Constraining Salt Marsh Carbon Cycling at the Seven Mile Island Innovation Laboratory

John (Jake) Supino, Kristen E. Fogaren, Emily J. Chua, Hilary Palevsky

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Boston College, Department of Earth and Environmental Sciences

June 2025

John (Jake) Supino

- (Incoming) 5th Year PhD Candidate at Boston College
- Hometown: Fresno, California
- Previously:
  - MSc, Geology from CUNY The City College of New York
  - NASA GISS Graduate Research Intern
  - Undergrad at New York University
- Research Interests:
  - Autonomous Sensors
  - Ecosystem Metabolism
  - Controls on carbon cycling (e.g., nutrients, physics)
  - mCDR and Nature-Based Climate Solutions (obviously)

Salt Marshes Provide Many Ecosystem Services

Water quality regulation - including purification, pollution improvement, disease regulation

Wave attenuation- coastal erosion protection

Nutrient cycling

Coastal defence- Flood reduction

Waterbird habitat- bird watching

Cultural importance – spiritual, cultural heritage value

Tourism & Recreation – amenity, aesthetic values, education

Regulating

Cultural

Supporting

Provisioning

Carbon storage & sequestration

Trophic enrichment of coastal waters – high biodiversity & productivity

Resting areas for migratory birds & habitat for birds – including breeding & feeding grounds.

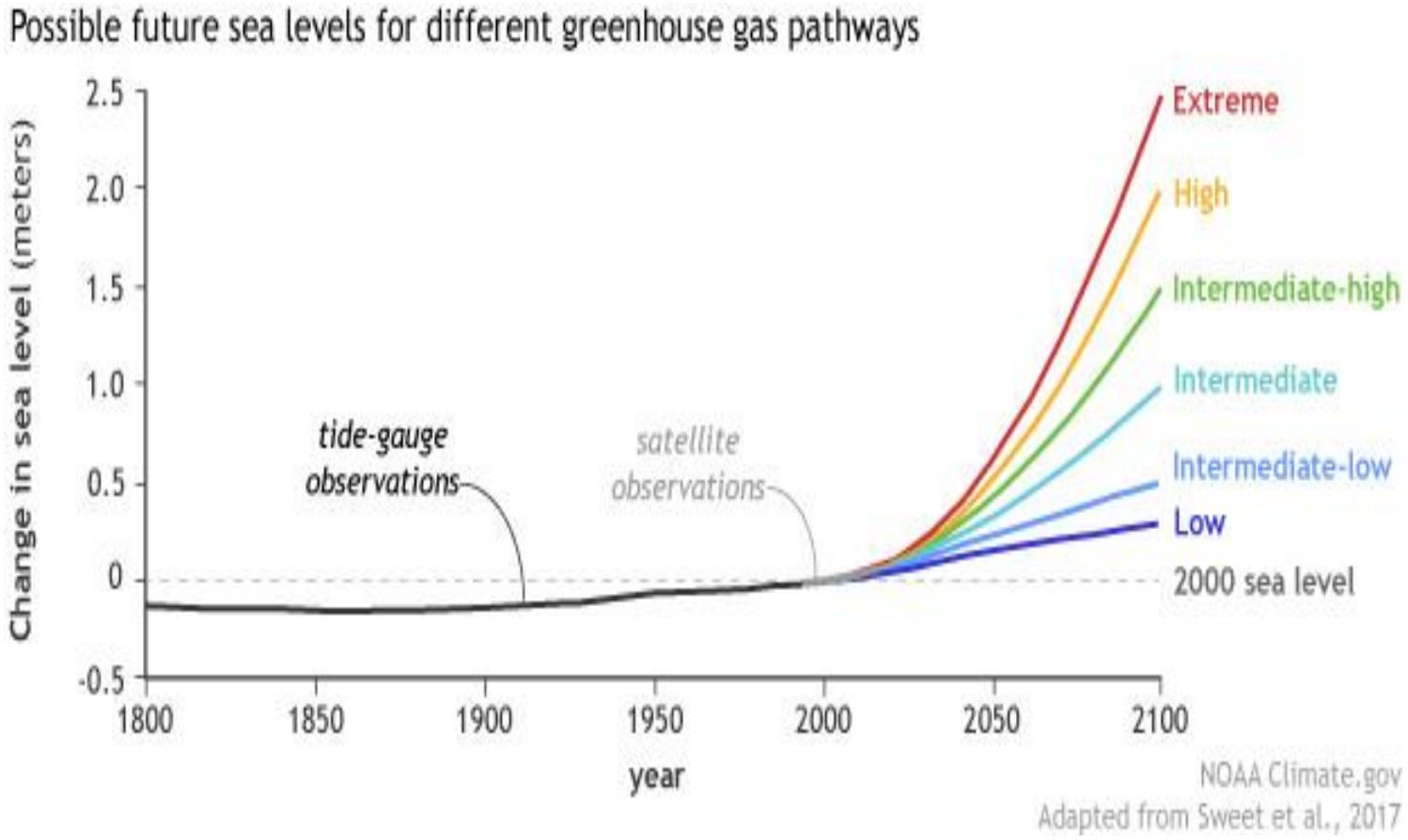
BLUE CARBON

Food, fuel, fibre – e.g. through saline Agriculture

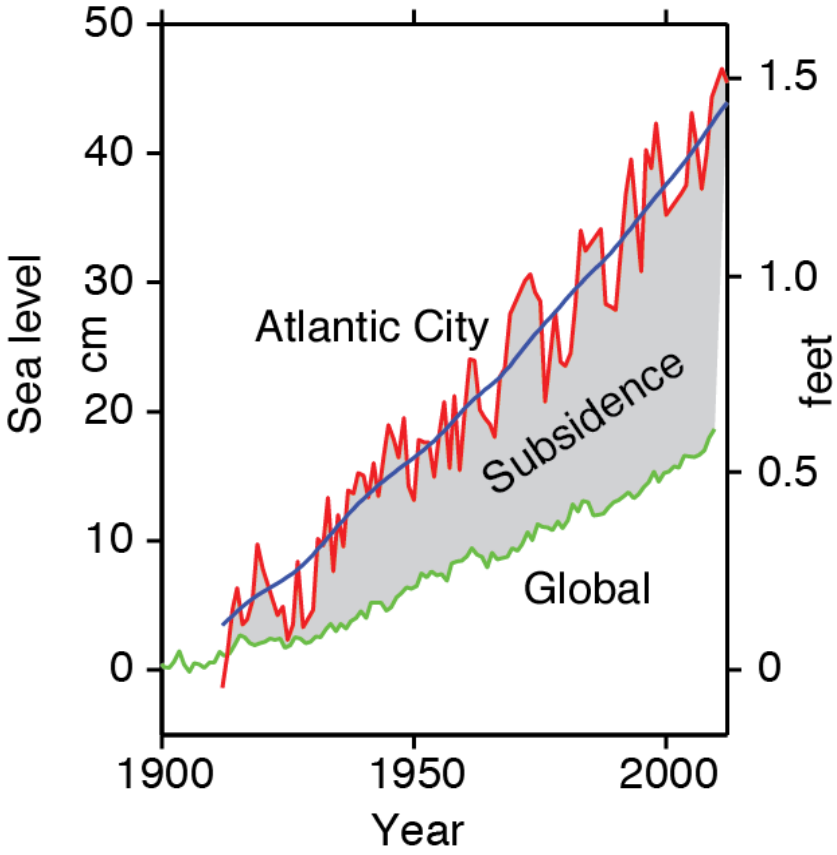
Habitat for aquatic invertebrates

Nursery for fish species – permanent or transient, including important habitat for commercial & recreational fisheries.

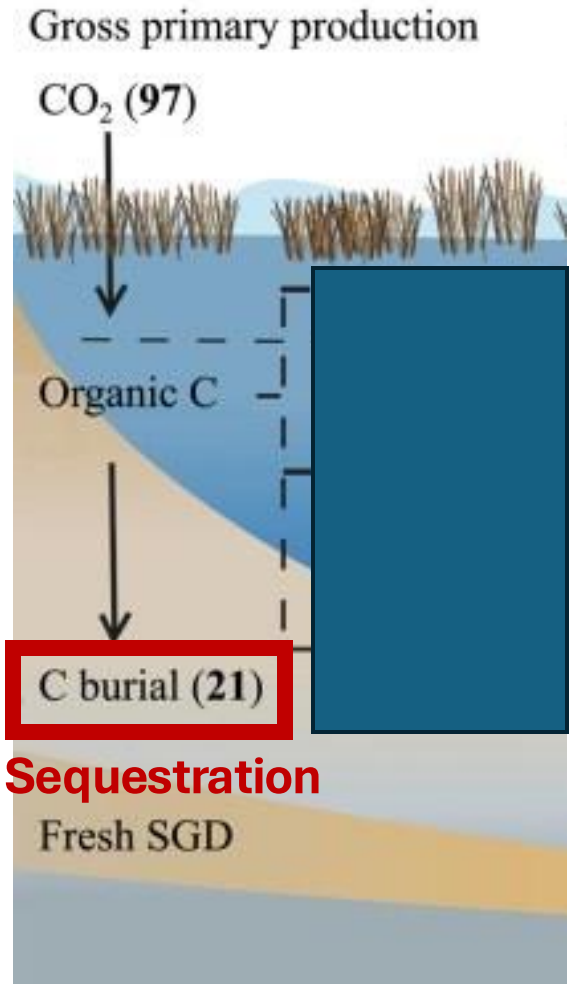
Salt Marshes are under threat by Sea Level Rise



Global = 3.4 mm/year
New Jersey = 4.1 mm/year



Coastal Carbon Cycling is Complex!



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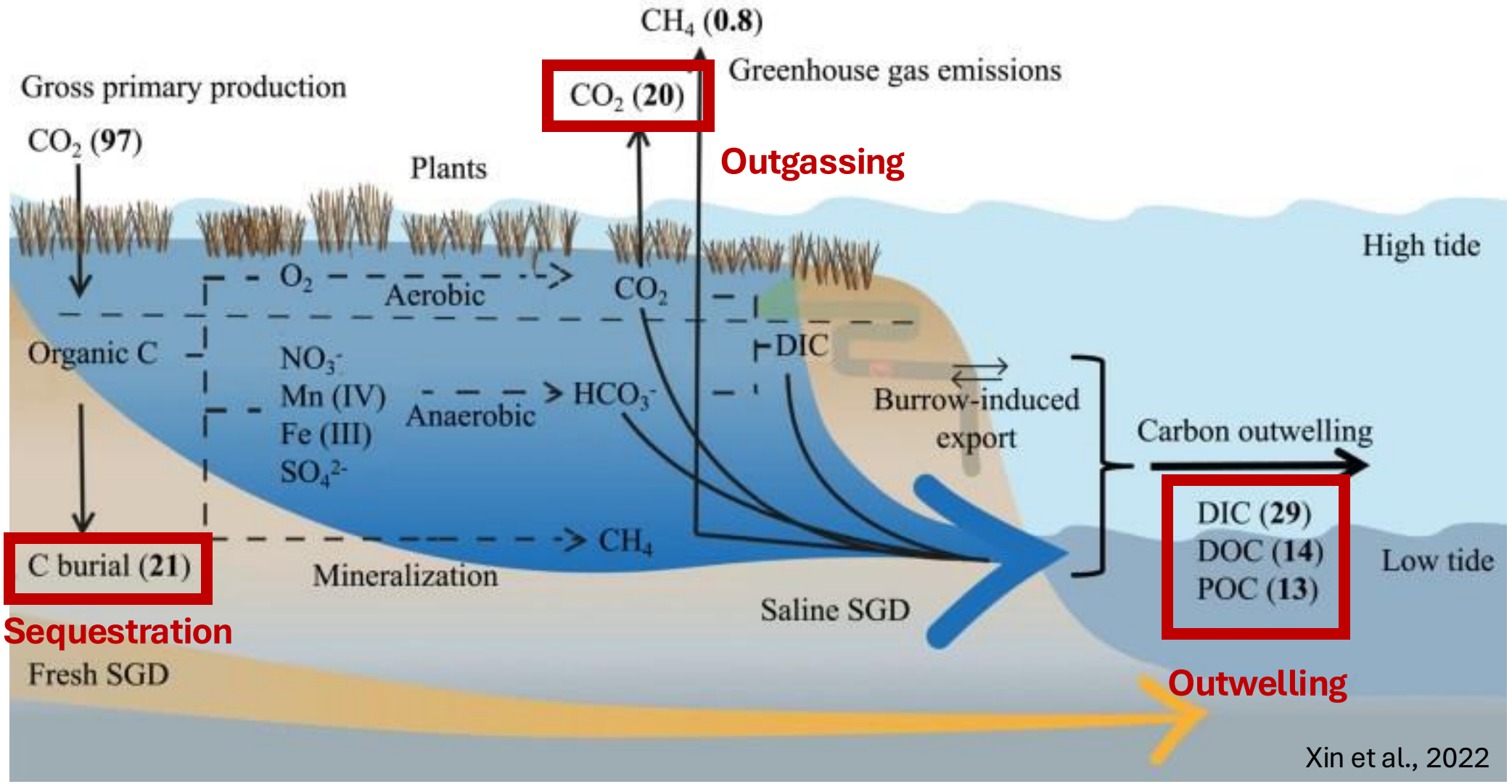

