Mesoamerican Barrier Reef System coral buoyant weights from the Sapodilla Caye, Belize from UNC starting 2010 (OA - Ocean Acidification and Warming Impact on Calcification project)

Website: https://www.bco-dmo.org/dataset/4003
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Project
» Investigation of the Effects of CaCO3 Saturation State and Temperature on the Calcification Rate and Skeletal Properties of Benthic Marine Calcifiers (OA - Ocean Acidification and Warming Impact on Calcification)

Program
» Ocean Carbon and Biogeochemistry (OCB)

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Dataset Description

MBRS coral buoyant weights for OA experiments

Methods & Sampling

In July 2011, eighteen colonies of the tropical coral *S. siderea* were collected at 3 to 5 m depth on the Mesoamerican Barrier Reef System in southern Belize. Colonies were collected from nearshore, backreef, and forereef reef zones. *Siderastrea siderea* corals were transported to the University of North Carolina at Chapel Hill and each coral colony was sectioned into 18 comparatively sized specimens (approximately 3 cm x 2 cm x 1 cm) using a rock saw and glued with cyanoacrylate on to plastic microscope slides. The corals were allowed to recover for approximately 30 days under laboratory conditions in two 500 L recirculating artificial seawater systems until the start of the 15-day acclimation period, in which the corals were incrementally exposed to the experimental treatment conditions.

In the laboratory experiments, *Siderastrea siderea* coral specimens from each of the 18 colonies were reared for 95 days (5 August − 8 November 2011) in each of twelve 38 L glass aquaria (18 specimens per tank; 216 specimens in total) filled with artificial seawater formulated at a salinity of 35 with *Instant Ocean Sea Salt* and deionized water. Four pCO2 partial pressures [324, 477, 604, and 2553) ppm)], established by mixing pure CO2 with compressed air using *Aalborg* mass flow controllers, were bubbled with microporous ceramic airstones into the triplicate glass aquaria (12 tanks total). Coral specimens from each of the 18 colonies were reared in each of the 12 replicate tanks. The pCO2 experiments were maintained at an average temperature of

28 ºC.

Experimental growth conditions for the seawater temperature experiment were similar to those for the CO2-induced ocean acidification experiment described above. *Siderastrea siderea* coral specimens from each of the 18 colonies were reared for 95 days (5 August − 8 November 2011) in each of nine 38 L glass aquaria (18 specimens per tank; 162 specimens in total) filled with artificial seawater formulated at a salinity of 35 with *Instant Ocean Sea Salt* and deionized water. Three experimental seawater temperatures [25, 28, and 32 ºC] were maintained in triplicate (9 tanks total) for this experiment. Coral specimens from each of the 18 colonies were reared in each of the 9 replicate tanks. Compressed air with an average pCO2 of 488 ppm was bubbled with microporous ceramic airstones into the triplicate glass aquaria.

Coral calcification rates were estimated using a buoyant weight technique. *Siderastrea siderea* specimens were weighed at the beginning of the experiment and a final measurement taken at approximately 95 days. Each coral specimen was suspended by aluminum wire at 10-cm depth from a *Cole-Parmer* bottom-loading scale (precision ± 0.001; accuracy ± 0.002) in an aquarium filled with artificial seawater maintained at a temperature of 25 ºC and salinity of 33. A standardized plastic-coated zinc mass was intermittently weighed to ensure consistency of the buoyant weight method throughout the duration of the experiment.

Data Processing Description

These experiments utilize a combined repeated measures/split-plot design. Temperature and pCO2 represent whole-plot treatments while the reef zone of an individual coral colony represents a split-plot treatment. Hierarchical mixed-effects models were employed to account for this experimental design. Time measurements were treated as nested in corals, and corals were treated as nested in aquaria. Each coral's measured buoyant weight (mg) was divided by its initial surface area (cm2) to yield a normalized weight (mg cm-2). In both the pCO2 and temperature experiments normalized buoyant weight (mg cm-2) was regressed against continuous time and treatment to assess the overall effect of treatment on *S. siderea* calcification rates for the 95-day duration of the experiments. Of interest here was the coefficient of time in the regression model and the extent to which it varied by treatment. Normalized calcification rate (mg cm-2 d-1) was then obtained by extracting the regression coefficient of the continuous time variable in the model. Difference-adjusted confidence intervals were used to provide a simple graphical display of the differences among pCO2 and temperature treatment groups. All mixed models were estimated with the nlme package of R 2.15.2.

