

Nitrogen assimilation and f-ratios in the Indian Ocean



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Aim:

- To estimate the new production in the Indian Ocean using ^{15}N isotope to assess the carbon fixing capability of the region and its role in carbon cycle.**
- To estimate the Primary Productivity using Remote Sensing data (IRSP4 OCM) and use the above results to get new production estimates.**

Cruises Participated

Arabian Sea:

November 2001 (SK-176)

Northeast monsoon - 1-20th January 2003 (SK-186)

- 28th February- 5th March 2003 (SS-212)

Bay of Bengal:

Post-monsoon - 17th September-11th October 2002 (SK-182)

Pre-monsoon - 16th April-6th May 2003 (SK-191)

Southern Indian Ocean:

Late Austral Summer- 25th Jan – 1st April 2006

$$\text{PRIMARY PRODUCTION} = \text{NEW PRODUCTION} + \text{REGENERATED PRODUCTION}$$

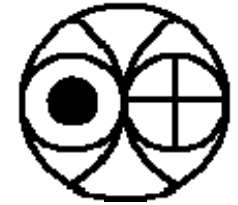
(Dugdale and Goering; 1967)

$$\text{f-ratio} = \text{NEW PRODUCTION} / \text{TOTAL PRODUCTION}$$

Averaged over time (annual)

$$\text{New Production} = \text{Export Production}$$

(Eppley and Peterson; 1983)



$$\text{Uptake rate (mmol N/I/hr)} = ({}^{15}\text{N}_{\text{xs}} * \text{PON}) / ({}^{15}\text{N}_{\text{enr}} * T)$$

where, ${}^{15}\text{N}_{\text{xs}}$ = Excess ${}^{15}\text{N}$ in post incubation sample

PON = Particulate nitrogen content of sample
(nmol/I)

${}^{15}\text{N}_{\text{enr}}$ = ${}^{15}\text{N}$ enrichment in dissolved fraction

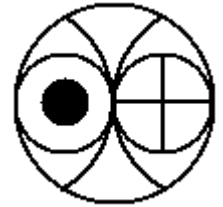
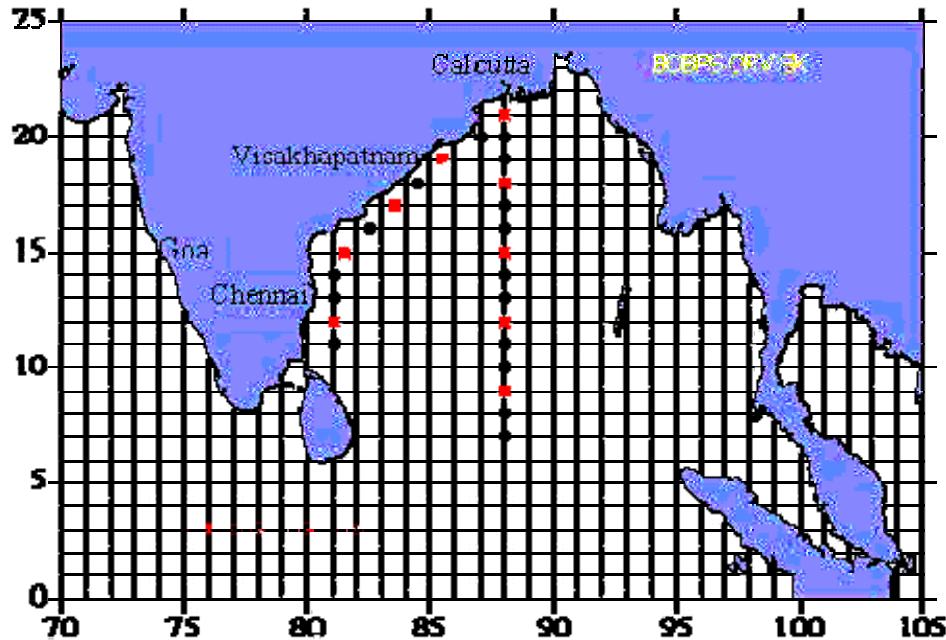
T = Time of incubation in hrs.

(Dugdale and Wilkerson 1986)

Conversion in terms of Carbon using Redfield ratio
($1\text{mmol N m}^{-2} \text{ d}^{-1} \sim 80\text{mgC m}^{-2} \text{ d}^{-1}$)

CRUISE DETAILS

Bay of Bengal Process Studies



SK-182 and SK-191

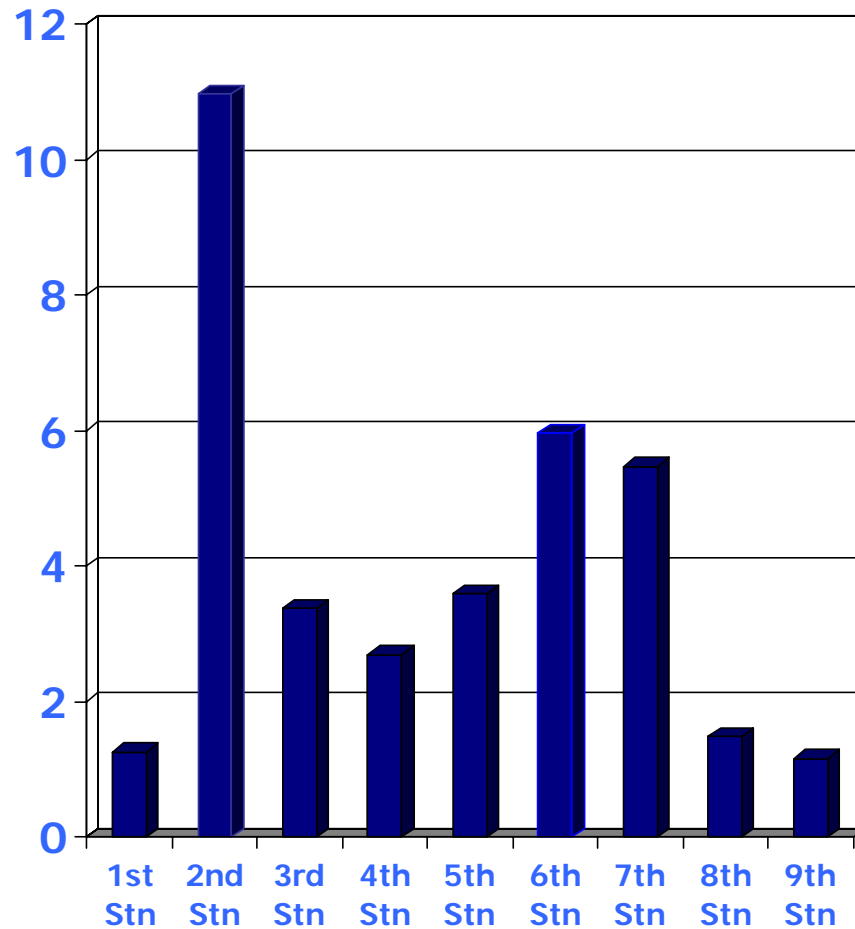
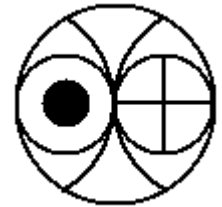
Period: Sep-Oct 2002 and Apr-May 2003

9 PP Stations – ^{15}N Experiments were performed (Red dots)

24 CTD stations – Samples were collected to assess natural variability in the nitrogen isotopic composition of phytoplankton.

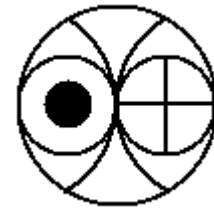
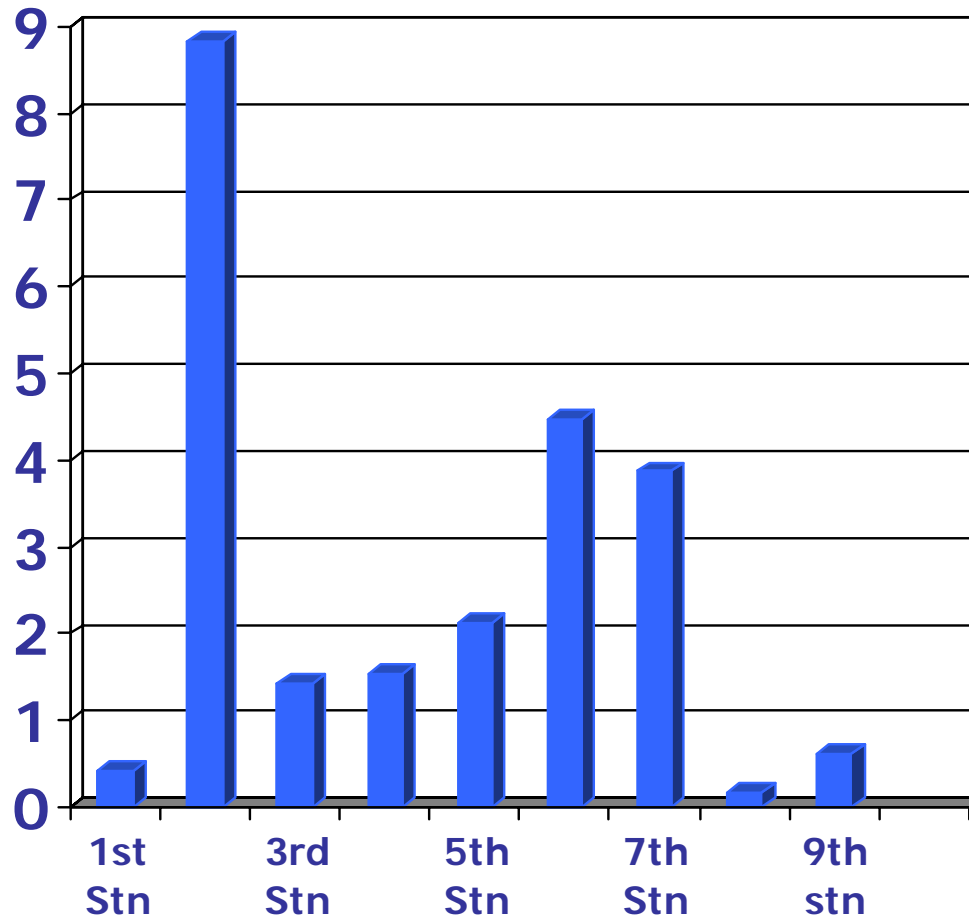
Column Production during Post monsoon 2002

(mmol N m⁻² d⁻¹)



