Benthic fluxes of solutes measured by in-situ benthic flux chambers along two depth transects in the Santa Barbara Basin during November 219

Website: https://www.bco-dmo.org/dataset/896706
Data Type: Cruise Results
Version: 1
Version Date: 2023-06-01

Project
» Collaborative Research: Do benthic feedbacks couple sulfur, nitrogen and carbon biogeochemistry during transient deoxygenation? (BASIN)

Contributors	Affiliation	Role
Treude, Tina	University of California-Los Angeles (UCLA)	Principal Investigator
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Abstract
This dataset includes benthic fluxes of solutes (ammonium, nitrate, phosphate, and iron) measured by in-situ benthic flux chambers along two depth transects in the Santa Barbara Basin during the November 2019 R/V Atlantis cruise AT42-19.

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Coverage

Spatial Extent: **N**:34.3626 **E**:-120.015 **S**:34.1422 **W**:-120.053
Temporal Extent: 2019-11-01 - 2019-11-08

Methods & Sampling

Benthic fluxes of solutes where determined with three in-situ benthic flux chambers (BFC) according to Treude et al. (2009). The BFCs consisted of a frame equipped with a cylindrical polycarbonate chamber (inner diameter = 19 centimeters) with its lower portion sticking out of the frame. The upper side of the chamber was closed by a lid containing a stirrer (Type K/MT 11, K.U.M., Kiel, Germany), oxygen optodes (Type 4330, Aanderaa Data Instruments, Bergen Norway and Hydroflash, Contros/Kongsberg Maritime, Kongsberg, Norway), a conductivity sensor (type 5860, Aanderaa Data Instruments), and a valve for water to escape when the chamber is inserted into the sediments.

Prior to deployment by the ROV Jason, the chambers were held upside down by the ROV manipulating arms within approximately 10 meters of the seafloor and moved back and forth to make sure water from shallower depths that may have been trapped was replaced by bottom water. Chamber incubations lasted between 240 and 390 minutes. Each BFC was outfitted with a custom-built syringe sampler containing seven 50-milliliter (mL) syringes that were connected by tubes to sampling ports in the upper portion of the wall of the chambers: one injection syringe and six sampling syringes that were fired at approximately 60-minute increments, depending on the total duration of the incubation. The injection syringe contained deionized water that was purged with helium to remove oxygen and the volume of the overlaying water (typically 2.5 to 4 liters depending on sediment characteristics and chamber handling by ROV) was determined based on the observed reduction in conductivity after sensor readings stabilized (i.e., full mixing was achieved) 10-30 minutes after injection (Kononets et al., 2021). Samples obtained from the overlaying water of the BFC were examined for NH4+, PO43-, Fe2+ (according to Grasshoff et al., 1999), and NO3- (according to García-Robledo et al., 2014). Benthic fluxes of the solutes were calculated as follows:

$J=\Delta c/\Delta t*V/A$

Where J is the diffusive flux in millimoles per square meter per day ($mmol/m^2/d$), Δc is the concentration change in millimoles per cubic meter ($mmol/m^3$), Δt is the time interval in days (d), V is the overlying water volume in cubic meters (m^3), and A is the surface area of the sediment covered by the benthic flux chamber in square meters (m^2). One chamber per site contained 200 micromoles 5N-NO3- in the injection syringe for in-situ nitrogen cycling experiments. The injection of 15N-NO3- roughly doubled the concentration of NO3- in the overlying chamber water compared to the natural concentration. The effect of the nitrate addition on conductivity and, hence, volume determination was negligible (<1%).

Data Processing Description

BCO-DMO Processing:
- renamed fields to comply with BCO-DMO naming conventions;
- converted the date-time fields to ISO 8601 format;
- removed "-" and "no entry" as missing data values (missing data/no data values are blank/empty in the final csv file).

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Data Files

File	
basin_2019_benthic_flux.csv	(Octet Stream, 4.93 KB) MD5:3658dd9297a27327d606130216278b90
Primary data file for dataset ID 896706	

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Related Publications

García-Robledo, E., Corzo, A., & Papaspyrou, S. (2014). A fast and direct spectrophotometric method for the sequential determination of nitrate and nitrite at low concentrations in small volumes. Marine Chemistry, 162, 30–36. https://doi.org/10.1016/j.marchem.2014.03.002
Methods

Grasshoff, K., Kremling, K., & Ehrhardt, M. (Eds.). (1999). Methods of Seawater Analysis. doi:10.1002/9783527613984
Methods

Kononets, M., Tengberg, A., Nilsson, M., Ekeroth, N., Hylén, A., Robertson, E. K., van de Velde, S., Bonaglia, S., Rütting, T., Blomqvist, S., & Hall, P. O. J. (2021). In situ incubations with the Gothenburg benthic chamber landers: Applications and quality control. Journal of Marine Systems, 214, 103475. https://doi.org/10.1016/j.jmarsys.2020.103475
Methods

