

Alongtrack data from RV/Tioga cruise TI668, full water-column to the Wilkinson Basin, Gulf of Maine, May 2013 (Gulf of Maine Pteropods project, GoME OA Pteropods project)

Website: <https://www.bco-dmo.org/dataset/472104>

Data Type: Cruise Results

Version: 2

Version Date: 2021-06-10

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

This alongtrack data set contains information on environmental conditions for each day of the RV/Tioga cruise TI668 to the Gulf of Maine, May 2013.

Methods & Sampling

Alongtrack measurements were made continuously during the course of the cruise. Data collection was handled by a number of computers and custom software programs, including Calliope, the central program which collects, logs, and distributes the data. Sea surface temperature, salinity, and fluorescence data were collected once per minute upon leaving port. Atmospheric measurements of air temperature, barometric pressure, wind speed and direction, and other meteorological variables were also collected along with time, latitude, and longitude once per minute. These data were saved on the ship's server on a daily basis.

Data Processing Description

BCO-DMO Processing Notes and Edits: Parameter names were modified to conform to BCO-DMO

convention. Replaced 'nan' and '-999' with 'nd', where applicable. Leading spaces in front of values were deleted. [Time was converted from HH:MM:SS format to GMT format. day_gmt, month_gmt, year, and yrday_new were added (computed based on date column).]

The following parameters were removed from display:

- GPS_UT - redundant with date and time
- secondary wind speed (WX_TS) - no good values reported; only a few 4.3 values
- secondary wind direction (WX_TSD) - no good values reported; only a few 255 values
- HdChkSum=6 - column used for QC only

BCO-DMO data manager processing notes:

- * Parameter info removed for "temp_hull" which is not a column in the dataset.
- * Added parameter info for date_gps

Version 2 (2021-06-10) replaces version 1 (2013-11-20).

* Made the following changes in source file "T1130520_00.csv" line 651.

* Values for wind_speed and wind_dir were replaced with missing data value "nd" since the values were "bad" characters not numeric values. Converted to utf-8.

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Data Files

| File |
|--|
| alongtrack_T1668.csv (Comma Separated Values (.csv), 1.60 MB) MD5:f24be8098d506c9cf0ac549119cc321c |
| Primary data file for dataset ID 472104 |

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Parameters

| Parameter | Description | Units |
|----------------|--|-------------------|
| cruise_id | cruise identification | unitless |
| date | date as year/month/day (GMT time) | yyyymmdd |
| time | Time GMT; 24 hour clock. [Values converted from HH:MM:SS format to HHMM.SS format.] | HH:MM:SS |
| lat | Latitude; negative = South. | decimal degrees |
| lon | Longitude; negative = West. | decimal degrees |
| temp_air_port | Air temperature in degrees C. Obtained from Vaisala WXT520 mounted on port side forward mast xx m above waterline. Name changed from 'WXTP_Ta' during processing. | degrees C |
| press_bar_port | Barometric pressure obtained from WXT520 mounted on the port side forward mast xx m above sea level. Data has been corrected for sensor altitude. Name changed from 'WXTP_Pa' during processing. | hPa |
| depth_w | Depth in meters obtained from the Knudsen 200 kHz channel. x meter transducer depth correction has been applied.??? Name changed from 'Depth200' during processing. | m |
| cog | Course over ground (true); best source; obtained from a Garmin GPS receiver. | degrees (azimuth) |
| sog | Speed over ground (best source) obtained from a Garmin GPS receiver. Name changed from 'SOG' during processing. | knots |

