In situ N2 production rates from the Eastern Tropical North Pacific Oxygen Deficient Zone on the R/V Sikuliaq cruise SKQ201617S in January 2017 and R/V Revelle in April 2018 cruise RR1805

Website: https://www.bco-dmo.org/dataset/1002907
Data Type: Other Field Results
Version: 1
Version Date: 2026-07-24

Project
» Dimensions: Diversity, assembly and function of microbial communities on suspended and sinking particles in a marine Oxygen Deficient Zone (ETNP_ParticleOmics)

Program
» Dimensions of Biodiversity (Dimensions of Biodiversity)

Contributors	Affiliation	Role
Devol, Allan	University of Washington (UW)	Principal Investigator
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Ruef, Wendi	University of Washington (UW)	Scientist
Duffy, Megan E.	University of Washington (UW)	Student
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Abstract
In situ N2 production rates with and without the addition of sinking particles were obtained using in situ incubator sediment trap systems in the Eastern Tropical North Pacific Oxygen Deficient Zone on two cruises. The R/V Sikuliaq cruise SKQ201617S in January 2017 sampled two stations: St P2 (16.5N 107W) and St P1 (20.1N 106.2W). St P2 is offshore in the core of the Oxygen Deficient Zone, and St P1 is on the continental slope. The R/V Revelle cruise RR1805 sampled approximately the same two stations in April 2018: St P2 (16.9N 107W) and St P1 (20.3N 106.1W). These two stations included an anoxic Oxygen Deficient Zone from 105-820 m for St P2 and 90-800 m for St P1. For both the 2017 and 2018 cruises, two types of traps were deployed: 1) in shallow waters (<150 m), traps with a solid plastic cone top (0.46 m2 opening area) were used, 2) in deep waters (>150 m), net traps (1.24 m2 opening area) were used. For all types of trap, the cod end had bottoms that were open during deployment and during an 8 hour equilibration period at the target depth performed to remove oxygen contamination. Cod ends were closed with a gate valve, using a pre-programmed electronic dissolving link (burn wire) system controlled by an onboard Arduino microcontroller to start collection at the correct depth, and a second gate valve that closed the top of the cod end before incubation and closed a bottle containing only seawater. 15N labeled nitrite was added in situ to both the +particles chamber and the water only chamber using a syringe and the Arduino microcontroller. Incubations were 12-36 hours. Immediately after returning the sediment trap-in situ incubator systems shipboard, the experimental chambers were sampled using single-use needles into 12 mL septum-capped glass Exetainer vials (LabCo, UK) that had been purged with helium gas for 5 minutes. Duplicate vials were sampled for each incubation. Vials were poisoned with 50% (w/v) zinc chloride and stored in the dark at room temperature. To obtain background isotopic composition of N2 gas, water from CTD casts was collected into Exetainers by overfilling the exetainer four times and closing the exetainer with a needle inserted to just below the septa, to cause any bubbles to be removed during closing. Exetainers were measured for 29N2 and 30N2 accumulation on a Thermo Delta V IRMS in continuous flow mode using helium gas at the University of Washington. Allan Devol, Wendi Ruef and Rick Keil designed these in situ incubator trap systems. Megan Duffy, Allan Devol and Rick Keil from the University of Washington deployed and sampled these in situ incubator sediment trap systems. Clara Fuchsman from the University of Washington and Horn Point Laboratory, part of the University

of Maryland Center for Environmental Science, ran the rate measurements on the mass spectrometer and did the initial data analysis. Both Megan Duffy and Clara Fuchsman did further data analysis.

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Coverage

Location: Eastern Tropical North Pacific Oxygen Deficient Zone
Spatial Extent: **N**:20.305 **E**:-106.0001 **S**:16.5207 **W**:-107.1392
Temporal Extent: 2017-01-01 - 2018-04-24

Methods & Sampling

In situ N2 production rates with and without the addition of sinking particles were obtained from the Eastern Tropical North Pacific on the R/V *Sikuliaq* cruise SKQ201617S in January 2017, which sampled two stations: St P2 (16.5ºN 107ºW) and St P1 (20.1 ºN 106.2ºW), and the R/V *Revelle* cruise RR1805 sampled approximately the same two stations in 2018: St P2 (16.9ºN 107ºW) and St P1 (20.3 ºN 106.1ºW).

