Calcification rates of communities and sediment in a flume from Richard B Gump Research Station - Moorea LTER, French Polynesia from 2013 (MCR LTER project, OA_Corals project)

Website: https://www.bco-dmo.org/dataset/544398
Data Type: experimental
Version: 2014-11-04

Project
» Moorea Coral Reef Long-Term Ecological Research site (MCR LTER)
» RUI: Ocean Acidification- Category 1- The effects of ocean acidification on the organismic biology and community ecology of corals, calcified algae, and coral reefs (OA_Corals)

Programs
» Long Term Ecological Research network (LTER)
» Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES): Ocean Acidification (formerly CRI-OA) (SEES-OA)

Contributors	Affiliation	Role
Carpenter, Robert	California State University Northridge (CSUN)	Principal Investigator
Edmunds, Peter J.	California State University Northridge (CSUN)	Co-Principal Investigator
Comeau, Steeve	California State University Northridge (CSUN)	Contact
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

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Dataset Description

This data set includes calcification rates of both the flume community (coral, calcified algae, sediment) and the sediment alone. To investigate the response of coral reef communities to OA, we used large outdoor flumes in which communities composed of calcified algae, corals, and sediment were combined to match the percentage cover of benthic communities in the shallow back reef of Moorea, French Polynesia. Reef communities in the flumes were exposed to ambient (400 µatm) and high pCO2 (1300 µatm) for 8 weeks, and calcification 10 rates measured for the constructed communities including the sediments. Community calcification was depressed 59% under high pCO2, with sediment dissolution explaining 50% of this decrease; net calcification of corals and calcified algae remained positive, but was reduced 29% under elevated pCO2.

Related Reference:
Comeau, S., Carpenter, R. C., Lantz, C. A., and Edmunds, P. J. (2015) Ocean acidification accelerates dissolution of experimental coral reef communities, Biogeosciences, 12, 365-372, doi:10.5194/bg-12-365-2015. www.biogeosciences.net/12/365/2015/

Comeau, S., Edmunds, P. J., Lantz, C. A., & Carpenter, R. C. (2014). Water flow modulates the response of coral reef communities to ocean acidification. Scientific Reports, 4. doi:10.1038/srep06681

Additional related datasets:
carbonate chemistry - flume expt
algae_calcification
coral_calification
carbonate_chemistry
light_dark_calcification
mean_calcification

Methods & Sampling

Collection and sample preparation:
This study was carried out in August-October 2013 in Moorea, French Polynesia, using organisms collected from the back reef of the north shore at ~1-2m depth. The organisms were used to construct communities in outdoor flumes matching the contemporary (in 2013) mean cover of a back reef in Moorea (Carpenter, 2014; Edmunds, 2014). Coral communities were built from the four dominant coral taxa found on the back reefs of Moorea: massive Porites spp. (11% cover), Porites rus (6%), Montipora spp. (3 %), and Pocillopora spp. (2 %), that together accounted for 98% of the coral cover. In addition to corals, 6% of the surface comprised crustose coralline algae that consisted of 66% Porolithon onkodes and 33% Lithophyllum flavescens. After collection of corals and algae (10cm×10 cm), they were returned to the Richard B. Gump South Pacific Research and attached to plastic supports using epoxy glue. Following preparation, samples were left to recover in a seawater table for 3 d. Sediments were collected from the lagoon on the north shore, ~200m from the reef crest, at 2m depth using 24 custom made boxes (0.4m×0.3m×0.3m). Sediment boxes were inserted into the sediment and left in situ for 4 d to allow sediment stratification to be established naturally before transfer to the flumes.

The 4 outdoor flumes consisted of a working section measuring 5.0m×0.3m×0.3m. Water was re-circulated using water pumps (W. Lim Wave II 373 J s-1) to obtain a 10 cm s-1 flow. Flow was measured across the working section of the flume using a Nortek Vectrino Acoustic Doppler Velocimeter. At each end of the flume seawater passed through an 88 cm transition section (rectangular to circular) that housed 20 cm (length) flow straighteners made of stacked, 3 cm diameter PVC pipe, and then into a 12.5 cm return section. Fresh sand-filtered seawater, pumped from Cook's Bay at 12m depth, was dispensed continuously into the flume at 5 L min-1. Flumes experienced natural sunlight that was attenuated using screen to maintain irradiances similar to ambient irradiances in the back reefs of Moorea (daily maximum of ~1500 µmol photons m-2 cm-1 over the incubation period determined with a 4 quantum sensor LI-193 and a LiCor LI-1400 meter).

