MOCNESS tow log sheets from Gulf of Maine Tioga cruises, 2013 from R/V Tioga cruises in the Wilkinson Basin, Gulf of Maine from 2013-2014 (Gulf of Maine Pteropods project, GoME OA Pteropods project)

Website: https://www.bco-dmo.org/dataset/472317
Version: final
Version Date: 2013-11-29

Project
» Seasonal and Ontogenetic Effects of Ocean Acidification on Pteropods in the Gulf of Maine (Gulf of Maine Pteropods)
» Acidification of the Coastal Ocean: Are deep waters of the Gulf of Maine already corrosive to pteropods? (GoME OA Pteropods)

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

Contributors	Affiliation	Role
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Dataset Description

Hand-written MOC-1/4 'flyer' notes from the Tioga Gulf of Maine Pteropod cruises, scanned into pdfs. These are an important addition for getting the full picture on the MOC tows and also those data sets that are based on the tows.

Notes:

TI700: the date written on the log sheets says May but it's actually August. Tow 2 date is shown as May 27 but is actually Aug. 28.

Methods & Sampling

The MOCNESS was equipped with nine 150-um mesh nets (nets 0-8).

TI668: The underwater unit used was #169; temperature probe was #535 and conductivity probe was #120. A connector cable converting from the 4-pin Seacon connector at the wet end of the 0.322" EM cable on the

Tioga's winch to the 2-pin EO connector required by the MOCNESS was required. Both the MOCNESS and CTD required the same pins and so the dry end connectors needed to be swapped out between operations. To simplify this change over, for this cruise, Captain Ken Houtler had a new connector made for the wheelhouse, connecting the ground and first pin wires in the wheelhouse junction box to a BNC connector. The MOC or CTD deck units were then connected to this BNC. In addition to the standard temperature and conductivity probes the system also had a beta-type strobe-light unit for reducing avoidance of the nets by some zooplankton and possibly small fish. The strobe system has two units each with 12 LED sets (LUXEON Rebel LED) with peak output between 490-520 nm. The LEDs are powered by the MOCNESS battery and their pulse width, amplitude, flash rate period, and on/off are controlled by the MOCNESS software. The 5A fuse in the underwater unit that connects to the strobe blew on the first net cast and the canister was subsequently disconnected from the system. The strobe system was removed from the MOCNESS the morning of day 2 since it was not being used.

The MOCNESS was deployed from the aft winch and A-frame. Upon recovery the nets were all hosed down with seawater and the cod-ends were sequentially removed, placed in buckets, and transferred to the forward sink and table. Net 0 was split and half was examined for Limacina retroversa, which were put in RNAlater and the remainder of the modified split was subsequently also stored in 70% ethanol. For all other nets, whole samples were preserved in 70% ethanol.

Oblique casts with the MOCNESS were made to ca. 5 m off bottom (based on the Knudsen echosounder on the ship’s depth estimate) with a ship speed nominally of 2 kts. Sampling occurred consistently for the top 5 nets which were taken at 150-100, 100-75, 75-50, 50-25, and 25-0 m. The bottom two nets were chosen adaptively to cover the lower water column and ensure that the lowest net occurred exclusively in the nephloid layer.

Cast depth has been to 10m off bottom. Typically there has been a region of fairly constant or gradually changing transmission at the bottom of the BNL, with a region of steeply changing transmission at shallower depths, ending at the top of the BNL where transmission levels off. The protocol has been to sample with net 1 from the max depth to the top of the region of constant/gradually changing transmission and then with net 2 from there to the top of the region of steeply changing transmission (ie to the top of the BNL). All samples had the ethanol replaced with fresh 70% ethanol ~24 hours after sampling.

