The Second GEOSS Asia-Pacific Symposium, Tokyo, 14-16th April 2008

Time-series observations in the Northern Indian Ocean

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National Institute of Oceanography
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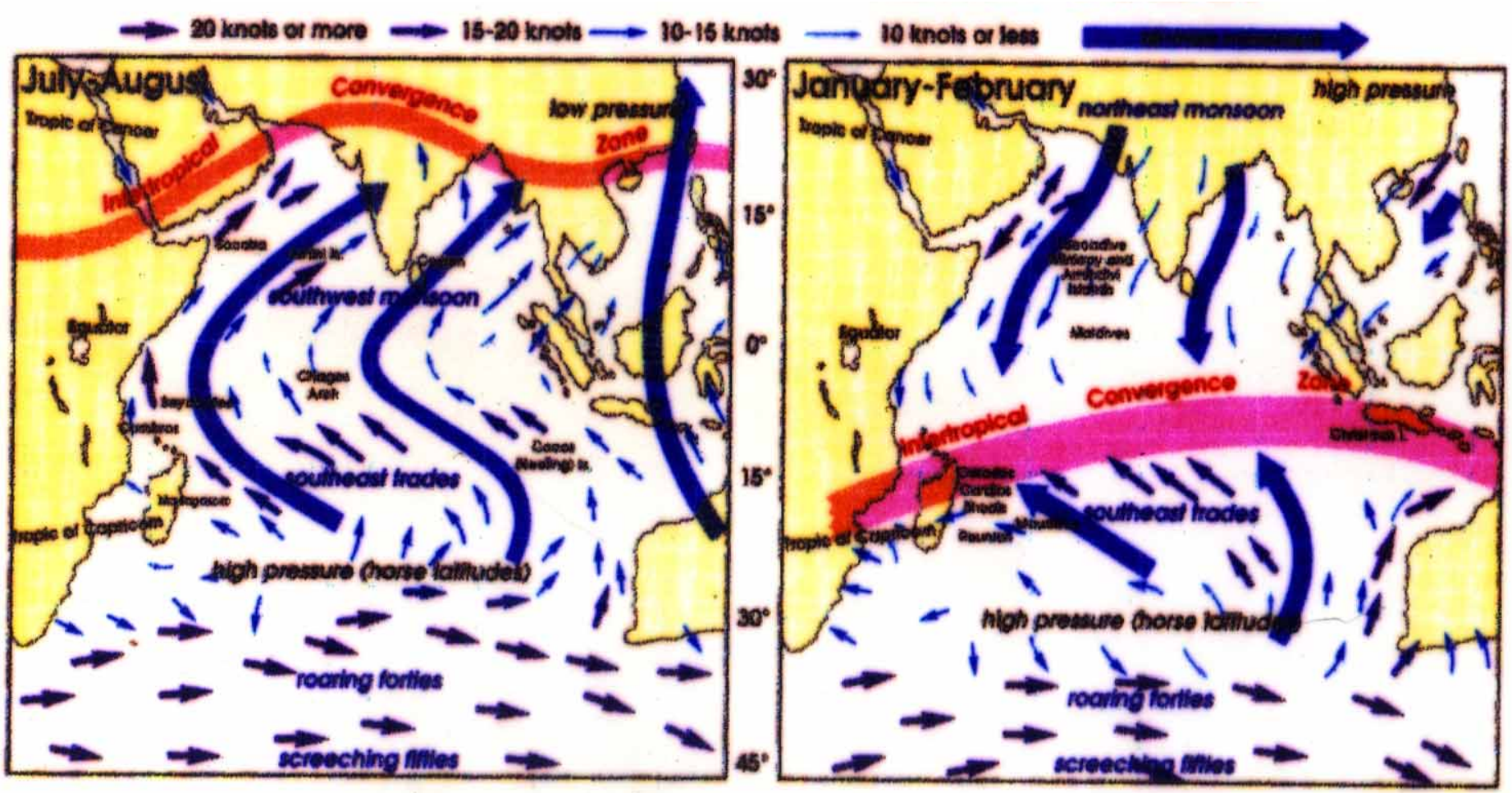
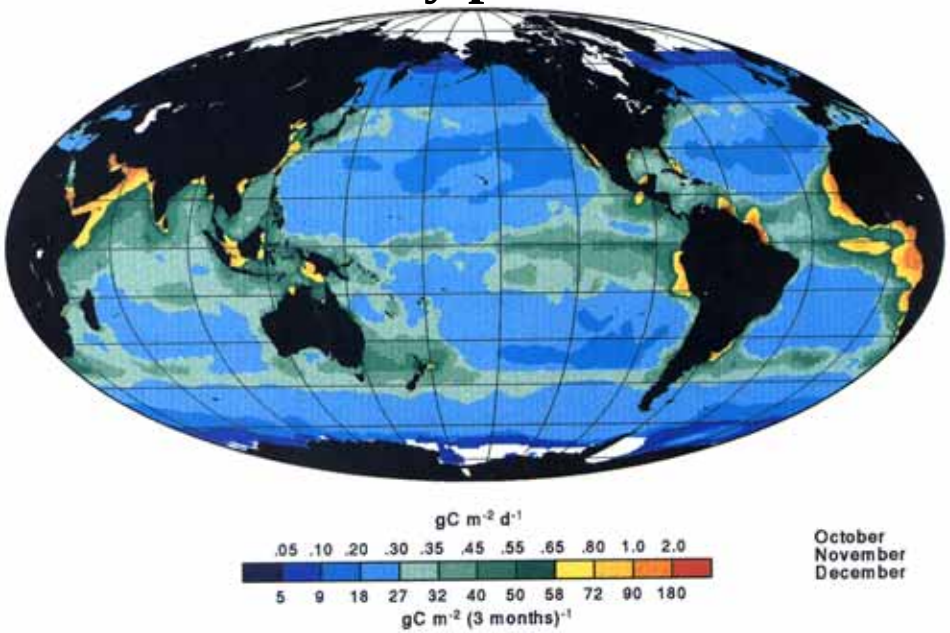
Seasonal variations in winds, currents and ITCZ in NIO

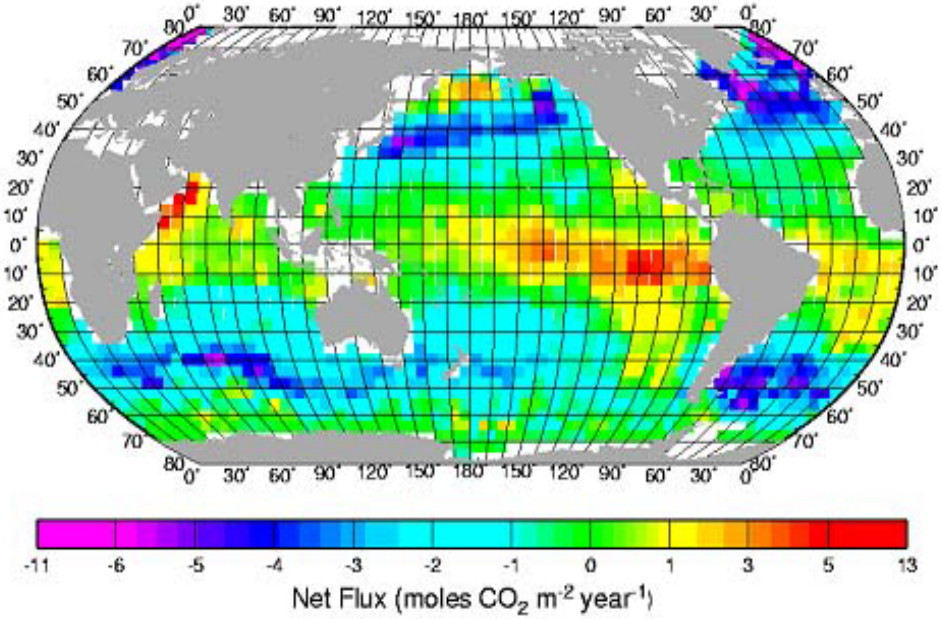


Importance of N. Indian Ocean

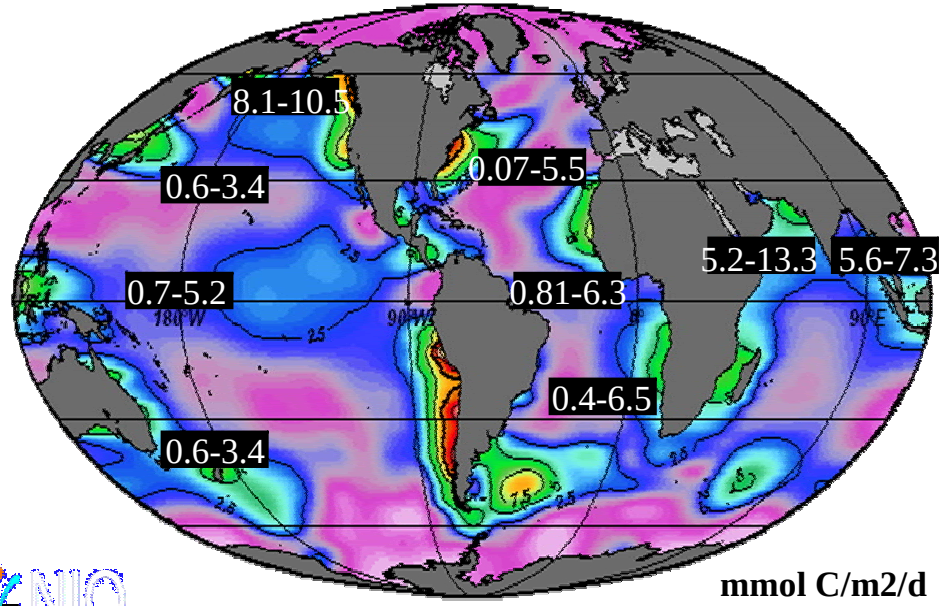
Primary production



Sea-to-air flux of CO2

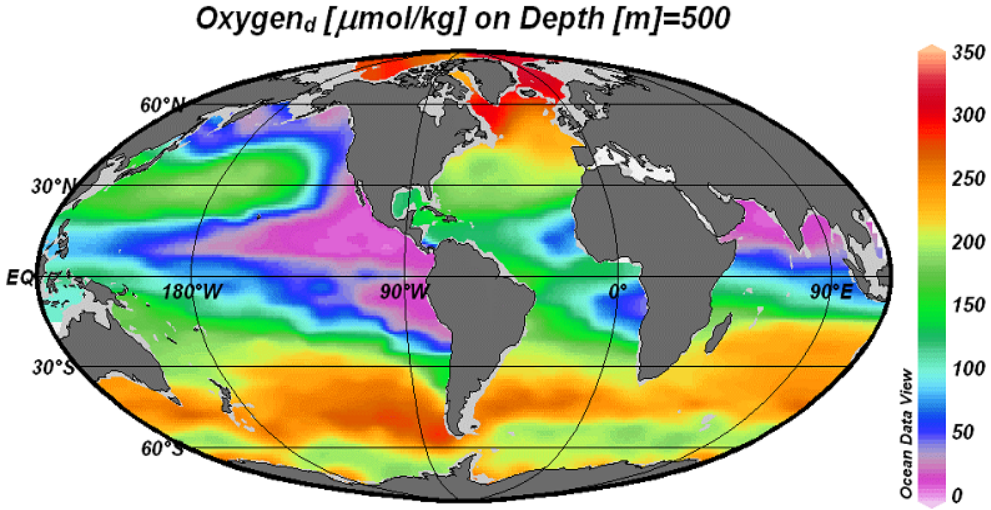


Sinking organic carbon



mmol C/m2/d

Oxygen at 500 m deep



micromol/kg

NCP and sea-to-air fluxes of CO_2

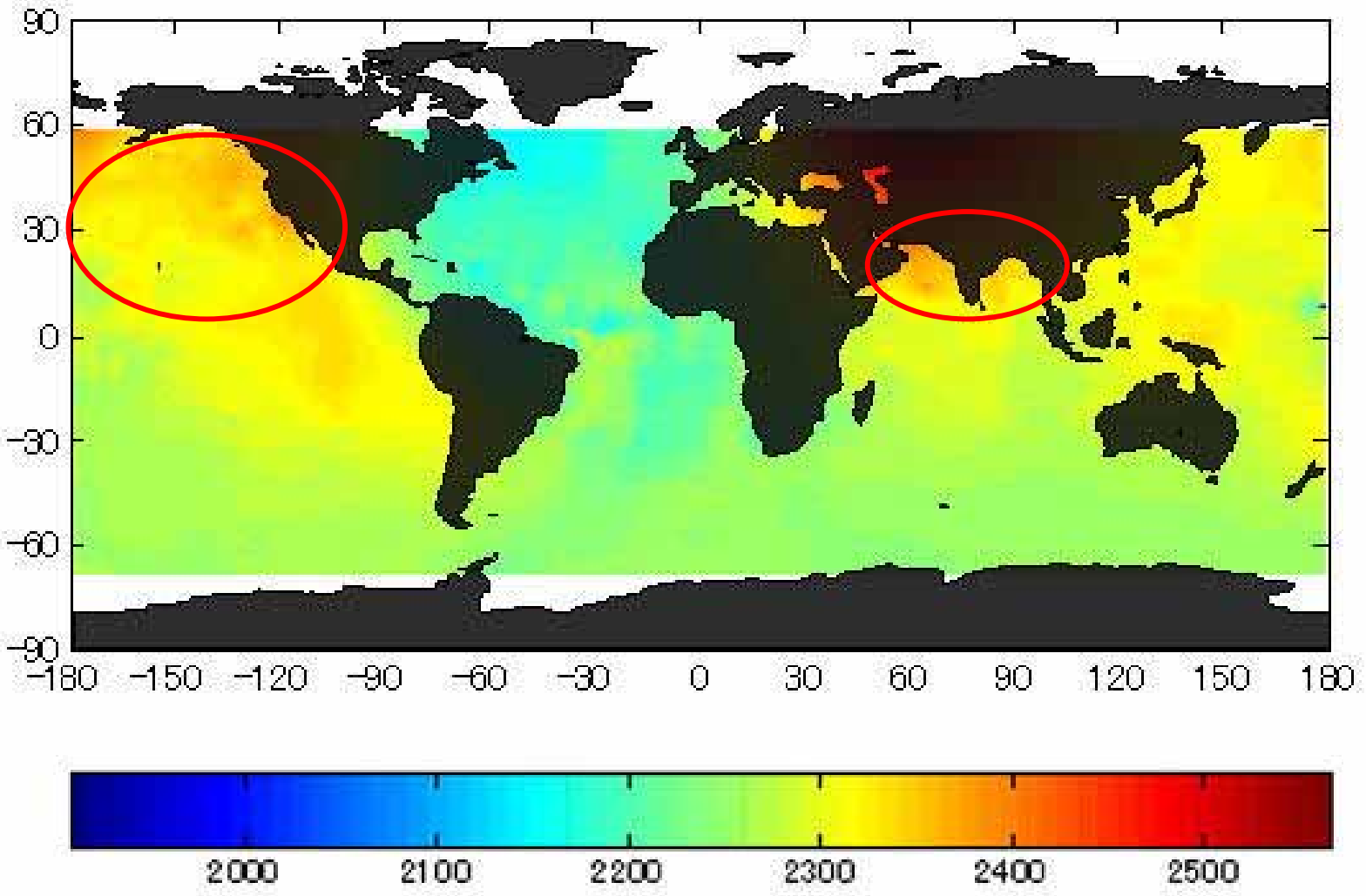
($PgC\ y^{-1}$)

