Two decibar-averaged CTD profiles from the Hawaii Ocean Time-Series cruises from 1988-2023 (HOT project)

Website: https://www.bco-dmo.org/dataset/3937
Data Type: Cruise Results
Version: 2
Version Date: 2025-04-07

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)

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Abstract
The dataset includes CTD data collected by the Hawaii Ocean Time-series (HOT) ocean measurement program on cruises taken from October 1988 to December 2023, during the monthly expedition to Station ALOHA. HOT CTD data are collected using a SeaBird CTD 9-11 (9-11 Plus with dual sensors as of HOT-54) at the maximum sampling rate of 24 samples per second (24 Hz). They are screened for errors and processed to 2-dbar averages. The majority of the sampling effort, approximately 60-72 h per standard HOT cruise, is spent at Station ALOHA. High vertical resolution environmental data are collected with a Sea-Bird CTD having external temperature (T), conductivity (C), dissolved oxygen (DO) and fluorescence (F) sensors and an internal pressure (P) sensor. A Sea-Bird 24-place carousel and an aluminum rosette that is capable of supporting 24 12-L PVC bottles are used to obtain water samples from desired depths. The CTD and rosette are deployed on a 3-conductor cable allowing for real-time display of data and for tripping the bottles at specific depths of interest.

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Coverage

Location: central North Pacific Ocean at 22' 45'N, 158' 00'W approximately 100 km north of the island of Oahu
Spatial Extent: **N**:23.4398 **E**:-157.4567 **S**:21.2283 **W**:-159.7002
Temporal Extent: 1988-10-30 - 2023-12-31

Methods & Sampling

The majority of our sampling effort, approximately 60-72 h per standard HOT cruise, is spent at Station ALOHA. High vertical resolution environmental data are collected with a Sea-Bird CTD having external temperature (T), conductivity (C), dissolved oxygen (DO) and fluorescence (F) sensors and an internal pressure (P) sensor. A Sea-Bird 24-place carousel and an aluminum rosette that is capable of supporting 24 12-L PVC bottles are used to obtain water samples from desired depths. The CTD and rosette are deployed on a 3-conductor cable allowing for real-time display of data and for tripping the bottles at specific depths of interest. The CTD system takes 24 samples s-1 and the raw data are stored both on the computer and, for redundancy, on VHS-format video tapes (prior to HOT-322) and as an audio signal on a laptop PC (HOT-322 - present).

In February 2006, before cruise 178, we replaced our 24 aging 12-L PVC rosette bottles with new 12-L bottles fabricated at the University of Hawaii Engineering Support Facility, using plans and specifications from John Bullister (Pacific Marine Environmental Laboratory).

Continuous measurements of temperature, salinity, oxygen, and fluorescence are made with a Sea-Bird SBE-9/11Plus CTD package with dual temperature, salinity, oxygen sensors, and fluorometer described in Tupas et al. (1995). In 2022 the CTD underwater unit #91361 was used during cruises HOT-335 through HOT-339.

Details of the CTD processing for each year can be found in HOT Data Reports #1-34 (*HOT: Yearly Data Reports*). CTD data are written to files using formats specified by the WOCE Hydrographic Programme Office. These formats are based on NODC formats, and are detailed in the WHP Office Report WHPO 90-1.

Since November 2001 CTD fluorescence data have been regularly calibrated against Chlorophyll bottle data and reported in the CTD files as Chloropigments (CHLPIG) in microgram/liter (uG/L). Bottle Fluorometric Chlorophyll-a plus Pheopigments above 175 dbar are matched against the upcast CTD Fluorometry to calibrate the downcast Fluorescence reported in the CTD files. All CTD files for prior cruises were calibrated and updated to reflect this change.

Starting HOT-177 (2006), the Transmissometer (XMISS) data that used to be included in the CTD files have been replaced by continuous Nitrate measured using Satlantic's InSitu Underwater Spectrometer (ISUS V2). Satlantic's ISUS V2 is a chemical free sensor that uses UV absorption technology to provide accurate nitrate concentration measurements in real-time.

