Application of Bio-Argo float in understanding denitrification in the northern Indian ocean

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Introduction

•North India is an important ocean in the biogeochemical aspect.

•The Indian Ocean is one of the most productive basins in the world ocean. The high demand for oxygen, as well as the low ventilation, makes the north Indian ocean one of the most intense oxygen minimum zones (OMZs).

•OMZs are the intermediate-depth layers of the ocean characterized by very low oxygen concentrations. OMZs occur in regions of low dynamical supply and high oxygen demand.

•This oxygen deficiency is due to the decomposition of the high amount of organic matter and the absence of physical replenishments of oxygen.

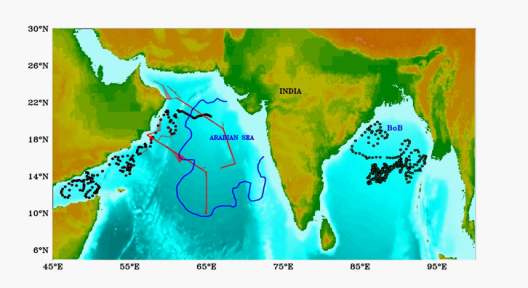
•This anoxic condition leads to the reduction of nitrate to molecular nitrogen is known as 'denitrification'

Denitrification Reaction Sequence

$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$

Nitrate → Nitrite → Nitric Oxide → Nitrous Oxide → Nitrogen Gas

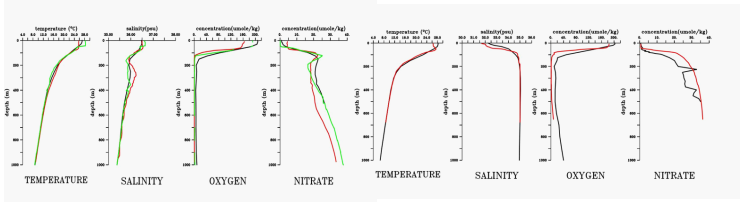
Data & Methods



. Plot of the study area overlain with Argo trajectories and JGOFS cruise tracks.

•There are several methods used by the researchers to quantify the denitrification process. *Gruber and Sarmiento (1994)* 1994 used N* to quantify the denitrification process. N* describes the combined effect of denitrification and nitrogen fixation or remineralization of the nitrogen-rich organic compound. N*=(NO3) − (16 × (PO4)3) + 2.9. Where NO3 is the nitrate and PO4 is the phosphate concentration.

•For this styudy two Argos used each in Arabian sea (AS) (WMO Id: 5903712) , Bay of Bengal (BoB) (WMO id:5903586) and JGOFS data (1994).



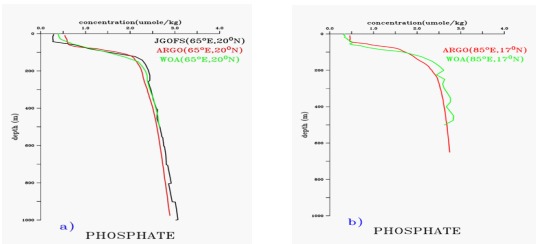
Comparison plots of derived variables frome Argo with JGOFS and WOA 13.

•Since Bio-Argo floats does not provide phosphate data which is needed for N* calculation, phosphate for Arabian Sea and the Bay of Bengal is calculated using two equation (Johnson et al., 2019).

((PO4)-3)AS=1.075+0.00756*AOU-0.00325*T

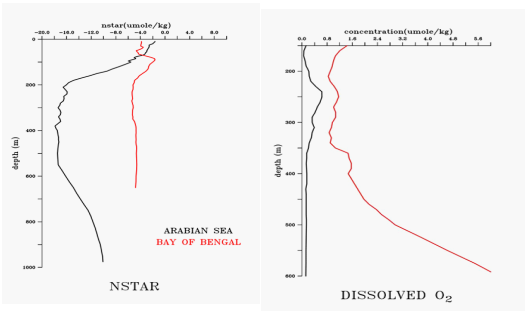
((PO4)-3)BoB=1.808+0.00521*AOU-0.0552*T

• Apparent Oxygen Utilization(AOU) is calculated by Weiss (1970)



Comparison Profiles of calculated phospahte from argo data (black line) with insitiue phosphate WOA13 data(red line) JGOFS data(green line).

Result



Profile of DO and N* (Arabian sea- black line) and 850E,200N(Bay of Bengal- red line) between 150m to 600m

•in OMZ the concentration of oxygen is very close to zero and always below 0.5 µmol/kg in Arabian sea. Whereas oxygen concentration in the Bay of bengal is higher than in the Arabian sea and it is around 1 µmol/Kg.

•Though the difference in the oxygen concentration is very less, Arabian Sea experiences denitrification remain above the threshold level. level of denitrification [Sarma, 2002; Naqvi et al, 2006].

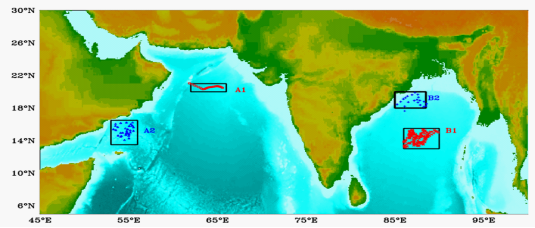
•The Bay of Bengal doesn't show significant variability of N*, while Arabian sea shows high variability (Fig 12). In the upper 200m, N* reduces rapidly in Arabian sea, afterwards, N* concentration remains almost the same till 600m.

•It then increases slightly after 600m. So the depth between 200 and 600m is taken as the denitrification depth for this study. Lower N* is an indication for denitrification.

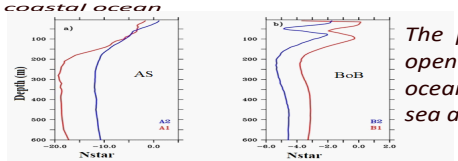
•There is an observed oxygen minimum zone at both basins at a depth ranging from 150m to 1000m. N* value in OMZ goes lower than -16µmol/kg in AS while it is -4µmol/kg in Bay of Bengal OMZ. This implies that the rate of denitrification is high in the Arabian sea OMZ, whereas denitrification in Bay is not evident.

•The reason for the absence of denitrification in the Bay of Bengal is the elevated level of oxygen. This is in agreement with the study of the Johnson et al ., 2019.

•In this study, they attributed the elevated level of oxygen in the Bay of Bengal OMZ to the supply of oxygen by the mesoscale eddies.



Bathymetry map of Indian ocean with the open ocean(A1,B1) and coastal ocean(A2,B2) boxes chosen in the Arabian Sea and the Bay of Bengal. Red is the argo track in the open ocean and blue is the argo track in the coastal ocean



The profile of N in the open ocean and coastal ocean for both Arabian sea and Bay of Bengal*

•Profile of the N averaged for these boxes in the Arabian sea(Fig 16.a) shows that in the open ocean, the N* value averaged for the box A1,which is inside the defined denitrification zone by Naqvi et al 2006, is very low ,~-20µmol/kg. This implies high denitrification in this region. The N* value averaged for the coastal box A2 , which is far away from the denitrification zone also shows a larger negative value (~-10µmol/kg).*

•This illustrates that coastal region is also getting vulnerable to the denitrification process in the recent years which can have far consequences on the ecosystem and the global climate.