A Mesocosm Experiment: Effects of Eelgrass Density on Greenhouse Gas Fluxes

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Abstract

Seagrass beds provide key ecosystem benefits, including playing a critical role in climate mitigation. We tested the effects of different eelgrass densities on greenhouse gas (GHG) fluxes at the water-atmosphere interface by creating six treatments (4 replicates each) with different shoot densities (per m^2): bare (0), sparse (~60), low (~120), medium (~150), medium-high (~180), and high (~215) in 115-gallon mesocosms with unfiltered flow-through Narragansett Bay water. Results indicate that there are significant increases in CH_4 and N_2O emissions with increasing eelgrass densities measured at high tide. During the day and night, system greenhouse gas fluxes (CO_2e-100y) are dominated by CO_2 (67 – 108%) followed by N_2O (-9.0 – 32%) and CH_4 (0.98 – 1.1 %). We suspect that there was not greater CO_2 uptake by higher density eelgrass treatments as expected due to respiration from epifauna and epiphytes, which colonized leaf surfaces, as well as rapid organic matter mineralization. We observed N_2O uptake during the day in bare, sparse, low and high treatments, but at night, N_2O was emitted across all density treatments. Nitrate reduction and denitrification might account for the uptake of N_2O during the day while incomplete denitrification might account for the emissions of N_2O at night.

Objective

Question: Do different densities of eelgrass affect greenhouse gas fluxes of CO_2, CH_4, and N_2O under light and dark conditions?

Methods

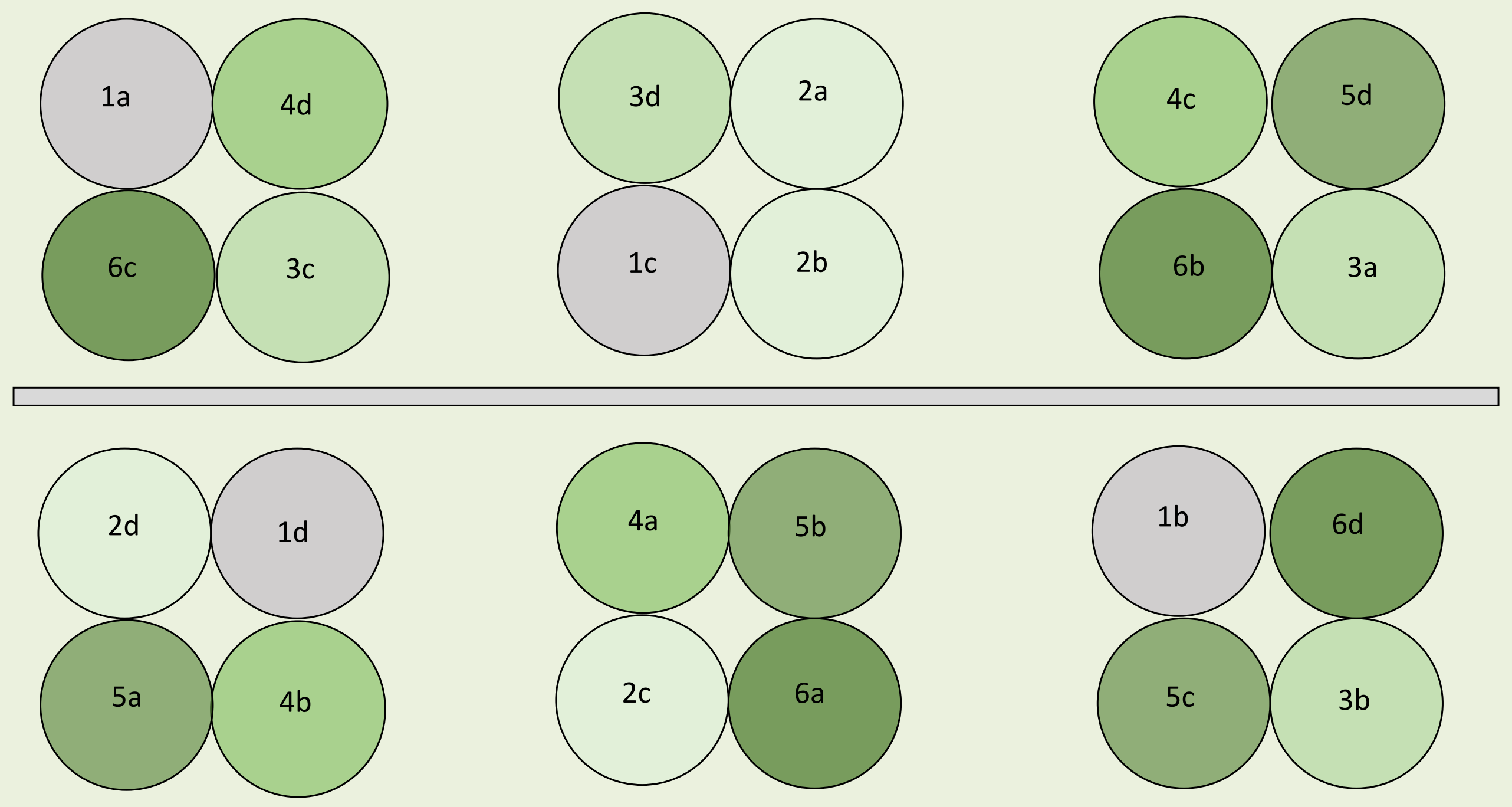

Figure 1.1. Experimental design: 24 tanks with 6 different eelgrass density treatments (1-6; *see **Figure 2*** for shoot ranges for each treatment), 4 replicates each.

