Discrete bottle samples for BATS Validation cruises from April 1991 through June 2023

Website: https://www.bco-dmo.org/dataset/917255
Data Type: Cruise Results
Version: 4
Version Date: 2023-12-19

Project
» Bermuda Atlantic Time-series Study (BATS)

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
Data presented here are discrete bottle samples for BATS validation (BVAL) Cruise # 1 (April 1991) through BVAL cruise # 60 (June 2023). Following the first several years of the BATS project it was deemed necessary by the JGOFS steering committee and BATS PIs to conduct validation cruises in the vicinity of the nominal BATS site to better understand the mesoscale and larger scale variability of the region. In particular, a focus of the BVAL cruises was to assess the spatial scale representation of the BATS and Hydrostation 'S' programs. Initial focus of the BVAL cruises was to investigate mesoscale variability and meridional gradients of the local region. Later, cruises focused on specific mesoscale eddies (e.g., McGillicuddy et al., 1998; McGillicuddy et al., 1999) and effects of tropical cyclones through the local region. In the year 2000 it was deemed more important to document the larger scale changes in the North Atlantic Subtropical gyre so BVAL cruises established a transect line from ~ 35N to 19N (Bermuda to Puerto Rico) very similar to the WOCE A22 repeat hydrography line (Johnson et al., 2020). These annual Bermuda to Puerto Rico transects have been run since 2000 and target stations at every one degree of latitude and typically have been conducted in September/October of each year to capture maximal heat content in the upper ocean. However, since this timeframe coincides with high tropical cyclone activity the cruises were reluctantly (as of 2022) moved to begin in June/July of each year for safety and operational reasons. In the pentad prior to 2022 every BVAL cruise was significantly impacted by multiple tropical cyclones. Parameters presented are the same as provided in the standard BATS bottle files. To browse cruise tracks please see the supplemental information.

Table of Contents

Coverage

Location: Survey cruises in the Sargasso Sea ranging from 19N to 36N and 60W to 80W. See cruise tracks in Supplemental Files section
Spatial Extent: **N**:36 **E**:-60 **S**:19 **W**:-80
Temporal Extent: 1991-04-29 - 2023-06-30

Methods & Sampling

Cruises
Data were collected on BATS Validation (BVAL) cruises, from cruise #1 (April 1991) through BATS cruise # 60 (June 2023). Please note that BVAL cruises 4, 25, 43, and 54 were cancelled and hence no reporting. However, all bottle files are included for this dataset, even those that do not have any BATS core parameters, to provide data from ancillary measurements for re-use.

Research was conducted on the R/V Weatherbird II through 2005 and thereafter on the R/V Atlantic Explorer. There were numerous Chief Scientists for these cruises including Rachel Dow, Anthony Michaels, Kjell Gundersen, Rodney Johnson, Paul Lethaby, Mike Lomas, Steven Bell, Gwyn Evans, and Claire Medley. Cruise track information showing CTD station locations and cruise dates for each BVAL cruise conducted between 1991 and 2022 are available in the Supplemental Files section below.

Water sampling
Full depth water sampling and data collection at the BATS site are achieved with a total of three hydrocasts using a General Oceanics Intelligent Rosette® with an array of 24 12L water bottles and a Sea-Bird Scientific CTD system. Water samples are collected during the upcast with a 1-minute resting period between reaching the sampling depth and triggering the bottle to close. Bottom measurements/ sampling are achieved within 20 meters from the bottom, as determined using an altimeter.

Water samples are taken right after Rosette® recovery. On any cast, if only a single water bottle is collected to sample all biogeochemical parameters, then gas samples are collected first due to their exposure to air when opened. However, if enough bottles are available, two bottles can be taken for a single depth. Water is usually split between large-volume particulate samples (POCN, HPLC, POP and PSi) and all other small volume samples, including gas samples. When two bottles are taken for a single depth, particulate samples are collected first to prevent settling within the Niskin bottle. Samples are fixed or frozen once all same-sample bottles from one cast have been collected. Particulate samples are filtered as soon as collected.

Nutrients
The BATS nutrient methodology is based on the Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements (Intergovernmental Oceanographic Commission, 1994) which describes the method for the determination of dissolved inorganic macronutrients in seawater: nitrite (NO2 –), nitrate + nitrite (NO3 – + NO2 –), orthophosphate (PO4 3 –) and reactive silicate (Si(OH)4) using Continuous Flow Analysis (CFA).

