Zooplankton Community Structure from tows during cruises from Feb-1994 (HOT 52) to Sep-2022 (HOT 339) at Station ALOHA

Website: https://www.bco-dmo.org/dataset/911470
Data Type: Cruise Results
Version: 1
Version Date: 2023-10-13

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
Mesozooplankton (weak swimmers 0.2-20 mm size) are collected using oblique tows of a one meter squared net (202-µm mesh netting) from the surface to approximately 175 meters depth. The catch is size fractionated by washing through a nested set of net filters and each fraction analyzed for dry weight, C and N.

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Dataset Description

Summary
Mesozooplankton (weak swimmers 0.2-20 mm size) are collected using oblique tows of a 1-m^2 net (202-µm mesh netting) from the surface to approximately 175 m depth. The catch is size fractionated by washing through a nested set of net filters and each fraction analyzed for dry weight, C and N.

Methods & Sampling

Principle
Large zooplankton and micronekton play important roles in the export of organic material from surface waters in the open ocean. Global Ocean Flux planning models suggest that the relationship between primary production and passive particulate export flux is strongly influenced by size structure of the zooplankton

community (e.g., Paffenhöffer & Knowles, 1979; Small et al., 1987; Frost, 1984). Active vertical migrations also have important implications for the transport and transformation of surface-derived organic particulates to dissolved inorganic constituents at depth (Longhurst & Harrison, 1988; Longhurst et al., 1990; Al-Mutairi & Landry, 2001; Hannides et al., 2008). The zooplankton component of the time-series sampling effort allows such processes to be considered in the interpretation of seasonal and interannual variations in measured flux and the elemental mass balance (e.g., carbon and nitrogen sources and sinks) of the euphotic zone.

At Station ALOHA, 6 net tows are scheduled per cruise. Three midnight (2200 - 0200) and 3 mid-day (1000 - 1400) oblique tows are done using a 1-m2 net (3-m length) with 202-µm mesh Nitex netting. The net is towed obliquely at approximately 1 knot, from the surface to approximately 175 m and then back to the surface. Towing time is approximately 20-30 minutes. The tows are subsequently size-fractioned and analyzed for mesozooplankton wet and dry weight and C and N biomass.

2. Field Operations

2.1. Hardware

Two net systems have been used for routine time-series collections of zooplankton at Station ALOHA. From 1994 to 2005 (Cruises 50-175), we used a 1 meter squared single-net frame with wire attachments and weighting similar to a MOCNESS (Landry et al., 2001; Sheridan & Landry, 2004). A flow meter with a low-speed rotor (Model 2030R, General Oceanics, Miami, FL) was attached across the net opening to measure distance towed, and a temperature-pressure data logger (Model XL-200, Richard Brancker Research, Ottawa, Canada) was fastened to the net frame to measure depth of tow. From HOT cruise 175 to present, the collection procedure was simplified by switching to a 1 meter square diameter ring net, with GO 2030R flow meter and Vemco minilog Time-Depth Recorder. Both frames are fitted with 202 micron filter mesh nets with similar aspect ratios, and they have roughly comparable mouth areas under tow. They are lowered to depth and returned to the surface similarly (by capstan). The main difference is a preceding bridle on the ring net, which may be easier to avoid by larger animals with fast escape responses compared to the side bridles of the original rectangular net. As reported by Valencia et al. (2018), the two net systems were compared in a series of tows on the same cruise, revealing no significant differences in areal estimates of mesozooplankton biomass for either day or night tows (Mann-Whitney test, $p > 0.05$). They are therefore assumed to be equally efficient samplers in the time series. Since even very large, fast-towed nets (7.3 m2 Isaacs-Kidd mid-water trawl and 96 m2 Cobb nets; 2-4 kts) are unlikely to sample micronekton quantitatively (Kuba, 1970), neither of the small HOT nets is assumed to capture this fraction well.

2.2. Post-recovery processing

At the end of the tow, the outer side of the net is sprayed down with surface seawater to concentrate the animals in the collecting bucket. As soon as possible after collection, the sample is split using a Folsom plankton splitter. Subsamples are taken for preservation and size-fractionationed biomass. Half of the tow is preserved in borate-buffered formaldehyde (0.5% final concentration), with strontium chloride (0.27 mM final concentration) added to aid in preservation of acantharians. The samples are stored in borosilicate-glass jars. Generally ¼ of the tow is size-fractioned through nested filters of the following mesh sizes: 5-mm, 2-mm, 1-mm, 500-µm, and 200-µm. Each fraction is concentrated onto a 47-mm 200-µm pre-weighed Nitex filter, rinsed with isotonic ammonium formate, placed in a labeled cryotube, and then frozen (liquid nitrogen or -85ºC freezer).

