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

Alberto V. Borges[1,*], Willy Champenois[1], Mary I. Scranton[2], Francis Strobbe[3], Thomas Vandenberghe[3], Ruth Lagring[3], Nathalie Gypens[4],

[1] Université de Liège
[2] Stony Brook University
[3] Belgian Marine Data Centre, Royal Belgian Institute of Natural Sciences
[4] Université Libre de Bruxelles

Abstract
Dissolved CH_4 concentrations in the Belgian coastal zone (North Sea) ranged between 670 nmol L^{-1} near-shore and 4 nmol L^{-1} off-shore. Spatial variations of CH_4 were related to sediment organic matter (OM) content and gassy sediments. In near-shore stations with fine sand or muddy sediments, the CH_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_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_4 might originate from dimethylsulfide (DMS) or dimethylsulfoniopropionate (DMSP) or methylphosphonate transformations in the most off-shore stations. Yet, the average seasonal CH_4 cycle was unrelated to those of DMS(P), very abundant during the *Phaeocystis* bloom. The annual average CH_4 emission was 126 mmol m^{-2} yr^{-1} in the most near-shore stations (~4 km from the coast) and 28 mmol m^{-2} yr^{-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^{-2} yr^{-1}). The strong control of CH_4 by sediment OM content and by temperature suggests that marine coastal CH_4 emissions, in particular in shallow areas, should respond to future eutrophication and warming of climate. This is supported by the comparison of CH_4 concentrations at five stations obtained in March 1990 and 2016, showing a decreasing trend consistent with alleviation of eutrophication in the area.