Ammonia oxidation, nitrite oxidation, and nitrate reduction rates from R/V Atlantis (AT15-61) cruise in Jan-Feb 2010 and R/V Melville (MV1104) cruise in Mar-Apr 2011 in the Eastern Tropical South Pacific

Website: https://www.bco-dmo.org/dataset/826782
Data Type: experimental, Cruise Results
Version: 1
Version Date: 2020-10-14

Project
» Expression of Microbial Nitrification in the Stable Isotopic Systematics of Oceanic Nitrite and Nitrate (Microbial Nitrification)

Contributors	Affiliation	Role
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Abstract
Ammonia oxidation, nitrite oxidation, and nitrate reduction rates from cruises R/V Atlantis (AT15-61) in Jan-Feb 2010 and R/V Melville (MV1104) in Mar-Apr 2011 in the Eastern Tropical South Pacific

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Coverage

Spatial Extent: **N**:-9.943 **E**:-80 **S**:-20.01 **W**:-100
Temporal Extent: 2010-02-02 - 2011-04-20

Methods & Sampling

Seawater samples were collected on R/V Atlantis (AT15-61) cruise in Jan-Feb 2010 and on R/V Melville (MV1104) cruise in Mar-Apr 2011. Water samples were collected at discrete depths using Niskin bottle type rosette samplers equipped with either 24 bottles (10L), or 12 bottles (20L), and an SBE9plus conductivity-temperature-depth (CTD) sensor package (SeaBird Electronics, Bellevue, WA). Water for rate incubations was collected into 160 mL glass serum bottles (AT15-61) or 500 mL Tedlar sampling bags (MV1104). See below in Processing Description for further details.

Ammonia and nitrite oxidation rates were determined using 15N tracer additions. Full methods can be found in the manuscript Santoro et al. (submitted). As described below, incubation methods varied slightly between the first and second cruises.

In Year 1 (2010), rates were determined at four depths at all six stations. Incubations were conducted in 160 mL glass serum vials. Six serum bottles were filled and sealed from each incubation depth, spiked with 15N tracer (100-200 nM 15NH4Cl or Na15NO2-), and incubated in flowing seawater incubators screened to mimic the *in situ* light environment (euphotic zone samples) or temperature controlled chambers (sub-euphotic zone). Duplicate bottles were sacrificed at timepoints of 0, 12, and 24 h from each incubation depth, 0.2 µm syringe-filtered into a 60 mL HDPE bottle, and frozen at -20ºC.

In Year 2 (2011), rates were determined at six depths at five stations. No rates were determined at Stn 5 in Year 2. Incubations were conducted in 500 mL Tedlar bags. Duplicate incubation bags per treatment were filled from the Niskin bottles using silicone tubing, and 15N tracer (200 nM 15NH4Cl or Na15NO2) was added via the septum injection port. As in the previous year, bags were incubated at as close to *in situ* light and temperature as possible. At timepoints of 0, 12, 24, and 36 h, 50 mL samples were drawn from each bag through the three-way sampling port using a 60 mL syringe. At each timepoint, incubation water was 0.2 µm syringe filtered into a 60 mL HDPE bottle tripled rinsed with sample, and frozen at -20ºC.

Frozen samples were transported frozen to the laboratory, thawed, and prepared for 15NNO2+NO3 analysis using the 'denitrifier method' (Sigman *et al.*, 2001). For nitrite oxidation rate samples, the added 15NO2- tracer was removed using sulfamic acid addition and subsequent neutralization with NaOH (Granger *et al.*, 2006) prior to sample preparation and analysis. For 2010 samples, where only three timepoints were taken, rates were calculated using the linear fitting method of Dugdale and Goering (Dugdale and Goering, 1967). For 2011, where four timepoints were taken, rates were calculated using a least squares fitting approach that accounts for changes in 15NNO2+NO3 from co-occurring nitrate uptake (Santoro *et al.*, 2010 and attached analysis files).

