Functional and compositional responses of periphyton mats to simulated saltwater intrusion in the southern Everglades.

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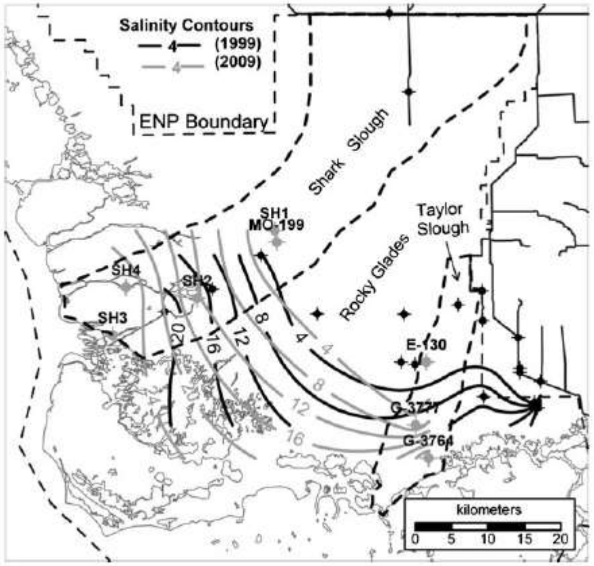
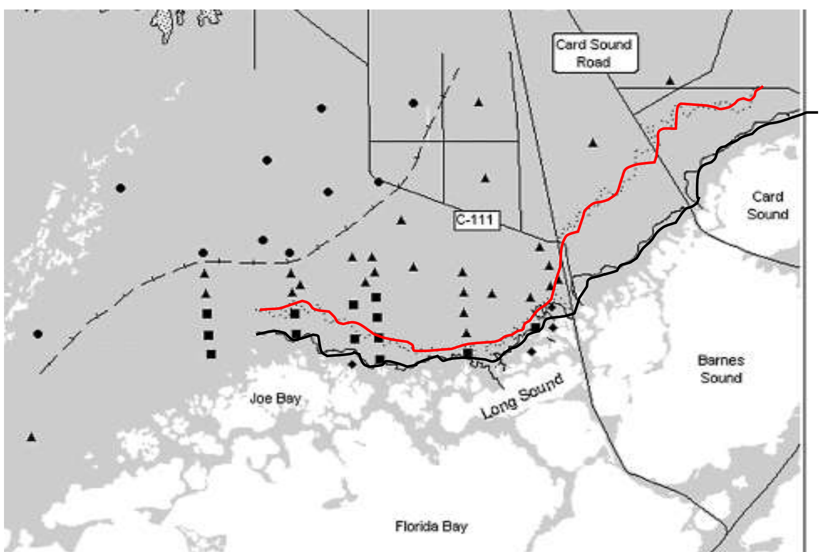
Sea level rise and reduced freshwater inputs facilitate intrusion of marine water into the southern Everglades

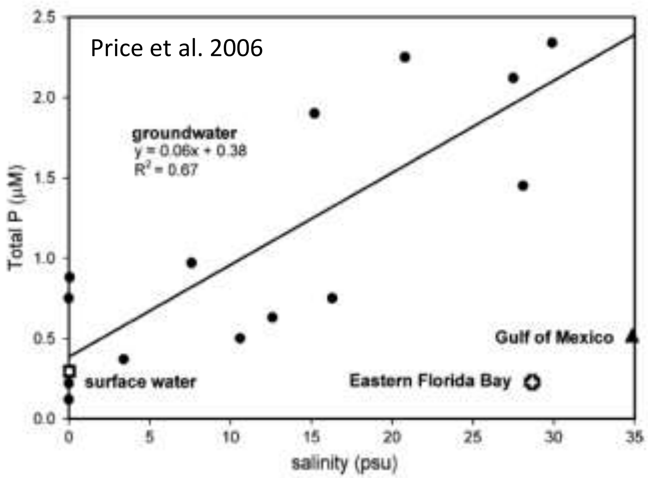


Salinity contours in 1999 and 2009 (Saha et al. 2011)



Ecotone landward migration from 1940 1994 (Ross et al. 2000)

- Low elevation and permeable limestone bedrock make this wetland especially susceptible to surface and below-ground marine water intrusion (MWI).
  - Pulse (extreme dry seasons, tides, storms) and press (higher sea level) exposure.
- MWI **elevates salinity** and delivers excess **phosphorus** (P) into this naturally oligotrophic, freshwater landscape (Saha 2011, Price et al. 2006).



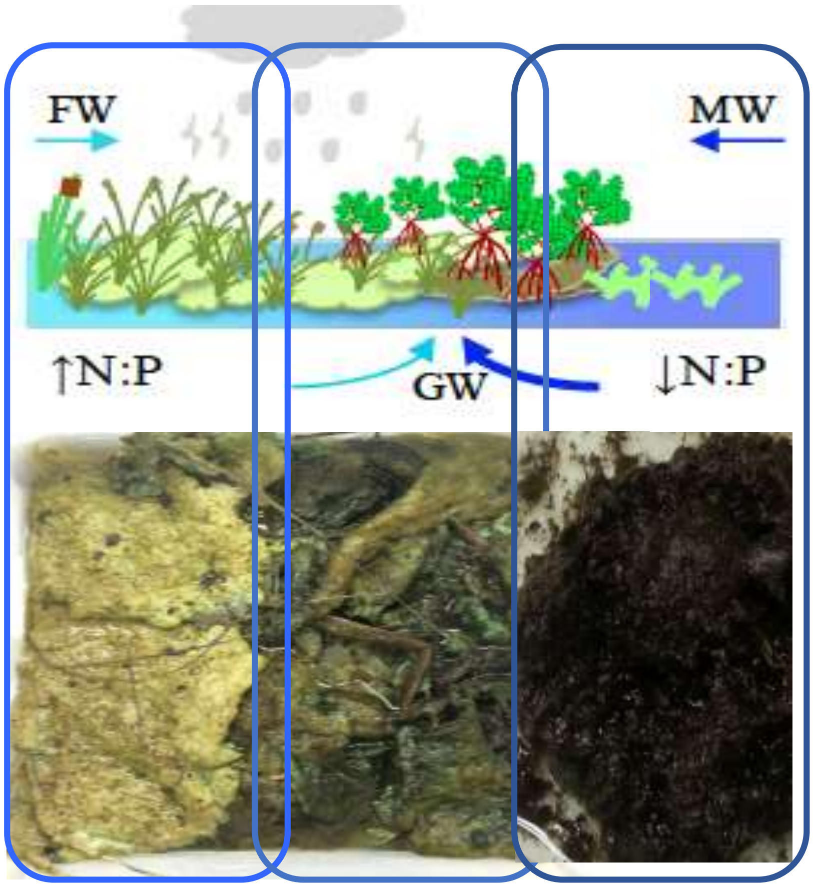
- Understanding ecosystem-scale response to MWI requires studying individual responses of key ecosystem components (e.g., soils, plants, periphyton)

