Primary productivity measurements for the Hawaii Ocean Time-Series (HOT) program from October 1988 to December 2023 at Station ALOHA

Website: https://www.bco-dmo.org/dataset/737163
Data Type: Cruise Results, experimental
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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
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Abstract
Primary productivity measurements from the Hawaii Ocean Time-Series (HOT) program from 1988 through 2023. The 14C-radiotracer method was used to measure the assimilation of dissolved inorganic carbon (DIC) by phytoplankton as an estimate of the rate of photosynthetic production of organic matter in the euphotic zone. All incubations from 1990 through mid-2000 were conducted in situ at eight depths (5, 25, 45, 75, 100, 125, 150 and 175m) over one daylight period using a free-drifting array as described by Winn et al. (1991). Beginning October 2000 (HOT-119), samples were collected from only the upper six depths while the lower two depths were modeled based on the monthly climatology. Starting July 1989 (HOT-008), all incubations were conducted in situ on a free floating, surface tethered array. Integrated carbon assimilation rates were calculated using the trapezoid rule with the shallowest value extended to 0 meters and the deepest extrapolated to a value of zero at 200 meters.

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Coverage

Location: Station ALOHA (circle of 6 mile radius in the Pacific Ocean north of Hawaii)

Spatial Extent: **Lat**:22.75 **Lon**:-158
Temporal Extent: 1988-10-31 - 2023-12-27

Dataset Description

The ^{14}C-radiotracer method is used to measure the assimilation of dissolved inorganic carbon (DIC) by phytoplankton as an estimate of the rate of photosynthetic production of organic matter in the euphotic zone. These data are from monthly measurements of primary production collection at Station ALOHA as part of the HOT TimeSeries program

Methods & Sampling

Photosynthetic production of organic matter was measured by the ^{14}C tracer method. All incubations from 1990 through mid-2000 were conducted in situ at eight depths (5, 25, 45, 75, 100, 125, 150 and 175m) over one daylight period using a free-drifting array as described by Winn et al. (1991). Starting October 2000 (HOT-119), samples were collected from only the upper six depths while the lower two depths were modeled based on the monthly climatology. Beginning July 1989 (HOT-008), all incubations were conducted *in situ* on a free floating, surface tethered array. Integrated carbon assimilation rates were calculated using the trapezoid rule with the shallowest value extended to 0 meters and the deepest extrapolated to a value of zero at 200 meters.

A summary of methodology is listed below. Full details can be found at the HOT Field & Laboratory Protocols page. (http://hahana.soest.hawaii.edu/hot/protocols/protocols.html#) or below in Related Publications section (Karl et al.)

1. Principle
The ^{14}C method, originally proposed by Steeman-Nielsen (1952), is used to estimate the uptake of dissolved inorganic carbon (DIC) by photoautotrophic microorganisms in the water column. The method is based on the fact that the biological uptake of ^{14}C-labeled DIC is proportional to the biological uptake of ^{12}C-DIC. If one knows the initial concentration of DIC in a water sample, the DIC pool specific radioactivity (^{14}C/^{12}C), the ^{14}C retained in particulate matter (^{14}C-POC) at the end of the incubation and the metabolic discrimination between the two isotopes of carbon (i.e., 6% discrimination against the heavier ^{14}C isotope), then it is possible to estimate the total uptake of carbon from the following relationship:

$$\text{C uptake} = \frac{\text{DIC} * {}^{14}\text{C-POC} * 1.06}{{}^{14}\text{C-DIC added}}$$

2. Precautions
Due to the potentially toxic effects of trace metals on phytoplankton metabolism in oligotrophic waters, the following procedure is used to minimize the contact between water samples and possible sources of contamination. Trace metal grade HCl (i.e. FisherScientific) solution (1M) is prepared with high purity hydrochloric acid and deionized water (DIW). Polycarbonate bottles (500 ml) are rinsed twice with trace metal grade 1M HCl and left overnight filled with the same acid solution. The acid is discarded and the bottles are rinsed at least three times with DIW before air drying in a clean environment.