Nitrate reduction rates to nitrite were determined in Year 2 using 15NO3- tracer additions (>98 atm% Na15NO3). 15NO3- incubations were only conducted in the euphotic zone (three depths). Tedlar incubation bags were prepared and filled as above, and 200 or 400 nM (final concentration) of Na15NO3 was added to each bag using a plastic syringe. Timepoints were sampled and preserved as for the nitrification rate incubations above. In the laboratory, samples were prepared for 15NNO2 determination using the 'azide method' (McIlvin and Altabet, 2005). Following azide conversion to N2O, samples and standards (N23, N7373, and N10219; (Casciotti *et al.*, 2007) were analyzed by IRMS and rates were calculated as described above.

Light inhibition experiments were conducted in Year 2 to test the effect of sunlight on ammonia oxidation, nitrite oxidation, and nitrate reduction. These incubations were conducted at the two shallowest incubation depths, approximating the 1% and 10% light depths at Stations 7, 9, and 11. For these experiments, one set of duplicate incubation bottles for each rate type was incubated at ambient light (bottles 1 and 2 in the data file) and the other in the dark (bottles 3 and 4 in the data file). Tracer addition, subsampling, analysis, and rate calculations were as described above.

Data Processing Description

MATLAB processing:
The MATLAB script 'etsp_rates_2011_indvT0.m' loads two types of files: initial conditions ('initials...') and isotope data ('data...'). Compiled rates were deposited in a tab-delimited text file. For more information, see Supplemental Files section.

Parameters for Initial Conditions file(s) called "initials"

- AP15N = Starting atom percent of 15N in the substrate pool; [15N/(15N+14N)], expressed as a fraction (e.g. 99atm% is 0.99)
- Init_conc_No_15 = Initial concentration of 15N (micromoles) in the product pool
- Init_conc_No_14 = Initial concentration of 14N (micromoles) in the product pool

Parameters for the Isotope Data file(s) called "data":

- bottle = bottle (either replicate or treatement)
- time = time duration in hours
- 15R = ratio of 15N to 14N in nitrate

BCO-DMO processing:
- Added a conventional header with dataset name, PI name, version date
- Adjusted parameter names to comply with database requirements.

- Combined year, month, day fields into one date field.
- Units removed and added to Parameter Description metadata section.
- Default missing identifier of 'NaN' replaced with 'nd' ('nd' is BCO-DMO system default missing data identifier), but BDL (below detection limit) was preserved.

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Data Files

File
TableS2_ETSP_15N_rates.csv (Comma Separated Values (.csv), 8.13 KB) MD5:cd44f916bd80e224737e8a8529738fa5 Primary data file for dataset ID 826782

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Supplemental Files

File
etsp_rates_2011_indvT0.m (MATLAB Programming Script (.m), 4.01 KB) MD5:429d25c9444bc3bf1b7b0bef8cb5a1db MATLAB script calculates the nitrification rates for six stations in the Eastern Tropical South Pacific in 2011. Calls the function 'nitr_rate_rev.m' and requires the optimization toolbox to use lsqcurvefit.m
initial_conditions_files.zip (ZIP Archive (ZIP), 40.95 KB) MD5:ba02f9983cf4d72be399458094fbbcaf Contains 24 files of initial conditions that are used with this dataset's Supplemental Files (listed below) to calculate rates of ammonia oxidation, nitrite oxidation, and nitrate reduction: • MATLAB script 'etsp_rates_2011_indvT0.m' • MATLAB function 'nitr_rate_rev.m' • raw_data_files named by station, nitrogen compound, and incubation conditions To be compatible with the script, the data files do not have headers. The columns are: 1. depth (in meters) 2. AP15N (starting atom percent of 15N in the substrate pool expressed as a fraction) 3. No_15 (initial concentration of 15N (uM) in the product pool) 4. No_14 (initial concentration of 14N (uM) in the product pool)
nitr_rate_rev.m (MATLAB Programming Script (.m), 1.08 KB) MD5:6a581e82b432110ec638492769442107 MATLAB function defining the change in 15R (15N/14N ratio) over time, used to calculate rates of 15N-labeled substrate production (NO2- or NO3-) in micromoles (uM) per hour given a time series of 15R-NO2- or 15R-NO3-.