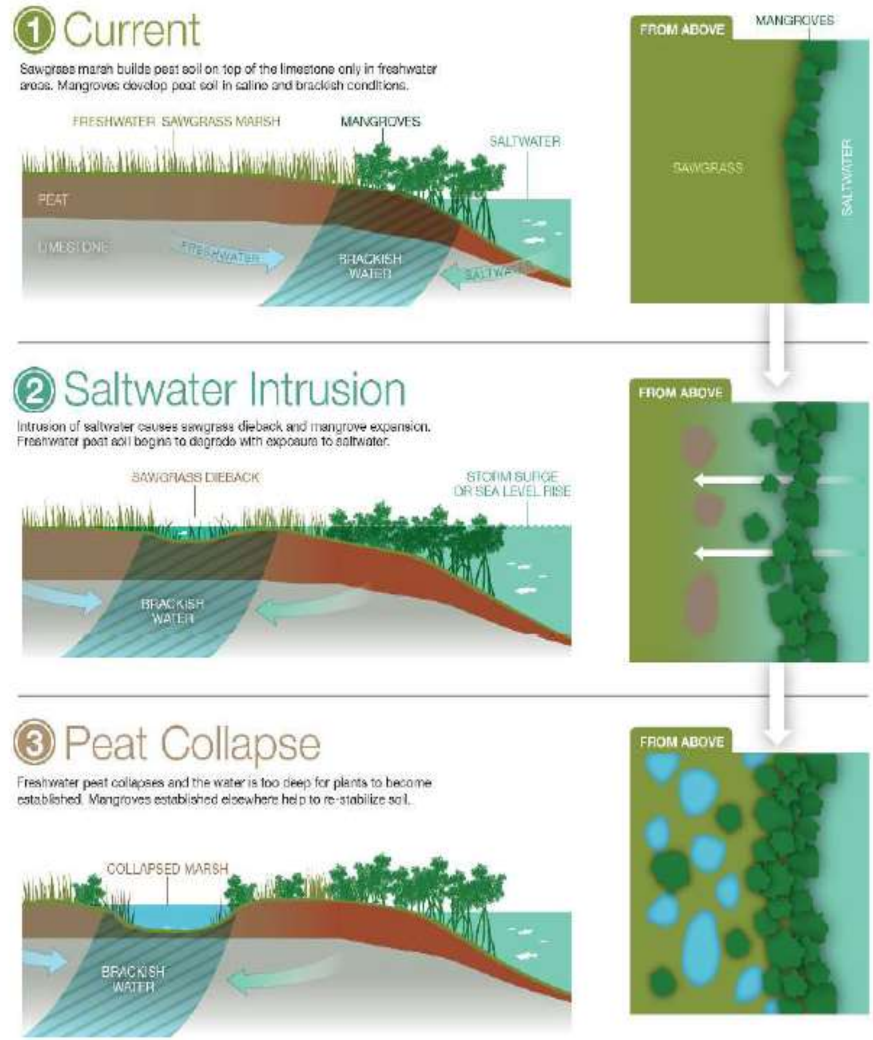
Calcareous periphyton is a characteristic feature of the Everglades with important ecosystem functions.

(primary production, food web dynamics, habitat, inorganic and organic C cycling, and nutrient cycling)

- Biomass averaging 100 g C m^{-2} and up to 10,000 g AFDM m^{-2} (Ewe et al. 2006, Iwaniec et al. 2006, Gaiser 2009; Gaiser et al. 2011, Troxler et al. 2013)
- Sensitive to elevated salinity (absence of calcareous-cohesive mats from coastal areas) and P (Gaiser et al. 2004).

Transition from **cohesive, calcareous** mats to **loose, organic mats** along a salinity and P gradient



