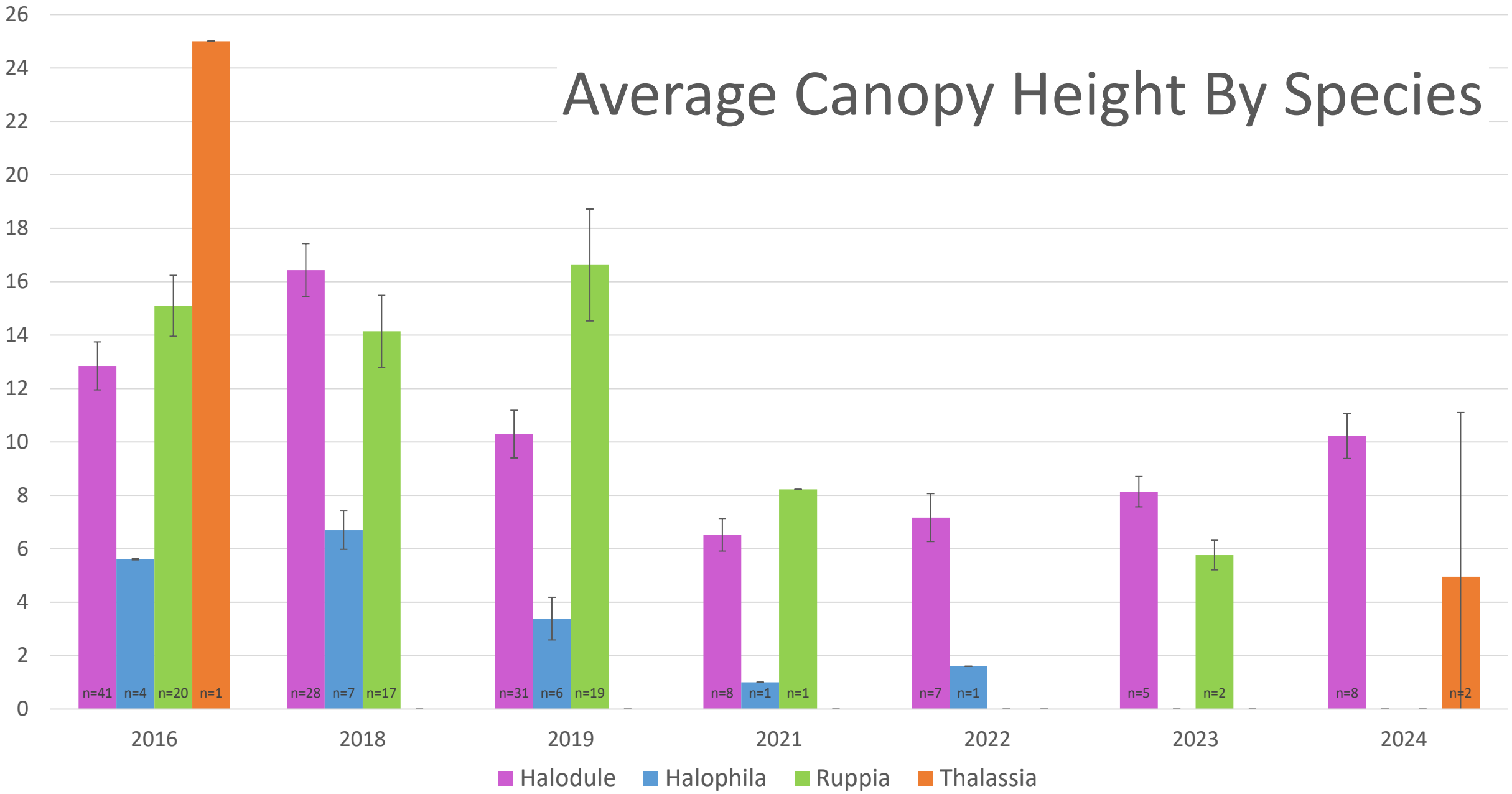


After

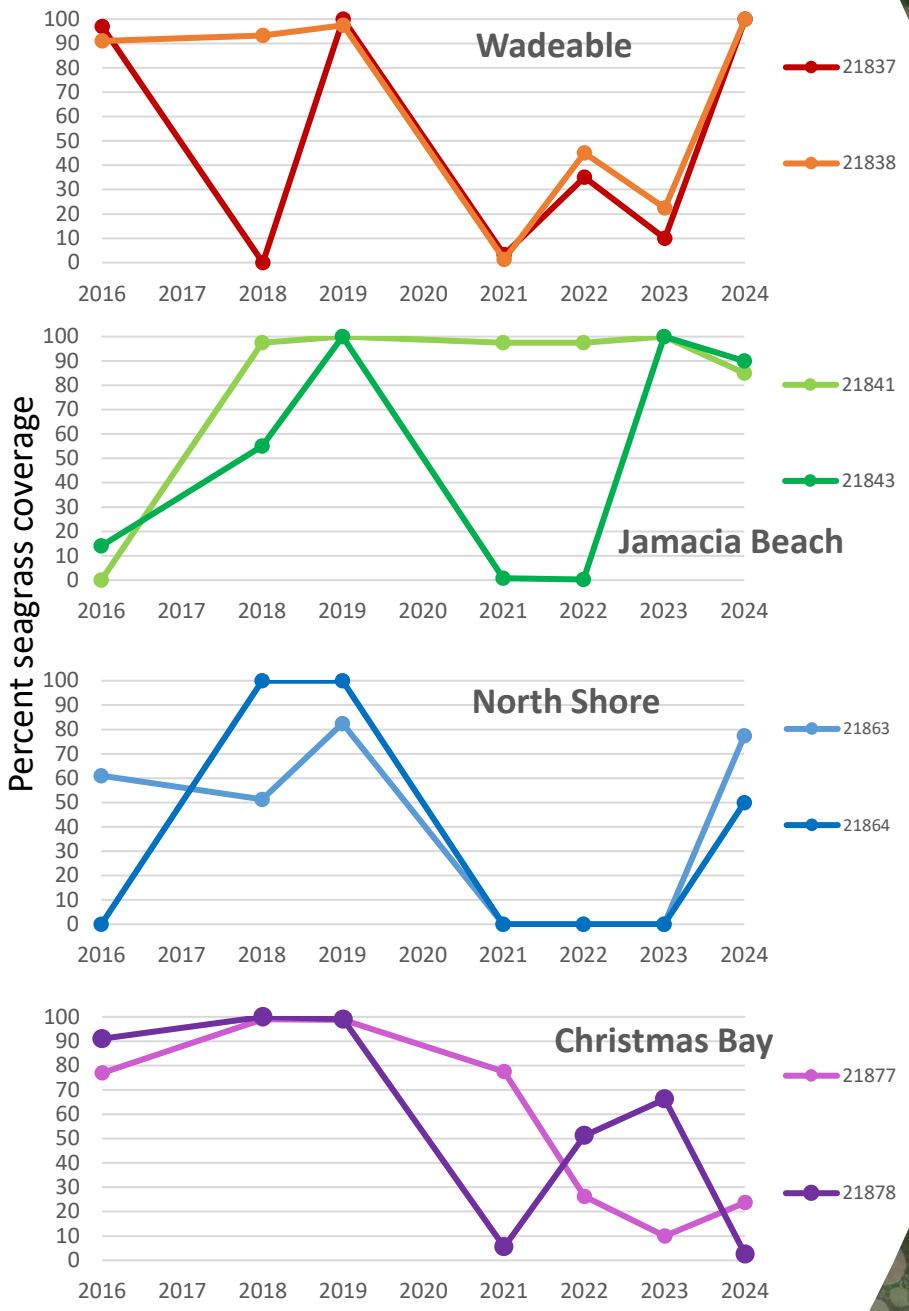


Total seagrass coverage and median percent of seagrass

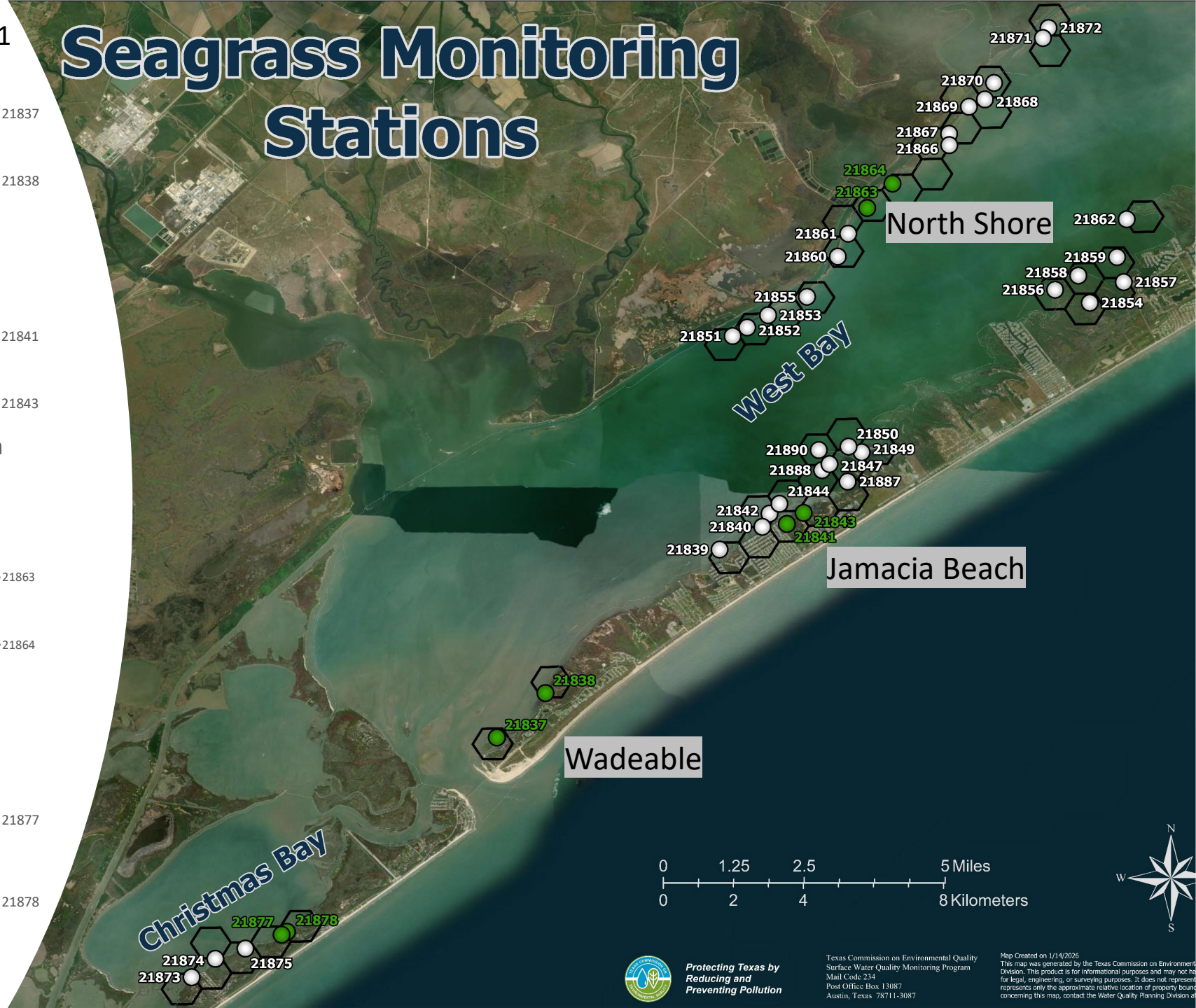



Average Canopy Height By Species
26
24
22
20
18
16
14
12
10
8
6
4
2
0
n=41
n=4
n=20
n=1
n=28
n=7
n=17
n=31
n=6
n=19
n=8
n=1
n=1
n=7
n=1
n=5
n=2
n=8
n=2
2016
2018
2019
2021
2022
2023
2024
Halodule
Halophila
Ruppia
Thalassia

Stations with >20% seagrass coverage since 2021



Seagrass Monitoring Stations



Protecting Texas by Reducing and Preventing Pollution

Texas Commission on Environmental Quality
Surface Water Quality Monitoring Program
Mail Code 234
Post Office Box 13087
Austin, Texas 78711-3087

Map Created on 1/14/2026
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In summary…

- Long-term seagrass monitoring provides a baseline for detecting both gradual change and isolated disturbance events.
  - Standardized methods and interagency coordination support efficient use of resources and allow comparisons across large spatial and temporal scales.
- Seagrass recovery patterns may be localized to small areas, emphasizing the importance of continued, site-specific monitoring in Galveston Bay.

