

# TSUNAMI 2004 AND THE BIOLOGICAL OCEANOGRAPHY OF BAY OF BENGAL

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## Introduction

Bay of Bengal, one of the Large Marine Ecosystems (LME) of the world experiences severe monsoonal storm surges and cyclones, but lacks large scale seasonal upwelling. The Bay of Bengal LME is grouped under Class II - moderately productive ecosystem (150-300g C m<sup>2</sup>/yr). Recently primary and secondary production has been found to increase, after the super cyclone 1999 (Madhu *et al.*, 2002 and Stephen *et al.*, 2005). The Sumatra earthquake and tsunami of December 26<sup>th</sup> 2004 is the most devastating event in recorded history. The catastrophic tsunami that hit the Andaman Sea and East coast of India caused havoc in the coastal regions.

The physical changes caused by the tsunami and the destruction felt in Andaman and Nicobar Islands are discussed by Jain *et al.* (2005). Inundation of coastal areas of Andaman Nicobar and Tamil Nadu coasts are discussed by Ramamurthy *et al.* (2005) and Jayakumar *et al.* (2005). The increase in suspended sediment concentration along the South, West and East coast is shown by remote sensing data by Ramakrishnan *et al.* (2005). They report that tsunami churns the shallow water sediments and increases the sediment load in coastal waters suggesting strong turbulence and mixing in near shore waters. Chadha *et al.* (2005) gives the tsunami run-up heights at different locations in the south coast of India. Further Department of Ocean Development, (Govt, of India, 2005) had published a preliminary report on tsunami from affected areas of Tamil Nadu and Kerala coast and discussed the change in chemical and biological properties. So far the reported biotic impacts of tsunami on marine population have been evident only on the fish catch and other harvested crustacean groups. The plankton, the subtle basic marine community and the ecosystem changes are not yet addressed. The physical factors associated with the above can alter the structure of plankton community quantitatively and qualitatively. The data on plankton collections and relevant environmental features of cruise - 209, 215 and 232 of FORV Sagar Sampada from the Bay of Bengal are considered for the assessment of biological production before and after the tsunami.

## Materials and Methods

Under the MR-LR project of the National Institute of Oceanography, Regional Centre, Kochi, regular zooplankton collections are being made along the EEZ of India. The cruises undertaken in the Bay of Bengal before and after the tsunami namely cruise 209, 215 and 232 (Fig. 1) are selected for this study. The former two Cruise 209 and 215 are considered for pre and post tsunami zooplankton study. Zooplankton and hydrographic parameters were collected on board FORV Sagar Sampada. The MPN samples collected from the mixed layer only are utilized here.

## Results and Discussion

The published data on physical changes are given in Fig. 2 and 3 (Ramakrishnan *et al.*, 2005 and Chadha *et al.*, 2005). The hydrographical features along with general zooplankton observed during the two phases are given in Table 1. The SST showed a wider range after the tsunami varying between 27.3 and 29.2°C compared to the pre tsunami condition of 26.39 and 28.00°C. An increase of 1°C in SST is observed in the post tsunami study (Table 1).

Table 1 Hydrographical properties of the Bay of Bengal

Collection	SST(°C)		S‰ psu		DO µm/l		NO <sub>3</sub> µm/l	PO <sub>4</sub> µm/l		SiO <sub>4</sub> µm/l		
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.		
Before tsunami	26.39	28.00	24.2	33.7	4.20	4.8	0.02	1.6	0.06	0.44	0.2	3.71
After tsunami	27.3	29.2	29.7	34	2.15	8.23	0.01	0.85	0.4	1.29	4	6.56

The salinity also varied during the periods mentioned (24.20 - 33.7 psu before tsunami and 29.7 - 34.00 psu after tsunami). Marked fluctuation is noticed in the DO values after the tsunami (2.15-8.23 µm/l) whereas prior to the tsunami the DO values ranged between 4.20 and 4.80 µm/l. The nutrient values also were high after the tsunami especially the SiO<sub>4</sub> (4.00-6.56µm/l).

## Primary production

The primary productivity showed a peak between 13°N and 15°N reaching upto 1250g C/mVyr in the near shore stations (Fig. 4). The chlorophyll - *a* value also was high ~ 50 mg/m<sup>3</sup> (Fig. 5). In the offshore stations there was no marked difference in primary production in the pre and post tsunami observations.

## Zooplankton

The mesozooplankton biomass distribution for both the periods is shown in Fig. 6. The average biomass during the pre tsunami period was 135.8ml/1000m<sup>3</sup> compared to 91.0ml/1000m<sup>3</sup> in the post tsunami period. The average value for the major zooplankton taxa are presented in Table 2.

