



**The Abdus Salam
International Centre for Theoretical Physics**



2066-20

**Workshop and Conference on Biogeochemical Impacts of Climate and
Land-Use Changes on Marine Ecosystems**

2 - 10 November 2009

Distribution of N₂-Fixation in the Open Ocean

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Distribution of N_2 -Fixation in the Open Ocean

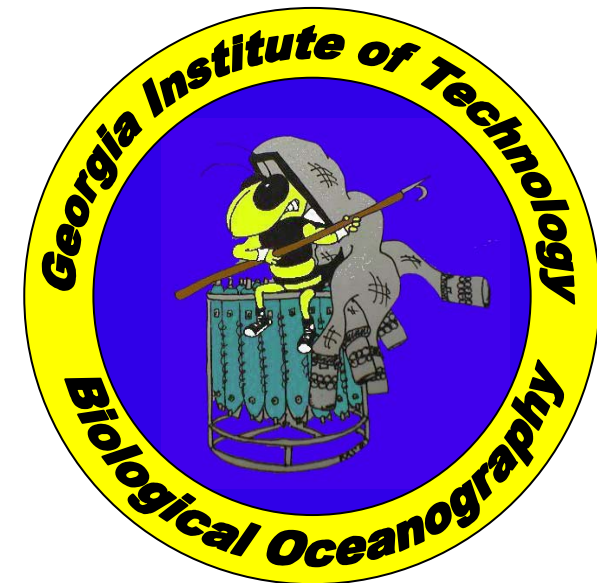
Georgia
Tech



Joseph P. Montoya
(ICTP-Trieste, 9 November 2009)

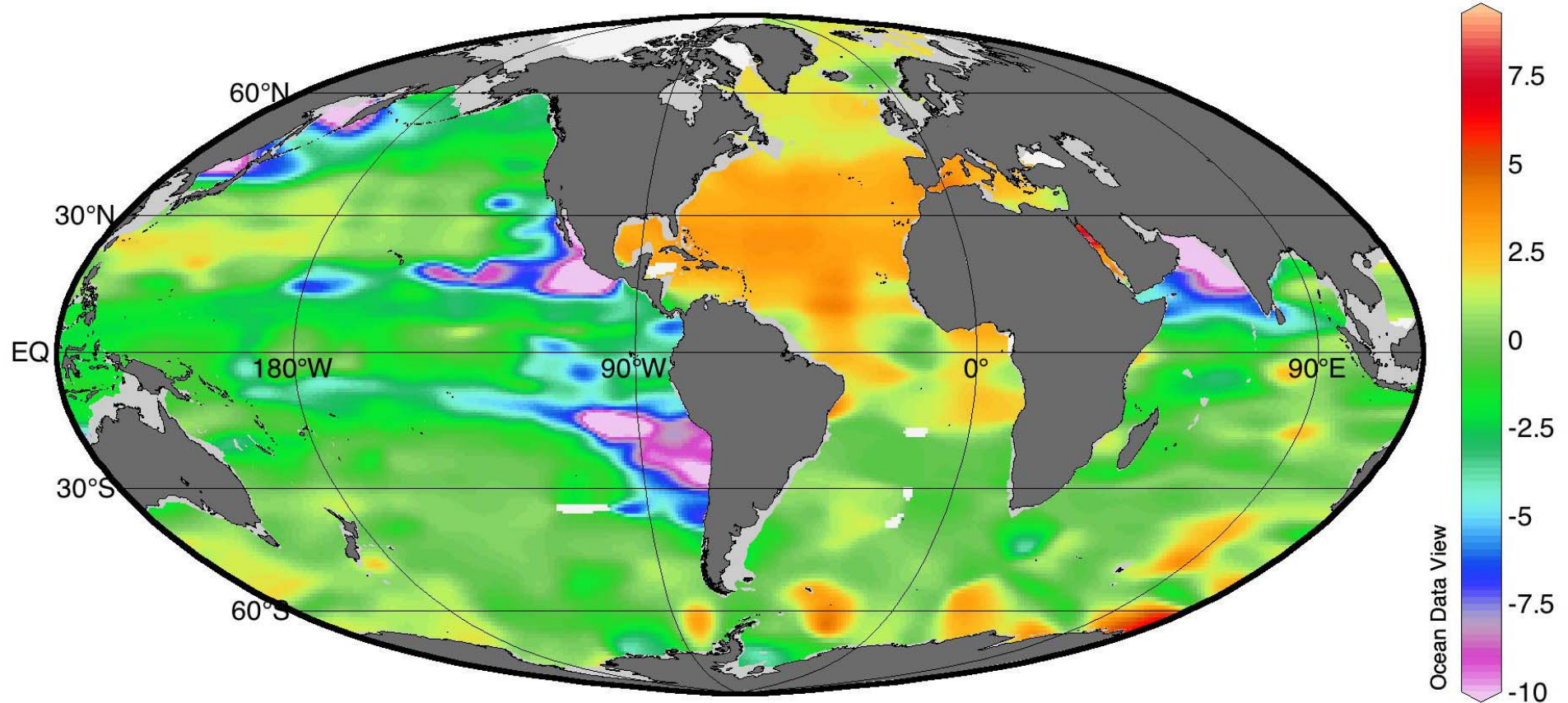
Plan for Today

- Marine N cycle
 - N:P stoichiometry
 - Oceanic N budget
- North Atlantic
 - North Atlantic Distribution
 - Biogeography?
- Southwest Pacific
 - Rates
 - Players



N* Distribution Shows Interplay Between N₂-Fixation and Denitrification

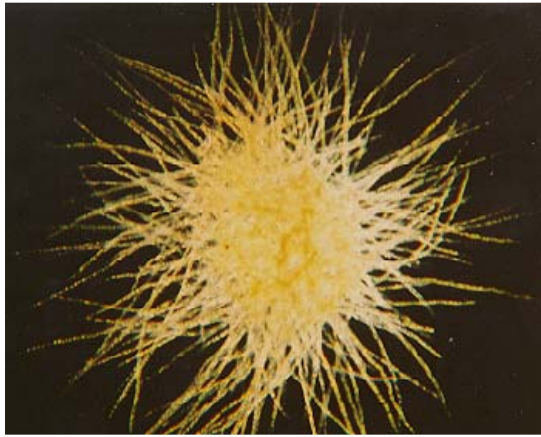
N* [umol/kg] on Depth = 300 m



$$N^* = 0.87([\text{NO}_3^-] - 16[\text{PO}_4^{3-}] + 2.9) \quad (\text{Gruber \& Sarmiento 1997})$$

Trichodesmium: The Usual Suspect

- Diazotrophs, including *Trichodesmium*, are broadly distributed in nutrient poor oceanic waters, but their contribution to the marine N budget remains poorly constrained.

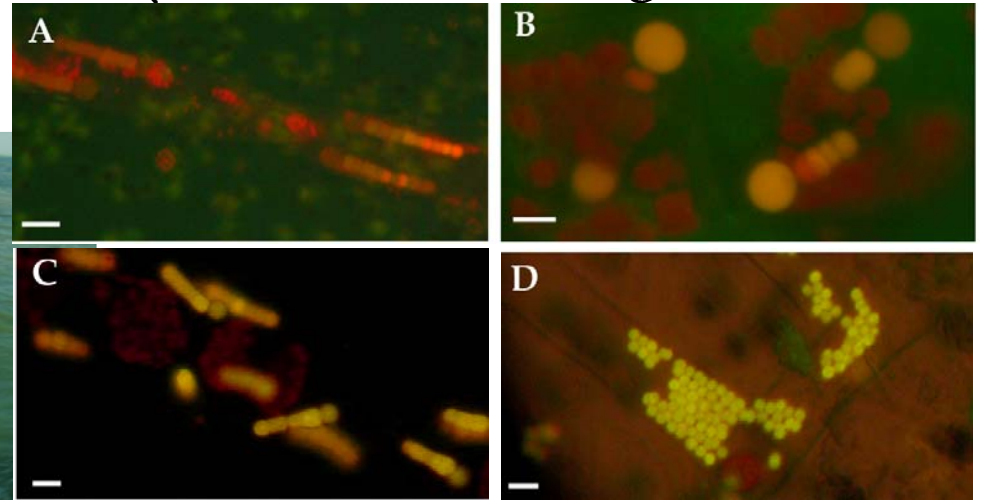
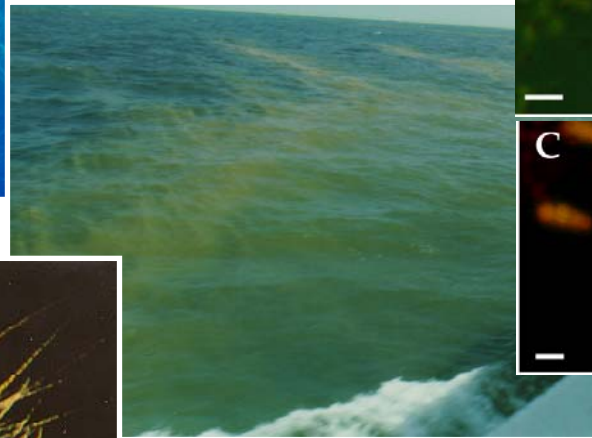


Trichodesmium blooms from aboard ship (left) and from space (below).

