Single cell N2 fixation measurements from UCYN-A symbiosis in the Southern California Current System from May 2017 (SP1714) and October (SP1724) SCCS cruises.

Website: https://www.bco-dmo.org/dataset/881078
Data Type: Other Field Results
Version: 1
Version Date: 2024-06-24

Project
» Collaborative Research: Biogeochemical significance of the abundant, uncultivated symbiotic cyanobacteria UCYN-A (BSUCS)

Contributors	Affiliation	Role
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Abstract
Single cell N2 fixation measurements from UCYN-A symbiosis in the Southern California Current System from May 2017 (SP1714) and October (SP1724) SCCS cruises.

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Coverage

Spatial Extent: **N**:32.846 **E**:-115.914 **S**:28.289 **W**:-120.249

Dataset Description

These data were published in Turk-Kubo et al. (2021). Table 1, Figure 6, Table S6, Table S7.

Methods & Sampling

Samples were collected using standard oceanographic techniques. A CTD Rosette with 24 10L Niskin bottles was lowered to the maximum sampling depth and then brought back to the surface. Seawater was sampled directly from Niskin® bottles into acid-washed 1.2 l polycarbonate bottles through 210 µm Nitex® mesh (Wildco, Yulee, FL) to remove large grazers.

Methodology described in depth in Turk-Kubo et al. (2021)

Data Processing Description

Subsamples (95 ml) taken from the incubation bottles were fixed with sterile-filtered formaldehyde (MilliporeSigma) at a final concentration of 1.85% (v/v) for >1 h at 4 °C, then concentrated with 0.6 µm pore-size polycarbonate filters (MilliporeSigma) under gentle vacuum, air-dried and stored at −80 °C. UCYN-A1 and UCYN-A2 symbioses were targeted using 5′-horseradish peroxidase-labeled oligonucleotide probes (Biomers, Inc., Ulm/Donau, Germany), using helper and competitor probes for both symbionts and hosts (Biomers). Protocols for CARD-FISH hybridizations followed procedures described in detail by Cabello et al. 2016.

Samples were visualized, transferred, and mapped to facilitate nanoSIMS analyses according to protocols detailed in Mills et al. 2020. Individual symbioses were analyzed on a Cameca nanoSIMS 50 L at the Stanford Nano Shared Facilities (Stanford, CA). Once targets were located using the charged-coupled device camera and the secondary electron image, image fields were rastered with a 16 keV Cesium primary ion beam (~5 pA) focused into ca. 120 nm spot diameter (256 × 256 pixels, dwell time 1 ms per pixel). Images of 12C−, 13C−, 12C14N−and 12C15N− were measured over 30–100 planes with a mass resolving power of ca. 8000. Regions of interest were defined around UCYN-A and host cells using Look@nanoSIMS. Isotope ratios of UCYN-A and haptophyte cells were calculated as described in Mills et al. 2020.

Methodology described in depth in Turk-Kubo et al. (2021)

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Data Files

File
881078_v1_singlecelln2.csv (Comma Separated Values (.csv), 5.74 KB) MD5:80657c657f6b19ab115eb2b4a2527b36 Primary data file for dataset ID 881078, version 1

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Related Publications

Turk-Kubo, K. A., Mills, M. M., Arrigo, K. R., van Dijken, G., Henke, B. A., Stewart, B., Wilson, S. T., & Zehr, J. P. (2021). UCYN-A/haptophyte symbioses dominate N2 fixation in the Southern California Current System. ISME Communications, 1(1). https://doi.org/10.1038/s43705-021-00039-7
Results

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Parameters

Parameter	Description	Units
Cruise	Cruise: SP1714 or SP1727	unitless
Station	Station number	unitless
Latitude	Latitude of sampling, south is negative	decimal degrees
Longitude	Longitude of sampling, west is negative	decimal degrees
nearshore_offshore	nearshore or offshore sample	unitless
Cell	cell number	unitless
ROI	Region of interest: Host, UCYN-A1 or UCYN-A2	unitless
PN	Particulate Nitrogen	Femtomole Nitrogen per cell (fmol N cell-1)
at_15N	Atom % (percentage) enrichment of the particulate nitrogen	precentage (%)
individual_single_cell_N2_fixation_rate	Individual single-cell N2 fixation rate	Femtomole Nitrogen per cell per day (fmol N cell-1 d-1)
at_15N2_mean	Atom % enrichment of the N2 pool - average	precentage (%)
at_15N2_stdev	Atom % enrichment of the N2 pool - standard deviation	precentage (%)

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Instruments

Dataset-specific Instrument Name	Cameca nanoSIMS 50L
Generic Instrument Name	Mass Spectrometer
Dataset-specific Description	Samples for single cell N2 fixation and CO2 fixation rates were analyzed using a Cameca nanoSIMS 50L (https://www.cameca.com/products/sims/nanosims) located at Stanford University's nano shared facilities (SNSF, https://snsf.stanford.edu/equipment/xsa/nanosims.html).
Generic Instrument Description	General term for instruments used to measure the mass-to-charge ratio of ions; generally used to find the composition of a sample by generating a mass spectrum representing the masses of sample components.

