Exploring Methane Flux from the South Bay Salt Pond Restoration Project

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INTRODUCTION

- Coastal wetland ecosystems provide many ecological services, including: habitat for endangered species, flood protection, and improved water quality.
- These ecosystems can sequester large quantities of carbon in their soils, now known as "Blue Carbon," of particular interest within emerging carbon markets in California (**Figure 1**).
- With 85% of San Francisco's historic salt marshes lost, restoration of these ecosystems is important (**Figure 4**). There is growing interest in using carbon sequestration to drive these restoration efforts, but this requires a better understanding of methane (CH_4) cycling.
- Under anaerobic conditions, microbes in coastal soils have the potential to release the potent greenhouse gas CH_4 as a byproduct of decomposition of organic material (**Figure 2**).
- Methane has a sustained global warming potential 45-times that of carbon dioxide (CO_2), suggesting that the release of CH_4 may negate large amounts of carbon sequestered within the soils.
- Previous studies suggest that saline coastal ecosystem do not produce CH_4 at salinities above ~18 ppt (**Figure 3**).
- The South Bay Salt Pond Restoration Project (SBSPRP) is the largest tidal restoration project on the west coast at 15,100 acres, serving as case study to explore methane flux from a variety of coastal environments (**Figure 4**).

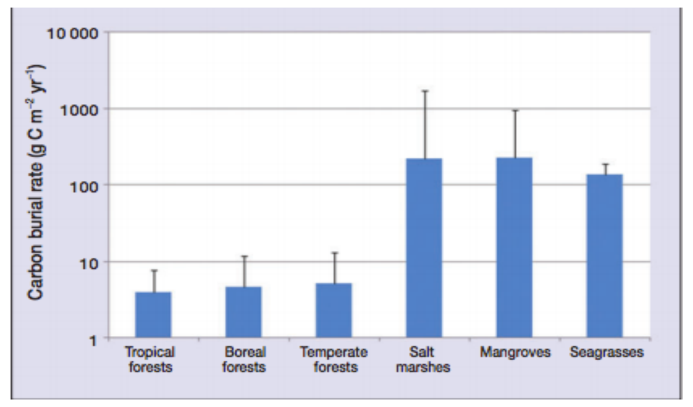


Figure 1. *Comparison of carbon burial rates in terrestrial and coastal ecosystems.*[1]

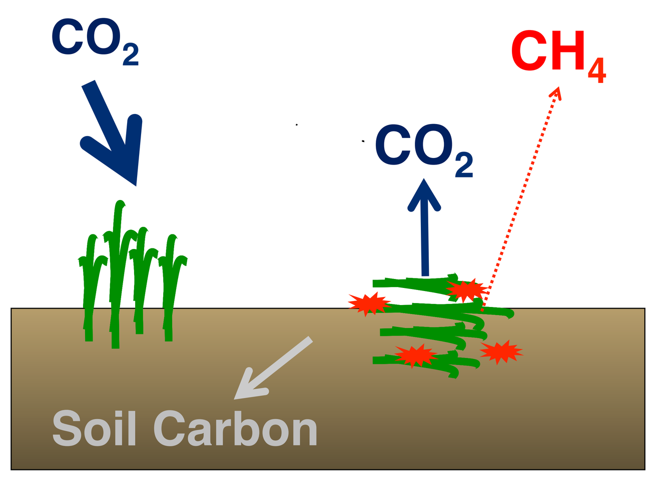


Figure 2. *Soil carbon sequestration and greenhouse gas (CH_4) production in salt marshes and ponds, simplified.*

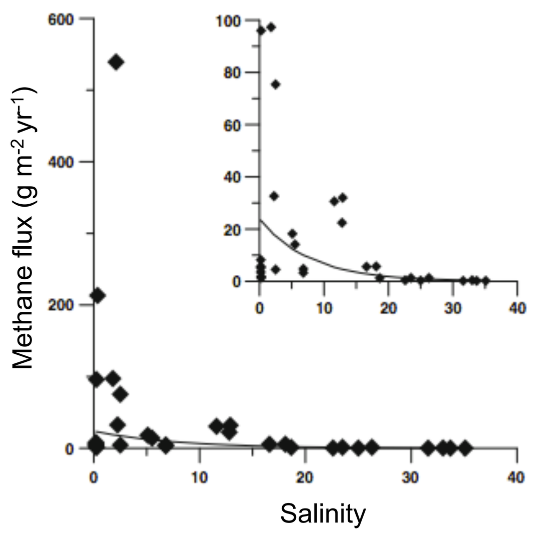


Figure 3. *Methane fluxes from saline coastal wetland systems.*[2]