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Data Files

File
MOC_logs.csv (Comma Separated Values (.csv), 876 bytes) MD5:9e390b592580ff68f716a3444c90a4a5 Primary data file for dataset ID 472317

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Parameters

Parameter	Description	Units
date	sampling date, local time	unitless
cruise_id	cruise identification	unitless

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Instruments

Dataset-specific Instrument Name	MOC.25
Generic Instrument Name	MOCNESS.25
Dataset-specific Description	The MOCNESS was equipped with nine 150-um mesh nets (nets 0-8). The underwater unit used was #169; temperature probe was #535 and conductivity probe was #120. A connector cable converting from the 4-pin Seacon connector at the wet end of the 0.322" EM cable on the Tioga's winch to the 2-pin EO connector required by the MOCNESS was required. Both the MOCNESS and CTD required the same pins and so the dry end connectors needed to be swapped out between operations. To simplify this change over, for this cruise, Captain Ken Houtler had a new connector made for the wheelhouse, connecting the ground and first pin wires in the wheelhouse junction box to a BNC connector. The MOC or CTD deck units were then connected to this BNC. In addition to the standard temperature and conductivity probes the system also had a beta-type strobe-light unit for reducing avoidance of the nets by some zooplankton and possibly small fish. The strobe system has two units each with 12 LED sets (LUXEON Rebel LED) with peak output between 490-520 nm. The LEDs are powered by the MOCNESS battery and their pulse width, amplitude, flash rate period, and on/off are controlled by the MOCNESS software. The 5A fuse in the underwater unit that connects to the strobe blew on the first net cast and the canister was subsequently disconnected from the system.
Generic Instrument Description	The Multiple Opening/Closing Net and Environmental Sensing System or MOCNESS is a family of net systems based on the Tucker Trawl principle. The MOCNESS-1/4 carries nine 1/4-m2 nets usually of 64 micrometer mesh and is used to sample the larger micro-zooplankton.

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Deployments

TI668

Website	https://www.bco-dmo.org/deployment/59095
Platform	R/V Tioga
Report	http://bcodata.whoi.edu/GoME_Pteropods/cruise_reports/Tioga668_Cruise_Report_final_Dec.pdf
Start Date	2013-05-21
End Date	2013-05-22
Description	The central goal of this cruise was to sample the carbonate chemistry profile of two sites in the GoME and to document the abundance and vertical distribution of the pteropod species Limacina retroversa. The long-term goal of this research is to understand forcings by climate, enhanced atmospheric CO2 levels, and coastal eutrophication on seasonal and inter-annual variability in carbonate chemistry of the Gulf of Maine and the associated implications to planktonic calcifiers, notably pteropods. The specific goals of this project are to: 1. Quantify seasonal variations of carbonate system parameters and buffer intensity in deep waters of the Gulf of Maine in order to evaluate the sensitivity of these waters in response to acidification due to anthropogenic forcing, such as increase in atmospheric CO2, freshening of the GoME (decrease in total alkalinity) and increases in water-column respiration due to eutrophication. We will test the hypotheses that deep waters of the GoME are already seasonally under-saturated with respect to aragonite saturation state, and that these waters have low buffer intensity compared to overlying water, which would cause them to be more susceptible to acidification pressures and to reach critical ecological thresholds (OA < 1) more readily. 2. Quantify seasonal patterns in the abundance of the pteropod Limacina retroversa and its vertical distribution relative to concurrent measurements of water column chemical properties, testing the hypothesis that this species is absent in the acidic waters of the near-bottom nepheloid layer. The specific goals of this particular cruise were to: 1. Measure the carbonate chemistry of the water column at multiple sites in the Gulf of Maine, targeting regions where there the depth is greatest and the deep waters are mostly likely to be undersaturated 2. Measure the carbonate chemistry in the nephloid layer 3. Catch pteropods with a vertically stratified net system to quantify their size class, abundance and vertical distribution in the context of the carbonate chemistry. 4. Collect surface water and pteropods to test out methods for shell (70% ethanol), physiology (live) and gene expression studies (RNAlater). DMO NOTE: Revised cruise report with updated eventlog submitted 20 Dec. 2013.

