Benthic nitrate reduction processes following natural bottom water oxygenation

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As hypoxia caused by eutrophication is spreading in coastal areas around the world [1], there is a pressing need to understand how nutrient cycles function under shifting oxygen (O_2) conditions. One of the largest eutrophication-induced hypoxic areas in the world is the Baltic Sea [2]. After a decade of O_2 depletion, a large intrusion of water took place in the winter of 2014-2015. This Major Baltic Inflow (MBI) brought O_2 to large areas of the Baltic Sea's hypoxic sediments and was followed by several smaller inflows at different depths. During three campaigns in 2016-2018, we studied the benthic nitrogen cycle at one permanently oxic (60 m depth, 280-340 µM O_2) and three newly oxygenated (130-210 m depth, 5-45 µM O_2) sites. Sediment-water fluxes of O_2, dissolved inorganic carbon and nutrients were measured *in situ* using a benthic chamber lander. Nitrate (NO_3^-) reduction processes were measured *in situ* as well as in whole core and slurry incubations with ^{15}N-substrates.

At the newly oxygenated sites, the MBI led to a rise in bottom water NO_3^- concentrations from below 0.05 to about 10 µM. The increased availability of NO_3^- in turn stimulated NO_3^- reduction processes, of which dissimilatory NO_3^- reduction to ammonium (DNRA) and denitrification were equally important. Microsensor measurements showed production of nitrous oxide (N_2O) , a potent greenhouse gas, in the sediment at all stations. At the permanently oxic station this was a result of nitrification, and no net N_2O fluxes from the sediment could be detected. Conversely, at the newly oxygenated stations the sedimentary N_2O production was sustained by incomplete denitrification, this accounted for 30–100 % of the total denitrification rate (N_2O + nitrogen gas production). Thus, oxygenation of long-term anoxic sediments did initiate NO_3^- reduction processes. However, this lead to a system mainly dominated by N_2O production and recycling of bioavailable nitrogen through DNRA, while N_2 production was of minor importance.

[1] Diaz & Rosenberg (2008), *Science* 321, 926-929. [2] Carstensen, Andersen, Gustafsson & Conley (2014), *Proc. Natl. Acad. Sci.* 111, 5628–5633.