Long-term EXPORTS 2018 North Pacific incubation data

Website: https://www.bco-dmo.org/dataset/1002908
Data Type: Cruise Results
Version: 1
Version Date: 2026-07-24

Project
» Collaborative Research: Diatoms, Food Webs and Carbon Export - Leveraging NASA EXPORTS to Test the Role of Diatom Physiology in the Biological Carbon Pump (Diatoms and carbon export)

Program
» EXport Processes in the Ocean from Remote Sensing (EXPORTS)

Contributors	Affiliation	Role
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Abstract
This dataset includes the concentrations of dissolved (5 micrometer (µm)) chlorophyll a and biogenic silica (bSi); size-fractionated (0.4-5 µm and >5 µm) labile particulate elemental phosphorus (P), Ni, and Cd; and particulate organic carbon and nitrogen (POC and PON, respectively) from four incubations. Treatments included various additions of macronutrients and/or iron (Fe) to either induce severe nutrient stress or relieve nutrient limitation. For each incubation, triplicate initial control samples were collected and then triplicate samples from each treatment were collected on the final day. This study provides insight into the macronutrient-micronutrient levers that may be responsible for the lack of full dissolved nickel (Ni) depletion in ocean surface waters by marine phytoplankton.

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Coverage

Location: Ocean Station Papa, subarctic North Pacific Ocean
Spatial Extent: **N**:50.8 **E**:-144.4 **S**:49.8 **W**:-145.4
Temporal Extent: 2018-08-17 - 2018-09-06

Methods & Sampling

Incubation setup:

Note that these four incubations were carried out over the course of six total experiments, but only the long-term incubation data are presented here; hence, the incubations are labeled as 2, 3, 5, and 6.

Seawater for all four incubation experiments was collected near Ocean Station Papa (50 °N, 145 °W) using a trace metal clean towfish system (Mellett and Buck 2020) on the R/V Roger Revelle August 17 to 29 of 2018. Seawater from ~ 2 meters (m) depth was prefiltered inline to remove large grazers using an acid-cleaned 150-micrometer (µm) mesh and collected in acid-cleaned and Milli-Q (MQ; ≥ 18.2 MΩ cm)-conditioned 20-liter (L) polycarbonate (PC) carboys (see Hollister et al. (2020) for carboy cleaning protocol). Each carboy was rinsed three times with seawater prior to filling. Water was collected underway at 5 to 10 knots, and the carboys were filled round-robin style to homogenize any natural surface variability. Discrete samples were also collected during the filling process to check for changes in nutrients and dissolved trace metals during setup. Incubations 2 (Inc 2) and 5 (Inc 5) were conducted in the 20-L carboys; for incubations 3 (Inc 3) and 6 (Inc 6), homogenized seawater from the 20-L carboys was aliquoted into 4-L PC bottles for incubation.

Nutrient amendments for Inc 2 and 5 were selected to induce nutrient stress of a particular nutrient, and all Fe additions were accomplished with a stable isotope tracer in the form of $^{57}FeCl_3$ (Isoflex). Treatments included multi-nutrient additions of +20 micromolar (µM) nitrate +1.25 µM phosphate +20 µM silicic acid ("AllButFe") and +20 µM nitrate +1.25 µM phosphate +5 nM Fe ("AllButSi") to induce Fe and Si stress, respectively. For Inc 3 and Inc 6, single treatments of +1 nM Cu, +5 nM Fe or +20 µM silicic acid, as well as a combined +5 nM Fe +20 µM silicic acid treatment, were used to assess relief of specific nutrient limitation. For each incubation, triplicates of the controls were sampled for initial conditions (day 0) once all 20-L carboys or 4-L incubation bottles were amended, and remaining carboys and bottles were placed in deck-board incubators. These carboys and bottles were incubated in the deck-board incubators, which were flushed continuously with surface seawater for temperature maintenance and covered with mesh screening to replicate surface water light levels. Incubations 2 and 3 were carried out for 6 days, and Inc 5 and 6 were carried out for 8 days. For the final time points of the incubations, triplicates of each treatment were gently mixed by inversion and sampled in a trace-metal-clean (TMC) bubble. Between each incubation the 20-L carboys and 4-L bottles were rinsed once with MQ, twice with methanol, three times with 10 % hydrochloric acid (HCl; trace metal grade), and then four times with MQ again. They were also rinsed three times with seawater during the setup of subsequent incubations.

