Zooplankton biomass measured from net tows conducted during ongoing monthly cruises, from April 1994 to March 2022, at the Bermuda Atlantic Time-series Study (BATS) site in the Sargasso Sea

Website: https://www.bco-dmo.org/dataset/881861
Data Type: Cruise Results
Version: 1
Version Date: 2023-04-05

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
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Abstract
This dataset includes measurements of zooplankton biomass from net tows conducted during ongoing monthly cruises, from April 1994 to March 2022, at the Bermuda Atlantic Time-series Study (BATS) site (31° 40' N 64° 10'W) in the Sargasso Sea. Mesozooplankton were collected by oblique tows using a rectangular frame net with 202 micrometer (µm) mesh. Samples from tows were immediately split on board for subsequent wet and dry weight measurments.

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Coverage

Spatial Extent: **N**:31.975 **E**:-63.779 **S**:31.411 **W**:-64.505
Temporal Extent: 1994-04-06 - 2022-03-30

Acquisition Description

Sampling was conducted on ongoing monthly cruises, starting in April 1994, at the Bermuda Atlantic Time-series Study (BATS) site (31° 40' N 64° 10'W) in the Sargasso Sea. Mesozooplankton were collected with a rectangular frame (0.8 x 1.2 meters) net with 202 micrometer (µm) mesh. Two replicate double oblique tows through the euphotic zone at a ship speed of 1 nautical mile per hour (nm/h) were made during the day (between about 0900 and 1500 h) and night (between about 2000 and 0200 h) on each BATS cruise. The targeted maximum net depth was between 150 and 200 meters (m) and absolute depth was recorded with a temperature-depth recorder. The volume of water filtered by the net (m^3) was measured with a General Oceanics flowmeter.

Samples from the tows were split immediately on board. One half-split was fractionated by wet sieving through nested sieves with mesh sizes of 5.0, 2.0, 1.0, 0.5 and 0.2 millimeters (mm), with individual fractions transferred to preweighed disks of 0.2 mm nitex netting and frozen for subsequent wet and dry weight (in milligrams) analyses.

Processing Description

BCO-DMO Processing:
- added 'Z' to end of date-time string to indicate time zone of UTC, as per ISO 8601 standard.

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Data Files

File
bats_zooplankton.csv (Comma Separated Values (.csv), 188.02 KB) MD5:aa52998a134c5cedd312f11331a082ba Primary data file for dataset ID 881861

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Related Publications

Ivory, J. A., Steinberg, D. K., & Latour, R. J. (2018). Diel, seasonal, and interannual patterns in mesozooplankton abundance in the Sargasso Sea. ICES Journal of Marine Science, 76(1), 217–231. https://doi.org/10.1093/icesjms/fsy117
General

Lomas, M. W., Bates, N. R., Johnson, R. J., Knap, A. H., Steinberg, D. K., & Carlson, C. A. (2013). Two decades and counting: 24-years of sustained open ocean biogeochemical measurements in the Sargasso Sea. Deep Sea Research Part II: Topical Studies in Oceanography, 93, 16–32. doi:10.1016/j.dsr2.2013.01.008
General

Madin, L. P., Horgan, E. F., & Steinberg, D. K. (2001). Zooplankton at the Bermuda Atlantic Time-series Study (BATS) station: diel, seasonal and interannual variation in biomass, 1994–1998. Deep Sea Research Part II: Topical Studies in Oceanography, 48(8–9), 2063–2082. https://doi.org/10.1016/s0967-0645(00)00171-5
Results

Steinberg, D. K., Carlson, C. A., Bates, N. R., Johnson, R. J., Michaels, A. F., & Knap, A. H. (2001). Overview of the US JGOFS Bermuda Atlantic Time-series Study (BATS): a decade-scale look at ocean biology and biogeochemistry. Deep Sea Research Part II: Topical Studies in Oceanography, 48(8–9), 1405–1447. https://doi.org/10.1016/s0967-0645(00)00148-x https://doi.org/10.1016/S0967-0645(00)00148-X
General

