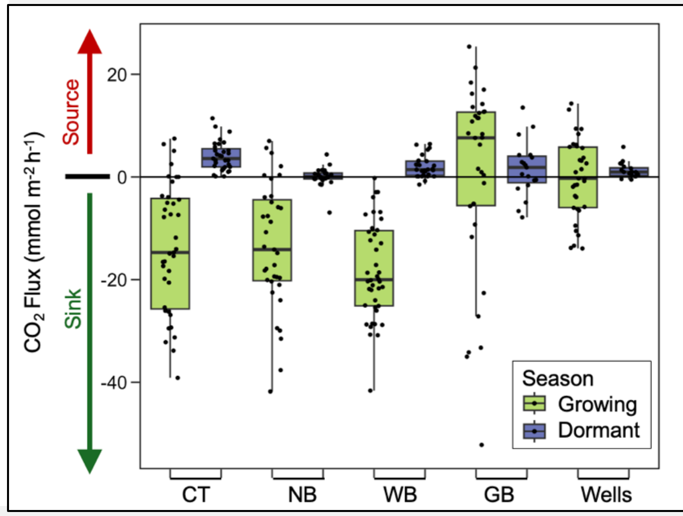
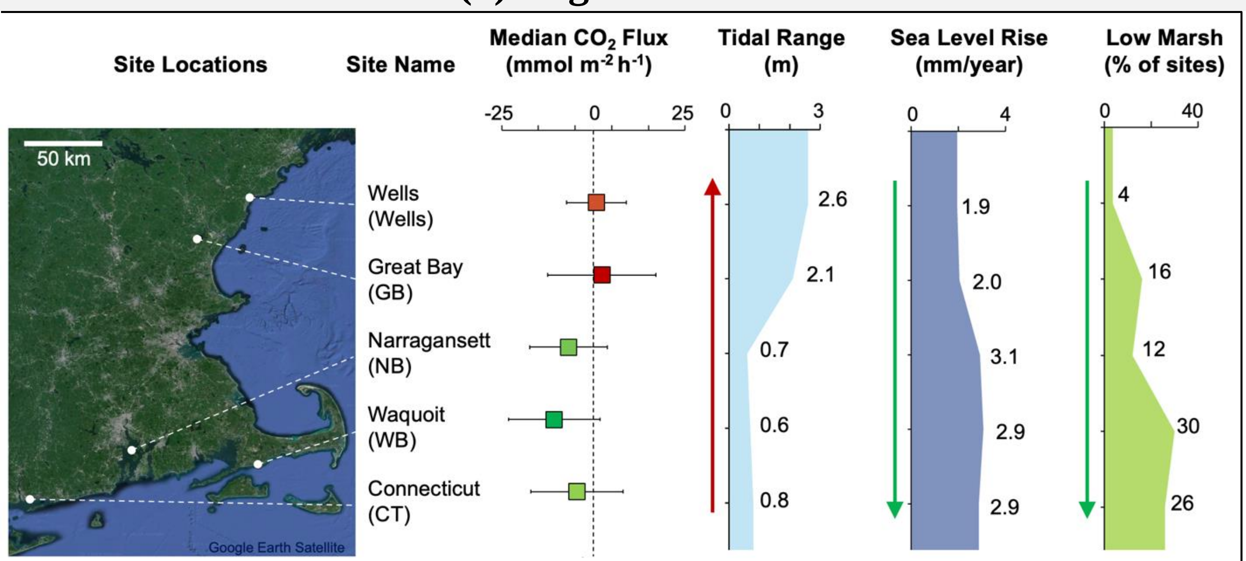
Results Summary ~ Regional and Seasonal Patterns

(1) Seasonal Trends

In this year-round dataset for New England marshes, the vertical CO_2 fluxes ranged from a sink of -52.2 to a source of 25.4 mmol m^{-2} h^{-1} (Figure 3). Comparing the growing and dormant seasons reveals a higher median dormant season flux, indicating that the sites were primarily a small source of CO_2 to the atmosphere in the winter. However, during the growing season (May to September), the salt marshes were primarily a sink for C with a median flux of -7.5 mmol m^{-2} h^{-1}. Note however, that there is a large range between the minimum and maximum flux of 77.6 mmol m^{-2} h^{-1}, indicating substantial variability throughout the growing season and between sites within and between marshes. The dormant season (December and February) was a source of C with a median flux of 1.3 mmol m^{-2} h^{-1}, which was ~17% of the magnitude of the summer median.



(2) Regional Trends



We observed a higher annual median CO_2 flux in the northern sites (Figure 2). This general seasonal trend may reflect the shorter growing season (so May and September measurements were at the ends of growing season) as well as a minimal impact of weather conditions on the chosen sampling days.

Additionally, the lower median CO_2 fluxes in southern New England may be related to regional gradients of tidal range and marsh geomorphology. The southern sites have a smaller tidal range, higher rates of sea level rise, and larger areas of *Spartina alterniflora* marsh and low marsh, which corresponded to higher rates of CO_2 uptake overall.

(3) Relationships with Weather Conditions

Comparing the CO_2 fluxes to air temperature and light levels at the time of sampling indicates a small influence of weather conditions on flux levels.