Sampling and analyses:

Trace metals:

Incubation samples for dissolved trace metals were collected through sequential acid-cleaned 5 µm and 0.4 µm polycarbonate track-etched (PCTE) filters via a custom-made trace metal clean vacuum filtration apparatus (Burns et al. 2023). Trace metal samples were acidified (0.024 M; Optima HCl) and stored at room temperature until returned to the lab for analysis. Following preconcentration on the seaFAST pico (ESI) offline, a suite of trace metals were analyzed by high-resolution inductively coupled plasma mass spectrometry (HR-ICP-MS) on an Element XR (ThermoScientific) by standard addition (Burns et al. 2023). Prior to preconcentration, samples were ultraviolet (UV) oxidized in a UVO-Cleaner (Model No. 342; Jelight Company Inc.) for 90 minutes (Biller and Bruland 2012; Hollister et al. 2020). Samples were also re-run without UV oxidation and final Ni and cadmium (Cd) concentrations for each sample, which did not significantly change with or without UV oxidation, are presented as the average of all runs (i.e., both UV and no UV).

Labile particulate trace metals were collected on the 0.4 µm and 5 µm PCTE filters used to filter the dissolved trace metal samples. Filters were folded into eighths and stored frozen (-20 degrees Celsius (ºC)) in 1.5-milliliter (mL) snap-cap polypropylene microcentrifuge tubes that had been acid-cleaned in 10% HCl (TraceMetalGrade, Fisher). Labile particulate trace metals were extracted via the Berger leach method (Berger et al. 2008) to quantify the biologically cycled particulate metals (Rauschenberg and Twining 2015). Briefly, microcentrifuge tubes containing the folded sample filters were thawed at room temperature and placed into a 4-Way Flipper™ Rack (Fisher) capable of holding up to 32 tubes. For each sample, 1 mL of a solution of 25% acetic acid (Fisher, Optima) with 0.02 M hydroxylamine hydrochloride (Fisher, ≥99%) was pipetted into each tube. The sample rack was then placed into a 90 ºC water bath for 10 minutes, and then removed and allowed to cool to room temperature for 1 hour and 50 minutes. For each sample, 1 mL of the leach solution was transferred into a trace-metal-clean 15-mL Teflon flat interior vial (PFA, Savillex) using a pipette, and the filter was rinsed with three 1-mL aliquots of MQ water that were also transferred to the vial. Leach solutions and rinses were spiked with 100 microliters (µL) HNO_3 (Fisher, Optima) and then dried down on a hot plate. This digestion was

repeated again with another 100 µL HNO_3 (Fisher, Optima), and the final residue was redissolved in 3 mL of 2% HNO_3 (Fisher, Optima) containing 10 parts per billion (ppb) indium (In) internal standard for analysis on the HR-ICP-MS Element 2 (ThermoScientific) system at the National High Magnetic Field Laboratory. Concentrations of labile particulate trace metals and phosphorus were measured by standard addition.

An internal dissolved QC surface seawater sample was made from the North Pacific EXPORTS cruise in August 2018. Dissolved reference materials (SAFe S, GSP) with consensus values available on the GEOTRACES website were used to assess accuracy. Three replicates of air blanks were measured during each seaFAST run (Hollister et al. 2020; Burns et al. 2023) and subtracted from the calculated dissolved sample concentrations as process blanks. Limits of detection were calculated as triple the standard deviation of the air blanks. For the labile particulate samples, blank PCTE filters were processed on the filter rigs with MQ during each sampling event and treated the same as samples to account for processing blanks.

