Dataset: Water column nitrate+nitrite d15N measurements from R/V L'Atalante in the southwest Pacific Ocean between New Caledonia and Tahiti from February to March 2015

Project(s): Quantifying nitrogen fixation along unique geochemical gradients in the southwest Pacific Ocean (SW Pac N2 fixation)

Abstract: Constraining the rates and spatial distribution of di-nitrogen (N2) fixation fluxes to the ocean informs our understanding of the environmental sensitivities of N2 fixation as well as the timescale over which the fluxes of nitrogen (N) to and from the ocean may respond to each other. Here we quantify rates of N2 fixation as well as its contribution to export production along a zonal transect in the Western Tropical South Pacific (WTSP) Ocean using N isotope ("d15N") budgets. Comparing measurements of water column nitrate+nitrite d15N with the d15N of sinking particulate N at a western, central, and eastern station, these d15N budgets indicate high, modest, and low rates of N2 fixation at the respective stations. The results also imply that N2 fixation supports exceptionally high, i.e., >50%, of export production at the western and central stations, which are also proximal to the largest iron sources. These geochemically-based rates of N2 fixation are equal to or greater than those previously reported in the tropical North Atlantic, indicating that the WTSP Ocean has the capacity to support globally significant rates of N2 fixation, which may compensate for N removal in the oxygen deficient zones of the eastern tropical Pacific. For a complete list of measurements, refer to the supplemental document 'Field_names.pdf', and a full dataset description is included in the supplemental file 'Dataset_description.pdf'. The most current version of this dataset is available at: http://www.bco-dmo.org/dataset/733237

Description: Water column nitrate+nitrite d15N measurements

This data set includes water column nitrate+nitrite d15N measurements. These measurements were used together with measurements of the d15N of particulate nitrogen collected in floating sediment traps that were deployed for several days to calculate the relative contribution of subsurface nitrate and nitrogen from N2 fixation for supporting export production ("d15N budgets"). The results suggest that N2 fixation supported a majority of export at Long Duration (LD) stations A and B, and a minor fraction of export at LD C. The results at LD stations A and B are unique compared to other d15N budgets from the oligotrophic regions, whereas the results from LD C are similar to prior reports from the eastern tropical South Pacific as well as the North Pacific near Hawaii. Additionally, these data are compared with other metrics of N2 fixation made on the same cruise.

Acquisition Description: NO3-+NO2- d15N analysis was 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 nmols N2O, which was then purged from the vial using a helium carrier gas. The d15N of N2O in samples was calibrated with the international isotopic reference materials described in the Processing Description.

References:

Casciotti, K. L., D. M. Sigman, M. Galanter Hastings, J. K. Böhlke, and A. Hilkert (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

McIlvin, Matthew R. and Karen L. Casciotti (2011) Technical Updates to the Bacterial Method for Nitrate Isotopic Analyses. Analytical Chemistry. *83* (5), 1850-1856 DOI: 10.1021/ac1028984

Sigman, D. M., K. L. Casciotti, M. Andreani, C. Barford, M. Galanter, and J. K. Böhlke (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

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

Processing Description: Nitrate+nitrite concentration was measured by others using colorimetric methods, and can be found at:
http://www.obs-vlfr.fr/proof/php/outpace/outpace.php

The average precision of nitrate+nitrite d15N measurements was <0.2 per mil, but with the standard deviation for duplicate analyses of each sample reported here. Samples were calibrated with IAEA N3 and USGS 34 NO3- d15N isotopic reference materials as described in McIlvin and Casciotti, 2011.

BCO-DMO Processing Notes:

- added conventional header with dataset name, PI name, version date.
- modified parameter names to conform with BCO-DMO naming conventions.

- re-formatted date from dd Month yyyy (day month year) to yyyymmdd.
- appended date, latitude, and longitude to each data entry.
- If an observation did not exist, 'nd' (no data) was inserted.

Project Information

Quantifying nitrogen fixation along unique geochemical gradients in the southwest Pacific Ocean

NSF abstract: The availability of nitrogen in the surface ocean plays a critical role regulating rates of primary productivity in the ocean, and thus through modification of the carbon cycle, nitrogen has the capacity to influence climate. The dominant source of biologically available nitrogen to the ocean is through a process known as di-nitrogen (N2) fixation, which involves the reduction of N2 gas dissolved in seawater to ammonium by microbes referred to as diazotrophs. While significant progress has been made identifying a diversity of marine diazotrophs in recent years using molecular tools, quantifying global rates of N2 fixation, and identifying which ocean basin supports the highest fluxes, has remained a vexing question. This research will quantify rates of N2 fixation as well as its importance for supporting production in the southwest Pacific Ocean. Results from this research will shed light on the sensitivities of N2 fixation (temperature, iron concentrations) as well as the extent of spatial and temporal coupling of nitrogen sources and sinks in the ocean. The work will be carried out by an early career scientist, and involve mentoring of young women, middle school girls and minorities, training of undergraduate and graduate researchers, and international collaborations. Identifying the spatial distribution of the largest di-nitrogen (N2) fixation fluxes to the ocean remains a critical goal of chemical oceanography. The spatial distribution can inform our understanding of the environmental sensitivities of N2 fixation and the capacity for the dominant marine nitrogen (N) source and sink processes to respond to each other and thus influence the global carbon cycle and climate. In addition to temperature, two factors are at the heart of the current debate over what influences the spatial distribution of N2 fixation in the ocean: 1) the presence of adequate iron to meet the needs of N2 fixing microbes, and, 2) the absolute concentrations as well as ratios of surface ocean nitrate and phosphate concentrations that are low relative to the "Redfield" ratio, which are thought to favor N2 fixing microbes. This project will test the effects of gradients in atmospheric dust deposition on N2 fixation rates when surface waters have relatively constant but favorable nitrate to phosphate concentrations. The work will be carried out in the southwest Pacific, a region highlighted by new modeling work for its unique geochemical characteristics that are expected to favor significant N2 fixation fluxes. Nitrate+nitrite d15N as well as total dissolved nitrogen (TDN) concentration and d15N will be measured in water column samples collected on a French cruise and sediment traps were deployed to capture the sinking particulate N flux. The results will be compared with published work to evaluate which ocean regions support the largest N2 fixation fluxes. More information:

This project was part of the Oligotrophy to UlTra-oligotrophy PACific Experiment (OUTPACE) cruise in the Southwest Pacific between New Caledonia (166°28' E; 22°14' S) and Tahiti (149°36' W; 17°34' S) 0-2000 m * OUTPACE cruise (doi: http://dx.doi.org/10.17600/15000900) * OUTPACE website: https://outpace.mio.univ-amu.fr/?lang=en

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Deployment Information

Deployment description for R/V L'Atalante OUTPACE

Oligotrophy to UlTra-oligotrophy PACific Experiment (OUTPACE) cruise
DOI: http://dx.doi.org/10.17600/15000900 For more information see the cruise website: https://outpace.mio.univ-amu.fr/?lang=en South west Pacific between New Caledonia (166°28' E; 22°14' S) and Tahiti (149°36' W; 17°34' S) 0-2000 m

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Instrument Information

Instrument	Thermo Finnigan Delta V isotope ratio mass spectrometer.
Description	Nitrate+nitrite d15N was measured using a Thermo Finnigan Delta V isotope ratio mass spectrometer.
Generic Instrument Name	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).