Leibniz Institute For Baltic Sea Research Warnemünde

Microbial methane consumption in the water column of the central Baltic Sea (Gotland Deep)

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Scientific Background

Compared to the number of studies on the microbial processes of methane oxidation in sediments, water column studies are scarce, and could to date just identify the turnover through oxygen and sulfate.
Extensive water column investigations in the Baltic Sea identified the strongest methane enrichment within the stagnant anoxic water bodies of the deep basins. In contrast, surface water methane concentrations in these areas are only slightly enriched compared to the atmospheric equilibrium, indicating an effective mechanism that prevents the escape of methane from the deep water into the atmosphere (1). ■

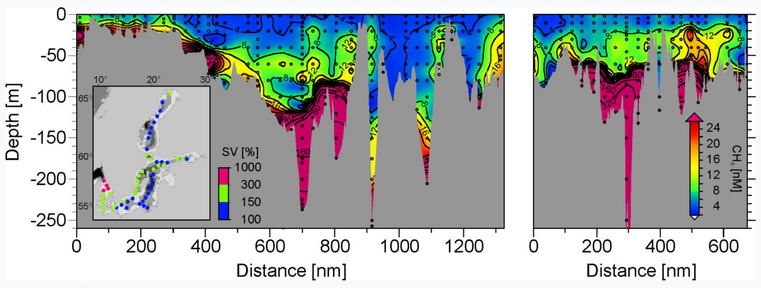


Figure 1: Surface water and verticle distributions of methane concentration in the Baltic Sea.

Motivation

Little is as yet known about the processes that regulate the methane flux in the deep basins. In this work, we use a multidisciplinary approach that combines gas chemistry, molecular biology and lipid biomarker geochemistry and present data on a microbial methane sink within the pelagic redox zone of the Gotland Deep. Thus, this study aims to investigate whether aerobic methane oxidation also plays a role in the more dynamic and turbulent redox zone of the central Baltic Sea.

An additional target is the identification of other possible microbial processes which may oxidize methane within the redox zone by the use of alternative oxidants (e.g. nitrite or nitrate). ■

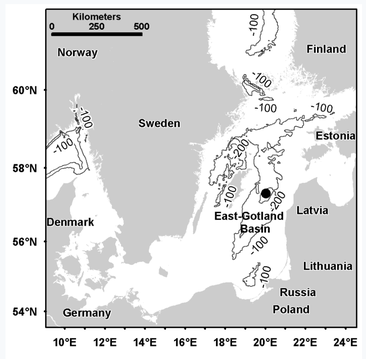


Figure 2: The Baltic Sea and the location of the Gotland Deep. The study area is indicated with a black dot.

Gas-chemical, microbiological and biomarker evidences for aerobic methanotrophy

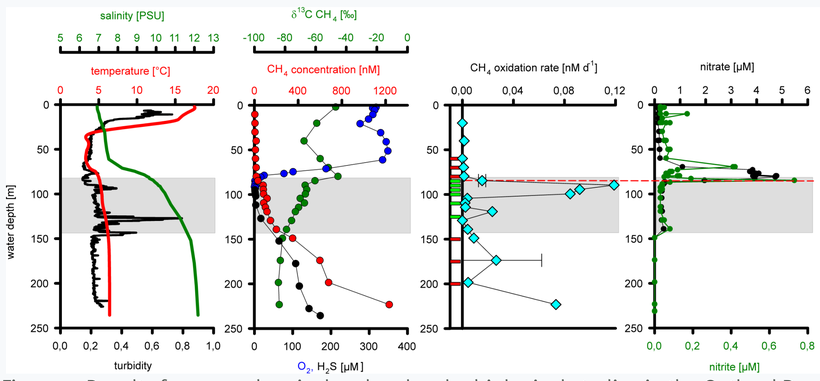


Figure 3: Results from gas chemical and molecular biological studies in the Gotland Deep.

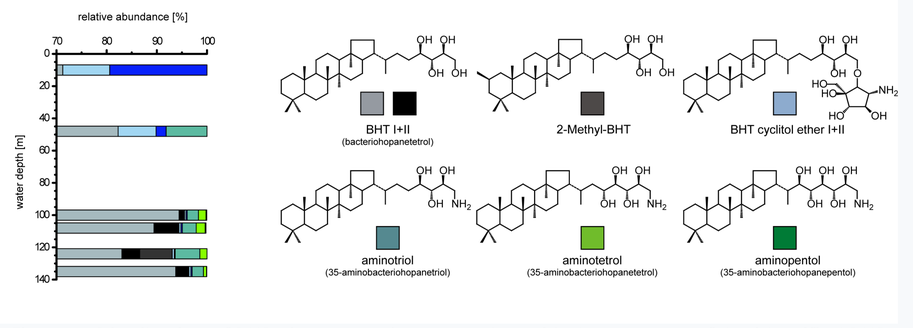


Figure 4: Distribution of BHPs in water column together with the structure of the identified BHPs.

