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Tidal dynamics control microbial methane oxidation in the water column above an active cold seep (Doggerbank, North Sea)

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Methane is a potent greenhouse gas with strongly increasing atmospheric concentrations since industrialisation. In the ocean, methane is most dominantly produced in sediments and is of microbial and/or thermogenic origin. Uprising methane may escape from the ocean floor to the overlying water column where it can be oxidized by methane oxidizing bacteria. The aerobic methane oxidation (MOx) is thus an important final barrier, which can mitigate methane release from the ocean to the atmosphere where it contributes to global warming. Nevertheless, there is rather little knowledge on the temporal dynamics of the microbial methane filter capacity in the water column. To gain a better understanding of the dynamics, we conducted a 48 hours' time-series experiment in a clearly stratified water column above an active methane seep in the North Sea (Doggerbank, 41m water depth). We detected gas flares during echosounder surveys and visually observed bubbles at the sea surface. Methane concentrations were highly elevated with up to 2800 nM in bottom waters and 450 nM in surface waters. δ13C-signatures of dissolved methane ranged from -65 ‰ to -85 ‰ (VPDB), indicating a microbial methane origin and seismic data suggest (methane) gas pocket at >50 m sediment depth. Methane concentrations maxima in both bottom and surface waters showed a $\sim$12 h periodicity, indicating that the flux of methane from the seep was linked to the local tidal pattern with the lowest methane concentrations at rising tide and enhanced flux at falling tide. MOx activity showed a similar temporal behaviour suggesting that tidal dynamics are an important control on the efficiency of the microbial methane filter in the water column. MOx rates were highest in bottom waters (up to 7.6 nM/day), however we also found high MOx rates in near-surface waters (3.2 nM/day) at times of elevated seep activity. This unusual finding suggests that methanotrophs were transported upwards (possibly induced by the drag of rising bubbles), through the pycnocline into the epilimnion. Our further analyses aim at determining the identity and abundance of these water column methanotrophs.