Nitrous oxide concentrations (depths of 5-175 m) at Station ALOHA collected during Hawaii Ocean Time-Series cruises between 2008 and 2016 (HOT project)

Website: https://www.bco-dmo.org/dataset/713977
Data Type: Cruise Results
Version:
Version Date: 2017-08-28

Project
» [Current] Hawaii Ocean Time-series (HOT): 2023-2028; [Previous] Hawaii Ocean Time-series (HOT): Sustaining ocean ecosystem and climate observations in the North Pacific Subtropical Gyre (HOT)

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
Karl, David M.	University of Hawaii (UH)	Principal Investigator
Wilson, Samuel	University of Hawaii (UH)	Contact
York, Amber D.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Table of Contents

Coverage

Spatial Extent: **Lat**:22.75 **Lon**:-158
Temporal Extent: 2008-12-01 - 2016-11-27

Dataset Description

Nitrous oxide concentrations (depths of 5-175 m) at Station ALOHA (2008-2016). This dataset includes pressure, temperature, salinity, density, dissolved oxygen, N2O (atmospheric), N2O (equilibrium), and N2O (measured).

Related dataset: Methane concentrations at Station ALOHA

Methods & Sampling

The following describes the methodology for both this (N2O) dataset as well as the CH4 dataset since the analysis was done together. CH4 results can be found on the page: Methane concentrations at Station ALOHA

Calibration of the analytical system was conducted using gaseous standards purchased from Scott-Marin (CH4: 20.15 ± 1% ppmv; N2O: 4.81 ± 2% ppmv in a balance of N2) and NOAA (CH4: 1965.32 ppbv; N2O: 357.56 ppbv in a balance of air). From March 2016 onwards, the calibration for CH4 and N2O was compared against reference standards prepared by John Bullister at NOAA PMEL on behalf of SCOR Working Group #143. In all instances, standards were injected prior to the purge and trap set-up and therefore passed through the purge chamber and gas drying apparatus. A linear curve was applied to the CH4 calibration values and a polynomial curve was fitted to the N2O calibration values. The precision of CH4 measurements for surface seawater with concentrations of 2.57 ± 0.07 (SD) nmol kg-1 (n=14), as calculated by the coefficient of variation was 3%. The accuracy of CH4 measurements was evaluated by analyzing filtered (0.2 µm) seawater samples that had been equilibrated with atmospheric air at a range of set temperatures between 19–27°C which were maintained using a water-bath. The measured values agreed to within 2.4 ± 0.9% of predicted values. The precision of N2O measurements in surface seawater, with concentrations of 6.47 ± 0.14 (SD) nmol kg-1 (n=14), as calculated by the coefficient of variation was 2%. Using the same air-equilibrated seawater set-up, as described for CH4, the accuracy of N2O measurements was 2.6 ± 1.9% of predicted values.

Instruments:

For quantifying the dissolved gases, the analytical column (30 m x 0.32 mm GS-CarbonPLOT capillary column; J&W Scientific) was housed within a gas chromatograph (GC) Agilent 7890A equipped with a flame ionization detector (FID) and an electron capture detector (ECD). The carrier flow was alternated from the FID to the ECD using a Dean’s switch® (Agilent Technologies) which allowed the quantification of both CH4 and N2O from a single sample.

Reference:

Wilson, S. T., Ferrón, S., & Karl, D. M. (2017). Interannual variability of methane and nitrous oxide in the North Pacific Subtropical Gyre. Geophysical Research Letters, 44, 9885–9892.
https://doi.org/10.1002/2017GL074458

Data Processing Description

BCO-DMO Data Manager Processing Notes:
* added a conventional header with dataset name, PI name, version date
* modified parameter names to conform with BCO-DMO naming conventions (e.g. no spaces, slashes, special characters)
* blank values replaced with no data value 'nd'
* changed name "Logitude" -> "Longitude"
* changed lat lon (22.75 N, 158 W) to (28.45, -158)
* added ISO_DateTime_UTC from HST date, time