The methane gradient within the suboxic zone implied microbial methane consumption in the redox zone. The oxidation of methane within this zone was evident by the enrichment of ^{13}C-CH_4 and elevated oxidation rates. Notably, methane monoxygenase gene expression analysis demonstrated that accordant methanotrophic activity was probably due to only one phylotype of the aerobic type I methanotrophic bacteria (2,4). ■

An imprint of these organisms on the particular organic matter was revealed by distinctive lipid biomarkers showing lipid fatty acids (not shown) and bacteriohopanepolyols (BHPs) characteristic for aerobic type I methanotrophs (e.g., aminotetrol and –pentol), corroborating their role in aerobic methane oxidation in the suboxic zone of the central Baltic Sea (3). ■

Pelagic microbial methane oxidation by alternative oxidants

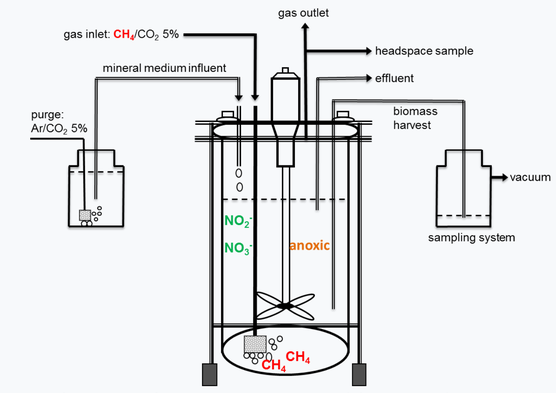


Figure 5: Bioreactor setup to cultivate methanotrophs.

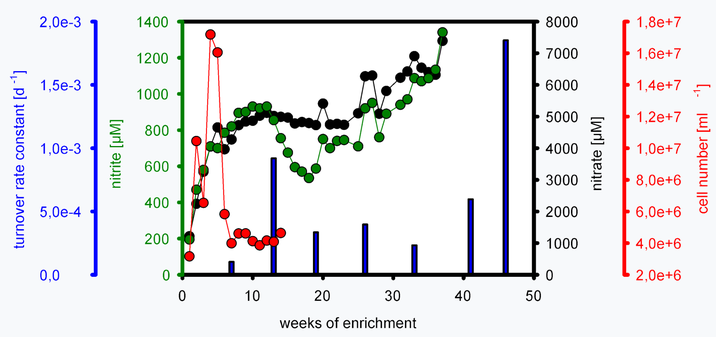


Figure 6: Observations in the bioreactor during the time of cultivation.

Within the suboxic zone the concentration distribution of methane and nitrogen-species suggests microbial methane consumption by the use of nitrite and/or nitrate (Fig. 3). To study this process and to identify the involved microorgansims, we carried out an enrichment experiment. To detect the responsible organisms, the culture was incubated with $^{13}CH_4$ and $^{15}NO_2^-$ and the cell-specific incorporation of these labes was analysed with NanoSIMS. ■

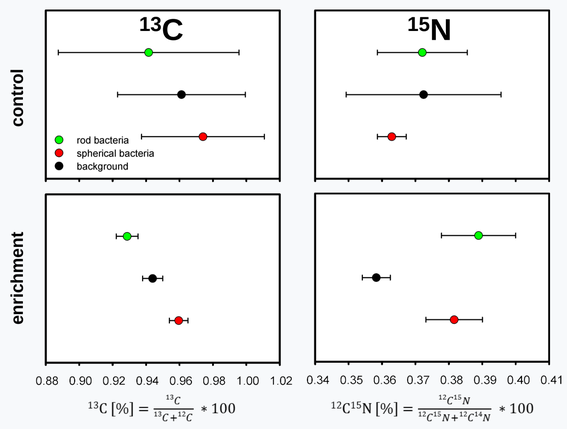
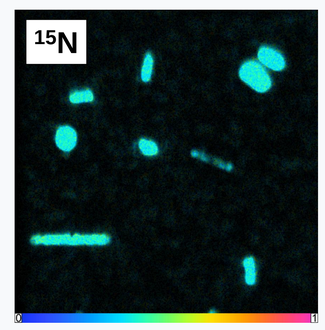


Figure 8: ^{15}N and ^{13}C enrichment within rod- and spherical-shaped bacteria during incubation with $^{15}NO_2^-$ and $^{13}CH_4$.

IOW NanoSIMS-Lab



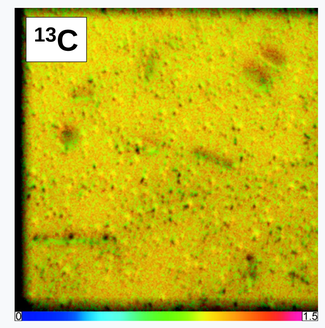


Figure 7: Visual identification of bacteria-classes together with the spatial distribution of ^{15}N and ^{13}C.

Acknowlegdements

DFG
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(1) Schmale, O. et al. (2010), Distribution of methane in the water column of the Baltic Sea, Geophysical Research Letters, 37(12), L12604, doi.1029/2010gl043115.
(2) Schmale, O. et al. (2012). Aerobic methanotrophy within the pelagic redox-zone of the Gotland Deep (central Baltic Sea). Biogeosciences 9: 4969-4977.
(3) Berndmeyer, C. et al. (2013), Biomarkers for aerobic methanotrophy in the water column of the stratified Gotland Deep (Baltic Sea), Org. Geochem., 55, 103-111.
(4) Jakobs, G. et al. (2013), Comparative studies of pelagic microbial methane oxidation within two anoxic basins of the central Baltic Sea (Gotland Deep and Landsort Deep), Biogeosciences Discuss., 10, 12251-12284.