Primary productivity estimates from the incubation of seawater collected at the Bermuda Atlantic Time-series Study (BATS) site from December 1988 through December 2024

Website: https://www.bco-dmo.org/dataset/893182
Data Type: Cruise Results, Other Field Results
Version: 6
Version Date: 2025-06-20

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)

Contributors	Affiliation	Role
Bates, Nicholas	Bermuda Institute of Ocean Sciences (BIOS)	Principal Investigator
Johnson, Rodney J.	Bermuda Institute of Ocean Sciences (BIOS)	Co-Principal Investigator
Lethaby, Paul J.	Bermuda Institute of Ocean Sciences (BIOS)	Scientist
May, Rebecca	Bermuda Institute of Ocean Sciences (BIOS)	Scientist
Medley, Claire	Bermuda Institute of Ocean Sciences (BIOS)	Scientist
Smith, Dominic	Bermuda Institute of Ocean Sciences (BIOS)	Scientist
Stuart, Emma	Bermuda Institute of Ocean Sciences (BIOS)	Scientist
Gerlach, Dana Stuart	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager
Mickle, Audrey	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Data presented are primary production estimates at the Bermuda Atlantic Time-series Study (BATS) site in the Sargasso Sea from December 1988 (BATS Cruise 10003) through December 2024 (BATS cruise 10422). The rate of carbon fixation by autotrophs in seawater was determined by tracing the uptake of radioactive 14C from the inorganic form to the particulate organic form. Incubations were performed in situ at depths ranging from the surface to 140 meters from dusk to dawn. Seawater samples were collected prior to sunrise, separated into three light bottles and one dark bottle, and a radioactive 14C tracer added. The bottles were then deployed on an incubation array at their collection depths, and allowed to drift on the array for the full light day. Samples were recovered after sunset and filtered for subsequent analysis on a liquid scintillation counter.

Table of Contents

- Funding

Coverage

Location: The Bermuda Atlantic Time-series Study site in the Sargasso Sea. Nominal location 31 degrees 40'N , 64 degrees 10'W
Spatial Extent: **N**:32.108 **E**:-64.012 **S**:31.135 **W**:-64.914
Temporal Extent: 1988-12-18 - 2024-12-16

Methods & Sampling

Primary production is measured *in situ* as part of the monthly Bermuda Atlantic Time Series (BATS) cruises. Research was conducted on many research vessels including R/V Weatherbird I, R/V Weatherbird II, R/V Cape Henlopen, R/V Cape Hatteras, R/V Oceanus, R/V Endeavor, R/V Atlantic Explorer. Nominal deployment location at BATS site (31 40'N, 64 10'W). Numerous Chief Scientists: Tony Knap, Rachel Dow, Anthony Michaels, Kjell Gundersen, Rodney Johnson, Ann Close, Deborah Steinberg, Paul Lethaby, Julian Mitchell, Vivienne Lochhead, Deborah Lomas, Steven Bell, Jonathan Whitefield, Gwyn Evans, James Sadler, Samuel Monk, Samuel Stevens, Afonso Goncalves, Matt Enright, Fernando Pacheco, Zac Anderson, Claire Medley, Dominic Smith.

Scope and field of application
Primary production is a fundamental ecological variable for understanding the flow of energy into an ecosystem as it supports the availability of organic material as building blocks for higher trophic levels. This method uses a radiocarbon ^{14}C spike and liquid scintillation counter (LSC) techniques to quantify the rate of primary production. This procedure describes the method for the determination of primary production in seawater, expressed as milligrams of carbon per cubic meter per day (mg C m^{-3} day^{-1}) . This method is suitable for the assay of all levels of primary production found in the ocean.

Primary production is defined as the rate of uptake of inorganic carbon (DIC) into particulate organic carbon (POC),

$$\text{C uptake} = \frac{DIC_n * POC^{14}C * 1.05}{DIC^{14}C}, \text{ where}$$

C uptake = rate of carbon fixation (mg Carbon m^{-3} day^{-1})
DIC_n = naturally occurring dissolved inorganic carbon
$POC^{14}C$ = ^{14}C spiked particulate organic carbon
$DIC^{14}C$ = ^{14}C spiked dissolved inorganic carbon
1.05 = metabolic discrimination factor due to biological isotopic fractionation (preferable uptake of lighter isotopes)

Principle of analysis
The rate of carbon fixation by autotrophs in seawater is measured by tracing the uptake of radioactive ^{14}C from the inorganic form to the particulate organic form. Radiocarbon is added at an assumed ratio to the total inorganic carbon content of the seawater sample. The uptake of radiocarbon by the particulate phytoplankton is converted to total carbon uptake by the application of this radiocarbon: total carbon ratio. Inorganic carbon is not measured because samples are acidified before analysis. The seawater is collected using the CTD at discrete depths every 20 meters from the surface to 140 meters. The radioactive ^{14}C spike is added and samples are incubated in situ at their respective depths using a free-floating array. The array is deployed prior to first light and recovered after sunset to capture the dawn to dusk light cycle.