While the definition of the dissolved fraction has changed throughout the years that the BATS time series has operated, the pore size used has remained constant in order to create a comparable temporal dataset. While similar studies in oligotrophic ocean regions have opted to forego the use of nutrient filters under the assumption that the particulate nutrient pool is negligible, we continue the use of filters for the sake of continuity. Sample filtration also removes the potential for turbidity-derived uncertainties during analysis, and may aid preservation of frozen samples.

Discrete samples are collected at the Bermuda Atlantic Time-series Study (BATS) site from surface to bottom depths (~4,200 meters). Sea water is filtered directly from the Niskin spigot using a 0.8 µm membrane to remove particulates. Collected sea water is preserved by freezing until analysis. Replicate samples are taken during each cast to ensure quality control standards are met during analytical and data processes. Dissolved inorganic nutrients are measured using a SEAL AA500 Autoanalyzer by Continuous Flow Analysis (CFA). During this process, a subset of sample is drawn and further split into four different channels driven by a peristaltic pump. The sample stream is segmented with air or nitrogen bubbles throughout the flow path to enhance the mixing of reagents with the sample. The nutrients, NO_2-, nitrate + nitrite (NO_3– + NO2-) , PO_4^{3-} and Si, are

chemically reacted in the separate channels to produce a color change and are measured colorimetrically at different wavelengthsusing a flow-through colorimeter located at the end of the flow path. The light absorption by the sample-reagent mixture is proportional to the concentration of nutrient in the sample according to the principles of the Beer-Lambert Law. Raw absorbance units are converted into nutrient concentrations according to a linear calibration curve formulated from known standards.

Bacterial enumeration
In addition to the casts for shallow water, mode water, and deep water, a separate cast is deployed for the estimation of bacterial growth rates using 3H-Thymidine. Heterotrophic bacteria are expected to grow and assimilate 3H-thymidine into nucleic acid material under incubation conditions.

Three replicate samples from the same depth are used as live tubes for thymidine incorporation, and are incubated for four hours. Samples used as killed controls (aka kill tubes) are treated with 100 microliters of 100% TCA (trichloroacetic acid) at the beginning of the incubation to halt biological activity. After incubation, 10 microliters (µl) from the live tubes are extracted for Specific Activities measurements and the biological activity in the live tubes is halted by adding 100% TCA.

All tubes are centrifuged at 14,000 RPM at 4°C for 7 minutes. The supernatant is discarded and DNA is extracted by adding 100% TCA; centrifuging again for 7 minutes at 4°C at 14,000 RPM; adding 80% ethanol and centrifuging once more for 7 minutes at 4°C at 14,000 RPM. The DNA in the resulting pellet is resuspended in Ultima Gold by vortexing. Samples are stored at room temperature until analysis.

Full methodology
Detailed methods are available in Knap et al. (1997).

Data Processing Description

Determination of Oxygen Anomaly
Measured concentrations of oxygen were compared to _____ (reference?) values from ___???. What factors were considered and what calculations were made?

Oxygen Fixation Temperature
Please list any equation or calculations if factors like salinity, pressure, and other dissolved species have an effect.

Nutrient data processing
The light absorption by the sample-reagent mixture is proportional to the concentration of nutrient in the sample according to the principles of the Beer-Lambert Law. A standard curve is measured at the start of every run (prior to measuring the samples) to produce a linear calibration curve used to convert light absorbance units into nutrient concentrations.

BCO-DMO Processing Description

Primary Data File
- Imported data from source files "bval_bottle_v004.txt" and "bval_bottle_qcmask_004.txt" into the BCO-DMO data system using missing data identifiers 'nd' and '-999'.
- Merged the mask and bottle data files to create one comprehensive file
- Combined the date (yyyymmmdd) and Time (HHMM) columns into single DateTime column in ISO Date 8601 format
- Created columns for Cruise, Cast, and Bottle based on the ID column

Supplemental Files
- Created a cruise metadata table with cruise ID, cruise dates, plus number of casts
- Zipped folder of cruise sampling location maps are in PDF format

Problem Description

Please note that BVAL cruises 4, 25, 43, and 54 were canceled and hence no reporting.