TI700

Website	https://www.bco-dmo.org/deployment/472226
Platform	R/V Tioga
Report	http://bcodata.whoi.edu/GoME_Pteropods/cruise_reports/Tioga700_Cruise_Report_final.pdf
Start Date	2013-08-27
End Date	2013-08-28
Description	The central goal of this cruise was to sample the carbonate chemistry profile of two sites in the GoME and to document the abundance and vertical distribution of the pteropod species Limacina retroversa. The long-term goal of this research is to understand forcings by climate, enhanced atmospheric CO2 levels, and coastal eutrophication on seasonal and inter-annual variability in carbonate chemistry of the Gulf of Maine and the associated implications to planktonic calcifiers, notably pteropods. The specific goals of this project are to: 1. Quantify seasonal variations of carbonate system parameters and buffer intensity in deep waters of the Gulf of Maine in order to evaluate the sensitivity of these waters in response to acidification due to anthropogenic forcing, such as increase in atmospheric CO2, freshening of the GoME (decrease in total alkalinity) and increases in water-column respiration due to eutrophication. We will test the hypotheses that deep waters of the GoME are already seasonally under-saturated with respect to aragonite saturation state, and that these waters have low buffer intensity compared to overlying water, which would cause them to be more susceptible to acidification pressures and to reach critical ecological thresholds (OA < 1) more readily. 2. Quantify seasonal patterns in the abundance of the pteropod Limacina retroversa and its vertical distribution relative to concurrent measurements of water column chemical properties, testing the hypothesis that this species is absent in the acidic waters of the near-bottom nepheloid layer. The specific goals of this particular cruise were to: 1. Measure the carbonate chemistry of the water column at multiple sites in the Gulf of Maine, targeting regions where there the depth is greatest and the deep waters are mostly likely to be undersaturated 2. Measure the carbonate chemistry in the nephloid layer 3. Catch pteropods with a vertically stratified net system to quantify their size class, abundance and vertical distribution in the context of the carbonate chemistry. 4. Collect surface water and pteropods to test out methods for shell (70% ethanol), physiology (live) and gene expression studies (RNAlater).

TI715

Website	https://www.bco-dmo.org/deployment/472270
Platform	R/V Tioga
Report	http://bcodata.whoi.edu/GoME_Pteropods/cruise_reports/Tioga715_Cruise_Report_final.pdf
Start Date	2013-10-21
End Date	2013-10-23
Description	The central goal of this cruise was to sample the carbonate chemistry profile of two sites in the GoME and to document the abundance and vertical distribution of the pteropod species Limacina retroversa. The long-term goal of this research is to understand forcings by climate, enhanced atmospheric CO2 levels, and coastal eutrophication on seasonal and inter-annual variability in carbonate chemistry of the Gulf of Maine and the associated implications to planktonic calcifiers, notably pteropods. The specific goals of this project are to: 1. Quantify seasonal variations of carbonate system parameters and buffer intensity in deep waters of the Gulf of Maine in order to evaluate the sensitivity of these waters in response to acidification due to anthropogenic forcing, such as increase in atmospheric CO2, freshening of the GoME (decrease in total alkalinity) and increases in water-column respiration due to eutrophication. We will test the hypotheses that deep waters of the GoME are already seasonally under-saturated with respect to aragonite saturation state, and that these waters have low buffer intensity compared to overlying water, which would cause them to be more susceptible to acidification pressures and to reach critical ecological thresholds (OA < 1) more readily. 2. Quantify seasonal patterns in the abundance of the pteropod Limacina retroversa and its vertical distribution relative to concurrent measurements of water column chemical properties, testing the hypothesis that this species is absent in the acidic waters of the near-bottom nepheloid layer. The specific goals of this particular cruise were to: 1. Measure the carbonate chemistry of the water column at multiple sites in the Gulf of Maine, targeting regions where there the depth is greatest and the deep waters are mostly likely to be undersaturated 2. Measure the carbonate chemistry in the nephloid layer 3. Catch pteropods with a vertically stratified net system to quantify their size class, abundance and vertical distribution in the context of the carbonate chemistry. 4. Collect surface water and pteropods to test out methods for shell (70% ethanol), physiology (live) and gene expression studies (RNAlater).

