Dissolved Organic Matter and the Carbon Cycle - Arabian Sea and Indian Ocean

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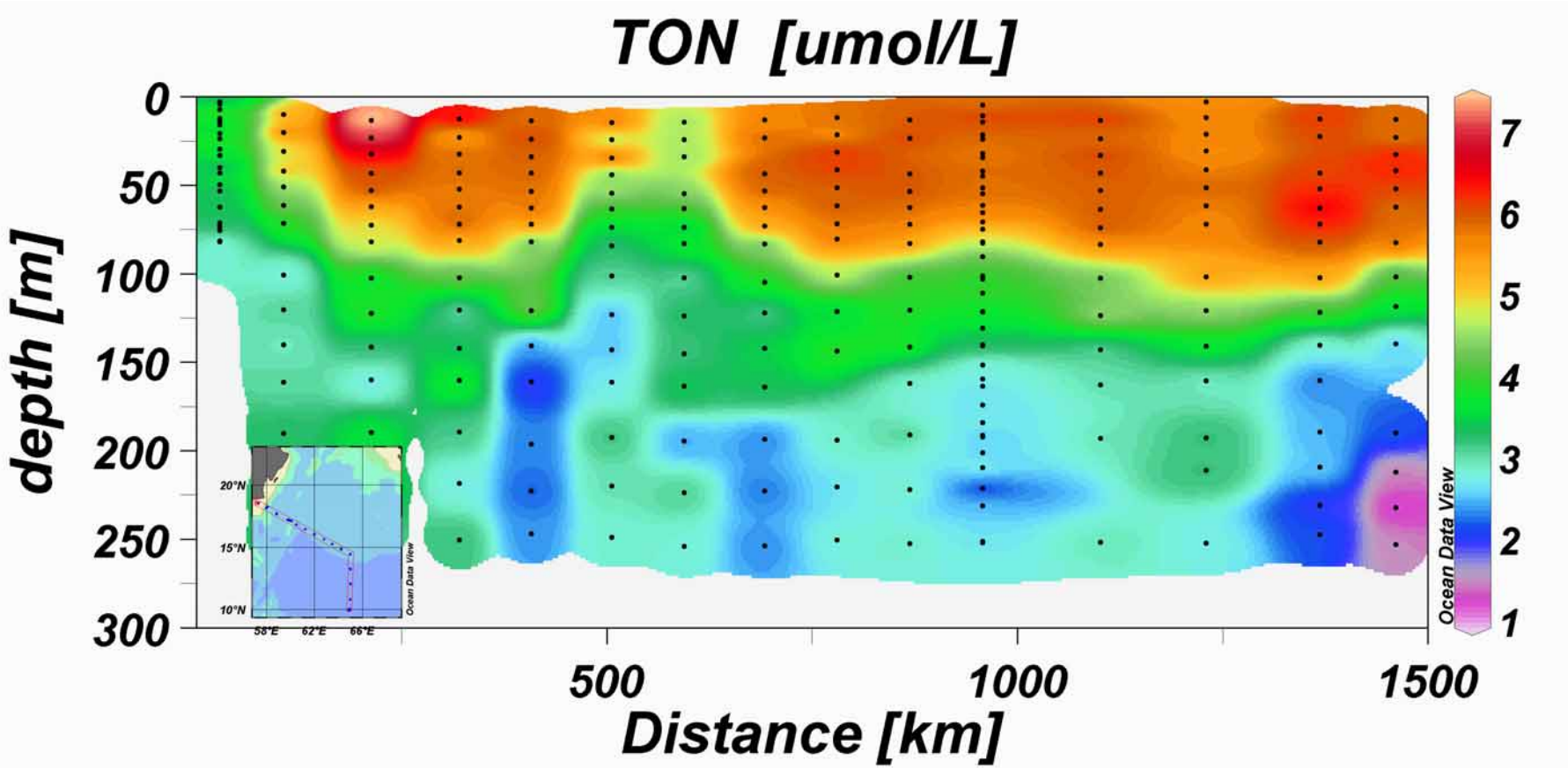
University of Miami

DOC analyses in the Arabian Sea conducted in collaboration with Dr. Ed Peltzer


TON [umol/L]
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Distance [km]
7
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2
1
Ocean Data View
20°N
15°N
10°N
58°E
62°E
66°E
Ocean Data View

Fundamental Questions for Marine Dissolved Organic Matter (DOM)

- What role does DOM play as:
  - A sink for carbon fixed by autotrophs (where and when does it occur?)
  - A source of material for export to depth (contribution to the biological pump)

Today's Topics

- **Briefly, the Carbon Cycle and Dissolved Organic Matter**
- **Arabian Sea DOC seasonal variability and net production**
- **Indian Ocean DOC distribution and export**

Absent: Bay of Bengal, marginal seas, small scale dynamics (biological turnover), mesoscale features (filaments, eddies)

Water Column DOM in the Indian Ocean

- Menzel, D.W., 1964. The distribution of dissolved organic carbon in the western Indian Ocean. *Deep-Sea Research* 11, pp. 757–766.

- Dileep Kumar, M., Rajendran, A., Somasunder, K., Haake, B., Jenisch, A., Shuo, Z., Ittekkot, V. and Desai, B.N., 1990. Dynamics of dissolved organic carbon in the northwestern Indian Ocean. *Marine Chemistry* 31, pp. 299–316.

- Hansell, D.A. and C.A. Carlson. 1998. Deep ocean gradients in dissolved organic carbon concentrations. *Nature* 395: 263-266.

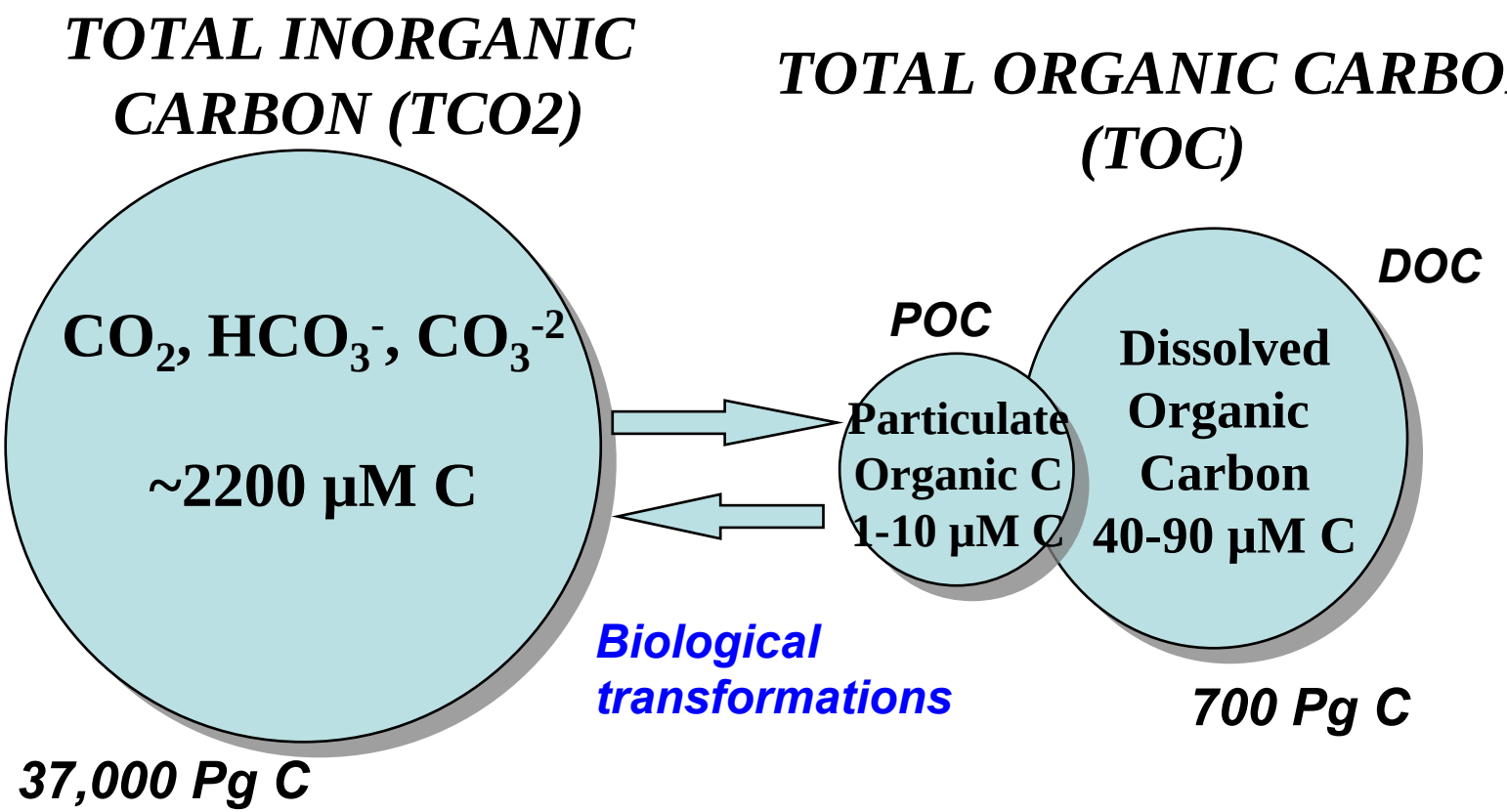
- Hansell, D.A. and E.T. Peltzer. 1998. Spatial and temporal variations of total organic carbon in the Arabian Sea. *Deep-Sea Research II* 45: 2171-2193.

- Doval, M. and D.A. Hansell. 2000. Organic carbon and apparent oxygen utilization in the western South Pacific and central Indian Oceans. *Marine Chemistry* 68: 249-264.

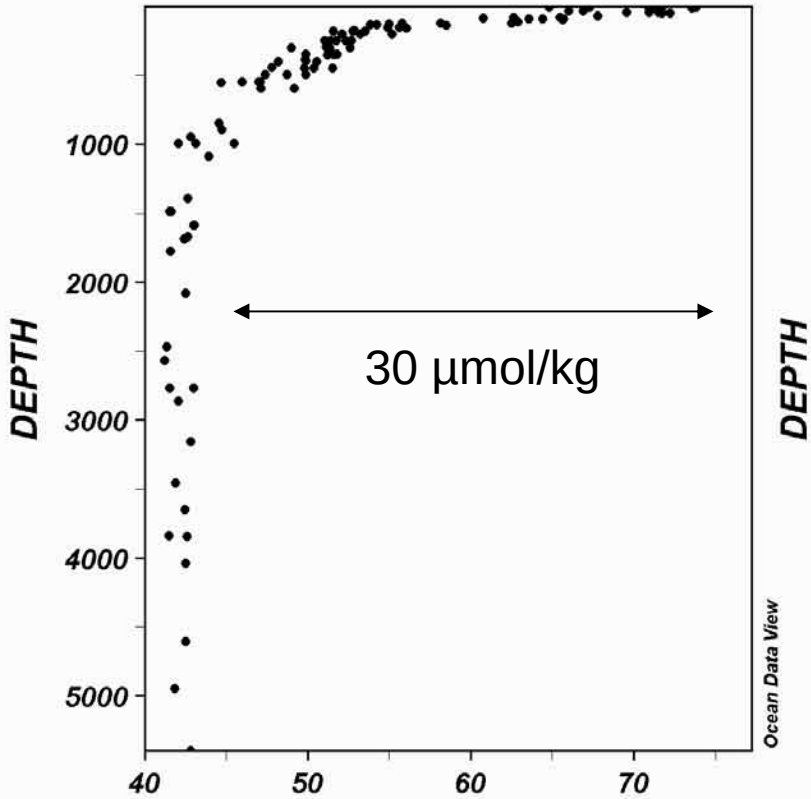
- Sardessai, S. and S.N. de Sousa. 2001. Dissolved organic carbon in the INDEX area of the Central Indian Basin DSR II 48 (16): 3353-3361

- Naqvi, SWA, VVSS Sarma, DA Jayakumar. 2002. Carbon cycling in the northern Arabian Sea during the northeast monsoon: Significance of salps. MEPS 226: 35-44.

