P17N Ocean Acidification Pteropod Study: Carbonate chemistry system and hydrography samples from R/V New Horizon NH1208 from a transect 35-50 degrees North, Pacific Ocean, Aug-Sep 2012 (OAPS project)

Website: https://www.bco-dmo.org/dataset/653330
Data Type: Cruise Results
Version:
Version Date: 2016-08-09

Project
» Horizontal and Vertical Distribution of Thecosome Pteropods in Relation to Carbonate Chemistry in the Northwest Atlantic and Northeast Pacific (OAPS)

Programs
» Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES): Ocean Acidification (formerly CRI-OA) (SEES-OA)
» Ocean Carbon and Biogeochemistry (OCB)

Contributors	Affiliation	Role
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Dataset Description

CTD and Niskin sample measurements include silicate, total alkalinity, total dissolved inorganic carbon, pH, and oxygen.

These data are published in: Chu, S. N., Z. Aleck Wang, S. C. Doney, G. L. Lawson, and K. A. Hoering (2016), Changes in anthropogenic carbon storage in the Northeast Pacific in the last decade, J. Geophys. Res. Oceans,121, doi:10.1002/2016JC011775.

Methods & Sampling

Conductivity-Temperature-Depth sensor (CTD, Seabird SBE 911plus) and a SBE43 dissolved oxygen (DO) sensor was used to collect discrete seawater samples for analysis of total dissolved inorganic carbon (DIC), total alkalinity (TA), pH, DO, nutrients (nitrate, phosphate, and silicate), and salinity. Seawater samples were collected for pH, DIC, TA, and nutrients at all 34 stations for all sampling depths. Salinity and DO samples were collected at all stations at every third depth for calibrations of the conductivity and DO sensors on the CTD Rosette. Samples for DO were collected first from the Niskin bottles, followed by pH, DIC/TA (in the same bottle), nutrients, and salinity. Standard protocols were followed for sampling procedures [Dickson et al., 2007]. DIC and TA samples were collected into 250 ml Pyrex borosilicate bottles after being filtered with a 0.45 µm in-line capsule filter (Farrwest Environmental Supply, Texas). Each sample was poisoned with 100 µL of a saturated mercuric chloride solution for preservation [Dickson et al., 2007] and sealed with a ground-glass stopper coated with APIEZON®-L grease and was secured with a rubber band applied to the bottle top.

Dissolved oxygen (DO) samples were collected from CTD Niskin bottles into 150 mL brown glass tincture bottles. Sodium iodide-sodium hydroxide mixture and manganese chloride were added sequentially to the sample immediately after collection and mixed thoroughly. One mL of sulfuric acid was added and mixed into the sample prior to measurement. DO samples were measured after temperature equilibration, within 3 days, on an automated dissolved oxygen titrator developed at Woods Hole Oceanographic Institution [Knapp et al. 1990]. The system is based on the Winkler technique. This method has an accuracy of 1.0 µmol kg-1 and precision of 0.2 µmol kg-1. The titrator was standardized with sodium thiosulfate for each group of analyses, usually about 30 samples. A custom procedure was developed and implemented to detect concentrations of dissolved oxygen < 90 µmol kg-1. In situ temperature was used to calculate potential density in order to convert from mL L-1 to µmol kg-1 for bottle samples. Ideally, the conversion temperature should be the temperature measured at the time of sample drawing, but those were not measured. Bottle values were used to calibrate CTD values.

Salinity samples were collected into 250 mL square cross-sectioned, borosilicate glass bottles and measured on an Autosal Salinometer (Guildline 8400B). PSS-78 salinity was calculated from measured conductivity ratios. Measurements were performed after samples had equilibrated to laboratory temperature, within 3 days after collection. The machine was standardized for each group of analyses, approximately 50 samples. International Association for the Physical Sciences of the Oceans (IAPSO) Standard Seawater Batch P-152 was used for standardization. This method has an accuracy of ±0.003 and precision of ± 0.0002. Bottle analyses were used to calibrate CTD salinity values.