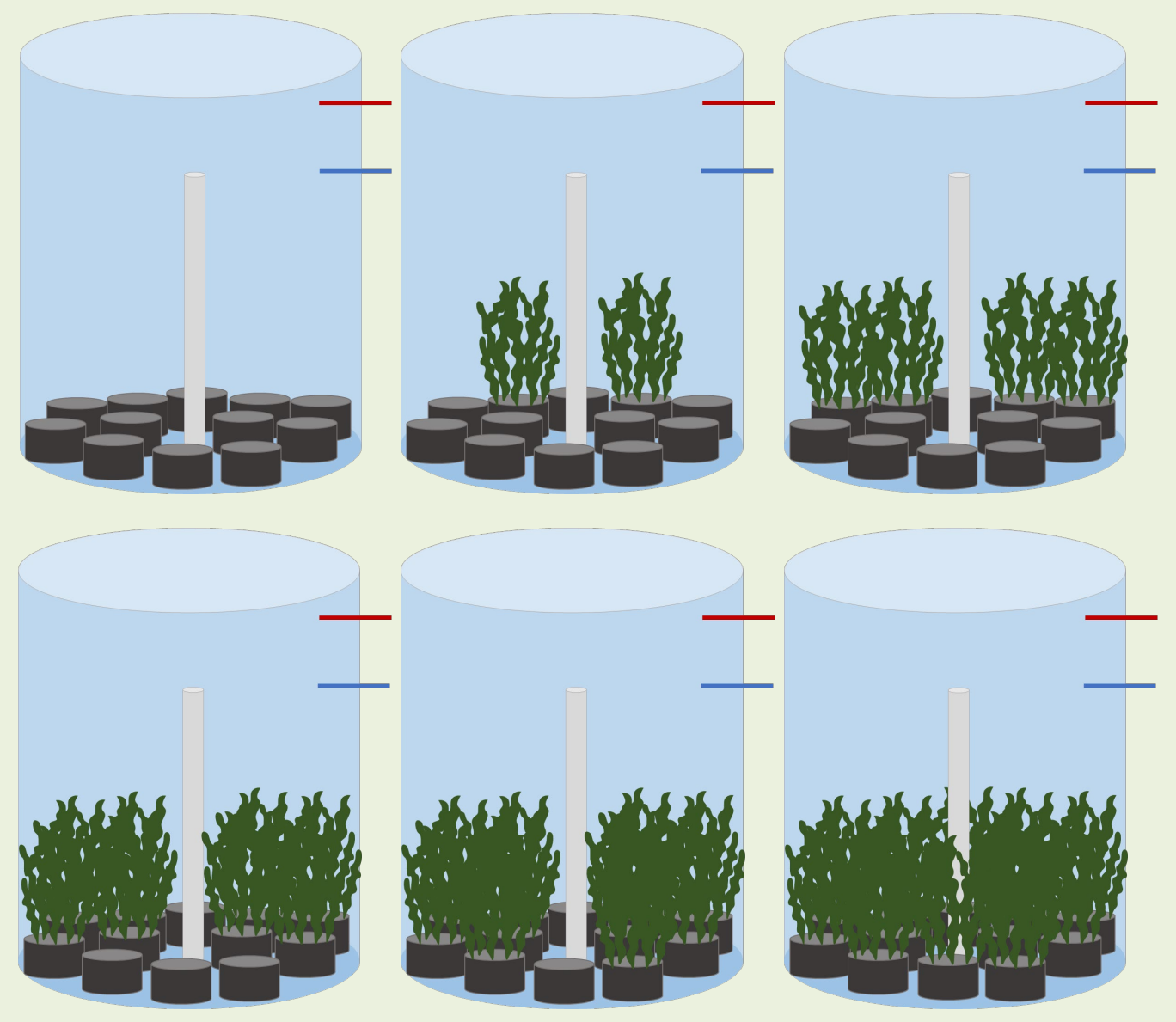

Figure 1.2. Eelgrass density treatments (1-6; bare – high). High and low tide indicated by the red and blue line, respectively. ***(Only reporting high tide data)***

Tank ID		Treatment	Number of Pots	
Number	*Rep*	*Eelgrass Density*	*Plants*	*Bare*
1	a	Bare	0	14
1	b	Bare	0	14
1	c	Bare	0	14
1	d	Bare	0	14
2	a	Sparse	4	10
2	b	Sparse	4	10
2	c	Sparse	4	10
2	d	Sparse	4	10
3	a	Low	8	6
3	b	Low	8	6
3	c	Low	8	6
3	d	Low	8	6
4	a	Medium	10	4
4	b	Medium	10	4
4	c	Medium	10	4
4	d	Medium	10	4
5	a	Medium/High	12	2
5	b	Medium/High	12	2
5	c	Medium/High	12	2
5	d	Medium/High	12	2
6	a	High	14	0
6	b	High	14	0
6	c	High	14	0
6	d	High	14	0

Figure 1.3. Table describing the six different eelgrass density treatments.

