

# Experimental and biogeochemical surveys from R/V Kilo Moana, R/V Knorr, and R/V Ka`imikai-O-Kanaloa cruises in the North Pacific Subtropical Gyre and Hawaiian Islands: stations Kahe, ALOHA, Kena and WHOTS Mooring from 2008 to 2009

Website: <https://www.bco-dmo.org/dataset/3883>

Version: 01 March 2013

Version Date: 2013-03-01

## Project

» [Silica Cycling and the Role of Diatoms in the North Pacific Subtropical Gyre](#) (Silica Cycling)

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## Dataset Description

BioGeoChem - Experimental and Survey Biogeochemical Data

**BCO-DMO Note 1: The chlorophyll data belong to Tracy Villareal. Information on his method was not provided.**

**BCO-DMO Note 2: These data are VERY preliminary. They will be reviewed after March 30th. srg/01March2013**

## Methods & Sampling

### Links to Protocols Documentation:

[32Si\\_HOT\\_Protocol](#) - <sup>32</sup>Si Sample Processing - HOT Cruises

[32Si\\_Protocol](#) - <sup>32</sup>Si Production Protocol - POOB Cruises

[delta\\_bSi\\_HOT\\_Protocol](#) - delta bSi Production Protocol - HOT Cruises

[delta\\_bSi\\_Protocol](#) - delta bSi Production Protocol - POOB Cruises

[dSi\\_Protocol](#) - Dissolved Si Analysis

[HOT\\_Sample\\_Collection](#) - HOT Sample Collection

[pSi\\_Protocol](#) - Particulate Si Analysis

## Data Processing Description

### BCO-DMO Processing/Edits

- Generated from original file: "POOB\_ALLDATA.xlsx" contributed by Janice Jones  
Sheets: "POOB08", "POOB2009" and "HOT"
- BCO-DMO compatible parameter header generated  
Spaces converted to underscores  
Units removed from variable names  
Special characters removed/replaced
- Date reformatted to YYYYMMDD
- Time reformatted to HHMM
- "~" converted to "nd"
- blank cells converted to "nd"

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## Data Files

File
<b>BioGeoChem.csv</b> (Comma Separated Values (.csv), 130.22 KB) MD5:bf81b7cac1ef72b314dc7b65e5ac01fe Primary data file for dataset ID 3883

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## Parameters

Parameter	Description	Units
Cruise	cruise during which sample was collected	text
Station	sampling station	dimensionless
C	type of sample (for ODV use only - currently set to C)	C
Date	local date	YYYYMMDD
Time	local time	HHMM
Lat	latitude in decimal degrees (South is negative)	decimal degrees
Lon	longitude in decimal degrees (West is negative)	decimal degrees
Bot_Depth	bottom depth in meters	meters
Event_Number	event number as yyjulhhh using Julian Day and GMT OR HOT event number as per HOT protocol	yyjulhhh GMT
Station_Number	station number	dimensionless
Cast	CTD cast number	dimensionless
Cast_Type	cast type (CTD or sediment trap)	dimensionless
Target_Depth	target bottle tripping depth in meters	meters
Actual_Depth	actual bottle tripping depth in meters	meters
Rosette_Bottle	rosette bottle number	dimensionless
Percent_lo	percent light level (PAR sensor)	percentage
SiOH4	silicic acid concentration in micromoles (also known as dissolved silicon concentration or dSi)	uM
bSi_0point6um	particulate biogenic silica in >0.6um fraction in nanomoles Si per litre	nmol Si/L
bSi_10um	particulate biogenic silica in >10um fraction in nanomoles Si per litre	nmol Si/L
Lsi_0point6um	particulate lithogenic silica in >0.6um fraction in nanomoles Si per litre	nmol Si/L
Chl_a_0point4um	chlorophyll a in >0.4um fraction in micrograms per litre *** DATA BELONGS TO TRACY VILLAREAL	ug/L
Chl_a_10um	chlorophyll a in >10um fraction in micrograms per litre *** DATA BELONGS TO TRACY VILLAREAL	ug/L
Si32_rho	gross silica production rate	umol Si/L/d
Si32_Vb	specific silica production rate (gross normalized to biogenic silica concentration)	d-1
delta_bSi_rho	net silica production rate	nmol Si/L/d
rho_dissolution	gross silica dissolution rate	nmol Si/L/d
V_dissolution	specific silica dissolution rate (gross normalized to biogenic silica concentration)	d-1

