Sinking Organic Particle fluxes and stable C isotopes (collected with sediment traps) from the Eastern Tropical North Pacific on cruises SKQ201617S, RR1805, and KM1920 (2017–2019)

Website: https://www.bco-dmo.org/dataset/948735
Data Type: Cruise Results
Version: 2
Version Date: 2026-08-03

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
Keil, Richard	University of Washington (UW)	Principal Investigator
Devol, Allan	University of Washington (UW)	Co-Principal Investigator
Fuchsman, Clara	University of Washington (UW)	Scientist, Contact
Duffy, Megan E.	University of Washington (UW)	Student
Neibauer, Jacquelyn A.	University of Washington (UW)	Technician
Ruef, Wendi	University of Washington (UW)	Technician
Soenen, Karen	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager
York, Amber D.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Fluxes of sinking organic carbon and nitrogen and the isotopic composition of organic carbon were obtained from free floating, unpoisoned surface tethered sediment traps during three cruises in the Eastern Tropical North Pacific Oxygen Deficient Zone: 1) at St P1 (20.1ºN 106.2ºW) and St P2 (16.9ºN 107ºW) in January 2017 from the R/V Sikuliaq on cruise SKQ201617S, 2) at St P1 and St P2 in April 2018 from the R/V Revelle on cruise RR1805, and 3) at St P2 and St P3 (21.8°N 109.9°W) in October 2019 from the R/V Kilo Moana on cruise KM1920. Trap depths ranged between 50 m and 965 m, and trap deployments ranged between 21 and 91 hours with deeper traps deployed for longer. For 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 2019, cone-net hybrid sediment traps were used (0.46 m2 opening area). They consisted of a cone trap with impervious fabric above the cone used to increase the aspect ratio. 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 retrieval. Some trap deployments functioned as simple sediment traps, and some deployments were combined trap and in situ incubators. The combined trap incubators consisted of upper and lower chambers. The material used to calculate fluxes reported here was collected from the upper chamber and was not incubated. After every deployment, sediment trap material was filtered onto pre-combusted GF-75 filters (0.3 µm nominal pore size). To conform to community standards, zooplankton carcasses were not included in the measurements of carbon and nitrogen flux. Filter samples (particles only) were wafted with HCl overnight to remove carbonate. Samples from St P1 and St P2 from 2017 were sent to the University of Washington Isolab facility in the Department of Earth and Space Sciences (Seattle, WA) for C and N analysis while samples from 2018 and 2019 were sent to the UC Davis Stable Isotope Facility (Davis, CA) for C and N analysis. These data were collected to improve our understanding of sinking fluxes of organic matter in the offshore Oxygen Deficient Zone, and to see whether Oxygen Deficient Zones reduce organic matter attenuation Allan Devol and Rick Keil and Wendi Ruef from the University of Washington designed these trap systems. Megan Duffy, Jacquelyn Neibauer, and Allan Devol and Rick Keil from the University of Washington and Clara Fuchsman from Horn Point Laboratory, part of the

University of Maryland Center for Environmental Science, deployed and sampled these sediment trap systems. Megan Duffy and Clara Fuchsman analyzed the data.

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Coverage

Location: Eastern Tropical North Pacific (St P1, St P2 & St P3)
Spatial Extent: **N**:21.83 **E**:-106 **S**:16.52 **W**:-110.01
Temporal Extent: 2017-01-01 - 2019-10-15

Methods & Sampling

Free floating, unpoisoned surface tethered sediment traps were used to quantify fluxes of sinking particles during three cruises in the Eastern Tropical North Pacific Oxygen Deficient Zone: 1) at St P1 (20.1ºN 106.2ºW) and St P2 (16.9ºN 107ºW in January 2017 from the R/V *Sikuliaq* on cruise SKQ201617S, 2) at St P1 and St P2 in April 2018 from the R/V *Revelle* on cruise RR1805, and 3) at St P2 and St P3 (21.8°N 109.9°W) in October 2019 from the R/V *Kilo Moana* on cruise KM1920.