Overall Average ~ 4mmolN m⁻² d⁻¹

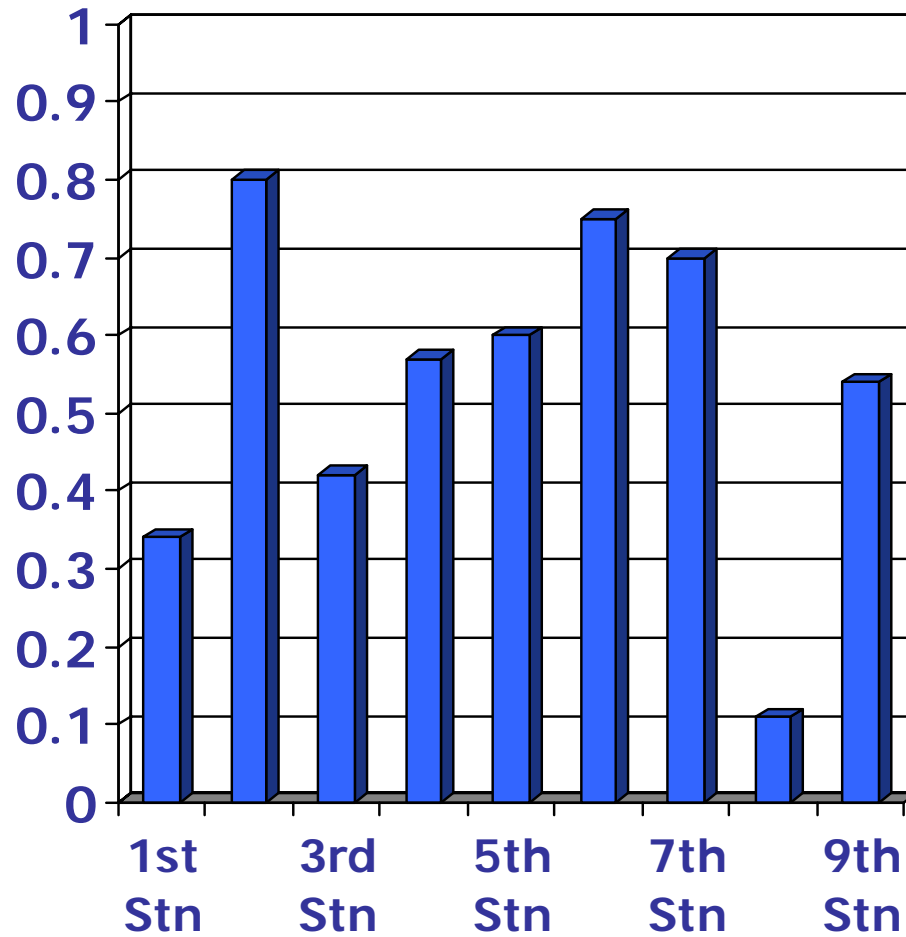
New Production during Post-monsoon 2022 ($\text{mmol N m}^{-2}\text{d}^{-1}$)



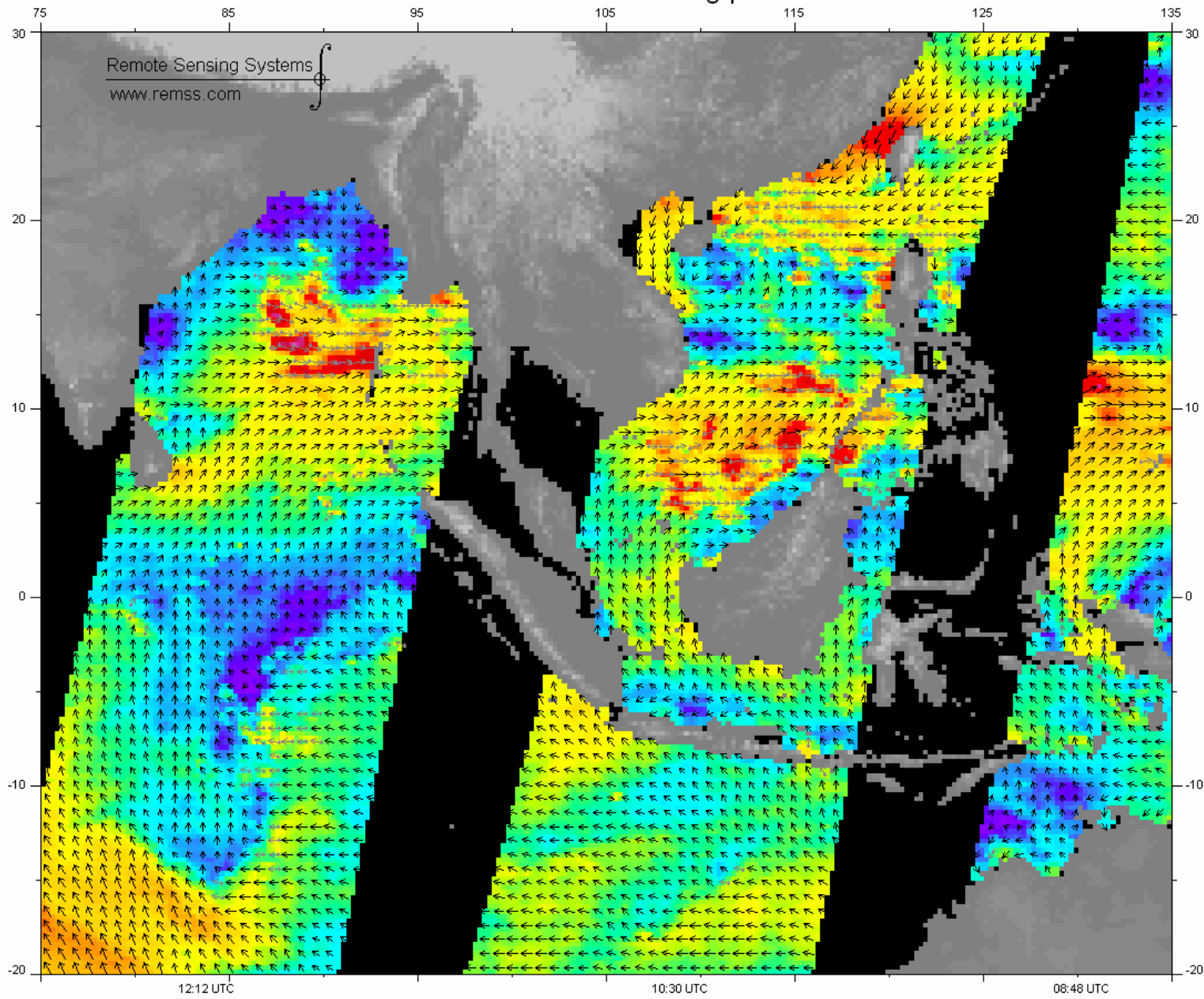
 Nitrate

Average $\sim 2.6\text{mmol N m}^{-2}\text{ d}^{-1}$

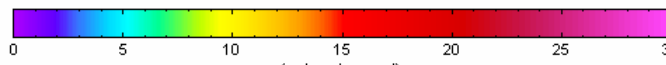
f-ratio during post-monsoon 2002 in the Bay of Bengal



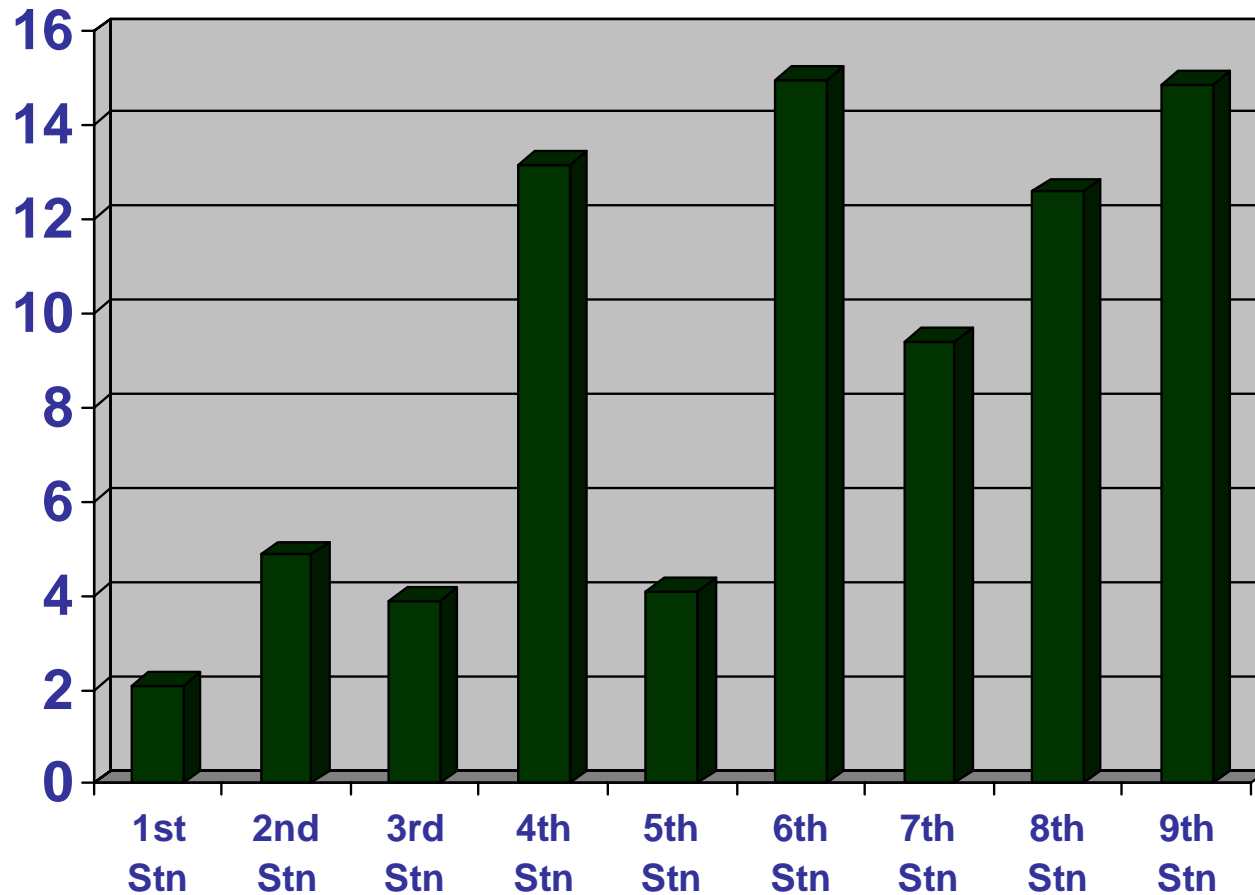
QuikScat wind vectors: 2002/09/17 - evening passes - South East Asia



Wind Speed:



Column Production during Pre-monsoon 2003 in the Bay of Bengal ($\text{mmol N m}^{-2} \text{d}^{-1}$)