Xin et al., 2022

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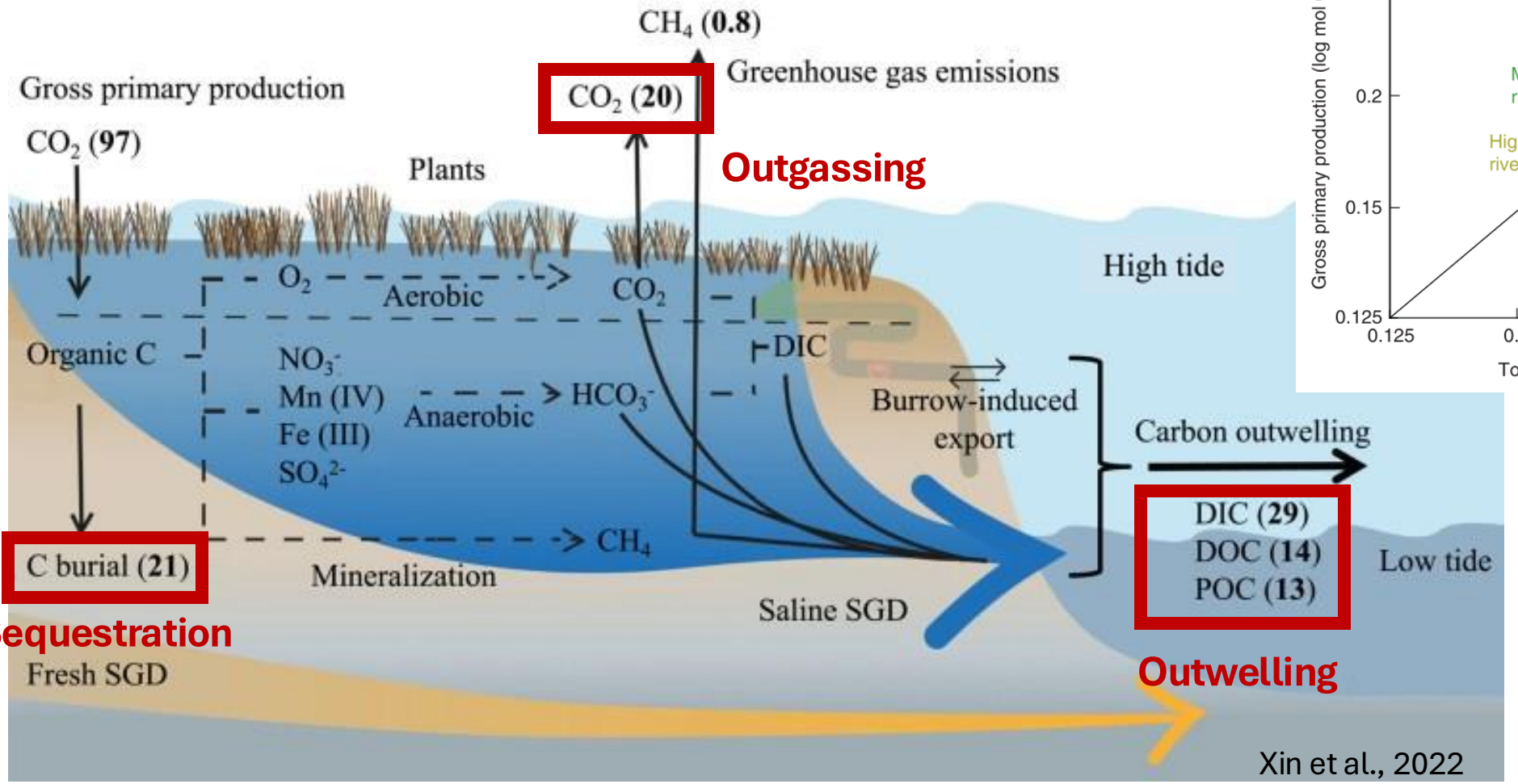
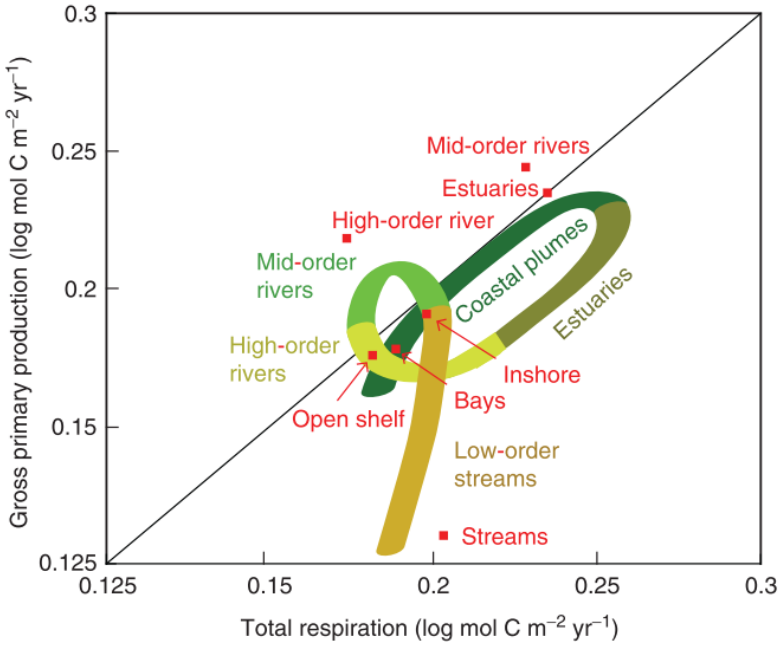
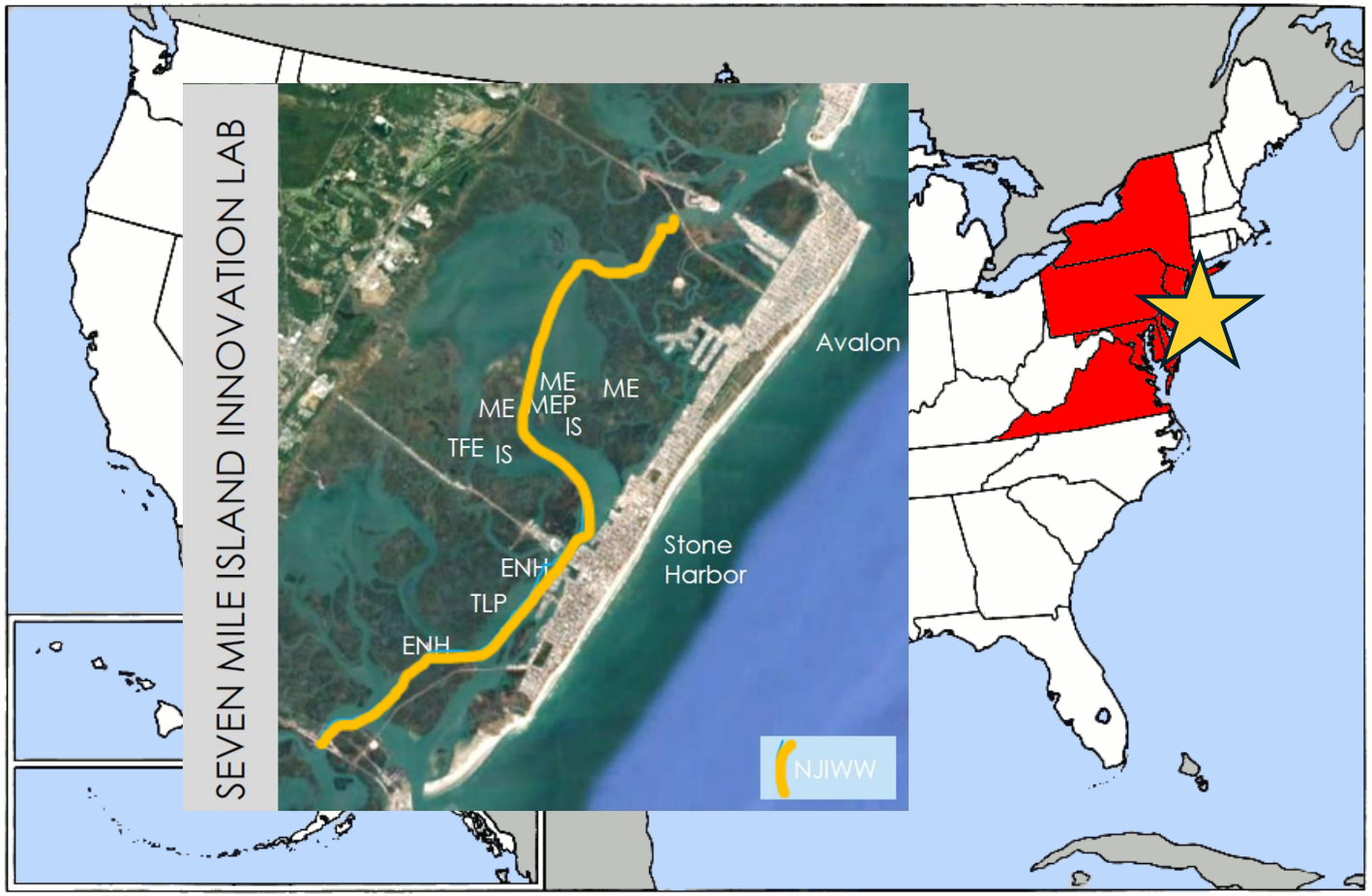


Xin et al., 2022



Heath (1995)

The Seven Mile Island Innovation Laboratory (SMIIL)



- 62 sq. kilometers of tidal marshes, coastal lagoons, shallow bays, sounds, and tidal inlets
- Test bed to advance and improve dredging and marsh restoration techniques
- Bisected by the Atlantic Intracoastal Waterway which the US Army Corps of Engineers maintains for safe maritime navigation

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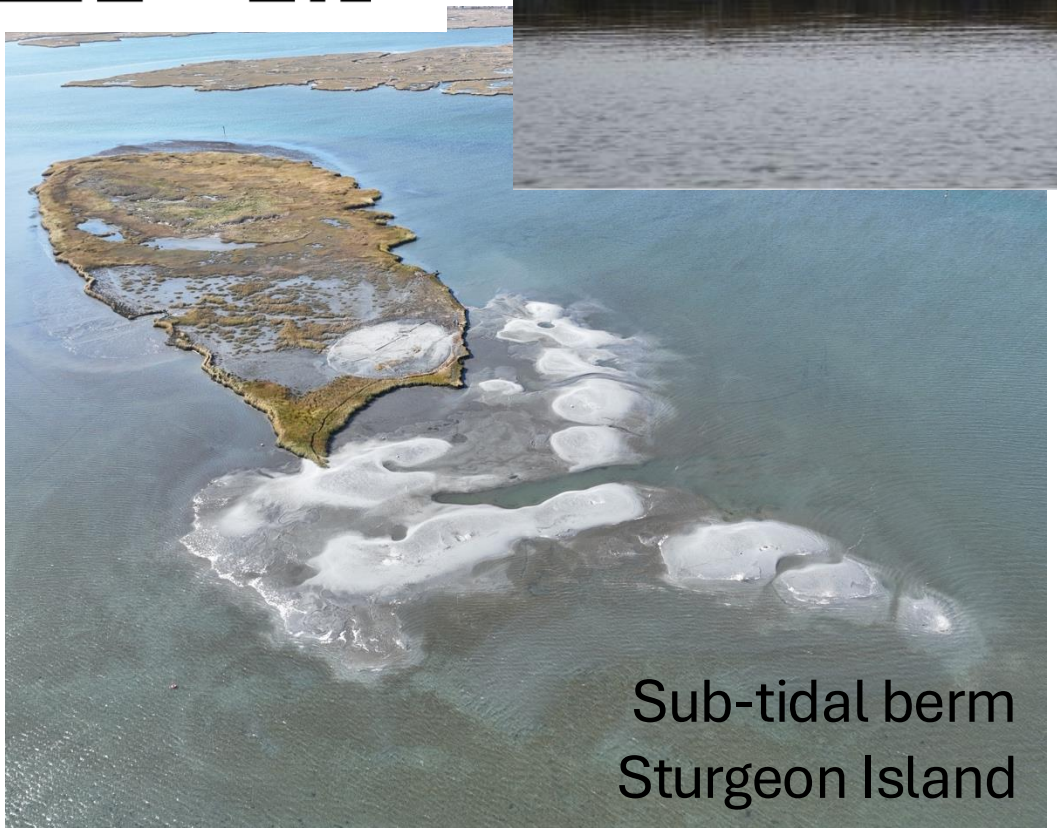

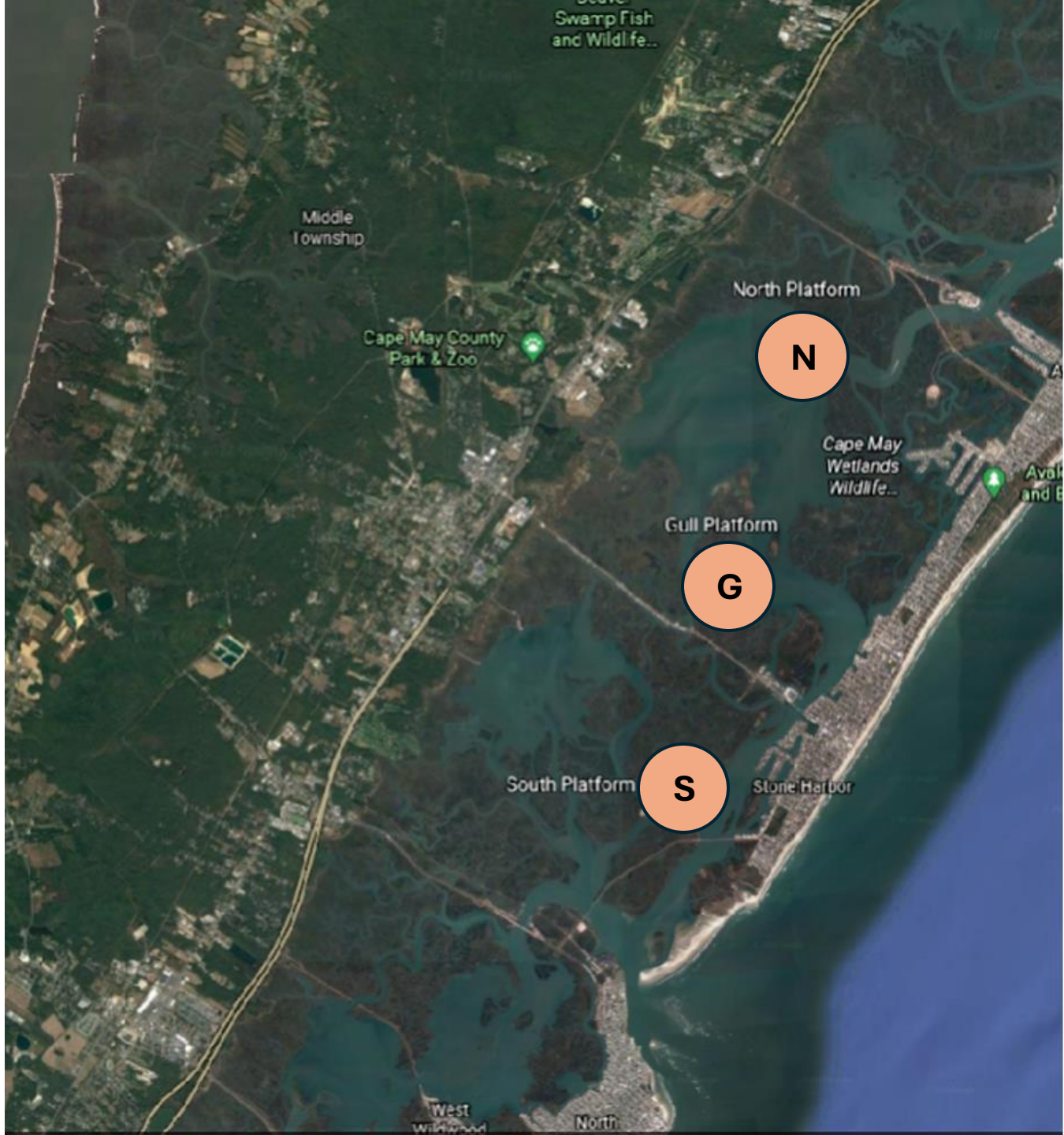
Swamp Fish and Wildlife...
Middle Township
North Platform
N
Cape May County Park & Zoo
Cape May Wetlands Wildlife...
Gull Platform
G
South Platform
S
Stone Harbor
West
North


