Enhanced Chlorophyll/Phytoplankton Blooms Due to Tropical Cyclones in the North Indian Ocean: Using Ocean Colour and Scatterometer Data

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Bay of Bengal (BOB) is considered to be less productive than the Arabian Sea (AS). Earlier studies attributed the reason to be strong stratified layer, which is not broken normally, for its less productivity. Monsoon winds with less wind speed are unable to break the stratified layer. Hypothetically, had there not been stratified layer in BOB, its productivity would have been comparable to that of AS. To meet the requirement of breaking stratified layer higher wind speeds are required, which are produced during cyclones. Thus the seasonal productivity comparisons has been done during cyclones, cyclones are quite common in different seasons in both BOB and AS. Four seasons of monsoon that North Indian Ocean (NIO) experience are; Spring intermonsoon (Apr –May), Southwest monsoon (June – Sep), Fall intermonsoon (Oct – Nov) and Northeast monsoon (Dec – Mar). Eighteen cyclones have been observed covering all the four seasons during for the years 1998 – 2009. During the southwest and fall seasons, cyclones occurred in either BOB or In AS and thus the comparison could not be done. Thus BOB and AS productivity during cyclones has been performed independently without comparison between them. During the spring intermonsoon four cyclones, two in BOB (two in AS) have been observed. Four parameters of SST drop, MLD deepening, raise the percent of chlorophyll-a and increase in NPP have been derived. The parameters estimated in BOB (AS) during the cyclones are: SST drop of 5ºC to 6.5ºC (6.5ºC to 8.5ºC), MLD deepening of 30m to 90m (30m to 120m), raise in chlorophyll-a by 220% (> 1000 %) and increase in NPP by 43% (115%). From the observations it is clear that AS is more productive than BOB during cyclones. As the spring season availability of sunlight is not different in either basin. Thus the only reason for less new production in BOB could be less concentration of nutrient. In-situ Pycnocline/nutricline is required to confirm this.

During northeast monsoon seven cyclones, four in BOB (three in AS) have been observed. In BOB, out of four cyclones, two were observed in north and two in south, where as in AS one in north and two in south were observed. Comparison was made based on latitude considering availability of sun light to be the same. The parameters estimated in northern BOB (AS) during the cyclones are: SST drop of 1.5ºC to 3.75ºC (7ºC), MLD deepening of 20m to 50m (50m to 120m), raise in chlorophyll-a by 14% (454 %) and increase in NPP by 35% (67%). The same parameters in Southern BOB (AS) are: SST drop of 3.75ºC to 4ºC (3ºC to 5.25ºC), MLD

deepening of 30m to 70m (40m to 100m), raise in chlorophyll-a by 112% (65%) and increase in NPP by 40% (45%). From the above study, northern BOB is less productive compare to that of southern BOB. Reason could be the shallow euphotic depth (< 10 m), due to suspended sediment, because of river water influence and resuspension.

In northern AS, due to winter convection high production is observed even before cyclone. Cyclone helped in sustaining the productivity for larger duration. In southern BOB, coastal waters have less sediment and more nutrients. Also East Indian Coastal Current (EICC) brings nutrient rich water from north to south during Northeast monsoon. Because of these reasons southern BOB is more productive than north. Southern AS during Northeast monsoon is less productive due to reverse direction in surface currents moving northward, carrying low saline, low nutrient waters from equatorial region. Thus it is observed that more productive of AS in northern region holds good always. On contra southern BOB is showing more productive compared to southern AS during cyclones. As already mentioned independent basin study has been done during Southwest monsoon over AS. The parameters observed during the only one cyclone are: SST drop of 7ºC, MLD deepening of 40m to 85m, raise the chlorophyll-a by 192% and increase in NPP by 55%. Southwest monsoon winds bring nutrients to the surface, and high production is observed, and cyclone helped to prolong the same due to new production. During the fall intermonsoon over BOB, two cyclones (TC04B and TC05B) occurred consecutively in the same year. The parameters retrieved during TC04B (TC05B) are: SST drop of 5.7ºC (4ºC), MLD deepening of 20m to 70m (20m to 90m), raise in chlorophyll-a by 109% (80%) and increase in NPP by 173% (72%). From the fall monsoon data it is clear that increase in parameters during TC05B is less compared with that of TC04. As both occurred during the same month consecutively the TC05B helped in sustain productivity for longer duration, productive waters generated during the TC04B and TC05B advected towards east nearly 500 Km from the cost. In addition cold care eddy present in Open Ocean. Advected productive waters together with cold core eddy sustained high productivity for very long duration of one month.

It has been observed that cyclone is breaking the stratified layer, bringing nutrients and increases productivity. Doubt will arise whether high wind speeds are sufficient to raise the productivity. If this were true, there should have been increase in chlorophyll-a throughout the cyclone wake. Satellite images reveal that the increase is not substantial and equal along the cyclone wake. The reason for this is the cyclone eye formation, its symmetricity, and the resonance effect that are contributing to raise in productivity due to more upwelling. Cyclones, increases productivity are helping reduce the green house gas (CO2) which is fixed into the ocean from the atmosphere. Thus atmospheric temperature falls down delaying early global warming. Earlier studies neglected the cyclone’s effect while computing seasonal productivity changes. Now that cyclone plays a curtail role in the productivity enhancement, care has to be taken.