

# Experimental seawater chemical properties for larval mussel shell study from SIO, UCSD from 2012-2013 (OA\_Proxies project)

**Website:** <https://www.bco-dmo.org/dataset/522939>

**Data Type:** experimental

**Version:** 1

**Version Date:** 2014-08-14

## Project

» [Development of geochemical proxies to evaluate larval pH-exposure history](#) (OA\_Proxies)

## Program

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

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## Abstract

Experimental seawater chemical properties for larval mussel shell study from SIO, UCSD from 2012 and 2013. (OA\_Proxies project)

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## Coverage

**Spatial Extent:** N:34.4128 E:-117.203 S:32.725 W:-119.842

**Temporal Extent:** 2012-05-05 - 2013-01-23

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## Dataset Description

Experimental seawater chemical properties for larval mussel shell study from SIO, UCSD from 2012 and 2013. This table has been modified from tables in Frieder et al. 2014 GCB and Frieder et al. 2014 ES&T; see those publications for additional corresponding salinity and other carbonate chemistry variables.

## Methods & Sampling

Mass flow controllers were used to deliver a gas mixture of N<sub>2</sub>, O<sub>2</sub>, and CO<sub>2</sub> to gas membrane contactors (Liqui-Cel Part No. G501), which in turn delivered the gas mixture to the seawater to maintain the desired CO<sub>2</sub> and O<sub>2</sub> concentrations in each treatment replicate (Bockmon et al. 2013, Biogeosciences).

A pH sensor (Honeywell Durafet III) and Aanderaa oxygen optode were used to continuously record from one replicate per treatment, per day. Along with daily discrete samples measured for pH and [O<sub>2</sub>], this sensor monitoring confirmed the stability of conditions, with the average offset of replicates to be 0.01 pH units and 3 μmol O<sub>2</sub> kg<sup>-1</sup> (Frieder et al. 2014, GCB). Discrete pH measurements were determined spectrophotometrically and the discrete [O<sub>2</sub>] values were determined using a Winkler Titration method (as described in Frieder et al. 2014, GCB).

Discrete samples were taken at the beginning and end of each experiment for the determination of total alkalinity and salinity. Total alkalinity measurements were determined using an open-cell, potentiometric titration with an accuracy of ± 2 μmol kg<sup>-1</sup> (Dickson et al., 2007). Salinity was calculated from density measured at 20°C on a Density Meter (Mettler Toledo DE45) with an accuracy of 0.05 salinity units. HOBO Pendant temperature data loggers with an accuracy of ±0.5°C continuously measured temperature every 5 min in all replicates.

## Data Processing Description

### BCO-DMO Processing Notes:

- data submitted in Excel file "Levin\_BCO-DMO Table 1. Experimental Seawater Conditions - Mussels.xlsx" sheet "Seawater conditions" extracted to tsv
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- removed special characters
- replaced / with -; replaced space with \_
- reordered columns

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## Data Files

File
<b>seawater_chem_Tbl1.csv</b> (Comma Separated Values (.csv), 2.08 KB) MD5:78862d61ec73d22aadca8025a923102e
Primary data file for dataset ID 522939

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## Related Publications

Bockmon, E. E., Frieder, C. A., Navarro, M. O., White-Kershek, L. A., & Dickson, A. G. (2013). Technical Note: Controlled experimental aquarium system for multi-stressor investigation of carbonate chemistry, oxygen saturation, and temperature. *Biogeosciences*, 10(9), 5967–5975. doi:[10.5194/bg-10-5967-2013](https://doi.org/10.5194/bg-10-5967-2013)  
*Methods*

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) 2007. Guide to best practices for ocean CO<sub>2</sub> measurements. PICES Special Publication 3, 191 pp. ISBN: 1-897176-07-4. URL: [https://www.nodc.noaa.gov/ocads/oceans/Handbook\\_2007.html](https://www.nodc.noaa.gov/ocads/oceans/Handbook_2007.html) <https://hdl.handle.net/11329/249>  
*Methods*

Frieder, C. A., Gonzalez, J. P., & Levin, L. A. (2014). Uranium in Larval Shells As a Barometer of Molluscan Ocean Acidification Exposure. *Environmental Science & Technology*, 48(11), 6401–6408. doi:[10.1021/es500514j](https://doi.org/10.1021/es500514j)  
*Results*

Frieder, C. A., Gonzalez, J. P., Bockmon, E. E., Navarro, M. O., & Levin, L. A. (2014). Can variable pH and low oxygen moderate ocean acidification outcomes for mussel larvae? *Global Change Biology*, 20(3), 754–764.

