

# Composition and concentration of individual biomarkers in particulate organic carbon collected during two cruises to the Amazon River plume during R/V Knorr cruise KN197-08 in 2010 and R/V Melville cruise MV1110 in 2011

**Website:** <https://www.bco-dmo.org/dataset/936596>

**Data Type:** Cruise Results

**Version:** 1

**Version Date:** 2024-09-06

## Project

» [Amazon iNfluence on the Atlantic: CarbOn export from Nitrogen fixation by DiAtom Symbioses](#) (ANACONDAS)

## Programs

» [Integrated Marine Biogeochemistry and Ecosystem Research -US](#) (IMBER-US)

» [Ocean Carbon and Biogeochemistry](#) (OCB)

» [Emerging Topics in Biogeochemical Cycles](#) (ETBC)

» [Marine Microbiology Initiative](#) (MMI)

Contributors	Affiliation	Role
<a href="#">Medeiros, Patricia M.</a>	University of Georgia (UGA)	Principal Investigator
<a href="#">Utsumi, Giovanna A.</a>	Federal University of São Paulo (UNIFESP)	Student
<a href="#">Rauch, Shannon</a>	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

## Abstract

These data include composition and concentration of individual biomarkers collected during two cruises to the Amazon River plume. Particulate organic carbon (POC) was collected in 2010 (high discharge) on a cruise aboard the R/V Knorr between 2010-05-23 and 2010-06-21, and in 2011 (low discharge) on a cruise aboard the R/V Melville between 2011-09-05 and 2011-10-06. Water was collected using CTD water sampling and particulate material was collected using 0.7 micrometer GF/F filters. These data help to clarify the Amazon River plume's impact on the biological pump of the tropical Atlantic Ocean, consistent with a river plume fueling primary production, and with increased zooplankton and bacteria contributions to POC composition at depth and in the POC that is vertically exported. All POC samples were collected by Dr. Patricia Medeiros at the University of Georgia.

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## Coverage

**Location:** Amazon River Plume and surrounding Atlantic Ocean

**Spatial Extent:** N:12.4055 E:-44.6382 S:4.8787 W:-56.4252

**Temporal Extent:** 2010-05-25 - 2011-10-06

## Methods & Sampling

Particulate organic carbon (POC) samples were collected in the Amazon River plume and adjacent ocean in May/June 2010 during high river discharge conditions and in September/October 2011 during low river discharge (onboard the R/V Knorr and R/V Melville, respectively, as part of the ANACONDAS expeditions; Medeiros et al., 2015).

Stations sampled during high discharge conditions are labeled H followed by the station number, while during low discharge they are labeled L followed by the station number.

Suspended samples were collected at the surface (~2 meters (m)), immediately below the plume (at ~20 m) and at depth (~1000 m and 2000 m) using CTD-rosette casts. At key oceanic stations, more highly resolved vertical profiles were also collected, including samples at the chlorophyll-a maximum and oxygen minimum depths. Seawater was filtered through 0.7-micrometer ( $\mu\text{m}$ ) Whatman GF/F filters (pre-combusted at 450 degrees Celsius ( $^{\circ}\text{C}$ ) for 5 hours), carefully wrapped using pre-combusted aluminum foil, and kept frozen at  $-20^{\circ}\text{C}$  until analysis. Samples were processed within 1-2 weeks after the end of the expeditions, minimizing the effects of any possible degradation that may have occurred during storage.