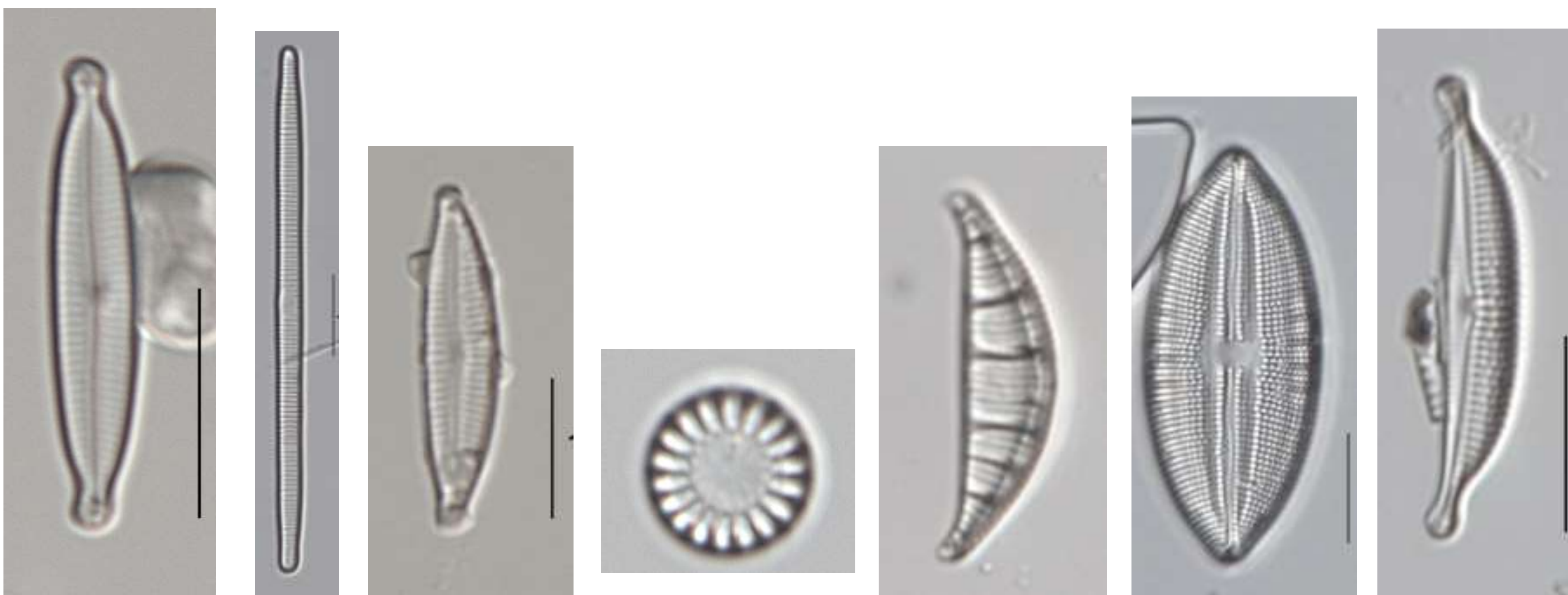


Cohesive calcareous mats, with a **high C storage** capacity, replaced by loose filamentous mats and biofilms with **low C storage** capacity.

Change in periphyton structure is related to shifts in algal species composition

Diatom community is a particularly useful tool to track and predict changes associated with saltwater intrusion.

These communities respond predictably to salinity and P associated with MWI, but the sensitivity of this response to **small-scale pulses** in salinity is less well understood.



Question

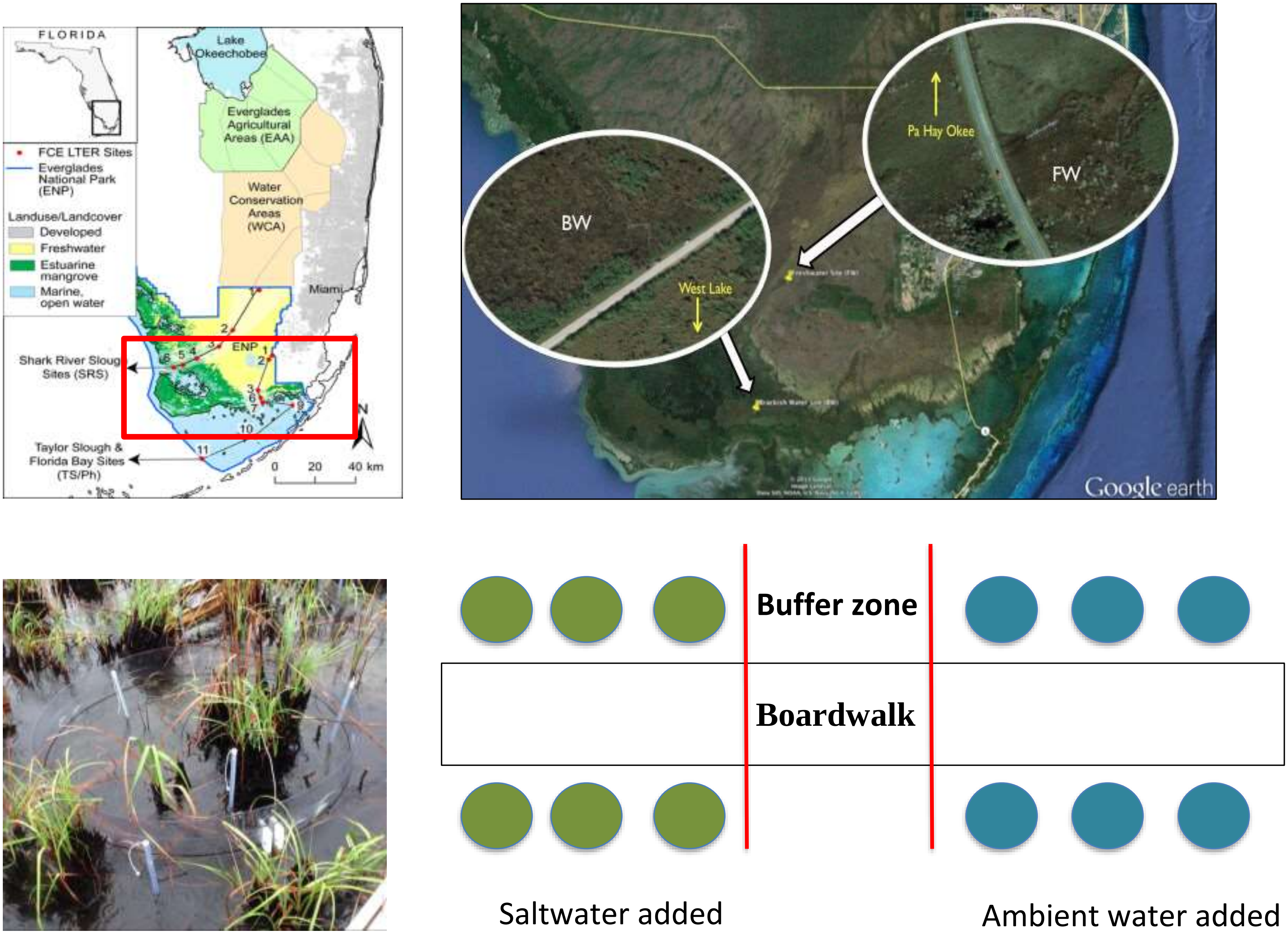
How will saltwater intrusion affect benthic algal mat function and diatom species composition in freshwater (FW) and brackish water (BW) marshes?