DIC was analyzed using an Apollo SciTech DIC auto-analyzer (Model AS-C3), which uses a nondispersive infrared (NDIR) method. The sample is acidified with a 10% phosphoric acid in 10% sodium chloride solution, and CO2 is purged with high purity nitrogen gas and measured by a LI-COR 7000 infrared analyzer. Certified Reference Material (CRM) from Dr. A. Dickson at Scripps Institution of Oceanography was used to calibrate the DIC auto-analyzer at least once daily. In addition, CRM was measured as a sample every few hours to gauge and correct any potential drift. The precision and accuracy of the instrument was ~ ±2.0 µmol kg-1.

TA was measured with an Apollo SciTech alkalinity auto-titrator (Model AS-ALK2), a Ross combination pH electrode and a pH meter (ORION 3 Star) to perform a modified Gran titration [Wang and Cai, 2004]. The electrode and concentration of hydrochloric acid was calibrated every day. The CRMs were also measured as samples every few hours to correct any potential small drift. The accuracy and precision of the instrument was about ± 2.0 µmol kg-1.

Seawater pH samples were collected directly into 10 cm cylindrical optical cells via silicone tubing and thermostated to 25.0 ± 0.1°C for at least an hour before measurement. Samples were analyzed using an Agilent 8453 UV-VIS spectrophotometer and meta-cresol purple (m-CP) as the indicator [Dickson et al., 2007]. Sample pH was measured on the total scale. Measurements of pH were corrected for indicator perturbation and indicator impurity [Clayton and Byrne, 1993; Dickson et al., 2007; Liu et al., 2011; Yao et al., 2007]. The average of combined corrections was 0.0026 ± 0.0046. The instrument accuracy and precision was 0.002 and 0.001, respectively.
The nutrient samples were filtered through 0.2 µm filters, collected into vials that had been cleaned with 10% hydrochloric acid and were immediately frozen after collection. Samples were analyzed at the University of California at Santa Barbara Marine Science Institute. Nutrient data from NH1208 were found to have relatively larger scatter than the previous P17N cruise data. This may be due to storage issues that involved freezing and possible melting of samples.

PACIFICA recommended adjustments for CLIVAR P17N 2001 are shown below along with deep isopycnal crossover results for NH1208 2012 cruise adjusted to the CLIVAR 2001 PACIFICA-corrected data. These values are listed in the data file as ‘deepcorr’ values. Salinity, DIC, and TA factors are additive, while oxygen and silicate factors are multiplicative. Units for all parameters are in µmol kg-1 except for salinity, which is measured on the practical salinity scale.

	SALINITY	OXYGEN	SILICATE	DIC	TA
CLIVAR 2001	0	1	1.048	-4	8
NH1208 2012	0	0.955	1.032	11	10

Cited References:

Clayton, T. D., and R. H. Byrne (1993), Spectrophotometric seawater pH measurements: total hydrogen ion concentration scale calibration of m-cresol purple and at-sea results, Deep. Res., 40(10), 2115-2129, doi:10.1016/0967-0637(93)90048-8.
Dickson, A., C. Sabine, and J. Christian (2007), Guide to best practices for ocean CO2 measurement, PICES Spec. Publ.,191.
Knapp, George P., Marvel C. Stalcup, and Robert J. Stanley (1990), Automated oxygen titration and salinity determination. Woods Hole Oceanographic Institution.
Liu, X., M. C. Patsavas, and R. H. Byrne (2011), Purification and characterization of meta-cresol purple for spectrophotometric seawater ph measurements, Environ. Sci. Technol., 45(11), 4862-4868, doi:10.1021/es200665d.
Wang, Z. A., and W.-J. Cai (2004), Carbon dioxide degassing and inorganic carbon export from a marsh-dominated estuary (the Duplin River): A marsh CO2 pump, Limnol. Oceanogr., 49(2), 341-354, doi:10.4319/lo.2004.49.2.0341.
Yao, W., X. Liu, and R. H. Byrne (2007), Impurities in indicators used for spectrophotometric seawater pH measurements: Assessment and remedies, Mar. Chem., 107(2), 167-172, doi:10.1016/j.marchem.2007.06.012.