3. Isotope Stock
For the preparation of the isotope stock, a 60 ml acid-washed Teflon bottle and a 100 ml acid-washed Teflon bottle are rinsed three times with DIW. A six millimolar (6 mM) sodium carbonate solution containing anhydrous Na_2CO_3 in DIW (Sigma-Aldrich; 99.999% purity; 0.064 g:100 ml DIW) is made up in the Teflon bottle.

NaH-$^{14}CO_3$ (MPBiomedicals # 17441H, 2 mCi ml-1) is mixed with the above-prepared Na2CO3 solution in the Teflon bottle to yield a working stock solution of 200 microCuries per milliliter (µCi ml^{-1}). The working stock solution is made up to the volume required for each cruise. The radiocarbon activity is measured by counting triplicate 10 µl samples with 1 ml beta-phenethylamine (Sigma-Aldrich) in 10 ml Ultima Gold LLT (Perkin-Elmer). Triplicate 10 µl stock samples are also acidified with 1 ml of 2 M HCl, vented for 24 hours and counted in 10 ml Ultima Gold LLT to assess the level of ^{14}C-organic carbon contamination. The acidification is done under the hood. The acidified dpm should be <0.001% of the total dpm of the 14C preparation or else the working stock 14C solution should not be used. These last two steps are performed periodically, and always when receiving new batches from the manufacturer.

4. Incubation Systems
Typically primary production is measured using *in situ* incubation techniques, but both *in situ* and on-deck procedures have been used in the HOT program. A free-floating array equipped with VHF radio and strobe light is used for the *in situ* incubations. Incubation bottles are attached to a horizontal polycarbonate spreader bar which is then attached to the 200 m, 1/2" polypropylene *in situ* line at the depths corresponding to the sample collections. Generally six to eight incubation depths are used with the top 175 meters.

5. Sampling
Approximately 3 hours before local sunrise, seawater samples are collected using the PVC bottles mounted on the CTD rosette. Under low-light conditions, water samples are collected into the sample rinsed incubation bottles (500 ml clear PC bottles) directly from the spigot, filled to the brim, capped and stored in the dark. Powder-free vinyl gloves are worn during sample collection and inoculation procedures.

6. Isotope Addition and Sample Incubation
Three field replicate bottles are collected at each depth for in situ incubation. After all water samples have been drawn from the appropriate bottles, 200 µl of the ^{14}C-$NaHCO_3$ stock solution is added to each sample using a clean re-pipettor tip (final 14C-activity ~ 80-100 µCi l-1). The bottles are capped tightly. The samples are deployed before dawn on a free-floating, drifter buoy array. At local sunset, the free-floating array is recovered and all in situ bottles are immediately placed in the dark and processed as soon as possible. The time of recovery is recorded.

7. Filtration
Filtration of the samples is done under low light conditions and begins as soon as the incubation bottles are recovered from the *in situ* array. From each incubation bottle 250 µl are removed and placed into 20 mL glass liquid scintillation counting (LSC) vials. This sample is used for the determination of total radioactivity in each sample and to calculate the specific activity of ^{14}C-inorganic carbon in the samples. The remainder of the sample is filtered through a 25 mm diameter GF/F filter. The filter is placed into a second clean glass LSC vial and stored at -20 °C.

8. ^{14}C Sample Processing
One ml of 2 M HCl is added to each sample vial containing a filter (in a fume hood). Vials are left open to vent under the hood for 24 hours. After the samples have vented 10 mL of Ultima Gold LLT scintillation cocktail is added per vial including the vials for total ^{14}C radioactivity. The samples are counted in a liquid scintillation counter. Samples are counted again after one month. Only the last count is used for primary production calculations. Counts per min (cpm) are converted to disintegration per min (dpm) by using the instrument's tSIE protocol (transformed Spectral Index of the External standard) and quench curve (Perkin-Elmer TR 2800).

Analysis History for HOT program

- HOT-1 to HOT-7: on deck incubations only
- HOT-8 to HOT-17: on deck and *in situ* incubations
- HOT-18 to present: *in situ* incubations only
- HOT 97 to present: sampled from CTD rosette mounted PVC bottles only. Previously used Go-Flo bottles with Kevlar line and Teflon messengers.
- HOT 119 to present: six incubation depths (5 to 125 meters) with ight bottles only. Previously had eight depths (5 to 175 meters) with both light and dark incubations
- HOT 178: began using Ultima Gold LLT scintillation cocktail. Switched from Aquasol II that was used previously.