[table of contents | back to top]

Data Files

File
N2O.csv (Comma Separated Values (.csv), 72.05 KB) MD5:0a312c3ddab6fc029e3a1ae38d23b77d Primary data file for dataset ID 713977

[table of contents | back to top]

Parameters

Parameter	Description	Units
Cruise_ID	Cruise identifier	unitless
HOT_cruise	Hawaiian Ocean Time-Series cruise identifier	unitless
Latitude	Latitude	unitless
Longitude	Longitude	unitless
Station	Station number	unitless
Cast	Cast number	unitless
Bottle	Bottle number	unitless
Press	Sample pressure	decibars
Date_HST	Local date (HST) in format yyyy-mm-dd	unitless
Time_HST	Local time (HST) in format HH:MM	unitless
ISO_DateTime_UTC	ISO timestamp based on the ISO 8601:2004(E) standard in format YYYY-mm-ddTHH:MMZ (UTC)	unitless
Temp	Temperature from CTD	degrees Celsius
Salinity	Salinity	Practical Salinity Units (PSU)
Density	Density	kilograms per meter cubed (kg/m3)
O2	Dissolved oxygen	micromoles per kilogram (umol/kg)
Atmos_N2O	Nitrous oxide (N2O) (atmospheric) MLO flask	mole fraction (ppb)
N2O_equilib	Nitrous oxide (N2O) (equilibrium)	nanomoles per kilogram (nmol/kg)
N2O_measured	Nitrous oxide (N2O) (measured)	nanomoles per kilogram (nmol/kg)

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Sea-Bird SBE 911Plus
Generic Instrument Name	CTD Sea-Bird SBE 911plus
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	gas chromatograph (GC) Agilent 7890A
Generic Instrument Name	Gas Chromatograph
Dataset-specific Description	For quantifying the dissolved gases, the analytical column (30 m x 0.32 mm GS-CarbonPLOT capillary column; J&W Scientific) was housed within a gas chromatograph (GC) Agilent 7890A equipped with a flame ionization detector (FID) and an electron capture detector (ECD). The carrier flow was alternated from the FID to the ECD using a Dean's switch® (Agilent Technologies) which allowed the quantification of both CH4 and N2O from a single sample.
Generic Instrument Description	Instrument separating gases, volatile substances, or substances dissolved in a volatile solvent by transporting an inert gas through a column packed with a sorbent to a detector for assay. (from SeaDataNet, BODC)

[table of contents | back to top]

Deployments

HOT_cruises

Website	https://www.bco-dmo.org/deployment/58879
Platform	Unknown Platform
Report	http://hahana.soest.hawaii.edu/hot/
Start Date	1988-10-31
Description	Since October 1988, the Hawaii Ocean Time-series (HOT) program has investigated temporal dynamics in biology, physics, and chemistry at Stn. ALOHA (22°45' N, 158°W), a deep ocean field site in the oligotrophic North Pacific Subtropical Gyre (NPSG). HOT conducts near monthly ship-based sampling and makes continuous observations from moored instruments to document and study NPSG climate and ecosystem variability over semi-diurnal to decadal time scales.

[table of contents | back to top]

Project Information

[Current] Hawaii Ocean Time-series (HOT): 2023-2028; [Previous] Hawaii Ocean Time-series (HOT): Sustaining ocean ecosystem and climate observations in the North Pacific Subtropical Gyre (HOT)

Website: https://hahana.soest.hawaii.edu/hot/

Coverage: North Pacific Subtropical Gyre; 22 deg 45 min N, 158 deg W

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 Hawaii Ocean Time-series (HOT) research program, which began in 1988, for an additional five years. Continuity of these observations will improve the value of the dataset for deciphering how natural and human-influenced climate signals affect ecosystem structure in the Pacific Ocean. All HOT program data are publicly available and are frequently used by researchers and policy makers around the world. HOT also serves as (1) a testbed for the development of new sensors and methodologies, (2) a calibration/validation site, (3) an invaluable training ground that attracts students and researchers from around the globe, and (4) a forum for international collaboration and capacity building.