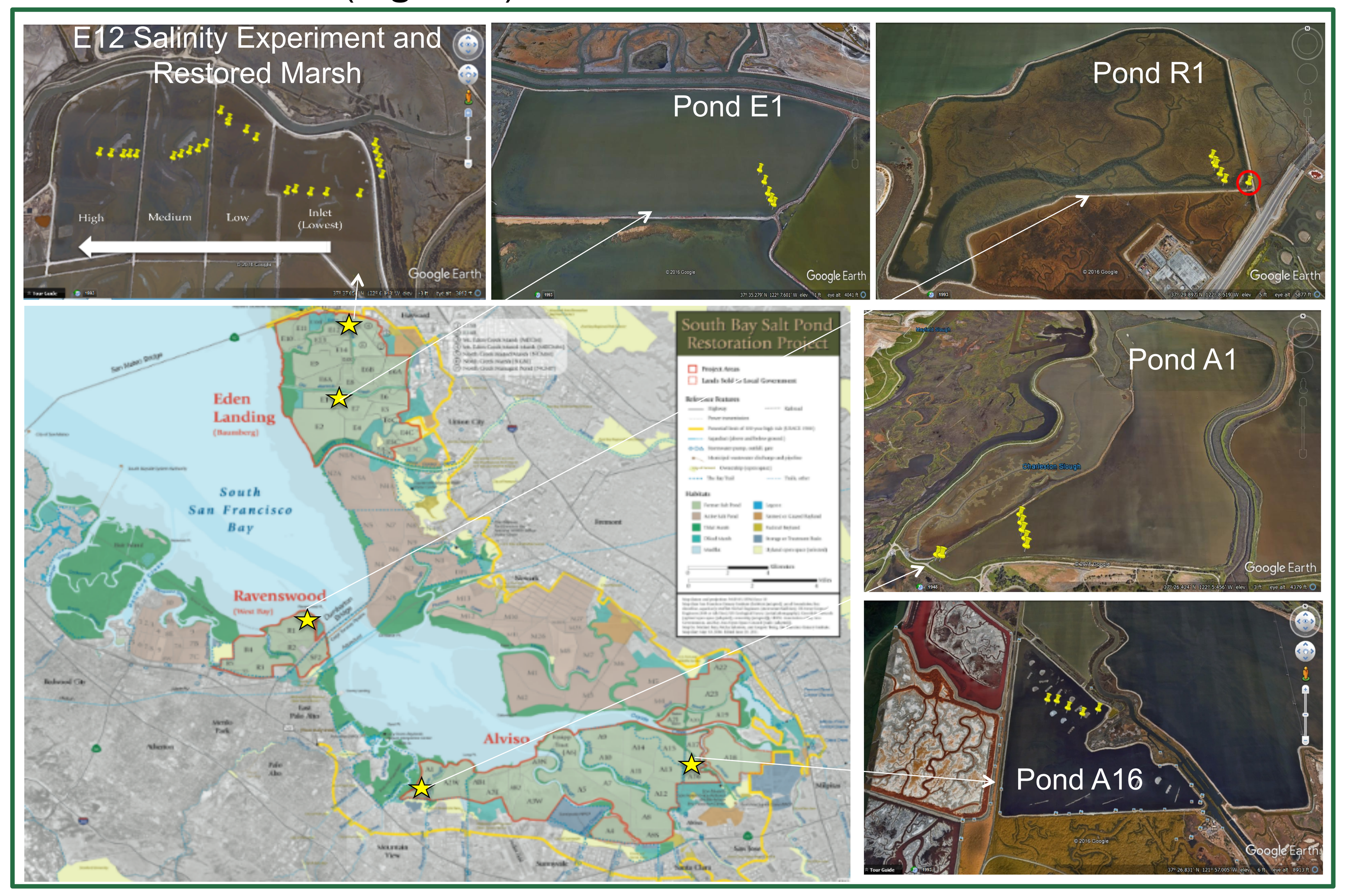


Figure 4. *The South Bay Salt Pond Restoration Project is part of a long term goal to restore a total of 40,000 acres of tidal salt marsh habitat in the San Francisco Bay area.*[3]

RESEARCH QUESTION

The objective of this study is to investigate CH_4 fluxes throughout a one year period from salt ponds and an associated marsh at the South Bay Salt Pond Restoration Project.

