O2 consumption of pteropods held for 1-14 days in three CO2 treatments with pteropods collected with a Reeve net during R/V Tioga cruises in the Gulf of Maine from 2013 to 2014

Website: https://www.bco-dmo.org/dataset/780886
Version: 1
Version Date: 2019-11-05

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

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

Contributors	Affiliation	Role
Maas, Amy	Woods Hole Oceanographic Institution (WHOI)	Principal Investigator
Lawson, Gareth	Woods Hole Oceanographic Institution (WHOI)	Co-Principal Investigator
Tarrant, Ann M.	Woods Hole Oceanographic Institution (WHOI)	Co-Principal Investigator
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Coverage

Spatial Extent: **N**:42.3683 **E**:-69.71 **S**:42 **W**:-70.2567
Temporal Extent: 2013-10 - 2014-11

Dataset Description

O2 consumption of pteropods held for 1-14 days in three CO2 treatments with pteropods collected with a Reeve net during R/V Tioga cruises in the Gulf of Maine from 2013 to 2014.

These data were published in Maas et al. (2018) and Maas et al. (in review).

Related Datasets:
* Pteropod shell quality: https://www.bco-dmo.org/dataset/780791
* Pteropod abundance and distribution: https://www.bco-dmo.org/dataset/780874

Methods & Sampling

Methodology:

Pteropod adult (>0.5 mm, with fully developed wings/parapodia) were captured for experiments using a Reeve net with 333-m mesh and a large cod end that was deployed at slow speeds, for a short duration (< 1 h) with the aim of gently sampling live, undamaged specimens on various cruises. Tows were conducted at multiple stations in the Gulf of Maine (C42 22.1' - 42 0.0' N and 69 42.6' - 70 15.4' W). Individuals for respiration experiments were returned via coolers to a walk-in cold-room facility at the Woods Hole Oceanographic Institution within 8 h of collection. The cold-room was set at a constant temperature of 8C for all experiments. During each experimental period, water had been collected from an offshore site concurrent to pteropod sampling and had been returned to the lab in advance for filtration (0.2-m) and thermal equilibration. It had been bubbled with ambient air, which ranged from a calculated 380 to 440 atm over the seasonal cycle, for ~12 h prior to the arrival of the pteropods. Upon arrival, pteropods were placed in 1-L beakers of water containing the filtered in situ water (15 ind L-1) for 8-12 h to allow for further temperature acclimatization and gut clearance. After this period, healthy looking individuals (actively swimming or with parapodia extended) were placed into glass respiration chambers (containing optode spots; OXFOIL: PyroScience, Aachen Germany) with 2-3 mL fresh 0.2-m filtered water. A control chamber, without a pteropod, was set up for every fourth chamber to determine background bacterial respiration. The oxygen concentration was measured non-invasively at the start of the experiment and 24 h later using a FireStingO2 optical oxygen meter (PyroScience, Aachen Germany). At the conclusion of the experiment, each organism was visually inspected to confirm survival, briefly rinsed with DI water, placed in a pre-weighed aluminum dish, and weighed on a Cahn microbalance (C-33; 1 g precision) for wet mass. They were then dried for 3-7 days in a drying oven at 60C and weighed again to obtain dry mass. Final oxygen consumption rates were calculated based on the change in oxygen between the final and initial oxygen measurements, corrected for the bacterial respiration from the control chambers (mol O2 h-1).

Sampling and analytical procedures:

Temperature in the experiments was continually monitored using the Pyrosciences temperature logger that comes with the Firesting meter and are reported for only the ~24 duration of the respiration experiments.

Carbonate chemistry parameters are calculated as the average (over the course of the whole 14 day experiment) of measured pH, DIC and TA values using CO2sys. To monitor the carbonate chemistry during the experiments, subsamples of water (50 mL) from each carboy were taken every 2–3 days and measured spectrophotometrically for pH as described in White et al. (2013). To more fully characterize the carbonate chemistry of the experimental treatments, discrete samples for analysis of dissolved inorganic carbon (DIC) and total alkalinity (TA) were also collected from the pre-equilibrated water at weekly intervals, prior to its transfer to the carboys (day 0 and 7) and from the water in each carboy right before it was replaced during water transfers (day 7 and 14). This provided both the starting and ending DIC and TA of each batch of water for the first two weeks, and the starting conditions for week 3. DIC was measured using an Apollo SciTech DIC auto-analyzer, while TA was measured using an Apollo SciTech alkalinity auto-titrator, a Ross combination pH electrode, and a pH meter (ORION 3 Star) based on a modified Gran titration method (detailed in Wang et al., 2017). pH is reported on the seawater scale (pHsw). Salinity was measured with a Hannah refractometer.

Data Processing Description

CO2sys_v2.1

BCO-DMO Data Manager Processing Notes:
* Excel file exported as csv
* added a conventional header with dataset name, PI name, version date
* modified parameter names to conform with BCO-DMO naming conventions
* blank values in this dataset are displayed as "nd" for "no data." nd is the default missing data identifier in the BCO-DMO system.
* columns O2,MO2_DM,MO2_WM rounded to two decimal places

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Data Files

File
pter_resp.csv (Comma Separated Values (.csv), 28.26 KB) MD5:d0a27ecc6ca24e4a1b847bf6154c1da9 Primary data file for dataset ID 780886

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Related Publications

Maas, A. E., Lawson, G. L., Bergan, A. J., & Tarrant, A. M. (2017). Exposure to CO2influences metabolism, calcification and gene expression of the thecosome pteropodLimacina retroversa. The Journal of Experimental Biology, 221(3), jeb164400. doi:10.1242/jeb.164400
General

