Time series HPLC pigment data as measured by Horn Point Laboratory (HPL) from B/O Hermano Gines cruises CAR-124 to CAR-175 in the CARIACO basin from 2006-07-04 to 2010-12-08 (CARIACO Ocean Time-Series Program)

Website: https://www.bco-dmo.org/dataset/3235
Data Type: Cruise Results
Version: 1
Version Date: 2019-09-24

Project
» CARIACO Ocean Time-Series Program (CARIACO)

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

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Abstract
The CARIACO Ocean Time-Series Program (formerly known as CArbon Retention In A Colored Ocean) started on November 1995 (CAR-001) and ended on January 2017 (CAR-232). Throughout the CARIACO time-series, High Performance Liquid Chromatography (HPLC) data was analyzed by four different laboratories: Bermuda Biological Research Station; Mote Marine Laboratory; Horn Point Laboratory; and NASA Goddard Space Flight Center. This package contains the data analyzed at Horn Point Laboratory, covering cruises CAR-124 to CAR-175 from 2006-07-04 to 2010-12-08. Some of the parameters analyzed were different along time and along the different laboratories. To keep the continuity of the HPLC time-series analyzed by different laboratories, all the HPLC files have the same units and contain the same number and order of columns/parameters (with “nd” to indicate when a parameter was no determined). Fluorometric Chlorophyll-a and Phaeopigments (measured at Estación de Investigaciones Marinas de Margarita, Fundación La Salle, EDIMAR-FLASA) are also included. HPLC was not analyzed for cruises CAR-069 to CAR-123. A general description of the CARIACO Ocean Time-Series Program can be found at www.imars.usf.edu/cariaco.

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Coverage

Spatial Extent: **N**:10.5116 **E**:-64.391 **S**:10.2931 **W**:-64.6838
Temporal Extent: 2006-07-04 - 2010-12-08

Dataset Description

High Performance Liquid Chromatography (HPLC) pigment data from the CARIACO time series stations and analyzed at Horn Point Laboratory for cruises from 2006-07-04 to 2010-12-08.

Below are the additional CARIACO HPLC data at BCO-DMO which were analyzed at different laboratories:

NASA Goddard Space Flight Center from 2011-01-11 to 2017-01-12 (cruises CAR-176 to CAR-232):
www.bco-dmo.org/dataset/777689
Mote Marine Laboratory from 1998-06-09 to 2001-07-10 (cruises CAR-031 to CAR-068):
www.bco-dmo.org/dataset/3292
Bermuda Biological Research Station from 1995-12-13 to 1998-04-21 (cruises CAR-002 to CAR-030):
www.bco-dmo.org/dataset/3293

These data were also funded by the following awards:
- 23914: Ley Orgánica de Ciencia, Tecnología e Innovación, LOCTI (Estación de Investigaciones Marinas), Venezuela.
- 2011000353: Inter-American Institute for Global Change Research, IAI (IAI-CRN3094).

Methods & Sampling

Water for the HPLC filters was collected from the first cast done during the CARIACO core cruises, carried out around 5 am local time. During periods of low primary production, 2000 ml. of water were vacuum filtered through a 47mm GF/F filter pad. During periods of high primary production, water was filtered until the filter was clogged. The volume of water filtered was annotated. Eight depths were sampled: 1, 7, 15, 25, 35, 55, 75 and 100 m. If a chlorophyll maximum was found at a different depth, this depth was also sampled. A duplicate was taken at one of these depths (usually at 1m), for QA/QC assessment. Filters were carefully folded in half, stored in aluminum foil and refrigerated until reaching shore. Once back on shore, they were stored frozen at -40°C. Filters were transported from Margarita Island to USF and stored frozen (at -40°C) until they were shipped in a liquid-nitrogen storage to the laboratory that performed the HPLC analysis. The CARIACO samples of HPLC were analyzed by: Bermuda Biological Research Station, BBRS (CAR-002 to CAR-030); MOTE Marine Laboratory & Aquarium (CAR-031 to CAR-068), Horn Point Laboratory, HPL (CAR-124 to CAR-175); and NASA Goddard Space Flight Center, GSFC (CAR-176 to CAR-232). Analysis at HPL and GSFC were carried out according to the method described in Hooker et al. (2005), Chapter 5. The HPLC parameter names as reported in this dataset correspond to the pigment names as defined in the NASA SeaWiFS Bio-optical Archive and Storage System (SeaBASS) (https://seabass.gsfc.nasa.gov/wiki/stdfields). Fluorometric estimations of chlorophyll-a and phaeopigments concentrations were done with a Turner Design10-AU-005 Fluorometer using standard methods (Holm-Hansen et al., 1965; Falkowski and Kiefer, 1985). The detailed methodology for the