The unpoisoned trap-incubator design collected particles using either a hard plastic cone or mesh net design similar to (Peterson et al., 2005). Despite these differences, the plastic cone and mesh net trap styles were demonstrated to have similar collection efficiencies in the ETNP in 2017 (Cram et al., 2022). The gate valves at the tops and bottoms to incubation chambers, as well as the plungers of 15N tracer-injecting syringes, were held open with tensioned rubber tubing restrained with nylon-jacketed electronic dissolving links (“burn wires”) prior to deployment. The chamber gate valves and syringes were controlled using a preprogrammed onboard Arduino microcontroller that directed current from two 9V alkaline batteries to individual electronic dissolving links. The nylon jacket on the electronic dissolving link was stripped at 1-cm wide sections which held open a gate valve or syringe plunger. When current was applied by the Arduino microcontroller, the electronic dissolving links corroded in seawater and released either the attached gate valves or syringe plungers. Sediment trap incubators were deployed with all gates open to facilitate the dissipation of any trapped air bubbles during an 8-hour acclimation period in anoxic waters at the target depth.

Particles collected in the trap fell into a vertically-oriented 1 L incubation chamber (“+particles chamber”) that was initially open on both ends. Another vertically-oriented 1 L incubation chamber (“water column chamber”) sat to the side of the sediment trap and was deployed open on both ends, but closed immediately before incubation. The bottom of the +particles chamber was programmed to close after the 8-hour acclimation period at the target depth, beginning a collection phase of 12-36 hours. After the collection phase, the top of the +particles closed, along with both top and bottom of the water column chamber. At the beginning of the incubation phase, 15N-labeled nitrite was injected into both +particles and water column chambers. A second 500 mL collection chamber (“top collector”) immediately above the +particles chamber collected additional sinking particles during the incubation phase for use in flux calculations.

Immediately after returning the sediment trap-*in situ* incubator systems shipboard, the experimental chambers were sampled using single-use needles into 12 mL septum-capped glass Exetainer vials (LabCo, UK) that had

been purged with helium gas for 5 minutes. Duplicate vials were sampled for each incubation. Vials were poisoned with 50% (w/v) zinc chloride and stored in the dark at room temperature. Water from CTD casts was collected into Exetainers to measure the background isotopic composition of N2 gas by overfilling the exetainer four times and closing the exetainer with a needle inserted to just below the septa, to cause any bubbles to be removed during closing. Each Exetainer was checked for bubbles. Exetainers were measured for 29N2 and 30N2 accumulation on a Thermo Delta V isotope ratio mass spectrometer in continuous flow mode using helium gas at the University of Washington. Each datapoint was background corrected. A tank of N2 gas was the internal standard and was measured three times during each sample measurement. Each sample was in turn measured three times. Air was used as an external standard and was added to helium purged Exetainers using a range of volumes. These air standards were measured regularly throughout the run to quantify any drift. Rate measurements were calculated following de Brabandere et al. (2014) using incubation durations and the volumes of the experimental chambers.

Data Processing Description

The goal in the incubations was to arrive at N2 production rate values that represented 1) the overall N2 production rate in the water column, which was obtained from the water column chambers; and 2) the N2 production rate due solely attributed to the sinking particles in the water column. Because the incubations occurred with particles that had been collected over a 12 hour period, we thus adjusted the initial rates in the +particles chambers to account for this concentration factor and arrive at an adjusted rate relevant to the actual concentration of particles in the water column. To do this, we adjusted the labeled N2 accumulation rate in the +particles chamber to be the rate for the mass concentration (m/V, in mol organic C/m3) for sinking particles in the water column at the target depth. This concentration (mol C m-3) was determined using the calculated fluxes of organic carbon in sinking particles (mol C m-2 day-1) derived from the sediment traps and the average sinking rate of particles (m day-1). While particle sinking rates were not directly measured during our cruises; we used a value for sinking particles in the ETNP ODZ determined with a particle settling column from Cavan et al. (2017) who reported the ratio of slow sinking vs. fast sinking particle flux to be 18:0.6, with sinking rates measured at a range from 6.5 m day-1 and 69 m day-1. We therefore used an average sinking rate value of 8.45 m day-1 in these adjustments. The mass concentration of organic carbon in sinking particles at depth (mol C m-3) was then used with the actual concentration organic carbon in the top collector chamber (umol C m-3) to calculate a unitless "concentration factor" that was used to adjust the initial N2 production rates (nmol N day-1) to account for this factor and arrive at the N2 production rate due to sinking particles (nmol N day-1).

