Nitrate plus nitrite isotopic compositions from Leg 1 of the Antarctic Circumnavigation Expedition (ACE) research cruise onboard the R/V Akademik Treshnikov from December 2016 to January 2017

Website: https://www.bco-dmo.org/dataset/904358
Data Type: Cruise Results
Version: 1
Version Date: 2023-07-18

Project

» Collaborative Research: Quantifying the effects of variable light and iron on the nitrate assimilation isotope effect of phytoplankton (Nitrate Assimilation Phytoplankton)

Contributors	Affiliation	Role
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Abstract

Here we present nitrate plus nitrite isotopic compositions from Leg 1 of the Antarctic Circumnavigation Expedition (ACE) research cruise onboard the R/V Akademik Treshnikov. This cruise sampled surface and water-column profiles of the summertime Indian Sector of the Southern Ocean, starting in Cape Town, South Africa and ending in Hobart, Australia from December 2016 to January 2017. The data collected focused on potential drivers of the nitrate plus nitrite isotope effect.

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Coverage

Spatial Extent: **N**:-46.0848 **E**:141.9254 **S**:-55.116 **W**:37.63233
Temporal Extent: 2016-12-26 - 2017-01-17

Methods & Sampling

Samples were collected during Leg 1 of the Antarctic Circumnavigation Expedition (ACE) research cruise onboard the R/V Akademik Treshnikov, which took place in the Indian Sector of the Southern Ocean from December 2016 to January 2017. Water column samples were collected by Niskin bottle on a CTD rosette. Surface samples were collected from the ship's underway intake (at ~5 meters depth). Nitrate and nitrite (NO3- + NO2-) d15N and d18O analyses were by the "denitrifier method" and followed the methods described by Sigman et al. (2001), Casciotti et al. (2002), McIlvin and Casciotti (2011), and Weigand et al. (2016). Briefly, NO3-+NO2- was quantitatively reduced to N2O by *Pseudomonas aureofaciens* and *Pseudomonas chlororaphis*, which was then cryogenically focused and analyzed on an isotope ratio mass spectrometer. A volume of sample was added to each bacterial vial to achieve a final quantity of 10 or 20 nanomoles (nmols) N2O, which was then purged from the vial using a helium carrier gas. The d15N and d18O of samples were calibrated with the international isotopic reference materials as described below.

The average precision of nitrate+nitrite d15N measurements was <0.2 per mil and for d18O was <0.3 per mil. NO3-+NO2- d15N and d18O analyses were calibrated with IAEA N3 and USGS 34 NO3- d15N isotopic reference materials as described in McIlvin and Casciotti (2011). NO3-+NO2- d18O was also calibrated with the USGS 35 isotopic reference material as described in McIlvin and Casciotti (2011).

Data Processing Description

BCO-DMO Processing:
- imported original file named "Thomas_ACE_NO3d15N_d18O_CTD_UDW.xlsx" into the BCO-DMO system;
- marked "no data" as a missing data value (missing data are blank/empty in the final csv file);
- renamed fields to comply with BCO-DMO naming conventions;
- converted Sampling_Date column to %Y-%m-%d format;
- added the ISO 8601 date-time column (UTC);
- named the final file "904358_v1_ace_leg1_no3_isotopes.csv".

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Data Files

File
904358_v1_ace_leg1_no3_isotopes.csv (Comma Separated Values (.csv), 17.84 KB) MD5:6ebc24a3681035e386e927485c10fb34 Primary data file for dataset ID 904358, version 1.

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Related Publications

Casciotti, K. L., Sigman, D. M., Hastings, M. G., Böhlke, J. K., & Hilkert, A. (2002). Measurement of the Oxygen Isotopic Composition of Nitrate in Seawater and Freshwater Using the Denitrifier Method. Analytical Chemistry, 74(19), 4905–4912. doi:10.1021/ac020113w
Methods

McIlvin, M. R., & Casciotti, K. L. (2011). Technical Updates to the Bacterial Method for Nitrate Isotopic Analyses. Analytical Chemistry, 83(5), 1850–1856. doi:10.1021/ac1028984
Methods

Sigman, D. M., Casciotti, K. L., Andreani, M., Barford, C., Galanter, M., & Böhlke, J. K. (2001). A Bacterial Method for the Nitrogen Isotopic Analysis of Nitrate in Seawater and Freshwater. Analytical Chemistry, 73(17), 4145–4153. doi:10.1021/ac010088e
Methods

Weigand, M. A., Foriel, J., Barnett, B., Oleynik, S., & Sigman, D. M. (2016). Updates to instrumentation and protocols for isotopic analysis of nitrate by the denitrifier method. Rapid Communications in Mass Spectrometry, 30(12), 1365–1383. doi:10.1002/rcm.7570
Methods