Thanks to:

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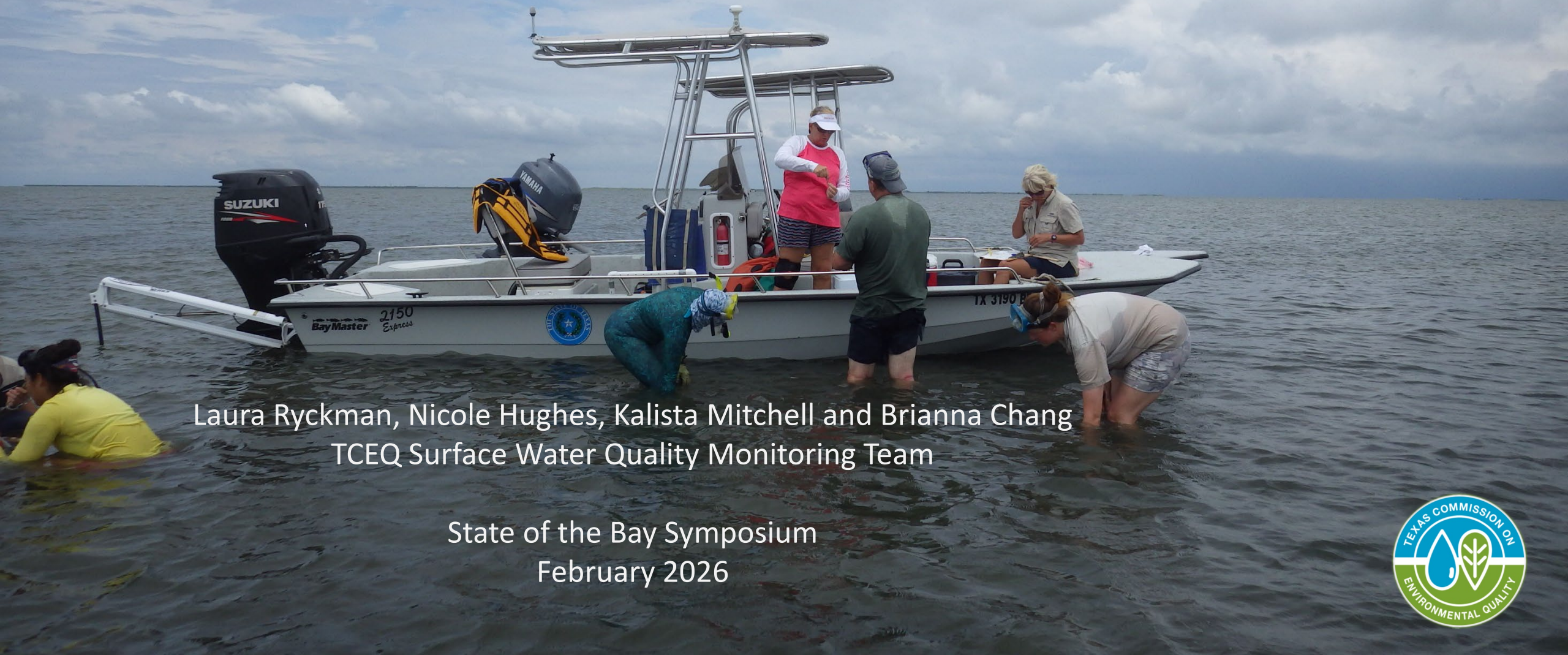
Kim Jackson, Victoria Congdon, Kyle Capistrant-Fossa, Lisa Young, Ken Dunton

Seagrass Community in West Bay and Christmas Bay: Observations from 2016 - 2024



Laura Ryckman, Nicole Hughes, Kalista Mitchell and Brianna Chang
TCEQ Surface Water Quality Monitoring Team

State of the Bay Symposium
February 2026

Evaluation of microplastic loading in marsh habitats associated with Texas Diamondback Terrapin (*Malaclemys terrapin littoralis*)

Gabrielle Hammerbach[1,2*], Mandi Gordon[2], Danielle DeChellis[2], Lydia Thurman[1,2], Cynthia Howard[1]

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Galveston, TX; February 24th and 25th, 2026

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Other Contributors

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Permitting, Institutional Protocols, Access Permissions

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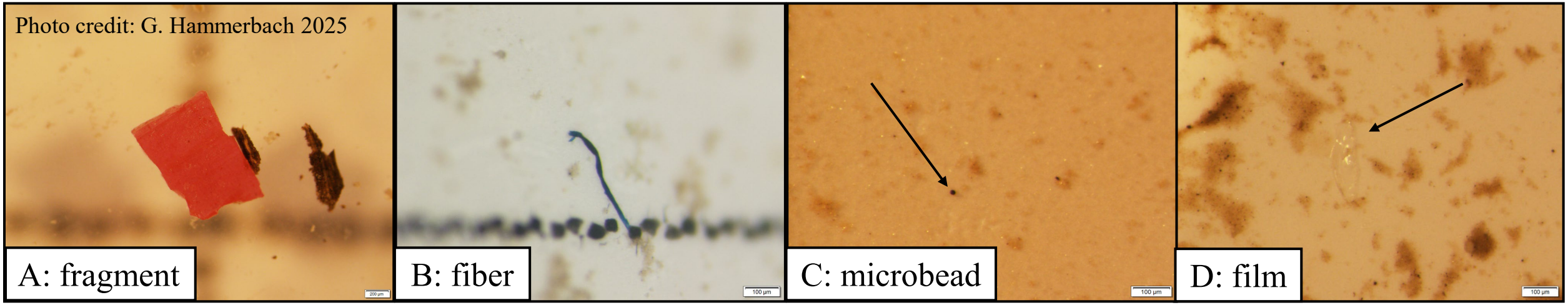
University of Houston Clear Lake

Environmental Institute of Houston

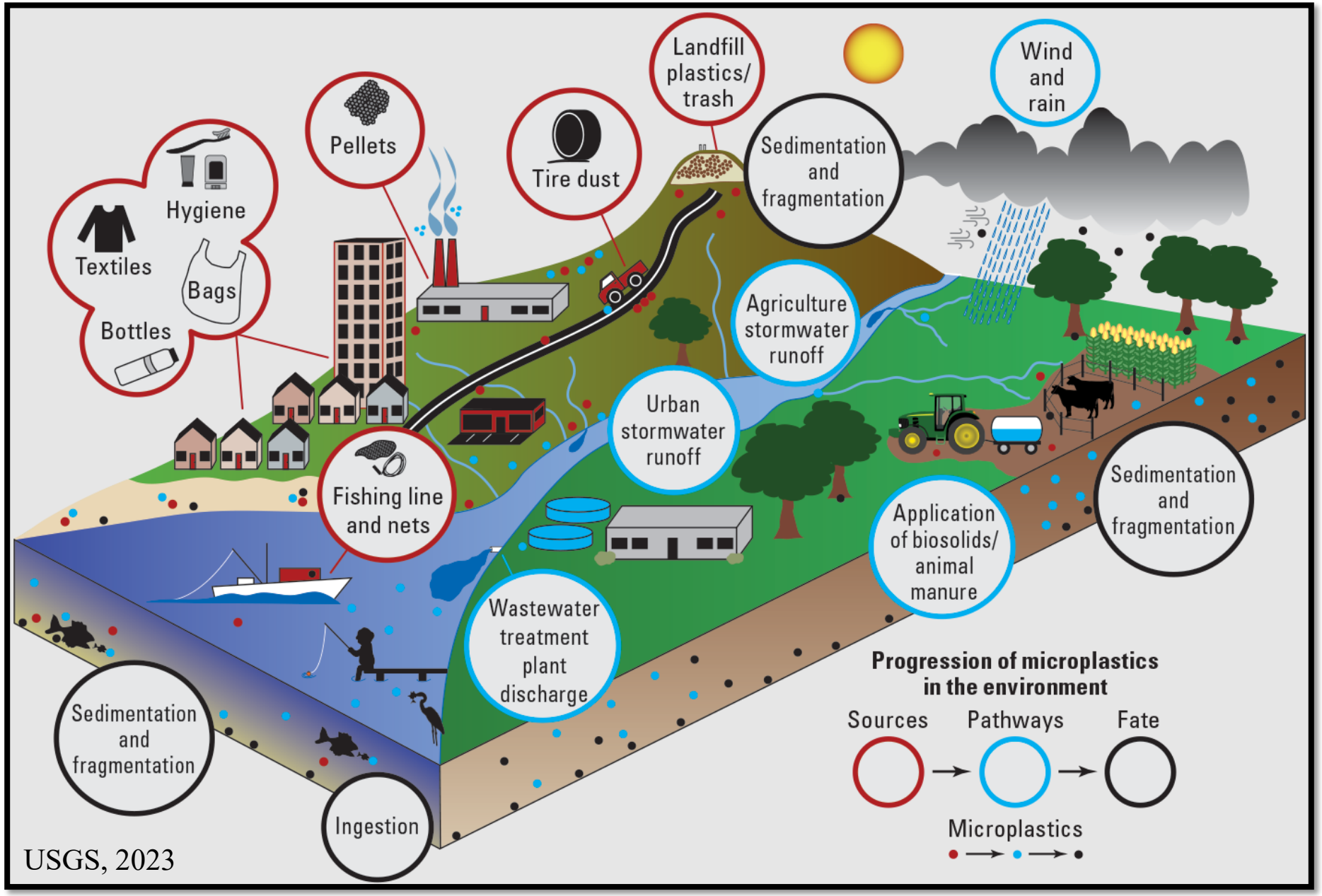
MATAGORDA BAY MITIGATION TRUST

Introduction – What are Microplastics?

- 1-µm to 5-mm in dimension (Dong et al., 2023)
- Composed of synthetic polymers such as polyethylene (PE), polyvinyl chloride (PVC), polypropylene (PP), polystyrene (PS) (Hou and Rao, 2022)
- Classified by type (i.e., fragment, fiber, microbead, film, etc.) (Markley et al. 2024)



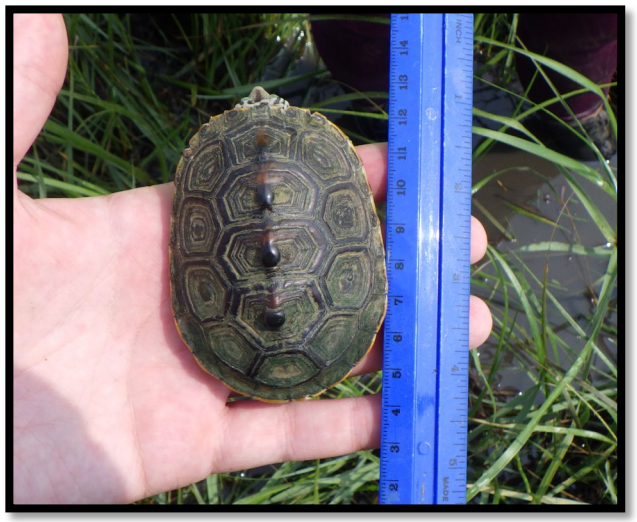
Introduction – How do they get into the environment?



Terrapin as a Sentinel Species

Texas Diamondback Terrapin (*Malaclemys terrapin littoralis*)

- Species of greatest conservation need (TPWD, 2023)
- Representative of many species
- Long life span (Brennessel, 2006)
- Critical habitat (brackish, low-lying wetlands)



Introduction – Objectives and Hypotheses

1. Quantify surficial microplastic distribution in salt marshes associated with a species of concern

H_o: There will be no statistical differences between microplastic concentrations across sites

H_a: There will be statistical differences between microplastic concentrations across sites

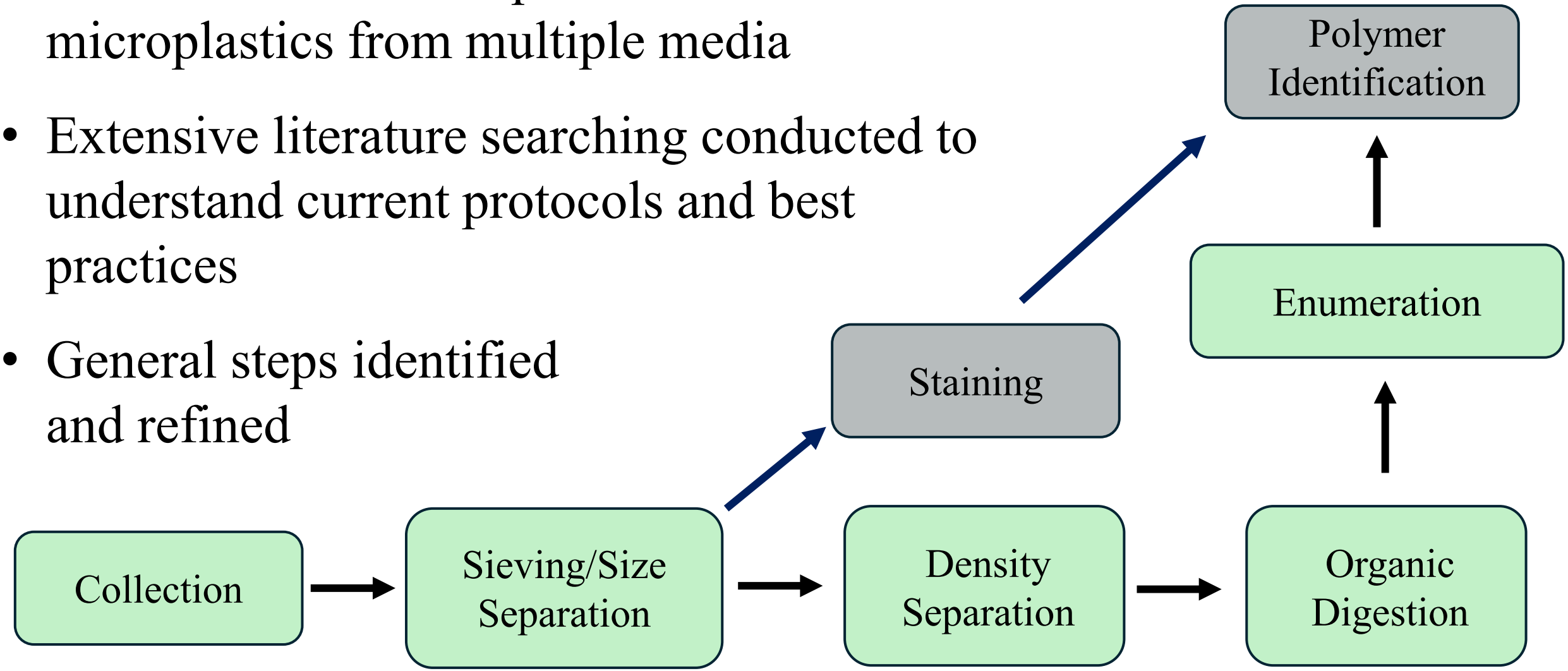
2. Evaluate distinctions in quantities and types of microplastics between sample types (a) taken at shorelines and (b) taken at locations at the inner marsh.

