

Deciphering the cryptic cycling of methane in a coastal wetland system

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Methane emitted from wetlands, Earth's largest natural source, comes primarily from biological methanogenesis (MG) by groups of archaea, and is the product of the last step of organic matter degradation. In anoxic marine sediments, methane can be efficiently metabolized by anaerobic oxidation of methane (AOM), whereby a microbial consortium of methanotrophic archaea and sulfate-reducing bacteria oxidize methane to bicarbonate in a zone called the sulfate-methane transition zone (SMTZ). Above the SMTZ, organoclastic sulfate reduction tends to thermodynamically suppress MG when in competition for hydrogen and acetate. But MG can persist with non-competitive substrates, such as methanol and methylated amines. Methane produced within the sulfate reduction zone has the potential to directly fuel AOM, leading to a "cryptic methane cycling" above the SMTZ. Here we will present our preliminary and ongoing research on the direct relationship between MG and AOM above the SMTZ in the Carpinteria Salt Marsh Reserve, a coastal wetland located south of Santa Barbara, CA, USA.

Sediment push cores were collected from a shallow hypersaline pool (~130 PSU, 72 mM sulfate). The cores had a black, sulfidic top layer (0-8 cm) and a brownish bottom layer (8-16 cm). Sediment samples were subjected to whole-core and batch incubations, radioisotope labelling, gas chromatography, and porewater analytics. Results from radiotracer incubations of sediment revealed the activity of AOM, as well as sulfate reduction within the first 4 cm of the sediment. Below 4 cm, AOM activity continued, while sulfate reduction was absent despite 67 mM sulfate. We therefore postulate that AOM in the bottom layer was coupled to the reduction of iron, which was supported by the brownish colouring of the sediment, indicating the presence of iron oxides. The addition of mono-methylamine and methanol resulted in distinct methane production in both sediment layers, pointing to the presence of a methanogenic community that was utilizing these non-competitive substrates. The addition of molybdate, a sulfate reducer inhibitor, triggered methane production in the top layer in which also sulfate reduction was detected, but at a much lower rate compared to the mono-methylamine and methanol additions. We will further present data from time-series labelling experiments with ¹⁴C-methylamine, which were designed to follow cryptic methane cycling from the methanogenic conversion of methylamine to methane, to the methanotrophic oxidation of methane to CO₂.