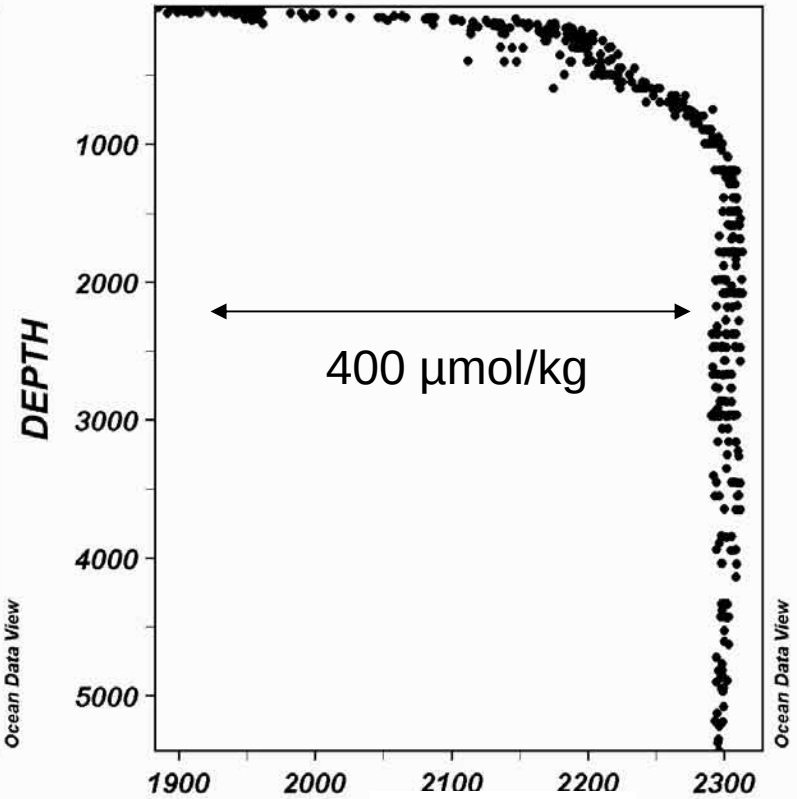
Ocean Carbon Variables



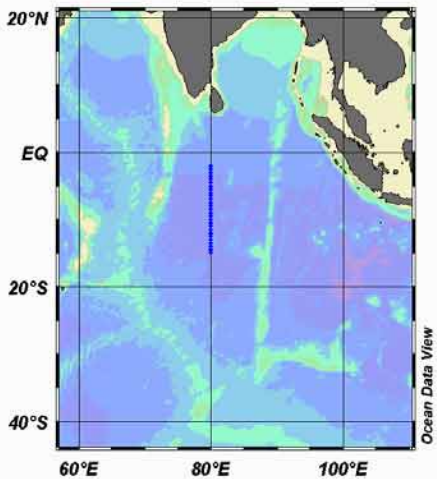
1 Pg C = 10^{15} gC



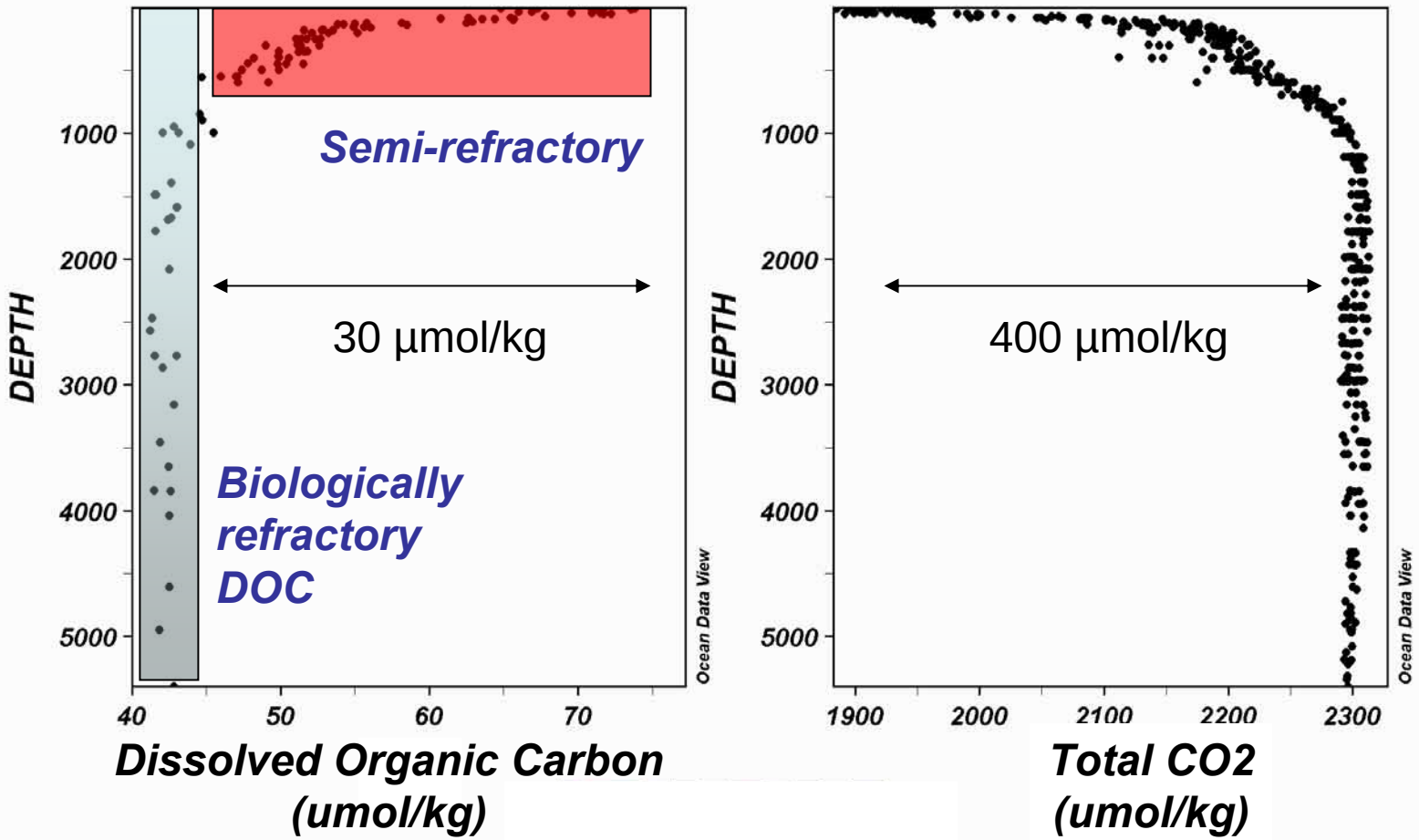
Dissolved Organic Carbon (umol/kg)



Total CO2 (umol/kg)



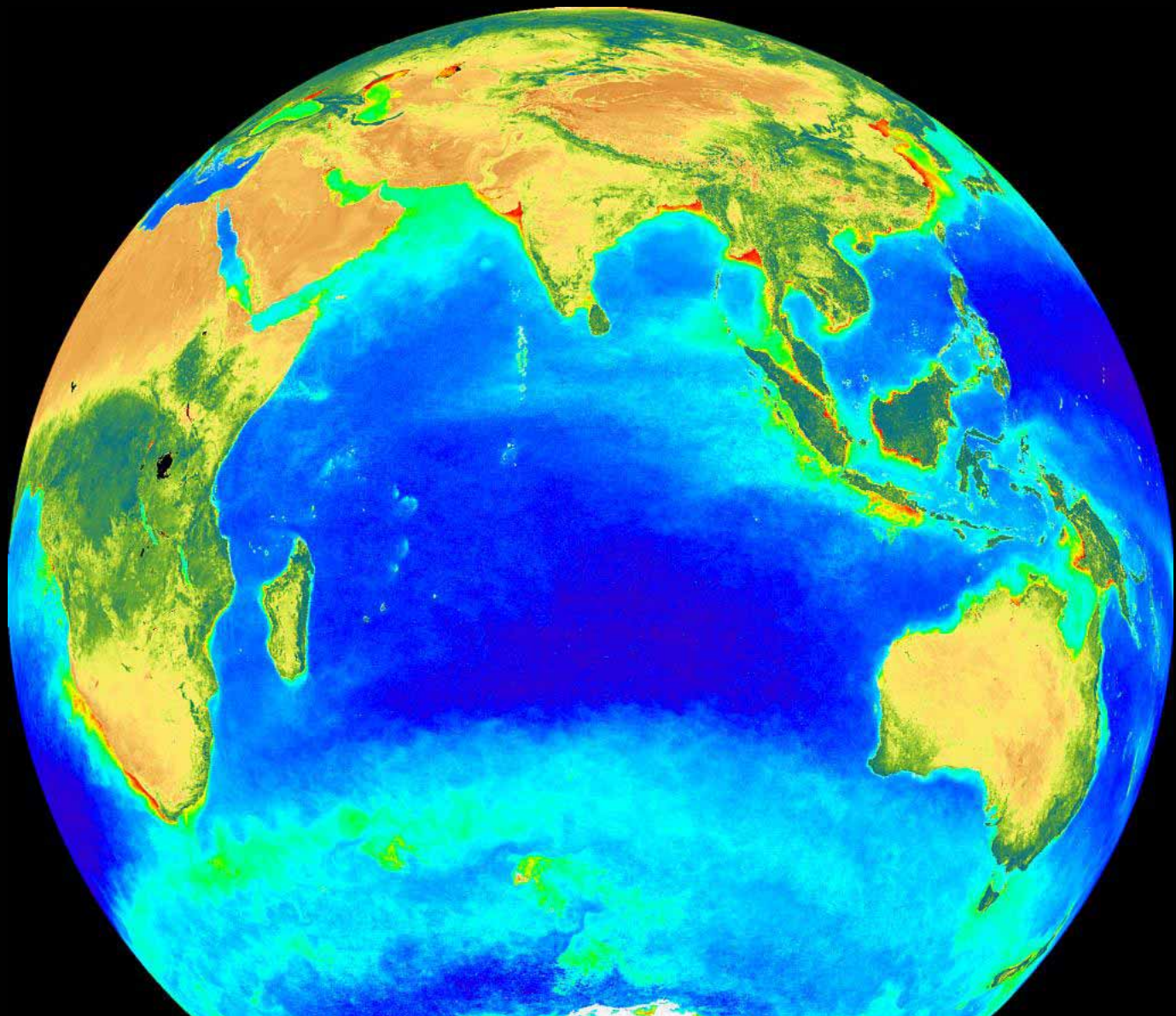
DOC accounts for ~10% of TCO2 drawdown in upper ocean



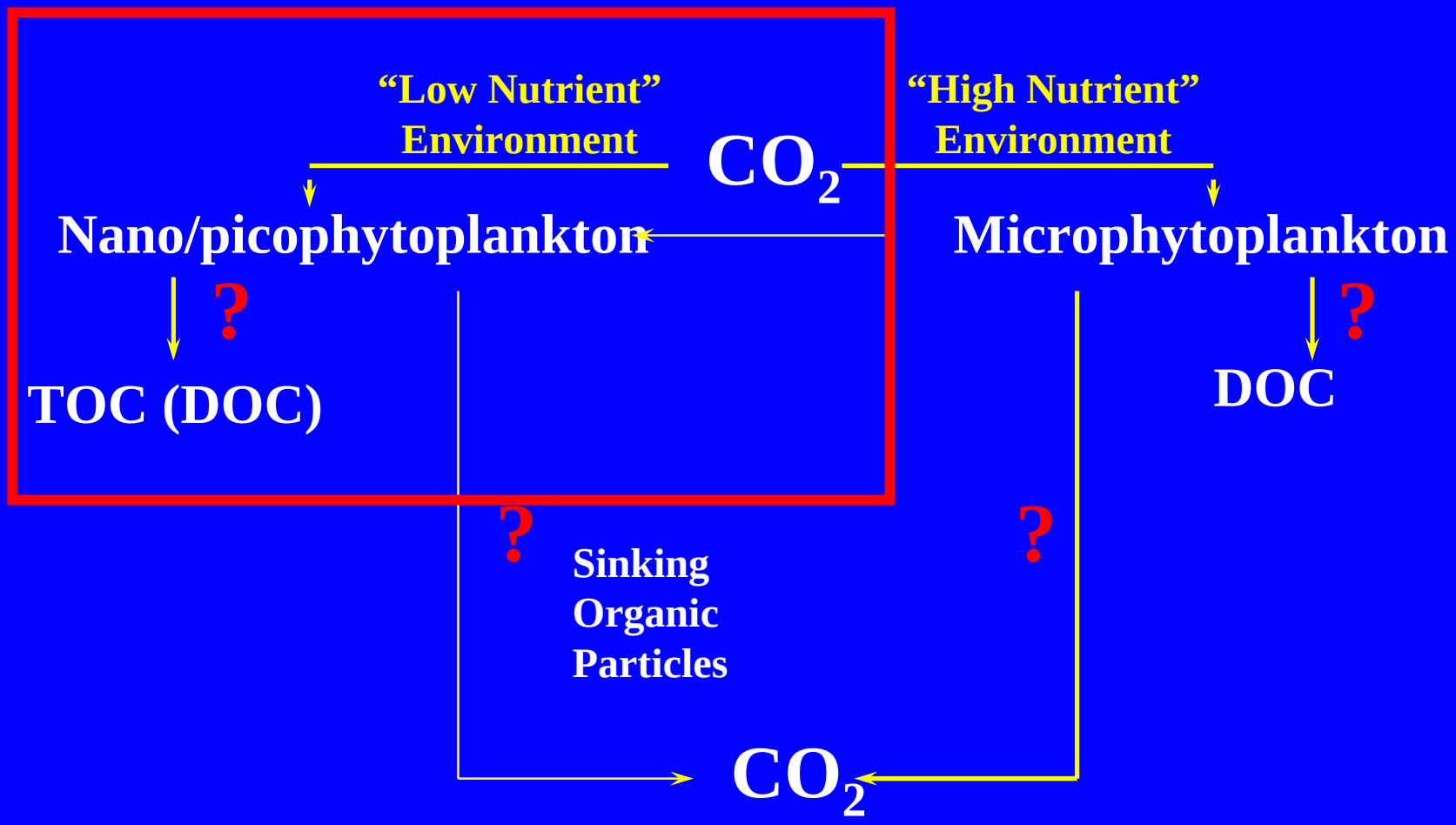
1) *Where/when is the semi-labile fraction formed*