Region	Sea-to-air flux (F)	New/NCP(NP)	F/NP Ratio
Eq.Pacific (HNLC) (1980-2000)	0.80 to 1.00 (*Feely et al.*, 2002)	0.65 to 0.98 (*LeBorgne et al.*, 2002)	1.0-1.2
Arabian Sea (1995)	0.07 to 0.09 (*Sarma.*, 2003)	0.17 to 0.20 (*Sarma*, 2004)	0.4-0.45
Bay of Bengal	0.0025 to 0.005 (*Takahashi et al.*, 2002)	0.059-0.077 (*Sarma*, 2006)	0.19-0.22

Deep water DIC in the World Oceans

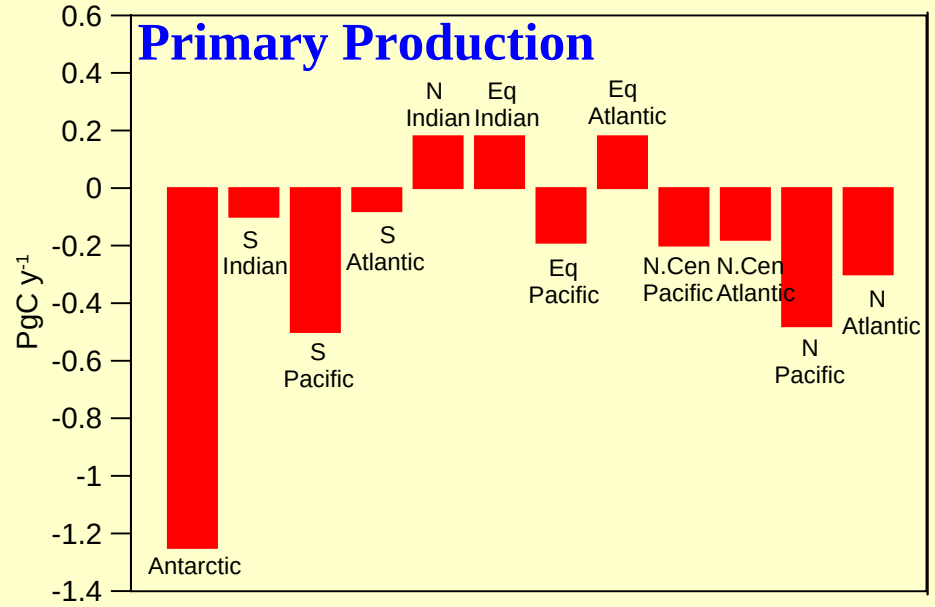
Source: WOCE data on sigma-3: 41.488 (~3000m)

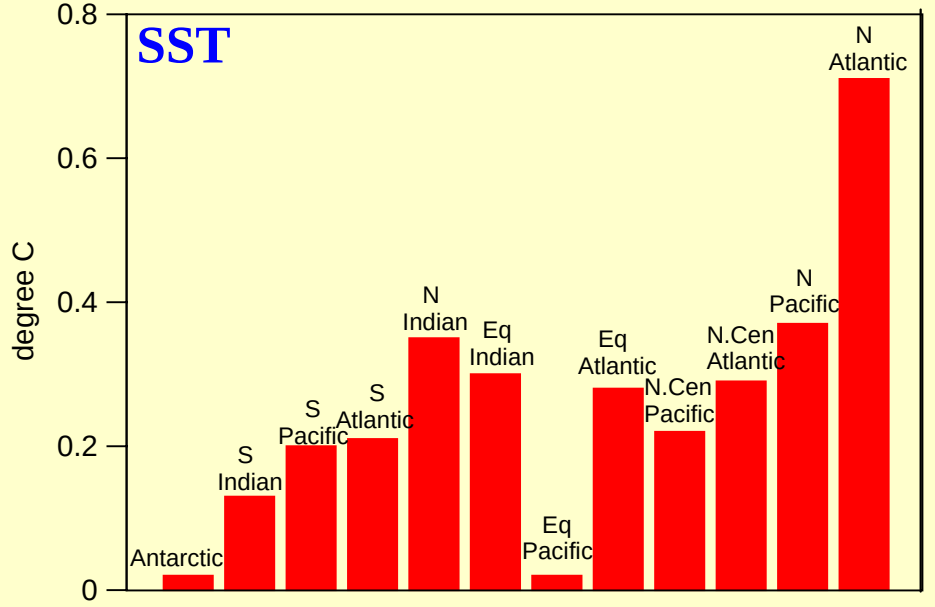
(μmol kg^{-1})

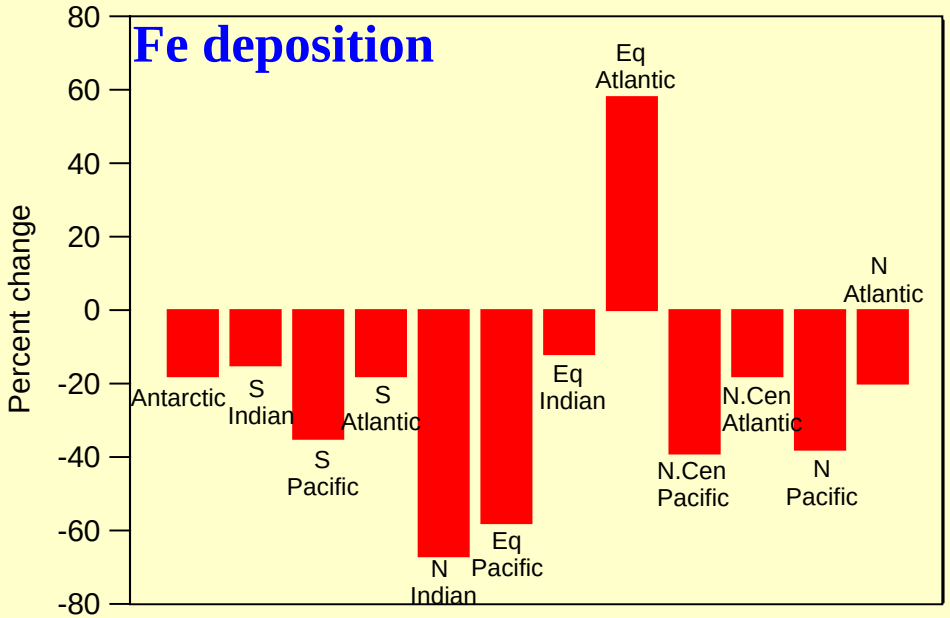


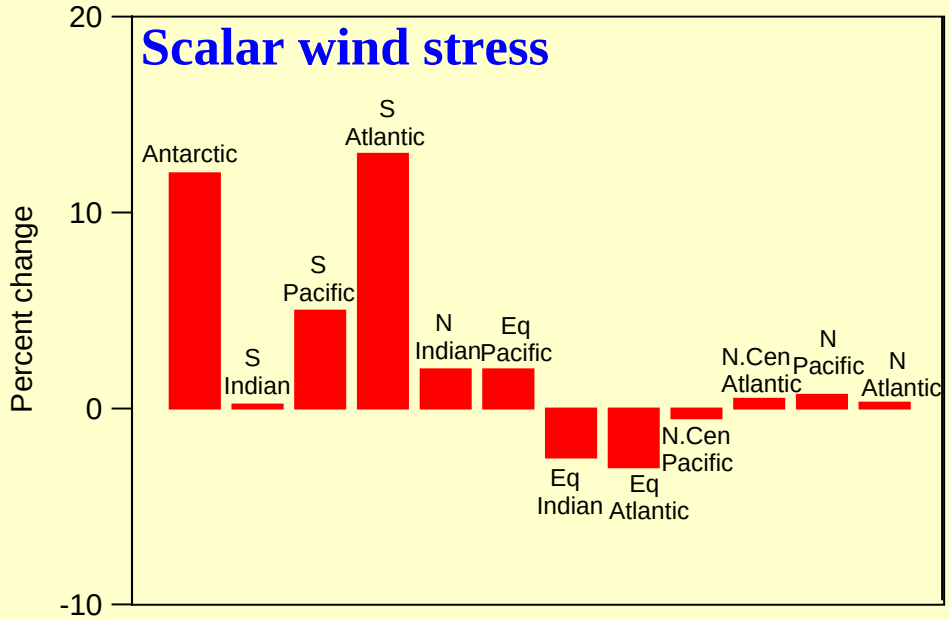
Sarma et al. 2007

Change in conditions from SeaWiFS to CZCS era



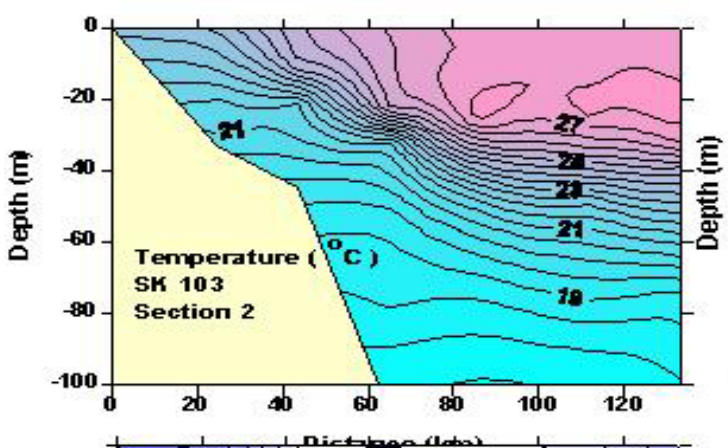


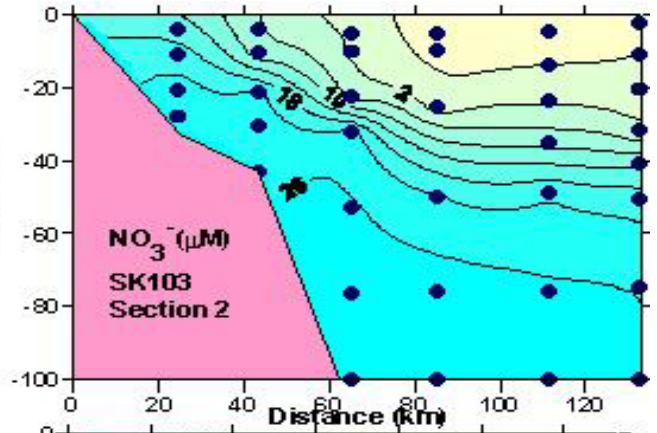


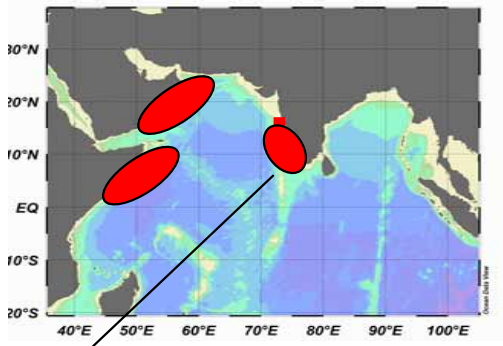


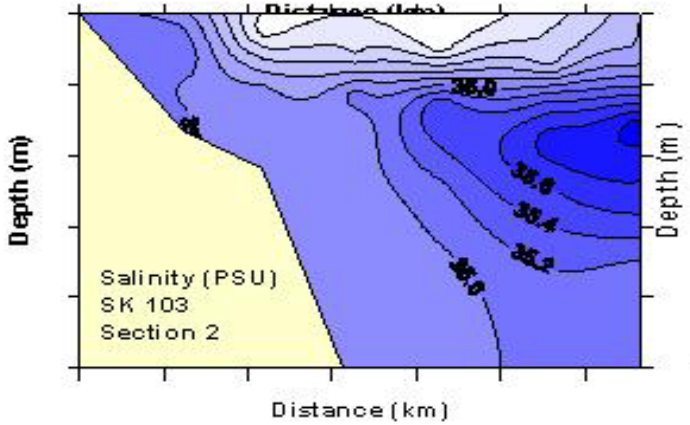
Gregg et al., 2002

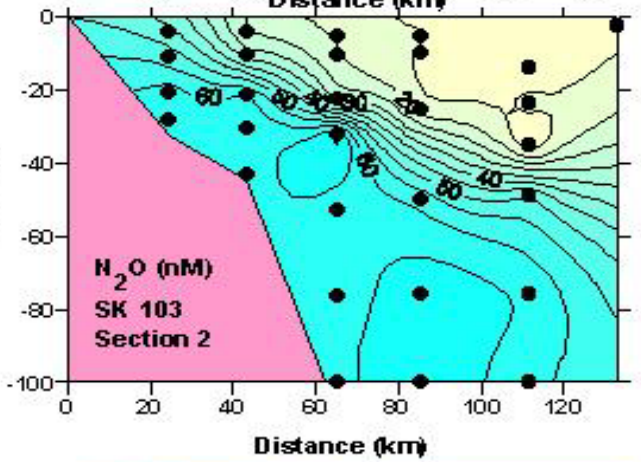
Physical forcing..upwelling in the Arabian Sea