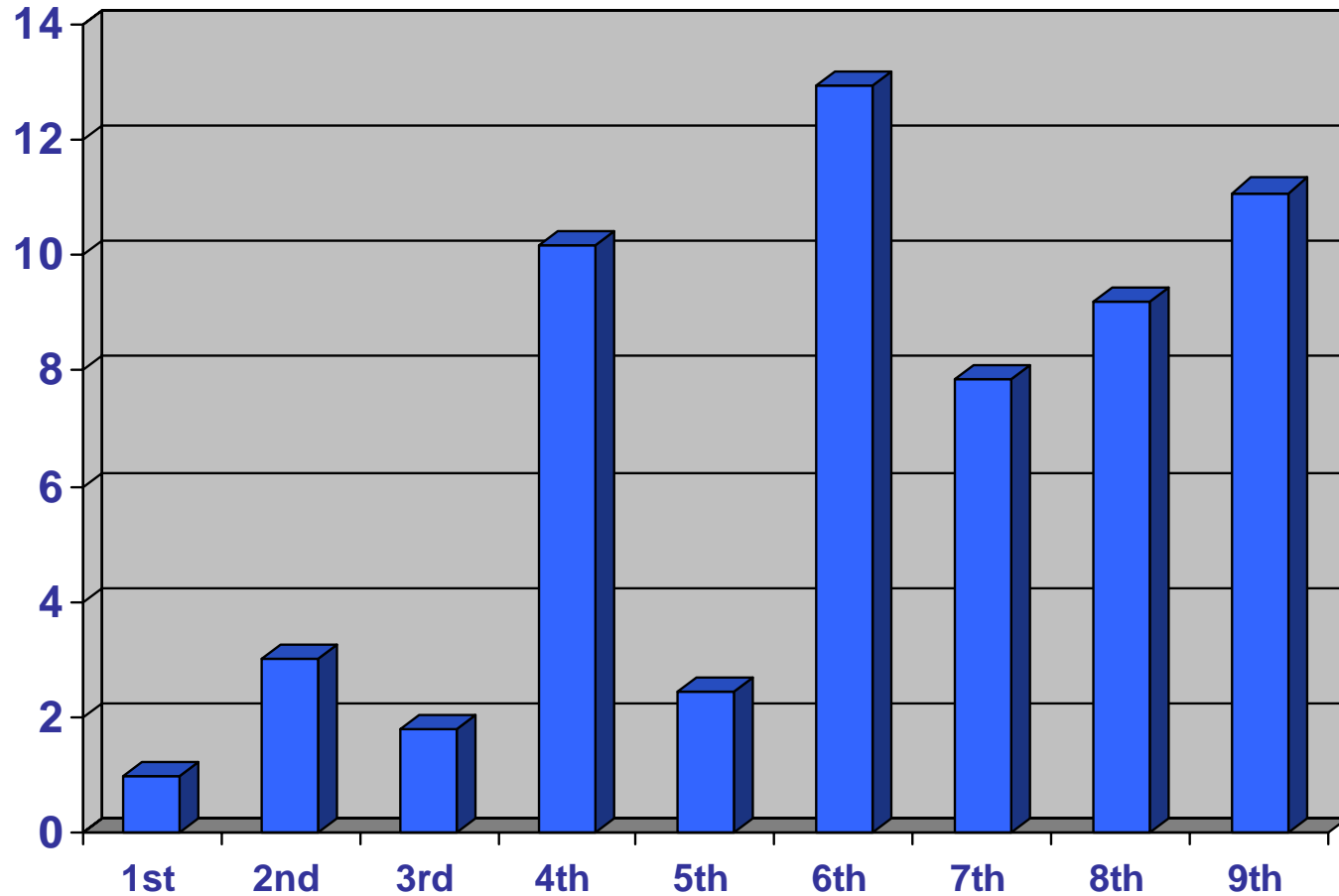


Overall Average $\sim 9 \text{ mmol Nm}^{-2}\text{d}^{-1}$

Open Ocean $\sim 6 \text{ mmol Nm}^{-2}\text{d}^{-1}$

Coastal $\sim 11 \text{ mmol Nm}^{-2}\text{d}^{-1}$

New Production during Pre-monsoon 2003 in the Bay of Bengal ($\text{mmol N m}^{-2} \text{d}^{-1}$)



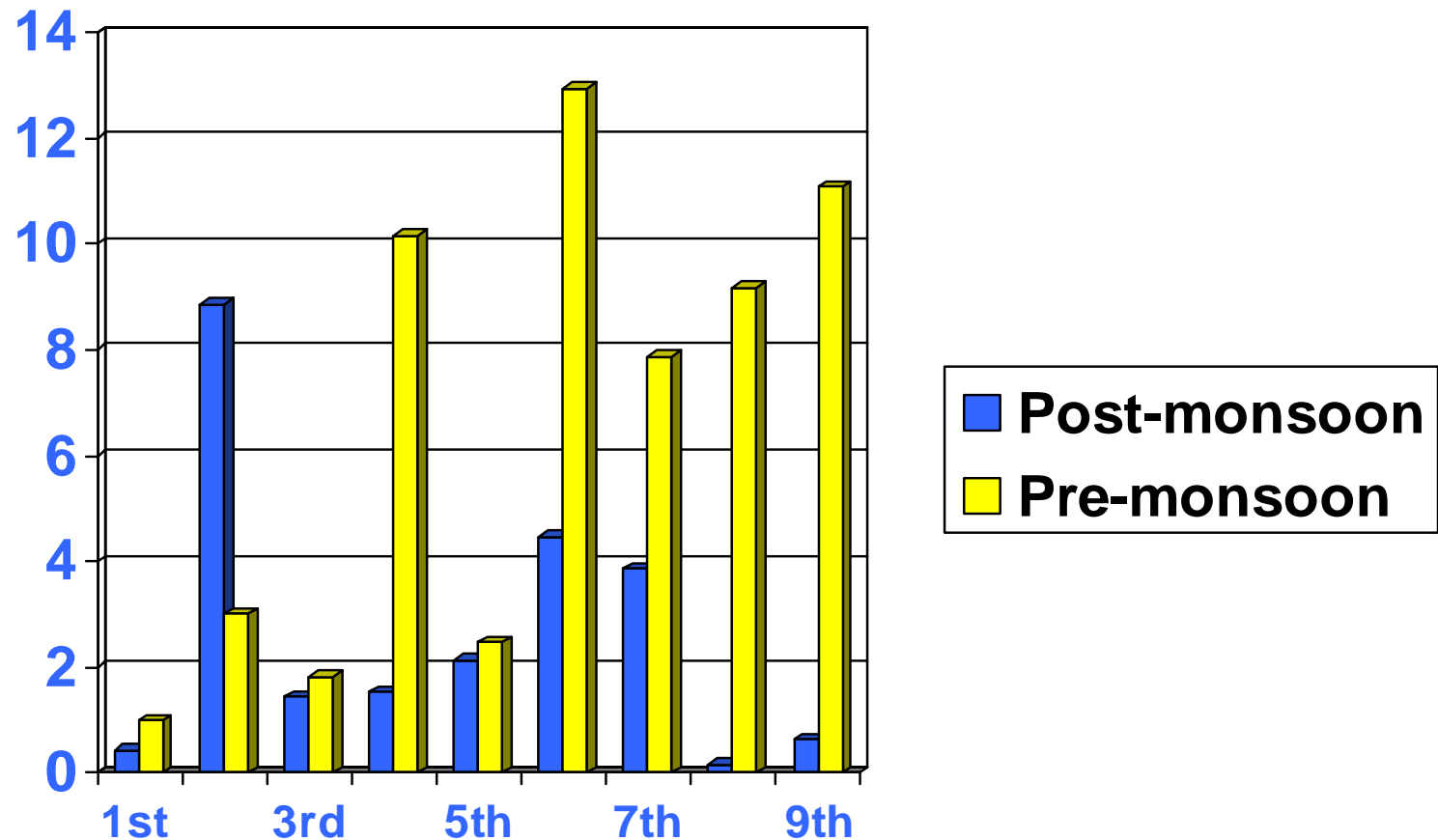
Overall Average $\sim 6 \text{ mmol N m}^{-2} \text{d}^{-1}$

Open Ocean $\sim 4 \text{ mmol N m}^{-2} \text{d}^{-1}$

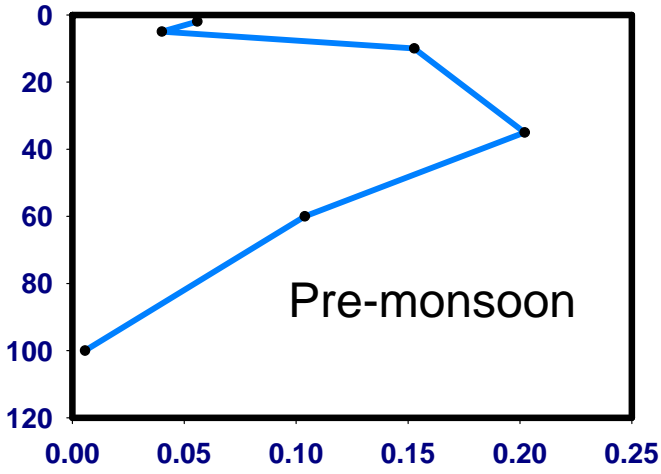
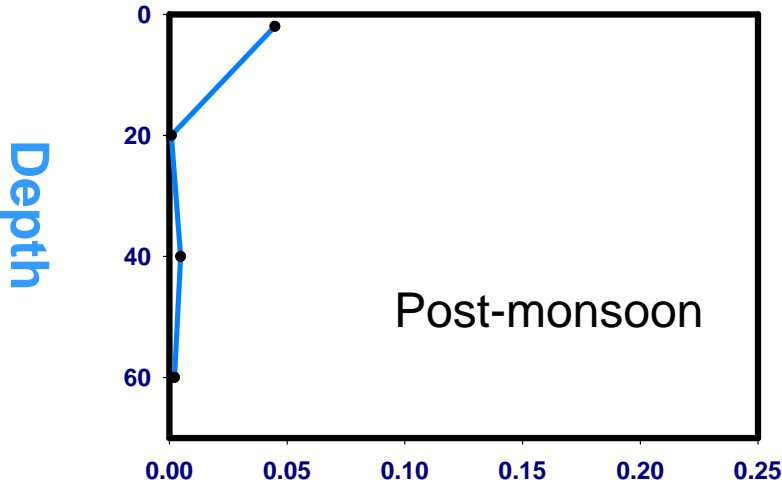
Coastal $\sim 8 \text{ mmol N m}^{-2} \text{d}^{-1}$

Station

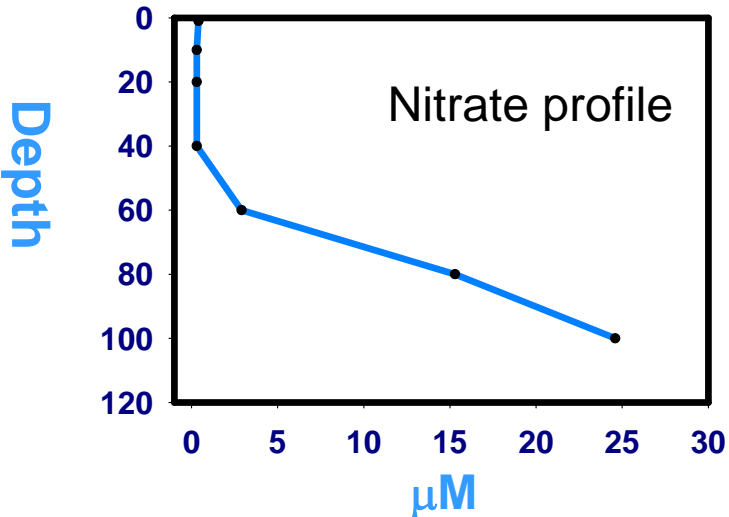
Comparison of New Production during post and Pre-monsoon in the Bay of Bengal ($\text{mmol N m}^{-2} \text{d}^{-1}$)