Temperature is reported in the ITS-90 scale. Salinity and all derived units were calculated using the UNESCO (1981) routines; salinity is reported in the practical salinity scale (PSS-78). Oxygen is reported in µmol kg-1. Chloropigment (Fluorescence) is reported in µg/l.

Data Processing Description

CTD data were acquired at a rate of 24 samples per second. Digital data were stored on a laptop personal computer and for redundancy, the CTD signal was recorded using a USB sound card and Audacity® software on a separate laptop. Backups of CTD data were made onto USB storage cards and compact disks. The raw CTD data were quality controlled and screened for spikes described in Winn et al. (1993). Data alignment, averaging, correction and reporting were done as described in Tupas et al. (1993). Salinity spike rejection parameters were modified for some cruises in 2022 because of rough sea conditions. Spikes occur when the CTD samples the disturbed water of its wake; therefore, samples from the downcast are rejected when the CTD moves upward or when its acceleration exceeds 0.5 m s-2 in magnitude.

Some cruises were conducted under relatively rough conditions. To relax the data rejection criteria and avoid eliminating excessive points, the CTD acceleration cutoff value had to be increased to between 0.55 and 1 m s-2 for some casts.

The data were additionally screened by comparing the temperature and conductivity sensor pairs. These differences permitted identification of problems in the sensors. Only the data from one set of T-C sensors and one oxygen sensor, deemed most reliable, are reported here.

Pressure

The pressure calibration strategy employed a high-quality quartz pressure transducer as a transfer standard. Periodic recalibrations of this laboratory standard were performed with a primary pressure standard. The transfer standard was used to check the CTD pressure transducers. The corrections applied to the CTD pressures included a constant offset determined when the CTD first enters the water on each cast, and a pressure-dependent offset, obtained from semi-annual bench tests between the CTD sensor and the transfer standard.

The transfer standard is a Digiquartz portable standard Paroscientific SN 136923 pressure gauge equipped with a 10,000-PSI transducer. This instrument was purchased in May 2016 and was initially calibrated against a primary standard. A subsequent recalibration was performed in May 2020 at Fluke.

CTD pressure transducer bench tests were done using an Ametek T-100 pump and a manifold to apply pressure simultaneously to the CTD pressure transducer and the transfer standard. All these tests had points at six pressure levels between 0 and 4500 dbar, increasing and decreasing pressures.

Pressure sensor #75434

This CTD was serviced and recalibrated at SeaBird in May 2021 due to damages when the winch wire parted, and the CTD fell and hit the ship's deck during the March 2021 HOT-328 cruise. The September 2021 test showed that the sensor’s characteristics changed after this incident.

A correction of 0.137 dbar (from the May 2021 calibration) was applied to the pressure offset at 0 dbar during data collection for casts conducted with sensor #75434 during the HOT-335 through HOT-339 cruises. However, a more accurate offset was later determined when the CTD first enters the water on each cast. On-deck CTD pressures are regularly recorded during cruises at the beginning, and the end of each CTD cast.

The 0-dbar pressure for sensor #75434 was near constant during 2021 through 2023. These pressures are smaller than the before-cast on-deck pressure because during bench tests the CTD is powered on at least 12 hours before testing to allow the pressure sensor to stabilize, while during cruises, the CTD is powered on only about 15 minutes before each cast. The bench tests show a slow sensor stabilization account for the observed differences.

The 0-4500 dbar pressure offset and hysteresis from the bench tests have been near-constant and within expected values, although the first has shown a slight regular increase. No linear pressure-dependent offset was applied during data collection for sensor #75434 to correct the 0-4500 dbar span offset.

Pressure sensor #53702

Sensor #53702 (CTD #1487) was acquired in 2022. It was factory-calibrated on January 5, 2022, and bench tested once in May 2022. The test showed a large 0-dbar offset. A correction of -0.98 dbar (from its original sensor calibration) was applied to the pressure offset at 0 dbar during data collection for casts conducted with this sensor during the WHOTS-18 cruise. However, a more accurate offset was later determined when the CTD first entered the water on each cast. A linear pressure-dependent offset was applied during data collection for this sensor to correct the 0-4500 dbar span offset. The hysteresis from the bench test was within expected values.