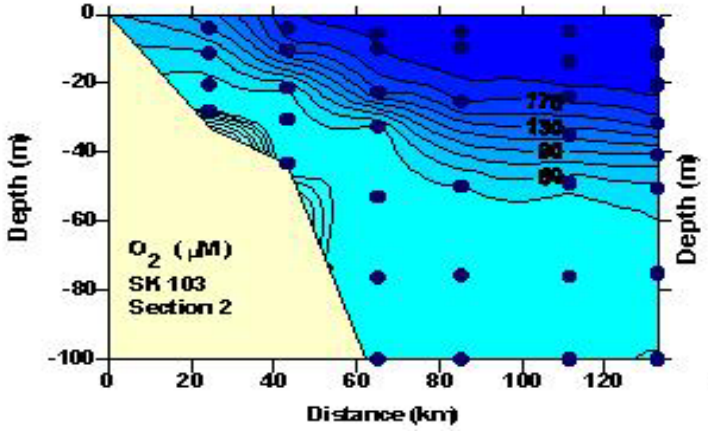


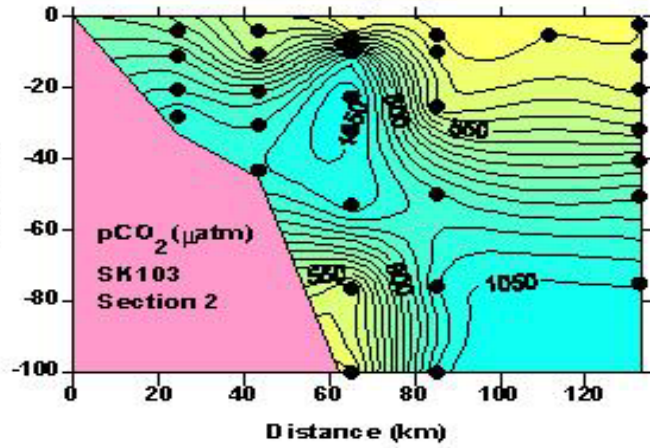




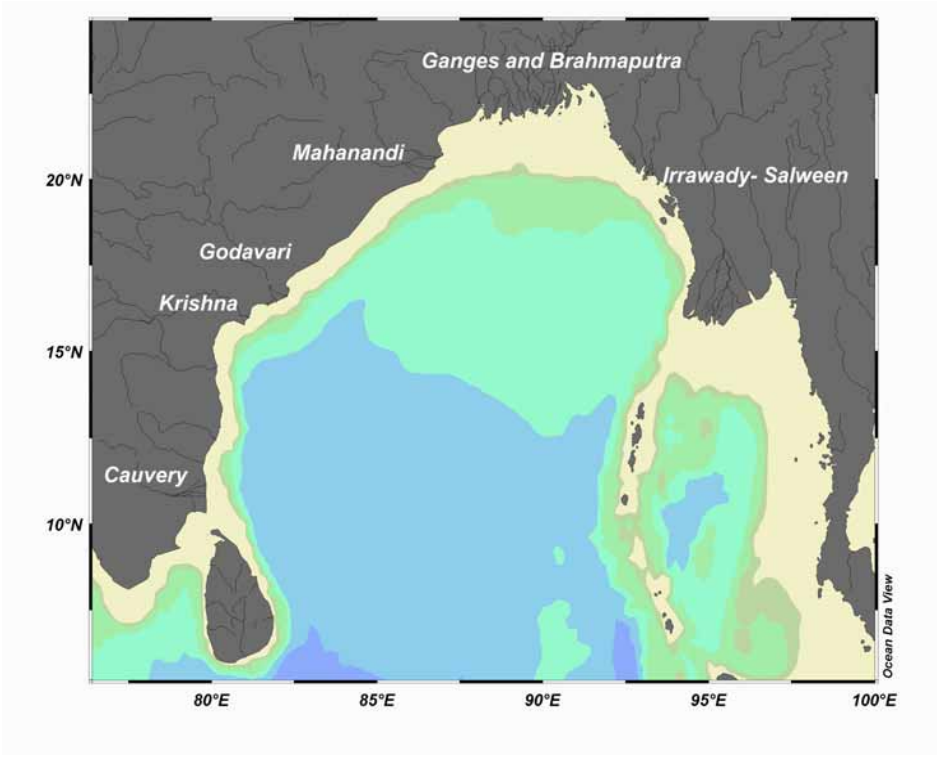


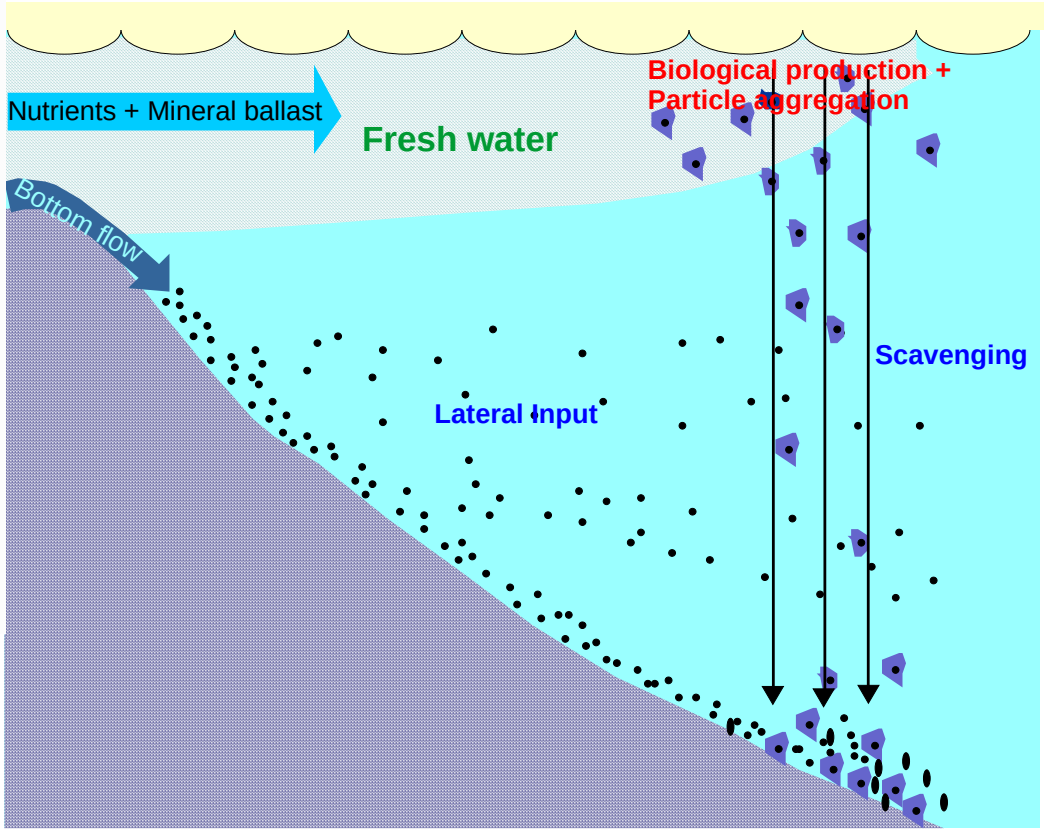




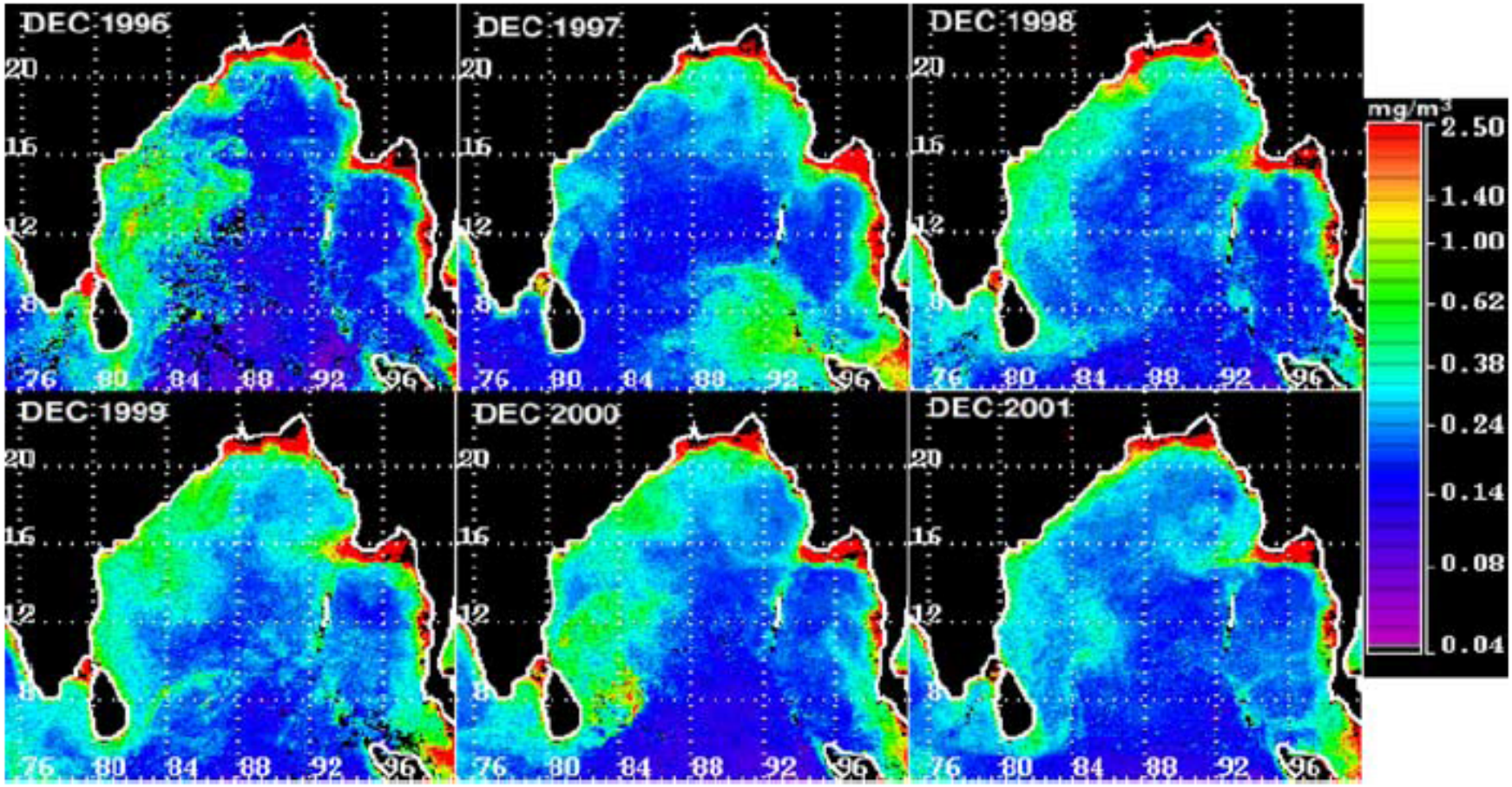


Particle ballast in the Bay of Bengal



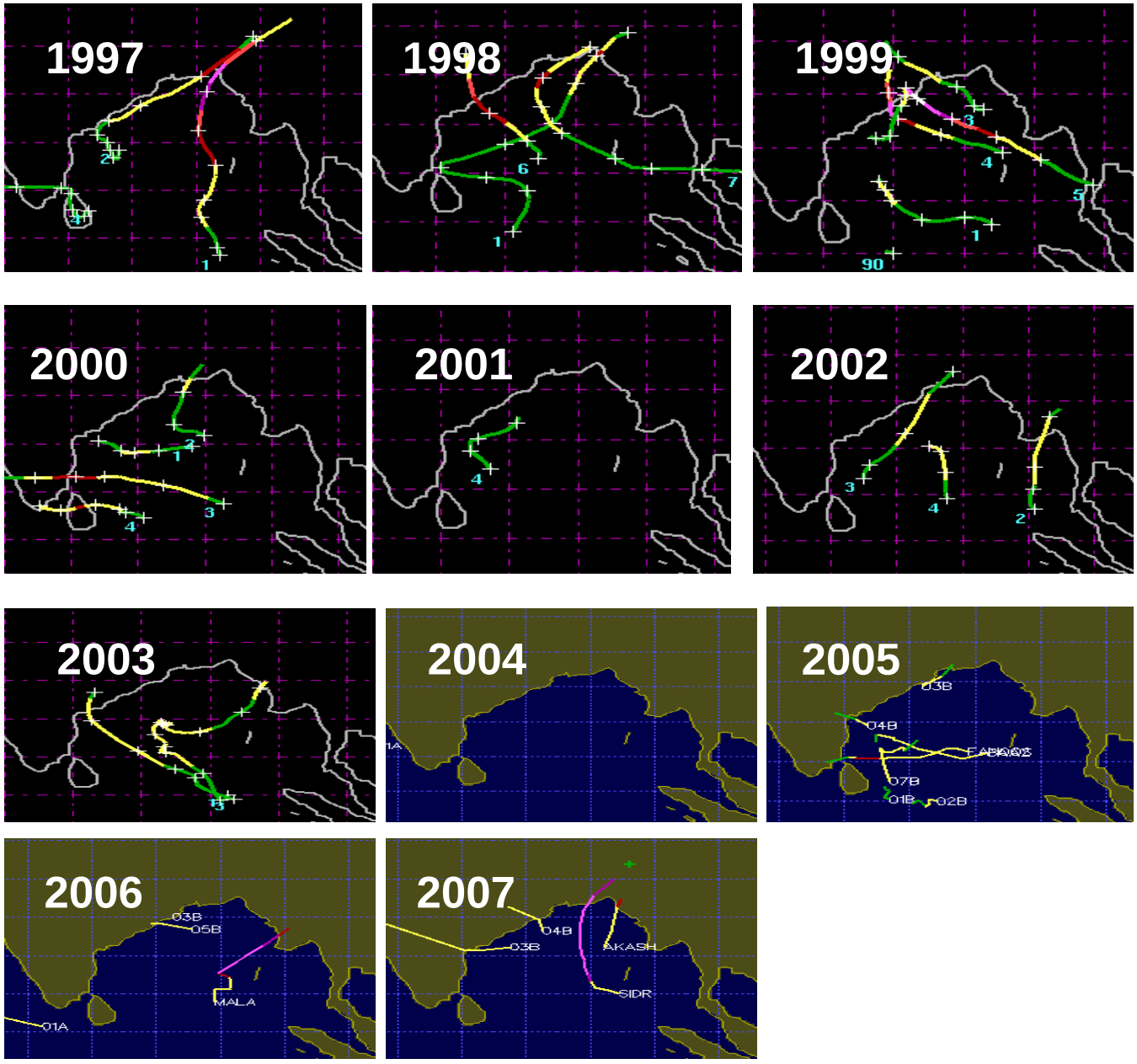


Phytoplankton Blooms in the Bay of Bengal



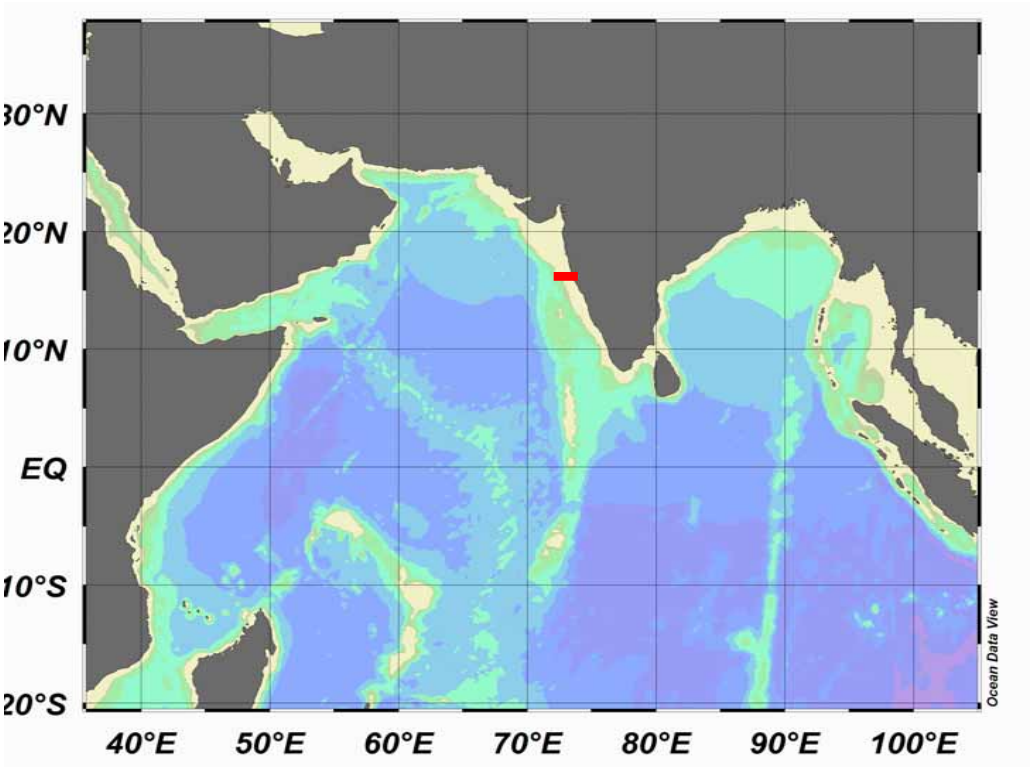
Vinayachandran et al 2003

Tracks of cyclones and depressions in the Bay of Bengal



Source : http://www.weather.unisys.com

