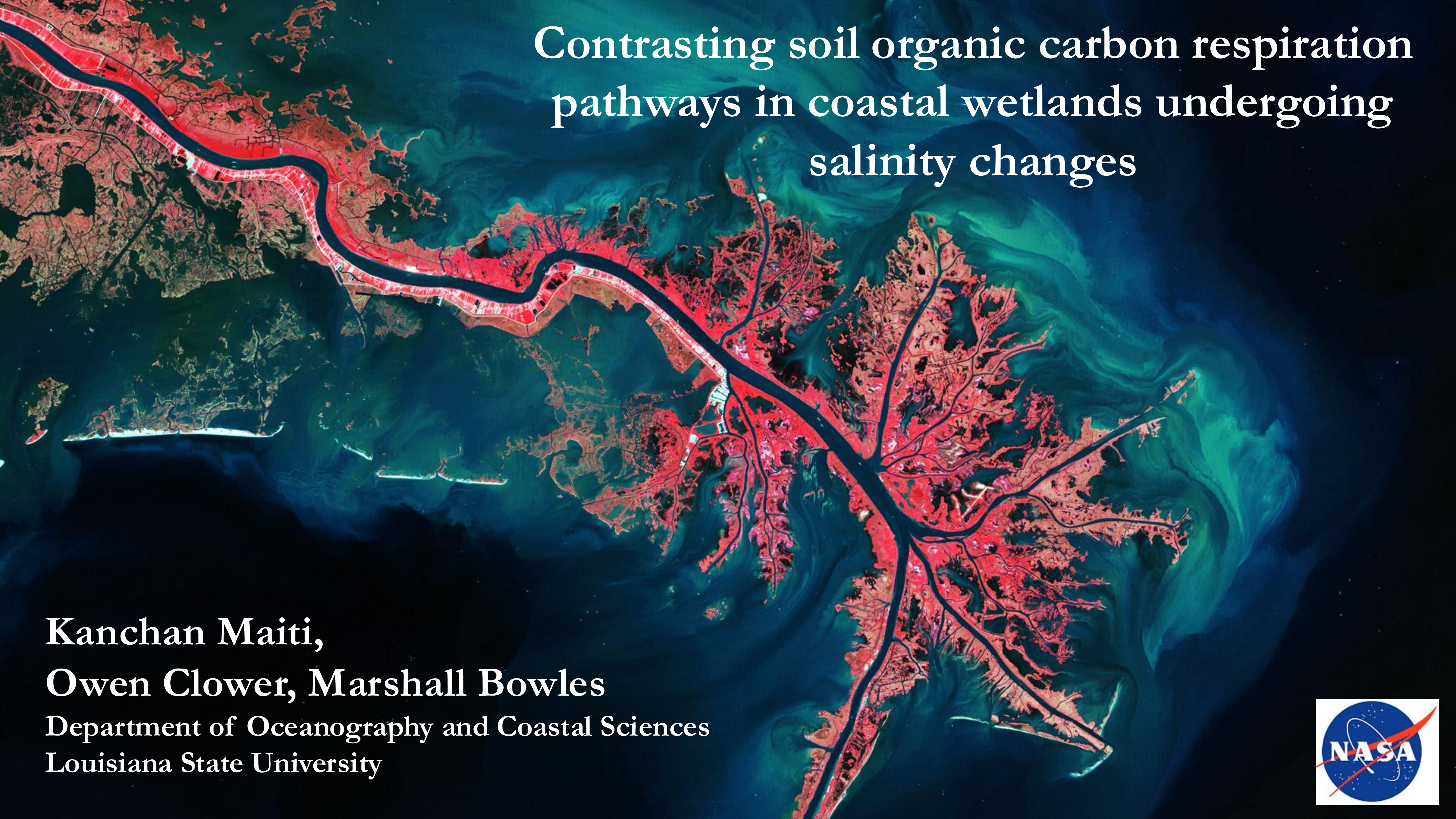

Contrasting soil organic carbon respiration pathways in coastal wetlands undergoing salinity changes