METHODS

- We measured CH_4 flux from a salt marsh and several salt ponds undergoing common management regimes at the SBSPRP. Sites were selected from the three pond complexes Ravenswood, Alviso and Eden Landing (**Table 1**).

Table 1. *Sampling locations and associated management regimes.*

Complex	Pond	Management Regime
Alviso	A1	Low-management
Alviso	A16	Nesting islands
Eden Landing	E12-High salinity	Salinity experiment
Eden Landing	E12-Medium salinity	Salinity experiment
Eden Landing	E12-Low salinity	Salinity experiment
Eden Landing	E12-Inlet	Salinity experiment
Eden Landing	E12 Adjacent Marsh	Marsh
Eden Landing	E1	Low-management
Ravenswood	R1	Seasonally flooded

Figure 5. *Sampling process of salt ponds with floating chambers and the Eden Landing salt marsh with fixed chambers.*

- At each site, 5-7 floating chambers were deployed along a transect **(Figure 5)**.
- Chambers accumulated gasses for a two hour period and gas samples were collected every 30 minutes from the chamber headspace. Air samples were analyzed for CH_4 using gas chromatography.
- Additionally, porewater, ambient air, and dissolved CH_4 samples were collected at each site.

RESULTS – METHANE FLUX

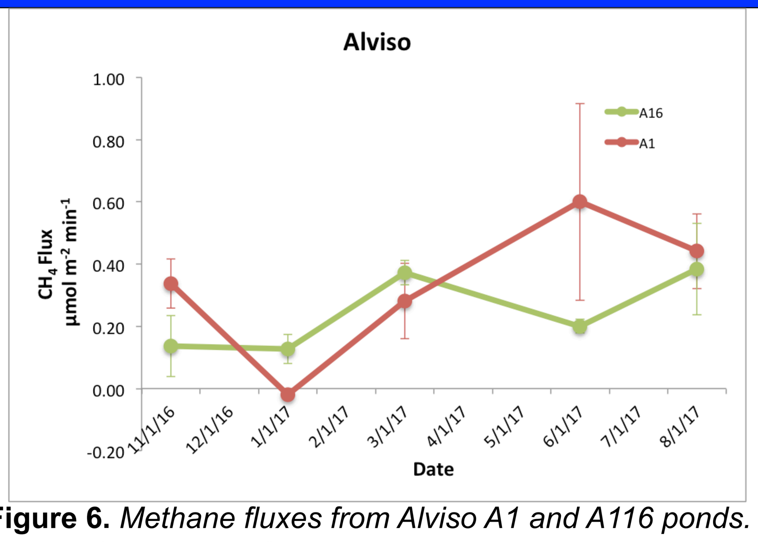


Figure 6. *Methane fluxes from Alviso A1 and A116 ponds. *Note – A1 November flux was driven up by a single chamber not included on this graph.*

