Ammonium (NH4) and Nitrite (NO2) concentrations from R/V Roger Revelle cruise RR2311 in the Eastern Tropical South Pacific from November to December 2023

Website: https://www.bco-dmo.org/dataset/931516
Data Type: Cruise Results
Version: 1
Version Date: 2024-07-31

Project
» Nitrite Oxidation in Oxygen Minimum Zones (NO2Ox_OMZs)

Contributors	Affiliation	Role
Ward, Bess B.	Princeton University	Principal Investigator
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Abstract
Water samples were collected as part of a 32-day cruise in the Eastern Tropical South Pacific, aiming to study nitrification in this oxygen minimum region of the ocean. In the Event Log for RR2311, transect stations are designated "T" and process stations are designated "PS". Nutrients were collected on the first cast upon arrival at a process station, and in one case on the last day, of a 2-5 day station occupation. Ammonium concentrations were initially planned to be measured in high-resolution depth profiles at each major process and transect station. However, due to the exceedingly low concentrations detected by the shipboard method, only the data from the first process station were included, with remaining samples frozen for later analysis ashore. Ammonium concentration was measured manually using fluorometric methods (Holmes et al. 1999), with water collected using Niskin bottles. Five ml volumes were analyzed immediately upon retrieval without filtration. High-resolution profiles were also obtained for nitrite measurements at both process and transect stations. Nitrite concentration was determined manually using colorimetric methods (Hansen and Koroleff 1999) on duplicate samples, measured immediately after collection without filtration.

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Coverage

Location: Eastern Tropical South Pacific, off the coast of Chile and Peru
Spatial Extent: **N**:-13.99992 **E**:-71.10026 **S**:-22.90058 **W**:-81.0005
Temporal Extent: 2023-11-18 - 2023-12-20

Methods & Sampling

Water Sample Collection

Water samples for both NO2 and NH4 analyses were collected using a 24 x 10-liter Niskin bottle rosette sampler equipped with a conductivity, temperature, and pressure instrument package (SBE9, Sea-Bird Electronics, Bellevue, Washington, U.S.A.). The sampler was also equipped with sensors for dissolved oxygen (SBE43, Sea-Bird) and chlorophyll fluorescence (FluoroSeatechWetlabsFLF Sensor). NH4 and NO2 were measured on board immediately after sample collection.

NO2 Analysis

Nitrite concentration was measured manually colorimetrically using standard methods (Hansen and Koroleff, 1999).

NH4 Analysis

Duplicate samples for ammonium concentration were measured immediately upon retrieval and were not filtered prior to analysis. Ammonium concentration was measured manually fluorometrically using standard methods (Holmes et al. 1999).

Data Processing Description

Measurements were compiled in Excel with CTD collection metadata.

BCO-DMO Processing Description

- Imported submitter files "RR2311_ETSP_2023_NO2andNH4data.xlsx", "rr2311_nh4_no2_check depths_corrected.xlsx", and "924943_v1_rr2311_bottle.csv" into the BCO-DMO system.
- Joined tables to include relevant CTD metadata, including collection time in UTC and location information in decimal degrees.
- Joined tables to include corrected target depths.
- Changed local date format from m-d-y to yyyy-mm-dd (ISO Date 8601 format).
- Renamed fields to comply with BCO-DMO naming conventions.
- Saved the final file as "931516_v1_rr2311_no2_nh4.csv".

Problem Description

Ammonium concentrations were very low. Many of the measurements were even lower than our MilliQ water blank. Thus many of the values appear as negative in the dataset. They can be interpreted as effectively zero, i.e., indistinguishable from zero within the sensitivity of our assay.

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Data Files

File	
931516_v1_rr2311_no2_nh4.csv	(Comma Separated Values (.csv), 31.46 KB) MD5:cefa12a6c84c368adbbff86689a9f866
Primary data file for dataset ID 931516, version 1	

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Related Publications

Hansen, H. P., & Koroleff, F. (1999). Determination of nutrients. Methods of Seawater Analysis, 159–228. Portico. https://doi.org/10.1002/9783527613984.ch10

Methods

Holmes, R. M., Aminot, A., Kérouel, R., Hooker, B. A., & Peterson, B. J. (1999). A simple and precise method for measuring ammonium in marine and freshwater ecosystems. Canadian Journal of Fisheries and Aquatic Sciences, 56(10), 1801–1808. doi:10.1139/f99-128
Methods

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Related Datasets

IsRelatedTo

Ward, B. B. (2024) **Event log of all over the side deployments on R/V Roger Revelle cruise RR2311 in the Eastern Tropical South Pacific from November to December 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-05-17 doi:10.26008/1912/bco-dmo.925001.1 [view at BCO-DMO]
Relationship Description: Time information and environmental conditions related to stations referenced in RR2311 NH4 and NO2 are available in RR2311 Event Log.

