Sediment mineralization processes and N *vs.* P limitation in the Baltic Sea

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Primary production is dominantly P limited in the Bothnian Bay whereas in the Bothnian Sea the spring bloom is P and summer production N limited. In the open Gulf of Finland and the main basin of the Baltic, production tends to be N limited. We propose that this pattern is linked to shifts in sediment microbial mineralization pathway. On the basis of indirect evidence (in lack of direct measurements), we conclude that the bottom sediments of the non-stratified and oligotrophic northernmost (the Bothnian Bay), and the poorly stratified and mesotrophic next northern (the Bothnian Sea), subbasins of the Baltic have tolerated the external nutrient load rather well, as they are still in a state in which Fe reduction and coupled cycling of Fe and P prevail in the surface sediments. Since Fe-reducing bacteria are unable to reduce Fe(III) oxides completely, part of the Fe-bound P may be permanently buried in the sediments. The good ability of the sediment to retain P results in low concentrations of P in water, a state that in turn promotes P limitation of primary production. In contrast, the sediments of the nutrient-loaded and stratified sub-basins, the Gulf of Finland (the most eutrophied subbasin) and the Baltic Proper, appeared to have reached a state in which SO_4 reduction is the dominant mineralisation pathway. Sulphate reduction followed by sulphide formation leads to efficient reduction of Fe(III) oxides. Subsequently, Fe-bound P dissolves into the pore water and is transported to the overlying water, whereas Fe is buried as sulphides (uncoupled Fe and P cycling). The capacity of sediments to retain P is limited; high amounts of bioavailable P exist in the water column, primary production tends to be N limited and extensive blue-green algal blooms are common. We maintain that the decisive factors controlling the above regional distribution of Fe and SO_4 reduction are the flux of labile organic matter to the sediments and the variation in hydrodynamics. Sulphate reduction will be triggered when the flux of organic matter reaches a critical threshold value, resulting in anoxia at the sediment–water interface, followed by the collapse of benthic fauna and inhibition of Fe re-oxidation. The only way to drive the sediments back into an Fe-reduced state is to strongly reduce bioavailable N and P loading to the Baltic Sea, and thus the flux of labile organic matter to the sediments. Even so, recovery may also necessitate favourable hydrodynamic conditions.