Data Processing Description

Integrated carbon assimilation rates were calculated using the trapezoid rule with the shallowest value extended to 0 meters and the deepest extrapolated to a value of zero at 200 meters.

From the data derived here we can estimate several properties of the phytoplankton populations at Station ALOHA:

1. Total daylight organic carbon production is calculated from the 12-hour uptake data (after corrections for 12-hour dark activities).
2. Net primary production is used as the estimate of phytoplankton carbon production for the purposes of

comparison to other ecosystem-level processes (e.g., standing stock assessments, vertical C-flux, etc.).

Quality Flags
Quality Flags were assigned for the bottle, chlorophyll, phaeopigments, light incubation, dark incubation, salinity & bacteria values respectively.
1: not quality controlled
2: good data
3: suspect (questionable) data
4: bad data
5: missing value
9: variable not measured during this cast

BCO-DMO Processing Description

Concatenated new data from calendar year 2023 to the previous 30+ years of primary production data

- Imported data into the BCO-DMO system from source files 'hot340-348.pp' into the BCO-DMO data system using missing data identifiers of -9, -9.00, -9.000, and -9.000
- Imported data from version 1 data using files hot001-012.pp, hot013-022.pp, hot023-032.pp, hot033-043.pp, hot044-050.pp, hot051-059.pp, hot060-068.pp, hot069-078.pp, hot079-088.pp, hot089-100.pp, hot101-110.pp, hot111-121.pp, hot122-133.pp, hot134-143.pp, hot144-154.pp, hot155-166.pp, hot167-176.pp, hot177-188.pp, hot189-198.pp, hot199-207.pp, hot208-217.pp, hot218-227.pp, hot228-238.pp, hot239-248.pp, hot249-258.pp, hot259-268.pp, hot269-279.pp, hot280-288.pp, hot289-298.pp, hot299-308.pp, hot309-317.pp, hot318-325.pp, hot326-334.pp, and hot335-339.pp
- Combined this new data from cruises 340 to 348 with previous data for cruises 1 through 339
- Adjusted parameter/column names to conform with BCO-DMO naming conventions
- Combined separate date and time columns into a single ISO8601 formatted date and converted datetimes from HST to UTC
- Converted T3330 on 2023-03-29 to be 0930 HST (1930 UTC) on the next day 2023-03-30
- Converted T3130 on 2000-12-20 to be 0730 HST (1730 UTC) on the next day 2000-12-21
- Added columns for latitude and longitude of Station ALOHA
- Separated the single combined flag and added columns for these individual parameter flags after the corresponding measurements/fields
- Added column for data source filename (e.g. hot326-334.pp)
- Checked for missing cruises (see Problems/Issues section for list)

Problem Description

Start and End times were not recorded for the following dates, so the times are 00:00
1988-10-31, 1988-12-02, 1989-01-08, 1989-02-28, 1989-03-27, 1989-05-18, 1989-06-24, and 1989-07-29

The following cruises do not have primary production data: HOT-20, 21, 24, 42, 43, 48, 59, 88, 123, 133, 138, 161, 183, 192, 207, 218, 219, 238, 240, 276, 278, 282, 288, 299, 302, 308, 310, 318, and HOT-334.

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Data Files

File	
737163_v4_prim_prod_hot001_hot348.csv	(Comma Separated Values (.csv), 540.78 KB) MD5:ad35dc6a957c55ee6687c8ca1ab099e9
Primary data file for dataset ID 737163, version 4	

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Related Publications

Karl, D., Winn, C., Hebel, D., and Letelier, R. Hawai'i Ocean Time-Series Program Field and Laboratory Protocols. https://hahana.soest.hawaii.edu/hot/protocols/protocols.html#
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

Nielsen, E. S. (1952). The Use of Radio-active Carbon (C14) for Measuring Organic Production in the Sea. ICES Journal of Marine Science, 18(2), 117–140. doi:10.1093/icesjms/18.2.117
Methods

