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Aerobic Microbial Respiration in Oceanic Oxygen Minimum Zones

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In the oxygen minimum zones (OMZs) of the tropical oceans, sluggish ventilation combined with strong microbial respiration of sinking organic matter results in the depletion of oxygen (O_2). When O_2 concentrations drop below $\sim$5 μmol/L, organic matter is generally assumed to be respired with nitrate, ultimately leading to the loss of fixed inorganic nitrogen via anammox and denitrification. However, direct measurements of microbial O_2 consumption at low O_2 levels are - apart from a single experiment conducted in the OMZ off Peru – so far lacking. At the same time, consistently observed active aerobic ammonium and nitrite oxidation at non-detectable O_2 concentrations (<1 μmol/L) in all major OMZs, suggests aerobic microorganisms, likely including heterotrophs, to be well adapted to near-anoxic conditions. Consequently, microaerobic ($\leq$5 μmol/L) remineralization of organic matter, and thus release of ammonium, in low- O_2 environments might be significantly underestimated at present.
Here we present extensive measurements of microbial O_2 consumption in OMZ waters, combined with highly sensitive O_2 (STOX) measurements and meta-omic functional gene analyses. Short-term incubation experiments with labelled O_2 (18-18O_2) carried out in the Namibian and Peruvian OMZ, revealed persistent aerobic microbial activity at depths with non-detectable concentrations of O_2 ($\leq$50 nmol/L). In accordance, examination of metagenomes and metatranscriptomes from Chilean and Peruvian OMZ waters identified genes encoding for terminal respiratory oxidases with high O_2 affinities as well as their expression by diverse microbial communities. Oxygen consumption was particularly enhanced near the upper OMZ boundaries and could mostly ($\sim$80%) be assigned to heterotrophic microbial activity. Compared to previously identified anaerobic microbial processes, microaerobic organic matter respiration was the dominant remineralization pathways and source of ammonium ($\sim$90%) in the upper Namibian and Peruvian OMZ. Our results reconcile so-far existing mismatches between ammonium sources and sinks in OMZs, and may help to improve biogeochemical modelling of the effects of future ocean de-oxygenation on aerobic and anaerobic organic matter remineralization in these zones.