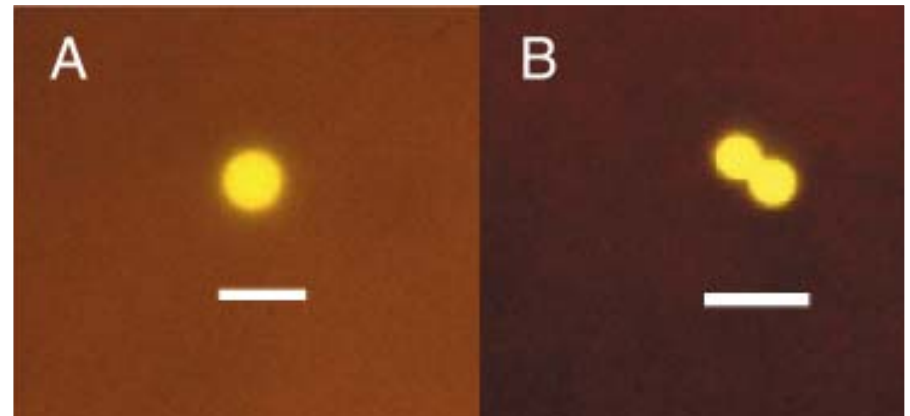
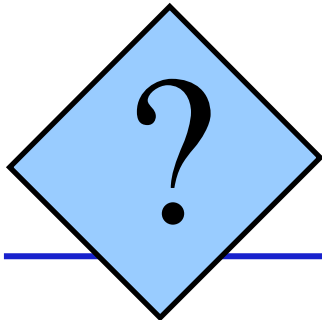
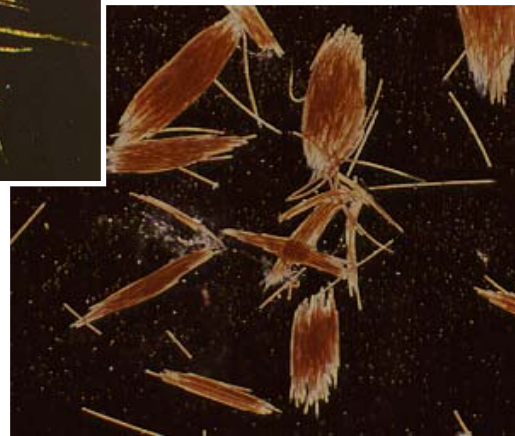
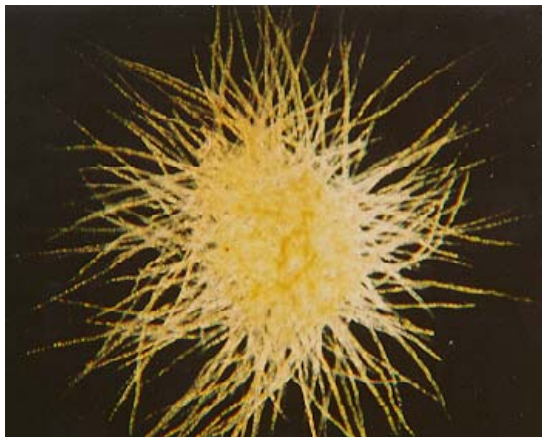


Trichodesmium puffs (above) and tufts (right).
Photos by Hans Paerl.

Diazotroph Diversity



(Images courtesy R. Foster)



(Zehr et al., 2001. Nature 412)

CTD-Rosette

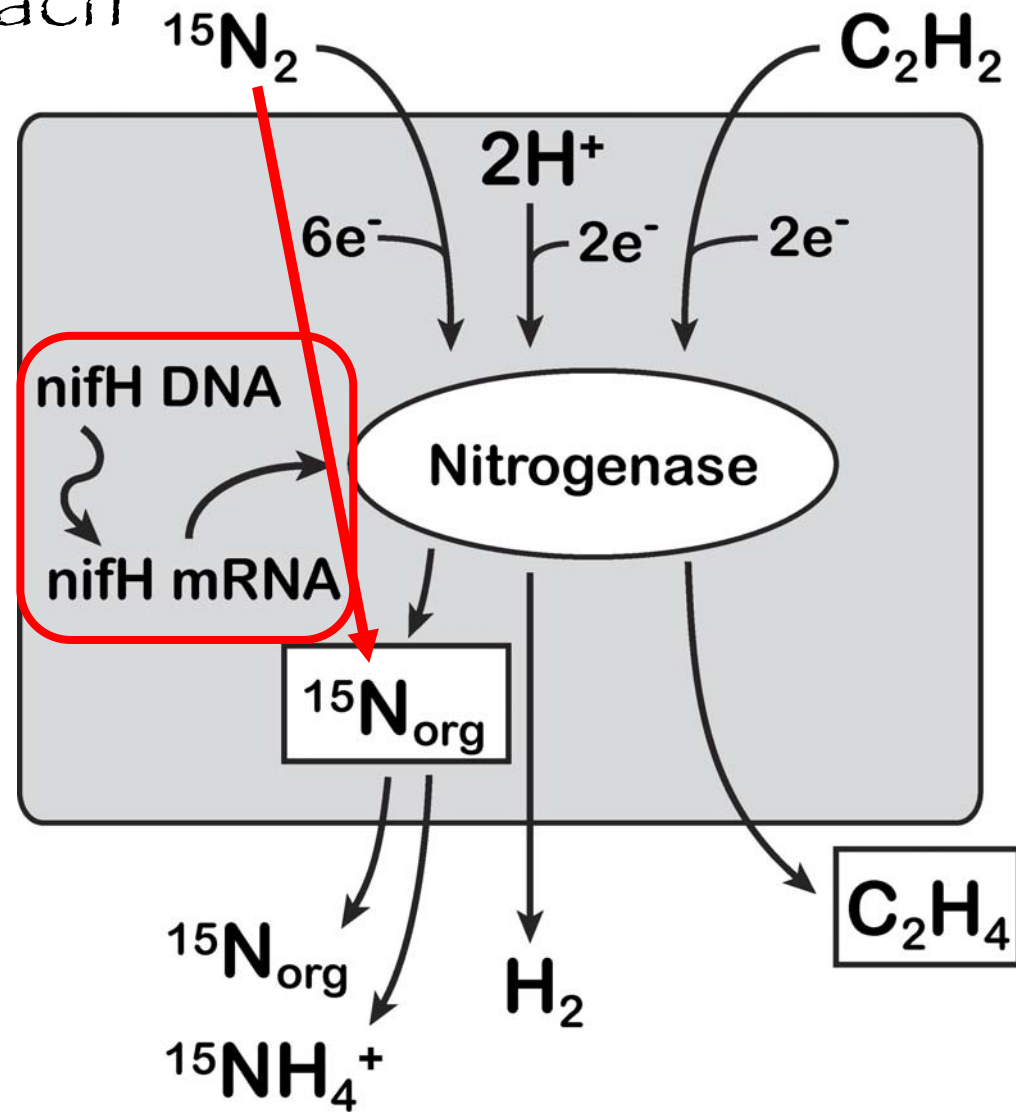


Experimental Approach

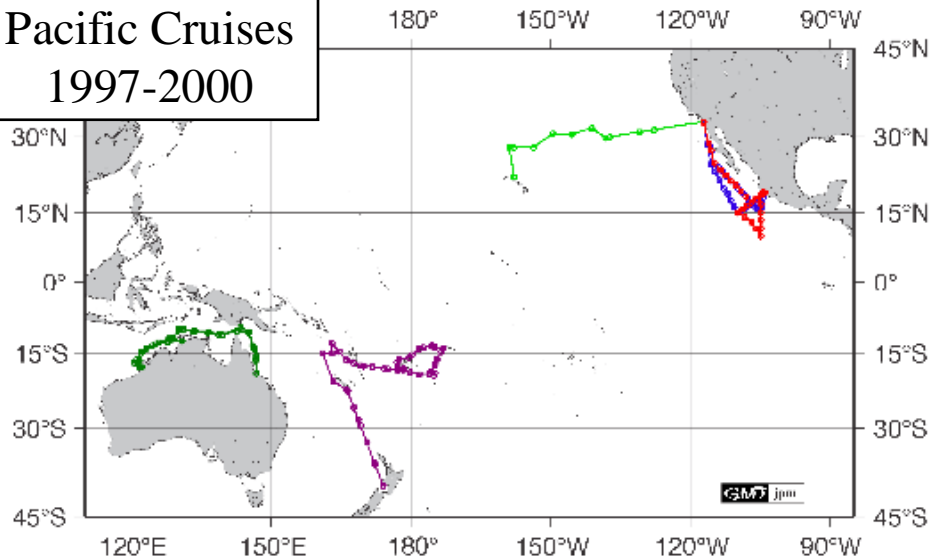
- $^{15}\text{N}_2$ -fixation measures net incorporation of N_2 into organic matter.



