

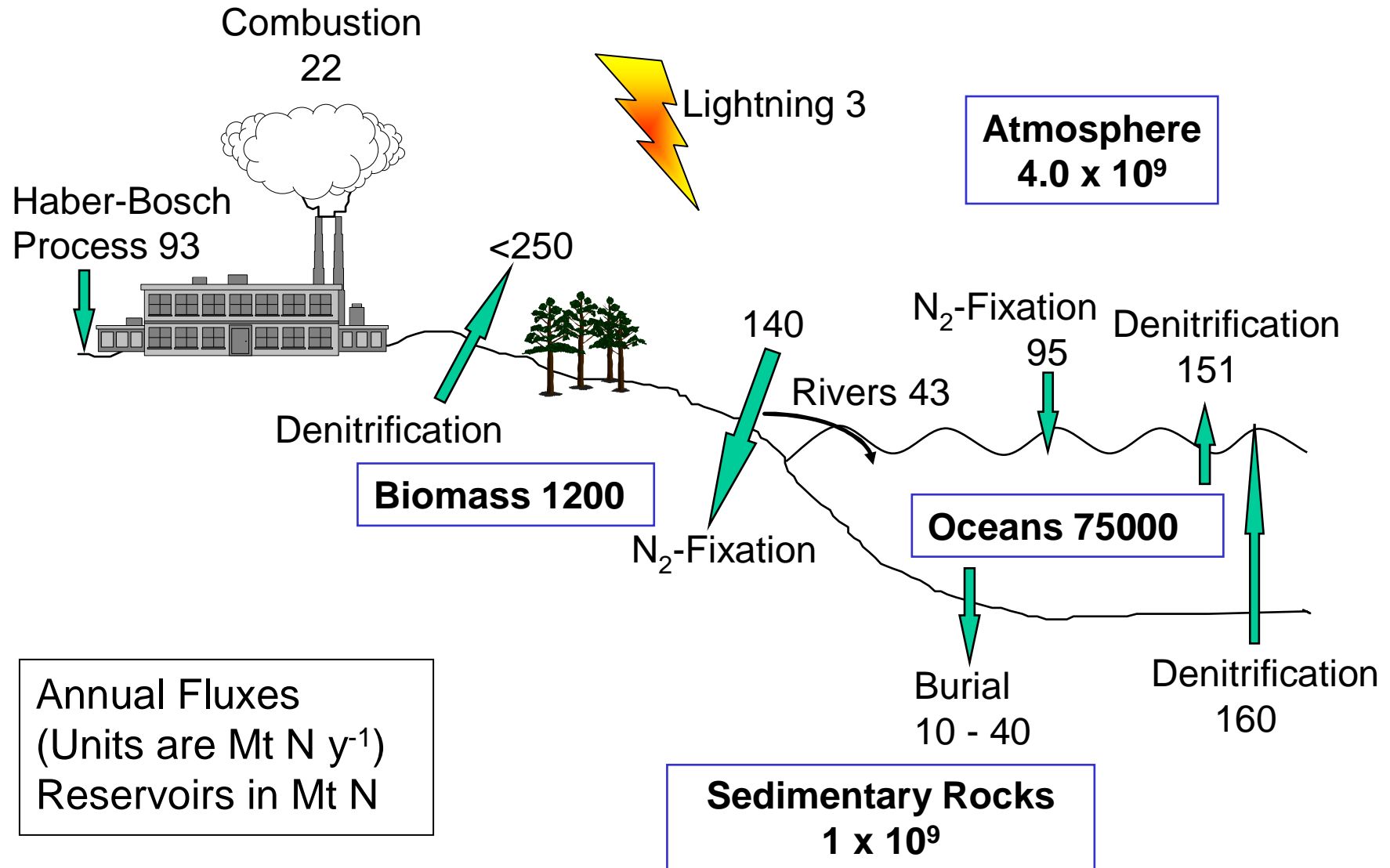
**Nitrogen fixation in tropical waters.  
Nutrition from the air?**