Prior to analyses, POC samples were allowed to dry at room temperature. Biomarkers were extracted from dried POC samples as in Medeiros et al. (2012) with a mixture of dichloromethane:methanol (2:1, v/v) using accelerated solvent extraction (ASE 350, Dionex) at  $100^{\circ}\text{C}$  and 1000 psi (3 static cycles). The extracts were concentrated in a RapidVap to about 2 milliliters (mL), then further concentrated to 500 microliters ( $\mu\text{L}$ ) using a stream of ultra-high purity nitrogen gas. Aliquots of the total extracts were converted to their trimethylsilyl derivatives using N,O-bis-(trimethylsilyl)trifluoroacetamide (BSTFA) containing 1% trimethylchlorosilane (TMCS) and pyridine (Pierce) for 3 hours at  $70^{\circ}\text{C}$ . Aliquots of 1  $\mu\text{L}$  of silylated total extracts were analyzed within 24 hours using an Agilent 6890 gas chromatograph interfaced with an Agilent 5975 mass selective detector (GC-MS). A DB5-MS capillary column (30 m x 0.25 mm I.D. and film thickness of 0.25  $\mu\text{m}$ ) was used with helium as the carrier gas. The injector and MS source temperatures were maintained at  $280^{\circ}\text{C}$  and  $230^{\circ}\text{C}$ , respectively. The column temperature program consisted of injection at  $65^{\circ}\text{C}$  and hold for 2 minutes, temperature increase of  $6^{\circ}\text{C}$  per minute to  $300^{\circ}\text{C}$ , followed by an isothermal hold at  $300^{\circ}\text{C}$  for 15 minutes. The MS was operated in electron impact (EI) mode with an ionization energy of 70 eV. The scan range was set from 50 to 650 Da and the samples were analyzed in splitless mode.

Data were acquired and processed with the Agilent-Chemstation software. Individual compounds were identified by comparison of mass spectra with literature and library data, comparison of mass spectra and GC retention times with those of authentic standards and/or interpretation of mass spectrometric fragmentation patterns. Compounds were quantified using the total ion current (TIC) peak area and converted to compound mass using calibration curves of standards.

## Data Processing Description

Data were processed using 6890GC-5975 MS Agilent-Chemstation software.

## BCO-DMO Processing Description

- Imported original file "BCO-DMO\_Amazon\_POC\_stations\_2010\_2011\_final.xlsx" into the BCO-DMO system.
- Extracted station location information from the primary data table.
- Removed dashes from datasets (in final CSV file, missing data are empty/blank).
- Unpivoted the table to create columns for station number and depth.
- Joined the primary data table to the location information to create columns for Latitude, Longitude, Date, and Time.
- Sorted by station number and depth.
- Renamed fields to comply with BCO-DMO naming conventions.
- Created date-time fields in ISO 8601 format (UTC and local).

- Saved the final file as "936596\_v1\_amazon\_plume\_poc\_biomarkers.csv"

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## Data Files

File
<b>936596_v1_amazon_plume_poc_biomarkers.csv</b> (Comma Separated Values (.csv), 363.31 KB) MD5:5de2447282c722ed56ee9e0d84cdb8fd
Primary data file for dataset ID 936596, version 1

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## Supplemental Files

File
<b>BCO-DMO_Amazon_POC_stations_2010_2011_final.xlsx</b> (Microsoft Excel, 71.72 KB) MD5:ba803646fe218e903ad755d1b442f0a0
Supplemental file for dataset ID 936596, version 1. This is the original data file submitted to BCO-DMO prior to conversion to CSV format. (Data are the same as in "936596_v1_amazon_plume_poc_biomarkers.csv" but in a different format.)

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## Related Publications

Medeiros, P. M., Seidel, M., Ward, N. D., Carpenter, E. J., Gomes, H. R., Niggemann, J., Krusche, A. V., Richey, J. E., Yager, P. L., & Dittmar, T. (2015). Fate of the Amazon River dissolved organic matter in the tropical Atlantic Ocean. *Global Biogeochemical Cycles*, 29(5), 677-690. Portico. <https://doi.org/10.1002/2015gb005115>

*Methods*

Medeiros, P. M., Sikes, E. L., Thomas, B., & Freeman, K. H. (2012). Flow discharge influences on input and transport of particulate and sedimentary organic carbon along a small temperate river. *Geochimica et Cosmochimica Acta*, 77, 317-334. <https://doi.org/10.1016/j.gca.2011.11.020>

