Dark DIC Fixation Rates collected from CliOMZ AT50-10 in the Eastern Pacific Ocean from May to June 2023 (CliOMZ project)

Website: https://www.bco-dmo.org/dataset/948396
Data Type: Cruise Results
Version: 4
Version Date: 2025-08-05

Project
» Collaborative Research: Underexplored Connections between Nitrogen and Trace Metal Cycling in Oxygen Minimum Zones Mediated by Metalloenzyme Inventories (CliOMZ)

Contributors	Affiliation	Role
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Abstract
These data include dark dissolved inorganic carbon (DIC) fixation rates measured on R/V Atlantis (CliOMZ AT50-10 expedition) from Golfito, Costa Rica to San Diego, USA in May-June 2023. We aimed at quantifying dark DIC fixation rates associated with nitrification by specifically inhibiting ammonia-oxidizing microorganisms. Instruments used were a CTD profiler and a scintillation counter (Perkin-Elmer Tri-Carb 2910 TR).

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Coverage

Location: Eastern Tropical and Subtropical Pacific Ocean
Spatial Extent: **N**:16.07453 **E**:-88.97095 **S**:-9.9999 **W**:-108.05027
Temporal Extent: 2023-05-04 - 2023-06-02

Methods & Sampling

Water samples were collected during cruise AT50-10 in the eastern tropical and subtropical Pacific Ocean. Discrete water samples were obtained using a CTD rosette sampler equipped with 24 x 10 L Niskin bottles. Different depths were sampled ranging from 55 meters to 1500 meters. The sampling strategy focussed on targeting low oxygen zones within the water column. For depths where O2 concentrations were above 20 µM, water was dispensed into 40 mL glass vials with teflon septa (TOC-certified, Fisher Scientific). For depths where in situ O2 concentrations were ≤20 µM, water was sampled directly from the Niskin bottle into 60 mL glass serum bottles using tygon tubing, allowing approximately three volumes of sample water to overflow the bottle prior to collection. Serum bottles were closed bubble-free with deoxygenated butyl rubber stoppers (De Brabandere et al. 2012) and sealed with aluminum crimps. A 20 mL helium (He) headspace was introduced to each serum bottle and oxygen was then added back to reach in situ concentrations by injecting air using gas-

tight syringes (Hamilton) with volumes calculated using the solubility equations of Garcia and Gordon (1992).

For each depth, seven replicate bottles were filled, sealed and spiked with 50 µCi [14C]-bicarbonate (specific activity 56 mCi mmol−1/2.072 × 109 Bq mmol−1; PerkinElmer). To three bottles, 10 µM phenylacetylene dissolved in DMSO (0.01% final concentration) was added to inhibit ammonia oxidation activities as described in Bayer et al. 2024. One bottle served as killed control to which formaldehyde (3% vol/vol) was added at the start of incubation. Bottles were incubated in the dark at in situ temperature and live incubations terminated after 24-72 hours by adding formaldehyde (3% vol/vol). After 30–60 minutes, samples were filtered onto 0.2 µm polycarbonate filters (GTTP, 25mm, Millipore) and rinsed with 10 mL of artificial seawater at a vacuum pump pressure of ~100 mbar. Incubation times were chosen according to the productivity of the sampling region (Bayer et al. 2024). The filters were transferred to scintillation vials, 10 mL of scintillation cocktail (Ultima Gold; PerkinElmer) was added, samples were shaken for ca. 30 seconds and incubated in the dark for at least 24 hours prior to counting the disintegrations per minute (DPM) in a scintillation counter (Perkin-Elmer Tri-Carb 2910 TR) for 15 minutes. Total radioactivity measurements were performed to verify added [14C]-bicarbonate concentrations and DIC fixation rates were calculated as described previously (Bayer et al. 2022).

Data Processing Description

The mean DPM of the samples were corrected for the DPM of the blank, converted into organic carbon fixed over time and corrected for the ambient seawater DIC concentration.

BCO-DMO Processing Description

Version 1 (948396_v1_dark_dic_fixation_rates.csv)
- Converted the primary data file from a variable-width plain text file to a CSV file.
- Dates converted from %d/%m/%Y to %Y-%m-%d.
- Latitude and longitude values corrected (original file contained transcription errors).
- This version contains altered (incorrect and inconsistent) data values caused by Excel. These errors have been corrected in Version 2 of the data.