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## Related Datasets

### References

Levin, L. A. (2020) **Larval mussel shell composition under high and low pH and O<sub>2</sub> from SIO, UCSD from 2012 and 2013 (OA Proxies project)**. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2014-08-07 doi:10.26008/1912/bco-dmo.521670.1 [\[view at BCO-DMO\]](#)

*Relationship Description: Larval mussel shell composition under high and low pH and O<sub>2</sub> from SIO, UCSD from 2012 and 2013*

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### Parameters

Parameter	Description	Units
date	date of analysis	yyyy/mm/dd
species	taxonomic name of experimental species	unitless
exp_id	experiment code: A = high pH/high O <sub>2</sub> = high pHOx; B = low pH/low O <sub>2</sub> = low; pHOx; C = high pH/low O <sub>2</sub> ; D = low pH/high O <sub>2</sub>	unitless
treatment	high and low pH and oxygen concentration	unitless
pH	pH: The measure of the acidity or basicity of an aqueous solution	pH scale
O <sub>2</sub>	dissolved oxygen concentration	mol kg <sup>-1</sup>
temp	temperature	degrees Celsius
AT	total alkalinity	mol kg <sup>-1</sup>
sal	salinity	unitless
pCO <sub>2</sub>	partial pressure of carbon dioxide for each treatment; CO <sub>2</sub> treatments are ambient vs. elevated (45 vs 85 Pa pCO <sub>2</sub> )	micro-atmospheres
omega_ar	aragonite saturation state	unitless
omega_calc	calcite saturation state	unitless
CO <sub>3</sub>	concentration of carbonate ion ([CO <sub>3</sub> ] <sup>2-</sup> ) in seawater	mol kg <sup>-1</sup>

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### Instruments

<b>Dataset-specific Instrument Name</b>	AOO
<b>Generic Instrument Name</b>	Aanderaa Oxygen Optodes
<b>Generic Instrument Description</b>	Aanderaa Oxygen Optodes are instrument for monitoring oxygen in the environment. For instrument information see the Aanderaa Oxygen Optodes Product Brochure.

<b>Dataset-specific Instrument Name</b>	density meter
<b>Generic Instrument Name</b>	density meter
<b>Dataset-specific Description</b>	Mettler Toledo DE45, accuracy of $\pm 0.5$ °C.
<b>Generic Instrument Description</b>	Portable or bench-top instruments to measure density of liquids. [lab]

<b>Dataset-specific Instrument Name</b>	ICP Mass Spec
<b>Generic Instrument Name</b>	Inductively Coupled Plasma Mass Spectrometer
<b>Dataset-specific Description</b>	LA-ICP-MS (Laser Ablation Inductively Coupled Plasma Mass Spectrometry): Thermo Element 2 single-collector ICP-MS operating in low-resolution mode with a New Wave Research UP-213 laser ablation unit (at the University of California Santa Barbara).
<b>Generic Instrument Description</b>	An ICP Mass Spec is an instrument that passes nebulized samples into an inductively-coupled gas plasma (8-10000 K) where they are atomized and ionized. Ions of specific mass-to-charge ratios are quantified in a quadrupole mass spectrometer.

<b>Dataset-specific Instrument Name</b>	MFC
<b>Generic Instrument Name</b>	Mass Flow Controller
<b>Dataset-specific Description</b>	Omega® mass flow controllers (N2: FMA 5418 0-5 SLM; O2: FMA 5411 0-2 SLM; and CO2: FMA 5402 0-10 sccm). See Bockman (2013) for further details.
<b>Generic Instrument Description</b>	Mass Flow Controller (MFC) - A device used to measure and control the flow of fluids and gases

<b>Dataset-specific Instrument Name</b>	pH Sensor
<b>Generic Instrument Name</b>	pH Sensor
<b>Generic Instrument Description</b>	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+).

