

# Experimental results on mussel growth at controlled pH and temperature from the lab Bodega Marine Laboratory in 2013 (OMEGAS-MaS project)

Website: <https://www.bco-dmo.org/dataset/554539>

Version: 2015-03-26

## Project

» [OCEAN ACIDIFICATION - Category 1: COLLABORATIVE RESEARCH: Acclimation and adaptation to ocean acidification of key ecosystem components in the California Current System](#) (OMEGAS-MaS)

## Programs

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

» [Partnership for Interdisciplinary Studies of Coastal Oceans](#) (PISCO)

Contributors	Affiliation	Role
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## Dataset Description

Measurements of mussel growth during an experiment conducted in February-March 2013 under controlled pH and temperature conditions.

### Related Reference:

These data are published in Kroeker, KJ, Gaylord B, Hill TM, Hosfelt JD, Miller SH, Sanford E. (2014) The role of temperature in determining species' vulnerability to ocean acidification: A case study using *Mytilus galloprovincialis*. PLoS ONE 9(7): e100353 ([link](#))

## Methods & Sampling

See related reference for [methodology](#).

## Data Processing Description

### BCO-DMO Processing:

- added conventional header with dataset name, PI name, version date, publication reference
- renamed parameters to BCO-DMO standard
- added lab, lat, lon for mapping access

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## Data Files

File
<b>mussel_growth.csv</b> (Comma Separated Values (.csv), 17.47 KB) MD5:57b6a6e81c260842c14489d1cd5c310c Primary data file for dataset ID 554539

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## Parameters

Parameter	Description	Units
lab	deployment id	unitless
lat	latitude; north is positive	decimal degrees
lon	longitude; east is positive	decimal degrees
pCO2_target	target pCO2 treatment level	uatm
temp_target	temperature treatment level	degrees Celsius
jar_id	replicate jar number nested within population	unitless
vol_init	initial volume on Day 1	milliliters
vol_final	final volume on Day 28	milliliters
vol_change	final volume-initial volume	milliliters
vol_change_rel	change in volume/initial volume	unitless
wgt_tissue	dry tissue weight	grams
wgt_shell	dry shell weight	grams

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## Instruments

<b>Dataset-specific Instrument Name</b>	handheld fluorometer
<b>Generic Instrument Name</b>	Fluorometer
<b>Dataset-specific Description</b>	Aqualflor 8000-010, Turner Designs - to measure algal concentrations for feeding rates
<b>Generic Instrument Description</b>	A fluorometer or fluorimeter is a device used to measure parameters of fluorescence: its intensity and wavelength distribution of emission spectrum after excitation by a certain spectrum of light. The instrument is designed to measure the amount of stimulated electromagnetic radiation produced by pulses of electromagnetic radiation emitted into a water sample or in situ.

<b>Dataset-specific Instrument Name</b>	temperature controlled water bath
<b>Generic Instrument Name</b>	In-situ incubator
<b>Generic Instrument Description</b>	A device on a ship or in the laboratory that holds water samples under controlled conditions of temperature and possibly illumination.

<b>Dataset-specific Instrument Name</b>	compound microscope
<b>Generic Instrument Name</b>	Microscope - Optical
<b>Dataset-specific Description</b>	Leica M125 with DC290 camera
<b>Generic Instrument Description</b>	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".

<b>Dataset-specific Instrument Name</b>	potentiometric pH/temperature meter
<b>Generic Instrument Name</b>	Multi Parameter Bench Meter
<b>Dataset-specific Description</b>	Accumet Excel XL60: measures pH/mV/Temperature/DO/ISE/Conductivity
<b>Generic Instrument Description</b>	An analytical instrument that can measure multiple parameters, such as pH, EC, TDS, DO and Temperature with one device.

<b>Dataset-specific Instrument Name</b>	Scale
<b>Generic Instrument Name</b>	scale
<b>Dataset-specific Description</b>	Mettler-Toledo XS204, 60.0001 g
<b>Generic Instrument Description</b>	An instrument used to measure weight or mass.

