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Quantifying the sources and sinks of nitrite in the oxygen minimum zone of the Eastern Tropical South Pacific

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In coastal upwelling regions, high surface productivity leads to high export and intense remineralization consuming oxygen. This, in combination with slow ventilation, creates oxygen minimum zones (OMZ) in eastern boundary regions of the ocean, such as the one off the Peruvian coast in the Eastern Tropical South Pacific.

The OMZ is characterized by a layer of high nitrite concentration coinciding with water column anoxia. Sharp oxygen gradients are located above and below the anoxic layer (upper and lower oxyclines). Thus, the OMZ harbors diverse microbial metabolisms, several of which involve the production and consumption of nitrite. The sources of nitrite are ammonium oxidation and nitrate reduction. The sinks of nitrite include anaerobic ammonium oxidation (anammox), canonical denitrification and nitrite oxidation to nitrate. To quantify the sources and sinks of nitrite in the Peruvian OMZ, incubation experiments with 15N-labeled substrates (ammonium, nitrite and nitrate) were conducted on a research cruise in January 2015. The direct measurements of instantaneous nitrite production and consumption rates were compared with ambient nitrite concentrations to evaluate the turnover rate of nitrite in the OMZ.

The distribution of nitrite in the water column showed a two-peak structure. A primary nitrite maximum (up to 0.5 μM) was located in the upper oxycline. A secondary nitrite maximum (up to 10 μM) was found in the anoxic layer. A nitrite concentration minimum occurred at the oxic-anoxic interface just below the upper oxycline. For the sources of nitrite, highest rates of ammonium oxidation and nitrate reduction were detected in the upper oxycline, where both nitrite and oxygen concentrations were low. Lower rates of nitrite production were detected within the layer of secondary nitrite maximum. For the sinks of nitrite, the rates of anammox, denitrification and nitrite oxidation were the highest just below the oxic-anoxic interface. Low nitrite consumption rates were also detected within the layer of the secondary nitrite maximum.

The imbalances between nitrite production and consumption rates help to explain the distribution of nitrite in the water column. The primary nitrite maximum in the upper oxycline is consistent with ammonium oxidation exceeding nitrite oxidation. Nitrite consumption rates exceeding rates of nitrite production result in the low nitrite concentration at the oxic-anoxic interface. Within the secondary nitrite maximum in the anoxic layer, production and consumption of nitrite are equivalent within measurement error. These low turnover rates suggest the stability of the nitrite pool in the secondary nitrite maximum over long time scales (decades to millennial). These data could be implemented into biogeochemical models to decipher the origin and the evolution of nitrite distribution in the OMZs.