Hypotheses

1) The osmotic stress caused by elevated salinity will **decrease periphyton productivity, C content, and nutrient uptake.**

2) These functional responses will be accompanied by **changes in diatom species composition** reflecting whole periphytic algal community shifts.

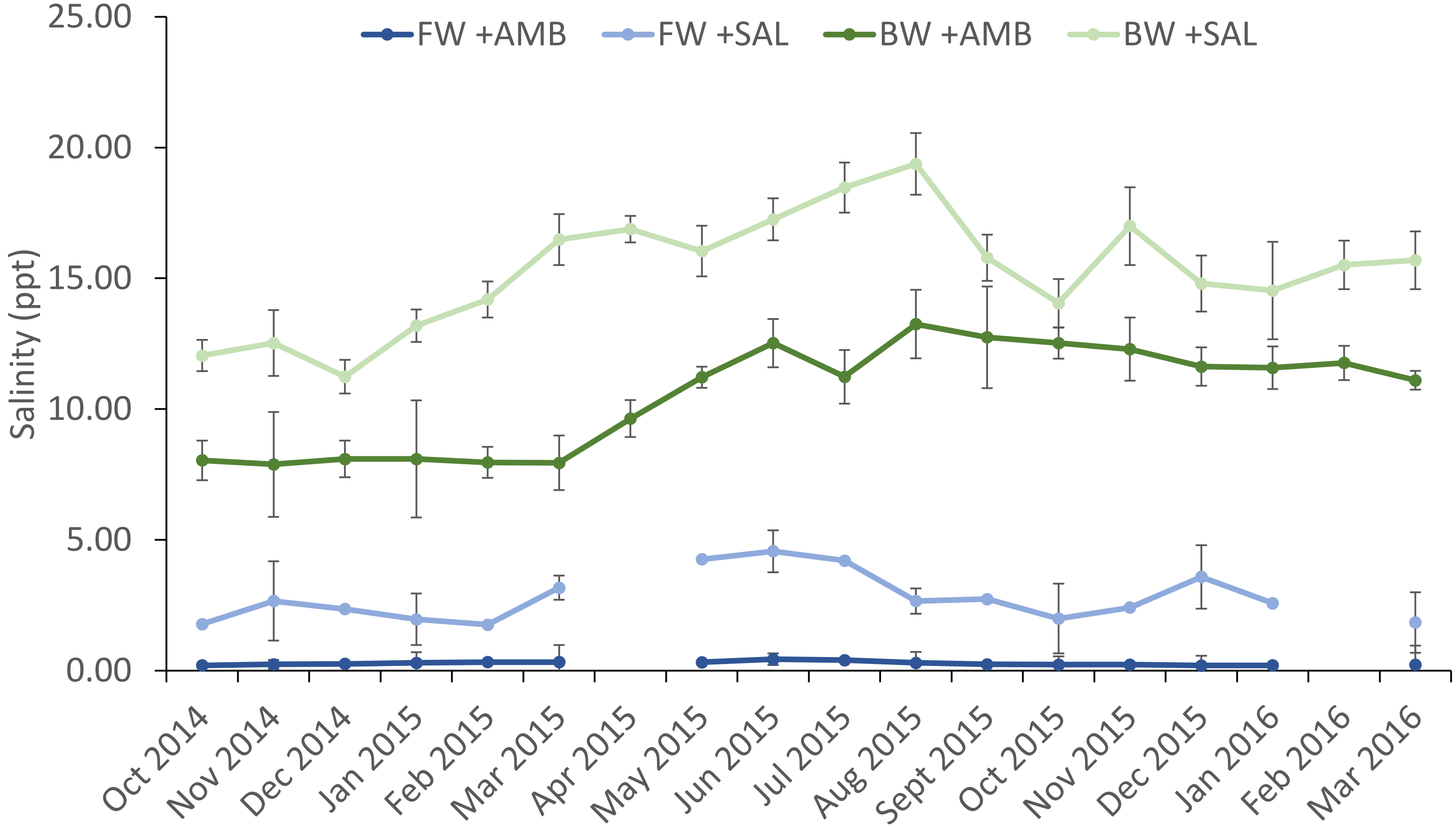
3) Periphyton mats from **FW marshes** will be **more responsive** to elevated salinity **compared to BW marshes**.