## Deployments

### BML\_Sanford\_2013

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/554551">https://www.bco-dmo.org/deployment/554551</a>
<b>Platform</b>	lab Bodega Marine Laboratory
<b>Start Date</b>	2013-02-01
<b>End Date</b>	2013-03-31
<b>Description</b>	mussel experiments

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## Project Information

**OCEAN ACIDIFICATION - Category 1: COLLABORATIVE RESEARCH: Acclimation and adaptation to ocean acidification of key ecosystem components in the California Current System (OMEGAS-MaS)**

**Website:** <http://omegas.science.oregonstate.edu>

**Coverage:** California Current Large Marine Ecosystem, Oregon, California

In 2010-2012/13, the OMEGAS consortium is investigating the impact of ocean acidification (OA) on two ecologically important, calcification-dependent marine invertebrates (sea urchins *Strongylocentrotus purpuratus* and mussels *Mytilus californianus*) in relation to local-to-coastal variation in carbonate chemistry in the California Current Large Marine Ecosystem (CCLME). An interdisciplinary team of investigators with expertise in physical and chemical oceanography, marine ecology, biochemistry, molecular physiology, and molecular genetics carry out integrated, lab and field, multi-site investigations of the ecological, physiological, and evolutionary responses of sea urchins and mussels to spatial and temporal variation in OA.

The research takes place in the context of a mosaic of variable oceanography, including recently documented latitudinal variation in carbonate chemistry along the upwelling-dominated US west coast. Variation in upwelling regimes from Washington to southern California generates spatial and temporal gradients in concentration of CO<sub>2</sub> that shoal to surface waters during upwelling events, extending shoreward into the inner shelf region. Because calcifiers in the upwelling-dominated CCLME probably have historically experienced wide fluctuation in pH, many likely are adapted to a variable carbonate chemistry environment. The new challenge to these organisms is that they may have limited ability to respond to additional increases in CO<sub>2</sub>. It is this challenge, the mechanistic ability of calcifying invertebrates to acclimate or adapt to increasing CO<sub>2</sub> and aragonite saturation states < 1.0, that is addressed in this program.

Our research includes several integrated elements that span our three project areas (Moorings and sensors; Genomics, physiology, and larval rearing; and Field transplants and growth experiments):

(1) Document the oceanographic context in which the study organisms operate in four regions of the CCLME with contrasting upwelling regimes.

(2) Examine physiological, genomic, and genetic mechanisms underlying acclimatization and adaptation to OA conditions with coordinated and integrated studies of adults and larvae of sea urchins and mussels collected from each of two sites within each of the four regions. In common-garden experiments culture sea urchins and mussels, respectively, under different CO<sub>2</sub> and temperature regimes, and use genomics techniques to determine the tolerance of larvae to present and future OA conditions.

(3) Determine evolutionary responses and adaptational potential to OA using genetic surveys of urchins and mussels across the 8 sites and relate detected variability to the oceanographic conditions.

(4) Examine ecological responses to OA with transplants of mussels and urchins in the field and monitor growth rates and shell accretion rates in relation to oceanographic and physical conditions.

The team will investigate the impact of ocean acidification (OA) on two ecologically important, calcification-dependent marine invertebrates (sea urchins *Strongylocentrotus purpuratus* and mussels *Mytilus californianus*) in relation to local-to-coastal variation in carbonate chemistry in the California Current Large Marine Ecosystem (CCLME). An interdisciplinary team of investigators with expertise in physical and chemical oceanography, marine ecology, biochemistry, molecular physiology, and molecular genetics will carry out an integrated, lab and field, multi-site investigation of the ecological, physiological, and evolutionary responses of sea urchins and mussels to spatial and temporal variation in OA. The research will take place in the context of a mosaic of variable oceanography, including recently documented latitudinal variation in carbonate chemistry along the upwelling-dominated US west coast. Variation in upwelling regimes from Washington to southern California generates spatial and temporal gradients in concentration of CO<sub>2</sub> that shoal to surface waters during upwelling events, extending shoreward into the inner shelf region. Because calcifiers in the upwelling-dominated CCLME probably have historically experienced wide fluctuation in pH, many likely are adapted to a variable carbonate chemistry environment. The new challenge to these organisms is that they may have limited ability to respond to additional increases in CO<sub>2</sub>. It is this challenge, the mechanistic ability of calcifying invertebrates to acclimate or adapt to increasing CO<sub>2</sub> and decreasing carbonate mineral saturation state, that is addressed in this project.

