Raw coral extension, density, and calcification data from Castillo lab research in Belize, 2009, 2012, and 2015

Website: https://www.bco-dmo.org/dataset/734491
Data Type: Other Field Results
Version: 1
Version Date: 2018-04-16

Project
» Investigating the influence of thermal history on coral growth response to recent and predicted end-of-century ocean warming across a cascade of ecological scales (Thermal History and Coral Growth)

Contributors	Affiliation	Role
Castillo, Karl D.	University of North Carolina at Chapel Hill (UNC-Chapel Hill)	Principal Investigator
Baumann, Justin	University of North Carolina at Chapel Hill (UNC-Chapel Hill)	Student, Contact
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset contains raw extension, density, and calcification data from corals sampled by the Castillo lab in Belize in 2009, 2012, and 2015.

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Coverage

Spatial Extent: **N**:18.000056 **E**:-87.557139 **S**:16.0917 **W**:-88.62881
Temporal Extent: 2009 - 2015

Dataset Description

This dataset contains raw extension, density, and calcification data from corals sampled by the Castillo lab in Belize in 2009, 2012, and 2015. These data are presented in Baumann et al (2019).

Methods & Sampling

Coral core extraction

Cores were extracted by SCUBA divers using a pneumatic core drill [1] in 2009 or a hydraulic drill (Chicago Pneumatic COR 5 in 2012 or CS Unitec model 2 1335 0010, 3.8 HP) in 2015, both equipped with a 5 cm diameter diamond-tipped core bit [1] Backreef S. siderea cores collected in 2015 were collected using a pneumatic drill with a 2.5 cm diameter diamond-tipped core bit due to permitting restrictions. All cores were extracted from colonies that appeared healthy (i.e., no bleaching, abnormalities, scarring, or disease) near the center of each colony. Cores were extracted parallel to the growth axis of each colony and spanned the entire height of the colony, with the exception of the backreef S. siderea cores collected in 2015 that ranged from

10-50 cm—spanning only the upper portion of the colony. Overall, core lengths ranged from 10 cm to > 1 m. After extracting each core, a concrete plug was inserted into the drilled hole and sealed with Z-spar underwater epoxy to prevent bioerosion. Epoxy was only placed on the skeleton and the concrete to avoid damage to the living tissue surrounding the hole. Cores were rinsed in ethanol, stored in PVC tubes for transport, and transported to the University of North Carolina at Chapel Hill for analysis. Collection permits were obtained from the Belize Fisheries Department and all cores were collected and transported pursuant to local, federal, and international regulations.

Coral CT Procedures

Coral cores collected in 2009 and 2012 were CT-scanned on a Siemens Somatom Definition AS (120 kV, 300 mAs, 0.6 mm slice thickness) [2-4] at Wake Radiology Chapel Hill in 2013 using methods modified from Carilli et al. [3] and De'ath et al. [5]. Briefly, whole (i.e., unslabbed) cores were CT scanned with the growth axis oriented perpendicular to the length of the CT table. The resulting CT scans were uploaded to the DICOM viewing program Osirix for further analysis following methods modified from Carilli et al. [3]. Transects were drawn parallel to the core growth axis using the "length" tool in Osirix. and within the exothecal space between corallite walls in order to standardize density measurements between transects and cores. Transects were performed in triplicate for each length of the core in order to establish an average, exported to XML, and read into the program RUNNINGCORALGUI, which identified the local density extrema (in Hounsfield units) of the data in each XML file. The locations of these local extrema were then quantified via pixel counting, with halfway points between local extrema defining the boundaries of low and high-density bands. The number of pixels between these halfway points and the average density in Hounsfield units was quantified for the set of pixels between the halfway points. The linear extension of each seasonal light and dark band was then quantified from the total length of the line tool data in pixels, which was then converted to cm.

Coral cores from 2015 were CT scanned on a Siemens Biograph mCT (120 kV, 250 mAs, 0.6 mm slice thickness) at UNC Biomedical Research Imaging Center (BRIC). CT images were reconstructed at 0.1 mm increments using the H70h "very sharp spine" window. All images were exported from the scanner as DICOM files, which were then read into the medical image viewer Horos v2.0.2 (open-source version of Osirix). Semiannual density bands were visualized using a 10-mm thick "Mean" projection oriented through the center of the core. In place of RUNNINGCORALGUI, all boundaries between high- and low-density bands were delineated manually and three sets of linear transects were drawn down the length of the cores using the ROI tool in Horos. Each set of transects was drawn within the exothecal space between corallite walls in order to standardize density measurements between cores and avoid abnormal density spikes in areas where the transect crossed a high-density corallite wall. By-pixel density measurements were then extracted from linear transects and average density was calculated for each semiannual density band. Linear extension (cm) was measured in Horos as the width of each density band, and calcification (g/cm2) was calculated as the product of average density and linear extension.