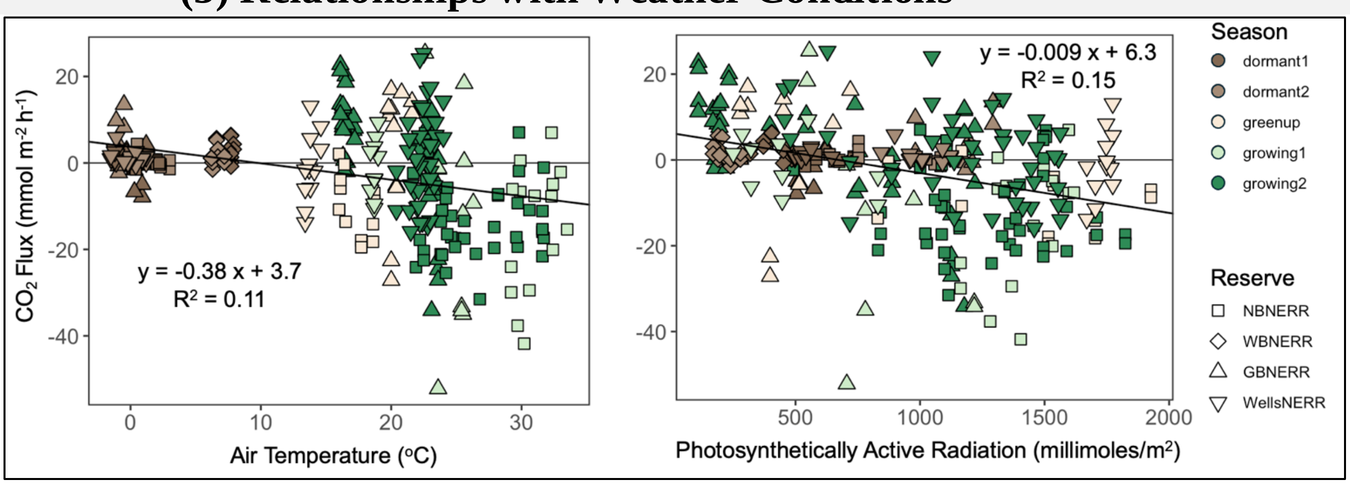


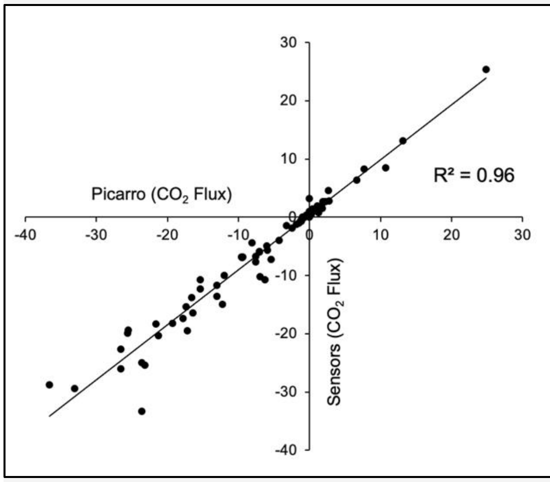
Figure 3 is a preliminary example of how the existing NERR meteorological station data can be leveraged for comparison to the CO_2 flux dataset. In our upcoming publications, we will include further analysis and modeling that combines multiple variables. *Note: Figure 3 is missing the WB meteorological data from May to August 2024, and all dates for CT.*

Results Summary ~ The Process

Major Outcomes…

- ✓ **Large dataset of GHG fluxes:** 483 total CO_2 fluxes measured!
- ✓ **Full regional record:** 5 New England Reserves
- ✓ **Year-round sampling:** December, February, May, July, August or September
- ✓ 26 people trained to collect GHG data
- ✓ 4 full group workshops & virtual trainings, 2 field trainings at each reserve
- ✓ 4 rounds of feedback and surveys
- ✓ 40 (or more) measurements collected during instrument loans to reserves
- ✓ Full written protocol and YouTube video: https://youtu.be/2r_bH0tsiSM
- ✓ Field validation and calibration techniques with gas standards
- ✓ R code to calculate fluxes from measured CO_2 concentrations

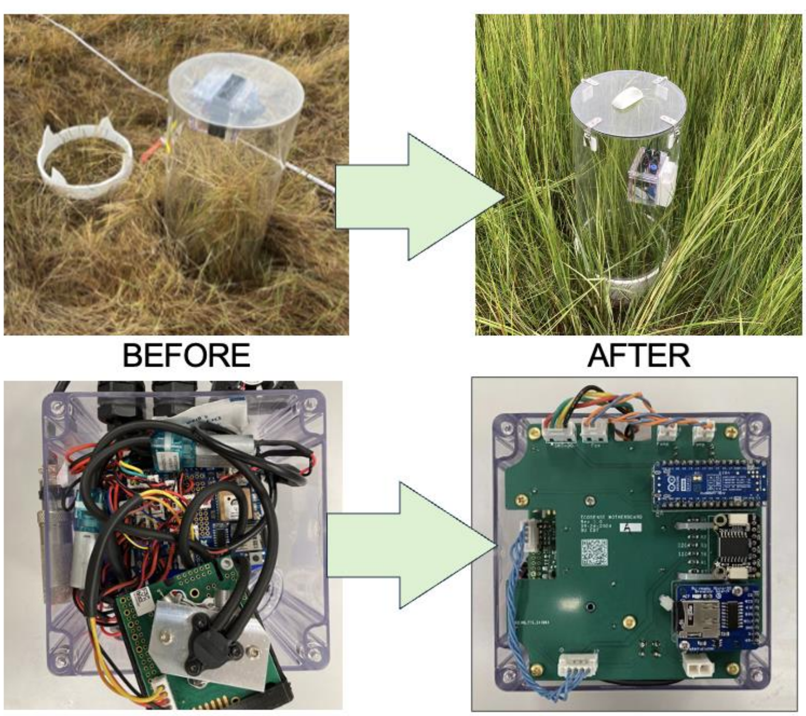
Validation Data Collected….



Sensors were validated with 76 flux measurements directly comparing a Picarro (GasScouter G4301) with sensors during all seasons (February, May, and July), all sensors, and at all reserves.

Calibration set up: 3 gas standards measured (0 ppm, 200 ppm, 400 ppm CO_2)

Instrument Feedback Incorporated….