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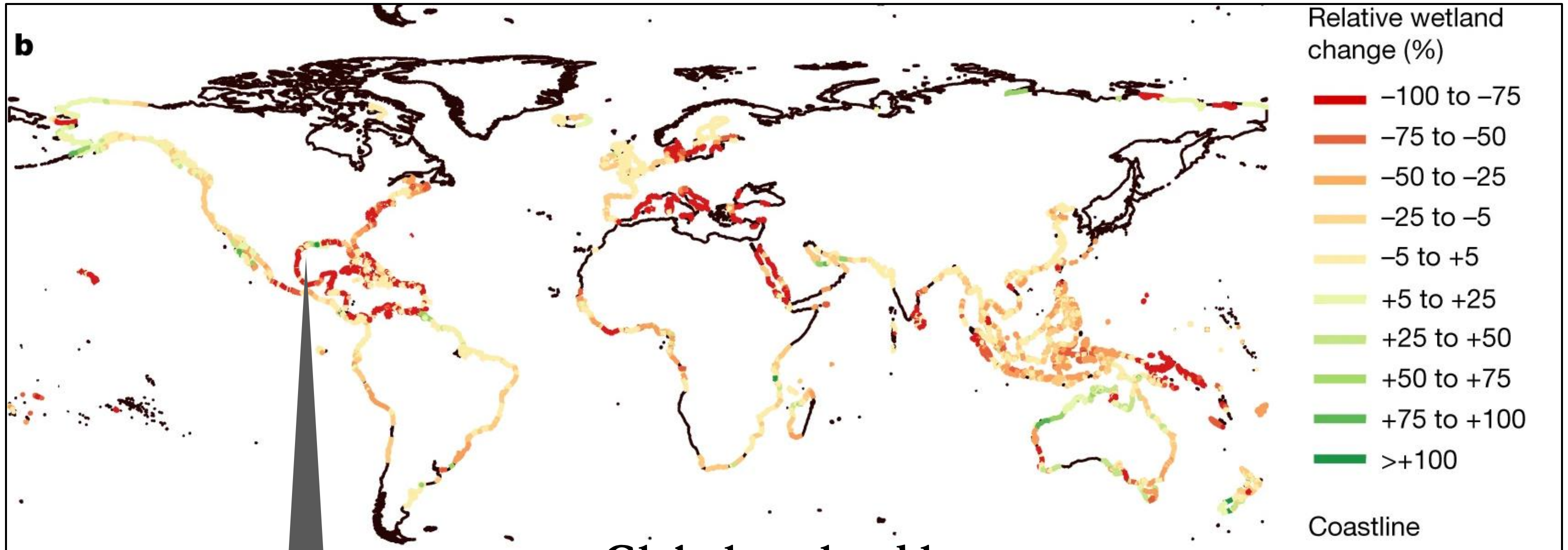
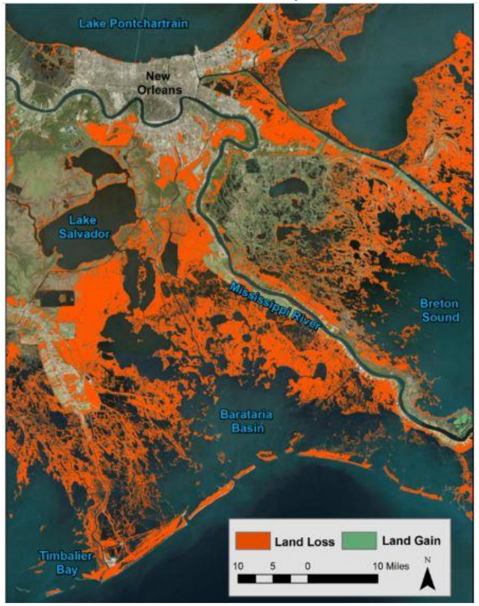
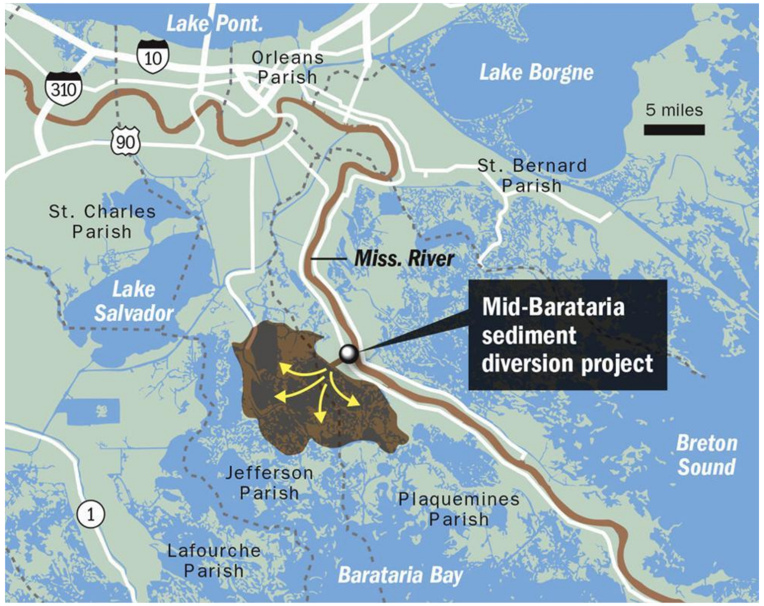
Research Motivation



