Effects of food on growth of larval Olympia oysters under different levels of ocean acidification; experiments conducted at Bodega Marine Laboratory (BML), UC Davis in June 2011

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Project
» Bodega Ocean Acidification Research (BOAR)

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Dataset Description

Effects of food on growth of larval Olympia oysters under different levels of ocean acidification.

Related datasets:
larval mass
metamorphosis

Methods & Sampling

Detailed methodology and results are described in the following publication:
Hettinger, A., E. Sanford, T.M. Hill, J.D. Hosfelt, A.D. Russell, and B. Gaylord. 2013. The influence of food supply on the response of Olympia oyster larvae to ocean acidification. Biogeosciences 10: 6629-6638. doi:10.5194/bg-10-6629-2013

Briefly (excerpted from above):
Adult Olympia oysters (n = 140) were collected from Tomales Bay, California (38 deg 06'58" N, 122 deg 51'16" W) in June 2011, transported to Bodega Marine Laboratory (BML) and distributed evenly among four 100 L

culturing cylinders. A similar average size of adult oysters was maintained among cylinders. Every day, adults in each cylinder were fed microalgae (*Isochrysis galbana*) at a high concentration to encourage larval release. Seawater, filtered to 0.45 um and held at 18– 22 degrees C, was changed every other day. Adults released larvae in two of the four culturing cylinders after 72 h. Larvae were distributed by pipette to 4.5 L glass jars on day 1 of the experiment (n = 1000 larvae per jar). Each jar held 2 L of filtered seawater at the appropriate pCO2 level, resulting in initial rearing concentrations of 1 larva per 2 mL of seawater.

In subsequent experimental trials, the investigators employed a target elevated seawater pCO2 concentration of 1000 uatm (~7.76 pH). The target control seawater pCO2 concentration was 500 uatm (~8.05 pH). All seawater used during larval rearing was pre-adjusted, prior to addition of larvae, to the appropriate pCO2 concentrations in 20 L carboys by bubbling filtered seawater for 2–3 days with NIST-traceable CO2 air mixtures (carboy water). To minimize net CO2 exchange across the seawater surfaces in the jars and help maintain seawater pCO2 concentrations at target levels within the jars, the same CO2 gas mixtures used to maintain carboy water were pumped continuously into sealed air spaces above the free surfaces of the seawater in the culture jars (hereafter "headspaces"). Five replicate jars per pCO2 concentration shared a given headspace. Carboys and jars were held in seawater tables maintained at 20 degrees C (+/- 0.2 degrees C).

Every other day, 90% of the seawater in each jar (jar water) was removed using reverse-filtration through 125 um mesh and replaced with carboy water at the target pCO2 concentration. Immediately following each water change, microalgae (I. galbana) were added to each jar to generate final densities in each jar of: 100,000, 50,000, or 10,000 cells per mL (n = 2 pCO2 levels × 3 food levels × 5 replicate jars = 30 jars). The three food levels were the equivalent of initial daily algal cell to larva ratios of 50, 25, and 5 cells per larva per day.

Seawater chemistry:
Jar water and carboy water were sampled for total alkalinity (TA) and dissolved inorganic carbon (DIC) every other day when a water change was performed. Seawater pH and temperature were measured using a potentiometric pH/temperature meter (Accumet Excel XL60). Raw pH readings (mV) were calibrated using two seawater buffers. pH was monitored primarily as a real-time indicator of changes in the carbonate system. Salinity was determined using a YSI Professional Plus Multiparameter instrument with a conductivity probe (YSI, Yellow Springs, OH). TA was measured using automated Gran titration with duplicates (Metrohm 809), and standardized using certified reference material (CRM) from A. Dickson. The offset between measured and certified TA values for Dickson CRM (Batches 104, 107, 111) was −0.01 (+/- 2.81) meq per kg (n = 91). Other carbonate system parameters were calculated using the carbonate system analysis software CO2SYS (Lewis andWallace, 1998).

Sampling of larval growth:
On day 1, prior to their placement in the culture jars, larvae were collected haphazardly by pipette (n = 20), placed on a 125 um Nitex plankton filter, rinsed, and left to dry at room temperature for 24 h. Larvae were photographed individually under a dissecting microscope (Leica M125 with DC290 camera) for analysis using ImageJ software (ver. 1.37, National Institutes of Health) to determine the initial projected area of the shell. Larvae were sampled similarly on day 5, 9, and 11 post-larval release (n = 10 larvae per jar at each time point). Larval growth was estimated as the change in projected shell area since larval release (day 1).

Sampling of larval total dry weight:
Total dry weight (body plus shell, ug) of the oysters was also determined on days 5, 9, and 11 post larval release. Larvae were collected haphazardly by pipette from each jar (n = 25), placed on a 125 um Nitex plankton filter, and rinsed. Total dry weights of larvae sampled were determined by transferring larvae individually to aluminum vessels pre-ashed at 500 degrees C for 3 h, drying the larval sample at 50 degrees C for >24 h, and weighing on a microbalance (Sartorius Ultramicro, Goettingen, Germany). Larvae were dried in their vessels a second time, reweighed to verify their weights, and combusted at 460 degres C for 4 h in a muffle furnace (Thermo Scientific FB1415M) to remove all organic matter (see also Gaylord et al., 2011). Ash-free dry tissue weights were determined from the weight difference before and after combusting.

