Comparison of bleaching data to stress bands in Porites corals on Palau reefs

Website: https://www.bco-dmo.org/dataset/709454
Data Type: Other Field Results
Version: 1
Version Date: 2017-07-21

Project
» Constraining Thermal Thresholds and Projections of Temperature Stress on Pacific Coral Reefs Over the 21st Century: Method Refinement and Application (Thermal Thresholds and Projections)

Contributors	Affiliation	Role
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Abstract
Comparison of bleaching data to stress bands in Porites corals on Palau reefs.

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Coverage

Spatial Extent: **N**:7.822 **E**:134.562 **S**:7.16 **W**:134.22
Temporal Extent: 1998-01-01 - 2010-12-31

Dataset Description

Comparison of bleaching data to stress bands in Porites corals on Palau reefs

These data were originally published in figure 4 of:
H.C. Barkley, A.L. Cohen. Skeletal stress markers in *Porites* corals estimate coral reef community bleaching. Coral Reefs, 35, 1407-1417 (2016). doi:10.1007/s00338-016-1483-3

Methods & Sampling

Coral skeletal core collection: We collected 101 skeletal cores from massive *Porites* coral colonies at ten reef sites representing two major reef environments, barrier reef and lagoon, the latter including fringing reefs around the uplifted karst Rock Islands. The two environments are broadly distinguishable in both physical (flow, temperature, and light regimes) and chemical (carbon system parameters, salinity) characteristics with generally higher flow, light, pH, and salinity and lower SST on the barrier reefs (Shamberger et al. 2014; Barkley et al. 2015).

Skeletal cores (20-40 cm in length) were collected in April 2011, September 2011, April 2012, August 2014, and January 2015 vertically from live coral colonies at 1-6 m depth using pneumatic drills with 3.8 cm diameter diamond drill bits. Core holes were filled with cement plugs hammered flush with the colony surface and sealed with underwater epoxy. Visual inspections of colonies 6-12 months after coring revealed significant overgrowth of plugs and no long-term impacts to the corals. Coral cores were oven-dried and scanned with a Siemens Volume Zoom Helical Computerized Tomography (CT) Scanner at Woods Hole Oceanographic Institution. 3-D CT scans of coral cores were analyzed using OsiriX freeware to visualize the 3-D image (Cantin et al. 2010; Crook et al. 2013) and an automated MATLAB code to quantify skeletal growth parameters and stress banding (DeCarlo et al. 2015).

Stress bands: Coral cores that included growth records prior to 1998 were assessed for the presence of high-density stress bands associated with elevated temperatures in 1998 (n = 86), and all cores were examined for stress bands in 2010. A stress band was defined as a region of the coral core > 1 mm in height and extending the entire width of the core where density values exceeded two standard deviations of the whole-core density mean. We defined a minimum band thickness in order to filter out smaller-scale density variability and high-density noise. A value of 1 mm for this thickness threshold was selected based on the average linear extension rates of Palau *Porites* corals (0.88 cm yr^{-1}, interquartile range = 0.35 cm yr^{-1}), where 1 mm represents, on average, approximately 10% of overall annual linear extension. High-density anomalies of this width therefore represent significant perturbations in growth. Density thresholds were set based on standard deviations from mean values in order to account for significant differences in density means and variability between individuals. Density values were normally distributed within coral cores, and values greater than two standard deviations were defined as the threshold for a stress band. This threshold was selected to aid in the identification of only the most anomalously high-density areas (i.e., areas with densities greater than approximately 95% of all values) while also minimizing the probability of type II errors in coral cores where stress bands exist but high-density values are slightly less extreme. Stress bands were identified as occurring within a particular year (specifically, 1998 and 2010) based on annual patterns of density banding, in which successive low density bands were counted down from the top of the core and subsequently dated based on the known date of collection. Although a small number of coral skeletal cores had occasional high-density regions in additional years, we did not consistently detect stress bands corresponding to years other than 1998 and 2010.

