Water-soluble fraction of silica in Synechococcus cells grown in different silicic acid concentrations from laboratory experiments at the Dauphin Island Sea Lab between 2013-2015 (Si_in_Syn project)

Website: https://www.bco-dmo.org/dataset/674240
Data Type: experimental
Version:
Version Date: 2017-12-04

Project
» Understanding the Role of Picocyanobacteria in the Marine Silicate Cycle (Si_in_Syn)

Contributors	Affiliation	Role
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Coverage

Spatial Extent: **N**:41.19 **E**:-65.6 **S**:22.495 **W**:-124.1668

Dataset Description

This dataset contains the fraction of water-soluble silica in Synechococcus cyanobacterium cells. The concentration of external silicic acid [Si(OH)4] during the experiment is also included. Experiments took place at the Dauphin Island Sea Laboratory (DISL) between March of 2013 to August of 2015.

These results are also presented in the following paper (Brzezinski et al., 2017).

Methods & Sampling

Culturing of Synechococcus clones:

Monocultures of six clones of Synechococcus were used to examine variation and controls on Si quotas and rates of Si accumulation. Cultures were procured from the National Center for Marine Algae and Microbiota (NCMA) at the Bigelow Laboratory for Ocean Sciences in Boothbay Harbor, Maine. Many of these clones are also available in other culture collections and have various strain names; here we will refer to each by their NCMA strain number (a.k.a. CCMP number).

All clones were maintained in aged surface Sargasso Sea water with f/2 media constituents with 10 – 100 uM Si

depending on the experiment as detailed below. The temperature was 21C with low light 65 microeinsteins per second per square meter (uE/m2/s) on a 12 h light: 12 h dark photocycle. pH was regulated in all cultures by bubbling with humidified ambient air which was sterilized by passage through a bacterial filter prior to entering each culture vessel. Unless otherwise specified, all experiments were conducted under these temperature and light conditions. pH was monitored daily and remained below 8.5 in all experiments.

Water-soluble cellular silicon:

The water-soluble fraction of cellular silicon was measured for all six clones at external silicic acid concentrations of 1, 60 and 120 uM. Replicate 10-mL aliquots of each exponential culture were filtered onto separate 0.2 um polycarbonate membrane filters in parallel with the samples for total cellular Si measurement. Each filter was placed in a separate 15-mL polypropylene tube, immediately resuspended into 5 mL of dilute HCl (0.01 N) to avoid solubilization of any particle-bound Si which may be an amorphous solid, and flash frozen in liquid nitrogen. After the freeze, samples were thawed in a 35 C water bath, vortexed, and refrozen in liquid nitrogen. In total, four freeze/thaw cycles were conducted to lyse the cells. This method was determined to be the most effective for lysing cells, as the small volumes required for preserving the small analytical signal precluded the use of larger volumes that would enable the use of probe sonicators or pressure cells (e.g. French type). After the freeze/thaw cycles, cell suspensions were syringe-filtered through a 0.2 um filter and the filtrate analyzed for silicic acid in the same manner as for solubilized biogenic silica using NaOH–HF digestion in Teflon tubes as described in Krause et al. (2013).

Full methods are described in Brzezinski et al. (in review as of 05 Jan 2017).

Data Processing Description

BCO-DMO Data Manager Processing Notes:
* added a conventional header with dataset name, PI name, version date
* modified parameter names to conform with BCO-DMO naming conventions
* blank values replaced with no data value 'nd'
* latitude and longitude of Dauphin Island Sea Lab added to dataset
* soluble si limited to three decimal places

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Data Files

File
Soluble_Si.csv (Comma Separated Values (.csv), 2.55 KB) MD5:012e11d8d56535c1f04d87f926fbae17 Primary data file for dataset ID 674240

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Related Publications

Brzezinski, M. A., Krause, J. W., Baines, S. B., Collier, J. L., Ohnemus, D. C., & Twining, B. S. (2017). Patterns and regulation of silicon accumulation in Synechococcus spp. Journal of Phycology, 53(4), 746–761. doi:10.1111/jpy.12545
Results

Krause, J. W., Brzezinski, M. A., Villareal, T. A., & Wilson, C. (2013). Biogenic silica cycling during summer phytoplankton blooms in the North Pacific subtropical gyre. Deep Sea Research Part I: Oceanographic Research Papers, 71, 49–60. doi:10.1016/j.dsr.2012.09.002
Methods

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Parameters

Parameter	Description	Units
clone_lat	Latitude of the clone collection site	decimal degrees
clone_lon	Longitude of the clone collection site	decimal degrees
clone_id	Synechococcus clone identifier (NCMA strain and CCMP number)	unitless
silicic_acid	Silicic acid concentration [Si(OH)4]	micromolar (uM)
soluble_Si	Fraction of total silica that is water-soluble	dimensionless

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Deployments

Krause_DISL_2013-2015

Website	https://www.bco-dmo.org/deployment/674230
Platform	lab Dauphin_Island_Sea_Lab
Start Date	2013-03-01
End Date	2015-08-31
Description	Laboratory experiments conducted at Dauphin Island sea lab. Clone collection locations included in deployment coordinates.