2) *Where is it exported?*

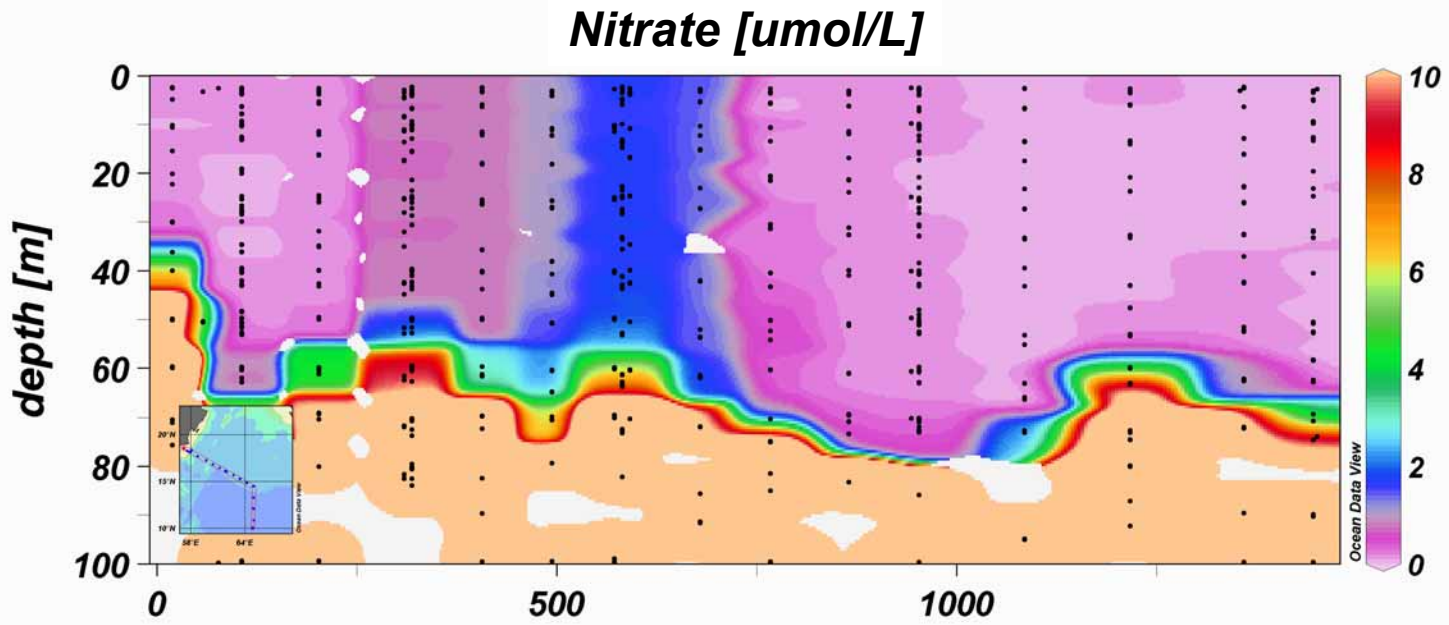
Community structure is expected to vary between seasons in the Arabian Sea. Impact on net DOM production?



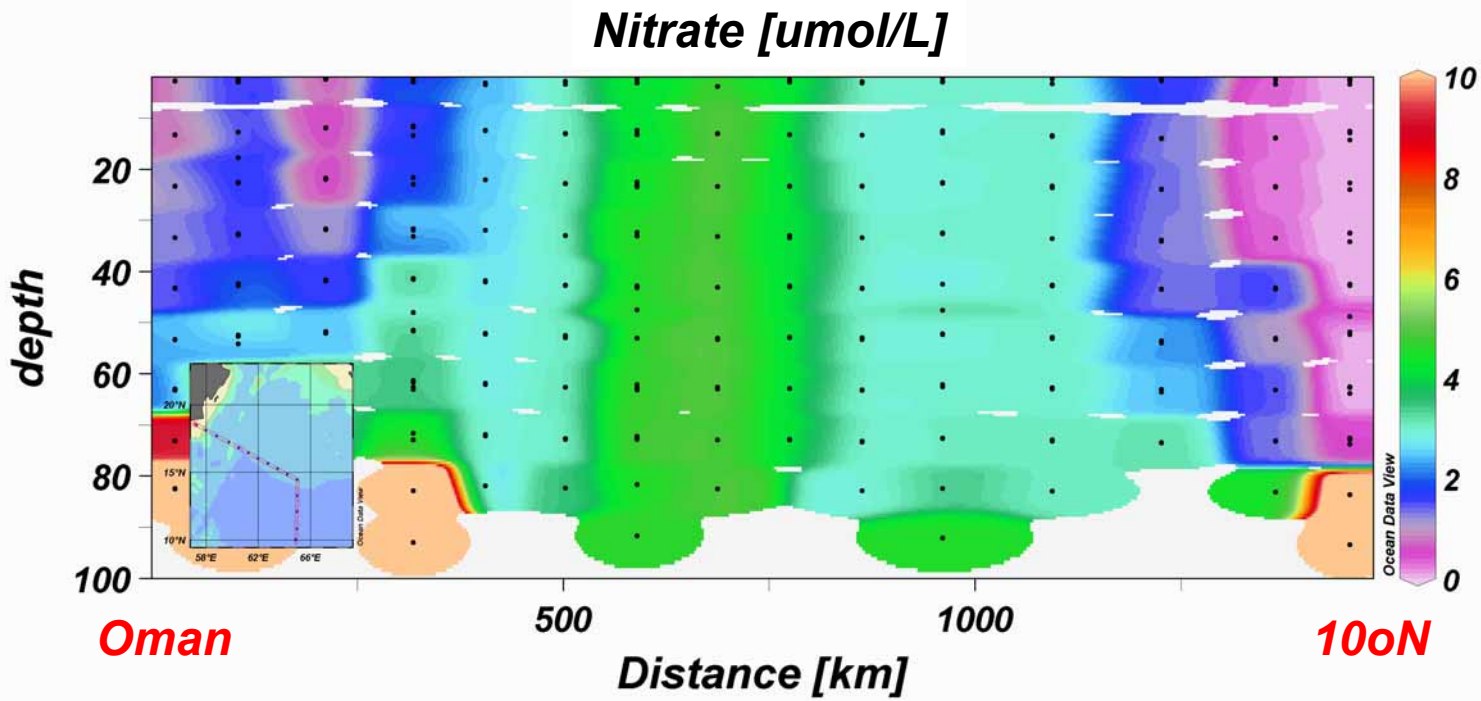
NE Monsoon


"Low Nutrient" Environment
CO_2
"High Nutrient" Environment
Nano/picophytoplankton
Microphytoplankton
?
TOC (DOC)
?
DOC
?
?
Sinking Organic Particles
CO_2

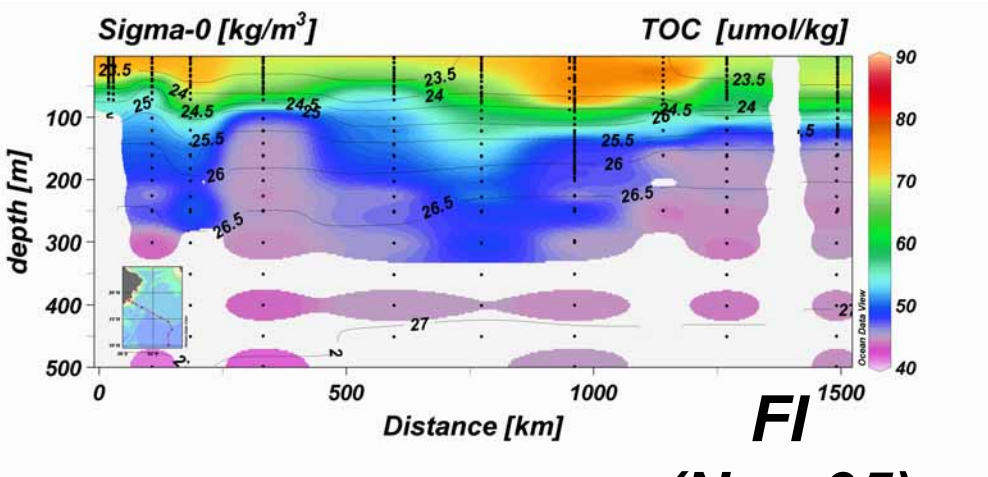
Fall Intermonsoon (December 95)



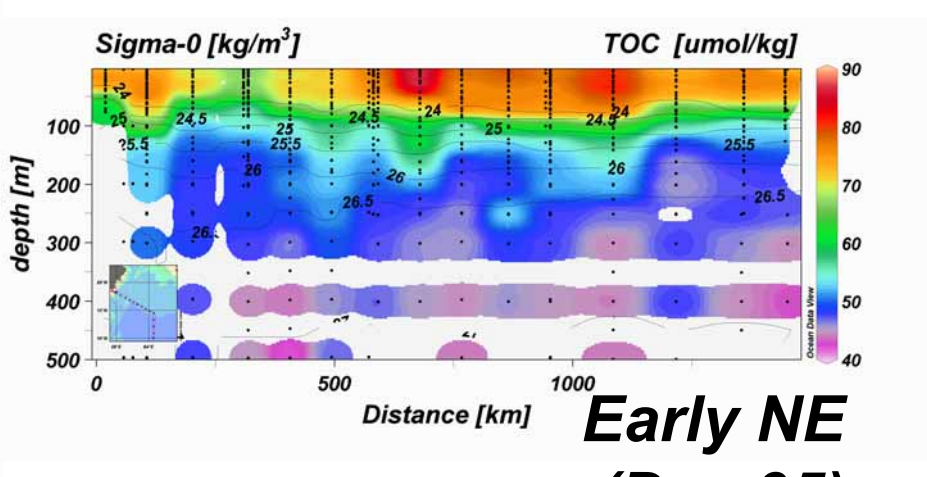
NE Monsoon (Jan/Feb 95)



