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Biogeochemistry of the eastern tropical south Pacific oxygen minimum zone

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Oxygen minimum zones develop along the eastern boundaries of the oceans and even though they account for less than 0.1% of the ocean volume they play a disproportionally large role in biogeochemical cycling and account for 20 – 40% of the oceanic fixed nitrogen removal. Along the coast of Chile and Peru the oxygen minimum is found from 50 – 80 m below the surface down to 300 – 400 m from 7.5°S to 26.5°S over a distance of more than 2000 km. We applied the novel STOX sensor for oxygen with detection limits around 10 nM and found that oxygen concentrations were below detection the core of the OMZ.

The removal of fixed nitrogen in this OMZ was discovered way back and was assumed to be due to N2 production by denitrification. Later when anammox was discovered and direct measurements were made this view was challenged. The direct 15N tracer measurements of N2 production in the OMZ indicated that anammox was responsible for almost all of the N2 production and that denitrification was only found sporadically. This was in contrast to the general understanding of denitrification being the major mineralization process in the OMZ and supplier of ammonium for anammox. To explain these results it was suggested that denitrification actually did occur but mainly in pockets of water rich in electron donor and that the relatively limited work done so far had failed to sample such hotspots. Our data from frequent sampling along a 2000 km cruise track parallel to the coast of Chile and Peru support this idea. We found that denitrification was responsible for 70% of the N2 production, reached higher rates and occurred less frequent than anammox.

The nitrogen cycle in the OMZ off northern Chile turned out to be linked to a hidden sulfur cycle. We found that both mineralization via sulfate reduction and sulfide oxidation contribute to elemental cycling in these waters. The sulfide produced never accumulated due to immediate re-oxidization to sulfate via denitrification and the ammonium liberated by sulfate reduction was utilized by the anammox bacteria. Comparing the measured sulfate reduction rates at the most active station to estimates of carbon mineralization within the OMZ showed that sulfate reduction could account for 1/3 of the carbon mineralization and deliver up to 22% of the ammonium required by anammox.