NanoSIMS measurements of skeletal organic matrix and aragonite extension in lab-grown scleractinian cold-water corals from February of 2022 to July 2023

Website: https://www.bco-dmo.org/dataset/959981
Data Type: experimental
Version: 1
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Project
» Collaborative Research: Refining the use of scleractinian cold-water coral skeleton-bound d15N as a proxy for marine N cycling (Coral-bound N)

Contributors	Affiliation	Role
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Abstract
This dataset contains both raw and processed NanoSIMS Data from analyses of cold-water coral skeletons. Data were collected using both cesium and oxygen ion beams in order to collect trace elements (both cations and anions). The raw data are included as .chk_im and .im files, which are data files output by Cameca's proprietary software. The processed data take the form of image files and matrices that provide quantitative and qualitative chemical image maps. The data were collected between February 2022 and July 2023 at the Environmental Molecular Sciences Laboratory. These data were collected to investigate the incorporation of a tracer isotope, 15N, into the coral organic matrix. They were also collected to understand the relationship between organic matrix deposition in coral skeletons and coral aragonite growth. Scientists interested in biomineralization and the impact of vital effects on coral trace element proxies are likely to find this data useful.

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Coverage

Temporal Extent: 2022-02-01 - 2023-09-01

Methods & Sampling

Cameca NanoSIMS 50L at the Environmental Molecular Sciences Laboratory at the Pacific Northwest National Lab (PNNL). In addition to NanoSIMS analyses of our experimental and control samples, we also analyzed regions of samples that were only naturally grown. Using both O^- (RF-plasma) and Cs^+ source beams, we reconstructed 35 x 35 μm^2 maps of elemental and isotope ratios. Specifically, negative ions collected included $^{12}C^{14}N^-$, $^{12}C^{15}N^-$, $^{12}C^-$, $^{12}C_2^-$, and $^{32}S^-$. Positive ions included $^{6}Li^+$, $^{23}Na^+$, $^{24}Mg^+$, $^{39}K^+$, $^{44}Ca^+$, $^{55}Mn^+$, and $^{88}Sr^+$. The primary beam current was 3pA for Cs^+ and 10 pA for O^- with a 3 ms dwell time per pixel. In order to standardize the N isotope composition of measured corals, natural abundance yeast standards were measured at the beginning of each day of Cs^+ analyses. No presputtering was used, but data were collected in a series of 6-8 planes, such that it was possible to remove frames associated with gold coating or with signs of surface contamination (usually indicated by high Na signals or low ^{12}C signals). Each NanoSIMS image stack consisted of 3-8 planes, depending on the number removed due to surface contamination, which were drift-corrected and summed to generate a single image for each secondary ion species detected.

Live B. elegans adults for this study were collected near Friday Harbor Labs, San Juan Island, Washington, USA in December 2020 at a depth of ~10 m by divers. Individuals were secured using flexible PVC tubes in seawater-filled plastic containers and shipped overnight with ice packs to Minnesota for coral culturing. Upon arrival at St. Olaf College, corals were kept in artificial seawater-filled bottles and planulae appeared in bottles almost immediately. After larvae settled and metamorphosed, both juvenile corals and adults were allowed to recover for ~6 months in plastic, artificial seawater-filled bottles and fed Artemia salina nauplii 2x weekly.

Data Processing Description

Raw data were processed using Look@NanoSIMS (Polerecky et al. 2012, **https://doi.org/10.1111/j.1462-2920.2011.02681.x**) and R (https://www.R-project.org/). NanoSIMS images of the same regions but collected using different ion source polarities were aligned using an interactive tool in Look@NanoSIMS . Alignments were made based on non-chemical features in the images, such as pits in the aragonite coral surface, which were most visible in the $^{12}C^-$ (Cs^+ source) and $^{44}Ca^+$ (O^- source) data. Lateral profiles were drawn on aligned images to compare the locations with CN, C_2, S, and ^{15}N-enrichment to the experimentally-induced banding in Mn/Ca, Sr/Ca, and ^6Li/Ca. Lateral profiles were drawn perpendicularly to growth banding in order to investigate the patterns of chemical behavior across a transect of a single nanoSIMS image. To increase signal to noise ratio on these transects, we averaged 5 pixels on either side of the lateral profile line. Look@NanoSIMS was used together with Matlab version MATLAB_R2022a.