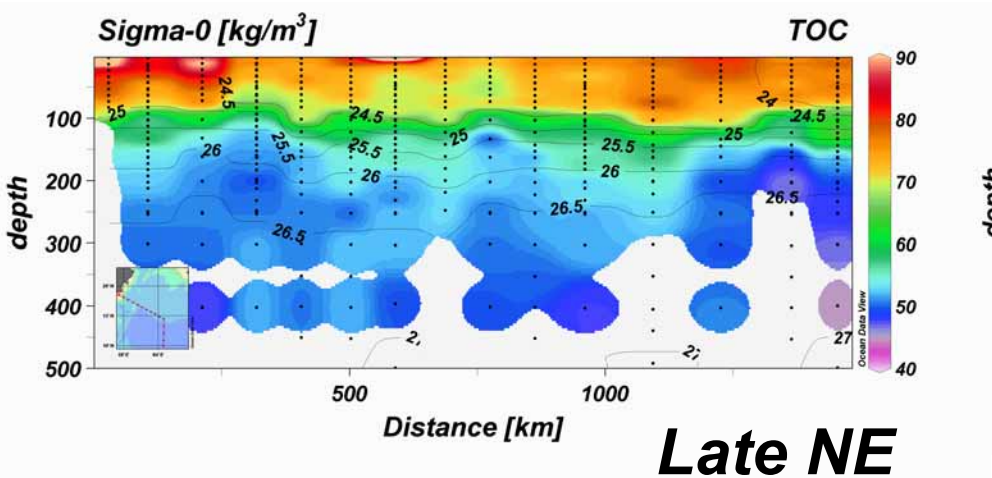
TOC over the Winter Monsoon Period



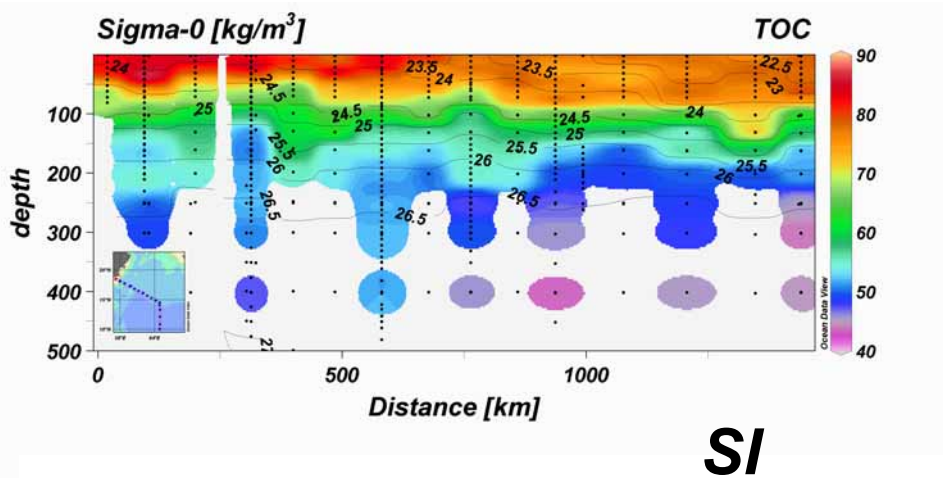
FI (Nov 95)



Early NE (Dec 95)



Late NE (Jan/Feb 95)

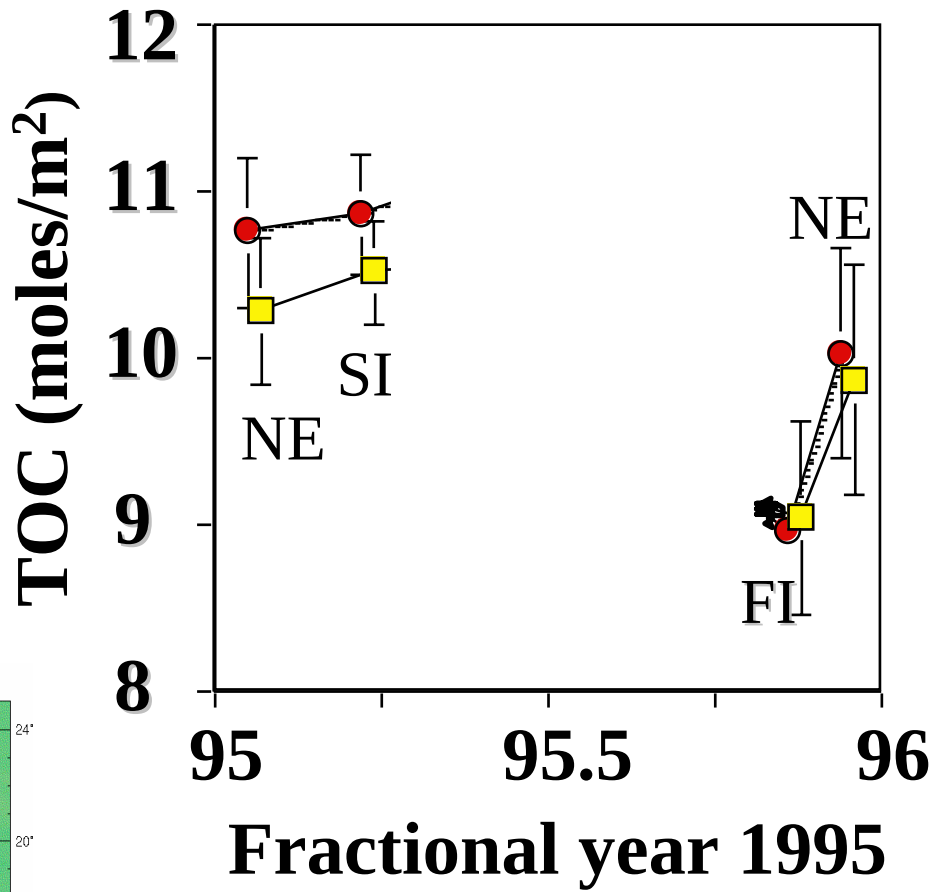


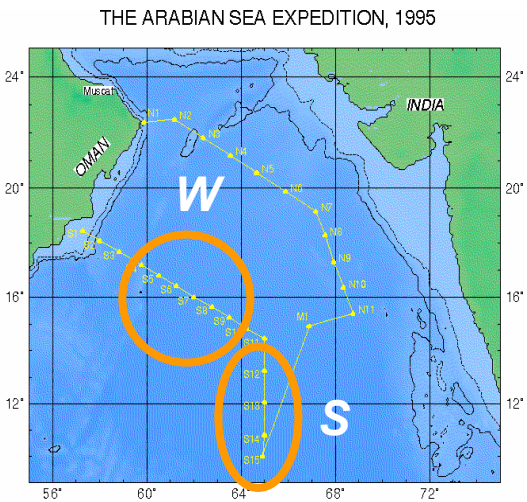
SI (Mar/Apr 95)

