Grazing by copepods Calanus pacificus and Acartia hudsonica at low to high pCO2 levels, 2014-2015 (OA-Copepod_PreyQual project)

Website: https://www.bco-dmo.org/dataset/675137
Data Type: experimental
Version:
Version Date: 2017-01-23

Project
» Impacts on copepod populations mediated by changes in prey quality (OA-Copepod_PreyQual)

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

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Dataset Description

This dataset includes grazing data for two species of calanoid copepods, *Calanus pacificus* and *Acartia hudsonica*, from 2014 and 2015 studies. The females were maintained in three levels of pCO2 (400, 800, 1200 uatm) to study the effect of ocean acidification on copepod grazing.

Methods & Sampling

* NOTE: Units for cell counts for the two different years vary: 2014 are raw settled counts while the 2015 counts are cells/ml from the coulter counter.

2014 Study:

This study consisted of two separate experiments in which Calanus pacificus was maintained at three target pCO2 levels, 400, 800, 1200 µatm at a temperature of 12˚C and was fed either Prorocentrum micans or Ditylum brighwellii cultured at the same pCO2 and temperature levels. Copepods and phytoplankton were acclimated to treatment pCO2 for 7 or 8 days. After this acclimation period the phytoplankton were sampled for Chlorophyll content, cell size and Carbon and Nitrogen content.

Adult female Calanus pacificus were collected with a 1-m diameter, 335-µm mesh, ring net lifted vertically from

200m to the surface in Rosario Strait, Washington State. During the morning (0900-1130 7/14/14; 0800-11:45 8/4/14) copepods were transported back to Shannon Point Marine Center (SPMC) where mature adult females were separated under the microscope and placed in 1 L jars of filtered (5 µm) seawater containing respective treatment pCO2 levels. Jars of adult females (5 per liter) were given a 75% water change daily with pre-equilibrated pCO2 seawater and were fed either phytoplankton acclimated to the same pCO2 as the copepods (Grazing 1 and 2) or prey held at pCO2 400 for all treatments (Grazing 3) twice daily. P. micans was used in experiment 1 (Grazing 1) at 150 cells per ml and D. brightwellii was used in experiment 2 (Grazing 2 and 3) at 120 cells/ml. In all experiments, the number of prey cells added equaled saturating food concentrations of 400 µg C per liter. Jars were covered in foil and kept in the dark and allowed to sit in the climate controlled room for 90 minutes prior to sampling the T=0 time point. During Experiment 2 (Ditylum) in addition to feeding every 12 hours, jars were also stirred 6 hours after each feeding to re-suspend cells that had settled out of the water column. After the T=0 time point, treatment bottles were placed in the environmental chambers supplied with CO2 gas of equal concentration to respective treatment.

Samples were fixed in alkaline Lugol's at each time point. Aliquots between 1 and 5 milliliters were later settled in 6 well culture plates and counted with an inverted microscope.

2015 Study:

This study consisted of two separate experiments in which Acartia hudsonica was maintained at three target pCO2 levels, 400, 800, 1200 µatm at two different temperatures (12˚C and 17˚C) and was fed Rhodomonas salina cultured at the same pCO2 and temperature levels. Copepods and R. salina were acclimated to treatment pCO2 for 5 and 4 days for the 12˚C and 17˚C experiments, respectively. After this acclimation period the physiology and biochemistry of R. salina was characterized.

A. hudsonica was attained from Michael Finiguerra (University of Connecticut) and was maintained at approximately 20˚C and fed R. salina ad libitum. Adult copepods for experiments were picked out of the culture over a two-day period. A subset of females was set up for initial egg production, hatching success, and naupliar development tests (described below) and the rest of the adults were divided into 45 adults per 500 mL jar of pCO2-equilibrated seawater and held in the Atmospheric Carbon Control Simulator (ACCS) for the duration of the acclimation period. During the acclimation period jars of adult females were given a 75% water change daily and fed pCO2 acclimated R. salina every 12 hours to maintain a concentration above the saturation feeding density of 400 µg C L-1. At the end of the acclimation period, grazing rates, carbon, nitrogen, and fatty acid content of the adult females (described below), as well as carbon, nitrogen, and fatty acid content of R. salina were measured.

The direct and indirect effects of R. salina cultured under different pCO2 levels on A. hudsonica grazing were each evaluated once per experiment. The direct effects were measured by comparing the grazing rates of acclimated A. hudsonica to R. salina cultured under the same pCO2 treatment. Indirect effects compared the grazing on R. salina cultured under ambient (400 µatm) pCO2, regardless of the copepod pCO2 acclimation treatment. Grazing rate tests were done in 250 ml bottles with 15 female A. hudsonica per bottle, with three replicates and two controls per treatment. Bottles were covered in foil and incubated for 24 hours. R. salina cell concentrations were counted before and after the incubation using a Beckman Z2 coulter counter, and compared to R. salina growth in the control bottles with no copepods.

Data Processing Description

Data are raw cell counts.

BCO-DMO Processing Notes:
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- combined data for all 2014 and 2015 grazing experiments
- added columns for species, year and expt
- replaced spaces with underscore
- replaced nd's with 12 for the 2014 temperature column (2017-01-23); updated version date from 2017-01-18.