*Methods*

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## Related Datasets

### IsRelatedTo

Lønborg, C., Carreira, C., Abril, G., Agustí, S., Amaral, V., Andersson, A., Arístegui, J., Bhadury, P., Bif, M. B., Borges, A. V., Bouillon, S., Calleja, M. L., Cotovicz, L. C. J., Cozzi, S., Doval, M., Duarte, C. M., Eyre, B. D., Fichot, C., García-Martín, E., ... Álvarez-Salgado, X. A. (2023). A *global database of dissolved organic matter (DOM) concentration measurements in coastal waters (CoastDOM v.1)* [Data set]. PANGAEA. <https://doi.org/10.1594/PANGAEA.964012>

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## Parameters

Parameter	Description	Units
Station	Station number. H = high discharge; L = low discharge.	unitless
Depth	Depth of sampling	meters
Compound	Compound name	unitless
Concentration	Concentration ( $\mu\text{g g}^{-1}$ OC) of individual compound in suspended POC	micrograms per gram organic carbon ( $\mu\text{g g}^{-1}$ OC)
Latitude	Latitude of station	decimal degrees
Longitude	Longitude of station	decimal degrees
ISO_DateTime_Local	Date and time of sampling in ISO 8601 format in the local time zone (Brasilia time zone, i.e., UTC -03:00)	unitless
ISO_DateTime_UTC	Date and time of sampling in ISO 8601 format in UTC	unitless

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## Instruments

<b>Dataset-specific Instrument Name</b>	Accelerated Solvent Extraction (ASE 350)
<b>Generic Instrument Name</b>	Accelerated Solvent Extractor
<b>Generic Instrument Description</b>	Accelerated solvent extraction (ASE) is a method for extracting various chemicals from a complex solid or semisolid sample matrix. The process uses high temperature and pressure, which results in the extraction taking less time and requiring less solvent, and possibly also giving better analyte recovery, than traditional methods that use less extreme conditions.

<b>Dataset-specific Instrument Name</b>	Agilent 6890 gas chromatograph interfaced with an Agilent 5975 mass selective detector (GC-MS)
<b>Generic Instrument Name</b>	Agilent 6850 networked gas chromatograph
<b>Generic Instrument Description</b>	A single channel, networked, gas chromatograph that separates and analyses compounds into separate components and can be used for chemical, petrochemical and petroleum analyses. The sample is introduced into the injector and then vaporised in the instrument. A chemically inert gas (e.g. helium and nitrogen) carries the vaporised solute into the column that is maintained in a temperature controlled oven. As the solute elutes from the column, it enters the heated detector. An electronic signal is generated upon interaction of the solute with the detector. The Agilent 6850 has a similar performance to the Agilent 6890N GC, but is half as wide. The local interface provides run control and status information and the instrument comes network-ready with a built-in LAN communications interface. There is a choice of detectors available, the Flame Ionization Detector (FID), Thermal Conductivity Detector (TCD) or Mass Selective Detector (MSD). There is an option of split/splitless or packed inlets, a variety of automated sample introduction systems and products available for headspace analysis. This model is no longer in production.

<b>Dataset-specific Instrument Name</b>	911+ Rosette 24-position, 10-liter bottle Rosette with dual T/C sensors for collection
<b>Generic Instrument Name</b>	CTD Sea-Bird SBE 911plus
<b>Generic Instrument Description</b>	The Sea-Bird SBE 911 plus is a type of CTD instrument package for continuous measurement of conductivity, temperature and pressure. The SBE 911 plus includes the SBE 9plus Underwater Unit and the SBE 11plus Deck Unit (for real-time readout using conductive wire) for deployment from a vessel. The combination of the SBE 9 plus and SBE 11 plus is called a SBE 911 plus. The SBE 9 plus uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3 plus and SBE 4). The SBE 9 plus CTD can be configured with up to eight auxiliary sensors to measure other parameters including dissolved oxygen, pH, turbidity, fluorescence, light (PAR), light transmission, etc.). more information from Sea-Bird Electronics

