Redox data from RV/Atlantic Explorer AE1812 in the northwest Atlantic, May 2018

Website: https://www.bco-dmo.org/dataset/762772

Data Type: Cruise Results

Version: 1

Version Date: 2019-03-20

Project

» Collaborative Research: Defining the biogeochemical drivers of diatom physiological ecology in the North Atlantic (North Atlantic Diatoms)

» Redox Cycling of Phosphorus in the Western North Atlantic Ocean (Phosphorus Redox Cycling)

Contributors	Affiliation	Role
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Abstract

This dataset includes redox data from RV/Atlantic Explorer AE1812 in the northwest Atlantic, May 2018.

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Coverage

Spatial Extent: **N**:41.19 **E**:-63.48 **S**:31.67 **W**:-70.97

Temporal Extent: 2018-05-02 - 2018-05-15

Dataset Description

This dataset includes redox data from RV/Atlantic Explorer AE1812 in the northwest Atlantic, May 2018.

Acquisition Description

All data were collected from a modified procedure as described in Van Mooy et al (2015).

Sampling - Sampling was conducted aboard the R/V Atlantic Explorer during a cruise in May 2018. Water samples for whole community analyses were collected from Niskin bottles deployed on a rosette with a CTD. Subsamples (1-4 L) for incubations were dispensed from the Niskin bottle into acid-washed polyethylene bottles and promptly taken to a laboratory van for incubation setup and processing. At two stations Trichodesmium colonies were also acquired for uptake and reduction experiments. Briefly, colonies were collected near the surface with a handheld 130 µm net. 6 to 20 colonies were washed twice with freshly filtered (0.2 µm pore size polycarbonate membrane) surface seawater before being transferred into

50 mL of filtered seawater for incubation as described below. At three stations sinking particles were collected using 1.25 m diameter free-floating net traps for 24-hour deployments (Peterson et al. 2005). Once recovered, the particle slurry was further split into 12 equal fractions using an electric splitter (Lamborg et al. 2008). One split was used for total phosphate uptake and reduction measurements as described below where particle slurries were incubated in the dark in 50 to 125 mL of seawater. [C.H. Lamborg, K.O. Bruesseler, J. Valdes, C.H. Bertrand, R. Bidigare, S. Manganini, etc, The flux of bio- and lithogenic material associated with sinking particles in the mesopelagic “twilight zone” of the northwest and North Central Pacific Ocean. Deep-Sea Res II 55, 1540 (2008). M.L. Peterson, S.G. Wakeham, C. Lee, M.A. Askea, J.C. Miquel, Novel techniques for collection of sinking particles in the ocean and determining their settling rates. Limnol Oceanogr Methods 3, 520 (2005).]

Phosphate uptake rates – 50 mL samples of seawater were added to acid-washed polycarbonate incubation bottles. Each incubation bottle was spiked with approximately 2 µCi of 33P-phosphoric acid. The final concentration of 33P-phosphate in the incubations was less than 10 pmol L-1, which was likely two orders of magnitude smaller than ambient phosphate concentrations. The bottles were capped and mixed by gently inverting. To account for any abiotic adsorption of the radioactive tracer, additional 50 mL subsamples were spiked with 10% paraformaldehyde prior to the addition of the 33P-phosphoric acid. These “killed controls” were used for blank subtractions in uptake and reduction rate calculations. All bottles were placed in a flow-through on-deck incubator that was maintained at surface seawater temperatures by continually flushing it with the surface seawater from the ship’s pumping system. Temperature in the incubators was occasionally monitored with a waterproof temperature logger (Onset). The incubators used blue transparent film to achieve a light intensity to mimic 30% PAR. About half of the surface water samples were placed in a dark incubator to determine the affect light had on the incubations. For depth profiles, the incubators used a combination of neutral density screening and blue transparent film to achieve a light intensity to mimic PAR throughout the water column while samples with less than 1% PAR were placed in a dark incubator. After an appropriate amount of time, the incubations were terminated and 5 mL of sample was vacuum filtered (approximately 200 mbar) onto 25 mm diameter 0.2 µm pore size polycarbonate membranes (Millipore). The membranes were quickly rinsed three times with freshly filtered (0.2 µm pore size polycarbonate membrane) surface seawater. The membranes were then immediately placed in a liquid scintillation vial containing 10 mL of UltimaGold liquid (Perkin Elmer) scintillation cocktail, which was then shaken vigorously. The 33P-radioacitivity in the vials was determined using a liquid scintillation counter (Perkin Elmer).