Major Feedback from Reserves Incorporated

1. **Protocol steps**
   (e.g., Epicollect App for data, order of steps and flow, where to place chambers, recording vegetation)
2. **Associated materials**
   (e.g., Separate collar, detachable chamber lid, sensor clip in chamber, handles and bag to carry
3. **GHG Sensors**
   (e.g., New sensor for methane, durable design, Remote WIFI connection

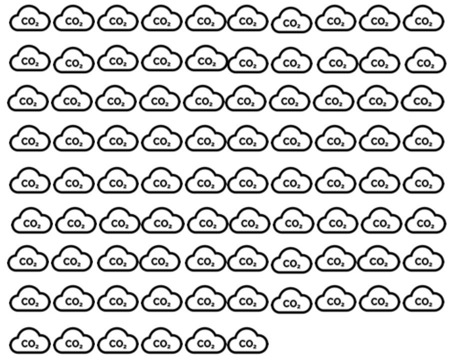
Feedback was generated through written reflection in surveys, conversations in the field during 2 field training trips (an initial trip in December and a later trip in May), and through virtual Zoom meetings with all the reserves where preliminary results were shown and questions and feedback discussed.

Site-Specific Data: Wells, ME

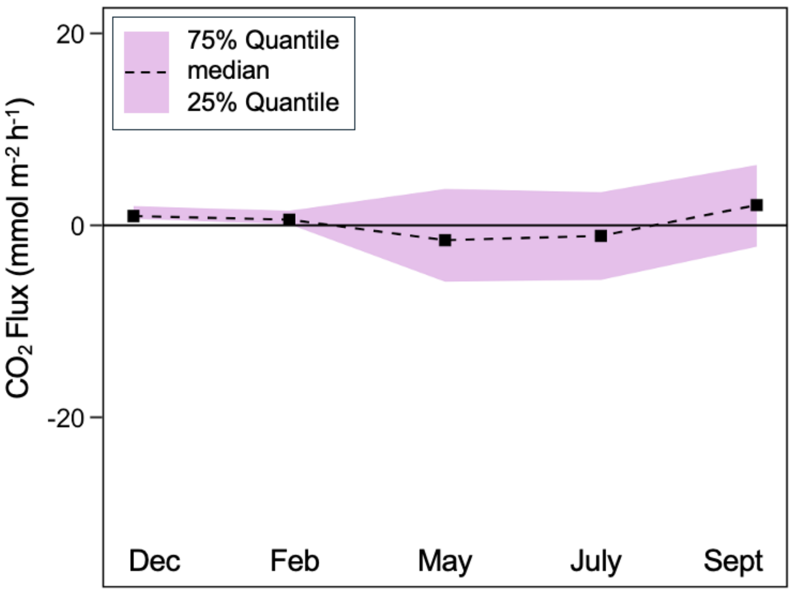
Outcomes at Wells …

✓ 86 total CO_2 Fluxes measured

Flux metrics (mmol m^{-2} h^{-1})
Overall Range: -15.9 to 25.3
Overall Median: 0.81
Summer Median (July): -1.1
Winter Median (February): 0.66



(A) Seasonal Patterns

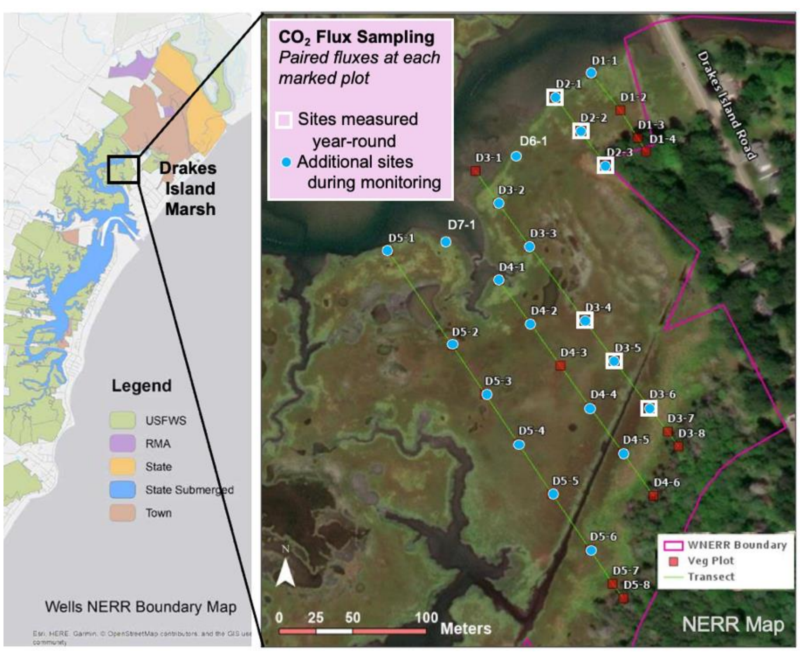


The seasonal patterns at Wells were relatively uniform throughout the year with a slight transition to CO_2 uptake during the May and July sampling (Figure A). During the winter months, Drakes Island sites were a low source of CO_2 and had a smaller range between different sites.

