Nitrification in Oceanic Oxygen Minimum Zones

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Abstract:

Nitrification, the oxidation of ammonium (NH_4^+) to nitrite (NO_2^-) and nitrate (NO_3^-), produces the substrates for denitrification, thus fueling the anaerobic nitrogen loss processes in oxygen minimum zones (OMZs). Incubations with $^{15}NH_4^+$ and $^{15}NO_2^-$ were performed to measure NH_4^+ and NO_2^- oxidation on cruises in the eastern tropical North (March/April 2012) and South (July 2013) Pacific (ETNP and ETSP, respectively) OMZs. We investigated the depth distribution of both processes, as well as their sensitivities to substrate concentration and light. $^{15}NO_2^-$ and $^{15}NO_3^-$ production were determined using isotopic ratio mass spectrometry, with the azide and the denitrifier methods, respectively. Both archaeal and β-proteobacterial *amoA* genes were quantified using qPCR. Subsurface maxima of both rates and *amoA* gene abundances were consistently found in the oxycline above the anoxic layer in both OMZs. The observed tight correlation between NH_4^+ oxidation and nitrous oxide concentration in the oxycline suggests that NH_4^+ oxidation was an important source of nitrous oxide. At anoxic depths, substantial number of *amoA* genes were detected, but NH_4^+ oxidation were undetectable or negligible, whereas NO_2^- oxidation rates were sometimes high. At an offshore station in the ETSP, NH_4^+ oxidation displayed an extremely high affinity for NH_4^+, with a half-saturation concentration of 27 nM. At 10% surface irradiance, NH_4^+ oxidation rates were detectable but lower than in the dark. No significant effect of light on NO_2^- oxidation was found. These results indicate a highly dynamic internal nitrogen cycling in OMZs, while the high rates of NO_2^- oxidation at anoxic depths remain a conundrum.