Steinberg, D. K., Lomas, M. W., & Cope, J. S. (2012). Long-term increase in mesozooplankton biomass in the Sargasso Sea: Linkage to climate and implications for food web dynamics and biogeochemical cycling. Global Biogeochemical Cycles, 26(1). https://doi.org/10.1029/2010gb004026 https://doi.org/10.1029/2010GB004026
Results

Stone, J., & Steinberg, D. (2014). Long-term time-series study of salp population dynamics in the Sargasso Sea. Marine Ecology Progress Series, 510, 111–127. https://doi.org/10.3354/meps10985
General

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Parameters

Parameter	Description	Units
cruisetow_number	unique combination of cruise+tow numbers as xxxyzz, where xxx = Cruise Number, y = Bloom Number (cruise_type = 2 for bloom cruises), and zz = Tow number.	unitless
cruise_number	BATS cruise number listed as a 5 digit ID. The first digit is cruise type: 1 = BATS core; 2 = BATS bloom A; 3 = BATS bloom B. Digits 2-5 are cruise number. e.g., 10218 = BATS 218.	unitless
cruise_type	type of cruise: 1 = BATS core; 2 = BATS bloom A; 3 = BATS bloom B.	unitless
R2R_cruise_ID	R2R cruise ID	unitless
tow_number	tow number	unitless
ISO_datetime	date and time (UTC) of tow in ISO8601 format	unitless
duration	duration of tow	minutes
lat	latitude at start of tow (North = positive values; South = negative values)	decimal degrees
lon	longitude at start of tow (East = positive values; West = negative values)	decimal degrees
depth	maximum depth of tow	meters (m)
vol_filt	volume of water filtered through the net	cubic meters (m^3)
wetwt_0200	zooplankton wet weight; 200 to 500 microns	milligrams (mg)
wetwt_0500	zooplankton wet weight; 500 to 1000 microns	milligrams (mg)
wetwt_1000	zooplankton wet weight; 1000 to 2000 microns	milligrams (mg)
wetwt_2000	zooplankton wet weight; 2000 to 5000 microns	milligrams (mg)
wetwt_5000	zooplankton wet weight; gt 5000 microns	milligrams (mg)
drywt_0200	zooplankton dry weight; 200 to 500 microns	milligrams (mg)
drywt_0500	zooplankton dry weight; 500 to 1000 microns	milligrams (mg)
drywt_1000	zooplankton dry weight; 1000 to 2000 microns	milligrams (mg)
drywt_2000	zooplankton dry weight; 2000 to 5000 microns	milligrams (mg)
drywt_5000	zooplankton dry weight; gt 5000 microns	milligrams (mg)

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Instruments

Dataset-specific Instrument Name	rectangular depressor plankton net with 202 µm mesh
Generic Instrument Name	Plankton Net
Dataset-specific Description	This type of net was designed by Larry Madin and the company Sea Gear.
Generic Instrument Description	A Plankton Net is a generic term for a sampling net that is used to collect plankton. It is used only when detailed instrument documentation is not available.

Dataset-specific Instrument Name	General Oceanics flowmeter
Generic Instrument Name	Flow Meter
Generic Instrument Description	General term for a sensor that quantifies the rate at which fluids (e.g. water or air) pass through sensor packages, instruments, or sampling devices. A flow meter may be mechanical, optical, electromagnetic, etc.

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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.

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Project Information

Bermuda Atlantic Time-series Study (BATS)

Website: http://www.bios.edu/research/projects/bats/

Coverage: Northwest Sargasso Sea at 32 deg 10' N 64 deg 30' W

A full description of the BATS research program (including links to the processed BATS data) is available from the BATS Web site (see http://www.bios.edu/research/projects/bats/). Any data contributed from selected ancillary projects will appear below in the datasets listing.

The Bermuda Atlantic Time-Series Study
Contributed by Mike Lomas (updated 30 September 2010)

Introduction and Scientific Background
The Bermuda Atlantic Time-series Study (BATS, 32° 10'N, 64° 30'W) was established in 1988 to study the ocean carbon cycle by analyzing important hydrographic and biological parameters throughout the water column. BATS complements the other Sargasso Sea time-series, the Ocean Flux Program (OFP) a deep sediment trap mooring in place since 1978, and Hydrostation "S" a hydrographic time-series sampled approximately biweekly since 1954. Currently, BATS makes monthly measurements of important hydrographic, biological and chemical parameters throughout the water column at different sites within the Sargasso Sea.