**Julie LaRoche**

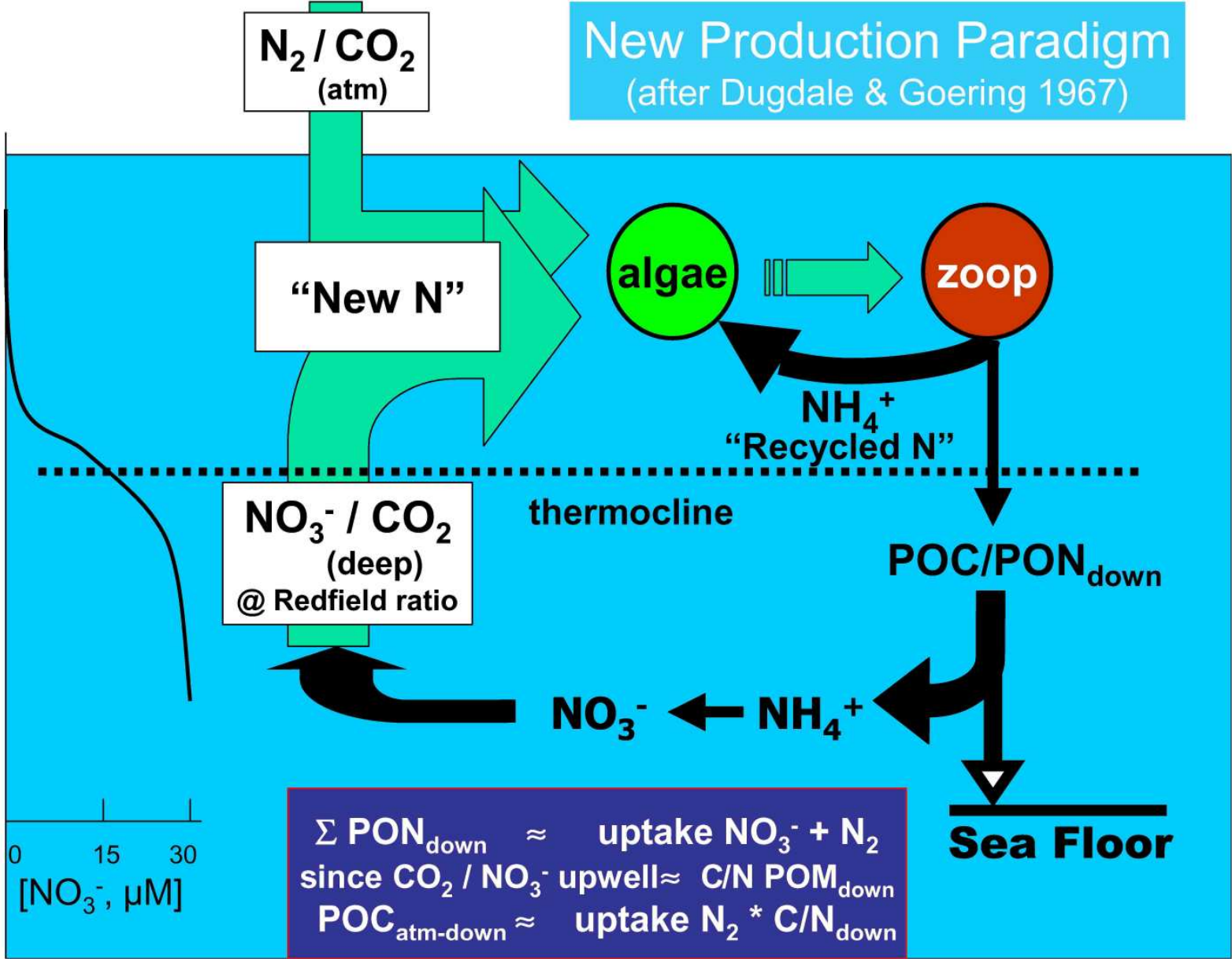
**Cape Verde Observatory workshop:  
“Integrated, long term ocean-atmosphere  
observations in the tropical Atlantic”**

**8-10 January 07**

# Global Nitrogen Cycle



# New Production Paradigm (after Dugdale & Goering 1967)



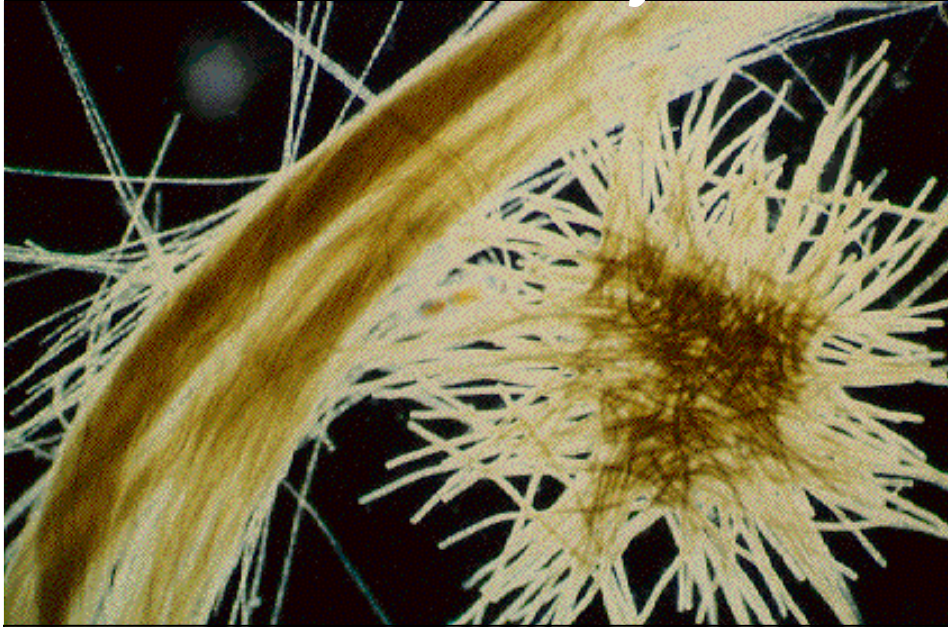
# ***Nitrogen Fixation***

- $\text{N}\equiv\text{N}$  → organic-N compounds
- requires significant energy
- relatively few species can do the job: All are prokaryotes (photosynthetic cyanobacteria and heterotrophic bacteria)
- Requires the nitrogenase enzyme (23 iron atoms)
- North Atlantic sub-tropics and tropics seem to be regions of net N-fixation

# ***Marine diazotrophs (nitrogen fixers): Some important questions***

- Who is out there?
- How many are out there?
- Who is actively fixing nitrogen?
- How much nitrogen are they fixing?
- What factors control their growth?
- What is the importance of dust-supplied Fe?
- How will they adapt to future conditions?

