Nitrate + nitrite isotope measurements from surface and water-column profiles in the Atlantic Sector of the Southern Ocean during the SCALE 2019 cruise aboard the S.A. Agulhas II from Oct 2019 to Nov 2019

Website: https://www.bco-dmo.org/dataset/986716
Data Type: Cruise Results
Version: 1
Version Date: 2025-11-26

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 + nitrite (NO_3^- + NO_2^-) isotopic compositions ($\delta^{15}N$ and $\delta^{18}O$) from Southern oCean Seasonal Experiment (SCALE) research cruise onboard the S.A. Agulhas II. This cruise sampled surface and water-column profiles of the late spring/early summer Atlantic Sector of the Southern Ocean, starting and ending in Cape Town, South Africa along the Good Hope line to the ice edge, from October 2019 to November 2019. These data focused on potential drivers of the nitrate plus nitrite isotope effect.

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Coverage

Location: Atlantic sector of the Southern Ocean
Spatial Extent: **N**:-55.991433333333 **E**:23.99466667 **S**:-59.4725 **W**:-0.184333333
Temporal Extent: 2019-10-14 - 2019-11-18

Methods & Sampling

Surface and water-column profiles were sampled aboard S/A Agulhas II in the late spring/early summer Atlantic Sector of the Southern Ocean, starting and ending in Cape Town, South Africa along the Good Hope line to the ice edge, from October 2019 to November 2019. Water column samples were collected by Niskin bottle on a CTD rosette ("CTD profile").

NO3-+NO2- d15N and d18O

The isotopic composition of NO3-+NO2- was determined 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*, 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 nmols N2O, which was then purged from the vial using a helium carrier gas. The d15N and d18O of samples was calibrated with the international isotopic reference materials as described above.

BCO-DMO Processing Description

- Imported "Knapp_SCALE19_NO3NO2d15N_d18O.xlsx" into the BCO-DMO system
- Created local, "ISO_DateTime_Local", and UTC, "ISO_DateTime_UTC" date times in ISO 8601 format using information in the "SamplingDate" and "SamplingTime" parameters
- Removed "SamplingDate" and "SamplingTime"
- Removed spaces and special characters from parameter names in keeping with BCO-DMO guidelines
- Added new field "CastType" to describe whether the sample was collected via CTD or Surface collection
- Exported file as "986716_v1_scale19_no3no2d15n_d18o.csv"

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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	Sampling cruise	unitless
ISO_DateTime_Local	Local datetime on the ship when the sample was collected, UTC+02:00	unitless
ISO_DateTime_UTC	UTC datetime on the ship when the sample was collected	unitless
Latitude	Position when sample was collected in decimal degrees; a positive value indicates a Northern coordinate	decimal degrees
Longitude	Position when sample was collected in decimal degrees; a positive value indicates a Eastern coordinate	decimal degrees
Station	Station number	unitless
CastType	Method of water collection (Surface or CTD)	unitless
CastID	Cast number	unitless
Depth	Sample collection depth below sea surface	meters (m)
NO3_NO2_d15N	The nitrogen isotopic value of the nitrate+nitrite in the sample	per mil vs. N2 in air
NO3_NO2_d18O	The oxygen isotopic value of the nitrate+nitrite in the sample	per mil vs. Vienna Standard Mean Ocean Water (VSMOW)

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Instruments

Dataset-specific Instrument Name	CTD rosette
Generic Instrument Name	CTD Sea-Bird SBE 911plus
Dataset-specific Description	Water column samples were collected by Niskin bottle on a CTD rosette (“CTD profile”).
Generic Instrument Description	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

Dataset-specific Instrument Name	Thermo Delta V isotope ratio mass spectrometer
Generic Instrument Name	Thermo Fisher Scientific DELTA V Advantage isotope ratio mass spectrometer
Dataset-specific Description	Nitrate+nitrite d15N and d18O: Thermo Delta V isotope ratio mass spectrometer
Generic Instrument Description	The Thermo Scientific DELTA V Advantage is an isotope ratio mass spectrometer designed to measure isotopic, elemental, and molecular ratios of organic and inorganic compounds. The DELTA V Advantage is the standard model of the DELTA V series of isotope ratio mass spectrometers, which can be upgraded to the DELTA V Plus. The DELTA V Advantage can be operated in Continuous Flow or Dual Inlet mode. The standard collector configuration is the Universal Triple Collector. H2 collectors with online hydrogen capability are optional. The DELTA V Advantage is controlled by an automated, integrated Isodat software suite. A magnet, whose pole faces determine the free flight space for the ions, eliminates the traditional flight tube. The magnet is designed for fast mass switching which is further supported by a fast jump control between consecutive measurements of multiple gases within one run. The sample gas is introduced at ground potential, eliminating the need for insulation of the flow path, ensuring 100 percent transfer into the ion source. The amplifiers register ion beams up to 50 V. The DELTA V Advantage has a sensitivity of 1200 molecules per ion (M/I) in Dual Inlet mode and 1500 M/I in Continuous Flow mode. It has a system stability of < 10 ppm and an effective magnetic detection radius of 191 nm. It has a mass range of 1 - 80 Dalton at 3 kV.

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Deployments

VOY040

Website	https://www.bco-dmo.org/deployment/989728
Platform	R/V S.A. Agulhas II
Report	https://www.sanap.ac.za/current-event-scale-winter-cruise-2019
Start Date	2019-10-12
End Date	2019-11-20
Description	This cruise sampled surface and water-column profiles of the late spring/early summer Atlantic Sector of the Southern Ocean, starting and ending in Cape Town, South Africa along the Good Hope line to the ice edge, from October 2019 to November 2019. https://www.sanap.ac.za/current-event-scale-winter-cruise-2019 https://www.bodc.ac.uk/resources/inventories/cruise_inventory/reports/ag...

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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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