Experimental counts and locations within columns of depth-varying pH to investigate the behavioral effects of ocean acidification on sand dollar larvae (Dendraster excentricus), July 2017

Website: https://www.bco-dmo.org/dataset/752953
Data Type: experimental
Version: 1
Version Date: 2019-01-14

Project
» RUI: Will climate change cause 'lazy larvae'? Effects of climate stressors on larval behavior and dispersal (Climate stressors on larvae)

Contributors	Affiliation	Role
Arellano, Shawn M	Western Washington University (WWU)	Principal Investigator
Olson, Brady M.	Western Washington University (WWU)	Co-Principal Investigator
Yang, Sylvia	Western Washington University (WWU)	Co-Principal Investigator
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Data collected from a laboratory water column experiment to investigate the behavioral effects of ocean acidification on sand dollar larvae (Dendraster excentricus).

Table of Contents

Coverage

Temporal Extent: 2017-07-18 - 2017-07-21

Dataset Description

Data collected from a laboratory water column experiment to investigate the behavioral effects of ocean acidification on sand dollar larvae (Dendraster excentricus).

Acquisition Description

Spawning and fertilization:

We collected adult sand dollars (D. excentricus) from Semiahmoo Bay, WA, on July 7, 2017, and maintained them in 14°C continuous flowing seawater at the Shannon Point Marine Center. On July 12, 2017, we induced twelve individuals to spawn by injecting 1-mL of 0.5-M KCl into the coelom following methods outlined by Strathmann (1987). We then collected and mixed concentrated gametes of four males and four females for fertilization. We added five drops of sperm to 500-mL of filtered seawater and 5-mL of eggs. We placed the fertilized eggs in 12°C incubator and bubbled them with ambient pCO2 condition for 12-hrs before dividing the embryos into pCO2 treatment conditions before gastrulation.

Larval Rearing

We reared D. excentricus larvae (2 individuals mL-1) at 12°C in eight 3-L jars that were individually bubbled with CO2 to achieve four replicates of ambient (400ppm) and acidic (1500ppm) pCO2 conditions. Each jar of larvae received a water change with pre-equilibrated 0.35-m filtered ambient and acidic seawater and fed the larvae D. tertiolecta (6,000 cells ml-1) daily. Pre-equilibrated ambient and acidic water was held in tanks within the same 12°C incubator as the rearing jars.

Experimental Design

We conducted two behavioral experiments; one when the larvae were 4-arm pleutei and one when the larvae were 6-armed pleutei.

To measure the effect of pH conditions on the vertical distribution of larvae we established three experimental pycnocline treatments within clear plexiglass water columns (2.5cm x 2.5cm x 30cm): (1) ambient water (400ppm) in the top layer and acidic water in the bottom layer (1500ppm), (2) ambient water (400ppm) in both top and bottom layers, and (3) acidic water (1500ppm) in the top layer and ambient water (400ppm) in the bottom layer. Each water layer was 60-mL of water and filled the column 10-cm high, so when each experimental treatment was established it filled the column to 20-cm. We established the experimental treatments by increasing the density of seawater in the bottom layer by 0.003-0.005 g ml-1 using PercollTM GE Healthcare (Podolsky & Emlet 1993). Experimental treatment water was kept at 12°C and pre-equilibrated to the desired pCO2 level and density. We also included blue food coloring (1 drop per 100-mL) to the dense bottom layer to more easily visualize the density layers while establishing experimental treatments. We set-up four replicate columns for each experimental treatment making twelve columns total per experiment.

Columns were positioned in a randomized order along the table of a walk-in incubator set to 12°C. Once columns were in position and treatments were established, we carefully injected 150 larvae by syringe into the bottom 2-cm of each column with no more than 2-mL of their culture water. Larvae were given 10 minutes in darkness to acclimate before we performed the first count of vertical positions of larvae in each water column. At 30 minutes of acclimation, we performed a second count of vertical positions of larvae in each column. For each larval count, we used a small hand-held flashlight and counted by eye the number of larvae occupying each centimeter of the water column beginning at the bottom and moving up to the top. We did these counts in the dark, so only one column received direct light from our small flashlight at a time to reduce the influence of light on the larvae's behavior.

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
- reformatted date from m/d/yy to yyyy-mm-dd

[table of contents | back to top]

Related Publications

Podolsky, R. D., & Emlet, R. B. (1993). Separating the effects of temperature and viscosity on swimming and water movement by sand dollar larvae (Dendraster excentricus). Journal of Experimental Biology, 176(1), 207-222.