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Data Files

File
copepod_grazing.csv (Comma Separated Values (.csv), 62.36 KB) MD5:80c7083dd96ea22f31aad216ab56b73f Primary data file for dataset ID 675137

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Parameters

Parameter	Description	Units
species	copepod species used for grazing experiments	unitless
year	year of experiment	unitless
expt	experiment identifier	unitless
sample_name	sample name (variously coded): CO2 treatment (high/H; moderate/M; low/L) + Grazers/G or Control/C + replicate number	unitless
sample_type	either female copopods or no grazer (control)	unitless
treatment_rep_count	treatment + sample replicate number + cell count replicate number	unitless
temp	temperature	degrees Celsius
time_point	2014: the number of hours after T0 2015: the number of hours after phytoplankton were added	hours
volume_settled	volume of sample settled for a cell count (2014 studies only)	milliliters
Pmicans_count	Prorocentrum micans cells counted for the given volume settled	cells/volume settled
Ditylum_count	Ditylum brighwelli cells counted for the given volume settled	cells/volume settled
Rhodomonas_count	Rhodomonas salina cells counted for the given volume settled	cells/milliliter

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Instruments

Dataset-specific Instrument Name	Beckman Z2 coulter counter
Generic Instrument Name	Coulter Counter
Dataset-specific Description	To perform cell counts, 2015 experiments
Generic Instrument Description	An apparatus for counting and sizing particles suspended in electrolytes. It is used for cells, bacteria, prokaryotic cells and virus particles. A typical Coulter counter has one or more microchannels that separate two chambers containing electrolyte solutions. from https://en.wikipedia.org/wiki/Coulter_counter

Dataset-specific Instrument Name	
Generic Instrument Name	Inverted Microscope
Dataset-specific Description	To perform cell counts, 2014 experiments
Generic Instrument Description	An inverted microscope is a microscope with its light source and condenser on the top, above the stage pointing down, while the objectives and turret are below the stage pointing up. It was invented in 1850 by J. Lawrence Smith, a faculty member of Tulane University (then named the Medical College of Louisiana). Inverted microscopes are useful for observing living cells or organisms at the bottom of a large container (e.g. a tissue culture flask) under more natural conditions than on a glass slide, as is the case with a conventional microscope. Inverted microscopes are also used in micromanipulation applications where space above the specimen is required for manipulator mechanisms and the microtools they hold, and in metallurgical applications where polished samples can be placed on top of the stage and viewed from underneath using reflecting objectives. The stage on an inverted microscope is usually fixed, and focus is adjusted by moving the objective lens along a vertical axis to bring it closer to or further from the specimen. The focus mechanism typically has a dual concentric knob for coarse and fine adjustment. Depending on the size of the microscope, four to six objective lenses of different magnifications may be fitted to a rotating turret known as a nosepiece. These microscopes may also be fitted with accessories for fitting still and video cameras, fluorescence illumination, confocal scanning and many other applications.

Dataset-specific Instrument Name	
Generic Instrument Name	Ring Net
Dataset-specific Description	1-m diameter, 335-µm mesh, ring net lifted vertically from 200m to the surface
Generic Instrument Description	A Ring Net is a generic plankton net, made by attaching a net of any mesh size to a metal ring of any diameter. There are 1 meter, .75 meter, .25 meter and .5 meter nets that are used regularly. The most common zooplankton ring net is 1 meter in diameter and of mesh size .333mm, also known as a 'meter net' (see Meter Net).

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Deployments

Lab_Olson_B

Website	https://www.bco-dmo.org/deployment/521277
Platform	WWU
Start Date	2011-03-31
End Date	2016-09-15
Description	laboratory experiments

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Project Information

Impacts on copepod populations mediated by changes in prey quality (OA-Copepod_PreyQual)

Coverage: Puget Sound, Salish Sea

Research shows that ocean acidification (OA) has physiological consequences for individual organisms, even those lacking calcium carbonate skeletal structures. However, this existing research does not adequately address how OA effects to individuals are linked across trophic levels. Pelagic copepods are critical players in most marine biogeochemical cycles. Their consumption of phytoplankton and microzooplankton is the primary mechanism by which bacterial and phytoplankton production is transferred to higher trophic levels. Despite their high abundance and ecological importance, copepods have received little research attention concerning OA. The few extant studies focused on direct acute effects to copepods (e.g. egg hatching, survival) under elevated pCO2, and few significant effects have been observed at predicted future pCO2. However, there is increasing recognition that OA significantly affects their phytoplankton prey, including elevating growth rates, increasing cell sizes, altering nutrient uptake and ratios, and chemical composition. Because copepod grazing, egg production, and hatching success all can vary with these prey characteristics, OA mediated changes in phytoplankton quality may be an important indirect mechanism through which OA acts on copepod populations and, ultimately, marine food webs.

This study that will advance our understanding of how copepod populations may be affected by OA, specifically through OA induced changes in phytoplankton quality. Our core objective is to determine how changes in phytoplankton physiology and biochemistry (e.g. lipid composition) affect copepod egg production, hatching, and ontogenetic development of nauplii. We will also include a subset of experiments to test whether OA affects copepod reproductive output independent of changes to prey. To achieve these research goals, the diatom, *Ditylum brightwellii*, and dinoflagellate, *Prorocentrum micans*, will be cultured semi-continuously under several pCO2 concentrations, during which time we will characterize changes in their physiology and biochemistry. The copepods, *Calanus pacificus*, a large, high lipid-bearing marine species, and *Acartia clausi*, a smaller, low lipid-bearing estuarine species, will be maintained across varying pCO2 concentrations and fed these pCO2-acclimated prey, and their grazing and reproductive capability quantified. The copepods and phytoplankton used in this study will be collected from the Salish Sea, a region already experiencing periods of high pCO2/H+ (>1000 ppm, pH 7.5) on varying timescales. Therefore, this research addresses a question of how future climate change may impact marine ecosystems, but also is relevant to pCO2/H+ variability presently experienced in coastal environments.

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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-1220664
NSF Division of Ocean Sciences (NSF OCE)	OCE-1220381

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