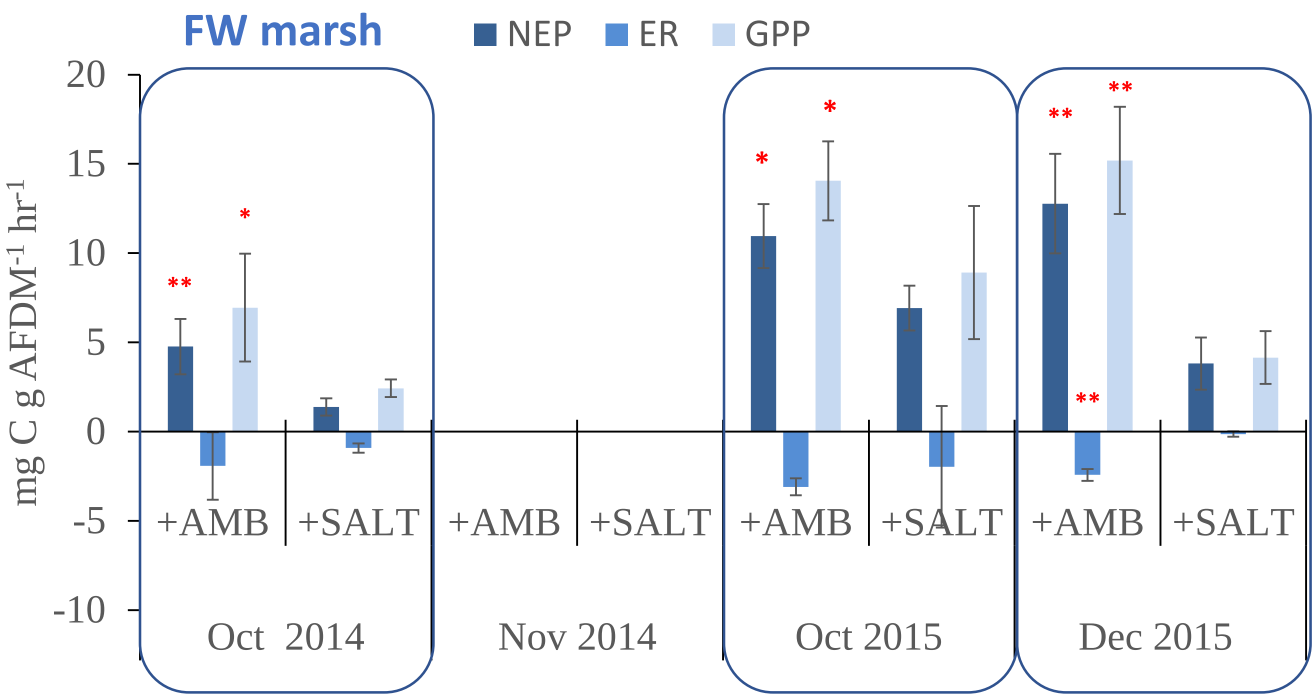

FLORIDA
Lake Okeechobee
Everglades Agricultural Areas (EAA)
Water Conservation Areas (WCA)
Miami
ENP
FCE LTER Sites
Everglades National Park (ENP)
Landuse/Landcover
Developed
Freshwater
Estuarine mangrove
Marine, open water
Shark River Sloug Sites (SRS)
Taylor Slough & Florida Bay Sites (TS/Ph)
0 20 40 km
N
Pa Hay Okee
FW
BW
West Lake
Google earth
Buffer zone
Boardwalk
Saltwater added
Ambient water added

Methods

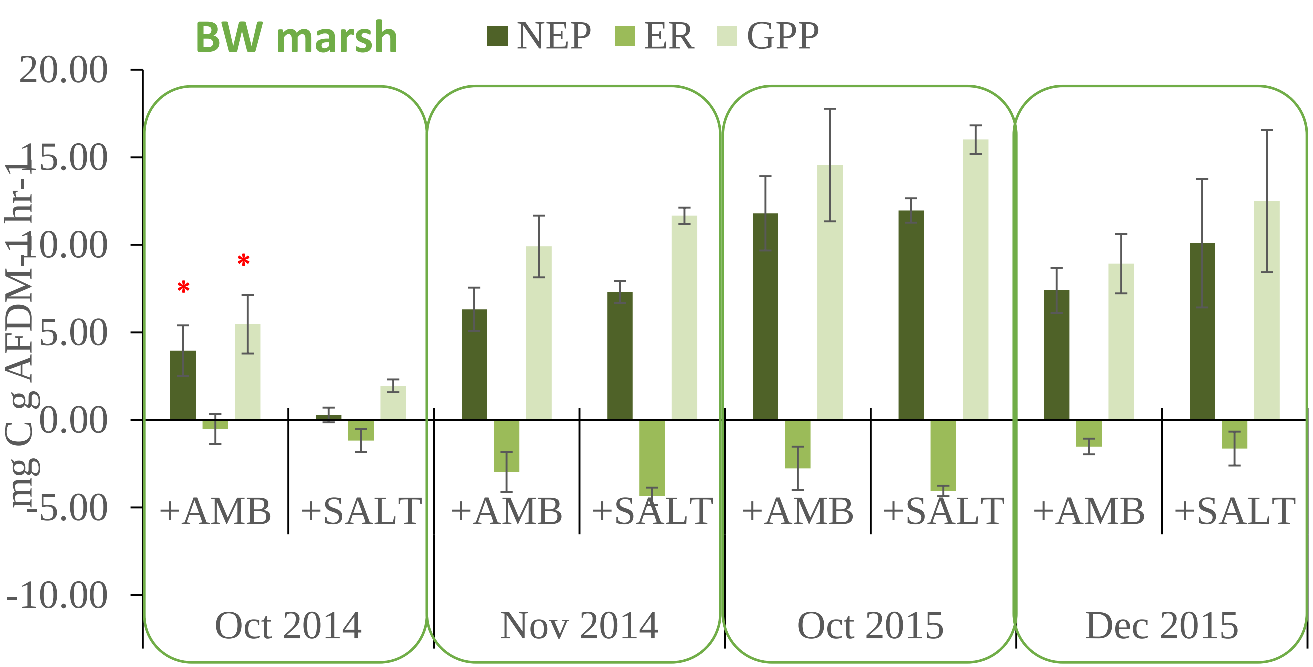
- 12 experimental chambers installed at both sites.
    - •6 controls (monthly dosing with site water)
    - •6 salinity treatment
    (monthly dosing using Instant Ocean + site water)
- Target PW salinity
    - •FW 5 ppt
    - •BW double ambient (~15 ppt)
- Periphyton measurements and samples (monthly the day after dosing)
    - NEP, ER, GPP
    - Chl-a
    - TC, TN, TP
    - ANOVAs to test for treatment effects
- Diatom community composition
    - ANOSIM and NMDS

