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Field and experimental evidence for low-O_2 affinity of aerobic methane oxidizers in coastal waters

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The coastal ocean accounts for more than 75 % of the global oceanic methane emissions. An important process in mitigating methane emissions from the seawater to the atmosphere is aerobic methane oxidation (MOx). Coastal oceans are highly dynamic systems, in particular with regard to the variability of temperature, salinity, and oxygen concentrations, all of which are potential key environmental factors controlling MOx. We conducted a two-year time-series study of MOx measurements in the water column of a coastal inlet in the southwestern Baltic Sea (Eckernförde Bay, Boknis Eck Time Series Station, 54°31.823 N, 10°02.764 E, 28 m water depth; www.bokniseck.de). Physicochemical parameters at this station have been monitored since 1957. Seasonal stratification during summer/autumn leads to intermittent oxygen depletion (hypoxic to anoxic) in bottom waters in the later part of the stratification period. The duration of these low-oxygen events increased since the 1970s (Lennartz et al., 2014). Furthermore, the organic-rich seafloor continuously produces methane, which leads to gas ebullition followed by accumulation of dissolved methane in bottom waters (up to 470 nM) and supersaturation (with respect to the atmospheric equilibrium) in surface waters (up to 27 nM). MOx communities were most active in bottom waters (1-5 nM/day), which usually contain the lowest oxygen concentrations (sometimes below the in situ detection limit of $\sim$1 μM). In order to better understand the effect of low oxygen concentrations, and thus of hypoxic and suboxic events, on MOx in coastal systems, we conducted lab-based experiments, during which we adjusted oxygen concentrations to values between 0.2 - 220 μM in methane-rich ($\sim$100 nM) Eckernförde Bay waters. These samples were then incubated with trace amounts of tritium-labeled methane to assess first order rate constants of methane oxidation. Highest MOx rates were detected at oxygen concentrations of $\sim$0.5 μM (considerably higher than at $\sim$200 μM), confirming results from the field study and attesting to an apparent Km of $\lesssim$ 0.5 μM. Enhancement of MOx at low O_2 levels was more pronounced in incubations with bottom waters, but was also observed in surface waters, which are exposed year-round to high O_2 levels in nature. This response to oxygen concentrations suggests a general low-O_2 affinity of aerobic methane oxidizers in Eckernförde Bay.

Lennartz, S. T., Lehmann, A., Herrford, J., Malien, F., Hansen, H.-P., Biester, H., and Bange, H. W.: Long-term trends at the Boknis Eck time series station (Baltic Sea), 1957–2013: does climate change counteract the decline in eutrophication?, Biogeosciences, 2014.