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The ejection of methane and benthic methanotrophs from an abandoned well site and its implication for the fate of methane within the dispersing plume

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In aquatic habitats, sediment-water column coupling is a continuous and multilayered process with several mechanisms contributing. A recent study showed that gas bubbles can transfer methane-oxidizing bacteria (MOB) from the sediment into the water column at methane seep sites [1]. However, detailed knowledge of bentho-pelagic MOB transport controls and their effect on the pelagic methane turnover remains vague but is a prerequisite for a proper understanding of the methane dynamics in seep regions.

In our present study, we selected an isolated seep site in the North Sea (known as the Blowout) to characterize the bentho-pelagic transportation of benthic MOB from a seep into the water column and quantify its impact on the pelagic methane turnover. The Blowout has been a hotspot of submarine methane release in the North Sea since a drilling accident occurred there ~30 years ago. We investigated the methane dynamics, the activity levels and size of the pelagic methanotrophic community. A particle-tracking model was then employed to simulate the release of methane and MOB from the crater and their subsequent dispersion within the plume.

Our data shows that methane and MOB were increased in the down-current water body of the Blowout by a factor of ~1.9 and ~1.3, respectively. This finding suggests the transportation of benthic MOB from the crater into the water column, possibly via the resuspension of sediments and direct gas-bubble-related transport processes. The benthic MOB inoculant increased the methane oxidation capacity in the sub-thermocline water body within the dispersing plume and thus decreased the methane turnover time by a factor of four. According to the particle-tracking model, the ejection of 62 ± 40.9 L CH_4 s^{-1} and 4.29 ± 1.9 x 10^{12} MOB cells s^{-1} in situ from the Blowout would produce the measured sub-thermocline methane and MOB levels.

These new findings highlight the importance of sediment-water column coupling at seep sites and their positive feedback on the pelagic methane sink. The same or similar processes are likely to affect other biogeochemical cycles in seep regions.

[1] Jordan *et al.* (2020), *Sci Rep* **10**, 4682