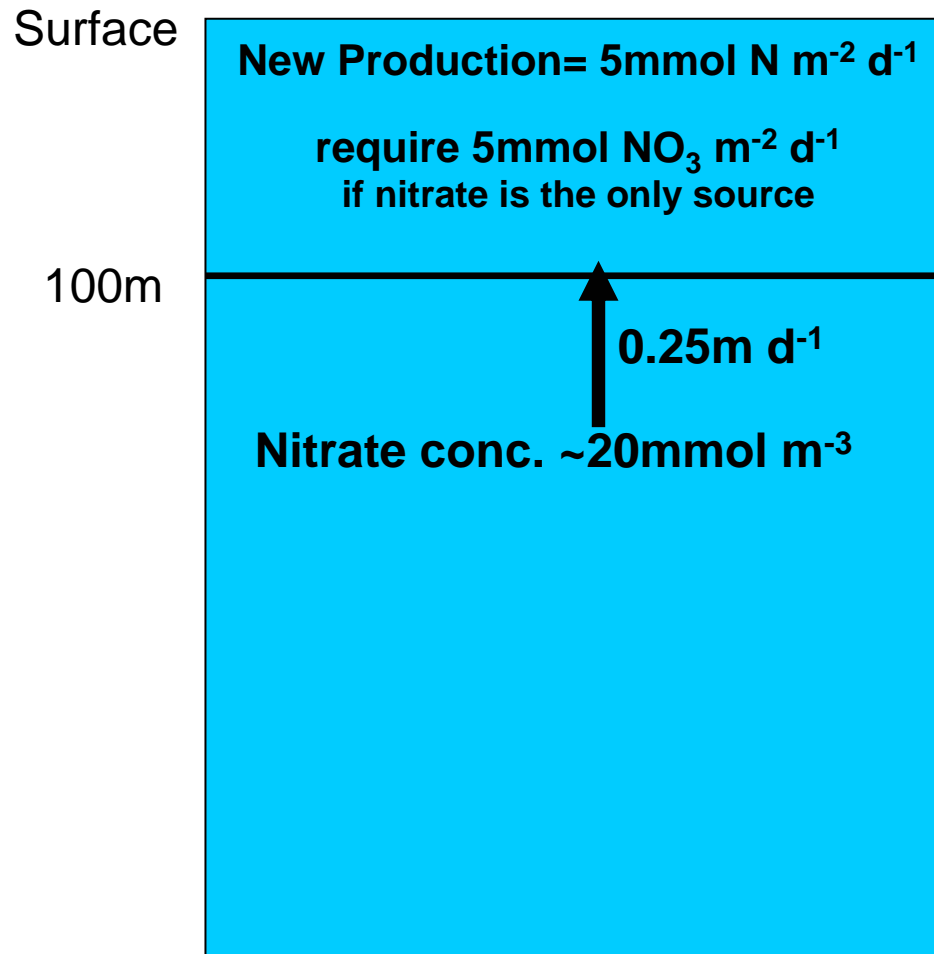
Comparison of uptake pattern during pre-and post-monsoon in the BOB



mmol N m⁻³ d⁻¹

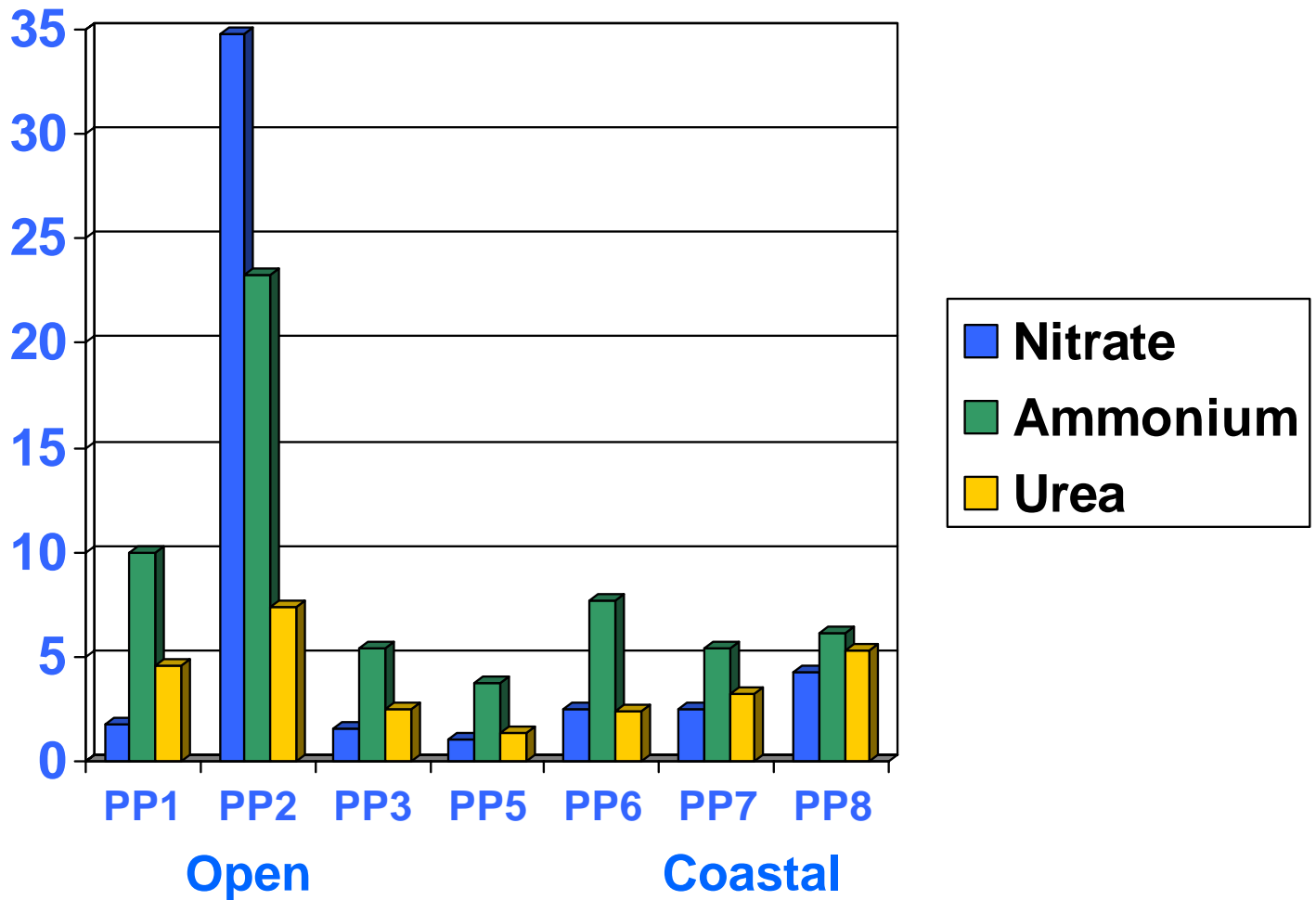


μM

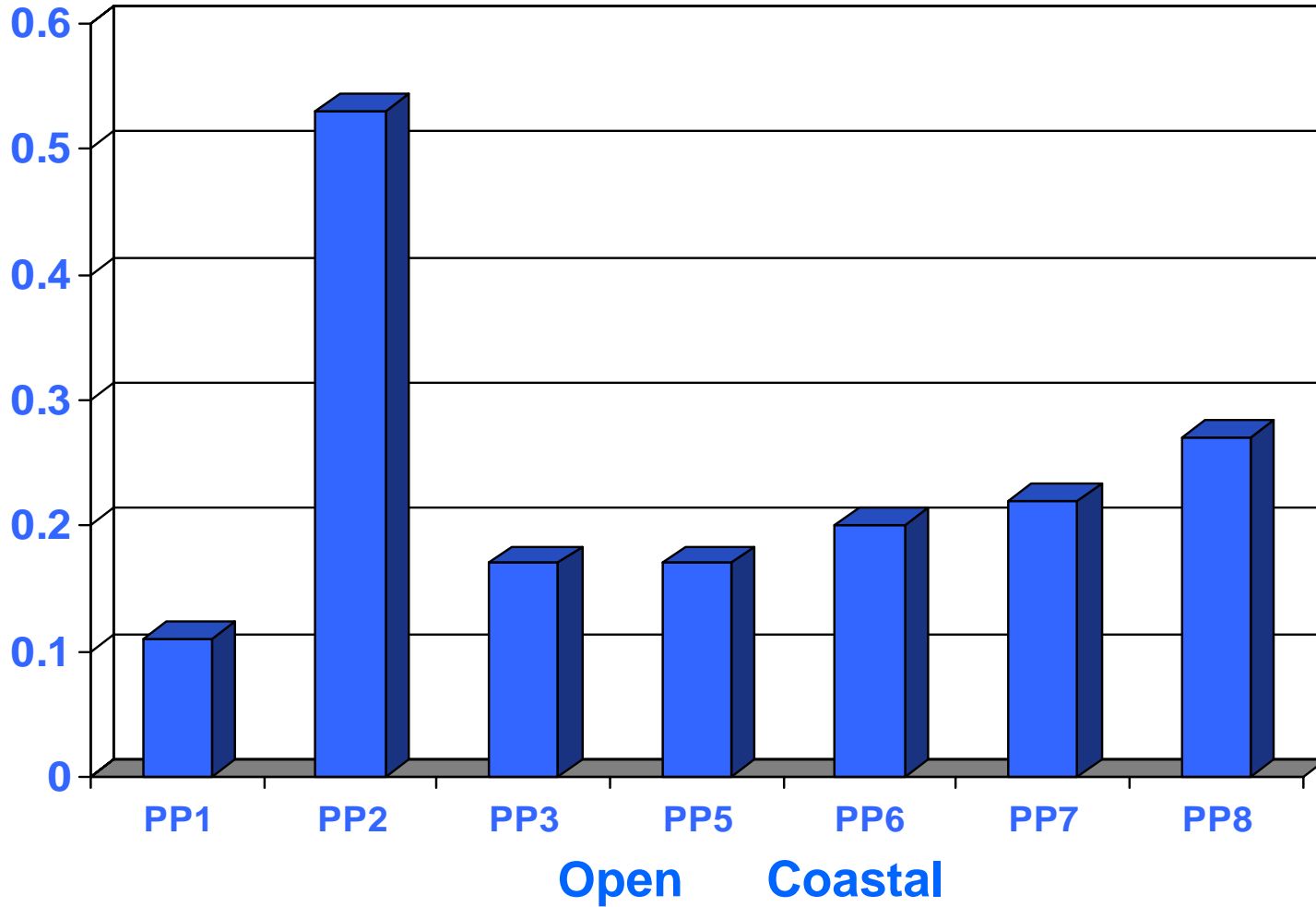


Pumping rate of around 0.9 m d^{-1} is known during November in the BOB (vinaychandran and Matthew; 2003)

