Montipora capitata and Porites compressa Physiological Measurements for Experimental Corals and Parent Colonies from 2014-2015 (RAPID Hawaii project)

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Project
» Will corals recover from bleaching under ocean acidification conditions? (RAPID Hawaii)

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Abstract
Physiological data for Montipora capitata and Porites compressa: endosymbiont cell density (cells cm-2), Contribution of Total Carbon to Animal Respiration (CTAR, %), calcification (mg day-1 cm-2), biomass (g cm-2), total lipids (J gdw-1), photosynthesis and respiration (µmol hr-1 cm-2), Contribution of Zooxanthellae (Symbiodiniaceae) to Animal Respiration (CZAR, %), feeding rate (brine shrimp hr-1 cm-2), and Contribution of Heterotrophy to Animal Respiration (CHAR, %). Measurements for experimental corals were taken from one of three time points (November 2015, June 2014, or December 2015).

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Coverage

Location: Moku o Loʻe in Kāneʻohe Bay
Spatial Extent: **N**:21.435 **E**:-157.681667 **S**:21.326667 **W**:-157.786667
Temporal Extent: 2014-11 - 2015-12

Methods & Sampling

Sampling Details

Between 10–12 November 2014, three weeks following the peak of the 2014 thermal stress event, six visibly non-bleached and six visibly bleached parent colonies of *Montipora capitata* and *Porites compressa* were collected from 1–3m depth from the fringing reefs surrounding Moku o Loʻe in Kāneʻohe Bay (centered at 21°26’6” N, 157°47’12” W) and in Waimānalo Bay (centered at 21°19’36” N, 157°40’54” W) using a hammer and chisel.

One ramet from each colony was immediately placed in a -20 °C freezer to evaluate the initial physiology of the parent colonies prior to experimental manipulation. An additional twelve ramets were collected from each parent colony of each species from each location (totaling 576 fragments) and mounted on pre-labeled plastic tiles for use in the manipulative experiment.

Experimental Tank Conditions

All experimental ramets were returned to the Hawaiʻi Institute of Marine Biology and allowed to recover under ambient seawater conditions in outdoor, unfiltered, flow-through seawater tanks for three days. Natural light levels were reduced using 40% neutral density shade cloth such that photosynthetically active radiation levels mimicked that at collection depth.

On 15 November 2014, ramets were equally divided among eight outdoor, 38 L experimental tanks supplied with unfiltered, flow-through seawater. Though the incoming seawater was unfiltered, virtually no zooplankton is delivered to experimental tanks at HIMB due to scouring of the inflowing seawater by in-line invertebrates. Two experimental tanks were randomly assigned to each of the following four treatments: 1) Control (ambient seawater of pH 7.97 and unfed), 2) Fed (ambient seawater of pH 7.97 and fed), 3) OA (acidified seawater of pH 7.74 and unfed), and 4) OA+Fed (acidified seawater pH 7.74 and fed).

Coral holobiont physiology was assessed for parent colonies (i.e., in situ reef controls) and a subset of experimental corals in December 2014 (2 months after 2014 peak thermal stress; 1 month in experimental tanks), June 2015 (8 months after 2014 peak thermal stress; 7 months in experimental tanks), and November 2015 (one month after 2015 peak thermal stress; 13 months in experimental tanks). At each experimental time point, physiological trait measurements were conducted (calcification, photosynthesis, respiration, and zooplankton feeding rate capacity). Once all live measurements were completed, these ramets were frozen for further analyses (endosymbiont cell density, tissue biomass, and total lipids).

The seawater pH was reduced in the simulated OA treatments by bubbling CO gas into the tanks. To ensure tanks remained within target pH range, all tanks were spot-checked with a calibrated pH probe every 1–2 days throughout the experiment. This data was recorded during periods when physiological measurements were being made. Small adjustments to the CO2 bubbling rate were made as needed to maintain the desired 0.2 pH offset between ambient and simulated OA treatments.