Long-term time series are a powerful tool for investigating ocean biogeochemistry and its effects on the global carbon cycle. The seasonal, interannual and longer-scale dynamics of carbon and nutrient cycles in the upper ocean control ecosystem productivity, the net exchange of CO_2 and other radiatively important gases between the atmosphere and the ocean, and the distribution of many biogenic elements in the marine environment. The Bermuda Atlantic Time-Series Study (BATS) is one of three long-term, ship-based ocean time series research sites, the other two being: the Hawaii Ocean Time-series (HOT) conducting systematic and sustained biogeochemical and physical oceanographic measurements at the deep-ocean site, Station ALOHA (A Long-Term Oligotrophic Habitat Assessment; 22° 45'N, 158° 00'W), located 100 km north of Oahu, Hawaii; and the Carbon Retention in a Colored Ocean Time Series (CARIACO) located in the southeastern Caribbean Sea, off the coast of Venezuela (10° 30'N, 64° 40'W) and visited by ship once per month since November 1995. Individually, the three ship-based ocean time series sites have been used to examine processes that occur in their respective geographic domains. Together, they have the potential to provide information on interannual to decadal-scale variability in global ocean processes and the climate system.

Understanding the controls on the Sargasso Sea carbon cycle requires that we not only understand each of its biogeochemical component processes but also the physical processes that move water within and through the BATS study region. The focus of the BATS program has been, and continues to be, improving our understanding of the "time-varying" components of the ocean carbon cycle, related biogenic elements of interest (e.g. nitrogen, phosphorus, silica), and identifying the relevant physical, chemical and ecosystem properties responsible for this variability. Within this context, there are a number of continuing goals and objectives for the BATS research program, including:

1. Document the seasonal, and interannual to decadal scale variability in carbon and nutrient cycles, and biological community structure in the oligotrophic gyre of the North Atlantic Ocean. This includes, for example, understanding the extent to which they are coupled or uncoupled in the surface ocean.

2. Quantify the role of ocean-atmosphere coupling and climate forcing on air-sea exchange of CO_2, and carbon export to the ocean interior. Carbon cycle studies include both inorganic and organic carbon, and for the latter, both particulate and dissolved phases. Of particular interest are the controls on partitioning of carbon between particulate and dissolved phases.

3. Study the role of physical forcing (e.g., surface fluxes of heat, freshwater and momentum) on planktonic community structure and function, and impact on biogeochemical cycles (including new and export productivity).

4. Study the role of climate-induced variability in surface fluxes on planktonic community structure and function.

5. Provide a testbed for the introduction and validation of new oceanographic tools and technologies; generate a dataset that can be utilized by empiricists and modelers to test new hypotheses; and build a framework for educating and training future oceanographers.

Temporal Dynamics of Hydrography and Element Cycles, and their Spatial Context
The BATS (1988-) and Hydrostation S (1954-) time-series allow observation of seasonal to interannual to decadal changes in hydrography and elemental cycles of carbon, nitrogen and phosphorus. In the section below, we briefly discuss some of the research findings resulting from the BATS project. Over the last twenty years, temperature and salinity in the upper ocean layers of the subtropical gyre at BATS has increased significantly with concurrent changes in stratification (Johnson and Knap, pers. comm.; Bates 2007) and reorganization of the hydrological cycle. Over the last 50 years, BATS/Hydrostation S data reveal a large increase in ocean heat (~0.01^{o} C y^{-1}) and salt (~0.002 y^{-1}) content in the upper ~300 m (Johnson and Knap, pers. comm.).