***Trichodesmium erythraeum***



**Fixes N<sub>2</sub>**



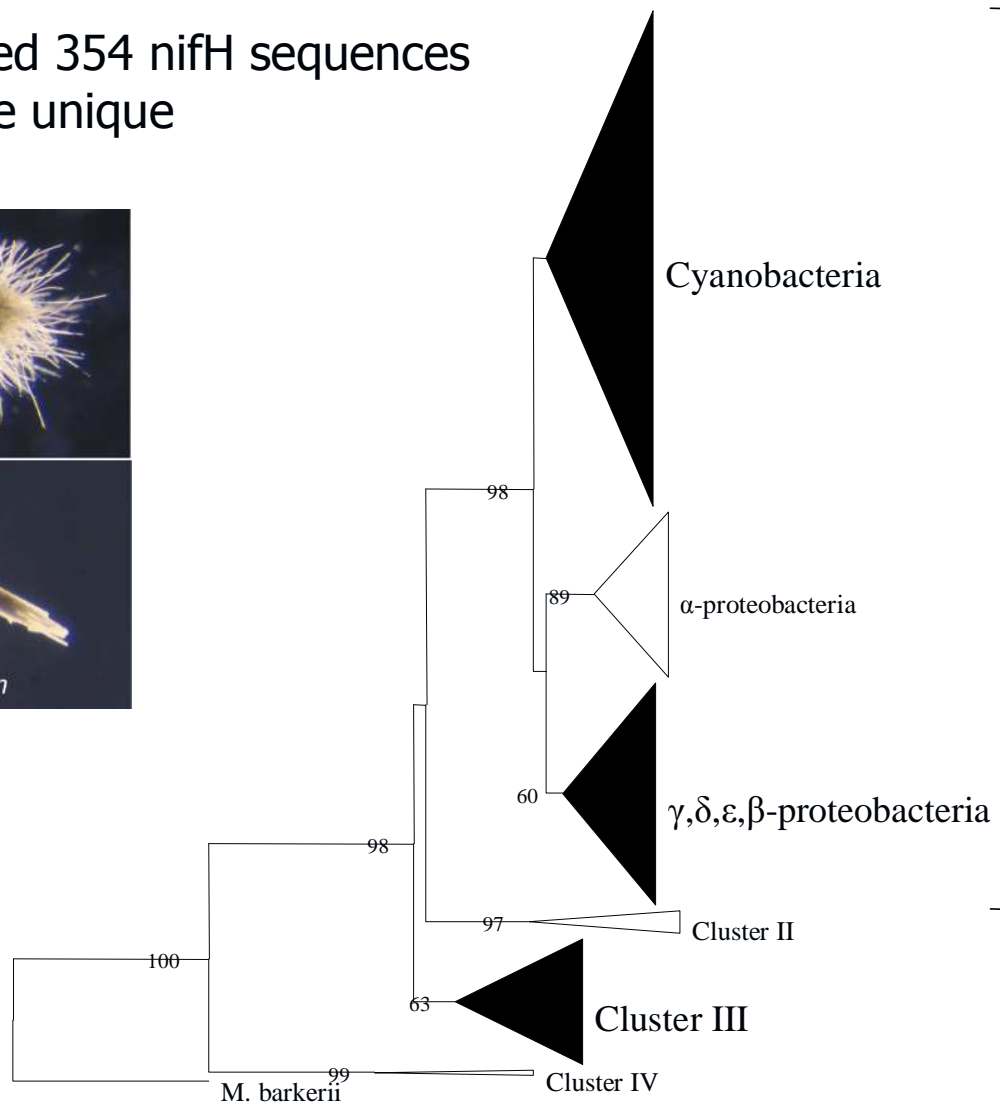
***Trichodesmium erythraeum* IMS101 (6500 Kb)**

*Trichodesmium* photo: Courtesy of Pernilla Lundgren  
Genomes: Joint Genome Institute web site

# Global *nifH* Protein Tree

(Langlois et al. 2005 AEM)