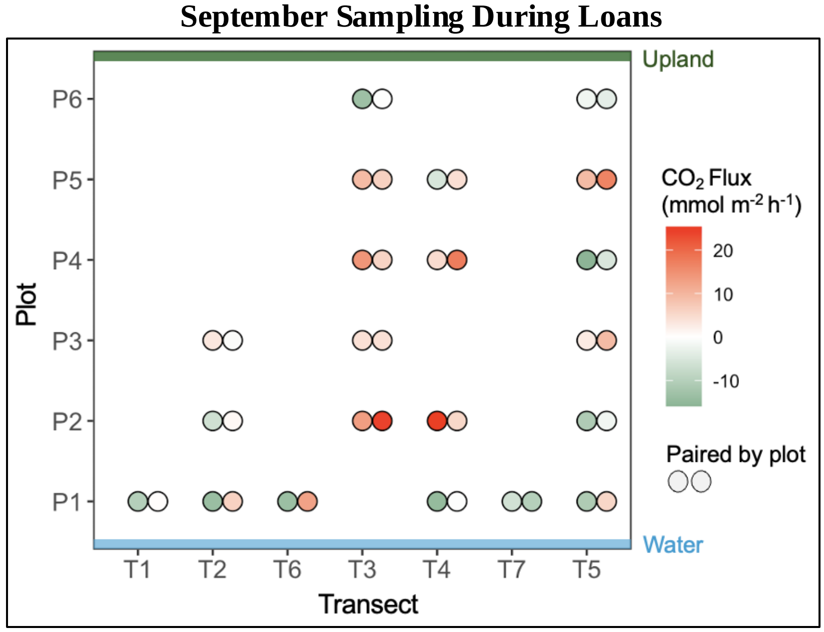
The median CO_2 flux in September was skewed towards CO_2 release from the marsh as the *Salicornia* was starting to senesce and there was dry vegetation around the runneled sites. However, we observed a large variability of CO_2 fluxes at the sites across the marsh in September (Figure B). The spatial patterns in Drakes Island marsh show large variability even at two paired plots (~3m apart on either side of the vegetation plot).

We observed more of a source of CO_2 release in the middle of the marsh, whereas the fringing edges of low marsh as well as the high marsh near the upland edge were areas of CO_2 sequestration.

(B) Spatial Patterns



September Sampling During Loans



Site-Specific Data: Great Bay, NH

Outcomes at Great Bay…

✓ 86 total CO_2 Fluxes measured

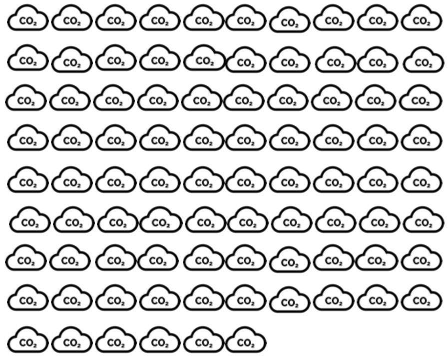
Flux metrics (mmol m^{-2} h^{-1})

Overall Range: -52.2 to 25.4

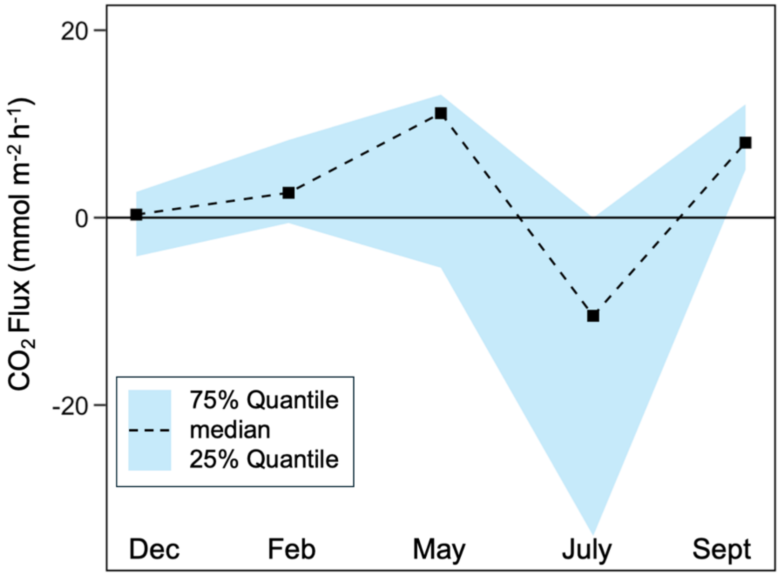
Overall Median: 2.3

Summer Median (July): -10.5

Winter Median (February): 0.61



(A) Seasonal Patterns

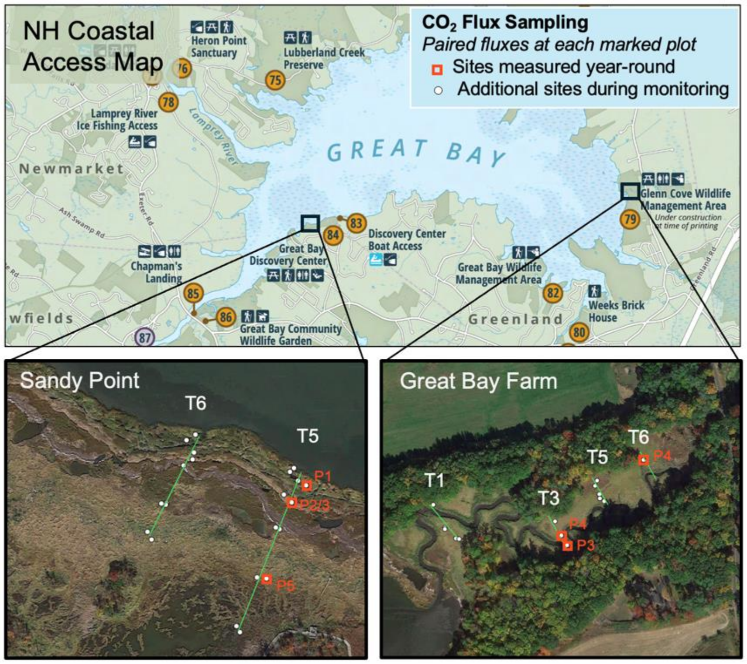


The seasonal patterns at GBNERR showed large changes throughout the year with the transition to strong CO_2 sequestration during the July sampling (Figure A). During the winter months, GBNERR sites were a source of CO_2 and the transition months during May green up and fall senescence released the highest amounts of CO_2.