Dissolved macronutrients:
Samples for the dissolved macronutrients nitrate+nitrite (N+N), silicic acid (Si), and soluble reactive phosphorus ("phosphate," or P) were collected along with dissolved trace metal samples from the 0.4 µm PCTE filtrate described above. Samples were frozen at -20°C and shipped to the analytical facility at the University of California Santa Barbara where they were thawed and analyzed on a Lachat Instruments QuikChem 8500 Series 2 analyzer (Parsons et al. 1984; Brzezinski et al. 2022).

Chlorophyll *a*:
Chlorophyll *a* (chl *a*) samples were collected on 0.6 µm and 5 µm GF/F Whatman glass microfiber filters by vacuum filtration. The filters were leached with 95% ethanol immediately following collection (Jesperson and Christoffersen 1987; Morison and Menden-Deuer 2015) and analyzed on a 10AU fluorometer (Turner Designs, Inc.) at sea.

Biogenic silica:
Biogenic silica on 0.6 µm and 5 µm filters was measured as described in Brzezinski et al. (2022) at the University of California, Santa Barbara (UCSB). Briefly, each filter was folded and stored in a plastic container and immediately frozen at -20°C to prevent opal dissolution. Biogenic silica was measured using a NaOH digestion method using manual colorimetry.

Particulate organic nitrogen and carbon:
Particulate organic carbon (POC) and particulate organic nitrogen (PON) samples were collected on 0.6 µm and 5 µm pre-combusted GF/F filters that were placed in glass scintillation vials and frozen at -20°C and analyzed at UCSB as described by Sharp (1991) using a CHN analyzer (Leeman Labs Inc., CE Model 440).

Data Processing Description

Data were flagged using the SeaDataNet quality flag scheme recommended by GEOTRACES (https://www.geotraces.org/geotraces-quality-flag-policy/) and described below. Notes specific to the application of these flags to this dataset are noted in brackets [...].

0: No Quality Control: No quality control procedures have been applied to the data value. This is the initial status for all data values entering the working archive. [Not used].

1: Good Value: Good quality data value that is not part of any identified malfunction and has been verified as consistent with real phenomena during the quality control process. [Used when replicates were in good agreement and/or when dataset agreed with previously published results].

2: Probably Good Value: Data value that is probably consistent with real phenomena, but this is unconfirmed or data value forming part of a malfunction that is considered too small to affect the overall quality of the data object of which it is a part. [Used when no replicates or published datasets to compare].

3: Probably Bad Value: Data value recognized as unusual during quality control that forms part of a feature that is probably inconsistent with real phenomena. [Not used].

4: Bad Value: An obviously erroneous data value. [Used when replicates did not agree].

5: Changed Value: Data value adjusted during quality control. Best practice strongly recommends that the value before the change be preserved in the data or its accompanying metadata. [Not used].

6: Value Below Detection Limit: The level of the measured phenomenon was less than the limit of detection (LOD) for the method employed to measure it. Values are replaced with ‘nd’ for ‘not detectable’. [Used when below detection].

7: Value in Excess: The level of the measured phenomenon was too large to be quantified by the technique employed to measure it. The accompanying value is the measurement limit for the technique. [Not used].

8: Interpolated Value: This value has been derived by interpolation from other values in the data object. [Not used].

9: Missing Value: The data value is missing. Any accompanying value will be a magic number representing absent data. [Not used].

A: Value Phenomenon Uncertain: There is uncertainty in the description of the measured phenomenon associated with the value such as chemical species or biological entity. [Not used].

BCO-DMO Processing Description

currently being processed

Problem Description

During filtration on 08/27/2018, two 0.4-µm filters were accidentally double-stacked in the filtration rig. Labile particulate Ni, Cd, and P is flagged as "4" for that reason.