File
raw_data_files.zip (ZIP Archive (ZIP), 9.31 KB) MD5:90094f1ecc7eec683b9b652a7494abd9 Contains 22 raw data files that are used with this dataset's Supplemental Files (listed below) to calculate rates of ammonia oxidation, nitrite oxidation, and nitrate reduction: • MATLAB script 'etsp_rates_2011_indvT0.m' • MATLAB function 'nitr_rate_rev.m') • initial conditions files named by station and nitrogen compound To be compatible with the script, the data files do not have headers. The columns are: 1. depth (in meters) 2. bottle (replicate and/or treatment) 3. time (duration in hours) 4. 15R-product pool where 15R is 15N/14N ratio in NO2 or NO3

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Related Publications

Casciotti, K. L., Böhlke, J. K., McIlvin, M. R., Mroczkowski, S. J., & Hannon, J. E. (2007). Oxygen Isotopes in Nitrite: Analysis, Calibration, and Equilibration. Analytical Chemistry, 79(6), 2427–2436. doi:10.1021/ac061598h
Methods

Dugdale, R. C., & Goering, J. J. (1967). UPTAKE OF NEW AND REGENERATED FORMS OF NITROGEN IN PRIMARY PRODUCTIVITY1. Limnology and Oceanography, 12(2), 196–206. doi:10.4319/lo.1967.12.2.0196
Methods

Granger, J., Sigman, D. M., Prokopenko, M. G., Lehmann, M. F., & Tortell, P. D. (2006). A method for nitrite removal in nitrate N and O isotope analyses. Limnology and Oceanography: Methods, 4(7), 205–212. doi:10.4319/lom.2006.4.205
Methods

McIlvin, M. R., & Altabet, M. A. (2005). Chemical Conversion of Nitrate and Nitrite to Nitrous Oxide for Nitrogen and Oxygen Isotopic Analysis in Freshwater and Seawater. Analytical Chemistry, 77(17), 5589–5595. doi:10.1021/ac050528s
Methods

Santoro, A. E., Buchwald, C., Knapp, A. N., Berelson, W. M., Capone, D. G., & Casciotti, K. L. (2020). Nitrification and nitrous oxide production in the offshore waters of the Eastern Tropical South Pacific. doi:10.1002/essoar.10503499.1
Results
,
Methods

Santoro, A. E., Buchwald, C., Knapp, A. N., Berelson, W. M., Capone, D. G., & Casciotti, K. L. (2021). Nitrification and Nitrous Oxide Production in the Offshore Waters of the Eastern Tropical South Pacific. Global Biogeochemical Cycles, 35(2). Portico. https://doi.org/10.1029/2020gb006716
https://doi.org/10.1029/2020GB006716
Results

Santoro, A. E., Casciotti, K. L., & Francis, C. A. (2010). Activity, abundance and diversity of nitrifying archaea and bacteria in the central California Current. Environmental Microbiology, 12(7), 1989–2006. doi:10.1111/j.1462-2920.2010.02205.x
Related Research

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

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Parameters

Parameter	Description	Units
ISO_Date_Local	Date of sampling in ISO format (yyyy-mm-dd), Time zone in 2010 was GMT-5, Time zone in 2011 was GMT-4	yyyy-mm-dd
Latitude	Latitude, South is negative	decimal degrees
Longitude	Longitude, West is negative	decimal degrees
Station	Station number	unitless
Cast	Cast number	unitless
Depth	Sample collection depth	meters
Incubation_bottle	Experimental conditions indicator (1=light1, 2=light2, 3=dark1, 4=dark2)	unitless
Amox	Ammonia oxidation rate	nanomoles per liter per day
Amox_SE	Standard error of fit for ammonia oxidation rate	nanomoles per liter per day
Amox_fittype	Fit function type for ammonia oxidation rate calculation (1=non-linear least-squares fit to four or more points; 2=linear fit to three or fewer points)	unitless
Nitox	Nitrite oxidation rate	nanomoles per liter per day
Nitox_SE	Standard error of fit for nitrite oxidation rate	nanomoles per liter per day
Nitox_fittype	Fit function type for ammonia oxidation rate calculation (1=non-linear least-squares fit to four or more points; 2=linear fit to three or fewer points)	unitless
NO3red	Rate of nitrate to nitrite reduction	nanomoles per liter per day

NO3red_fittype	Fit function type for ammonia oxidation rate calculation (1=non-linear least-squares fit to four or more points; 2=linear fit to three or fewer points)	unitless
Year	Year of sample collection	unitless
Month	Month of sample collection (local)	unitless
Day	Day of sample collection (local)	unitless