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Parameters

Parameter	Description	Units
CruiseID	Cruise identifier	unitless
Sampling_Date	Date on which the sample was collected	unitless
Time_UTC	Time (UTC) at which the sample was collected	unitless
ISO_DateTime_UTC	Date and time (UTC) of sample collection in ISO 8601 format	unitless
Latitude	Latitude at which the sample was collected; positive values = North	decimal degrees
Longitude	Longitude at which the sample was collected; positive values = East	decimal degrees
STN	Station number	unitless
Cast	Cast number	unitless
CastType	Type of cast: UDW (underway) or CTD	unitless
Depth	Depth at which the sample was collected	meters
PotentialDensity	Potential density of depth at which sample was collected	kilograms per cubic meter, with reference to sea surface (kg m-3)
NO3_NO2_d15N	Nitrogen isotopic composition of nitrate+nitrite in a sample	per mil vs. N2 in air
NO3_NO2_d18O_corrected	Oxygen isotopic composition of nitrate+nitrite in a sample	per mil vs. VSMOW

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Instruments

Dataset-specific Instrument Name	Thermo Delta V isotope ratio mass spectrometer
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Nitrate+nitrite d15N and d18O was measured using a Thermo Delta V isotope ratio mass spectrometer.
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

Dataset-specific Instrument Name	Niskin bottle on a CTD rosette
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.

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Deployments

ACE_Leg1

Website	https://www.bco-dmo.org/deployment/805465
Platform	R/V Akademik Tryoshnikov
Start Date	2016-12-20
End Date	2017-01-19
Description	ACE: Antarctic Circumnavigation Expedition. The 0-42°E section of the Antarctic Circumnavigation Expedition, Leg 1 (Cape Town to Hobart) and Leg 3 (Punta Arenas to Cape Town).

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Project Information

Collaborative Research: Quantifying the effects of variable light and iron on the nitrate assimilation isotope effect of phytoplankton (Nitrate Assimilation Phytoplankton)

Coverage: Southern Atlantic Ocean, Southern Ocean, laboratory experiments at FSU

NSF Award Abstract:
Phytoplankton are microscopic, single-celled organisms that play an important role in the Earth's ecosystems, elemental cycles, and climate. These organisms, which live in surface ocean waters, require sunlight and nutrients to grow and reproduce. In the oceans around Antarctica, nitrate (NO3-) as a nutrient source of nitrogen (N) is usually abundant while the nutrient iron is often sparse. Light availability also changes from complete darkness to 24 hours of constant sunlight, as well as from low light deeper in the water column to high, stressful light at the ocean surface. As a consequence, the phytoplankton in the Southern Ocean often live in a suboptimal environment in which conditions for growth are frequently changing. Scientists understand that nutrient supply and light availability affect these organisms and that these organisms, in turn, can alter the chemical composition of the seawater. For example, nitrate can occur in different forms, including a lighter (14N) and heavier (15N) form of NO3-, depending on which stable isotope of N is present in the molecule. Phytoplankton prefer to use the lighter isotope during uptake and incorporation into biomass, though the ratio of 15N/14N used by phytoplankton has been shown to vary depending on environmental conditions. Notably, the isotope ratio used by phytoplankton is recorded in sediments and can be used to determine both the historic composition of ocean waters and the productivity of phytoplankton. This project will test the hypothesis that enhanced light and/or iron stress change the isotopic ratios of water column nitrate- in specific ways. A combination of laboratory culture and field experiments will be conducted. Cultures of important Southern Ocean phytoplankton species will be grown under environmentally-relevant light and iron conditions

where ratio of 15N/14N used by phytoplankton, physiological changes, and molecular markers of iron and light stress and nitrate assimilation will be measured. Similar measurements will be done in shipboard experiments on a cruise in the Southern Ocean with South African colleagues. These data will increase our understanding of past and present productivity in the Southern Ocean, and how phytoplankton changed the chemical composition of the seawater. Undergraduates from underrepresented groups in the STEM field and graduate students from Florida State University and Old Dominion University as well as students from South Africa will collaborate on this project. The improved process understanding of the N isotope effect will be presented not only at scientific national and international conferences but also during local outreach events at local K12 schools.

Interpretation of both modern water column nitrate (NO3-) isotopic ratio (d15N) measurements generated by GEOTRACES and other cruises, as well as metrics of paleo-nutrient utilization, depend upon a mechanistic understanding of the degree to which NO3- assimilation by phytoplankton discriminates against the heavier isotope, 15NO3- (NO3- assimilation epsilon). We currently lack the ability to predict how iron and light stress impacts the NO3- assimilation epsilon. The proposed work will test the hypothesis that enhanced light and/or iron stress elevates the epsilon for NO3-assimilation. This hypothesis will be tested by a combination of laboratory culture work and field work on a cruise of opportunity in the Southern Ocean. Mesocosm experiments will include both increasing and alleviating light and/or iron stress on monoclonal phytoplankton cultures and in natural phytoplankton communities while measuring the response of the NO3- assimilation epsilon. Water column samples will be collected on the cruise for analysis of dissolved and size-fractionated particulate N concentration and d15N, as well as phytoplankton community composition, photophysiology and gene expression markers of iron and light stress and NO3- assimilation. In particular, the expression of iron and light stress markers will be used to evaluate the relative contribution of iron and light stress to field-based estimates of the NO3-- assimilation epsilon. The results from these field measurements, together with lab-based culture studies, will be used to constrain the range of the epsilon for NO3- assimilation under environmentally-relevant light and iron conditions, including the potential alleviation of iron stress as has been hypothesized to have occurred during the last glacial maximum (a.k.a. the Martin hypothesis).

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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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1851113

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