Bubble-mediated transport of benthic microorganisms into the water column and its implication on pelagic methane oxidation capacity at the blowout site in the North Sea

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Introduction

Gas bubble-releasing seep sites are relevant methane sources in aquatic systems. In the vicinity of these sites, methanotrophic microorganisms in the sediment and water column play a key role in controlling the methane flux into the atmosphere. Recent studies in the water column surrounding hydrocarbon seeps indicate an elevated abundance of methanotrophic bacteria (MOB) in the near field of gas bubbles. In our study at the Coal Oil Point seep field and the Blowout site in the North Sea (decommissioned well site 22/4b), we investigated how the bentho-pelagic transport of methanotrophic bacteria affects pelagic methane turnover.

Study Sites

Coal Oil Point:

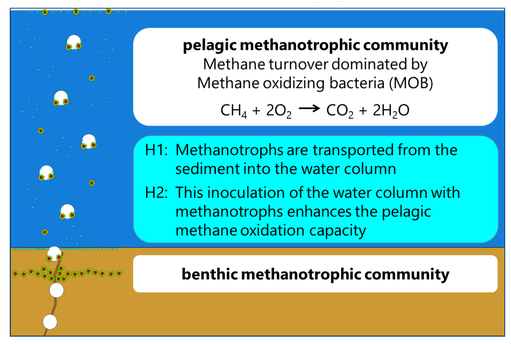
A diffusive gas flux from a variety of seeps with a wide diversity of seepage characteristics (e.g. bubble size and gas flux)

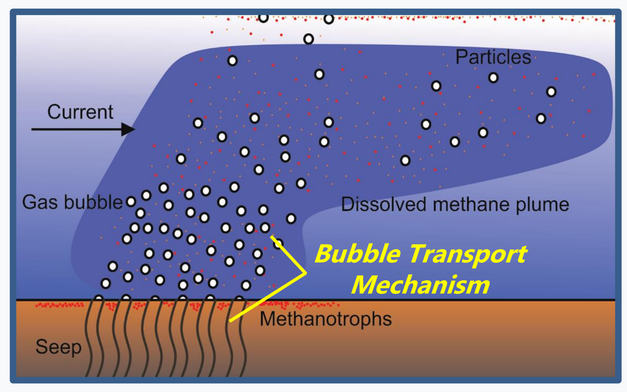
North Sea Blowout:

Strong focused gas flux from an abandoned well site/crater

Coal Oil Point seep field off Santa Barbara | **Blowout site in the North Sea**

Bubble Shuttle hypothesis



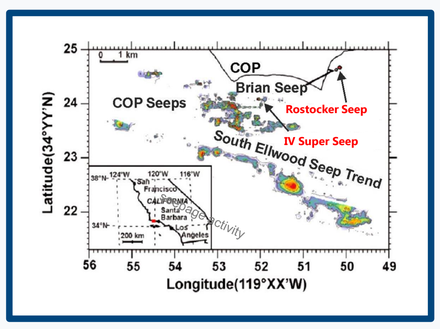


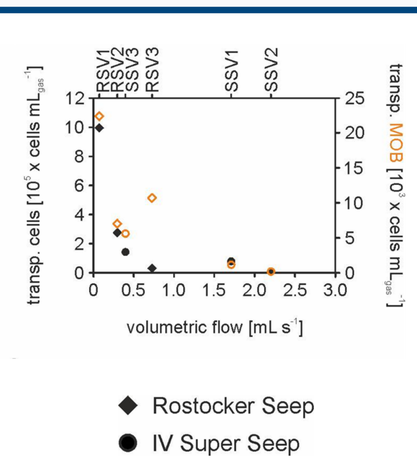
Coal Oil Pont: Testing the Bubble Shuttle hypothesis in field experiments

Key Question

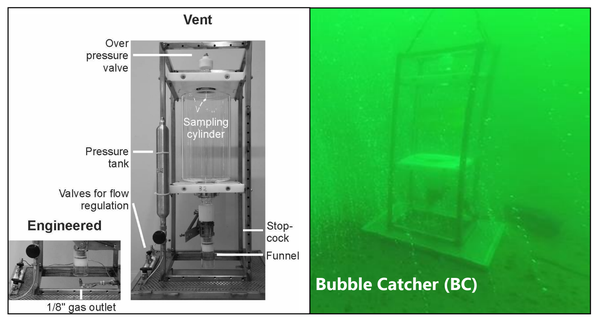
Does the Bubble Transport Mechanism exist?