Treude, T., Smith, C., Wenzhöfer, F., Carney, E., Bernardino, A., Hannides, A., Krüger, M., & Boetius, A. (2009). Biogeochemistry of a deep-sea whale fall: sulfate reduction, sulfide efflux and methanogenesis. Marine Ecology Progress Series, 382, 1–21. https://doi.org/10.3354/meps07972

Methods

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Parameters

Parameter	Description	Units
Station	Station name	unitless
Benthic_Flux_Chamber	Number identifying the benthic flux chamber	unitless
ROV_dive_ID	Dive ID number	unitless
Ammonium_flux	Ammonium (NH4+) flux. Positive fluxes represent fluxes from the sediment into the water column. Negative fluxes represent fluxes from the water column into the sediment.	millimoles per square meter per day (mmol m-2 d-1)
Ammonium_number_of_time_points	Number of time points used in Ammonium flux calculation	unitless
Ammonium_r2_of_flux_curve	r-square (r^2) value of Ammonium flux curve	unitless
Nitrate_flux	Nitrate (NO3-) flux. Positive fluxes represent fluxes from the sediment into the water column. Negative fluxes represent fluxes from the water column into the sediment.	millimoles per square meter per day (mmol m-2 d-1)
Nitrate_number_of_time_points	Number of time points used in Nitrate flux calculation	unitless
Nitrate_r2_of_flux_curve	r-square (r^2) value of Nitrate flux curve	unitless
Iron_II_flux	Iron II (Fe^2+) flux. Positive fluxes represent fluxes from the sediment into the water column. Negative fluxes represent fluxes from the water column into the sediment.	millimoles per square meter per day (mmol m-2 d-1)
Iron_II_number_of_time_points	Number of time points used in Iron II flux calculation	unitless
Iron_II_r2_of_flux_curve	r-square (r^2) value of Iron II flux curve	unitless
Phosphate_flux	Phosphate (PO4^3-) flux. Positive fluxes represent fluxes from the sediment into the water column. Negative fluxes represent fluxes from the water column into the sediment.	millimoles per square meter per day (mmol m-2 d-1)
Phosphate_number_of_time_points	Number of time points used in Phosphate flux calculation	unitless
Phosphate_r2_of_flux_curve	r-square (r^2) value of Phosphate flux curve	unitless
Latitude	Latitude where positive values = North	decimal degrees
Longitude	Longitude where negative values = West	decimal degrees
Water_Depth	Water depth	meters
Temperature	Temperature	degrees Celsius
Salinity	Salinity	PSU
Oxygen	Oxygen concentration	micromolar (uM)

Deployment_Start_DateTime_Local	Date and time (local time zone) at start of deployment. Local time zone is Pacific Time but Daylight Saving Time ended on November 3, 2019 during the cruise. Therefore, before November 3, local time is in Pacific daylight time (PDT) and after November 3, local time is in Pacific standard time (PST).	unitless
Deployment_Start_DateTime_UTC	Date and time (UTC) at start of deployment	unitless
Deployment_End_DateTime_Local	Date and time (local time zone) at end of deployment. Local time zone is Pacific Time but Daylight Saving Time ended on November 3, 2019 during the cruise. Therefore, before November 3, local time is in Pacific daylight time (PDT) and after November 3, local time is in Pacific standard time (PST).	unitless
Deployment_End_DateTime_UTC	Date and time (UTC) at end of deployment	unitless
Type_of_Incubation	Type of incubation; either 15N experiment or natural flux	unitless
Chamber_Volume_Determination	Chamber volume determination; either sensor (DI-water injection-based) or visual	unitless

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Instruments

Dataset-specific Instrument Name	oxygen optodes (Type 4330, Aanderaa Data Instruments)
Generic Instrument Name	Aanderaa Oxygen Optodes
Generic Instrument Description	Aanderaa Oxygen Optodes are instrument for monitoring oxygen in the environment. For instrument information see the Aanderaa Oxygen Optodes Product Brochure.

Dataset-specific Instrument Name	benthic flux chambers (BFC)
Generic Instrument Name	benthic incubation chamber
Dataset-specific Description	The three in-situ benthic flux chambers (BFC) each consisted of a frame equipped with a cylindrical polycarbonate chamber (inner diameter = 19 cm) with its lower portion sticking out of the frame. The upper side of the chamber was closed by a lid containing a stirrer, oxygen optodes, a conductivity sensor, and a valve for water to escape when the chamber is inserted into the sediments. Chamber incubations lasted between 240 and 390 minutes.
Generic Instrument Description	A device that isolates a portion of seabed plus overlying water from its surroundings. Either returns the entire system to the surface or incorporates sampling devices and/or in-situ sensors.