Table 2 Zooplankton (average values) of the Bay of Bengal

Collection	Biomass ml/1000m <sup>3</sup>	Forams	Polychaetes	Ostracods	Copepods	Chaetognaths	Fish eggs	Fish larvae
Before tsunami	135.8	1105	2313	8916	283731	10973	71041	386
After tsunami	91	79	461	3583	125655	5853	136	144

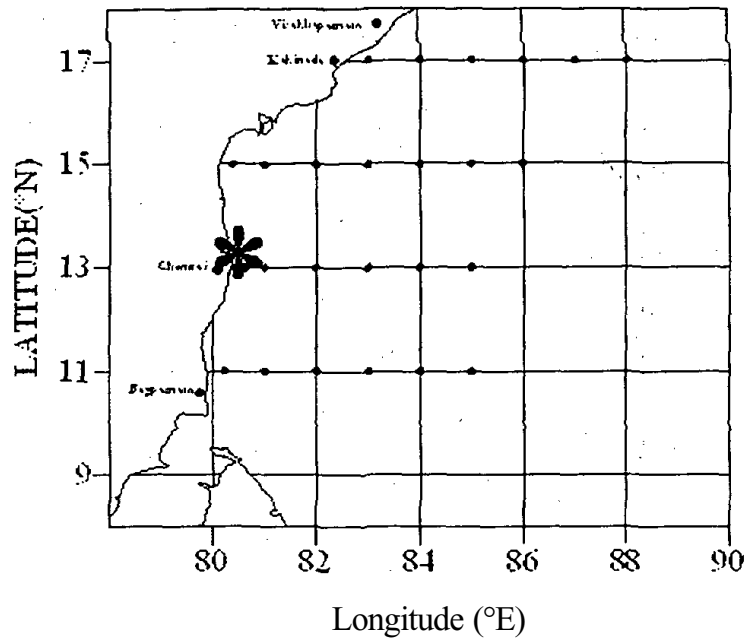
The highest biomass (2737 ml/1000m<sup>3</sup>) was recorded off Chennai. Copepods and Ostracods also showed maximum density namely 4089600 and 237600 No/1000m<sup>3</sup> in the pre tsunami study (Fig. 7 and 8). The maximum fish eggs (5215200 No/1000m<sup>3</sup>) and larvae (6800 No/1000m<sup>3</sup>) were also recorded in this station. In the post tsunami study the stations along this transect sustained comparatively high biomass and density (727.2ml, Copepods 2252727, Ostracods 14666 No/1000m<sup>3</sup>). This trend is also observed for the major zooplankton taxa. This region is a productive area in the Bay of Bengal where high productivity was noticed during all the previous observations. The hydrographical data also show the presence of high levels of nutrient suggesting local upwelling (Shetye *et al*, 1991). The chlorophyll-a and primary productivity data also showed localized boost in phytoplankton production due to the enrichment of the water column. The average density of the dominant plankton was also high before the tsunami - Copepod 283731, Ostracod 8916, Chaetognath 10973, fish eggs 71041 and fish larvae 386 per 1000m<sup>3</sup> as against the post tsunami data - Copepod 125655, Ostracod 3583, Chaetognath 5853, fish eggs 136 and fish larvae 144 per 1000m<sup>3</sup> (Fig. 9,10,11). The density of polychaetes is indicated in fig.12.

The analysis of the two sets of data showed clear evidence that zooplankton was high in the *pre* tsunami period. Subsequent to the tsunami nearly 50% reduction is observed in the corresponding values. Whether the drop in zooplankton is due to the increase in suspended load as a result of turbulence caused by the tsunami or whether it is only a transitional stage immediately after the tsunami which would get normalized in due course is to be verified by further zooplankton investigations in the same area.

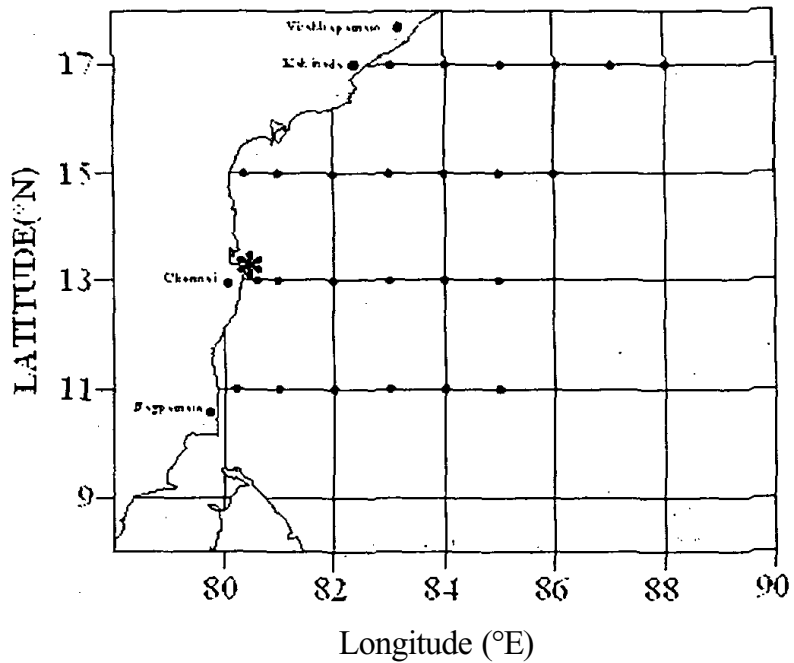
In the absence of any previous report on the biological alterations caused by tsunami, an unprecedented event has happened in recent times in the Bay of Bengal. This study throws light on the adverse effect of heavy mixing due to physical factors. The increased silicate in the mixed layer can be attributed to the churning of the bottom and vertical elevation of water body to surface. Any calamity in the marine environment is visually reflected in the fishery causing public alarm. Marine Biologists are faced with environmental crisis of new complexity, properties and consequences which are to be closely monitored.