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Deployments

SP1714

Website	https://www.bco-dmo.org/deployment/699986
Platform	R/V Robert Gordon Sproul
Start Date	2017-05-03
End Date	2017-05-11
Description	R/V Robert Gordon Sproul Cruise SP1714 May 3 - 11, 2017 Chief Scientist - Matthew Mills (mmmills@stanford.edu) See more cruise information from R2R: https://www.rvdata.us/search/cruise/SP1714

SP1727

Website	https://www.bco-dmo.org/deployment/774496
Platform	R/V Robert Gordon Sproul
Start Date	2017-10-04
End Date	2017-10-11
Description	R/V Robert Gordon Sproul Cruises SP1727 October 4 - 11, 2017 Chief Scientist - Matthew Mills (mmmills@stanford.edu) See more cruise information from R2R: https://www.rvdata.us/search/cruise/SP1727

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Project Information

Collaborative Research: Biogeochemical significance of the abundant, uncultivated symbiotic cyanobacteria UCYN-A (BSUCS)

Coverage: California Current waters off the Southern California shelf

NSF Award Abstract:
Nitrogen is a nutrient whose availability limits growth and productivity of ecosystems. Nitrogen is extremely abundant in the atmosphere in the inert form of gaseous N2, but most organisms cannot reduce N2 into a biologically available form. In all environments, including agricultural soils, there are microorganisms that can make available the N from gaseous N2 by reducing it to the biologically available form, ammonium. In the vast expanses of the open ocean, few organisms are known to have this ability, and recently a unique symbiosis between a single-celled cyanobacterium and a single-celled algae was discovered, which appears to be very widely distributed and likely of global biogeochemical significance. The cyanobacterium in this symbiotic partnership has very unusual metabolism and genomic streamlining. Little is known of the symbiosis because it is not detectable except by modern molecular biological techniques. Recent work has shown this symbiosis to be very widely spread through the oceans, and that there is previously unrecognized diversity in both the cyanobacterial and algal hosts. This research will examine the environmental distributions and the biogeochemical significance of this diversity in coastal US waters. The investigators will engage the public in ocean sciences through internship programs at local high schools and for undergraduate students at Stanford, and by documenting their field research in a 'virtual cruise' blog.

In the marine environment, the contribution of N2 fixation to the fixed nitrogen (N) pool is poorly quantified, in part due to an incomplete understanding on the abundance, activity, and physiology of diazotrophs. The symbiotic unicellular cyanobacteria (UCYN-A) is a poorly characterized, yet globally important, group of marine diazotrophs. UCYN-A is widely distributed in the marine environment, and lives symbiotically with a picoeukaryotic prymnesiophyte alga. We now know that there are multiple ecotypes of UCYN-A, which may be adapted to specific locations in the water-column and different oceanic provinces. Typically N2 fixation was considered unimportant in coastally influenced and non-tropical waters, however recent data shows that multiple subclades of UCYN-A are present. The distribution and rate of N2 fixation by UCYN-A subclades in coastal/nearshore environments is a major unknown in the oceanic N cycle. Its presence in nearshore waters may change the paradigm of the balance between basin N sources (N2 fixation) and sinks (denitrification).

Likewise, significant N2 fixation by UCYN-A will need to be considered when determining estimates of new production in coastally influenced waters. This project aims to quantify the significance of different UCYN-A subclades to coastal/nearshore N budgets. It tackles the issue of determining N2 fixation rates by different UCYN-A subclades in coastal waters through rigorous fieldwork off the west coast of North America. The temporal and spatial distribution of UCYN-A subclades, as well as the rates of N2 fixation, will be determined by coupling N2 fixation measurements of bulk communities and individual cells (nanoSIMS) with molecular assays to study these widespread, but dilute, diazotrophic symbionts and their hosts. Additionally the investigators will conduct experiments aimed at constraining the effects of light and nutrient ratios (N/P) on UCYN-A N2 fixation rates, and the prymnesiophyte host's rate of carbon fixation. They will conduct this work through seasonal sampling of a coastal site in the Southern California Bight (Scripps Pier) and on two process cruises in the coastal waters between central California and the Baja Peninsula. The cruise work will provide an opportunity to understand the temporal dynamics of the UCYN-A/prymnesiophyte associations over larger spatial scales. Finally, evidence suggests that unidentified UCYN-A subclades and hosts exist and the investigators have developed a strategy to identify and quantify their temporal and spatial distributions as well as their N2 fixation activities. Data on the coastal distribution, ecology and activity of UCYN-A is critical for obtaining a better understanding of their contribution to fixed N to the marine environment. The group-specific and bulk rates of N2 fixation measured in this study of coastally influenced waters, will provide data for future modeling efforts, which will make an important contribution to constraining oceanic N2 fixation inputs.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1559165
NSF Division of Ocean Sciences (NSF OCE)	OCE-1559152

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