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The role of marine snow for nitrogen loss from oxygen minimum zones

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Oxygen minimum zones (OMZs) are regions of the ocean where the depletion of oxygen leads to favorable conditions for microbial nitrogen (N) loss processes. Although OMZs make up less than 1% of the global ocean (oxygen $< 20\ \mu M$), they host 20-40% of global oceanic N-loss through the processes of denitrification and anammox. Recent studies indicate that marine snow aggregates play a vital role in OMZ N-loss by transporting organic matter from surface layers to the ocean interior. Aggregates are also hotspots of microbial activity, and it is speculated that a large proportion of N cycling occurs within and around aggregates. However, due to their fragile nature and difficulties in sampling, studies on single aggregates are limited and N-loss determinations are mostly based on bulk water incubations, which likely exclude sinking aggregates. To investigate the role of single aggregates in OMZ N cycling, we collected > 200 aggregates with sizes larger than 0.3 mm from the OMZ offshore Peru using a marine snow catcher. The aggregates, together with bulk water samples, were incubated and amended with stable nitrogen isotopes (^{15}N) to determine anammox and denitrification rates.

Based on our bulk water incubations, the areal anammox rates ranged between 1.7 and $10\ mmol \cdot N_2 \cdot m^{-2} \cdot day^{-1}$, with highest rates observed at coastal stations. Denitrification occurred more sporadically than anammox, ranging between 1.0 and $1.9\ mmol \cdot N_2 \cdot m^{-2} \cdot day^{-1}$. In contrast, N_2 production by denitrification was detected in the majority of the single aggregate incubations with rates in the range of pico- to nano-mole N per aggregate per day. Denitrification associated with these large ($> 0.3mm$) marine snow aggregates contributed between 2.5% and 50% to total N-loss from the investigated OMZ waters. Anammox rates were mostly insignificant for the large aggregates but bulk anammox rates strongly correlated with the abundance of smaller particles ($128 - 256\ \mu m$). Our results indicate that marine snow aggregates play a major role in N loss from the Peruvian OMZ.

Position

PhD Candidate

Affiliation

Max Planck Institute for Marine Microbiology Bremen

Email Address

ckarthae@mpi-bremen.de

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Yes

Primary author(s) : Ms KARTHÄUSER, Clarissa (Max Planck Institute for Marine Microbiology Bremen); Dr AHMERKAMP, Soeren (Max Planck Institute for Marine Microbiology Bremen); Dr BRISTOW, Laura A (University of Southern Denmark); Dr HAUSS, Helena (GEOMAR | Helmholtz-Zentrum für Ozeanforschung Kiel); Dr IVERSEN, Morten H. (MARUM - Zentrum für Marine Umweltwissenschaften der Universität Bremen); Dr KIKO, Rainer (GEOMAR | Helmholtz-Zentrum für Ozeanforschung Kiel); Dr LAVIK, Gaute (Max Planck Institute for Marine Microbiology Bremen); Prof. KUYPERS, Marcel M.M. (Max Planck Institute for Marine Microbiology Bremen)

Presenter(s) : Ms KARTHÄUSER, Clarissa (Max Planck Institute for Marine Microbiology Bremen)

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