Wawa

Research Goals

1. Quantify the baseline rates of carbon cycling at the SMIIL

2. Monitor how the system responds to episodic events and evaluate long-term changes

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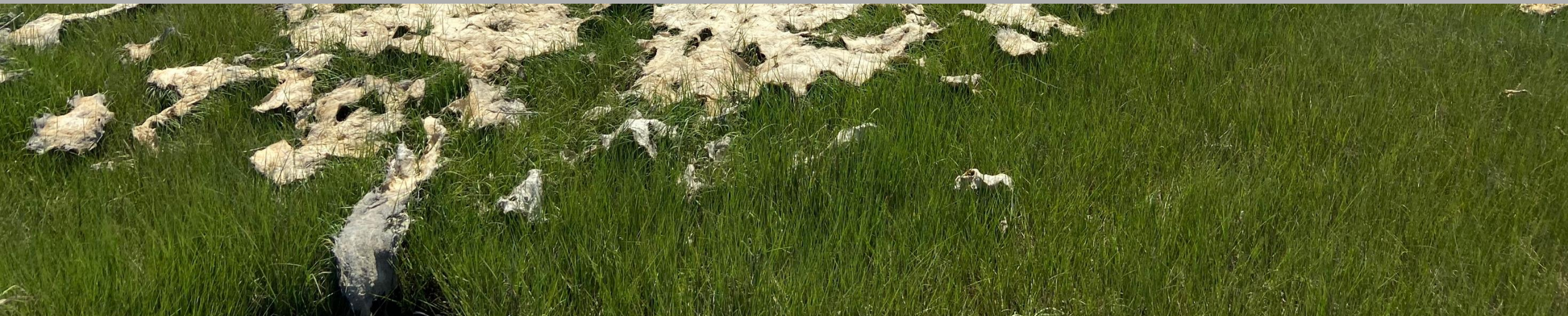
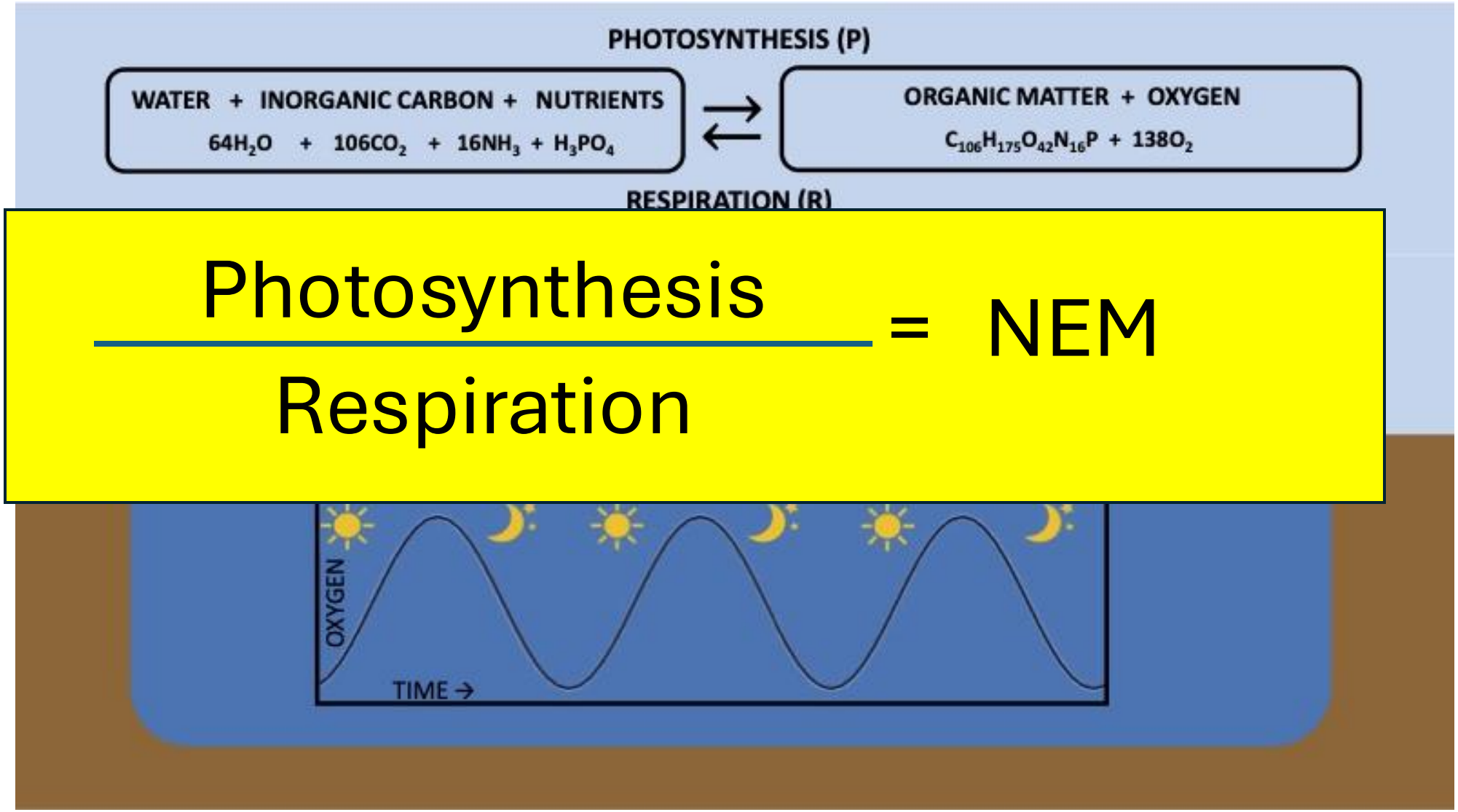
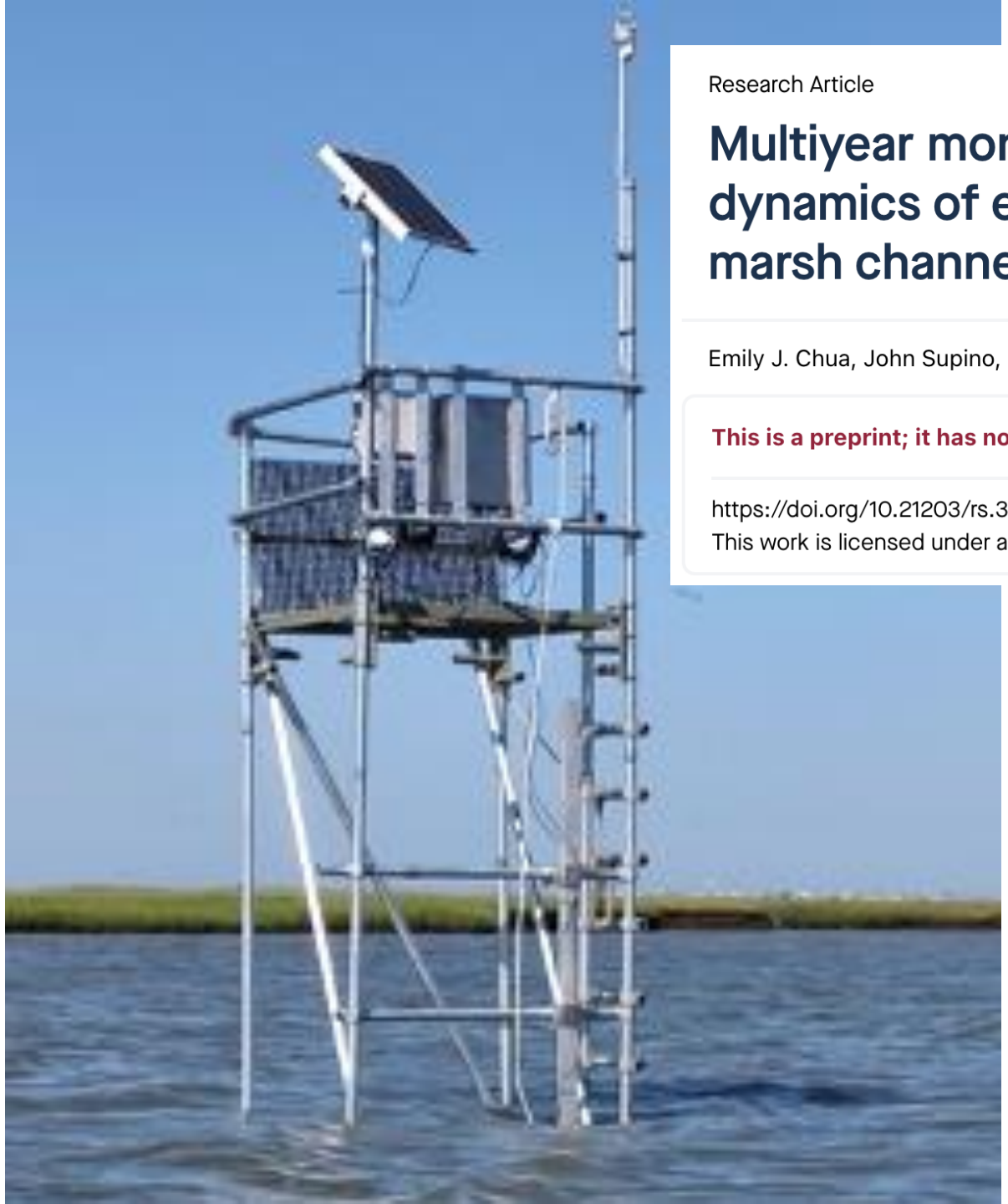


$$h\frac{\Delta DO_{obs}}{\Delta t} = NEM + Gas\ Exchange + Tidal\ Advection$$



$$\frac{\text{Photosynthesis}}{\text{Respiration}} = \text{NEM}$$

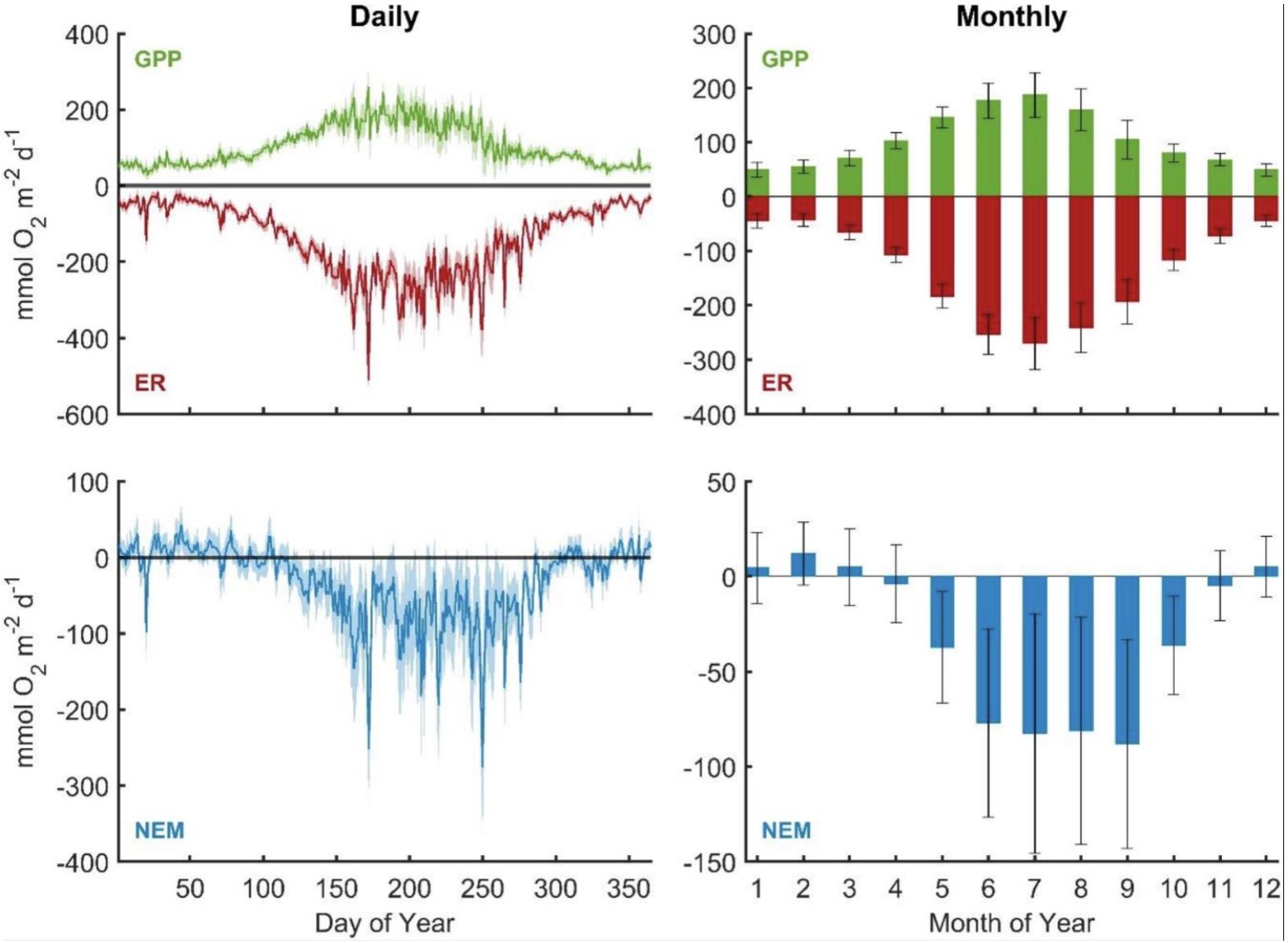


Research Article

Multiyear monitoring reveals seasonal and short-term dynamics of ecosystem metabolism in a temperate salt marsh channel

