Biogeochemistry and microbiology from the R/V Hermano Gines cruises in the Cariaco Basin from 1995 to 2015 (CARIACO Ocean Time-Series Program)

Website: https://www.bco-dmo.org/dataset/3120
Data Type: Cruise Results
Version: 1
Version Date: 2019-06-03

Project
» CARIACO Ocean Time-Series Program (CARIACO)

Programs
» U.S. Joint Global Ocean Flux Study (U.S. JGOFS)
» Ocean Time-series Sites (Ocean Time-series)
» Ocean Carbon and Biogeochemistry (OCB)

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Abstract
Biogeochemistry and microbiology measurements in the Cariaco Basin. Microbiology sampling were conducted during special CARIACO cruises (distinct from the monthly, core sampling, time-series cruises) from November 1995 to November 2015. The specialized microbiology cruises were usually during May and November, and could be opportunistic or process-driven. There were typically at least 2 cruises per year, during which different variables were sampled and at different depths from the standard monthly CARIACO cruises. Bacteria production data were also reported for the microbiology cruises.

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Coverage

Spatial Extent: **N**:10.716 **E**:-64.54 **S**:10.45 **W**:-65.587
Temporal Extent: 1995-11-14 - 2015-11-15

Dataset Description

Biogeochemistry and microbiology measurements in the Cariaco Basin. Microbiology sampling is conducted during special CARIACO cruises (distinct from the monthly, core sampling, time-series cruises). The specialized microbiology cruises are usually during May and November, and can be opportunistic or process-driven. There are typically at least 2 cruises per year, during which different variables are sampled and at different depths from the standard monthly CARIACO cruises. Bacteria production data are also reported for the microbiology cruises.

Methodology published at CARIACO site (http://imars.usf.edu/publications/methods-cariaco)
CARIACO Field Program general description (http://www.imars.usf.edu/cariaco)

Methods & Sampling

Sampling

Ocean time series samples are collected in standard 8L Niskin bottles. For samples in and below the oxycline, a nitrogen line is attached to the upper air vent to prevent air from entering the bottle during subsampling. Samples for live analysis are first transferred without headspace to a 1L glass sample bottle with Teflon standard taper stopper. In the ship's lab, subsamples are transferred to 25 or 40 ml incubation vials, also under nitrogen. All vials are filled from the bottom with overflow of about 3 vial volumes and then sealed with no headspace.

Low molecular weight fatty acids: Volatile fatty acids are measured using the technique developed by Yang (1991), Yang et al. (1993) and Wu and Scranton (1994). Detection limits are about 1 (M for acetate). However, in some cases, deep water values are lower than 1 micromolar for acetate in which case we have estimated blanks in individual files. Samples are poisoned with 1 ml 10N KOH per liter.

Fatty acid uptake rate constants: Acetate uptake rate constants are determined using radiolabeled tracers as described by Wu and Scranton (1994). Incubations are done anoxically in the dark in screw-top septum vials. Uptake includes both conversion of isotope to CO2 (respiration) and to biomass which can be filtered onto a 0.2 m Nuclepore filter (incorporation).

CH4:

CH4 is assayed by gas chromatography using the vial equilibration technique of Johnson et al. (1990) and a

Carle 211AC gas chromatograph. Samples are poisoned by addition of 10N KOH solution at a rate of 200 l per 50 ml vial.

H2S:

Samples for sulfide analysis are taken in well-flushed glass syringes without bubbles and are injected into vials containing Zn-acetate. Upon return to the laboratory, the ZnS is dissolved and is analyzed spectrophotometrically by the method of Cline (1969).

Microbial census:

Abundances of remineralizers (bacteria) and regenerators (protozoa) are determined using microscopic censuses. Preserved samples (2% formaldehyde) are stained with a fluorochrome (DAPI or acridine orange) and captured on the appropriate porosity Nuclepore membrane (0.2 or 0.8 m). Filter-retained cells are enumerated and sized by epifluorescence microscopy according to Taylor et al. (1986). Larger, less abundant protozoa are enumerated on settled samples using inverted microscopy. Abundance and distribution of methanogens are determined by an autofluorescence microscopic technique whereby the fluorescence of coenzymes F420 and F350 in cells produced by two sets of excitation and barrier filters is considered presumptive identification of methanogens (Doddema and Vogels 1978).

