Coral skeletal carbon and oxygen isotopes; measured photosynthesis to respiration ratios; isotope-based photosynthesis to respiration ratios from reef field sites in Puerto Morelos, Mexico & Kaneohe Bay, Hawaii

Website: https://www.bco-dmo.org/dataset/551060
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Project
» Physiology and Biogeochemistry of Repeatedly Bleached and Recovering Caribbean Corals (repeat coral bleaching)

Contributors	Affiliation	Role
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Dataset Description

Coral original and corrected skeletal carbon and oxygen isotopes; original and corrected measured photosynthesis to respiration ratios; original and corrected isotope-based photosynthesis to respiration ratios. *Orbicella faveolata, Porites astreoides*, and *Porites divaricata* were collected at Puerto Morelos, Mexico (20°50'N, 86°52'W). *Porites compressa, Montipora capitata,* and *Porites lobata* were collected at Kaneohe Bay, Hawaii (21°26.18'N, 157°47.56'W).

Methods & Sampling

Full details of the experimental design and analytical methods are in:
Schoepf V, Levas SJ, Rodrigues LJ, McBride M, Aschaffenburg MD, Matsui Y, Warner ME, Hughes AD, Grottoli AG. 2014. Kinetic and metabolic isotope effects in coral skeletal carbon isotopes: A re-evaluation using experimental coral bleaching as a case study. Geochimica et Cosmochimica Acta, 146: 164-178. doi:10.1016/j.gca.2014.09.033

A brief description of the methods follows:

Pacific coral bleaching experiments
A detailed description of the first bleaching experiment in Hawaii can be found in Rodrigues and Grottoli (2006). Briefly, coral fragments from branching *Porites compressa* and branching *Montipora capitata* were collected from Point Reef, Kaneohe Bay, Hawaii in late August 2003 from 2 m depth. After allowing them to acclimate for two weeks, half of all fragments were placed in shaded outdoor tanks with ambient seawater (26.8 degrees C

+/- 0.04 SE) (non-bleached controls), while the other half were placed in tanks with elevated temperature seawater (30.1 degrees C +/- 0.05 SE) (bleached corals). Temperature was gradually elevated over the course of three days. Corals were not fed during the experiment, and inflow pipes were fitted with a 50 um-filter. To minimize positional effects, corals were rotated within and among tanks of the same treatment daily. After one month, 25% of all treatment and control fragments were collected and frozen for isotopic analyses (= 0 month recovery), whereas the remaining corals were placed back on the reef to recover *in situ*. To assess short and long term recovery, a third of all remaining treatment and control corals were collected after 1.5, 4, and 8 months, respectively. A second, similar bleaching experiment was performed in summer 2006 to assess bleaching impacts on mounding *Porites lobata*.

Caribbean coral bleaching experiment
Coral fragments of mounding *Orbicella faveolata* (formerly *Montastraea faveolata*), encrusting to mounding *Porites astreoides*, and branching *Porites divaricata* were collected in July 2009 from shallow reefs (3–8 m) near Puerto Morelos Reefs National Park, Mexico. After allowing them to acclimate for 5 days, half of the coral fragments were placed in tanks with ambient seawater temperature (30.66 +/- 0.24 degrees C) (nonbleached controls), while the other half were placed in tanks with elevated temperature seawater (31.48 +/- 0.20 degrees C) (bleached corals). Seawater temperature in the treatment tanks was gradually elevated over the course of seven days. Corals were not fed, but had access to unfiltered seawater. Fragments were rotated daily within and among tanks of the same treatment to minimize any positional effects. After a total of 15 days, temperature in all tanks was returned to ambient levels, and all coral fragments were placed on the back reef to recover *in situ* for one full year. In July 2010, the bleaching treatment was repeated using the same experimental protocol. To assess short- and long-term recovery from repeat bleaching, one fragment from each colony and treatment was recollected from the reef after 1.5 and 11 months of recovery and then frozen for isotopic analyses.

Photosynthesis to respiration ratios
Net photosynthesis (P) and day respiration (R) rates were measured by quantifying changes in dissolved oxygen by incubating non-bleached and bleached corals in UV-transparent acrylic chambers under light and dark conditions. Refer to Schoepf et al. 2014 Geochimica et Cosmochimica Acta (doi:10.1016/j.gca.2014.09.033) for equations used in calculations (equation 1).