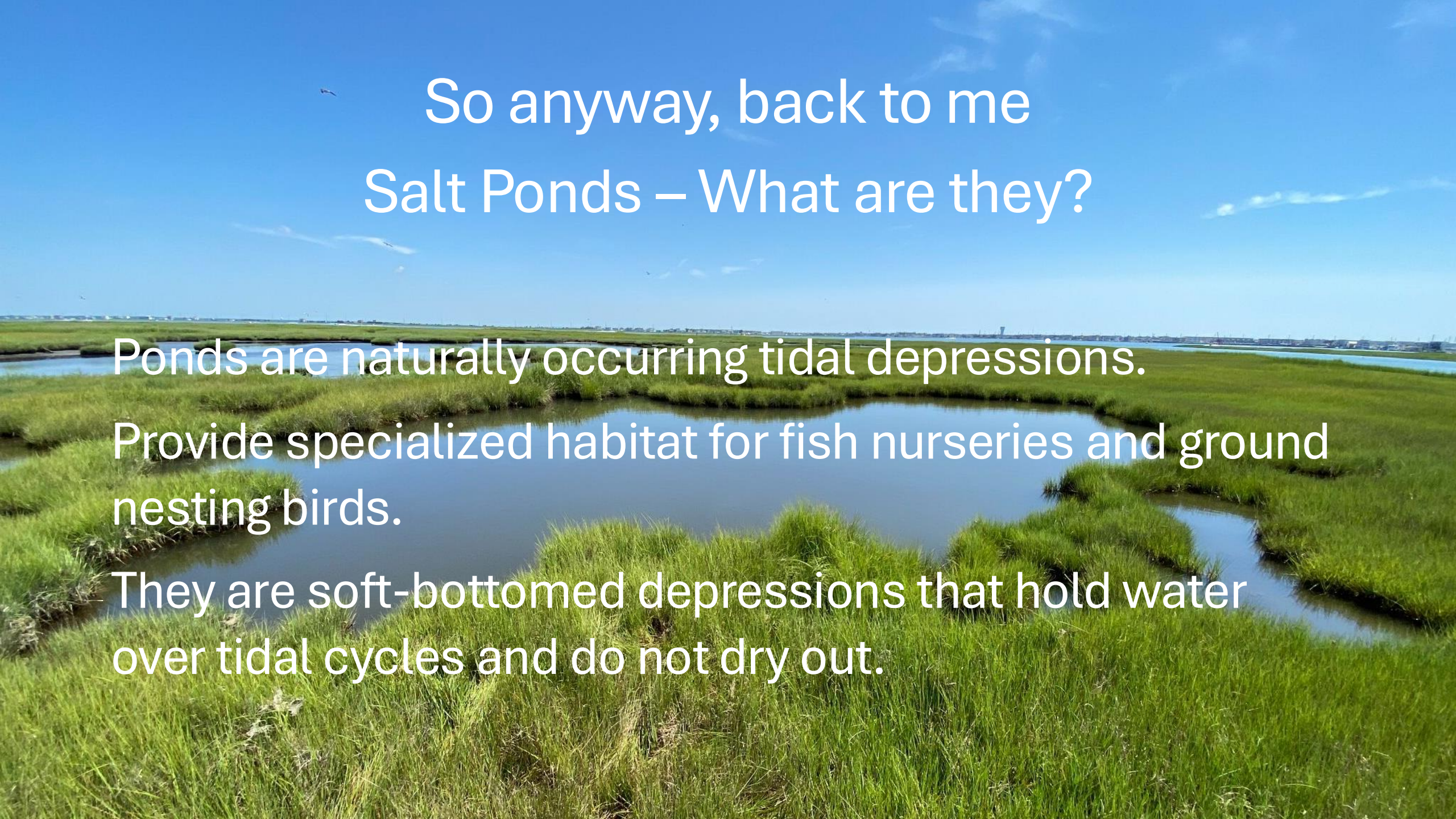
Emily J. Chua, John Supino, Kristen E. Fogaren, Hilary I. Palevsky

https://doi.org/10.21203/rs.3.rs-6759348/v1



Daily and monthly climatological mean metabolic rates calculated from the entire time series across all three channel sites. Site means were taken by day of year for **a)** gross primary production (GPP) and ecosystem respiration (ER) and **c)** net ecosystem metabolism (NEM), and by month of year for **b)** GPP and ER and **d)** NEM. The mean Monte Carlo propagated uncertainty is represented as shading in a) and c) and error bars in b) and d).

Mean NEM
-29.4 mmol O_2 m^{-2} d^{-1}



So anyway, back to me

Salt Ponds – What are they?

Ponds are naturally occurring tidal depressions.

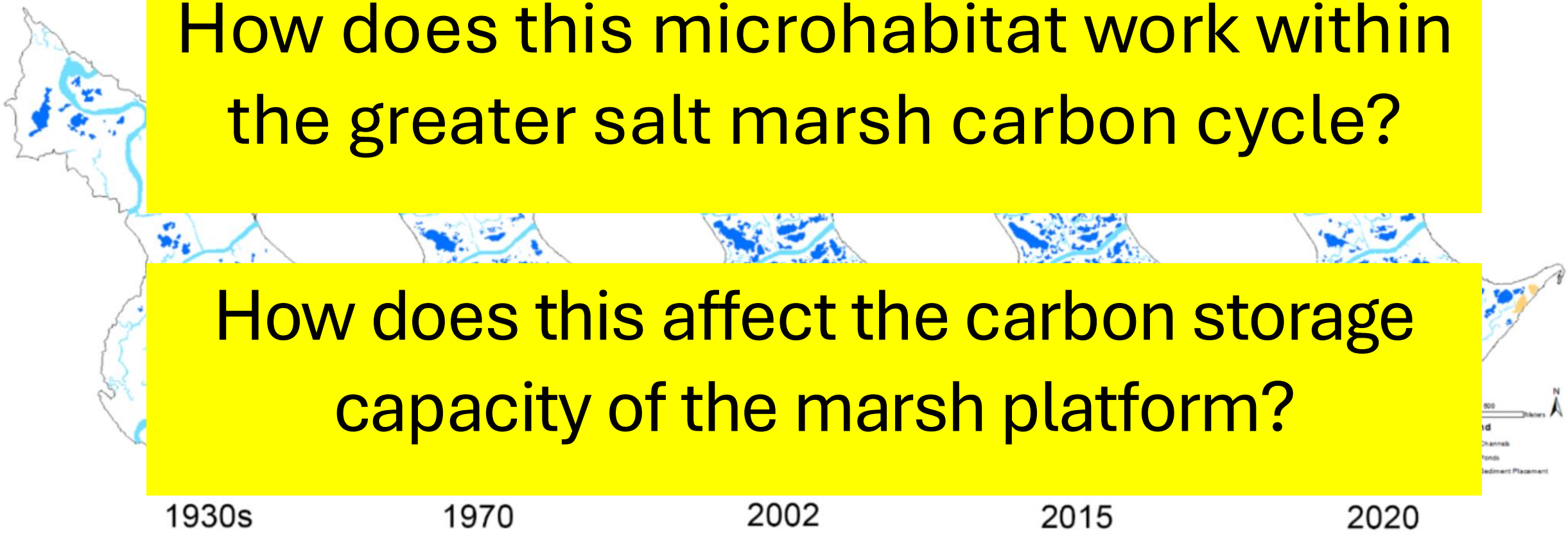
Provide specialized habitat for fish nurseries and ground nesting birds.

They are soft-bottomed depressions that hold water over tidal cycles and do not dry out.

Are ponds growing in number?

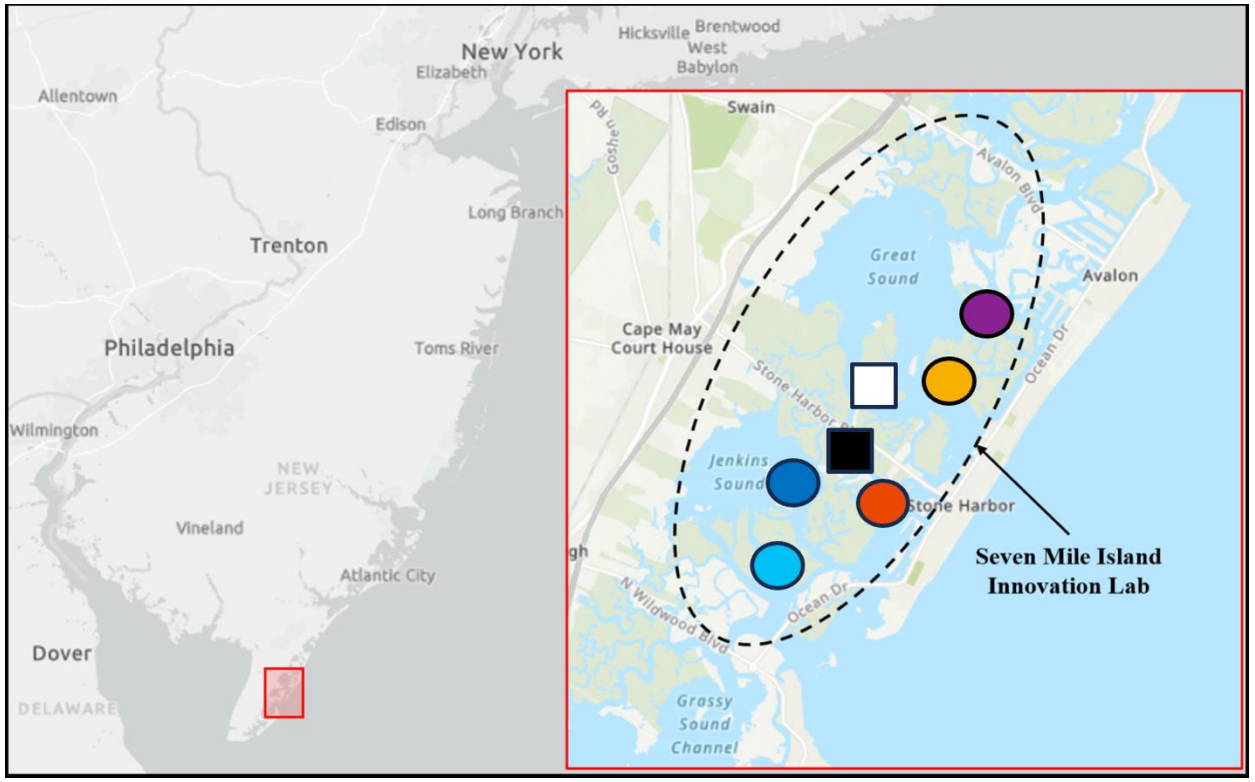
How does this microhabitat work within the greater salt marsh carbon cycle?

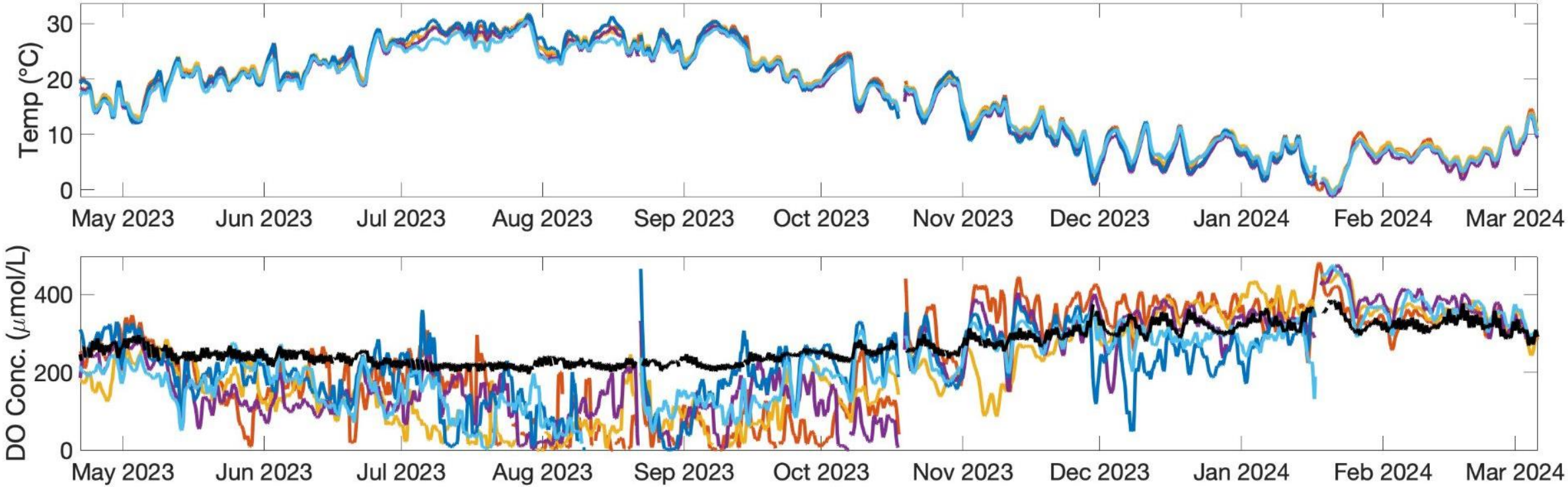
How does this affect the carbon storage capacity of the marsh platform?



Let’s monitor!

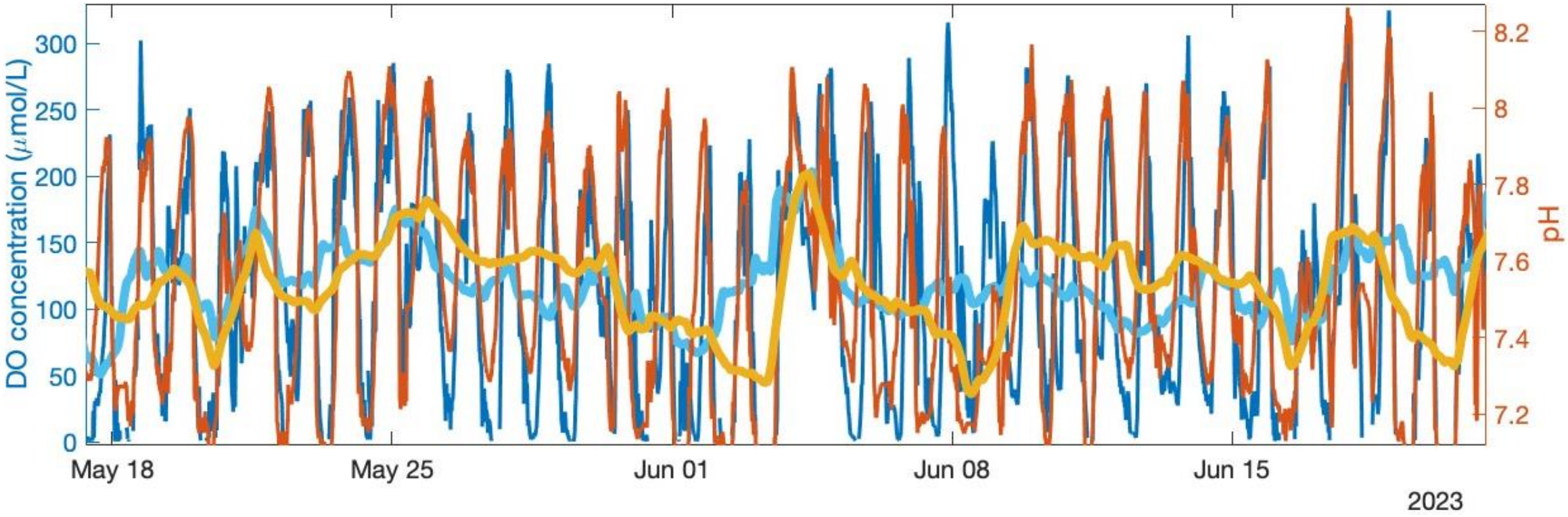
ID	Name	Appr. Age	Vegetated?	Appr. Area	Maximum Pond Depth
	Ring	80 years	Algae, plants	19,000 m^2	0.7 m
	Shark	100 years	None	150 m^2	1 m
	Long Reach	50 years	None	1,100 m^2	0.5 m
	White	40 years	Algae	7,000 m^2	1 m
	Drum	100 years	Seasonal algae	525 m^2	1.5 m





