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Unbalanced benthic P release in the Peruvian oxygen minimum zone – a revised mass budget and puzzling problem

Christian Hensen (1), Ulrike Schroller-Lomnitz (1), Simon Langer (2), Stefan Sommer (1), Andy W. Dale (1), Heide Schulz-Vogt (2), and Klaus Wallmann (1)

(1) GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Biogeochemistry, Kiel, Germany, (2) Leibniz-Institut für Ostseeforschung Rostock, Geomicrobiology, Rostock, Germany

Low oxygen concentrations in oxygen minimum zones (OMZ) generally favor the benthic release of phosphorus and other nutrients to the water column. This process may sustain a positive feedback enhancing primary productivity and further expansion of low-oxygen water masses. Data from the Peruvian OMZ between 2008 and 2017 measured during four research campaigns reveal trends in benthic P release along the Peruvian continental margin (78 - 1000 m water depth) across different seasons and environmental conditions. Surprisingly, P release as dissolved phosphate is more predictable than expected given the strong seasonality in upwelling and primary production. Below a water depth of 100 m, the in situ measured P release rates were comparable in all campaigns, regardless of whether the measurements took place during the upwelling or at the transition to the non-upwelling season. Further, stagnant and completely anoxic waters or temporally occurring short oxygen intrusions of up to 5 μM O_2 do not apparently affect the P release off Peru significantly.
However, our observations along the depth transect revealed that dissolved benthic phosphorus fluxes were always higher than the rain rate of total particulate phosphorus to the seabed, indicating a missing source of phosphorus to the sediments. Episodic release of phosphorus following the breakdown of polyphosphates has been suggested previously as most likely explanation for this phenomenon. Newest findings suggest that the contribution of phosphate released by large sulfur bacteria varies between 1 and 10 %. This is much less than expected and insufficient to account for the lacking source of phosphorus to the sediments. We present a revised P budget, summarizing measurements over the last 10 years along with new data on in and ex situ conducted oxygen and nutrient manipulation experiments.