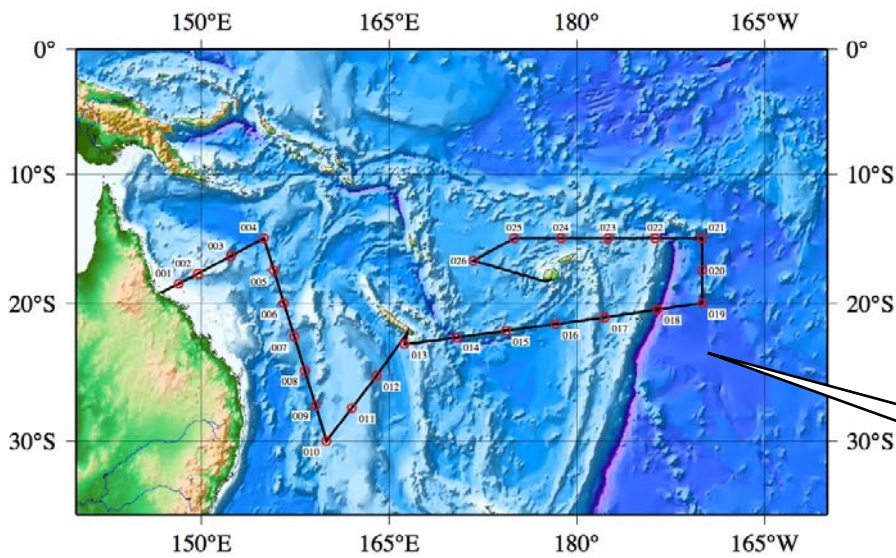
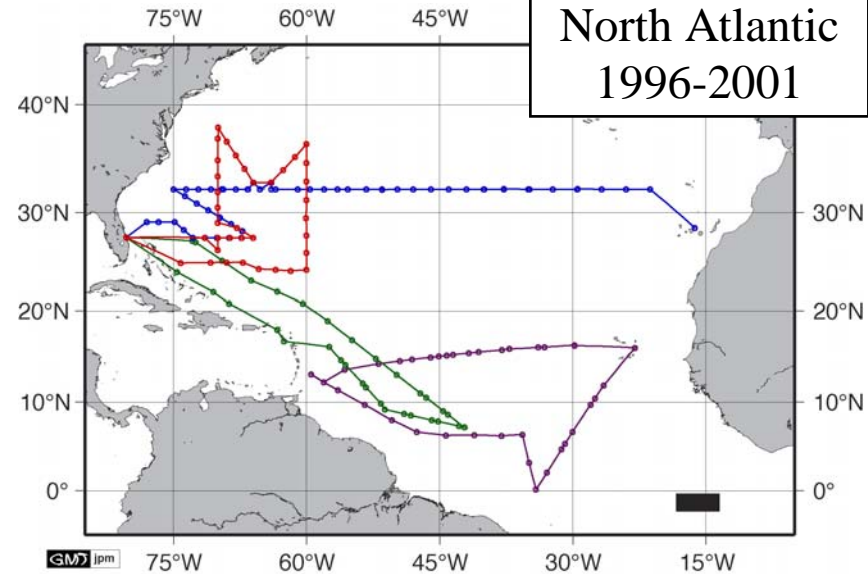
- Parallel studies (Zehr Lab) quantify the diversity of diazotrophs (nifH DNA) and their pattern of activity (nifH mRNA).