Global wetland loss

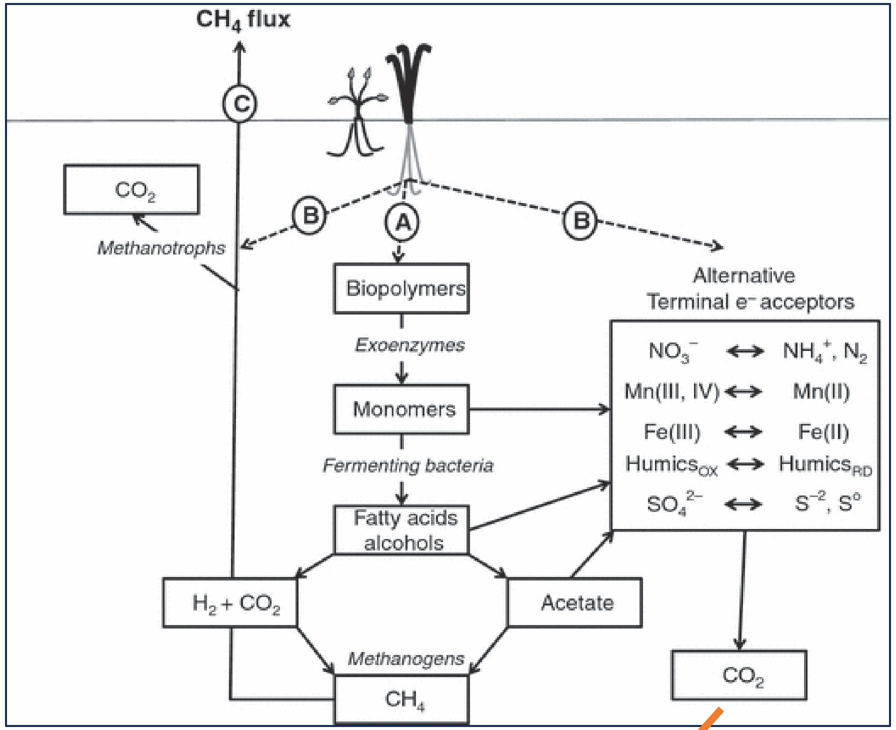


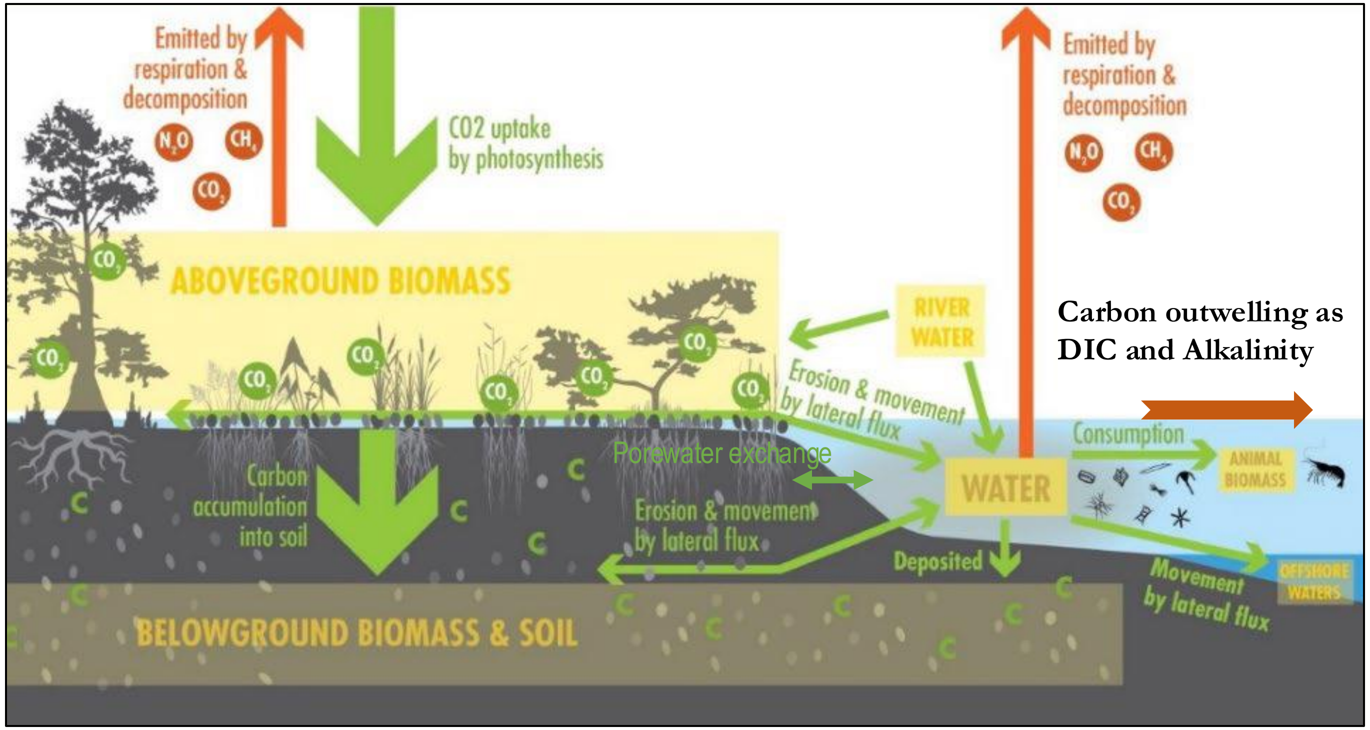
Restoration



- ❑ Up to 87 Tg C per year is sequestered in coastal wetlands.
- ❑ Impacted by dramatic changes in salinity due to sea level changes, drought, restoration efforts.
- ❑ Barataria Bay, in northern Gulf of Mexico with high relative sea-level rise and land loss is the focus of ~two-billion-dollar river diversion project to supply sediments.
- ❑ How will soil microbial respiration pathways shift in response to salinity changes and impact carbon cycling pathways?