Phosphate reduction to intracellular P(III) compounds – The remaining 45 mL of sample was vacuum filtered as described above. Next, the membranes were immersed in 1.0 mL of ultra-

high purity (UHP) deionized water (18 MΩ*cm) in a cryovial (Fisher). The vials were immediately capped and flash frozen for storage and transport back to the on-shore laboratory. For further analysis, the samples were subject to three freeze/thaw cycles where the cryovial was immersed in liquid nitrogen for approximately 10 min, before they were immersed in boiling-hot water for 10 min, and then vigorously shaken. Next, 100 µL aliquots of the samples were injected onto an IC system (Dionex) which pumped an eluent gradient of 23 mmol L-1 to 90 mmol L-1 sodium hydroxide through an IonPac AS18 (Dionex) column at a rate of 1.0 mL min-1. An ion suppressor using UHP water as a regenerant removed sodium hydroxide from the eluent. Three fractions were collected in 60 second intervals at retention times where pure standards of (1) hypophosphorus acid (2) methyl-phosphonate, 2-hydroxethyl-phosphonate, and (3) phosphorus acid elute and the 33P-radioactivity determined as described above. The 33P-radioactivity of the three fractions was summed, corrected for dilution, and then divided by the 33P-radioactivity from the parallel 33P-phosphate uptake subsamples to determine the fraction (%) of 33P uptake that was incorporated into P (III) compounds. All uptake samples were processed at sea in May 2018 and all reduction samples were processed onshore in July 2018. Radioactive decay was accounted for in the final counts per minute (cpm) values.

Processing Description

BCO-DMO Processing:

- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions

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Related Publications

Lamborg, C. H., Buesseler, K. O., Valdes, J., Bertrand, C. H., Bidigare, R., Manganini, S., Pike, S., Steinberg. D., Trull, T.,& Wilson, S. (2008). The flux of bio- and lithogenic material associated with sinking particles in the mesopelagic "twilight zone" of the northwest and North Central Pacific Ocean. Deep Sea Research Part II: Topical Studies in Oceanography, 55(14-15), 1540–1563. doi:10.1016/j.dsr2.2008.04.011

Peterson, M. L., Wakeham, S. G., Lee, C., Askea, M. A., & Miquel, J. C. (2005). Novel techniques for collection of sinking particles in the ocean and determining their settling rates. Limnology and Oceanography: Methods, 3(12), 520–532. doi:10.4319/lom.2005.3.520

Van Mooy, B. A. S., Krupke, A., Dyhrman, S. T., Fredricks, H. F., Frischkorn, K. R., Ossolinski, J. E., … Sylva, S. P. (2015). Major role of planktonic phosphate reduction in the marine phosphorus redox cycle. Science, 348(6236), 783–785. doi:10.1126/science.aaa8181

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Parameters

Parameter	Description	Units
Station	Numeric identifier for the station where the data was collected.	unitless
CTD_Cast	Numeric identifier for the CTD cast where the data was collected.	unitless
Sample_type	Sample type: Comm.=Whole community; CommD.=Whole communinty in dark incubation; Tricho.=Trichodesmium colonies; Sed.=Sinking particles	unitless
Depth	Depth at which the samples were collected.	meters
P33_PO4_incorp_PIII_rate	33P-phosphate incorporation into P(III) compounds (blank corrected).	counts per minutes per liter per hour (cpm/(L h))
P33_PO4_uptake	33P-phosphate uptake (blank corrected)	counts per minutes per liter per hour (cpm/(L h))
P33_PO4_incorp_PIII_pcent	Percentage of 33P-phosphate incorporation into P(III) compounds	percentage (%)

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Niskin bottle
Generic Instrument Description	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.