H_o: There will be no statistical differences in microplastic concentrations or types between shoreline and inner marsh samples

H_a: There will be statistically higher microplastic concentrations in samples collected at the shoreline compared to inner marsh

Steps for Identifying Microplastics

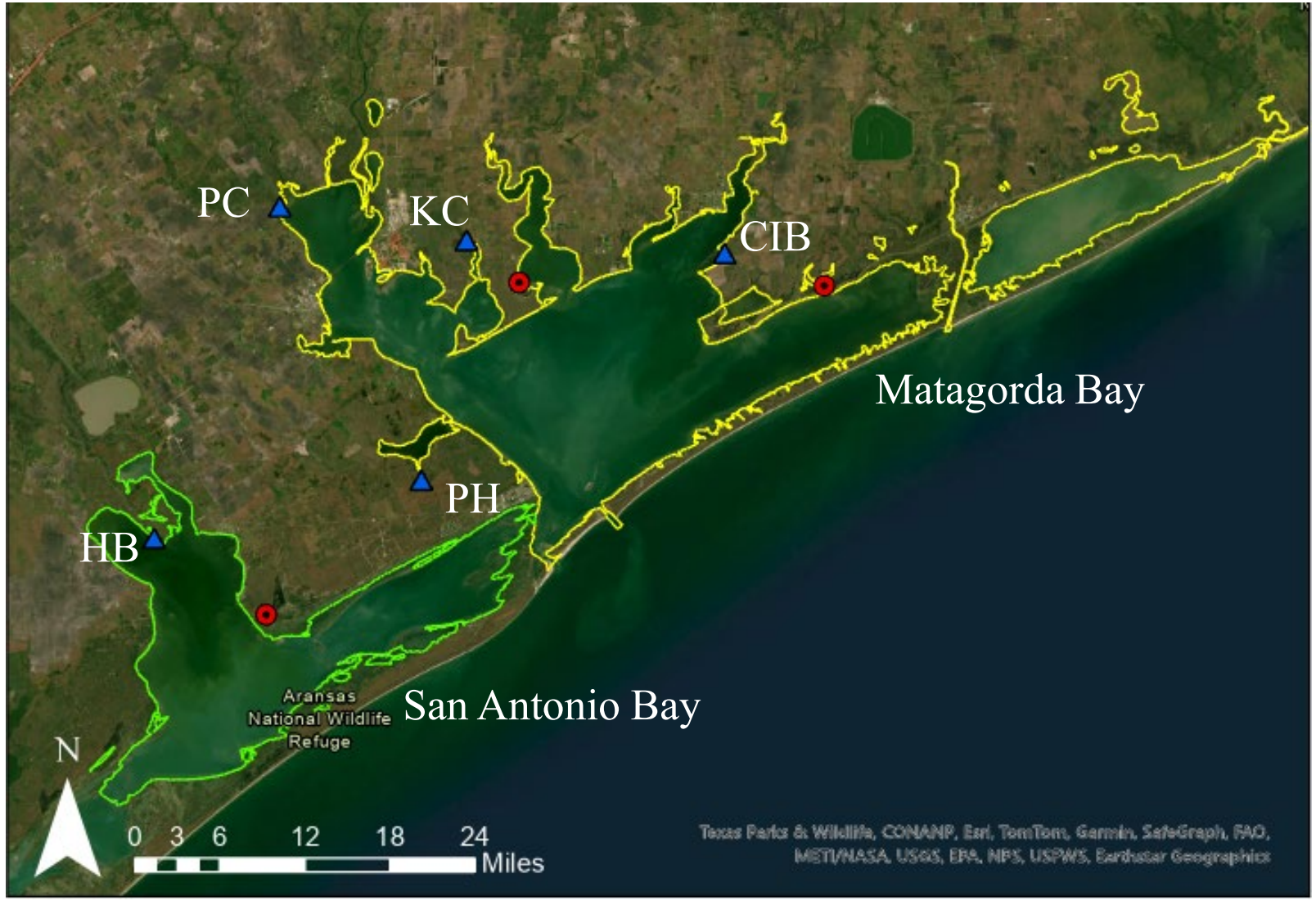
- Lack of standardized protocols for extraction of microplastics from multiple media
- Extensive literature searching conducted to understand current protocols and best practices
- General steps identified and refined



Methodology – Site Selection

Sites Evaluated

HB: Hynes Bay
PC: Placedo Creek
PH: Powderhorn WMA
KC: Keller Creek
CIB: Coon Island Bay



Sediment Sample Collection – Quadrat Selection

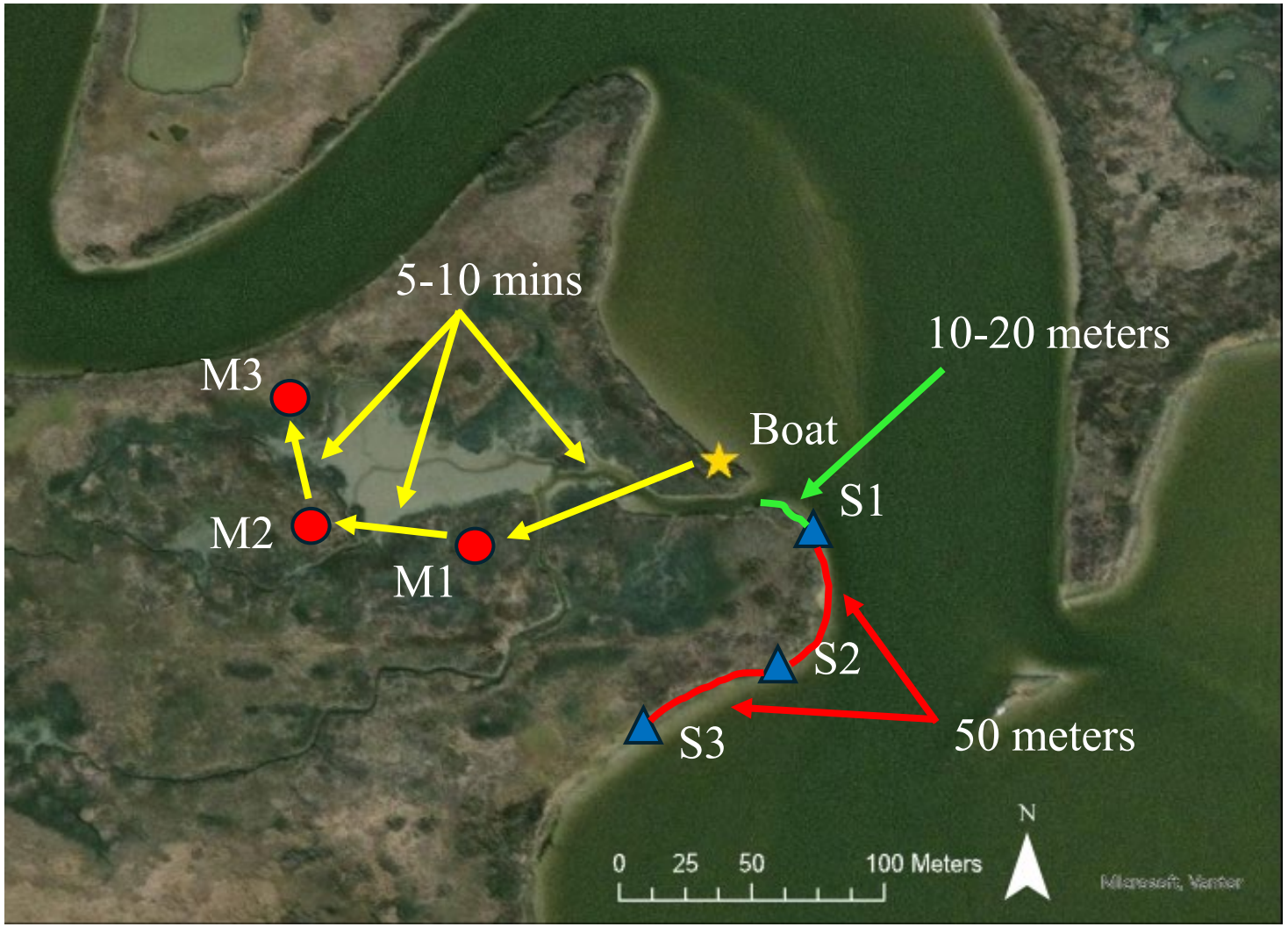
Shoreline Samples

- A direction and distance between 10 and 20 meters is randomized
- Subsequent quadrats are 50 meters apart or equidistant if marsh shoreline is <120 meters

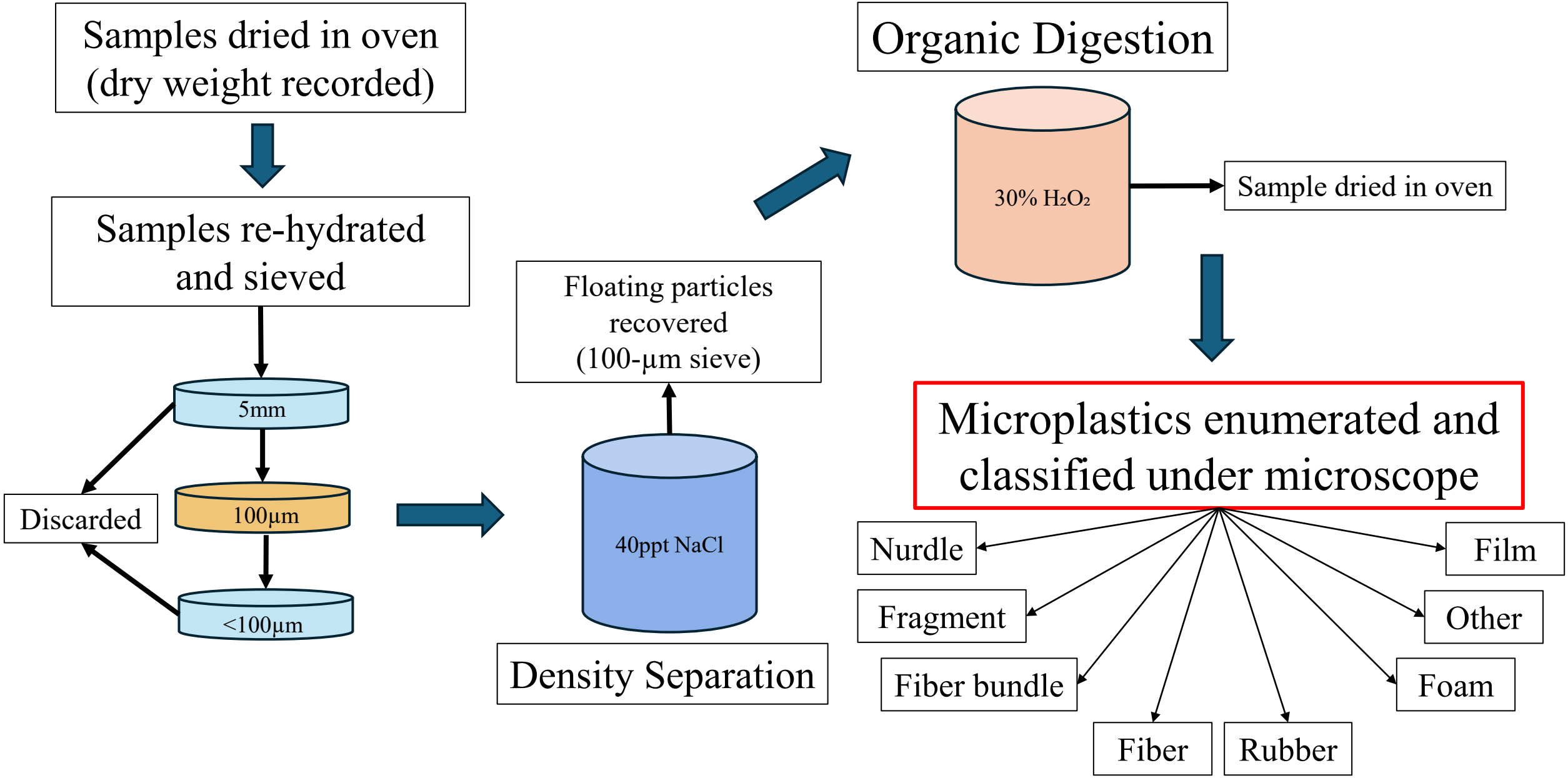
Inner Marsh Samples

- A randomized number of minutes between 5 and 10 is selected to transect (walk) to the quadrat