HasPart

Ward, B. B. (2024) **RR2311 bottle data from R/V Roger Revelle cruise RR2311 in the Eastern Tropical South Pacific from November to December 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-04-15 doi:10.26008/1912/bco-dmo.924943.1 [view at BCO-DMO]
Relationship Description: CTD time and depth for each water sample is derived from the RR2311 Bottle Data.

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Parameters

Parameter	Description	Units
CTD_ISO_DateTime_UTC	Date and time (UTC) of the cast/event in ISO 8601 format (source: CTD)	unitless
Date_Local	Local date of cast/event in UTC-3	unitless
CTD_Latitude	Latitude, N is positive (source: Ship)	decimal degrees
Lat_Deg	Latitude degrees, N is positive	degrees
Lat_Min	Latitude minutes	minutes
CTD_Longitude	Longitude, E is positive (source: Ship)	decimal degrees
Long_Deg	Longitude degrees, E is positive	degrees
Long_Min	Longitude minutes	minutes
Station	Station identifier, project-specific, PS = Process stations, T = Transect station	unitless
Cast_Number	CTD cast number	unitless
Niskin_Bottle	Niskin bottle number	unitless
CTD_Depth	Depth (source: CTD)	meters (m)
Target_Depth	Target depth of sample collection	meters (m)
Nitrite	Nitrite (NO2) concentration in µM	micromolar (uM)
NH4	Ammonium (NH4) concentration in µM	micromolar (uM)

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Instruments

Dataset-specific Instrument Name	SBE9 Sea-Bird Electronics
Generic Instrument Name	CTD Sea-Bird SBE 911plus
Dataset-specific Description	Water samples were collected using a 24 x 10-liter Niskin bottle rosette sampler equipped with a conductivity, temperature, and pressure instrument package (SBE9, Sea-Bird Electronics, Bellevue, Washington, U.S.A.), a sensor for dissolved oxygen (SBE43, Sea-Bird), and a sensor for chlorophyll fluorescence (FluoroSeatechWetlabsFLF_Sensor).
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	FluoroSeatechWetlabsFLF_Sensor
Generic Instrument Name	CTD-fluorometer
Dataset-specific Description	Water samples were collected using a 24 x 10-liter Niskin bottle rosette sampler equipped with a conductivity, temperature, and pressure instrument package (SBE9, Sea-Bird Electronics, Bellevue, Washington, U.S.A.), a sensor for dissolved oxygen (SBE43, Sea-Bird), and a sensor for chlorophyll fluorescence (FluoroSeatechWetlabsFLF_Sensor).
Generic Instrument Description	A CTD-fluorometer is an instrument package designed to measure hydrographic information (pressure, temperature and conductivity) and chlorophyll fluorescence.

Dataset-specific Instrument Name	10-liter Niskin bottle
Generic Instrument Name	Niskin bottle
Dataset-specific Description	10-liter 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	SBE43, Sea-Bird
Generic Instrument Name	Sea-Bird SBE 43 Dissolved Oxygen Sensor
Dataset-specific Description	Water samples were collected using a 24 x 10-liter Niskin bottle rosette sampler equipped with a conductivity, temperature, and pressure instrument package (SBE9, Sea-Bird Electronics, Bellevue, Washington, U.S.A.), a sensor for dissolved oxygen (SBE43, Sea-Bird), and a sensor for chlorophyll fluorescence (FluoroSeatechWetlabsFLF_Sensor).
Generic Instrument Description	The Sea-Bird SBE 43 dissolved oxygen sensor is a redesign of the Clark polarographic membrane type of dissolved oxygen sensors. more information from Sea-Bird Electronics

Dataset-specific Instrument Name	GENESYS 150 UV-VIS Spectrophotometer
Generic Instrument Name	Spectrophotometer
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.

Dataset-specific Instrument Name	Turner Designs fluorometer Model: 7200-000
Generic Instrument Name	Turner Designs Trilogy fluorometer
Dataset-specific Description	Fluorescence was measured on a Turner Designs fluorometer Model: 7200-000 using a 1 cm cell.
Generic Instrument Description	The Trilogy Laboratory Fluorometer is a compact laboratory instrument for making fluorescence, absorbance, and turbidity measurements using the appropriate snap-in application module. Fluorescence modules are available for discrete sample measurements of various fluorescent materials including chlorophyll (in vivo and extracted), rhodamine, fluorescein, cyanobacteria pigments, ammonium, CDOM, optical brighteners, and other fluorescent compounds.

