Results from experiment examining effects of 2 different isotope spikes 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/489449
Data Type: experimental
Version: 1
Version Date: 2014-02-03

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
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Abstract
Results from experiment examining effects of 2 different isotope spikes on growth rates of scleractinian corals; from the Cohen lab at WHOI in Woods Hole, MA.

Table of Contents

Dataset Description

This dataset contains results from an experiment in which two stable isotope spikes, Ba 135 and Sr 86, were used to mark corals of the species *Astrangia poculata* to assess their effects on coral growth.

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.

Ba 135 or Sr 86 isotope spikes (purchased as carbonate salts from Oak Ridge National Lab) were used as markers in some incubations. See the "coral growth dye experiment" dataset for results from marking experiments using one of four dyes (alizarin, alizarin complexone, calcein, and oxytetracycline).

The isotope spike marking was carried out as part of long term growth experiments (see Holcomb et al. 2010 and 2012). Six to sixteen corals were used in each of the isotope spike treatments. For marking with 86Sr, 60 microliters of an 86Sr solution were added to ~800 ml seawater and the corals were incubated for two days. Growth was estimated from changes in buoyant weight (per Holcomb et al., 2010) for the 5 months prior to and the month following the isotope spike. Corals were held at one of two temperatures: ~19 or ~26 degrees C throughout that six month period.

Spikes with 135Ba were carried out in a flow-through aquarium system (see Holcomb et al., 2012). Each reservoir supplying water to individual aquaria was spiked with 81 microliters of 135Ba solution per liter of seawater. The aquaria received spiked seawater for two days, after which unspiked seawater was added to the reservoir, diluting the spike. Buoyant weights were measured for the two months prior and one month following isotope exposure using a Sartorius G803S balance, and the aquaria were held at either 16 or 24 degrees C throughout this time.

Data Processing Description

Data from the 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. Growth rates were normalized to starting mass; a sign test (Zar, 1984) was used to test whether the post isotope treatment growth rate differed from the pre-treatment rate at each temperature.

References:
Holcomb, M., McCorkle, D.C., Cohen, A.L., 2010. Long-term effects of nutrient and CO2 enrichment on the temperate coral *Astrangia poculata* (Ellis and Solander, 1786). J. Exp. Mar. Biol. Ecol. 386, 27–33. DOI: 10.1016/j.jembe.2010.02.007.
Holcomb, M., Cohen, A.L., McCorkle, D.C., 2012. An investigation of the calcification response of the scleractinian coral *Astrangia poculata* to elevated pCO2 and the effects of nutrients, zooxanthellae and gender. Biogeosciences 9, 29–39. DOI: 10.5194/bg-9-29-2012.
Zar, J.H., 1984. Biostatistical Analysis. Prentice Hall, Englewood Cliffs, NJ.

[table of contents | back to top]

Data Files

File	
isotope_spike_expt.csv	(Comma Separated Values (.csv), 1.34 KB) MD5:a394a863586c562cace63a03fa237903
Primary data file for dataset ID 489449	

[table of contents | back to top]

Parameters

Parameter	Description	Units
treatment	Experimental treatment: combination of water temperature and isotope spike used to mark the coral. Corals marked with 86Sr were held at either 19 or 26 degrees Celsius. Corals marked with 135Ba were held at either 16 or 24 degrees Celsius.	dimensionless
growth_rate_pre	Relative coral growth pre-treatment. For 86Sr, growth was estimated from changes in buoyant weight (per Holcomb et al., 2010) for the 5 months prior to and the month following the isotope spike. For 135Ba, growth was estimated from changes in buoyant weight for the 2 months prior and one month following isotope exposure.	dimensionless
growth_rate_post	Relative coral growth post-treatment. For 86Sr, growth was estimated from changes in buoyant weight (per Holcomb et al., 2010) for the 5 months prior to and the month following the isotope spike. For 135Ba, growth was estimated from changes in buoyant weight for the 2 months prior and one month following isotope exposure.	dimensionless

[table of contents | back to top]

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	Balance
Generic Instrument Name	scale
Dataset-specific Description	Buoyant weights were measured using a Sartorius G803S balance.
Generic Instrument Description	An instrument used to measure weight or mass.

[table of contents | back to top]

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

[table of contents | back to top]

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.

[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)

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.

[table of contents | back to top]

Funding

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

[table of contents | back to top]