TOC in color
Density on lines

Mean TOC Stock

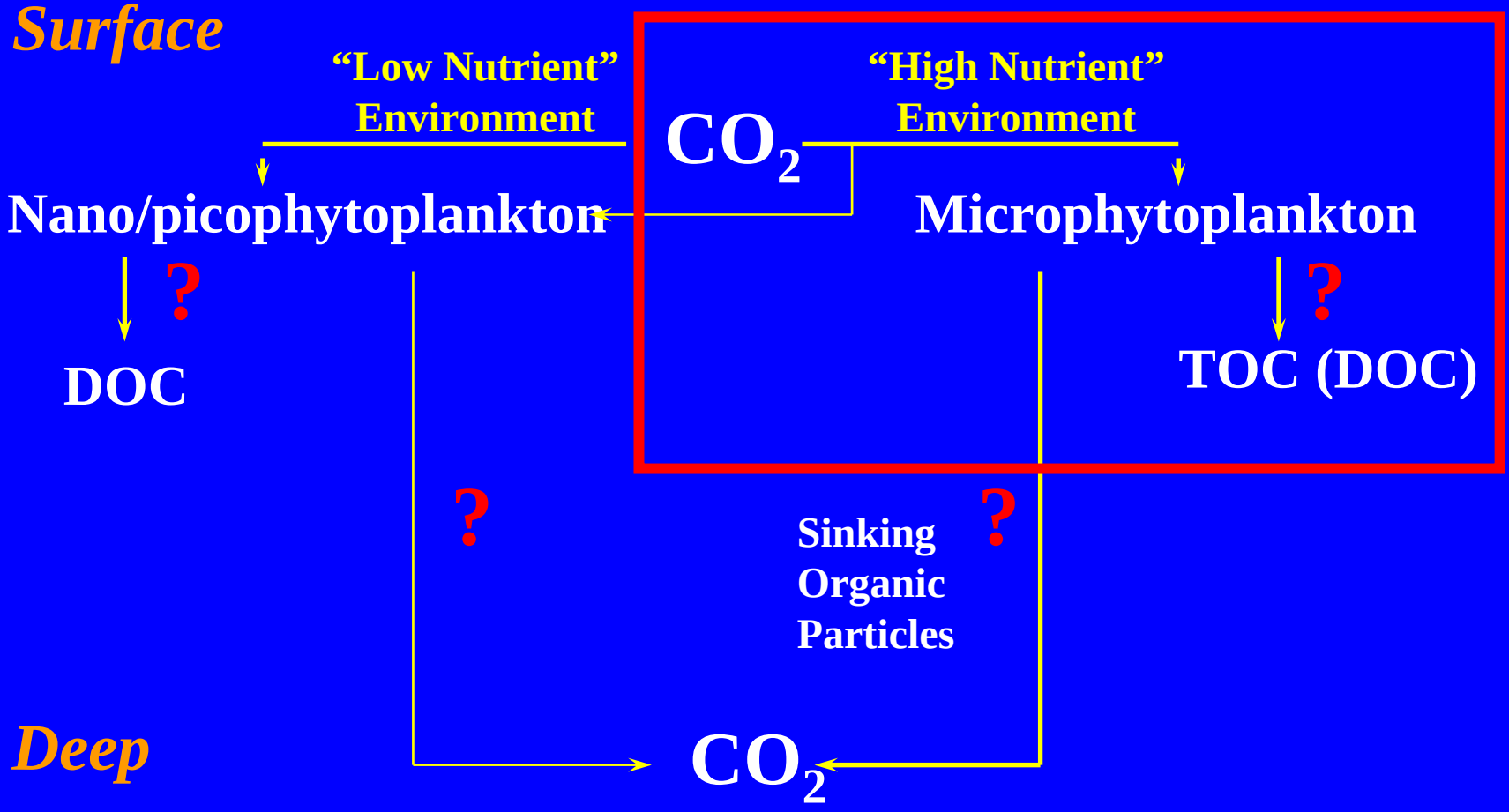
Upper 150 m along the South Line



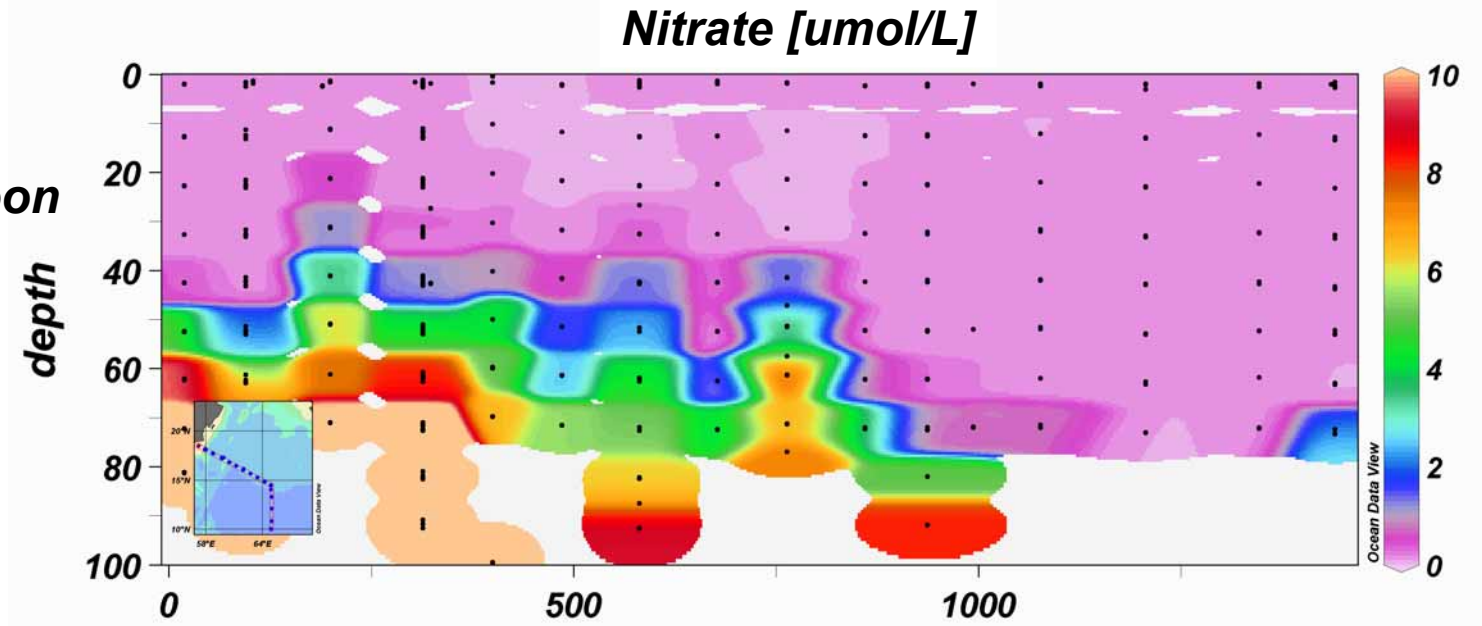


Net Production of organic carbon during the NE Monsoon of 1-2 mol C/m2

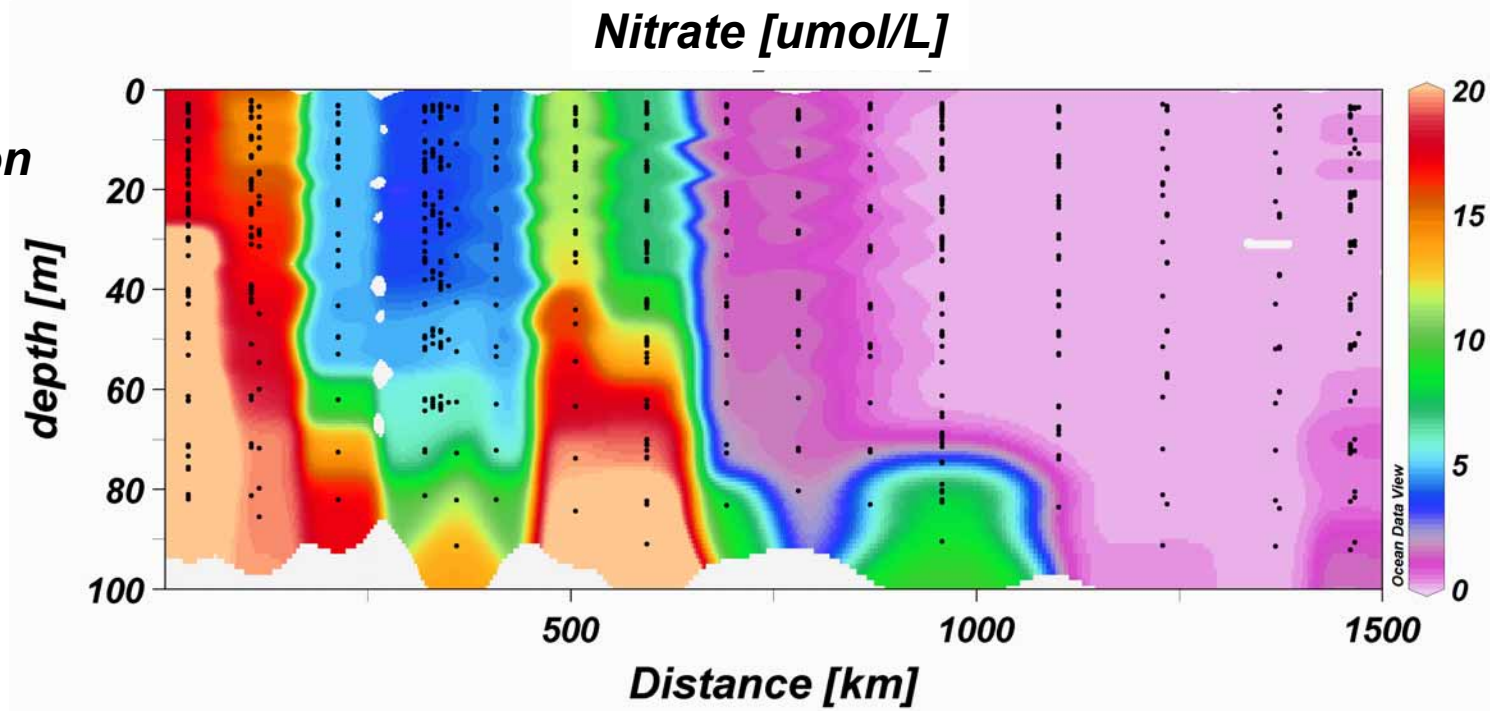
SW Monsoon


Surface
"Low Nutrient" Environment
CO_2
"High Nutrient" Environment
Nano/picophytoplankton
Microphytoplankton
?
?
DOC
TOC (DOC)
?
?
Sinking Organic Particles
Deep
CO_2

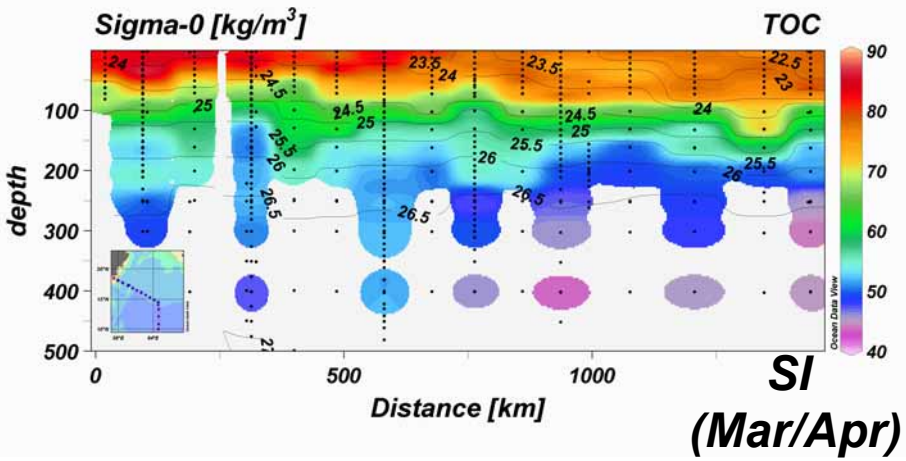
Spring
Intermonsoon
Mar/Apr



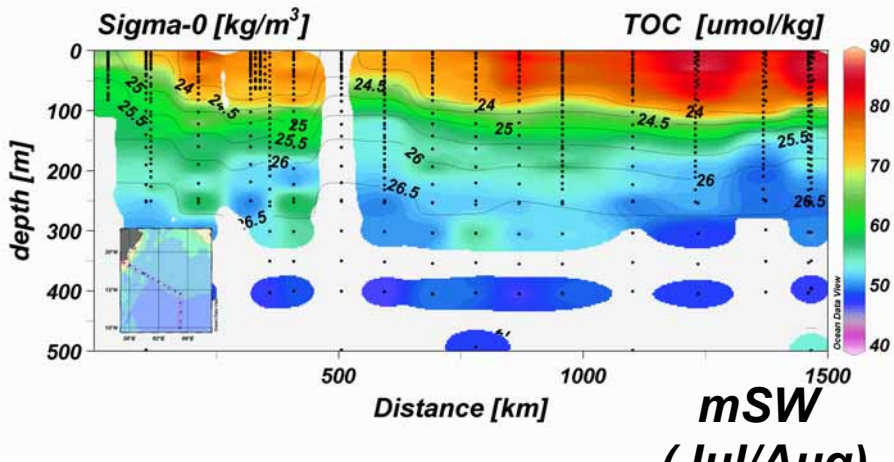
SW Monsoon
July/Aug



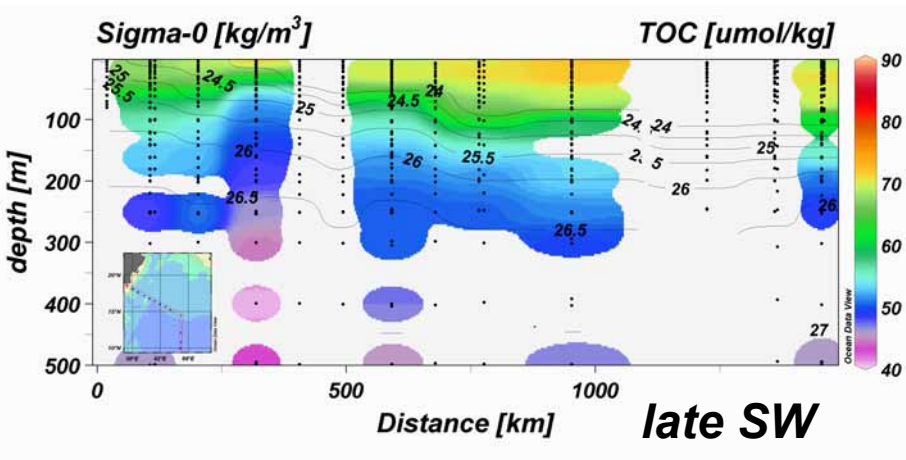
Total Organic Carbon
Over Period of SW Monsoon



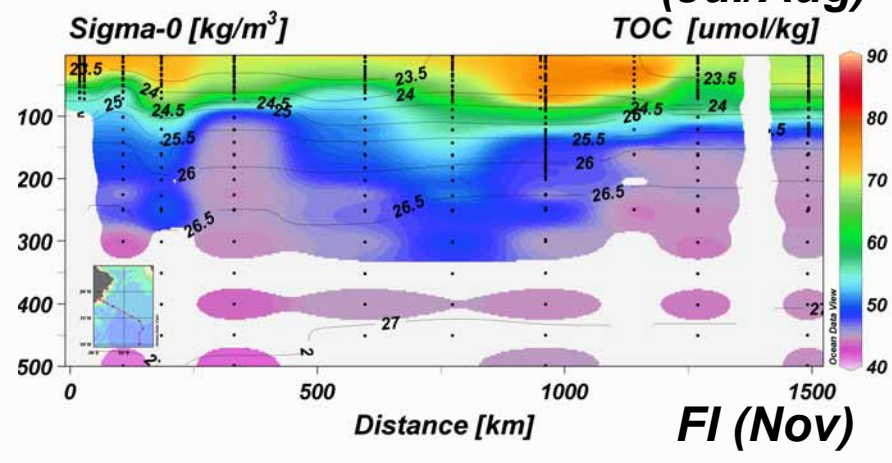
SI (Mar/Apr)



mSW (Jul/Aug)



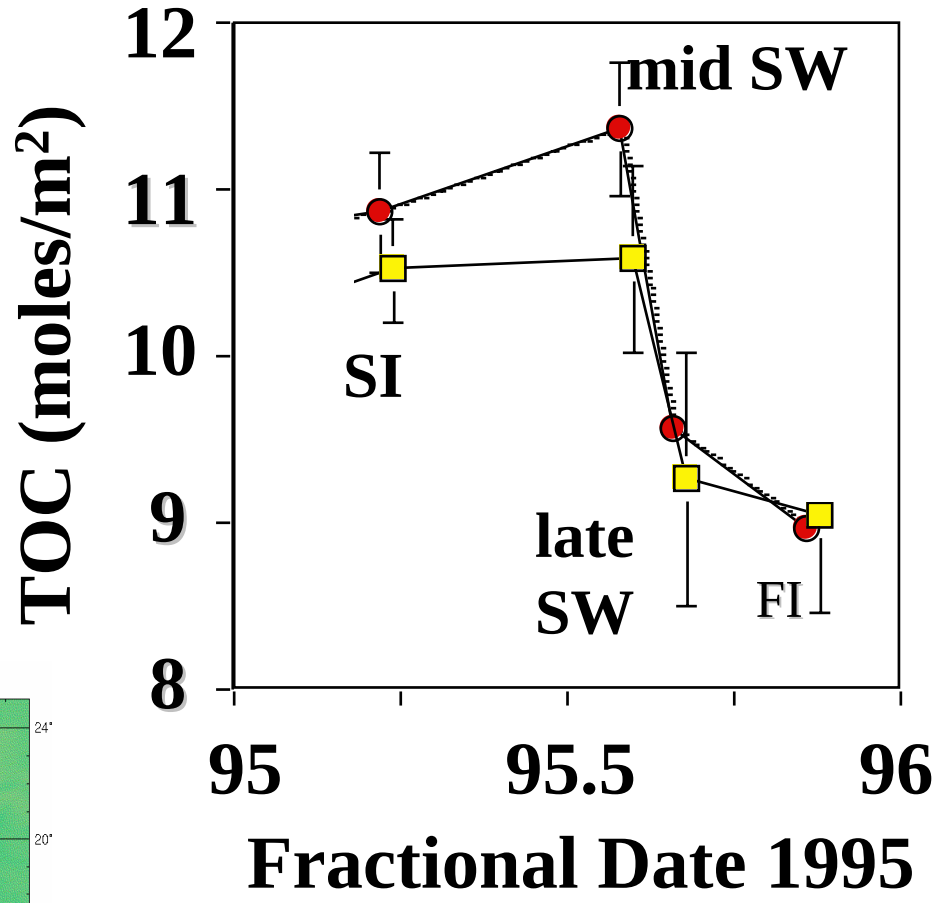
late SW (Aug/Sep)



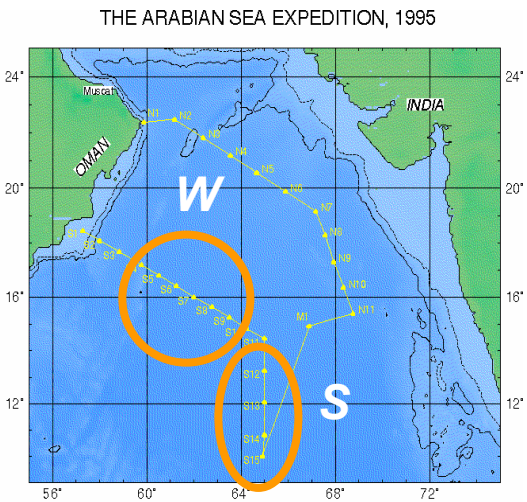
FI (Nov)