The percentage of *Porites* corals with stress bands was compared with community bleaching data for each reef site collected during the 1998 and 2010 high-temperature events. Bleaching data from 1998 were collected at nine reef sites in November 1998 using a point-intercept technique with three replicate 20-m transect surveys per site conducted at 3-5 m depth (Bruno et al. 2001). A subset of six of these nine sites was used to compare bleaching data to stress band records based on proximity to our core collection sites. Data from 2010 were collected at 80 randomly assigned reef sites in July and August 2010 with three replicate 30-m transect surveys conducted at 2-5 m depth (van Woesik et al. 2012). A subset of 31 of these sites was included in this study. Because *in situ* bleaching data were collected at randomized locations, the spatial matches between sites with bleaching data and sites with coral cores were not always exact. Therefore, for each coral core collection site, we averaged bleaching data from the two or three sites that both fell within a 10-km radius of each core site and that represented the same environment type to calculate a community bleaching estimate. Bleaching information about specific coral colonies from which we collected cores was not available.

Data Processing Description

BCO-DMO Processing:
- modified parameter names to comply with BCO-DMO naming conventions;
- replaced spaces with underscores;
- added site lats and lons obtained from the Supplmentary Material to Barkley and Cohen (2016).

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Data Files

File
stress_band_bleaching.csv (Comma Separated Values (.csv), 1.13 KB) MD5:1ceb8cfb1be6109b0c19e544d7dc5b75 Primary data file for dataset ID 709454

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Related Publications

Barkley, H. C., & Cohen, A. L. (2016). Skeletal records of community-level bleaching in Porites corals from Palau. Coral Reefs, 35(4), 1407–1417. doi:10.1007/s00338-016-1483-3
Results
,
Methods

Barkley, H. C., Cohen, A. L., Golbuu, Y., Starczak, V. R., DeCarlo, T. M., & Shamberger, K. E. F. (2015). Changes in coral reef communities across a natural gradient in seawater pH. Science Advances, 1(5), e1500328–e1500328. doi:10.1126/sciadv.1500328
Methods

Barkley, H. C., Cohen, A. L., McCorkle, D. C., & Golbuu, Y. (2017). Mechanisms and thresholds for pH tolerance in Palau corals. Journal of Experimental Marine Biology and Ecology, 489, 7–14. doi:10.1016/j.jembe.2017.01.003
General

Bruno, J., Siddon, C., Witman, J., Colin, P., & Toscano, M. (2001). El Niño related coral bleaching in Palau, Western Caroline Islands. Coral Reefs, 20(2), 127–136. doi:10.1007/s003380100151
Methods

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

Crook, E. D., Cohen, A. L., Rebolledo-Vieyra, M., Hernandez, L., & Paytan, A. (2013). Reduced calcification and lack of acclimatization by coral colonies growing in areas of persistent natural acidification. Proceedings of the National Academy of Sciences, 110(27), 11044–11049. doi:10.1073/pnas.1301589110
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

Shamberger, K. E. F., Cohen, A. L., Golbuu, Y., McCorkle, D. C., Lentz, S. J., & Barkley, H. C. (2014). Diverse coral communities in naturally acidified waters of a Western Pacific reef. Geophysical Research Letters, 41(2), 499–504. doi:10.1002/2013gl058489 https://doi.org/10.1002/2013GL058489
Methods

Van Woesik, R., Houk, P., Isechal, A. L., Idechong, J. W., Victor, S., & Golbuu, Y. (2012). Climate-change refugia in the sheltered bays of Palau: analogs of future reefs. Ecology and Evolution, 2(10), 2474–2484. doi:10.1002/ece3.363
Methods

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Parameters

Parameter	Description	Units
site	Name of reef site where cores were collected	unitless
reef_type	Reef environment at core collection site (Barrier or Lagoon)	unitless
latitude	Latitude of the reef site; North = positive	decimal degrees
longitude	Longitude of the reef site; East = positive	decimal degrees
year	Year for which stress bands and bleaching data were analyzed	unitless
num_cores	Number of cores analyzed	unitless
pcnt_stress_bands	Percent of coral cores containing stress bands	unitless (percent)
pcnt_stress_bands_SE	Standard error of proportion for percent of coral cores containing stress bands	unitless (percent)
mean_pcnt_bleaching	Mean observed community bleaching levels	unitless (percent)
mean_pcnt_bleaching_SE	Standard error of mean observed community bleaching levels	unitless (percent)

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Instruments

Dataset-specific Instrument Name	Siemens Volume Zoom Helical Computerized Tomography (CT) Scanner
Generic Instrument Name	Computerized Tomography (CT) Scanner
Dataset-specific Description	Siemens Volume Zoom Helical Computerized Tomography (CT) Scanner
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.

