Table 3: Calanus finmarchicus and Meganyctiphanes norvegica egg hatching success, 2011-2012

Website: https://www.bco-dmo.org/dataset/738651
Data Type: experimental
Version: 1
Version Date: 2018-06-13

Project
» Ocean Acidification-Category 1- Impact of ocean acidification on survival of early life stages of planktonic copepods in the genus Calanus in the northern (OA Calanus Survival)

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

Contributors	Affiliation	Role
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Abstract
This dataset reports hatching success for eggs of Calanus finmarchicus and Meganyctiphanes norvegica. Average temperature and pH are reported as well as hatching success for each replicate dish of eggs. Results are published in Preziosi et al (2017), Table 3.

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Coverage

Spatial Extent: **Lat**:43.7474 **Lon**:-69.501
Temporal Extent: 2011-05-27 - 2012-07-27

Dataset Description

This dataset reports hatching success for eggs of Calanus finmarchicus and Meganyctiphanes norvegica. Average temperature and pH are reported as well as hatching success for each replicate dish of eggs. Results are published in Preziosi et al (2017), Table 3.

Methods & Sampling

Overview: The goal of these laboratory experiments were to determine the degree to which lowered seawater

pH would inhibit egg hatching success in marine zooplankton and specifically in the copepod, Calanus finmarchicus. To do this, adult female zooplankton were collected at an open coastal site. The eggs from these females were then collected and incubated for several days in several tanks of seawater bubbled with premixed gas at a specific CO2 content. The proportion of eggs which hatched were determined in replicate. While the eggs were being incubated, waters in each tank were monitored with sensors for temperature, salinity, pH, and dissolved oxygen. Once or twice during an experiment, 2 L of seawater were withdrawn for measurement of the carbonate system parameters (salinity, alkalinity, total carbon dioxide) and nutrient concentrations. From these high-precision carbonate measurements, the total pH and other carbonate system parameters were calculated. Thus, inhibition of hatching success was related to the pH of the tanks.

Egg Collection: Zooplankton were collected from an open coastal site (43.7474 N, 69.5010 W) nearby the University of Maine's Darling Marine Center, using a 1-m 300 m mesh ring net towed from 100 m to the surface. Sufficient quantities of seawater was also collected from 30-40 m depth for most experiments. The copepod, Calanus finmarchicus, was studied in experiments 1-3 and 6-13, while the euphausid, Meganyctiphanes norvegica, was used in experiments 4 and 5. Females were separated from the catch and allowed to release their eggs for about a day. On occasional experiments, insufficient numbers of females were collected to supply the numbers of eggs required in an experiment. In this case, C. finmarchicus eggs from females maintained in the laboratory were used instead. These females were maintained at 6C and were fed twice daily at concentrations of >500 g C L-1 with an equal mixture of Gymnodinium sp., Rhodomonas sp. and Oxyrrhis marina. For experiments with the laboratory-maintained females, waters used in the experimental tanks were those pumped from the Marine Center's dock into the marine aquarium building, which housed our laboratory. The estuary's seawater was only slightly less saline (salinities of 30.2-31.1) than the open coastal waters (31.1-32.4). All seawaters used were filtered through 1.0 m filters.

Incubations at differing pH: After obtaining sufficient numbers of eggs, the eggs were separated in replicate Petri dishes with 30 eggs per dish. The dishes were specially modified with Nitex screen to allow exchange between the interior of the dish and the surrounding seawater. Between 3 and 5 tanks containing 12.5 L of seawater had been bubbled with specialty-purchased gas mixtures of 20% oxygen, a preselected CO2 concentration (between 913 and 15,290 ppm), and the remainder nitrogen. One experiment (experiment 7) used two gases to reach a very low pH, one gas cylinder containing 50,000 ppm CO2 in N2, and one containing 913 ppm CO2 in 20% O2 and the remainder N2. In this tank, the dissolved oxygen content in the tank remained about the same level as the other tanks in the experiment, above 70% of saturation. Each experiment was begun by placing up to 8 replicate Petri dishes with the eggs into each tank. The tanks were maintained in this state for about 24 hours past the hatching time determined by McLaren et al. (1969) for the particular temperature. The experiment ended by removing the replicate Petri dishes and manually counting the number of nauplii contained within each petri dish. Hatching success was the percentage of nauplii counted relative to the number of eggs initially in the dish.

Data Processing Description

BCO-DMO Processing Notes:
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- hid separator rows (all -99), and duplicate columns

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Data Files

File
table3.csv (Comma Separated Values (.csv), 4.55 KB) MD5:2a634f0e0be09480682dd43e4eceeca1 Primary data file for dataset ID 738651

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Related Publications

McLAREN, I. A., CORKETT, C. J., & ZILLIOUX, E. J. (1969). Temperature adaptations of the copepod eggs from the arctic to the tropics. The Biological Bulletin, 137(3), 486–493. doi:10.2307/1540170
Methods

Preziosi, B. M., Runge, J. A., Christensen, J. P., & Jones, R. J. (2017). Effects of pH and temperature on egg hatching success of the marine planktonic copepod, Calanus finmarchicus . Marine Biology, 164(11). doi:10.1007/s00227-017-3243-5
Results