3. Determination of Mass

3.1. Frozen samples are stored at -85ºC until processed. Then, they are defrosted at room temperature in the dark on a paper towel to blot excess moisture. Each sample (which represents a single size-fraction of the tow) is weighed wet on an analytical balance before (total fraction wet weight) and after subsamples of the zooplankton mass are set aside for gut pigment analysis and carbon/nitrogen biomass. The remaining sample is dried at 60ºC, and then reweighed for determination of the fraction's mass (total sample mass is the sum of all fraction masses). The mass of the sample is normalized to the ocean surface area using the volume of seawater filtered through the net as recorded by the flow meter (= volume filtered) and the depth to which the net fished as recorded by the data logger (= depth).

3.2. Calculation of fraction dry weight:

(1) dwt1 = (wwt1 - fwt) - [(wwt1 - fwt) * %water]
(2) %water = [(wwt2 - fwt) - (dwt2 - fwt)] / (wwt2 - fwt)
where:
dwt1 = fraction dry weight (mg)
dwt2 = fraction dry weight (including filter weight) after all subsamples removed (mg)
wwt1 = fraction wet weight including filter weight (mg)
wwt2 = fraction wet weight including filter weight after all subsamples removed (mg)
fwt = 47-mm 200-µm filter weight (mg)

%water = water content of fraction (assume water content is the same for wwt1 and wwt2)

3.3. Calculation of fraction mass:
(3) mg (dry wt.) m-2 = dwt1 * depth * (volume filtered)-1 * (fraction of tow)-1
where:
depth = towing depth from data logger pressure trace (m)
volume filtered = volume of seawater filtered through net from flow meter reading (m3)
fraction of tow = fraction of tow concentrated in each size-fraction (e.g., 1/2 or 1/4)

4. Particulate C and N
4.1. Carbon and nitrogen biomass are determined using a CHN Elemental Analyzer (Perkin Elmer Model 2400) on subsamples which have been dried at 60ºC in pre-weighed combusted aluminum foil boats and then weighed on an analytical balance (to 5-places) (see Chapter 10, sections 4 - 8). The dry weight of the sample is the difference between the final balance weight (sample + boat weight) and the pre-weighed boat weight.

4.2. Calculation of carbon and nitrogen content of fraction:
(4) C (mg) m-2 = C * dwt1 * depth * (volume filtered) - 1 * (fraction of tow)-1
(5) N (mg) m-2 = N * dwt1 * depth * (volume filtered) - 1 * (fraction of tow)-1
where:
C = concentration of carbon (mg g-1)
N = concentration of nitrogen (mg g-1)
dwt1 = fraction dry weight (g) (equation 1)
depth = towing depth from data logger pressure trace (m)
volume filtered = volume of seawater filtered through net from flow meter reading (m3)
fraction of tow = fraction of tow concentrated in each size-fraction

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Related Publications

Al-Mutairi, H., & Landry, M. R. (2001). Active export of carbon and nitrogen at Station ALOHA by diel migrant zooplankton. Deep Sea Research Part II: Topical Studies in Oceanography, 48(8–9), 2083–2103. https://doi.org/10.1016/s0967-0645(00)00174-0 https://doi.org/https://doi.org/10.1016/S0967-0645(00)00174-0
Related Research

Frost, B. W. (1984, September). Utilization of phytoplankton production in the surface layer. In Global ocean flux study: proceedings of a workshop (Vol. 10014, pp. 125-134). National Academy Press Washington, DC.
Related Research

Hannides, C. C. S., Landry, M. R., Benitez-Nelson, C. R., Styles, R. M., Montoya, J. P., & Karl, D. M. (2009). Export stoichiometry and migrant-mediated flux of phosphorus in the North Pacific Subtropical Gyre. Deep Sea Research Part I: Oceanographic Research Papers, 56(1), 73–88. https://doi.org/10.1016/j.dsr.2008.08.003
Related Research