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Related Publications

Berger, C. J. M., Lippiatt, S. M., Lawrence, M. G., & Bruland, K. W. (2008). Application of a chemical leach technique for estimating labile particulate aluminum, iron, and manganese in the Columbia River plume and coastal waters off Oregon and Washington. Journal of Geophysical Research, 113. doi:10.1029/2007jc004703 https://doi.org/10.1029/2007JC004703
Methods

Biller, D. V., & Bruland, K. W. (2012). Analysis of Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb in seawater using the Nobias-chelate PA1 resin and magnetic sector inductively coupled plasma mass spectrometry (ICP-MS). Marine Chemistry, 130-131, 12–20. doi:10.1016/j.marchem.2011.12.001
Methods

Brzezinski, M. A., Varela, D. E., Jenkins, B. D., Buck, K. N., Kafrissen, S. M., & Jones, J. L. (2022). The upper ocean silicon cycle of the subarctic Pacific during the EXPORTS field campaign. Elementa: Science of the Anthropocene, 10(1). https://doi.org/10.1525/elementa.2021.00087
Methods

Burns, S. M., Bundy, R. M., Abbott, W., Abdala, Z., Sterling, A. R., Chappell, P. D., Jenkins, B. D., & Buck, K. N. (2023). Interactions of bioactive trace metals in shipboard Southern Ocean incubation experiments. Limnology and Oceanography, 68(3), 525–543. Portico. https://doi.org/10.1002/lno.12290
Methods

Hollister, A. P., Kerr, M., Malki, K., Muhlbach, E., Robert, M., Tilney, C. L., Hubbard, K.A., & Buck, K. N. (2020). Regeneration of macronutrients and trace metals during phytoplankton decay: An experimental study. Limnology and Oceanography. doi:10.1002/lno.11429
Methods

Jespersen, A.-M., & Christoffersen, K. (1987). Measurements of chlorophyll-a from phytoplankton using ethanol as extraction solvent. Archiv Für Hydrobiologie, 109(3), 445–454. https://doi.org/10.1127/archiv-hydrobiol/109/1987/445
Methods

Morison, F., & Menden-Deuer, S. (2015). Early spring phytoplankton dynamics in the subpolar North Atlantic:

The influence of protistan herbivory. Limnology and Oceanography, 60(4), 1298–1313. doi:10.1002/lno.10099
Methods

Parsons, T. R., Maita, Y., and Lalli, C. M. (1984). A Manual of Chemical and Biological Methods for Seawater Analysis. Pergamon Press: Oxford, UK, 1984; ISBN 978-0-08-030288-1. (https://doi.org/10.25607/OBP-1830)
Methods

Rauschenberg, S., & Twining, B. S. (2015). Evaluation of approaches to estimate biogenic particulate trace metals in the ocean. Marine Chemistry, 171, 67–77. doi:10.1016/j.marchem.2015.01.004
Methods

Yang, S.M., Mellett, T., Caprara, S., Lerch, S., Gomes, K.M., Jenkins, B.D., Brzezinski, M.A., Jones, J.L., Morton, P., & Buck, K.N. (in prep). Sharp increase in nickel uptake by large North Pacific phytoplankton occurs with depletion of silicic acid or nitrate. Limnology and Oceanography.
Results

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Related Datasets

IsRelatedTo

Buck, K., Burns, S. M., Jenkins, B. D., & Brzezinski, M. A. (2023). *Dissolved trace metal (Mn, Fe, Co, Ni, Cu, Zn, Cd, Pb) and labile particulate elemental (P, V, Mn, Fe, Co, Ni, Cu, Zn, Cd, Pb) concentrations from shipboard incubation experiments conducted on the 2018 EXPORTS cruise (RR1813) near Ocean Station PAPA* (Version 1) [Dataset]. Biological and Chemical Oceanography Data Management Office (BCO-DMO). https://doi.org/10.26008/1912/BCO-DMO.896884.1 https://doi.org/10.26008/1912/bco-dmo.896884.1