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Parameters

Parameter	Description	Units
EXPERIMENT	Number of the experiment	#
STARTDATE	Date the experiment began in mm/dd/yyyy format.	unitless
SPECIES	Name of the species	name
SOURCE	Freshly caught or lab-maintained females	text
DURATION	Elapsed time for eggs in the tanks	hours
TANK	Number of the tank	#
AVERAGE_TEMP	Tank average of temperatures in Table 2	degrees C
AVERAGE_PHTTL	Tank average of pHttl in Table 2	pH units
HS1	% of eggs which hatched in replicate 1	percent
HS2	% of eggs which hatched in replicate 2	percent
HS3	% of eggs which hatched in replicate 3	percent
HS4	% of eggs which hatched in replicate 4	percent
HS5	% of eggs which hatched in replicate 5	percent
HS6	% of eggs which hatched in replicate 6	percent
HS7	% of eggs which hatched in replicate 7	percent
HS8	% of eggs which hatched in replicate 8	percent

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Instruments

Dataset-specific Instrument Name	Corning model 109
Generic Instrument Name	Benchtop pH Meter
Dataset-specific Description	Adapted so that the millivolt out was logged by computer through a 14 bit A to D converter. The electrode was an Orion Ross ultra semi-micro glass electrode model 8103-BNUWP.
Generic Instrument Description	An instrument consisting of an electronic voltmeter and pH-responsive electrode that gives a direct conversion of voltage differences to differences of pH at the measurement temperature. (McGraw-Hill Dictionary of Scientific and Technical Terms) This instrument does not map to the NERC instrument vocabulary term for 'pH Sensor' which measures values in the water column. Benchtop models are typically employed for stationary lab applications.

Dataset-specific Instrument Name	
Generic Instrument Name	Microscope - Optical
Dataset-specific Description	Used to count eggs and nauplii.
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of reflection and absorption of visible light. Includes conventional and inverted instruments. Also called a "light microscope".

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Project Information

Ocean Acidification-Category 1- Impact of ocean acidification on survival of early life stages of planktonic copepods in the genus Calanus in the northern (OA Calanus Survival)

Coverage: Gulf of Maine

The project description is a modification of the original NSF award abstract.

This research project is part of the larger NSF funded CRI-OA collaborative research initiative and was funded as an Ocean Acidification-Category 1, 2010 award. While attention concerning impacts of predicted acidification of the world's oceans has focused on calcifying organisms, non-calcifying plankton may also be vulnerable. In this project, the investigator will evaluate the potential for impacts of ocean acidification on the reproductive success of three species of planktonic copepods in the genus Calanus that are prominent in high latitude oceans. *C. finmarchicus* dominates the mesozooplankton biomass across much of the coastal and deep North Atlantic Ocean. *C. glacialis* and the larger *C. hyperboreus* are among the most abundant planktonic copepods in the Arctic Ocean. Previous research showed that hatching success of *C. finmarchicus* eggs was severely inhibited by increased CO2 and lower pH in seawater, but only tested at an extreme level. Preliminary results in the investigator's laboratory indicate that hatching success of *C. finmarchicus* is substantially reduced at increased seawater CO2 concentrations corresponding to pH levels between 7.9 and 7.5. Predictions of likely decline of surface pH levels to 7.7-7.8 over the next century raise questions about impacts on Calanus population dynamics if these preliminary results are confirmed. *C. finmarchicus*, for example, is presently at the southern edge of its range in the Gulf of Maine. The combination of higher surface layer temperature and lower pH may inhibit reproductive success during the late summer/fall bloom, which the PI

hypothesize is critical to sustain the overwintering stock in this region. The investigators will collect *C. finmarchicus* females from the Gulf of Maine and, with the assistance of Canadian colleagues, *C. glacialis* and *C. hyperboreus* females from the deep lower St. Lawrence Estuary. They will conduct laboratory experiments in which hatching success, development and growth of Calanus nauplius stages are measured in controls of natural seawater and at a series of treatments in which CO2 concentrations, pH and temperature are rigorously controlled to represent possible future states of the northern ocean. The investigators will measure present surface and deep pCO2 and pH across the Gulf of Maine, including its deep basins, during a research cruise. The study will evaluate the hypothesis that predicted levels of CO2 increase in the northern ocean will impact population dynamics of the Calanus species. Using the results from the research cruise and a recently developed 1-D, Individual-Based life cycle model, the PI will explore in detail scenarios of impact of higher temperature and lower surface and deep pH on population dynamics of *C. finmarchicus* in the Gulf of Maine.

The lipid-rich Calanus species are considered key intermediary links between primary production and higher trophic levels in North Atlantic and Arctic Ocean food webs. Impacts of higher surface temperature and lower pH on reproductive success may potentially lead to profound changes in energy transfer and structure of pelagic ecosystems in the northern oceans. In the Gulf of Maine, *C. finmarchicus* serves as primary prey for herring, sand lance, and mackerel, as well as the endangered northern right whale, warranting thorough evaluation of ocean acidification effects on its population dynamics.

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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)

Ocean Carbon and Biogeochemistry (OCB)

Website: http://us-ocb.org/

Coverage: Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research community and with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF.

The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO2 and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two.

The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1041081

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