Seasonality and Marsh Zonation Drive Carbon Sequestration Patterns in New England Salt Marshes

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Carbon sequestration by salt marshes plays an essential role in removing greenhouse gases from the atmosphere. However, the factors driving carbon uptake or release in salt marshes are still not well understood. Salt marshes exhibit inherent temporal and spatial variability in carbon fluxes, influenced by seasonal plant growth and species distribution gradients within the marsh. Current measurements of carbon fluxes are limited by a lack of year-round sampling and sparse data across the diverse plant communities within marsh ecosystems. To better capture these seasonal and spatial patterns, we conducted a regionally coordinated effort to measure CO_2 fluxes at National Estuarine Research Reserve (NERR) sites. We deployed low-cost, ultraportable greenhouse gas (GHG) sensor packages to measure vertical CO_2 fluxes in salt marshes at five NERR sites from Maine to Connecticut during five different periods throughout the year. These GHG sensors were deployed in the high and low marsh zones at 12-14 sites per estuary during the marsh dormant season (December and February), spring green-up (May), and peak biomass periods (July and August/September). Sensor accuracy was validated against a standard Picarro GasScouter instrument during the winter, spring, and summer months. The study revealed regional patterns in CO_2 fluxes across New England. Lower latitude marshes, from Connecticut to Massachusetts, were on average carbon sinks, with fluxes ranging from -6.6 to -11.5 mmol CO_2 m^{-2} h^{-1}. In contrast, the northern marshes in Maine and New Hampshire were slight carbon sources on average (0.3 to 0.8 mmol CO_2 m^{-2} h^{-1}), as the sampling periods captured more instances of carbon release. As one of the few studies to measure winter CO_2 fluxes in New England salt marshes, we found that dormant season CO_2 emissions averaged 2.6 mmol m^{-2} h^{-1}, a notable contrast to the growing season average of -10.3 mmol m^{-2} h^{-1}. A significant spatial pattern was observed between low and high marsh plant communities. Low marsh areas dominated by *Spartina alterniflora* (>50%) absorbed more carbon, with an average flux 8.4 mmol CO_2 m^{-2} h^{-1} lower than high marsh sites. Species-specific CO_2 flux differences were also evident, maintaining distinct low and high marsh patterns even in winter, when plant activity is minimal. This study highlights the importance of wintertime fluxes and the spatial distinctions between low and high marsh zones. This study also underscores the need for year-round, intra-marsh carbon flux measurements to accurately estimate carbon sequestration capacity, particularly considering climate-driven regional changes in temperature and seasonality.