Dataset-specific Instrument Name	
Generic Instrument Name	CTD profiler
Generic Instrument Description	The Conductivity, Temperature, Depth (CTD) unit is an integrated instrument package designed to measure the conductivity, temperature, and pressure (depth) of the water column. The instrument is lowered via cable through the water column and permits scientists observe the physical properties in real time via a conducting cable connecting the CTD to a deck unit and computer on the ship. The CTD is often configured with additional optional sensors including fluorometers, transmissometers and/or radiometers. It is often combined with a Rosette of water sampling bottles (e.g. Niskin, GO-FLO) for collecting discrete water samples during the cast. This instrument designation is used when specific make and model are not known.

Dataset-specific Instrument Name	free-floating NetTrap
Generic Instrument Name	Sediment Trap - Particle Interceptor
Dataset-specific Description	"Based on the design of a closing plankton net capable of collecting large amounts (~1 g) of very fresh sinking particulate material in short time periods (24-36 h) to facilitate microbial decomposition experiment." (Peterson et al, 2005)
Generic Instrument Description	A Particle Interceptor Trap is a prototype sediment trap designed in the mid 1990s to segregate 'swimmers' from sinking particulate material sampled from the water column. The prototype trap used 'segregation plates' to deflect and segregate 'swimmers' while a series of funnels collected sinking particles in a chamber (see Dennis A. Hansell and Jan A. Newton. September 1994. Design and Evaluation of a "Swimmer"-Segregating Particle Interceptor Trap, Limnology and Oceanography, Vol. 39, No. 6, pp. 1487-1495).

Dataset-specific Instrument Name	liquid scintillation counter (Perkin Elmer)
Generic Instrument Name	Liquid Scintillation Counter
Generic Instrument Description	Liquid scintillation counting is an analytical technique which is defined by the incorporation of the radiolabeled analyte into uniform distribution with a liquid chemical medium capable of converting the kinetic energy of nuclear emissions into light energy. Although the liquid scintillation counter is a sophisticated laboratory counting system used the quantify the activity of particulate emitting (ß and a) radioactive samples, it can also detect the auger electrons emitted from 51Cr and 125I samples.

Dataset-specific Instrument Name	IC system (Dionex)
Generic Instrument Name	Ion Chromatograph
Generic Instrument Description	Ion chromatography is a form of liquid chromatography that measures concentrations of ionic species by separating them based on their interaction with a resin. Ionic species separate differently depending on species type and size. Ion chromatographs are able to measure concentrations of major anions, such as fluoride, chloride, nitrate, nitrite, and sulfate, as well as major cations such as lithium, sodium, ammonium, potassium, calcium, and magnesium in the parts-per-billion (ppb) range. (from http://serc.carleton.edu/microbelife/research_methods/biogeochemical/ic....)

Dataset-specific Instrument Name	
Generic Instrument Name	Shipboard Incubator
Generic Instrument Description	A device mounted on a ship that holds water samples under conditions of controlled temperature or controlled temperature and illumination.

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Deployments

AE1812

Website	https://www.bco-dmo.org/deployment/739972
Platform	R/V Atlantic Explorer
Start Date	2018-05-01
End Date	2018-05-16

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Project Information

Collaborative Research: Defining the biogeochemical drivers of diatom physiological ecology in the North Atlantic (North Atlantic Diatoms)

Coverage: North Atlantic

NSF abstract: About half of photosynthesis on earth is generated by marine phytoplankton, single celled organisms that drift with tides and currents. Within the phytoplankton, the diatoms conduct nearly half of this photosynthesis, exerting profound control over global carbon cycling. Despite their importance, there are surprisingly fundamental gaps in understanding how diatoms function in their natural environment, in part because methods to assess in situ physiology are lacking. This project focuses on the application of a powerful new approach, called Quantitative Metabolic Fingerprinting (QMF), to address this knowledge gap and examine species-specific physiology in the field. The project will provide transformative insights into how ocean geochemistry controls the distribution of diatoms, the metabolic responses of individual diatom species, and how metabolic potential is partitioned between diatom species, thus providing new insights into the structure and function of marine systems. The overarching goal is to examine how diatom species respond to changes in biogeochemistry across marine provinces, from the coast to the open ocean, by following shifts in diatom physiology using QMF. This research is critical to understand future changes in oceanic phytoplankton in response to climate and environmental change. Furthermore, activities on this project will include supporting a graduate student and postdoctoral fellow and delivering the Artistic Oceanographer Program (AOP) to diverse middle school age children and teachers in the NYC metropolitan area and to middle-school girls in the Girl Scouts of RI, reaching an anticipated 60 children and 30 teachers annually. The programs will foster multidisciplinary hands-on learning and will directly impact STEM education at a critical point