Maas, A. E., Lawson, G. L., Bergan, A. J., Wang, Z. A., & Tarrant, A. M. (2020). Seasonal variation in physiology and shell condition of the pteropod Limacina retroversa in the Gulf of Maine relative to life cycle and carbonate chemistry. Progress in Oceanography, 186, 102371. https://doi.org/10.1016/j.pocean.2020.102371
General

Wang, Z. A., Lawson, G. L., Pilskaln, C. H., & Maas, A. E. (2017). Seasonal controls of aragonite saturation states in the Gulf of Maine. Journal of Geophysical Research: Oceans, 122(1), 372–389. doi:10.1002/2016jc012373 https://doi.org/10.1002/2016JC012373
Methods

White, M. M., McCorkle, D. C., Mullineaux, L. S., & Cohen, A. L. (2013). Early Exposure of Bay Scallops (Argopecten irradians) to High CO2 Causes a Decrease in Larval Shell Growth. PLoS ONE, 8(4), e61065. doi:10.1371/journal.pone.0061065
Methods

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Parameters

Parameter	Description	Units
Year	Year for cruise of collection	unitless
month	Month for cruise of collection	unitless
Cruise_ID	Tioga cruise number	unitless
xpt_duraiton	Length of organism experimental captivity	days
resp_num	replicate number	unitless
Treatment	treatment name	unitless
dry_mass	pteropod dry mass at end of experiment	milligrams (mg)
wet_mass	pteropod wet mass at end of experiment	milligrams (mg)
O2	pteropod oxygen consumption	micromoles per hour (umol h-1)
MO2_DM	dry mass specific pteropod oxygen consumption	micromoles per hour (umol h-1)
MO2_WM	wet mass specific pteropod oxygen consumption	micromoles per hour (umol h-1)
temp	avg. temp of the experiment	degrees Celsius (C)
salinity	avg. salinity of the experiment	Practical Salinity Units (PSU)
OM_ar	calculated avg. saturation state of experiment	dimensionless
pCO2	calculated avg. pCO2 of experiment	microatmospheres (uatm)
pH	avg. pH of experiment	pH scale

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Instruments

Dataset-specific Instrument Name	Apollo SciTech DIC auto-analyzer
Generic Instrument Name	Apollo SciTech AS-C3 Dissolved Inorganic Carbon (DIC) analyzer
Generic Instrument Description	A Dissolved Inorganic Carbon (DIC) analyzer, for use in aquatic carbon dioxide parameter analysis of coastal waters, sediment pore-waters, and time-series incubation samples. The analyzer consists of a solid state infrared CO2 detector, a mass-flow controller, and a digital pump for transferring accurate amounts of reagent and sample. The analyzer uses an electronic cooling system to keep the reactor temperature below 3 degrees Celsius, and a Nafion dry tube to reduce the water vapour and keep the analyzer drift-free and maintenance-free for longer. The analyzer can handle sample volumes from 0.1 - 1.5 milliliters, however the best results are obtained from sample volumes between 0.5 - 1 milliliters. It takes approximately 3 minutes per analysis, and measurement precision is plus or minus 2 micromoles per kilogram or higher for surface seawater. It is designed for both land based and shipboard laboratory use.

Dataset-specific Instrument Name	Apollo SciTech alkalinity auto-titrator
Generic Instrument Name	Automatic titrator
Generic Instrument Description	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	OXFOIL: PyroScience, Aachen Germany
Generic Instrument Name	Optode
Generic Instrument Description	An optode or optrode is an optical sensor device that optically measures a specific substance usually with the aid of a chemical transducer.

Dataset-specific Instrument Name	FireStingO2 optical oxygen meter
Generic Instrument Name	Oxygen Sensor
Dataset-specific Description	PyroScience, Aachen Germany
Generic Instrument Description	An electronic device that measures the proportion of oxygen (O2) in the gas or liquid being analyzed

Dataset-specific Instrument Name	
Generic Instrument Name	pH Sensor
Dataset-specific Description	Ross combination pH electrode, and a pH meter (ORION 3 Star) based on a modified Gran titration method (detailed in Wang et al., 2017).
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	
Generic Instrument Name	Reeve Net
Dataset-specific Description	Reeve net with 333-m mesh and a large cod end
Generic Instrument Description	A Reeve Net is a conventional ring net with a very large acrylic cylindrical cod-end (30 liters) designed to collect fragile gelatinous animals. The net is lowered to a particular depth and then hauled slowly back to the surface (5-10 m/min). Reeve (1981) also described a double net system with no bridle and flotation at the net mouth that is attached to a roller mechanism that rides on a tow wire. The roller system is locked in place by a pressure release device. Once below a set pressure, the roller and nets are released and they float slowly up the wire, gently collecting the zooplankton, without being influenced by the motion of the vessel and associated vertical wire movements. (from Wiebe and Benfield, 2003)

Dataset-specific Instrument Name	Hannah refractometer.
Generic Instrument Name	Refractometer
Generic Instrument Description	A refractometer is a laboratory or field device for the measurement of an index of refraction (refractometry). The index of refraction is calculated from Snell's law and can be calculated from the composition of the material using the Gladstone-Dale relation. In optics the refractive index (or index of refraction) n of a substance (optical medium) is a dimensionless number that describes how light, or any other radiation, propagates through that medium.

Dataset-specific Instrument Name	Pyrosciences temperature logger
Generic Instrument Name	Temperature Logger
Dataset-specific Description	Pyrosciences temperature logger that comes with the Firesting meter
Generic Instrument Description	Records temperature data over a period of time.

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Deployments

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]

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).

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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.

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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

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