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A nitrogen budget for the continental margin of the Peruvian oxygen minimum zone

Marcus Dengler (1), Lee Bryant (2), Stefan Sommer (1), Annie Bourbonnais (3), Christian Dullo (1), and Andy Dale (1)

(1) GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Kiel, Germany, (2) University of Bath, Bath, United Kingdom, (3) School for Marine Science and Technology, University of Massachusetts Dartmouth, MA, United States

In oxic environments, nitrogen (N) is frequently a limiting nutrient for primary production and hence a controlling element in marine ecosystems. The fixed form of N, i.e. bioavailable N for primary production, is primarily in the oxidized form of nitrate (NO_3-). However, in the sub-oxic environments of oxygen minimum zones (OMZs), N-species are biochemically converted to biogenic N2 gas which is then released, or lost, to the atmosphere. N-cycling under sub-oxic conditions thus diminishes the oceanic pool of bioavailable N. It has been suggested that although OMZs constitute only about 1% of global ocean volume, they account for about 20-40% of global oceanic N loss. However, to date these estimates are subject to largely uncertainties.

Here, we quantify the rate of N-cycling and the associated N-loss by evaluating all terms of a benthic-pelagic nutrient transport budget at the continental margin off Peru using observations from an extensive measurement program conducted along the continental slope and shelf region at 12°S. The data set was collected during austral summer in 2013 and consists of nutrient, microstructure and CTD/O_2 profiles as well as shipboard velocity data from two research cruises, a glider swarm experiment and current time series from a moored array. To constrain the benthic contribution to the nutrient budget, benthic nutrient fluxes were measured in benthic chambers using Biogeochemical Observatory (BIGO) landers.

Detailed budget determinations were performed on the upper continental slope and shelf break as well as at the shelf. Both regions were anoxic but different with regard to nutrient distribution as well as benthic nutrient release rates. Three major conclusions can be inferred from the study: (1) Unexpectedly, the results showed that diapycnal nutrient fluxes, driven by turbulent mixing caused by the breaking of non-linear internal waves, was one to two orders of magnitude larger than advective and lateral-diffusive fluxes. (2) The relative contribution of benthic nutrient fluxes to nutrient cycling was between 30% and 50%. (3) Nitrogen conversion rates on the shelf (50m-100m water depth) were an order of magnitude larger that at the continental slope (200m-300m water depth). The strong differences in the magnitude of the nutrient cycling rates most likely originate from the presence of sulfidic bottom waters that were observed on the shelf.