TI729

Website	https://www.bco-dmo.org/deployment/506265
Platform	R/V Tioga
Report	http://bcodata.whoi.edu/GoME_Pteropods/cruise_reports/Tioga729_Cruise_Report.pdf
Start Date	2014-01-29
End Date	2014-01-30
Description	The central goal of this cruise was to document the abundance and vertical distribution of the pteropod species Limacina retroversa, to capture live individuals for experimentation, and to sample the carbonate chemistry profile of two sites in the Gulf of Maine.

TI746

Website	https://www.bco-dmo.org/deployment/517985
Platform	R/V Tioga
Report	http://bcodata.whoi.edu/GoME_Pteropods/cruise_reports/Tioga746_Cruise_Report_V3.pdf
Start Date	2014-04-25
End Date	2014-04-27
Description	The central goal of this cruise was to document the abundance and vertical distribution of the pteropod species Limacina retroversa, to capture live individuals for experimentation, and to sample the carbonate chemistry profile of two sites in the GoME.

TI777

Website	https://www.bco-dmo.org/deployment/539885
Platform	R/V Tioga
Report	http://bcodata.whoi.edu/GoME_Pteropods/cruise_reports/Tioga777_Cruise_Report.pdf
Start Date	2014-08-19
End Date	2014-08-20
Description	Live capture of pteropod Limacina retroversa for experiments and water sampling for carbonate chemistry profile.

TI787

Website	https://www.bco-dmo.org/deployment/562792
Platform	R/V Tioga
Report	http://bcodata.whoi.edu/GoME_Pteropods/cruise_reports/Tioga787_Cruise_Report.pdf
Start Date	2014-11-04
End Date	2014-11-06
Description	Live capture of pteropod Limacina retroversa for experiments and water sampling for carbonate chemistry profile and MOCNESS tow for later analysis of pteropod community. [underway data not available at this time: 2015-07-28]

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Project Information

Seasonal and Ontogenetic Effects of Ocean Acidification on Pteropods in the Gulf of Maine (Gulf of Maine Pteropods)

Website: http://www.whoi.edu/people/glawson/

Coverage: Gulf of Maine

This project will involve a series of five short cruises in 2013 and 2014, during which a variety of hydrographic, chemical, and biological data and samples will be collected, as well as a number of laboratory experiments examining pteropod physiology and gene expression.

From NSF proposal abstract:

Dissolution of excess anthropogenic CO2 into the ocean is causing the marine environment to decrease in pH. This "ocean acidification" is predicted to threaten a broad variety of marine organisms, particularly calcifying animals such as the thecosome (i.e., shelled) pteropods. These pelagic gastropods form an aragonite shell, are prey for a number of commercially important fish, and are significant contributors to carbon biogeochemistry. Their ecosystem importance, abundance, and sensitivity to dissolution position them as an important group for investigating the impacts of acidification. Our understanding of the effect of high CO2 on pteropods and the pelagic ecosystem, however, is limited primarily to short-term studies of adult calcification and respiration response in the polar ecosystems. There have been no seasonal studies of sensitivity and our understanding of the effect of CO2 on pteropod early life stages is limited. Limacina retroversa is a particularly abundant thecosome pteropod in the North Atlantic, where it is prey for a number of fisheries species and other top predators. This species is also the most common pteropod in the Gulf of Maine (GoM) where it is present year round. L. retroversa thus offers the prospect of a useful model pteropod species, given both its ecological

