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Beyond the Fe-P-redox connection: Preferential regeneration of phosphorus from organic matter as a key control on Baltic Sea nutrient cycles

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Patterns of regeneration and burial of phosphorus (P) in the Baltic Sea are strongly dependent on redox conditions. Redox varies spatially along water depth gradients and temporally in response to the seasonal cycle and multi-decadal hydrographic variability. Alongside the well-documented link between iron oxyhydroxide dissolution and release of P from Baltic Sea sediments, we show that preferential remineralization of P with respect to carbon (C) and nitrogen (N) during degradation of organic matter plays a key role in determining the surplus of bioavailable P in the water column. Preferential remineralization of P takes place both in the water column and upper sediments and its rate is shown to be water-depth dependent, increasing with the severity of reducing conditions into the deep basins. Existing Redfield-based biogeochemical models of the Baltic may therefore underestimate the imbalance between N and P availability for primary production, and hence the vulnerability of the Baltic to sustained eutrophication via the fixation of atmospheric N. However, burial of organic P is also shown to increase during multidecadal intervals of expanded hypoxia, due to higher net burial rates of organic matter around the margins of the deep basins. Such intervals may be characterized by basin-scale acceleration of all fluxes within the P cycle, including productivity, regeneration and burial, sustained by the relative accessibility of the water column P pool beneath a shallow halocline.