Bacterial production:

Bacterial incorporation is measured using 3H-leucine incorporation as described by Kirchman (1993). Triplicate samples are incubated for 10-12 h in gas-tight screw-top vials to minimized alteration of the redox potential. Time course experiments have confirmed that uptake is linear for at least 15 hours. Due to the fact that some important anaerobic bacteria appear to not take up exogenous thymidine under anoxic conditions (McDonough et al. 1986; Gilmour et al. 1990), the more common method of Fuhrman and Azam (1982) is inappropriate for this system.

Data Processing Description

BCO-DMO Processing Notes:
- removed the duplicate column "SD dissolved Fe" from the originators file.
- added conventional header with dataset name, PI name, version date, and additional metadata
- modified parameter names to conform with BCO-DMO naming conventions
- replaced commas with semicolons
- added Core_CARIACO_ID by replacing the text "CAR-" in "Biogeochemical_Cruise_ID" with "93HG_".
- Added ISO_DateTime_local and ISO_DateTime_UTC for date time representations
- sorted by 'year', 'Biogeochemical_Cruise_ID', 'ISO_DateTime_UTC', then 'Depth'.

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Data Files

File
biogeochembact.csv (Comma Separated Values (.csv), 527.56 KB) MD5:2af562a2190b478d5e7ba7f69ce94705 Primary data file for dataset ID 3120

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Supplemental Files

File
Measurements Per Cruise filename: Measurements_per_Cruise.xlsx (Octet Stream, 16.58 KB) MD5:88fa520c1ab77e4664aa7920fcb49310 A table documenting what was measured during which cruise.

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Related Publications

Cline, J. D. (1969). Spectrophotometric Determination of Hydrogen Sulfide in Natural Waters. Limnology and Oceanography, 14(3), 454–458. doi:10.4319/lo.1969.14.3.0454
Methods

Doddema, H. J., & Vogels, G. D. (1978). Improved identification of methanogenic bacteria by fluorescence microscopy. Appl. Environ. Microbiol., 36(5), 752-754.
Methods

Fuhrman, J. A., & Azam, F. (1982). Thymidine incorporation as a measure of heterotrophic bacterioplankton production in marine surface waters: Evaluation and field results. Marine Biology, 66(2), 109–120. doi:10.1007/bf00397184 https://doi.org/10.1007/BF00397184
Methods

Gilmour, C. C., Leavitt, M. E., & Shiaris, M. P. (1990). Evidence against incorporation of exogenous thymidine by sulfate-reducing bacteria. Limnology and Oceanography, 35(6), 1401–1409. doi:10.4319/lo.1990.35.6.1401
Methods

Johnson, K. M., Hughes, J. E., Donaghay, P. L., & Sieburth, J. M. (1990). Bottle-calibration static head space method for the determination of methane dissolved in seawater. Analytical Chemistry, 62(21), 2408–2412. doi:10.1021/ac00220a030
Methods

Kirchman, D. L. (1993). Leucine incorporation as a measure of biomass production by heterotrophic bacteria. Handbook of methods in aquatic microbial ecology, 58, 509-512.
Methods

McDonough, R. J., Sanders, R. W., Porter, K. G., & Kirchman, D. L. (1986). Depth distribution of bacterial production in a stratified lake with an anoxic hypolimnion. Appl. Environ. Microbiol., 52(5), 992-1000.
Methods

Taylor, G., Karl, D., & Pace, M. (1986). Impact of bacteria and zooflagellates on the composition of sinking particles: An in situ experiment. Marine Ecology Progress Series, 29(2), 141-155. Retrieved from http://www.jstor.org/stable/24817583 https://www.jstor.org/stable/24817583
Methods

Wu, H., & Scranton, M. I. (1994). Cycling of some low molecular weight volatile fatty acids in a permanently anoxic estuarine basin. Marine Chemistry, 47(2), 97–113. doi:10.1016/0304-4203(94)90102-3
Methods

Yang, X. (1991). Concentrations and biological uptake of three methylamines in marine, estuarine and lacustrine waters. MS thesis. STATE UNIV OF NEW YORK AT STONY BROOK. https://apps.dtic.mil/docs/citations/ADA242982
Methods