The proposed research will rely on shipboard observations and experiments conducted on ten separate five-day expeditions per year along with near-continuous moored platform measurements of air-sea interactions, ocean mixing, and physical characteristics of the deep sea. Observations include biogeochemical and physical measurements required for continued assessment of dynamics in ocean carbon and nutrient pools and fluxes, plankton community structure, ecosystem productivity, and inherent optical properties of the water column. The major program goals and objectives over the next 5 years remain as in prior years and include: (1) sustain high quality, time-resolved oceanographic measurements on the interactions between ocean-climate and ecosystem variability in the North Pacific Subtropical Gyre (NPSG), (2) quantify time-varying (seasonal to decadal) changes in reservoirs and fluxes of carbon and associated bioelements (nitrogen, phosphorus, and silicon), (3) constrain processes controlling air-sea carbon exchange, rates of carbon transformation through the planktonic food web, and fluxes of carbon into the ocean?s interior, (4) extend to 40 years a climatology of hydrographic and biogeochemical dynamics from which to gauge anomalous or extreme changes to the NPSG habitat, forming a multi-decadal baseline from which to decipher natural and anthropogenic influences on the NPSG ecosystem, (5) continue to provide scientific and logistical support to ancillary programs that benefit from the temporal context, interdisciplinary science, and regular access to the open sea afforded by HOT program occupation of Station ALOHA, including projects implementing, testing, and validating new methodologies and transformative ocean sampling technologies, and (6) provide unique training and educational opportunities for the next generation of ocean scientists.

Hawai'i Ocean Time-Series Project Summary
Systematic, long-term observations are essential for evaluating natural variability of Earth's climate and ecosystems and their responses to anthropogenic disturbances. Since October 1988, the Hawaii Ocean Time-series (HOT) program has investigated temporal dynamics in biology, physics, and chemistry at Stn. ALOHA (22°45' N, 158°W), a deep ocean field site in the oligotrophic North Pacific Subtropical Gyre (NPSG). HOT conducts near monthly ship-based sampling and makes continuous observations from moored instruments to document and study NPSG climate and ecosystem variability over semi-diurnal to decadal time scales. HOT was founded to understand the processes controlling the time-varying fluxes of carbon and associated biogenic elements in the ocean and to document changes in the physical structure of the water column. To achieve these broad objectives, the program has several specific goals:

1. Quantify time-varying (seasonal to decadal) changes in reservoirs and fluxes of carbon (C) and associated bioelements (nitrogen, oxygen, phosphorus, and silicon).
2. Identify processes controlling air-sea C exchange, rates of C transformation through the planktonic food web, and fluxes of C into the ocean's interior.
3. Develop a climatology of hydrographic and biogeochemical dynamics from which to form a multi-decadal baseline from which to decipher natural and anthropogenic influences on the NPSG ecosystem.
4. Provide scientific and logistical support to ancillary programs that benefit from the temporal context, interdisciplinary science, and regular access to the open sea afforded by HOT program occupation of Sta. ALOHA, including projects implementing, testing, and validating new methodologies, models, and transformative ocean sampling technologies.

Over the past 24+ years, time-series research at Station ALOHA has provided an unprecedented view of temporal variability in NPSG climate and ecosystem processes. Foremost among HOT accomplishments are an increased understanding of the sensitivity of bioelemental cycling to large scale ocean-climate interactions, improved quantification of reservoirs and time varying fluxes of carbon, identification of the importance of the hydrological cycle and its influence on upper ocean biogeochemistry, and the creation of long-term data sets from which the oceanic response to anthropogenic perturbation of elemental cycles may be gauged.