Temperature

Four Sea-Bird SBE-3-Plus temperature transducers, #4448, #5519, #6672, and #6631, were used in 2022. The history of the sensors, as well as the procedures followed to obtain the sensor drift from the Sea-Bird calibrations, are well-documented in previous HOT Data Reports: Fujieki et al., 2023, 2021, 2020, 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012, 2011, 2010, 2008, 2007, 2006, 2005, 2004, 2002, Santiago-Mandujano et al., 2000, Tupas et al., 1993, 1994, 1995, 1997, 1998, 1999, Karl et al. 1996 (*HOT: Yearly Data Reports*). Sensors #6672 and #6631 are new sensors acquired in February 2022.

Calibration coefficients obtained at Sea-Bird and used in the drift estimates were used in the following formula that gives the temperature (in Deg C) as a function of the frequency signal (f):

$$\text{temperature} = 1/\{a + b[\ln(fo/f)] + c[\ln2(fo/f)] + d[\ln3(fo/f)]\} - 273.15$$

For each sensor, the final calibration consists of two parts: first, a single "baseline" calibration is chosen from among the ensemble of calibrations during the year; second, for each cruise a temperature-independent offset is applied to remove the temporal trend due to sensor drift. The offset, a linear function of time, is calculated by least-squares fit to the 0-30 Deg C average of each calibration during the year. The maximum drift correction in 2022 was less than 2.0 x 10-4 Deg C for the data collected with these sensors. The baseline calibration is selected for which the trend-corrected average from 0-5 Deg C is nearest to the ensemble mean of these averages.

A small residual pressure effect on the temperature sensors documented in Tupas et al. (1997) has been removed from measurments obtained with our sensors. Another correction to our temperature measurements was for the viscous heating of the sensor tip due to the water flow. This correction is thoroughly documented in Tupas et al. (1997).

Dual sensors were used during each of the 2022 cruises. The temperature differences between sensor pairs were calculated for each cast to evaluate the quality of the data, and to identify possible problems with the sensors. Means and standard deviations of the differences in 2-dbar bins were calculated from the ensemble of all casts at Station ALOHA for each cruise. Both sensors performed correctly during the 2022 cruises, showing temperature differences within expected values. The mean temperature difference as a function of pressure was typically less than 1 x 10-3 Deg C, with a standard deviation of less than 0.5 x 10-3 Deg C below 500 dbar. The largest variability was observed in the thermocline, with standard deviation values up to 5 x 10-3 Deg C.

Conductivity

Five conductivity sensors were used during the 2022 cruises, #3162, #3984, #4939, #6052, and #6056. The history of our sensors is well documented in previous HOT Data Reports: Fujieki et al., 2023, 2021, 2020, 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012, 2011, 2010, 2008, 2007, 2006, 2005, 2004, 2002, Santiago-Mandujano et al., 2000, Tupas et al., 1993, 1994, 1995, 1997, 1998, 1999, Karl et al. 1996 (*HOT: Yearly Data Reports*). Sensors #6052, and #6056 are new sensors acquired in February 2022 and were used during the WHOTS-18 cruise. The water pump for sensor #6052 had problems during this cruise and calibrations against salinity samples could not be conducted.

For each sensor, the nominal calibrations were used for data acquisition, and a final calibration was determined empirically from the salinities of discrete water samples acquired during each cast. Before empirical calibration, conductivity was corrected for the thermal inertia of the glass conductivity cell as described in Chiswell et. al. (1990).

Procedures for preliminary screening of bottle samples and empirical calibration of the conductivity cell are described in Tupas et al. (1993, 1994a). For cruises HOT-335 through -339, the standard deviation cutoff values for screening of bottle salinity samples were: 0.0034 (0-150 dbar), 0.0049 (151-500 dbar), 0.00185 (501- 1050 dbar), and 0.00092 (1051-5000 dbar).

A least squares fit (ΔC = b0 + b1C + b2C2) to the CTD-bottle conductivity differences was used. None of the cruises required a quadratic calibration. The calibrations were best below 500 dbar because the weaker vertical salinity gradients at depth lead to less error when the bottle and CTD pressures are slightly mismatched.