Coral core density standardization

Nine coral standards were used for density calibration. These standards were pieces of various coral species from the Caribbean that had the same width as the coral cores. Volume and mass of these standards were calculated with calipers and a Mettler Toledo XPE205 analytical balance. Real-world density for each standard was calculated as mass (determined by Mettler Toledo XPE205 analytical balance) divided by volume. The nine internal density standards were scanned along with the cores at least once per scanning session (3-4 scans were completed during each 1-2 hour scanning session). A standard curve was developed for each scanning session that related Houndsfield density (measured from CT scan) to actual coral density (g/cm3), similar to DeCarlo et al. [6].

1. Castillo et al (2011)
2. Saenger et al (2009)
3. Carilli et al (2012)
4. Cantin et al (2010)
5. De'ath G. et al (2009)
6. DeCarlo et al (2015)

Data Processing Description

BCO-DMO Processing Notes:
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions

- reduced number of significant digits from 9 to 6 to meet sampling precision methods for these parameters: density_g_cm3, density_SE, extension_cm, extension_SE, calcification_g_cm2, calc_SE

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Data Files

File
Belize_core.csv (Comma Separated Values (.csv), 903.71 KB) MD5:7465c29cd8ba04caeef8e36d882bd147 Primary data file for dataset ID 734491

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Related Publications

Baumann, J. H., Ries, J. B., Rippe, J. P., Courtney, T. A., Aichelman, H. E., Westfield, I., & Castillo, K. D. (2019). Nearshore coral growth declining on the Mesoamerican Barrier Reef System. Global Change Biology, 25(11), 3932–3945. doi:10.1111/gcb.14784
Results

Cantin, N. E., Cohen, A. L., Karnauskas, K. B., Tarrant, A. M., & McCorkle, D. C. (2010). Ocean Warming Slows Coral Growth in the Central Red Sea. Science, 329(5989), 322–325. doi:10.1126/science.1190182
Methods

Carilli, J., Donner, S. D., & Hartmann, A. C. (2012). Historical Temperature Variability Affects Coral Response to Heat Stress. PLoS ONE, 7(3), e34418. doi:10.1371/journal.pone.0034418
Methods

Castillo, K. D., Ries, J. B., & Weiss, J. M. (2011). Declining Coral Skeletal Extension for Forereef Colonies of Siderastrea siderea on the Mesoamerican Barrier Reef System, Southern Belize. PLoS ONE, 6(2), e14615. doi:10.1371/journal.pone.0014615
Methods

DeCarlo, T. M., Cohen, A. L., Barkley, H. C., Cobban, Q., Young, C., Shamberger, K. E., Brainard R.E., Golbuu, Y. (2015). Coral macrobioerosion is accelerated by ocean acidification and nutrients. Geology, 43(1), 7–10. doi:10.1130/g36147.1 https://doi.org/10.1130/G36147.1
Methods

De'ath, G., Lough, J. M., & Fabricius, K. E. (2009). Declining Coral Calcification on the Great Barrier Reef. Science, 323(5910), 116–119. doi:10.1126/science.1165283
Methods

Saenger, C., Cohen, A. L., Oppo, D. W., Halley, R. B., & Carilli, J. E. (2009). Surface-temperature trends and variability in the low-latitude North Atlantic since 1552. Nature Geoscience, 2(7), 492–495. doi:10.1038/ngeo552
Methods

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Parameters

Parameter	Description	Units
core_ID	core sample identifier	unitless
species	Atlantic and Gulf Rapid Reef Assessment (AGRRA) coral codes	unitless
site	site idenifier: nearby city name and reef zone	unitless
type	thermal regime code: 1=lowTP; 2=modTP; 3=highTP. These 3 categories are based on low; moderate; and high temperature parameters (see Baumann et al 2016 for details)	unitless
reef_zone	reef zone: ABR=atoll back reef ; AFR=atoll fore reef ; BR=back reef ; FR=fore reef ; NS=near shore	unitless
transect	transect identifier	unitless
core_diameter	diameter of core sample	centimeters
lat	latitude; north is positive	decimal degrees
long	longitude; east is positive	decimal degrees
year_collected	year sample was collected	unitless
year_growth	the year of growth referred to using CT images to line up banding patterns with years of growthyear of ?	unitless
density_g_cm3	density of coral core sample; available for 2015 samples only	grams/centimeter^3
density_SE	standard error of coral density	grams/centimeter^3
extension_cm	linear extension of each seasonal light and dark band pair in coral core	centimeters
extension_SE	standard error of extension values	centimeters
calcification_g_cm2	calcification of coral core sample; available for 2015 samples only	grams/centimeter^2
calc_SE	standard error of calcification	grams/centimeter^2
species_code	code for taxonomic genus and species name.	unitless

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Instruments

Dataset-specific Instrument Name	Siemens Biograph mCT (120 kV, 250 mAs, 0.6 mm slice thickness) at UNC Biomedical Research Imaging Center (BRIC)
Generic Instrument Name	Computerized Tomography (CT) Scanner
Dataset-specific Description	Used to collect coral slice densities measurements.
Generic Instrument Description	A CT scan makes use of computer-processed combinations of many X-ray measurements taken from different angles to produce cross-sectional (tomographic) images (virtual "slices") of specific areas of a scanned object.

