Physiological parameters of three corals species collected from Hawaii and exposed to four treatment conditions for 22-months as part of a mesocosm experiment

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Project
» Phenotype and genotype of coral adaptation and acclimatization to global change (Coral Adaptation)

Contributors	Affiliation	Role
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Abstract
This dataset includes physiological parameters of three corals species collected from six locations around O'ahu, Hawaii, which were exposed to four treatment conditions for 22-months: ambient temperature and ambient pCO2, elevated temperature, elevated pCO2, or elevated temperature and elevated pCO2.

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Coverage

Spatial Extent: **N**:21.592516 **E**:-157.674599 **S**:21.326287 **W**:-158.110337
Temporal Extent: 2015-08-29 - 2017-11-26

Methods & Sampling

Publication associated with this data set:
McLachlan RH, Price JT, Muñoz-Garcia A, Weisleder NL, Levas SJ, Jury CP, Toonen RJ, Grottoli AG. Physiological acclimatization in Hawaiian corals following a 22-month shift in baseline seawater temperature and pH. *Scientific Reports* (in press) – updated February 2022.

Locations
Corals were collected at the following locations:
Sampan, O'ahu, Hawai'i, USA 21.452394 N, -157.794870 W, depth 0.5–5m.
Hawai'i Institute of Marine Biology, O'ahu, Hawai'i, USA, 21.434167 N, -157.786335 W, depth 0.5–5m.
Waimānalo, O'ahu, Hawai'i, USA, 21.326287 N, -157.674599 W, depth 0.5–5m.
Hale'iwa, O'ahu, Hawai'i, USA, 21.592516 N, -158.110337 W, depth 0.5–5m.

Experiments were conducted at the Hawai'i Institute of Marine Biology, O'ahu, Hawai'i.

Coral species, sample collection, and acclimation
The corals *Montipora capitata* (branching and encrusting), *Porites compressa* (branching), and *Porites lobata* (massive) were collected at 2 ± 1m depth between 29 August and 11 November 2015 from four reef sites around the island of O'ahu, Hawai'i: Moku o Lo'e [21.434167 N, -157.786335 W] and Sampan [21.452394 N, -157.794870 W] within Kāne'ohe Bay, Waimānalo [21.326287 N, -157.674599 W], and Hale'iwa [21.592516 N, -158.110337 W]. *P. lobata* was not found at Moku o Lo'e and was not collected there. This broad spatial sampling of corals helped to ensure that a representative sample of the genetic variation present in these species from O'ahu was included in the study. Six genets of each species were collected at each site using a hammer and chisel for a total of 66 genets (24 parent colonies for *M. capitata*, 24 parent colonies for *P. compressa*, and 18 parent colonies for *P. lobata*). Species-specific microsatellite markers (developed by Concepcion et al. 2010; Gorospe and Karl 2013) were used to genotype all corals and ensure that they were genetically distinct. After removal from the reef, genets were placed in individual plastic bags filled with seawater from the collection site, and transported back to the Hawai'i Institute of Marine Biology [21.434167 N, -157.786335 W]. Four clonal ramets were cut from each genet using a band saw, and each ramet was mounted on a labelled ceramic plug using cyanoacrylate gel. The 264 ramets (i.e., 66 genets x 4 ramets) were distributed among the experimental outdoor flow-through mesocosm tanks, and allowed to recover and acclimate to the mesocosm system under ambient reef-supplied flow-through seawater for at least 12 weeks until 31 January 2016. Shade cloth above the mesocosm tanks attenuated sunlight by 30% to provide irradiance like that at collection depth, with a maximum instantaneous irradiance of ~1730 µmol m-2 s-1-1 (Wall et al. 2019).