Soil carbon respiration pathways and transport

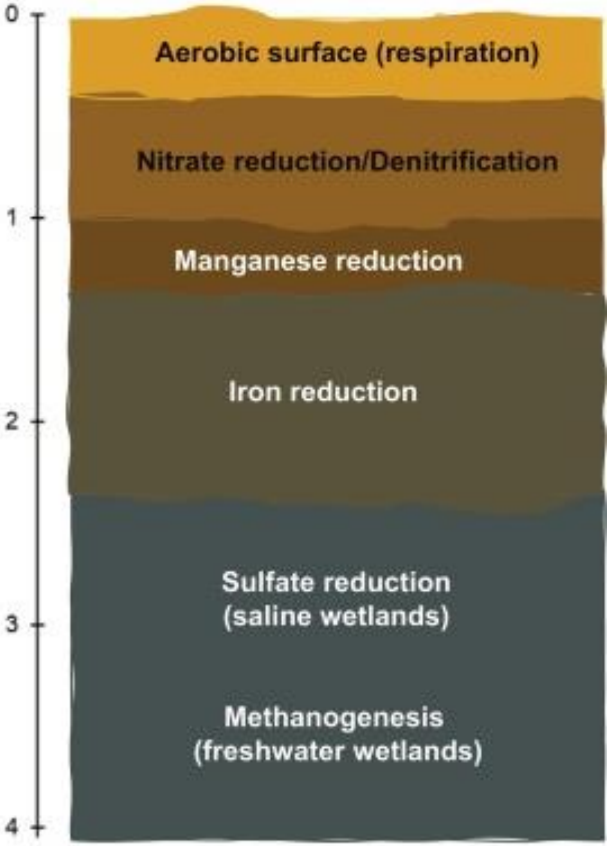




Contributes to porewater dissolved inorganic carbon (DIC = CO_2 + CO_3 + HCO_3) and Alkalinity pool

- The seasonal soil respiration results in a "marsh CO_2 pump".
- Lateral flux of carbon from tidal wetlands to estuaries is estimated to be 16 ± 10 Tg C per year (Windham-Myers et al. 2018).

Microbial Respiration Pathways and carbon transformation



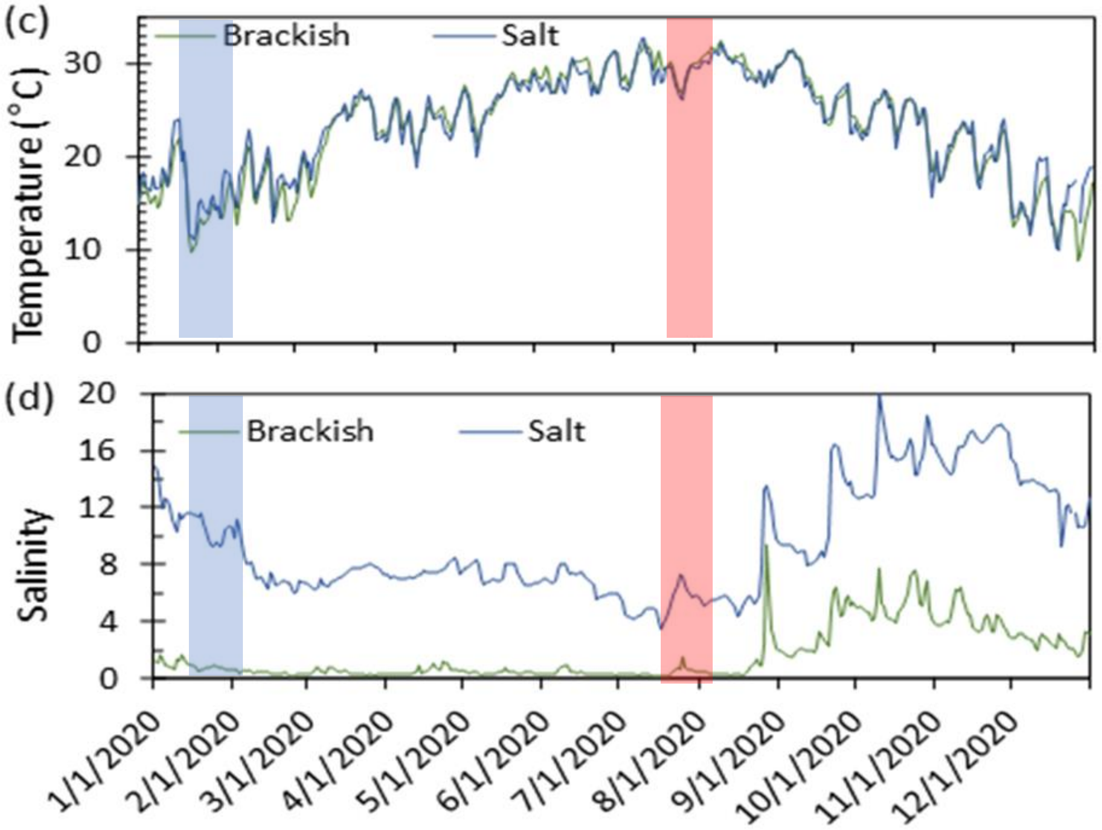
Mobilian, C., & Craft, C. B. (2022).