Recovered 354 *nifH* sequences  
170 were unique



57% **Filamentous:**  
*Trichodesmium sp.*

32% **Unicellular:**  
*Unicellular A*  
*Cyanothece*  
*Synechocystis*

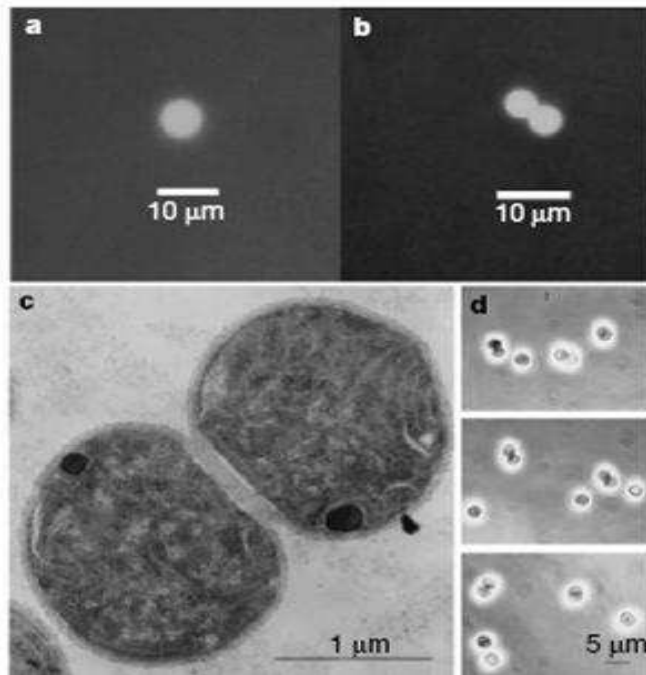


9% **Heterotrophic**

2% **Anaerobic**

# Unicellular photoautotrophic and heterotrophic diazotrophs are at best difficult to identify with traditional methods

Cyanobacteria



Autofluorescence

Heterotrophic bacteria



DAPI staining / epifluorescence

***Crocospaera watsonii* WH8501 (4000 Kb)**

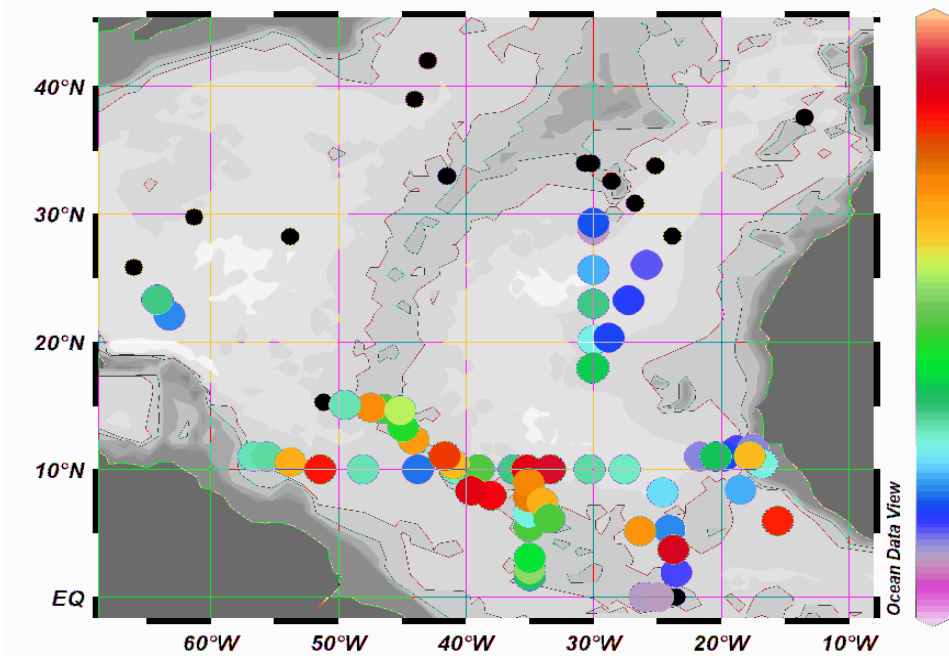
# Distribution and abundance of diazotrophs in the North Atlantic

- Our approach: make a probe for each phylotype and use quantitative real-time PCR to count them (from the DNA) or see who is active (RNA sample).
- Probes for 7 groups:
  - Cyanobacteria: Filamentous, *Croccosphaera*, *Cyanothece*, unicellular A
  - Heterotrophic bacterial phylotypes