Results

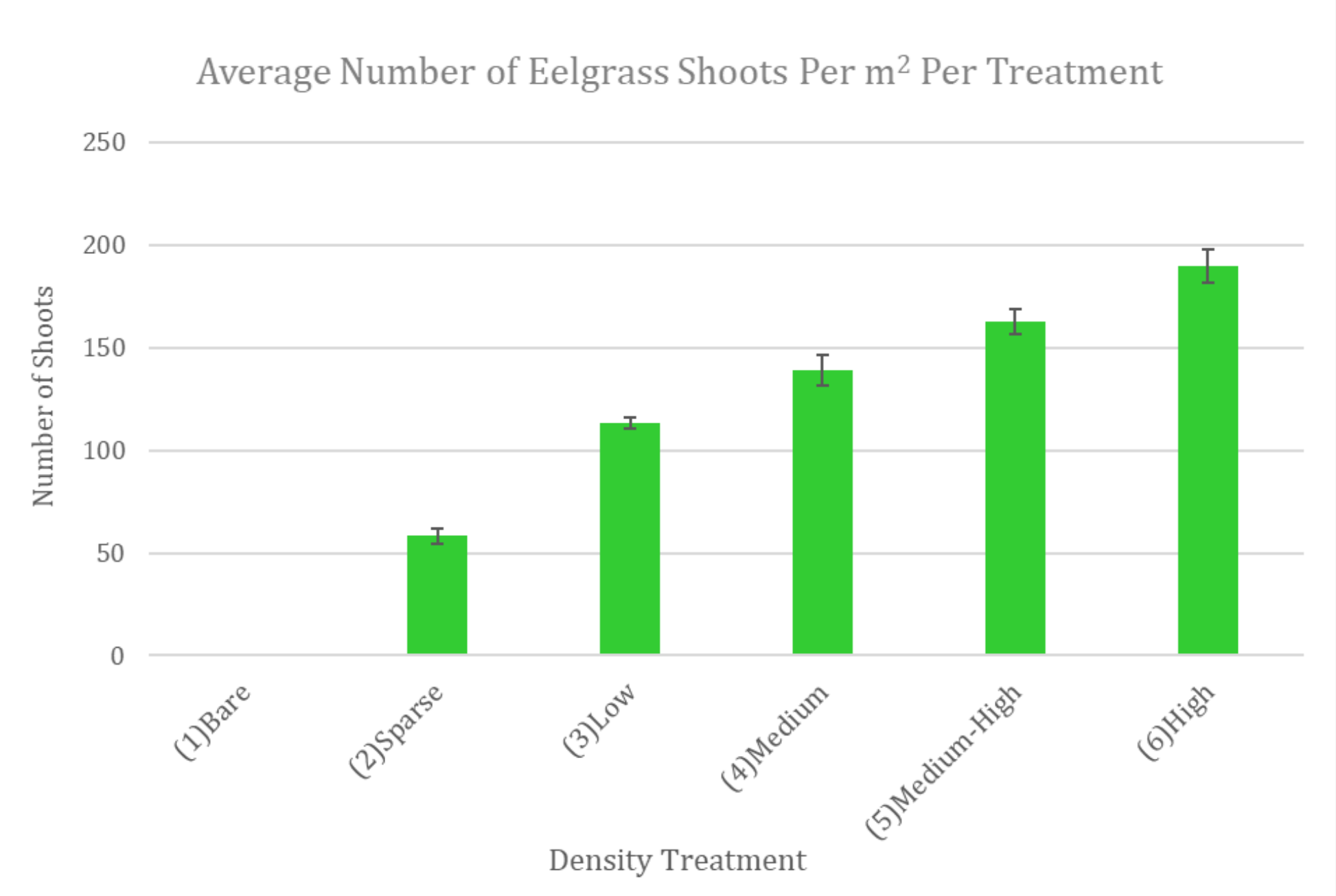

Figure 2. Average number of eelgrass shoots/m^2 in each density treatment two-weeks post-planting (± SE).

Figure 3. Measuring greenhouse gas fluxes from one of the mesocosms using a floating chamber connected to a Picarro gas analyzer. This instrument simultaneously measures CO_2, CH_4, and N_2O.

