Gas Fluxes in a Restored Pacific Northwest Salt Marsh

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Introduction

We are studying how Oregon's salt marshes "breathe" by measuring how they take and release greenhouse gases like carbon dioxide (CO_2) and methane (CH_4). We measured these gas fluxes across different marsh elevations over several months to understand how they change throughout time and space. These patterns contribute to our knowledge of potent greenhouse gases, like CH_4, which wetlands can emit in large amounts and which play a significant role in climate change.[1]

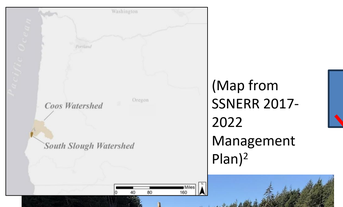
However, there is currently **limited understanding of greenhouse gas flux variability within marshes, across elevation gradients, and over different timescales** because wetlands are highly variable and dynamic. Also, **Oregon flux data sets are sparse** relative to California and Washington.

Research Question

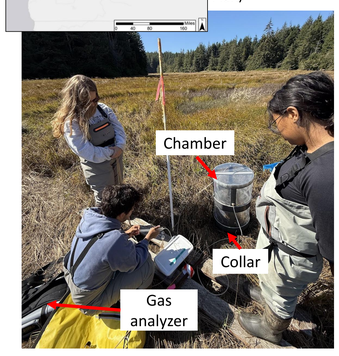
How do CO_2 and CH_4 fluxes vary across a salt marsh elevation gradient in the Pacific Northwest?

Methods

We measured CO_2 and CH_4 fluxes using a transparent chamber on 9 collars across low (L), mid (M), and high (H) marsh elevations from July to September, including one period of hourly measurements over 24 hours in the high marsh. A LI-COR 7810 gas analyzer was used to obtain gas concentrations of CO_2 and CH_4. Measurements were done at Kunz Marsh, a restored marsh, in Coos Bay, Oregon.



(Map from SSNERR 2017-2022 Management Plan)[2]



Import raw chamber measurements (csv)

fluxfinder R package: fit linear CO_2 and CH_4 regressions (need slope for flux estimate)

QC: Keep only strong fits ($R^2 \geq 0.33$ and $p \leq 0.05$)

Convert CH_4 flux nmol to µmol

Data wrangling flux data: reshape to long, clean site labels, assign elevation, add dates

Split by gas type → CO_2 and CH_4 datasets

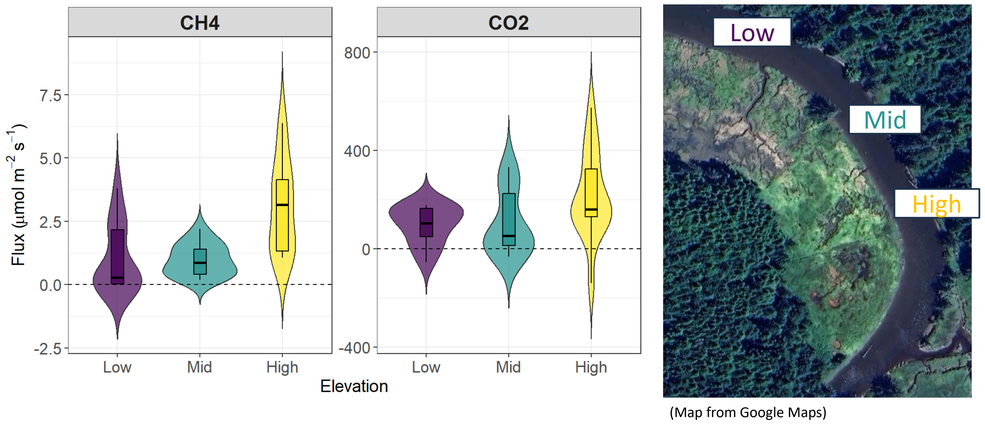
LME models: Elevation effects
flux ~ elevation + (1|site) + (1|date)
Tukey post-hoc via emmeans