Data Processing Description

Quality flags: 2-acceptable, 3-questionable, 4-bad, 6-duplicate, 9-missing

BCO-DMO Processing:
- added conventional header with dataset name, PI name, version date
- renamed parameters to BCO-DMO standard
- added instrument column
- replaced -999 with nd (no data)

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Data Files

File
ctd_chem.csv (Comma Separated Values (.csv), 116.12 KB) MD5:059941231ffee1adae1fd83739ec76d7 Primary data file for dataset ID 653330

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Related Publications

Chu, S. N., Wang, Z. A., Doney, S. C., Lawson, G. L., & Hoering, K. A. (2016). Changes in anthropogenic carbon storage in the Northeast Pacific in the last decade. Journal of Geophysical Research: Oceans, 121(7), 4618–4632. Portico. https://doi.org/10.1002/2016jc011775 https://doi.org/10.1002/2016JC011775
Results

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Parameters

Parameter	Description	Units
cruise_id	official cruise name from R2R	unitless
station	station	unitless
instrument	instrument name	unitless
cast	cast	unitless
sample	sample number	unitless
bottle	bottle number	unitless
bottle_FLAG_W	WOCE quality flag for the bottle sample	unitless
date	UTC date	unitless
time	UTC time	unitless
lat_start	latitude at start of cast; north is positive	decimal degrees
lon_start	longitude at start of cast; east is positive	decimal degrees
depth_w	depth of water	meters
press	CTD pressure	decibars
press_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
temp	CTD temperature	degrees Celsius

temp_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
sal	CTD salinity; corrected using discrete bottle measured salinity from salinometer	PSU
sal_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
SiO4	silicate	umol/kg
SiO4_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
TALK	total alkalinity	umol/kg
TALK_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
DIC	total dissolved inorganic carbon	umol/kg
DIC_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
pH	pH - total scale	unitless
pH_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
pH_temp	temperature at which pH was measured	degrees Celsius
pH_temp_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
O2	CTD oxygen corrected using discrete bottle measured oxygen from Winkler titration	umol/kg
O2_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
DIC_deepcorr	total dissolved inorganic carbon corrected by deep isopycnal analysis with CLIVAR 2001	umol/kg

DIC_deepcorr_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
O2_deepcorr	CTD oxygen corrected by deep isopycnal analysis with CLIVAR 2001	umol/kg
O2_deepcorr_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
SiO4_deepcorr	silicate corrected by deep isopycnal analysis with CLIVAR 2001	umol/kg
SiO4_deepcorr_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless
TALK_deepcorr	total alkalinity corrected by deep isopycnal analysis with CLIVAR 2001	umol/kg
TALK_deepcorr_flag	WOCE quality flag: 2-acceptable; 3-questionable; 4-bad; 6-duplicate; 9-missing	unitless

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Autosal salinometer
Dataset-specific Description	Autosal Salinometer (Guildline 8400B)
Generic Instrument Description	The salinometer is an instrument for measuring the salinity of a water sample.

Dataset-specific Instrument Name	
Generic Instrument Name	CTD Sea-Bird 911
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	
Generic Instrument Name	Elemental Analyzer
Dataset-specific Description	Apollo SciTech DIC auto-analyzer (Model AS-C3). The analyzer acidifies each sample and the total CO2 is purged and then measured using a LI 7000 infrared analyzer.
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

Dataset-specific Instrument Name	
Generic Instrument Name	Niskin bottle
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	
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	Agilent 8453 UV-VIS spectrophotometer: measures the relative absorption of pH-sensitive indicator at different wavelengths.
Generic Instrument Description	An instrument used to measure the relative absorption of electromagnetic radiation of different wavelengths in the near infra-red, visible and ultraviolet wavebands by samples.

Dataset-specific Instrument Name	
Generic Instrument Name	Titrator
Dataset-specific Description	Apollo SciTech alkalinity auto-titrator (Model AS-ALK2): acid-base titrator, which automates the Gran titration procedure to measure alkalinity.
Generic Instrument Description	Titrators are instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached.