Krumins et al., (2013)

Reaction Name	Reaction Equation	ΔDIC	ΔTA
Hydrolysis	$(CH_2O)_{106}(NH_3)_{16}(H_3PO_4) + 15H^+ \rightarrow 106CH_2O + 16NH_4^+ + H_2PO_4^-$	0	+0.14
Aerobic respiration	$CH_2O + O_2 \rightarrow CO_2 + H_2O$	+1	0
Denitrification	$CH_2O + 0.8NO_3^- + 0.8H^+ \rightarrow CO_2 + 0.4N_2 + 1.4H_2O$	+1	+0.8
Manganese reduction	$CH_2O + 2MnO_2 + 4H^+ \rightarrow CO_2 + 2Mn^{2+} + 3H_2O$	+1	+4
Iron reduction	$CH_2O + 4Fe(OH)_3 + 8H^+ \rightarrow CO_2 + 4Fe^{2+} + 11H_2O$	+1	+8
Sulfate reduction	$CH_2O + 0.5SO_4^{2-} + 0.5H^+ \rightarrow CO_2 + 0.5HS^- + H_2O$	+1	+1

DIC and **Alkalinity** determines the partitioning among carbonate species and thus influences key processes, such as air–water exchange of CO_2, acidification, and $CaCO_3$ precipitation/dissolution.

Experimental Design



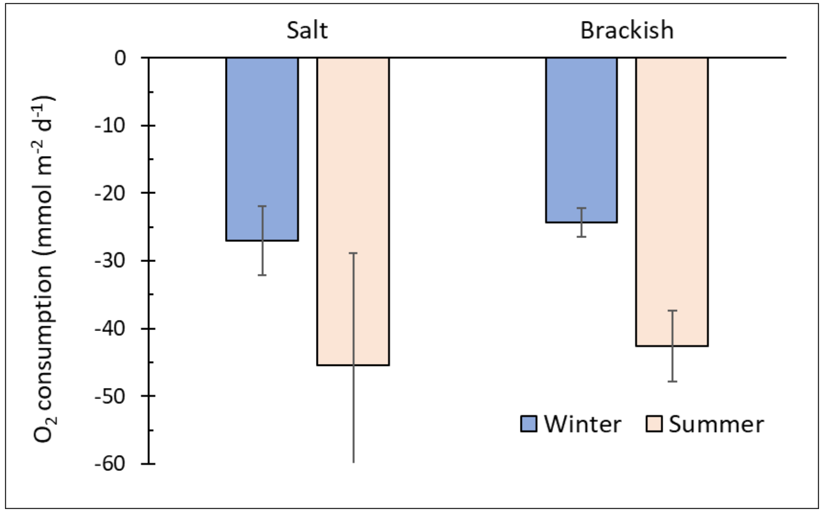
Samples were collected during **winter** (Jan-Feb) and **summer** (Jul-Aug) of 2020 from both the marshes.