Carbonate chemistry control and measurements:
Two flumes were maintained at ambient conditions and two at a pCO2 expected by the end of the present century under a pessimistic scenario (Representative Concentration Pathway 8.5, ~1300 µatm, Moss et al., 2010). Control of the pCO2 was accomplished using a pH-stat (Aquacontroller, Neptune systems, USA) and pH was maintained 0.1 unit lower at night (from 18:00:00 to 6:00:00 LT) than during the day to match the natural diel variation in pH in the back reef of Moorea. pH was measured daily using a portable pH meter (Orion 3-stars, Thermo-Scientific, USA) fitted with a DG 115-SC pH probe (Mettler Toledo, Switzerland) calibrated every other day with Tris/HCl buffers (Dickson et al., 2007). pH also was measured spectrophotometrically using m-cresol dye (Dickson et al., 2007) at regular intervals. Measurement of total alkalinity (AT) was made using open-cell potentiometric titrations (Dickson et al., 2007) using 50mL samples of seawater collected every 2-3 d. Parameters of the carbonate system in seawater were calculated using the R package seacarb (Lavigne and Gattuso, 2013).

Calcification measurements:
Calcification rates were measured using the total alkalinity anomaly method (Chisholm and Gattuso, 1991). Calcification measurements were made every 7 d on the constructed community, and in the analysis of sediments alone, after 7, 30, and 56 d incubation. During incubations, the addition of seawater was stopped so that each flume was a closed loop; seawater samples for AT were taken every 3 h during the day and every 6 h at night. To maintain AT and nutrients close to ambient levels, water in the flumes was refreshed every 6 h for 30 min. Nutrient changes in the flumes were monitored during 4 incubations and the changes in nitrate and ammonium during incubations were < 2 µmol L-1. To conduct incubations with sediments alone, corals and coralline algae were removed from the flumes for 24 h and held in a separate tank where conditions were identical to those in the flumes. Corals and coralline algal calcification was calculated by subtracting the mean light and dark net calcification of the sediment from the community calcification. For both corals and algae, buoyant weight (Davies, 1989) was recorded before and after incubation and converted to dry weight to quantify the contribution of each functional group to the calcification budget.

Data Processing Description

Statistical analysis:

All analyses were performed using R software (R Foundation for Statistical Computing) and assumptions of normality and equality of variance were evaluated through graphical analyses of residuals. Calcification rates were analyzed using a repeated measure ANOVA in which the within subject factor was time (week), pCO2 was a fixed effect, and duplicate flumes were a nested effect.

BCO-DMO Processing Notes:

-added conventional header with dataset name, PI name, version date, reference information
-renamed parameters to BCO-DMO standard
-added lab, lat, lon of experimental site (Richard B. Gump Research Site, Moorea), deployment id columns
-added 'day_local', 'month_local', 'year', 'yrday_local' to served view
-reformated date from m/d/yyyy to yyyy-mm-dd
-reduced number of significant digits

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Data Files

File
flume_calc_rate.csv (Comma Separated Values (.csv), 9.06 KB) MD5:eabd2f400e06d35d50eeb010a4e06003 Primary data file for dataset ID 544398

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Parameters

Parameter	Description	Units
lab	Unique descriptor for experiments indicating physical location where they were conducted (lab); lead investigator and lab location.	unitless
lat	Latitude component of geographic position where experiments were conducted; north is positive	decimal degrees
lon	Longitude component of geographic position where experiments were conducted; east is positive	decimal degrees
sample	Source of sample - either community (algae; coral; sediment) or sediment only	unitless
date_local	Local date of sampling	yyyy-mm-dd
flume_id	Identication number of flume	unitless
treatment	Experimental treatment of various concentrations of carbonate and bicarbonate ions used to test the effects of various carbonate chemistry regimes on coral and calcifying alga.	unitless
day_night	Part of day that sampling took place	unitless
calc_rate	Calcification rate	g CaCO3/m^2/d

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Instruments

Dataset-specific Instrument Name	pH-stat
Generic Instrument Name	Mass Flow Controller
Dataset-specific Description	Aquacontroller, Neptune systems, USA
Generic Instrument Description	Mass Flow Controller (MFC) - A device used to measure and control the flow of fluids and gases

Dataset-specific Instrument Name	portable pH meter & probe
Generic Instrument Name	pH Sensor
Dataset-specific Description	Portable pH meter (Orion 3-stars, Thermo-Scientific, USA) fitted with a DG 115-SC pH probe (Mettler Toledo, Switzerland)
Generic Instrument Description	An instrument that measures the hydrogen ion activity in solutions. The overall concentration of hydrogen ions is inversely related to its pH. The pH scale ranges from 0 to 14 and indicates whether acidic (more H+) or basic (less H+).

