Results from experiment examining effects of 4 different dyes on growth rates of scleractinian corals; from the Cohen lab at WHOI in Woods Hole, MA (OA Nutrition and Coral Calcification project)

Website: https://www.bco-dmo.org/dataset/489382
Data Type: experimental
Version: 1
Version Date: 2014-01-31

Project
» An Investigation of the Role of Nutrition in the Coral Calcification Response to Ocean Acidification (OA Nutrition and Coral Calcification)

Programs
» Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES): Ocean Acidification (formerly CRI-OA) (SEES-OA)
» Ocean Carbon and Biogeochemistry (OCB)

Contributors	Affiliation	Role
Cohen, Anne L.	Woods Hole Oceanographic Institution (WHOI)	Lead Principal Investigator
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Abstract
Results from experiment examining effects of 4 different dyes on growth rates of scleractinian corals; from the Cohen lab at WHOI in Woods Hole, MA.

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Dataset Description

This dataset contains results from an experiment in which four dyes (alizarin, alizarin complexone, calcein, and oxytetracycline) were used to mark corals of the species *Astrangia poculata* to assess the effect of the dye on coral growth. See the "coral growth isotope spike experiment" dataset for results from marking experiments using one of two isotope spikes (Ba 135 and Sr 86).

For more information on the experimental methods and results, see the following publication:
Holcomb M, Cohen AL, McCorkle DC. 2013. An evaluation of staining techniques for marking daily growth in scleractinian corals. Journal of Experimental Marine Biology and Ecology 440: 126-131. DOI: 10.1016/j.jembe.2012.12.003

Methods & Sampling

Methodology as described in Holcomb et al. (2013):

Colonies of the temperate scleractinian coral *Astrangia poculata* were collected and processed as previously described. Newly settled polyps and their associated substratum were attached to slides. The slides with corals were suspended vertically in a flow-through aquarium receiving 20 micrometers filtered Vineyard Sound seawater. Corals experienced a temperature range of 14 to 30 degrees C. Aquaria were aerated, and corals were maintained under these conditions for at least one month prior to use in experiments. A mixture of brown and white colonies (zooxanthellate and azooxanthellate colonies) was used for all treatments.

For the marking experiments, corals were placed in pre-washed containers with lids containing ~800 ml of water from the source aquarium. Airstones were added to each container and each container bubbled continuously. Containers were held within a water bath with a temperature similar to that of the source aquarium.

One of four dyes was used to mark the coral skeleton: alizarin red S (sodium salt – Alfa Aesar 42040 lot E22R017 – referred to as alizarin), alizarin complexone (Alfa Aesar A16699 lot E8180A), calcein (Alfa Aesar L10255 lot USLF006789), and oxytetracycline HCl (USB 23659 lot 113648).

The dye experiments took place from March to October 2009. Growth rates were estimated via alkalinity depletion measurements the day before (pre-treatment), the day of (treatment), and the day after (post-treatment) dye exposure. The alkalinity incubations were about 24 hours in duration (one full light-dark cycle). Temperatures ranged from 25 to 26 degrees C. Four to seven corals were used in each treatment, each in a separate incubation container. Irradiance in each container, measured using a diving-PAM underwater quantum sensor (WALZ), ranged from 10 to 40 micromoles photons/m^2/sec.

Samples for alkalinity were taken from each container about 1 hour after the corals were added, and once again at the end of the incubation. Salinity and pH were also measured at the end of each incubation for each container (and at the start for a sub-set of the containers). Aragonite deposition was assumed to be the only process affecting alkalinity, with 2 mol alkalinity consumed per mol of CaCO3 deposited. Alkalinity depletion rates were corrected for evaporation and background rates measured in the control containers (the control containers contained no slides).

Alkalinity was measured via titration with 0.01 N HCl containing 40.7 g NaCl/l using a Metrohm Titrando 808 Dosimat and a 730 Sample Changer controlled by Tiamo software to perform automated normalized Gran titrations of 1 ml samples.

Data Processing Description

Data from the dye experiments are expressed as relative growth rates: the ratio of the post-treatment growth rate to the pre-treatment growth rate. Rates were corrected for daily changes in calcification by dividing by the average relative growth rate of untreated corals run at the same time. Data from both the brown and white colonies were pooled because similar patterns were observed.

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Data Files

File
dye_expt.csv (Comma Separated Values (.csv), 1.38 KB) MD5:4f8015f534c3d654de54402c60aea957 Primary data file for dataset ID 489382

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Parameters

Parameter	Description	Units
treatment	Name of the dye used to mark the coral.	dimensionless
treatment_abbrev	Abbreviation used to identify the treatment type in Holcomb et al. 2013.	dimensionless
rel_growth_during_treatment	Relative coral growth rate estimated via alkalinity depletion measurements the day of dye exposure.	dimensionless
rel_growth_post_treatment	Relative coral growth rate estimated via alkalinity depletion measurements the day after dye exposure.	dimensionless

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Instruments

Dataset-specific Instrument Name	Aquarium
Generic Instrument Name	Aquarium
Generic Instrument Description	Aquarium - a vivarium consisting of at least one transparent side in which water-dwelling plants or animals are kept