On societally relevant timescales (e.g., decades to centuries), oceanic biological processes sequester large quantities of atmospheric carbon, modulating the concentrations of CO_2 in the lower atmosphere (IPCC 1990; 2001). The combined BATS/Hydrostation S CO_2 time-series (from 1983) is the longest continuous record of oceanic uptake of anthropogenic CO_2, changes in ocean acidification and an increase in CO_2 inventories (IPCC

2007; Bates 2007; Bates and Peters 2007). The surface ocean DIC content has increased at an average rate of ~0.7 µmoles kg^{-1} yr^{-1} while *p*H has increased, and carbonate saturation states have decreased (Bates 2007). Air-sea CO_2 fluxes have also increased over the last two decades as windspeed has increased in this sector of the subtropical gyre in response to climate change and climate mode variability (such as North Atlantic Oscillation, NAO; El Niño-Southern Oscillation, ENSO). However, in the North Atlantic subtropical gyre, the CO_2 content of the 18^{o}C subtropical mode water (i.e., Eighteen Degree Water, EDW; lying between the seasonal and permanent thermoclines) has increased at a rate (e.g., ~2.2 µmoles kg^{-1} yr^{-1}; Bates et al. 2002) that is double the rate in surface waters. This increase has been related to changes in ocean mixing and NAO variability, and has resulted in enhanced storage of CO_2 in EDW (with an upper limit of ~2.5 Pg C) over the last two decades. Over the last five years, the rate of increase in DIC content of EDW has slowed (although still increasing) while dissolved oxygen content of EDW has increased significantly by ~15 µmoles kg^{-1}, perhaps indicative of reduced remineralization of exported organic matter from the surface ocean or the site of EDW formation.

Seasonal to Interannual Variability in Macronutrient Cycles
Historically, biologists and geochemists have been at odds about whether N or P limits primary production in the world's ocean (e.g. Codispoti 1989; Falkowski et al. 1998; Tyrrell 1999). Leaving aside the now demonstrated importance of iron from this discussion (e.g. Coale et al. 1996), Michaels et al. 2001) have hypothesized that there are feedback-dependent oscillations between N- and P-limited states mediated by the activity of nitrogen-fixers. The dominant oceanic N_2-fixing species were believed to be *Trichodesmium* spp. and the diatom-symbiont *Richelia*, but new molecular biological techniques have found a great diversity of single-celled prokaryotes that possess and express the genes for N_2-fixation (e.g. Zehr et al. 2001). The presence of these additional diazotrophs may further enhance the important role of N_2-fixers in the global N cycle, and has significant implications for the coupling of phosphorus and nitrogen cycles in the ocean. At BATS, the presence of excess nitrate relative to Redfield proportions of phosphorus in the thermocline has been attributed to nitrogen fixation (e.g. Michaels et al. 1996; Gruber and Sarmiento 1997; Hood et al. 2001), but contradictory evidence remains about it's quantitative significance (e.g. Orcutt et al. 2001; Hansell et al. 2004). Studies on the controls and magnitude of new production in the oligotrophic gyre of the North Atlantic will continue through BATS and related projects, for example, to focus on nitrogen fixation, variability of excess nitrate (e.g. Bates and Hansell 2004) and non-Redfield C:N:P production and remineralization processes, mesoscale and submesoscale forcing/modulation of new and export production, and iron cycling and availability.

One of the significant advances made during the BATS program is a re-evaluation of the gravitational flux of particulate organic carbon (POC) from the euphotic zone which was thought to dominate biological carbon sequestration (i.e. the *Biological Carbon Pump*) to the deep ocean. Export production was scaled to rates of primary production (PP; e.g. Eppley and Peterson 1979), and gravitational flux scaled (exponentially decreasing with depth) to near surface sediment trap measurements (e.g. Martin et al. 1987). In contrast to expectations, however, no meaningful relationships have been found between PP and POC flux at either the BATS or HOT sites (e.g. Karl et al. 2001b; Brix et al. 2006). Instead, export pathways that were poorly quantified a decade ago - export of dissolved organic carbon (DOC), "active carbon transport" by diel migrant zooplankton and food web influences on the partitioning of primary production between POC and dissolved organic carbon (DOC) - have emerged as significant terms in the biological pump of carbon to the ocean interior (e.g. Carlson et al. 1994; Steinberg et al. 2000; Lomas et al. 2002). The question originally posed by the time-series sites, "what controls carbon export flux", is therefore still an open and active area of BATS research.

