Siderastrea siderea skeletal extension data from Sapodilla Caye, Belize starting 2010 (OA - Ocean Acidification and Warming Impact on Calcification project)

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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)

Contributors	Affiliation	Role
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Dataset Description

Annual skeletal extension for individual *Siderastrea siderea* cores from forereef, backreef, and nearshore reef environments in Belize.

Map showing core extraction sites from Castillo et al. (2011)

Methods & Sampling

Cores were extracted from colonies of *Siderastrea siderea* from the forereef, backreef, and nearshore reef zones of the in southern Belize. Forereef and backreef coral cores were obtained from the Sapodilla Cayes Marine Reserve, on the seaward and shoreward side of the reef crest, respectively. Nearshore coral cores were obtained from within 10 km of the coast in the Port Honduras Marine Reserve. Collection permits were obtained from the Belize Fisheries Department, and all cores were collected and transported pursuant to local, federal, and international regulations. A total of thirteen cores were extracted from thirteen different colonies of *S. siderea* in February of 2009. Seven cores were extracted from forereef colonies, 3 cores from backreef colonies, and 3 cores from nearshore colonies. Cores were extracted by SCUBA divers using a 2-horsepower hand-held pneumatic core drill (CP 315; Chicago Pneumatic; Westfield, Massachusetts) affixed with a hollow extension rod (5 cm in diameter, 90 cm in length) and a wet diamond core bit (5 cm in diameter, 30 cm in length). Compressed air from SCUBA cylinders located on a boat was used to power the pneumatic drill. Drilling each core required a total of 5 to 8 standard size SCUBA cylinders and approximately 30–45 minutes of continuous drilling. Coral cores, approximately 20 to 100 cm in length, and 5 cm in diameter, were collected from the center of each coral colony parallel to the coral's vertical growth axis. Cores were extracted from colonies that appeared healthy and were without any obvious abnormalities, scarring, bleaching, or disease. Coral samples were collected from colonies between depths of 4 and 5 m within each of the three reef zones. After extracting each core, a concrete plug was inserted into the drilled holes and sealed with Zspar underwater epoxy.

Related files and references:
Castillo KD, Ries JB, Weiss JM (2011) Declining Coral Skeletal Extension for Forereef Colonies of Siderastrea siderea on the Mesoamerican Barrier Reef System, Southern Belize. PLoS ONE 6(2): e14615. oi:10.1371/journal.pone.0014615]

Data Processing Description

Statistical analyses were carried out using the nlme package of R 2.9.0, and Proc Mixed of SAS/STAT H software version 9.1 of SAS System for Windows. Rather than assessing and comparing average annual skeletal extension alone, as is commonly described in the literature, our goal was to also describe how rates of change in annual skeletal extension of *S. siderea* varied throughout the last century and amongst the forereef, backreef, and nearshore colonies. A sequence of models was fit to determine how best to describe the structural form of the data and to test the hypotheses of interest. Several models were tested, including (1) an ordinary regression model, (2) a random intercepts model with no predictors (i.e., an unconditional means model), (3) a random intercepts model that includes time as a predictor, (4) a random slopes and intercepts model in which the intercept and coefficient of time (slope) were allowed to be random, (5) a more complex version of model 3 and 4 that included level-2 predictors such as reef zone, (6) a version of model 5 that included a level-1 (residual) correlation structure, and (7) a version of model 6 that possessed a residual correlation structure without additional random effects. The variable year was 'centered' using a centering constant of 1967 because this minimized correlation between the random slopes and intercepts. In general, centering enhances model interpretability and improves numerical stability by increasing the likelihood that the optimization algorithm converges on the correct solution. The estimate of the slope is unchanged by centering, but the intercept will estimate the mean value of the response variable in year 1967 (rather than in year zero of the uncentered model). The role of centering in mixed effects models is discussed in greater detail in O'Connor et al. (2007). Akaike Information Criterion (AIC) was used to identify the best-fit model. AIC provides a measure of the explanatory power of a model discounted by the number of parameters that contributed to its construction; a lower value indicates a better fitting model. Of all the models that were fit, the random intercepts model with an ARMA (1, 1) correlation structure for the residuals yielded the lowest AIC. An ARMA (1, 1) correlation structure combines an autoregressive model of order 1 with a moving average model of order 1. The appropriateness of the ARMA (1, 1) structure was also indicated by patterns observed in plots of the autocorrelation and partial autocorrelation functions of the residuals.

BCO-DMO Processing Notes
- Generated from original files Siderastrea siderea skeletal extension.csv" contributed by Karl Castillo
- Parameter names edited to conform to BCO-DMO naming convention found at Choosing Parameter Name

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Data Files

File
Skeletal_Extension.csv (Comma Separated Values (.csv), 7.01 KB) MD5:b77b5b39ac5450763d1ef416bf5c7c91 Primary data file for dataset ID 564260

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Parameters

Parameter	Description	Units
Year	Year of data collection	YYYY
FR_02	Skeletal growth data from forereef FR-02 reef zone	cm
FR_04	Skeletal growth data from forereef FR-04 reef zone	cm
FR_05	Skeletal growth data from forereef FR-05 reef zone	cm
FR_09	Skeletal growth data from foreeef FR-09 reef zone	cm
FR_11	Skeletal growth data from forereef FR-11 reef zone	cm
FR_12	Skeletal growth data from foreeef FR-12 reef zone	cm
FR_13	Skeletal growth data from forereef FR-13 reef zone	cm
BR_06	Skeletal growth data from backreef BR-06 reef zone	cm
BR_07	Skeletal growth data from backreef BR-07 reef zone	cm
BR_08	Skeletal growth data from backreef BR-08 reef zone	cm
NS_14	Skeletal growth data from nearshore NR-14 reef zone	cm
NS_15	Skeletal growth data from nearshore NR-15 reef zone	cm
NS_16	Skeletal growth data from nearshore NR-16 reef zone	cm

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Instruments

Dataset-specific Instrument Name	SCUBA and hand-held pneumatic core drill
Generic Instrument Name	Manual Biota Sampler
Dataset-specific Description	Cores were extracted by SCUBA divers using a 2-horsepower hand-held pneumatic core drill (CP 315; Chicago Pneumatic; Westfield, Massachusetts) affixed with a hollow extension rod (5 cm in diameter, 90 cm in length) and a wet diamond core bit (5 cm in diameter, 30 cm in length). Compressed air from SCUBA cylinders located on a boat was used to power the pneumatic drill. Drilling each core required a total of 5 to 8 standard size SCUBA cylinders and approximately 30–45 minutes of continuous drilling. Coral cores, approximately 20 to 100 cm in length, and 5 cm in diameter, were collected from the center of each coral colony parallel to the coral's vertical growth axis. Cores were extracted from colonies that appeared healthy and were without any obvious abnormalities, scarring, bleaching, or disease. Coral samples were collected from colonies between depths of 4 and 5 m within each of the three reef zones. After extracting each core, a concrete plug was inserted into the drilled holes and sealed with Zspar underwater epoxy.
Generic Instrument Description	"Manual Biota Sampler" indicates that a sample was collected in situ by a person, possibly using a hand-held collection device such as a jar, a net, or their hands. This term could also refer to a simple tool like a hammer, saw, or other hand-held tool.

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Deployments

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 CO_2-induced warming and ocean acidification by establishing pCO_2-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 CO_2 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
National Oceanic and Atmospheric Administration (NOAA)	NA11OAR431016
National Oceanic and Atmospheric Administration (NOAA)	NA13OAR4310186

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