Pacific Cruises
1997-2000

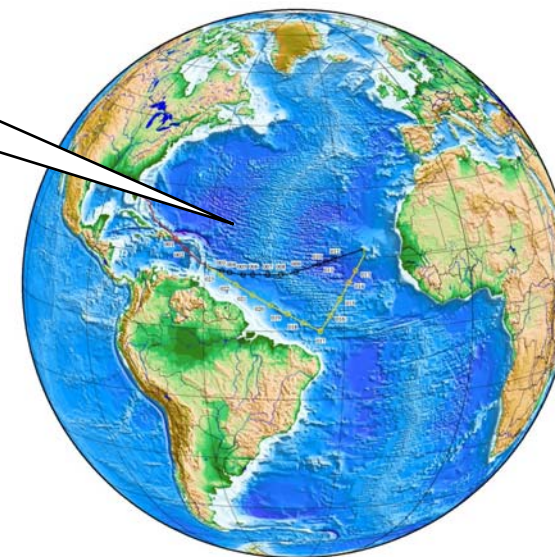


North Atlantic
1996-2001

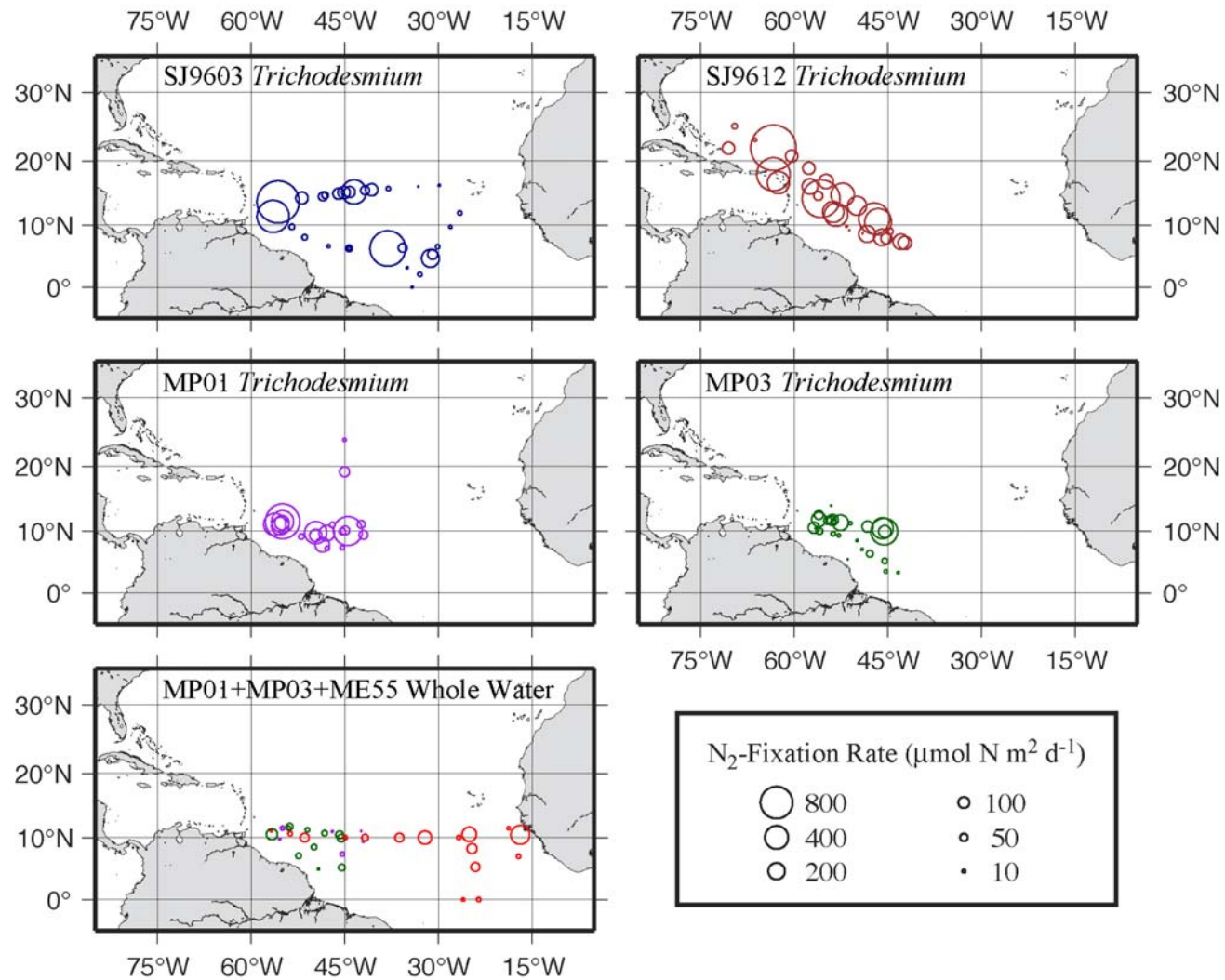


SJ0609
Jun-Jul 2006

KM0703
Mar-Apr 2007



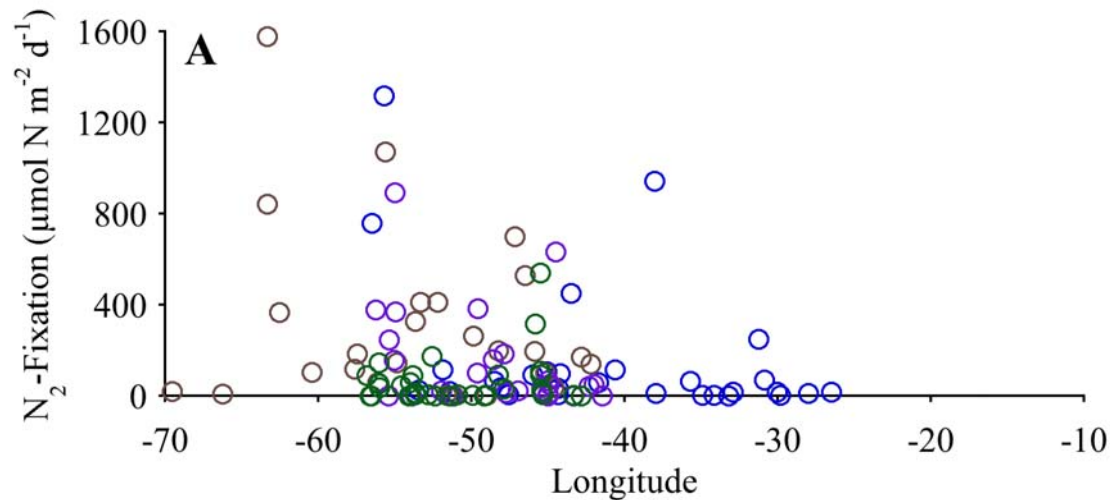
North Atlantic N₂-Fixation Rates



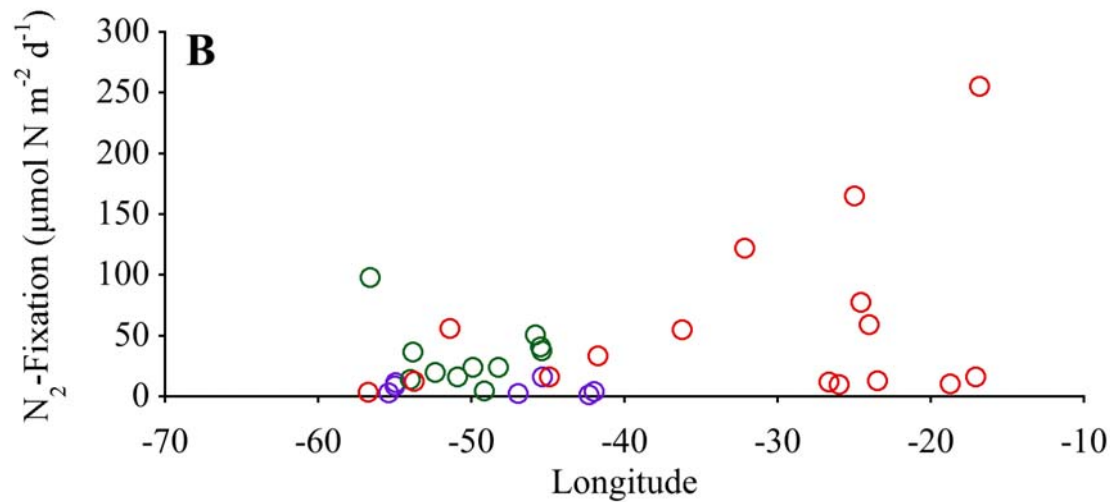
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(Montoya et al., 2007. *Biogeosciences* 4369-376)

N₂-Fixation Rate vs. Longitude



Trichodesmium

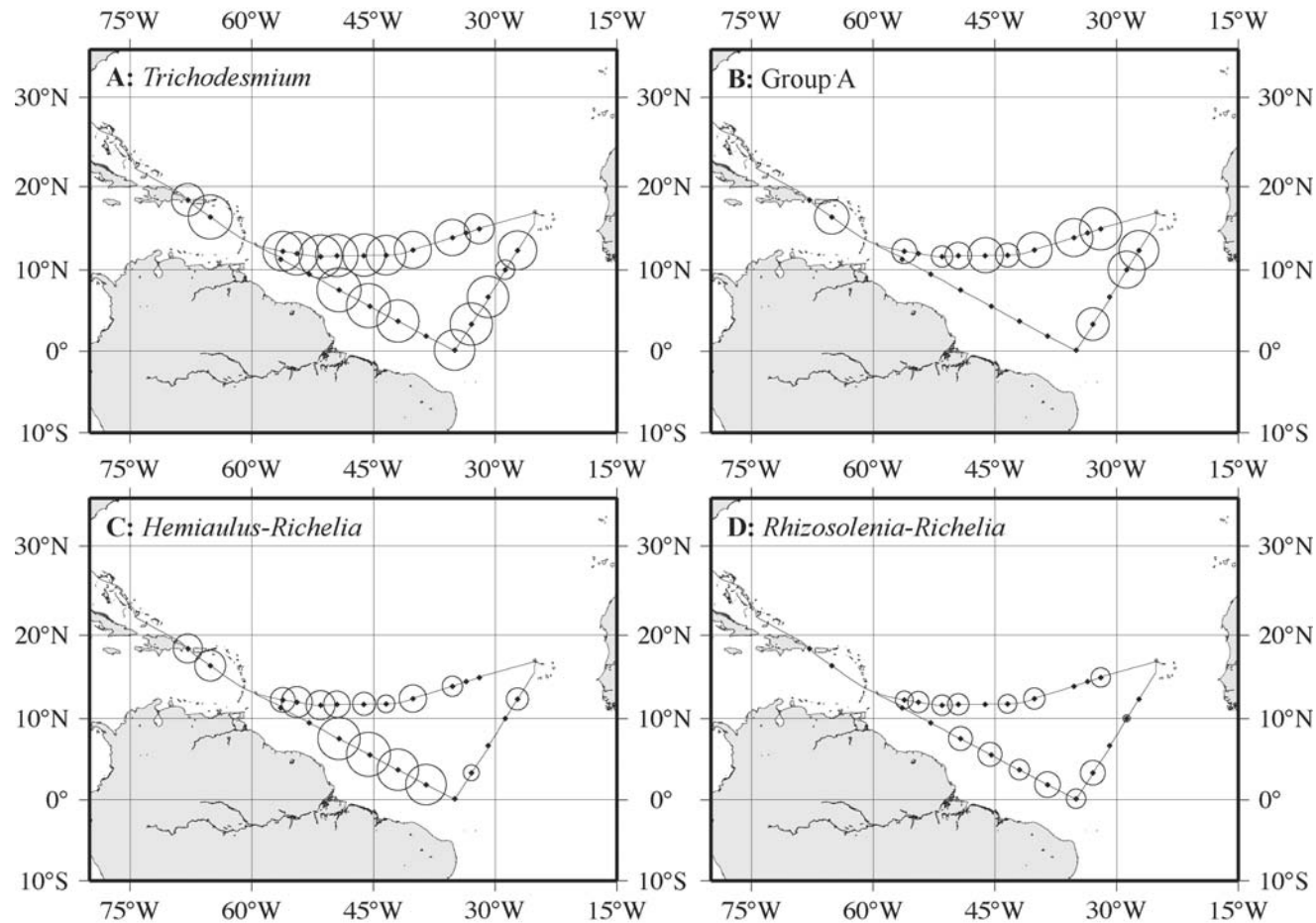
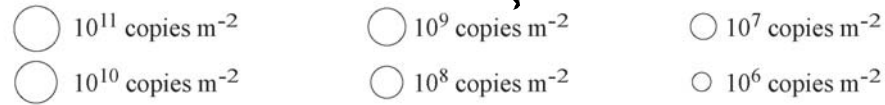


Whole Water

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(Montoya et al., 2007. Biogeosciences 4369-376)

