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Environmental control on aerobic methane oxidation in coastal waters

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Large quantities of methane are produced in anoxic sediments of continental margins and may be liberated to the overlying water column, where some of it is consumed by aerobic methane oxidizing bacteria (MOB). Aerobic methane oxidation (MOx) in the water column is consequently the final sink for methane before its release to the atmosphere, where it acts as a potent greenhouse gas. In the context of the ocean's contribution to atmospheric methane, coastal seas are particularly important accounting >75% of global methane emission from marine systems. Coastal oceans are highly dynamic, in particular with regard to the variability of methane and oxygen concentrations as well as temperature and salinity, all of which are potential key environmental factors controlling MOx. To determine important environmental controls on the activity of MOBs in coastal seas, we conducted a two-year time-series study with measurements of physicochemical water column parameters, MOx activity and the composition of the MOB community in a coastal inlet in the Baltic Sea (Boknis Eck Time Series Station, Eckernförde Bay – E-Bay). In addition, we investigated the influence of temperature and oxygen on MOx during controlled laboratory experiments. In E-Bay, hypoxia developed in bottom waters towards the end of the stratification period. Constant methane liberation from sediments resulted in bottom water methane accumulations and supersaturation (with respect to the atmospheric equilibrium) in surface waters. Here, we will discuss the factors impacting MOx the most, which were (i) perturbations of the water column (ii) temperature and (iii) oxygen concentration. (i) Perturbations of the water column caused by storm events or seasonal mixing led to a decrease in MOx, probably caused by replacement of stagnant water with a high standing stock of MOB by 'new' waters with a lower abundance of methanotrophs. b) An increase in temperature generally led to higher MOx rates. c) Even though methane was abundant at all depths, MOx was highest in bottom waters (1-5 nM/d), which usually contained the lowest oxygen concentrations. Lab-based experiments with adjusted oxygen concentrations in the range of 0.2 - 220 μM confirmed a sub-micromolar oxygen optimum. Additionally, we investigated the metabolic fate of methane-carbon at low (<0.5 μM) and high ($\sim$200 μM) oxygen concentrations during incubations with radio-labeled methane. The results suggest a differential partitioning of catabolic and anabolic processes at different oxygen concentrations.