[table of contents | back to top]

Related Publications

Bates, N. R., Takahashi, T., Chipman, D. W., & Knap, A. H. (1998). Variability of pCO2 on diel to seasonal timescales in the Sargasso Sea near Bermuda. Journal of Geophysical Research: Oceans, 103(C8), 15567–15585. doi:10.1029/98jc00247 https://doi.org/10.1029/98JC00247
Methods

Bermuda Atlantic Time-series Study Methods (online at https://bats.bios.edu/about/cruise-information/)
Methods

Intergovernmental Oceanographic Commission (1994) Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements. Paris, France, UNESCO-IOC, 170pp. (Intergovernmental Oceanographic Commission Manuals and Guides: 29), (JGOFS Report; 19). DOI: https://doi.org/10.25607/OBP-1409
Methods

Johnson, R.J., Bates, N.R., Lomas, M.W., Stevens, S., Lethaby, P., Anderson, A., Pacheco, F., and Knap, A.H. (2020, February 16-21) Meridional heat and salinity budgets of the Sargasso Sea inferred from two decades of ocean time-series and transect observations. [Poster session]. Ocean Sciences Meeting, San Diego, USA. https://agu.confex.com/agu/osm20/meetingapp.cgi/Paper/656848
Results

Knap, A.H., Michaels, A.F., Steinberg, D.K., Bahr, F., Bates, N.R., Bell, S., Countway, P., Close, A.R., Doyle, A.P., Dow, R.L., Howse, F.A., Gundersen, K., Johnson, R.J., Kelly, R., Little, R., Orcutt, K., Parsons, R., Rathburn, C., Sanderson, M. and Stone, S. (1997) BATS Methods Manual, Version 4 Woods Hole, MA, US. U.S. JGOFS Planning Office 136pp. http://eprints.soton.ac.uk/id/eprint/361194
Methods

McGillicuddy, D. J., Johnson, R., Siegel, D. A., Michaels, A. F., Bates, N. R., & Knap, A. H. (1999). Mesoscale variations of biogeochemical properties in the Sargasso Sea. Journal of Geophysical Research: Oceans, 104(C6), 13381–13394. Portico. https://doi.org/10.1029/1999jc900021 https://doi.org/https://doi.org/10.1029/1999JC900021
Results

McGillicuddy, D. J., Robinson, A. R., Siegel, D. A., Jannasch, H. W., Johnson, R., Dickey, T. D., McNeil, J., Michaels, A. F., & Knap, A. H. (1998). Influence of mesoscale eddies on new production in the Sargasso Sea. Nature, 394(6690), 263–266. https://doi.org/10.1038/28367
Results

[table of contents | back to top]

Parameters

Parameter	Description	Units
ID	A unique bottle ID which identifies cruise, cast, and Niskin number	unitless
ISO_DateTime_UTC	description	unitless
Latitude	Latitude of sampling	decimal degrees
Longitude	Longitude of sampling	decimal degrees
Cruise_num	Cruise number where the 5 represents a BATS Validation cruise followed by the BATS cruise ID	unitless
Cast_num	Cast number where 1-80 are CTD casts and 81-99 are Hydrocasts	unitless
Bottle_num	Niskin (or GoFlo) bottle number	unitless
QF_Niskin_GoFlo	Quality flag for bottle (-3 = suspect, 1 = unverified, 2 = verified/acceptable)	unitless