Fig. 1 Cruise station positions

Cruise track of MR-LR in Bay of Bengal before Tsunami 2004



Cruise track of MR-LR in Bay of Bengal after Tsunami 2004



\* Highest biomass recorded      ● Stations covered

Fig. 2 Physical changes associated with the Tsunami

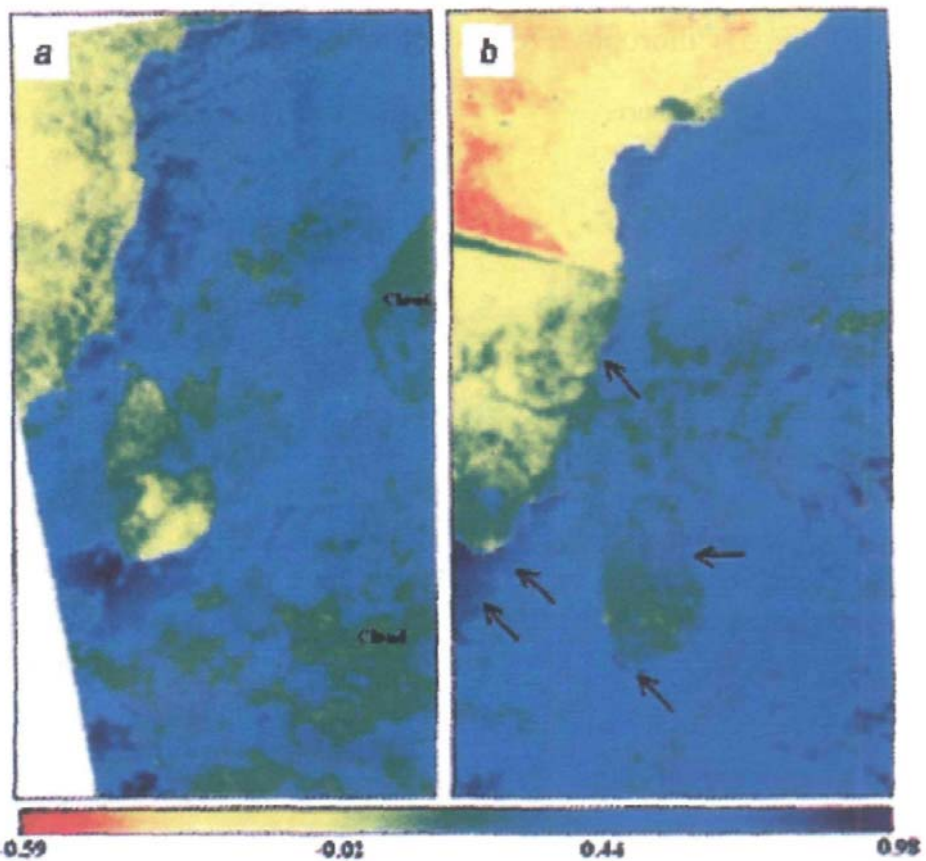
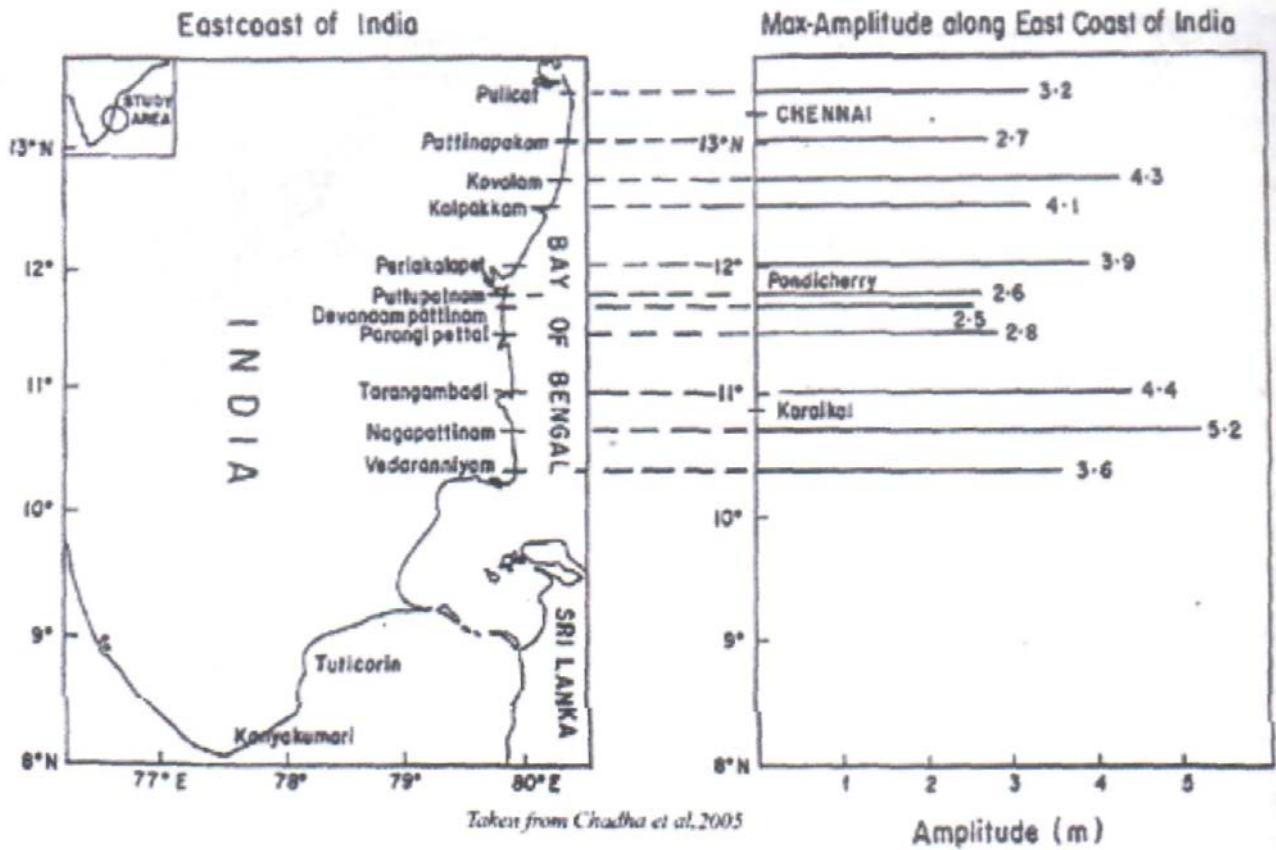


