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N-cycling in the suboxic Benguela upwelling system from dual N and O isotopic composition of nitrate

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Among all subtropical eastern boundary current regions, the Benguela upwelling system is the most productive marine ecosystem. Upwelling of Eastern South Atlantic Central Water and oxygen-depleted South Atlantic Central Water aggravate a tendency for shelf hypoxia on the Namibian shelf originating from oxygen demand owing to degradation of organic matter. Assimilation accounts for the removal of reactive nitrogen as surface water moves offshore; within the oxygen minimum zone, anammox and heterotrophic denitrification generate an additional nitrogen deficit. These mechanisms are expected to result in an isotopic enrichment of dissolved inorganic nitrogen with decreasing concentrations in ageing upwelled water.

However, δ^{15}N ratios of sediments reveal a different pattern: Decreasing δ^{15}N coincide with decreasing nitrate concentrations in surface water towards the outer shelf, suggesting that there must be an additional source of dissolved inorganic nitrogen. To identify this source and internal nitrogen cycling processes in the suboxic water column over the shelf, we performed a survey of water column nitrate stable isotope composition ($\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$) on the 23˚S transect off Walvis Bay.

We find that nitrate reduction to N_2 under suboxic conditions generates a nitrate deficit over phosphate on the inner shelf and leads to enriched $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$ ratios in the residual nitrate. Towards the outer shelf, nitrate concentrations decrease in surface water, but increase in bottom water. At the shelf break, $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$ ratios in bottom water of 5.9‰ and 2.1‰ respectively, reveal the influence of Atlantic Ocean deep water upwelling at the shelf break. This shelf-break upwelling leads to a decoupling of biogeochemical processes in the N-cycle on the shelf and beyond the shelf break.