Mesocosm experiment
The experiment consisted of four treatments (n = 10 mesocosms per treatment) as follows: control (present-day temperature with present-day pCO2), ocean acidification (present-day temperature with +350 µatm pCO2), ocean warming (+2 ℃ with present-day pCO2), and combined future ocean conditions (+2 ℃ with +350 µatm pCO2). The temperature and pCO_2 levels are consistent with current commitments under the Paris Climate Agreement (Rogelj et al. 2016). The ramets of *M. capitata, P. compressa,* and *P. lobata* were distributed among the 40 outdoor flow-through mesocosm tanks (70 L, 50 x 50 x 30 cm) at HIMB such that one ramet per genet was present within each of the four treatment conditions. Starting on 1 February 2016, temperature and pCO_2 were adjusted gradually over 20 days to minimize the likelihood of shocking the mesocosm communities. As the incoming waters from Kāne'ohe Bay are naturally slightly warmer and more acidic than other nearby reefs (Jury et al. 2013; Jury and Toonen 2019; Price 2020; McLachlan et al. 2021), the seawater being delivered to the control and ocean acidification treatment mesocosm tanks was chilled by 0.5 °C after 10 and 20 days while the seawater delivered to the ocean warming and combined future ocean treatment mesocosms was warmed by 0.5 °C after 10 and 20 days, then maintained at these offsets for the remainder of the study. At the same time, pH of the seawater being delivered to the ocean acidification and combined future ocean treatments was decreased by 0.05 units while the pH of the seawater being delivered to the control and ocean warming treatment mesocosm tanks was increased by 0.05 units after 10 days and again after 20 days then maintained at the offsets for the remainder of the study. Corals were maintained under experimental conditions for 22 months from 20 February 2016 to 13 December 2017 for a total of 662 days. Salinity, temperature, pCO_2, and pH were measured at mid-day in each mesocosm once weekly. This is a long-term experiment as defined by McLachlan et al. (2020e) and Grottoli et al. (2021) and the longest dual stress (i.e., combined ocean warming and acidification) experiment on corals to date (McLachlan et al., in press).

The mesocosms were designed to mimic the natural reef environment as closely as possible. Each mesocosm contained fragments from the eight most dominant reef-building coral species in Hawai'i (*Montipora capitata, Montipora flabellata, Montipora patula, Porites compressa, Porites lobata, Porites evermanni, Pocillopora meandrina,* and *Pocillopora acuta*) (Franklin et al. 2013; Rodgers et al. 2015), a layer of sand and carbonate rubble, a juvenile Convict tang (*Acanthurus triostegus*), and a juvenile Threadfin butterflyfish (*Chaetodon auriga*). Both fishes are generalist grazers, where the convict tang feeds on benthic algae and the butterflyfish feeds on non-coral invertebrates. They were at representative fish biomass densities for Hawaiian reefs (Gorospe et al. 2018), and together provide the essential functional role of herbivory and predation within the mesocosm communities. The flow-through mesocosms received unfiltered seawater pumped directly from the neighboring reef within Kāne'ohe Bay. Seawater was initially pumped into one of eight header tanks (two per treatment) within which temperature and pH were manipulated and then subsequently directed into the mesocosms such that each header tank supplied five mesocosms. Coral fragments were not directly fed but had access to dissolved and particulate organic matter from the reef-derived seawater and from daily feeding of the fish who were supplied ~3 g wet weight of frozen adult mysid or *Artemia* brine shrimp under flow-through conditions, thereby provisioning the fish and mesocosm communities with allochthonous (i.e., non-local, imported) non-living zooplankton at a rate similar to that measured in nature (Hamner et al. 1988).

The coral fragments grew faster than expected during the experimental period and therefore space within each mesocosm became limited near the end of the experiment. In order to prolong the experiment, three of

the eight coral species (*Montipora flabellata, Pocillopora meandrina,* and *Porites evermanni*) were transferred into a secondary mesocosm system at HIMB in the last month of this study on 18 November 2017, thereby increasing the available space to all remaining coral fragments. None of the *M. capitata, P. compressa and P. lobata* corals showed any obvious adverse reactions to having *M. flabellata, P. meandrina,* and *P. evermanni* removed from the primary mesocosm tanks.