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## Deployments

### KN197-08

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/58043">https://www.bco-dmo.org/deployment/58043</a>
<b>Platform</b>	R/V Knorr
<b>Report</b>	<a href="http://bcodata.whoi.edu/ANACONDAS/ANACONDAS1-FullCruiseReport.pdf">http://bcodata.whoi.edu/ANACONDAS/ANACONDAS1-FullCruiseReport.pdf</a>
<b>Start Date</b>	2010-05-22
<b>End Date</b>	2010-06-24
<b>Description</b>	ANACONDAS: Amazon iNfluence on the Atlantic: CarbOn export from Nitrogen fixation by DiAtom Symbioses ROCA: River Ocean Continuum of the Amazon Cruise information and original data are available from the NSF R2R data catalog: <a href="https://www.rvdata.us/search/cruise/KN197-08">https://www.rvdata.us/search/cruise/KN197-08</a> Cruise Track over Salinity Climatology (Image from Dr. Ajit Subramaniam)

## MV1110

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/58945">https://www.bco-dmo.org/deployment/58945</a>
<b>Platform</b>	R/V Melville
<b>Start Date</b>	2011-09-03
<b>End Date</b>	2011-10-08
<b>Description</b>	ANACONDAS: Amazon iNfluence on the Atlantic: CarbOn export from Nitrogen fixation by DiAtom Symbioses ROCA: River Ocean Continuum of the Amazon Original data are available from the NSF R2R data catalog: <a href="https://www.rvdata.us/search/cruise/MV1110">https://www.rvdata.us/search/cruise/MV1110</a> Cruise Track over Salinity Climatology (Image from Dr. Ajit Subramaniam)

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## Project Information

### Amazon iNfluence on the Atlantic: CarbOn export from Nitrogen fixation by DiAtom Symbioses (ANACONDAS)

**Website:** <http://amazoncontinuum.org/>

**Coverage:** Amazon River plume; NE coast of South America; Western Tropical North Atlantic - 15N-Equator and 60W to 45W - Region surrounding the Amazon River Plume

ANACONDAS is an IMBER endorsed project.

[View list of all IMBER endorsed projects](#)

View the ANACONDAS project [GCMD DIF record](#)

The ANACONDAS project was funded as part of the US National Science Foundation (NSF) Emerging Topics in Biogeochemical Cycles (ETBC) program (Directorate for Geosciences, NSF 07 -049, September 19, 2007) explicitly intended to support emerging areas of interdisciplinary research. The ETBC program aimed to foster transformational advances in the quantitative or mechanistic understanding of biogeochemical cycles that integrated physical-chemical-biological processes over the range of temporal and/or spatial scales in Earth's environments. The program especially sought proposals that addressed emerging topics in biogeochemical cycles, the water cycle or their coupling, across the interfaces of atmosphere, land, and oceans.

The ANACONDAS investigators hypothesize that large tropical river plumes with low N: P ratios provide an ideal niche for diatom-diazotroph assemblages (DDAs). They suggest that the ability of these organisms to fix N<sub>2</sub> within the surface ocean is responsible for significant C export in the Amazon River plume. Their previous observations in the Amazon River plume helped reveal that blooms comprised of the endosymbiotic N<sub>2</sub>-fixing cyanobacterium *Richelia* and its diatom hosts (e.g. *Hemiaulus*) were a significant source of new production and carbon export. The previous work focused largely on the sensitivity of DDAs to external forcing from dust and riverine inputs, so the ecology of these organisms and the fate of their new production were largely unstudied. It is now known that DDAs are responsible for a significant amount of CO<sub>2</sub> drawdown in the Amazon River plume, and floating sediment traps at 200 m measured 4x higher mass fluxes beneath the plume than outside the plume. This led the researchers to hypothesize that this greater export is due either to aggregation and sinking of DDAs themselves or to grazing of DDAs by zooplankton.