Version 2 (948396_v2_dark_dic_fixation_rates.csv)
- Removed blank rows from the provided data file.
- Dates converted from %d/%m/%Y to %Y-%m-%d.
- NA "no data" values in data file have been replaced with blank values.
- Version 2 of this dataset includes data corrections to the original file.

Version 3 (948396_v3_dark_dic_fixation_rates.csv)
- Latitude and longitude values were corrected (previous version contained flipped coordinate values).
- Latitude and longitude values were rounded to 6 degrees of precision.

Version 4 (948396_v4_dark_dic_fixation_rates.csv)
- Latitude and longitude values were corrected further.
- Latitude and longitude values were rounded to 6 degrees of precision.
- Missing measurement values were added to the primary data file.

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Data Files

File	
948396_v4_dark_dic_fixation_rates.csv	(Comma Separated Values (.csv), 17.65 KB) MD5:636a9e26ccfacd23c2f0d561a7cf672a
Primary data file for dataset ID 948396, version 4	

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Related Publications

Bayer, B., Kitzinger, K., Paul, N. L., Albers, J. B., Saito, M. A., Wagner, M., Carlson, C. A., & Santoro, A. E. (2024). Contribution of ammonia oxidizers to inorganic carbon fixation in the dark ocean. https://doi.org/10.1101/2024.11.16.623942
Methods

Bayer, B., McBeain, K., Carlson, C. A., & Santoro, A. E. (2022). Carbon content, carbon fixation yield and dissolved organic carbon release from diverse marine nitrifiers. Limnology and Oceanography, 68(1), 84–96. Portico. https://doi.org/10.1002/lno.12252
Methods

De Brabandere, L., Thamdrup, B., Revsbech, N. P., & Foadi, R. (2012). A critical assessment of the occurrence and extend of oxygen contamination during anaerobic incubations utilizing commercially available vials. Journal of Microbiological Methods, 88(1), 147–154. https://doi.org/10.1016/j.mimet.2011.11.001
Methods

Garcia, H. E., & Gordon, L. I. (1992). Oxygen solubility in seawater: Better fitting equations. Limnology and Oceanography, 37(6), 1307–1312. doi:10.4319/lo.1992.37.6.1307
Methods

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Parameters

Parameter	Description	Units
Cruise	Cruise name from which sampling took place.	unitless
Date	Date of sampling.	unitless
Latitude	Sampling latitude in decimal degrees; a positive value indicates a northern coordinate.	decimal degrees
Longitude	Sampling longitude in decimal degrees; a positive value indicates a western coordinate.	decimal degrees
Station	Station number of cruise AT50-10.	unitless
Cast	Cast from which sample was taken.	unitless
Depth	Sampling depth.	meters (m)
Treatment	Additional amendments to incubation bottle; treatment options include, none, phenylacetylene addition, and DMSO.	unitless
DIC_fixation	Dark DIC fixation rate.	nanomoles per liter per day (nmol/L/d)
Incubation_time	Length of incubation with 14C-bicarbonate.	hours (h)
DIC_conc	Concentration of dissolved inorganic carbon.	micromoles per liter (umol/L)

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Instruments

Dataset-specific Instrument Name	Perkin-Elmer Tri-Carb 2910 TR
Generic Instrument Name	Liquid Scintillation Counter
Dataset-specific Description	Disintegrations per minute (DPM) were counted in a scintillation counter (Perkin-Elmer Tri-Carb 2910 TR).
Generic Instrument Description	Liquid scintillation counting is an analytical technique which is defined by the incorporation of the radiolabeled analyte into uniform distribution with a liquid chemical medium capable of converting the kinetic energy of nuclear emissions into light energy. Although the liquid scintillation counter is a sophisticated laboratory counting system used the quantify the activity of particulate emitting (ß and a) radioactive samples, it can also detect the auger electrons emitted from 51Cr and 125I samples. Liquid scintillation counters are instruments assaying alpha and beta radiation by quantitative detection of visible light produced by the passage of rays or particles through a suitable scintillant incorporated into the sample.