Yang, X. H., Lee, C., & Scranton, M. I. (1993). Determination of nanomolar concentrations of individual dissolved low molecular weight amines and organic acids in seawater. Analytical Chemistry, 65(5), 572–576. doi:10.1021/ac00053a014
Methods

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Parameters

Parameter	Description	Units

Latitude	Latitude. Positive values indicate North	decimal degrees
Longitude	longitude. Positive values indicate East	decimal degrees
Biogeochemical_Cruise_ID	Biogeochemical cruise identifier	unitless
Cruise_number	cruise number identifier	unitless
Cruise_Leg	cruise leg identifier	unitless
Station	station identifier	unitless
Cast_number	Cast identifier	unitless
ISO_DateTime_UTC	Date and time formatted according to ISO8601	unitless
Date	Date formatted in YYYY-MM-DD	unitless
decimal_year	year as a decimal number	unitless
year	year	unitless
month	month	unitless
day	day	unitless
hour	hour of deployment	unitless
Depth	Depth	meters
Corrected_Depth	Corrected Depth	meters
Winkler_O2_avg	Oxygen	micromoles per liter
Winkler_O2_flags	Oxygen flag	unitless
NO3	Nitrate	micromoles per liter

NO2	Nitrite	micromoles per liter
NH4	Ammonium	micromoles per liter
PO4	Phosphate	micromoles per liter
H2S	Hydrogen sulfide	micromoles per liter
H2S_comment	Hydrogen sulfide comment	unitless
CH4	Methane	micromoles per liter
CH4_comment	methane comment	unitless
Acetate	Acetate	micromoles per liter
Propionate	Propionate	micromoles per liter
Incorporation_Acetate_Uptake_rate_constant	Acetate uptake rate constant (Incorporation)	per day (d-1)
Respiration_Acetate_Uptake_rate_constant	Acetate uptake rate constant (Respiration)	per day (d-1)
Total_Acetate_uptake_rate_constant	Acetate uptake rate constant (Total)	per day (d-1)
Sulfite	Sulfite	micromoles per liter
SD_Sulfite	Sulfite standard deviation	micromoles per liter
Thiosulfate	Thiosulfate	micromoles per liter
SD_Thiosulfate	Thiosulfate standard deviation	micromoles per liter
Particulate_Elemental_sulfur	Particulate Elemental sulfur	micromoles per liter
SD_Particulate_Elemental_sulfur	Particulate Elemental sulfur standard deviation	micromoles per liter
Particulate_element_sulfur_flags	particulate Elemental sulfur flag	unitless

Total_zero_valent_sulfur	Total zero valent sulfur	micromoles per liter
SD_Total_zero_valent_sulfur	Total zero valent sulfur standard deviation	micromoles per liter
Total_zero_valent_Sulfur_flags	total zero valent sulfur flag	unitless
Total_Prokaryote_Cell_Density	Total Prokaryotes	cells per liter
SD_Total_Prokaryotes	Total Prokaryotes standard deviation	cells per liter
Total_Prokaryote_Biomass_Estimates	Total Prokaryotes	microgram C per liter
SD_Prokaryote_Biomass_Estimates	Total Prokaryotes standard deviation	microgram C per liter
Cyanobacteria	Cyanobacteria	cells per liter
SD_Cyanobacteria	Cyanobacteria standard deviation	cells per liter
Methanogens	Methanogens	cells per liter
SD_Methanogens	Methanogens standard deviation	cells per liter
Flagellated_Protists	Flagellated Protists	cells per liter
SD_Flagellated_Protists	Flagellated Protists standard deviation	cells per liter
Ciliated_Protists	Ciliated Protists	cells per liter
SD_Ciliated_Protists	Ciliated Protists standard deviation	cells per liter
Viral_Like_Particles_VLP	Viral-Like Particles	cells per liter
SD_Viral_Like_Particles_VLP	Viral-Like Particles standard deviation	cells per liter
Heterotrophic_Bacterial_Production	Heterotrophic Bacterial Production	microgram C per L per day
SD_Heterotrophic_Bacterial_Production	Heterotrophic Bacterial Production standard deviation	microgram C per L per day