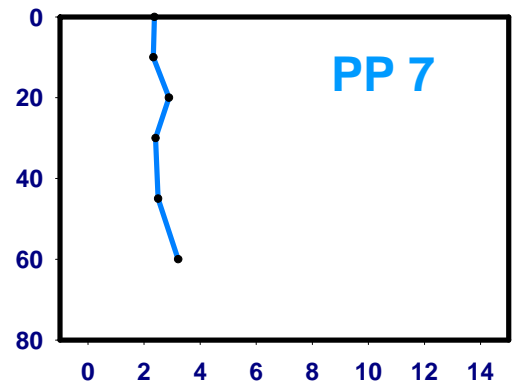
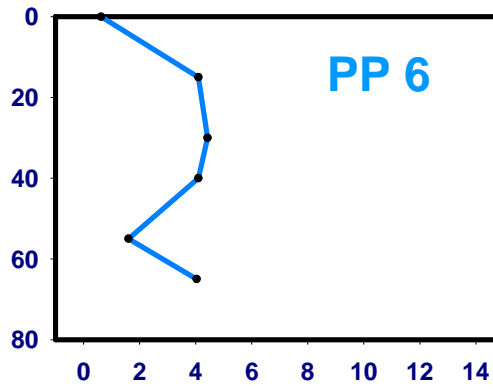
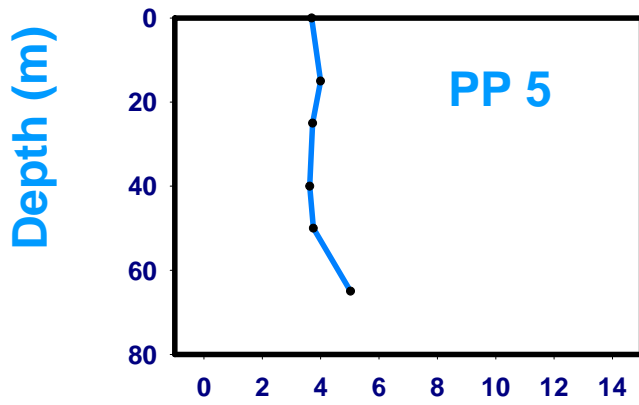
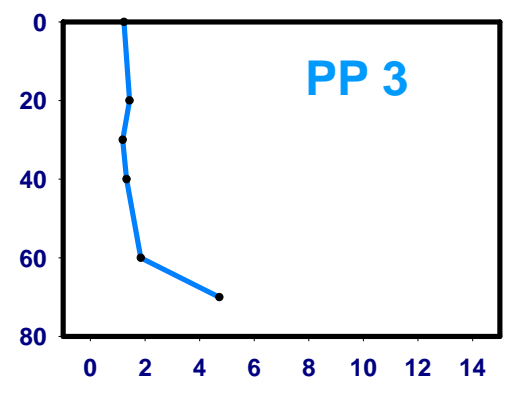
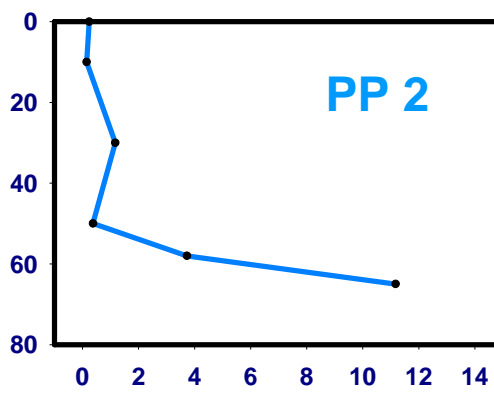
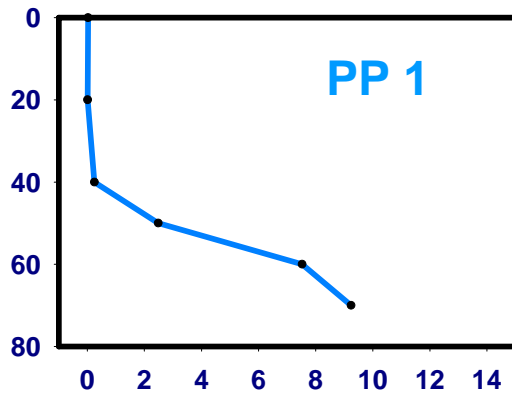
New and Regenerated production during January 2003 ($\text{mmol N m}^{-2} \text{d}^{-1}$) in the Arabian Sea



f-ratio during the month of January 2003 in the Arabian Sea

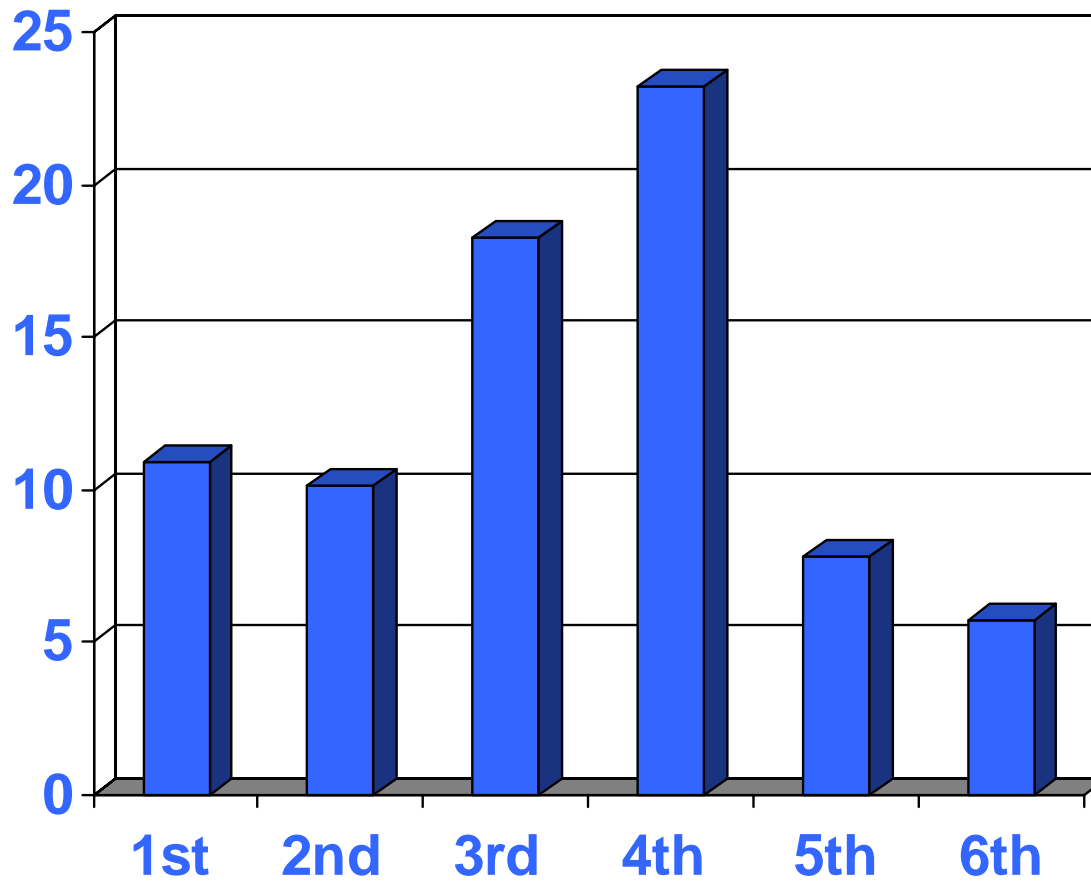


Vertical profiles of nitrate during January 2003 (SK-186)

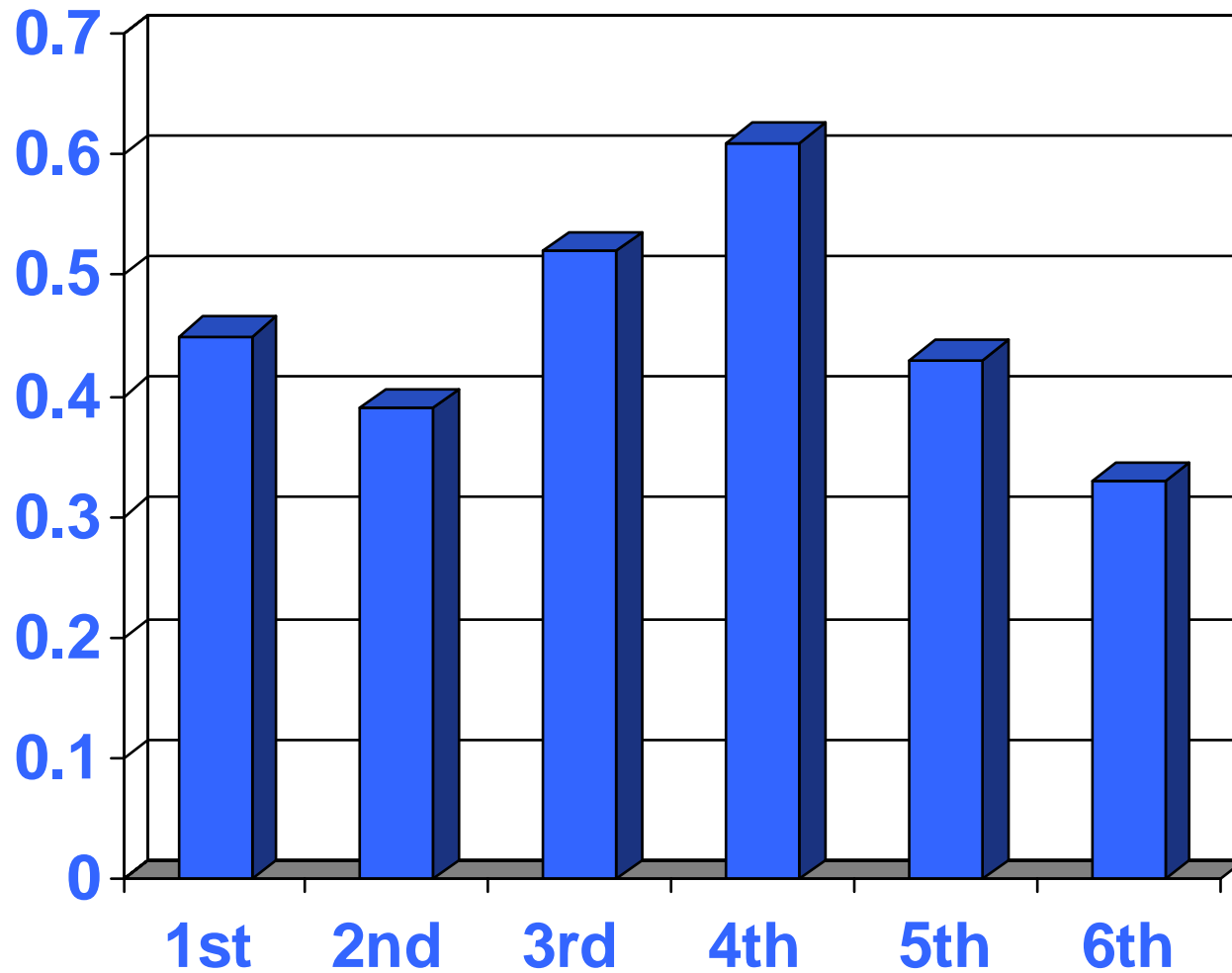


Nitrate (μM)