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Parameters

Parameter	Description	Units
CRUISE	Cruise during which sample was collected	unitless
SAMPLE_DATE	Date when the incubation sample was collected	unitless
JULIAN_DAY	Day of year sampled, beginning at 1 on Jan 1, 2018.	unitless
EPOCH	Assigned time block (8 or 9 days each) during the cruise, numbered 1 to 3.	unitless
EPOCH_DAY	Day within the epoch time block.	unitless
INCUBATION	Incubation number: 2, 3, 5, or 6.	unitless
TIMEPOINT	Stage of incubation, initial or final.	unitless
TREATMENT	Nutrient amendment.	unitless

REPLICATE	Incubations were conducted with triplicate bottles or carboys per treatment. Carboy (20-L) or bottle (4-L) number 1 to 3.	unitless
PHOSPHATE	Dissolved phosphate concentration in micromoles per liter; analyzed in UCSB MSI Analytical lab. nd = not detectable (below detection limit)	micromolar (µM)
PHOSPHATE_flag	Data quality flag for PHOSPHATE.	unitless
SILICIC_ACID	Silicic acid concentration in micromoles per liter. nd = not detectable (below detection limit)	micromolar (µM)
SILICIC_ACID_flag	Data quality flag for SILICIC_ACID.	unitless
NITRITE	Dissolved nitrite concentration in micromoles per liter; analyzed in UCSB MSI Analytical lab. nd = not detectable (below detection limit)	micromolar (µM)
NITRITE_flag	Data quality flag for NITRITE.	unitless
NITRATE_NITRITE	dissolved nitrate +nitrite concentration in micromoles per liter; analyzed in UCSB MSI Analytical lab. nd = not detectable (below detection limit)	micromolar (µM)
NITRATE_NITRITE_flag	Data quality flag for NITRATE_NITRITE.	unitless
Ni_D_CONC	Concentration of dissolved nickel (Ni). Units: nanomoles per liter (nM).	nanomolar (nM)
Ni_D_CONC_STDEV	Standard deviation of replicate analyses of this sample.	nanomolar (nM)
Ni_D_CONC_n	Number of times this sample was analyzed.	unitless
Ni_D_CONC_flag	Data quality flag for Ni_D_CONC.	unitless
Cd_D_CONC	Concentration of dissolved cadmium (Cd). Units: picomoles per liter (pM).	picomolar (pM)
Cd_D_CONC_STDEV	Standard deviation of replicate analyses of this sample.	picomolar (pM)
Cd_D_CONC_n	Number of times this sample was analyzed.	unitless

Cd_D_CONC_flag	Data quality flag for Cd_D_CONC.	unitless
CHLa_0_6um_to_5um	Chlorophyll a in micrograms per liter for the 0.6 to 5 micrometer (um) size fraction	micrograms per liter (µg/L)
CHLa_0_6um_to_5um_flag	Data quality flag for CHLa_0_6um_to_5um.	unitless
bSi_0_6um_to_5um	Particulate biogenic silica in nanomoles Si per liter for the 0.6 to 5 micrometer (um) size fraction	nanomolar (nM)
bSi_0_6um_to_5um_flag	Data quality flag for bSi_0_6um_to_5um.	unitless
P_SLP_CONC	Concentration of small labile particulate (SLP; 0.4-5 µm size fraction) phosphorus (P). Units: nanomoles per liter (nM).	nanomolar (nM)
P_SLP_CONC_Flag	Data quality flag for P_SLP_CONC. Note because sample not re-analyzed, 2 = Probably Good Value.	unitless
Ni_SLP_CONC	Concentration of small labile particulate (SLP; 0.4-5 µm size fraction) nickel (Ni). Units: nanomoles per liter (nM).	nanomolar (nM)
Ni_SLP_CONC_flag	Data quality flag for Ni_SLP_CONC. Note because sample not re-analyzed, 2 = Probably Good Value.	unitless
Cd_SLP_CONC	Concentration of small labile particulate (SLP; 0.4-5 µm size fraction) cadmium (Cd). Units: picomoles per liter (pM).	picomolar (pM)
Cd_SLP_CONC_flag	Data quality flag for Cd_SLP_CONC. Note because sample not re-analyzed, 2 = Probably Good Value.	unitless
P_LLP_CONC	Concentration of large labile particulate (LLP; >5 µm size fraction) phosphorus (P). Units: nanomoles per liter (nM).	nanomolar (nM)
P_LLP_CONC_Flag	Data quality flag for P_LLP_CONC. Note because sample not re-analyzed, 2 = Probably Good Value.	unitless
Ni_LLP_CONC	Concentration of large labile particulate (LLP; >5 µm size fraction) nickel (Ni). Units: nanomoles per liter (nM). Values below the limit of detection are replaced with ‘nd’ for ‘not detectable.’	nanomolar (nM)
Ni_LLP_CONC_flag	Data quality flag for Ni_LLP_CONC. Note because sample not re-analyzed, 2 = Probably Good Value. 6 = Value Below Detection Limit.	unitless