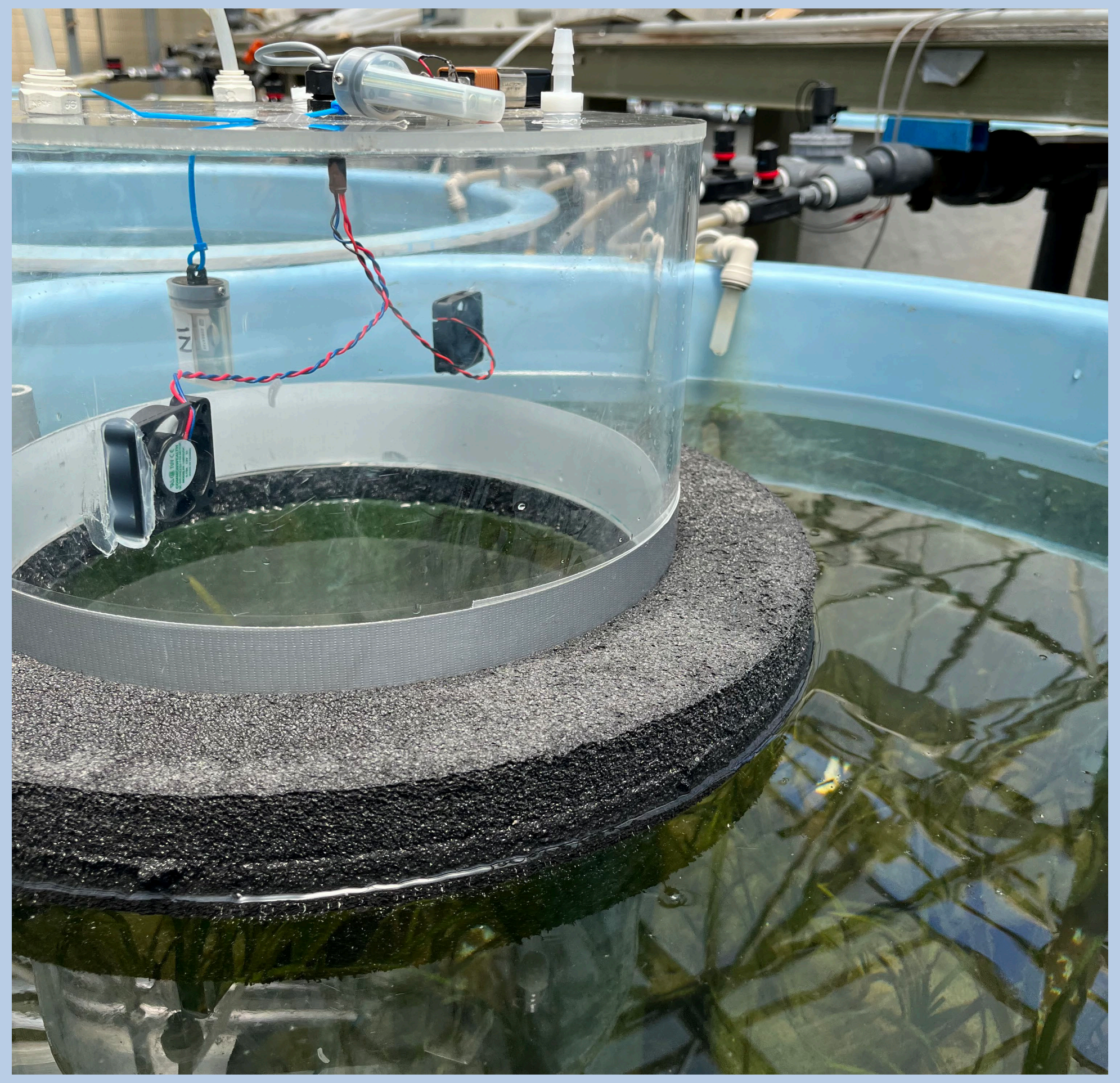

Figure 4. A floating chamber is used to measure greenhouse gas fluxes at the water-atmosphere interface. The incubation time for each measurement was six minutes. *(Dimensions: 30 cm diameter, 20 cm h)*

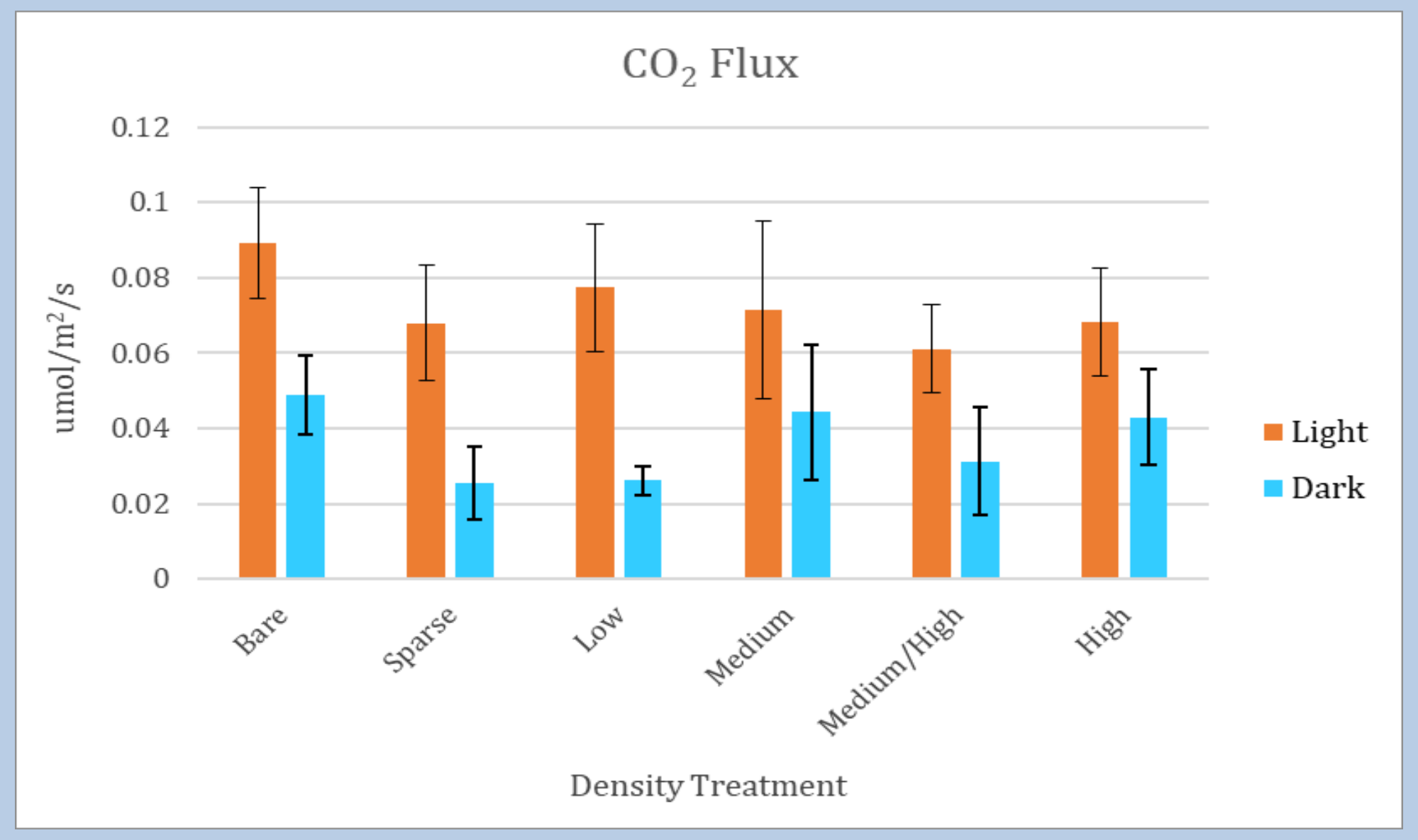

Figure 5.1. Average CO_2 emissions at high tide across all sampling dates (± SE). There was no significant difference between density treatments, but emissions were significantly greater ($P < 0.05$) in the light than dark.