Fig. 3 Pre-(a) and post-(b) bank ratio maps (b4 and b2) depicting the changes in suspended sediment concentration in coastal waters.

Fig. 4 Primary production before and after Tsunami 2004

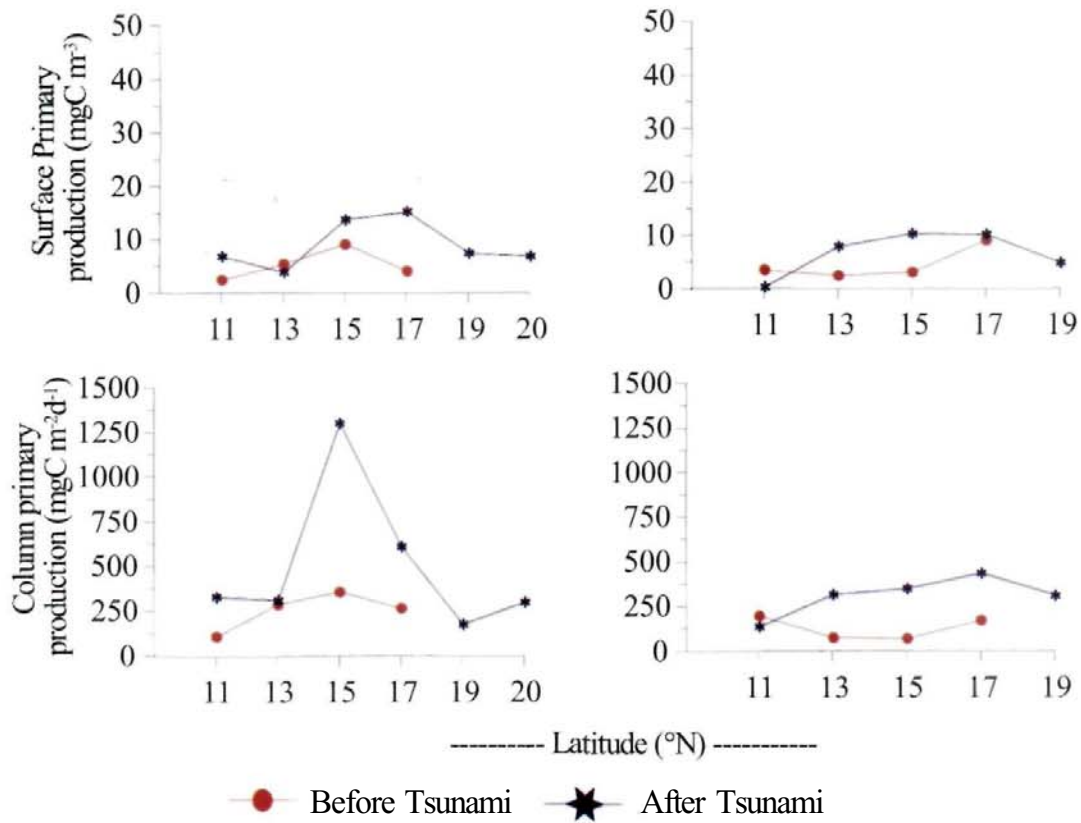


Fig. 5 Chlorophyll levels before and after Tsunami 2004

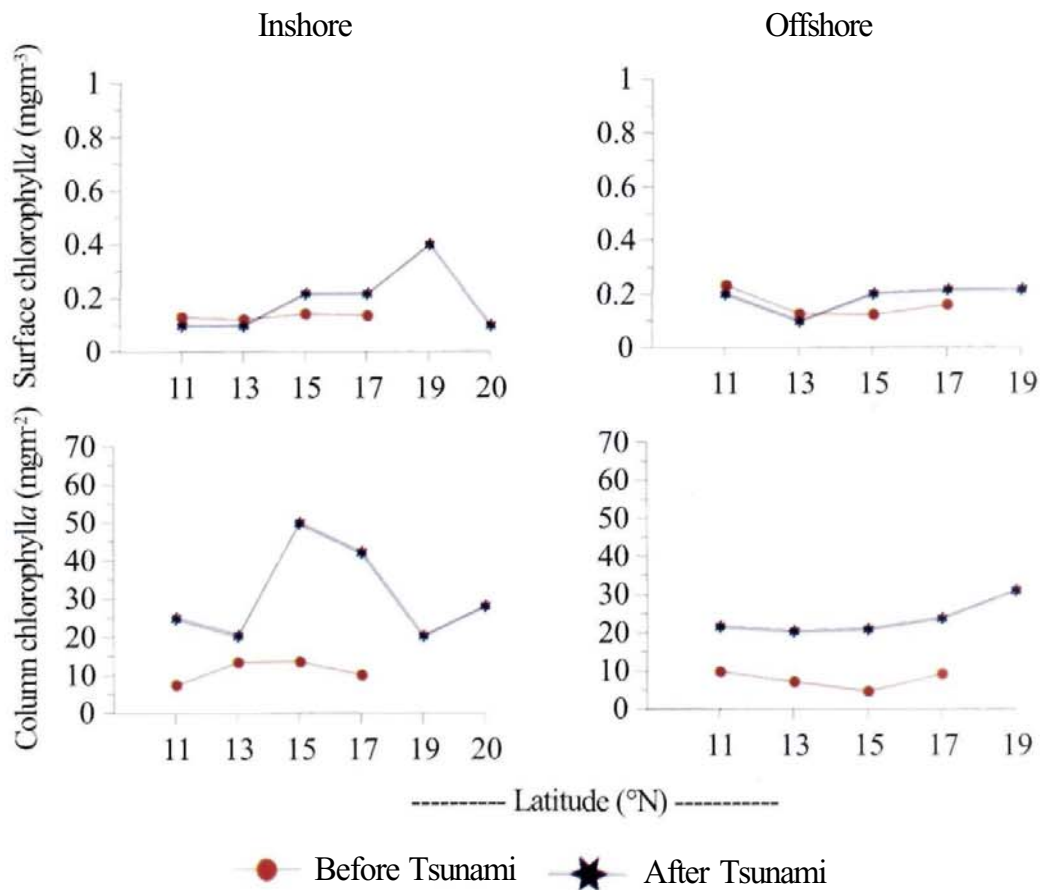




Fig. 6 Mesozooplankton biomass (ml/1000<sup>3</sup>) distribution in the mixed layer