Field Sampling

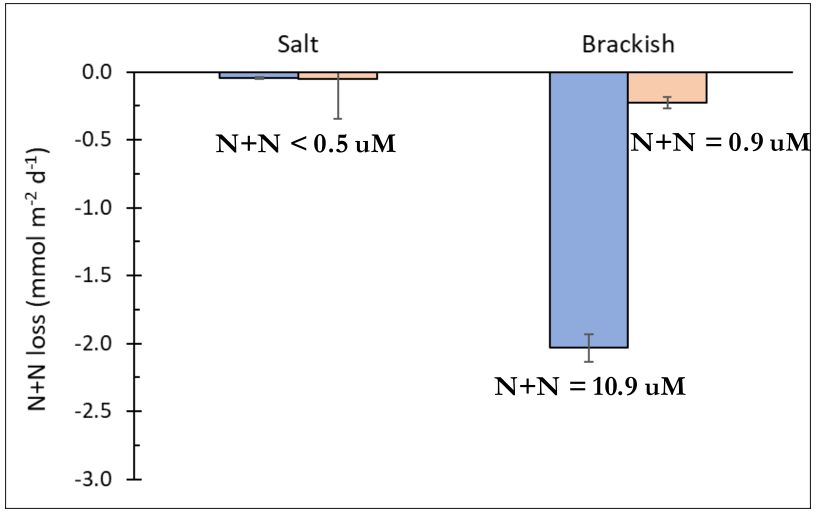
- Intact cores were collected in triplicate from each site during each season.
- Aerobic respiration and potential denitrification was measured through O_2 and N+N consumption during whole core incubation. N_2/Ar method could not be utilized to estimate net D_n due to instrumental failure.
- Iron reduction rates were determined through pre and post incubation changes in porewater Fe^{+2}.
- SO_4 reduction rates were determined using ^{35}S sulfate method.
- Methane fluxes were not measured as they are low in these freshwater marshes (< 1.87 mmol m^{-2} d^{-1}). Anaerobic methane oxidation, with sulfate as the electron acceptor, will also reduce methane fluxes and is likely incorporated in sulfate reduction rates (Segarra et al., 2013).

Seasonal respiration pathways across salinity gradient

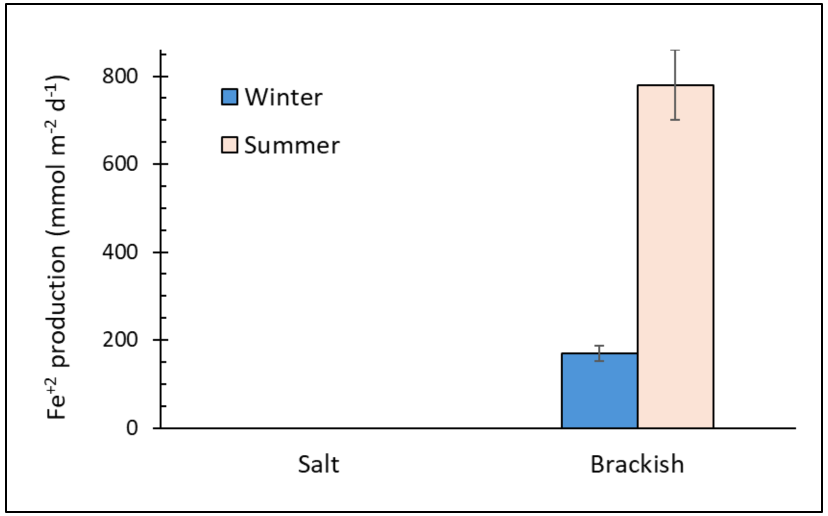
Aerobic Respiration



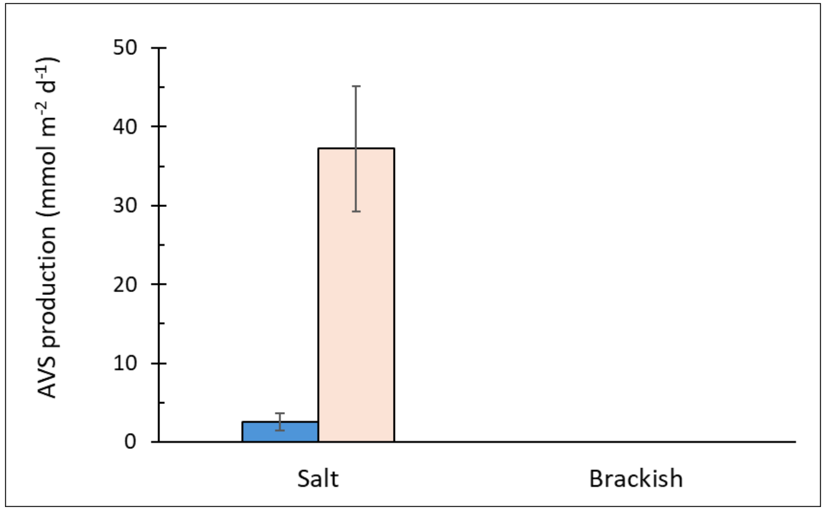
Potential Denitrification



Iron Reduction



Sulfate Reduction



- Aerobic respiration similar between marsh types.
- Denitrification rates are low due to low nitrate levels.
- Porewater Fe^{+2} was below detection in saltwater marsh during both seasons.
- Iron and sulfate reduction rates increase significantly in summer.