BCO-DMO Processing Description

- Converted NA values to blank values (=missing values).
- Converted date_deployed from format "%m/%d/%Y" to ISO date format "%Y-%m-%d"
- Renamed column N_production_+P to N_production_plus_P

Problem Description

Values listed as 'N/A' were due to incubation chambers that failed to close during deployment.

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Related Publications

Cavan, E. L., Trimmer, M., Shelley, F., & Sanders, R. (2017). Remineralization of particulate organic carbon in an ocean oxygen minimum zone. Nature Communications, 8(1). https://doi.org/10.1038/ncomms14847
Methods

Cram, J. A., Fuchsman, C. A., Duffy, M. E., Pretty, J. L., Lekanoff, R. M., Neibauer, J. A., Leung, S. W., Huebert, K. B., Weber, T. S., Bianchi, D., Evans, N., Devol, A. H., Keil, R. G., & McDonnell, A. M. P. (2022). Slow Particle Remineralization, Rather Than Suppressed Disaggregation, Drives Efficient Flux Transfer Through the Eastern Tropical North Pacific Oxygen Deficient Zone. Global Biogeochemical Cycles, 36(1). Portico.

https://doi.org/10.1029/2021gb007080 https://doi.org/10.1029/2021GB007080
Methods

De Brabandere, L., Canfield, D. E., Dalsgaard, T., Friederich, G. E., Revsbech, N. P., Ulloa, O., & Thamdrup, B. (2013). Vertical partitioning of nitrogen-loss processes across the oxic-anoxic interface of an oceanic oxygen minimum zone. Environmental Microbiology, 16(10), 3041–3054. Portico. https://doi.org/10.1111/1462-2920.12255
Methods

Peterson, M. L., Wakeham, S. G., Lee, C., Askea, M. A., & Miquel, J. C. (2005). Novel techniques for collection of sinking particles in the ocean and determining their settling rates. Limnology and Oceanography: Methods, 3(12), 520–532. doi:10.4319/lom.2005.3.520
Methods

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Related Datasets

IsRelatedTo

Fuchsman, C., Duffy, M. E., Devol, A., Keil, R., Neibauer, J. A. (2025) **Sinking Organic Particle fluxes and stable C isotopes (collected with sediment traps) from the Eastern Tropical North Pacific on the R/V Sikuliaq cruise SKQ201617S in January 2017.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-01-17 doi:10.26008/1912/bco-dmo.948735.1 [view at BCO-DMO]
Relationship Description: The sinking organic C fluxes are used in the calculation of final N2 production on particles.

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Parameters

Parameter	Description	Units
incubation_ID	Unique ID code for trap array and incubator depth	unitless
date_deployed	description	units
station	station sampled	unitless
latitude	location deployed	decimal degrees (DD)
longitude	location deployed	decimal degrees (DD)
depth	depth of trap-incubator system	meters (m)
particle_collection_time	duration of sediment trap particles collection into plus particles (+P) chamber	hours (hrs)
incubation_time	duration of incubation	hours (hrs)
N_production_plus_P	unadjusted N production rate in plus particles (+P) chamber	nanomols nitrogen per day (nM N/d)
N_production_WaterColumn	unadjusted N production rate in water column chamber	nanomols nitrogen per day (nM N/d)
N_production_sinking_particles	calculated N production rate due to sinking particles	nanomols nitrogen per day (nM N/d)

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Instruments

Dataset-specific Instrument Name	Thermo Delta V
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Thermo Delta V Isotope Ratio Mass Spectrometer was used to measure 15N of N2 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).