<b>Dataset-specific Instrument Name</b>	Water Temp Sensor
<b>Generic Instrument Name</b>	Water Temperature Sensor
<b>Dataset-specific Description</b>	HOBO Pendant temperature data loggers with an accuracy of $\pm 0.5$ °C.
<b>Generic Instrument Description</b>	General term for an instrument that measures the temperature of the water with which it is in contact (thermometer).

## Deployments

### Levin\_mussels

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/523534">https://www.bco-dmo.org/deployment/523534</a>
<b>Platform</b>	SIO Levin
<b>Start Date</b>	2012-11-22
<b>End Date</b>	2013-01-23
<b>Description</b>	Study of larval mussel shell trace elements. Adult <i>M. californianus</i> were collected from the Scripps Institution of Oceanography pier in southern California, U.S.A. (32.867° N 117.257° W), and adult <i>M. galloprovincialis</i> were collected from San Diego Bay, California, U.S.A. (32.725° N 117.203° W). Laser ablation was performed at UCSB (34.412824, -119.841964).

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## Project Information

### Development of geochemical proxies to evaluate larval pH-exposure history (OA\_Proxies)

**Coverage:** Southern California, 32 N 117 W

This research is funded as part of NSF CRI Ocean Acidification Category 2. The investigators will develop a new interdisciplinary partnership between connectivity ecology (Levin at SIO), metal isotope geochemistry (Anbar and Gordon at ASU), and paleoclimatology (Herrmann at ASU/LSU) to identify new proxies for ocean acidification that can be used to assess pH exposures in living organisms and, potentially to interpret the geologic record. The investigators hypothesize that the isotopic composition of larval calcium carbonates reflects changes in seawater chemistry driven by ocean acidification and, in some instances, with associated decline in oxygen levels. The large extent to which these two parameters vary in concert in the modern and past ocean (and thus have joint influence), and the extent to which they may be uncoupled by anthropogenic CO<sub>2</sub> inputs, merits considerable attention. Thus, the integration of pH and oxygen in proxy development would be an important advance.

The focus of this project is on proxy development to determine pH exposure history for living organisms in their larval state, and will center on calcium, boron, and uranium isotopes as well as multi-elemental fingerprints. For this project, the investigators will target open coast, front bay and backbay mytilid mussel species, each living naturally under a different pH regime, and statoliths of encapsulated market squid larvae from the open shelf. Larvae with known pH, oxygen and temperature exposure histories will be obtained from (1) laboratory larval rearing experiments that manipulate pH and oxygen and (2) in situ out planting of lab-spawned larvae in larval homes onto existing moorings where pH, T and oxygen are being monitored. Analyses will employ SIMS (for  $\delta^{11}\text{B}$ ), multicollector (for  $\delta^{44}\text{Ca}$ ,  $\delta^{238}\text{U}$ ), and laser ablation ICP-MS (targeting B, Cu, U, Pb, Mo, and a suite of additional pH- and redox-sensitive trace elements). Multivariate statistical tools will define ability to detect pH-induced signatures and to determine species or taxon-specific vital effects. The investigators are exploring proxies for invertebrate larvae that are untested in the context of acidification geochemistry. Targeting larvae is critical as many marine organisms produce larval carbonate structures and these stages may be most affected by ocean acidification. The retention of larval shell and statoliths after recruitment may ultimately allow us to test the importance of larval pH and O<sub>2</sub> exposure to survival and population persistence. An ability to assess past exposures through geochemical proxies will provide information about relative pH tolerances and ecosystem-level change in response to changes in the ocean's carbonate chemistry.

**NOTE:** A series of laboratory experiments were run in which *Mytilus* spp. larvae (*Mytilus californianus* and *Mytilus galloprovincialis*) and *Doryteuthis opalescens* (market squid) embryos were reared under controlled temperature, pH and oxygen conditions. Experimental conditions are given in [Table 1](#) (for mussel larvae) and [Table 2](#) (for squid embryos). Geochemistry data in the form of Metal:Ca ratios for mussels has been uploaded to BCO-DMO as "Mussel shell trace element ratios" and squid statolith geochemistry data are available on request.

## 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](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](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
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-1401349</a>

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