The role of nitrate as an electron acceptor in salt marsh organic matter decomposition

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Salt marshes efficiently store carbon due to large inputs of organic matter (OM) from primary production concurrent with slow decomposition rates; the balance between the two ultimately determines burial of OM. As nitrate loading to coastal waters continues to rise, it is unclear what effect it will have on carbon storage capacity of these systems. This uncertainty is largely driven by the dual role nitrate can play in biological processes, where it can either serve as a nutrient for primary production or a powerful electron acceptor fueling heterotrophic microbial metabolism. Distinguishing between the two is critical, since the former could promote carbon storage by enhancing fixation, while the latter could potentially deplete this service by stimulating microbial decomposition.

Here we present a series of controlled flow through reactor experiments that tested the role of nitrate as an electron acceptor and its effect on OM decomposition in salt marsh sediments. We exposed sediments collected at varying depths and prior nitrate exposure to 500 μM nitrate relative to a seawater control, and measured biogeochemical parameters to monitor metabolism. We also collected sediment prior to and following the experiments to examine OM properties and changes in the microbial community using 16S rRNA gene sequencing and metagenomics.

We observed a significant increase in OM decomposition in response to nitrate and found that this pattern persisted at sediment depths typically considered to be less labile. Nitrate altered both the microbial community and its associated functional potential, selecting for taxa belonging to groups known to reduce nitrate and oxidize more complex forms of OM. This pattern was not as pronounced in sediment that had been chronically exposed to nitrate, suggesting the effect of nitrate on OM decomposition is limited. These results suggest that nitrate can serve as an electron acceptor in metabolism and may expand the OM pool available to microbial oxidation, effectively reducing overall carbon storage potential in salt marsh systems.