Cd_LLP_CONC	Concentration of large labile particulate (LLP; >5 µm size fraction) cadmium (Cd). Units: picomoles per liter (pM).	picomolar (pM)
Cd_LLP_CONC_flag	Data quality flag for Cd_LLP_CONC. Note because sample not re-analyzed, 2 = Probably Good Value.	unitless
gt_5um_CHLa	Chlorophyll a in micrograms per liter for the size fraction of 5 micrometers (um) and greater	micrograms per liter (µg/L)
gt_5um_CHLa_flag	Data quality flag for gt_5um_CHLa.	unitless
gt_5um_bSi	Particulate biogenic silica in nanomoles Si per liter for the size fraction of 5 micrometers (um) and greater	nanomolar (nM)
gt_5um_bSi_flag	Data quality flag for gt_5um_bSi.	unitless
POC	Particulate organic carbon in micromoles per liter; analyzed in UCSB MSI Analytical lab.	micromolar (µM)
POC_flag	Data quality flag for POC.	unitless
PON	Particulate organic nitrogen (PON) in micromoles per liter; analyzed in UCSB MSI Analytical lab.	micromolar (µM)
PON_flag	Data quality flag for PON.	unitless

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Instruments

Dataset-specific Instrument Name	CHN analyzer (Leeman Labs Inc., CE Model 440)
Generic Instrument Name	CHN Elemental Analyzer
Dataset-specific Description	Used to measure POC and PON.
Generic Instrument Description	A CHN Elemental Analyzer is used for the determination of carbon, hydrogen, and nitrogen content in organic and other types of materials, including solids, liquids, volatile, and viscous samples.

Dataset-specific Instrument Name	Lachat Instruments QuikChem 8500 Series 2 analyzer
Generic Instrument Name	Lachat QuikChem 8500 flow injection analysis system
Dataset-specific Description	Used to measure dissolved macronutrients nitrate+nitrite (N+N), silicic acid (Si), and soluble reactive phosphorus ("phosphate," or P).
Generic Instrument Description	The Lachat QuikChem 8500 Series 2 Flow Injection Analysis System features high sample throughput and simple, but rapid, method changeover. The QuikChem 8500 Series 2 system maximises productivity in determining ionic species in a variety of sample types, from sub-ppb to percent concentrations. Analysis takes 20 to 60 seconds, with a sample throughput of 60 to 120 samples per hour.

Dataset-specific Instrument Name	SeaFAST pico
Generic Instrument Name	SeaFAST Automated Preconcentration System
Dataset-specific Description	An automated system used to preconcentrate dissolved trace metals for analysis on an ICP-MS.
Generic Instrument Description	The seaFAST is an automated sample introduction system for analysis of seawater and other high matrix samples for analyses by ICPMS (Inductively Coupled Plasma Mass Spectrometry).