How much carbon was respired?

Respiration Pathways	mmol/m²/d			
	Brackish Winter	Salt Winter	Brackish Summer	Salt Summer
Aerobic Respiration (O_2 mmol/m^2/d)	24.37 ± 2.15	27.0 ± 5.13	42.58 ± 5.29	45.45 ± 16.63
Potential Denitrification (NO_3 mmol/m^2/d)	2.03 ± 0.10	0.05 ± 0.01	0.23 ± 0.04	0.05 ± 0.30
Potential Iron Reduction (Fe mmol/m^2/d)	169.23 ± 12	B.D.	779.66 ± 48	B.D.
Sulfate Reduction (SO_4 mmol/m^2/d)	N/A	2.55 ± 1.06	N/A	37.20 ± 9.90

Reaction Name	Reaction Equation	Δ DIC
Aerobic Respiration	$CH_2O + O_2 \rightarrow CO_2 + H_2O$	+1
Denitrification	$CH_2O + 0.8NO_3^- + 0.8H^+ \rightarrow CO_2 + 0.4N_2 + 1.4H_2O$	+1
Manganese Reduction	$CH_2O + 2MnO_2 + 4H^+ \rightarrow CO_2 + 2Mn^{2+} + 3H_2O$	+1
Iron Reduction	$CH_2O + 4Fe(OH)_3 + 8H^+ \rightarrow CO_2 + 4Fe^{2+} + 11H_2O$	+1
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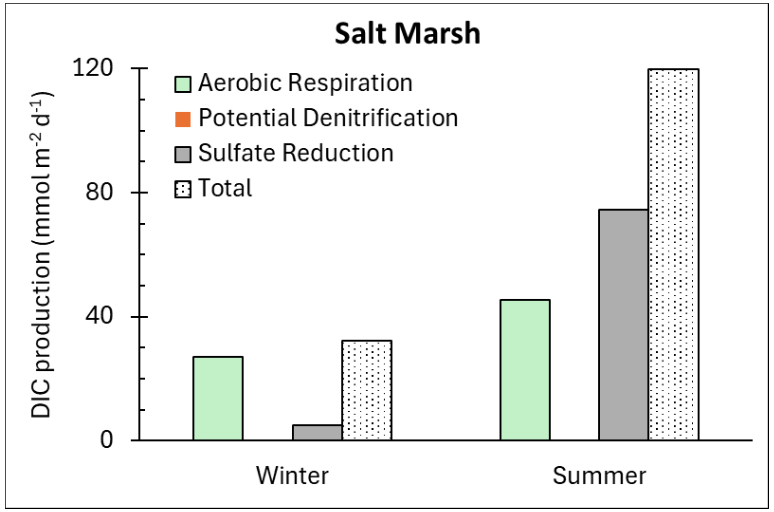
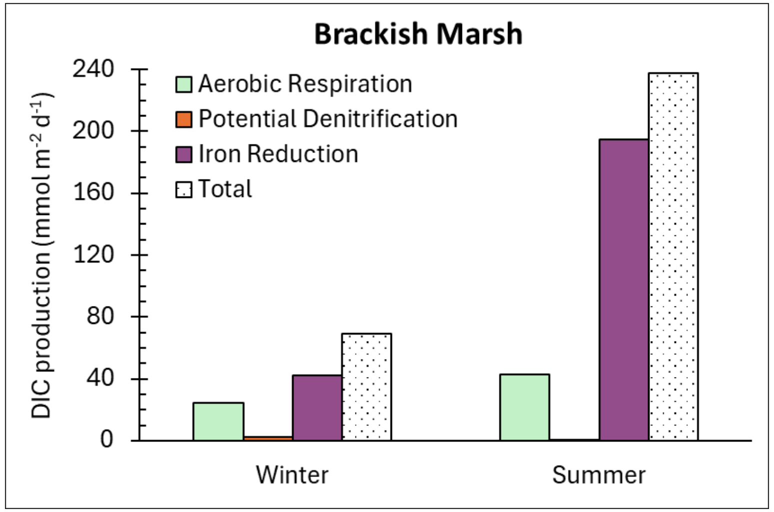
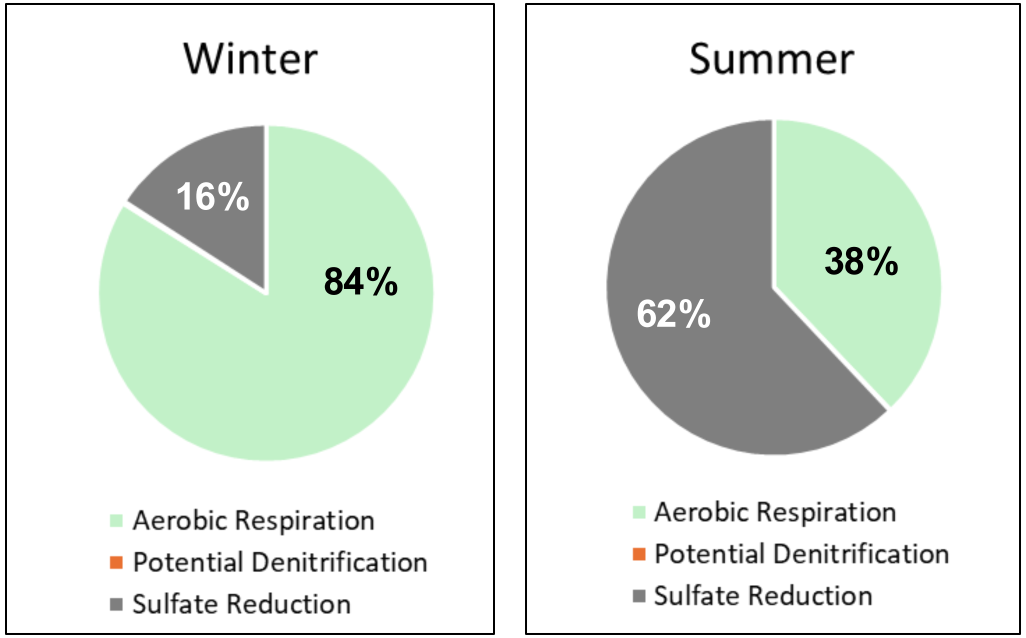