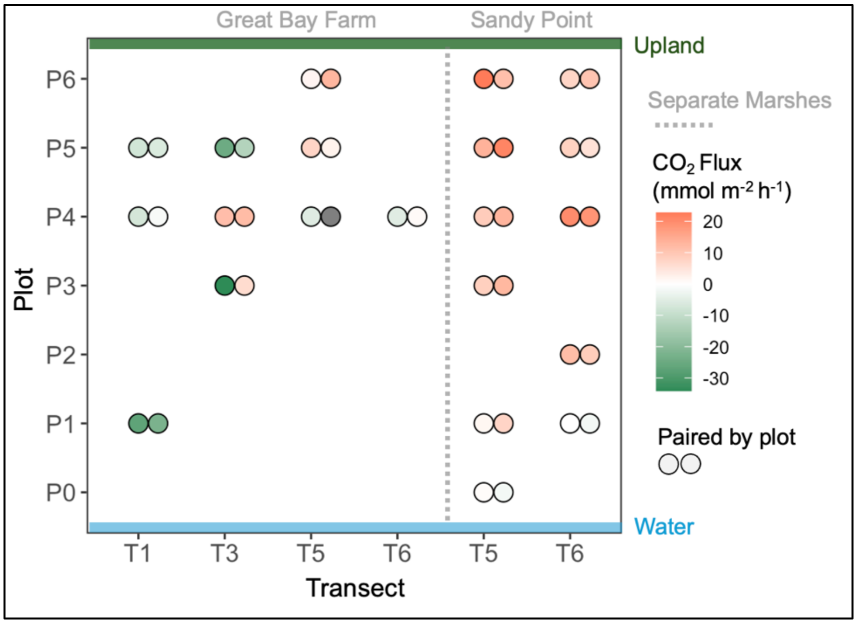
The median CO_2 flux in September was skewed towards CO_2 release especially for Sandy Point, which was a cloudy day with poor weather conditions for sequestration and some vegetation was starting to senesce. There was also substantial variability of CO_2 fluxes at the sites across the marsh in September (Figure B).

The spatial patterns in Great Bay Farm marsh are more variable and show large variability even at two paired plots (~3m apart on either side of the vegetation plot). We observed more CO_2 sequestration in the low marsh sites in Great Bay Farm transect 1 and Sandy Point plots 0 and 1, which are closer to the edge of the bay.

(B) Spatial Patterns



September Sampling During Loans



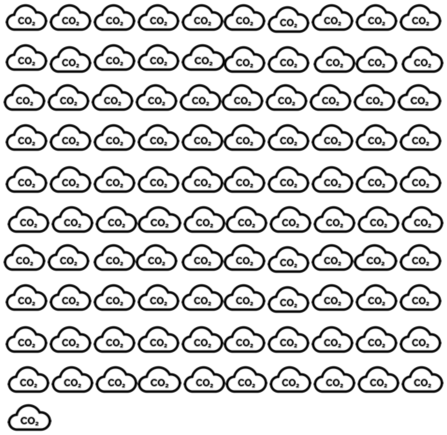
Site-Specific Data: Waquoit Bay, MA

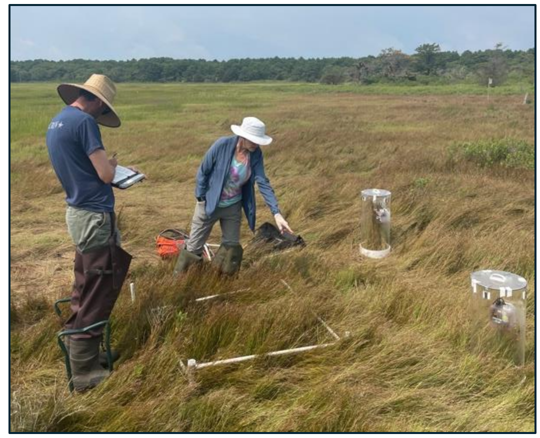
Outcomes at Waquoit Bay…

✓ 101 total CO_2 Fluxes measured

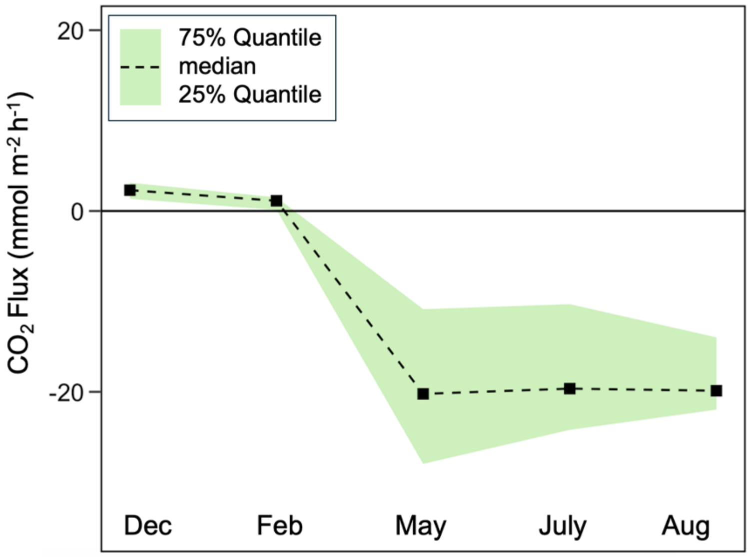
Flux metrics (mmol $m^{-2} h^{-1}$)

Overall Range: -41.6 to 6.4
Overall Median: -10.7
Summer Median (July): -19.6
Winter Median (February): 0.85