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Deployments

RR2311

Website	https://www.bco-dmo.org/deployment/924949
Platform	R/V Roger Revelle
Start Date	2023-11-18
End Date	2023-12-20
Description	See additional cruise information at R2R: https://www.rvdata.us/search/cruise/RR2311

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Project Information

Nitrite Oxidation in Oxygen Minimum Zones (NO2Ox_OMZs)

Coverage: Eastern Tropical South Pacific and Chesapeake Bay

NSF Award Abstract:
This research is grounded in the fundamental role of nitrogen in limiting production in the ocean. Nitrite is a pivotal compound in the nitrogen cycle: it can be oxidized to nitrate, and thus retained as an available nutrient, or it can be reduced to dinitrogen gas, and thus lost from the bioavailable nitrogen pool. Oxidation of nitrite by nitrite oxidizing bacteria (NOB) is the only biological pathway by which nitrate is produced, and all known NOB require oxygen for life. The reduction pathway is also carried out by microbes, in this case, bacteria that thrive only in the absence of oxygen. In previous experiments, however, both oxidation and reduction of nitrite were detected in the same samples from ocean waters in the absence of oxygen. We will investigate three explanations for the apparent oxidation of nitrite in the absence of oxygen on a research cruise to the low oxygen waters off the coast of Peru: 1) The presence of unknown kinds of NOB that do not require oxygen; 2) a new reaction called dismutation, which is possible but never detected in nature; 3) an artifact associated with oxygen stress in NOB. This research could lead to discovery of novel mechanisms and or novel organisms that determine the fate of nitrite and the availability of nitrogen to support primary production in the long run. This project will advance discovery and understanding while promoting teaching, training and learning by providing opportunities for Princeton students to get involved in and have hands on experience in research in the lab and potentially at sea. Both undergraduate and graduate students will participate in the research through internships and field experiences. We will also integrate our work at sea into teaching in the classroom via videos and assignments based on data collected during the cruise.

Nitrite oxidation is the only known biological process that produces nitrate, which comprises the largest fixed nitrogen reservoir in the ocean. Nitrite oxidation is carried out by nitrite oxidizing bacteria (NOB), and all known species are obligate aerobes. Nitrite reduction to N2 occurs in multiple microbial pathways, generally under anoxic conditions. Despite their apparent incompatibility regarding oxygen, both processes are detected in the low oxygen or anoxic waters of oxygen minimum zones (OMZs). Thus, the fate of nitrite in OMZs has implications for the global fixed N budget. Nitrite oxidation is detected at high rates in essentially zero oxygen water in the most oxygen depleted depth intervals in OMZ regions, which suggests that some nitrite oxidizers might possess anaerobic metabolic capabilities. Nitrite disproportionation (or dismutation), in which nitrite is simultaneously oxidized to nitrate and reduced to N2, is a thermodynamically favorable reaction, which would link the two processes in one organism – but it has never been observed in nature. The research proposed here will address two big questions about nitrite in the ocean: 1) How does anaerobic nitrite oxidation work? 2) What determines the fate of nitrite? The experimental approach will investigate three possible explanations for anaerobic nitrite oxidation: 1) Nitrite is oxidized to nitrate by different clades of NOB, which exhibit different tolerances/requirements for oxygen; 2) Nitrite dismutation, also performed by NOB, partially explains the cooccurrence of oxidation and reduction of nitrite; 3) Apparently anaerobic nitrite oxidation is indeed biologically mediated but does not always represent net production of nitrate from nitrite; rather it results from isotopic equilibration during enzyme-catalyzed interconversion of nitrite and nitrate. These questions will be addressed by performing a suite of 15N-tracer incubations at stations located within and outside of one of the major OMZs in the ocean, the Eastern Tropical South Pacific. The dependence of the rate processes on oxygen concentrations will be determined, and the composition of the microbial assemblages will be assessed in order to determine whether different microbial components are involved under different environmental conditions. The expression of genes involved in oxidation/reduction/ respiratory metabolisms at low oxygen concentrations will be measured across oxygen gradients and in oxygen manipulations to identify their potential role in supporting “anaerobic” nitrite oxidation. The possibility that the apparently anaerobic nitrite oxidation is due to an enzyme level interconversion between nitrite and nitrate, which does not lead to net nitrate production and is not linked to growth of nitrite oxidizing bacteria, will also be investigated.

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-1946516

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