- Seasonal and annual cycle in temperature and DO
- DO undersaturation in summer and supersaturation in late fall and winter

$$h\frac{\Delta DO_{obs}}{\Delta t} = NEM + Gas\ Exchange + Tidal\ Advection$$



Diel (daily) fluctuations in DO and pH due to photosynthesis and respiration

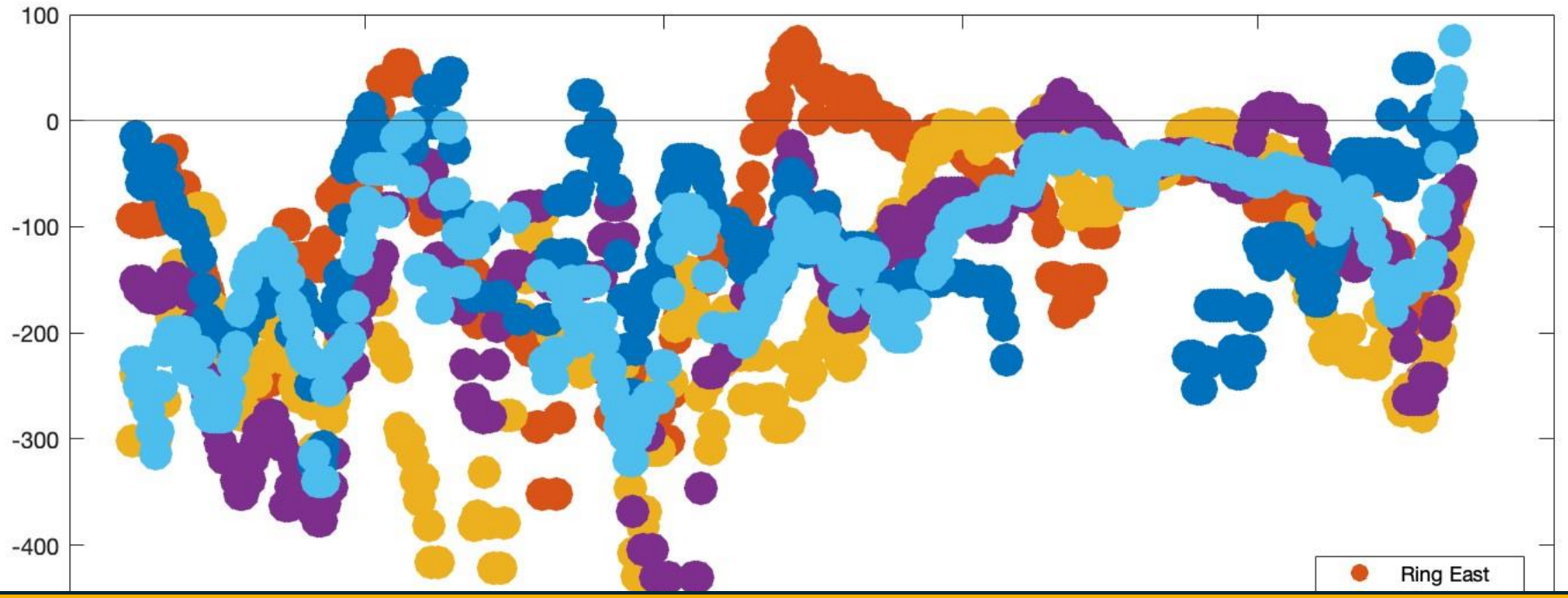
Pond NEM is net heterotrophic!

Mean NEM

-153.07 mmol O_2 m^{-2} d^{-1}

SINK

SOURCE



So, what should we do about this?

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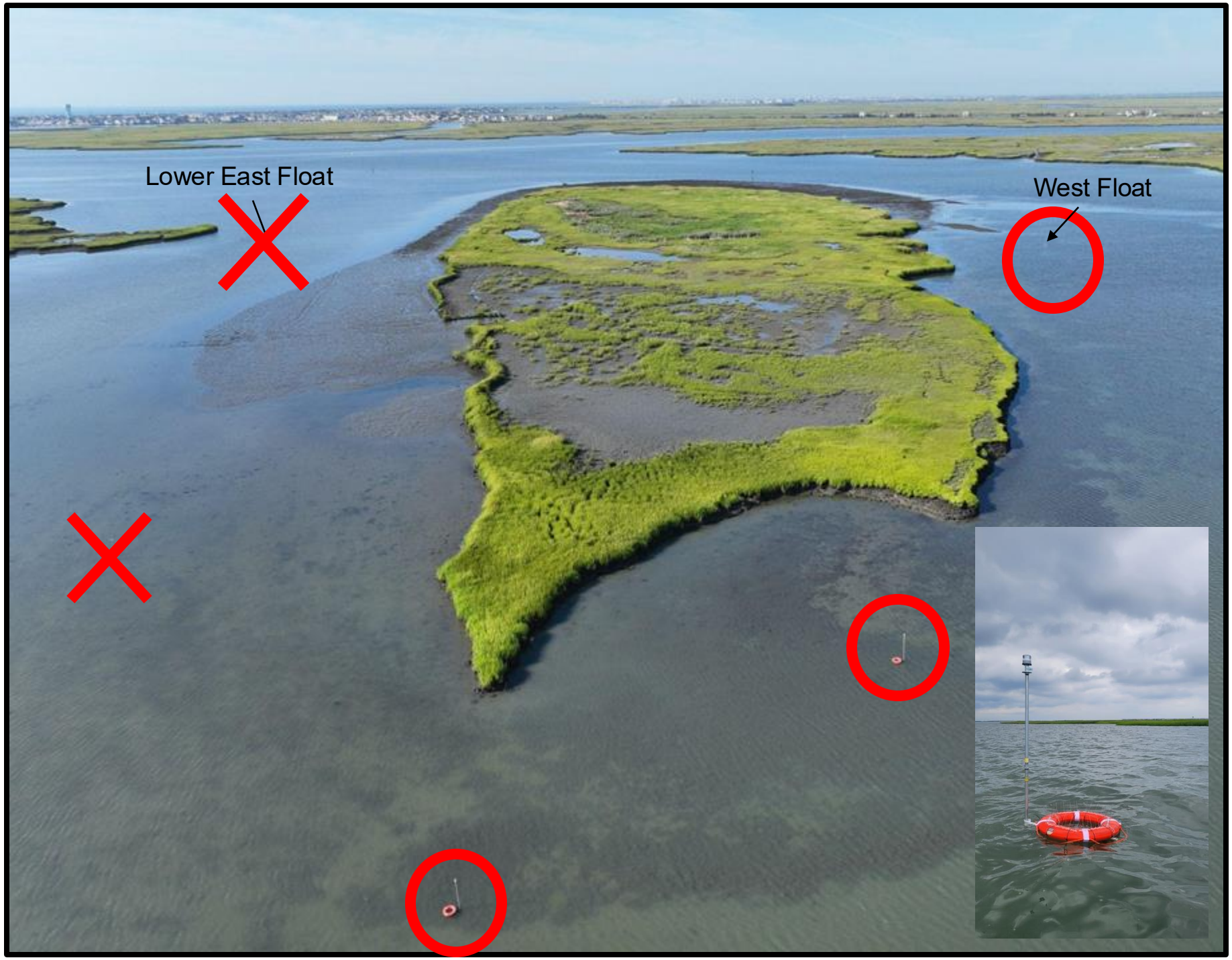
Is there a negative side effect for the ecosystem when sediment placement occurs, and does it change ecosystem productivity?



Sturgeon Island

Aug 1-2: Floats Deployed
Aug 19- Sept 18:
- Lower East Float lost
- East Float ends up staked in marsh

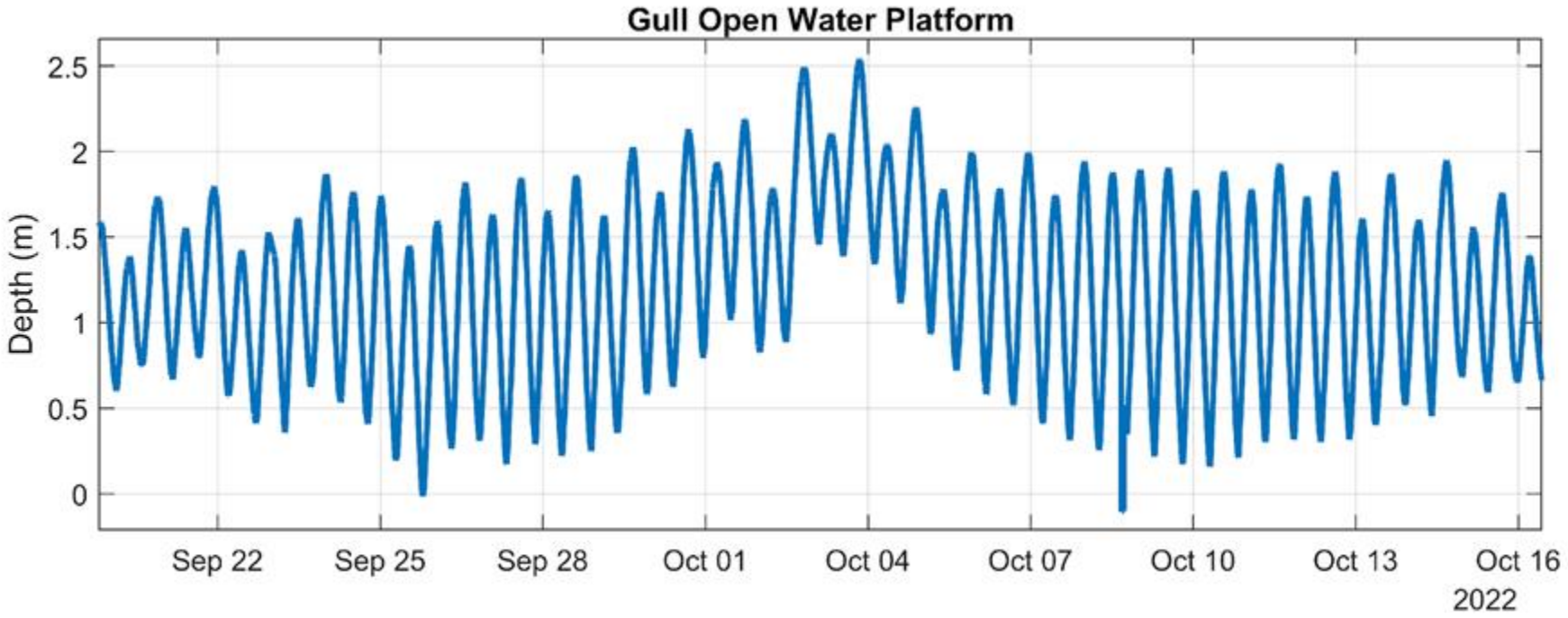
Sept 18:
- Northwest Float moved further out
- North Float moved further out
- East Float redeployed

Sept 22: Placement begins
Sept 29: Placement suspended
Oct 1- Oct 4: Tropical Storm Ian
Oct 2-Oct 3:
- East Float breaks free (recovered) and decommissioned
- North Float breaks free (lost)
- Northwest Float breaks free (returned to TWI)

Oct 6:
- West Float decommissioned

Oct 7: Placement resumes
Oct 9:
- Northwest Float redeployed
- North Float redeployed

Oct 28: Placement ends
Dec 7:
- Northwest Float decommissioned
- North Float decommissioned



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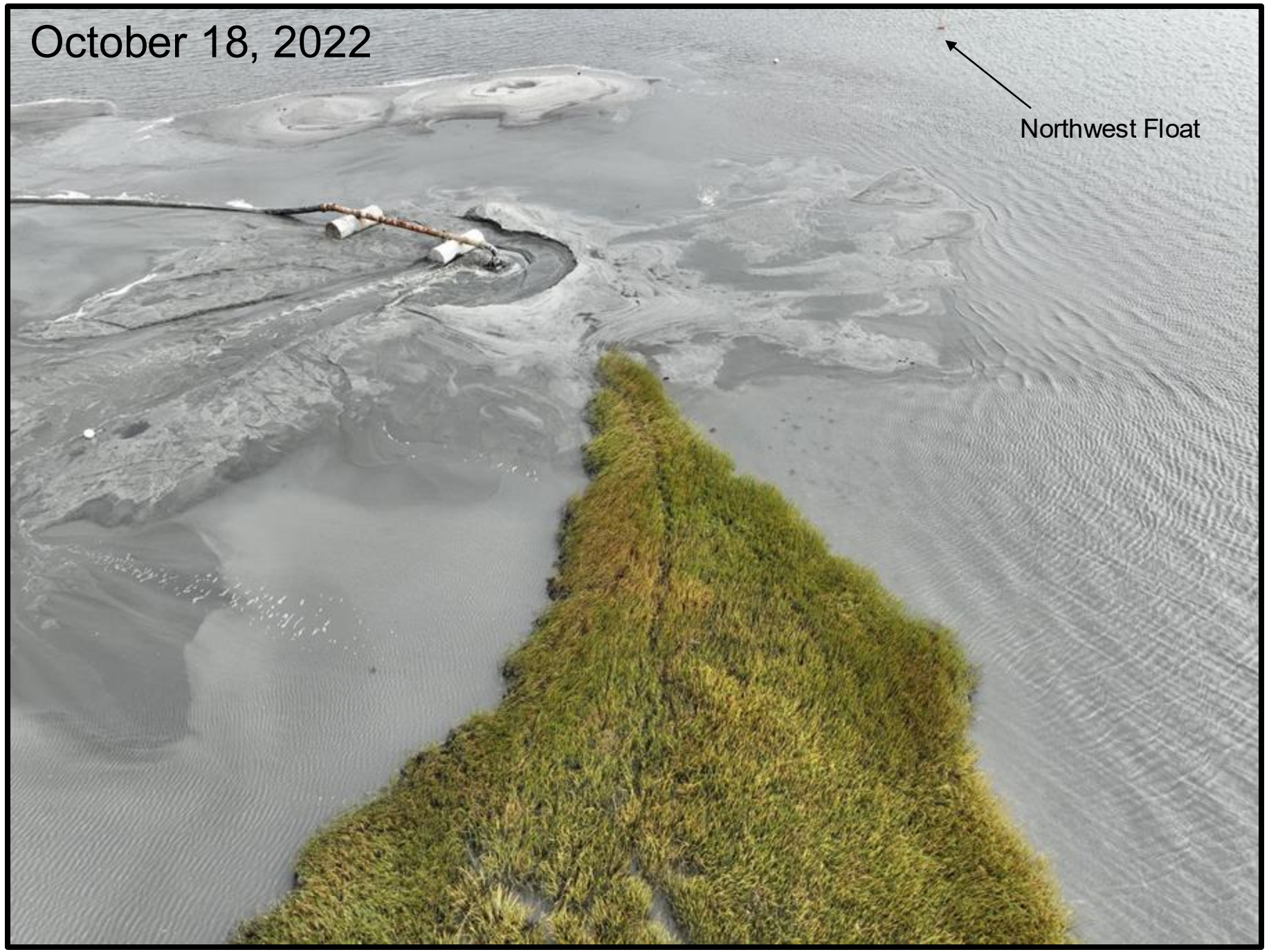