Salt addition significantly raised salinity levels in treatment chambers compared to controls at both FW and BW

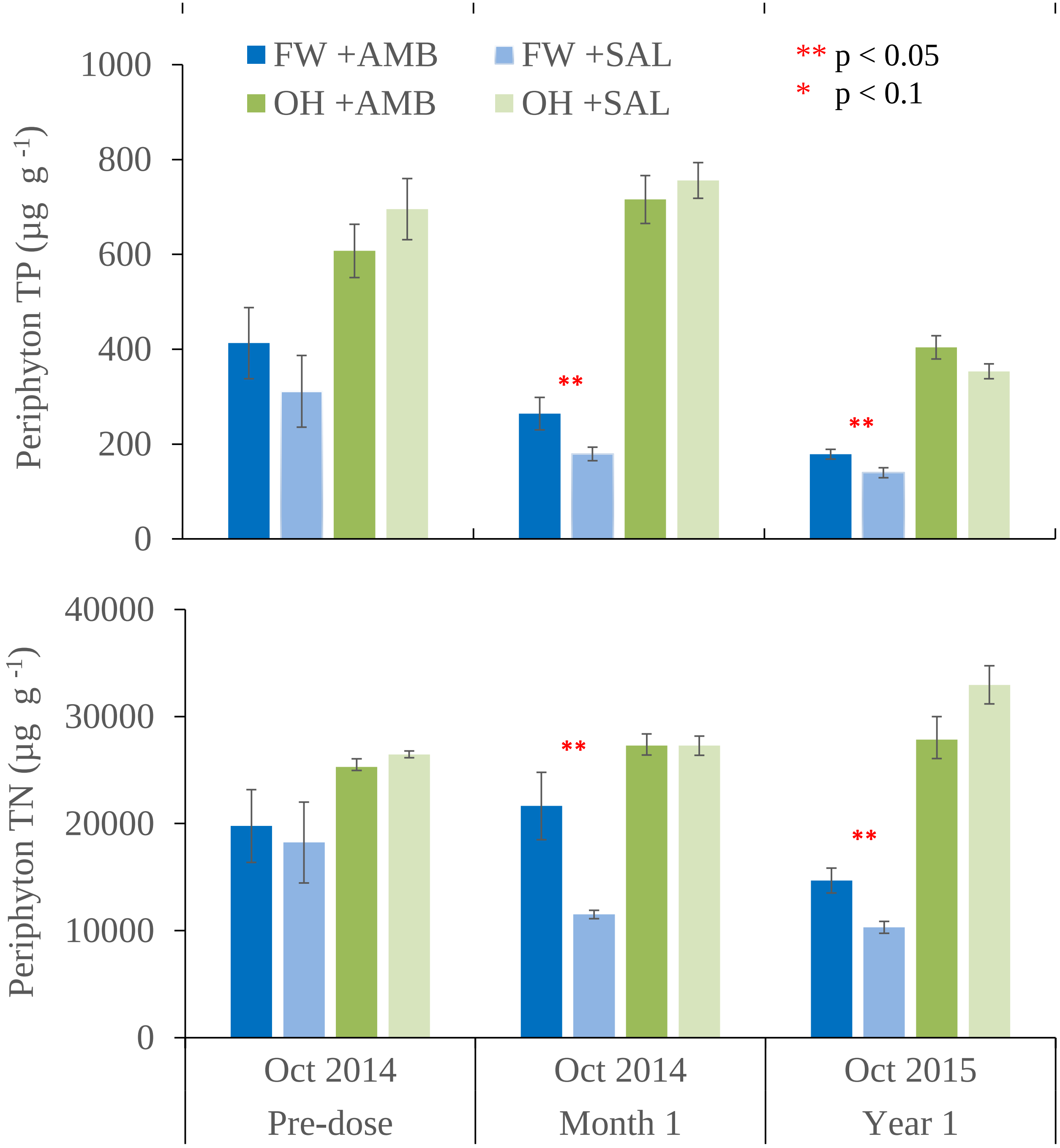




** $p < 0.05$
* $p < 0.1$



- After 1 simulated salinity pulse NEP and GPP decreased significantly in both **FW** and **BW** periphyton.
- NEP and GPP remained depressed after 12 monthly salinity pulses in FW periphyton.
- BW periphyton productivity recovered by the second month of dosing and continued unaffected through the first year.