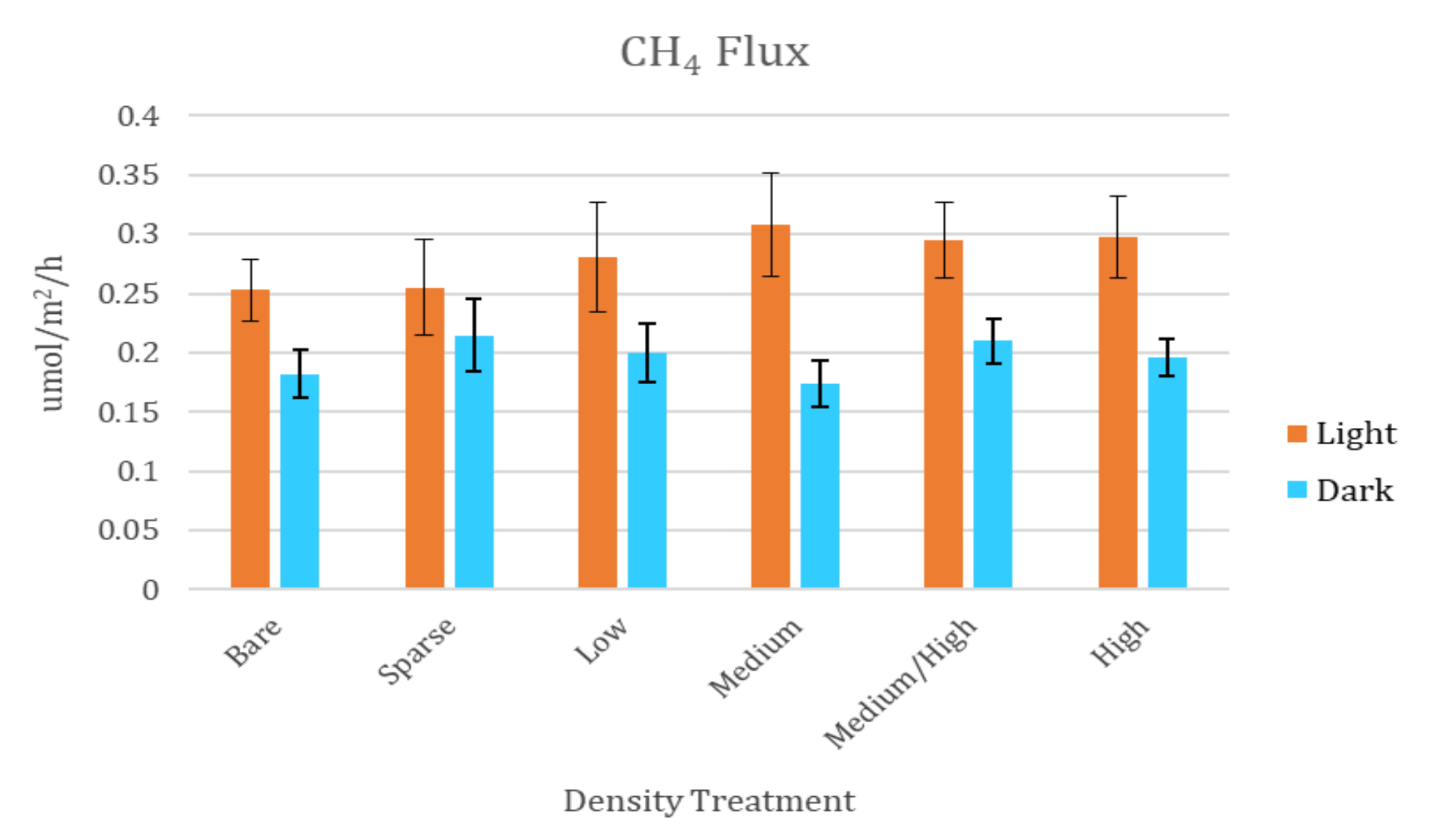

Figure 5.2. Average CH_4 emissions at high tide across all sampling dates (± SE). Emissions were significantly greater ($P < 0.05$) in the light than dark, and emissions significantly increased ($P = 0.0316$) with increasing eelgrass density.