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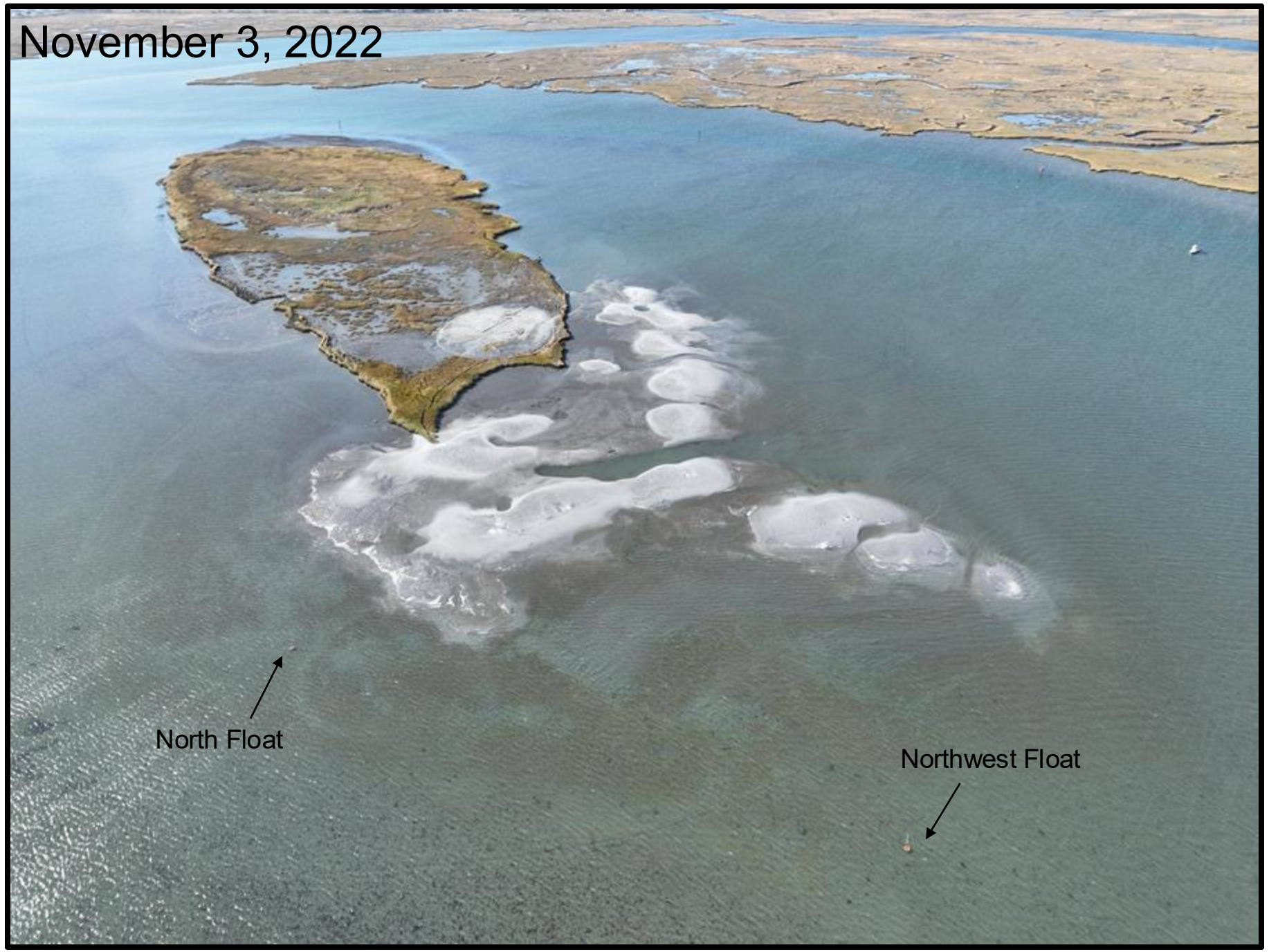

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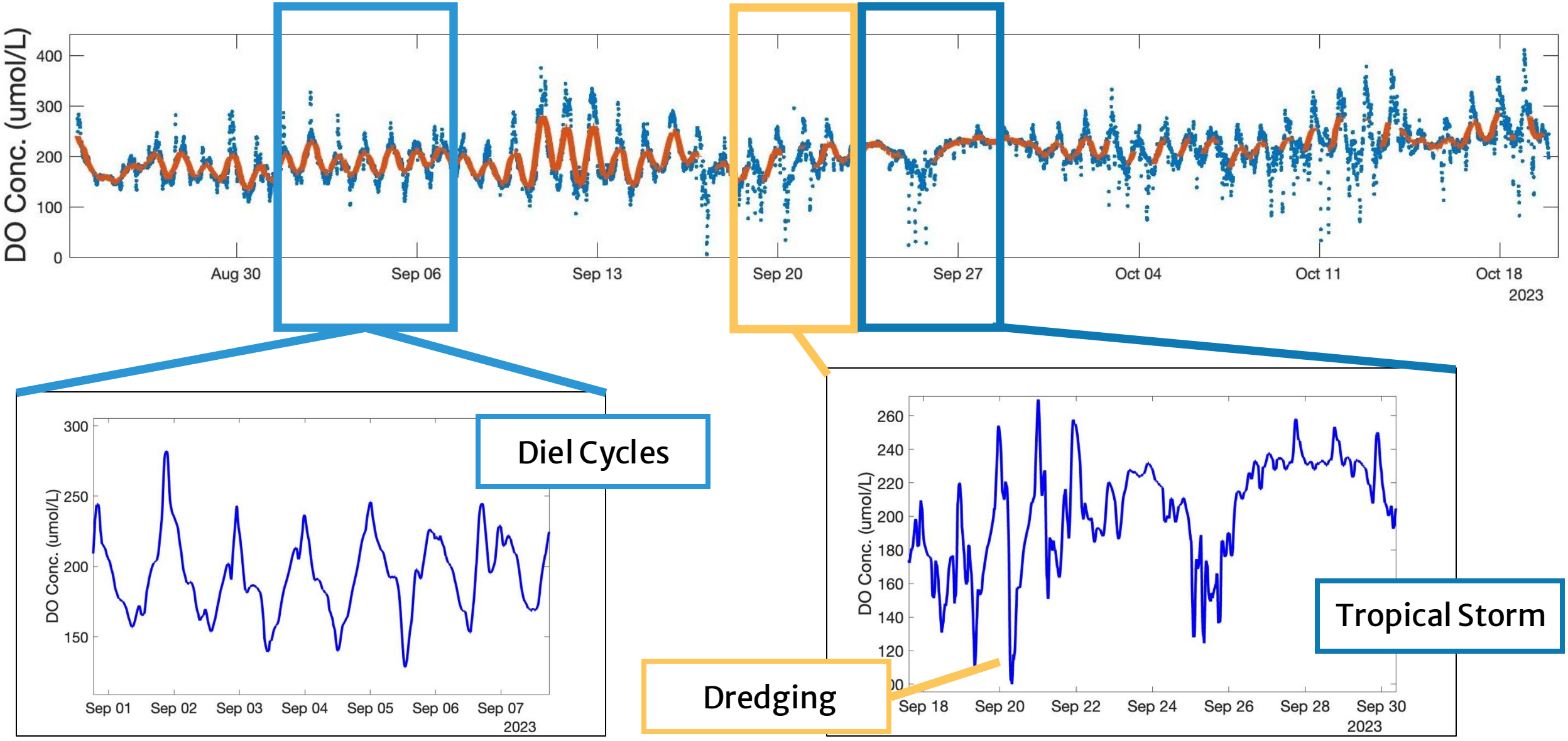
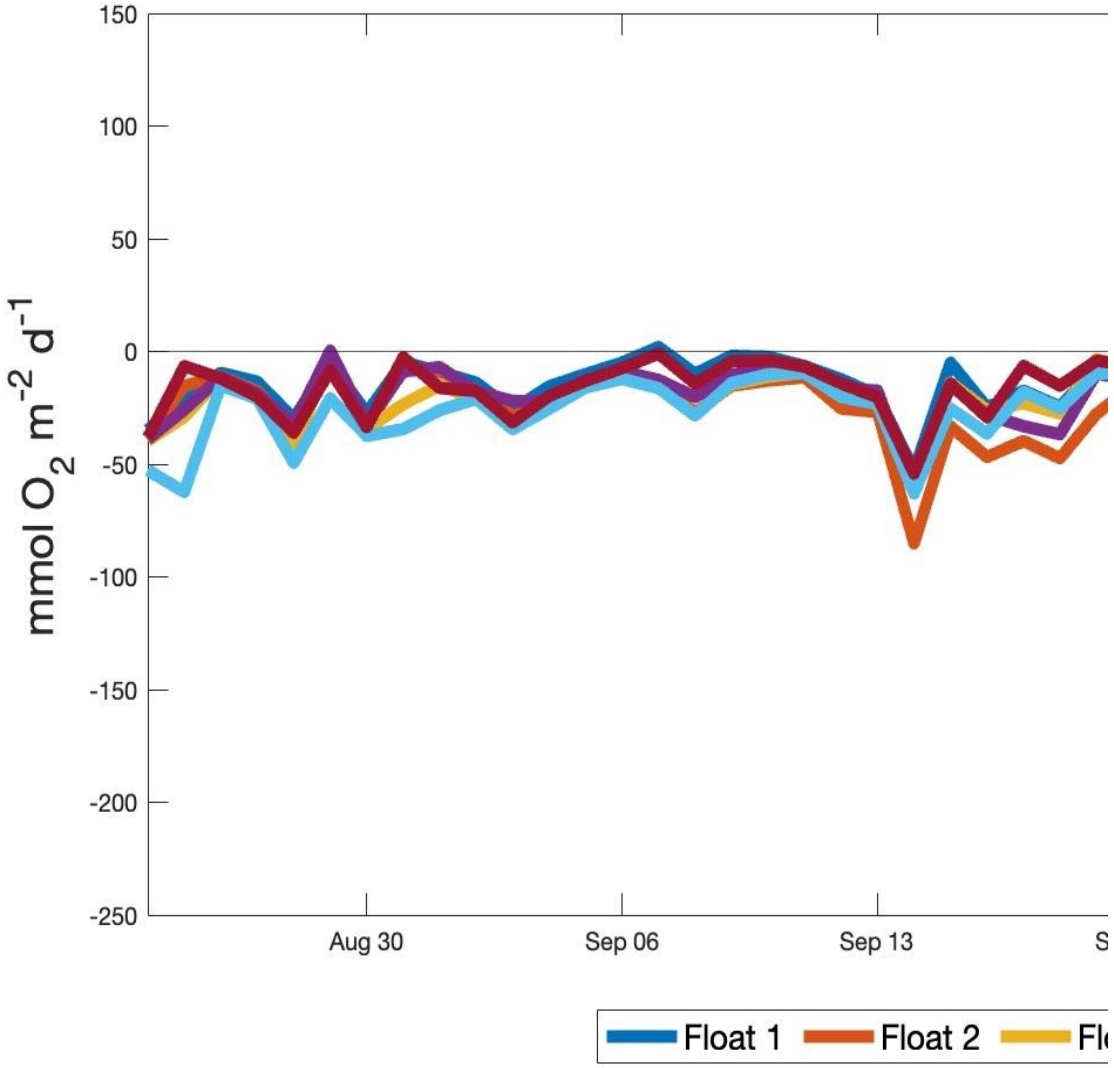
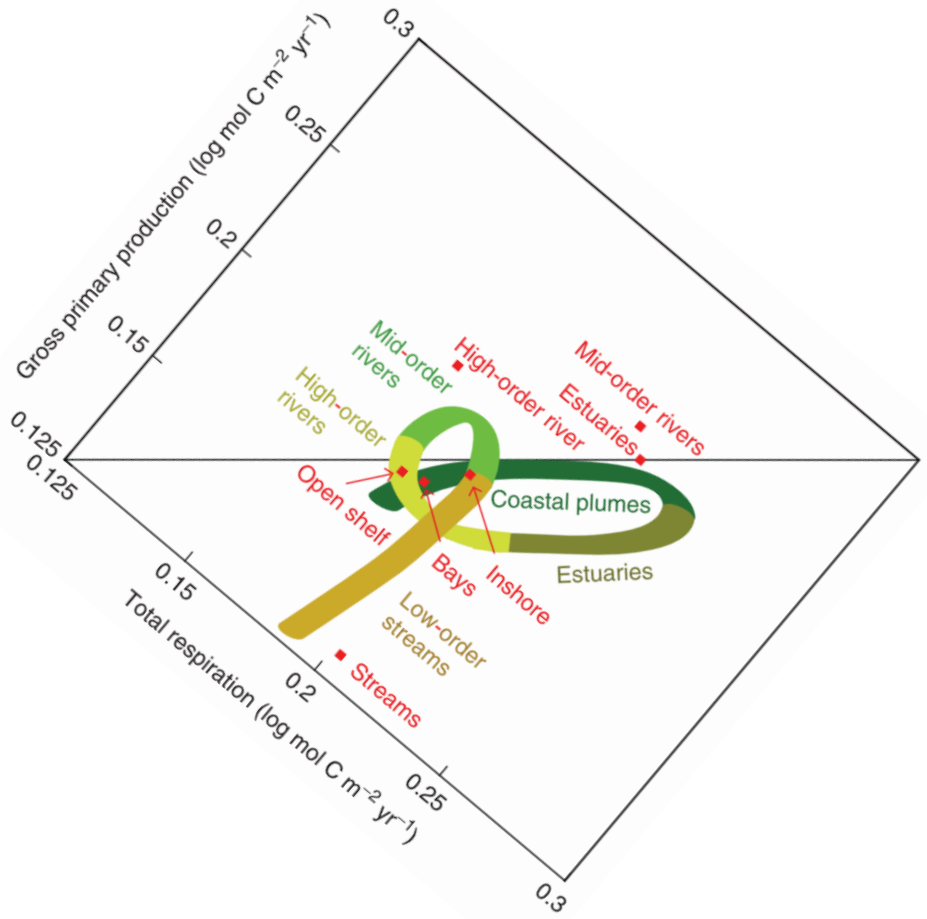

DO Conc. (umol/L)
400
300
200
100
0
Aug 30
Sep 06
Sep 13
Sep 20
Sep 27
Oct 04
Oct 11
Oct 18
2023
DO Conc. (umol/L)
300
250
200
150
Sep 01
Sep 02
Sep 03
Sep 04
Sep 05
Sep 06
Sep 07
2023
Diel Cycles
DO Conc. (umol/L)
260
240
220
200
180
160
140
120
Sep 18
Sep 20
Sep 22
Sep 24
Sep 26
Sep 28
Sep 30
2023
Tropical Storm
Dredging

NEM is slightly heterotrophic naturally.

