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Nitrogen transformations in the Arabian Sea Oxygen Minimum Zone as revealed by combined 15N-incubation experiments and functional gene expression analyses

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The Arabian Sea Oxygen Minimum Zone (OMZ) is considered to be one of the three major regions in the world´s Ocean where nitrogen loss occurs in the water column. However, the exact pathway and the microbial players involved in the dinitrogen gas production, as well as the cycling of other inorganic nitrogen species, are not entirely clear. We performed incubation experiments with 15N-labeled substrates to investigate the vertical distribution of nitrogen-loss (denitrification and anammox) and other nitrogen transformations through the OMZ from the Omani shelf offshore towards the Indian coast. Intriguingly, there was no evidence of either anammox or denitrification in the northeastern Arabian Sea, which has generally been considered the main region of N-loss in the Arabian Sea. Instead, our results pointed to a substantial N-loss due to anammox from the Omani upwelling area. Moreover, a close coupling was demonstrated in the Omani shelf waters between anammox and DNRA (dissimilatory nitrate reduction to ammonium), with the latter process providing a substantial proportion of ammonium for the former. The co-occurrence of these processes was further confirmed by independent expression analyses of the functional gene biomarkers (anammox-type nirS, denitrifier-nirS and nrfA) for all these processes.

Nitrification occurred particularly in the upper part of the OMZ and on the Omani shelf, predominantly mediated by crenarchaea over bacteria as shown by the expression of their respective ammonia monooxygenase genes (amoA). When detected, nitrification could supply at least 12% of the nitrite required by anammox. Meanwhile, nitrate reduction, traditionally regarded as the first step in denitrification, could be detected at higher rates than anammox and even at regions where dinitrogen gas production was not detected. This is consistent with the expression analyses of its biomarker gene (narG). In the northeastern Arabian Sea, our combined results suggested that there was only a net production of nitrite, but no detectable N-loss at least in the form of dinitrogen gas production.