Coral fragments were photographed for surface area and ramet whiteness analysis, and buoyant weighed on the weeks of 20 March 2016 and 27 November 2017 corresponding to one month after the target temperature and pH conditions were reached and the end of the experimental period, respectively. During the last 20 days of the experimental period (23 November–13 December 2017) the following live physiological measurements were conducted on all surviving coral ramets: photosynthesis, respiration, total organic carbon flux, and maximum *Artemia* feeding capacity. Then, all surviving coral fragments were sacrificed by freezing at -20 ℃. Samples were transported on dry ice to the Ohio State University (OH, USA) where they were stored at -80 ℃ awaiting further analyses of biomass, lipids, proteins, Symbiodiniaceae density, and surface area according to methods published in protocols.io (McLachlan et al. 2020d, 2020c, 2020a, 2020b; McLachlan and Grottoli 2021).

Laboratory analyses

Coral color and surface area
Photographs of corals were taken from six different angles next to a scale bar and white reference card. Using ImageJ software, coral whiteness was assessed via photographic image analysis using the greyscale model to quantify the bleaching appearance (Amid et al. 2018). The percent whiteness was used as a proxy for bleaching intensity of corals because it is known to be highly correlated with chlorophyll *a* and Symbiodiniaceae density (Chow et al. 2016; Amid et al. 2018). Coral surface area was estimated from photographs using the geometric method (Naumann et al. 2009) for which a detailed protocol is described in McLachlan and Grottoli (2021).

Calcification
Calcification rate was determined using the buoyant weight technique (Jokiel et al. 1978). Daily calcification rates were calculated as the difference between initial and final weights, divided by the respective number of days elapsed, and normalized to the initial weight of the skeleton.

Photosynthesis, respiration, and total organic carbon flux
Maximal photosynthesis and day and night respiration rates were measured via changes in dissolved oxygen for each individual coral ramet (Rodrigues and Grottoli 2007) at respective treatment seawater temperatures and pCO_2 levels, and normalized to ash-free dry weight (AFDW). Total respiration was calculated by summing day and night respiration rates multiplied by the respective number of hours per day (i.e., 11 daytime hours and 13 nighttime hours at the time of our measurements in Hawai'i). Photosynthesis and respiration rates were corrected for any change in seawater oxygen concentration due to microorganism respiration which occurred in a seawater blank control chamber. Due to the high growth rates exhibited by many of the corals during the experiment, they were far too large to fit into the original respirometry chambers by the end of the study. Therefore, a smaller sub-ramet was cut from each ramet of *M. capitata* and *P. compressa* using a band saw with a diamond-coated blade and each sub-ramet was mounted on a labelled ceramic plug using cyanoacrylate gel for respirometry. The *P. lobata* grew primarily horizontally rather than vertically and thus were not cut prior to live physiological analyses and instead new wider respirometry chambers were constructed to accommodate them.

Total organic carbon (TOC) water samples were collected following night respiration incubations because coral feeding is known to occur primarily after dusk, using methods adapted from Levas et al. (2015). Following night respiration incubations, the water level in respirometry bins was lowered to expose the top of coral incubation chambers. While wearing nitrile gloves, lids were removed, and corals returned to experimental tanks. A 30 ml water sample was removed from each chamber using a new disposable 10 ml pipet, filtered through a 55 µm Nitex mesh, and collected in a pre-cleaned 50 ml Nalgene bottle. All water samples were acidified within 10 minutes of collection using 1 ml of 1.2 M hydrochloric acid (ACS Reagent Grade). TOC concentrations were determined using high-temperature catalytic oxidation using a Shimadzu model TOC-L analyzer, were corrected for the volume of water in respirometry chambers, and divided by the incubation duration to obtain the flux values per hour. The TOC value of the non-coral containing control chambers were subtracted from coral chamber TOC values. Corrected TOC fluxes were normalized to AFDW.

Carbon budget
The carbon budget of each coral ramet was calculated to determine the proportionate contribution of photosynthesis and heterotrophy to total metabolic demand (i.e., respiration). Photosynthesis and total respiration rates were used to calculate the percent Contribution of Zooxanthellae (i.e., Symbiodiniaceae) to

Animal Respiration (CZAR) (Muscatine et al. 1981), while total respiration and nighttime TOC flux rates were used to calculate the percent Contribution of Heterotrophy from TOC to Animal Respiration (CHARTOC) (Levas et al. 2015). *Artemia* feeding capacity was not used to calculate CHARzoop as the *Artemia* concentrations were not representative of reef zooplankton densities or mesocosm zooplankton densities. The Contribution of the Total acquired fixed carbon relative to Animal Respiration (CTAR) (Grottoli et al. 2014) was calculated as the sum of CZAR and CHARTOC. However, we acknowledge that this is likely an underestimate of CTAR as it does not account for heterotrophic carbon derived from zooplankton nor any potential gains or losses in CHARTOC that may have occurred during the day.