TOC in color
Density in lines

Mean TOC Stock
Upper 150 m along the South Line



West
South



Mean TOC Stock
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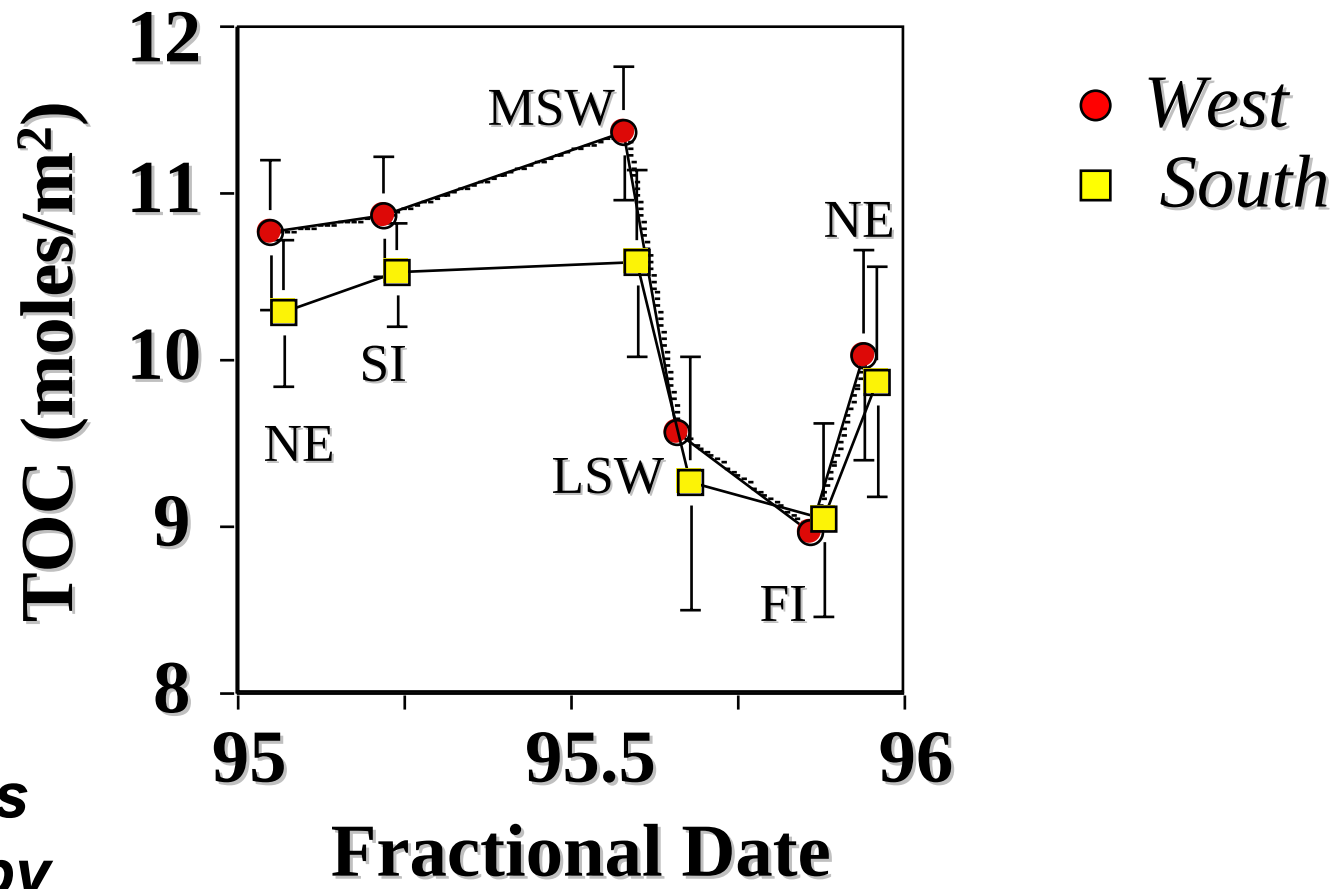
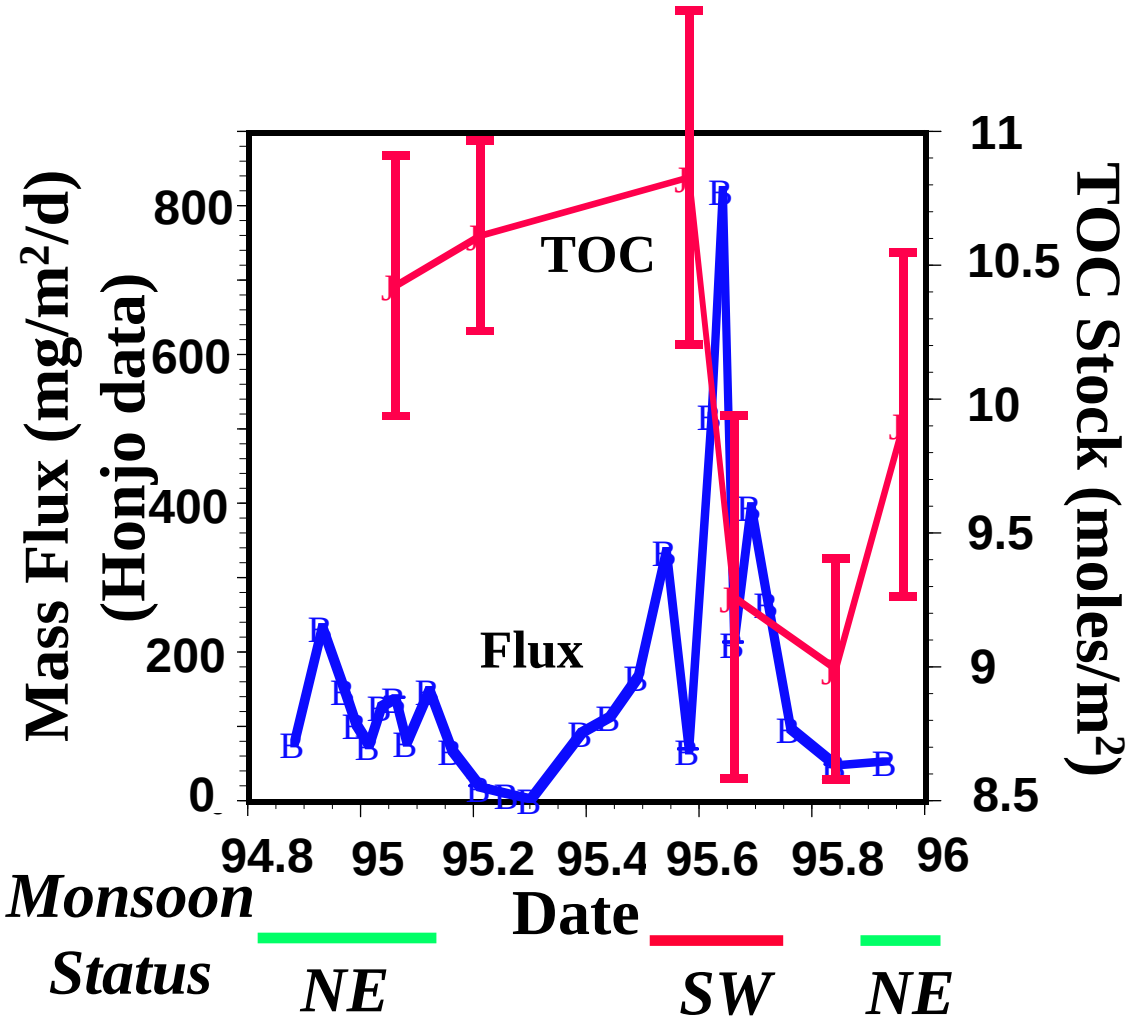