Dataset-specific Instrument Name	automatic titrator
Generic Instrument Name	Titrator
Dataset-specific Description	A Mettler-Toledo T50 model automatic titrator was employed to analyze samples for total alkalinity using open cell, potentiometric titration.
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.

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Deployments

lab_Carpenter_Moorea

Website	https://www.bco-dmo.org/deployment/58885
Platform	Richard B Gump Research Station - Moorea LTER
Start Date	2011-07-17
End Date	2011-08-12
Description	Laboratory experiments carried out by R. Carpenter and P. Edmunds of California State University Northridge at the Richard B. Gump Research Station in French Polynesia, for the project "RUI: Ocean Acidification- Category 1- The effects of ocean acidification on the organismic biology and community ecology of corals, calcified algae, and coral reefs".

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Project Information

Moorea Coral Reef Long-Term Ecological Research site (MCR LTER)

Website: http://mcr.lternet.edu/

Coverage: Island of Moorea, French Polynesia

NSF Award Abstract:

Coral reefs provide important benefits to society, from food to exceptional biodiversity to shoreline protection and recreation, but they are threatened by natural perturbations and human activities, including those causing global-scale changes. These pressures increasingly are causing coral reefs to undergo large, often abrupt, ecological changes where corals are being replaced by seaweeds or other undesirable organisms. Historically, the major agent of disturbance to coral reefs has been powerful storms, but in recent decades, episodes of mass coral bleaching from marine heat waves have become more frequent and severe as the temperature of ocean surface waters continues to rise. Coral reefs are further stressed by local human activities that cause nutrient pollution and deplete herbivorous fishes that control growth of seaweeds. Studying how coral reefs respond to these two types of disturbance under different levels of nutrient pollution and fishing provides essential information on what affects the ability of coral reefs to buffer environmental change and disturbances without collapsing to a persistent, degraded condition. The fundamental goals of the Moorea Coral Reef Long Term Ecological Research program (MCR LTER) are to understand how and why coral reefs change over time, to assess the consequences of these changes, and to contribute scientific knowledge needed to sustain coral reef ecosystems and the important societal services they provide. This research improves understanding and management of coral reefs, which benefits all groups concerned with the welfare of this ecologically, economically and culturally important ecosystem. In addition to academic communities, scientific findings are communicated to interested individuals, non-governmental organizations, island communities and governmental entities. These findings also are integrated into K-12, undergraduate, graduate and public education activities through a multi-pronged program that includes inquiry-based curricula, interactive and media-based public education programs, and internet-based resources. MCR?s research, training, education and outreach efforts all emphasize broadening participation in STEM fields and strengthening STEM literacy.

New research activities build on MCR LTER?s powerful foundation of long-term observations and broad ecological understanding of oceanic coral reefs to address the following core issues: How is the changing disturbance regime (recurrent heat waves in addition to cyclonic storms) altering the resilience of coral reefs, and what are the ecological consequences of altered resilience? Research activities are organized around a unifying framework that explicitly addresses how reef communities are affected by the nature and history of coral-killing disturbances, and how those responses to disturbance are influenced by the pattern of local human stressors. New studies answer three focal questions: (1) How do different disturbance types, which either remove (storms) or retain (heat waves) dead coral skeletons, affect community dynamics, abrupt changes in ecological state, and resilience? (2) How do local stressors interact with new disturbance regimes to create spatial heterogeneity in community dynamics, ecosystem processes, and spatial resilience? And (3) What attributes of coral and coral reef communities influence their capacity to remain resilient under current and future environmental conditions? These questions provide an unparalleled opportunity to test hypotheses and advance theory regarding ecological resilience and the causes and consequences of abrupt ecological change, which is broadly relevant across aquatic and terrestrial ecosystems.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

From http://www.lternet.edu/sites/mcr/ and http://mcr.lternet.edu/:
The Moorea Coral Reef LTER site encompasses the coral reef complex that surrounds the island of Moorea, French Polynesia (17°30'S, 149°50'W). Moorea is a small, triangular volcanic island 20 km west of Tahiti in the Society Islands of French Polynesia. An offshore barrier reef forms a system of shallow (mean depth ~ 5-7 m), narrow (~0.8-1.5 km wide) lagoons around the 60 km perimeter of Moorea. All major coral reef types (e.g., fringing reef, lagoon patch reefs, back reef, barrier reef and fore reef) are present and accessible by small boat.