# Distribution and abundance of *nifH* phylotypes in the North Atlantic

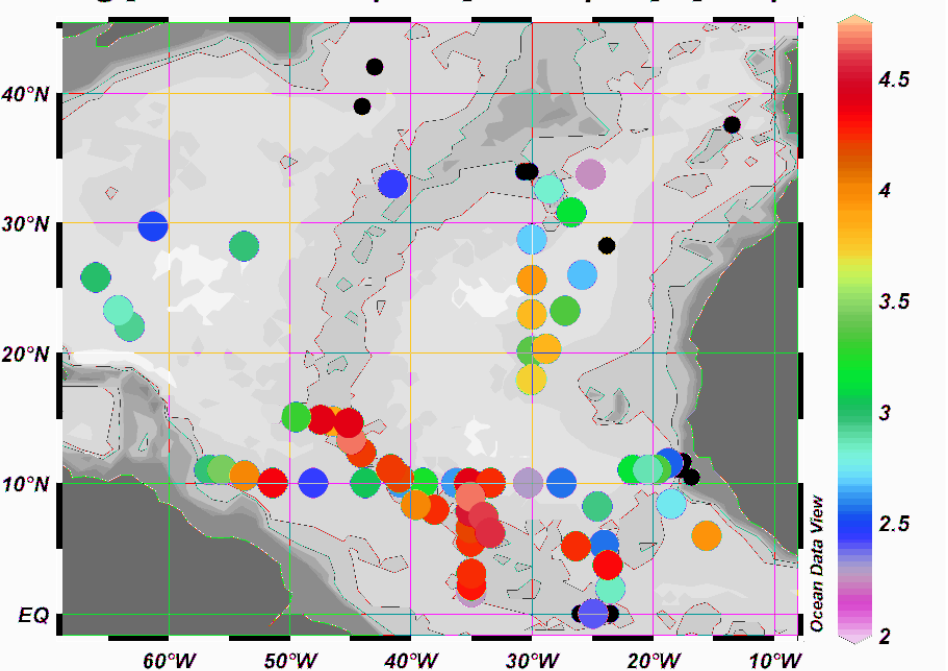
*Trichodesmium*-like

*log [Fil nifH copies/l] on Depth [m]=Top*



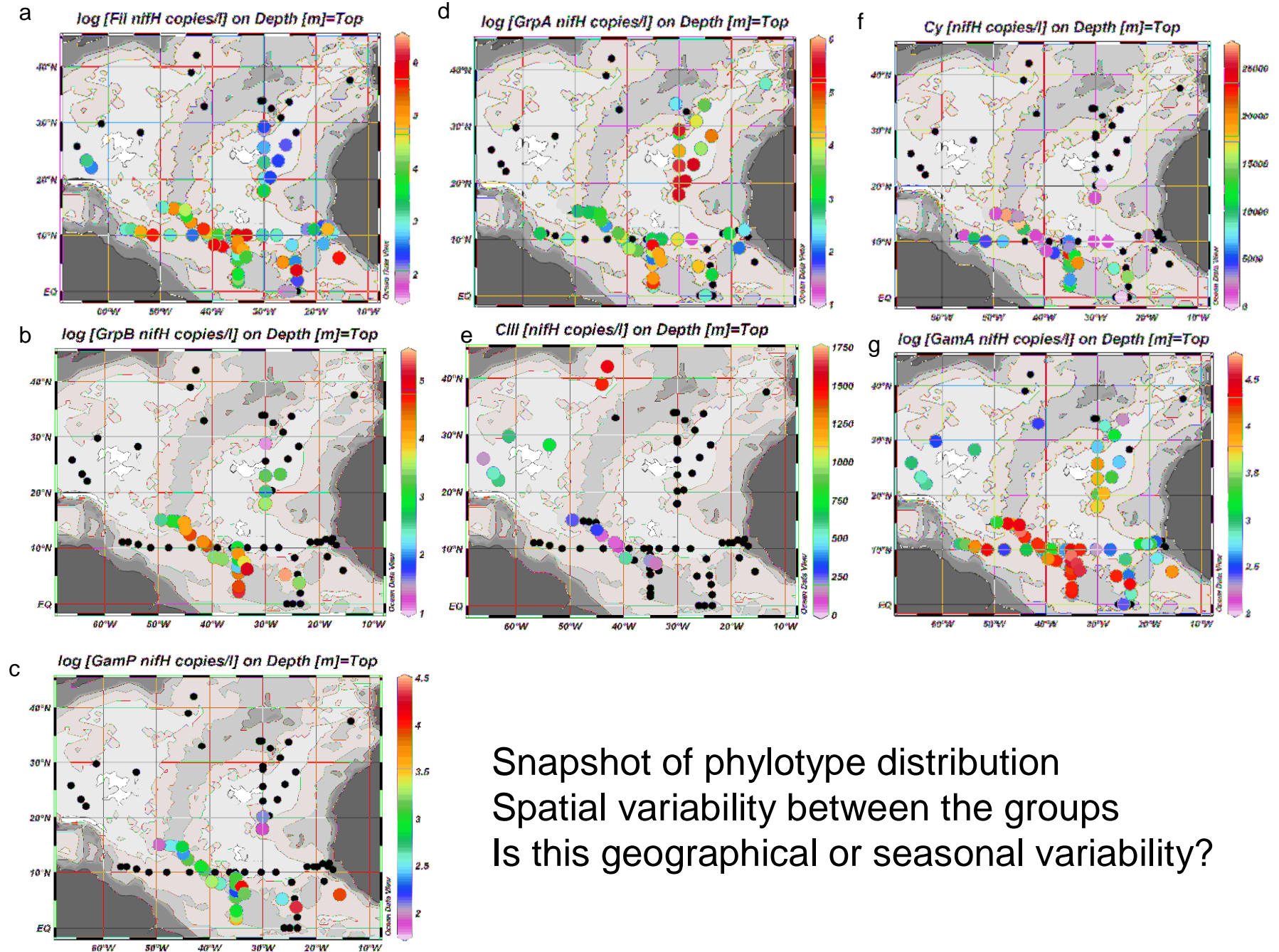
$\gamma$ -proteobacteria AO

*log [GamA nifH copies/l] on Depth [m]=Top*



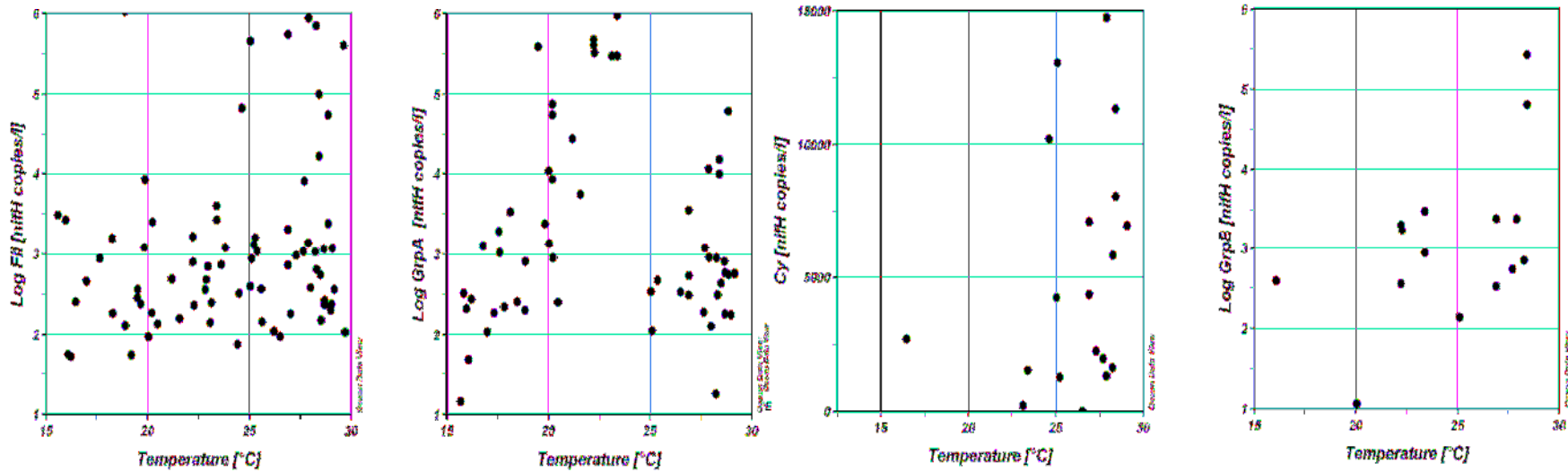
Note the log scale

Black dots are where we did not detect the group  
(Rebecca Langlois unpublished results)