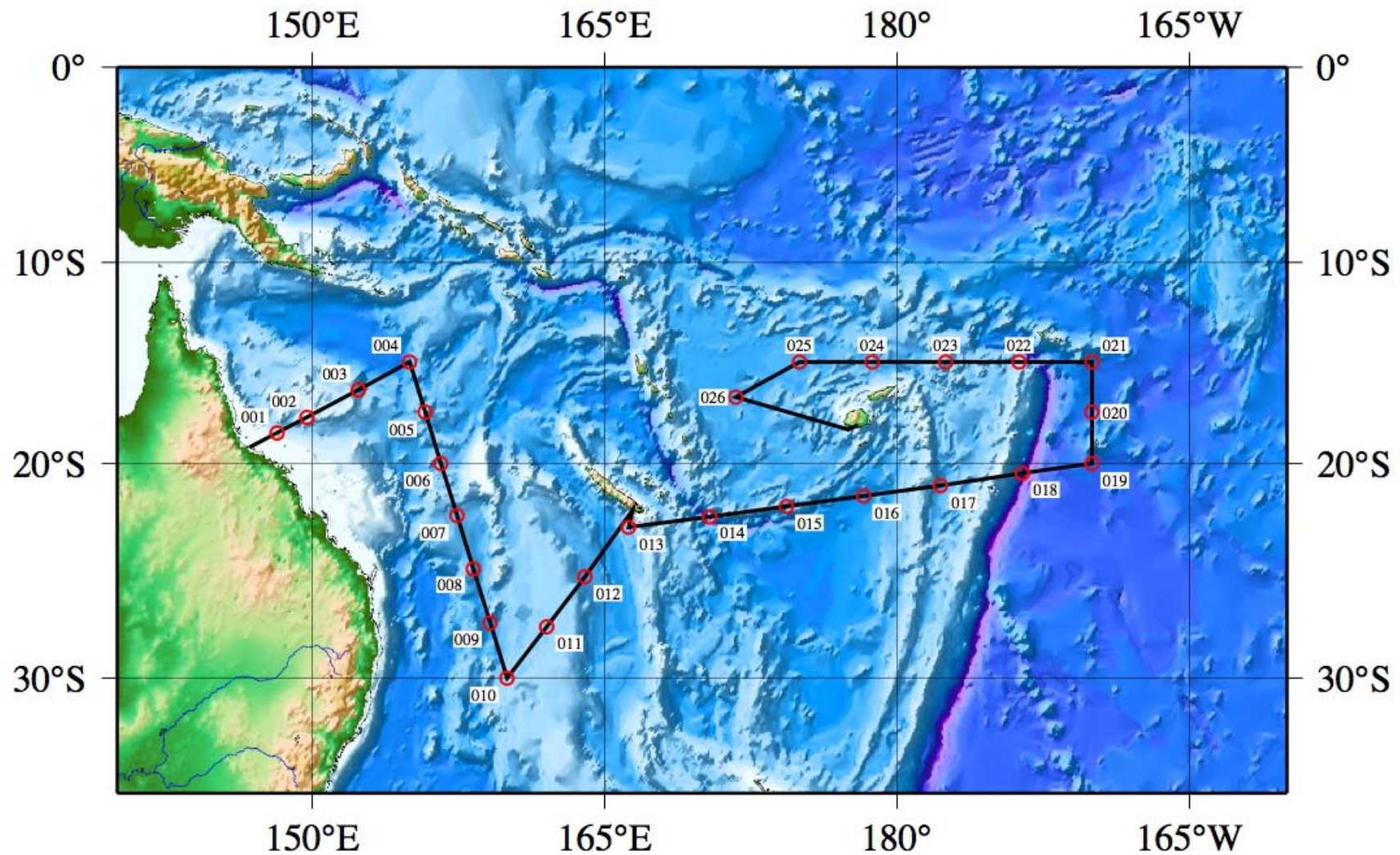
Atlantic Diazotroph Distribution

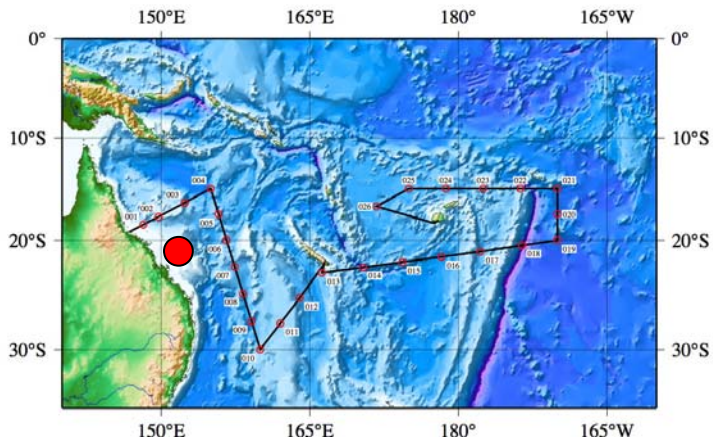


Georgia Tech Biological Oceanography

(Goebel, Zehr, et al. in prep)

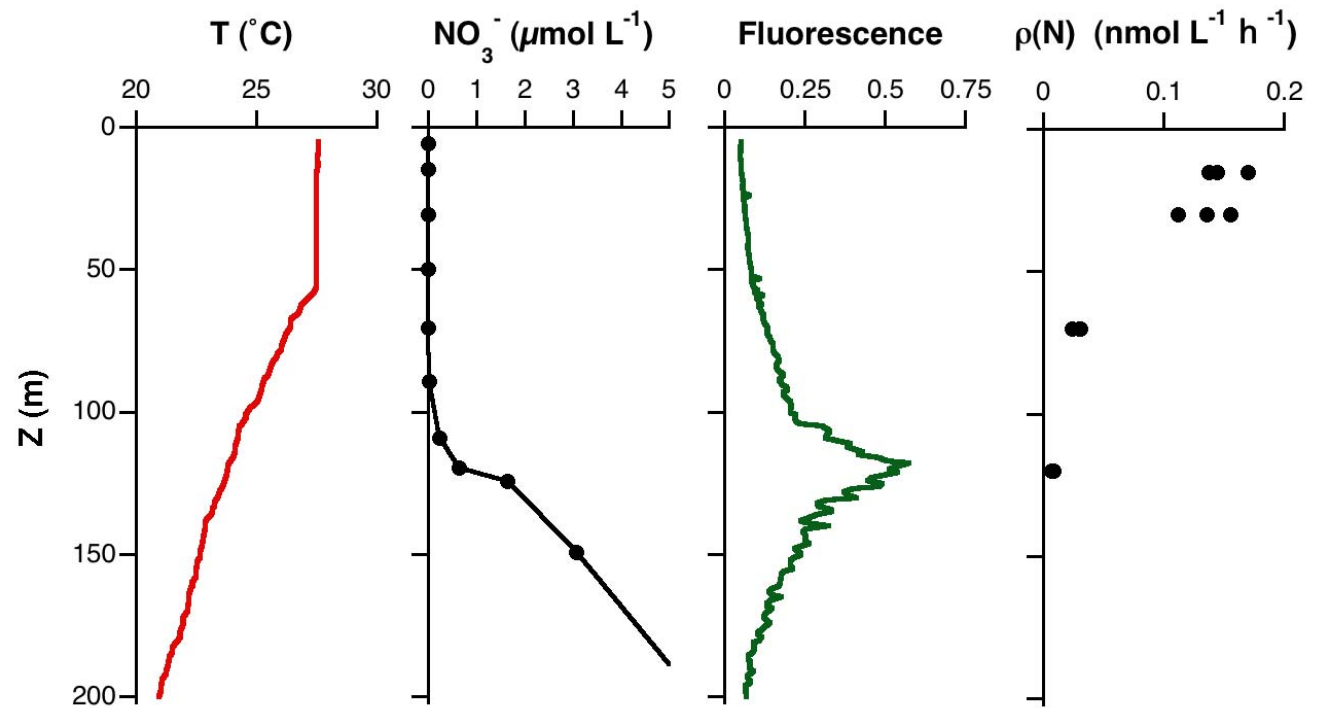
KMo703: 11 Mar - 15 Apr 2007





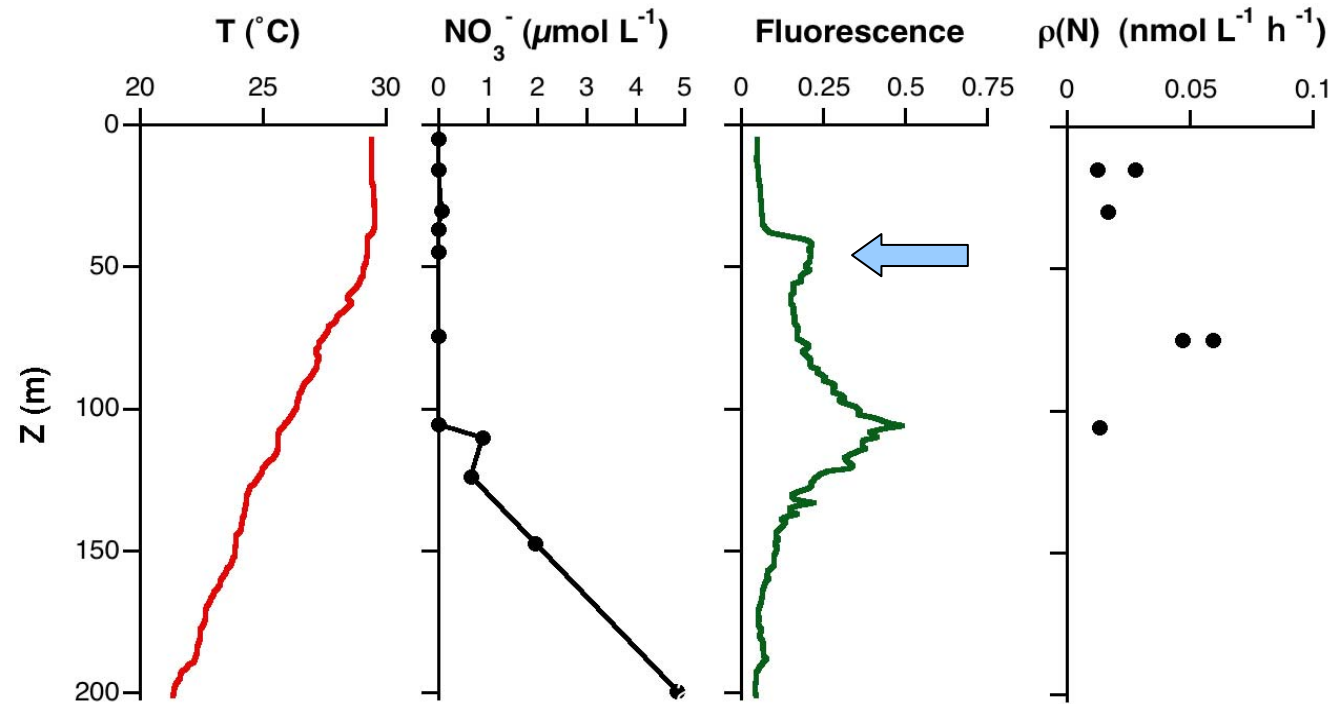
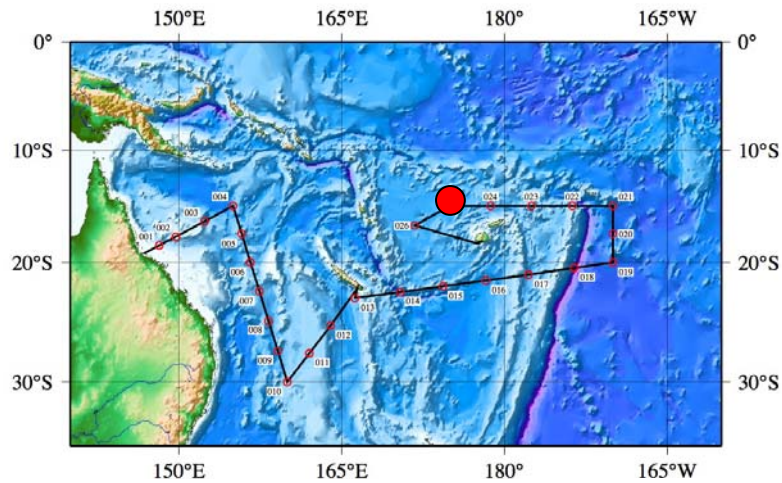
KM0703-006