n = 3 cores per quadrat
n = 18 per site, per visit



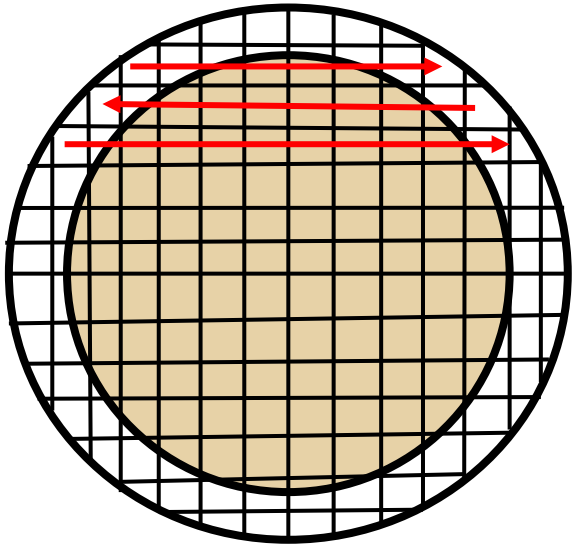
Laboratory Processing Flow Chart

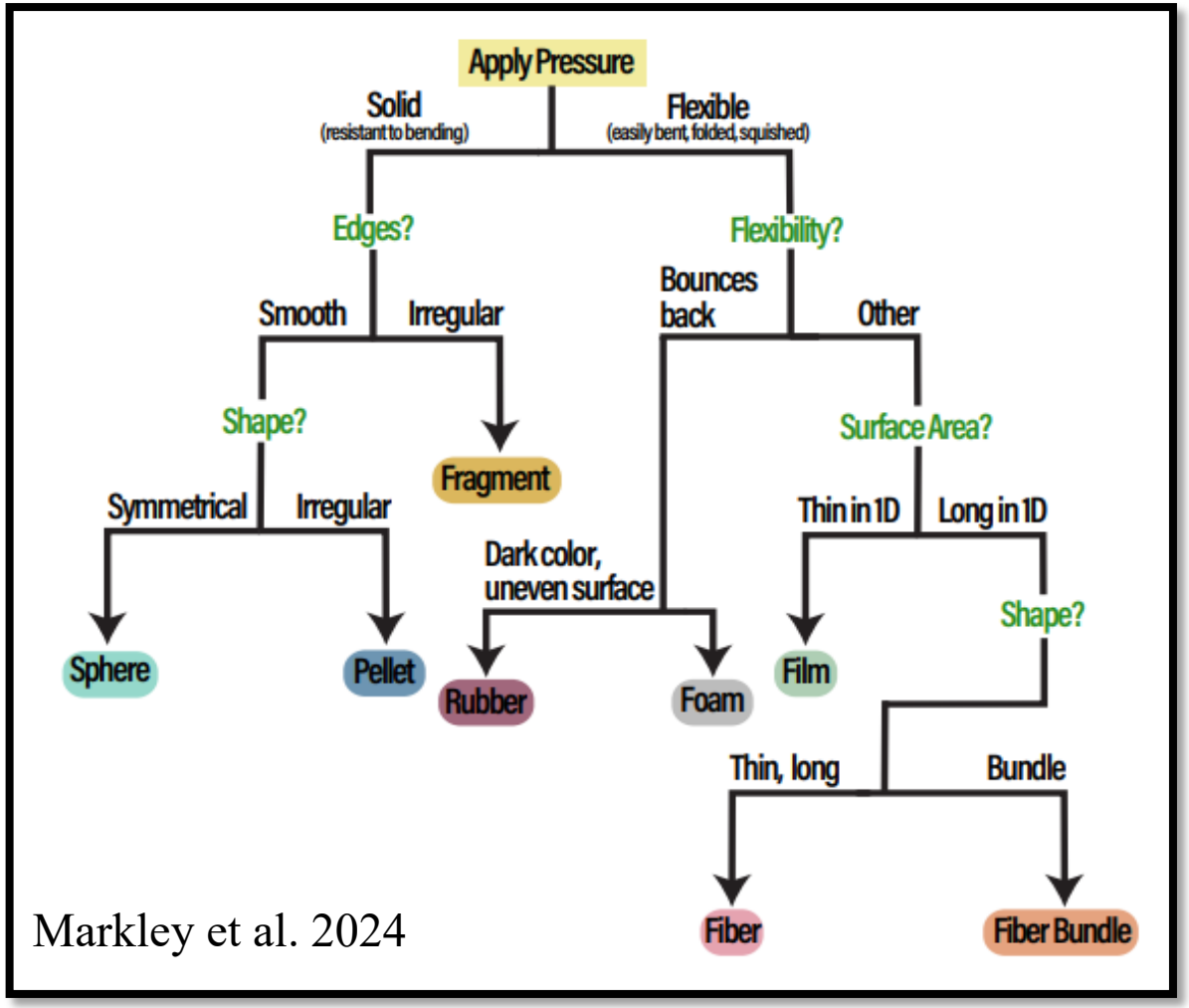


Enumeration

Microplastics enumerated and classified under microscope

- Nurdle
- Fragment
- Fiber bundle
- Fiber
- Rubber
- Foam
- Other
- Film

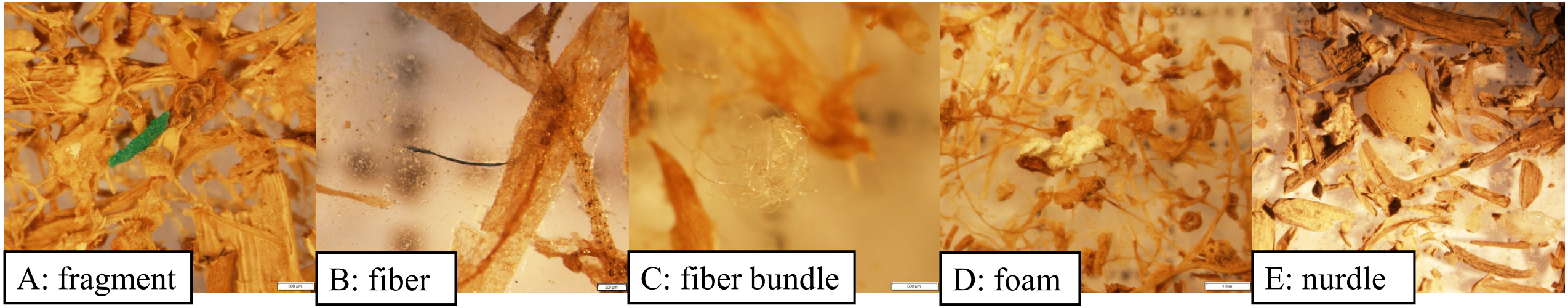




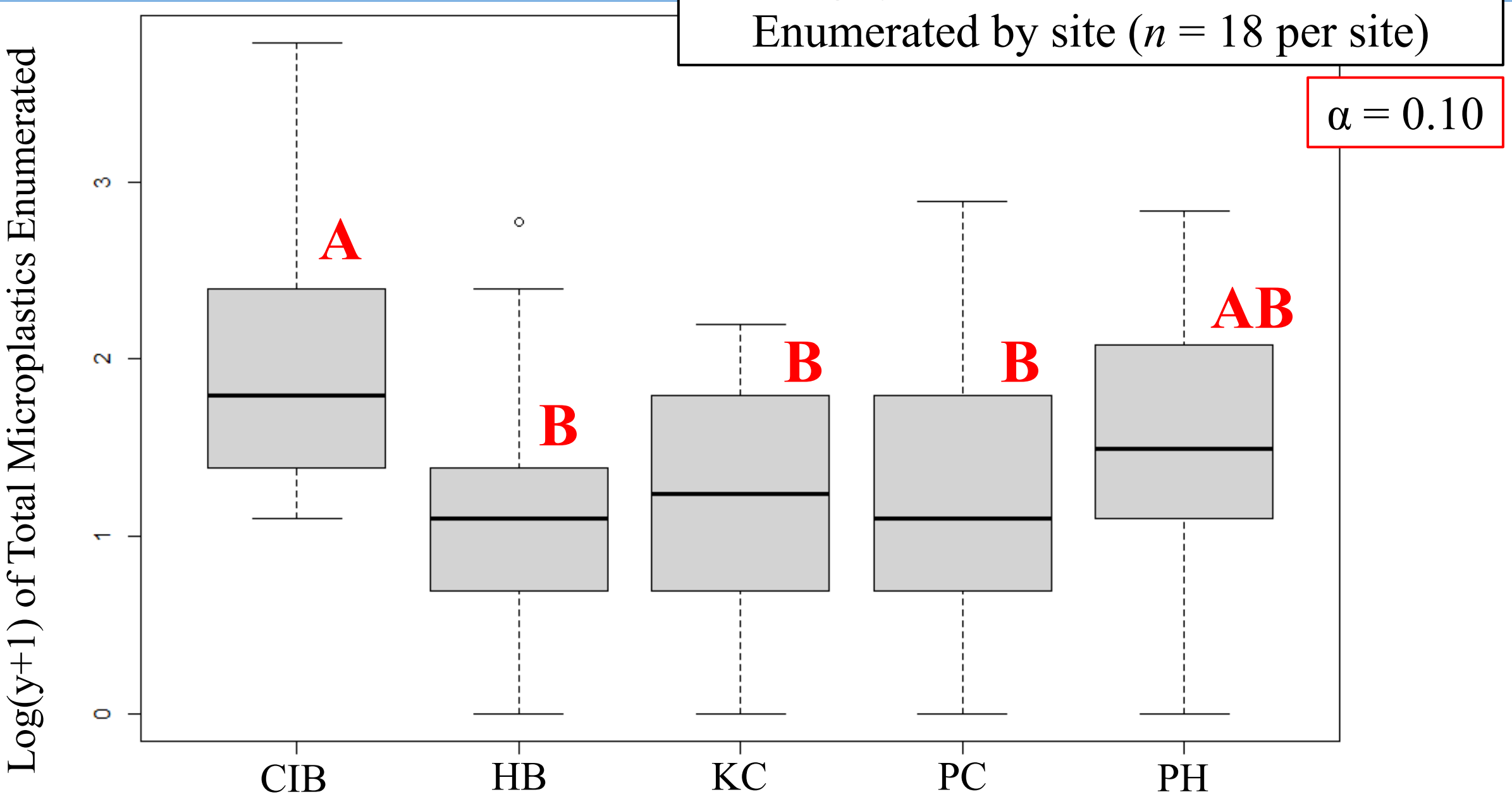
Markley et al. 2024

Results

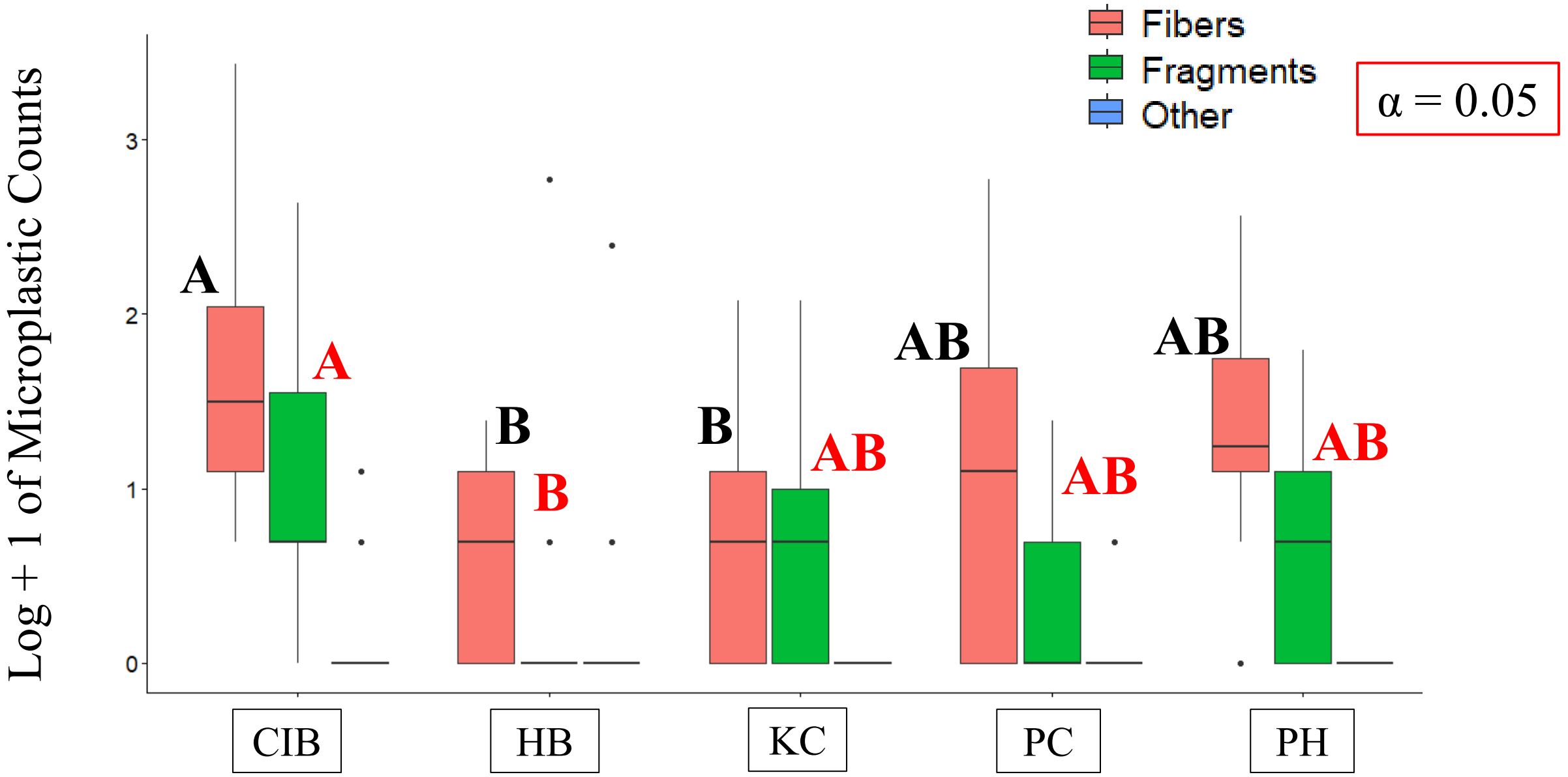
- 430 individual microplastics counted, 5 microplastic types identified ($n = 90$)
- 87% samples contained at least 1 microplastic
- Approximately 4 microplastics per 100-g of sediment collected