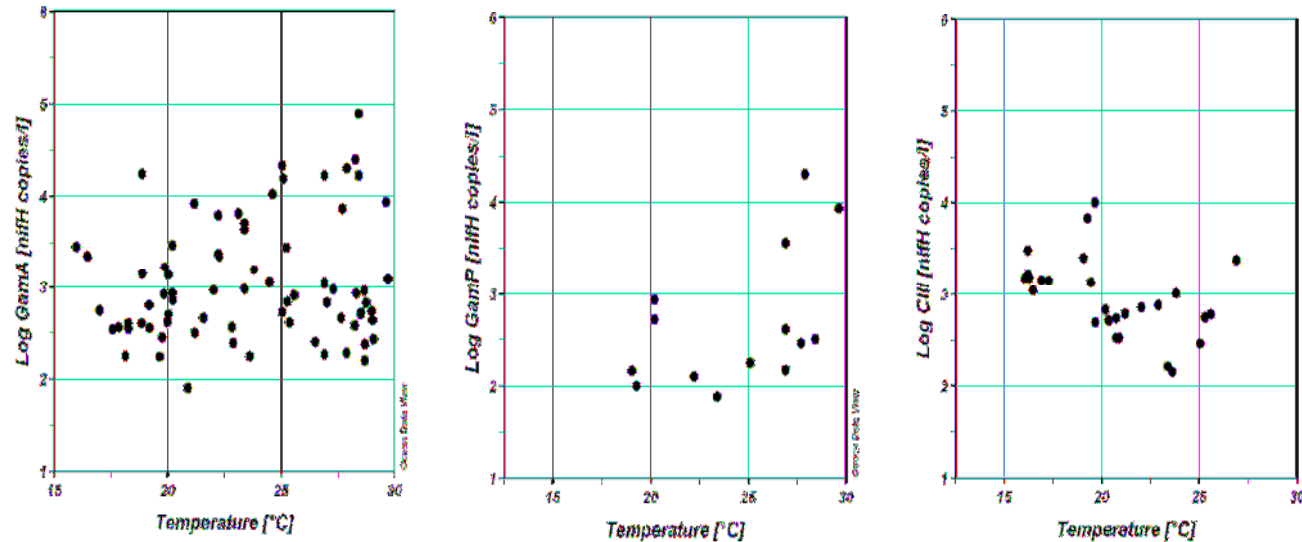


Snapshot of phylotype distribution  
 Spatial variability between the groups  
 Is this geographical or seasonal variability?

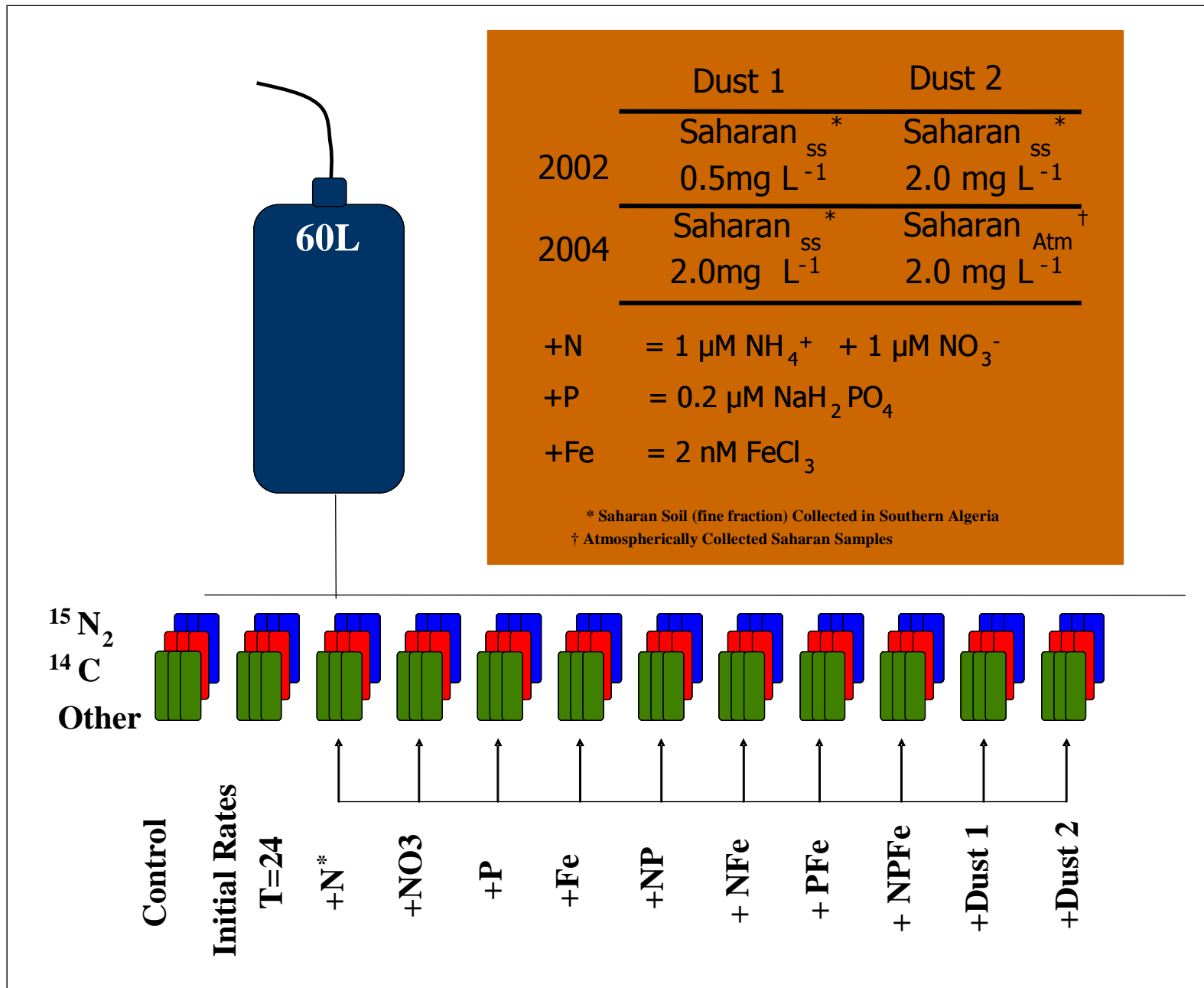
# Distribution of cyanobacterial diazotrophs as a function of temperature