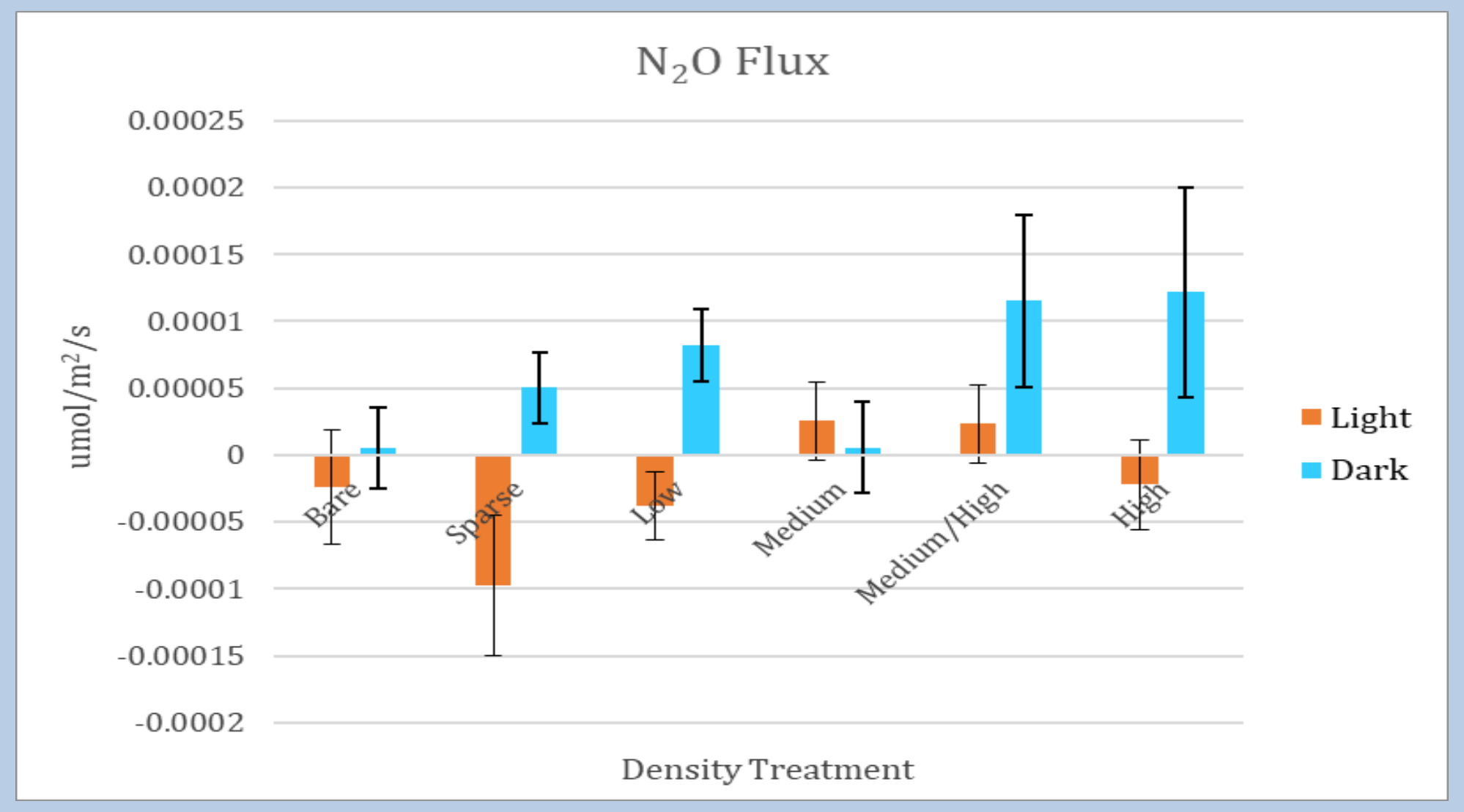

Figure 5.3. Average N_2O fluxes at high tide across all sampling dates (± SE). Emissions were significantly greater ($P < 0.05$) in the dark than light, and emissions significantly increased ($P = 0.0251$) with increasing eelgrass density.