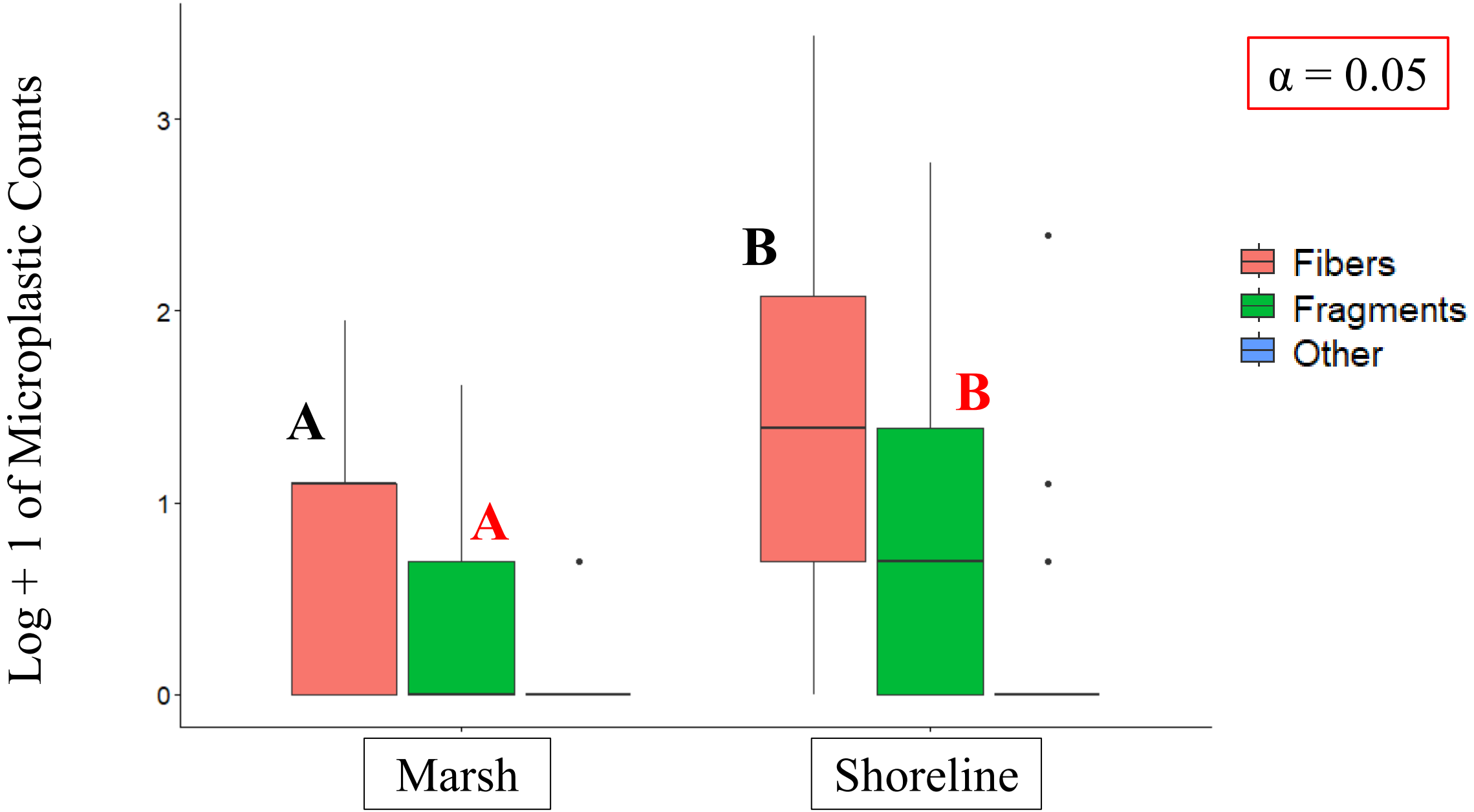
Results


Log (y +1) of Total Microplastics
Enumerated by site (n = 18 per site)
α = 0.10
Log(y+1) of Total Microplastics Enumerated
0
1
2
3
A
B
B
B
AB
CIB
HB
KC
PC
PH

Results – Site Comparison



Results – Sample Type Comparison



Results – What does 430 Microplastics mean?

No. of Microplastics in $n = 18$ samples

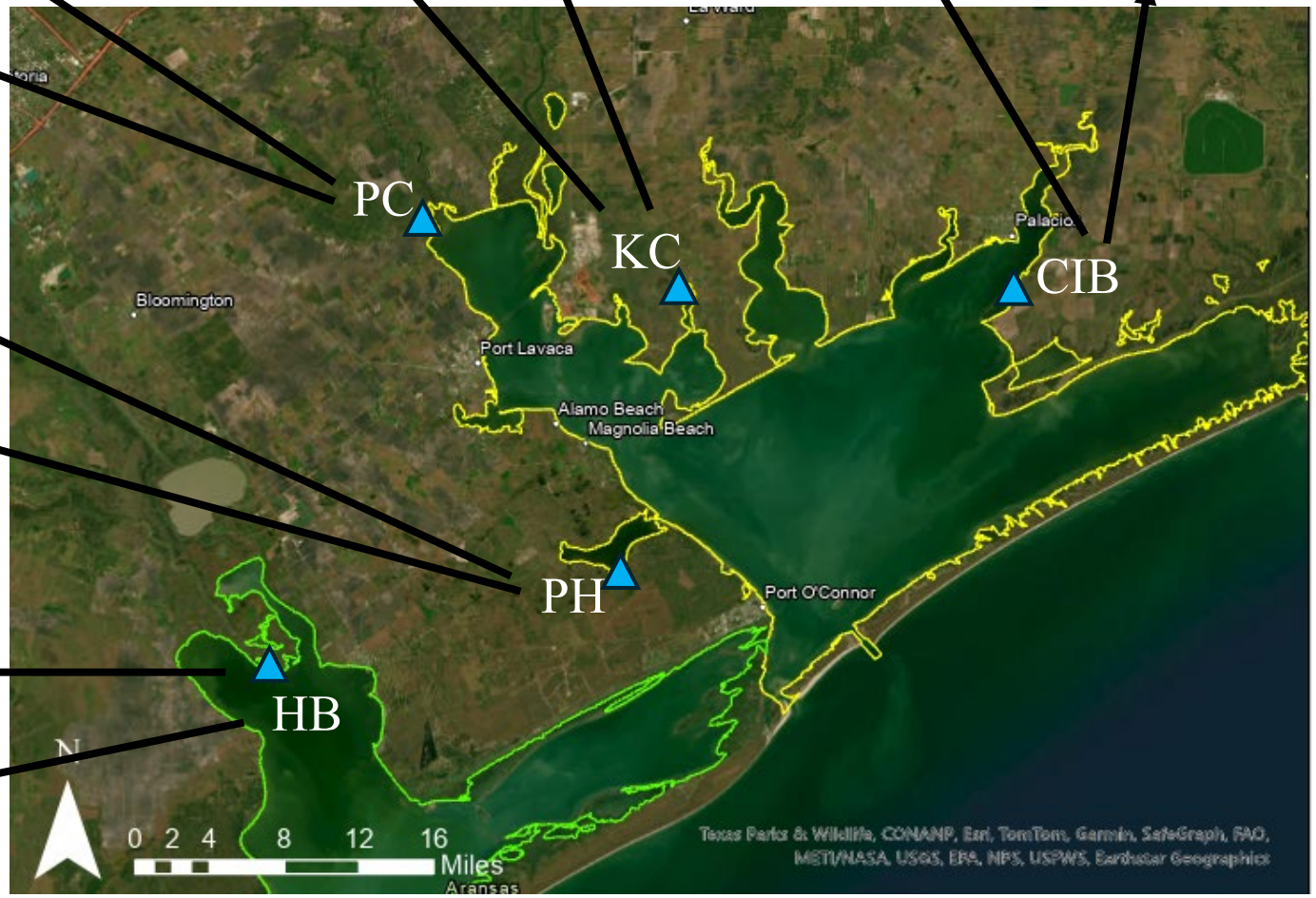
↓

Extrapolate by surface area/volume of core

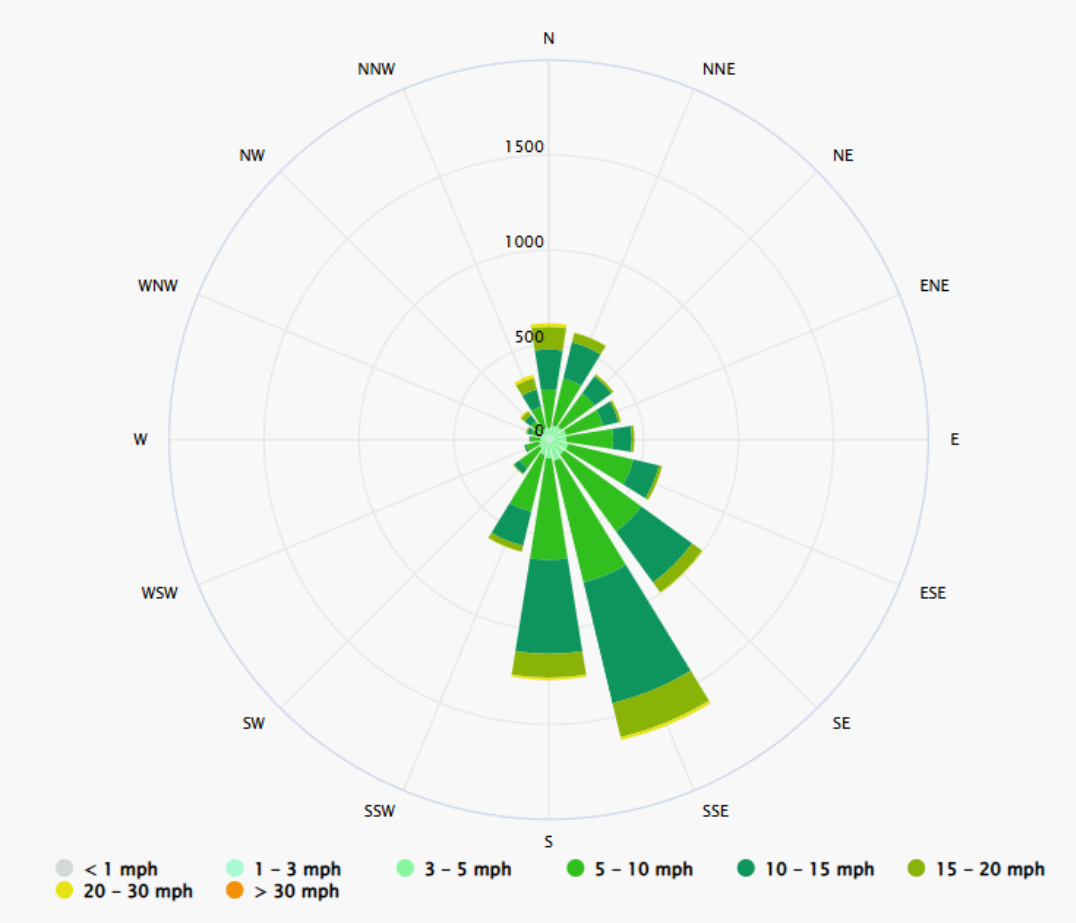
↓

Multiply by approximate surface area of site

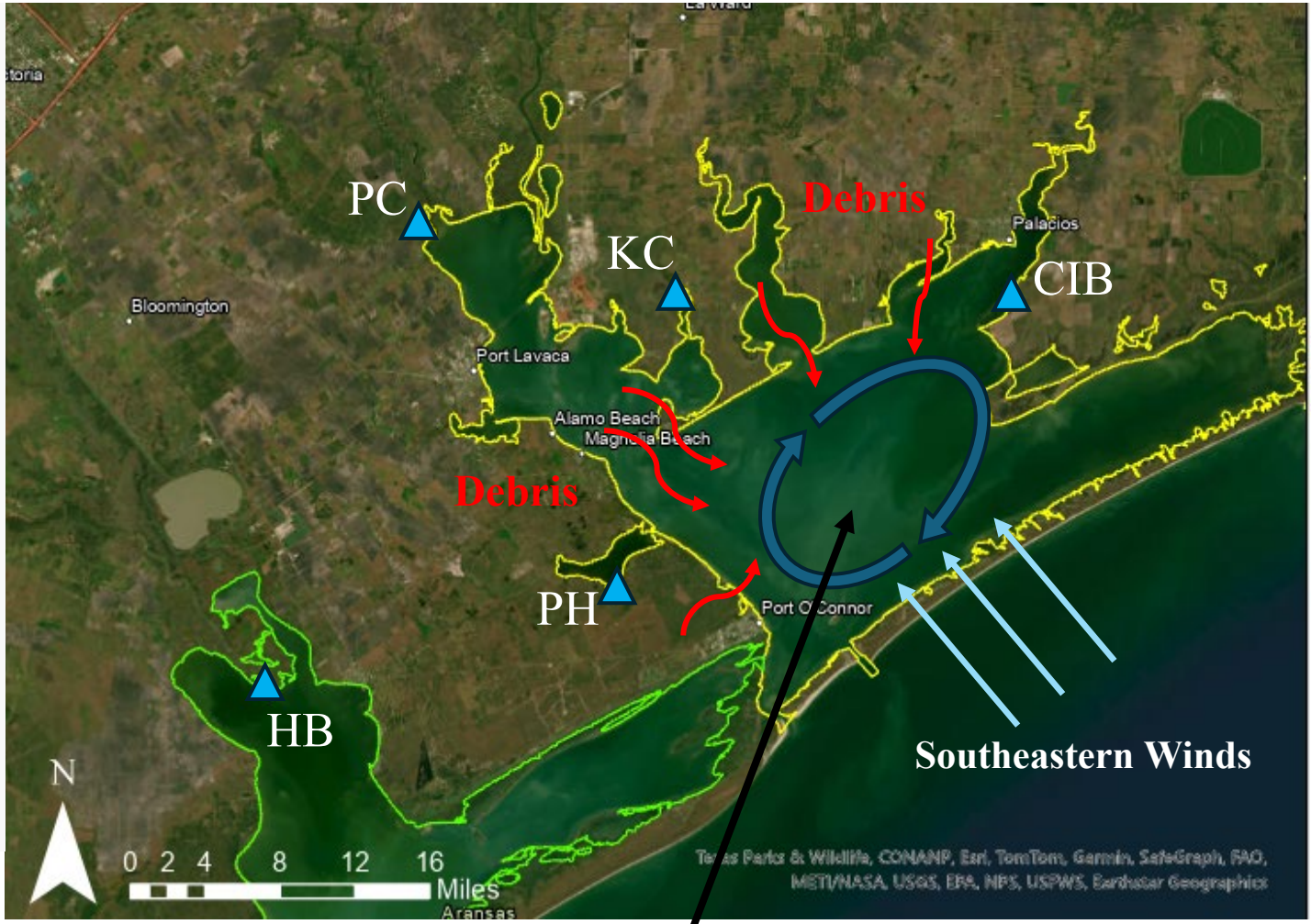
No. Per 1-m²	No. Throughout Site
869	654
7.06 x 10^8	6.39 x 10^8
1,119	2,113
9.56 x 10^8	1.09 x 10^9
654	
3.21 x 10^9	