Dataset-specific Instrument Name	core drill
Generic Instrument Name	Drill Core
Dataset-specific Description	A pneumatic core drill or a hydraulic drill (Chicago Pneumatic COR 5 or CS Unitec model 2 1335 0010, 3.8 HP) with a 5 cm diameter diamond tipped core bit. Back reef S. siderea cores collected in 2015 were collected using a pneumatic drill with a 2.5 cm diameter diamond tipped core bit.
Generic Instrument Description	A core drill is a drill specifically designed to remove a cylinder of material, much like a hole saw. The material left inside the drill bit is referred to as the core. Core drills are used frequently in mineral exploration where the coring may be several hundred to several thousand feet in length. The core samples are recovered and examined by geologists for mineral percentages and stratigraphic contact points. This gives exploration companies the information necessary to begin or abandon mining operations in a particular area.

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Project Information

Investigating the influence of thermal history on coral growth response to recent and predicted end-of-century ocean warming across a cascade of ecological scales (Thermal History and Coral Growth)

Website: http://www.unc.edu/~kdcastil/research.html

Coverage: Western Caribbean

Description from NSF award abstract:
Rising global ocean surface temperatures have reduced coral growth rates, thereby negatively impacting the health of coral reef ecosystems worldwide. Recent studies on tropical reef building corals reveal that corals' growth in response to ocean warming may be influenced by their previous seawater temperature exposure - their thermal history. Although these recent findings highlight significant variability in coral growth in response to climate change, uncertainty remains as to the spatial scale at which corals' thermal history influences how they have responded to ocean warming and how they will likely respond to predicted future increases in ocean temperature. This study investigates the influence of thermal history on coral growth in response to recent and predicted seawater temperatures increases across four ecologically relevant spatial scales ranging from reef ecosystems, to reef communities, to reef populations, to an individual coral colony. By understanding how corals have responded in the past across a range of ecological scales, the Principal Investigator will be able to improve the ability to predict their susceptibility and resilience, which could then be applied to coral reef conservation in the face of climate change. This research project will broaden the participation of undergraduates from underrepresented groups and educate public radio listeners using minority voices and narratives. The scientist will leverage current and new partnerships to recruit and train minority undergraduates, thus allowing them to engage high school students near field sites in Florida, Belize, and Panama. Through peer advising, undergraduates will document this research on a digital news site for dissemination to the public. The voice of the undergraduates and scientist will ground the production of a public radio feature exploring the topic of acclimatization and resilience - a capacity for stress tolerance within coral reef ecosystems. This project will provide a postdoctoral researcher and several graduate students with opportunities for field and laboratory research training, teaching and mentoring, and professional development. The results will allow policy makers from Florida, the Mesoamerican Barrier Reef System countries, and several Central American countries to benefit from Caribbean-scale inferences that incorporate corals' physiological abilities, thereby improving coral reef management for the region.

Coral reefs are at significant risk due to a variety of local and global scale anthropogenic stressors. Although various stressors contribute to the observed decline in coral reef health, recent studies highlight rising seawater temperatures due to increasing atmospheric carbon dioxide concentration as one of the most significant stressors influencing coral growth rates. However, there is increasing recognition of problems of scale since a coral's growth response to an environmental stressor may be conditional on the scale of description. This research will investigate the following research questions: (1) How has seawater temperature on reef ecosystems (Florida Keys Reef Tract, USA; Belize Barrier Reef System, Belize; and Bocas Del Toro Reef Complex, Panama), reef communities (inshore and offshore reefs), reef populations (individual reefs), and near reef colonies (individual colonies), varied in the past? (2) How has seawater temperature influenced rates of coral growth and how does the seawater temperature-coral growth relationship vary across these four ecological spatial scales? (3) Does the seawater temperature-coral growth relationship forecast rates of coral growth under predicted end-of-century ocean warming at the four ecological spatial scales? Long term sea surface temperature records and small-scale high-resolution in situ seawater temperature measurements will be compared with growth chronologies for the reef building corals Siderastrea siderea and Orbicella faveolata, two keystone species ubiquitously distributed throughout the Caribbean Sea. Nutrients and irradiance will be quantified via satellite-derived observations, in situ measurements, and established colorimetric protocols. Field and laboratory experiments will be combined to examine seawater temperature-coral growth relationships under recent and predicted end-of-century ocean warming at four ecologically relevant spatial scales. The findings of this study will help us bridge the temperature-coral growth response gap across ecologically relevant spatial scales and thus improve our understanding of how corals have responded to recent warming. This will lead to more meaningful predictions about future coral growth response to climate change.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1459522

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