(A) Seasonal Patterns

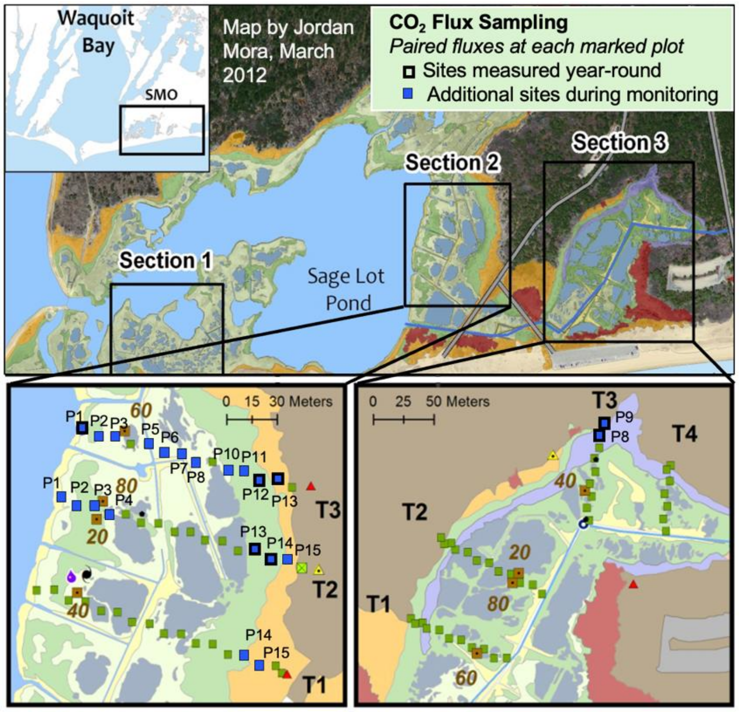


The seasonal patterns at WBNERR showed large changes between the growing and dormant seasons with the transition to strong CO_2 sequestration during the May, July, and August samplings (Figure A). During the winter months, WBNERR sites were a small source of CO_2. The median CO_2 flux in August showed strong CO_2 sequestration at both Doghead and Sage Lot marshes.

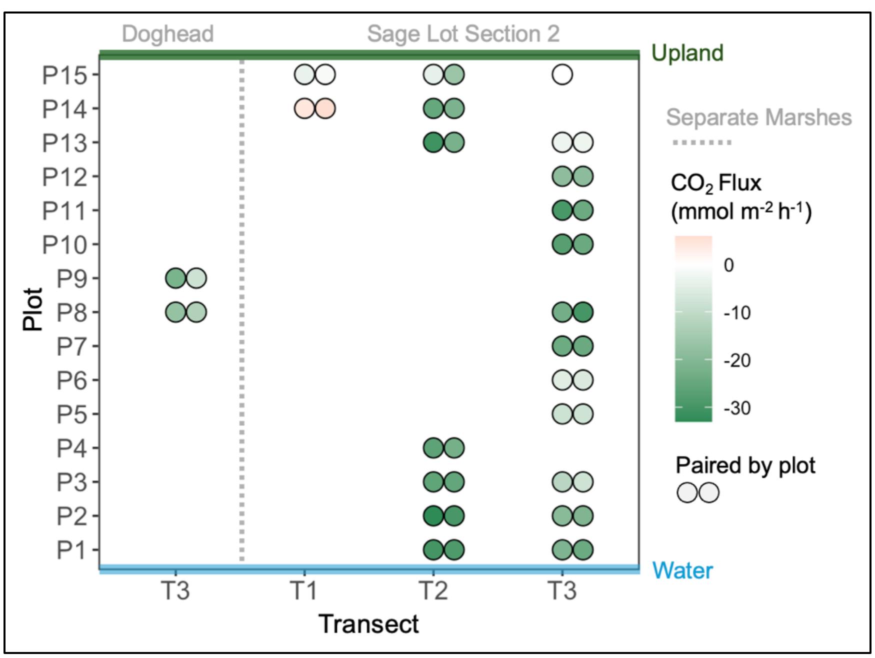
The spatial patterns of August fluxes in Sage Lot Pond marsh show uniformity between the two paired plots (~3m apart on either side of the vegetation plot, Figure B). The top plots of Sage Lot transect 1 which are in the high marsh to marsh border areas had slight release of CO_2 (Figure B).

In WBNERR, we observed relatively consistent CO_2 sequestration across the growing season and across the marsh platform and between the two marshes in August during the period of peak biomass.

(B) Spatial Patterns



August Sampling During Loans

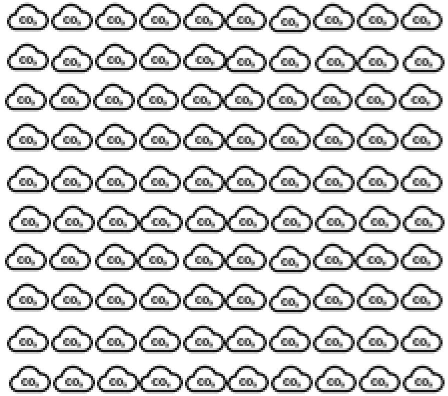


Site-Specific Data: Narragansett Bay, RI

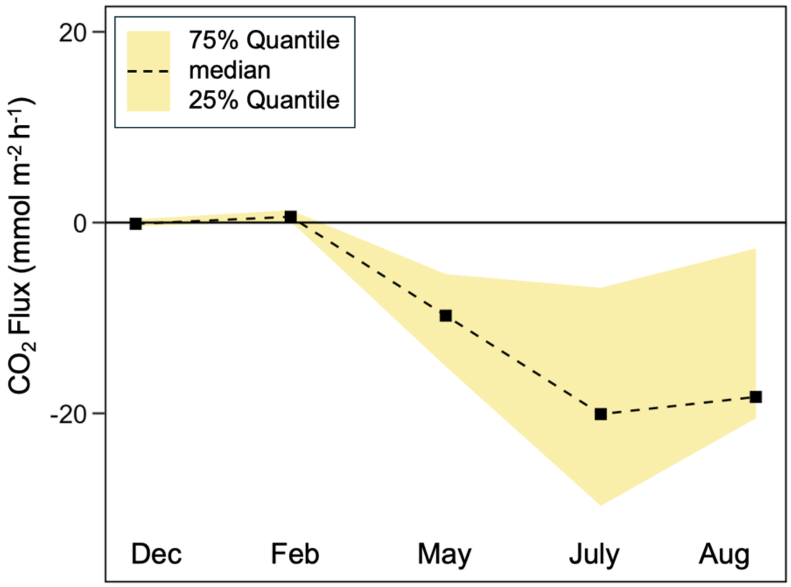
Outcomes at Narragansett…

✓ 100 total CO_2 Fluxes measured

Flux metrics (mmol m^{-2} h^{-1})
Overall Range: -41.8 to 7.05
Overall Median: -6.8
Summer Median (July): -20.1
Winter Median (February): 1.0