| | | |
|-------------------|--|------------------|
| precip_port | Rain accumulation in mm. Data obtained from Vaisala WXT520 mounted on port side forward mast xx m above waterline. The accumulation value is reset only when the sensor power is reset. Name changed from 'WXTP_Rc' during processing. | mm |
| precip_rate_port | Rain intensity in mm/hour obtained from Vaisala WXT520 mounted on port side forward mast xx m above waterline. Name changed from 'WXTP_Ri' during processing. | mm/hr |
| humidity_port | Relative humidity (%) obtained from Vaisala WXT520 mounted on port side forward mast at xx m above water line. Name changed from 'WXTP_Ua' during processing. | % |
| wind_dir_r_port | Relative wind direction from port side. Data obtained from Vaisala WXT520 and has not been corrected for sensor mounting alignment error. A 0-degree wind comes over the bow; 90-degree wind comes over the stbd side. Name changed from 'WXTP_Dm' during processing. | degrees |
| wind_speed_r_port | Relative wind speed from port side obtained from Vaisala WXT520. Wind speed average in m/s (2 Hz; 10 sec sample period). Name changed from 'WXTP_Sm' during processing. | m/s |
| cond_mS | Surface conductivity from the SBE45 thermosalinograph. Name changed from 'SBE45C' during processing. | mS/cm |
| flr | Fluorescence measured by WetLabs Wet-Star fluorometer located in the Wet Lab clean seawater piping. Units are counts (1 volt dc = 1000). | counts |
| sal_ss | Sea surface salinity measured by SBE45 thermosalinograph. Name changed from 'SBE45S' during processing. | PSU |
| sound_vel | Surface sound velocity from the SBE45 thermosalinograph. Name changed from 'SBE45SV' during processing. | m/s |
| temp_ss | Sea surface temperature measured by SBE45T thermosalinograph sensor. Name changed from 'SBE45T' during processing. | degrees C |
| head | The ship's heading obtained from true heading source (gyro). Name changed from 'HDT' during processing. | degrees(azimuth) |
| wind_direction | Wind direction. Name changed from 'WXWnd_dir' during processing. | degrees |
| wind_speed | Wind speed. Name changed from 'WXWnd_spd' during processing. | m/s |
| wind_dir_c_port | True wind direction in degrees from port side. Values are calculated from the Vaisala WXT520. Raw data corrected for sensor alignment error and combined with the ship's gyro heading and sog and cog values. A 0-degree wind comes from the north. Name changed from 'WXTP_TD' during processing. | degrees |
| wind_speed_c_port | True wind speed from port side. Values calculated from the Vaisala WXT520. Raw data corrected for sensor alignment error and combined with the ship's heading and sog and cog values. Name changed from "WXTP_TS" during processing. | m/s |
| yrday_gmt | GMT day and decimal time, as 326.5 for the 326th day of the year, or November 22 at 1200 hours (noon). | |
| day | day, UTC | |
| month | month, UTC | |
| year | year | |
| ISO_DateTime_UTC | Date/Time (UTC) ISO formatted, based on ISO 8601:2004(E). | |
| date_gps | GPS date in format ddmmyy (e.g. 180513 for May 18th, 2013). | unitless |

Instruments

| | |
|---|---|
| Dataset-specific Instrument Name | Fluorometer |
| Generic Instrument Name | Fluorometer |
| Generic Instrument Description | A fluorometer or fluorimeter is a device used to measure parameters of fluorescence: its intensity and wavelength distribution of emission spectrum after excitation by a certain spectrum of light. The instrument is designed to measure the amount of stimulated electromagnetic radiation produced by pulses of electromagnetic radiation emitted into a water sample or in situ. |

| | |
|---|---|
| Dataset-specific Instrument Name | GPS |
| Generic Instrument Name | Global Positioning System Receiver |
| Generic Instrument Description | The Global Positioning System (GPS) is a U.S. space-based radionavigation system that provides reliable positioning, navigation, and timing services to civilian users on a continuous worldwide basis. The U.S. Air Force develops, maintains, and operates the space and control segments of the NAVSTAR GPS transmitter system. Ships use a variety of receivers (e.g. Trimble and Ashtech) to interpret the GPS signal and determine accurate latitude and longitude. |

| | |
|---|---|
| Dataset-specific Instrument Name | MicroTSG |
| Generic Instrument Name | MicroTSG Thermosalinograph |
| Dataset-specific Description | Sea-Bird SBE45 |
| Generic Instrument Description | An externally powered, high-accuracy instrument, designed for shipboard determination of sea surface (pumped-water) conductivity and temperature. Salinity and sound velocity can also be computed. |

| | |
|---|---|
| Dataset-specific Instrument Name | SBE48 |
| Generic Instrument Name | Sea-Bird SBE 48 Hull Temperature Sensor |
| Generic Instrument Description | The SBE 48 is a high-accuracy temperature recorder with non-volatile memory, designed for shipboard determination of sea surface temperature. Installed with magnets just below the water line, the SBE 48's temperature sensor is in contact with the inside of the ship's hull. For more information, see the SBE48 Manual. |

| | |
|---|--|
| Dataset-specific Instrument Name | WXT520 |
| Generic Instrument Name | Weather Transmitter |
| Generic Instrument Description | The ship-mounted Vaisala Weather Transmitter WXT520 measures: Wind speed and direction; Liquid precipitation: rainfall, duration, intensity; Barometric pressure; Air temperature and Relative humidity. (for more information see http://www.vaisala.com/en/products/multiweathersensors/Pages/WXT520.aspx) |

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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 | <p>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 <i>Limacina retroversa</i>. 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 undersaturated 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 <i>Limacina retroversa</i> 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 nepheloid 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 (RNA later). DMO NOTE: Revised cruise report with updated eventlog submitted 20 Dec. 2013.</p> |

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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. Pilskalns. Prof. Pilskalns 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. Pilskalns'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 |
|------------------------|--|
| WHOI (WHOI - internal) | COI-2012: Wang, Lawson, Maas |

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