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Sediment chemoautotrophy in the coastal ocean

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A key process in the biogeochemistry of coastal sediments is the reoxidation of reduced intermediates formed during anaerobic mineralization which in part is performed by chemoautotrophic micro-organisms. These microbes fix inorganic carbon using the energy derived from reoxidation reactions and in doing so can fix up to 32% of the CO_2 released by mineralization. However the importance and distribution of chemoautotrophy has not been systematically investigated in these environments. To address these issues we surveyed nine coastal sediments by means of bacterial biomarker analysis (phospholipid derived fatty acids) combined with stable isotope probing (^{13}C-bicarbonate) which resulted in an almost doubling of the number of observations on coastal sedimentary chemoautotrophy.

Firstly, sediment chemoautotrophy rates from this study and rates compiled from literature (0.07 to 36 mmol C m^{-2} d^{-1}) showed a power-law relation with benthic oxygen uptake (3.4 to 192 mmol O_2 m^{-2} d^{-1}). Benthic oxygen uptake was used as a proxy for carbon mineralization to calculate the ratio of the CO_2 fixed by chemoautotrophy over the total CO_2 released through mineralization. This CO_2 efficiency was 3% in continental shelf, 9% in nearshore and 21% in salt marsh sediments. These results suggest that chemoautotrophy plays an important role in C-cycling in reactive intertidal sediments such as salt marshes rather than in the organic-poor, permeable continental shelf sediments. Globally in the coastal ocean our empirical results show that chemoautotrophy contributes $\sim$0.05 Pg C y^{-1} which is four times less than previous estimates.

Secondly, five coastal sediment regimes were linked to the depth-distribution of chemoautotrophy: 1) permeable sediments dominated by advective porewater transport, 2) bioturbated sediments, and cohesive sediments dominated by diffusive porewater transport characterized by either 3) canonical sulfur oxidation, 4) nitrate-storing Beggiatoa, or 5) electrogenic sulfur oxidation. Sediments with an O_2-H_2S interface exhibited highest chemoautotrophy activity in the top centimeter via canonical sulfur oxidation, whereas in the presence of electrogenic sulfur oxidation a uniform distribution of chemoautotrophy throughout the top centimeters of the sediment was evidenced. Lowest dark carbon fixation was found in permeable advective-driven sediments with deep oxygen penetration resulting in higher subsurface than surface activity. Hence, the depth-distribution of chemoautotrophy in coastal sediments varies due to several biogeochemical characteristics such as grain size, organic carbon content, presence of filamentous sulfur oxidizing bacteria, and macrofaunal activity.