Is the Arabian Sea getting more productive?

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Recent observations based on ocean colour show that summer productivity in the western Arabian Sea has been increasing during the last seven years, reportedly due to the warming of the Eurasian land mass. Our analysis of eight years' record of satellite ocean colour data over northeastern Arabian Sea suggests that chlorophyll concentration has not changed significantly in this region, and is thirse that in the southeastern part. Although we see some seasonal variations in different parts of the Arabian Sea, a significant secular trend is not discernible. The reported trend in Chl $a$ in the western Arabian Sea is not observed in the eastern Arabian Sea. Hence, we conclude that the increasing trend in the western Arabian Sea may not be entirely attributable to global warming.

Keywords: Arabian Sea, chlorophyll concentration, global warming, summer productivity.

The Arabian Sea is one of the most productive regions in the world and is characterized by strong seasonal oscillations in biological production. In summer, the strong southwest monsoon causes intense upwelling in the western Arabian Sea, while in winter surface cooling in the north results in enhanced vertical mixing. In both the above cases the photic zone gets nutrients from below which results in high productivity, i.e. phytoplankton fixes carbon through photosynthesis. The Arabian Sea also has a global significance; the increased production in the above two seasons leads to the formation of oxygen minimum zone (at depths of 150–1000 m) where denitrification takes place, in the northern part of Arabian Sea. Emission of N$_2$O as a result of denitrification, which is a potent greenhouse gas, is a cause of concern and has significant implications to the global warming.

During the Indian IGOFS, the Arabian Sea was studied in detail – the biological and chemical properties of the ocean and the physical forcings responsible for the same. However, these studies were limited to a seasonal time span. There is still not much detail about the interannual variability in terms of biological properties. The only possible way to monitor the variation in biological properties of the ocean on a larger spatial scale is by remote sensing, a method of collecting information about the constituents of water using optical signals in the visible range. It is well established that the concentration of phytoplankton influences the colour of the ocean water. Chlorophyll $a$ (Chl $a$), which is the main photosynthetic constituent in the phytoplankton, absorbs more in blue than in green; as the concentration of phytoplankton increases, the backscattered light progressively shifts towards the green. This property is successfully used to derive the Chl $a$ concentration with the help of a satellite. Phytoplankton and sunlight are the fundamental requirements for primary production in the oceans. In the tropics, where variation in sunlight is not significant on an interannual scale, variation in chlorophyll concentration can indicate variation in primary production. Satellite ocean colour data provide the spatial and temporal variations in phytoplankton biomass and hence in the primary production on a larger scale. Since the launch of SeaWiFS (sea-viewing wide field of view sensor) in August 1997, global ocean colour data are available to the science community on a regular basis.

Gregg et al. were the first to report an increase in the primary production of northern Indian Ocean (which includes both the Arabian Sea and the Bay of Bengal). This was confirmed by Goes et al. They used satellite data to show that summer productivity in the western Arabian Sea (47°–55°E and 5°S to 10°N; 52°–57°E and 5°S to 10°N) has been increasing, and proposed the cause to be the warming of the Eurasian land mass – the melting of the Himalayan snow cover in the recent past due to global warming resulting in enhancement of the land–sea contrast in summer temperature, thus enhancing monsoon winds. Notably this attribution was not made by Gregg et al. It is known from the literature on palaeomonsoon that whenever the southwest monsoon weakened (e.g. at the last glacial c. 21,000 years ago), the northeast monsoon strengthened and vice versa. If this is taken in conjunction with the result of Goes et al., one would expect a decreasing trend in the winter productivity in the northeastern Indian Ocean. To verify this we have analysed the chlorophyll data over a period of eight years (1997–2005), obtained from SeaWiFS to characterize the interannual variation in the northeastern Arabian Sea, where winter cooling in the north and upwelling in south are prominent, causing an increase in the primary production. To see the variation in the chlorophyll concentrations over the last eight years (from 1997–2005), we have taken monthly composites Level-3 Version 4, 9 km resolution mapped SeaWiFS chlorophyll images. From these images chlorophyll values were obtained using SEADAS software (provided by NASA for ocean colour image processing). SeaWiFS uses OC2 algorithm for deriving Chl $a$ values from the recorded radiance. This algorithm overestimates Chl $a$ when it is more than 1.5 mg Chl m$^{-3}$. Sensitivity studies on the algorithm for Chl $a$ retrieval from measured sensor-detected radiances show that the retrieved Chl $a$ values have the accuracy of ~30% (the radiances have an error of ~1%). For this analysis, pixels having values more than 5 mg Chl m$^{-3}$ are not considered, but such values are rare.

The seasonality of the northeast Arabian Sea SST (sea surface temperature) is also inspected over the same region.

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