(A) Seasonal Patterns

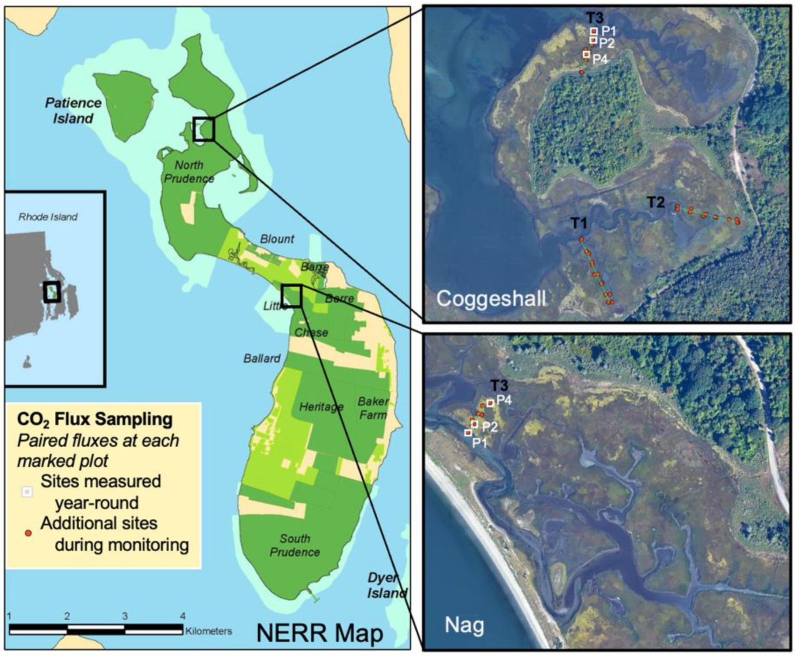


The seasonal patterns at NBNERR showed large changes between the growing and dormant seasons with a transition to CO_2 sequestration during the May, July, and August samplings (Figure A). During the winter months, NBNERR sites were near zero fluxes or a small source of CO_2.

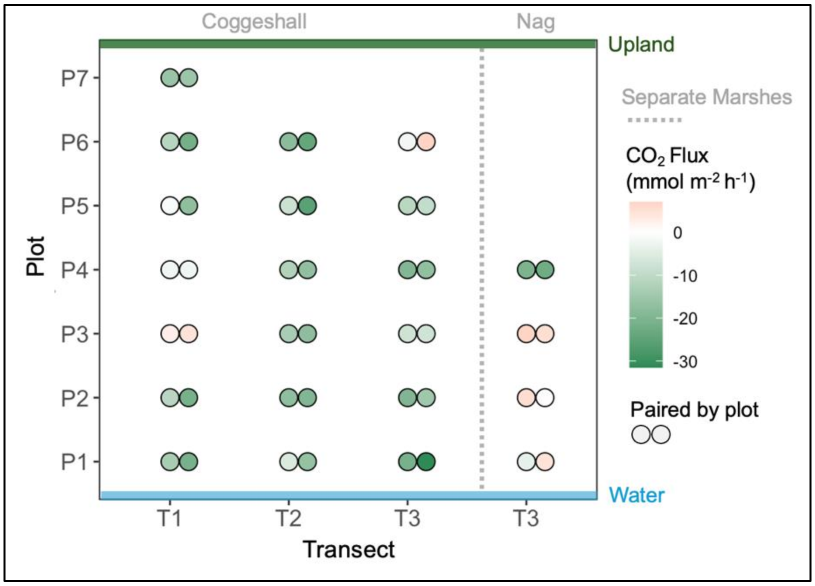
Between the marshes sampled, Coggeshall showed more uniform CO_2 sequestration. The spatial patterns mainly show uniformity between the two paired plots (~3m apart on either side of the vegetation plot, Figure B). There are no clear gradients of CO_2 fluxes across the marsh, but there are patches of low CO_2 release, for example in plots 1 to 3 at Nag marsh (Figure B).

In NBNERR, we observed the greatest CO_2 sequestration during the growing season and across most of the Coggeshall marsh platform during the period of peak biomass.