Discussion

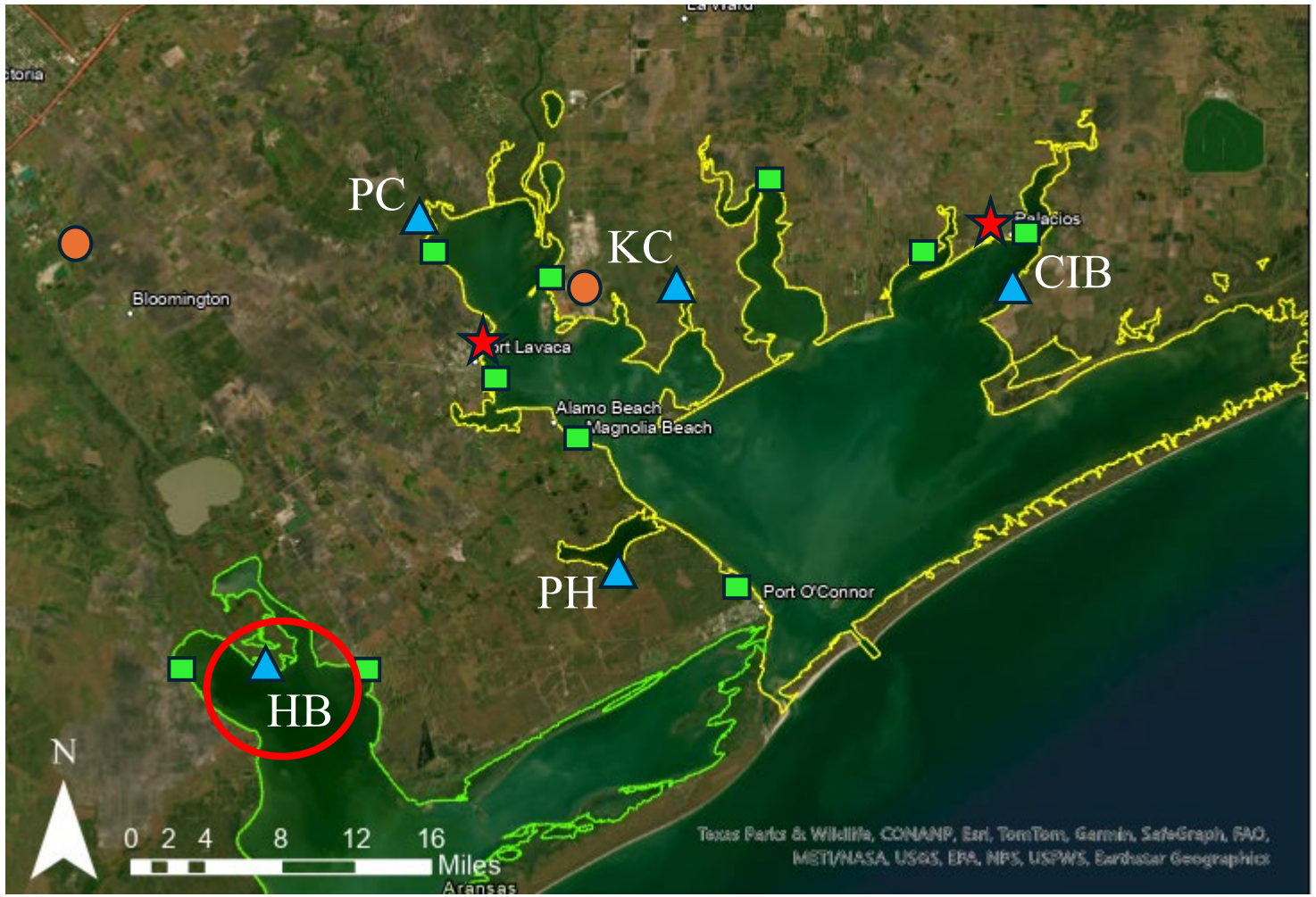


Wind rose for Matagorda, TX, indicating how many hours a year the wind blows from the indicated direction (Metoblue, 2025).



Clockwise Circulation

Discussion



= Wastewater treatment facility

= Plastic production facility

= Public boat ramp

= Site(s) evaluated

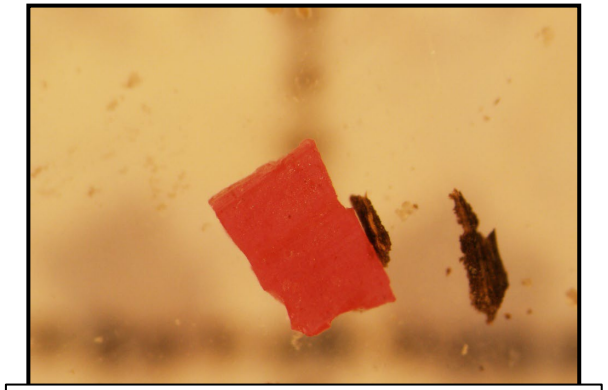
Why?

- Proximity to recreational and commercial fishing activities
- Proximity to point sources
  - Urbanized residential areas
  - Wastewater treatment facilities
  - Plastic production facilities

Discussion – Concern for Wildlife and Terrapin

In Summary:

- Microplastics are present in saltmarsh habitats associated with a species of concern
- Microplastics may pose a toxicological concern for wildlife
- Further investigation is needed to determine extent of effects across trophic levels



Microplastics

Discussion – Contamination Mitigation and Next Steps

- Contamination mitigation
  - Vibrant, neon yellow shirt worn during collection
  - 100% cotton lab coats worn during processing
  - Rinsing equipment and processing sediment with <100-µm filtered water
  - Metal tools, aluminum foil collection receptacles
- Continuation of sample processing: surficial samples, profile samples, fecal samples
- Additional data coming from Galveston Bay through proxy site, South Deer Island
- Recommendation of implementing new protocols: fluorescent staining and/or polymer identification methods

Thank you!

University of Houston Clear Lake

Environmental Institute of Houston

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MATAGORDA BAY MITIGATION TRUST

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Supplemental Table

Table 1 Extrapolation of the number of microplastics potentially present in each site at any given time, using estimations from the samples analyzed. The total number of microplastics present at the site was divided by the surface area of the sediment evaluated.

Site	No. of microplastics in $n = 18$ samples	Potential No. of microplastics per 1-m^2	Estimated area of site (m^2)	Potential No. of microplastics throughout the site
Coon Island Bay	168	2,113	515,922	1.09×10^9
Keller Creek	52	654	976,331	6.39×10^8
Placedo Creek	69	869	812,191	7.06×10^8
Hynes Bay	52	654	4,910,877	3.21×10^9
Powderhorn WMA	89	1,119	853,924	9.56×10^8

Supplemental Table

Table 2 Types of microplastics identified in *n* = 90 samples, and the number of samples containing at least 1 of the specified type

Microplastic Type	Total Count	No. of Samples	% of Samples
Fiber	278	69	76 %
Fragment	136	49	54 %
Nurdle	10	1	0.01 %
Fiber Bundle	4	4	0.04 %
Foam	2	1	0.01 %

Varied Phenology and Partial Seasonal Migration in Juvenile Green Turtles: Evolutionary Safeguards for Adaptive Potential?

Madelyn H. Rupp [1,2], Simonitis L.E.[3], Morris T. [1,2], Marshall C.D.[1, 2, 5]

[1] Gulf Center for Sea Turtle Research, Texas A&M University

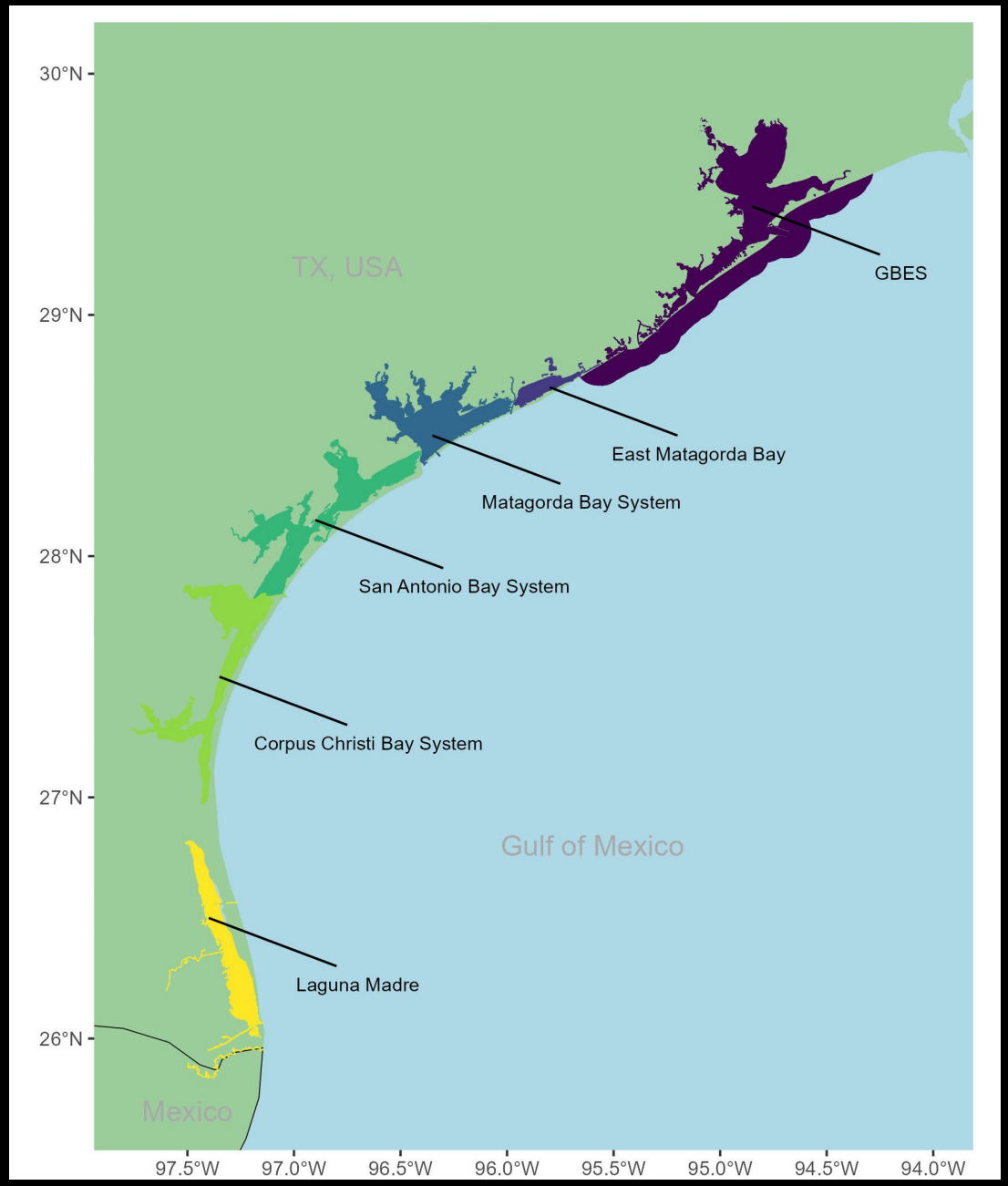
[2] Department of Marine Biology, Texas A&M University at Galveston

[3] Department of Biological Sciences, Florida Atlantic University

[4] Department of Ecology and Conservation Biology, Texas A&M University

Study System: GBES

- Galveston Bay Estuary System (GBES)
  - Comprised of lower Galveston Bay Watershed, and includes Galveston Bay proper, Trinity, East, South, West, Christmas, Bastrop, Drum, and Arcadia Bays, as well as the adjacent coastal habitats