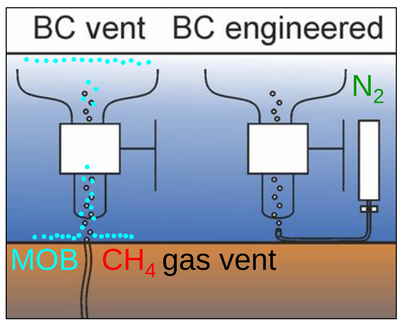
- Bubble Catcher experiments at diverse vent sites with different gas flux intensities
- Parameterization of flux intensity and transport rate of methantrophs





Experimental Approach





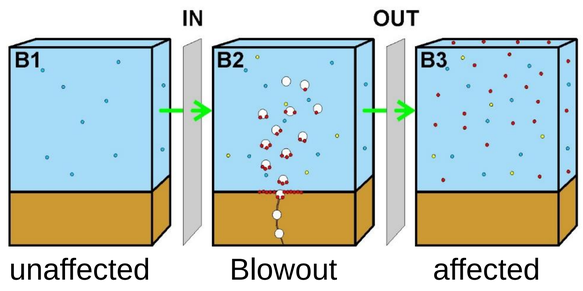
Key Findings

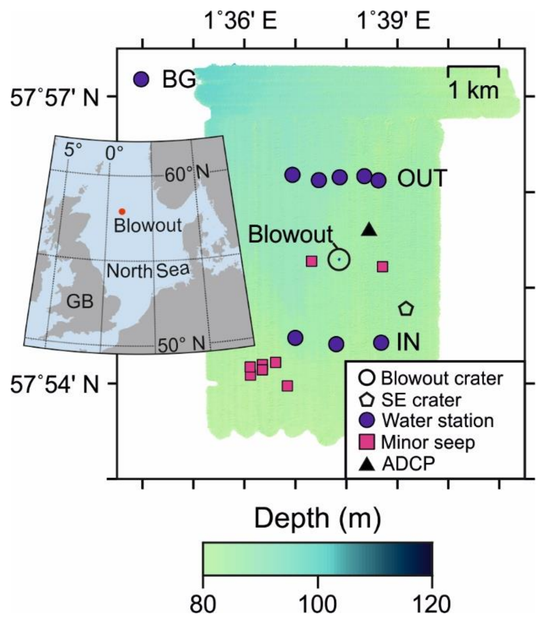
- All experiments indicate a cell transport between sediment and water column
- Decreasing cell transport with increasing volumetric gas flow

➢ Sparging of cells from the sediment

North Sea Blowout: Bubble Shuttle effect on the pelagic methane sink

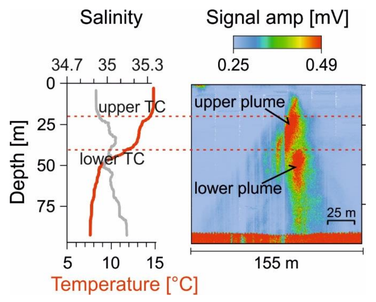
Concept and sampling strategy

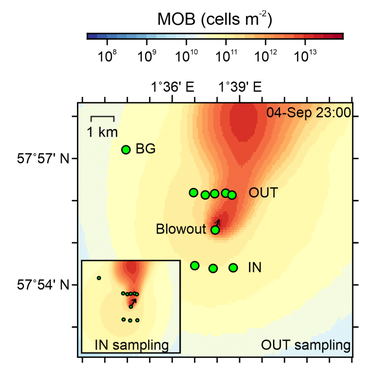


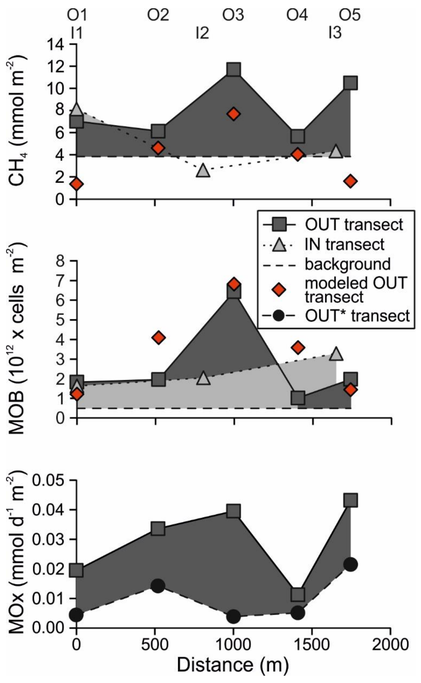


Key Findings

- Our findings suggest the ejection of benthic MOB into the water column by sediment resuspension and gas-bubble-mediated transport
- The particle-tracking model showed that tides controlled the distribution of MOB
- Our investigations showed, that the dislocation of benthic methanotrophs into the water column can spontaneously boost the methane oxidation capacity within the dispersing methane plume by a factor of five
- We showed that the blowout emits 62 ± 40.9 L CH_4 s^{-1} into the water column. The emission thus remains at the same level as in 2011 (81 L CH_4 s^{-1}, Leifer 2015)







Publications:

Schmale et al. (2015). Bubble transport mechanism: indications for a gas bubble-mediated inoculation of benthic methanotrophs into the water column. Cont. Shelf Res. 103: 70-78, doi: 10.1016/j.csr.2015.04.022

Jordan et al. (2020). Bubble-mediated transport of benthic microorganisms into the water column: Identification of methanotrophs and implication of seepage intensity on transport efficiency. Sci. Rep. 10: 4682, doi: 10.1038/s41598-020-61446-9

Jordan et al. (2021). Pelagic methane sink enhanced by benthic methanotrophs ejected from a gas seep. Geophys. Res. Lett. 48: e2021GL094819, doi: 10.1029/2021GL094819

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