(B) Spatial Patterns



Late August Sampling During Loans

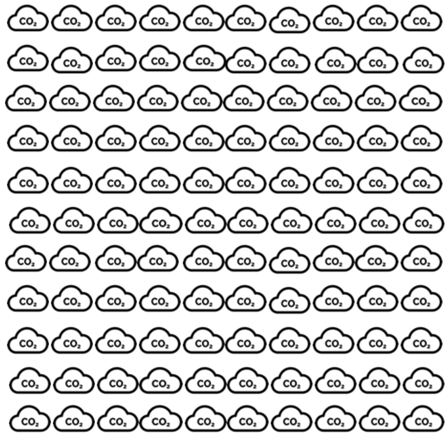


Site-Specific Data: Connecticut, CT

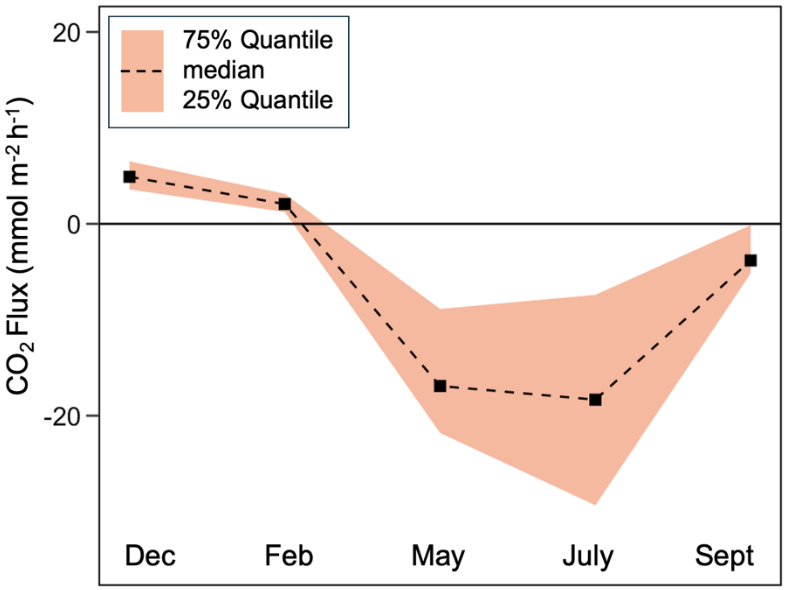
Outcomes at Connecticut…

✓ 110 total CO_2 Fluxes measured

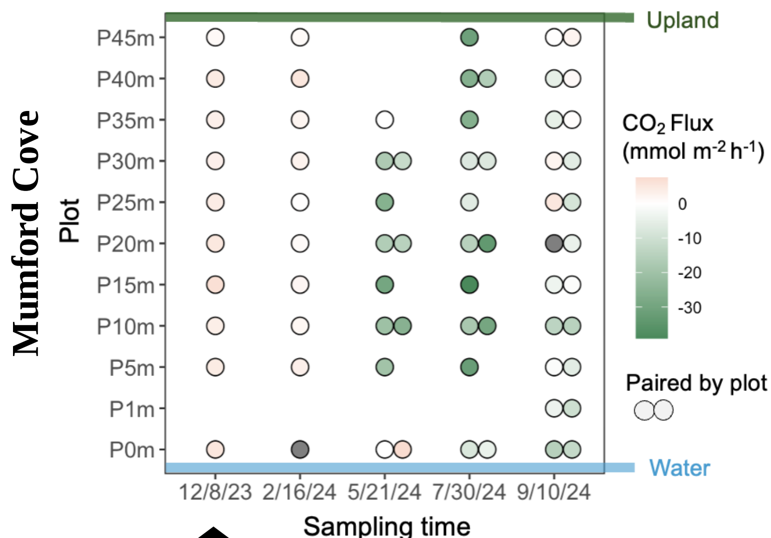
Flux metrics (mmol m^{-2} h^{-1})
Overall Range: -44.1 to 11.4
Overall Median: -4.5
Summer Median (July): -18.3
Winter Median (February): 2.3

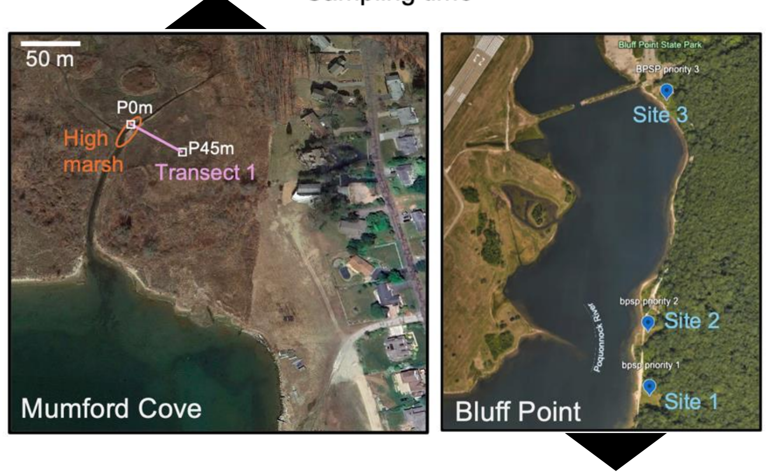


(A) Seasonal Patterns

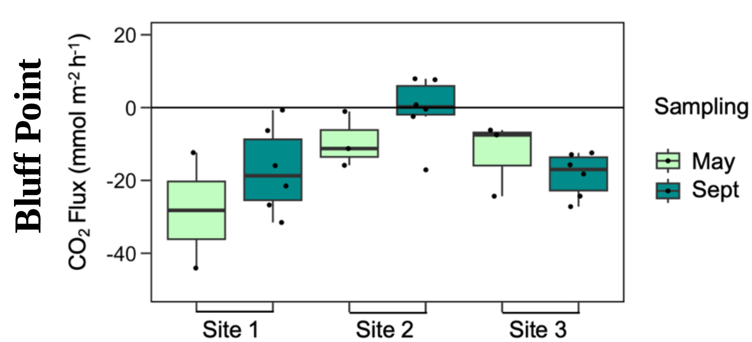


(B) Spatial Patterns





(C) Pre-Restoration



The seasonal patterns at CT NERR showed large changes between the growing and dormant seasons with a transition to CO_2 sequestration during the May, July, and September samplings (Figure A). During the winter months, CT NERR sites were a small source of CO_2. In CT NERR, we observed the greatest CO_2 sequestration during May and July and across most of the marsh areas during the period of peak biomass.

Where to place vegetation transects:
The Mumford Cove transect shows variability of CO_2 fluxes across the marsh, with most of the gradients occurring in patches of about 10m long (Figure B). The spatial patterns also show variability between the two paired plots (on either side of the transect).

Pre-restoration sampling at Bluff Point:
Comparing the three marshes at Bluff Point behind restricted culverts, Site 2 shows the highest CO_2 fluxes, least sequestration, and this site was sometimes releasing CO_2 (Figure C).