Dataset-specific Instrument Name	24x10 L Niskin Bottles
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Discrete water samples were collected using a rosette sampler equipped with 24×10 L Niskin bottles.
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

AT50-10

Website	https://www.bco-dmo.org/deployment/916122
Platform	R/V Atlantis
Report	https://www.rvdata.us/search/cruise/AT50-10
Start Date	2023-05-02
End Date	2023-06-09

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Project Information

Collaborative Research: Underexplored Connections between Nitrogen and Trace Metal Cycling in Oxygen Minimum Zones Mediated by Metalloenzyme Inventories (CliOMZ)

Coverage: Eastern Tropical Pacific

NSF abstract:
Though scarce and largely insoluble, trace metals are key components of sophisticated enzymes (protein molecules that speed up biochemical reactions) involved in biogeochemical cycles in the dark ocean (below 1000m). For example, metalloenzymes are involved in nearly every reaction in the nitrogen cycle. Yet, despite direct connections between trace metal and nitrogen cycles, the relationship between trace metal distributions and biological nitrogen cycling processes in the dark ocean have rarely been explored, likely due to the technical challenges associated with their study. Availability of the autonomous underwater vehicle (AUV) Clio, a sampling platform capable of collecting high-resolution vertical profile samples for biochemical and microbial measurements by large volume filtration of microbial particulate material, has overcome this challenge. Thus, this research project plans an interdisciplinary chemistry, biology, and engineering effort to test the hypothesis that certain chemical reactions, such as nitrite oxidation, could become limited by metal availability within the upper mesopelagic and that trace metal demands for nitrite-oxidizing bacteria may be increased under low oxygen conditions. Broader impacts of this study include the continued development and application of the Clio Biogeochemical AUV as a community resource by developing and testing its high-resolution and adaptive sampling capabilities. In addition, metaproteomic data will be deposited into the recently launched Ocean Protein Portal to allow oceanographers and the metals in biology community to examine the distribution of proteins and metalloenzymes in the ocean. Undergraduate students will be supported by this project at all three institutions, with an effort to recruit minority students. The proposed research will also be synergistic with the goals of early community-building efforts for a potential global scale microbial biogeochemistry program modeled after the success of the GEOTRACES program, provisionally called "Biogeoscapes: Ocean metabolism and nutrient cycles on a changing planet".

The proposed research project will test the following three hypotheses: (1) the microbial metalloenzyme distribution of the mesopelagic is spatially dynamic in response to environmental gradients in oxygen and trace metals, (2) nitrite oxidation in the Eastern Tropical Pacific Ocean can be limited by iron availability in the upper mesopelagic through an inability to complete biosynthesis of the microbial protein nitrite oxidoreductase, and (3) nitrite-oxidizing bacteria increase their metalloenzyme requirements at low oxygen, impacting the distribution of both dissolved and particulate metals within oxygen minimum zones. One of the challenges to characterizing the biogeochemistry of the mesopelagic ocean is an inability to effectively sample it. As a sampling platform, we will use the novel biogeochemical AUV Clio that enables high-resolution vertical profile samples for biochemical and microbial measurements by large volume filtration of microbial particulate material on a research expedition in the Eastern Tropical Pacific Ocean. Specific research activities will be orchestrated to test the hypotheses. Hypothesis 1 will be explored by comparison of hydrographic, microbial distributions, dissolved and particulate metal data, and metaproteomic results with profile samples collected by Clio. Hypothesis 2 will be tested by incubation experiments using 15NO2- oxidation rates on Clio-collected incubation samples. Hypothesis 3 will be tested by dividing targeted nitrite oxidoreductase protein copies by qPCR (quantitative polymerase chain reaction)-based nitrite oxidizing bacteria abundance (NOB) to determine if cellular copy number varies with oxygen distributions, and by metalloproteomic analyses of NOB cultures. The demonstration of trace metal limitation of remineralization processes, not just primary production, would transform our understanding of the role of metals in biogeochemical cycling and provide new ways with which to interpret sectional data of dissolved and particulate trace metal distributions in the ocean. The idea that oxygen may play a previously underappreciated role in controlling trace metals due not just to metals' physical chemistry, but also from changing biological demand, will improve our ability to predict trace metal distributions in the face of decreasing ocean oxygen content.

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-1924512

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