A defining characteristic of the NPSG is the perennially oligotrophic nature of the upper ocean waters. This biogeochemically reactive layer of the ocean is where air-sea exchange of climate reactive gases occurs, solar radiation fuels rapid biological transformation of nutrient elements, and diverse assemblages of planktonic organisms comprise the majority of living biomass and sustain productivity. The prevailing Ekman convergence and weak seasonality in surface light flux, combined with relatively mild subtropical weather and persistent stratification, result in a nutrient depleted upper ocean habitat. The resulting dearth of bioessential nutrients limits plankton standing stocks and maintains a deep (175 m) euphotic zone. Despite the oligotrophic state of the NPSG, estimates of net organic matter production at Sta. ALOHA are estimated to range ~1.4 and 4.2 mol C m^2 yr^1. Such respectable rates of productivity have highlighted the need to identify processes supplying growth limiting nutrients to the upper ocean. Over the lifetime of HOT numerous ancillary science projects have leveraged HOT science and infrastructure to examine possible sources of nutrients supporting plankton productivity. Both physical (mixing, upwelling) and biotic (N2 fixation, vertical migration) processes supply nutrients to the upper ocean in this region, and HOT has been instrumental in demonstrating that these processes are sensitive to variability in ocean climate.

Station ALOHA - site selection and infrastructure
Station ALOHA is a deep water (~4800 m) location approximately 100 km north of the Hawaiian Island of Oahu. Thus, the region is far enough from land to be free of coastal ocean dynamics and terrestrial inputs,

but close enough to a major port (Honolulu) to make relatively short duration (<5 d) near-monthly cruises logistically and financially feasible. Sampling at this site occurs within a 10 km radius around the center of the station. On each HOT cruise, we begin each cruise with a stop at a coastal station south of the island of Oahu, approximately 10 km off Kahe Point (21' 20.6'N, 158' 16.4'W) in 1500 m of water. Station Kahe (termed Station 1 in our database) is used to test equipment and train new personnel before departing for Station ALOHA. Since August 2004, Station ALOHA has also been home to a surface mooring outfitted for meteorological and upper ocean measurements; this mooring, named WHOTS (also termed Station 50), is a collaborative project between Woods Hole Oceanographic Institution and HOT. WHOTS provides long-term, high-quality air-sea fluxes as a coordinated part of HOT, contributing to the program's goals of observing heat, fresh water and chemical fluxes. In 2011, the ALOHA Cabled Observatory (ACO) became operational. This instrumented fiber optic cabled observatory provides power and communications to the seabed (4728 m). The ACO currently configured with an array of thermistors, current meters, conductivity sensors, 2 hydrophones, and a video camera.

HOT Sampling Strategy

HOT relies on the UNOLS research vessel Kilo Moana operated by the University of Hawaii for most of our near-monthly sampling expeditions. The exact timing of HOT cruises is dictated by the vessel schedule, but to date, our sampling record is not heavily aliased by month, season, or year. When at Station ALOHA, HOT relies on a variety of sampling strategies to capture the dynamic range of time-variable physical and biogeochemical dynamics inherent to the NPSG ecosystem, including high resolution conductivity-temperature-depth (CTD) profiles; biogeochemical analyses of discrete water samples; in situ vertically profiling bio-optical instrumentation; surface tethered, free-drifting arrays for determinations of primary production and particle fluxes; bottom-moored, deep ocean (2800 m, 4000 m) sediment traps; and oblique plankton net tows. The suite of core measurements conducted by HOT has remained largely unchanged over the program's lifetime. On each HOT cruise, samples are collected from the surface ocean to near the sea bed (~4800 m), with the most intensive sampling occurring in the upper 1000 m (typically 13-15 CTD hydrocasts to 1000 m and 2 casts to ~4800 m). HOT utilizes a "burst" vertical profiling strategy where physical and biogeochemical properties are measured at 3-h intervals over a 36-h period, covering 3 semidiurnal tidal cycles and 1 inertial period (~31 h). This approach captures energetic high-frequency variability in ocean dynamics due to internal tides around Sta. ALOHA.

