Nitrite, ammonium, nitrate, and nitrous oxide 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/1005453
Data Type: Cruise Results
Version: 1
Version Date: 2026-08-18

Project
» Nitrite Oxidation in Oxygen Minimum Zones (NO2Ox_OMZs)

Contributors	Affiliation	Role
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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. Nitrite, ammonium, nitrate, and nitrous oxide concentrations were measured. High-resolution profiles were obtained at 5 process and 2 transect stations. Nitrous oxide samples 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.

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Coverage

Location: Eastern Tropical South Pacific
Spatial Extent: **N**:-14 **E**:-70.2508 **S**:-21.4003 **W**:-81
Temporal Extent: 2023-11-21 - 2023-12-18

Methods & Sampling

Collection

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. High-resolution profiles were obtained at 5 process and 2 transect stations. In the Event Log for RR2311 (see Related Dataset section), transect stations are designated "T" and process stations are designated "PS". Nitrous oxide samples 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.

Samples were collected in duplicate into 60-ml serum vials, preserved with HgCl2 and stored until analysis on the Delta V mass spectrometer (Frey et al. 2024).

Analysis

Duplicate samples for measurements of *in situ* N_2O concentration were collected from Niskin bottles into 60 mL serum bottles after overflowing three times the bottle's volume. Samples were then immediately preserved with 100 µL saturated $HgCl_2$. N_2O concentrations were measured on an isotope ratio mass spectrometer (Delta V) based on the major ion (m/z = 44) peak area compared to the reference N_2O gas (Frey et al. 2024).

BCO-DMO Processing Description

- Loaded data from the "NO2+NH4" sheet of Copy of RR2311_ETSP_2023_NO2NH4NO3N2O.xlsx, using row 4 as the header row; rows 1-3 (title lines and a blank row) were automatically discarded since they preceded the header row; empty string, "nd", and "N/A" were set as missing value sentinels; preserved cell formatting and adjusted for floating point error
- Renamed columns to BCO-DMO naming convention: "Date (local)" to Date_local, "Depth (m)" to Depth, "Nitrite (uM)" to Nitrite, "NH4 (µM)" to NH4, "NO3 (µM)" to NO3, "N2O (nM)" to N2O, "Lat N (deg)" to lat_deg, "Lat N (min)" to lat_min, "Long W (deg)" to lon_deg, "Long W (min)" to lon_min
- Computed a new latitude column in decimal degrees from lat_deg and lat_min, subtracting the minutes fraction when lat_deg was negative and adding it otherwise (to preserve sign)
- Computed a new longitude column in decimal degrees from lon_deg and lon_min, subtracting the minutes fraction when lon_deg was negative and adding it otherwise (to preserve sign)
- Rounded latitude and longitude columns to 4 decimal places, preserving trailing zeros
- Converted Date_local (parsed as %m-%d-%y) into ISO 8601 date format (%Y-%m-%d), overwriting the Date_local column with a date-typed output
- Deleted columns lat_deg, lat_min, lon_deg, lon_min
- Reordered columns to: Station, Date_local, latitude, longitude, Cast, Niskin, Depth, Nitrite, NH4, NO3, N2O, Notes
- Output as 1005453_v1_no2_nh4_no3_n2o.csv

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Related Publications

Frey, C., Tang, W., Ward, B. B., & Lehmann, M. F. (2024). Sample preservation methods for nitrous oxide concentration and isotope ratio measurements in aquatic environments. Limnology and Oceanography: Methods, 22(10), 771–788. Portico. https://doi.org/10.1002/lom3.10638
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: Event log from this cruise identifying station metadata. Referenced in methods.

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Parameters

Parameter	Description	Units
Station	Station Identifier	unitless
Date_local	date (UTC - 4 hr)	unitless
latitude	Latitude of cast; S is negative (Source:Ship)	decimal degrees
longitude	Longitude of cast; W is negative (Source:Ship)	decimal degrees
Cast	CTD Cast Number	unitless
Niskin	Niskin Bottle Number	unitless
Depth	depth (Source:CTD)	meters (m)
Nitrite	dissolved nitrite	micromoles per liter (µmol/L)
NH4	dissolved ammonium	micromoles per liter (µmol/L)
NO3	dissolved nitrate	micromoles per liter (µmol/L)
N2O	dissolved nitrous oxide	nanomoles per liter (nmol/L)
Notes	notes for missing samples	unitless

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Instruments

Dataset-specific Instrument Name	Seabird SBE-911+
Generic Instrument Name	CTD Sea-Bird SBE 911plus
Dataset-specific Description	Water at different depths was collected from a rosette system equipped with twelve 30-L Niskin bottles and with a CTD profiler (Seabird SBE-911+)
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	Delta V
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	N2O concentrations were measured on an isotope ratio mass spectrometer (Delta V) based on the major ion (m/z = 44) peak area compared to the reference N2O gas.
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	30-L Niskin bottles
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Water at different depths was collected from a rosette system equipped with twelve 30-L Niskin bottles and with a CTD profiler (Seabird SBE-911+)
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

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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