The OMEGAS Moorings and Sensors team will document the oceanographic context in which the study organisms operate in four regions of the CCLME with contrasting upwelling regimes. This project also coordinates closely with other OMEGAS projects [(i) Genetics, physiology, larval rearing and (ii) Field transplants] to achieve goals of the project to determine acclimatization and adaptational capacity to present and future OA conditions .

## **PUBLICATIONS PRODUCED AS A RESULT OF THIS RESEARCH**

Gaylord, B., T. M. Hill, E. Sanford, E. A. Lenz, L. A. Jacobs, K. N. Sato, A. D. Russell, and A. Hettinger. "Functional impacts of ocean acidification in an ecologically critical foundation species", *Journal of Experimental Biology*, v.214, 2011, p. 2586.

Howarth, R., F. Chan, D. J. Conley, S. C. Doney, R. Marino, and G. Billen. "Coupled biogeochemical cycles: eutrophication and hypoxia in temperate estuaries and coastal marine ecosystems", *Frontiers in Ecology and the Environment*, v.9, 2011, p. 18.

Yu, P. D., P. G. Matson, T. R. Martz, and G. E. Hofmann. "The ocean acidification seascape and its relationship to the performance of calcifying marine invertebrates: laboratory experiments on the development of urchin larvae framed by environmentally-relevant pCO<sub>2</sub>/pH", *Journal of Experimental Marine Biology and Ecology*, v.400, 2011, p. 288.

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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](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 \(NSF\)](#)

**Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)**

**Website:** <http://www.piscoweb.org/>

**Coverage:** West coast of North America from Mexico to Alaska

The Partnership for Interdisciplinary Studies of Coastal Oceans is a long-term ecosystem research and monitoring program established with the goals of:

- understanding dynamics of the coastal ocean ecosystem along the U.S. west coast
- sharing that knowledge so ocean managers and policy makers can make science based decisions regarding coastal and marine stewardship
- producing a new generation of scientists trained in interdisciplinary collaborative approaches

Over the last 10 years, PISCO has successfully built a unique research program that combines complementary disciplines to answer critical environmental questions and inform management and policy. Activities are conducted at the latitudinal scale of the California Current Large Marine Ecosystem along the west coast of North America, but anchored around the dynamics of coastal, hardbottom habitats and the oceanography of

the nearshore ocean – among the most productive and diverse components of this ecosystem. The program integrates studies of changes in the ocean environment through ecological monitoring and experiments. Scientists examine the causes and consequences of ecosystem changes over spatial scales that are the most relevant to marine species and management, but largely unstudied elsewhere.

Findings are linked to solutions through a growing portfolio of tools for policy and management decisions. The time from scientific discovery to policy change is greatly reduced by coordinated, efficient links between scientists and key decision makers.

Core elements of PISCO are:

- Interdisciplinary ecosystem science
- Data archiving and sharing
- Outreach to public and decision-making user groups
- Interdisciplinary training
- Coordination of distributed research team

Established in 1999 with funding from The David and Lucile Packard Foundation, PISCO is led by scientists from core campuses Oregon State University (OSU); Stanford University’s Hopkins Marine Station; University of California, Santa Cruz (UCSC); and University of California, Santa Barbara (UCSB). Collaborators from other institutions also contribute to leadership and development of PISCO programs. As of 2005, core PISCO activities are funded by collaborative grants from The David and Lucile Packard Foundation and the Gordon and Betty Moore Foundation. Core support, along with additional funding from diverse public and private sources, make this unique partnership possible.

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## Funding

Funding Source	Award
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-1041089</a>
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-1220648</a>

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