Scientific Background and Findings

Central to the mission of the HOT program is continued quantification of ocean carbon inventories and fluxes, with a focus on describing changes in the sizes of these pools and fluxes over time. HOT routinely quantifies the vertical distributions of the major components of the ocean carbon cycle: dissolved inorganic carbon (DIC), pH, total alkalinity, dissolved organic carbon (DOC), and particulate carbon (PC). The HOT dataset constitutes one the longest running records from which to gauge the oceanic response to continued anthropogenic changes to the global carbon cycle. The 24+ year record of ocean carbon measurements at Station ALOHA document that the partial pressure of CO2 (pCO2) in the mixed layer is increasing at a rate (1.92 ± 0.13 microatm yr-1), slightly greater than the trend observed in the atmosphere (1.71 ± 0.03 microatm yr^{1}). Moreover, mixed layer concentrations of salinity-normalized DIC are increasing at 1.03 ± 0.07 micromol kg^{1} yr^{1} (Winn et al., 1998; Dore et al., 2009). These long-term changes in upper ocean carbon inventories have been accompanied by progressive decreases in seawater pH (-0.0018 ± 0.0001 yr^{1}) and declines in aragonite and calcite saturation states (Dore et al., 2009). Although the penetration of anthropogenic CO2 is evidenced by long-term decreases in seawater pH throughout the upper 600 m, the rate of acidification at Sta. ALOHA varies with depth. For example, in the upper mesopelagic waters (~160-310 m) pH is decreasing at nearly twice the rate observed in the surface waters (Dore et al., 2009). Such depth-dependent differences in acidification derive from a combination of regional differences in the time-varying climate signatures imprinted on the ventilation history of the waters, mixing, and changes in biological activity associated with different water masses.

Superimposed on these progressive long-term trends in the seawater carbonate system are seasonal- to decadal-scale variations in climate and biogeochemical dynamics that ultimately influence CO2 inventories, fluxes, and trends. Changes in temperature, evaporation-precipitation, and mixing all impart complex, time-varying signatures on the ocean carbon cycle. For example, interactions among low-frequency climate oscillations such as those linked to the El-Niño Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), and North Pacific Gyre Oscillation (NPGO) influence the frequency, intensity, and tracks of winter storms in the NPSG (Lukas, 2001), which in turn modifies physical forcing (wind and air-sea heat/water fluxes) and upper ocean response (stratification, currents and mixing). Such dynamics have important, often non-linear, influences on ocean carbon uptake and biogeochemistry.

Time-series measurements at HOT have also highlighted complex relationships between ecosystem dynamics and climate-driven physical forcing. Historically, the abundances and distributions of the resident plankton

community of the NPSG were thought to be relatively stable in both space and time. However, HOT program measurements have identified remarkable temporal (and spatial) heterogeneity in biogeochemical processes and planktonic community structure over seasonal to interannual time scales. In many cases, climate-forced fluctuations in plankton population dynamics resonate from the base of the picoplankton food web to higher trophic levels (Karl, 1999; Karl et al., 2001; Sheridan and Landry, 2004; Corno et al., 2007; Bidigare et al., 2009). However, we currently lack a complete mechanistic understanding of the processes underlying variability in NPSG biogeochemistry.