The final step of conductivity calibration was a cast-dependent bias correction described in Tupas et. al. (1993) to allow for drift during each cruise or sudden offsets due to fouling. Note that a change of 1 x 10-4 Siemens m-1 in conductivity is approximately equivalent to 0.001 in salinity.

Conductivity differences between sensor pairs were calculated the same way for the temperature sensors. The range of variability as a function of pressure was about ± 1 x 10-4 Siemens m-1, with a standard deviation of less than 0.5 x 10-4 Siemens m-1 below 500 dbar, from the ensemble of all the cruise casts. The largest variability was in the halocline, with standard deviations reaching up to 5 x 10-4 Siemens m-1 between 50 and 300 dbar.

Oxygen

During the 2022 cruises, our three Sea-Bird SBE-43 oxygen sensors were used: #43262, #433761, and #43918. Two new sensors #434232 and #434246 acquired in February 2022 were used during the WHOTS-18 cruise. Sensor #433761 was found with a punctured membrane during the March 2022 Sea-Bird calibration, and its membrane was replaced. The electrolyte housing of sensor #43262 was found cracked during the March 2022 calibration and it was fixed. The history of our sensors is documented in previous HOT Data Reports: Fujieki et al., 2023, 2021, 2020, 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012, 2011, 2010, 2008, 2007, 2006, 2005, 2004, 2002, Santiago-Mandujano et al., 2000, Tupas et al., 1993, 1994, 1995, 1997, 1998, 1999, Karl et al. 1996 (*HOT: Yearly Data Reports*). All these sensors have been calibrated annually at Sea-Bird.

Water bottle oxygen data were screened and the oxygen sensors were empirically calibrated following procedures described previously (Winn et. al. 1992; Tupas et. al., 1993). The calibration procedure follows Owens and Millard (1985) and fits a non-linear equation to the CTD oxygen current and oxygen temperature. The bottle values of dissolved oxygen and the downcast CTD observations at the potential density of each bottle trip were grouped for each cruise to find the best set of parameters with a non-linear least squares algorithm. Two sets of parameters were usually obtained per HOT cruise, corresponding to the casts at Station 1 and 2 (calibration coefficients from cast 2 are also used to calibrate the cast at station 6, 50 and 52). The calibration procedure for the Sea-Bird SBE-43 sensors is documented in Santiago-Mandujano et. al. (2001).

Dual sensors were used during cruises, but only the sensor whose data were deemed more reliable is reported.

BCO-DMO Processing Description

- Imported all SUM and CTD files for years 29-35 (some missing files retrieved from the Hawaii Ocean Time-series (HOT) website in Feb 2025) into the BCO-DMO system
- Extracted all header metadata from each file and added this information to each row of data collected
- Converted all date and time information to ISO datetime format
- Converted all lat and lon values to decimal degrees and represented S values as negative
- Combined all files with existing published and archived dataset "ctd.csv"
- Removed redundant date fields and combined cruise ID fields
- Replaced the "\" character with "_" to prevent potential user problems
- Removed seconds from published data ISO datetime field
- Sorted all rows from most recent cast to oldest cast
- Exported file as "3937_v2_hot_ctd.csv"

Problem Description

Some cruises were conducted under relatively rough conditions. To relax the data rejection criteria and avoid eliminating excessive points, the CTD acceleration cutoff value had to be increased to between 0.55 and 1 m s-2 for some casts.

The data were additionally screened by comparing the temperature and conductivity sensor pairs. These differences permitted identification of problems in the sensors. Only the data from one set of T-C sensors and one oxygen sensor, deemed most reliable, are reported here.