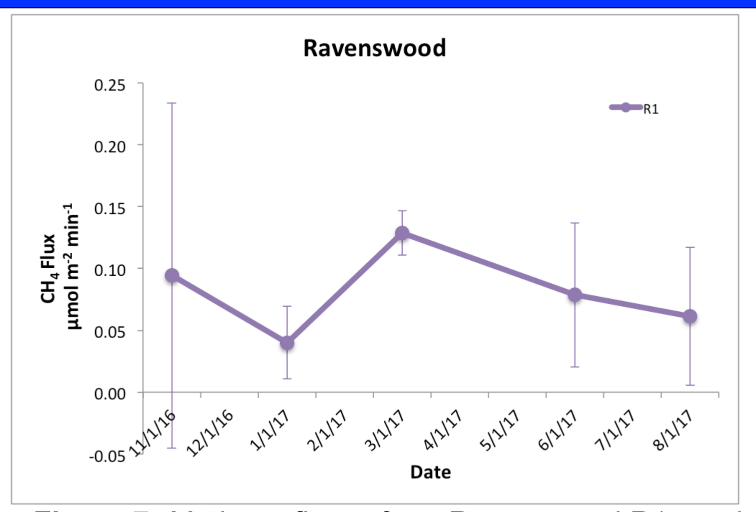


Figure 7. *Methane fluxes from Ravenswood R1 pond.*

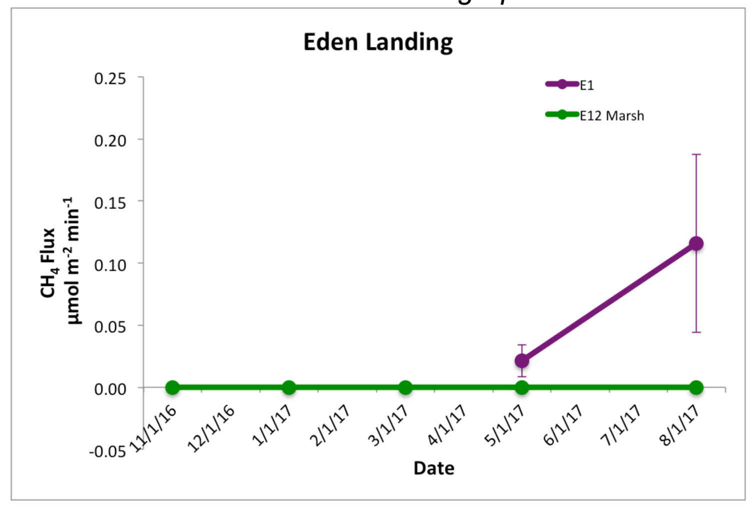


Figure 8. *Methane fluxes from Eden Landing E1 pond and E12 marsh.*

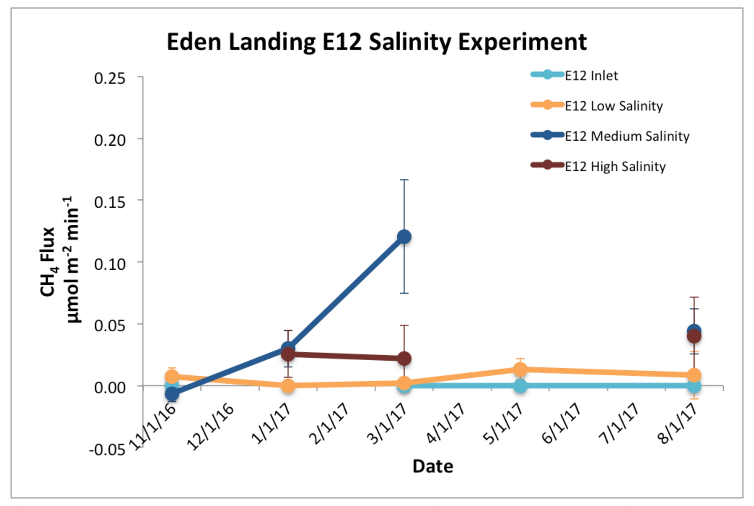


Figure 9. *Methane fluxes from Eden Landing E12 pond cells. *Note – adverse conditions and snowy plover nesting system prevented sampling some months.*