Trap depths ranged between 50 m and 965 m, and trap deployments ranged between 21 and 91 hours with deeper traps deployed for longer. Traps were deployed in arrays of two traps per line except in 2019 when they were deployed as 4 per trap line. In 2017 and 2018, two types of traps were deployed: 1) in shallow waters (<150 m), traps with a solid plastic cone top (0.46 m^2 opening area) were used, 2) in deep waters (>150 m), net traps (1.24 m^2 opening area) modeled from (Peterson et al., 2005) were used. For both 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 retrieval. The aspect ratio, or height/trap mouth diameter, of the net traps was 2.5 while the aspect ratio of the cone traps was 0.6. These two types of traps have been shown to collect material with similar efficiency when normalized by opening area (Cram et al., 2022). No salt solution was used with these traps and no poisons were used in any chamber. For 2019, cone traps were modified to add a 36 inch tall canvas cylinder to the top of the cone to increase its aspect ratio to 1.7, but the opening area was still 0.46 m^2. All other aspects of the trap were the same as described above.

Some trap deployments functioned as simple sediment traps, and some deployments were combined trap and in situ incubators. The combined trap incubators consisted of upper and lower chambers. The material used to calculate fluxes reported here was collected from the upper chamber and was not incubated. Sinking material was collected in the lower incubation chamber, then isolated by closed a gate valve and injected with $^{15}N\text{-}NO_2^-$. While the incubation occurred (in situ), sinking material was collected in an upper chamber that never encountered the spiked material. However, we do not report $d^{15}N$ natural stable isotopes for the sediment trap material here due to proximity to the incubation.

After every deployment, sediment trap material was filtered onto pre-combusted GF-75 filters (0.3 µm nominal pore size). To conform to community standards, zooplankton carcasses were not included in the measurements of carbon and nitrogen flux. Samples were stored frozen. Filter samples (particles only) were wafted with HCl overnight to remove carbonate, dried at 40°C, packed into silver foil cups. Samples from 2017 were sent to the University of Washington Isolab facility in the Department of Earth and Space Sciences (Seattle, WA) for C and N analysis utilizing an Costech elemental analyzer attached to an isotope ratio mass spectrometer (ThermoFinnegan MAT 253). Samples from 2018 and 2019 were sent to UC Davis Stable Isotope Facility (Davis, CA), where they used an elemental analyzer (Elementar Vario EL Cube) attached to an isotope ratio mass spectrometer (Isoprim VisION) for C and N analysis.

Data Processing Description

ug C and N were converted to fluxes in Microsoft Excel using the area of the trap opening and the duration of the deployment.

BCO-DMO Curation Notes

Version 2 processing, approved by submitter:
* Updated metadata (abstract, methodology, deployment, parameters, location and time)
* Combined sediment-trap data from two source files: the Excel file “ETNP_2017P1-2018P1P2-2019P2P3_sediment_traps.xlsx” and the CSV file “948735_v1_etnp-2017-sedtrap-fluxes.csv.” Blank cells and values recorded as “nd” or “NA” were treated as missing data.
* Cleaned the latitude and longitude values from the Excel file by removing degree symbols and converting South and West coordinates to negative decimal values.
* Matched the corresponding columns from both files and merged the records into one table containing 14 variables.
* Standardized deployment dates that were provided in two different formats, such as 15-Jan-17 and 2017-01-15, to the consistent format YYYY-MM-DD.
* Sorted the combined dataset chronologically by deployment date.

Version 1:
* Sheet 1 of submitted file "ETNP_2017_P2_sediment_traps.xlsx" was imported into the BCO-DMO data system. Table will appear as Data File: 948735_v1_etnp-2017-sedtrap-fluxes.csv (along with other download format options).
** In the BCO-DMO data system missing data identifiers are displayed according to the format of data you access. For example, in csv files it will be blank (null) values. In Matlab .mat files it will be NaN values. When viewing data online at BCO-DMO, the missing value will be shown as blank (null) values.
* Date converted to ISO 8601 format
* Lat lon converted to decimal degrees (south and west are negative, degree symbols and directional NSEW removed)
* Supplemental reference table was attached without format changes.

Problem Description

Some sediment trap deployments were paired with in situ incubations with spiked 15N. While the material described here was not involved in those incubations, we choose not to report natural 15N for this material due to its proximity to spiked 15N.

For some samples, the N content was below the detection limit.