Dataset-specific Instrument Name	conductivity sensor (type 5860, Aanderaa Data Instruments)
Generic Instrument Name	Conductivity Meter
Generic Instrument Description	Conductivity Meter - An electrical conductivity meter (EC meter) measures the electrical conductivity in a solution. Commonly used in hydroponics, aquaculture and freshwater systems to monitor the amount of nutrients, salts or impurities in the water.

Dataset-specific Instrument Name	ROV Jason
Generic Instrument Name	ROV Jason
Generic Instrument Description	The Remotely Operated Vehicle (ROV) Jason is operated by the Deep Submergence Laboratory (DSL) at Woods Hole Oceanographic Institution (WHOI). WHOI engineers and scientists designed and built the ROV Jason to give scientists access to the seafloor that didn't require them leaving the deck of the ship. Jason is a two-body ROV system. A 10-kilometer (6-mile) fiber-optic cable delivers electrical power and commands from the ship through Medea and down to Jason, which then returns data and live video imagery. Medea serves as a shock absorber, buffering Jason from the movements of the ship, while providing lighting and a bird's eye view of the ROV during seafloor operations. During each dive (deployment of the ROV), Jason pilots and scientists work from a control room on the ship to monitor Jason's instruments and video while maneuvering the vehicle and optionally performing a variety of sampling activities. Jason is equipped with sonar imagers, water samplers, video and still cameras, and lighting gear. Jason's manipulator arms collect samples of rock, sediment, or marine life and place them in the vehicle's basket or on "elevator" platforms that float heavier loads to the surface. More information is available from the operator site at URL.

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Deployments

AT42-19

Website	https://www.bco-dmo.org/deployment/867020
Platform	R/V Atlantis
Start Date	2019-10-29
End Date	2019-11-10
Description	BASIN project cruise to study chemical processes that occur in oxygen-limited waters along the continental margins. See more information at R2R: https://www.rvdata.us/search/cruise/AT42-19

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Project Information

Collaborative Research: Do benthic feedbacks couple sulfur, nitrogen and carbon biogeochemistry during transient deoxygenation? (BASIN)

Coverage: Santa Barbara Basin, California, USA

NSF Award Abstract:
This study focuses on chemical processes that occur in oxygen-limited waters along the world's continental margins. These processes are influenced by the activities of microbes and control the fate of key elements that are deposited to sediments in these areas including carbon, nitrogen and sulfur. As a result, they are key to the health and function of the ocean. The intellectual merit of this research is to study the coupled chemical and microbial processes that occur in these environments by combining robotic technology with experiments that will be conducted at the ocean floor and in the shipboard laboratory. The broader impacts of this project will provide at-sea training and educational opportunities to undergraduate and graduate students and the results will be broadly distributed to stakeholders and interested parties. Results from this research promise to identify and quantify rates for key processes that couple carbon, nitrogen and sulfur in marine environments adjacent to the continents. The project addresses an important aspect of environmental change in the ocean (i.e., decreased oxygen due to warming and nutrient enrichment) and its influence on chemical and biological cycles and ocean ecosystems.

The dynamics of oxygen minimum zones along continental margins, and their potential for future expansion, are important because of their intersection with global biogeochemical cycles and because of their far-reaching impacts on ocean ecosystems. However, the impacts of transient deoxygenation on biogeochemical cycles of carbon, nitrogen and sulfur at the sea floor are not well established and are the focus of this study. This study will test the overarching hypothesis that deoxygenation triggers a positive feedback loop between bacterial mats at the sea floor that consume hydrogen sulfide, a sulfur species that can be toxic to higher organisms, and an underlying community of bacteria that produce hydrogen sulfide. By this hypothesis, the establishment of sea floor mats, which depend on inorganic nitrogen sources to run their sulfur metabolism, accelerates nitrogen cycling in the uppermost sediment horizon following deoxygenation. The accelerated nitrogen cycling allows for upward expansion of the sulfide-producing bacteria, which in-turn provide a shallow source of sulfide as substrate to further support nitrogen cycling in the sea floor mat. The results of this study will enable understanding of the relationship between oxygen dynamics in the water column and the biogeochemical processes at the sea floor that link the transformations of carbon, nitrogen and sulfur. The results of this study promise to define the environmental conditions under which the sulfur and nitrogen cycles are coupled and subject to strong positive feedbacks at the seafloor, as well as the conditions under which they are decoupled. This study provides training in research and innovative analytical and experimental techniques to four graduate students and several undergraduates. Undergraduates will be engaged in research at two institutions, one of which has recently been designated as a Hispanic serving institution. Approximately 10 undergraduate students (20 in total) will participate in each of the two proposed oceanographic expeditions, through an established course entitled: Field Studies in Marine Biogeochemistry. This course provides an opportunity for students to develop an independent research project in advance of the expedition, to participate on the expedition, and to conduct research projects while at sea.

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-1829981
NSF Division of Ocean Sciences (NSF OCE)	OCE-1830033

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