Dataset-specific Instrument Name	Titrator
Generic Instrument Name	Automatic titrator
Dataset-specific Description	Alkalinities were measured via titration with 0.01 N HCl containing 40.7 g NaCl/l using a Metrohm Titrando 808 Dosimat and a 730 Sample Changer controlled by Tiamo software to performautomated normalized Gran titrations of 1 ml samples.
Generic Instrument Description	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	pH Probe
Generic Instrument Name	Benchtop pH Meter
Dataset-specific Description	A Thermo-Orion ROSS 8165BNWP electrode, read to 0.1 mV, was used to measure the pH of each experimental container.
Generic Instrument Description	An instrument consisting of an electronic voltmeter and pH-responsive electrode that gives a direct conversion of voltage differences to differences of pH at the measurement temperature. (McGraw-Hill Dictionary of Scientific and Technical Terms) This instrument does not map to the NERC instrument vocabulary term for 'pH Sensor' which measures values in the water column. Benchtop models are typically employed for stationary lab applications.

Dataset-specific Instrument Name	Conductivity Probe
Generic Instrument Name	Conductivity Meter
Dataset-specific Description	A Hach conductivity probe (read to 0.1, accurate to ~1) was used to determine the salinity of each experimental container.
Generic Instrument Description	Conductivity Meter - An electrical conductivity meter (EC meter) measures the electrical conductivity in a solution. Commonly used in hydroponics, aquaculture and freshwater systems to monitor the amount of nutrients, salts or impurities in the water.

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Deployments

lab_Cohen_WHOI

Website	https://www.bco-dmo.org/deployment/59089
Platform	WHOI
Description	Experiments and analyses carried out in Anne Cohen's lab at Woods Hole Oceanographic Institution (WHOI) as part of the project "An Investigation of the Role of Nutrition in the Coral Calcification Response to Ocean Acidification". See: Project description from Cohen Lab

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Project Information

An Investigation of the Role of Nutrition in the Coral Calcification Response to Ocean Acidification (OA Nutrition and Coral Calcification)

Coverage: global; experimental

The project description is a modification of the original NSF award abstract.

This research project is part of the larger NSF funded CRI-OA collaborative research initiative and was funded as an Ocean Acidification-Category 1, 2010 award. Over the course of this century, all tropical coral reef ecosystems, whether fringing heavily populated coastlines or lining remote islands and atolls, face unprecedented threat from ocean acidification caused by rising levels of atmospheric CO2. In many laboratory experiments conducted to date, calcium carbonate production (calcification) by scleractinian (stony) corals showed an inverse correlation to seawater saturation state OMEGAar), whether OMEGAar was manipulated by acid or CO2 addition. Based on these data, it is predicted that coral calcification rates could decline by up to 80% of modern values by the end of this century. A growing body of new experimental data however, suggests that the coral calcification response to ocean acidification may be less straightforward and a lot more variable than previously recognized. In at least 10 recent experiments including our own, 8 different tropical and temperate species reared under nutritionally-replete but significantly elevated CO2 conditions (780-1200 ppm, OMEAGar ~1.5-2), continued to calcify at rates comparable to conspecifics reared under ambient CO2. These experimental results are consistent with initial field data collected on reefs in the eastern Pacific and southern Oman, where corals today live and accrete their skeletons under conditions equivalent to 2X and 3X pre-industrial CO2. On these high CO2, high nutrient reefs (where nitrate concentrations typically exceed 2.5 micro-molar), coral growth rates rival, and sometimes even exceed, those of conspecifics in low CO2, oligotrophic reef environments.

The investigators propose that a coral's energetic status, tightly coupled to the availability of inorganic nutrients and/or food, is a key factor in the calcification response to CO2-induced ocean acidification. Their hypothesis, if confirmed by the proposed laboratory investigations, implies that predicted changes in coastal and open ocean nutrient concentrations over the course of this century, driven by both climate impacts on ocean stratification and by increased human activity in coastal regions, could play a critical role in exacerbating and in some areas, modulating the coral reef response to ocean acidification. This research program builds on the investigators initial results and observations. The planned laboratory experiments will test the hypothesis that: (1) The coral calcification response to ocean acidification is linked to the energetic status of the coral host. The relative contribution of symbiont photosynthesis and heterotrophic feeding to a coral's energetic status varies amongst species. Enhancing the energetic status of corals reared under high CO2, either by stimulating photosynthesis with inorganic nutrients or by direct heterotrophic feeding of the host lowers the sensitivity of calcification to decreased seawater OMEGAar; (2) A species-specific threshold CO2 level exists over which enhanced energetic status can no longer compensate for decreased OMEGAar of the external seawater. Similarly, we will test the hypothesis that a nutrient threshold exists over which nutrients become detrimental for calcification even under high CO2 conditions; and (3) Temperature-induced reduction of algal symbionts is one stressor that can reduce the energetic reserve of the coral host and exacerbate the calcification response to ocean acidification.

The investigator's initial findings highlight the critical importance of energetic status in the coral calcification response to ocean acidification. Verification of these findings in the laboratory, and identification of nutrient and CO2 thresholds for a range of species will have immediate, direct impact on predictions of reef resilience in a high CO2 world. The research project brings together a diverse group of expertise in coral biogeochemistry, chemical oceanography, molecular biology and coral reproductive ecology to focus on a problem that has enormous societal, economic and conservation relevance.

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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

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)

Ocean Carbon and Biogeochemistry (OCB)

Website: http://us-ocb.org/

Coverage: Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research community and with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF.

The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO2 and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two.

The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1041106

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