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Data Files

File
948735_v2_sedimentflux.csv (Comma Separated Values (.csv), 5.25 KB) MD5:68ade3ff8c1fa4ada532aa516ea36507 Primary data file for dataset ID 948735, version 2

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Supplemental Files

File
Standard analysis filename: Standards_2017_sediment_traps_ETNP.xlsx (Microsoft Excel, 40.76 KB) MD5:fbb5f43b9efd4d0f889ef4329e3bba63 A comparison of reference standards analyzed with this data to their official values.

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Related Publications

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
Results

Fuchsman, C. A., Duffy, M. E., Cram, J. A., Huanca-Valenzuela, P., Gregory, B. P., Plough, L. V., Pierson, J. J., Fitzgerald, C. L., Devol, A. H., & Keil, R. G. (2025). Contributions of Vertically Migrating Metazoans to Sinking and Suspended Particulate Matter Fuel N2 Production in the Eastern Tropical North Pacific Oxygen Deficient Zone. Global Biogeochemical Cycles, 39(3). Portico. https://doi.org/10.1029/2024gb008365 https://doi.org/10.1029/2024GB008365
Results

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

Clara Fuchsman, Megan E. Duffy, Allan Devol, Richard Keil, Wendi Ruef (2026) **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.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2026-08-03 doi:10.26008/1912/bco-dmo.1002907.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Station	station sampled	unitless
latitude	location deployed	decimal degrees
longitude	location deployed	decimal degrees
Date_deployed	date deployed	unitless
Duration	Length of time for organic matter collection	hours (hr)
Depth	depth of trap	meters (m)
TrapID	Unique number for trap array	unitless
TrapType	cone or net trap	unitless
Incubator	Did an insitu incubation occur as part of this deployment	unitless
Trap_Area	The area of the trap opening	meters squared (m2)
Flux_C	The sinking flux of organic C	micromols per meters squared per day umol/m2-d
Flux_N	The sinking flux of organic N	micromols per meters squared per day umol/m2-d
C_to_N	ratio of molar concentrations of flux material	unitless
d13C_VPDB	isotopic composition of C	permil (0/00)

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Costech International Elemental Combustion System (ECS) 4010
Dataset-specific Description	Carbon and Nitrogen amounts and isotopic composition was measured with a Costech Elemental Analyzer attached to ThermoFinnigan MAT 253 isotope ratio mass spectrometer at the University of Washington Isolab facility in the Department of Earth and Space Sciences (Seattle, WA).
Generic Instrument Description	The ECS 4010 Nitrogen / Protein Analyzer is an elemental combustion analyser for CHNSO elemental analysis and Nitrogen / Protein determination. The GC oven and separation column have a temperature range of 30-110 degC, with control of +/- 0.1 degC.

Dataset-specific Instrument Name	Elementar Vario EL Cube
Generic Instrument Name	Elementar Vario EL Cube elemental analyzer
Dataset-specific Description	2018 & 2019 samples, UC Davis
Generic Instrument Description	A laboratory instrument used for quantifying organic elements. It can measure C, H, N and S and optionally O, Cl and TIC. It was first developed in 2006 as a successor to the vario EL III. It uses a high-temperature combustion unit that is able to complete sample digestion at up to 1200 deg C (or 1800 deg C at the point of combustion when tin foil is used) and a jet injection of oxygen directly to the sample during combustion. Separation of gas components are performed on up to 3 gas-selective columns which trap gases until they are heated up and the prior gas peak has reached the baseline during detection. It uses a Thermal Conductivity Detector (TCD) as standard. An infrared (IR) detector for sulfur and oxygen and electrochemical detector for chlorine are optionally available. The instrument can measure C / N elemental ratios of up to 12,000:1 and provides an elemental detection limit of < 40 ppm (TCD).

Dataset-specific Instrument Name	Isoprim VisION
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).

Dataset-specific Instrument Name	ThermoFinnigan MAT 253
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Carbon and Nitrogen amounts and isotopic composition was measured with a Costech Elemental Analyzer attached to ThermoFinnigan MAT 253 isotope ratio mass spectrometer at the University of Washington Isolab facility in the Department of Earth and Space Sciences (Seattle, WA).
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

KM1920

Website	https://www.bco-dmo.org/deployment/849547
Platform	R/V Kilo Moana
Start Date	2019-10-02
End Date	2019-10-22
Description	More information is available from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/km1920 Cruise DOI: 10.7284/908379

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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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