Discrete bottle samples collected during BATS Validation (BVAL) cruises from April 1991 through July 2024

Website: https://www.bco-dmo.org/dataset/917255
Data Type: Cruise Results
Version: 7
Version Date: 2025-07-09

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 50001 (April 1991) through BVAL cruise 50061 (June/July 2024). The sample parameter list has been mostly consistent for the full time-series record and includes: salinity, dissolved oxygen, dissolved inorganic carbon, alkalinity, nutrients (nitrate + nitrite, nitrite, phosphate, silicate), particulate organics (carbon, nitrogen, phosphorous), particulate silicate, total organic carbon and nitrogen, total dissolved phosphorus, bacterial enumeration, and flow cytometry counts of picoplankton.

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**:39.455 **E**:-59.649 **S**:19.225 **W**:-74.167
Temporal Extent: 1991-04-29 - 2024-07-09

Methods & Sampling

BATS Validation Cruises

Following the first several years of the BATS project it was deemed necessary by the JGOFS steering committee and BATS PI's 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 2000 it was deemed more important to document the larger scale changes in the North Atlantic Subtropical gyre and 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 start in June/July of each year for safety and operational reasons. In the pentad prior to 2022 every BVAL cruise was significantly impacted but multiple tropical cyclones. Parameters presented are the same as provided in the standard BATS bottle files.

Data were collected on BVAL cruises from April 1991 (BVAL cruise #50001) through June/July 2024 (BVAL cruise #50061). 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, Claire Medley, and Dominic Smith.

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 wavelengths using 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

Data processing steps are outlined in the BATS Methods Manual.

BCO-DMO Processing Description

- imported "bval_bottle_v0067.txt" and "bval_bottle_qcmask_v007.txt" into BCO-DMO system
m using missing data identifiers 'nd' and '-999'.
- joined "bval_bottle_qcmask_v007.txt" and "bval_bottle_v007.txt" to add flag columns for the parameters
- converted longitude values to decimal degrees (degrees West are negative)
- converted date to ISO yyyy-mm-dd format
- combine date and time to create ISO UTC timestamp
- added Cruise_type, Cruise_num, Cast, Cast_type, and Bottle_number columns (extracted from ID column)
- added vessel names as defined in "bval_pigments_v006.txt"

- added cast types as defined in "bval_pigments_v006.txt"
- modified parameter names to conform with BCO-DMO naming conventions and to be more consistent with other BATS data submissions
- renamed parameters from mask file to reflect parameter names from data file

Version 7 Notes:
- There are no new cruises for this version
- New values are included for measurements made since last version (bacterial abundance, FCM, etc.)
- See release notes for more information

Problem Description

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

[table of contents | back to top]

Data Files

File	
917255_v7_bats_bval_bottle.csv	(Comma Separated Values (.csv), 4.03 MB) MD5:d7377b8485f2e9a3cf0761693a7dc07d
BATS Validation cruise bottle data (v007) with quality flags. Primary data file for dataset ID 917255, version 7	

[table of contents | back to top]

Supplemental Files

File	
BVAL bottle data update file for version v007 filename: bval_bottle_release_v007_update.txt	(Plain Text, 1.08 KB) MD5:773c4a7cf3353355d3e8b41d3002e683
BATS Validation (BVAL) bottle data version v007 update file. ASCII file listing changes in current version (v007) from previous versions.	

[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	Sampling date in ISO8601 format	unitless
Vessel	Name of vessel used for cruise	unitless
Latitude	Latitude of sampling	decimal degrees
Longitude	Longitude of sampling	decimal degrees
Cruise_type	Cruise type (BATS Validation)	unitless
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_Bottle	Quality flag for bottle (-3 = suspect, 1 = unverified, 2 = verified/acceptable)	unitless
Depth	Depth of sampling	meters (m)
QF_Depth	Quality flag for depth; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless

Temp	Temperature (ITS-90 scale)	degrees Celsius
QF_Temp	Quality flag for temperature; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
CTD_Sal	CTD Salinity (PSS-78 scale)	PSS-78
QF_CTD_Sal	Quality flag for CTD salinity; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Sal1	Salinity-1 (PSS-78 scale)	PSS-78
QF_Sal1	Quality flag for Salinity-1; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Sigma_theta	Sigma-theta potential density	kilogram per cubic meter (kg/m^3)
QF_Sigma_theta	Quality flag for sigma-theta; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
O2	Oxygen-1	micromole per kilogram (umol/kg)
QF_O2	Quality flag for oxygen; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
DIC	Dissolved inorganic carbon	micromole per kilogram (umol/kg)
QF_DIC	Quality flag for DIC (dissolved inorganic carbon); Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Alkalinity	Alkalinity	microequivalents (uequiv)
QF_Alkalinity	Quality flag for alkalinity; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
NO3_NO2	Nitrate + Nitrite	micromole per kilogram (umol/kg)