Strathmann, M. F. (2017). Reproduction and development of marine invertebrates of the northern Pacific coast: data and methods for the study of eggs, embryos, and larvae. University of Washington Press.

Parameters

Parameter	Description	Units
date	Date of experiment formatted as yyyy-mm-dd	unitless
larvae_stage	Stage of Dendraster excentricus larvae used in the experiment: 4-arm or 6-arm stage plutei	unitless
larvae_treatment	Indicates the pCO2 treatment condition larvae were reared in from the time of spawning to the time of the experiment. "acidic" condition was treatment water maintained at 1500ppm and "neutral" condition was treatment water maintained at 400ppm.	unitless
column_treatment	Identifies the experimental treatment of the water column that larvae were placed into. The first word indicates the pCO2 condition of the water layer at the top of the column and the second word indicates the pCO2 condition of the water layer at the bottom of the column. "Acidic" water was bubbled to be 1500ppm and the "neutral" water was bubbled to be 400ppm.	unitless
column_name	code for: (1) the pCO2 treatment of the water in the top of the column (A or N); (2) the pCO2 treatment the larvae were reared within (A or N); (3) the pCO2 treatment of the water in the bottom of the column (A or N); and (4) the replicate number. "A"= acidic water that was bubbled to be 1500 pCO2; "N" = neutral water that was bubbled to be 400 pCO2	unitless
count_id	Identifies the count number (1 or 2) per experimental date. The vertical positions of larvae in the columns were counted twice for each experiment; the first count at 10 minutes post larval introduction into the column and the second count at 30 minutes post larval introduction into the column.	unitless
height_cm	The height above the bottom of the water column where larvae were counted	centimeters
middepth_cm	Middepth of the section of the water column in which larvae were counted	centimeters
larvae_count	The number of larvae occupying that area of the water column during the count	# of larvae
proportion_larvae	Proportion of total larvae occupying that area of the water column during the count	unitless

[table of contents | back to top]

Project Information

RUI: Will climate change cause 'lazy larvae'? Effects of climate stressors on larval behavior and dispersal (Climate stressors on larvae)

Coverage: Coastal Pacific, USA

In the face of climate change, future distribution of animals will depend not only on whether they adjust to new conditions in their current habitat, but also on whether a species can spread to suitable locations in a changing habitat landscape. In the ocean, where most species have tiny drifting larval stages, dispersal between habitats is impacted by more than just ocean currents alone; the swimming behavior of larvae, the flow environment the larvae encounter, and the length of time the larvae spend in the water column all interact to impact the distance and direction of larval dispersal. The effects of climate change, especially ocean acidification, are already evident in shellfish species along the Pacific coast, where hatchery managers have noticed shellfish cultures with 'lazy larvae syndrome.' Under conditions of increased acidification, these 'lazy larvae' simply stop swimming; yet, larval swimming behavior is rarely incorporated into studies of ocean acidification. Furthermore, how ocean warming interacts with the effects of acidification on larvae and their swimming behaviors remains unexplored; indeed, warming could reverse 'lazy larvae syndrome.' This project uses a combination of manipulative laboratory experiments, computer modeling, and a real case study to examine whether the impacts of ocean warming and acidification on individual larvae may affect the distribution and restoration of populations of native oysters in the Salish Sea. The project will tightly couple research with undergraduate education at Western Washington University, a primarily undergraduate university, by employing student researchers, incorporating materials into undergraduate courses, and pairing marine science student interns with art student interns to develop art projects aimed at communicating the effects of climate change to public audiences As studies of the effects of climate stress in the marine environment progress, impacts on individual-level performance must be placed in a larger ecological context. While future climate-induced circulation changes certainly will affect larval dispersal, the effects of climate-change stressors on individual larval traits alone may have equally important impacts, significantly altering larval transport and, ultimately, species distribution. This study will experimentally examine the relationship between combined climate stressors (warming and acidification) on planktonic larval duration, morphology, and swimming behavior; create models to generate testable hypotheses about the effects of these factors on larval dispersal that can be applied across systems; and, finally, use a bio-physically coupled larval transport model to examine whether climate-impacted larvae may affect the distribution and restoration of populations of native oysters in the Salish Sea.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1538626

[table of contents | back to top]