SINK

SOURCE

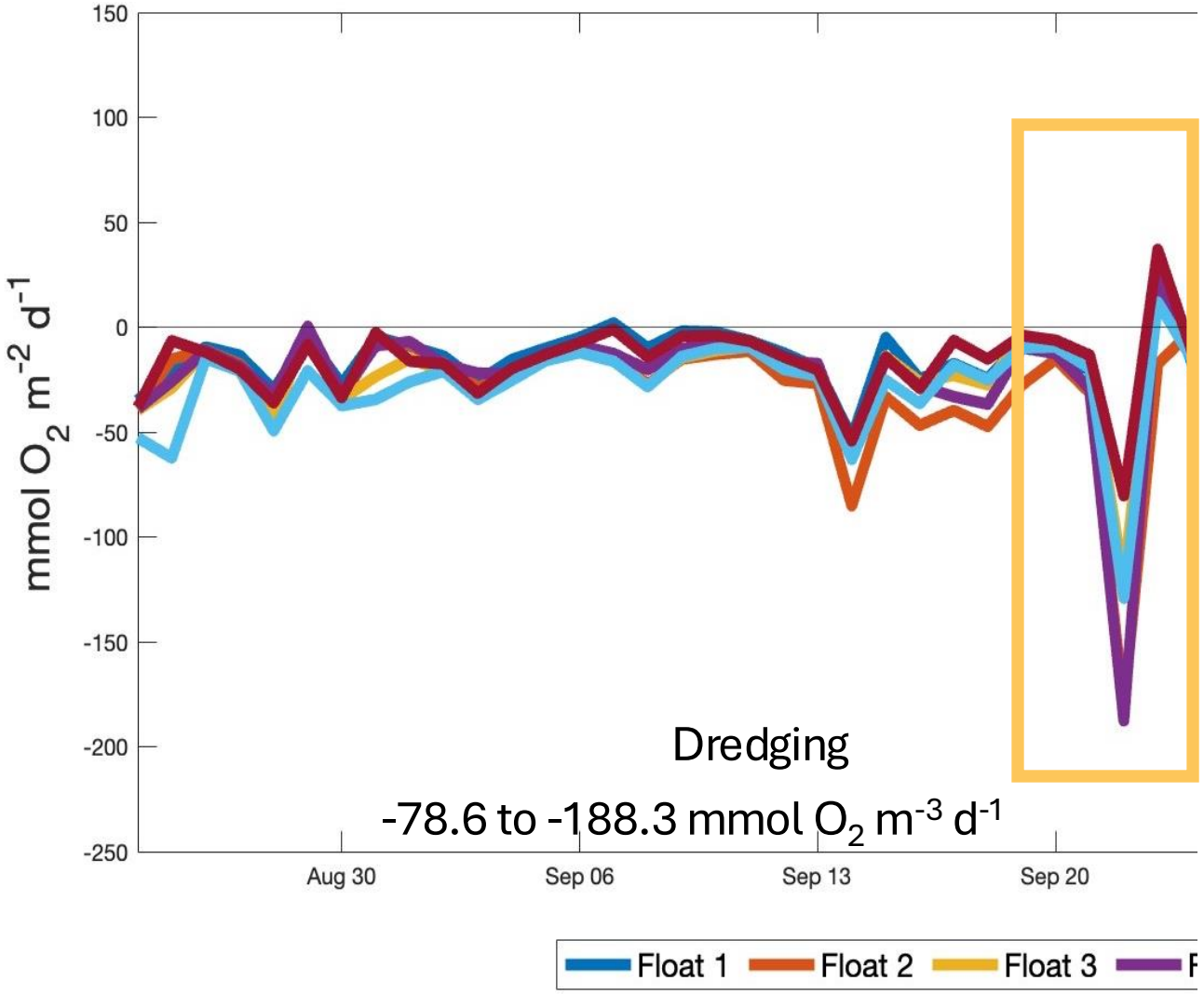




Sediment placement created strong net heterotrophy.

SINK

SOURCE

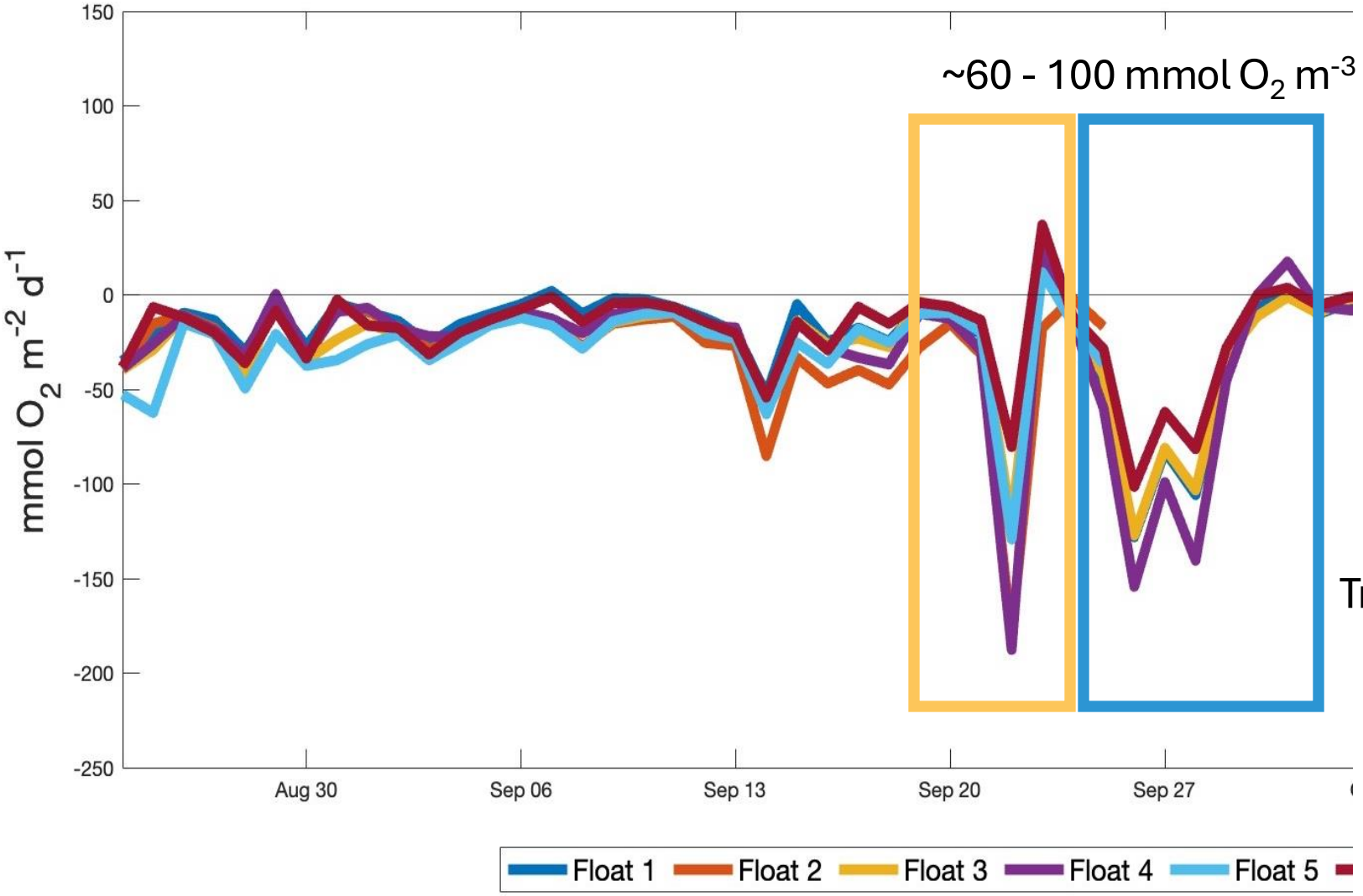


11.2 - 37.5 mmol O_2 m^{-3} d^{-1}

Tropical Storm Ophelia created strong net heterotrophy.

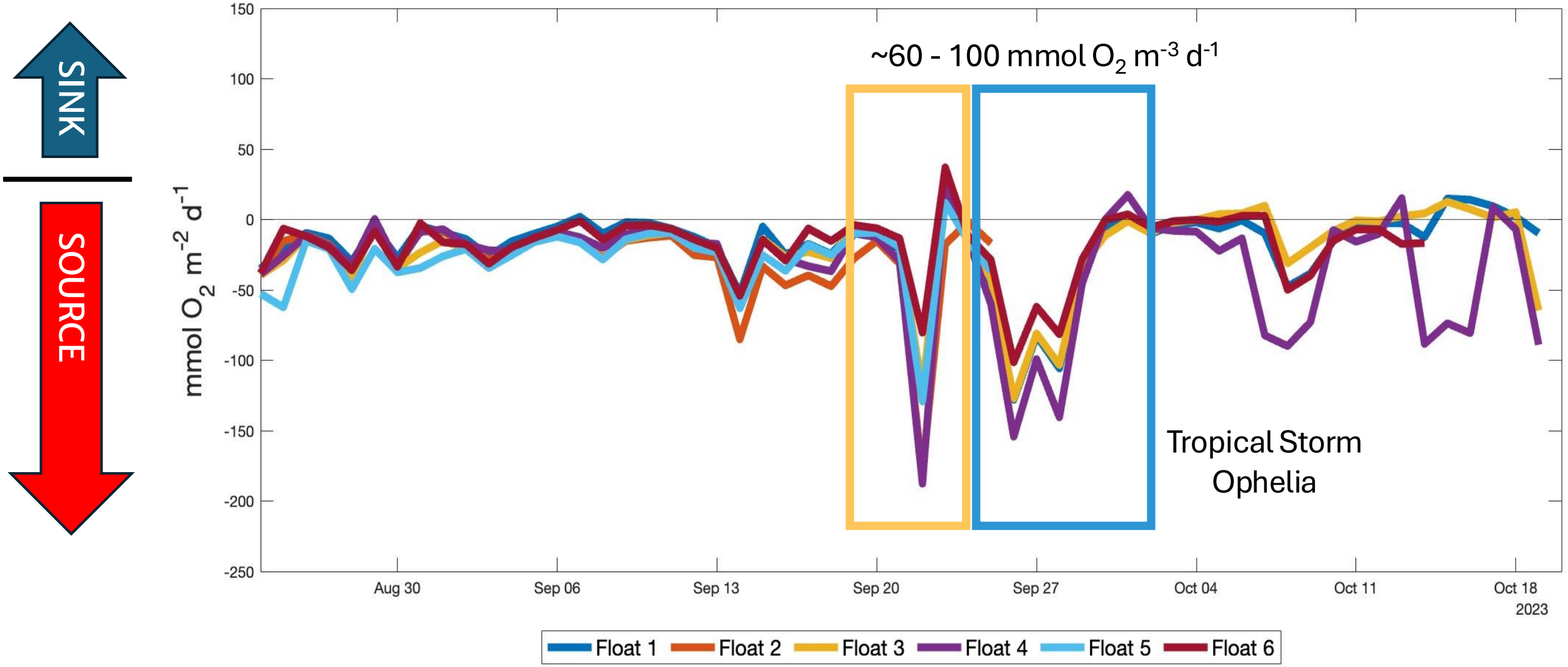
SINK

SOURCE



Tropical Storm Ophelia

The system returns to some kind of normalcy soon after.



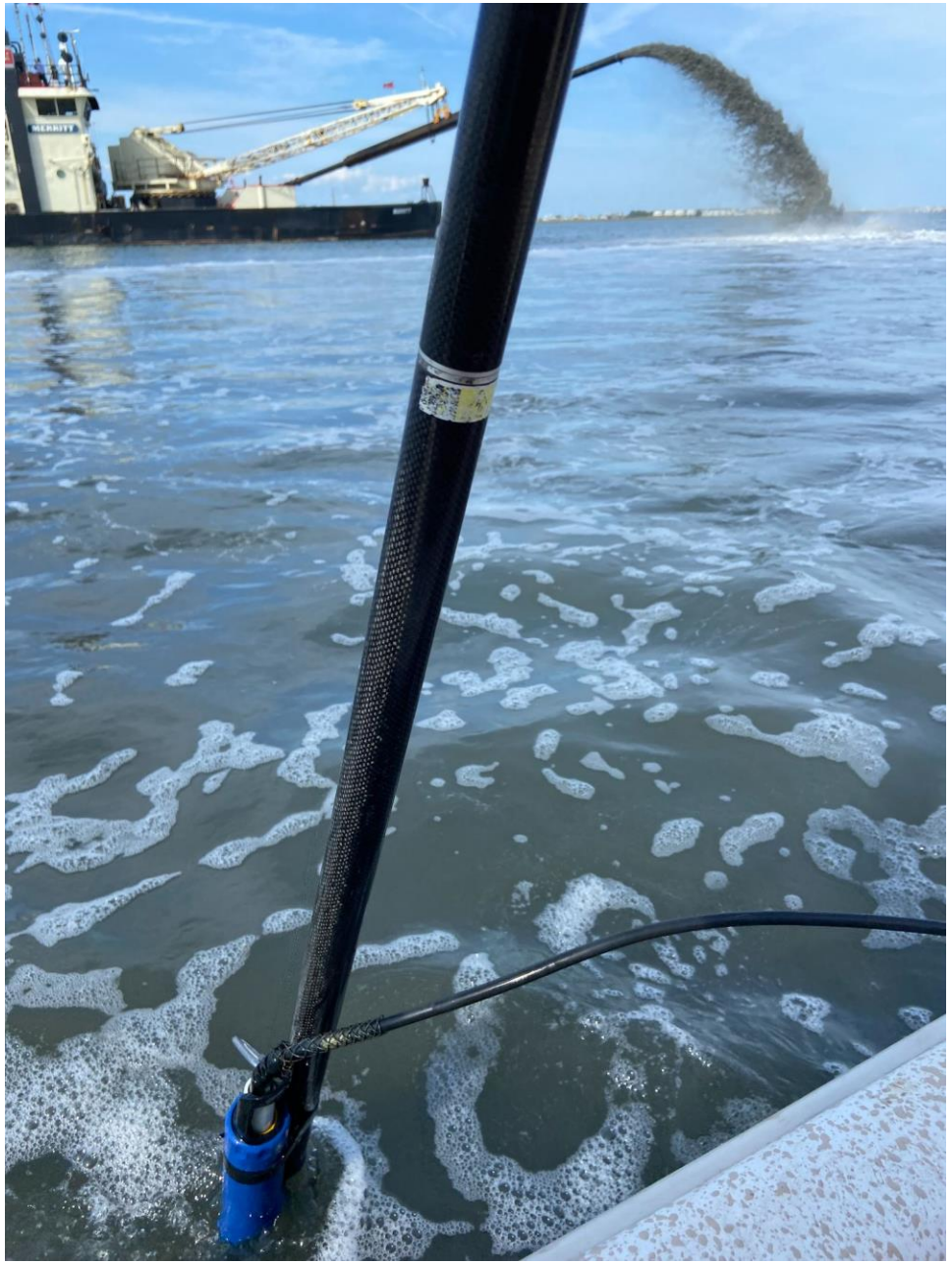
Conclusions

- NEM is a useful measurement of ecosystem productivity and health and how we can evaluate the success of NBS strategies.

- SMIIL salt marsh channels are naturally heterotrophic without ongoing sediment placements. Salt ponds are VERY heterotrophic.

- Both sediment placement and tropical storms resulted in relatively strong heterotrophic signals that were short lived over an area < 1.5 km^2.