Stock varies seasonally by ≈2 mol C/m2

TOC STOCKS AND PARTICLE EXPORT



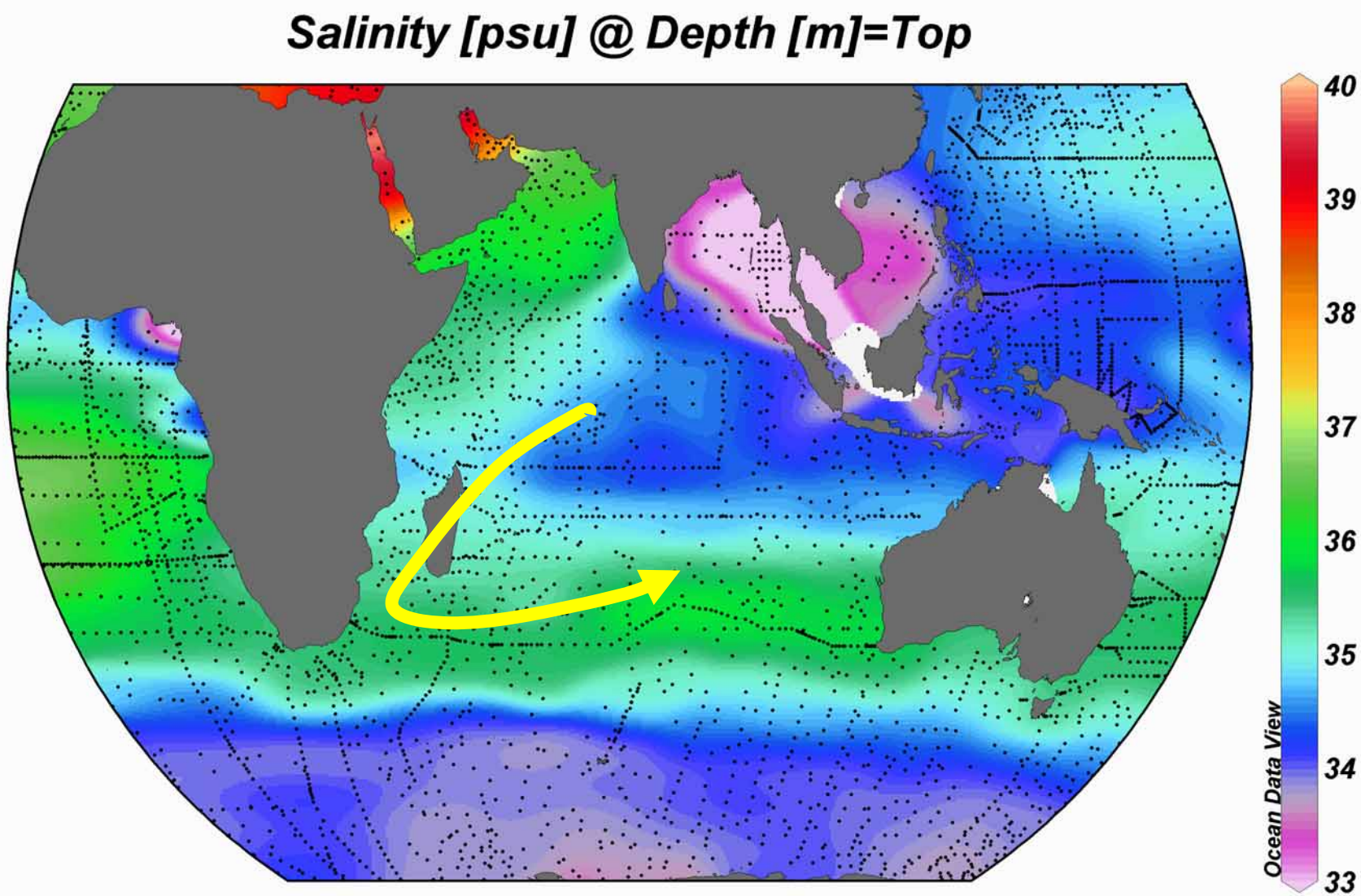
NE Monsoon

- convective overturn
- low particle export
- net DOC production

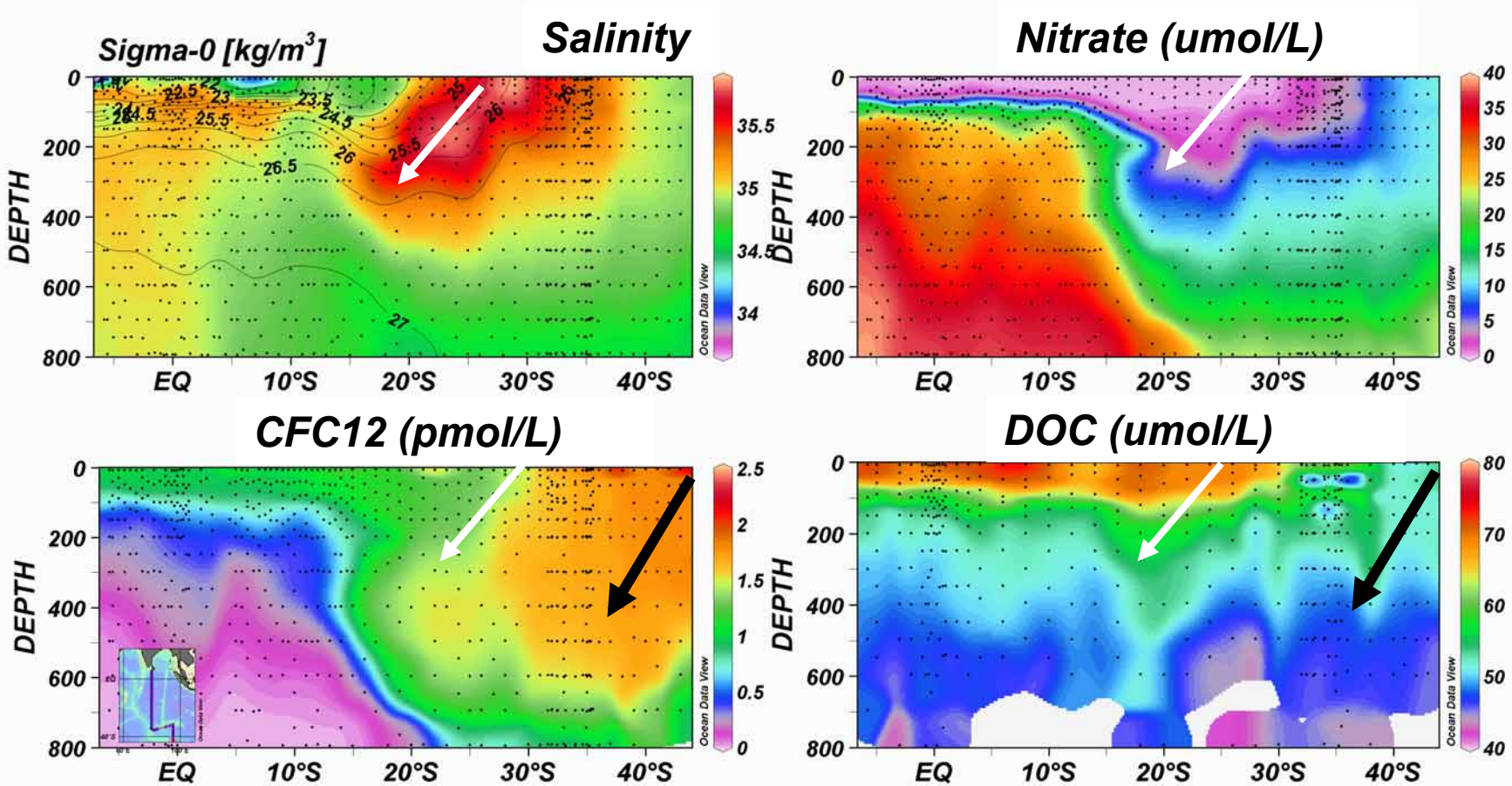
SW Monsoon

- coastal upwelling
- high vertical export
- DOC loss

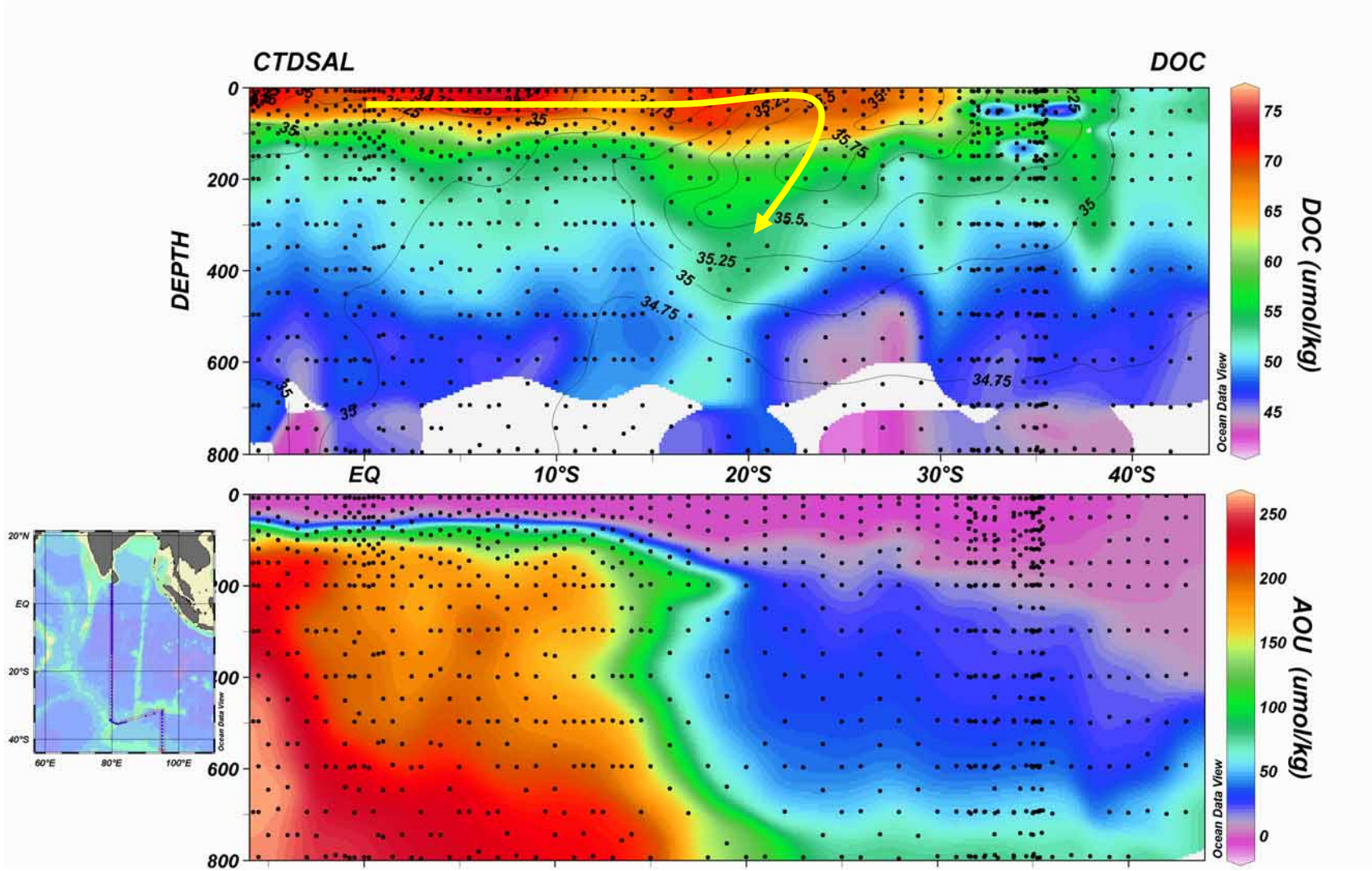
Transporting Surface Accumulated DOC to Sites of Export



WOCE I-8 (80oE; 1995)



Ventilation with subtropical water exports DOC;
Ventilation with higher latitude (southern) waters does not



DOC mineralization contributes to AOU development in mid-latitudes, but less so in higher latitudes

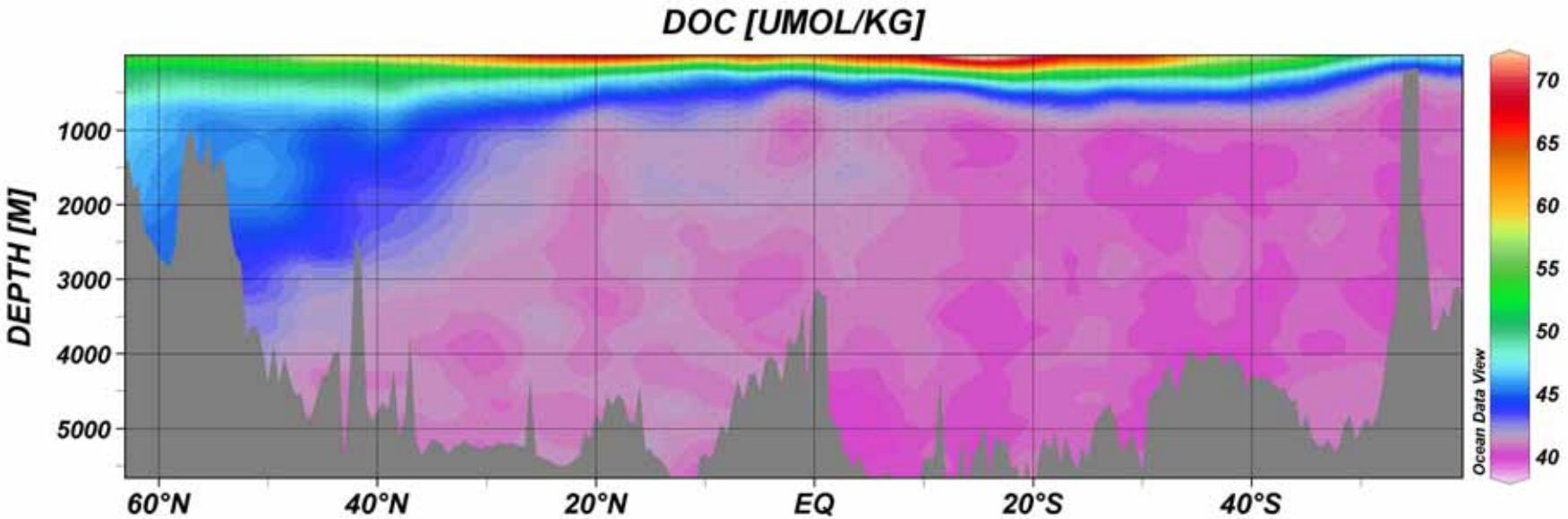
Dissolved Organic Carbon in the Indian Ocean

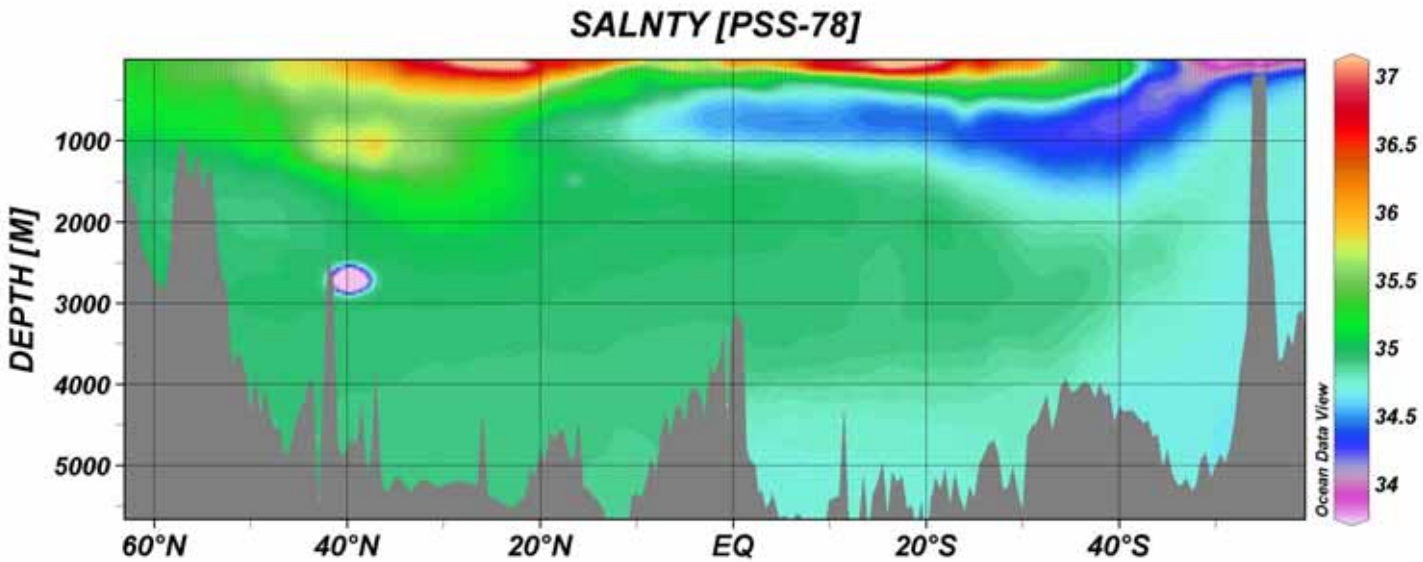
1) Net DOM production occurs at sites and times of net community production, particularly when nutrients are at low/moderate levels (supporting *small* phytoplankton and the associated food web)

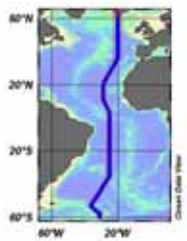
2) DOM is transported with surface circulation to sites of ocean ventilation

3) Low latitude ventilation can export DOC such that **20-40% of AOU is supported by DOC mineralization**; higher latitude ventilation exports less DOC, so most AOU driven by mineralization of sinking particles.