importance and its abundance in readily accessible waters. The investigators will conduct a series of short cruises to sample L. retroversa on a seasonal basis from local waters of the GoM near Cape Cod. The carbonate chemistry of the GoM fluctuates seasonally, providing the opportunity to assess the response of wild caught pteropods to natural changes in CO2. By characterizing the carbonate chemistry of the water column and measuring the metabolic rate, shell quality, and gene expression of pteropods throughout the year, the researchers will achieve a time series of pteropod sensitivity to CO2. Subsequently, using experimental manipulations the investigators will explore the effect of seasonal acclimation on pteropod response to short- and medium-term exposure to enhanced CO2. Pteropods frequently lay eggs in captivity, and at WHOI there is institutional expertise in maintaining these individuals in the laboratory. Building on these strengths, the researchers will also study the effect of CO2 on embryonic and larval development in L. retroversa. These earliest life-stages of marine calcifiers are thought to be especially sensitive since initial shell precipitation and the highly energetic processes of growth and development are impeded by CO2 exposure. They will also document mortality, shell production, abnormality, and developmental rate of clutches of pteropod embryos exposed to increased CO2.

Intellectual Merit: Thecosome pteropods are an abundant group of calcifying zooplankters that have been chronically understudied, particularly in temperate regions. Due to its accessibility and ecological importance, L. retroversa can be developed as a valuable model, interesting both as the dominant pteropod in the commercially-important GoM region and also an abundant pteropod in the temperate waters of the North Atlantic. The goal of this research is to augment our knowledge of the distribution of L. retroversa, to attain an understanding of their seasonal sensitivity to natural variability in CO2, and to see how this exposure impacts responses to both short- and medium-term CO2 exposure. Using powerful transcriptomic technologies, the research will transform our understanding of this group by investigating the molecular mechanisms of response in L. retroversa to both seasonality and varying durations and intensities of acidification, contextualized by ecosystem- and organism-level metrics. Furthermore the study will examine the effect of CO2 on the eggs of pteropods for the first time, providing insight into their sensitivity to an acidifying environment.

Acidification of the Coastal Ocean: Are deep waters of the Gulf of Maine already corrosive to pteropods? (GoME OA Pteropods)

Coverage: Gulf of Maine

ABSTRACT
As a result of increases in atmospheric carbon dioxide (CO2), the ocean is taking up extra CO2 and becoming more acidic, in a process referred to as ocean acidification (OA). Certain coastal regions, such as the upwelling system along the U.S. West Coast, are more susceptible to the effects of ocean acidification than others, because their waters are naturally low in pH and saturation of aragonite (a calcium carbonate mineral), but higher CO2 concentration, at least at some times of year. In such OA ‘hot-spots’, continued anthropogenic perturbations to the carbonate chemistry will quickly push the system towards a more corrosive (aragonite under-saturated, OA < 1) environment that many calcium carbonate shell-forming organisms may not tolerate. Coastal acidification in the Gulf of Maine (GoME) has generally not been considered to be a pressing concern, but new data collected by our group and collaborators suggest that in the deep waters of the GoME low seawater pH may cause aragonite saturation states (OA) to be close to a chemical and ecological threshold (i.e. OA = 1). Currently, there are no year-round CO2 system measurements to assess conclusively whether the deep waters in the GoME are already experiencing seasonal OA under-saturation. If seasonal undersaturation is present, however, this may have detrimental consequences to thecosome pteropods, a group of aragonite shell-forming zooplankton that are important members of the pelagic food web and key contributors to biogeochemical cycles.

We propose an interdisciplinary project aiming to assess seasonal variations of the CO2 system in the deep GoME and the associated impacts on thecosome pteropods. The main objectives of this project are to: (1) investigate if deep waters of the GoME are already seasonally under-saturated with respect to aragonite saturation state, and if these waters are more susceptible to acidification pressures; (2) quantify seasonal patterns in the abundance of the most common thecosome pteropod in the GoME, Limacina retroversa, and examine the impacts of potential under-saturation of aragonite on its vertical distribution; (3) investigate the physiological response of the animal to its chemical environment. Demonstration that the deep waters of the GoME are already seasonally undersaturated with respect to aragonite would be an important development. If the GoME does indeed qualify as a coastal acidification ‘hot spot,’ the proposed study would undoubtedly have

significant implications for future funding of coastal acidification research in the GoME.