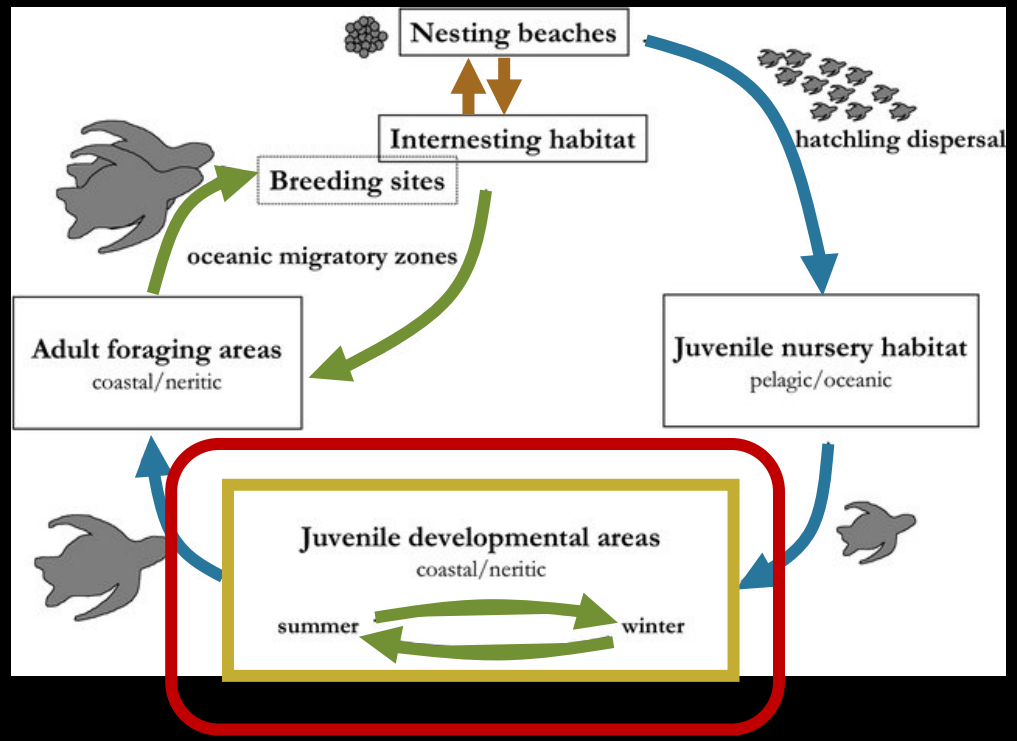
Species in the GBES

Green turtles in the GBES

- Most abundant species
- Juveniles
  - ~25-70cm SCL
- Seasonal development ground
- Natal rookeries unknown
- Adult foraging ground unknown

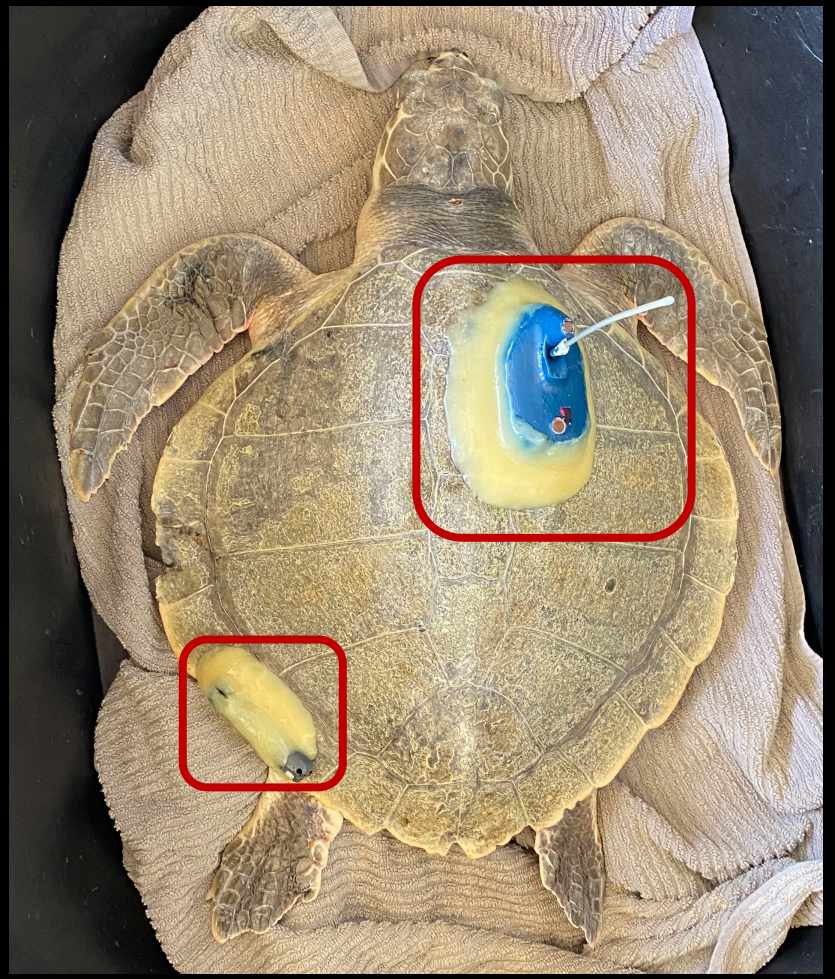
Study System: Sea Turtle Life History

- Background:
  - Movement between habitats
    - Dispersal/Recruitment
    - Migration
      - Seasonal habitats
  - Movement within a habitat
    - Habitat connectivity
  - Development grounds



Movement Data

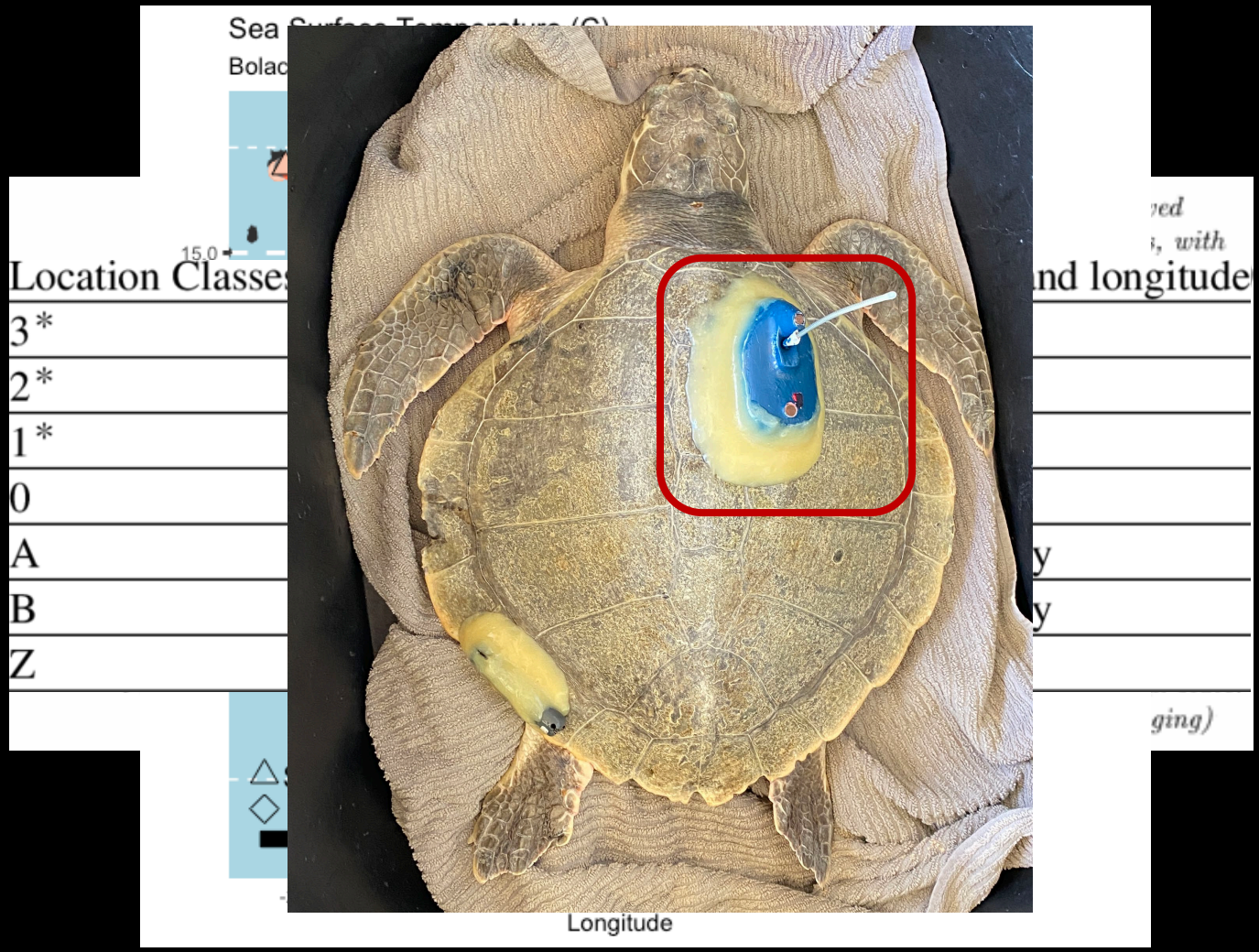
- Acoustic telemetry
  - Presence/absence data
  - High spatial resolution
  - Manual data recovery
  - Geographically constrained
- Satellite telemetry
  - Geolocation data
  - Location error
  - Automatic data transmission



Satellite Telemetry

- Identify habitats
  - Migrations
- Infer behavioral state
- Environmental variables
  - Extraction
  - Collection

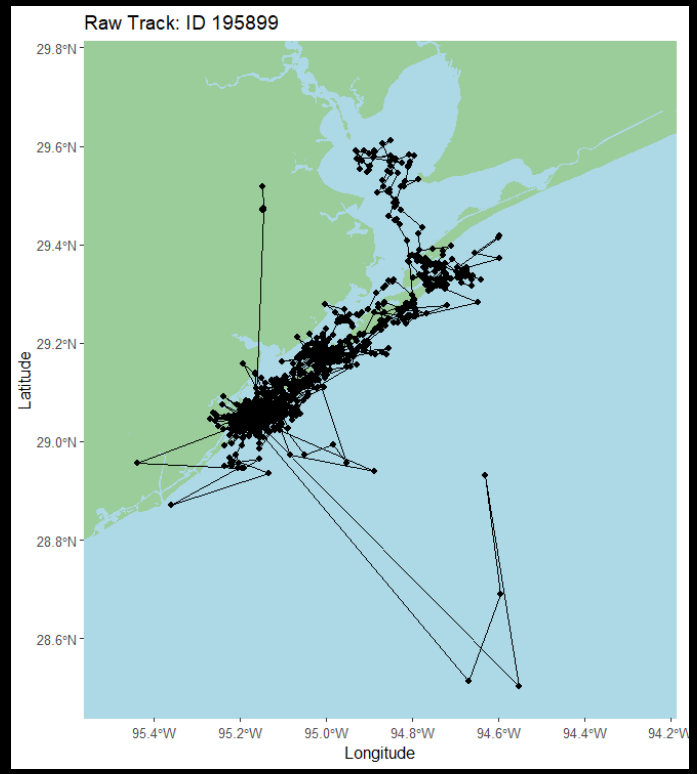
- Tag loss
- Observation Error
- Location error

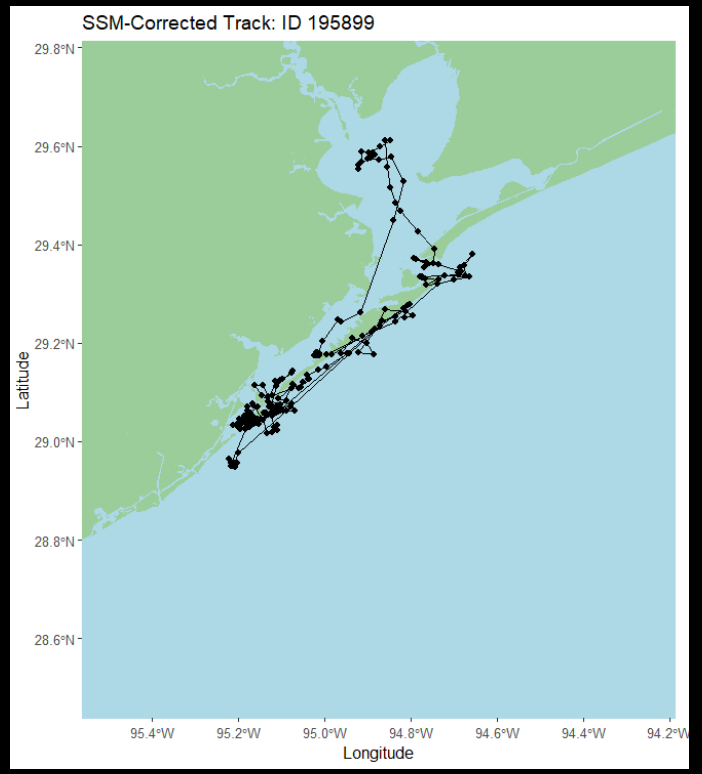


From Patterson et al.,

Satellite Telemetry – State-Space Models (SSMs)

- Accounts for:
  - Observation error
  - Location error
- Regularizes time intervals
- Hierarchical SSMs
  - More robust
  - Uses movement parameters of the entire sample, not a single individual