Areal Rate: $204 \mu\text{mol N m}^{-2} \text{d}^{-1}$



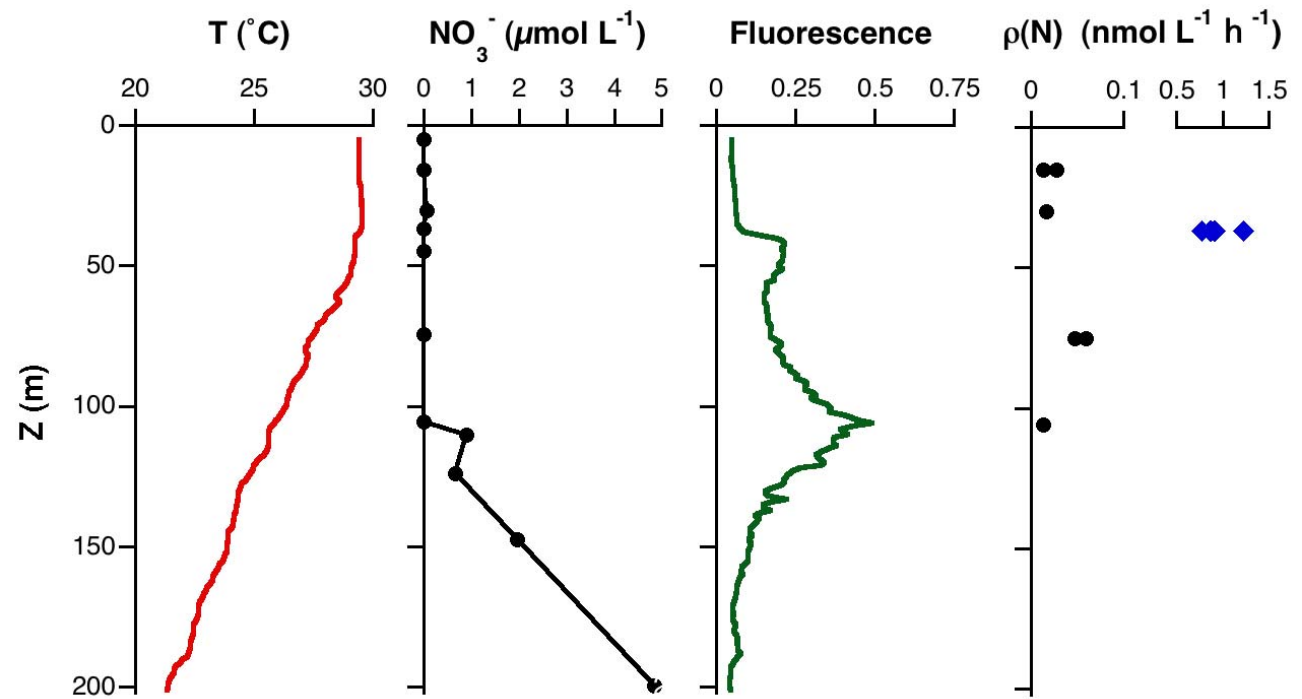
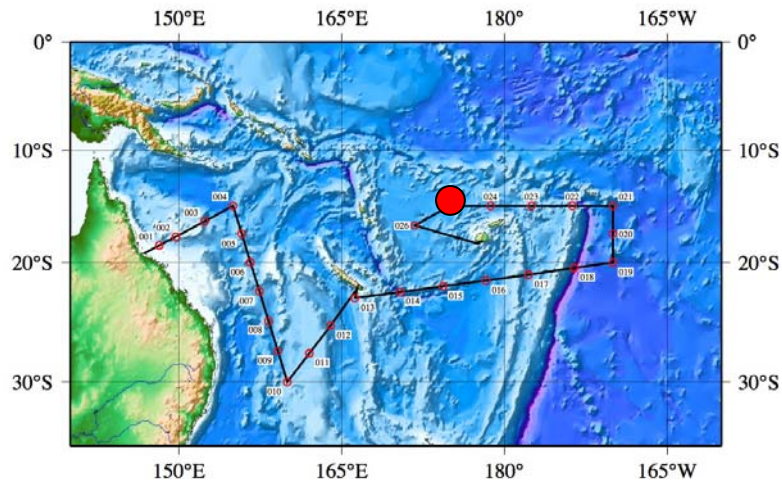
KM0703-025

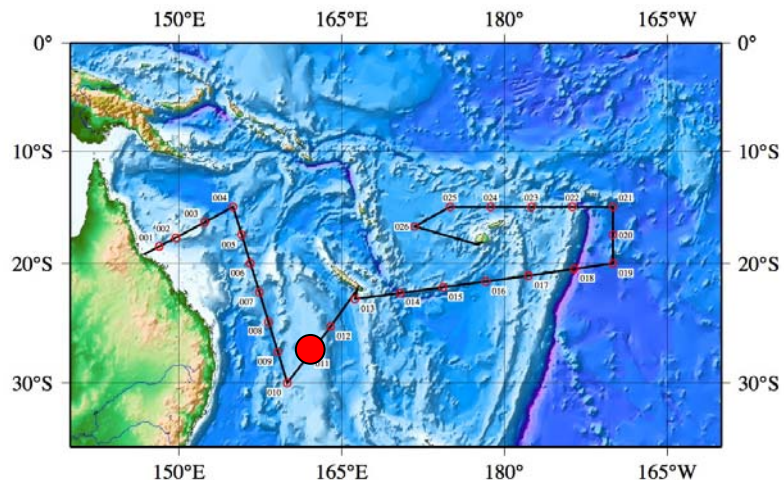
Areal Rate: $76 \mu\text{mol N m}^{-2} \text{d}^{-1}$



KM0703-025 (+)

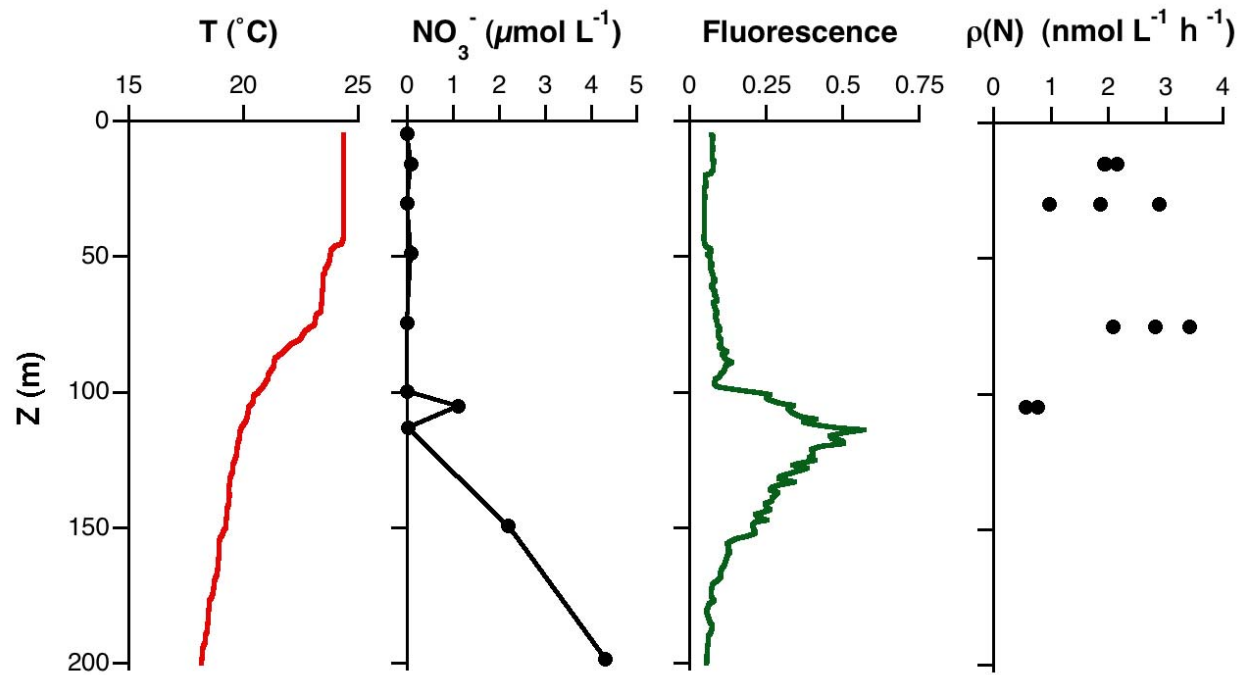
Areal Rate: $187 \mu\text{mol N m}^{-2} \text{d}^{-1}$