Winn, C., C. Sabine, D. Hebel, F. Mackenzie and D. M. Karl. (1991) Inorganic carbon system dynamics in the central Pacific Ocean: Results of the Hawaii Ocean Time-series program. EOS, Transactions of the American Geophysical Union 72, 70.
Results

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Parameters

Parameter	Description	Units
HOT_ID	Cruise number (HOT-ID)	unitless
Latitude	Latitude	decimal degrees
Longitude	Longitude (west is negative)	decimal degrees
Incubation_type	Incubation type; O = GO-FLO sampled On-deck incubation, I = GO-FLO sampled In-situ incubation, R = Rosette sampled in-situ incubation, N = External closing Niskin sampled in-situ incubation	unitless
Flag_Bottle	Quality flag for Bottle sample where 1 = not quality controlled, 2 = good data, 3 = suspect (questionable) data, 4 = bad data, 5 = missing value, 9 = variable not measured during this cast	unitless
Incub_duration	Incubation time	hours
Start_ISO_DateTime_UTC	Start date and time in ISO 8601 format	unitless
End_ISO_DateTime_UTC	End date and time in ISO 8601 format	unitless
Depth	Depth of sampling	meters (m)

Chl_a_mean	Chlorophyll a mean value	milligrams per cubic meter (mg/m3)
Chl_a_sd	Chlorophyll a standard deviation	milligrams per cubic meter (mg/m3)
Flag_Chla	Quality flag for Chlorophyll a measurement where 1 = not quality controlled, 2 = good data, 3 = suspect (questionable) data, 4 = bad data, 5 = missing value, 9 = variable not measured during this cast	unitless
Pheo_mean	Phaeopigments mean value	milligrams per cubic meter (mg/m3)
Pheo_sd	Phaeopigments standard deviation	milligrams per cubic meter (mg/m3)
Flag_Pheo	Quality flag for Phaeopigment measurement where 1 = not quality controlled, 2 = good data, 3 = suspect (questionable) data, 4 = bad data, 5 = missing value, 9 = variable not measured during this cast	unitless
Light_rep1	Primary production measured in Light bottle replicate #1	milligrams Carbon per cubic meter (mg C/m3)
Light_rep2	Primary production measured in Light bottle replicate #2	milligrams Carbon per cubic meter (mg C/m3)
Light_rep3	Primary production measured in Light bottle replicate #3	milligrams Carbon per cubic meter (mg C/m3)
Flag_Light	Quality flag for Light incubation bottles where 1 = not quality controlled, 2 = good data, 3 = suspect (questionable) data, 4 = bad data, 5 = missing value, 9 = variable not measured during this cast	unitless
Dark_rep1	Primary production measured in Dark bottle replicate #1	milligrams Carbon per cubic meter (mg C/m3)

Dark_rep2	Primary production measured in Dark bottle replicate #2	milligrams Carbon per cubic meter (mg C/m3)
Dark_rep3	Primary production measured in Dark bottle replicate #3	milligrams Carbon per cubic meter (mg C/m3)
Flag_Dark	Quality flag for Dark incubation bottles where 1 = not quality controlled, 2 = good data, 3 = suspect (questionable) data, 4 = bad data, 5 = missing value, 9 = variable not measured during this cast	unitless
Salt	Salinity (PSS-78)	unitless
Flag_Salt	Quality flag for Salinity where 1 = not quality controlled, 2 = good data, 3 = suspect (questionable) data, 4 = bad data, 5 = missing value, 9 = variable not measured during this cast	unitless
Prochloro	Prochlorococcus abundance	count per milliliter
Flag_Prochl	Quality flag for Prochlorococcus where 1 = not quality controlled, 2 = good data, 3 = suspect (questionable) data, 4 = bad data, 5 = missing value, 9 = variable not measured during this cast	unitless
Hetero	Heterotrophic bacteria abundance	count per milliliter
Flag_Hetero	Quality flag for Heterotrophic Bacteria where 1 = not quality controlled, 2 = good data, 3 = suspect (questionable) data, 4 = bad data, 5 = missing value, 9 = variable not measured during this cast	unitless
Synecho	Synechococcus abundance	count per milliliter
Flag_Synecho	Quality flag for Synechococcus where 1 = not quality controlled, 2 = good data, 3 = suspect (questionable) data, 4 = bad data, 5 = missing value, 9 = variable not measured during this cast	unitless
Euk	Eukaryotes abundance	count per milliliter
Flag_Euk	Quality flag for Eukaryotes where 1 = not quality controlled, 2 = good data, 3 = suspect (questionable) data, 4 = bad data, 5 = missing value, 9 = variable not measured during this cast	unitless