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## Instruments

<b>Dataset-specific Instrument Name</b>	CTD Sea-Bird SBE 911plus
<b>Generic Instrument Name</b>	CTD Sea-Bird SBE 911plus
<b>Dataset-specific Description</b>	CTD Sea-Bird SBE 911plus
<b>Generic Instrument Description</b>	The Sea-Bird SBE 911 plus is a type of CTD instrument package for continuous measurement of conductivity, temperature and pressure. The SBE 911 plus includes the SBE 9plus Underwater Unit and the SBE 11plus Deck Unit (for real-time readout using conductive wire) for deployment from a vessel. The combination of the SBE 9 plus and SBE 11 plus is called a SBE 911 plus. The SBE 9 plus uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3 plus and SBE 4). The SBE 9 plus CTD can be configured with up to eight auxiliary sensors to measure other parameters including dissolved oxygen, pH, turbidity, fluorescence, light (PAR), light transmission, etc.). more information from Sea-Bird Electronics

<b>Dataset-specific Instrument Name</b>	Niskin bottle
<b>Generic Instrument Name</b>	Niskin bottle
<b>Generic Instrument Description</b>	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

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## Deployments

### KM0812

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/58162">https://www.bco-dmo.org/deployment/58162</a>
<b>Platform</b>	R/V Kilo Moana
<b>Start Date</b>	2008-07-01
<b>End Date</b>	2008-07-22
<b>Description</b>	This cruise was funded by NSF award OCE-0648130. Original cruise data are available from the NSF R2R data catalog. Note that the cruise dates were determined from the information reported in the UNOLS STRS system and the R2R catalog.

### KM0919

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/58874">https://www.bco-dmo.org/deployment/58874</a>
<b>Platform</b>	R/V Kilo Moana
<b>Start Date</b>	2009-07-29
<b>End Date</b>	2009-08-14
<b>Description</b>	This cruise was funded by NSF OCE-0648130. Original cruise data are available from the NSF R2R data catalog.

#### KM0801

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59000">https://www.bco-dmo.org/deployment/59000</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2008-01-28
<b>End Date</b>	2008-02-01
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0802

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59001">https://www.bco-dmo.org/deployment/59001</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2008-02-22
<b>End Date</b>	2008-02-26
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0806

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59002">https://www.bco-dmo.org/deployment/59002</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2008-05-26
<b>End Date</b>	2008-05-30
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0811

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59003">https://www.bco-dmo.org/deployment/59003</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2008-06-24
<b>End Date</b>	2008-06-28
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0813

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59004">https://www.bco-dmo.org/deployment/59004</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2008-07-25
<b>End Date</b>	2008-07-29
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0815

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59005">https://www.bco-dmo.org/deployment/59005</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2008-08-15
<b>End Date</b>	2008-08-19
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0820

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59006">https://www.bco-dmo.org/deployment/59006</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2008-10-09
<b>End Date</b>	2008-10-13
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0822

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59007">https://www.bco-dmo.org/deployment/59007</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2008-11-29
<b>End Date</b>	2008-12-03
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0902

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59008">https://www.bco-dmo.org/deployment/59008</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2009-01-19
<b>End Date</b>	2009-01-23
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0907

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59009">https://www.bco-dmo.org/deployment/59009</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2009-02-16
<b>End Date</b>	2009-02-20
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KN195-07

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59010">https://www.bco-dmo.org/deployment/59010</a>
<b>Platform</b>	R/V Knorr
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2009-04-27
<b>End Date</b>	2009-05-01
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets