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Deployments

SKQ201617S

Website	https://www.bco-dmo.org/deployment/828218
Platform	R/V Sikuliaq
Start Date	2016-12-20
End Date	2017-01-16
Description	Cruise DOI: 10.7284/907444 See more cruise information from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/SKQ201617S

RR1805

Website	https://www.bco-dmo.org/deployment/779193
Platform	R/V Roger Revelle
Start Date	2018-04-14
End Date	2018-05-02
Description	More information is available at R2R: https://www.rvdata.us/search/cruise/RR1805

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Project Information

Dimensions: Diversity, assembly and function of microbial communities on suspended and sinking particles in a marine Oxygen Deficient Zone (ETNP_ParticleOmics)

Coverage: Eastern Tropical North Pacific

Extracted from the NSF award abstract:

Marine oxygen deficient zones (ODZs) are waters that are functionally devoid of oxygen. Without oxygen, some microbes are capable of converting nitrogen in the water into N2 gas, which then leaves the ocean and enters the atmosphere. This loss of an important nutrient from the ocean has impacts on phytoplankton growth and marine food webs. While oxygen deficient zones occupy a very small percentage of the ocean, they account for as much as half of the oceanic loss of N as N2. Moreover, the size of these regions is predicted to expand during this century due to climate change. The microbes that are capable of producing N2 gas are extremely diverse, and use several different biochemical pathways to carry out this process. They may occur both free-floating in the water and attached to small particles that are suspended or sinking from the surface waters and providing them a carbon source. However the importance of these two lifestyles (free-living vs particle attached) in terms of contributions to N loss from the oceans is not well understood. This project will identify the major organisms that result in N2 gas production on both suspended and sinking particles, the chemical reactions they carry out, and the rates at which this occurs. This information will be used to improve global climate models to better predict rates of N loss in a future ocean. Elementary and middle school teachers enrolled in a Masters in Science for Science Teachers program will be involved in the project and the graduate students and post-doctoral researchers supported by the project will have opportunities to participate in their classrooms. Underserved populations will also be integrated into the research at the undergraduate and middle school level through a series of summer internships.

ODZs have very complex elemental cycles, implying great microbial diversity. Intertwined with the microbial complexity of ODZ regions is the relatively unexplored interplay between free-living bacteria and those living on

either suspended or sinking particles. Determining how these communities and niches interact and relate is one of the most challenging components of ODZ system studies today. Current climate models portray the dynamics of particles in the ODZs and throughout the deep ocean through prescribed functions based on sparse data from the oxic ocean with microbes represented only by the net chemical reactions of the community. However, in reality a phylogenetically and metabolically diverse group of microbes, likely acting in consortia, are responsible for the nitrogen transformations that ultimately result in the production of N2. To explore the processes maintaining the genetic diversity and functional redundancy in N loss processes, four research areas will be integrated: the community phylogenetic diversity (both taxonomic and genomic diversity) the genetic diversity of the proteins that carry out key N transformation processes (as seen through quantitative proteomics), the resulting biogeochemical functions (15N labeled nitrogen transformation rate measurements) and predictions about how this diversity and corresponding function may change in response to climate change (biogeochemical modeling). The approach will be to assay both phylogenetic (16S rRNA tag sequencing) and functional genetic diversity (genomics) on sinking particles collected using large-volume sediment traps. Phylogenetic and genomic studies will be intimately tied to measurements of activity - who is doing key biogeochemical transformations (proteomics) and what are the in situ rates at which they are doing them (using novel incubation systems). Data will then be used to model how diversity and corresponding function change on a range of time and space scales, from the sinking of a single particle to seasonal cycles. To understand the relationship of community diversity and function on suspended and sinking particles, a series of three cruises will be conducted in the Eastern Tropical North Pacific ODZ.

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Program Information

Dimensions of Biodiversity (Dimensions of Biodiversity)

Website: http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503446

Coverage: global

(adapted from the NSF Synopsis of Program)
Dimensions of Biodiversity is a program solicitation from the NSF Directorate for Biological Sciences. FY 2010 was year one of the program. [MORE from NSF]

The NSF Dimensions of Biodiversity program seeks to characterize biodiversity on Earth by using integrative, innovative approaches to fill rapidly the most substantial gaps in our understanding. The program will take a broad view of biodiversity, and in its initial phase will focus on the integration of genetic, taxonomic, and functional dimensions of biodiversity. Project investigators are encouraged to integrate these three dimensions to understand the interactions and feedbacks among them. While this focus complements several core NSF programs, it differs by requiring that multiple dimensions of biodiversity be addressed simultaneously, to understand the roles of biodiversity in critical ecological and evolutionary processes.

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Funding

Funding Source	Award
NSF Division of Environmental Biology (NSF DEB)	DEB-1542240

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