Kuba, D.M. (1970). Sampling midwater fish using the ten-foot Isaacs-Kidd midwater trawl and the Cobb pelagic trawl. [Master's Thesis, University of Hawaii].
Related Research

Landry, M. R., Al-Mutairi, H., Selph, K. E., Christensen, S., & Nunnery, S. (2001). Seasonal patterns of mesozooplankton abundance and biomass at Station ALOHA. Deep Sea Research Part II: Topical Studies in Oceanography, 48(8–9), 2037–2061. https://doi.org/10.1016/s0967-0645(00)00172-7 https://doi.org/10.1016/S0967-0645(00)00172-7
Methods

Longhurst, A. R., & Glen Harrison, W. (1988). Vertical nitrogen flux from the oceanic photic zone by diel migrant zooplankton and nekton. Deep Sea Research Part A. Oceanographic Research Papers, 35(6), 881–889. https://doi.org/10.1016/0198-0149(88)90065-9
Related Research

Longhurst, A. R., Bedo, A. W., Harrison, W. G., Head, E. J. H., & Sameoto, D. D. (1990). Vertical flux of respiratory carbon by oceanic diel migrant biota. Deep Sea Research Part A. Oceanographic Research Papers, 37(4), 685–694. https://doi.org/10.1016/0198-0149(90)90098-g https://doi.org/10.1016/0198-0149(90)90098-G
Related Research

Ortner, P.B., Cummings, S.R., Aftring, R.P., & Edgerton, H.E. (1979). Silhouette photography of oceanic zooplankton. Nature, 277(5691), 50–51. https://doi.org/10.1038/277050a0
Related Research

Paffenhöfer, G. A. (1979). Ecological implications of fecal pellet size, production and consumption by copepods.
Related Research

Sheridan, C. C., & Landry, M. R. (2004). A nine-year increasing trend in mesozooplankton biomass at the Hawaii Ocean Time-series Station ALOHA. ICES Journal of Marine Science, 61(4), 457–463. https://doi.org/10.1016/j.icesjms.2004.03.023
Methods

Small, L. F., Knauer, G. A., & Tuel, M. D. (1987). The role of sinking fecal pellets in stratified euphotic zones. Deep Sea Research Part A. Oceanographic Research Papers, 34(10), 1705–1712. https://doi.org/10.1016/0198-0149(87)90019-7
Related Research

Strickland, J. D. H. and Parsons, T. R. (1972). A Practical Hand Book of Seawater Analysis. Fisheries Research Board of Canada Bulletin 157, 2nd Edition, 310 p.
Methods

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	Temperature-pressure data logger (Model XL-200, Richard Brancker Research)
Generic Instrument Name	Data Logger
Dataset-specific Description	A temperature-pressure data logger (Model XL-200, Richard Brancker Research, Ottawa, Canada) was fastened to the net frame to measure depth of tow.
Generic Instrument Description	Electronic devices that record data over time or in relation to location either with a built-in instrument or sensor or via external instruments and sensors.

Dataset-specific Instrument Name	Vemco Minilog Time-Depth recorder
Generic Instrument Name	Data Logger
Dataset-specific Description	From cruise 175 to present, the collection procedure was simplified by switching to a ring net, with flow meter and Vemco minilog Time-Depth Recorder.
Generic Instrument Description	Electronic devices that record data over time or in relation to location either with a built-in instrument or sensor or via external instruments and sensors.

Dataset-specific Instrument Name	General Oceanics Model 2030R Flow meter
Generic Instrument Name	Mechanical Flowmeter
Dataset-specific Description	A flow meter with a low-speed rotor (Model 2030R, General Oceanics, Miami, FL) was attached across the net opening to measure distance towed
Generic Instrument Description	Manufactured by General Oceanics, a mechanical flow meter is used with plankton tows to determine the volume of water which flows through the net. Flow meters are also used in rivers, estuaries, canals, sewer outfalls, pipes, and harbor entrances to determine water velocity and flow distance information.

Dataset-specific Instrument Name	1 meter square diameter Ring Net
Generic Instrument Name	Ring Net
Generic Instrument Description	A Ring Net is a generic plankton net, made by attaching a net of any mesh size to a metal ring of any diameter. There are 1 meter, .75 meter, .25 meter and .5 meter nets that are used regularly. The most common zooplankton ring net is 1 meter in diameter and of mesh size .333mm, also known as a 'meter net' (see Meter Net).

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Deployments

HOT_cruises

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

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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

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