High new production in the Bay of Bengal: Possible causes and implications

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[1] We report the first measurements of new production (^{15}N tracer technique), the component of primary production that sustains on extraneous nutrient inputs to the euphotic zone, in the Bay of Bengal. Experiments done in two different seasons consistently show high new production (averaging around 4 mmol N m^{-2} d^{-1} during post monsoon and 5.4 mmol N m^{-2} d^{-1} during pre monsoon), validating the earlier conjecture of high new production, based on pCO_2 measurements, in the Bay. Averaged over annual time scales, higher new production could cause higher rate of removal of organic carbon. This could also be one of the reasons for comparable organic carbon fluxes observed in the sediment traps of the Bay of Bengal and the eastern Arabian Sea. Thus, oceanic regions like Bay of Bengal may play a more significant role in removing the excess CO_2 from the atmosphere than hitherto believed. *INDEX TERMS:* 4845 Oceanography: Biological and Chemical: Nutrients and nutrient cycling; 4806 Oceanography: Biological and Chemical: Carbon cycling; 4805 Oceanography: Biological and Chemical: Biogeochemical cycles (1615); 4870 Oceanography: Biological and Chemical: Stable isotopes. **Citation:** Kumar, S., R. Ramesh, S. Sardesai, and M. S. Sheshshayee (2004), High new production in the Bay of Bengal: Possible causes and implications, *Geophys. Res. Lett.*, *31*, L18304, doi:10.1029/2004GL021005.

1. Introduction

[2] Major international scientific programmes such as JGOFS (Joint Global Ocean Fluxes Study), aimed at assessing the role of oceans as source/sink of atmospheric CO_2, concentrated mostly on highly productive regions of the oceans, e.g., Arabian Sea [*Smith*, 2001]. Intense upwelling during summer and convective mixing due to surface cooling in winter enhance the productivity of the Arabian Sea [*Madhupratap et al.*, 1996]. In contrast, the limited studies carried out in the adjacent Bay of Bengal (henceforth BOB) suggest it to be less productive because of frequent cloud cover and stratification of the surface layers by copious riverine discharge from the subcontinent, inhibiting vertical mixing and the supply of nutrients from below [*Prasanna Kumar et al.*, 2003]. Data of air-sea exchange rates of CO_2 for the northern Indian Ocean in general, and BOB in particular, are inadequate in space and time. Limited data [*Kumar et al.*, 1996] during presouthwest monsoon and northeast monsoon of 1991 reveal that a large area of BOB is characterized by pCO_2 levels far below the atmospheric value (~350 μatm), more prominent during northeast monsoon when the air-sea pCO_2 gradient sometimes exceeds 100 μatm. *Kumar et al.* [1996] surmised that biological activity could account for most of the observed pCO_2 decrease due to moderately high new production sustained by external nutrients brought in by rivers or atmospheric deposition.

[3] Although the Arabian Sea is more productive than BOB, the time averaged sediment trap data from BOB and the Arabian Sea show comparable organic carbon fluxes [*Ittekkot et al.*, 1991; *Lee et al.*, 1998; *Unger et al.*, 2003], barring the highly productive western Arabian Sea. *Ittekkot et al.* [1991] have suggested the ballasting of the organic carbon-lithogenic aggregates in the Bay as a possible cause. However, consistent high new production observed by us could be an additional reason as new production and particle sinking are coupled over longer time scales [*Eppley et al.*, 1983]. Here we present the first independent estimates of ^{15}N based new production (defined here as nitrate uptake) for BOB and discuss possible causes and implications.

2. Study Area

[4] BOB, a semi-enclosed tropical basin, is a part of northern Indian Ocean and experiences seasonal changes in circulation and climate due to the monsoons. BOB receives a large freshwater influx ($1.6*10^{12}$ m^3 yr^{-1} compared to $0.3*10^{12}$ m^3 yr^{-1} for the Arabian Sea [*Subramanian*, 1993]) from the rivers draining the subcontinent. This input causes a considerable variation of salinity during and after the monsoons over the whole basin and causes stratification of the sea surface. Also, in contrast to the Arabian Sea, precipitation in BOB exceeds evaporation by 0.80 myr^{-1}. The surface salinity of open ocean stations during Sep–Oct 2002 decreased from south to north (34 psu at 7°N to 32 psu at 16°N) and dropped further by 3 psu at 17°N. The coastal stations also exhibited a similar salinity pattern, but the drop from 16°N to 17°N was higher (34 psu to 21 psu). During Apr–May 2003 the overall variation in salinity was between 32 to 34 psu. Sea surface temperature (SST) during post monsoon along open BOB varied marginally from 28.2 to 29°C from south to north while along the coastal transect it did not show any trend (average ~30°C). During pre monsoon SST varied from 29 to 31.4°C in the open ocean, and from 29.1 to 30.4°C in coastal locations. The riverine inputs are a major potential source of nutrients such as nitrate, phosphate and silica to the Bay. Additional sources include mixing due to cyclones, frequent in the BOB during post monsoon. The measured nitrate concentrations in the surface Bay during post monsoon, in general, were low (mostly below the detection limit, <0.1 μM; coastal average ~0.18 μM and open ocean ~0.10) and for

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