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Shallow Salt Marsh Tidal Ponds – An Environment with Extreme Oxygen Dynamics

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Abstract:

In marshes, tidal ponds are increasing in number and areal coverage. Getting a better understanding of their unique biogeochemistry is a prerequisite for foreseeing their future role in salt marsh ecosystems. Using *in situ* microprofiling, this study investigated the spatiotemporal dynamics of O_2, pH, and CO_2 in shallow salt marsh tidal ponds in the summer time. High benthic photosynthesis activity, fuelled by CO_2 from the sediment, resulted in steep vertical O_2 gradients at the sediment-water interface, increasing from anoxia to extremely supersaturated peak concentrations up to 886 ± 139 µmol L^{-1} (391 % atmospheric O_2 saturation) over a short distance of 6 mm. These characteristic peaks developed even at low light conditions down to 150 µmol photons m^{-2} s^{-1} photosynthetically active radiation (PAR). The oxygen gradients were restricted to the layer of benthic microalgae on the sediment surface and did not extend into the water column, which was well-mixed throughout the day showing no vertical variation. The benthic photosynthesis and respiration controlled the oxygen concentration in the water column, creating net supersaturated conditions during the day and hypoxic conditions at night. The tidal ponds were generally well-buffered showing only attenuated pH fluctuations ranging from 6.2 to 7.3, and no persistent gradients built up, despite the high photosynthetic activity at the sediment water interface. CO_2 accumulated in the sediment and was present in the water column during the morning hours, but depleted in the afternoon due to the high photosynthetic uptake. Tidal ponds also experienced event-driven changes in their biogeochemistry. Sea foam developed on the water surface during the day and accumulated on one side of the pond blocking light penetration and lowering oxygen concentrations under the foam. Inundation at high tide caused a short-lived temporal variation in O_2 and pH, which was restricted to the time of the flood. As the flooding water receded, the preceding O_2 and pH conditions were immediately restored. Altogether shallow tidal ponds comprise a marsh habitat with distinctive spatiotemporal oxygen dynamics driven by benthic photosynthesis and respiration, which differ from the surrounding vegetated marsh, and could drive changes in salt marsh biogeochemistry in response to increased pond coverage.

Keywords: O_2, CO_2, pH, optode, salt marsh, microprofiling, benthic microalgae (BMA), Plum Island Estuary