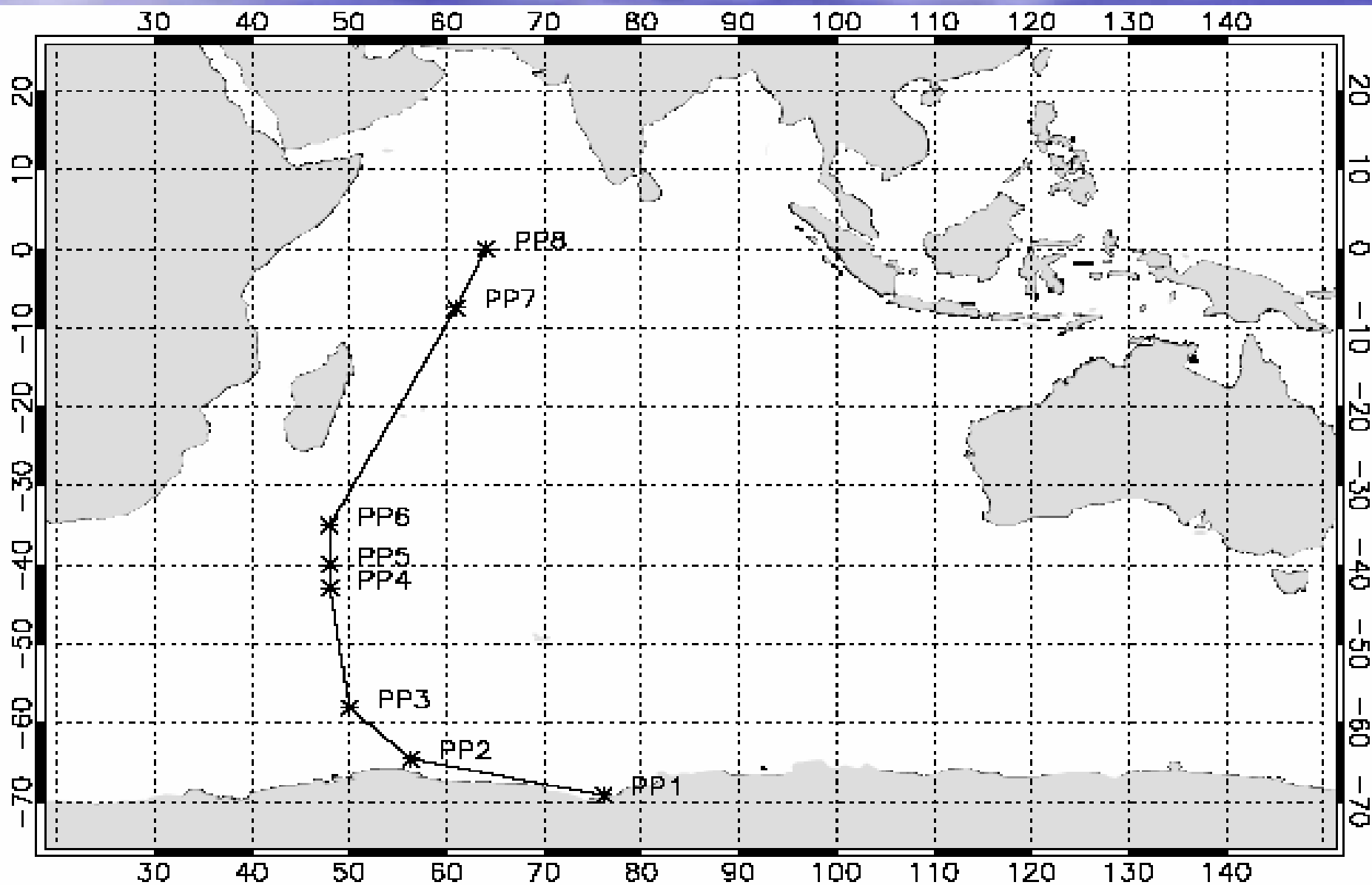
New Production in the Arabian Sea during Feb-March 2003 (mmol N m⁻² d⁻¹)



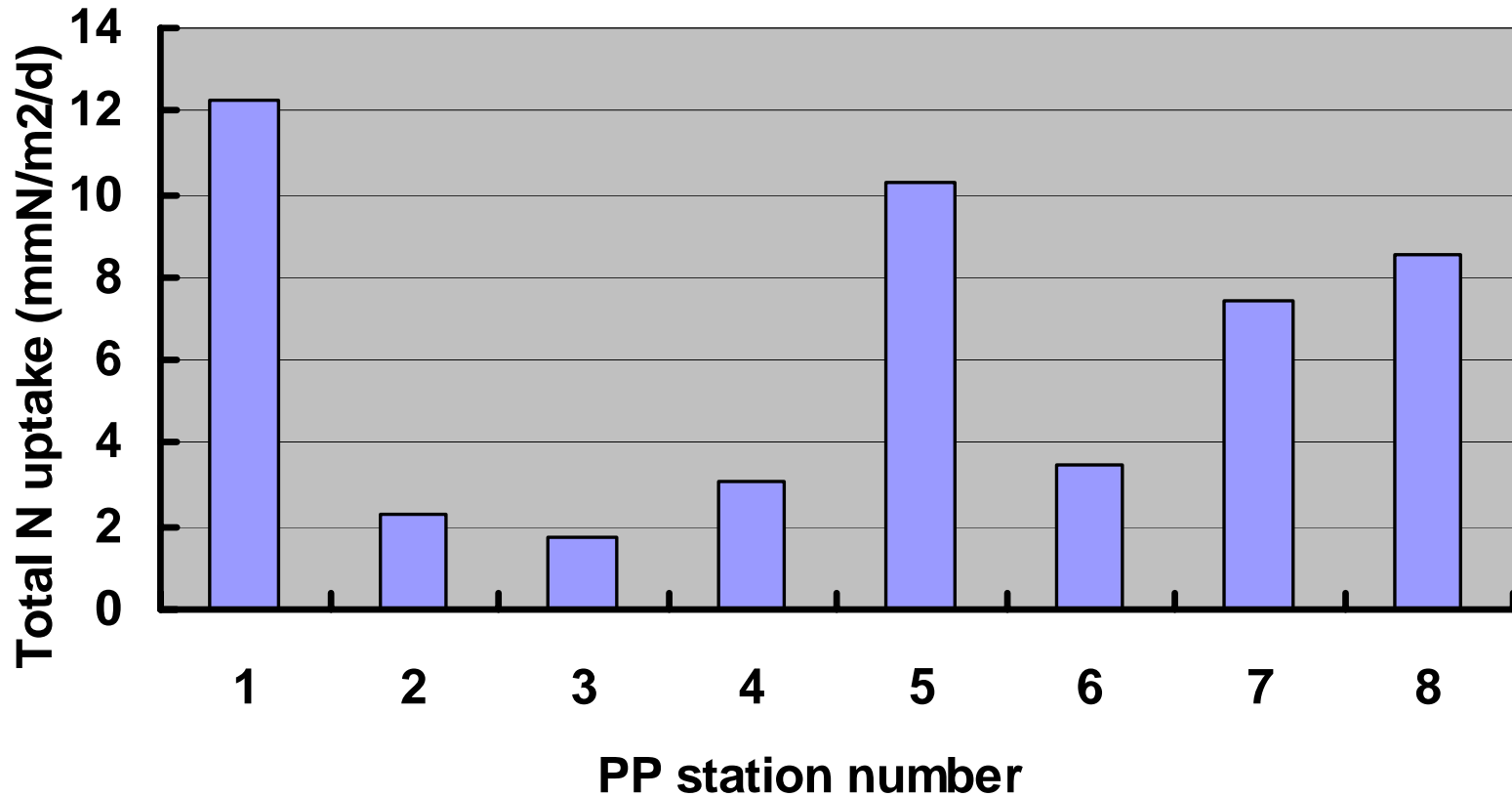
f-ratio during Feb-March 2003

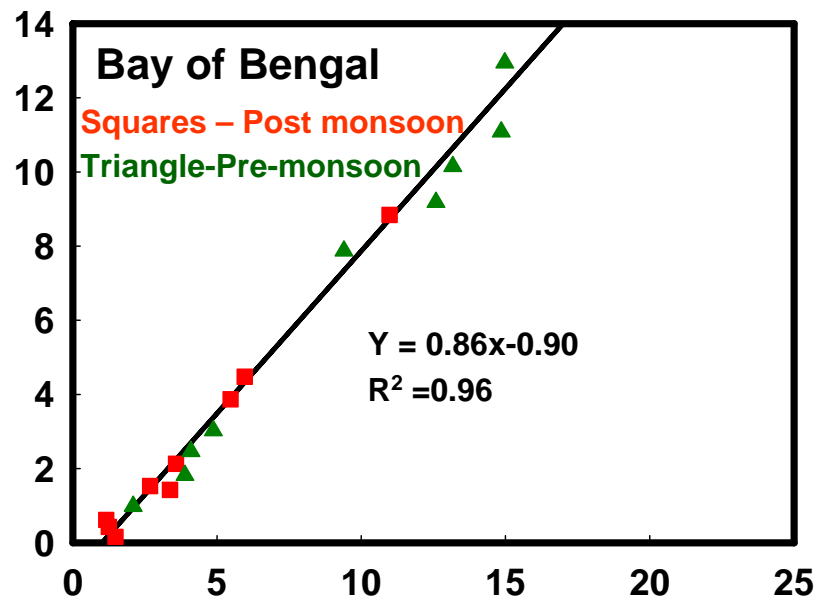
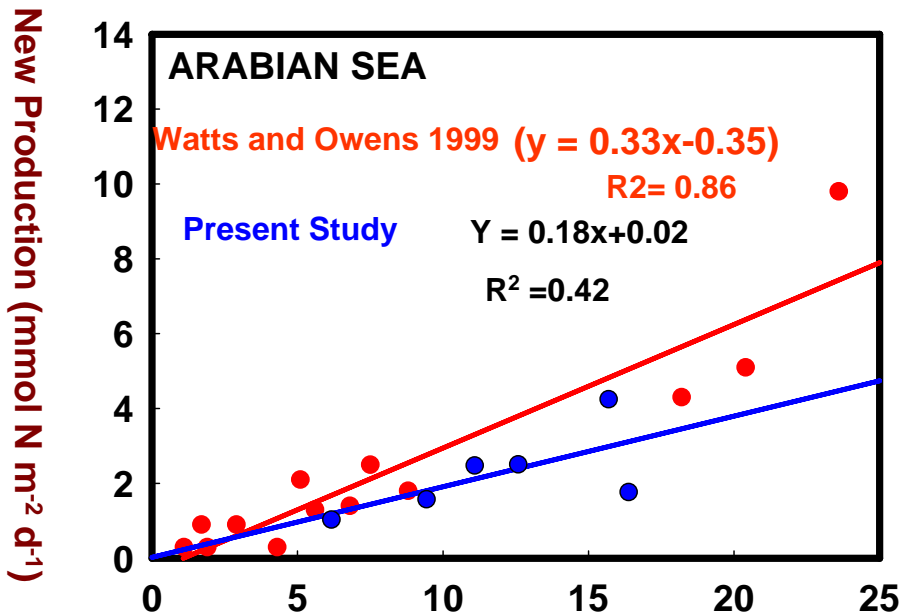


