Experimental results on purple sea urchin larval growth from the lab Bodega Marine Laboratory in 2011 (OMEGAS-MaS project)

Website: https://www.bco-dmo.org/dataset/554419
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
Sanford, Eric	University of California-Davis (UC Davis-BML)	Lead Principal Investigator
Gaylord, Brian	University of California-Davis (UC Davis-BML)	Co-Principal Investigator
Hill, Tessa M.	University of California-Davis (UC Davis-BML)	Co-Principal Investigator
Russell, Ann D.	University of California-Davis (UC Davis)	Co-Principal Investigator
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Table of Contents

Dataset Description

Measurements of purple urchin *Strongylocentrotus purpuratus* larval growth during a pH/CO2 controlled experiment in January-March 2011.

Methods & Sampling

Lengths were measured of calcareous skeletal rods, body length and stomach area. Growth and morphometrics of sea urchin larvae cultured at control pCO2 (400 µatm) vs. elevated pCO2 (900 µatm). Results are from larvae collected on days 11, 13, 15, and 17 (postfertilization) of trial 1.

Larval Culture of Sea Urchins: Adult urchins were collected from seven populations from Central Oregon to Southern California, spanning 1,200 km of the S. purpuratus species range, and were shipped to Bodega Marine Laboratory (see SI Text for complete experimental details). Adults were spawned in the laboratory, and for each population gametes were mixed from 10 females and 10 males. Fertilized embryos were cultured under present-day global-mean pCO2 (partial pressure of CO2~400 µatm) and a fossil-fuel intensive projection (~900 µatm) (48). After 24 h, hatched blastulae were transferred to four replicate jars per population and CO2 level, and were maintained at 14 °C in jars with oscillating paddles (SI Text). Seawater was exchanged and sampled for pH and alkalinity, and larvae were fed and sampled every other day during 50-d trials, from 3 d postfertilization to metamorphosis.

Related Reference:

Pespeni, M.H., E. Sanford, B. Gaylord, T. M. Hill, J. D. Hosfelt, H. Jaris, M. LaVigne, E. A. Lenz, A. D. Russell, M. K. Young, S. R. Palumbi. 2013. Evolutionary change during experimental ocean acidification. Proceedings National Academy of Sciences 110 (17): 6937-6942.

Pespeni supporting information with detailed methods: http://www.pnas.org/content/suppl/2013/04/04/1220673110.DCSupplemental/pnas.201220673SI.pdf#nameddest=STXT

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, year for mapping access
- changed blank cells to nd
- transformed body part and length columns to rows

[table of contents | back to top]

Data Files

File
urchin_growth.csv (Comma Separated Values (.csv), 437.03 KB) MD5:56940c218cd5832bc22166f1464a20e3 Primary data file for dataset ID 554419

[table of contents | back to top]

Parameters

Parameter	Description	Units
lab	deployment id	unitless
lat	latitude; north is positive	decimal degrees
lon	longitude; east is positive	decimal degrees
year	year of experiment (Jan-March)	yyyy
age_days	days post-fertilization	days
pCO2	pCO2 treatment level	uatm
population	location code of population: SH = Strawberry Hill, Oregon, USA BMR = Bodega Marine Reserve, California, USA SHB = Sand Hill Bluff, California, USA ALG = Alegria; California; USA	unitless
jar_id	replicate jar number nested within population	unitless
larva_id	replicate larva nested within jar	unitless
body_part	body part measured: LA = left anterolateral rod length (mm) RA = right anterolateral rod length (mm) BLM = body length at midline (mm) Stomach = stomach area (mm^2) LPO = left postoral rod (mm) RPO = right postoral rod (mm) LBR = left body rod (mm) RBR = right body rod (mm)	unitless
size	length or area	mm; mm^2

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	compound microscope
Generic Instrument Name	Microscope - Optical
Dataset-specific Description	Leica DM1000 compound microscope
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".

[table of contents | back to top]

Deployments

BML_Sanford_2011

Website	https://www.bco-dmo.org/deployment/554489
Platform	lab Bodega Marine Laboratory
Start Date	2011-01-01
End Date	2011-03-31
Description	The Sanford Lab

[table of contents | back to top]

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 CO2 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 CO2. It is this challenge, the mechanistic ability of calcifying invertebrates to acclimate or adapt to increasing CO2 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 CO2 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 ecological 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 CO2 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 CO2. It is this challenge, the

mechanistic ability of calcifying invertebrates to acclimate or adapt to increasing CO2 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 regimesThis 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 theperformance of calcifying marine invertebrates: laboratory experiments on the development of urchin larvae framed by environmentally-relevant pCO2/pH", *Journal of Experimental Marine Biology and Ecology*, v.400, 2011, p. 288.

[table of contents | back to top]

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)

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.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1041089
NSF Division of Ocean Sciences (NSF OCE)	OCE-1220648

[table of contents | back to top]