QF_NO3_NO2	Quality flag for nitrate + nitrite; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
NO2	Nitrite	micromole per kilogram (umol/kg)
QF_NO2	Quality flag for nitrite; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
PO4	Phosphate	micromole per kilogram (umol/kg)
QF_PO4	Quality flag for phosphate; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Silicate	Silicate	micromole per kilogram (umol/kg)
QF_Silicate	Quality flag for silicate; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
POC	Particulate organic carbon	micrograms per kilogram (ug/kg)
QF_POC	Quality flag for POC; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
PON	Particulate organic nitrogen	micrograms per kilogram (ug/kg)
QF_PON	Quality flag for PON; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
TOC	Total organic carbon	micromole per kilogram (umol/kg)
QF_TOC	Quality flag for TOC; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
TN	Total nitrogen	micromole per kilogram (umol/kg)

QF_TN	Quality flag for total nitrogen; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Bact	Bacteria enumeration	cells times 10^8 per kilogram (cells*10^8/kg)
QF_Bact	Quality flag for bacteria enumeration; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
POP	Particulate organic phosphorus	micromole per kilogram (umol/kg)
QF_POP	Quality flag for POP; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
TDP	Total dissolved phosphorus	nanomole per kilogram (nmol/kg)
QF_TDP	Quality flag for TDP; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
SRP	Low-level phosphorus	nanomole per kilogram (nmol/kg)
QF_SRP	Quality flag for low-level phosphorus; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Bio_Si	Particulate biogenic silica	micromole per kilogram (umol/kg)
QF_Bio_Si	Quality flag for particulate biogenic silica; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Lith_Si	Particulate lithogenic silica	micromole per kilogram (umol/kg)
QF_Lith_Si	Quality flag for particulate lithogenic silica; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Prochlorococcus	Prochlorococcus abundance	cells per milliliter (cells/mL)

QF_Prochlorococcus	Quality flag for prochlorococcus abundance; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Synechococcus	Synechococcus abundance	cells per milliliter (cells/mL)
QF_Synechococcus	Quality flag for synechococcus abundance; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Picoeukaryotes	Picoeukaryote abundance	cells per milliliter (cells/mL)
QF_Picoeukaryotes	Quality flag for picoeukaryote abundance; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Nanoeukaryotes	Nanoeukaryote abundance	cells per milliliter (cells/mL)
QF_Nanoeukaryotes	Quality flag for nanoeukaryote abundance; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
decy	Decimal Year	unitless
Time	Time in Hour Minute format (hhmm)	unitless
yyyymmdd	Date in Year Month Day format	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

BVAL_cruises

Website	https://www.bco-dmo.org/deployment/944358
Platform	Multiple Vessels
Start Date	1991-04-29
Description	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. 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 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. 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.

[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 36-40) *(Awards OCE-2241455, OCE-2241456 and OCE-2241457)*
NSF award abstract

Long-term observations of ocean physics, biology, and chemistry across decades provide a powerful lens for understanding the response of the oceans to environmental change. This award will continue the Bermuda Atlantic Time-series Study (BATS) research program, which began in 1988, for another five years. Observations at the BATS site provide crucial information for understanding the ocean?s role in the global climate system and the response of the ocean carbon system and marine ecosystems to climate perturbations. The research goals of the BATS program continue to be to improve our understanding of the time-varying components of the ocean carbon cycle and related elements of interest (such as nitrogen, phosphorus, and silica) and to identify the physical, chemical, and ecosystem properties responsible for this variability. The BATS program has substantial broader impacts, contributing to the field of ocean sciences by providing high-quality ocean observations and a framework in which other researchers can conceive and test hypotheses. In addition, the recent acquisition of the Bermuda Institute of Ocean Sciences by the Global Futures Laboratory of Arizona State University provides new avenues for educational opportunities and innovation.

In the subtropical gyre of the North Atlantic Ocean, warming, salinification, deoxygenation, ocean ecosystem changes, and acidification have accelerated their rate of change. Fundamental questions and challenges remain about understanding present and future ocean function, prediction, and modelling. An overarching question for the BATS program is: Will ocean biogeochemistry and ecosystem functioning continue to change in response to the acceleration of ocean warming, salinification, stratification, deoxygenation and acidification?

With this question in mind, the sustained goals for the BATS program are: 1. Quantify the role of ocean-atmosphere coupling and climate variability on air-sea exchange of carbon dioxide (CO2) and carbon export to the ocean interior; 2. Document trends and controls of the following: (a) the interannual to decadal scale variability in carbon and nutrient cycles and their coupling in the surface and deep ocean via the Redfield Ratio paradigm; and, (b) biological community structure in the oligotrophic North Atlantic Ocean in response to low-frequency climate variability; 3. Quantify the response of planktonic and microbial community structure and function and impact on biogeochemical cycles (including new and export productivity) to variability in surface fluxes (e.g., heat, freshwater and momentum) and physical processes (e.g., mesoscale eddies, Rossby Waves, internal waves); 4. Facilitate development, calibration and validation of next-generation oceanographic sensors, tools and technologies; 5. Generate datasets that can be used by empiricists and modelers to test new hypotheses about North Atlantic Ocean biogeochemistry and ecosystem functioning; 6. Use BATS cruise, infrastructure, laboratory and analytical expertise, and data to improve education and training programs for BATS staff, STEM-literate students, and future oceanographers.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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

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[table of contents | back to top]