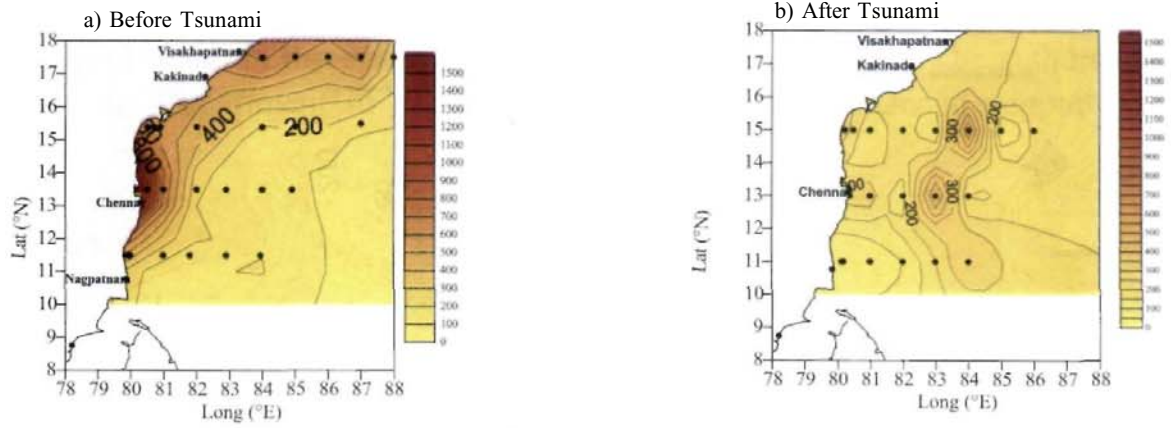


Fig. 7 Density of Copepods (no/1000m<sup>3</sup>) in the Mixed layer

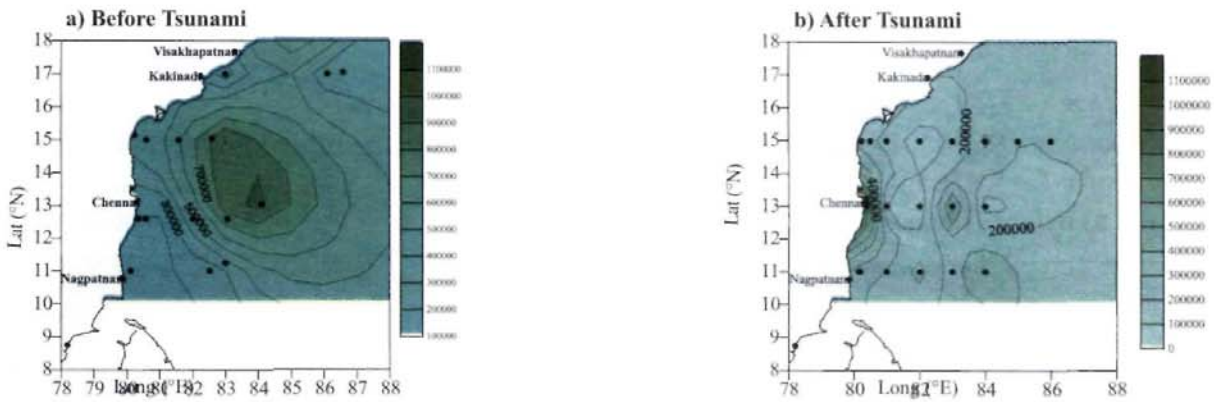


Fig. 8 Density of Ostracods (no/1000m<sup>5</sup>) in the mixed layer

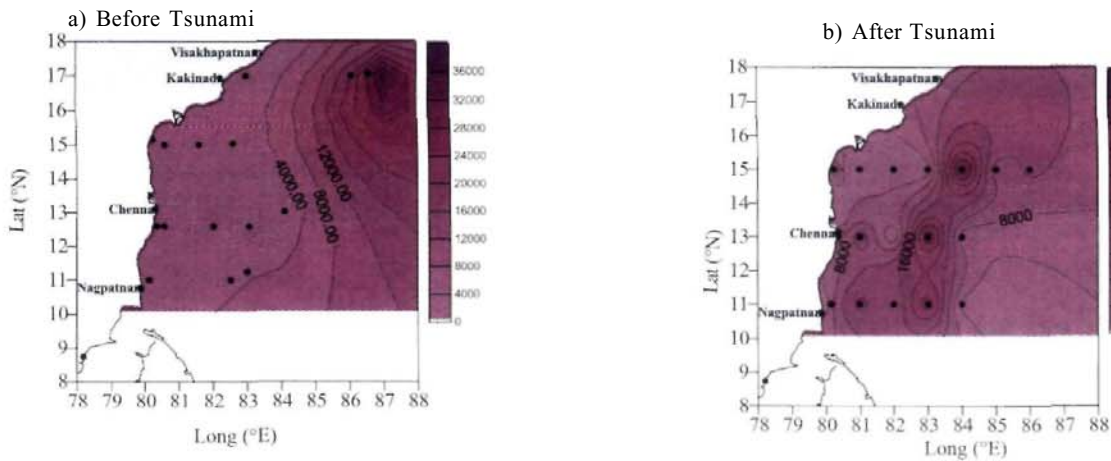


Fig. 9 Density of Chaetognaths (no/1000m<sup>3</sup>) in the mixed layer

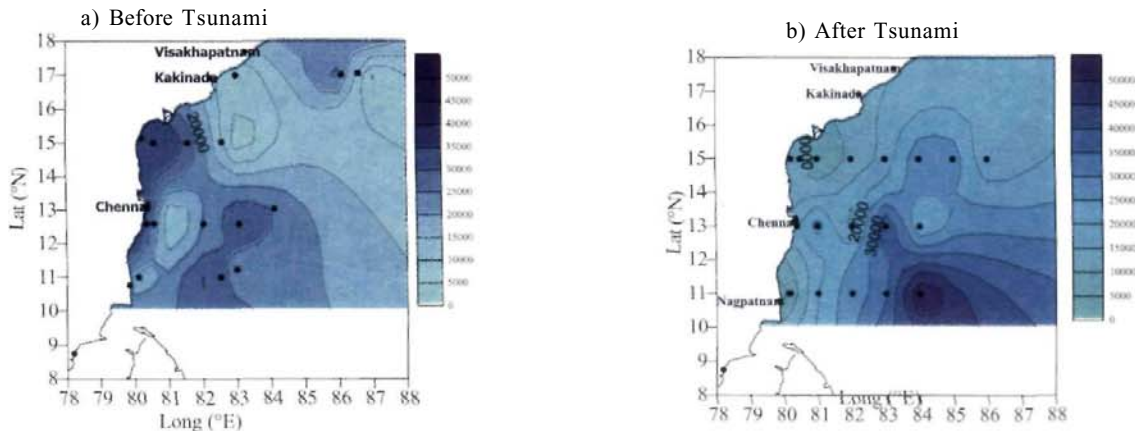


Fig. 10 Density of fish eggs (no/1000m<sup>3</sup>) in the mixed layer

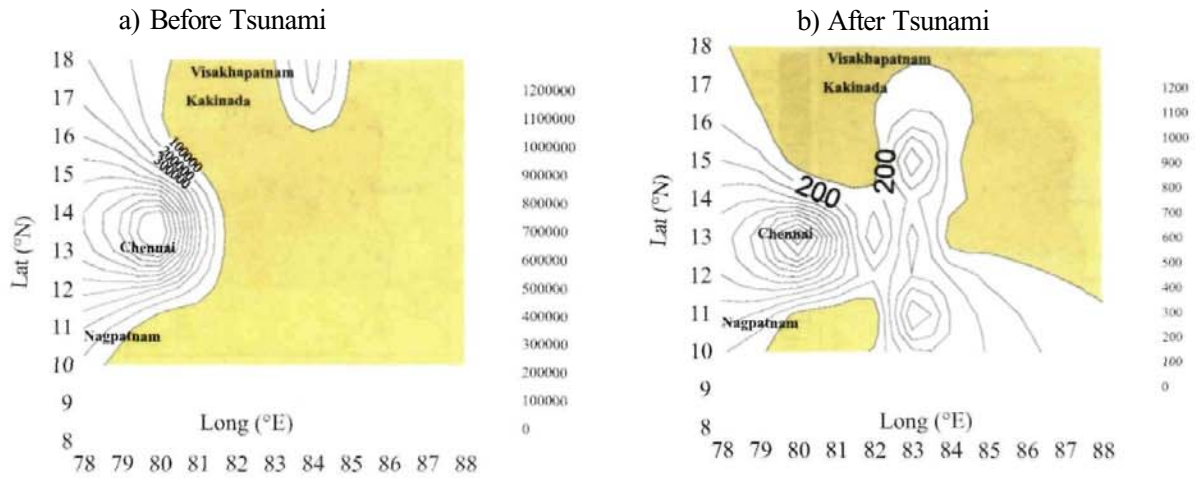


Fig. 11 Density of Fish larvae (no/1000m<sup>3</sup>) in the mixed layer

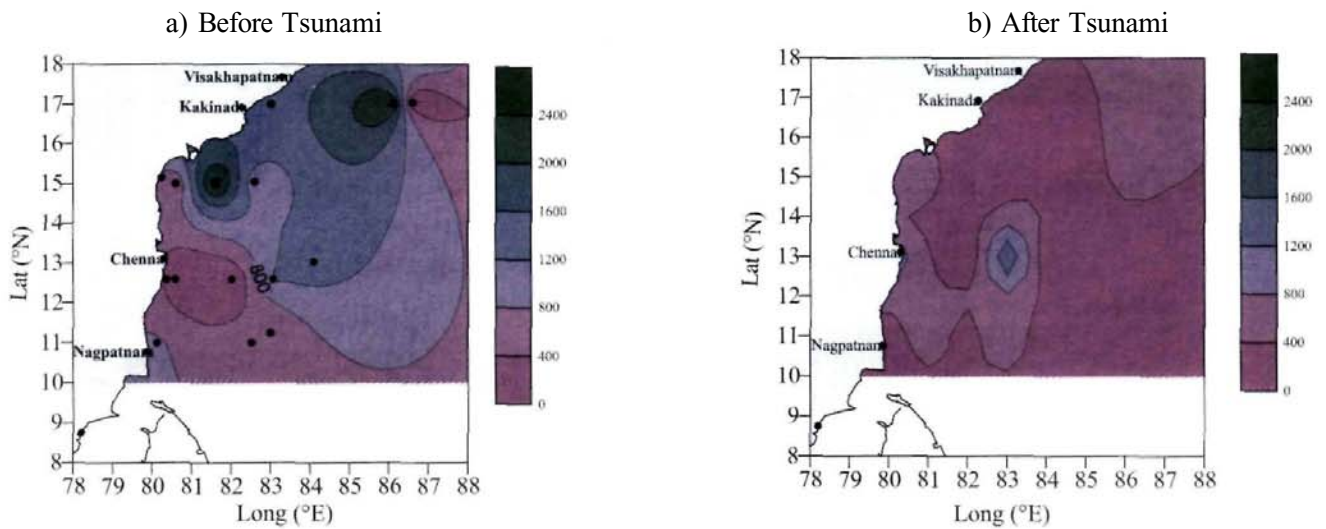
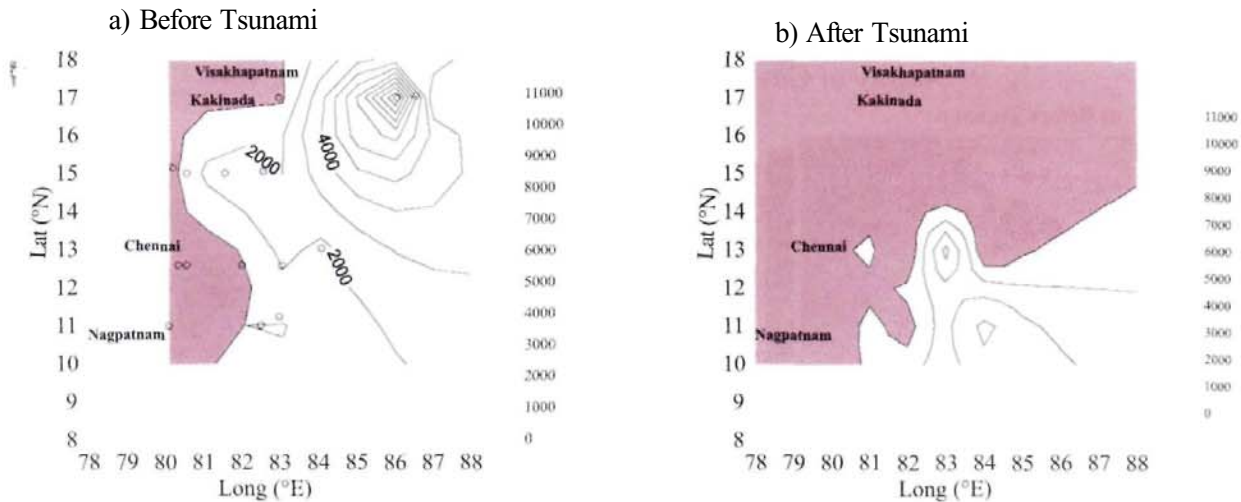


Fig. 12 Density of Polychaetes (no/1000m<sup>3</sup>) in the mixed layer





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## References