Time-series observations in the northwestern Indian Ocean

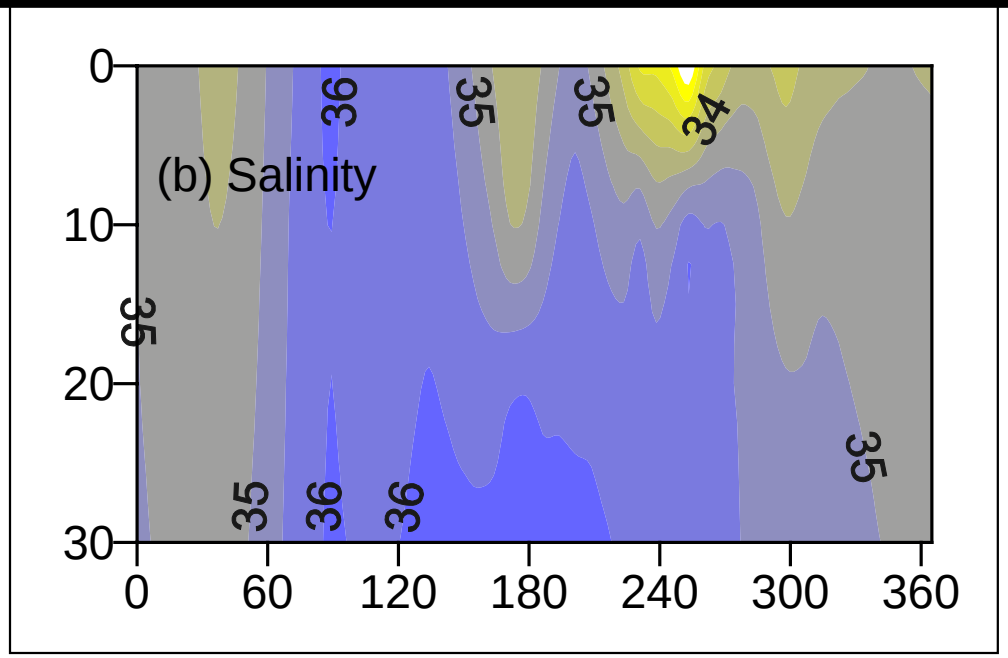


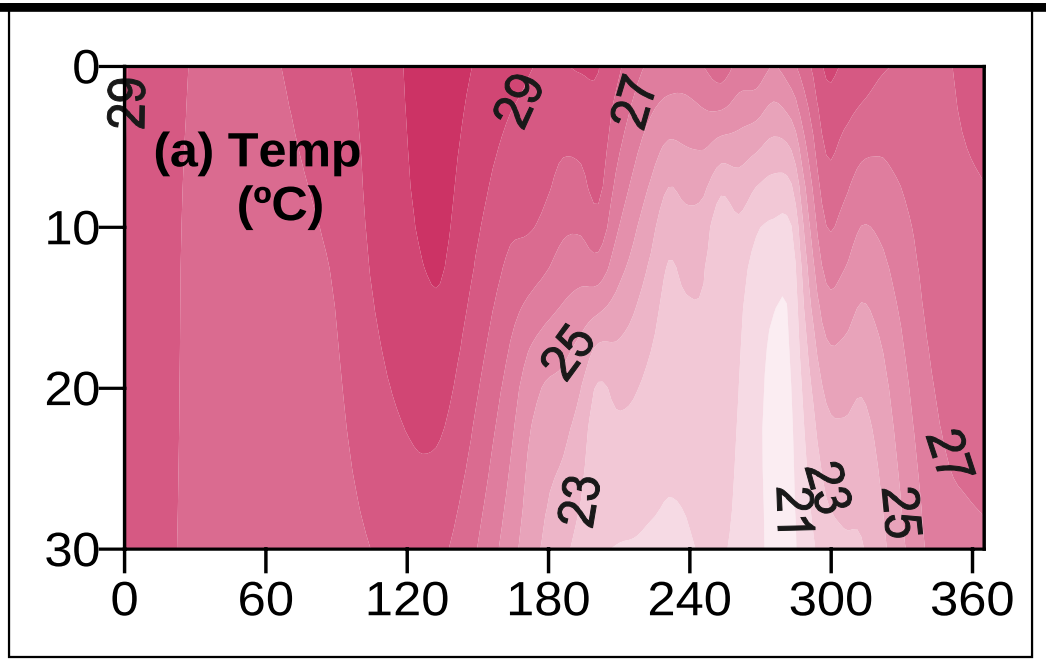
Ongoing time-series projects in the west coast of India (eastern Arabian Sea)

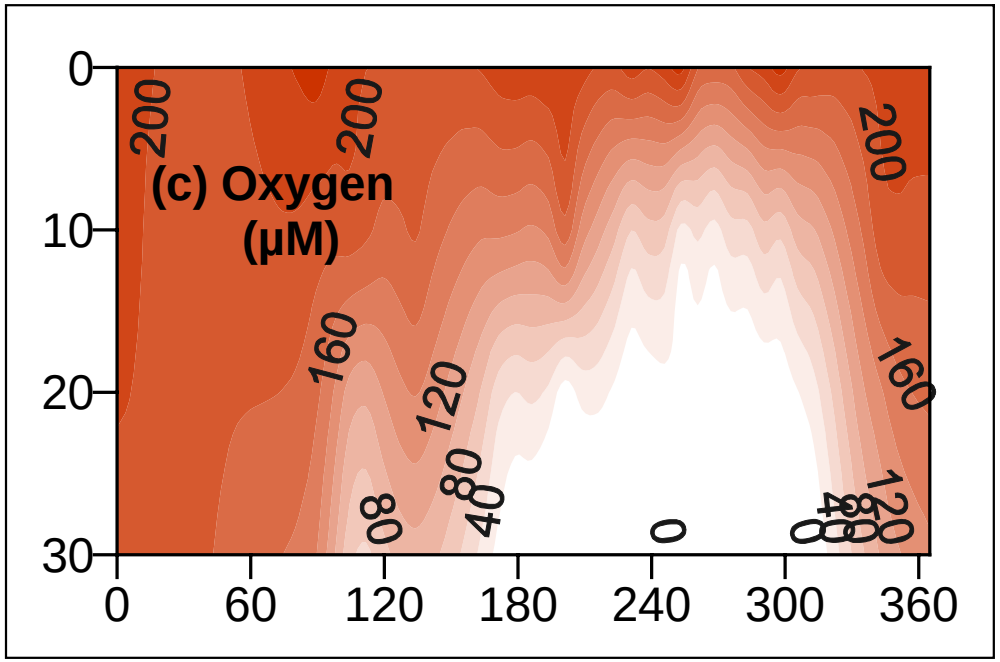
- *Impact of anthropogenic perturbations on oceanographic – atmospheric processes in and around India in the context of Global Change (CSIR Network Project No. CMM 009) Since 2002*

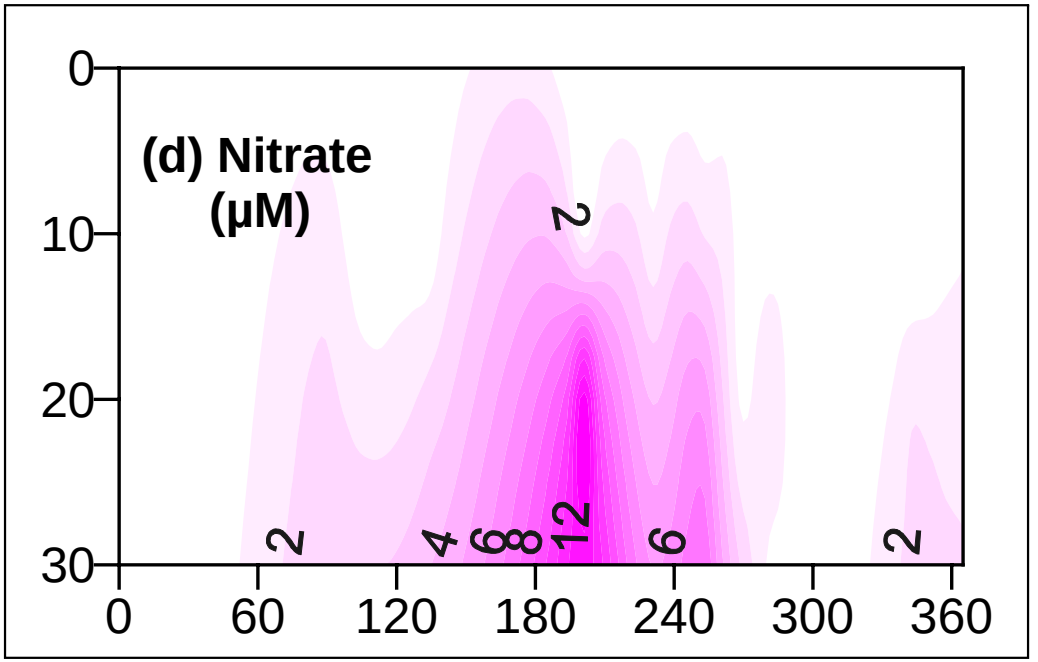
Sampling at Monthly Scale

Evolution .. anoxia & H_2S..