determination of Chlorophyll a and Phaeopigments can be found in the HANDBOOK OF METHODS FOR THE ANALYSIS OF OCEANOGRAPHIC PARAMETERS AT THE CARIACO TIME-SERIES STATION, edited by Astor, Lorenzoni and Scranton (2011).
(https://seabass.gsfc.nasa.gov/archive/USF/FMK/CARIACO/2015/documents/CARIACO_Methods_Manual.pdf)

Data Processing Description

BCO-DMO processing notes:
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- cruise 93HG_163 had longitude values that were positive, indicating a location in the Eastern hemisphere. This was incorrect for the scope of the package, however multiplying by -1 alligned the longitude values with the other cruises.

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Data Files

File
hplc_hpl.csv (Comma Separated Values (.csv), 231.61 KB) MD5:f2f3e4044a0dae0e193386c949fb2ffc Primary data file for dataset ID 3235

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Related Publications

Falkowski, P., & Kiefer, D. A. (1985). Chlorophyll a fluorescence in phytoplankton: relationship to photosynthesis and biomass. Journal of Plankton Research, 7(5), 715–731. doi:10.1093/plankt/7.5.715
Methods

Holm-Hansen, O., Lorenzen, C. J., Holmes, R. W., & Strickland, J. D. H. (1965). Fluorometric Determination of Chlorophyll. ICES Journal of Marine Science, 30(1), 3–15. doi:10.1093/icesjms/30.1.3
Methods

Hooker, S.; L. Van Heukelem; C. S. Thomas; H. Claustre, J. Ras; R. Barlow; H. Sessions; L. Schlüter; J. Perl and C. Trees; V. Stuart; E. Head; L. Clementso; J. Fishwick; C. Llewellyn and J. Aiken. 2005. The Second SeaWiFS HPLC Analysis Round-Robin Experiment (SeaHARRE-2). NASA Technical Memorandum NASA/TM-2005-212785. https://oceancolor.gsfc.nasa.gov/fsg/hplc/SH2_TM2005_212785.pdf
Methods

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Parameters

Parameter	Description	Units
Cruise_ID1	cruise ID for OCB;	unitless
Cruise_ID2	cruise ID for the CARIACO project;	unitless
Cruise_number	number of cruise;	unitless

leg	number of cruise in the same month;	unitless
cast	number of the rosette cast;	unitless
Date	date; yyyymmdd	unitless
sample_number	number of sample;	unitless
Analyzed_by	laboratoory that did the analysis;	unitless
lon_n	intended longitude; west indicated with negative values	decimal degrees
lat_n	intended latitude; north indicated as positivie values	decimal degrees
lon	actual longitude; west indicated with negative values	decimal degrees
lat	actual latitude; north indicated as positivie values	decimal degrees
year	year of sampling;	unitless
month	month of sampling;	unitless
day	day of sampling;	unitless
depth_bottom	maximum depth;	meters (m)
depth	sample depth;	meters (m)
time_start_local	starting time of the cast (Venezuelan Standard Time; VET);	unitless
time_end_local	end time of the cast (Venezuelan Standard Time; VET);	unitless
time_start_UTC	starting time of the cast (UTC);	unitless
time_end_UTC	end time of the cast (UTC);	unitless
Date_time_local	date and time of sampling (Venezuelan Standard Time; VET);	unitless