BCO-DMO Processing Notes
- Generated from original files "OA_Expt_BW_MBRSCorals.csv" contributed by Karl Castillo

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Data Files

File	
BW_MBRSCorals_OA_Expt.csv	(Comma Separated Values (.csv), 7.01 KB) MD5:38d5cf6ebb36fc055f2551b57c95b72f
Primary data file for dataset ID 4003	

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Parameters

Parameter	Description	Units
No	Number	Integer
Reefzone	Reefzone collection area NS=Neashore BR= Backreef FR=Forereef	text
Colony	Individual *Siderastrea siderea* colony	text
Coral_ID	Individual coral piece from a selected colony The letter represents the colony and the number indicate the number of that piece from that colony	text
Tank_No	Replicate tanks (three per treatment)	integer
pCO2	Partial pressure of mixed CO2 gases used to bubble seawater for the ocean acidification experiments	micro atmospheres
Temperature	Temperature treatment	degrees celsius
Buoyant_Weight_T0	Initial buoyant weight	grams
Buoyant_Weight_T90	Final buoyant weight	grams

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Instruments

Dataset-specific Instrument Name	Microporous Ceramic Airstones
Generic Instrument Name	Airstone
Dataset-specific Description	In the laboratory experiments, Siderastrea siderea coral specimens from each of the 18 colonies were reared for 95 days (5 August − 8 November 2011) in each of twelve 38 L glass aquaria (18 specimens per tank; 216 specimens in total) filled with artificial seawater formulated at a salinity of 35 with Instant Ocean Sea Salt and deionized water. Four pCO2 partial pressures [324, 477, 604, and 2553) ppm)], established by mixing pure CO2 with compressed air using Aalborg mass flow controllers, were bubbled with microporous ceramic airstones into the triplicate glass aquaria (12 tanks total). Coral specimens from each of the 18 colonies were reared in each of the 12 replicate tanks. The pCO2 experiments were maintained at an average temperature of 28 ºC.
Generic Instrument Description	Airstone - Also called an aquarium bubbler, is a piece of aquarium furniture, traditionally a piece of limewood or porous stone, whose purpose is to gradually diffuse air into the tank, eliminating the noise and large bubbles of conventional air filtration systems

Dataset-specific Instrument Name	38 L glass aquaria
Generic Instrument Name	Aquarium
Dataset-specific Description	In the laboratory experiments, Siderastrea siderea coral specimens from each of the 18 colonies were reared for 95 days (5 August − 8 November 2011) in each of twelve 38 L glass aquaria (18 specimens per tank; 216 specimens in total) filled with artificial seawater formulated at a salinity of 35 with Instant Ocean Sea Salt and deionized water. Four pCO2 partial pressures [324, 477, 604, and 2553) ppm)], established by mixing pure CO2 with compressed air using Aalborg mass flow controllers, were bubbled with microporous ceramic airstones into the triplicate glass aquaria (12 tanks total). Coral specimens from each of the 18 colonies were reared in each of the 12 replicate tanks. The pCO2 experiments were maintained at an average temperature of 28 ºC.
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	Aalborg Mass Flow Controller
Generic Instrument Name	Mass Flow Controller
Dataset-specific Description	In the laboratory experiments, Siderastrea siderea coral specimens from each of the 18 colonies were reared for 95 days (5 August − 8 November 2011) in each of twelve 38 L glass aquaria (18 specimens per tank; 216 specimens in total) filled with artificial seawater formulated at a salinity of 35 with Instant Ocean Sea Salt and deionized water. Four pCO2 partial pressures [324, 477, 604, and 2553) ppm)], established by mixing pure CO2 with compressed air using Aalborg mass flow controllers, were bubbled with microporous ceramic airstones into the triplicate glass aquaria (12 tanks total). Coral specimens from each of the 18 colonies were reared in each of the 12 replicate tanks. The pCO2 experiments were maintained at an average temperature of 28 ºC.
Generic Instrument Description	Mass Flow Controller (MFC) - A device used to measure and control the flow of fluids and gases

Dataset-specific Instrument Name	Cole-Parmer Bottom-loading Scale
Generic Instrument Name	scale or balance
Dataset-specific Description	Each coral specimen was suspended by aluminum wire at 10-cm depth from a Cole-Parmer bottom-loading scale (precision ± 0.001; accuracy ± 0.002
Generic Instrument Description	Devices that determine the mass or weight of a sample.