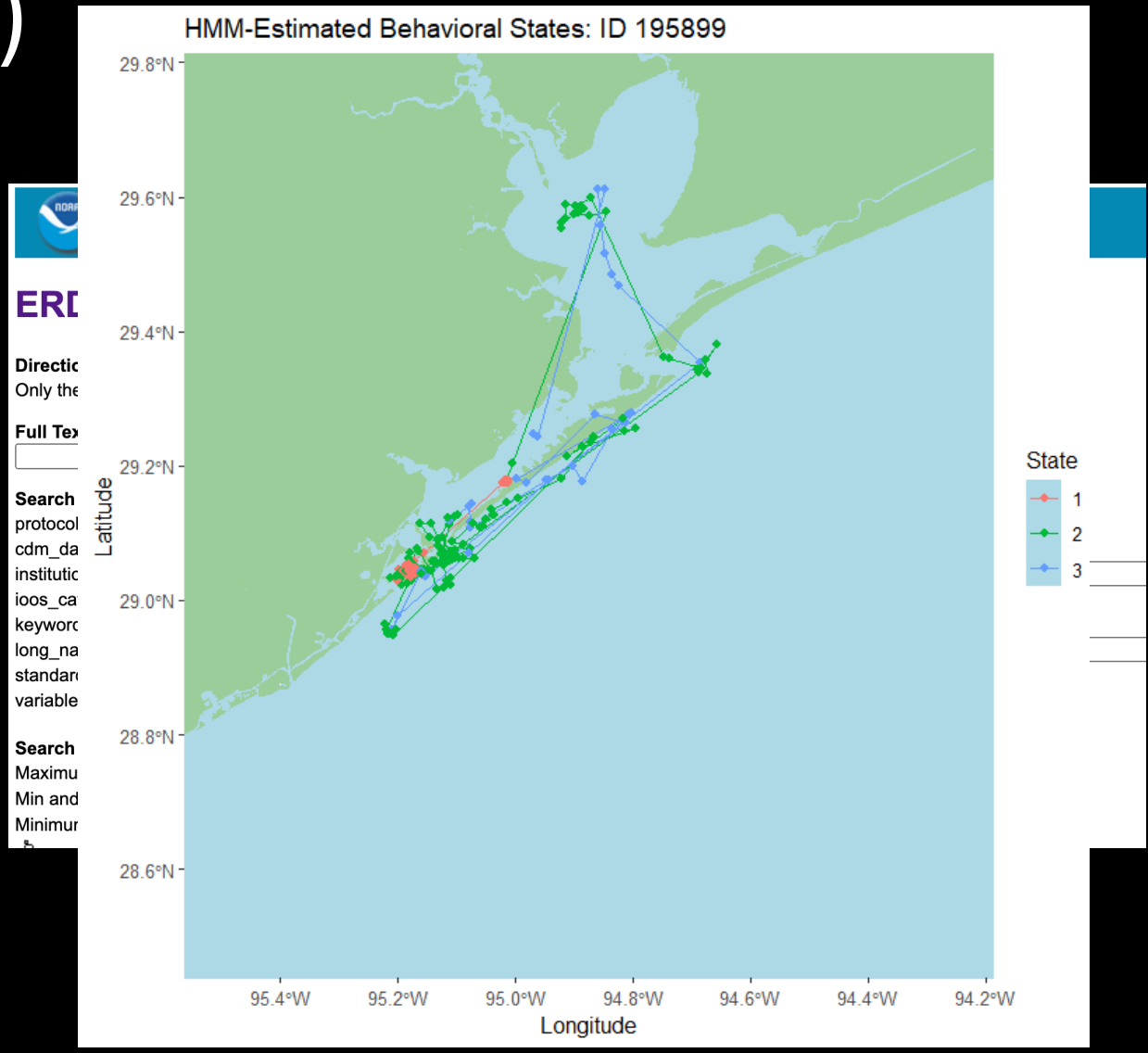




Environmental Drivers of Movement – Hidden Markov Models (HMMs)

- Estimate behavioral state value for each point

- Investigate environmental covariates effect on behavioral state
  - Chl-a
  - SST
  - SSHa
  - Depth
  - Month
  - Individual ID
  - Seasonal behavior



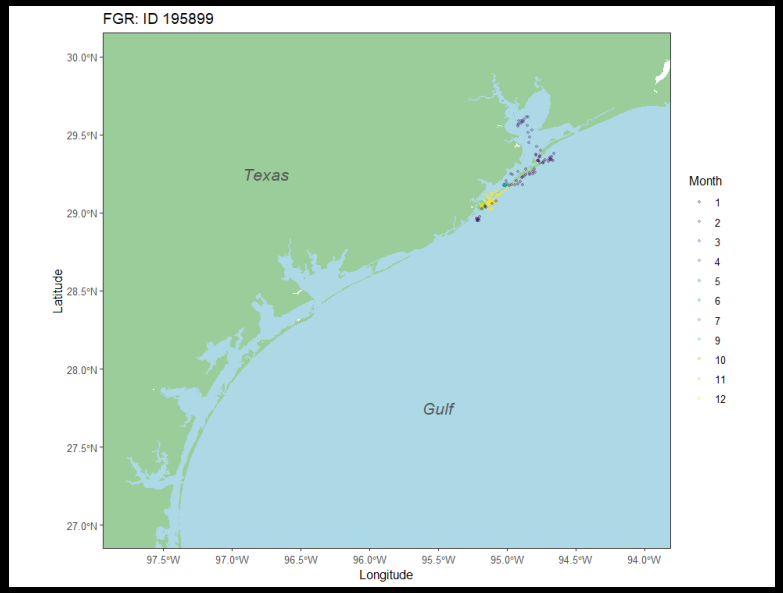
Expected Results

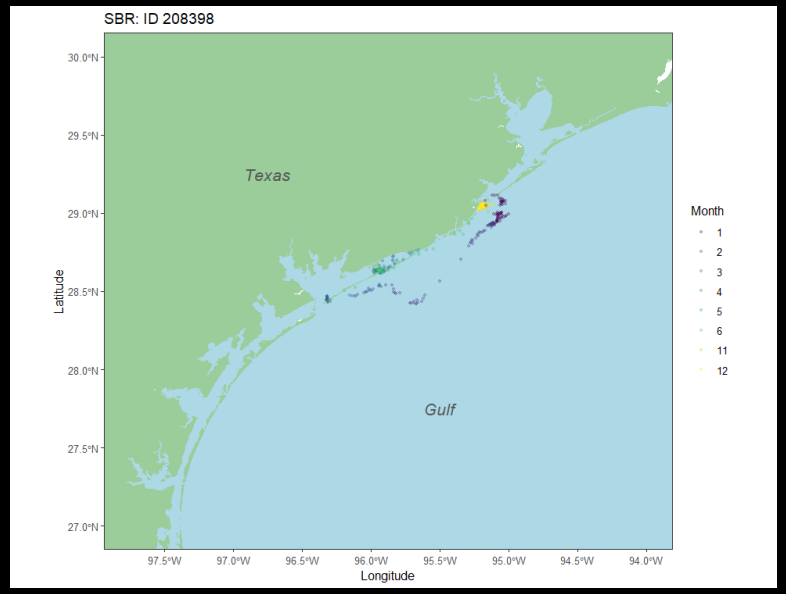
- Green turtles ingress and egress the GBES
- Seasonal migrations between foraging grounds
- SST and chl-a will be the most significant environmental drivers
- In the Gulf, high frontal probability, SSH, and SSHa will be significant predictors of foraging habitat

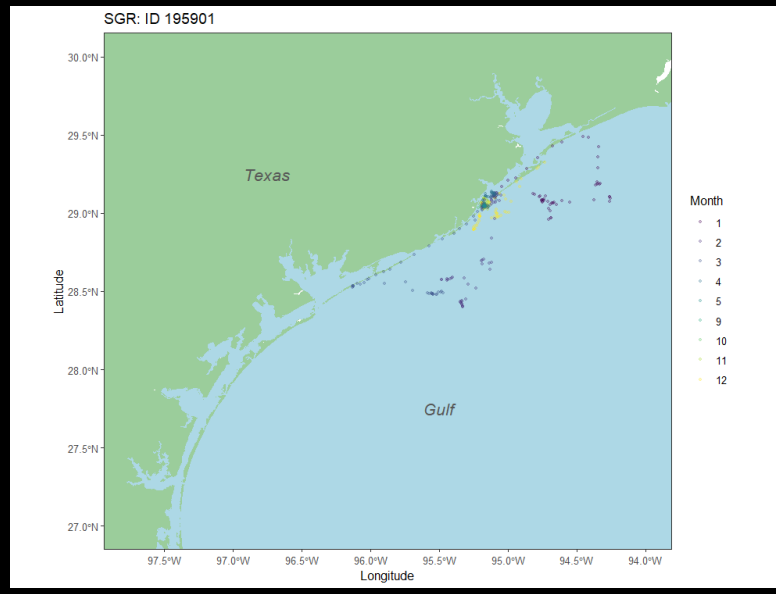
Results & Implications

1.) Partial seasonal migration and several distinct seasonal behaviors

- Several distinct foraging grounds
- Reservoir of adaptive potential
  - Multiple habitats
  - Varied phenology



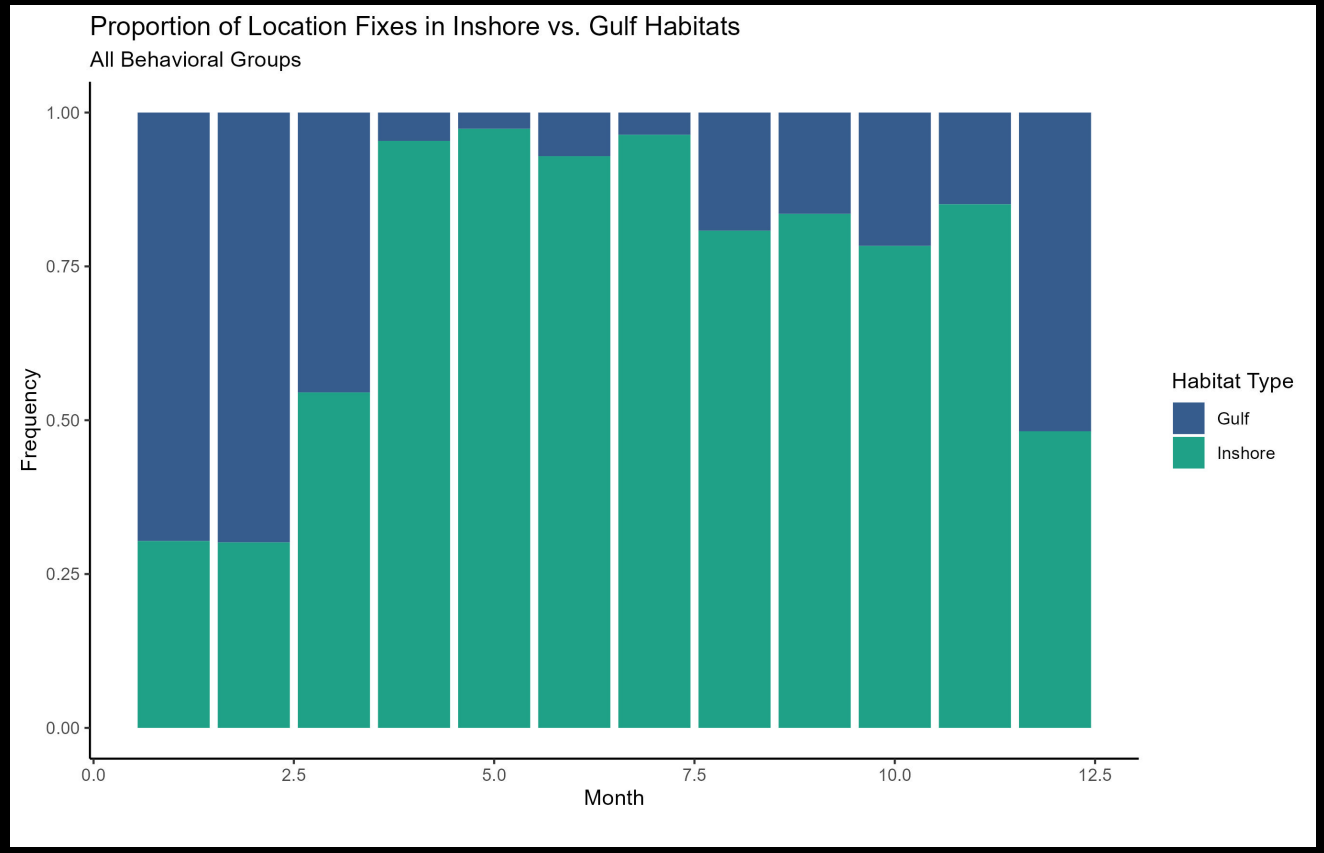




Results

2.) Phenology of seasonal behavior varied

- Reservoir of adaptive potential
- Mass mortality events
- Trade-off: cold-stuns



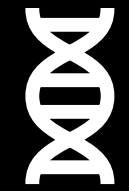
Results

3.) Depth is the most significant environmental driver

- Dynamic variables less important than expected
- Intrinsic trigger for seasonal behavior?
- Influence of dynamic variables with limited inshore data?

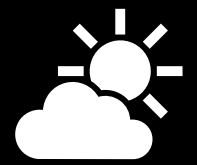
Future Directions

- Molecular studies:
  - Genetic basis of partial migration?
  - Identifying adult foraging grounds and natal rookeries



- Other dynamic variables as drivers of seasonal behavior?





- Does surviving a cold-stun event trigger a change in seasonal behavior or its phenology?



Thank you!
Any comments or questions?