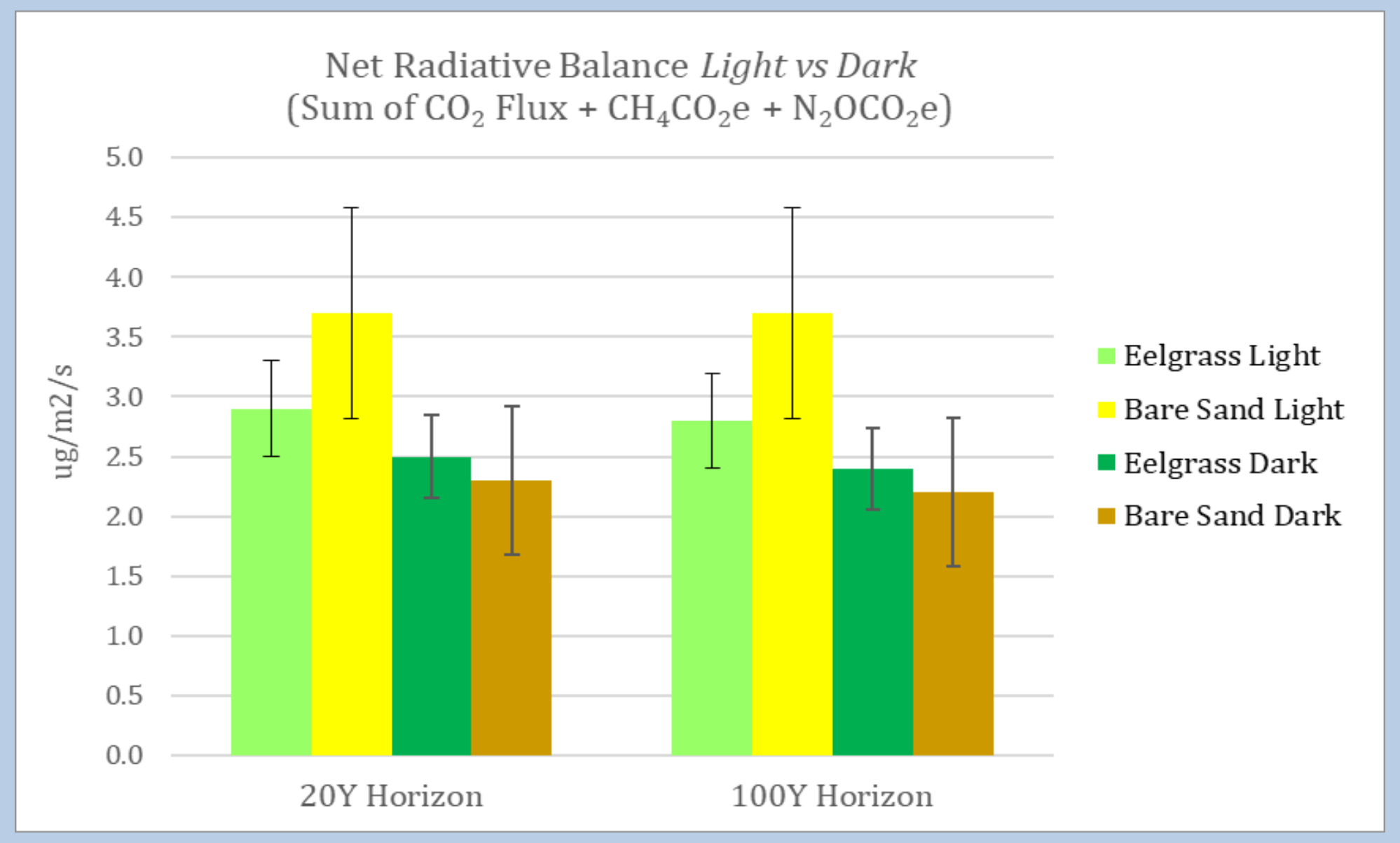

Figure 6. Net radiative balance calculated across all eelgrass treatments vs bare sand across all dates for 20Y and 100Y horizons, respectively. There was no significant difference across density treatments or between light and dark. **All treatments were net sources of GHG emissions.**

Results & Discussion

Methane and CO_2 emissions were significantly greater in the light than the dark. In contrast, the N_2O fluxes were greater under dark than light conditions. Both N_2O and CH_4 emissions increased with increasing shoot density. There was no significant difference in CO_2e (100y and 20y horizons) fluxes among the different density treatments or between dark and light conditions. The net radiative balance was positive, primarily driven by the high CO_2 emissions, indicating that the eelgrass and associated community in the mesocosms were a source of greenhouse gases. In the field, similar results revealed that eelgrass habitat in eutrophic salt ponds in southern RI had the highest GHG emissions compared to oyster and bare habitats. The historical increase in groundwater nutrient loading to RI coastal lagoons may contribute to the overall heterotrophic state of the systems (*See **Figure 7***). Biotic components such as macroalgae, epiphytes, and epifauna associated with the eelgrass in the field and mesocosms might contribute to high respiration rates and rapid organic matter mineralization (*See **Figure 8***). Preliminary field research results indicate that the greenhouse gas emissions associated with the eelgrass habitat in the eutrophic coastal lagoons might offset about 45 – 70% of the carbon stored in the sediments (i.e., blue carbon). Even with the high greenhouse gas emissions associated with eelgrass systems in eutrophic waters, there would be a net climate benefit due to long-term carbon storage in the sediments.