# Distribution of heterotrophic diazotrophs as a function of temperature

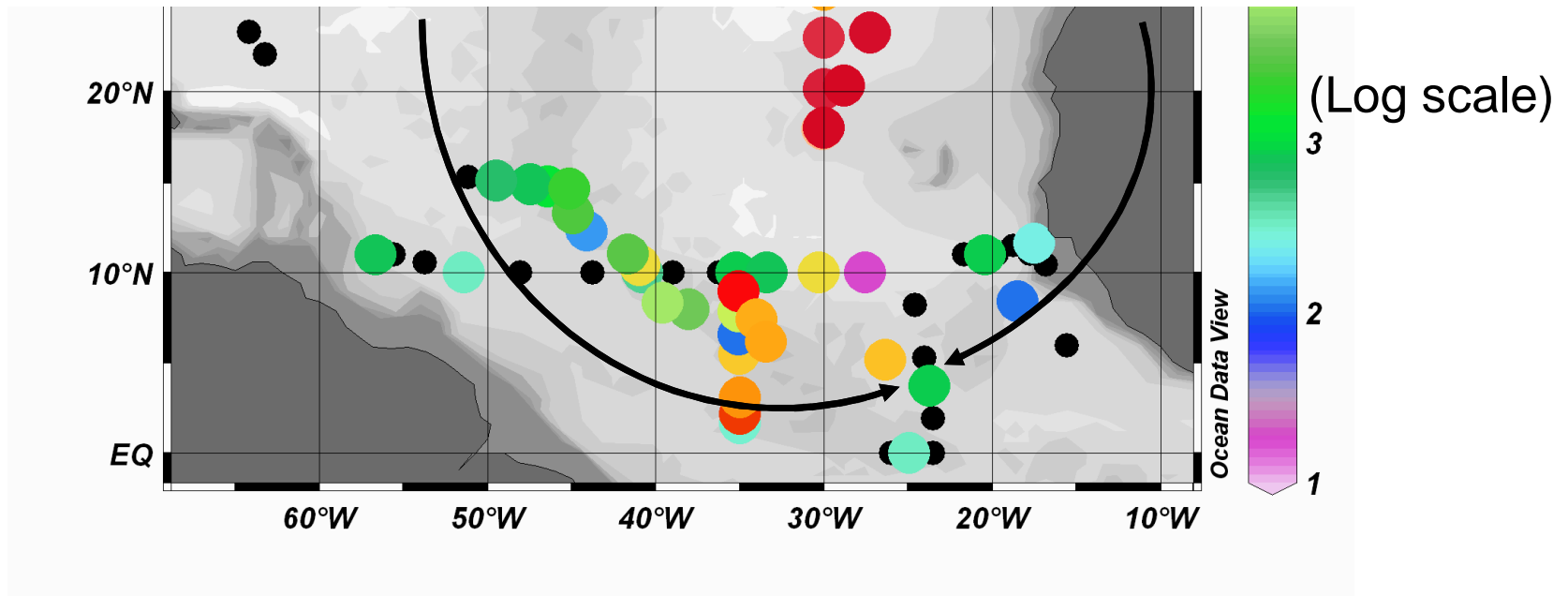
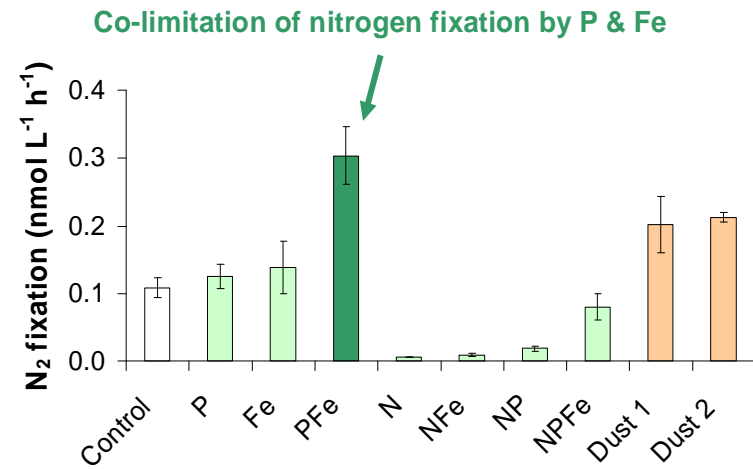
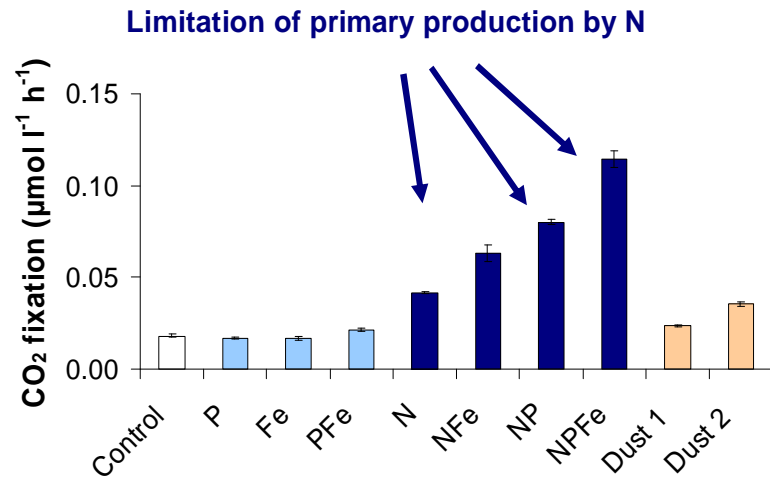