OBJECTIVES

The long-term goal of this research is to understand forcing by climate, enhanced atmospheric CO2 levels, and coastal eutrophication, on seasonal and inter-annual variability in carbonate chemistry of the Gulf of Maine and the associated implications to planktonic calcifiers, notably pteropods. The specific goals of this project are to:

1. Quantify seasonal variations of carbonate system parameters and buffer intensity in deep waters of the Gulf of Maine in order to evaluate the sensitivity of these waters in response to acidification due to anthropogenic forcing, such as increase in atmospheric CO2, freshening of the GoME (decrease in total alkalinity) and increases in water-column respiration due to eutrophication. We will test the hypotheses that deep waters of the GoME are already seasonally under-saturated with respect to aragonite saturation state, and that these waters have low buffer intensity compared to overlying water, which would cause them to be more susceptible to acidification pressures and to reach critical ecological thresholds (OA < 1) more readily.

2. Quantify seasonal patterns in the abundance of the pteropod Limacina retroversa and its vertical distribution relative to concurrent measurements of water column chemical properties, testing the hypothesis that this species is absent in the acidic waters of the near-bottom nepheloid layer.

3. Measure variations in L retroversa metabolic rate as a function of local microenvironments of the Gulf of Maine, controlling temperature and carbonate chemistry in the lab to recreate conditions naturally experienced by the pteropods at shallow and deep depths in the water column, testing whether there is a physiological response of the animals to their chemical environment.

PROPOSED RESEARCH

We propose three 2-day research cruises on the R/V Tioga to the deep portions of Wilkinson Basin (~300m) in the GoME, targeting the time periods of late spring/early summer, late summer/early fall, and late fall/early winter when aragonite under-saturation is most likely. During each cruise, full water-column CTD casts will be taken at two or more stations near the deepest part of the basin, along with in-situ measurements of O2 and particle backscatter (to identify the bottom nepheloid layer). We will make bottle measurements of DIC, TA, and pH. This will allow us to fully define the seawater CO2 system for calculation of OA and various buffer factors (Egleston et al. 2010), which characterize the sensitivity of seawater against changes in acidity (pH), and OA under acidification. Underway measurements of pCO2, DIC, pH, fluorescence, and CTD will also be made along the cruise track to identify productive waters.

At each station, pteropods will be sampled with a ¼-m2 Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS) with six 150-µm mesh nets. MOCNESS tows will be performed immediately after CTD casts and will target depth layers chosen based on examination of the CTD's dissolved oxygen, and transmissometry data as indices of chemical conditions, such that some nets will sample exclusively within the nepheloid layer, as well as at shallower intervals. A subset of captured pteropods will be picked out of the samples and transported alive in 1-L jars to WHOI. The remainder of each sample will be preserved in 95% ethanol for later quantification of abundance and size.

Profiles will be made with a Video Plankton Recorder to further quantify pteropod abundance and vertical distribution, and to quantify particle abundance for our collaborator C. Pilskaln. Prof. Pilskaln or one of her graduate students will participate in the cruises at no-cost to this project, and will collect large-volume (5-10 L) filtered particle samples from Niskin bottles triggered in the nearbottom particle resuspension (i.e., nepheloid) layer. Prof. Pilskaln's measurements will thus target the particulate fraction and help constrain the overall water column carbonate budget. Water will also be collected for use in later metabolic lab studies.

Pteropods transported to WHOI will be used in laboratory studies of acute metabolic effects of high CO2/low pH. After an 8 hour acclimation period to clear their guts, individual animals will be exposed in respiration chambers for 48 hours to conditions recreating the temperature and carbonate chemistry of deep and shallow portions of the water column (created starting with water collected at the point of capture). Rates of respiration and ammonia excretion in manipulated and control animals will be measured following standard techniques (see Maas et al., 2012).

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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)

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1316040
WHOI internal funding (unspecified) (WHOI - internal)	COI-2012: Wang,Lawson,Maas

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