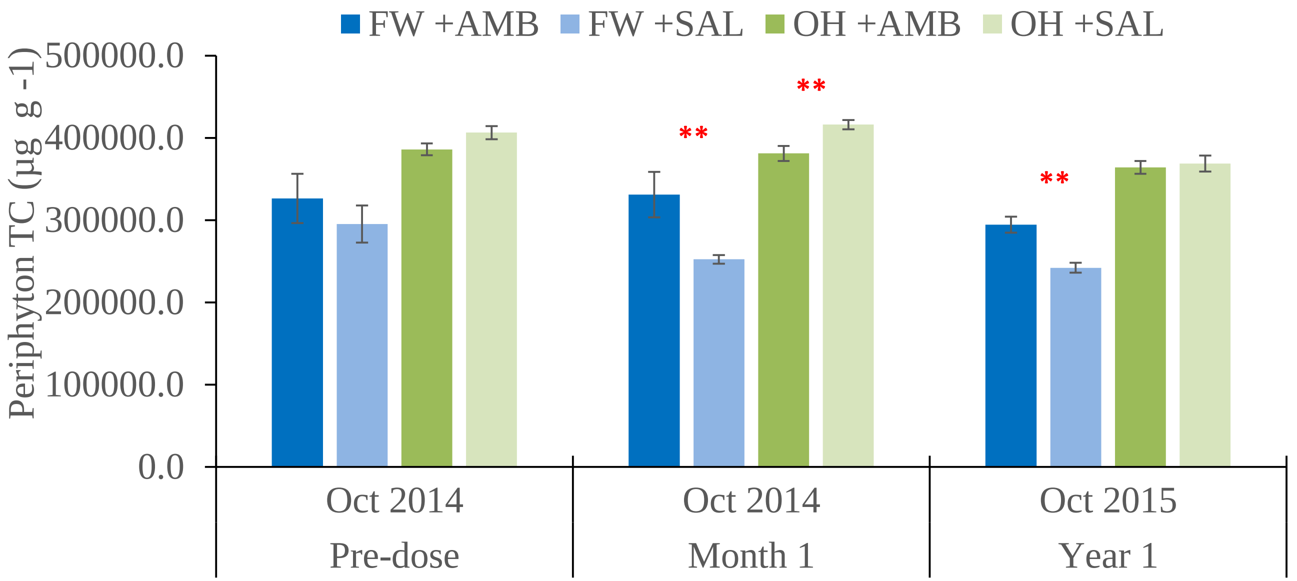


Periphyton TP and TN significantly reduced in treatments at FW marsh.

Decrease in nutrient content may be caused by:

1. Osmotic stress reduces active nutrient uptake capacity.
2. Elevated salinity shifts community composition to salt tolerant species with different stoichiometry than freshwater species.

Elevated salinity decreases periphyton TC and % organic content at FW site



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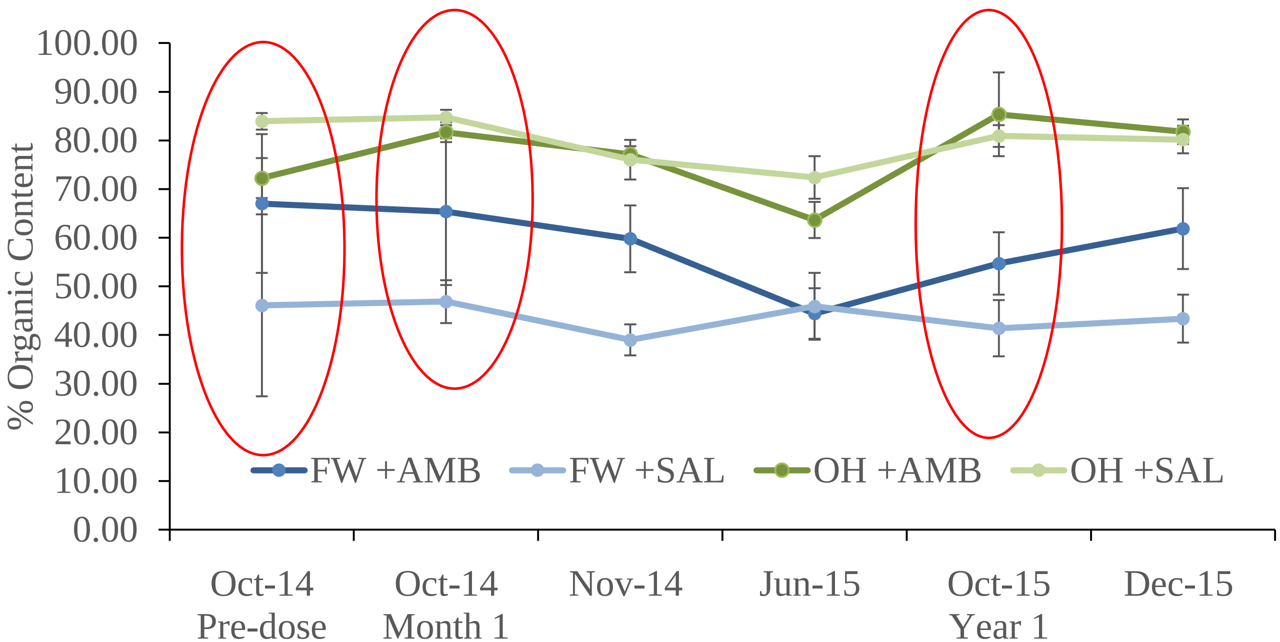
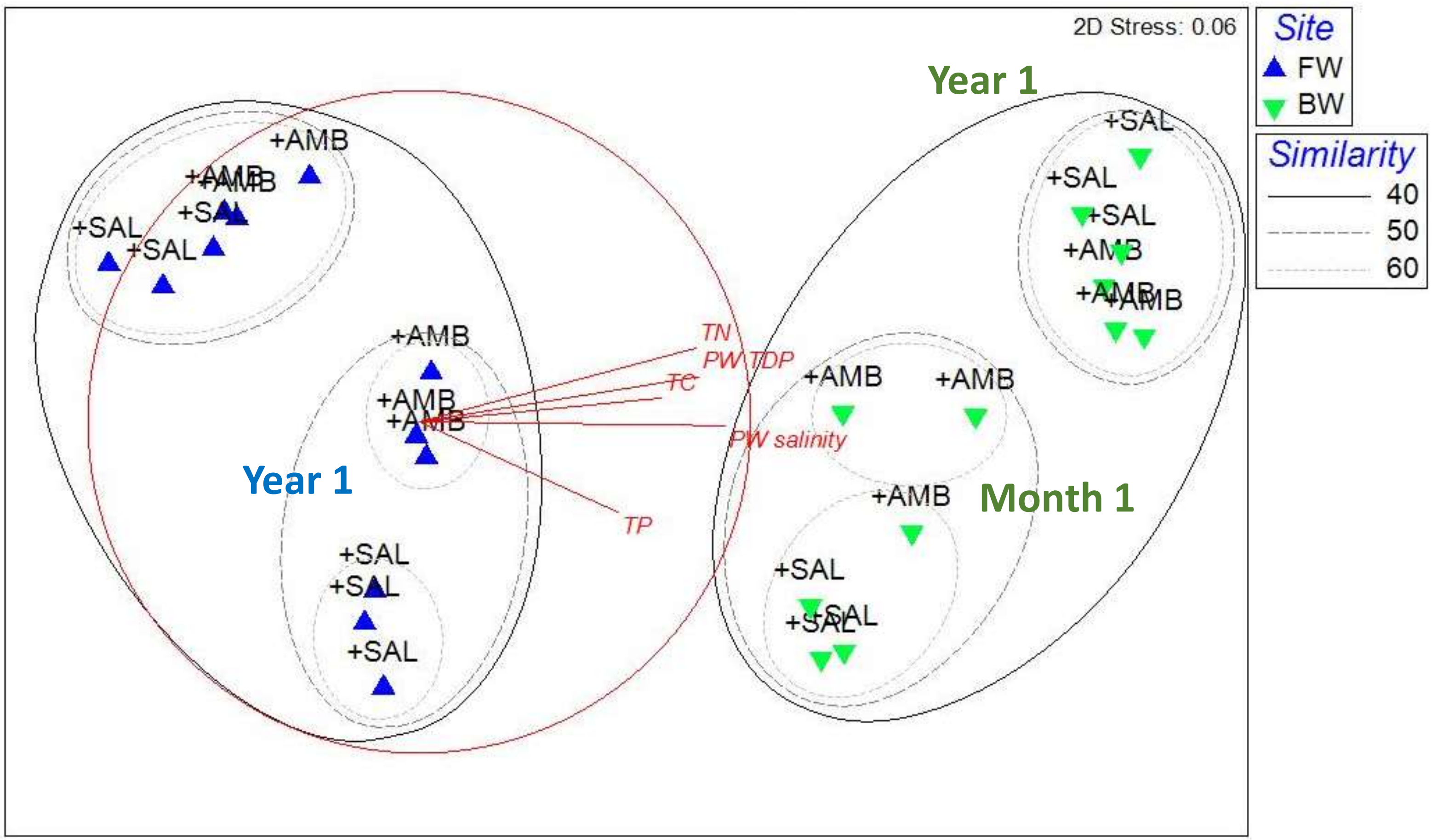