Sampling Stations in the Southern Indian Ocean

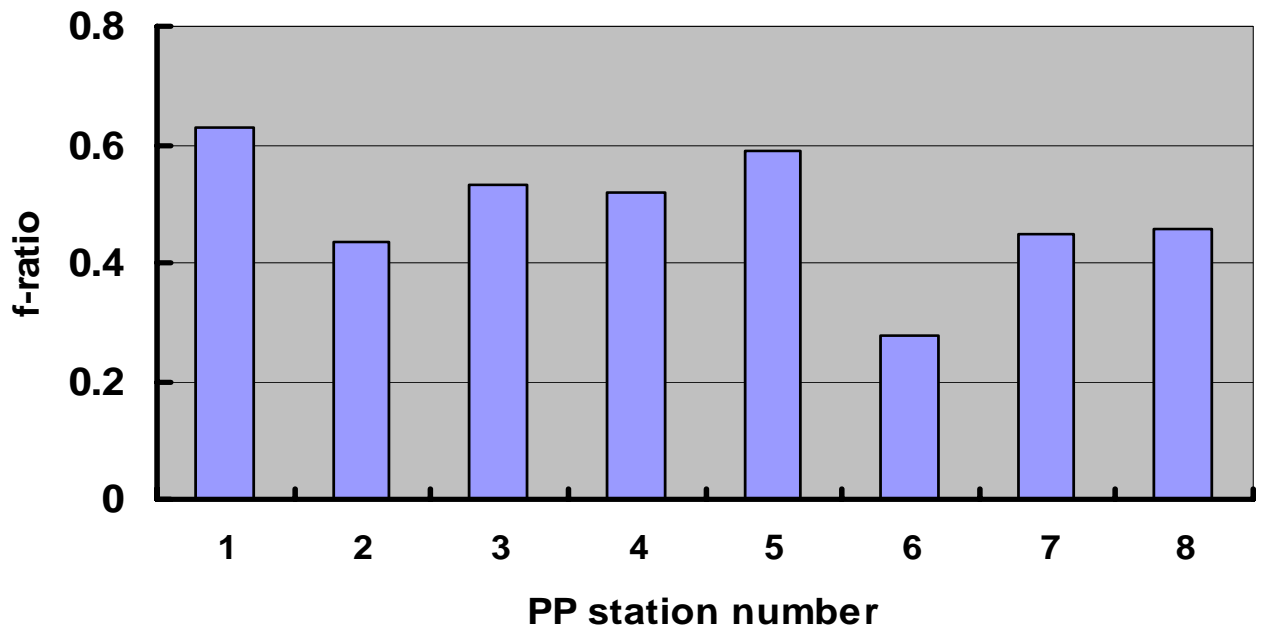


Column Production in the Southern Indian Ocean (mmolN/m²/day)



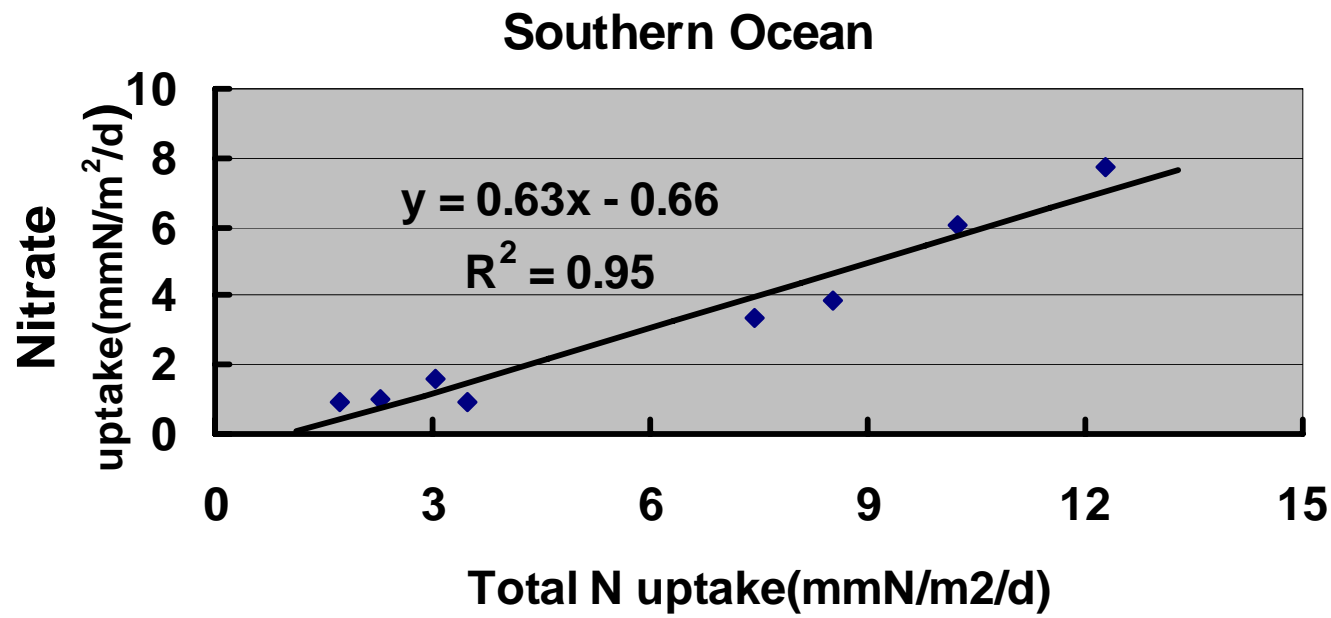


Total Production (mmol N m⁻² d⁻¹)



F-Ratio in the Southern Ocean

Relation between nitrate uptake and Total N uptake



CONCLUSIONS

- The magnitude of new production in the Bay of Bengal is comparable to that of the Arabian Sea.
- During the post-monsoon the new production is higher in open ocean locations and during pre-monsoon it is higher at coastal locations indicating the availability of nutrients by different sources i.e., due to wind mixing during post-monsoon and by EICC during pre-monsoon.
- Consistent high new production may be one of the reasons for comparable organic carbon fluxes in Arabian Sea and Bay of Bengal for longer time scale.

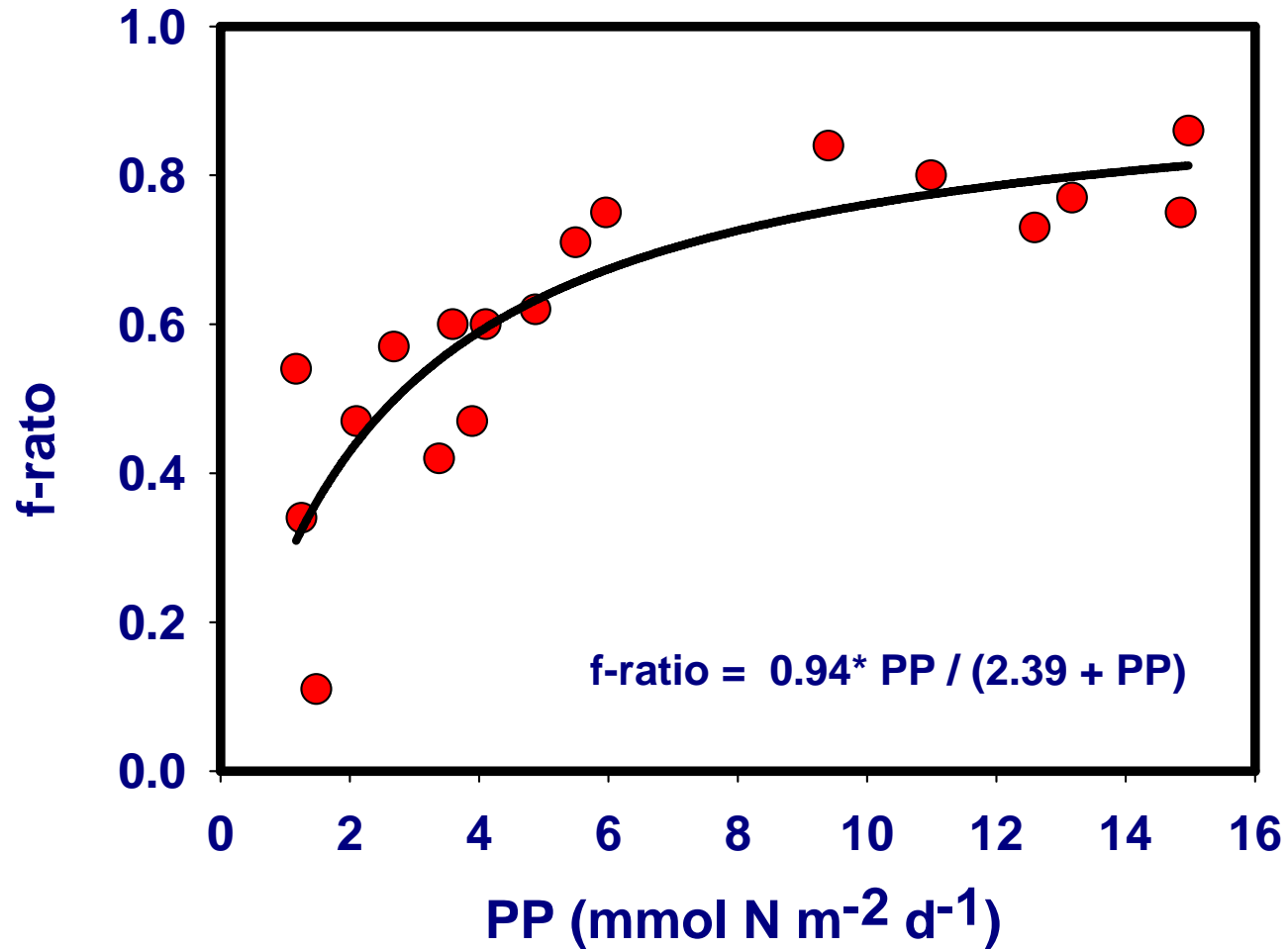
Important Findings in Southern Indian Ocean

1. Nitrate is preferred over urea and ammonia in the Southern Ocean
2. f-ratio is moderately high
3. Although the Southern Ocean has more chlorophyll than the equatorial region, productivity is low. This is because production per unit chlorophyll in this region is very low due to lack of Iron.
4. despite a lesser standing stock of phytoplankton the equatorial region is more productive. This is because production per unit chlorophyll is very high as this region receives iron dust from Asian and African subcontinents.