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Deployments

lab_Ries_UNC_Chapel_Hill

Website	https://www.bco-dmo.org/deployment/58723
Platform	Ries
Report	http://www.unc.edu/~jries/index.html
Start Date	2010-09-01
End Date	2099-01-01
Description	The Ries Lab

lab_Ries_Sapodilla_Caye

Website	https://www.bco-dmo.org/deployment/58722
Platform	Ries
Report	http://www.unc.edu/~jries/field_sites.html
Start Date	2010-09-01
End Date	2099-01-01
Description	The Ries Lab - Sapodilla Caye, Belize

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Project Information

Investigation of the Effects of CaCO3 Saturation State and Temperature on the Calcification Rate and Skeletal Properties of Benthic Marine Calcifiers (OA - Ocean Acidification and Warming Impact on Calcification)

Website: http://www.unc.edu/~jries/index.html

Coverage: Chapel Hill, North Carolina (lab) and Mesoamerican Barrier Reef System - Sapodilla Caye, Belize (16.2 N 88.5 W)

Description from NSF award abstract:
Anthropogenic elevation of atmospheric pCO2 is increasing the acidity of the oceans, thereby reducing the saturation state of seawater with respect to calcium carbonate (CaCO3). Of mounting concern is the potential impact of these changes on the ability of calcifying organisms to form their shells and skeletons. Recent studies, including pilot work conducted by investigator Ries and his colleagues on a suite of benthic marine calcifiers spanning broad taxonomic, mineralogical, and ecological ranges, have revealed that marine organisms exhibit a wide range of calcification responses to CO2-induced ocean acidification, including positive, negative, parabolic, threshold, and neutral responses. Marine calcifiers build their shells and skeletons from various forms (polymorphs) of CaCO3, most commonly aragonite, high-Mg calcite, and low-Mg calcite. These polymorphs differ greatly in their solubility in seawater and, therefore, in their potential response to CO2-induced ocean acidification. X-ray diffraction analysis of shells secreted by the organisms investigated in the pilot study reveals that the proportion of calcite (the less soluble form of CaCO3) to aragonite (the more soluble form) within their shells increases under elevated pCO2, while the Mg:Ca ratio of their calcite declines. These observations suggested that some marine calcifiers may partially adapt to a declining CaCO3 saturation state by accreting a greater proportion of the less-soluble form of CaCO3 (low-Mg calcite) at the expense of the more soluble forms (aragonite, high-Mg calcite). However, it is likely that such mineralogical and compositional changes in the shells and skeletons of marine organisms would alter their structural and biomechanical properties.

The project seeks to build upon the results of a pilot study by rearing a suite of benthic marine calcifiers under past (280 ppm), present (385 ppm), and predicted future (540, 840 ppm) pCO2 and under three distinct temperatures to investigate changes in: (1) their rates of calcification and linear extension; (2) the relative abundance and micron-scale distribution of the various CaCO3 polymorphs within their shells/skeletons; (3) the ultrastructure and crystal morphology of their shells/skeletons; and (4) their biomechanical properties. The research also builds upon the pilot experiments by utilizing a more thoroughly replicated study design, by more precisely constraining the chemical parameters of the experimental seawater treatments, by investigating calcification responses under 3 different temperature regimes, and by employing a "pre-industrial" pCO2 level (280 ppm). The results of the proposed research should advance our understanding of how benthic marine calcifiers shall respond to future CO2-induced changes in seawater temperature and CaCO3 saturation state. By investigating the response of organisms over the range of atmospheric pCO2 that has occurred since late Paleozoic time, this research should inform our understanding of the putative links between atmospheric pCO2, mass extinction events, and secular variation in the polymorph mineralogy of marine calcifiers throughout geologic time. Finally, comparison of the observed biological responses to variable pCO2-T scenarios with that already established for abiogenic carbonates will advance our understanding of the very mechanisms by which marine calcifiers build their shells and skeletons.

Results of this research project will inform the decisions of policy makers and legislators working to mitigate the impacts of CO2-induced warming and ocean acidification by establishing pCO2-T tolerances for a range of marine calcifiers.

Note (02 Oct 2014): Funding for this project has transferred from award OCE-1031995 to OCE-1357665, coincident with Principal Investigator's affiliation change from University of North Carolina at Chapel Hill to Northeastern University.

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Program Information

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-1031995
NSF Division of Ocean Sciences (NSF OCE)	OCE-1357665

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