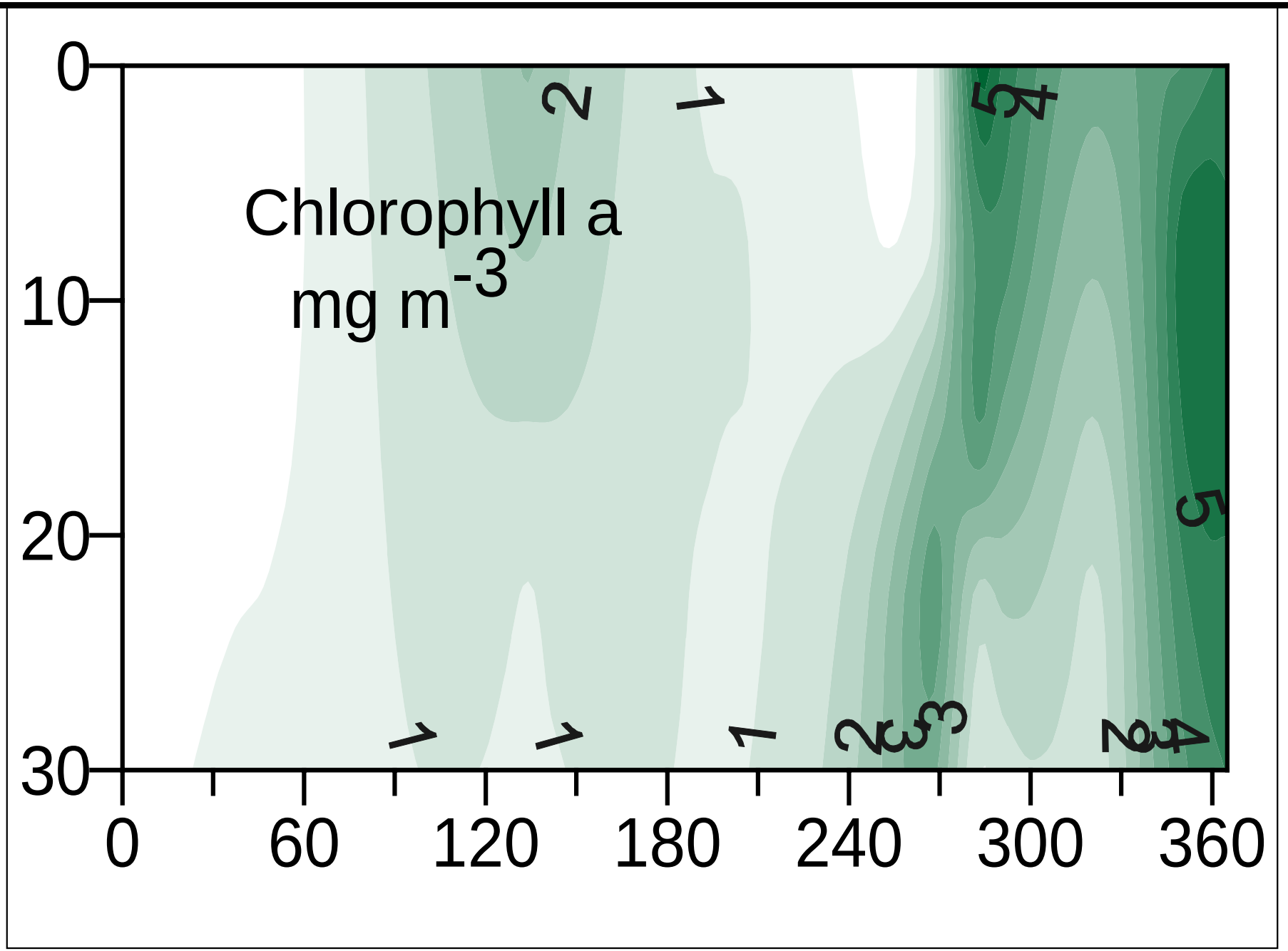




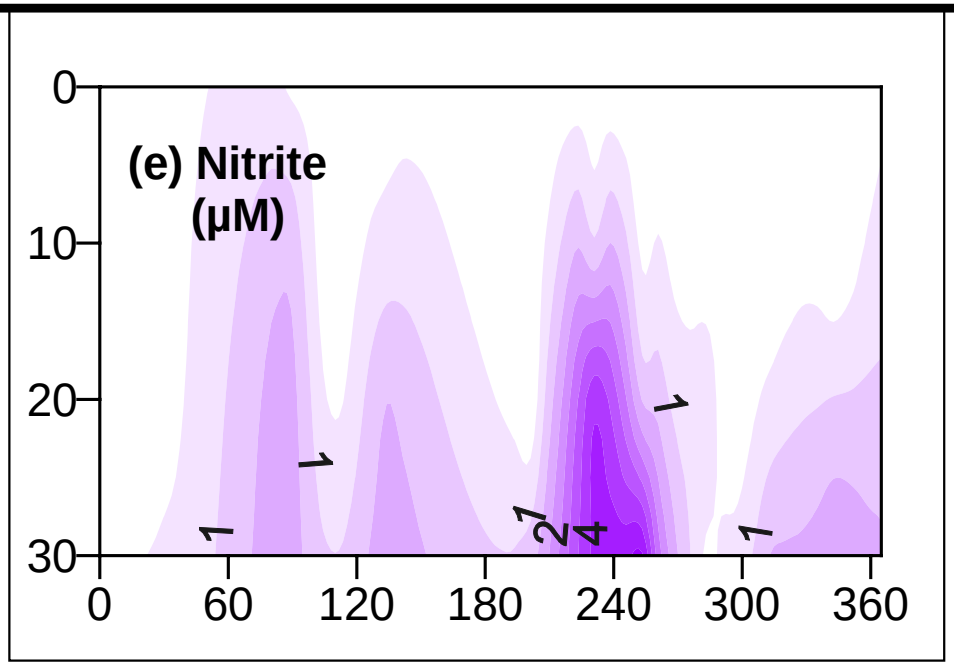


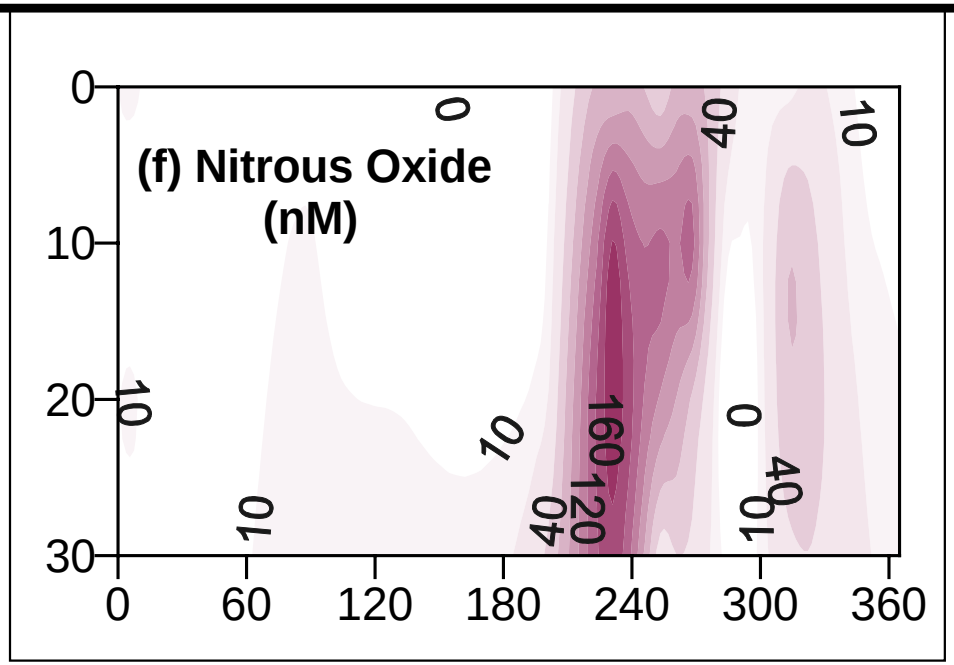


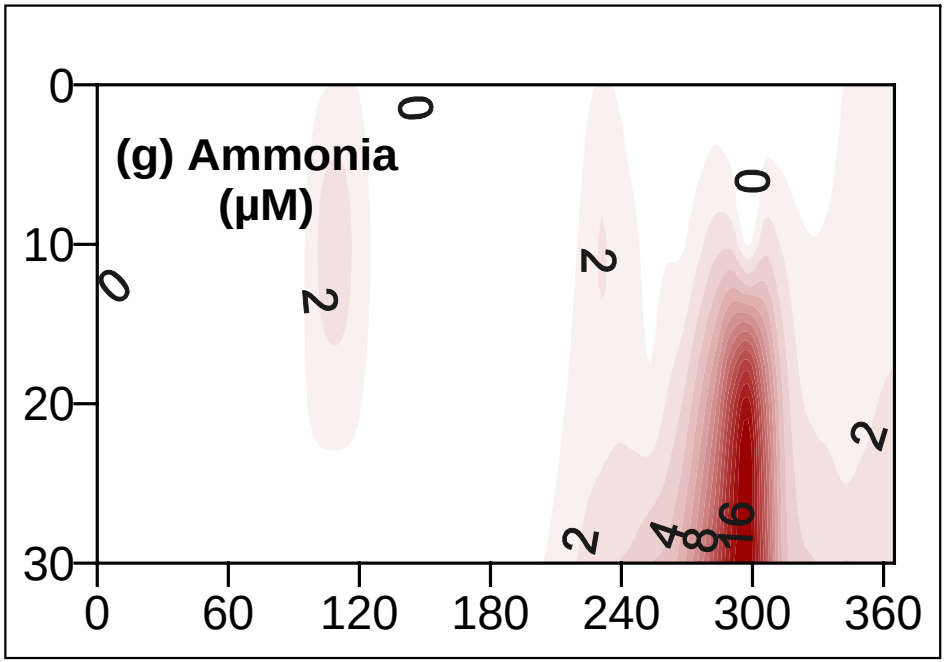
Evolution .. anoxia & H_2S..

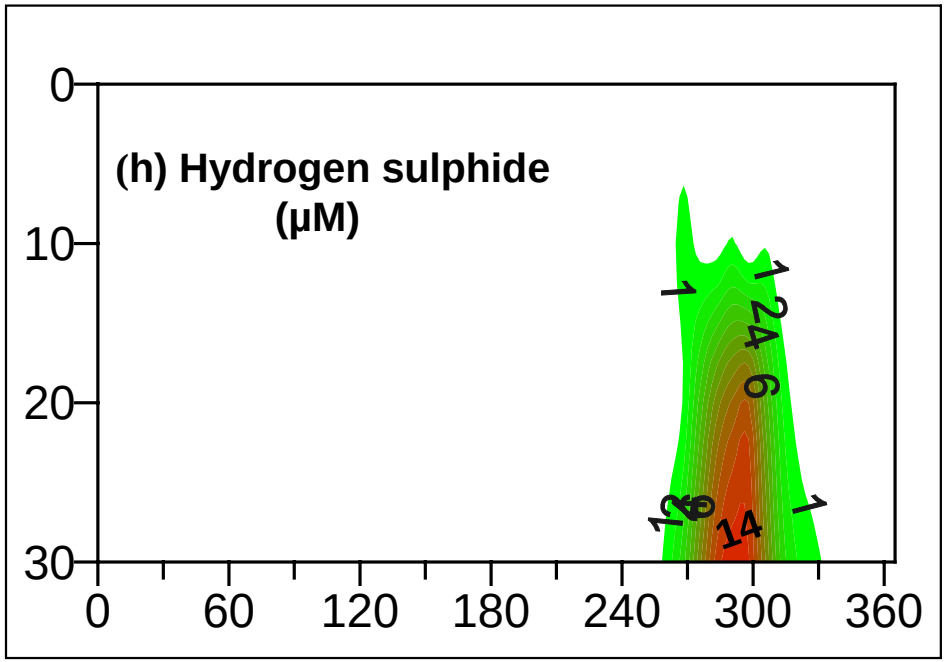


Evolution anoxia & H_2S..









Time-series observations in the northeastern Indian Ocean

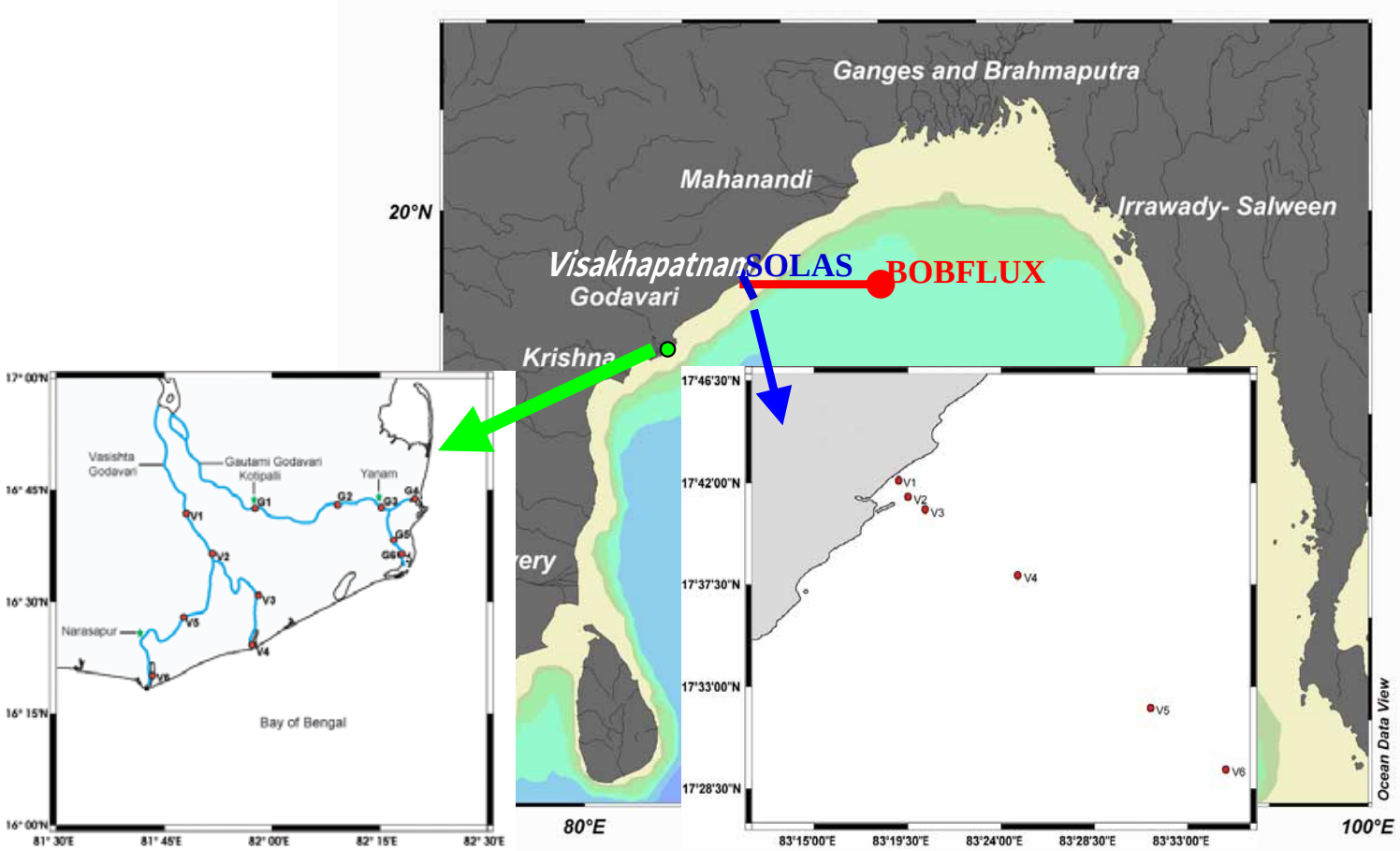


Figure1. Sampling locations in Gautami (G1 - G6) and Vasishta (V1 - V6) estuarine systems
(G1,G3 stations for pilot experiment)

Ongoing time-series projects in the east coast of India (western Bay of Bengal)

- *Biogeochemical Response of coastal waters off Visakhapatnam To extreme climatic events and human interference – Surface Ocean Lower Atmosphere Study (SOLAS) since 2006*

  Sampling at Monthly Scale

- *Bay of Bengal Carbon Flux Study (BOBFLUX) – Council of Scientific and Industrial Research (CSIR) Since 2008*

  Sampling at diurnal to seasonal Scale

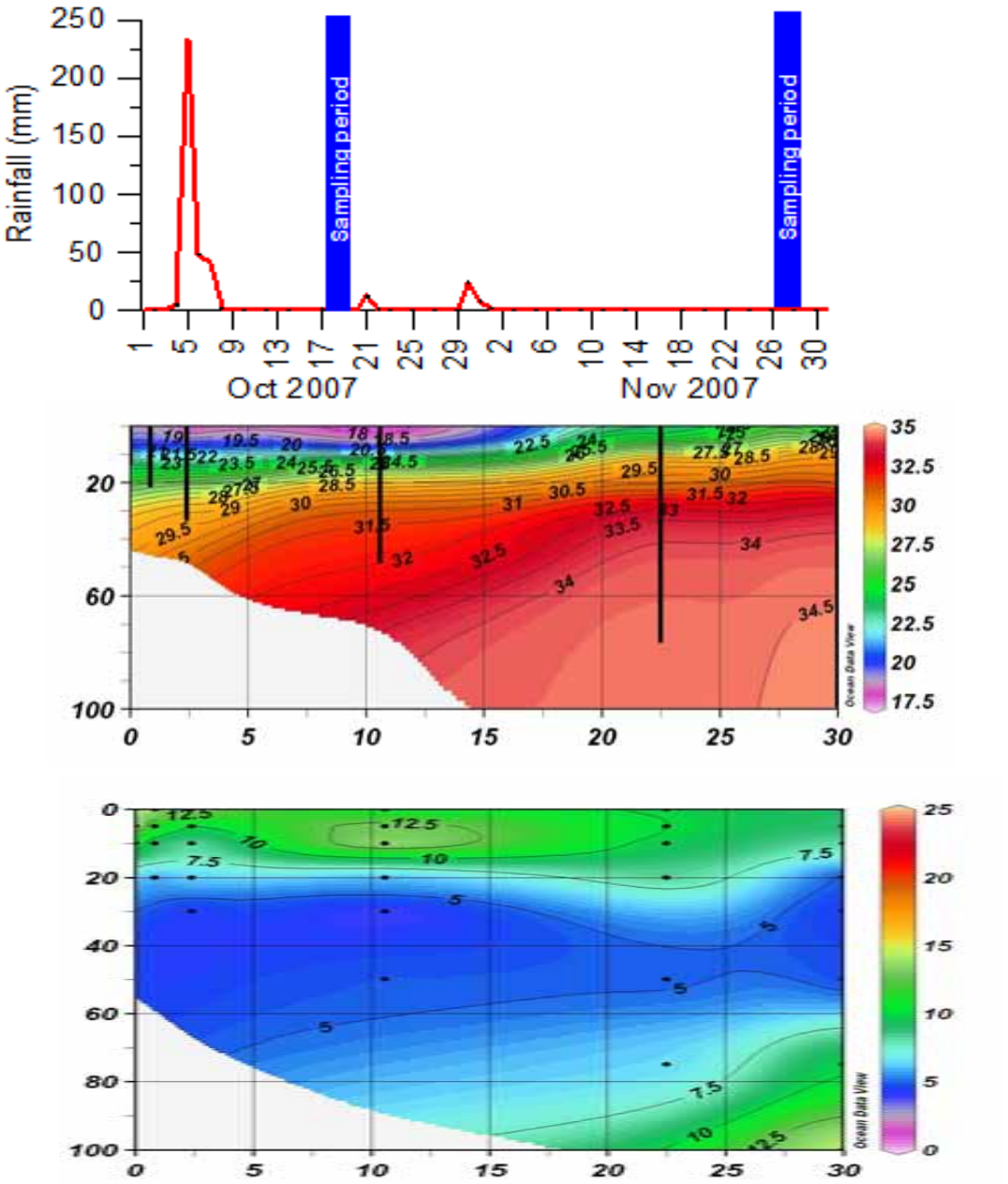
- *Variability of Ecosystem and Biogeochemistry in Godavari Estuarine System (VEBGES) – Supra Institutional Project (SIP) Of Council of Scientific and Industrial Research (CSIR) since 2007.*