In this study the researchers will undertake a suite of field, satellite and modeling studies aimed at understanding the ecology and tracing the fate of C and N fixed by DDAs and other phytoplankton living in the plume. By examining C and silicate (Si) export from offshore surface waters, through the upper oceanic food web, the mesopelagic, and down to the deep sea floor, they will quantify the impact of the Amazon River on biological processes that control C sequestration and the implications of these regional processes on C, N and Si budgets. The study will go beyond previous research because they will quantify 1) the distribution, nutrient demands, and activity of DDAs in the context of phytoplankton species succession, 2) the sensitivity of the CO<sub>2</sub> drawdown to the mix of phytoplankton, 3) the grazing and aggregation processes contributing to the sinking flux, 4) the composition of this flux, and 5) the proportion of this material that reaches the seafloor.

This effort truly represents a measure of C sequestration and pump efficiency. Ecological modeling will be used to place observational results from field studies and satellites into the context of the larger Atlantic basin with tropical climate variability on interannual and longer time scales.

Three cruises were carried out during the ANACONDAS project:

AN10/KN197-08 - R/V KNORR - May/June 2010 - [Cruise Track over Salinity Climatology](#) (Image: Yager, et al, 2007)

AN11/MV1110 - R/V MELVILLE - September/October 2011 - [Cruise Track over Salinity Climatology](#) (Image: Yager, et al, 2007)

AN12/AT21-04 - R/V ATLANTIS - July/2012 - [Cruise Track over Salinity Climatology](#) (Image: Yager, et al, 2007)

The ANACONDAS project builds on observations made by MANTRA/PIRANA in 2001 and 2003 (RV Knorr and Seward Johnson I cruises to the same region) to address specifically 1) how carbon cycling and sequestration in the western tropical North Atlantic (WTNA) is influenced by the Amazon River through its impact on pelagic ecosystem dynamics and 2) the sensitivity of this ecosystem to anthropogenic climate change. PIRANA revealed the importance of both riverine and atmospheric inputs for driving the high productivity of the WTNA through N<sub>2</sub>-fixation, and demonstrated the significance of the region to basin-wide biogeochemistry and C cycling. ANACONDAS will now focus on what drives phytoplankton community succession through the plume, light and nutrient requirements, factors limiting productivity, and the fate of production. These components are critical to understand the role of the plume in the regional C cycle, and to predict its response to climate variability and change.

The NSF-funded ANACONDAS project will also serve as a platform for additional measurements supported by the Gordon and Betty Moore Foundation's Marine Microbiology Initiative. ROCA (River-Ocean Continuum of the Amazon) brings additional focus on marine microbial community structure and activities, along with high-resolution measurements of organic matter along the river-ocean continuum.

**ANACONDAS:** Amazon influence on the Atlantic: CarbOn export from Nitrogen fixation by DiAtom Symbioses  
**ROCA:** River Ocean Continuum of the Amazon

The project is funded by NSF-OCE-0934095 and NSF-OCE-0934036: Collaborative Research: ETBC: Amazon influence on the Atlantic: CarbOn export from Nitrogen fixation by DiAtom Symbioses and by the Gordon and Betty Moore Foundation through GBMF-MMI-2293: River Ocean Continuum of the Amazon.

## Planned Cruise Sampling

### Water Column Characterization (hydrographic sampling with CTD/Rosette):

Nutrient (NO<sub>2</sub>, NO<sub>2</sub>+NO<sub>3</sub>, PO<sub>4</sub>, SiO<sub>4</sub>) concentrations  
Chlorophyll a and pigments concentrations  
Inorganic carbon (discrete DIC, ALK, underway pCO<sub>2</sub>)  
Organic carbon, nitrogen, phosphorus  
Phytoplankton and Diazotroph Abundance (using rosette and also small nets to collect)  
Carbon and Nitrogen Fixation by plankton  
Kinetic and Physiological Measurements of phytoplankton  
Stable Isotopic Measurements of particulate material  
Microbial heterotrophy  
Microbial community structure and gene expression  
Organic carbon and biomarker characterization

### MOCNESS tows for zooplankton

Zooplankton collection for abundance and biomass  
Zooplankton grazing and POC flux measurements

### Multicorer for deep sea sediment analyses

Solid phase analysis  
Pore water chemistry  
Isotopic composition (Pb, Th, C)

### Other instrumentation over the side:

The in-water light field will be characterized with a free-falling 14 channel spectroradiometer  
Two "Carbon Explorers" - autonomous Sounding Oceanographic Lagrangian Observer profilers  
Sediment Trap Studies (using 48h deployments of floating Particle Interceptor Traps; PITs)  
Surface water pumps - directly bring large volumes of surface water to the deck of the ship for processing.