Multi-year variability in Macronutrient Cycles
During the last decade, complex coupling between ocean physics and longer time scale modes of climate variability (such as NAO and ENSO) has increasingly been demonstrated. Only more recently has coupling between ocean biogeochemical dynamics/biological community structure and mode of climate variability been demonstrated, for example, in the Pacific Ocean (Chavez et al. 2003). In the North Atlantic, significant correlative relationships between NAO and the interannual variability of many biogeochemical properties (e.g. mixed layer depth, SST, PP, nutrients; Bates 2001b; Oschlies 2001) have been shown. An inverse correlation has also been found at BATS between the NAO index and the relative abundance of haptophytes (e.g., coccolithophores; Lomas and Bates 2004) during the winter/spring bloom. Given the potential importance of this taxonomic group in the mineral ballasting of POC fluxes (e.g., Armstrong et al. 2002) greater understanding of coccolithophore population dynamics, and their role in subtropical biogeochemical cycles, under current and future ocean scenarios is clearly necessary.

Diatoms and other large phytoplankton are relatively rare (based upon size-fractionation and pigment bio-markers; Glover et al. 1988; Steinberg et al. 2001) but are actively growing and sedimenting from the surface ocean (Brzezinski and Nelson 1995a; Brzezinski and Kosman 1996; Nelson and Brzezinski 1997; Krause et al. submitted). Indeed, diatom populations at BATS contribute disproportionately to overall system productivity (Sweeney et al. 2003; Mcgillicuddy et al. 2007) and export (Nelson and Brzezinski 1997; Krause et al.

submitted) through short-lived episodic events, a finding consistent with other research conducted in the North Atlantic subtropical gyre (Maranon et al. 2001). To highlight their importance for biogeochemical cycles in the Sargasso Sea, from ~1996 to ~2000 presumed active growth of resident diatom populations let to a nearly 50% drawdown in ambient silica concentrations within the euphotic zone, while suspended, but presumably sinking, biogenic silica concentrations from 200-1000 m doubled during that same period (Krause, Nelson and Lomas, in prep). The winters of 1996 to 2000 were characterized by low and sometimes negative NAO values, but since then silicate concentrations have returned to pre-1996 values (~0.8 - 1.0 µmol kg^{-1}) and suspended biogenic silica concentrations below 200 m have decreased.

Mesoscale Variability and Spatial Context

Several major projects and BATS ancillary projects over the last five years have provided invaluable understanding of process and context for interpreting temporal variability at BATS. For example, mesoscale eddies have long been postulated as modulators of nutrient dynamics in the subtropical gyre (e.g., McGillicuddy et al. 1998a), and the recent EDDIES project has provided new understanding of this role (e.g., McGillicuddy et al. 2007). Nutrient dynamics and organic matter export were the focus of recent studies focusing on winter convective mixing (Lomas, Lipschultz, Nelson and Bates) while the CLIMODE project (Marshall, Joyce et al.) is focused on understanding the formation and fate of EDW formation in the subtropical gyre. In addition, there are ongoing studies of iron cycling (Sedwick and Church), dynamics of DMS (Dacey, Toole and Bates) and DOP (Lomas, Dyhrman and Ammerman), and water mass age-tracers such as ^{7}Be (Kadko) at BATS. BATS provides the temporal context and observations for empirical and model understanding of these synergistic projects (e.g., EDDIES), while these studies themselves help elucidate process and mechanisms that lead to better understanding of the causes of seasonal to decadal variability at BATS and in the subtropical gyre of the North Atlantic Ocean.

Proposed Research

The goals and objectives outlined above provide the motivation and rationale for the BATS project. The key questions and hypotheses emerging from past data synthesis and interpretation that will be evaluated in the next phase (years 21-25) of the project are described briefly below. The BATS program sampling strategy describes a core list of physical and biochemical measurements that are made, and the quality control and assurance protocols that are in place. In addition to the core sampling program, numerous ancillary research projects utilize the BATS project.