- Dredged sediment placements may offer a nature-based solution to beneficially use unwanted sediment for marsh resilience, with minor consequences for ecosystem productivity and carbon biogeochemistry.



Special thanks to:

Boston College Marine Biogeochemistry Lab

US Army Corps of Engineers
- Engineer Research and Development Center
- Philadelphia District

The Wetlands Institute

Rutgers Marine Field Station
Roland Hagan

Thank you!

Shameless Plug

I'm hitting the job market soon!

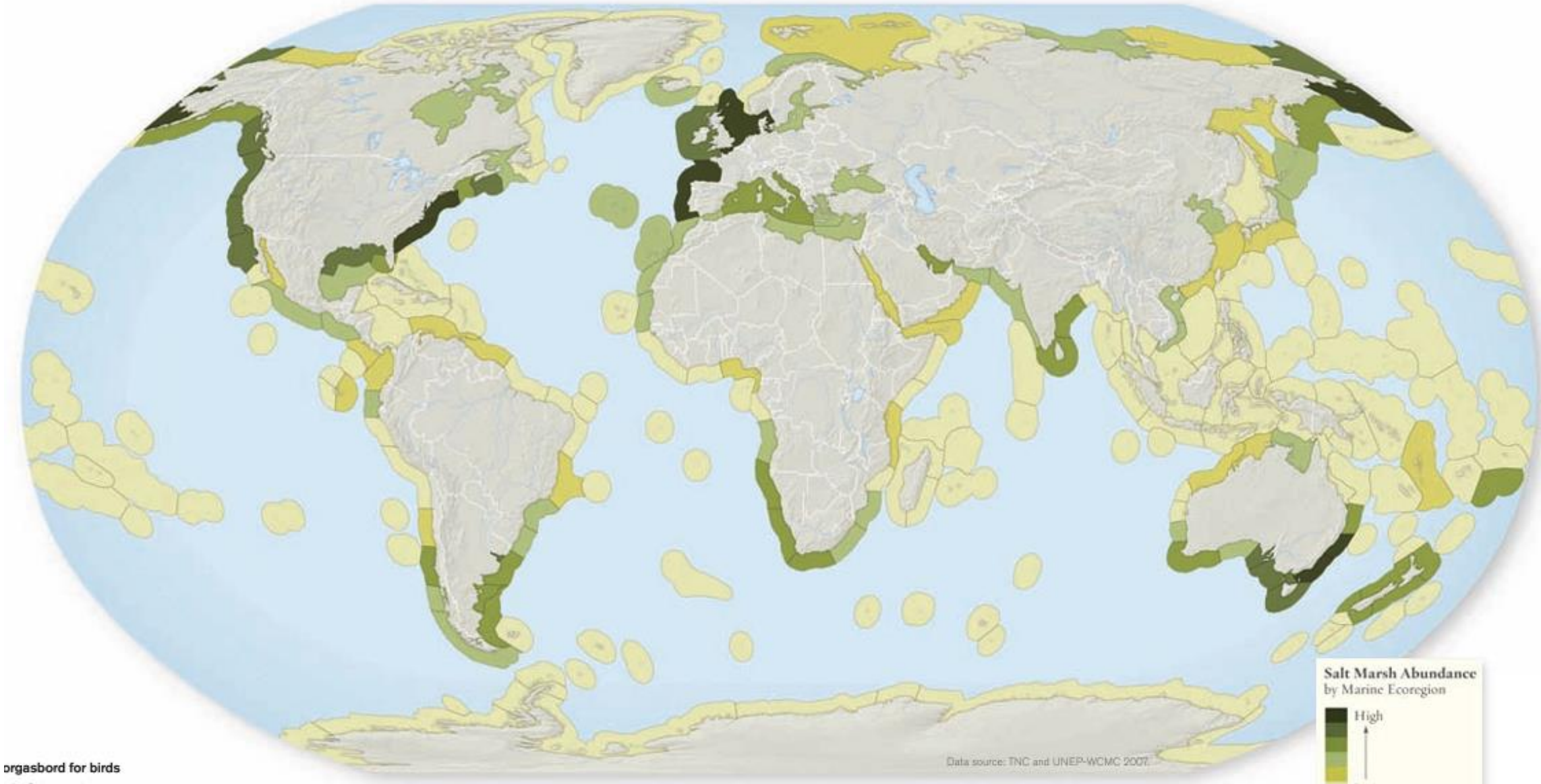
I'm interested in a wide variety of marine scientific work, either in i... postdoc! And depe... gets in America, I'm definit... open to moving!

Questions?

I'd love to learn more about nutrient cycles, ocean physics' role in metabolism, mCDR studies, NBS studies, etc.

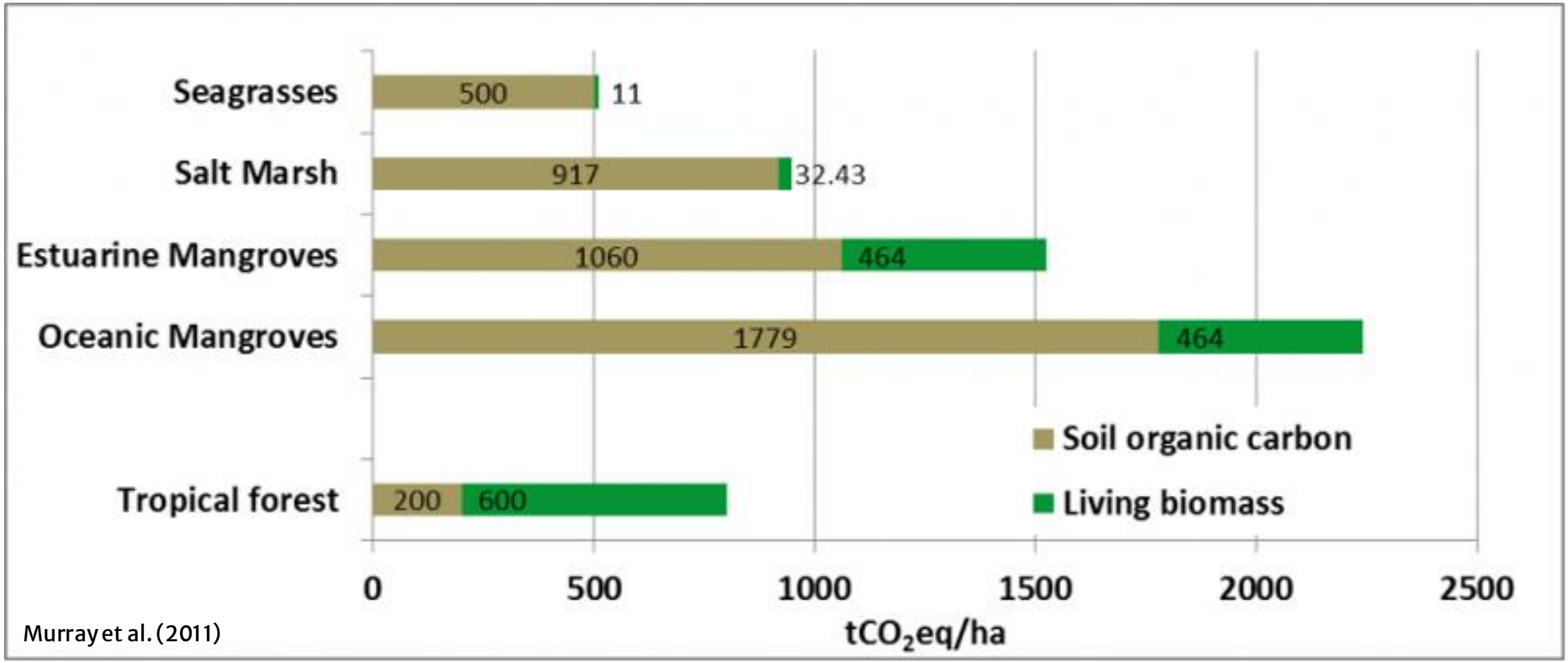
Please let me know if you or someone you know is looking for someone with my expertise!

Appendix

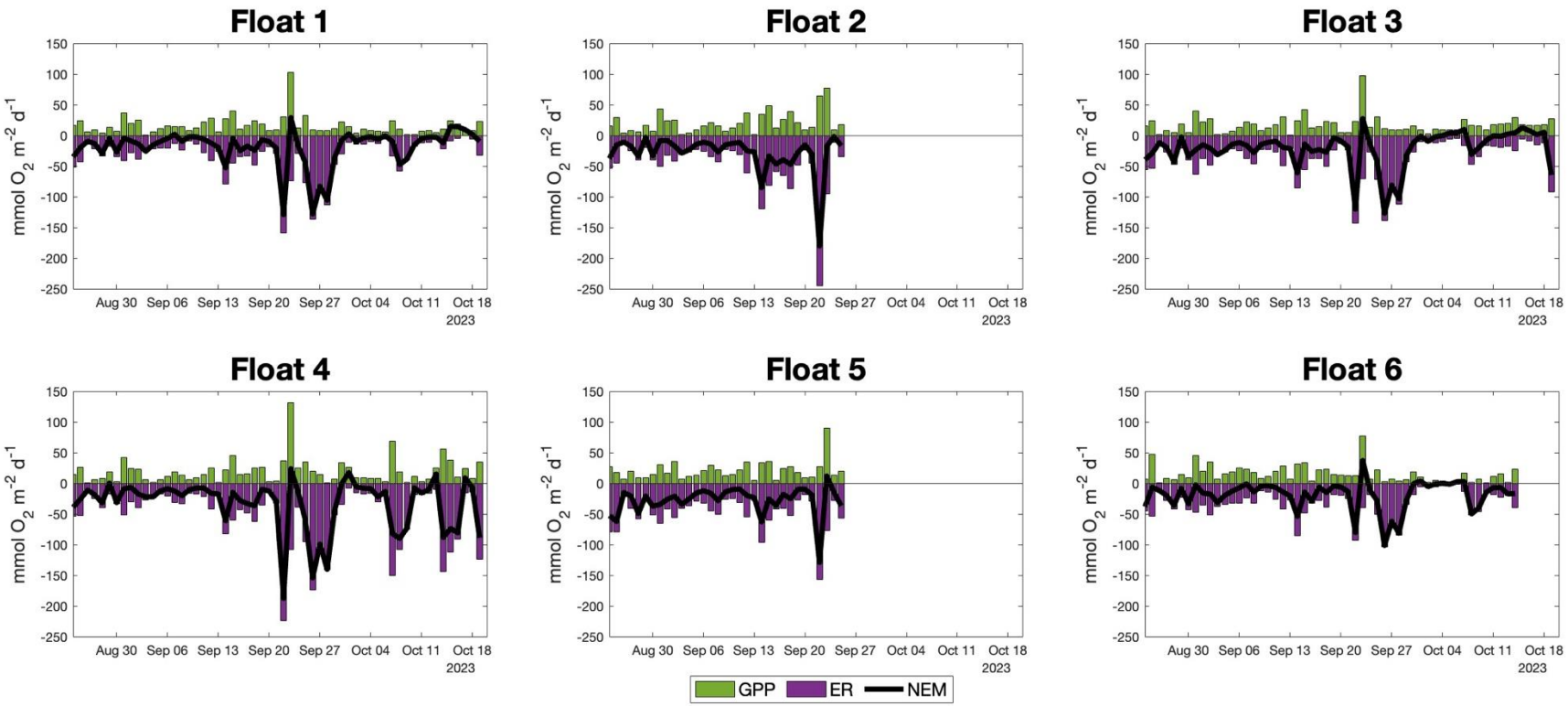


orgasbord for birds
sh. Salt marshes
e rich feeding

SALT MARSH HABITAT Salt marshes are a major coastal habitat in many low-lying



Murray et al. (2011)


Float 1
Float 2
Float 3
Float 4
Float 5
Float 6
mmol O2 m-2 d-1
150
100
50
0
-50
-100
-150
-200
-250
Aug 30
Sep 06
Sep 13
Sep 20
Sep 27
Oct 04
Oct 11
Oct 18
2023
GPP
ER
NEM

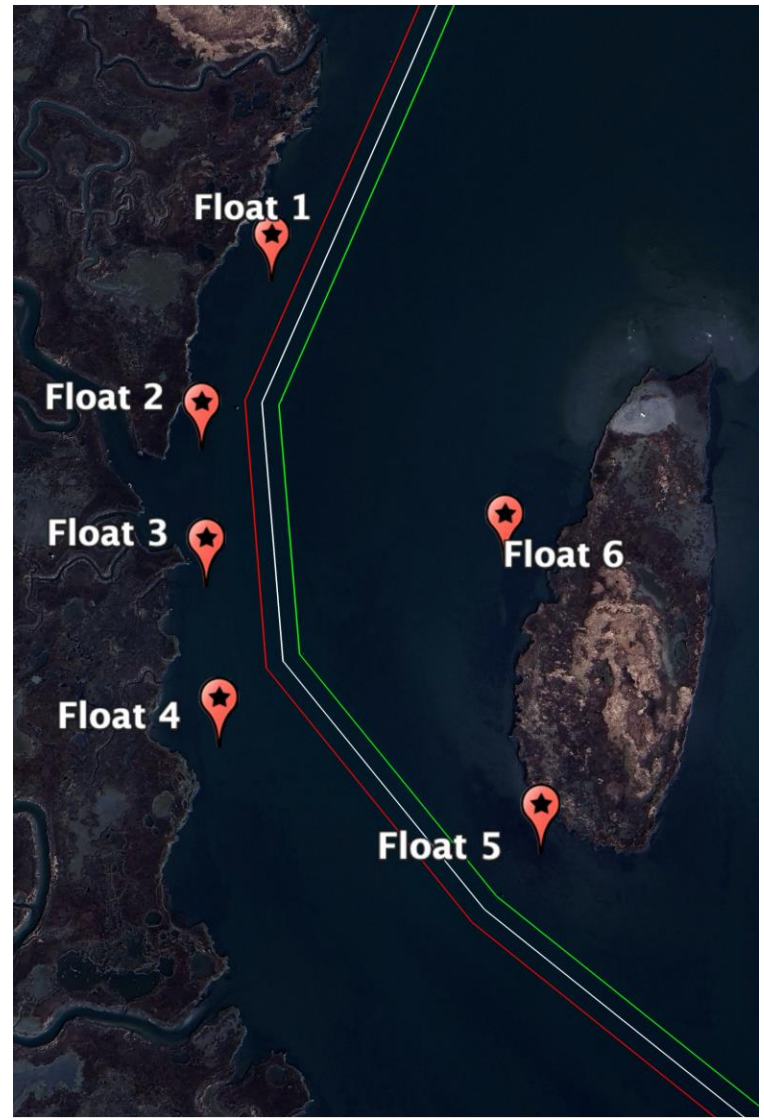

Float 1
Float 2
Float 3
Float 4
Float 5
Float 6

Figure 2. FY 2022 USACE CW Regular Direct Appropriations (in Millions) by Business Line[1/ 2]