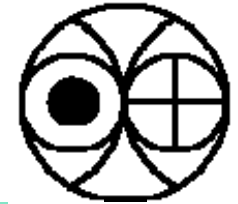


Thank You

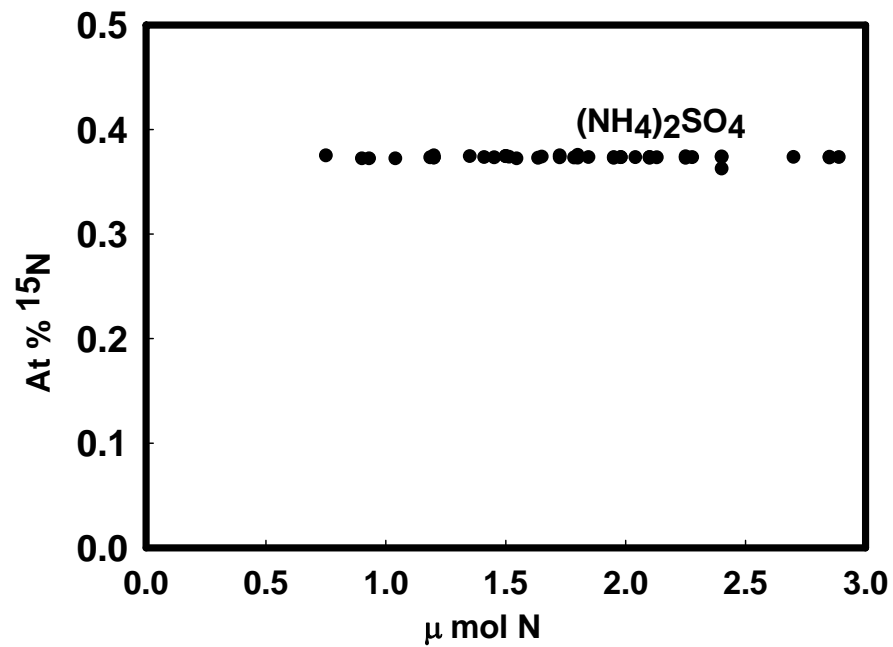
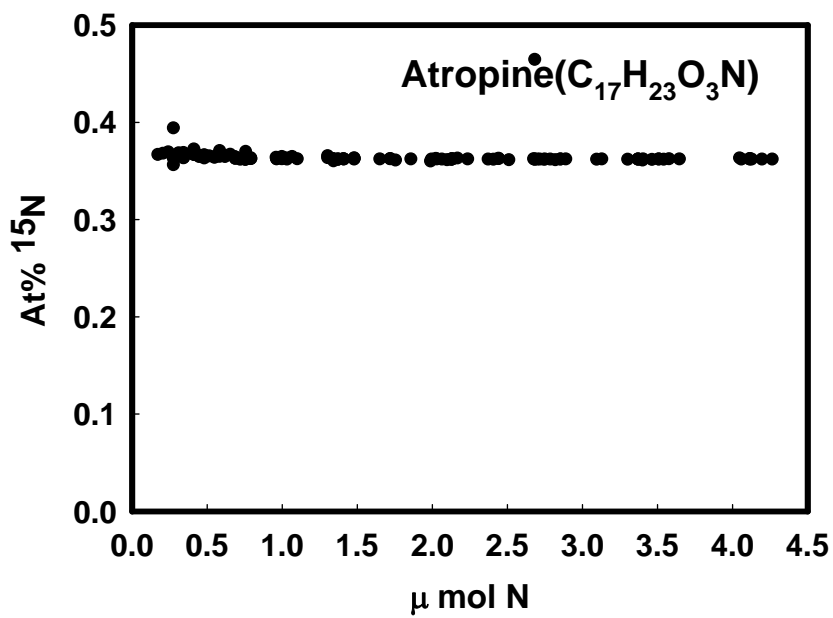
f-ratio and total production during post- and pre- monsoon season

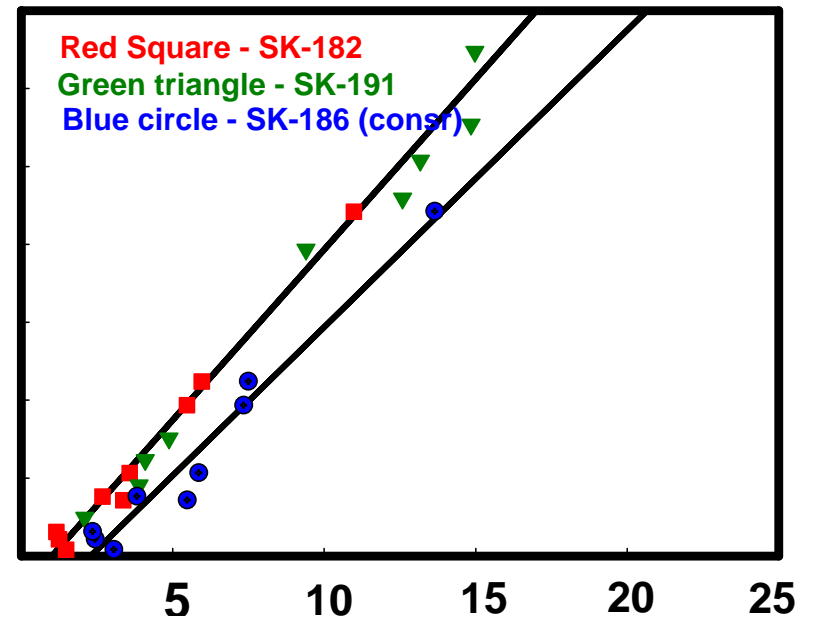
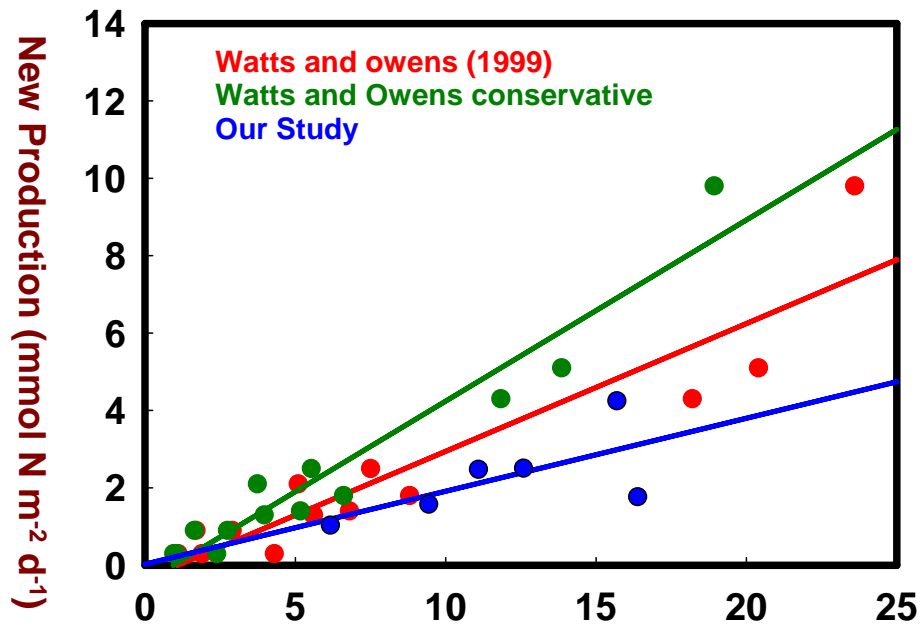


ANALYTICAL UNCERTAINTIES



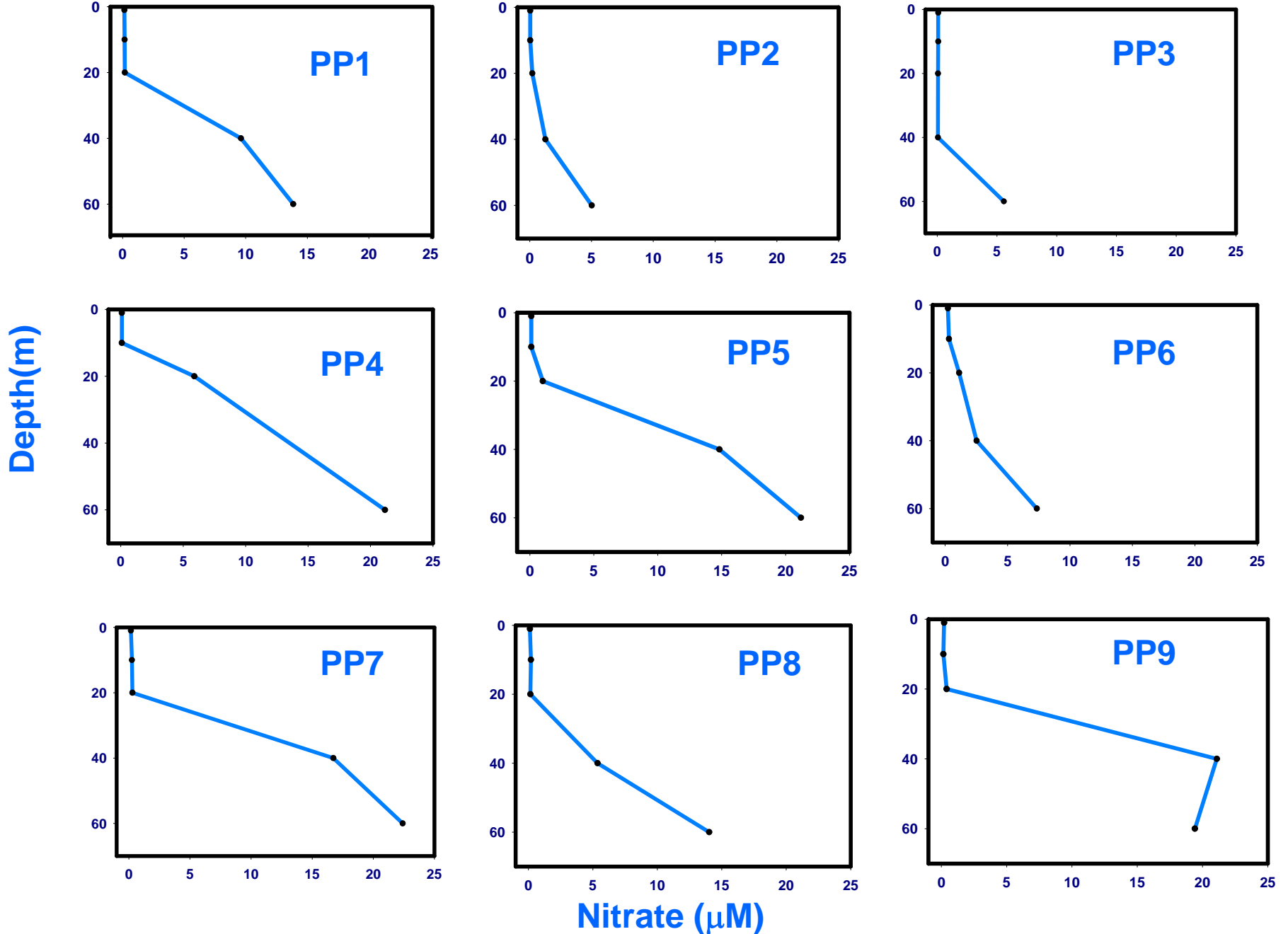
Error in	percentage
PON	10
¹⁵N atom% of	
Nitrate	< 0.20
Ammonia	< 3.57
Urea	< 1.4





Total Production (mmol N m⁻² d⁻¹)

Vertical Profile of nitrate during post-monsoon in the Bay of Bengal (SK-182)



Vertical profile of nitrate during premonsoon in the Bay of Bengal (SK-191)