Key Questions and Hypotheses

The goals and objectives described above form the basis for continued research at the BATS site. Further to these points, it is becoming increasingly apparent that biogeochemical variability at BATS originates from a wide range of temporal scales from sub-mesoscale to multi-year/decadal. Local physical forcing link these timescales and are ultimately tied to larger-scale and longer-term atmospheric and climatic changes. Climatological forcing of ocean ecosystems by ENSO has been demonstrated in the Pacific Ocean (e.g., Karl et al. 2001a; Chavez et al. 2003). Likewise, in the deeper ocean of the Sargasso Sea, relationships between physics and climate can be clearly demonstrated (e.g., Joyce and Talley 1996). However, in the upper ocean, the inherent mesoscale variability of the Sargasso Sea (McGillicuddy and Robinson 1997; McGillicuddy et al. 1998b; McGillicuddy et al. 1999; McGillicuddy and Kosnyrev 2001) potentially masks the impact of atmospheric forcing over annual or shorter timescales, while exhibiting a very scientifically interesting dynamic in its own right. Indeed, long term modeling studies suggest the upper ocean heat and salinity budgets are balanced locally with 1-D models capturing 90% of the observed variance for the upper 100m (e.g., Johnson 2003). Despite these problems, modes of climate variability, such as NAO and ENSO have been shown to impact the interannual variability of hydrography, biogeochemistry and planktonic community structure at BATS (e.g., Bates 2001a; Bates et al. 2002; Gruber et al. 2002; Lomas and Bates 2004). For example, anomalies of temperature, integrated primary production, mixed layer depth and CO_2 concentrations at BATS are significantly correlated to variability of NAO, whereas anomalies of salinity and alkalinity are correlated to ENSO variability. As the BATS time series record extends past two decades, our ability to observe and decipher relationships between climate and biogeochemistry continues to improve. Thus, one of the on-going objectives of BATS is to further investigate the mechanistic relationships between climate forcing and surface ocean biogeochemistry and ultimately improve our ability to predict the effects of climate change on subtropical ocean ecosystems.

Biological community structure within the pelagic food web has significant impacts on vertical transport and cycling of elements in the sea; in particular the partitioning of carbon fixed during primary production between particulate and dissolved pools. Generally speaking, the size distribution of primary producers, the trophic position of consumers and the extent to which both population cycles are coupled or uncoupled determines the proportion of primary production that is exported from the surface ocean as particles. This producer/consumer balance also governs the composition and sedimentation rate of these sinking particles. In many oceanic biogeographical provinces, it is blooms of diatoms that result in high rates of particle export; at BATS, diatoms and other large phytoplankton are relatively rare in the euphotic zone (based upon size-fractionation and pigment bio-markers; Glover et al. 1988; Steinberg et al. 2001) but are actively growing and sedimenting from the surface ocean (Brzezinski and Nelson 1995a; Brzezinski and Kosman 1996; Nelson and Brzezinski 1997; Krause, Nelson and Lomas, in prep.). Indeed, diatom populations at BATS contribute disproportionately to overall system productivity through short-lived episodic events (Nelson and Brzezinski 1997), a finding consistent with other research conducted in the North Atlantic subtropical gyre (Maranon et al. 2001). A recent analysis suggests that Haptophytes are also important in the partitioning of carbon between dissolved and particulate pools with anomalies in Haptophyte abundance, controlled to some extent by variability in the NAO, negatively related to particle export. The 18-years of BATS data allow us to examine how phytoplankton community structure impacts the flow of carbon in the surface ocean. A testable hypothesis is that increases in the relative abundances of diatoms at BATS should increase particle flux while increases in Haptophytes would decrease particle flux. Determining the complex interactions between the biological community and export production, for example, has added importance for understanding the potential changes in phytoplankton species succession and dominance (e.g., Tortell et al. 2002) and export production (e.g., Bopp et al. 2001) under climate change scenarios of changing ocean circulation and mixing.

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

List of References (PDF)

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Program Information

Ocean Carbon and Biogeochemistry (OCB)

Website: http://us-ocb.org/

Coverage: Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research community and with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF.

The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO_2 and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two.

The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

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

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

Coverage: Global

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

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

Ocean Time-series Sites (Ocean Time-series)

Coverage: Bermuda, Cariaco Basin, Hawaii

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

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

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

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

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

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

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Funding

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

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