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Deployments

Palau_reefs_2011-13

Website	https://www.bco-dmo.org/deployment/489112
Platform	PICRC Small Boats
Start Date	2011-09-19
End Date	2013-11-12
Description	Between September 2011 and November 2013, samples were collected from sites throughout the Palauan archipelago. Sampling was performed from small boats taken out daily from the Palau International Coral Reef Center (PICRC). Sampling was done as part of the project, "An Investigation of the Role of Nutrition in the Coral Calcification Response to Ocean Acidification".

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Project Information

Constraining Thermal Thresholds and Projections of Temperature Stress on Pacific Coral Reefs Over the 21st Century: Method Refinement and Application (Thermal Thresholds and Projections)

Description from NSF award abstract:
Sea surface temperature (SST) across much of the global tropics has increased by 0.5-1 degrees C in the past 4 decades and, with it, the frequency and geographic extent of coral bleaching events and reef mortality. As levels of atmospheric CO2 continue to rise, there is mounting concern that CO2-induced climate change will pose the single greatest threat to the survival of coral reefs. Averaged output of 21 IPCC climate models for a mid-range CO2 emissions scenario predicts that tropical SSTs will increase another 1.5-3 degrees C by the end of this century. Combined with current estimates of thermal thresholds for coral bleaching, the outlook for the future of coral-reef ecosystems, worldwide, appears bleak. There are several key issues that limit accurate predictions of the full and lasting impact of rising SSTs. These include (1) level of confidence in the spatial and temporal patterns of the predicted warming, (2) knowledge of thermal thresholds of different reef-building coral species, and (3) the potential for corals to increase resistance to thermal stress through repeated exposure to high temperature events.

New skeletal markers have been developed that constrain the thermal thresholds and adaptive potential of multiple, individual coral colonies across 3-D space and through time. The method, based on 3-D CAT scan reconstructions of coral skeletons, has generated initial data from two coral species in the Red Sea, Great Barrier Reef and Phoenix Islands. Results showed that large, abrupt declines in skeletal growth occur at thresholds of accumulated heat stress defined by NOAA's Degree Heating Weeks Index (DHWs). In addition, there was a significant correlation between host lipid reserve, an independent measure of stress and mortality risk, and rates of skeletal growth. Because the coral skeleton archives the history of each coral's response to and recovery from successive, documented thermal anomalies, this approach pinpoints the thermal thresholds for sub-lethal impacts, the recovery time (if any) following a return to normal oceanographic conditions, and tests for a dampened response following successive events, indicative of acclimation.

This research program builds on initial work, focusing on method refinement and application to corals on two central Pacific reefs. With contrasting thermal histories, these reefs are considered at greatest risk from future ocean warming. In parallel, new experiments will be run on an ocean general-circulation model (OGCM) that is well suited to the tropical Pacific and of sufficiently high resolution, both horizontal and vertical, to maximize projections of thermal stress on specific central Pacific Reef sites over the next few decades. The OGCM output will also be of sufficient temporal resolution to compute DHWs, thus addressing a major limitation of the direct application of global climate model output (as archived for the IPCC AR4) toward coral-reef studies. Specifically, this study will: (1) collect multiple new, medium-length (15-30 yrs) cores and branches from two dominant reef-building species at 1-30m depth in the Gilbert and Jarvis Islands, central tropical Pacific; (2) apply 3-D CAT scanning and image analysis techniques to quantify systematically thermal thresholds, rates of recovery and resilience for each species, at each reef site and with depth; (3) quantify energetic reserve and symbiont genotype amongst thermally more- and less- resilient colonies, establishing a quantitative link between calcification stress and mortality risk, and determining the physiological basis for calcification responses to thermal stress; (4) use an OGCM specifically tailored to the tropical Pacific to produce a dynamically consistent set of forecasts for near-term climate change at the target reef sites; and (5) combine coral data with model output and refine the projected thermal stress forecast, in degree heating weeks, for corals in this central Pacific Island group over the 21st century.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1031971

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