Maximum *Artemia* capture rate
The maximum *Artemia* capture rate of corals was assessed using methods adapted from (Ferrier-Pagès et al. 2010). Briefly, corals were placed upon a small plastic stand in individual 500 ml glass beakers filled with seawater from their respective treatments. Beakers were placed on top of a magnetic stir plate (200 RPM) within a 100 L water bath maintained at the desired experimental temperature and placed in front of a window. Conducting feeding measurements under natural moonlight has been observed to increase polyp expansion and feeding behavior (Grottoli pers. obs.). Corals were placed in the feeding beakers one hour before sunset to ensure polyp expansion. Approximately 30 min after sundown, a concentrated solution of 2-day old *Artemia* salina nauplii was added to each beaker at an average concentration of 3000–3500 *Artemia* L-1. This concentration is much higher than in situ zooplankton concentrations, but was chosen to assess the maximum zooplankton capture rate of corals, as feeding rate in known to increase with prey concentration (Palardy et al. 2005, 2006). Five 10 ml subsamples were removed from each beaker using a 10 ml glass pipette after 2 and 40 minutes and the number of *Artemia* in the pipette was immediately counted under a light microscope. The counted *Artemia* solution was returned to the beaker within 30 seconds of its initial removal. After the final count, corals were removed from beakers and returned to their experimental tanks. The maximum *Artemia* feeding rate was calculated as the difference between average initial and end concentrations of *Artemia*, divided by the volume of water in the feeding beaker and the duration of the feeding trial. Capture rates were corrected for any change in *Artemia* concentration which occurred in a control beaker without coral. Maximum *Artemia* capture rates were normalized to AFDW.

Biomass, lipid, protein, and Symbiodiniaceae density
Frozen coral fragments were ground into a homogenous paste using a chilled mortar and pestle and partitioned using methods described in McLachlan et al. (2020a). Between 0.5–1 g of ground material was partitioned for analyses of total biomass ash-free dry weight, total soluble lipid, total soluble protein (henceforth referred to as biomass, lipid, and protein, respectively), and Symbiodiniaceae density based on pre-determined needs for each analysis. Briefly, biomass was quantified by drying ground coral subsamples to a constant weight (60 ℃ for 24 hr) and burning it (450 ℃ for 6 hr) according to protocol methods detailed in McLachlan et al. (2020a). Lipids were extracted using 2:1 chloroform methanol using methods modified from Rodrigues and Grottoli (2007) and the protocol detailed in McLachlan et al. (2020c). Protein was quantified using the Bradford method (Bradford 1976) with protocol details in McLachlan et al. (2020d). Symbiodiniaceae density was quantified by counting the number of cells in four replicate (4 µL) subsamples using a Countess™ II FL Automated Cell Counter which is detailed in McLachlan et al. (2020b). Coral biomass was normalized to surface area (McLachlan and Grottoli 2021), and lipid, protein, and Symbiodiniaceae density were normalized to AFDW to facilitate comparison among species of varying morphologies with different surface-area-to-volume ratios (Edmunds and Gates 2002).

Data Processing Description

BCO-DMO Processing:
- replaced "." with "nd" as the "no data" indicator;
- renamed fields to comply with BCO-DMO naming conventions.