Dataset-specific Instrument Name	Element 2 Inductively Coupled Plasma Mass Spectrophotometer
Generic Instrument Name	Thermo Fisher Scientific ELEMENT 2 inductively coupled plasma mass spectrometer
Dataset-specific Description	Used to analyze dissolved and labile particulate trace metal concentrations.
Generic Instrument Description	The Thermo Scientific Element 2 ICP-MS is a double-focussing magnetic-sector-field Inductively Coupled Plasma Mass Spectrometer equipped with a discrete dynode detector system, linear over nine orders of magnitude - from ppq to ppm concentrations. Other features include: Sensitivity (Concentric Nebuliser) greater than 1 x 10^9 counts per second (cps)/ppm In; Dark noise less than 0.2 cps; Mass resolution 300, 4,000, 10,000 (10 percent valley, equivalent to 5 percent height), 600, 8,000, 2,000 (FWHM); Signal stability better than 1 percent RSD over 10 minutes or 2 percent RSD over 1 hour; Mass stability: 25 ppm / 8 hours; Magnetic scan speed: m/z 7 to 240 to 7 in less than 150 ms, Electronic scan speed: 1 ms/jump, independent of mass range.

Dataset-specific Instrument Name	Element XR Inductively Coupled Plasma Mass Spectrophotometer
Generic Instrument Name	Thermo Scientific ELEMENT XR high resolution inductively coupled plasma mass spectrometer
Dataset-specific Description	Used to analyze dissolved and labile particulate trace metal concentrations.
Generic Instrument Description	A high-resolution (HR) inductively coupled plasma (ICP) mass spectrometer (MS) composed of a dual mode secondary electron multiplier (SEM) and a Faraday detector. The ELEMENT XR instrument has a dynamic range of 5 x 10^7 to 1 x 10^12 counts per second (cps), and allows simultaneous measurement of elements at concentrations over 1000 ug/g.

Dataset-specific Instrument Name	trace metal clean towfish system
Generic Instrument Name	towed unmanned submersible
Dataset-specific Description	A vehicle towed by rigid cable through the water column at fixed or varying depth with no propulsion and no human operator that was used to collect trace-metal-clean seawater.
Generic Instrument Description	A vehicle towed by rigid cable through the water column at fixed or varying depth with no propulsion and no human operator (e.g. Towfish, Scanfish, UOR, SeaSoar).

Dataset-specific Instrument Name	10AU fluorometer (Turner Designs, Inc.)
Generic Instrument Name	Turner Designs Fluorometer-10
Dataset-specific Description	Used to measure chl a.
Generic Instrument Description	The Turner Designs Model 10 fluorometer (manufactured by Turner Designs, turnerdesigns.com, Sunnyvale, CA, USA) is used to measure Chlorophyll fluorescence. No information could be found for this specific model.

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Deployments

RR1813

Website	https://www.bco-dmo.org/deployment/772777
Platform	R/V Roger Revelle
Report	https://datadocs.bco-dmo.org/docs/EXPORTS/data_docs/RR1813_Cruise_Report.pdf
Start Date	2018-08-10
End Date	2018-09-12
Description	Additional cruise information is available from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/RR1813

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Project Information

Collaborative Research: Diatoms, Food Webs and Carbon Export - Leveraging NASA EXPORTS to Test the Role of Diatom Physiology in the Biological Carbon Pump (Diatoms and carbon export)