  Sampling at daily Scale

- *Coastal Ocean Monitoring and Prediction system (COMPAS)- Ministry of Earth Science since 2008*

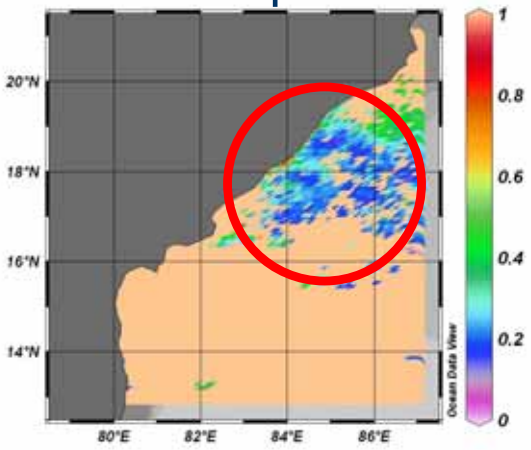
  Sampling at seasonal Scale

Impact of rainfall on biogeochemical processes

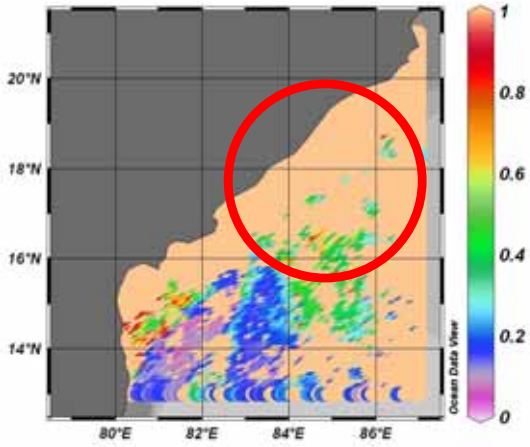


Impact of Rainfall on Chlorophyll distribution in the coastal Bay of Bengal

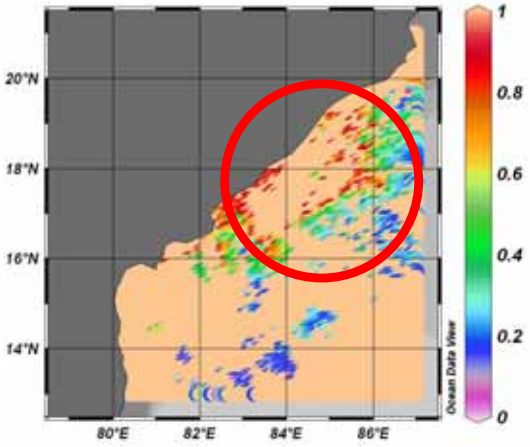
14-21 Sep 2007



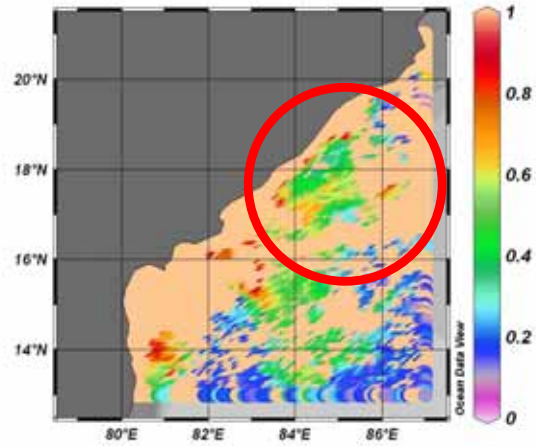
22-29 Sep 2007



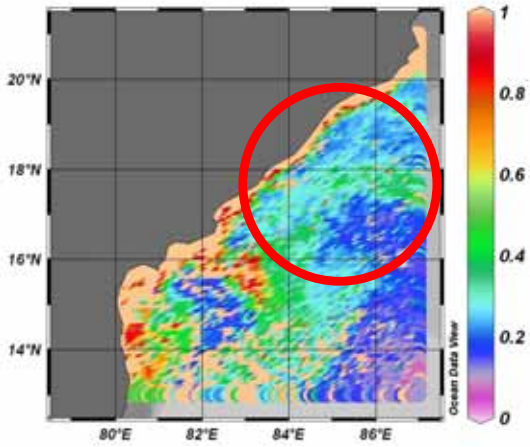
30-07 Oct 2007



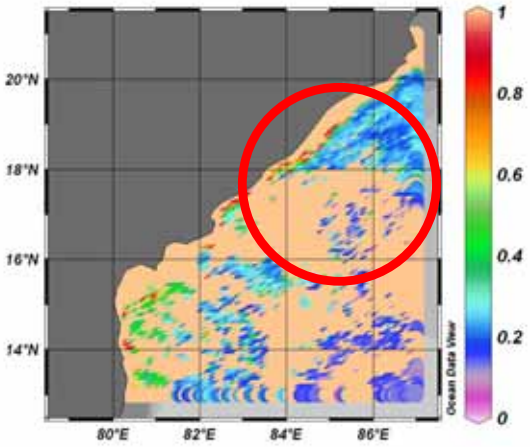
08-15 Oct 2007



16-23 Oct 2007

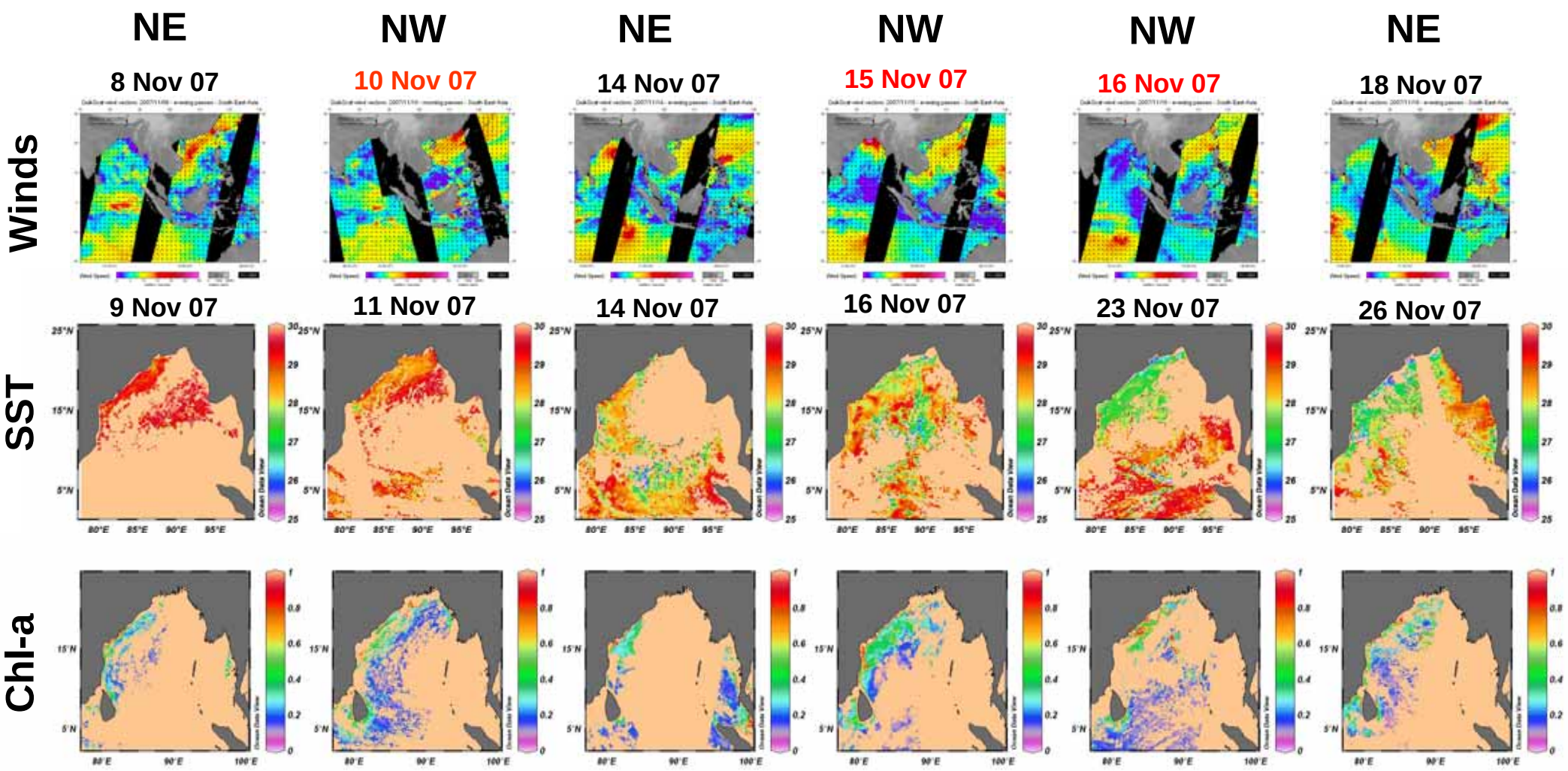


23-31 Oct 2007



***Source**: Weekly average chlorophyll-a by SeaWiFS from NASA*

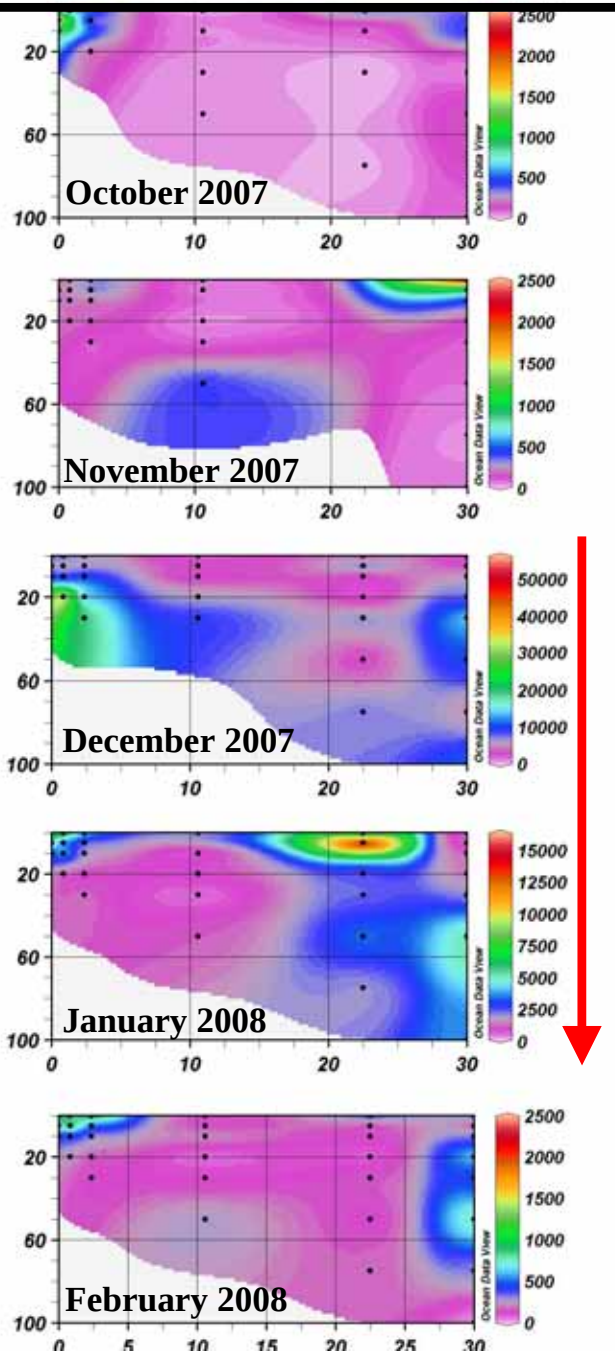
Influence of episodic atmospheric events on SST & chl-a



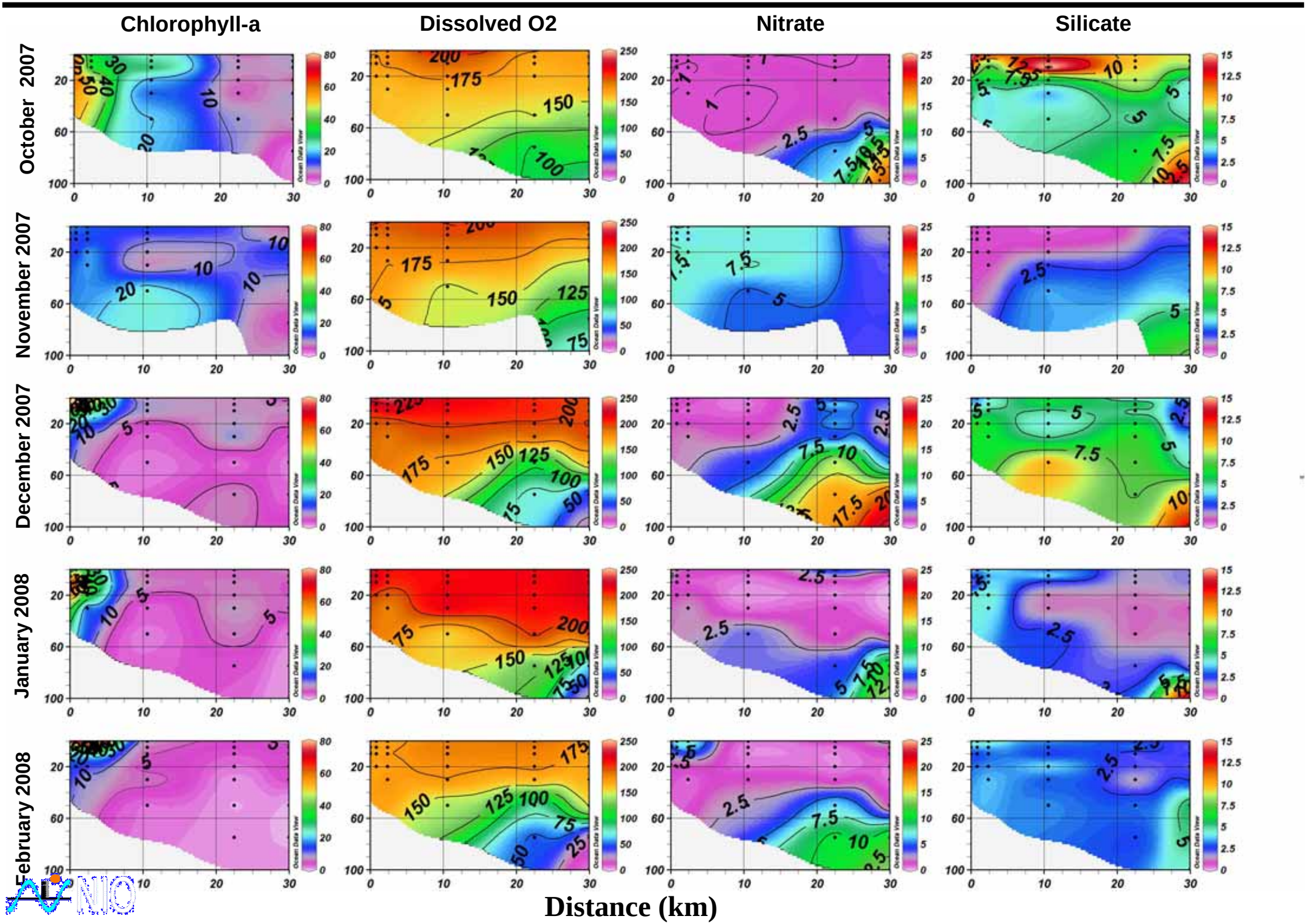
Phytoplankton production versus Bacterial Biomass