Linear models: Seasonal effects
flux ~ elevation × sampling date

Model diagnostics: residuals, QQ, hist

Result 1

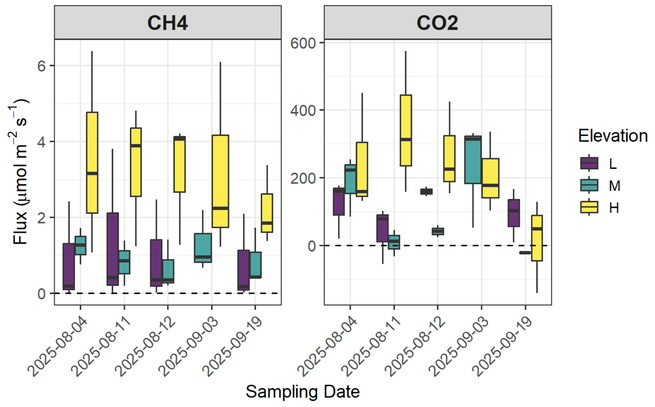
Gas flux trends higher in high marsh



(Map from Google Maps)

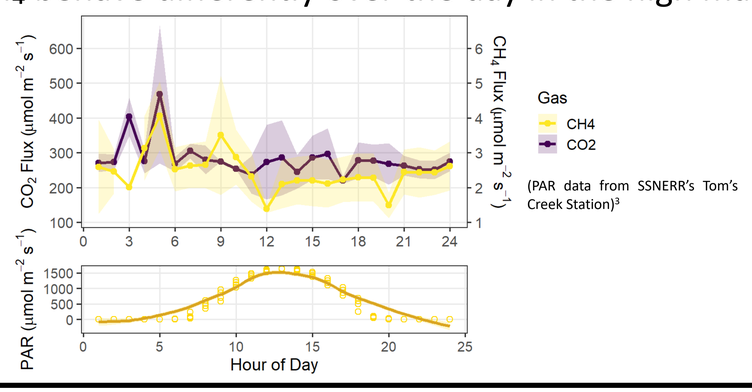
Result 2

CH_4 steady, CO_2 varies with time and elevation



Result 3

CO_2 and CH_4 behave differently over the day in the high marsh



(PAR data from SSNERR's Tom's Creek Station)[3]

Conclusions

Results 1

- CO_2 and CH_4 fluxes tend to be higher in high marsh compared to mid and low marsh, though differences are not statistically significant.
- These trends may partly be due to differences in vegetation cover, with more vegetated areas potentially supporting higher gas flux.
- High and mid marshes are generally more vegetated, while low marsh is primarily bare.

Results 2

- CO_2 flux shows a significant increase with elevation ($p = 0.027$) and a marginal trend across dates ($p = 0.074$).
- CH_4 flux is significantly higher in high marsh compared to mid and low marsh ($p < 0.001$) and remains steady across sampling dates.
- No significant elevation × date interactions were observed for either gas.
- These patterns suggest CH_4 is mainly controlled by marsh elevation, while CO_2 responds to both elevation and temporal variability.
- CO_2 might be more influenced by short-term environmental changes (e.g., temperature, tides).

Results 3

- Photosynthesis activity may influence CO_2 and CH_4 flux differently.
- CO_2 flux peaks before photosynthesis and drops once it begins.

References

1. Salimi, S., Almuktar, S. A., & Scholz, M. (2021). Impact of climate change on wetland ecosystems: A critical review of experimental wetlands. *Journal of Environmental Management*, *286*, 112160.
2. Schrager, H., Bragg, J., Yednock, B., Schmitt, J., Helms, A., Tally, J., Rudd, D., Dean, E., Muse, R., Cornu, C., Gaskill, T., & Wilson, P. (n.d.). *South Slough National Estuarine Research Reserve Management Plan 2017–2022*. Oregon Department of State Lands.
3. NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data accessed from the NOAA NERRS Centralized Data Management Office website: http://www.nerrsdata.org; *accessed* 3 December 2025. doi:10.25921/vw8a-8031.

Acknowledgments

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