Isotopic analyses
Seawater dissolved inorganic carbon (DIC) isotopes: A total of nine filtered seawater samples from Kaneohe Bay, Hawaii, were collected throughout 2006/07 for d13CDIC analyses. They were preserved with anhydrous HgCl. In the laboratory, each sample was acidified on a vacuum extraction line under high-purity helium flow, with the resulting CO2 gas cryogenically isolated under vacuum, and the DIC concentration was determined. The CO2 from each DIC sample was sealed in Pyrex ampoules and introduced into a Finnigan Delta IV Stable Isotope Ratio Mass Spectrometer (SIRMS) via an automated 10-port inlet. All d13C values were reported as per mil values relative to Vienna-Pee Dee Belemnite limestone standard (v-PDB). d13CDIC analyses were not performed for seawater from Puerto Morelos, Mexico.

Tissue and skeletal isotopes: A detailed description of the isotopic analyses for the Pacific corals can be found in Rodrigues and Grottoli (2006) and Levas et al. (2013), and for the Caribbean corals in Schoepf (2013).

Data correction: Coral skeletal carbon isotopes (d13Csorig) were corrected (d13Cscorr) using skeletal oxygen isotopes (d18Os) to remove kinetic effects according to the equation developed by Heikoop et al. (2000). Refer to equation 2 of Schoepf et al. 2014 Geochimica et Cosmochimica Acta (doi:10.1016/j.gca.2014.09.033).

Carbon isotopic equilibrium: Carbon isotopic equilibrium (d13Ceq) for aragonite was calculated following the precedence of McConnaughey et al. (1997) and Heikoop et al. (2000) using the equation of Romanek et al. (1992). Refer to equation 3 of Schoepf et al. 2014 Geochimica et Cosmochimica Acta (doi:10.1016/j.gca.2014.09.033).

Oxygen isotopic equilibrium: Two different methods, Grossman and Ku (1986) and Maier (2004), exist in the literature to calculate oxygen isotopic equilibrium in carbonates (d18Oeq), where only Grossman and Ku (1986) incorporate temperature-dependent fractionation. Both methods were used in this study. Refer to equations 4 and 5 of Schoepf et al. 2014 Geochimica et Cosmochimica Acta (doi:10.1016/j.gca.2014.09.033).

Isotope-based P/R ratios: P/R ratios were calculated from skeletal and tissue isotopes according following the equations of Maier (2004) and Kaandorp et al. (2005). Refer to equations 6 and 7 of Schoepf et al. 2014 Geochimica et Cosmochimica Acta (doi:10.1016/j.gca.2014.09.033).

Data Processing Description

All samples of *Orbicella faveolata, Porites astreoides, Porites divaricata* and *Porites lobata* were processed at The Ohio State University, Columbus, OH, USA. All samples of *Porites compressa* and *Montipora capitata* were processed at the University of Pennsylvania, Philadelphia, PA, USA.

Details of the statistical analysis methods are in Schoepf et al. 2014 Geochimica et Cosmochimica Acta (doi:10.1016/j.gca.2014.09.033).

There were three outliers not included in the final analysis; those values have been replaced with 'nd' in the dataset.

BCO-DMO edits:
- Modified parameter names to conform with BCO-DMO naming conventions.
- Replaced spaces with underscores in the species column.
- Replaced '.' with 'nd' to indicate 'no data'.
- Added lat/lon of collection site from the metadata form.

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Data Files

File
coral_skel_isotopes.csv (Comma Separated Values (.csv), 36.91 KB) MD5:9276c5a2a7d875b3b618ec6ace5e0742 Primary data file for dataset ID 551060