Flag	Quality Flags (original combined format) for the bottle, chlorophyll, phaeopigments, light incubation, dark incubation, salinity & bacteria values respectively. 1: not quality controlled, 2: good data, 3: suspect (questionable) data, 4: bad data, 5: missing value, 9: variable not measured during this cast	unitless
file_name	Original filename of the primary production data from HOT	unitless
Date	Original Date in HST	unitless
Start	Original Start time in HST	unitless
End	Original End time in HST	unitless
Cruise_num	HOT cruise number (numerical portion of HOT-ID)	unitless

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Instruments

Dataset-specific Instrument Name	Go-Flo bottles (only until HOT-096)
Generic Instrument Name	GO-FLO Bottle
Dataset-specific Description	Go-Flo bottles were used for sampling from HOT-001 through HOT-096. Beginning with HOT-097, Niskin bottles were used.
Generic Instrument Description	GO-FLO bottle cast used to collect water samples for pigment, nutrient, plankton, etc. The GO-FLO sampling bottle is specially designed to avoid sample contamination at the surface, internal spring contamination, loss of sample on deck (internal seals), and exchange of water from different depths.

Dataset-specific Instrument Name	liquid scintillation counter
Generic Instrument Name	Liquid Scintillation Counter
Dataset-specific Description	liquid scintillation counter (Packard model 4640; United Technologies Inc.)
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	External closing niskin
Generic Instrument Name	Niskin bottle
Dataset-specific Description	External closing niskin sampled in-situ Incubation.
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.

Dataset-specific Instrument Name	NORDA/USM incubation system
Generic Instrument Name	Shipboard Incubator
Dataset-specific Description	temperature- and light-controlled deck incubation system (NORDA/USM incubation system)
Generic Instrument Description	A device mounted on a ship that holds water samples under conditions of controlled temperature or controlled temperature and illumination.

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Deployments

HOT_cruises

Website	https://www.bco-dmo.org/deployment/58879
Platform	Multiple Vessels
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.

KOK1007

Website	https://www.bco-dmo.org/deployment/965824
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2010-04-05
End Date	2010-04-09

KOK1011

Website	https://www.bco-dmo.org/deployment/965832
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2010-05-17
End Date	2010-05-21

KOK1013

Website	https://www.bco-dmo.org/deployment/965840
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2010-06-07
End Date	2010-06-11

KM1012

Website	https://www.bco-dmo.org/deployment/965848
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2010-07-07
End Date	2010-07-11

KM1102A

Website	https://www.bco-dmo.org/deployment/965856
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2011-01-27
End Date	2011-01-31

KM1120

Website	https://www.bco-dmo.org/deployment/965864
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2011-07-18
End Date	2011-07-22

KM1124

Website	https://www.bco-dmo.org/deployment/965872
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2011-08-29
End Date	2011-09-01

KM1127

Website	https://www.bco-dmo.org/deployment/965879
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2011-09-25
End Date	2011-09-28

KOK1113

Website	https://www.bco-dmo.org/deployment/965886
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2011-11-03
End Date	2011-11-07

KOK1114

Website	https://www.bco-dmo.org/deployment/965894
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2011-11-27
End Date	2011-12-01

KOK1201

Website	https://www.bco-dmo.org/deployment/965907
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2012-01-17
End Date	2012-01-21

KOK1202

Website	https://www.bco-dmo.org/deployment/965922
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2012-04-30
End Date	2012-05-04