#### KOK0909

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59011">https://www.bco-dmo.org/deployment/59011</a>
<b>Platform</b>	R/V Ka`imikai-O-Kanaloa
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2009-05-26
<b>End Date</b>	2009-05-30
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0915

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59012">https://www.bco-dmo.org/deployment/59012</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2009-07-02
<b>End Date</b>	2009-07-06
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0918

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59013">https://www.bco-dmo.org/deployment/59013</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2009-07-23
<b>End Date</b>	2009-07-27
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KM0920

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59014">https://www.bco-dmo.org/deployment/59014</a>
<b>Platform</b>	R/V Kilo Moana
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2009-08-17
<b>End Date</b>	2009-08-21
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KOK0916



<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59015">https://www.bco-dmo.org/deployment/59015</a>
<b>Platform</b>	R/V Ka`imikai-O-Kanaloa
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2009-09-23
<b>End Date</b>	2009-09-27
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KOK0917

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59016">https://www.bco-dmo.org/deployment/59016</a>
<b>Platform</b>	R/V Ka`imikai-O-Kanaloa
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2009-11-02
<b>End Date</b>	2009-11-06
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

#### KOK0920

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/59017">https://www.bco-dmo.org/deployment/59017</a>
<b>Platform</b>	R/V Ka`imikai-O-Kanaloa
<b>Report</b>	<a href="http://hahana.soest.hawaii.edu/hot/cruises.html">http://hahana.soest.hawaii.edu/hot/cruises.html</a>
<b>Start Date</b>	2009-12-08
<b>End Date</b>	2009-12-12
<b>Description</b>	HOT - Cruise Schedules, Chief Scientist Reports and Cast Sheets Cruise information and original data are available from the NSF R2R data catalog.

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## Project Information

### Silica Cycling and the Role of Diatoms in the North Pacific Subtropical Gyre (Silica Cycling)

**Coverage:** North Pacific Subtropical Gyre north of Hawaii, near (30 N, 140 W)

This study examines the unique silicon cycle of the North Pacific Subtropical Gyre (NPSG).

Most marine silicon cycle studies have focused on the more productive coastal waters or the Southern Ocean where diatoms typically dominate the phytoplankton. Although diatom biomass is much lower in subtropical gyres, silica production is significant in global terms. Silicon cycle studies of the Sargasso Sea in the 1990's implied that subtropical gyres account for 13% of global marine silica production. More recent data from the NPSG show much higher rates of silica production that would increase the contribution of subtropical gyres to as much as 40%. The new estimate is uncertain and based on few data, but suggests that the contribution of subtropical gyres has been underestimated. Differences in the silicon cycle between the NPSG and the Sargasso Sea go beyond differences in average production rates. The two systems are several months out of phase with each other in terms of their seasonal silica production cycles. Unlike the Sargasso Sea, where diatoms bloom regularly in spring in response to winter convective overturn, permanent stratification prevents

spring diatom blooms events in the NPSG, where annual diatom blooms occur in summer, when stratification is strongest and nutrient concentrations are at a seasonal minimum. These enigmatic summer blooms contribute significantly to carbon and nitrogen export in the NPSG and likely dominate the annual silicon cycle.

Time series of rate measurements will be made in collaboration with the HOT program to define the annual silicon cycle at station ALOHA. The project will also collaborate with the new "Center for Microbial Oceanography: Research and Education" (CMORE) Science and Technology Center at the University of Hawaii to study summer blooms. Funding for this portion of the project is from NSF OCE-0648130.

Separately funded laboratory studies (NSF OCE-0726726; Title: Biological characterization of the nitrogen-fixing *Rhizosolenia-Richelia* symbiosis), looked at the role of diatom-diazotroph associations (DDAs) in elemental cycling in the NPSG.

Nitrogen-fixation provides a key input of new nitrogen into oligotrophic, oceanic regions. Work over the past two decades has highlighted the role of *Trichodesmium*. More recently, the role of coccoid cyanobacteria as well as symbiotic associations of the filamentous cyanobacteria *Richelia intracellularis* with species of diatoms (*Rhizosolenia* and *Hemiaulus*) has received attention. Little is known of the growth rates, nutrient needs, chemical composition, or environmental tolerances of these DDAs. However, it is clear that DDAs are numerically important in some oceans and can play a major role in mediating new nitrogen inputs. Recent models have identified the need for species-specific parameters, but these are lacking for DDAs. In particular, temperature dependent properties require quantification for application to global warming scenarios.