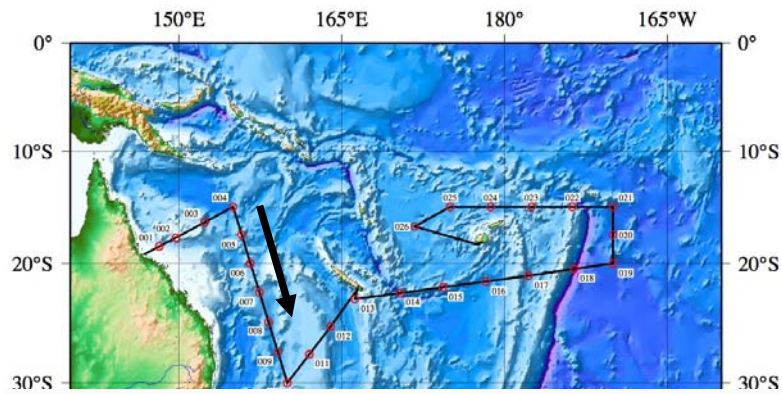




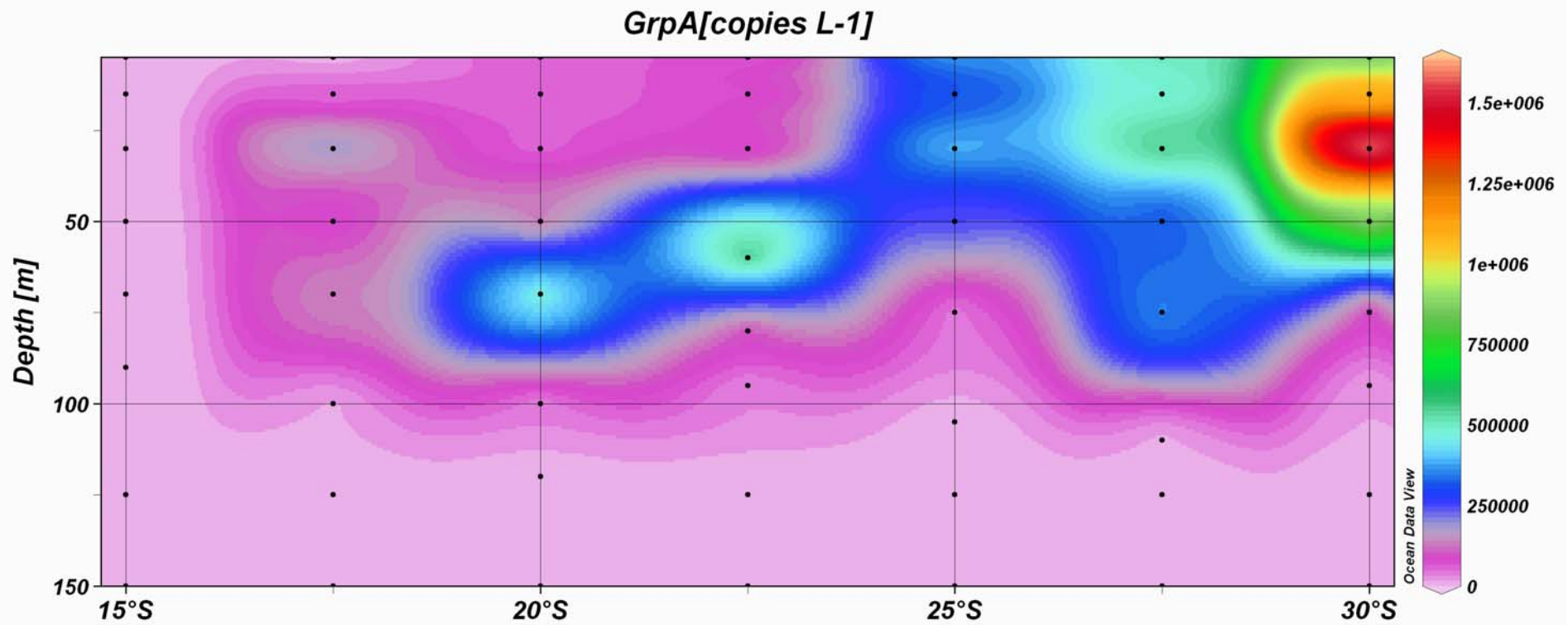
KM0703-011

Areal Rate: $5,173 \mu\text{mol N m}^{-2} \text{d}^{-1}$



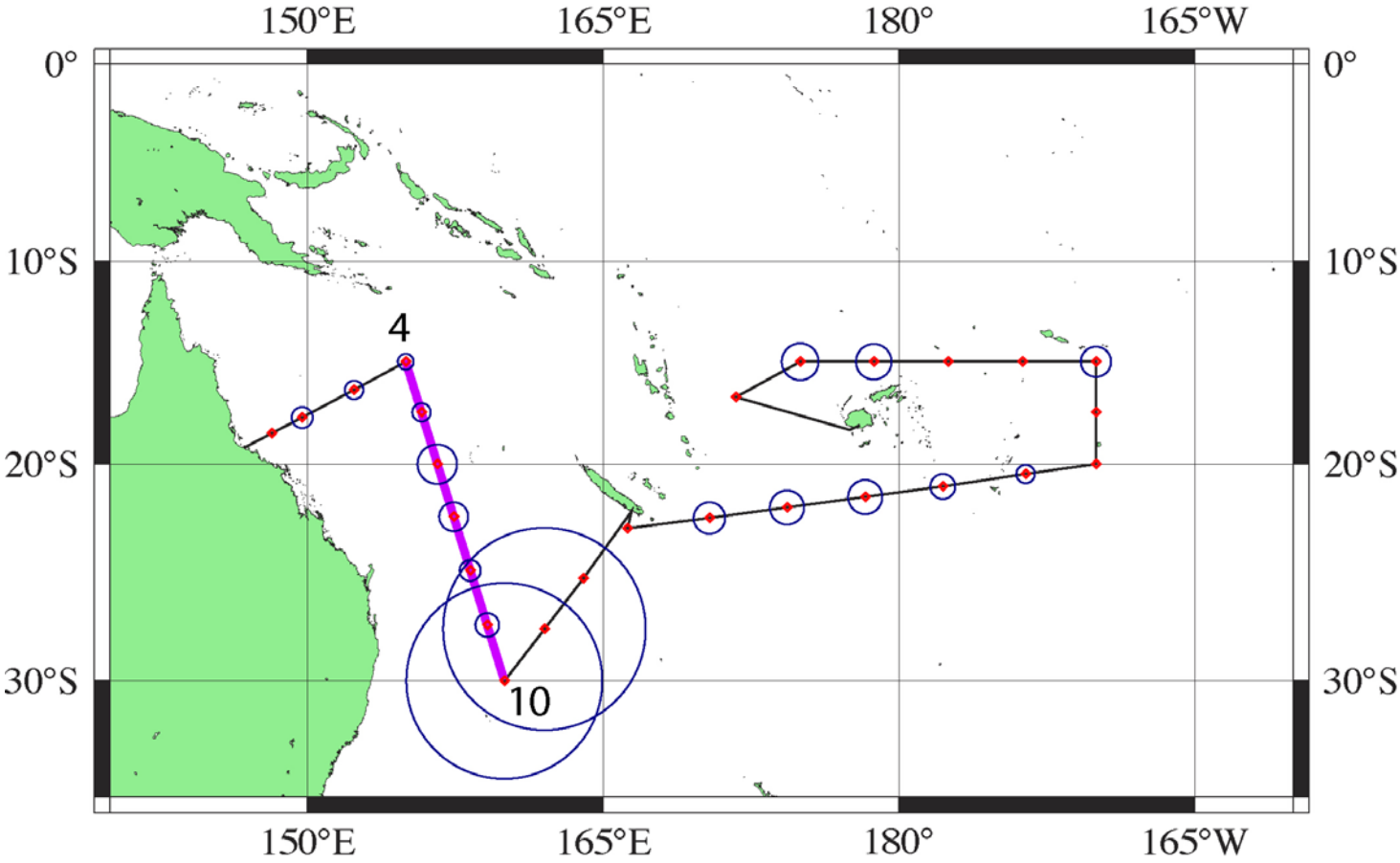
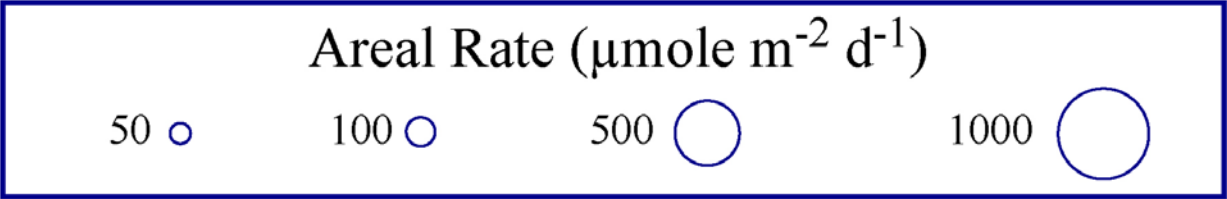