Dark_carbon_fixation_rate	Dark carbon fixation rate	micrograms C per Liter per day
SD_Dark_carbon_fixation_rate	Dark carbon fixation rate standard deviation	micrograms C per Liter per day
dissolved_Mn	Dissolved Manganese	nmol/L
SD_dissolved_Mn	Dissolved Manganese standard deviation	nmol/L
dissolved_Fe	Dissolved Iron	nmol/L
SD_dissolved_Fe	Dissolved Iron standard deviation	nmol/L
Core_CARIACO_ID	Core CARIACO_ID	unitless
Notes	additional notes	unitless
Comments	additional notes	unitless
ISO_DateTime_local	Date and Time in local time (UTC/GMT - 4) represented following ISO8601 format.	unitless

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Instruments

Dataset-specific Instrument Name	Carle 211AC gas chromatograph
Generic Instrument Name	Gas Chromatograph
Dataset-specific Description	CH4 is assayed by gas chromatography using the vial equilibration technique of Johnson et al. (1990) and a Carle 211AC gas chromatograph.
Generic Instrument Description	Instrument separating gases, volatile substances, or substances dissolved in a volatile solvent by transporting an inert gas through a column packed with a sorbent to a detector for assay. (from SeaDataNet, BODC)

Dataset-specific Instrument Name	Niskin Bottle
Generic Instrument Name	Niskin bottle
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.

Dataset-specific Instrument Name	spectrophotometrically
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	Upon return to the laboratory, the ZnS is dissolved and is analyzed spectrophotometrically by the method of Cline (1969).
Generic Instrument Description	An instrument used to measure the relative absorption of electromagnetic radiation of different wavelengths in the near infra-red, visible and ultraviolet wavebands by samples.

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Deployments

HG93_CARIACO

Website	https://www.bco-dmo.org/deployment/57845
Platform	B/O Hermano Gines
Start Date	1995-11-08
Description	Monthly oceanographic cruises to the CARIACO station (10.5 degrees N, 64.67 degrees W) have been conducted since November 1995 to examine the hydrography, primary production, and settling flux of particulate material. The research vessel is the 75-foot B/O (Barco Oceanografico) Hermano Gines of the Fundaciòn La Salle de Ciencias Naturales (FLASA) located on Margarita Island, Venezuela. Water is collected using a rosette ensemble equipped with twelve 8-liter bottles and a CTD (conductivity-temperature-depth meter); the CTD also has an oxygen sensor, a fluorometer for chlorophyll-a estimates, and a transmissometer. Data are read out real-time on a computer screen on board the ship as the rosette ensemble is lowered to approximately 1,380 m, the bottom of the Cariaco Basin. Water samples are analyzed for various parameters including phytoplankton biomass, dissolved and particulate nutrient and carbon concentration, primary productivity rates and total bacterial production.

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Project Information

CARIACO Ocean Time-Series Program (CARIACO)

Website: http://www.imars.usf.edu/CAR/index.html

Coverage: CARIACO basin

Since 1995, the CARIACO Ocean Time-Series (formerly known as the CArbon Retention In A Colored Ocean) Program has studied the relationship between surface primary production, physical forcing variables like the wind, and the settling flux of particulate carbon in the Cariaco Basin. This depression, located on the continental shelf of Venezuela (Map), shows marked seasonal and interannual variation in hydrographic properties and primary production (carbon fixation rates by photosynthesis of planktonic algae).

This peculiar basin is anoxic below ~250 m, due its restricted circulation and high primary production (Muller-Karger et al., 2001). CARIACO observations show annual primary production rates exceed 500 gC/m^2y, of which over 15-20% can be accounted for by events lasting one month or less. Such events are observed in other locations where time series observations are collected, and suggest that prior estimates of regional production based on limited sampling may have been underestimated. The annual primary production rates in the Cariaco Basin are comparable to rates estimated using time series observations for Monterey Bay (460 gC/m^2y; Chavez, 1996), and higher than previous rates estimated for Georges Bank, the New York Shelf, and the Oregon Shelf (380, 300, and 190 gC/m^2y, respectively; Walsh, 1988).

The Cariaco Basin has long been the center of attention of scientists trying to explain paleoclimate. Due to its high rates of sedimentation (30 to >100 cm/ky; Peterson et al., 2000) and excellent preservation, the varved sediments of the Cariaco Basin offer the opportunity to study high resolution paleoclimate and better understand the role of the tropics in global climate change (Black et al., 1999; Peterson et al., 2000; Haug et al., 2001; Black et al., 2004; Hughen et al., 2004).