Coverage: Sub-Arctic Pacific, Ocean Station Papa

NSF Award Abstract:
This project focuses on a group of microscopic single-celled photosynthetic organisms in the ocean called diatoms. Diatoms float in the surface ocean as part of a group of organisms collectively called phytoplankton. There are thousands of different species of diatoms distributed across the global ocean. A famous oceanographer Henry Bigelow once said "All fish is diatoms" reflecting the importance of diatoms as the base of the food chain that supports the world's largest fisheries. Despite their small size, diatom photosynthesis produces 20% of the oxygen on earth each year. That's more than all of the tropical rain forests on land. The major objective of the research is to understand how the metabolic differences among diatom species affects the amount of diatom organic carbon that is carried, or exported, from the surface ocean to the deep ocean. As diatoms are photo-synthesizers like green plants, their biological carbon comes from converting carbon dioxide dissolved in seawater from the atmosphere into organic forms. Diatoms also require a series of other nurtrients supplied by the ocean such as nitrogen and phosphorous and, uniquely for diatoms, the silicon used to construct their glass shells. This research will investigate how genetic and physiological differences among diatoms influence how each species react to changes in nutrient levels in the ocean and how those shifts affect the export of diatom carbon to the deep sea. The link between diatoms' physiological response and their carbon export comes about because shifts in physiology affect diatom attributes like how fast they sink and how tasty they are to predators. So if we can relate the physiological condition of different diatoms to the food-web pathways followed by different species, we can ultimately use knowledge of diatom physiological status and food web structure to predict how much diatom carbon gets to the deep sea. The research involves investigators with expertise in the physiology and genomics of diatoms and in the ocean's chemistry. The work will initially take place in the subarctic North Pacific in conjunction with the NASA Export Processes in the Ocean from RemoTe Sensing (EXPORTS) field program. The EXPORTS program is using a wide variety of methods to quantify the export and fate of photo-synthetically fixed carbon in the upper ocean. The research supports the training of undergraduate students, graduate students and a postdoctoral scholar. The research will also serve as the basis for activities aimed at K-12 and junior high school students.

The research will broadly impact our understanding of the biology of the biological pump (the transport of photo-synthetically fixed organic carbon to the deep sea) by forming a mechanistic basis for predicting the export of diatom carbon. It is hypothesized that the type and degree of diatom physiological stress are vital aspects of ecosystem state that drive export. To test this hypothesis, the genetic composition, rates of nutrient use and growth response of diatom communities will be evaluated and supported with measurements of silicon and iron stress to evaluate stress as a predictor of the path of diatom carbon export. The subarctic N. Pacific ecosystem is characterized as high nutrient low chlorophyll (HNLC) due to low iron (Fe) levels that are primary controllers constraining phytoplankton utilization of other nutrients. It has been a paradigm in low Fe, HNLC systems that diatoms grow at elevated Si:C and Si:N ratios and should be efficiently exported as particles significantly enriched in Si relative to C. However, Fe limitation also alters diatoms species composition and the high Si demand imposed by low Fe can drive HNLC regions to Si limitation or Si/Fe co-limitation. Thus, the degree of Si and/or Fe stress in HNLC waters can all alter diatom taxonomic composition, the elemental

composition of diatom cells, and the path cells follow through the food web ultimately altering diatom carbon export.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Program Information

EXport Processes in the Ocean from Remote Sensing (EXPORTS)

Website: http://oceanexports.org/

EXport Processes in the Ocean from Remote Sensing (EXPORTS) is a large-scale NASA-led field campaign that will provide critical information for quantifying the export and fate of upper ocean net primary production (NPP) using satellite observations and state of the art ocean technologies.

Ocean ecosystems play a critical role in the Earth’s carbon cycle and the quantification of their impacts for both present conditions and for predictions into the future remains one of the greatest challenges in oceanography. The goal of the EXport Processes in the Ocean from Remote Sensing (EXPORTS) Science Plan is to develop a predictive understanding of the export and fate of global ocean net primary production (NPP) and its implications for present and future climates. The achievement of this goal requires a quantification of the mechanisms that control the export of carbon from the euphotic zone as well as its fate in the underlying "twilight zone" where some fraction of exported carbon will be sequestered in the ocean’s interior on time scales of months to millennia. In particular, EXPORTS will advance satellite diagnostic and numerical prognostic models by comparing relationships among the ecological, biogeochemical and physical oceanographic processes that control carbon cycling across a range of ecosystem and carbon cycling states. EXPORTS will achieve this through a combination of ship and robotic field sampling, satellite remote sensing and numerical modeling. Through a coordinated, process-oriented approach, EXPORTS will foster new insights on ocean carbon cycling that maximizes its societal relevance through the achievement of U.S. and International research agency goals and will be a key step towards our understanding of the Earth as an integrated system.

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