1. Chadha, R.K., G. Latha, H. Yeh, C. Peterson and T. Katada, 2005. The tsunami of the great Sumatra earthquake of M 9.0 on 26 December 2004 - Impact on the east coast of India. *Current Science*, 88 (8): 1297-1303.
2. DOD, ICMAM, 2005. Preliminary assessment of impact of tsunami in selected coastal areas of India. 1-42p.
3. Madhu, N.V., P.A. Maheswaran, R. Jyothibabu, V. Sunil, C. Revichandran, T. Balasubramanian, T.C. Gopalakrishnan and K.K.C. Nair, 2002. Enhanced biological production off Chennai triggered by October 1999 super cyclone (Orissa), *Current Science*, 82:12.
4. Jayakumar, S., D. Ilangovan, K. A.Naik, R.Gowthaman, G. Tirodkar, Ganesh N.Naik, P. Ganeshan , R.M. Murali, G.S. Michael, M.V. Ramana and G.C. Bhattacharya, 2005. Run-up inundation limits along southeast coast of India during the 26 December 2004 Indian Ocean tsunami. *Current Science*, 88 (11): 1741-1743.
5. Ramakrishnan,D., S.K.Ghosh, V.K.M.Raja, RV Chandran and A. Jeyram, 2005. Trails of the killer tsunami: A preliminary assessment using satellite remote sensing technique. *Current Science*, 88 (5): 709-711.
6. Shetye, S.R., S.C.Shenoi, A.D.Gouveia, G.S.Michael and G.Nampoothiri, 1991. Wind-driven coastal upwelling boundary of the Bay of Bengal during the southwest. *Shelf Res.*, 11 : 1397-1408.
7. Stephen, R, A.P Rashiba, N.V.Mahdu, and K.K.C. Nair, 2005. Cyclone in the Bay of Bengal and induction of mesopelagic calanoid Copepod species into the mixed layer (Abstract). Dynamic Planet 2005, IAG, IAPSO and IABO, Cairns Australia.
8. Sudhir,J. K., C.V.R. Murty, Durgesh C. Rai, Javed N.Malik, Alpa Sheth and Aravind Jaiswal, 2005. Effects of M 9 Sumatra earthquake and tsunami of 26 December 2004. *Current Science*, 88 (3): 357-359.