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The Bubble Transport Mechanism: Indications for a bubble-mediated transfer of microorganisms from the sediment into the water column

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Gas releasing seep areas are known to impact the methane biogeochemistry in the surrounding sediment and water column. Due to microbial processes most of the methane is oxidized under anaerobic and aerobic conditions before the greenhouse gas can escape into the atmosphere. However, methane gas bubbles can largely bypass this microbial filter mechanism, enabling highly efficient transport of methane from the sediment towards the sea surface. Studies in the water column surrounding hydrocarbon seeps indicated an elevated abundance of methanotrophic microorganism in the near field of gas bubble plumes. The enhanced methane concentration in the seep-affected water column stimulates the activity of methane oxidizers and leads to a rapid rise in the abundance of methane-oxidizing microorganisms in the aging plume water.

In our study we hypothesized that a bubble-mediated transport mechanisms between the benthic and pelagic habitats represents an exchange process, which transfers methanotrophic microorganisms from the sediment into the water column, a process we termed the "Bubble Transport Mechanism". This mechanism could eventually influence the pelagic methanotrophic community, thereby indirectly providing feedback mechanisms for dissolved methane concentrations in the water column and thus impacting the sea/atmosphere methane flux.

To test our hypothesis, field studies were conducted at the "Rostocker Seep" site (Coal Oil Point seep area, California, USA). Catalyzed Reporter Deposition Fluorescence In Situ Hybridization (CARD-FISH) analyzes were performed to determine the abundance of aerobic and anaerobic methanotrophic microorganisms. Aerobic methane oxidizing bacteria were detected in the sediment and the water column, whereas anaerobic methanotrophs were detected exclusively in the sediment. The key device of the project was a newly developed "Bubble Catcher" used to collect naturally emanating gas bubbles at the sea floor together with particles attached to the bubble surface rim. Bubble Catcher experiments were carried out directly above a natural bubble release spot and on a reference site at which artificially released gas bubbles were caught, which had no contact with the sediment. CARD-FISH analyzes showed that aerobic methane oxidizing bacteria were transported by gas bubbles from the sediment into the water column. In contrast anaerobic methanotrophs were not detected in the bubble catcher.

Based on our study we hypothesize that the Bubble Shuttle transport mechanism contributes to the pelagic methane sink by a sediment-water column transfer of methane oxidizing microorganisms. Furthermore, this Bubble Shuttle may influence the methanotrophic community in the water column after massive short-term submarine inputs of methane (e.g. release of methane from bore holes). Especially in deep-sea regions, where the abundance of methane oxidizing microorganisms in the water column is low in general, the Bubble Transport Mechanism may inject a relevant amount of methane oxidizing microorganisms into the water column during massive inputs, supporting indirectly the turnover of this greenhouse active trace gas in the submarine environment.