Net community Production (mmol O_2/m2/d)

Station	Oct 2007	Nov 2007	Dec 2007	Jan 2008	Feb 2008
V1	147.2	137.8	699.7	260.30	297.9
V2	246.2	27.3	659.3	142.50	356.9
V4	61.8	40.9	2.5	0.60	-93.8
V6	97.7	75.8	-42.9	-78.8	-134.8



Formation of sub-oxic conditions in the Shelf waters



Variability of Ecosystem and Biogeochemistry in Godavari Estuarine System (VEBGES)

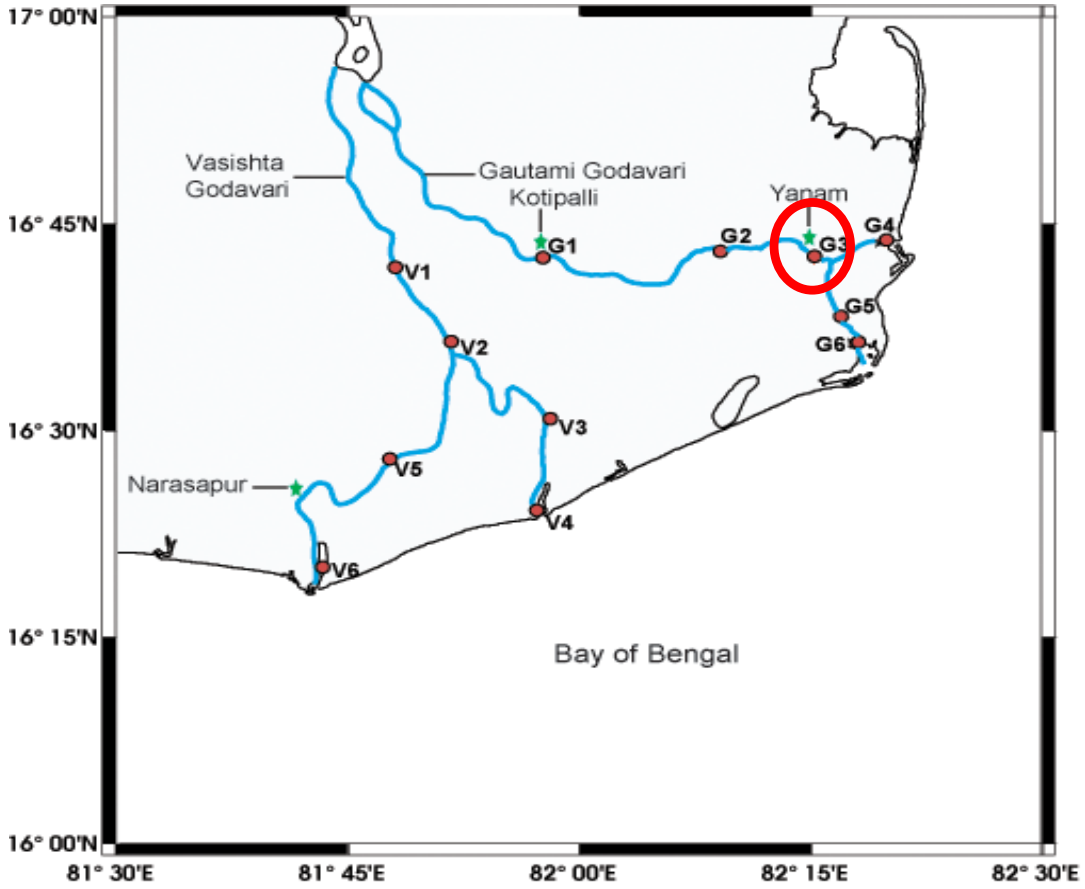
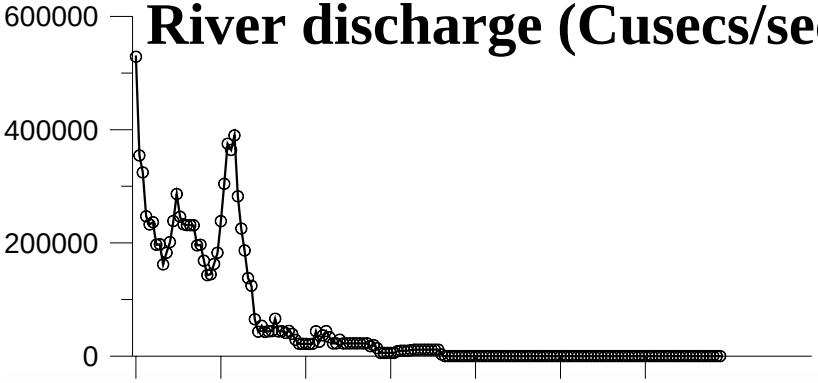


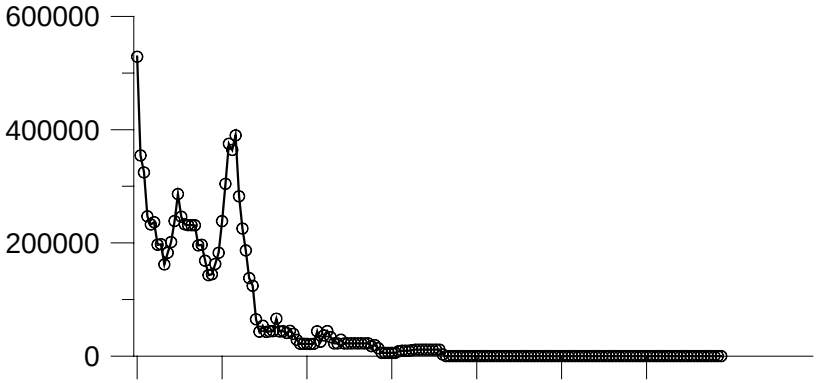
Figure1. Sampling locations in Gautami (G1 - G6) and Vasishta (V1 - V6) estuarine systems

(G1,G3 stations for pilot experiment)

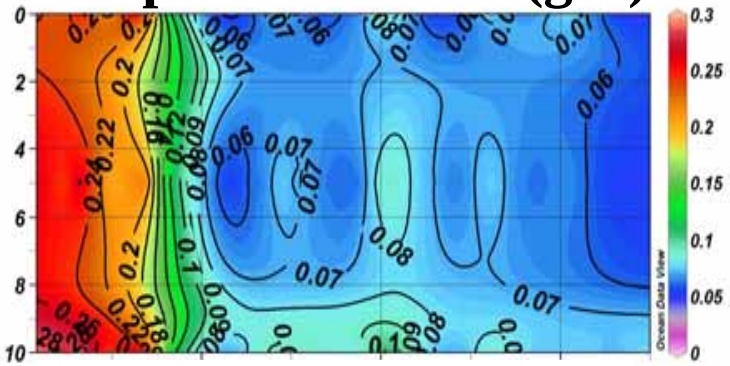
Time-series variations in Godavari Estuary

River discharge (Cusecs/sec)

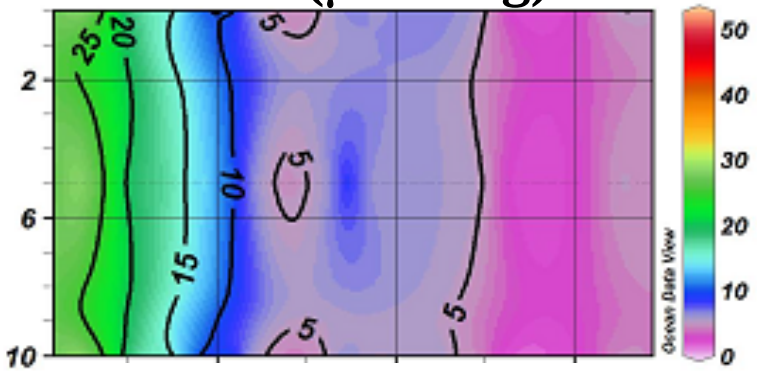




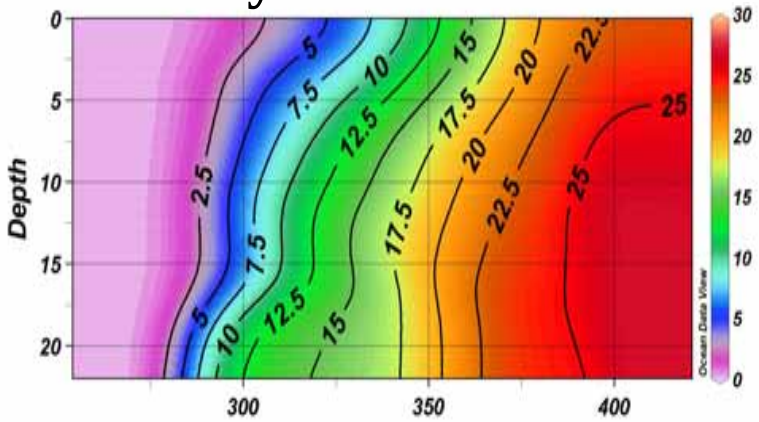
Suspended matter (g/L)



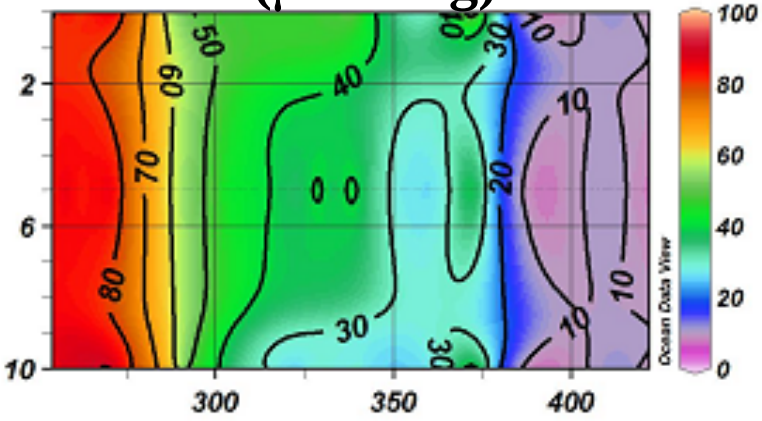
Nutrients (µmol/kg)



Salinity



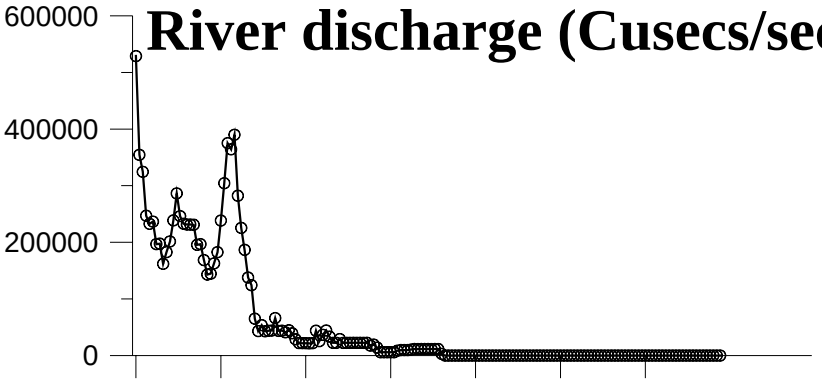
Silicate (µmol/kg)

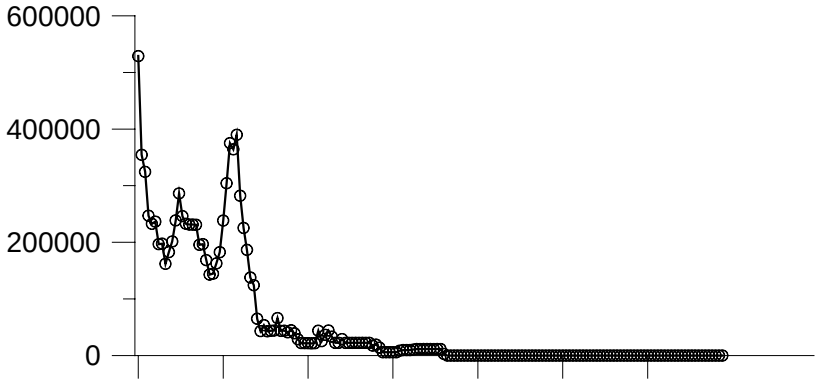


Julien Days (Sep 07-Feb 08)

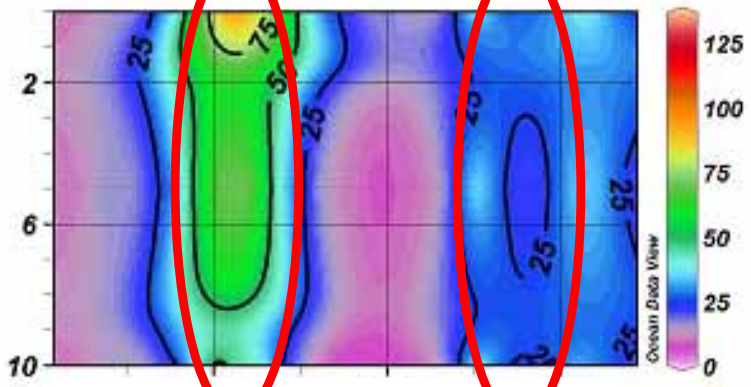
Time-series variations in Godavari Estuary

River discharge (Cusecs/sec)

