EGU2020-19291, updated on 18 May 2022
https://doi.org/10.5194/egusphere-egu2020-19291
EGU General Assembly 2020

Coupled benthic cycling of iron, phosphorus and sulfur in the Benguela upwelling system

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The Benguela upwelling system (BUS) offshore Namibia is among the most productive ocean regions worldwide and is a globally important reservoir of biodiversity and biomass. The forcing of cold, nutrient-rich deep waters up the coastal shelf leads to high rates of primary productivity in surface waters, intense carbon remineralization and consequently to (bottom water) oxygen depletion on the shelf that varies temporally and spatially with the intensity of the upwelling.
Recurring events of deoxygenation have a severe impact on marine ecosystems, for instance increased mortality and altered biogeochemical cycles of key elements such as carbon (C), iron (Fe), phosphorus (P) and sulfur (S). Therefore, it is crucial that we establish a clear mechanistic framework of the impact of oxygen depletion on (global) biogeochemical cycles, not only to allow for the reconstruction of climate-ocean feedbacks in upwelling regions in the past, but to enable predictions of future behavior.
During an expedition with *RV Pelagia* in February of 2019, we collected water column and sediment samples from the shelf and slope off Namibia (100 to 1517 m water depth, bottom water O_2 between 0.5 and 175 µmol L^{-1}) and measured nutrient fluxes in on-board sediment incubations to understand the early diagenetic behavior of those key elements and trace metals underlying the (periodically) oxygen-depleted waters of the BUS.
We analyzed dissolved concentrations as well as solid-phase speciation of key elements such as iron (Fe), manganese (Mn), phosphorus (P) and sulfur (S) to understand the chemical and physical processes controlling their distribution along the depth/redox-transect.
Our results show intense P cycling on the shelf, as evidenced by very high pore-water P concentrations, an enhanced efflux of PO_4 to suboxic bottom waters and indications of phosphorite formation at depth in the sediment. N/P ratios well below Redfield indicate N depletion and (relative) P accumulation in the water column, a shift in nutrient stoichiometry that can impact the composition of microbial communities in such waters. Meanwhile, the slope sediments are overlain by oxic bottom waters, retain P more efficiently and exhibit N/P ratios close to Redfield stoichiometry.
The capacity of the sediment to buffer toxic sulfide and prevent its release to the water column was dependent on the abundance of sulfide oxidizers at the sediment surface. Furthermore, the variable accumulation of sulfide affected Fe speciation and sedimentary P retention.
Overall, we show an intimate coupling between sedimentary cycles of essential elements in the Benguela upwelling system, a stark contrast between shelf and slope environments that is further

enhanced by local variation of oxygen depletion and a very strong role of microbes in driving the cycles.