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Data Files

File
coral_physio_mesocosm.csv (Comma Separated Values (.csv), 63.59 KB) MD5:a4edffef2c9713703a62bff669502c98
Primary data file for dataset ID 849259

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Related Publications

Amid, C., Olstedt, M., Gunnarsson, J. S., Le Lan, H., Tran Thi Minh, H., Van den Brink, P. J., … Tedengren, M. (2018). Additive effects of the herbicide glyphosate and elevated temperature on the branched coral Acropora formosa in Nha Trang, Vietnam. Environmental Science and Pollution Research, 25(14), 13360–13372. doi:10.1007/s11356-016-8320-7
Methods

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Methods

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Methods

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Methods

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Methods

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Methods

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Methods

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Methods

Gorospe, K. D., & Karl, S. A. (2013). Genetic relatedness does not retain spatial pattern across multiple spatial scales: dispersal and colonization in the coral,Pocillopora damicornis. Molecular Ecology, 22(14), 3721–3736. doi:10.1111/mec.12335
Methods

Gorospe, K. D., Donahue, M. J., Heenan, A., Gove, J. M., Williams, I. D., & Brainard, R. E. (2018). Local Biomass Baselines and the Recovery Potential for Hawaiian Coral Reef Fish Communities. Frontiers in Marine Science, 5. https://doi.org/10.3389/fmars.2018.00162
Methods

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Methods

Grottoli, A. G., Warner, M. E., Levas, S. J., Aschaffenburg, M. D., Schoepf, V., McGinley, M., Baumann, J., & Matsui, Y. (2014). The cumulative impact of annual coral bleaching can turn some coral species winners into losers. Global Change Biology, 20(12), 3823–3833. Portico. https://doi.org/10.1111/gcb.12658
Methods

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Methods

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Methods

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Methods

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Methods

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Methods

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Methods

McLachlan, R. H., Price, J. T., Muñoz-Garcia, A., Weisleder, N. L., Levas, S. J., Jury, C. P., Toonen, R. J., & Grottoli, A. G. (2022). Physiological acclimatization in Hawaiian corals following a 22-month shift in baseline seawater temperature and pH. Scientific Reports, 12(1). https://doi.org/10.1038/s41598-022-06896-z
Results

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Methods

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Methods

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Methods

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Methods

Mclachlan, R., Munoz, A., & Grottoli, A. (2020). Extraction of Total Soluble Lipid from Ground Coral Samples v1 (protocols.io.bc4qiyvw). Protocols.io. doi:10.17504/protocols.io.bc4qiyvw
Methods

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Methods

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Methods

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Methods

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Methods

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Methods

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Methods

Price JT (2020) Influences of environment and climate change on coral-associated microbial communities and trophic strategies. The Ohio State University
Methods

Rodgers, K. S., Jokiel, P. L., Brown, E. K., Hau, S., & Sparks, R. (2015). Over a Decade of Change in Spatial and Temporal Dynamics of Hawaiian Coral Reef Communities. Pacific Science, 69(1), 1–13. https://doi.org/10.2984/69.1.1
Methods

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Methods

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Methods

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Methods

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Methods

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Parameters

Parameter	Description	Units
id	coral fragment identifier code	unitless
species	genus and species name of coral	unitless
collection_site_name	location where coral was sampled from	unitless
genet_id	id number of unique genets within each species-site combination	unitless
ramet_id	id number of unique ramets taken from each genet	unitless

tank_number	mesocosm tank number (between 1 and 40)	unitless
header_tank_number	header tank which fed mesocosm tanks:1 & 7 were ambient temperature & ambient pCO2;3 & 5 were ambient temperature & elevated pCO2; 2 & 8 were elevated tempperature and ambient pCO2; and 4 & 6 were elevated temperature and elevated pCO2.	unitless
temperature_treatment	low = ambient; Hi = +2 degrees C above ambient	unitless
pCO2_treatment	low = ambient; Hi = +~350 uatm above ambient	unitless
treatment_code	LL = ambient temperature & ambient pCO2;LH = ambient temperature & elevated pCO2; HL = elevated temperature and ambient pCO2; HH = elevated temperature and elevated pCO2.	unitless
survived	1 = fragment had >40% living tissue at end of experiment; 0 = fragment had < 40% living tissue at end.	unitless
biomass_mg_cm_2	tissue biomass of each fragment	milligrams per square centimeter (mg cm-2)
lipid_mg_cm_2	total lipid concentration of each fragment	milligrams per square centimeter (mg cm-2)
lipid_mg_gdw_1	total lipid concentration of each fragment	milligrams per gram dry weight (mg gdw-1)
lipid_kJ_gdw_1	total lipid concentration of each fragment	kilojoules per gram dry weight (kJ gdw-1)
protein_mg_cm_2	total soluble protein concentration of each fragment	milligrams per square centimeter (mg cm-2)
protein_mg_gdw_1	total soluble protein concentration of each fragment	milligrams per gram dry weight (mg gdw-1)