Sampling of percent metamorphosis:
Settlement of larvae and metamorphosis into benthic juveniles was assessed daily starting on day 11, two days after larval transfers were made into the substrate jars. When <5% of larvae remained swimming (used as the assay point for settlement) in each pCO2 treatment, the bases of each substrate jar were removed, and the proportion of metamorphosed individuals was determined by first subtracting dead and non-metamorphosed larvae (e.g., pediveligers) from the total initial number of larvae, then dividing by the total initial number of larvae (1000). Any metamorphosed individuals on the walls of the glass jars were also included in the proportion of metamorphosed individuals.

Data Processing Description

BCO-DMO processing:
- modified parameter names to conform with BCO-DMO naming conventions;
- replaced blanks (missing data) with "nd" ("no data").

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Data Files

File
food_larval_growth.csv (Comma Separated Values (.csv), 1.01 KB) MD5:6ab620f11fed6d6abb229d365a86261b Primary data file for dataset ID 659625

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Parameters

Parameter	Description	Units
target_pCO2	Target pCO2	microatmospheres (uatm)
food_level	Food level (low, medium, high)	unitless
jar	Jar identifier	unitless
headspace	Headspace identifier	unitless
day5_larval_shell_area	Day 5 larval shell area	square millimeters (mm^2)
day9_larval_shell_area	Day 9 larval shell area	square millimeters (mm^2)
day11_larval_shell_area	Day 11 larval shell area	square millimeters (mm^2)

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Instruments

Dataset-specific Instrument Name	DC290
Generic Instrument Name	Camera
Dataset-specific Description	Larvae were photographed individually under a dissecting microscope (Leica M125 with DC290 camera) for analysis using ImageJ software.
Generic Instrument Description	All types of photographic equipment including stills, video, film and digital systems.

Dataset-specific Instrument Name	Leica M125
Generic Instrument Name	Microscope - Optical
Dataset-specific Description	Larvae were photographed individually under a dissecting microscope (Leica M125 with DC290 camera) for analysis using ImageJ software.
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".

Dataset-specific Instrument Name	YSI Professional Plus Multiparameter instrument
Generic Instrument Name	Multi Parameter Portable Meter
Dataset-specific Description	Salinity was determined using a YSI Professional Plus Multiparameter instrument with a conductivity probe (YSI, Yellow Springs, OH).
Generic Instrument Description	An analytical instrument that can measure multiple parameters, such as pH, EC, TDS, DO and temperature with one device and is portable or hand-held.

Dataset-specific Instrument Name	Accumet Excel XL60
Generic Instrument Name	pH Sensor
Dataset-specific Description	Seawater pH and temperature were measured using a potentiometric pH/temperature meter (Accumet Excel XL60).
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	Metrohm 809
Generic Instrument Name	Titrator
Dataset-specific Description	TA was measured using automated Gran titration with duplicates (Metrohm 809)
Generic Instrument Description	Titrators are 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	Accumet Excel XL60
Generic Instrument Name	Water Temperature Sensor
Dataset-specific Description	Seawater pH and temperature were measured using a potentiometric pH/temperature meter (Accumet Excel XL60).
Generic Instrument Description	General term for an instrument that measures the temperature of the water with which it is in contact (thermometer).

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Deployments

BML_Gaylord

Website	https://www.bco-dmo.org/deployment/658395
Platform	lab Bodega Marine Laboratory
Start Date	2010-09-01
End Date	2011-06-30

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Project Information

Bodega Ocean Acidification Research (BOAR)

Website: http://bml.ucdavis.edu/research/research-programs/climate-change/oceanacidification/

Coverage: Central California coast (northeast Pacific)

The absorption of human-produced CO2 into the world's oceans is decreasing seawater pH and causing marked declines in the saturation state for calcium carbonate, a major building block for shells, skeletons, and tests of many marine species. Such changes (collectively termed "ocean acidification") have the potential to devastate a broad array of organisms, both at the level of individuals and at population and ecosystem scales. Although awareness of these issues is rapidly growing, most of what is known is based on studies of coral reef organisms and plankton.

The proposed work will enhance understanding of impacts from ocean acidification by providing rigorous data on several new fronts applicable to temperate systems. The project will operate within one of the strongest upwelling centers of the eastern Pacific, where global trends in acidification are amplified by the presence of cold water characterized by already-high levels of aqueous CO2. Using an integrated, comparative approach that exploits the expertise of oceanographers, marine chemists, and biologists, the project will explicitly couple moored and shipboard measurements of seawater chemistry to controlled laboratory and field studies of

biological responses.

Two vital foundation species (the California mussel, *Mytilus californianus*, and the Olympia oyster, *Ostrea conchaphila*) will be targeted. These two species play disproportionately important roles in open-coast and estuarine systems, respectively. Larvae (which are often the most vulnerable stages) of mussels and oysters will be cultured under elevated-CO2 conditions through the full pelagic period and into juvenile life. Growth and survivorship will be quantified, and water temperature and salinity will be varied to test for interactive effects of multiple factors. Intraspecific variation in response of larvae from different parental lineages will be examined. "Carry-over" effects that originate from exposure during the larval stage, but influence subsequent juvenile growth and survival, will be determined both in the laboratory and using field outplants. Because larval and juvenile stages play important roles as demographic age-structure bottlenecks, overall population consequences will be estimated through comparison of observed impacts on early life stages to other recognized sources of recruitment variation.

Data Status: Data will be reported from the BML offshore oceanographic moorings and from moorings within nearby Tomales Bay. The moorings will be outfitted with autonomously recording pH and pCO2 sensors, and these measurements will be supplemented with discrete water samples collected monthly along two associated transects.

Live Data: For live-streaming data from Tomales Bay, visit http://www.ipacoa.org/Explorer and click on the icon in Tomales Bay.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0927255

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