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Instruments

Dataset-specific Instrument Name	SBE9plus conductivity-temperature-depth (CTD) sensor package
Generic Instrument Name	CTD Sea-Bird 9
Dataset-specific Description	SBE9plus conductivity-temperature-depth (CTD) sensor package
Generic Instrument Description	The Sea-Bird SBE 9 is a type of CTD instrument package. The SBE 9 is the Underwater Unit and is most often combined with the SBE 11 Deck Unit (for real-time readout using conductive wire) when deployed from a research vessel. The combination of the SBE 9 and SBE 11 is called a SBE 911. The SBE 9 uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3 and SBE 4). The SBE 9 CTD can be configured with auxiliary sensors to measure other parameters including dissolved oxygen, pH, turbidity, fluorometer, altimeter, etc.). Note that in most cases, it is more accurate to specify SBE 911 than SBE 9 since it is likely a SBE 11 deck unit was used. more information from Sea-Bird Electronics

Dataset-specific Instrument Name	Thermo Delta Plus XP isotope ratio mass spectrometer
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Thermo Delta Plus XP isotope ratio mass spectrometer is specially designed for measurement of light environmental stable isotopes (2H, 13C, 15N, 18O, 34S) and is a sensitive and selective instrument with applications in hydrology, geology, environmental protection, paleoclimate.
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	standard 24-bottle Niskin rosette sampler
Generic Instrument Name	Niskin bottle
Dataset-specific Description	standard 24-bottle Niskin rosette sampler
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

AT15-61

Website	https://www.bco-dmo.org/deployment/58785
Platform	R/V Atlantis
Start Date	2010-01-29
End Date	2010-03-03
Description	See more information at R2R: https://www.rvdata.us/search/cruise/AT15-61

MV1104

Website	https://www.bco-dmo.org/deployment/555585
Platform	R/V Melville
Start Date	2011-03-23
End Date	2011-04-23
Description	See more information at R2R: https://www.rvdata.us/search/cruise/MV1104

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Project Information

Expression of Microbial Nitrification in the Stable Isotopic Systematics of Oceanic Nitrite and Nitrate (Microbial Nitrification)

Coverage: Eastern Tropical South Pacific

Description from NSF award abstract:
Closing the marine budgets of nitrate and nitrous oxide are central goals for researchers interested in nutrient-driven changes in primary productivity and climate change. With the implementation of new methods for oxygen isotopic analysis of seawater nitrate, it will be possible to construct a budget for nitrate based on its oxygen isotopic distribution that is complementary to nitrogen isotope budgets. Before we can effectively use

oxygen isotopes in nitrate to inform the current understanding of the marine nitrogen cycle, we must first understand how different processes that produce (nitrification) and consume (assimilation, denitrification) nitrate affect its oxygen isotopic signature.

In this study, researchers at the Woods Hole Oceanographic Institution will provide a quantitative assessment of the oxygen isotopic systematics of nitrification in the field and thus fill a key gap in our understanding of 18O variations in nitrate, nitrite, and nitrous oxide. The primary goal is to develop a quantitative prediction of the oxygen isotopic signatures of nitrite and nitrate produced during nitrification in the sea. The researchers hypothesize that oxygen isotopic fractionation during nitrification is the primary factor setting the 18O values of newly produced nitrate and nitrite. Secondly, they hypothesize that oxygen atom exchange is low where ammonia oxidation and nitrite oxidation are tightly coupled, but may increase in regions with nitrite accumulation, such as in the primary and secondary nitrite maxima. They will test these hypotheses with a series of targeted laboratory and field experiments, as well as with measurements of nitrite and nitrate isotopic distributions extending through the euphotic zone, primary nitrite maximum, and secondary nitrite maximum of the Eastern Tropical South Pacific. The results of these experiments are expected to provide fundamental information required for the interpretation of 18O isotopic signatures in nitrite, nitrate, and N2O in the context of underlying microbial processes. A better understanding of these features and the processes involved is important for quantifying new production, controls on the N budget, and N2O production in the ocean -- which should lead to a better understanding of the direct and indirect interactions among the nitrogen cycle, marine chemistry, and climate.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0961098

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