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GEOTRACES Atlantic Section: Phytoplankton photochemical efficiency, physiology and taxonomic assemblage in relation to trace element concentrations and biogeochemical zones in the Atlantic.

We propose to capitalize on the intensive and high quality geochemical observations of the GEOTRACES Atlantic sector cruise to explore the relative importance to ecosystem function of phytoplankton physiology and taxonomic assemblage in relation to (macro and micro) nutrient availability, and the potential global relevance of photochemical efficiency of phytoplankton as a diagnostic indicator of biogeochemical regions. Specifically for GEOTRACES, our primary question will be:

> Can diel patterns of phytoplankton photochemical efficiency adequately predict biogeochemical regions?

The diel range of the photochemical efficiency of the surface mixed layer has been proposed as a diagnostic for defining biogeochemical regimes in the Eastern and tropical Pacific Ocean [*Behrenfeld et al., 2006*]. Preliminary results of photochemical efficiency from two recent cruises through the western Pacific appear to follow similar but not identical diel patterns as those identified in the above reference [*Johnson, unpublished*]. Our hypothesis is that photochemical efficiency patterns alone are not sufficient to differentiate among multiple biogeochemical zones in the Atlantic as will be identified by the GEOTRACES suite of observations. Rather, knowledge of phytoplankton assemblage within the water column will be required in addition to photochemical efficiency properties to distinguish characteristic zones of biogeochemistry and biological productivity. Molecular indicators of physiological stress due to macronutrient and/or trace metal limitation will support interpretation of photochemical physiology. While the GEOTRACES Science Plan and Atlantic Sector Implementation Plan both express interest in biological productivity, we have been advised that the traditional methods of primary productivity and quantum yield of photosynthesis measurements (via ^{14}C uptake incubations) will not be permitted, therefore, we plan to utilize photochemical parameters to estimate primary productivity. We have considerable experience measuring primary production and would consider revising our proposal to include it if we have misinterpreted the guidance we have received.

We propose the following measurements/estimates/observations in a combination of profile and discrete and continuous underway modes:

- Phytoplankton photochemical efficiency parameters
  - Variable fluorescence efficiency (F_V/F_M)
  - PSII functional cross-section absorbance (σ)
  - PSII photosystems turnover rate (τ)
- Phytoplankton biomass and assemblage indicators
  - Fluorometric, extracted chlorophyll for 3 size fractions

Flow cytometry (cell counts, size-differentiated from bacterial to 20μm cell counts, indicates *Prochlorococcus, Synechococcus,* picoeukaryotes, pennate diatoms and coccolithophorids)

Phytoplankton absorption (filter pad/spectrophotometric method)

Molecular indicators of nutrient stress (i.e. iron stress ferrodoxin/flavodoxin)

PAR Light availability (PAR sensors on deck and in profile)

We plan to collect our profile samples from the "shallow euphotic zone" cast which is discussed in the text of the implementation plan but for which cruise time and water budgets are not explicitly defined. If a rosette with 24 x 10L bottles is deployed, we would request sample collections from about 8 light depths which gives nominally 30L of sample water per depth (assuming complete agreement among users as to those depths). Our sampling scheme would require about 4-5L per depth. Note that this water volume requirement does NOT include the volume required for HPLC phytoplankton pigment concentrations which we understand will be included in the core GEOTRACES proposal. **Our proposal assumes that HPLC pigments will be measured by others and those data will be shared among participants.**

We are also interested in spanning the productivity question to net community productivity of the biogeochemical zones integrated over the time scale of weeks as indicated by O_2/Ar ratios. Preliminary results from the Southern Ocean Gas Exchange program indicate autotrophic net community productivity may vary directly with primary productivity while heterotrophic net community productivity shows no relationship with primary productivity [*Lance, unpublished and personal communication with Roberta Hamme*]. We have discussed the possibility of collaborating with Rachel Stanley to have the EIMS instrument run underway. In this arrangement, we would be able to follow net community productivity and photochemical efficiency on the same underway water as we pass through biogeochemical fronts or regions.

Literature Cited:

Behrenfeld, M. J.,Worthington, K.,Sherrell, R. M.,Chavez, F. P.,Strutton, P.,McPhaden, M.,Shea, D. M., 2006. Controls on tropical Pacific Ocean productivity revealed through nutrient stress diagnostics. *Nature* 442, 1025-1028.