The MCR LTER was established in 2004 by the US National Science Foundation (NSF) and is a partnership between the University of California Santa Barbara and California State University, Northridge. MCR researchers include marine scientists from the UC Santa Barbara, CSU Northridge, UC Davis, UC Santa Cruz, UC San Diego, CSU San Marcos, Duke University and the University of Hawaii. Field operations are conducted from the UC Berkeley Richard B. Gump South Pacific Research Station on the island of Moorea, French Polynesia.

MCR LTER Data: The Moorea Coral Reef (MCR) LTER data are managed by and available directly from the MCR project data site URL shown above. The datasets listed below were collected at or near the MCR LTER sampling locations, and funded by NSF OCE as ancillary projects related to the MCR LTER core research themes.

This project is supported by continuing grants with slight name variations:

- LTER: Long-Term Dynamics of a Coral Reef Ecosystem
- LTER: MCR II - Long-Term Dynamics of a Coral Reef Ecosystem
- LTER: MCR IIB: Long-Term Dynamics of a Coral Reef Ecosystem
- LTER: MCR III: Long-Term Dynamics of a Coral Reef Ecosystem
- LTER: MCR IV: Long-Term Dynamics of a Coral Reef Ecosystem

RUI: Ocean Acidification- Category 1- The effects of ocean acidification on the organismic biology and community ecology of corals, calcified algae, and coral reefs (OA_Corals)

Coverage: Moorea, French Polynesia

While coral reefs have undergone unprecedented changes in community structure in the past 50 y, they now may be exposed to their gravest threat since the Triassic. This threat is increasing atmospheric CO2, which equilibrates with seawater and causes ocean acidification (OA). In the marine environment, the resulting decline in carbonate saturation state (Omega) makes it energetically less feasible for calcifying taxa to mineralize; this is a major concern for coral reefs. It is possible that the scleractinian architects of reefs will cease to exist as a mineralized taxon within a century, and that calcifying algae will be severely impaired. While there is a rush to understand these effects and make recommendations leading to their mitigation, these efforts are influenced strongly by the notion that the impacts of pCO2 (which causes Omega to change) on calcifying taxa, and the mechanisms that drive them, are well-known. The investigators believe that many of the key processes of mineralization on reefs that are potentially affected by OA are only poorly known and that current knowledge is inadequate to support the scaling of OA effects to the community level. It is vital to measure organismal-scale calcification of key taxa, elucidate the mechanistic bases of these responses, evaluate community scale calcification, and finally, to conduct focused experiments to describe the functional relationships between these scales of mineralization.

This project is a 4-y effort focused on the effects of Ocean Acidification (OA) on coral reefs at multiple spatial and functional scales. The project focuses on the corals, calcified

algae, and coral reefs of Moorea, French Polynesia, establishes baseline community-wide calcification data for the detection of OA effects on a decadal-scale, and builds on the research context and climate change focus of the Moorea Coral Reef LTER.

This project is a hypothesis-driven approach to compare the effects of OA on reef taxa and coral reefs in Moorea. The PIs will utilize microcosms to address the impacts and mechanisms of OA on biological processes, as well as the ecological processes shaping community structure. Additionally, studies of reef-wide metabolism will be used to evaluate the impacts of OA on intact reef ecosystems, to provide a context within which the experimental investigations can be scaled to the real world, and critically, to provide a much needed reference against which future changes can be gauged.

Datasets listed in the "Dataset Collection" section include references to results journal publications published as part of this project.