Date_time_UTC	date and time of sampling (UTC);	unitless
Tot_Chl_a	HPLC divinyl chlorophyll a + monovinyl chlorophyll a + chlorophyllide a + chlorophyll a allomer + chlorophyll a prime;DV_Chl_a + MV_Chl_a + Chlide_a + Chl_a allomers + Chl_a epimers	miligrams per meter cubed (mg/m^3)
Tot_Chl_b	HPLC divinyl chlorophyll b + monovinyl chlorophyll_b;DV_Chl_b + MV_Chl_b + Chl_b epimers	miligrams per meter cubed (mg/m^3)
Tot_Chl_c	HPLC chlorophyll c1 + chlorophyll c2 (or chl_c1_c2) + chlorophyll c3;Chl_c3 + Chl_c12	miligrams per meter cubed (mg/m^3)
alpha_beta_Car	HPLC alpha beta carotenes;alpha (beta; epsilon) + beta (beta; beta) carotene.	miligrams per meter cubed (mg/m^3)
alpha_Car	HPLC carotene-alpha;	miligrams per meter cubed (mg/m^3)
beta_Car	HPLC carotene-beta;	miligrams per meter cubed (mg/m^3)
But_fuco	HPLC 19'-Butanoyloxyfucoxanthin;	miligrams per meter cubed (mg/m^3)
Hex_fuco	HPLC 19'-Hexanoyloxyfucoxanthin;	miligrams per meter cubed (mg/m^3)
Allo	HPLC Alloxanthin;	miligrams per meter cubed (mg/m^3)
Diadino	HPLC Diadinoxanthin;	miligrams per meter cubed (mg/m^3)
Diato	HPLC Diatoxanthin;	miligrams per meter cubed (mg/m^3)
Fuco	HPLC Fucoxanthin;	miligrams per meter cubed (mg/m^3)
Perid	HPLC Peridinin;	miligrams per meter cubed (mg/m^3)
Zea	HPLC Zeaxanthin;	miligrams per meter cubed (mg/m^3)
MV_Chl_a	HPLC Monovinyl Chorophyll a;	miligrams per meter cubed (mg/m^3)

DV_Chl_a	HPLC Divinyl Chorophyll a;	miligrams per meter cubed (mg/m^3)
Chlide_a	HPLC chlorophyllide a;	miligrams per meter cubed (mg/m^3)
Chl_a_allom	HPLC chlorophyll a allomer;	miligrams per meter cubed (mg/m^3)
Chl_a_prime	HPLC chlorophyll a prime (Chl_a_Prime is the 132S-epimer of Chi a3);	miligrams per meter cubed (mg/m^3)
MV_Chl_b	HPLC Monovinyl Chorophyll b;	miligrams per meter cubed (mg/m^3)
DV_Chl_b	HPLC Divinyl Chorophyll b;	miligrams per meter cubed (mg/m^3)
Chl_c1	HPLC chlorophyll c1;	miligrams per meter cubed (mg/m^3)
Chl_c2	HPLC chlorophyll c2;	miligrams per meter cubed (mg/m^3)
Chl_c1c2	HPLC chlorophyll c1 plus c2;Chlorophyll c2 + chlorophyll c1 + MGDVP	miligrams per meter cubed (mg/m^3)
Chl_c3	HPLC chlorophyll c3;	miligrams per meter cubed (mg/m^3)
Lut	HPLC Lutein;	miligrams per meter cubed (mg/m^3)
Neo	HPLC Neoxanthin;	miligrams per meter cubed (mg/m^3)
Viola	HPLC Violaxanthin;	miligrams per meter cubed (mg/m^3)
Phytin_a	HPLC Pheophytin a;pheophytin a + pheophytin a'	miligrams per meter cubed (mg/m^3)
Phide_a	HPLC total pheophorbide a;multiple peaks	miligrams per meter cubed (mg/m^3)
Pras	HPLC Prasinoxanthin;	miligrams per meter cubed (mg/m^3)
Anth	HPLC Antheraxanthin;	miligrams per meter cubed (mg/m^3)