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Data Files

File
3937_v2_hot_ctd.csv (Comma Separated Values (.csv), 630.76 MB) MD5:b3319fa233d4e822ffdcada548503b2e Primary data file for dataset ID 3937, version 2

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Related Publications

Chiswell, S., E. Firing, D. Karl, R. Lukas and C. Winn. 1990. Hawaii Ocean Time- series Program Data Report 1, 1988-1989. SOEST Tech. Rept. #1, School of Ocean and Earth Science and Technology, Univ. of Hawaii, Honolulu, HI, 269 pp. https://hahana.soest.hawaii.edu/hot/reports/rep_y1.pdf

Methods

HOT: CTD Temperature, Salinity, Oxygen and Potential Density. Accessed 24 Mar. 2025.
https://hahana.soest.hawaii.edu/hot/methods/ctdtsod.html
Methods

HOT: Sensor Correction & Calibration. https://hahana.soest.hawaii.edu/hot/methods/sensors.html. Accessed 24 Mar. 2025.
Methods

HOT: Yearly Data Reports. Accessed 24 Mar. 2025 https://hahana.soest.hawaii.edu/hot/reports/reports.html
Methods

Mazzoni, Dominic. Audacity [Computer software]. https://www.audacityteam.org/
http://audacity.sourceforge.net/
Software

Santiago-Mandujano, F., J. Dore, L. Tupas, D. Hebel, L. Fujieki, R. Lukas and D. Karl. 2001. Hawaii Ocean Time-series Program Data Report 11: 1999. https://hahana.soest.hawaii.edu/hot/reports/rep_y11.pdf
Methods

Tupas, L., F. Santiago-Mandujano, D. Hebel, C. Nosse, L. Fujieki, E. Firing, R. Lukas and D. Karl. 1997. Hawaii Ocean Time-series Program Data Report 8: 1996. SOEST Tech. Report 97-7, School of Ocean and Earth Science and Technology, Univ. of Hawaii, Honolulu, HI, 296 pp.
https://hahana.soest.hawaii.edu/hot/reports/rep_y8.pdf
Methods

Tupas, L., F. Santiago-Mandujano, D. Hebel, E. Firing, R. Lukas, and D. Karl. 1995. Hawaii Ocean Time-series Program Data Report 6: 1994. SOEST Tech. Report 95-6, School of Ocean and Earth Science and Technology, Univ. of Hawaii, Honolulu, HI, 199 pp. https://www.soest.hawaii.edu/HOT_WOCE/data_rep/rep_y6.pdf
Methods
,
Results

Tupas, L., F. Santiago-Mandujano, D. Hebel, R. Lukas, D. Karl and E. Firing. 1993. Hawaii Ocean Time-series Program Data Report 4: 1992. SOEST Tech. Report 93-14, School of Ocean and Earth Science and Technology, Univ. of Hawaii, Honolulu, HI, 248 pp. https://hahana.soest.hawaii.edu/hot/reports/rep_y4.pdf
Methods
,
Results

Winn, C., R. Lukas, D. Karl and E. Firing. 1993. Hawaii Ocean Time- series Program Data Report 3: 1991. SOEST Tech. Report 93-3, School of Ocean and Earth Science and Technology, Univ. of Hawaii, Honolulu, HI, 228 pp.
https://www.soest.hawaii.edu/HOT_WOCE/data_rep/rep_y3.pdf
Methods
,
Results

Winn, C., S. Chiswell, E. Firing, D. Karl and R. Lukas. 1992. Hawaii Ocean Time- series Program Data Report 2, 1990. SOEST Tech. Rept. 92-1, School of Ocean and Earth Science and Technology, Univ. of Hawaii, Honolulu, HI, 175 pp. https://hahana.soest.hawaii.edu/hot/reports/rep_y2.pdf
Methods