KM0703 Stns. 4 - 10 Group A Abundance



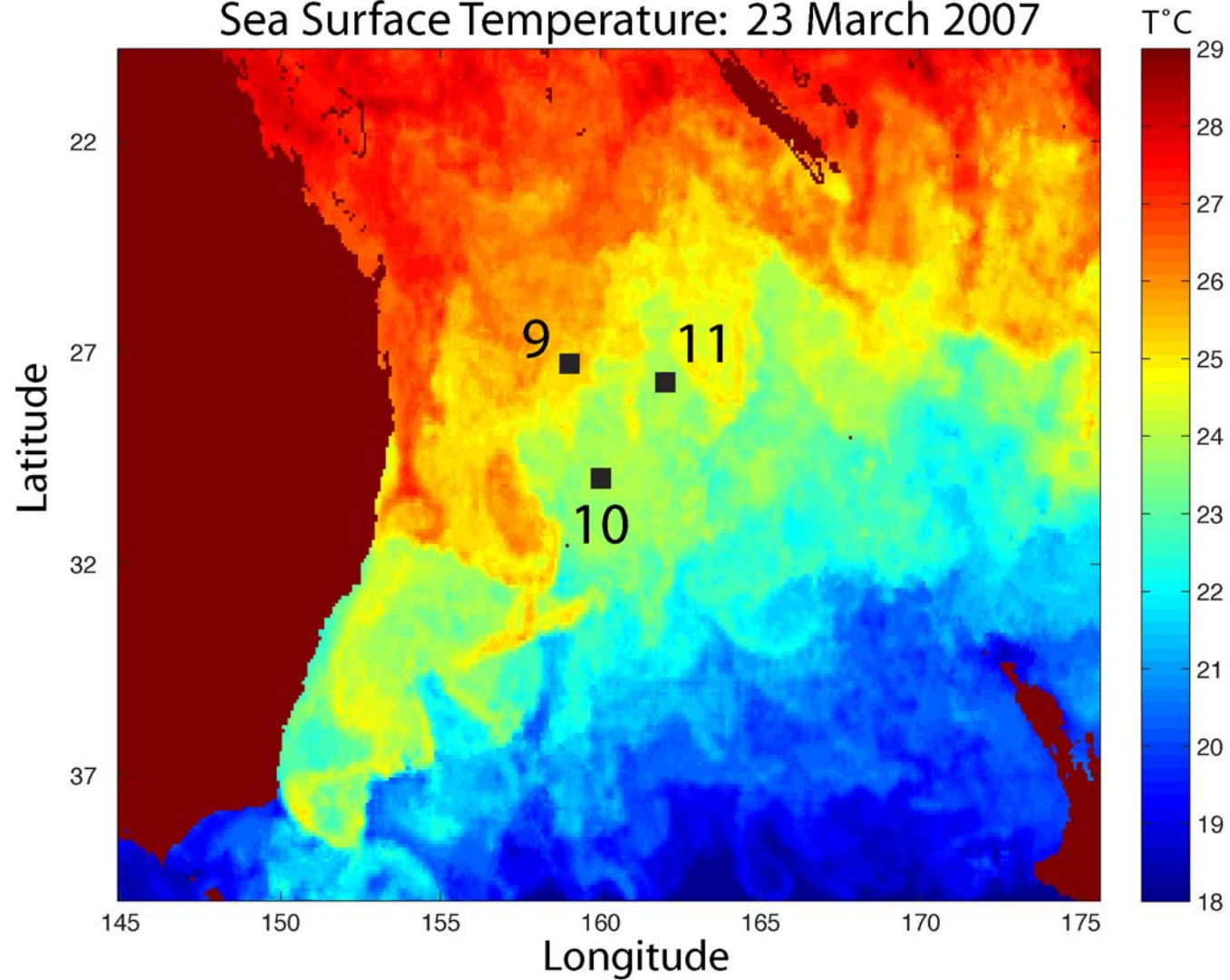
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(Moisander et al., in prep)



KM0703 Stations 9 - 11 and SST

Sea Surface Temperature: 23 March 2007

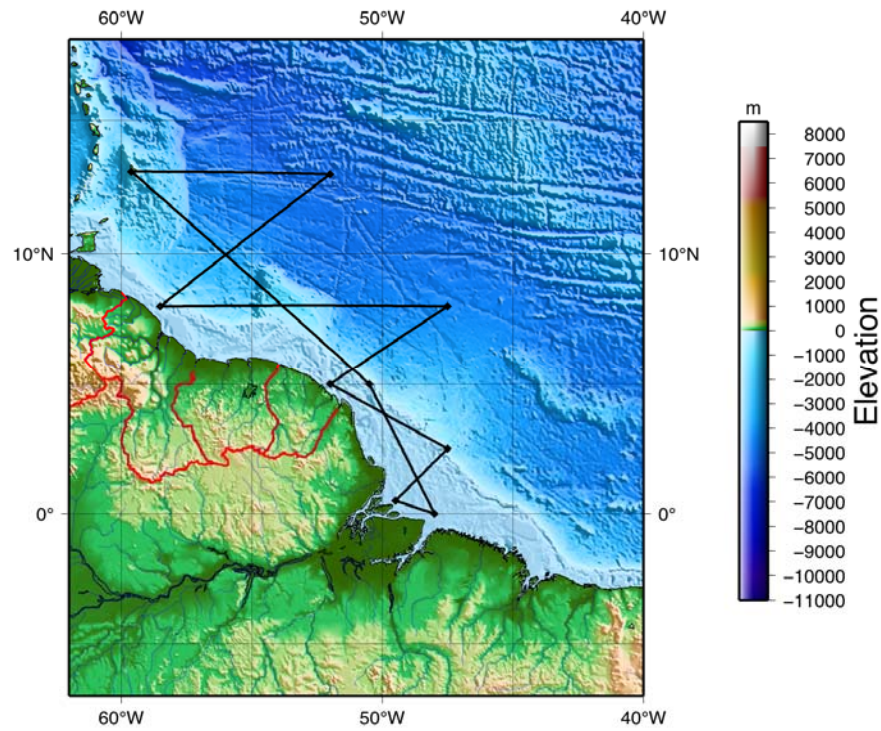


Areal Rates of N₂-Fixation

Location/System	Dates	Areal Rate ($\mu\text{mol N m}^{-2} \text{d}^{-1}$)	SE	N
Station ALOHA	2000 - 2001	66	19	7
Kaneohe Bay	2000 - 2002	24	6	12
Eastern North Pacific Gyre	Jun - Jul 2002	505	165	10
Timor - Arafura & Coral Seas	Nov 1999	126	47	7
Arafura Sea (Stations 26 & 27)	Nov 1999	3955		2
<i>Trichodesmium</i> (range)	1964 - 2001	35 - 283		
<i>Richelia/Hemiaulus</i> (bloom)	Oct 1996	3110		
KM0703 (range)	Mar - Apr 2007	50 - 5485		

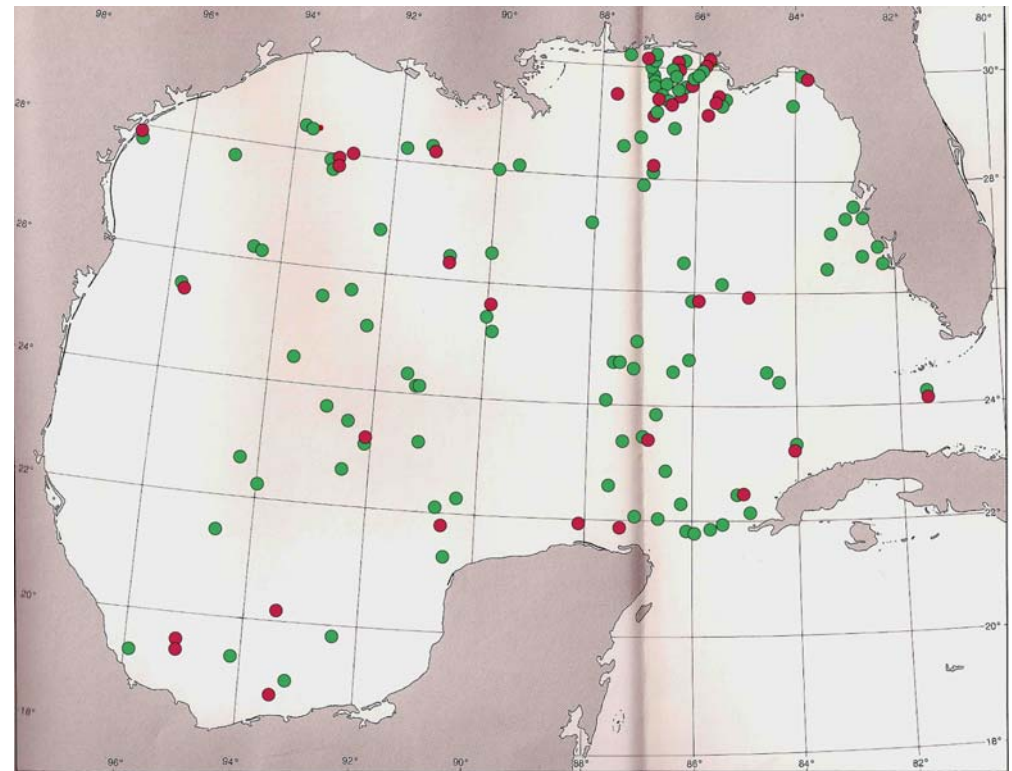
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(Refs in Montoya et al., 2004. Nature 430: 1027-1031)



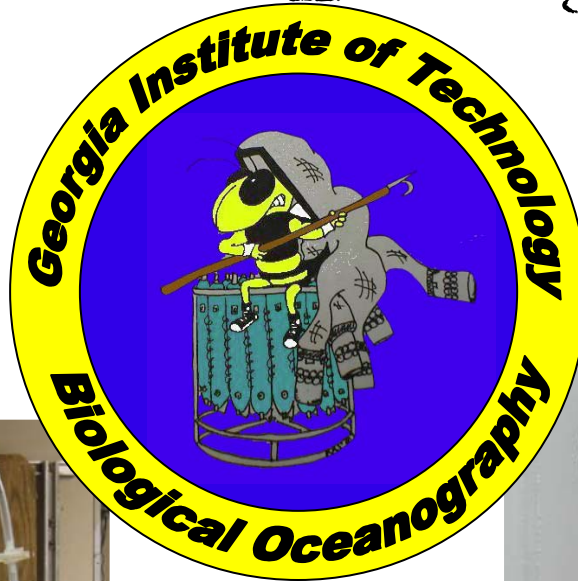
Where next?

- Amazon Plume
- Gulf of Mexico



Right: Saunders R, Fryxell G (1972) Diatom distribution. In: Bushnell V (ed) Chemistry, Primary Productivity, and Benthic Algae of the Gulf of Mexico, Vol Folio 22. American Geographical Society, New York, Map 3

Thanks for Listening!



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