## **Shipboard Instrumentation:**

ADCP 75 kHz

Bathymetry System 12 kHz

Bathymetry System 3.5 kHz

Deionized Water System

Fume Hood

HiSeasNet

Multibeam

Uncontaminated Seawater System

CTD/Water Sampling: 911+ Rosette 24-position, 10-liter bottle Rosette with dual T/C sensors

Biospherical underwater PAR (1000m depth limit)

SBE43 oxygen sensor

Wet Labs C\*Star transmissometer (660nm wavelength)

Wet Labs ECO-AFL fluorometer

Dissolved Oxygen Titration System (Portable modified Winkler titration system)

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## **Program Information**

### **Integrated Marine Biogeochemistry and Ecosystem Research -US (IMBER-US)**

**Website:** <http://www.imber.info/>

**Coverage:** global

The BCO-DMO database includes data from IMBER endorsed projects lead by US funded investigators. There is no dedicated US IMBER project or data management office. Those functions are provided by US-OCB and BCO-DMO respectively.

The information in this program description pertains to the Internationally coordinated IMBER research program. The projects contributing data to the BCO-DMO database are those funded by US NSF only. The full IMBER data catalog is hosted at the Global Change Master Directory (GCMD).

**IMBER Data Portal:** The IMBER project has chosen to create a metadata portal hosted by the NASA's Global Change Master Directory (GCMD). The GCMD IMBER data catalog provides an overview of all IMBER endorsed and related projects and links to datasets, and can be found at URL <http://gcmd.nasa.gov/portals/imber/>.

IMBER research will seek to identify the mechanisms by which marine life influences marine biogeochemical cycles, and how these, in turn, influence marine ecosystems. Central to the IMBER goal is the development of a predictive understanding of how marine biogeochemical cycles and ecosystems respond to complex forcings, such as large-scale climatic variations, changing physical dynamics, carbon cycle chemistry and nutrient fluxes, and the impacts of marine harvesting. Changes in marine biogeochemical cycles and ecosystems due to global change will also have consequences for the broader Earth System. An even greater challenge will be drawing together the natural and social science communities to study some of the key impacts and feedbacks between the marine and human systems.

To address the IMBER goal, four scientific themes, each including several issues, have been identified for the IMBER project: Theme 1 - Interactions between Biogeochemical Cycles and Marine Food Webs; Theme 2 - Sensitivity to Global Change: How will key marine biogeochemical cycles, ecosystems and their interactions, respond to global change?; Theme 3 - Feedback to the Earth System: What are the roles of the ocean biogeochemistry and ecosystems in regulating climate?; and Theme 4 - Responses of Society: What are the relationships between marine biogeochemical cycles, ecosystems, and the human system?

### **Ocean Carbon and Biogeochemistry (OCB)**

**Website:** <http://us-ocb.org/>



**Coverage:** Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research community and with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF.

The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO<sub>2</sub> and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two.

The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

### **Emerging Topics in Biogeochemical Cycles (ETBC)**

**Website:** <http://www.nsf.gov/pubs/2007/nsf07049/nsf07049.jsp>

**Coverage:** global

The original call for proposals for Emerging Topics in Biogeochemical Cycles (ETBC) was issued in September 2007 by the US NSF Directorate for Geosciences (NSF 07-049).