Laboratory studies of both the *Rhizosolenia-Richelia* and *Hemiaulus-Richelia* DDA are now possible due to the reproducible cultivation of this association. This four-year research program will quantify temperature and salinity effects on growth rates and NB2B-fixation rates. It will explore the role of silicate and phosphate (inorganic and organic) in controlling growth rates, chemical composition and NB2B-fixation through host-symbiont interactions. Field studies will address the distribution of both these DDAs and their contribution to Si cycling in large diatom blooms reported from the central N. Pacific gyre.

The mass accumulation of the DDAs in sediment traps as well as in the sedimentary record suggest DDAs are important vectors to depth. The potentially high sinking rates relative to *Trichodesmium* permit rapid export of new N and sequestration of C. This work will quantify settling rates under conditions of phosphate and silicate-limited growth and provide the first estimates of potential losses due to sinking. This program will provide the first broad characterization of a DDA and provide valuable input data for models.

DDA blooms are potential means to remove C and N quickly from the euphotic zone via mass sedimentation of the diatom host. Diatom remains in sediments suggest this is an important vector for sedimentary deposition. The autecological work in this study will produce information important for interpreting how such events can occur. In addition, temperature tolerance studies will yield data useful for understanding how this DDA could respond to warming oceans.

The proposed research on Si cycling combined with ongoing studies of C, N and P cycling at station ALOHA will allow, for the first time, an opportunity for a coordinated analysis the cycling of all four of these elements simultaneously in an oligotrophic gyre. The pairing of field work with laboratory studies to determine the role of DDAs will expand understanding of the mechanisms controlling the contribution of diatoms to elemental cycling in open ocean ecosystems.

## **RELATED PUBLICATIONS**

Brzezinski MA, Krause JW, Church MJ, Karl DM, Li B, Jones JL, Updyke B. "The annual silica cycle of the North Pacific subtropical gyre," *Deep Sea Research I*, v.58, 2011, p. 998.

Duhamel S., Bjorkman K. M., Van Wambeke F., Moutin T., Karl DM. "Characterization of alkaline phosphatase activity in the North and South Pacific Subtropical Gyres: Implications for phosphorus cycling," *Limnology and Oceanography*, v.56, 2011, p. 1244.

Krause J.W., Brzezinski M.A., Jones J.L. "Application of low-level beta counting of  $^{32}\text{Si}$  for the measurement of silica production rates in aquatic environments," *Marine Chemistry*, v.127, 2011, p. 40.

Krause J.W., Brzezinski M.A., Villareal, T.A., Wilson C. "Increased kinetic efficiency for silicic acid uptake as a driver of summer diatom blooms in the North Pacific subtropical gyre," *Limnology and Oceanography*, v.57, 2012, p. 1084.

Villareal, T.A.; Adornato, L.; Wilson, C.; Shoenbachler, C.A. "Summer blooms of diatom-diazotroph assemblages (DDAs) and surface chlorophyll in the N. Pacific gyre - a disconnect" *Journal of Geophysical Research-Oceans*,

v.116, 2011, p. DOI: 10.1.

Villareal T.A., Brown, C. G., Brzezinski M.A., Krause J.W., Wilson C.. "Summer Diatom Blooms in the North Pacific Subtropical Gyre: 2008-2009," PLoS ONE, v.7, 2012, p. e33109.

Watkins-Brandt K.S., Letelier R.M., Spitz Y.H., Church M.J., Bottjer D., White Angelique. "Addition of inorganic or organic phosphorus enhances nitrogen and carbon fixation in the oligotrophic North Pacific," Marine Ecology Progress Series, v.432, 2011, p. 17.

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## Funding

Funding Source	Award
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-0648130</a>

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