A liquid scintillation counter (LSC) is used to calculate the level of radioactivity in the sample and therefore the amount of ^{14}C particulate organic carbon. The LSC measures the conversion of radioactive decay events into photons of light, which are detected by photomultiplier tubes and converted into electrical pulses. In order to aid the detection of radioactivity, a liquid scintillation cocktail is added (Ultima gold for this method). The cocktail contains both solvent and scintillator molecules. The radioactive decay from the ^{14}C excites the solvent molecule, and the energy is transferred to the scintillator which re-emits the energy in the form of light. Often more than one type of scintillator is present in the cocktail to allow for the emission of light at a suitable

wavelength to be detected by the photomultiplier tubes. The resulting electrical signal that is generated is recorded as counts per minute (CPM).

Field sampling
Samples for primary production are collected two hours before dawn (pre-dawn production cast) and no other samples are taken during this cast. Nitrile gloves are used during the handling of samples. The polycarbonate incubation bottles are filled directly from the Niskins under low light conditions. Each bottle is rinsed 3 times before filling. Five bottles are filled for each sample depth. 250 µl of the ^{14}C working solution is added to each of the five bottles in the shared use radioisotope lab container. Low light levels are maintained by using red lights in the lab. One of the five bottles is wrapped in electrical tape; this bottle is then wrapped in aluminium foil to ensure it is kept in dark conditions. One of the five productivity bottles is used as the time-zero (T-0) sample. The spike is added, the sample is then thoroughly shaken before 50 ml is filtered. A 250 µl aliquot -- to be used for counting total added ^{14}C activity -- is removed from each of the T-0 bottles and is placed in a 20 ml glass scintillation vial containing 250 µl ethanolamine.

Approximately one hour before sunrise the productivity array is deployed. The incubation occurs throughout the day and the array is recovered approximately half an hour after sunset. Upon recovery and under low light conditions, a 50 ml aliquot is withdrawn from each productivity bottle and filtered onto a 25 mm Whatman® Glass Fibre Filter, maintaining vacuum levels of 70 mm Hg or less. Neither the filter nor the syringe is rinsed. The filter is placed into a 20 ml glass scintillation vial. Under a fume hood, excess radioactive carbon is driven off by adding 250 µl 0.5 N hydrochloric acid. A 250 µl aliquot for counting total added ^{14}C activity (Time End Specific Activity) is removed from one of the light productivity bottles. This is placed in a 20 ml glass scintillation vial containing 250 µl ethanolamine (Sigma), similar to the T-0 described in Time Zero Specific Activity Sample. The samples are then stored at room temperature until analysis.

For additional details, please see Protocols for the Bermuda Atlantic Time-series Study Core Measurements.

BCO-DMO Processing Description

- Imported data from source files "bats_primary_production_v006.txt", "bats_primary_production_qcmask_v006.txt", and "bats_primary_production_qcmask_v006.txt" into the BCO-DMO data system. Data file imported using missing data identifiers "NA" and all variants of -999
- Joined "bats_primary_production_v006.txt" and "bats_primary_production_qcmask_v006.txt" on Id, yymmdd_in, Lat_in, and Lat_out, bringing all QF flag fields into the dataset
- Converted longitude to decimal degrees (west is negative)
- Added columns for Cruise type, Cruise number, Cast number, and Bottle number based on the Id
- Zero padded the time column (HHMM_in and HHMM_out) values and then combined with the yymmdd_in and yymmdd_out time column to create datetime colum
- Converted date and datetime to ISO8601 format
- Created a separate Date field formatted as YYYY-MM-DD, since not all row have time values
- Created type fields for Cruise and Cast numbers
- Joined "bats_primary_production_v006.txt" and "BATS_bottle_v006_unique_vessel_cruise_combos.txt"
- Modified parameter (column) names to conform with BCO-DMO naming conventions and to be more similar to other BATS datasets. The only allowed characters are A-Z,a-z,0-9, and underscores. No spaces, hyphens, commas, parentheses, or Greek letters
- Added Vessel values for cruises not included in "BATS_bottle_v006_unique_vessel_cruise_combos.txt"
- Exported dataset file as "893182_v6_bats_primary_production.csv"

Version 4 (v004)

All no data notation was replaced with blanks. Mask file information was incorporated into the dataset. Dataset and metadata updated with latest extents, vessels used, and cruises.