RESULTS – BIOGEOCHEMICAL PREDICTORS

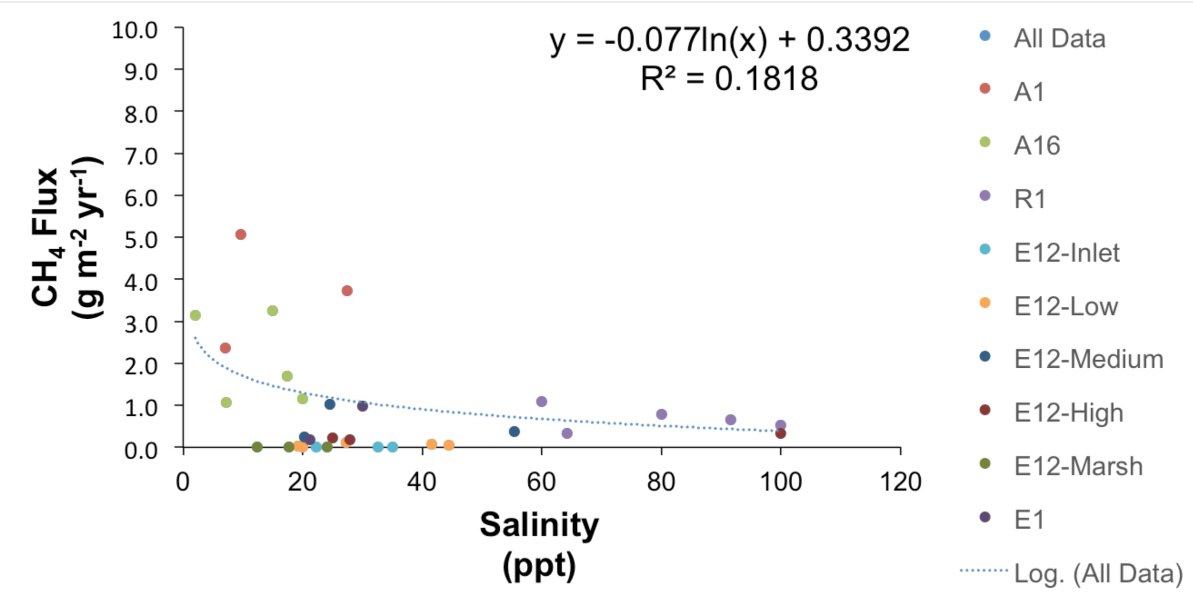


Figure 10. *Site salinity vs. methane fluxes.*

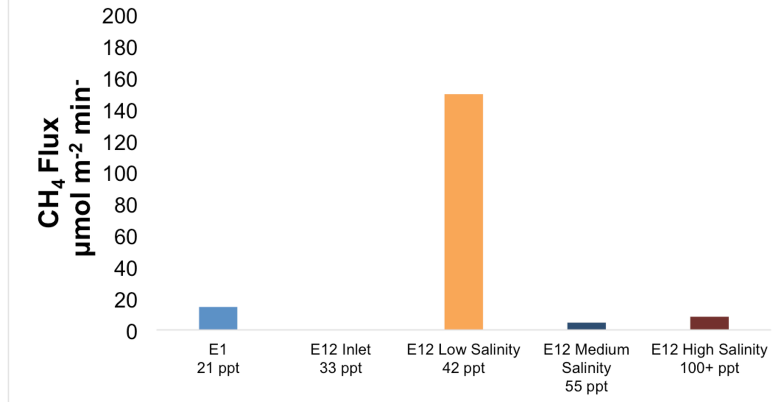
Table 2. *Average salinities of A1 and R1 ponds during sampling.*

SIte	Month	Average Salinity
A1	November	29
A1	January	16
A1	March	7
A1	June	10
A1	August	27
R1	November	80
R1	January	64
R1	March	60
R1	June	92
R1	August	100+

- Congruent with current literature, low salinity salt pond systems seem more likely to produce more CH_4 than their saltier counterparts.
- However, **Figure 10** shows that SBSPRP systems **do** produce small but measurable quantities of methane above the previously hypothesized 18 ppt salinity threshold (**Table 2**).

CONCLUSIONS AND FUTURE RESEARCH

- Methane flux from the SBSPRP is measurable, and thus cannot be ignored in the context of blue carbon.
- Mechanistic drivers of CH_4 production are rather complex, and we saw high spatial and temporal variability from these systems.
- While we saw some biogeochemical patterns play out with salinity, this factor is highly variable and not a perfect predictor of CH_4 flux.
- No detectable CH_4 fluxes were measured from the Eden Marsh site, suggesting that marsh restoration could possibly decrease CH_4 from the SBSPRP, but future work is necessary to confirm this pattern.



- There appear to be CH_4 "hot spots" in SBSPRP (see **Figure 11**). These hotspots tended to be located near weirs.
- More research needs to be done to manage blue carbon systems.

Figure 11. *Methane flux from additional chambers deployed at weirs of several sites in Eden Landing in June and August 2017. Note the change in scale from previous figures: these small corners of the ponds are producing methane orders of magnitude larger than chambers along our transects.*

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[1]McLeod, E., Chmura, G. L., Bouillon, S., Salm, R., Björk, M., Duarte, C. M., Lovelock, C. E., Schlesinger, W. H. and Silliman, B. R. (2011) A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. *Frontiers in Ecology and the Environment* 9: 552–560.
[2]Poffenbarger, HJ, et al. "Salinity Influence on Methane Emissions from Tidal Marshes." *WETLANDS,* vol. 31, no. 5, n. d., pp. 831-842.
[3]*South Bay Salt Pond Restoration Project*. http://www.southbayrestoration.org. Accessed 8 February 2017.