# What controls dinitrogen fixation?



# Response of microbial community to nutrients and dust

Comb



Study these effects where the dust input is large and variable

Compare to time series sites that are less affected by dust deposition

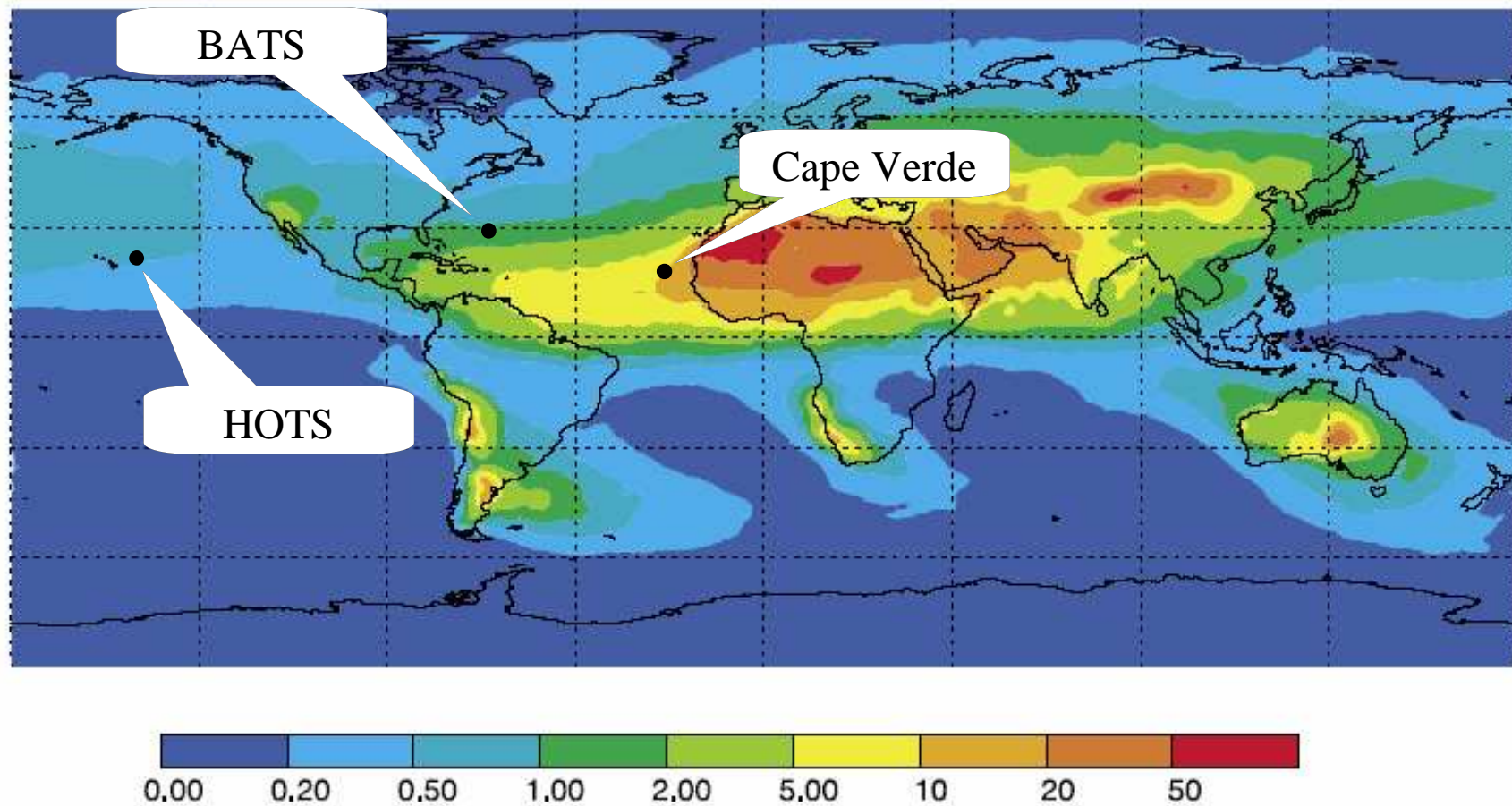


Figure 1. Iron Fast Track estimates of global dust deposition fluxes ( $\text{g m}^{-2} \text{ yr}^{-1}$ )

Jickells T et al. (2005) Science, 308: 67

# Work planned at the Cape Verde time series site

- Up to now we have a snapshot view of the distribution of different diazotrophs in the North Atlantic
- Cape Verde site allows us to obtain a detailed view of diazotrophy and the role of dust in supplying iron
- Time series sampling: temporal and seasonal variations as a function of environmental factors such as dust deposition
- Intensive campaigns for bioassay experiments and diel cycle studies (one each year for the next three years)

# Acknowledgements

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