Depth	Depth of sampling	meters (m)
QF1_Depth	Quality flag for depth	unitless
Temp	Temperature (ITS-90 scale)	degrees Celsius
QF2_Temp	Quality flag for temperature	unitless
CTD_Sal	CTD Salinity (PSS-78 scale)	PSS-78
QF3_CTD_Sal	Quality flag for CTD salinity	unitless
Sal1	Salinity-1 (PSS-78 scale)	PSS-78
QF4_Sal1	Quality flag for Salinity-1	unitless
Sigma_theta	Sigma-theta potential density	kilogram per cubic meter (kg/m^3)
QF5_Sigma_theta	Quality flag for sigma-theta	unitless
O2	Oxygen-1	micromole per kilogram (umol/kg)
QF6_O2	Quality flag for oxygen	unitless
OxFixT	Oxygen Fix Temperature	degrees Celsius
QF7_OxFixT	Quality flag for oxygen fix temperature	unitless
Oxy_Anom1	Oxygen anomaly	micromole per kilogram (umol/kg)
QF8_Oxy_Anom1	Quality flag for oxygen anomaly	unitless
DIC	Dissolved inorganic carbon	micromole per kilogram (umol/kg)
QF9_DIC	Quality flag for DIC (dissolved inorganic carbon)	unitless
Alkalinity	Alkalinity	microequivalents (uequiv)
QF10_Alkalinity	Quality flag for alkalinity	unitless
NO3_NO2	Nitrate + Nitrite	micromole per kilogram (umol/kg)
QF11_NO3_NO2	Quality flag for nitrate + nitrite	unitless
NO2	Nitrite	micromole per kilogram (umol/kg)
QF12_NO2	Quality flag for nitrite	unitless
PO4	Phosphate	micromole per kilogram (umol/kg)
QF13_PO4	Quality flag for phosphate	unitless
Silicate	Silicate	micromole per kilogram (umol/kg)
QF14_Silicate	Quality flag for silicate	unitless
POC	Particulate organic carbon	micrograms per kilogram (ug/kg)
QF15_POC	Quality flag for POC	unitless
PON	Particulate organic nitrogen	micrograms per kilogram (ug/kg)
QF16_PON	Quality flag for PON	unitless
TOC	Total organic carbon	micromole per kilogram (umol/kg)
QF17_TOC	Quality flag for TOC	unitless

TN	Total nitrogen	micromole per kilogram (umol/kg)
QF18_TN	Quality flag for total nitrogen	unitless
Bact	Bacteria enumeration	cells times 10^8 per kilogram (cells*10^8/kg)
QF19_Bact	Quality flag for bacteria enumeration	unitless
POP	Particulate organic phosphorus	micromole per kilogram (umol/kg)
QF20_POP	Quality flag for POP	unitless
TDP	Total dissolved phosphorus	nanomole per kilogram (nmol/kg)
QF21_TDP	Quality flag for TDP	unitless
SRP	Low-level phosphorus	nanomole per kilogram (nmol/kg)
QF22_SRP	Quality flag for low-level phosphorus	unitless
Bio_Si	Particulate biogenic silica	micromole per kilogram (umol/kg)
QF23_Bio_Si	Quality flag for particulate biogenic silica	unitless
Lith_Si	Particulate lithogenic silica	micromole per kilogram (umol/kg)
QF24_Lith_Si	Quality flag for particulate lithogenic silica	unitless
Prochlorococcus	Prochlorococcus abundance	cells per milliliter (cells/mL)
QF25_Prochlorococcus	Quality flag for prochlorococcus abundance	unitless
Synechococcus	Synechococcus abundance	cells per milliliter (cells/mL)
QF26_Synechococcus	Quality flag for synechococcus abundance	unitless
Picoeukaryotes	Picoeukaryote abundance	cells per milliliter (cells/mL)
QF27_Picoeukaryotes	Quality flag for picoeukaryote abundance	unitless
Nanoeukaryotes	Nanoeukaryote abundance	cells per milliliter (cells/mL)
QF28_Nanoeukaryotes	Quality flag for nanoeukaryote abundance	unitless
yyyymmdd	Date in Year Month Day format	unitless
decy	Decimal Year	unitless
Time	Time in Hour Minute format (hhmm)	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	centrifuge
Generic Instrument Name	Centrifuge
Dataset-specific Description	All tubes are centrifuged at 14,000 RPM and 4°C for 7 minutes
Generic Instrument Description	A machine with a rapidly rotating container that applies centrifugal force to its contents, typically to separate fluids of different densities (e.g., cream from milk) or liquids from solids.

Dataset-specific Instrument Name	Seabird 911+
Generic Instrument Name	CTD Sea-Bird SBE 911plus
Dataset-specific Description	Samples were collected using a Seabird 911+
Generic Instrument Description	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

Dataset-specific Instrument Name	Incubation cooler
Generic Instrument Name	Incubator
Dataset-specific Description	Incubation coolers are used to hold samples at temperature within ±4°C of their Niskin sampling temperature.
Generic Instrument Description	A device in which environmental conditions (light, photoperiod, temperature, humidity, etc.) can be controlled. Note: we have more specific terms for shipboard incubators (https://www.bco-dmo.org/instrument/629001) and in-situ incubators (https://www.bco-dmo.org/instrument/494).

