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Phosphorus recycling and burial in Baltic Sea sediments with contrasting redox conditions

Caroline P. Slomp (1), Haydon P. Mort (1), Dan C. Reed (1), Tom Jilbert (1), and Bo G. Gustafsson (2)

(1) Utrecht University, Faculty of Geosciences, Utrecht, Netherlands (slomp@geo.uu.nl), (2) Baltic Nest Institute, Stockholm University, Sweden

The Baltic Sea is a classical example of a coastal system that is subject to an increased intensity and spatial extent of hypoxia due to human activities. The expansion of hypoxia since the 1960s is the result of increased inputs of nutrients from land (both from fertilizer and wastewater) and is negatively affecting living conditions for benthic organisms. In addition, the biogeochemical cycling of carbon and nutrients has been significantly altered. Water column studies have shown that the availability of dissolved inorganic phosphorus (DIP) is positively correlated with hypoxia due to release of phosphorus from sediment Fe-oxides and from organic matter upon the transition from oxic to hypoxic conditions. Thus, a large internal source of phosphorus exists in the sediment that largely controls short-term variability in water column DIP concentrations.

In this presentation, we focus on results of recent field and modeling work for various parts of the Baltic Sea that confirm the role of Fe-bound P from seasonally hypoxic sediments at intermediate water depths as a major source of DIP. We also show that extended hypoxia and anoxia leads to depletion of sediment Fe-bound P and, ultimately, lower rates of sediment-water exchange of P. Authigenic Ca-P minerals appear to be only a relatively minor burial sink for P. The lack of major inorganic P burial makes the Baltic Sea sensitive to the feedback loop between increased hypoxia, enhanced regeneration of P and increased primary productivity. Historical records of bottom water oxygen at two sites (Bornholm, Northern Gotland) show a decline over the past century which is accompanied by a rise in values of typical sediment proxies for anoxia (total sulfur, molybdenum and organic C/P ratios). While sediment reactive P concentrations in anoxic basins are equal to or higher than at oxic sites, burial rates of P at hypoxic and anoxic sites are up to 20 times lower because of lower sedimentation rates. Nevertheless, burial of phosphorus in the hypoxic and anoxic areas is significant because of their large surface area and must be accounted for in budgets and models for the Baltic Sea.