Gyro	HPLC Gyroxanthin-Diester;	miligrams per meter cubed (mg/m^3)
TChl	HPLC total chlorophylls;Tot_Chl_a +Tot_Chl_b +Tot_Chl_c	miligrams per meter cubed (mg/m^3)
PPC	HPLC photoprotective carotenoids;allo + diadino + diato + zea + alpha-beta-car	miligrams per meter cubed (mg/m^3)
PSC	HPLC photosynthetic carotenoids;but-fuco + fuco + hex-fuco + perid	miligrams per meter cubed (mg/m^3)
PSP	HPLC phosynthetic pigments;PSC + TChl	miligrams per meter cubed (mg/m^3)
Tcar	HPLC total carotenoids ;PPC + PSC	miligrams per meter cubed (mg/m^3)
Tacc	HPLC total accessory pigments;PPC + PSC + Tot_Chl_b + Tot_Chl_c	miligrams per meter cubed (mg/m^3)
Tpg	HPLC total pigments;TAcc + Tot_Chl_a	miligrams per meter cubed (mg/m^3)
DP	HPLC total diagnostic pigments;PSC + allo + zea + Tot_Chl_b	miligrams per meter cubed (mg/m^3)
Tacc_TChla	HPLC ratio of total accessory pigments to total chlorophll a;[Tacc]/[Tchla]	unitless
PSC_Tcar	HPLC ratio of photsynthetic carotenoids to total carotenoids;[PSC]/[TCar]	unitless
PPC_Tcar	HPLC ratio of photprotective carotenoids to total carotenoids;[PPC]/[Tcar]	unitless
TChl_Tcar	HPLC ratio of total chlorophyll to total carotenoids;[TChl]/[TCaro]	unitless
PPC_Tpg	HPLC ratio of photoprotective carotenoids to total pigments;[PPC]/[Tpg]	unitless
PSP_Tpg	HPLC ratio of photsynthetic pigments to to total pigments;[PSP]/[TPg]	unitless
TChla_Tpg	HPLC raito of total chlorophyll a to total pigments;[TChla]/[TPg]	unitless
mPF	HPLC microplankton [mPF];	unitless
nPF	HPLC nanoplankton [nPF];	unitless

pPF	HPLC picoplankton [pPF];	unitless
Fluor_Chl_a	Fluorometric Chlorophyll-a ;Measured at La Salle	miligrams per meter cubed (mg/m^3)
Fluor_Phaeo	Fluorometric Phaeopigments;Measured at La Salle	miligrams per meter cubed (mg/m^3)
Comments	additional comments	unitless

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Instruments

Dataset-specific Instrument Name	High Performance Liquid Chromatography
Generic Instrument Name	High-Performance Liquid Chromatograph
Generic Instrument Description	A High-performance liquid chromatograph (HPLC) is a type of liquid chromatography used to separate compounds that are dissolved in solution. HPLC instruments consist of a reservoir of the mobile phase, a pump, an injector, a separation column, and a detector. Compounds are separated by high pressure pumping of the sample mixture onto a column packed with microspheres coated with the stationary phase. The different components in the mixture pass through the column at different rates due to differences in their partitioning behavior between the mobile liquid phase and the stationary phase.

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.

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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

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.

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.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-9401537
NSF Division of Ocean Sciences (NSF OCE)	OCE-9729697
NSF Division of Ocean Sciences (NSF OCE)	OCE-0326268
NSF Division of Ocean Sciences (NSF OCE)	OCE-9216626
NSF Division of Ocean Sciences (NSF OCE)	OCE-9711318
National Aeronautics & Space Administration (NASA)	NAS5-97128
NSF Division of Ocean Sciences (NSF OCE)	OCE-9415790
NSF Division of Ocean Sciences (NSF OCE)	OCE-9729284
National Aeronautics & Space Administration (NASA)	NAG5-6448
NSF Division of Ocean Sciences (NSF OCE)	OCE-0963028
NSF Division of Ocean Sciences (NSF OCE)	OCE-0752139
Fondo Nacional de Ciencia, Tecnología e Innovación of Venezuela (FONACIT)	96280221
NSF Division of Ocean Sciences (NSF OCE)	OCE-0326313
National Aeronautics & Space Administration (NASA)	NNX14AP62A
Fondo Nacional de Ciencia, Tecnología e Innovación of Venezuela (FONACIT)	2000001702
Fondo Nacional de Ciencia, Tecnología e Innovación of Venezuela (FONACIT)	2011000353

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