With continued lengthening of the time series record, HOT measurements have become increasingly useful for identifying low-frequency, interannual- to decadal-scale signals in ocean climate and biogeochemistry. Upper ocean physical dynamics, nutrient availability, plankton productivity, biomass and community structure, and material export at Sta. ALOHA have all been shown to be sensitive to regional- to basin- scale climate oscillations of the Pacific (Karl et al., 1995; Karl, 1999; Dore et al., 2002; Corno et al., 2007; Bidigare et al., 2009). One of the most notable examples coincided with major phase shifts in the ENSO, PDO, and NPGO indices in 1997-1998. Fluctuations in mixing and hydrological forcing accompanying these transitions had important consequences for ocean biogeochemistry and plankton ecology, including changing upper ocean nutrients, concentrations of DIC, and ultimately influencing organic matter export (Dore et al., 2003; Corno et al., 2007; Bidigare et al., 2009). Moreover, these dynamics preceded a shift in plankton community composition, as reflected through nearly 40% increases in concentrations of 19-butanoyoxyfucoxanthin (19-but), 19-hexoyloxyfucoxanthin (19-hex), and fucoxanthin pigment biomarkers used as proxies for pelagophytes, prymnesiophytes, and diatoms, respectively (Bidigare et al., 2009). Similarly, mesozooplankton biomass increased nearly 50% during this period, suggesting sensitivity of trophodynamic coupling to interannual to subdecadal scale variations in ocean climate.
HOT also provides some of the only decadal-scale measurements of in situ primary production necessary for assessing seasonal to secular scale change. Since 1988, depth integrated (0-125 m) inventories of both chlorophyll a and 14C-based estimates of primary production at Sta. ALOHA and BATS have increased significantly (Corno et al., 2007; Saba et al., 2010). However, these long-term trends are punctuated by considerable interannual variability, much of which occurs in the mid- to lower regions of the euphotic zone (>45 m depth), below depths of detection by Earth-orbiting satellites. The emerging data emphasize the value of in situ measurements for validating remote and autonomous detection of plankton biomass and productivity and demonstrate that detection of potential secular-scale changes in productivity against the backdrop of significant interannual and decadal fluctuations demands a sustained sampling effort.

Careful long-term measurements at Stn. ALOHA also highlight a well-resolved, though relatively weak, seasonal climatology in upper ocean primary productivity. Measurements of 14C-primary production document a ~3-fold increase during the summer months (Karl et al., 2012) that coincides with increases in plankton biomass (Landry et al., 2001; Sheridan and Landry, 2004). Moreover, phytoplankton blooms, often large enough to be detected by ocean color satellites, are a recurrent summertime feature of these waters (White et al., 2007; Dore et al., 2008; Fong et al., 2008). Analyses of ~13-years (1992-2004) of particulate C, N, P, and biogenic Si fluxes collected from bottom-moored deep-ocean (2800 m and 4000 m) sediment traps provide clues to processes underlying these seasonal changes. Unlike the gradual summertime increase in sinking particle flux observed in the upper ocean (150 m) traps, the deep sea particle flux record depicts a sharply defined summer maximum that accounts for ~20% of the annual POC flux to the deep sea, and appears driven by rapidly sinking diatom biomass (Karl et al., 2012). Analyses of the 15N isotopic signatures associated with sinking particles at Sta. ALOHA, together with genetic analyses of N2 fixing microorganisms, implicates upper ocean N2 fixation as a major control on the magnitude and efficiency of the biological carbon pump in this ecosystem (Dore et al., 2002; Church et al., 2009; Karl et al., 2012).

Motivating Questions
Science results from HOT continue to raise new, important questions about linkages between ocean climate and biogeochemistry that remain at the core of contemporary oceanography. Answers have begun to emerge from the existing suite of core program measurements; however, sustained sampling is needed to improve our understanding of contemporary ecosystem behavior and our ability to make informed projections of future changes to this ecosystem. HOT continues to focus on providing answers to some of the questions below:

1. How sensitive are rates of primary production and organic matter export to short- and long-term climate variability?
2. What processes regulate nutrient supply to the upper ocean and how sensitive are these processes to climate forcing?
3. What processes control the magnitude of air-sea carbon exchange and over what time scales do these processes vary?
4. Is the strength of the NPSG CO2 sink changing in time?
5. To what extent does advection (including eddies) contribute to the mixed layer salinity budget over annual

to decadal time scales and what are the implications for upper ocean biogeochemistry?
6. How do variations in plankton community structure influence productivity and material export?
7. What processes trigger the formation and demise of phytoplankton blooms in a persistently stratified ocean ecosystem?

References

[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-1260164

[table of contents | back to top]