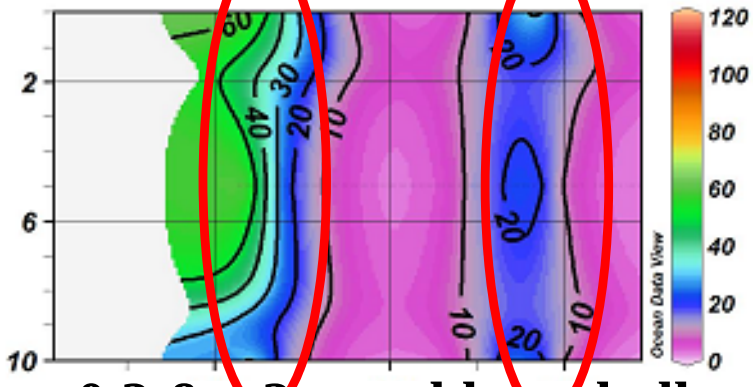




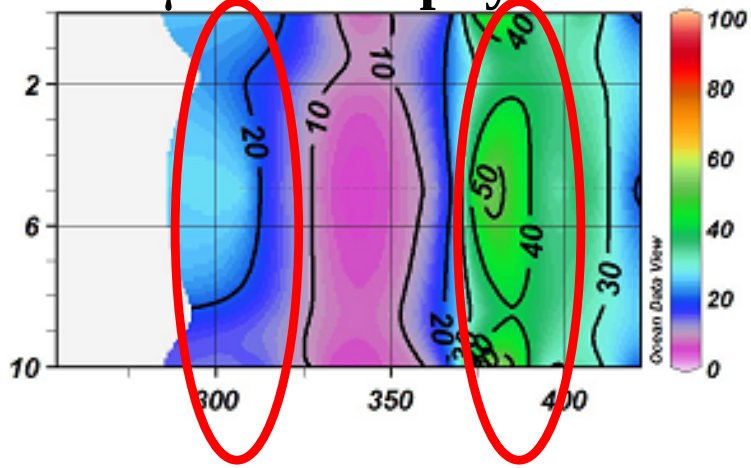
Bulk chlorophyll



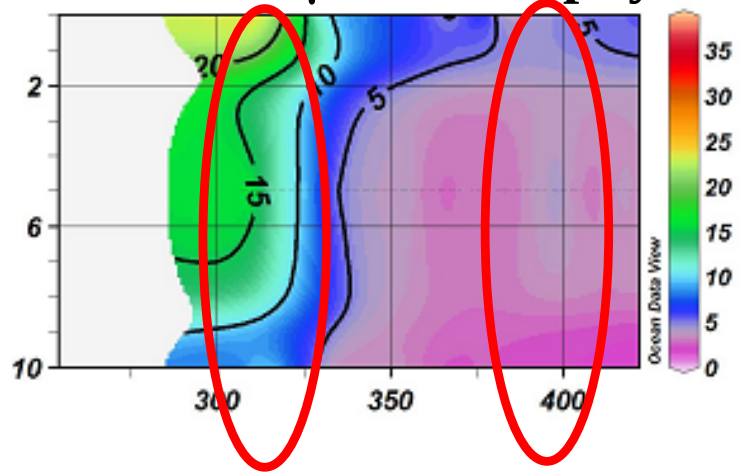
>2 & <10 μm chlorophyll



>10 μm chlorophyll



>0.2 & <2 μm chlorophyll

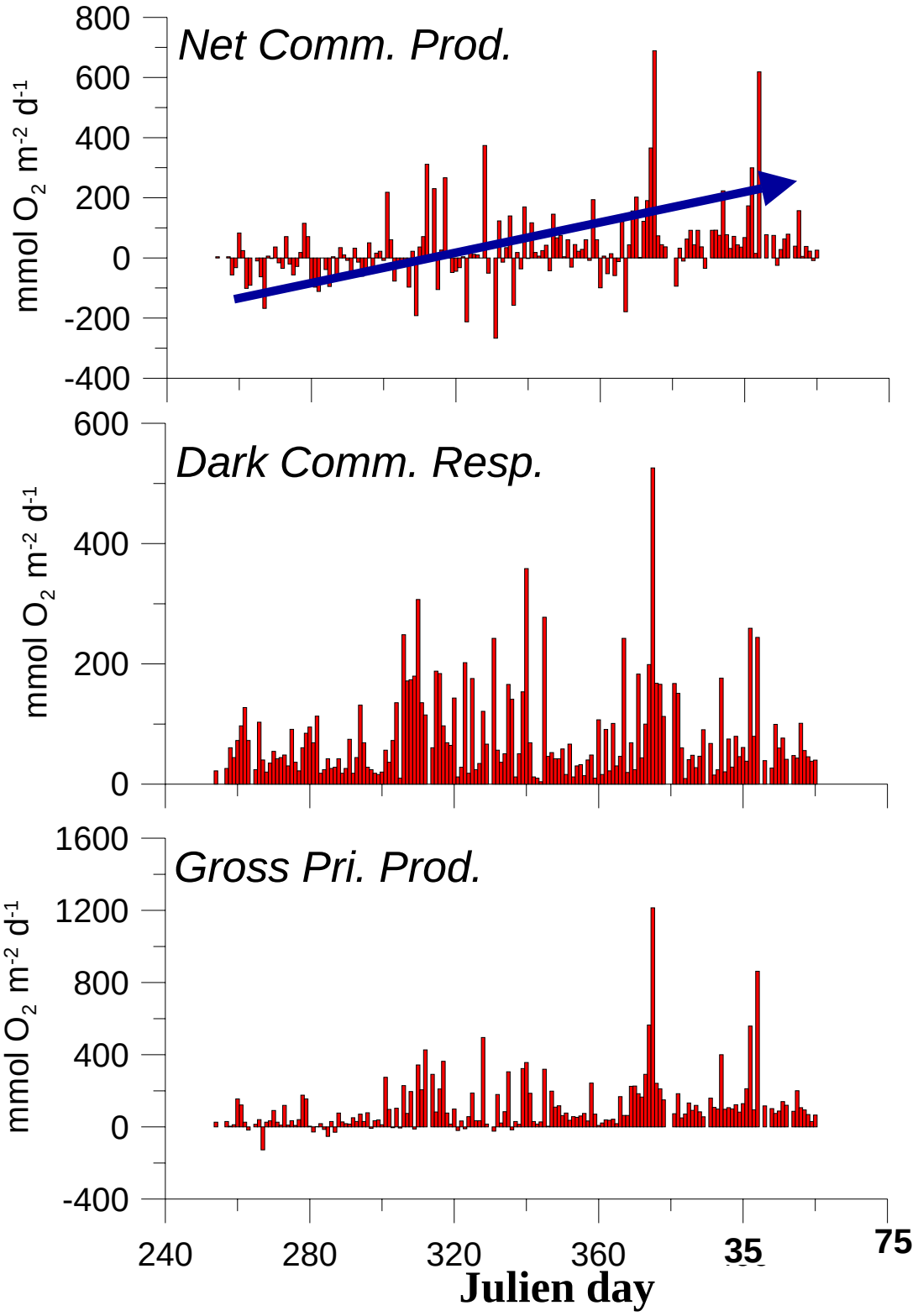


Julien Days (Sep 07-Feb 08)

Rates of changes in salinity and nutrients in Godavari Estuary

Parameter	Rate of change per day
Salinity	+0.2 psu
Dissolved O2	+0.2 μmol/kg
Nitrate	-0.1 μmol/kg
Phosphate	-0.01 μmol/kg
Silicate	-0.4 μmol/kg

Time-series variations in plankton metabolic rates in Godavari estuary



Heterotrophy ➔ Autotrophy

2 fold increase in Production

~65% of the GPP is respired

Future plans:both coastal & estuary time-series stations

Time-series measurements of triple oxygen isotopes and O_2/Ar ratios in the surface ocean

Time-series measurements of inorganic carbon parameters

Measurements of $\delta^{13}C$, $\delta^{15}N$ of dissolved and particulate (both organic & Inorganic)

Processing HPLC and DOC samples and isotopic ratios of $\delta^{13}C$ of DOC

Phytoplankton growth and grazing rates (once in a week!!)

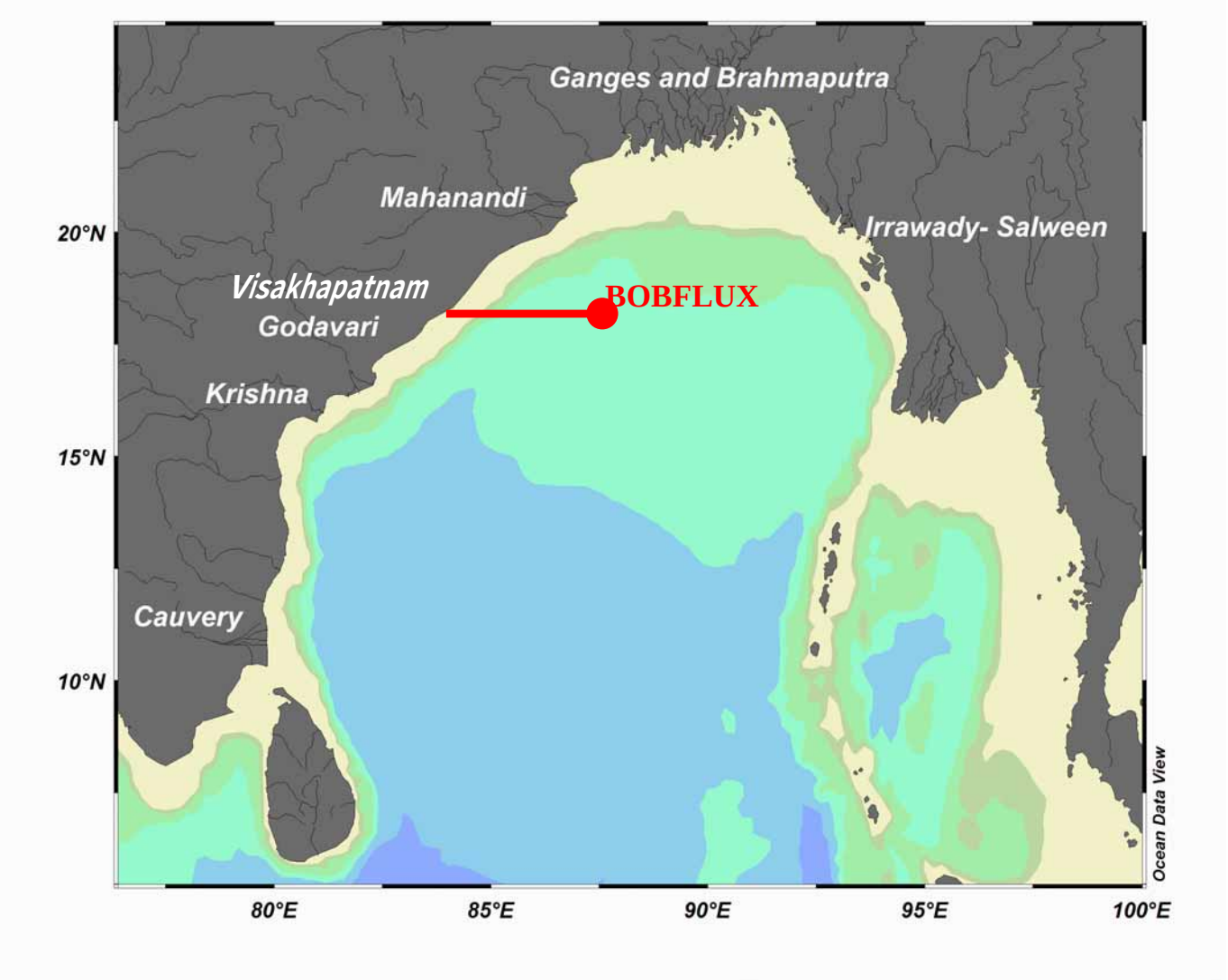
Nutrients utilization rates (once in a week!!)

Bacterial respiration rates (Unisense sensor)

Consumption and exchanges rates of carbon at the Benthic boundary

Water exchange rates using Radon isotopes.

Bay of Bengal Carbon Flux Study (BOBFLUX)



Objectives of Bay of Bengal Carbon Flux Study (BOBFLUX)

1. What is the short-term to inter-annual variability in plankton metabolic rates such as gross and net community production, and community respiration?

2. How river inputs influence the plankton metabolic rates?

3.What is the influence of cyclones on nutrient injections, primary production and air-sea exchange of trace gases?

4. What is the seasonal to inter-annual variability in export production?

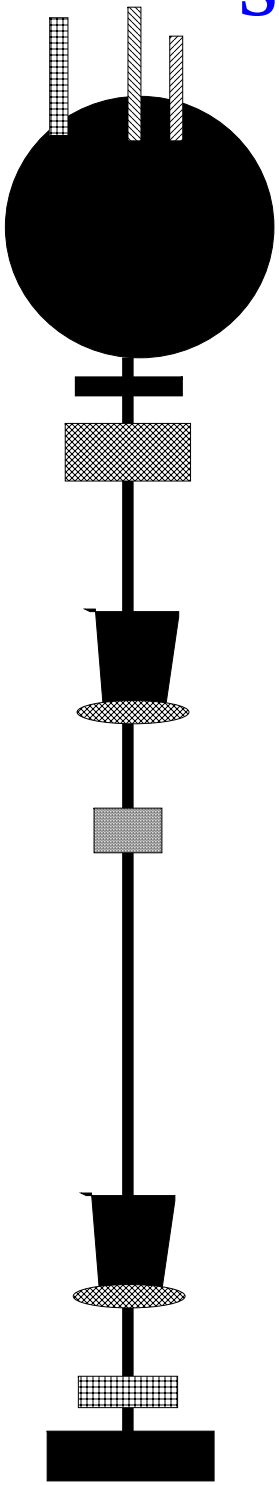
5. What is the relationship between primary and export production?

6. What is the influence of river runoff on bacterial growth rates and respiration?

7. What are the seasonal variations in transfer velocities of trace gases?

8. What are the temporal and spatial variations in the air-sea exchange of trace gases?

Schematic of mooring in the Bay of Bengal



Meteorological Buoy

Optode/current meter (20 m)
Remote Access Sampler (30 m)

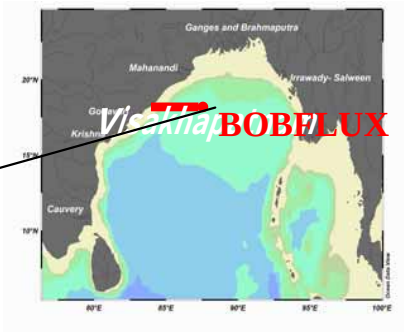
Floating sediment
Traps – sampling
Once in 3 months

Sediment trap (150 m) – Weekly sampling

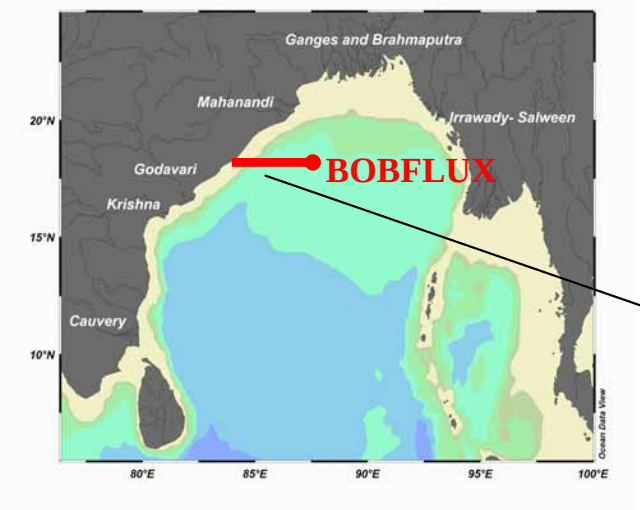
Optode/current meter (500 m)

Sediment trap (1700 m) – Weekly sampling

ADCP (1800 m)
Bottom (2000 m)



Time-series transect observations



Sampling : Bi-monthly
Starts from September 2008

➔ 0.25° water column sampling for biogeo-chemical parameters – nutrients, chl-a, HPLC, DIC, TA, pH, DOC, SSM, O2 isotopes, O2/Ar, Plankton composition etc.

➔ Underway pCO2 system, SST,SSS, Chl-a, & dissolved O2

➔ Underway plankton metabolic rates by triple oxygen isotopes & O2/Ar

➔ Isotopic ratios of $\delta^{13}C$-DIC, DOC of dissolved $\delta^{13}C$ & $\delta^{15}N$ of particulate matter

Thank You