No N2 fixation in the Bay of Bengal?

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The Bay of Bengal (BoB) has long stood as a biogeochemical enigma with subsurface waters containing extremely low, but persistent, concentrations of oxygen (O₂) in the nanomolar range which - for some, yet unconstrained reason- are prevented from becoming anoxic. One reason for this may be the low productivity of the BoB waters due to nutrient limitation, and the resulting lack of respiration of organic material at intermediate waters. Thus, the parameters determining primary production are key to understanding what prevents the BoB from developing anoxia. Primary productivity in the sunlit surface layers of tropical oceans is mostly limited by the supply of reactive nitrogen through upwelling, riverine flux, atmospheric deposition, and biological dinitrogen (N₂) fixation. In the BoB, a stable stratification limits nutrient supply via upwelling in the open waters, and riverine or atmospheric fluxes have been shown to support only less than one quarter of the nitrogen for primary production. This leaves a large uncertainty for most of the BoB's nitrogen input, suggesting a potential role of N₂ fixation in those waters.

Here, we present a survey of N₂ fixation and carbon fixation in the BoB during the winter monsoon season. We detected a community of N₂ fixers comparable to other OMZ regions, with only a few cyanobacterial clades and a broad diversity of non-phototrophic N₂ fixers present throughout the water column (samples collected between 10 m and 560 m water depth). While similar communities of N₂ fixers were shown to actively fix N₂ in other OMZs, N₂ fixation rates were below the detection limit in our samples covering the water column between the deep chlorophyll maximum and the OMZ.

Consistent with this, no N₂ fixation signal was visible in δ¹⁵N signatures. We suggest that the absence of N₂ fixation may be a consequence of a micronutrient limitation or of an O₂ sensitivity of the OMZ diazotrophs in the BoB. To explore how the onset of N₂ fixation by cyanobacteria compared to nonphototrophic N₂ fixers would impact on OMZ O₂ concentrations, a simple model exercise was carried out. We observed that both, photic zone-based and OMZ-based N₂ fixation are very sensitive to even minimal changes in water column stratification, with stronger mixing increasing organic matter production and export, which would exhaust remaining O₂ traces in the BoB.