Phosphorus redox and water column phosphorus data from R/V Neil Armstrong AR16 in the Western North Atlantic from 2017-05-04 to 2017-05-20

Website: https://www.bco-dmo.org/dataset/754508
Data Type: Cruise Results
Version: 1
Version Date: 2019-01-31

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

Contributors	Affiliation	Role
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Coverage

Spatial Extent: **N**:40.59278 **E**:-64.44075 **S**:29.16425 **W**:-71.21921
Temporal Extent: 2017-05-04 - 2017-05-20

Dataset Description

Sampling was conducted aboard the R/V Neil Armstrong during a cruise in May of 2017. Water samples for whole community analyses were collected from Niskin bottles deployed on a rosette with a CTD.

Methods & Sampling

All data collected from a modified procedure as described in Van Mooy et al (2015).
Sampling - Samples were taken at depths corresponding to 30% PAR (10-36 m). At Station 6, samples were taken at depths 5 m, 25 m, 60 m, 90 m, 110 m, 150 m, 205 m, 250 m, and 500 m. Subsamples for incubations were dispensed from the Niskin bottle directly into triplicate acid-cleaned 50 mL polycarbonate bottles and processed as described below.

Phosphate uptake rates - The incubation bottles were carried to a laboratory van that was designated solely for work with radioactive isotopes. Each incubation bottle was spiked with approximately 10 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 triplicate 50 mL subsamples were spiked with 10% paraformaldehyde prior to the addition of the 33P-phosphoric acid. These “kill 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 mimick 30% PAR. For the depth profile at Station 6, the incubators used a combination of neutral density screening and blue transparent film to achieve a light intensity to mimick PAR throughout the water column while samples with less than 1% PAR were placed in black plastic bags for complete darkness. Incubations proceeded for an average of 3.32 h (0.95 to 10.5 h) then 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. After resting for a few hours, the 33P-radioacitivity in the vials was determined using a liquid scintillation counter (Perkin Elmer). A steady-state phosphate turnover rate was calculated by dividing the total 33P radioactivity retained on the membranes by the total 33P radioactivity added to the incubations and the incubation time.

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 immersed in liquid nitrogen for approximately 10 min, before they were immersed in boiling-hot water for 10 min, and then vigorously shaken. This freeze-thaw cycle was repeated two additional times, after which generally little discernable cellular debris was visible. 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 40 second intervals at retention times where pure standards of (1) methyl-phosphonate, 2-hydroxethyl-phosphonate, and (3) phosphite elute (fraction 2 did not have a known phosphonate compound at time of analysis) 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. Environmental triplicates were averaged, and the standard deviation was propagated as analytical error. All samples were processed at sea in May 2017 except samples from Station 9, which were flash-frozen in liquid nitrogen, transported to the laboratory in a cryogenic dry shipper, and stored in liquid nitrogen until their analysis in June 2017.

MAGIC Soluble reactive phosphorus (SRP) concentrations. SRP (i.e. phosphate) was determined in seawater samples (done in triplicate) and incubations using MAGnesium Induced Coprecipitation (MAGIC) as described by Karl and Tien (1992).

Total particulate phosphorus (TTP) concentrations. TPP was determined in seawater samples using a wet chemical oxidation method using potassium persulfate as described in Suzumura (2008). Briefly, 1 to 2 liters of seawater were filtered onto 47 mm 0.2 µm pore size polyvinylidene fluoride membranes (Millipore) and frozen (-80°C) until analysis. One fourth of these filters were cut with clean stainless-steel scissors and placed in 8 mL glass vials for oxidation. 2 mL of 5% (0.19 M) persulfate was added to each vial and the samples were then autoclaved for 30 minutes at 120°C. To remove any residual material, the samples were filtered through 0.45 µm syringe filters (Millipore Millex-HV). The persulfate was shown to inhibit color development when greater than 2%, therefore, the samples were diluted to 0.5% (0.019 M). As with the SRP samples, the TPP samples were analyzed via the molybdenum blue method using a spectrophotometer (Thermo).

Data 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.
- Reformatted dates to ISO0861 convention.
- Appended latitude/longitude information.
- combined the P redox data and water column P data into one dataset using the station and cast number as mapping keys.

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Data Files

File
phos.csv(Comma Separated Values (.csv), 20.32 KB) MD5:719832e20868a1e8866ceff099d870d7 Primary data file for dataset ID 754508

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Related Publications

Karl, D. M., & Tien, G. (1992). MAGIC: A sensitive and precise method for measuring dissolved phosphorus in aquatic environments. Limnology and Oceanography, 37(1), 105–116. doi:10.4319/lo.1992.37.1.0105
Methods

Suzumura, M. (2008). Persulfate chemical wet oxidation method for the determination of particulate phosphorus in comparison with a high-temperature dry combustion method. Limnology and Oceanography: Methods, 6(11), 619–629. doi:10.4319/lom.2008.6.619
Methods

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
Methods

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Parameters

Parameter	Description	Units
Date	Sampling date formatted as YYYY-MM-DD	unitless
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
lat	latitude of sampling. Positive values indicate North	decimal degrees
lon	longitude of sampleing. Negative values indicate West	decimal degrees

Depth	depth at which samples were collected	meters (m)
MAGIC_SRP	Soluble reactive phosphorus measured by magnesium induced co-precipitation (nd-not determined; bdl-below detection limit;bdl=1.25 nMol per Liter)	nmol per liter (nM/L)
TPP	Total particulate phosphorus (nd – not determined; bdl – below detection limit; bdl = 4.07 nmol per liter)	nmol per liter
Sample_type	type of sample (Comm.=Whole community)	unitless
P33_phosphate_incorporation_into_P_3_compounds	33P-phosphate incorporation into P(III) compounds (Blank corrected; Average value for given CTD cast; Station 9 data were collected in June 2017 and are decay-corrected to May 2017)	counts per minutes per liter per hour (cpm/(L h))
P33_phosphate_uptake	33P-phosphate uptake (Blank corrected; Average value for given CTD cast; Station 9 data were collected in June 2017 and are decay-corrected to May 2017)	counts per minutes per liter per hour (cpm/(L h))
P33_phosphate_incorporation_into_P3_compounds_pcnt	33P-phosphate incorporation into P(III) compounds as percentage	unitless
P33_phosphate_incorporation_into_P3_compounds_analytical_error	33P-phosphate incorporation into P(III) compounds analytical error as percentage	unitless

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Instruments

Dataset-specific Instrument Name	liquid scintillation counter (Perkin Elmer)
Generic Instrument Name	Liquid Scintillation Counter
Dataset-specific Description	After resting for a few hours, the 33P-radioacitivity in the vials was determined using a liquid scintillation counter (Perkin Elmer).
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	bottle
Generic Instrument Name	Niskin bottle
Dataset-specific Description	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	spectrophotometer (Thermo)
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	As with the SRP samples, the TPP samples were analyzed via the molybdenum blue method using a spectrophotometer (Thermo).
Generic Instrument Description	An instrument used to measure the relative absorption of electromagnetic radiation of different wavelengths in the near infra-red, visible and ultraviolet wavebands by samples.

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Deployments

AR16

Website	https://www.bco-dmo.org/deployment/747056
Platform	R/V Neil Armstrong
Start Date	2017-05-03
End Date	2017-05-22

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Project Information

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-1536346

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