Dataset-specific Instrument Name	
Generic Instrument Name	Winkler Oxygen Titrator
Dataset-specific Description	Automated dissolved oxygen titrator developed at Woods Hole Oceanographic Institution [Knapp et al. 1990]
Generic Instrument Description	A Winkler Oxygen Titration system is used for determining concentration of dissolved oxygen in seawater.

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Deployments

NH1208

Website	https://www.bco-dmo.org/deployment/58830
Platform	R/V New Horizon
Report	http://hdl.handle.net/1834/43090
Start Date	2012-08-09
End Date	2012-09-18
Description	The primary objective of this cruise was to quantify the distribution, abundance, species composition, shell condition, and vertical migratory behavior of oceanic thecosome pteropods in the northeast Pacific, and correlate these quantities to concurrent measurements of carbonate chemistry. Underway data collection and station activities were conducted on a transect running between 35 and 50N along CLIVAR line P17N. Six instrument types were used: (1) a 1-m2 MOCNESS plankton net system and a 1-m diameter Reeve net; (2) a profiling Video Plankton Recorder mounted on the CTD package that includes a Rosette system with Niskin bottles for water sampling; (3) a deep (500 meter) towed broadband acoustic scattering system; (4) a surface narrowband multi-frequency acoustic scattering system; (5) an underway multi-parameter inorganic carbon analyzer and a GO underway pCO2 system; and (6) a suite of chemistry-related lab instruments for bottle sample analysis including a DIC auto-analyzer, an alkalinity auto-titrator, and an Agilent spectrophotometer for pH measurement. The R/V New Horizon departed from Newport OR, and set a course for the transect start point at 50N 150W. Following instrument package test deployments over the continental shelf, the transect ran in a single zig-zag between the start point and the end at 35N 135W; a total of 34 stations were sampled along the transect, every 1/2 degree of latitude. In addition 10 other stations were sampled with a Reeve net for live experimental pteropods. The science party, divided into biology and chemistry teams conducted 24-hour operations. Cruise information and original data are available from the NSF R2R data catalog.

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Project Information

Horizontal and Vertical Distribution of Thecosome Pteropods in Relation to Carbonate Chemistry in the Northwest Atlantic and Northeast Pacific (OAPS)

Coverage: 35 and 50 degrees North in the northwest Atlantic and northeast Pacific

Modified version of the NSF award abstract:
The impact of ocean acidification on marine ecosystems represents a vital question facing both marine scientists and managers of ocean resources. Thecosome pteropods are a group of calcareous planktonic molluscs widely distributed in coastal and open ocean pelagic ecosystems of the world¡¦s oceans. These

animals secrete an aragonite shell, and thus are highly sensitive to ocean acidification due to the water column's changing carbonate chemistry, and particularly the shoaling of the aragonite compensation depth at which seawater becomes corrosive to aragonite. In many regions, however, relatively little is known about the abundance, distribution, vertical migratory behavior, and ecological importance of pteropods. Assessing the likely ecosystem consequences of changes in pteropod dynamics resulting from ocean acidification will require a detailed understanding of pteropod distribution and abundance relative to changing aragonite saturation in the water column.

The primary objective of this project is to quantify the distribution, abundance, species composition, shell condition, and vertical migratory behavior of oceanic thecosome pteropods in the northwest Atlantic and northeast Pacific, and correlate these quantities to hydrography and concurrent measurements of carbonate chemistry, including vertical and horizontal distributions of aragonite saturation. In particular, the project will capitalize on present-day variability in the depth distribution of aragonite saturation levels within and between the Atlantic and Pacific Oceans as a "natural experiment" to address the hypotheses that pteropod vertical distribution, species composition, and abundance vary as the compensation depth becomes shallower. Secondary objectives are to develop acoustic protocols for the remote quantification of pteropod abundance for future integration into ocean acidification monitoring networks, and to characterize carbonate chemistry and nutrients along portions of two WOCE/CLIVAR Repeat Hydrography transects (A20 in the Atlantic and P17N in the Pacific) to identify decadal-scale changes in the carbonate system. These hypotheses and objectives will be addressed through two cruises along survey transects between 35 and 50 degrees North in the northwest Atlantic and northeast Pacific involving a combination of station-work and underway measurements, and a comprehensive array of instruments, including acoustic, optical, towed net, hydrographic, and carbonate chemistry sensors and sampling systems.

