Productivity and temperature as drivers of seasonal, spatial and long-term variations of dissolved methane in the Southern Bight of the North Sea

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Abstract

Dissolved CH\textsubscript{4} concentrations in the Belgian coastal zone (North Sea) ranged between 670 nmol L\textsuperscript{-1} near-shore and 4 nmol L\textsuperscript{-1} off-shore. Spatial variations of CH\textsubscript{4} were related to sediment organic matter (OM) content and gassy sediments. In near-shore stations with fine sand or muddy sediments, the CH\textsubscript{4} seasonal cycle followed water temperature, suggesting methanogenesis control by temperature in these OM rich sediments. In off-shore stations with permeable sediments, the CH\textsubscript{4} seasonal cycle showed a yearly peak following the Chlorophyll-a spring peak, suggesting that in these OM poor sediments, methanogenesis depended on freshly produced OM delivery. This does not exclude the possibility that some CH\textsubscript{4} might originate from dimethylsulfide (DMS) or dimethylsulfoniopropionate (DMSP) or methylphosphonate transformations in the most off-shore stations. Yet, the average seasonal CH\textsubscript{4} cycle was unrelated to those of DMS(P), very abundant during the Phaeocystis bloom. The annual average CH\textsubscript{4} emission was 126 mmol m\textsuperscript{-2} yr\textsuperscript{-1} in the most near-shore stations (~4 km from the coast) and 28 mmol m\textsuperscript{-2} yr\textsuperscript{-1} in the most off-shore stations (~23 km from the coast), 1,260 to 280 times higher than the open ocean average value (0.1 mmol m\textsuperscript{-2} yr\textsuperscript{-1}).

The strong control of CH\textsubscript{4} by sediment OM content and by temperature suggests that marine coastal CH\textsubscript{4} emissions, in particular in shallow areas, should respond to future eutrophication and warming of climate. This is supported by the comparison of CH\textsubscript{4} concentrations at five stations obtained in March 1990 and 2016, showing a decreasing trend consistent with alleviation of eutrophication in the area.