Significant shifts in diatom community composition in response to increased salinity in both FW and BW periphyton

FW: begin to diverge after the first saltwater dosing and continued to deviate more strongly after month 12 of dosing.

BW: deviated strongly after the first saltwater dose but reverted back to a community more closely resembling that in the controls at month 12.

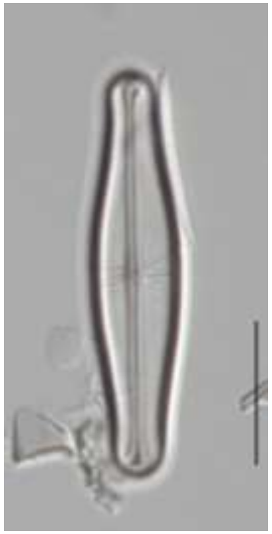


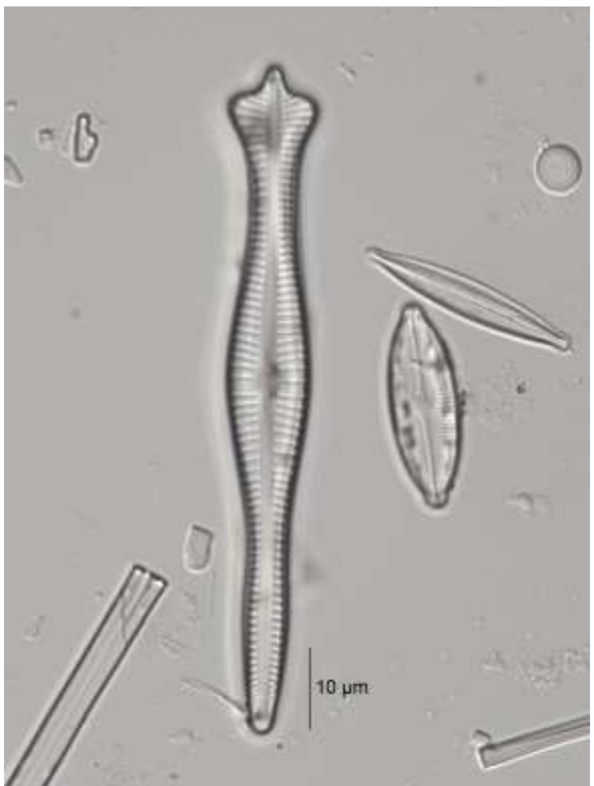
FW marsh

- Short term exposure (month 1) to pulsed salinity reduced NEP, GEP, TC, TN, and TP and remained depressed after long term exposure (1 year).
- Long term exposure shifted community composition to potentially salt tolerant species with lower performance than native communities.

BW marsh

- Short term exposure reduced NEP, GPP, and TC but no long term effects.
- Pulsed salinity increases caused community composition to diverge initially but become more similar over time.
- This resilience is likely a result of historic exposure to fluctuating salinity as well as the greater availability of P, which may offset salt stress.





Concluding Remarks

- Simulated saltwater intrusion causes functional (i.e. metabolism and nutrient uptake) and compositional responses in periphyton from both FW and BW marshes, although BW marshes are more resilient.
- Diatom community composition is a powerful tool to assess short term changes in periphyton and the environment associated with saltwater intrusion.
- Working with collaborators studying other key ecosystem components to develop an ecosystem–level model of Everglades response to pulsed saltwater intrusion.

Acknowledgements

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