KM1223

Website	https://www.bco-dmo.org/deployment/965930
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2012-10-06
End Date	2012-10-10

KM1227

Website	https://www.bco-dmo.org/deployment/965938
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2012-12-02
End Date	2012-12-06

KM1302

Website	https://www.bco-dmo.org/deployment/965946
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2013-02-11
End Date	2013-02-15

KM1305

Website	https://www.bco-dmo.org/deployment/965954
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2013-03-05
End Date	2013-03-09

TN294

Website	https://www.bco-dmo.org/deployment/965962
Platform	R/V Thomas G. Thompson
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2013-04-04
End Date	2013-04-08

KM1308

Website	https://www.bco-dmo.org/deployment/965970
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2013-05-16
End Date	2013-05-20

KM1311

Website	https://www.bco-dmo.org/deployment/965978
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2013-06-24
End Date	2013-06-28

KM1315

Website	https://www.bco-dmo.org/deployment/965986
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2013-09-10
End Date	2013-09-14

KM1317

Website	https://www.bco-dmo.org/deployment/965994
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2013-09-30
End Date	2013-10-04

KM1319

Website	https://www.bco-dmo.org/deployment/966002
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2013-10-26
End Date	2013-10-30

KM1321

Website	https://www.bco-dmo.org/deployment/966010
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2013-11-25
End Date	2013-11-29

KM1323

Website	https://www.bco-dmo.org/deployment/966018
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2013-12-19
End Date	2013-12-23

KM1402

Website	https://www.bco-dmo.org/deployment/966026
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2014-01-14
End Date	2014-01-18

KM1406

Website	https://www.bco-dmo.org/deployment/966034
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2014-02-13
End Date	2014-02-17

KM1408

Website	https://www.bco-dmo.org/deployment/966042
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2014-03-04
End Date	2014-03-08

KM1410

Website	https://www.bco-dmo.org/deployment/966050
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2014-04-09
End Date	2014-04-13

KOK1404

Website	https://www.bco-dmo.org/deployment/966058
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2014-05-30
End Date	2014-06-03

KM1414

Website	https://www.bco-dmo.org/deployment/966066
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2014-06-29
End Date	2014-07-03

KM1421

Website	https://www.bco-dmo.org/deployment/966074
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2014-10-12
End Date	2014-10-16

KM1425

Website	https://www.bco-dmo.org/deployment/966082
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2014-11-20
End Date	2014-11-24

KM1428

Website	https://www.bco-dmo.org/deployment/966090
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2014-12-15
End Date	2014-12-19

KOK1502

Website	https://www.bco-dmo.org/deployment/966098
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2015-02-23
End Date	2015-02-27

KOK1503

Website	https://www.bco-dmo.org/deployment/966106
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2015-03-27
End Date	2015-03-31

KM1504

Website	https://www.bco-dmo.org/deployment/966114
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2015-04-20
End Date	2015-04-24

KM1508

Website	https://www.bco-dmo.org/deployment/966122
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2015-05-22
End Date	2015-05-26

KM1510

Website	https://www.bco-dmo.org/deployment/966130
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2015-06-18
End Date	2015-06-22

KM1512

Website	https://www.bco-dmo.org/deployment/966138
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2015-07-18
End Date	2015-07-22

KOK1508

Website	https://www.bco-dmo.org/deployment/966146
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2015-08-11
End Date	2015-08-15

KOK1515

Website	https://www.bco-dmo.org/deployment/966154
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2015-10-12
End Date	2015-10-16

KOK1516

Website	https://www.bco-dmo.org/deployment/966168
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2015-12-07
End Date	2015-12-11

KM1601

Website	https://www.bco-dmo.org/deployment/966175
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2016-01-11
End Date	2016-01-15

KM1602

Website	https://www.bco-dmo.org/deployment/966182
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2016-02-08
End Date	2016-02-12

KOK1605

Website	https://www.bco-dmo.org/deployment/700778
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://dmoserv3.whoi.edu/data_docs/ProEco/cs283.pdf
Start Date	2016-04-13
End Date	2016-04-17
Description	Note the cruise report identifies this cruise as KOK16-04. KOK16-04 was the intial cruise ID but it was changed to KOK16-05 after completion of the cruise do to changes in the ship's schedule.