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Project Information

Understanding the Role of Picocyanobacteria in the Marine Silicate Cycle (Si_in_Syn)

Coverage: Samples collected in western North Atlantic Ocean between Puerto Rico, Bermuda, and Gulf of Maine.

Extracted from the NSF award abstract:

INTELECTUAL MERIT: The investigators will follow-up on their discovery of significant accumulation of silicon by marine picocyanobacteria of the genus Synechococcus to assess the contribution of these organisms to the cycling of biogenic silica in the ocean. Oceanographers have long assumed that diatoms are the dominant marine organisms controlling the cycling of silica in the ocean. Recently, however, single-cell analyses of picocyanobacterial cells from field samples surprisingly revealed the presence of substantial amounts of silicon within Synechococcus. The contribution of Synechococcus to biogenic silica often rivaled that of living diatoms in the two systems examined. Moreover, size fractionation of biogenic silica indicates that up to 25% of biogenic silica can exist in the picoplanktonic size fraction. Given that picocyanobacteria dominate phytoplankton biomass and primary production over much of the world's ocean, these findings raise significant questions about the factors controlling the marine silica cycle globally, as well as the proper interpretation of biogenic silica measurements, Si:N ratios in particulate matter, and ratios of silicate and nitrate

depletion. It also suggests that picocyanobacterial populations may be subject to previously unknown constraints on their productivity.

The project will have both laboratory and field components. Because cellular Si varies substantially among the field-collected samples and laboratory strains so far analyzed, the laboratory component will document variability in Si uptake and cellular Si concentrations, while determining what role physiological and phylogenetic factors play in this variability. The investigators will use strains of Synechococcus for which there are already genome sequences. Laboratory experiments will 1) use 32Si radiotracer uptake experiments to assess the degree of variability in Si content and Si uptake kinetics among strains of Synechococcus acclimated to different levels of silicate, 2) characterize the intracellular distribution and chemistry of silicon within cells using fractionation techniques, density centrifugation, electron microscopy and x-ray absorption spectroscopy, and 3) use bioinformatic analyses of published genomes to determine whether uptake of Si can be predicted based on phylogenetic relationships, to identify candidate genes involved in cyanobacterial Si metabolism, and to develop probes for community structure that can be related to cellular Si content. Field work at the Bermuda Atlantic Time Series (BATS) site will assess the contribution of Synechococcus and diatoms to total biogenic silica in surface waters at times of the year when the former are typically dominant. Field measurements will include size fractionation of biogenic silica biomass and Si uptake, and synchrotron-based x-ray fluorescence microscopy, and the phylogenetic composition of the Synechococcus assemblage.

BROADER IMPACTS: This project has the potential to drive a major paradigm shift in our understanding of the marine silicon cycle. In addition, one PhD student will be trained at Stony Brook. Each PI will provide research experience to a number of undergraduates working on original research projects for credit, as a part of an REU program or as the basis for undergraduate theses. Stony Brook research programs for undergraduates are supported with summer research money from the Undergraduate Research and Creative Activities (URECA) program, and draw on its very diverse student body. The investigators will also engage promising high school level students through several residential programs that the PIs have been a part of in the past. These include the BLOOM program at Bigelow and the Simons Summer Research Fellowship Program at Stony Brook. The PI has continuing relationship with a regional high school (Brentwood) with a high proportion of underrepresented minorities. PI Twining is involved in the Café Scientifique program at Bigelow. Baines will engage in similar outreach through the Center for Science and Mathematics Education (CESAME) sponsored Open Science Nights. Finally, PI Baines will cooperate with CESAMEs teacher education programs, with the aim of incorporating biological oceanography into K-12 curricula. PIs Krause and Brzezinski will incorporate aspects of phytoplankton ecology into UCSB's Oceans to Classroom Program that brings marine research at UCSB to life for over 18,000 K-12 students each year.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1335012

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