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Parameters

Parameter	Description	Units
region	Name of the region where samples were collected.	unitless
site_name	Name of the site where samples were collected.	unitless
lat	Latitude of the collection site. Positive values = North.	decimal degrees
lon	Longitude of the collection site. Positive values = East.	decimal degrees
species	Name of the coral species.	unitless
recovery_mos	Recovery time (in months).	months
treatment_type	Treatment type.	unitless
genotype	Genotype (parent colony).	unitless
delta_13C_s_orig	The original coral skeletal carbon isotopic composition in permil relative to the standard v-PDB.	per mil (‰)
delta_18O_s_orig	The original coral skeletal oxygen isotopic composition in permil relative to the standard v-PDB.	per mil (‰)
delta_13C_s_corr	The corrected coral skeletal carbon isotopic composition in permil relative to the standard v-PDB.	per mil (‰)
P_to_R_ratio_meas	The photosynthesis to respiration ratio measured directly via respirometry.	unitless (ratio)
P_to_R_ratio_orig_Grossman	Tthe P/R ratio calculated from original isotopes using d18Oeq from Grossman and Ku (1986).	unitless (ratio)
P_to_R_ratio_orig_Maier	The P/R ratio calculated from original isotopes using d18Oeq from Maier (2004).	unitless (ratio)
P_to_R_ratio_corr_Grossman	The P/R ratio calculated from corrected isotopes using d18Oeq from Grossman and Ku (1986).	unitless (ratio)
P_to_R_ratio_corr_Maier	The P/R ratio calculated from corrected isotopes using d18Oeq from Maier (2004).	unitless (ratio)

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Instruments

Dataset-specific Instrument Name	Finnigan Delta IV Stable Isotope Ratio Mass Spectrometer
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	The CO2 from each DIC sample was sealed in Pyrex ampoules and introduced into a Finnigan Delta IV Stable Isotope Ratio Mass Spectrometer (SIRMS).
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

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Deployments

Coral_physiology_field_exper

Website	https://www.bco-dmo.org/deployment/517699
Platform	Reef Field Sites

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Project Information

Physiology and Biogeochemistry of Repeatedly Bleached and Recovering Caribbean Corals (repeat coral bleaching)

Coverage: Puerto Morelos, Mexico

(Extracted from the NSF award abstract)

The overall stability and health of coral reefs is declining world-wide at an unprecedented rate. Mass coral bleaching, wherein exposure to elevated temperature leads to the loss of significant numbers of endosymbiotic dinoflagellates (Symbiodinium spp., commonly called zooxanthellae) and/or photosynthetic pigments, serves as a primary global example of how fragile this symbiosis is. While we have begun to understand the ecological and physiological impacts of bleaching, there remain key fundamental gaps in knowledge. In particular, it is becoming increasingly clear that a) not all corals either respond to, or recover from, bleaching events the same way, and that b) the impact of annual or repeated bleaching events on corals has not been examined in sufficient detail. Several non-mutually exclusive ecological and physiological pathways could impact how a particular coral species succumbs to or recovers from bleaching. Recent evidence suggests that the following features may play key roles for coral survival in the face of future seawater warming and mass bleaching events: 1) shifts in trophic partitioning (e.g., proportional reliance on autotrophy and heterotrophy) and energy reserve utilization, 2) enhanced thermal tolerance through host and algal-mediated physiological responses, and 3) harboring of different Symbiodinium phylotypes. However, these mechanisms have yet to be investigated in a unified approach that covers the entire coral holobiont system (algae, host tissue, and skeleton), or under scenarios of repeated bleaching.

The overall objectives of this study are as follows: 1) to determine the effect of single and repeated bleaching

on the physiology, biogeochemistry, and recovery of some Caribbean coral species, and 2) to determine which Symbiodinium-type and host-species combinations are more resilient to single and repeated bleaching, what aspects of their physiology and biogeochemistry render them resilient, and to use this information to evaluate the long-term persistence of Caribbean coral reefs. To address these objectives, the following physiological variables will be measured: 1) Symbiodinium type, photochemical function and algal stress physiology, and 2) animal host energy reserves, defense enzyme concentration, skeletal growth, and feeding capacity in the corals Porites porites, Porites astreoides, and Montastraea faveolata. Corals will be examined immediately following thermal stress designed to approximate natural bleaching, and recovery will be monitored over short and long-term time scales. Next, the impact of repeated bleaching will be examined in the subsequent year, followed by examination over the next recovery period. This research is designed to simultaneously evaluate the symbiotic algae, coral host, and skeleton, and to identify patterns of physiological responses and recovery of each Symbiodinium-type and host-species combination that would be indicative of the resilience capacity of Caribbean corals to future more frequent thermal perturbations.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0825413

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