OC1605B

Website	https://www.bco-dmo.org/deployment/966203
Platform	R/V Oceanus
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2016-05-27
End Date	2016-05-31

KOK1608

Website	https://www.bco-dmo.org/deployment/966211
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2016-07-10
End Date	2016-07-14

KOK1611

Website	https://www.bco-dmo.org/deployment/966219
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2016-08-08
End Date	2016-08-12

OC1610A

Website	https://www.bco-dmo.org/deployment/966227
Platform	R/V Oceanus
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2016-10-14
End Date	2016-10-18

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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

Hawai'i Ocean Time-Series Project Summary
This continuing award for the HOT research program sustains the open-ocean climatology of biological, chemical, and physical observations into a 4th decade.

Intellectual Merit
The scientific mission of HOT continues to be monitoring of temporal dynamics in the cycling of carbon and associated bioelements, and observations of the variability of hydrological and ecological properties, heat fluxes, and circulation of the North Pacific Subtropical Gyre (NPSG). The proposed research will rely on shipboard observations and experiments conducted on 10 separate 5-day expeditions per annum along with near-continuous moored platform measurements of air-sea interactions, ocean mixing, and physical characteristics of the deep sea. The HOT program maintains the high-quality suite of 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. Continuity of these observations improves the value of the dataset for deciphering how low-frequency natural and anthropogenic climate signals influence ecosystem structure in the NPSG as well as providing up-to-date measurements to place current signals in the longer-term context. Such efforts will continue to aid on-going modeling efforts required for predicting how future habitat perturbations may influence ecosystem dynamics in the NPSG. All HOT program data are publicly available and are frequently used by researchers and policy makers around the world. HOT data provide reference baselines for essential ocean variables, allow for characterization of natural patterns of ocean system variability and associated links to regional climate indices, and support calibration/validation of autonomous in situ and remote (satellite, airborne) sensors.

Broader Impacts
The long-term, continuous HOT data are critical to assess variability on seasonal to decadal time-scales and thus are essential to determine the emergence of anthropogenic signals in the oligotrophic North Pacific. Further sustaining HOT measurements will strengthen our capacity to test hypotheses about poorly understood interactions between ocean dynamics, climate, and biogeochemistry and increase the value of HOT data for understanding the response of ocean ecosystems to both natural and anthropogenic climate perturbations. Over the next 5 years, we will continue to promote the value of HOT research through high quality, high visibility peer-reviewed journal and book articles, newspaper and newsletter articles, and community outreach. With partners BCO-DMO and OceanSITES we will also continue to strive for a FAIR data model (see data management plan) as metadata standards and conventions evolve in the community. We will continue working with an Earthcube Research Coordination Network for Marine Ecological Time Series (METS) to support efforts that bring together different cross-sections of METS data producers, data users, data scientists, and data managers in large- and small-group formats to foster the necessary dialog to develop FAIR data solutions across multiple time-series. In addition, HOT is a community resource that helps support the research of numerous ocean scientists who rely on the program's infrastructure (ship time, staff, laboratories, equipment) to conduct their research, education, and outreach activities. Moreover, HOT PIs maintain a strong commitment to mentoring and training of undergraduate and graduate students, and will continue these activities as well as facilitates access to the sea by a number of ancillary students and scientists.

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.

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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 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.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0926766
NSF Division of Ocean Sciences (NSF OCE)	OCE-1260164
NSF Division of Ocean Sciences (NSF OCE)	OCE-1756517
NSF Division of Ocean Sciences (NSF OCE)	OCE-2241005
NSF Division of Ocean Sciences (NSF OCE)	OCE-0752606
NSF Division of Ocean Sciences (NSF OCE)	OCE-0327513
NSF Division of Ocean Sciences (NSF OCE)	OCE-0326616
NSF Division of Ocean Sciences (NSF OCE)	OCE-9617409
NSF Division of Ocean Sciences (NSF OCE)	OCE-9301368
NSF Division of Ocean Sciences (NSF OCE)	OCE-9303094

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