Weekly, pH and total alkalinity measurements were made on seawater samples collected from each tank at18:00 h. Total alkalinity was measured using a modified Gran titration and checked for accuracy and precision (~5 µmol kg) using certified reference materials obtained from A. Dickson (Scripps Institution of Oceanography). pH was measured spectrophotometrically at 25 °C with m-cresol purple (precision ~0.002 pH units).

These parameters were then entered into CO2Sys to calculate pH in situ. The CO bubbling rate was then adjusted as necessary, pH was measured again using a calibrated pH probe, and any further adjustments were made until the desired pH was consistently read. In December 2014, March 2015, and June2015, diel cycle chemistry was measured over a 24-hour period across all tanks using the same method.

Data Processing Description

Differences in the physiological profiles (including endosymbiont cell density, CTAR, calcification, tissue biomass, and total lipids) between species, sites, and sites within species was assessed with a multivariate analysis of similarity (ANOSIM).

Physiological profiles of experimental ramets in December 2014 and June 2015 were evaluated using both multivariate and univariate analyses.

Additional details of statistical analyses are outlined in the associated results publication (Dobson et al.).

BCO-DMO Processing Description

- Time_point (date) field converted from %d-%y (e.g., Nov-14) to %m-%Y (e.g., 11-2014) format

- Converted latitude and longitude fields from degrees, minutes, seconds to decimal degree format, and rounded these fields to six degrees of precision

- Empty cells represent "No data" within the dataset

Problem Description

Following the 2015 thermal stress event, almost all P. compressa ramets died, resulting in sample sizes too small for analysis in December 2015.

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Data Files

File	
914498_v1_coral_physiological_measurements.csv	(Comma Separated Values (.csv), 100.71 KB) MD5:2a832196e7645711f30c5d660056ff76
Primary data file for dataset ID 914498, version 1	

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Supplemental Files

File	
Experimental tank parameters.xlsx	(Microsoft Excel, 137.35 KB) MD5:9dd575d5778b4d5f96d065a18ed92cf0
Experimental tank parameter data including temperature (in situ, °C), salinity (psu), weekly and diel chemistry measurements (pH ex-situ, total alkalinity TA, temperature ex-situ °C, pH in situ, fCO2 in situ, pCO2 in situ, HCO3 in situ, CO3 in situ), and spot pH measurements for all tanks across the duration of the experiment.	

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Related Publications

Dobson, K. L., Jury, C. P., Toonen, R. J., McLachlan, R. H., Williams, J. C., & Grottoli, A. G. (2024). Ocean acidification does not prolong recovery of coral holobionts from natural thermal stress in two consecutive years. Communications Earth & Environment, 5(1). https://doi.org/10.1038/s43247-024-01672-5
Results

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Parameters

Parameter	Description	Units

Species	Species of parent colony from which samples were collected. MC = Montipora capitata; PC = Porites compressa.	unitless
Collection_site	Collection site representing the location of the parent colony from which samples were collected. KB = K_ne_ohe Bay; W = Waim_nalo Bay.	unitless
Lat	Collection site latitude in degrees, minutes, seconds.	decimal degrees
Long	Collection site longitude in degrees, minutes, seconds.	decimal degrees
Colony	Colony identification number.	unitless
Sample_ID	Unique sample identification number.	unitless
Health_status	Health status of parent colony. NB = non-bleached; B = bleached.	unitless
pH	Seawater pH of experimental tanks. AMB = ambient seawater pH (7.97); OA = acidified seawater / low pH (7.74).	unitless
Feeding_status	Feeding status of experimental tank. NF = not fed; F = fed.	unitless
Treatment	Treatment or parent colony status of experimental sample. Parent colony = parent colony; BL AMB F = bleached, ambient pH, fed; BL AMB NF = bleached, ambient pH, not fed; BL OA F = bleached, low pH, fed; BL OA NF = bleached, low pH, not fed; NB AMB F = non-bleached.	unitless
Tank	Tank identification number.	unitless
Time_point	Collection time for Parent colony and time of removal from experiment for those in treatment.	unitless
Endo_density	Endosymbiont cell density of coral sample.	cells cm-2
Calc	Calcification of coral sample.	mg day-1 cm-2
Total_biomass	Total biomass of sample.	g cm-2
Total_lipids	Total lipids.	J gdw-1
Gross_P	Gross photosynthesis.	umol O2 min-1 cm-2