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.

[table of contents | back to top]

Deployments

BATS_cruises

Website	https://www.bco-dmo.org/deployment/58883
Platform	Unknown Platform
Report	http://bats.bios.edu/bats-data/
Start Date	1988-10-20
Description	Bermuda Institute of Ocean Science established the Bermuda Atlantic Time-series Study with the objective of acquiring diverse and detailed time-series data. BATS makes monthly measurements of important hydrographic, biological and chemical parameters throughout the water column at the BATS Study Site, located at 31 40N, 64 10W.

[table of contents | back to top]

Project Information

Bermuda Atlantic Time-series Study (BATS)

Website: http://bats.bios.edu

Coverage: Northwest Sargasso Sea at 31 deg 40' N, 64 deg 10' W

A full description of the BATS research program (including links to the processed BATS data) is available from the BATS Web site (see above for Project URL/ Project Website links). Any data contributed from selected ancillary projects are listed (linked) in the 'Datasets Collection' section below.

Collaborative Research: The Bermuda Atlantic Time-series Study: Sustained Biogeochemical, Ecosystem and Ocean Change Observations and Linkages in the North Atlantic (Years 31-35) ***Awards OCE-1756105, OCE-1756054, and OCE-1756312)***
NSF award abstract
Long-term observations over several decades are a powerful tool for investigating ocean physics, biology, and chemistry, and the response of the oceans to environmental change. The Bermuda Atlantic Time-Series Study, known as BATS, has been running continuously since 1988. The research goals of the BATS program are: (1) to improve our understanding of the time-varying components of the ocean carbon cycle and the cycles of related nutrient elements such as nitrogen, phosphorus, and silicon; and, (2) to identify the relevant physical, chemical and ecosystem properties responsible for this variability. In addition, the BATS program has strong and diverse broader impacts, contributing to the field of ocean sciences by providing high quality ocean observations and data for seagoing scientists and modelers, and a framework through which researchers can

conceive and test hypotheses. This award will support the operations of the BATS program for five more years.

The primary BATS research themes are as follows: (1) Quantify the role of ocean-atmosphere coupling and climate variability on air-sea exchange of CO2, and carbon export to the ocean interior; (2) Document trends and the controls on the interannual to decadal scale variability in carbon and nutrient cycles to their coupling in the surface and deep ocean via the Redfield Ratio paradigm; (3) Quantify the response of planktonic community structure and function, and impact on biogeochemical cycles to variability in surface fluxes and dynamical processes; (4) Facilitate development, calibration and validation of next generation oceanographic sensors, tools and technologies; and, (5) Generate a dataset that can be utilized by empiricists, modelers and students. This research integrates ocean physics, chemistry and biology into a framework for understanding oceanic processes and ocean change in the North Atlantic subtropical gyre. The existing 29 years of BATS data provide robust constraints on seasonal and interannual variability, the response of the Sargasso Sea ecosystem to natural climate variability, and signal detection of potential ocean changes. This project would extend the BATS program through years 31-35 to address a series of ten interlinked questions through integrated research approaches and a multitude of collaborative efforts. In addition to the themes above, and embedded into the ten questions and approaches, the BATS team will focus on, for example, coupling of particle production and biogeochemistry; revisiting the complexities of the biological carbon pump; oxygen decline; and changes in the hydrography, physics, ocean carbon cycle and biogeochemistry of the Sargasso Sea. The highest quality data observation and collection will be maintained and used to address these questions. Importantly, a wide range of collaborations at the BATS site, spanning the physical and biogeochemical disciplines, will aid these broad goals. Strong links to community stakeholders, and close collaboration (including methods intercomparisons and personnel exchanges) with the Hawaii Ocean Time-series are proposed. This work will extend the research findings of the project into educational and training opportunities within and beyond the oceanographic community, including training and mentorship of both undergraduate and graduate students.

Please see the BATS Web site (http://bats.bios.edu) for additional information.

List of References (PDF)

[table of contents | back to top]

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.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1756105

[table of contents | back to top]