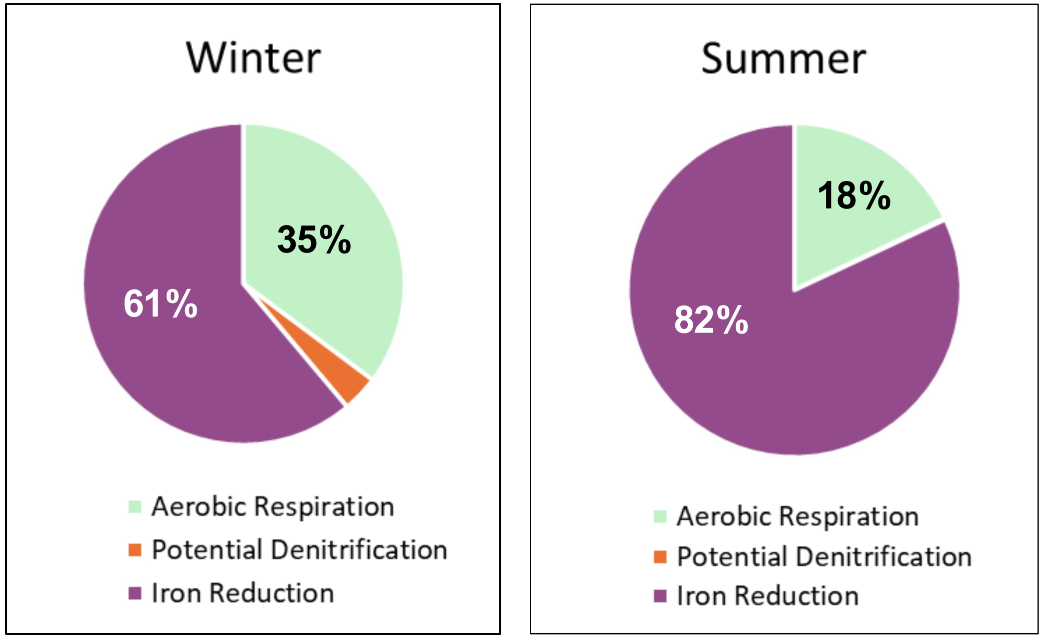


Dominant pathways for carbon respiration

Salt Marsh



Brackish Marsh



- ❑ Aerobic respiration is important across both marshes.
- ❑ Sulfate reduction is responsible for 16% - 62% of carbon remineralization in the salt marsh.
- ❑ Carbon remineralization through iron reduction exceeds aerobic respiration in brackish marsh for both seasons.

Summary and Implications for restoration

- Rising sea level could shift dominant carbon remineralization pathway in salt marshes towards sulfate reduction leading to increased alkalinity production, which represents a longer-term sink of carbon than DIC.

- Increased freshwater input from restoration projects such as river diversion could result in increased iron reduction pathway for carbon remineralization through increased supply of reactive iron into the system.

- Increased freshwater input could also lead to enhanced denitrification due to higher nitrate loading in many freshwater systems.

- Further work is need to better understand the interplay between various soil respiration processes and their impact on blue carbon preservation as well lateral transport of various forms of carbon to coastal ocean.

Questions