Now, the CARIACO program provides a link between the sediment record and processes near the surface of the ocean. Sediment traps maintained by the CARIACO program show that over 5% of autochtonous material reaches 275 m depth, and that nearly 2% reaches 1,400 m. The significance of this flux is that it represents a sink for carbon and that it helps explain the record of ancient climate stored at the bottom of the Cariaco Basin.

Acknowledgements: This work was supported by the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and Venezuela's Fondo Nacional de Ciencia, Tecnología e Innovación (FONACIT). For more information please see this Acknowledgements link.

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Program Information

U.S. Joint Global Ocean Flux Study (U.S. JGOFS)

Website: http://usjgofs.whoi.edu/

Coverage: Global

The United States Joint Global Ocean Flux Study was a national component of international JGOFS and an integral part of global climate change research.

The U.S. launched the Joint Global Ocean Flux Study (JGOFS) in the late 1980s to study the ocean carbon cycle. An ambitious goal was set to understand the controls on the concentrations and fluxes of carbon and associated nutrients in the ocean. A new field of ocean biogeochemistry emerged with an emphasis on quality measurements of carbon system parameters and interdisciplinary field studies of the biological, chemical and physical process which control the ocean carbon cycle. As we studied ocean biogeochemistry, we learned that our simple views of carbon uptake and transport were severely limited, and a new "wave" of ocean science was born. U.S. JGOFS has been supported primarily by the U.S. National Science Foundation in collaboration with the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the Department of Energy and the Office of Naval Research. U.S. JGOFS, ended in 2005 with the conclusion of the Synthesis and Modeling Project (SMP).

Ocean Time-series Sites (Ocean Time-series)

Coverage: Bermuda, Cariaco Basin, Hawaii

Program description text taken from Chapter 1: Introduction from the **Global Intercomparability in a Changing Ocean: An International Time-Series Methods Workshop** report published following the workshop held November 28-30, 2012 at the Bermuda Institute of Ocean Sciences. The full report is available from the workshop Web site hosted by US OCB: http://www.whoi.edu/website/TS-workshop/home

Decades of research have demonstrated that the ocean varies across a range of time scales, with anthropogenic forcing contributing an added layer of complexity. In a growing effort to distinguish between natural and human-induced earth system variability, sustained ocean time-series measurements have taken on a renewed importance. Shipboard biogeochemical time-series represent one of the most valuable tools scientists have to characterize and quantify ocean carbon fluxes and biogeochemical processes and their links to changing climate (Karl, 2010; Chavez et al., 2011; Church et al., 2013). They provide the oceanographic community with the long, temporally resolved datasets needed to characterize ocean climate, biogeochemistry, and ecosystem change.

The temporal scale of shifts in marine ecosystem variations in response to climate change are on the order of several decades. The long-term, consistent and comprehensive monitoring programs conducted by time-series sites are essential to understand large-scale atmosphere-ocean interactions that occur on interannual to decadal time scales. Ocean time-series represent one of the most valuable tools scientists have to characterize and quantify ocean carbon fluxes and biogeochemical processes and their links to changing climate.

Launched in the late 1980s, the US JGOFS (Joint Global Ocean Flux Study; http://usjgofs.whoi.edu) research program initiated two time-series measurement programs at Hawaii and Bermuda (HOT and BATS, respectively) to measure key oceanographic measurements in oligotrophic waters. Begun in 1995 as part of the US JGOFS Synthesis and Modeling Project, the CARIACO Ocean Time-Series (formerly known as the CArbon Retention In A Colored Ocean) Program has studied the relationship between surface primary production, physical forcing variables like the wind, and the settling flux of particulate carbon in the Cariaco Basin.

The objective of these time-series effort is to provide well-sampled seasonal resolution of biogeochemical variability at a limited number of ocean observatories, provide support and background measurements for process-oriented research, as well as test and validate observations for biogeochemical models. Since their creation, the BATS, CARIACO and HOT time-series site data have been available for use by a large community of researchers.

Data from those three US funded, ship-based, time-series sites can be accessed at each site directly or by selecting the site name from the Projects section below.

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 CO2 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.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0326268
NSF Division of Ocean Sciences (NSF OCE)	OCE-9711318
NSF Division of Ocean Sciences (NSF OCE)	OCE-9415790
NSF Division of Ocean Sciences (NSF OCE)	OCE-0752139

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