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Parameters

Parameter	Description	Units
cruise_name	Cruise identifier	unitless

EXPOCODE	This code allows for the identification of cast. It consists of a 4 character NODC country-ship code; a maximum of 8 character cruise number followed by a _ and leg number.	unitless
station	Station identifier	unitless
cast	CTD cast number	unitless
ISO_DateTime_UTC	Time of cast in ISO-8601 format following the convention YYYY-mm-ddTHH:MMZ (UTC time)	unitless
lon	Longitude with west being negative	decimal degrees
lat	Latitude with south being negative	decimal degrees
depth_max	Depth measured by shipboard echo sounder in meters. The nominal depth for Station 1 = 1500m and for Station 2 = 4750m.	meters (m)
pres_max	Deepest pressure sampled	decibars (db)
HOT_summary_file_name	Filename from which the cruise summary information was obtained	unitless
parameters	A list of the parameters measured from the water samples collected during the cast. The identification numbers are listed here. 1 = Salinity; 2 = Oxygen; 3 = Silicate; 4 = Nitrate; 5 = Nitrite; 6 = Phosphate; 7 = Freon 11; 8 = Freon 12; 9 = Tritium; 10= Helium; 11= Carbon 14; 12= Carbon 13; 13= Krypton 85; 14= Argon; 15= Argon 39; 16= Neon; 17= Radium; 18= Radium 226; 19= Oxygen isotope ratio (18O/16O); 20= Strontium 90; 21= Cesium 137	unitless
num_bottles	Number of bottles used during the cast	unitless
section	WOCE Hydrographic Programme Office section designator	unitless
depth_hgt	Bottom depth less the maximum pressure sampled	meters (m)
CTDPRS	Pressure	Decibars (db)
CTDTMP	Temperature, ITS-90 scale	Degrees Celsius
CTDSAL	Salinity (1978 International Practical Salinity Scale)	PSU

CTDOXY	Oxygen	micromoles per kilogram (umol/kg)
CHLPIG	Chloropigments	microgram per liter (ug/L)
XMISS	Transmission; measured until HOT-176	percent transmission (%)
NITRATE	Nitrate; measured starting with HOT-177	micromoles per kilogram (umol/kg)
QUALT1	Quality (defined by investigator); The quality word is the left-to-right concatenation of required quality bytes for the variables measured. They apply in the following order: CTDPRS, CTDTMP, CTDSAL, CTDOXY, CHLPIG, and XMISS (until HOT-177) /NITRATE (from HOT-178). They are defined as follows: 1 = Not calibrated with water samples; 2 = Acceptable measurement; 3 = Questionable measurement; 4 = Bad measurement; 5 = Not reported; 6 = Interpolated value; 7 = Not assigned for CTD data; 8 = Not assigned for CTD data; 9 = Not sampled	unitless
NUMBER	Number of observations averaged at this pressure level	unitless
comments	Cast comments	unitless

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Instruments

Dataset-specific Instrument Name	SeaBird CTD 9-11
Generic Instrument Name	CTD Sea-Bird 911
Dataset-specific Description	HOT CTD data are collected using a SeaBird CTD 9-11 (9-11 Plus with dual sensors as of HOT-54) at the maximum sampling rate of 24 samples per second (24 Hz).
Generic Instrument Description	The Sea-Bird SBE 911 is a type of CTD instrument package. The SBE 911 includes the SBE 9 Underwater Unit and the SBE 11 Deck Unit (for real-time readout using conductive wire) for deployment from a vessel. The combination of the SBE 9 and SBE 11 is called a SBE 911. The SBE 9 uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3 and SBE 4). The SBE 9 CTD can be configured with auxiliary sensors to measure other parameters including dissolved oxygen, pH, turbidity, fluorescence, light (PAR), light transmission, etc.). More information from Sea-Bird Electronics.

Dataset-specific Instrument Name	SeaBird CTD 9-11 Plus
Generic Instrument Name	CTD Sea-Bird SBE 911plus
Dataset-specific Description	HOT CTD data are collected using a SeaBird CTD 9-11 (9-11 Plus with dual sensors as of HOT-54) at the maximum sampling rate of 24 samples per second (24 Hz).
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

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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.

KOK1005

Website	https://www.bco-dmo.org/deployment/965818
Platform	R/V Ka`imikai-O-Kanaloa
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2010-03-08
End Date	2010-03-12

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

KM1131

Website	https://www.bco-dmo.org/deployment/965901
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2011-12-18
End Date	2011-12-22

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

KM1205

Website	https://www.bco-dmo.org/deployment/965915
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2012-03-23
End Date	2012-03-27

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

KM1518

Website	https://www.bco-dmo.org/deployment/966162
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2015-11-12
End Date	2015-11-16

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

KM1603

Website	https://www.bco-dmo.org/deployment/966190
Platform	R/V Kilo Moana
Report	http://hahana.soest.hawaii.edu/hot/cruises.html
Start Date	2016-03-07
End Date	2016-03-11

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 4^{th} 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

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