The Geosciences Directorate (GEO) is substantially augmenting our past funding sources to explicitly support emerging areas of interdisciplinary research. We seek to foster transformational advances in our quantitative or mechanistic understanding of biogeochemical cycles that integrate physical-chemical-biological processes over the range of temporal and/or spatial scales in Earth's environments. We encourage submission of proposals that address emerging topics in biogeochemical cycles, the water cycle or their coupling, across the interfaces of atmosphere, land, and oceans. Proposals must cross the disciplinary boundaries of two or more divisions in Geosciences (e.g. ATM, EAR, OCE) or of at least one division in Geosciences and a division in another NSF directorate.

Although funding programmatic disciplines continues to provide a robust and adaptable framework to build our understanding of the geosciences and the earth as a system, there are classes of emerging and challenging problems that require integration of concepts and observations across diverse fields. Our goal is to enhance such integration. Successful proposals need to develop intellectual excitement in the participating disciplinary communities. Also encouraged are proposals that have broader educational, diversity, societal, or infrastructure impacts that capitalize on this interdisciplinary opportunity.

### **Marine Microbiology Initiative (MMI)**

**Website:** <https://www.moore.org/initiative-strategy-detail?initiativeld=marine-microbiology-initiative>

A Gordon and Betty Moore Foundation Program.

Forging a new paradigm in marine microbial ecology:

Microbes in the ocean produce half of the oxygen on the planet and remove vast amounts of carbon dioxide, a greenhouse gas, from the atmosphere. Yet, we have known surprisingly little about these microscopic organisms. As we discover answers to some long-standing puzzles about the roles that marine microorganisms play in supporting the ocean's food webs and driving global elemental cycles, we realized that we still need to learn much more about what these organisms do and how they do it—including how they evolved and contribute to our ocean's health and productivity.

The Marine Microbiology Initiative seeks to gain a comprehensive understanding of marine microbial communities, including their diversity, functions and behaviors; their ecological roles; and their origins and evolution. Our focus has been to enable researchers to uncover the principles that govern the interactions among microbes and that govern microbially mediated nutrient flow in the sea. To address these opportunities, we support leaders in the field through investigator awards, multidisciplinary team research projects, and efforts to create resources of broad use to the research community. We also support development of new instrumentation, tools, technologies and genetic approaches.

Through the efforts of many scientists from around the world, the initiative has been catalyzing new science through advances in methods and technology, and to reduce interdisciplinary barriers slowing progress. With our support, researchers are quantifying nutrient pools in the ocean, deciphering the genetic and biochemical bases of microbial metabolism, and understanding how microbes interact with one another. The initiative has five grant portfolios:

Individual investigator awards for current and emerging leaders in the field.

Multidisciplinary projects that support collaboration across disciplines.

New instrumentation, tools and technology that enable scientists to ask new questions in ways previously not possible.

Community resource efforts that fund the creation and sharing of data and the development of tools, methods and infrastructure of widespread utility.

Projects that advance genetic tools to enable development of experimental model systems in marine microbial ecology.

We also bring together scientists to discuss timely subjects and to facilitate scientific exchange.

Our path to marine microbial ecology was a confluence of new technology that could accelerate science and an opportunity to support a field that was not well funded relative to potential impact. Around the time we began this work in 2004, the life sciences were entering a new era of DNA sequencing and genomics, expanding possibilities for scientific research – including the nascent field of marine microbial ecology. Through conversations with pioneers inside and outside the field, an opportunity was identified: to apply these new sequencing tools to advance knowledge of marine microbial communities and reveal how they support and influence ocean systems.

After many years of success, we will wind down this effort and close the initiative in 2021. We will have invested more than \$250 million over 17 years to deepen understanding of the diversity, ecological activities and evolution of marine microbial communities. Thanks to the work of hundreds of scientists and others involved with the initiative, the goals have been achieved and the field has been profoundly enriched; it is now positioned to address new scientific questions using innovative technologies and methods.

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## Funding

Funding Source	Award
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-0934095</a>
Gordon and Betty Moore Foundation: Marine Microbiology Initiative (MMI)	<a href="#">GBMF2293</a>
<a href="#">Gordon and Betty Moore Foundation: Marine Microbiology Initiative (MMI)</a>	<a href="#">GBMF2928</a>

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