Version 5 (v005)

New authors added. Dataset and metadata updated with latest extents, vessels used, and cruises.

Version 6 (v006)

Dataset and metadata updated with latest extents, vessels used, and cruises.

See the supplemental release/update notes for more information.

Problem Description

Flag definitions are consistent with the WOCE bottle parameter quality flags and defined here as : 1= unverified , 2= verified acceptable, 3= questionable, 4= bad, 9= no data. The Niskin/Goflo flag for designating the quality of the collection bottles is as follows: -3 = possible misfire, 1 = unverified, 2= verified acceptable).

Times of array deployment and recovery were recorded starting in 2006.
Cruises 10196 and 20197 do not include latitude and longitude information for array deployment or recovery.

Latitude and longitude of array recovery was recorded consistently after 2008.

Data for cruise 10418 will be published in the next submission.

[table of contents | back to top]

Data Files

File	
893182_v6_bats_primary_production.csv	(Comma Separated Values (.csv), 803.54 KB) MD5:6e2a14acd796b56e6352285393de23d0
Primary data file for dataset ID 893182, version 6	

[table of contents | back to top]

Supplemental Files

File	
bats_production_release_v006_update.txt	(Plain Text, 527 bytes) MD5:32f86f2254e7f2c24d00b63616154835

[table of contents | back to top]

Related Publications

BATS (2023). Protocols for the Bermuda Atlantic Time-series Study Core Measurements. Bermuda Institute of Ocean Sciences, 142 pp.
Methods

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

Fitzwater, S. E., Knauer, G. A., & Martin, J. H. (1982). Metal contamination and its effect on primary production measurements1. Limnology and Oceanography, 27(3), 544–551. doi:10.4319/lo.1982.27.3.0544
Methods

Joint, I., Pomroy, A., Savidge, G., & Boyd, P. (1993). Size-fractionated primary productivity in the northeast Atlantic in May–July 1989. Deep Sea Research Part II: Topical Studies in Oceanography, 40(1–2), 423–440. https://doi.org/10.1016/0967-0645(93)90025-i
Methods

Laws, E. A., DiTullio, G. R., Betzer, P. R., Karl, D. M., & Carder, K. L. (1989). Autotrophic production and elemental fluxes at 26°N, 155°W in the North Pacific subtropical gyre. Deep Sea Research Part A. Oceanographic Research Papers, 36(1), 103–120. https://doi.org/10.1016/0198-0149(89)90021-6
Methods

Lohrenz, S. E., Wiesenburg, D. A., Rein, C. R., Arnone, R. A., Taylor, C. D., Knauer, G. A., & Knap, A. H. (1992). A comparison of in situ and simulated in situ methods for estimating oceanic primary production. Journal of Plankton Research, 14(2), 201–221. https://doi.org/10.1093/plankt/14.2.201
Methods

Richardson, K. (1991). Comparison of 14C primary production determinations made by different laboratories. Marine Ecology Progress Series, 72, 189–201. https://doi.org/10.3354/meps072189
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
ID	A unique bottle ID which identifies cruise, cast, and Niskin number	unitless
Date	Date productivity array was deployed in YYYY-MM-DD format	unitless
ISO_DateTime_UTC_in	Datetime productivity array was deployed in ISO8601 format	unitless
ISO_DateTime_UTC_out	Datetime productivity array was recovered in ISO8601 format	unitless
Vessel	Name of vessel used for cruise	unitless
Latitude_in	Latitude productivity array was deployed in decimal degrees, South is negative	decimal degrees
Longitude_in	Longitude productivity array was deployed in decimal degrees, West is negative	decimal degrees
Latitude_out	Latitude productivity array was recovered in decimal degrees, South is negative	decimal degrees
Longitude_out	Longitude productivity array was recovered in decimal degrees, West is negative	decimal degrees
Cruise_type	Cruise type (BATS Core, Bloom A, or Bloom B)	unitless
Cruise_num	BATS Cruise number	unitless
Cast_type	Cast type (CTD or Hydrocast)	unitless
Cast_num	Cast Number (1-80 = CTD, 81-99 = Hydrocast)	unitless

