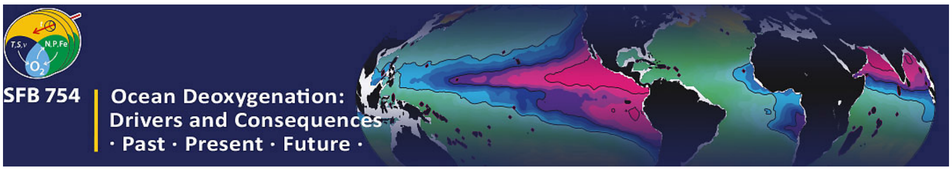

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Strong intensification of the Arabian Sea oxygen minimum zone in response to Arabian Gulf warming

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Semi-enclosed seas are prone to amplified warming under future climate change due to their landlocked nature and strong sensitivity to continental climate. This is particularly true for the Arabian Gulf (AG) due to its shallow depth and proximity to the fast warming Arabian Peninsula. While the predicted rapid warming of the AG is expected to challenge its local ecosystem already subject to extreme temperatures, the potential consequences for such a warming on the biogeochemistry of the Indian Ocean at large have not yet been investigated. In particular, the effects of such changes on the oxygen minimum zone (OMZ) of the Arabian Sea remain unclear. Here, we investigate the impacts of the AG warming on the intensity of the Arabian Sea OMZ, and examine the biogeochemical and ecological implications of these changes. We show that a warming of the AG that is consistent with future regional climate projections can lead to a substantial intensification of the OMZ in the northern Arabian Sea. To this end, we performed a series of eddy-resolving regional simulations of the Arabian Sea and its marginal seas using the Regional Ocean Modeling System (ROMS) coupled to a nitrogen-based nutrient-phytoplankton-zooplankton-detritus (NPZD) ecosystem model. We find that when a moderate (+2℃) surface warming is applied to the AG, the volume of suboxic water in the Arabian Sea increases by 20% while denitrification increases by 19%. This is caused by a reduction of the ventilation of the Arabian Sea OMZ by the AG waters that gain buoyancy and lose oxygen due to surface warming. A stronger warming (+4℃) of the AG produces, however, a weaker increase in suboxic volume (+11%) and denitrification (+12%). This is because denitrification rates increase in the top 150m almost twice as fast as under moderate warming. This enhances nitrate depletion in the upper northeastern Arabian Sea and results in a reduction of NPP (-6%) that limits oxygen consumption at depth and weakens the intensification of OMZ below 200m. Our findings indicate that perturbations of the AG can have important consequences not only for its local ecosystem but also for the large-scale biogeochemistry of the Indian Ocean. These results also stress the need for improving the representation of marginal and semi-enclosed seas in the current generation of climate models.

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