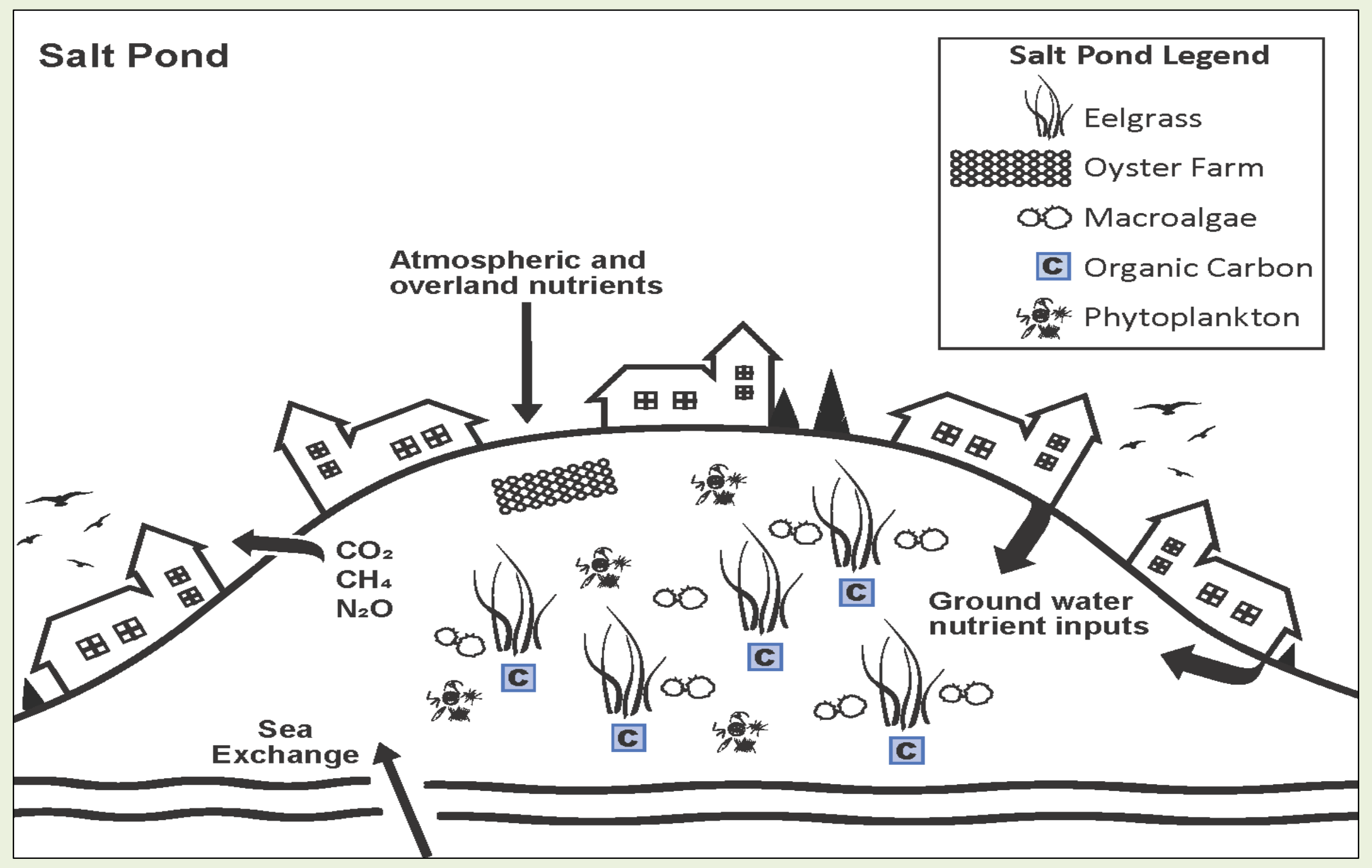

Figure 7. An illustration of the field study systems: shallow, coastal lagoons subject to eutrophication from nutrient laden groundwater input.

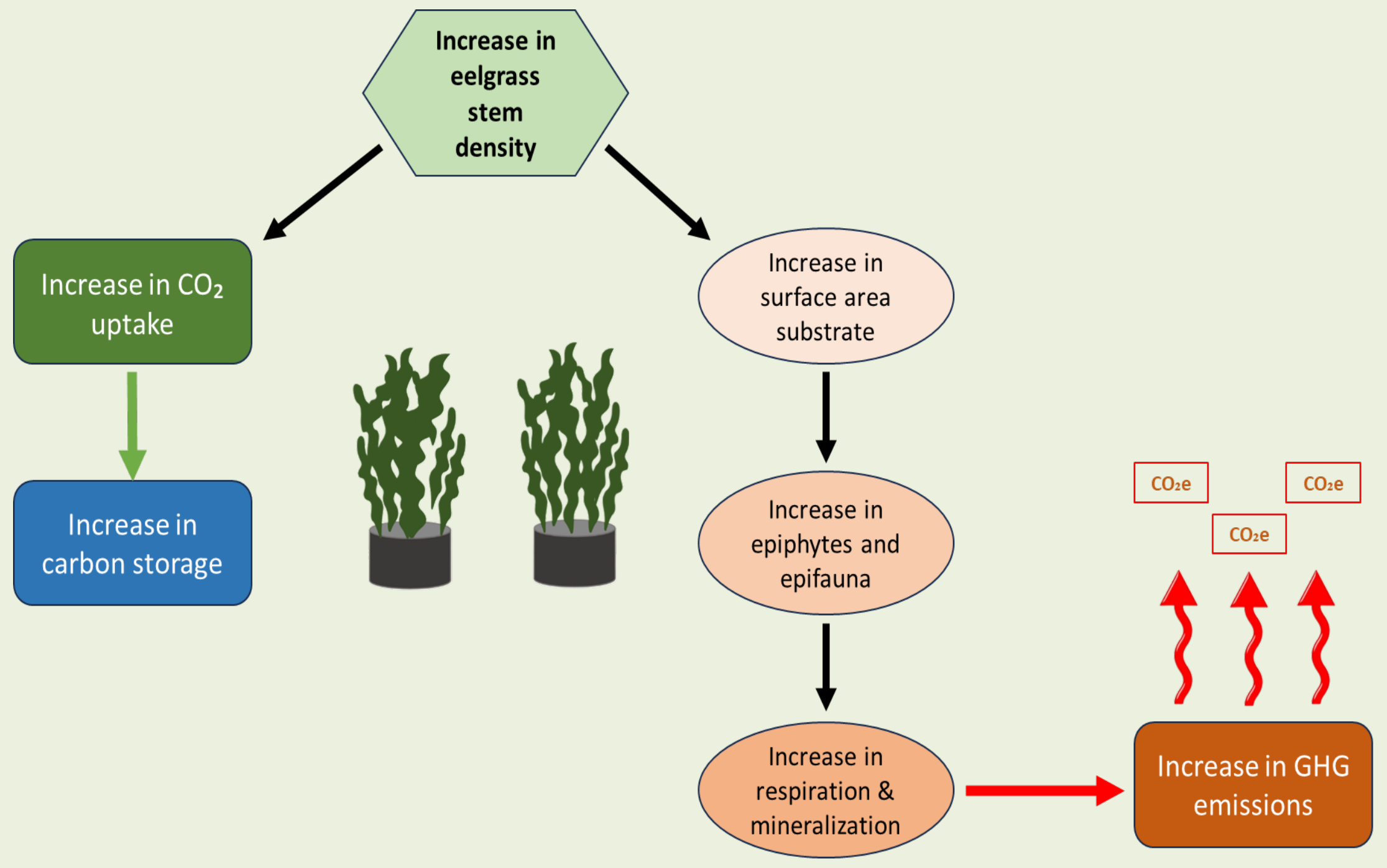

Figure 8. An increase in eelgrass stem density increases colonization by epiphytes and epifauna resulting in increased community respiration and rapid organic matter mineralization. Increased GHG emissions may offset the climate benefit (blue carbon storage) of eelgrass systems.

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