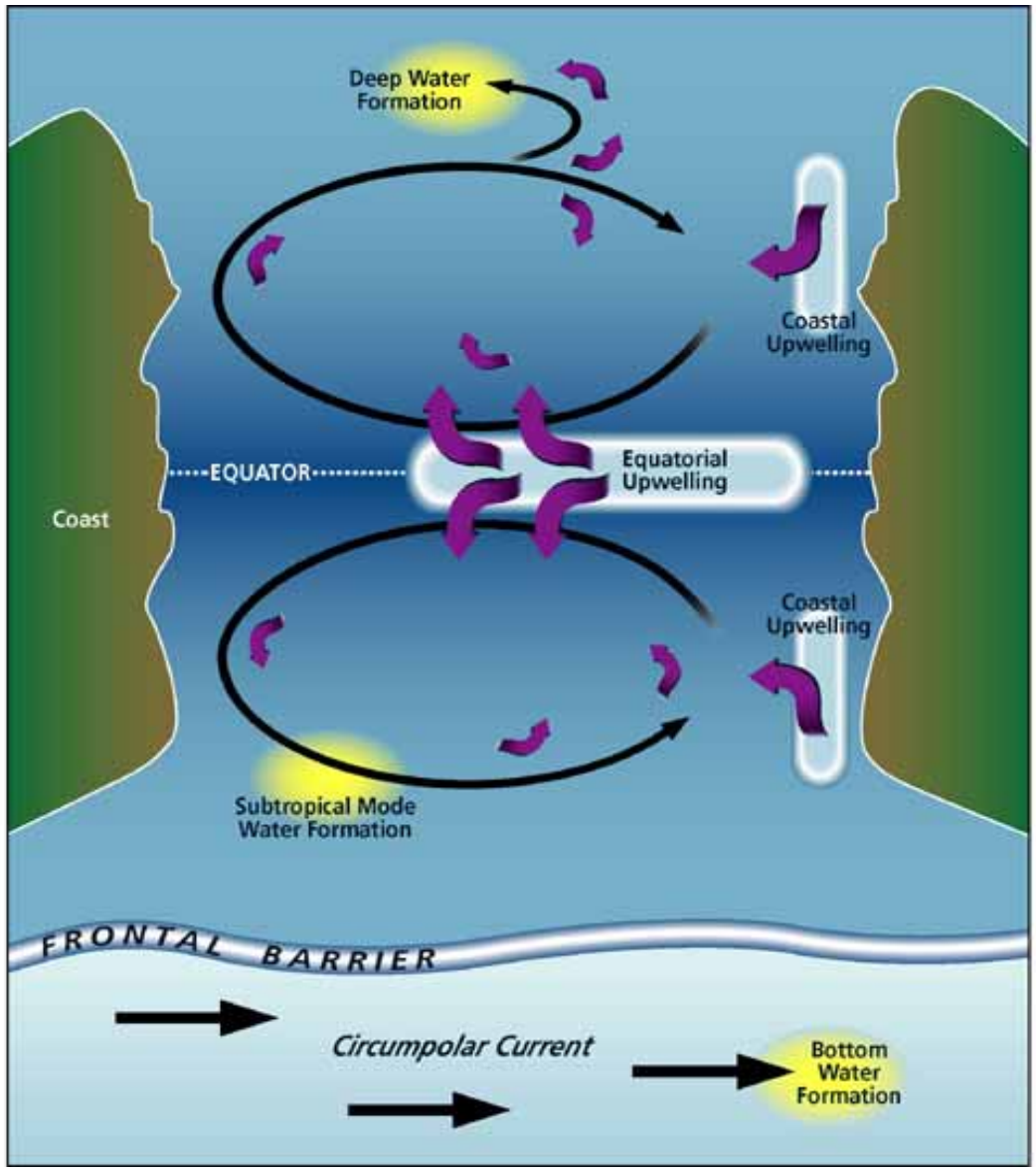
DOC in the Atlantic Ocean (CLIVAR Line A16)





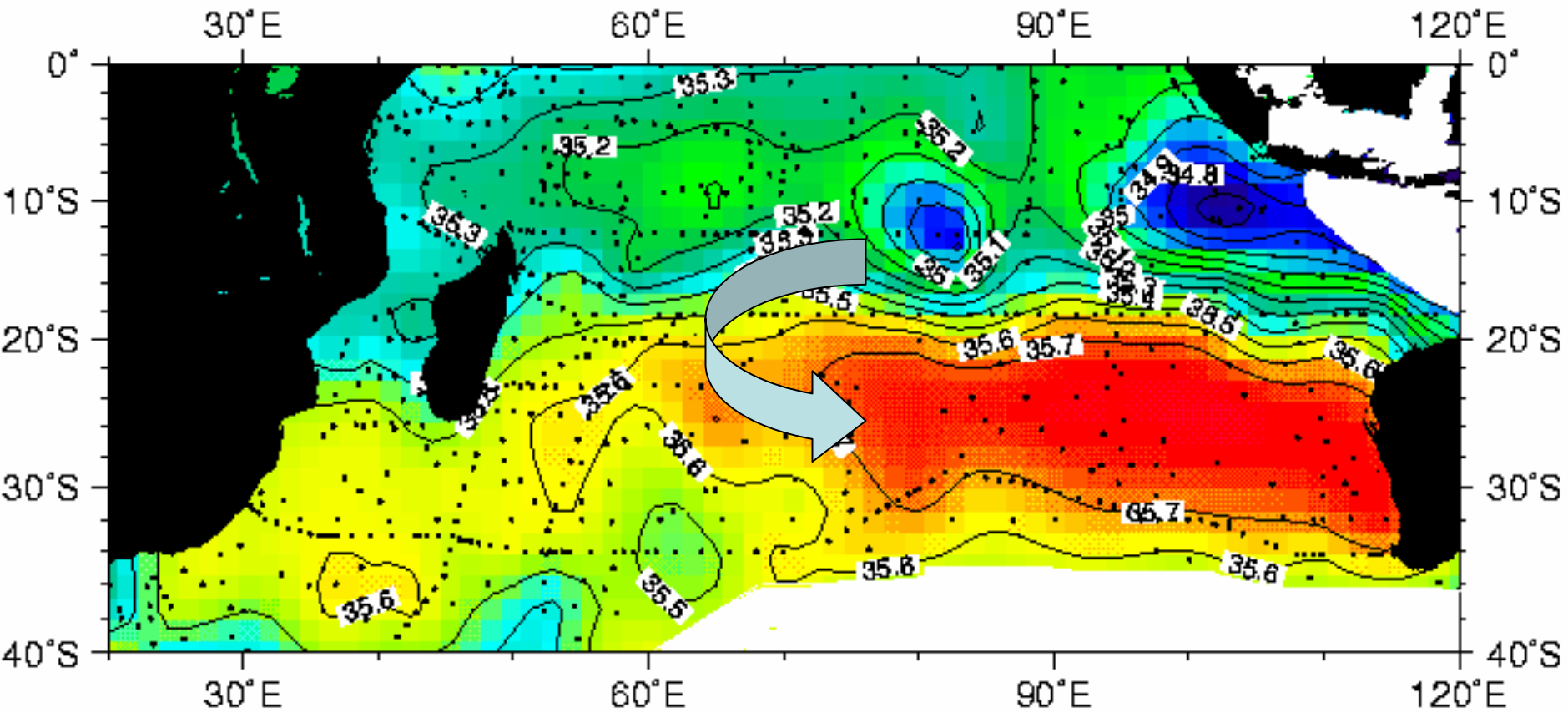


DOC production, surface transport, and downward mixing (export)



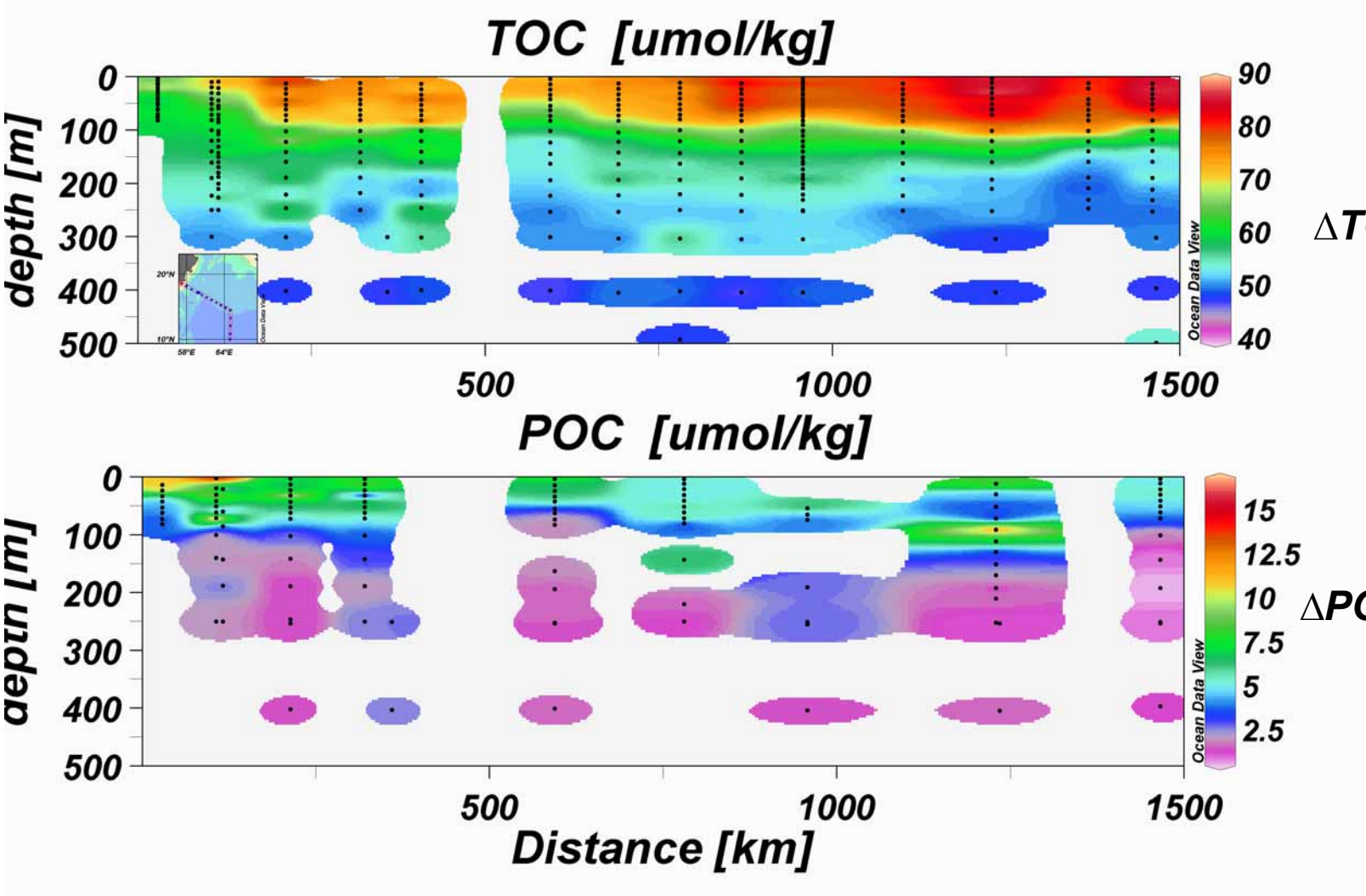
Darker colors represent higher DOC concentrations

Need to move dissolved organic carbon from areas of formation to areas of ventilation



Surface Salinity using Reid Historical Hydrographic Data (fig. by Bridgette O'Connor)

TOC and POC during early SW Monsoon (prior to TOC fallout)



ΔTOC >10 uM

ΔPOC <5 uM

1) Surface – variable DOC/low AOU

2) Ventilation – DOC decreases; AOU increase (20-40%)

3) Deep – DOC constant; AOU increases