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Phosphate removal in oxygen minimum zones off Africa

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The flux of limiting nutrients (N, P, Si and Fe) to the surface ocean controls phytoplankton growth and species composition. Shelf and margin sediments release considerable amounts of nutrients into the bottom water from which they are eventually transported to surface waters. However not well understood is how the flux of phosphate (P) across the benthic boundary layer (BBL) is controlled by geochemical and biologically mediated processes such as redox reaction, chelation, particle formation, sorption and desorption to organic and inorganic particles. P transformation between the dissolved and the particulate phase significantly influences the P distribution in the water column and, for example, might lead to the significant P accumulation observed for anoxic bottom waters of the oxygen minimum zone (OMZ) off Namibia. To investigate P accumulation on particles in the water column under oxic and anoxic conditions we conducted isotope labeling experiments during two cruises in 2011 to the OMZs of Mauritania and Namibia. We applied radioactive tracer ($^{33}PO_4^3$) incubations, sequential P extraction and nanoSIMS analyses to measure particulate P formation rates and to discriminate between biotic and abiotic accumulation. Under oxic conditions, formation rates of particulate P ranged between 3.1 and 29.7 nmol P L^{-1} d^{-1} and increased in the BBL towards the seafloor. Sequential P extraction revealed that 34-67% of phosphate was taken up into biomass. Calculated cellular uptake rates of $\sim$0.24 to 29 x 10^{-18} mol $cell^{-1}$ d^{-1} were significantly above those calculated from oxygen consumption and Redfield ratio suggesting intracellular P storage. In contrast, in near anoxic bottom waters (<1 μM O_2) the formation of phosphate particles took place within less than 1 hour of which 74-99% was bound to inorganic particles. The results indicate that P is efficiently trapped abiotically at oxic-anoxic interfaces, while biotic accumulation of P is dominant in oxic waters. Therefore, climate-change induced expansion of OMZs may regulate the trapping and release of particle-bound P in unexpected ways.