Bottle_num	Niskin bottle number	unitless
QF_Niskin_GoFlo	Niskin/GoFlo quality flag (-3 = suspect, 1=unverified, 2= verified/acceptable)	unitless
Depth	Collection depth	meters (m)
QF1_Depth	Quality control flag for depth; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Pressure	Pressure (dbar) from CTD	units
QF2_Pressure	Quality control flag for pressure; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Temp	CTD temp (C)	units
QF3_Temp	Quality control flag for temperature; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
Sal	Salinity from Goflo bottle or CTD	units
QF4_Sal	Quality control flag for salinity; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
lt1	14C Primary Production light bottle #1	mgC/m^3/day
QF5_it1	Quality control flag for 14C Primary Production light bottle #1; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
lt2	14C Primary Production light bottle #2	mgC/m^3/day
QF6_lt2	Quality control flag for 14C Primary Production light bottle #2; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
lt3	14C Primary Production light bottle #3	mgC/m^3/day

QF7_lt3	Quality control flag for 14C Primary Production light bottle #3; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
dark	14C Primary Production dark bottle	mgC/m^3/day
QF8_dark	Quality control flag for 14C Primary Production dark bottle; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
t0	14C Primary Production Time zero	mgC/m^3/day
QF9_t0	Quality control flag for 14C Primary Production Time zero; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
pp	Primary Production Mean Light values - Dark value	mgC/m^3/day
QF10_pp	Quality control flag for Mean Light values - Dark value; Parameter quality flags defined as 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data	unitless
yyyymmdd_in	Year, month, and day productivity array was deployed in YYYYMMDD format	unitless
yyyymmdd_out	Year, month, and day productivity array was recovered in YYYYMMDD format	unitless
decy_in	Date productivity array was deployed in Decimal Year format	unitless
decy_out	Date productivity array was recovered in Decimal Year format	unitless
Time_in	Time productivity array was deployed in HHMM format	unitless
Time_out	Time productivity array was recovered in HHMM format	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	CTD
Generic Instrument Name	CTD Sea-Bird 911
Dataset-specific Description	The seawater is collected using the CTD at discrete depths every 20 meters from the surface to 140 meters.
Generic Instrument Description	The Sea-Bird SBE 911 is a type of CTD instrument package. The SBE 911 includes the SBE 9 Underwater Unit and the SBE 11 Deck Unit (for real-time readout using conductive wire) for deployment from a vessel. The combination of the SBE 9 and SBE 11 is called a SBE 911. The SBE 9 uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3 and SBE 4). The SBE 9 CTD can be configured with 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	light and dark incubation bottles
Generic Instrument Name	Light-Dark Bottle
Dataset-specific Description	Seawater samples were collected prior to sunrise, separated into three light bottles and one dark bottle, and a radioactive 14C tracer added. The bottles were then deployed on an incubation array at their collection depths, and allowed to drift on the array for the full light day.
Generic Instrument Description	The light/dark bottle is a way of measuring primary production by comparing before and after concentrations of dissolved oxygen. Bottles containing seawater samples with phytoplankton are incubated for a predetermined period of time under light and dark conditions. Incubation is preferably carried out in situ, at the depth from which the samples were collected. Alternatively, the light and dark bottles are incubated in a water trough on deck, and neutral density filters are used to approximate the light conditions at the collection depth.Rates of net and gross photosynthesis and respiration can be determined from measurements of dissolved oxygen concentration in the sample bottles.

Dataset-specific Instrument Name	Liquid Scintillation Counter
Generic Instrument Name	Liquid Scintillation Counter
Dataset-specific Description	A Liquid Scintillation Counter is used to calculate the level of radioactivity in the sample and therefore the amount of 14C particulate organic carbon
Generic Instrument Description	Liquid scintillation counting is an analytical technique which is defined by the incorporation of the radiolabeled analyte into uniform distribution with a liquid chemical medium capable of converting the kinetic energy of nuclear emissions into light energy. Although the liquid scintillation counter is a sophisticated laboratory counting system used the quantify the activity of particulate emitting (ß and a) radioactive samples, it can also detect the auger electrons emitted from 51Cr and 125I samples. Liquid scintillation counters are instruments assaying alpha and beta radiation by quantitative detection of visible light produced by the passage of rays or particles through a suitable scintillant incorporated into the sample.

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	Multiple Vessels
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 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

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0752366
NSF Division of Ocean Sciences (NSF OCE)	OCE-1756105
NSF Division of Ocean Sciences (NSF OCE)	OCE-2241455

[table of contents | back to top]