This highly inter-disciplinary project, combines expertise in zooplankton ecology, acoustics, and marine chemistry. The proposed work will result in a detailed baseline understanding of variability in the horizontal and vertical distribution, as well as species composition, of thecosome pteropods in the northwest Atlantic and northeast Pacific, making a key contribution to zooplankton ecology generally. In addition, by quantifying the response to current spatial variability within and between the Atlantic and Pacific Oceans, the project will provide important information on the likely response of pteropod distribution to future changes in the vertical distribution of aragonite saturation levels, a necessary component in modeling the impacts of ocean acidification on marine ecosystem function, services, and resources.

Ocean acidification is increasingly appreciated as an urgent societal concern. Thecosome pteropods are key prey for a variety of commercially-exploited fish species, and the improved understanding the PIs seek of pteropod distribution and likely response to changing water column carbonate chemistry will have important implications for our understanding of potential effects of ocean acidification on marine resources.

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Program Information

Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES): Ocean Acidification (formerly CRI-OA) (SEES-OA)

Website: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503477

Coverage: global

NSF Climate Research Investment (CRI) activities that were initiated in 2010 are now included under Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES). SEES is a portfolio of activities that highlights NSF's unique role in helping society address the challenge(s) of achieving sustainability. Detailed information about the SEES program is available from NSF (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504707).

In recognition of the need for basic research concerning the nature, extent and impact of ocean acidification on oceanic environments in the past, present and future, the goal of the SEES: OA program is to understand (a) the chemistry and physical chemistry of ocean acidification; (b) how ocean acidification interacts with processes at the organismal level; and (c) how the earth system history informs our understanding of the effects of ocean acidification on the present day and future ocean.

Solicitations issued under this program:
NSF 10-530, FY 2010-FY2011
NSF 12-500, FY 2012
NSF 12-600, FY 2013
NSF 13-586, FY 2014
NSF 13-586 was the final solicitation that will be released for this program.

PI Meetings:
1st U.S. Ocean Acidification PI Meeting(March 22-24, 2011, Woods Hole, MA)
2nd U.S. Ocean Acidification PI Meeting(Sept. 18-20, 2013, Washington, DC)
3rd U.S. Ocean Acidification PI Meeting (June 9-11, 2015, Woods Hole, MA – Tentative)

NSF media releases for the Ocean Acidification Program:

Press Release 10-186 NSF Awards Grants to Study Effects of Ocean Acidification

Discovery Blue Mussels "Hang On" Along Rocky Shores: For How Long?

Discovery nsf.gov - National Science Foundation (NSF) Discoveries - Trouble in Paradise: Ocean Acidification This Way Comes - US National Science Foundation (NSF)

Press Release 12-179 nsf.gov - National Science Foundation (NSF) News - Ocean Acidification: Finding New Answers Through National Science Foundation Research Grants - US National Science Foundation (NSF)

Press Release 13-102 World Oceans Month Brings Mixed News for Oysters

Press Release 13-108 nsf.gov - National Science Foundation (NSF) News - Natural Underwater Springs Show How Coral Reefs Respond to Ocean Acidification - US National Science Foundation (NSF)

Press Release 13-148 Ocean acidification: Making new discoveries through National Science Foundation research grants

Press Release 13-148 - Video nsf.gov - News - Video - NSF Ocean Sciences Division Director David Conover answers questions about ocean acidification. - US National Science Foundation (NSF)

Press Release 14-010 nsf.gov - National Science Foundation (NSF) News - Palau's coral reefs surprisingly resistant to ocean acidification - US National Science Foundation (NSF)

Press Release 14-116 nsf.gov - National Science Foundation (NSF) News - Ocean Acidification: NSF awards $11.4 million in new grants to study effects on marine ecosystems - US National Science Foundation (NSF)

Ocean Carbon and Biogeochemistry (OCB)

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

Coverage: Global

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

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

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

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

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1041068

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