Distribution and Abundance of *nifH* Phylotypes in the Northern Atlantic Ocean

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The Importance of Diazotrophs

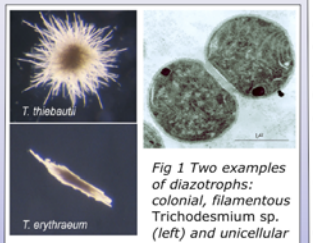

Fig 1 Two examples of diazotrophs: colonial, filamentous Trichodesmium sp. *(left) and unicellular* Crocosphaera watsonii *(right).*

Diazotrophs are key microorganisms to the global nitrogen cycle as they have the ability to utilize atmospheric N_2 and reduce it to more labile forms. Until recently, *Trichodesmium* (Fig 1), a large colony forming diazotroph capable of forming blooms, has been considered the dominant diazotroph[1]. A molecular technique involving the PCR of the *nifH* gene encoding nitrogenase's Fe-protein has led to the discovery of several novel marine diazotrophic organisms[2]. However, the spatial, temporal, and growth constraints of these elusive organisms remain poorly characterized, making it difficult to assess their contributions to the global marine N-cycle[3].

In order to better characterize the abundances and locations of diazotrophs in the Atlantic Ocean, specific TaqMan® probes and primers were designed to target seven unique phylotypes, or groups of related organisms based on genetic sequences. Subsequent quantitative-PCR (Fig 2) of samples from four cruises to the Atlantic Ocean (Fig 3) resulted in enumerations of one filamentous (Fil) and three unicellular cyanobacterial (GrpA, GrpB, and Cy), two heterotrophic _-proteobacterial (GamA and GamP), and one anaerobic bacterial (CIII) phylotypes.

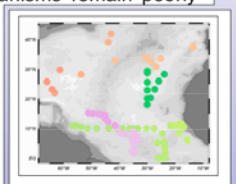

Fig 3 Cruise tracks of FS Sonne 152 (Nov-Dec 2000), FS Poseidon 284 (March 2002), FS Meteor 55 (Oct-Nov 2002) and 60/5 (March-April 2005).

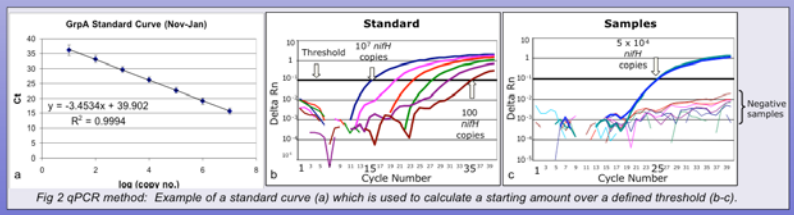

Fig 2 qPCR method: Example of a standard curve (a) which is used to calculate a starting amount over a defined threshold (b-c).

Distributions of Major Groups

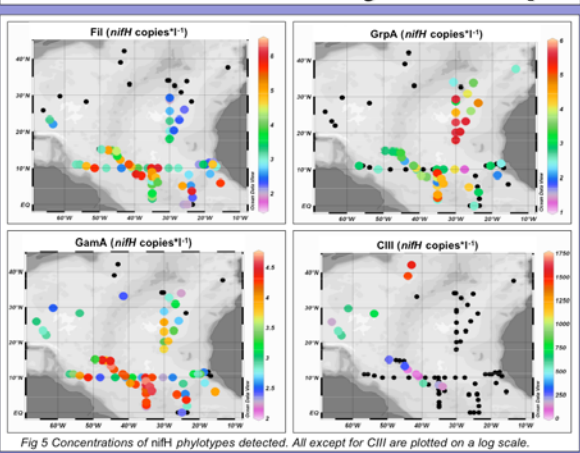

Fig 5 Concentrations of nifH phylotypes detected. All except for CIII are plotted on a log scale.

- Fil detected mostly between 0°-25°N and 35°-52°W ($1x10^2$ – $1x10^6$ *nifH* copies*l^{-1})
- GrpA was detected in high concentrations ($1x10^6$ *nifH* copies*l^{-1}) at 20°N, 30°W
- GamA was not detected at high concentrations (max $1x10^5$ *nifH* copies*l^{-1}), but almost everywhere
- Only low concentrations of CIII were detected in the eastern basin
- Other phylotypes were rarely detected

Phylotype Abundances

- 93% of all detected sequences were cyanobacterial (Fil, UA, GB, Cy)
- 6% were heterotrophic (GA, GP)
- <1% were anaerobic (CIII)

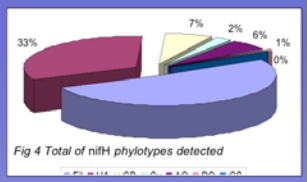

Fig 4 Total of nifH phylotypes detected

Temperature Distributions

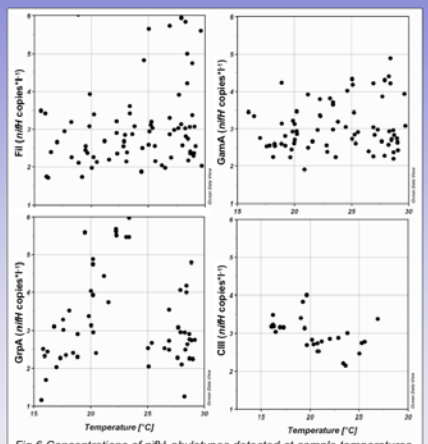

Fig 6 Concentrations of nifH phylotypes detected at sample temperatures Note that concentration are plotted on a log scale

- Fil reached highest densities at 25-30°C
- Max. abundances of GrpA detected at 20-25°C
- In contrast, GamA showed no temperature preference
- CIII detected most commonly between 15-25°C

Conclusions

- Data reconfirms that cyanobacteria, especially Fil, are important to marine N_2 fixation
- Heterotrophic and anaerobic bacteria may also play a major role
- Diazotroph distribution is not limited to tropical waters, nor waters warmer than 20°C
- Samples still need to be tested for nitrogenase activity in these areas

References:

[1]**Capone, D., J. Burns, J. P. Montoya, A. Subramaniam, C. Mahaffey, T. Gunderson, A. F. Michaels, and E. J. Carpenter. 2005.** Nitrogen fixation by Trichodesmium spp.: An important source of new nitrogen to the tropical and subtropical North Atlantic Ocean. Global Biogeochemical Cycles 19:doi:10.1029/2004GB002331

[2]**Zani, S., M. T. Mellon, J. L. Collier, and J. P. Zehr.** 2000. Expression of nifH Genes in Natural Microbial Assemblages in Lake George, New York, Detected by Reverse Transcriptase PCR. Appl. Envir. Microbiol. **66:** 3119-3124

[3]**Langlois, R. J., J. La Roche, and P. A. Raab.** 2005. Diazotrophic Diversity and Distribution in the Tropical and Subtropical Atlantic Ocean. Appl. Envir. Microbiol. **71:**7910-7919

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