LEDR	Light enhanced dark respiration.	unitless
CZAR	Contribution (percentage) of Zooxanthellae (Symbiodiniaceae) to Animal Respiration.	unitless
FR	Feeding rate.	Brine shrimp hr-1 cm-2
CHAR	Contribution (percentage) of heterotrophy to animal respiration.	unitless
CTAR	Contribution (percentage) of total fixed carbon to animal respiration.	unitless

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Instruments

Dataset-specific Instrument Name	YSI ProODO Optical DIssolved Oxygen
Generic Instrument Name	Oxygen Sensor
Dataset-specific Description	YSI ProODO Optical Dissolved Oxygen probes were used to measure dissolved oxygen during coral incubations for use in the calculation of photosynthesis and respiration rates.
Generic Instrument Description	An electronic device that measures the proportion of oxygen (O2) in the gas or liquid being analyzed

Dataset-specific Instrument Name	Thermo Scientific Genesys
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	A Thermo Scientific Genesys spectrophotometer was used to measure the intensity of light transmission at specific wavelengths for chlorophyll a.
Generic Instrument Description	An instrument used to measure the relative absorption of electromagnetic radiation of different wavelengths in the near infra-red, visible and ultraviolet wavebands by samples.

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Project Information

Will corals recover from bleaching under ocean acidification conditions? (RAPID Hawaii)

Coverage: Oahu, HI; Hawaii Institute of Marine Biology

Following the second hottest month on record since the 1940s, water temperatures on O'ahu reached 30 degrees C. The result of this ~2 degree C increase above summer mean temperatures has been a severe bleaching event across the entire length of the Hawaiian Archipelago, with as many as 75% of the dominant coral species in Kane'ohe Bay losing color or bleaching completely white. This event exceeds the magnitude of the only major bleaching event previously documented for Hawaii in 1996. Although tragic, this event provides a rare natural experiment to understand the impact of coral bleaching on the ability of Hawaiian corals to recovery from high temperature stress in the context of climate change and ocean acidification. The proposed will leverage previous work by the PIs to compare recovery following this event and the 1996 mass bleaching event to the recovery rates of Hawaiian corals under future climate change scenarios. Results from this work will provide data on coral resistance and recovery potential from bleaching events of the future.

Coral reefs are among the most diverse ecosystems on the planet, housing an estimated 25% of marine species. But, that diversity appears particularly susceptible to the effects of global change. Massive coral bleaching poses a substantial threat to the integrity of coral reef habitat in US waters, and is predicted to be the major source of mortality for reefs under future climate scenarios. Although previous work on the recovery of corals from bleaching sets the groundwork for this project, it remains to be seen how recovery from bleaching will be impacted by climate change and ocean acidification. To address this fundamental question, we take advantage of the natural difference in baseline temperature and *p*CO2 conditions between Kane'ohe Bay and Waimanalo Bay, HI, both of which are currently impacted by the massive bleaching event in the Hawaiian Archipelago. This natural experiment makes possible a rare opportunity to test three basic questions about the rates of recovery of bleached and unbleached corals under future climate change scenarios:
1) Will ocean acidification slow rates of recovery from bleaching?;
2) Does zooplankton feeding minimize the impact?; and
3) Do corals acclimated to warmer, more acidic baseline conditions (Kane'ohe Bay) recover more quickly under future conditions than corals from present day mean oceanic conditions (Waimanalo Bay)?

This research addresses broad scientific questions relating to the ability of corals to acclimate or adapt to both local environments and future climate conditions, and to help identify coral populations that may be resilient to the predicted impacts of climate change on the reefs of the future.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1514859
NSF Division of Ocean Sciences (NSF OCE)	OCE-1514861

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