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Related Publications

A.M. Gothmann, J. Daniel, Y. Chan , P. Diaz , J.B. Cliff, L. Polerecky, J. Granger, J.L. Mottram, M. Prokopenko , L. Boehm Vock , A. Logan, N. Mersy, T. Smith, J. Stolarski . (n.d.) NanoSIMS mapping of skeletal organic matrix and aragonite formation in a scleractinian cold-water coral. Geochimica et Cosmochimica Acta. In Review.
Results

MathWorks (2022), R2022a at a Glance, The Mathworks, Inc. Retrieved from https://www.mathworks.com/products/new_products/release2022a.html
Software

Polerecky, L. (2012). Look@NanoSIMS User's manual (version 24-04-2012). Made available by author Lubos Polerecky, Max-Planck Institute for Marine Microbiology, Bremen, Germany through Dropbox. Accessible on April 29th, 2025 from https://www.dropbox.com/scl/fo/c187i9lk38it6poi78e77/ABY2eMuEphJhfmfdvm7CXzw/manual?dl=0&preview=LANS-manual.pdf&rlkey=nck17vtdq7pddkzdxefuvc5l0&subfolder_nav_tracking=1
Methods

Polerecky, L., Adam, B., Milucka, J., Musat, N., Vagner, T., & Kuypers, M. M. M. (2012). Look@NanoSIMS – a tool for the analysis of nanoSIMS data in environmental microbiology. Environmental Microbiology, 14(4), 1009–1023. Portico. https://doi.org/10.1111/j.1462-2920.2011.02681.x
Methods

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Related Datasets

Software

Gothmann, A. (2025). agothmann/ImageAnalysis_CWC_NanoSIMS: Calculating co-occurrence from NanoSIMS Chemical Images (NanoSIMS_CoOccurence) [Computer software]. Zenodo. https://doi.org/10.5281/ZENODO.15270676 https://doi.org/10.5281/zenodo.15270676

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Cameca NanoSIMS 50L
Generic Instrument Description	SIMS Microprobe for Isotopic and Trace Element Analysis at High Spatial Resolution The NanoSIMS 50L is a unique ion microprobe optimizing SIMS analysis performance at high lateral resolution. It is based on a coaxial optical design of the ion beam and the secondary ion extraction, and on an original magnetic sector mass analyzer with multicollection. (source: https://www.cameca.com/products/sims/nanosims)

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Project Information

Collaborative Research: Refining the use of scleractinian cold-water coral skeleton-bound d15N as a proxy for marine N cycling (Coral-bound N)

Coverage: Global ocean

NSF abstract:

Refining the use of scleractinian cold-water coral skeleton-bound d15N as a proxy for marine N cycling

Recent studies show that cold-water corals and their skeletons provide valuable information about the marine nitrogen (N) cycle. This information can shed light on the processes that both drive and respond to changes in Earth’s climate. Cold-water corals are found across the global ocean and can be dated with decadal precision, offering spatial and temporal records of the N cycle in the past. In addition, a single skeleton can be used to reconstruct both surface and deep ocean composition. Despite the promise of cold-water corals, we don’t fully understand how they record changes in the marine N cycle. We must strengthen this understanding before we use cold-water corals to produce reliable records of marine N cycling across space and time, across different coral species, and under different lifestyle and feeding patterns. This project examines how the isotopic composition of organic N trapped in coral skeletons is linked to marine N cycle properties. The study includes a series of lab experiments, measurements of live corals sampled from the natural environment, and measurements of coral skeletal material from different ocean regions and depth horizons archived in museums. The project involves undergraduates at St. Olaf College, Pomona College and Mt. San Antonio College, one of the largest community colleges in Southern California. These students will conduct the research with scientists and peers in collaborating labs. Participation in the project will build student research skills and scientific knowledge for advanced study and prepare students for the scientific workforce. The project will also develop educational materials, including YouTube videos, to promote interest in marine science and awareness of how climate change influences global oceans. These educational materials will be created in collaboration with high school students from underrepresented groups.

The main tool used to investigate marine N cycle history is the isotope composition of particulate organic nitrogen (δ15N-PON) exported from the euphotic zone, which can be accessed using sedimentary archives such as foraminiferal tests, anoxic sediments and soft corals. Recently, the δ15N of organic N trapped within asymbiotic scleractinian cold-water coral (CWC) skeletons has been shown to record the δ15N-PON exported from the surface ocean (Wang et al. 2014; Wang et al. 2017). In order to reliably apply CWC δ15N as a proxy, however, we must explain a ~8.5‰ offset between the δ15N of organic nitrogen within the CWC skeleton and the exported δ15N-PON in regions of coral growth (Wang et al. 2014). The nature of the δ15N offset must be accounted for to be confident that CWC records marine N cycle history consistently across space and time, across different coral species, and for corals with different lifestyle conditions. Through coral culture experiments, measurements of live corals samples from the natural environment, and archives of corals skeletal material from different ocean regions and depth horizons, this research will test whether the offset arises from: (1) a biosynthetic isotope offset between CWC tissue and skeleton, (2) an unusual trophic transfer between CWC tissue and diet, and/or (3) coral feeding on material with elevated δ15N relative to exported δ15N-PON. This work will also provide estimates of N turnover time in CWC, which are scant, and will inform trophic ecology of CWC.

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
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