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Program Information

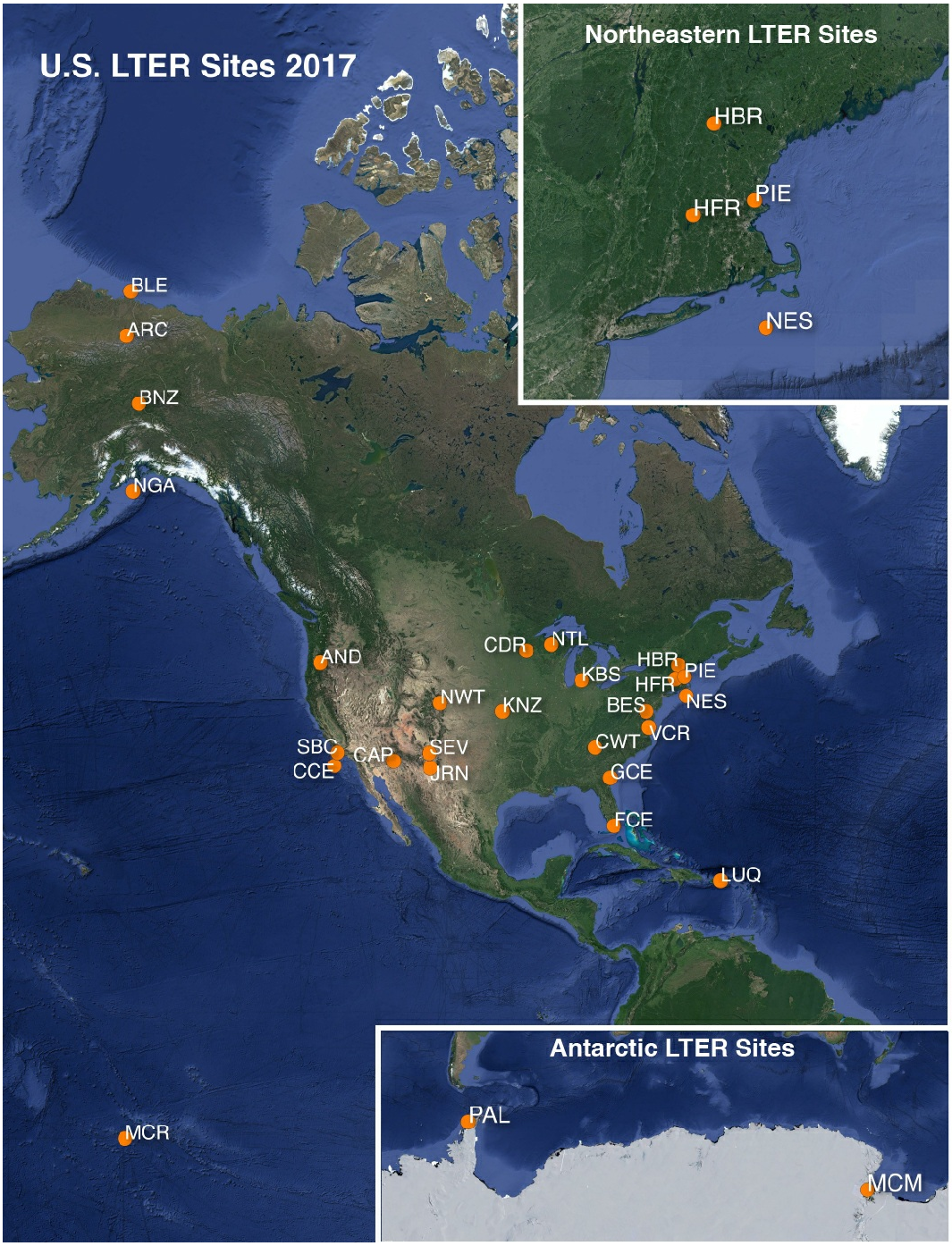
Long Term Ecological Research network (LTER)

Website: http://www.lternet.edu/

Coverage: United States

adapted from http://www.lternet.edu/

The National Science Foundation established the LTER program in 1980 to support research on long-term ecological phenomena in the United States. The Long Term Ecological Research (LTER) Network is a collaborative effort involving more than 1800 scientists and students investigating ecological processes over long temporal and broad spatial scales. The LTER Network promotes synthesis and comparative research across sites and ecosystems and among other related national and international research programs. The LTER research sites represent diverse ecosystems with emphasis on different research themes, and cross-site communication, network publications, and research-planning activities are coordinated through the LTER Network Office.



Site Codes

AND	Andrews Forest LTER
ARC	Arctic LTER
BES	Baltimore Ecosystem Stu
BLE	Beaufort Lagoon Ecosystems LTER
BNZ	Bonanza Creek LTER
CCE	California Current Ecosystem LTER
CDR	Cedar Creek Ecosystem Science Reserve
CAP	Central Arizona-Phoenix LTER
CWT	Coweeta LTER
FCE	Florida Coastal Everglades LTER
GCE	Georgia Coastal Ecosystems LTER
HFR	Harvard Forest LTER
HBR	Hubbard Brook LTER
JRN	Jornada Basin LTER
KBS	Kellogg Biological Station LTER
KNZ	Konza Prairie LTER
LUQ	Luquillo LTER
MCM	McMurdo Dry Valleys LT
MCR	Moorea Coral Reef LTEF
NWT	Niwot Ridge LTER
NTL	North Temperate Lakes I
NES	Northeast U.S. Shelf LTE
NGA	Northern Gulf of Alaska I
PAL	Palmer Antarctica LTER
PIE	Plum Island Ecosystems LTER
SBC	Santa Barbara Coastal L
SEV	Sevilleta LTER
VCR	Virginia Coast Reserve L

2017 LTER research site map obtained from https://lternet.edu/site/lter-network/

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)

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1041270

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