Investigating Diatom Growth in an HNLC Zone of the Southern Ocean

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Introduction

The Southern Ocean contains the largest high-nutrient, low-chlorophyll (HNLC) zone in the world. These zones arise due to a lack of dissolved iron that limits phytoplankton growth. However, diatoms are thriving in a sector of the Southern Ocean despite iron limitation. Understanding diatom growth in this region will provide insights into their role in global nutrient cycles and CO2 uptake. Our samples were collected along the Pacific Sector of the Southern Ocean during a CLIVAR S04P cruise during the summer of 2011.

Objectives/Hypothesis

- Describe ocean chemistry of the region
- Identify which nutrient metals the diatoms are taking up
  - Within the organic cellular matter
  - Within the inorganic frustule (silicified cell wall)
- What nutritional balance do diatoms prefer?

Methods

Seawater sampling:
50 stations sampled, 15 analyzed
12 depths per station (20-1000 m below the surface)
2-10 L of seawater passed through 0.4 um polycarbonate filters
Filters subdivided into thirds for three different treatments:
1. Total digestion: dissolved biogenic, lithogenic, and authigenic fractions
2. Labile leach (Berger et al., 2008): weaker treatment to isolate biogenic and authigenic phases
3. Biogenic silica (bSi): dissolves only biogenic frustules

Solutions prepared from Total digestion and Labile leach procedures were analyzed by Thermo Finnigan ELEMENT2 High Resolution-Inductively Coupled Plasma-Mass Spectrometer (HR-ICP-MS).

Results & Discussion

Indicators of Diatom Growth within HNLC Zone

Higher concentrations of surface fucoxanthin (an accessory pigment unique to diatoms and related photosynthetic bacteria) and biogenic silica (component of diatom frustules) were observed surrounding the P16 transect of the cruise at 150°W, 68-76°S. Concentrations increased towards the shelf, indicative of diatom growth stimulated by nutrient inputs from the coast. Total particulate P concentrations were dominated by the labile fraction, suggesting most P is biogenic material.

Optimum Nutrient Ratios and Fe Limitation

Dissolved Si:NO3 ratios of 1-2 mol/mol are thought to be a “sweet spot” for diatom growth (Brzezinski et al., 2015). Surface Si:NO3 ratios within this range coincided with the highest concentrations of surface bSi and fucoxanthin, meaning this Si:NO3 ratio does seem to be ideal for diatom growth. Further evidence of iron limitation was demonstrated by low Labile Fe concentrations across the entire cruise. The nearly 1:1 ratio of total Fe to total Al shows that almost all Fe in the region is associated with refractory lithogens, rather than biology.

Diatom Effects on Ocean Chemistry

Elevated concentrations of Labile Ni, Zn, Cd, and U were observed in surface waters along the P16 transect, where diatoms are most abundant. This suggests diatoms are removing these trace metals from surface waters to be incorporated in their cellular material. Zn and Cd are needed for the enzyme carbonic anhydrase, which removes CO2 from seawater, while Ni is needed for an isoform of the enzyme superoxide dismutase (needed to remove reactive oxygen species). Biological U enrichment is a side effect of P cycling.

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References