in the pipeline by targeting diverse middle-school aged groups in both NY and RI. In laboratory studies with cultured isolates, there are profound differences among diatom species' responses to nutrient limitation. Thus, it is likely that different species contribute differently to nutrient uptake, carbon flux and burial. However, marine ecosystem models often rely on physiological attributes drawn from just one species and apply those attributes globally (e.g. coastal species used to model open ocean dynamics) or choose a single average value to represent all species across the world's oceans. In part, this is due to a relatively poor understanding of diatom physiological ecology and a limited tool set for assessing in situ diatom physiological ecology. This research project will address this specific challenge by explicitly tracking metabolic pathways, measuring their regulation and determining their taxonomic distribution in a suite of environmentally significant diatoms using a state of the art, species-specific approach. A research expedition is set in the North Atlantic, a system that plays a major role in carbon cycling. Starting with a New England coastal shelf site, samples will be collected from the coast where diatoms thrive, to the open ocean and a site of a long term ocean time series station (the Bermuda Atlantic Time Series) where diatom growth is muted by nutrient limitation. This research takes advantage of new ocean observatories initiative (OOI) and time series information. Through the research expedition and downstream laboratory experiments, the molecular pathways of nutrient metabolism and related gene expression in a suite of environmentally significant diatoms will be identified. Data will be combined to predict major limiting factors and potentially important substrates for diatoms across marine provinces. Importantly, this integrated approach takes advantage of new advances in molecular and bioinformatics tools to examine in situ physiological ecology at the species-specific level, a key knowledge gap in the field.

Redox Cycling of Phosphorus in the Western North Atlantic Ocean (Phosphorus Redox Cycling)

Coverage: western north Atlantic

NSF Award Abstract: Redox Cycling of Phosphorus in the Western North Atlantic Ocean Benjamin Van Mooy ID: 1536346 Understanding controls on the growth of plankton in the upper ocean, which plays an essential role in the sequestration of carbon dioxide, is an important endeavor for chemical oceanography. Phosphorus is an essential element for marine plankton, and has been a research focus of chemical oceanography for nearly a century. Yet, phosphorus redox cycling rates are almost completely unknown throughout the ocean, and the specific molecular identities of the phosphonates, a form of phosphate, in seawater have defied elucidation. This project will explore and refine entirely new pathways for the biological cycling of phosphorus. This project will support teaching and learning by funding the PhD research of a graduate student, and through the continuation of conducting K-

12 classroom laboratory modules and hosting 6-8th grade science fair participants in the investigator's lab. Phosphorus has never been viewed by oceanographers as an element that actively undergoes chemical redox reactions in the water column, and it was believed to occur only in the +5 valence state, in compounds such as phosphate. However, over the last 17 years, numerous lines of geochemical and genomic information have emerged to show that phosphorus in the +3 valence state (P(+3)), particularly dissolved phosphonate compounds, may play a very important role within open ocean planktonic communities. This is particularly true in oligotrophic gyres such as the Sargasso Sea, where growth of phytoplankton can be limited by the scarcity of phosphate. To better understand these new data, the investigators will design and execute a research program that spans at-sea chemical oceanographic experimentation, state-of-the-art chromatography and mass spectrometry, and novel organic synthesis of 33P-labeled P(+3) compounds. Specifically, they will answer questions about rates of production and consumption of low molecular weight P(+3) compounds, the impact of phosphate availability on the production and consumption of P(+3) compounds, and the groups of phytoplankton that utilize low molecular weight P(+3) compounds. Results of this project have the potential to contribute to the transformation of our understanding of the marine phosphorus cycle.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1558490
NSF Division of Ocean Sciences (NSF OCE)	OCE-1558506
NSF Division of Ocean Sciences (NSF OCE)	OCE-1536346

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