protein_kJ_gdw_1	total soluble protein concentration of each fragment	kilojoules per gram dry weight (kJ gdw-1)
zoox_density_num_cells_cm_2	Symbiodiniaceae density	number of cells per square centimeter (# cells cm-2)
zoox_density_num_cells_gdw_1	Symbiodiniaceae density	number of cells per gram dry weight (# cells gdw-1)
color_pcnt_whiteness	percent whiteness of each fragment (e.g., 0 = black, 100 = white)	percent
toc_flux_umol_hr_1_cm_2	total organic carbon flux	micromoles C per hour per square centimeter (umol C hr-1 cm-2)
toc_flux_umol_hr_1_gdw_1	total organic carbon flux	micromoles C per hour per gram dry weight (umol C hr-1 gdw-1)
net_P_umol_hr_1_cm_2	net photosynthesis	micromoles O2 per hour per square centimeter (umol O2 hr-1 cm-2)
net_P_umol_hr_1_gdw_1	net photosynthesis	micromoles O2 per hour per gram dry weight (umol O2 hr-1 gdw-1)
gross_P_umol_hr_1_cm_2	gross photosynthesis	micromoles O2 per hour per square centimeter (umol O2 hr-1 cm-2)
gross_P_umol_hr_1_gdw_1	gross photosynthesis	micromoles O2 per hour per gram dry weight (umol O2 hr-1 gdw-1)

day_R_umol_hr_1_cm_2	day respiration rate	micromoles O2 per hour per square centimeter (umol O2 hr-1 cm-2)
day_R_umol_hr_1_gdw_1	day respiration rate	micromoles O2 per hour per gram dry weight (umol O2 hr-1 gdw-1)
night_R_umol_hr_1_cm_2	night respiration rate	micromoles O2 per hour per square centimeter (umol O2 hr-1 cm-2)
night_R_umol_hr_1_gdw_1	night respiration rate	micromoles O2 per hour per gram dry weight (umol O2 hr-1 gdw-1)
total_R_umol_hr_1_cm_2	total (day + night) respiration rate	micromoles O2 per hour per square centimeter (umol O2 hr-1 cm-2)
total_R_umol_hr_1_gdw_1	total (day + night) respiration	micromoles O2 per hour per gram dry weight (umol O2 hr-1 gdw-1)
artemia_feeding_rate_num_artemia_min_1_cm_2	maximum artemia capture rate in 40 mins	number of artemia per minute per square centimeter (# artemia min-1 cm-2)
artemia_feeding_rate_num_artemia_min_1_gdw_1	maximum artemia capture rate in 40 mins	number of artemia per minute per gram dry weight (# artemia min-1 gdw-1)
calcification_mg_CaCO3_d_1_g_1	calcification rate	milligrams CaCO3 per day per gram initial weight (mg CaCO3 day-1 g-1 initial weight)

czar_pcnt	percent Contribution of Zooxanthellae (i.e., Symbiodiniaceae) to Animal Respiration (%)	percent
charTOC_pcnt	percent Contribution of Heterotrophy from TOC to Animal Respiration (%)	percent
ctar_pcnt	Total acquired fixed carbon relative to Animal Respiration, i.e. CZAR + CHAR TOC (%)	percent

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Instruments

Dataset-specific Instrument Name	mesocosm tank
Generic Instrument Name	Aquarium
Generic Instrument Description	Aquarium - a vivarium consisting of at least one transparent side in which water-dwelling plants or animals are kept

Dataset-specific Instrument Name	Countess II FL Automated Cell Counter
Generic Instrument Name	Automated Cell Counter
Generic Instrument Description	An instrument that determines the numbers, types or viability of cells present in a sample.

Dataset-specific Instrument Name	hammer and chisel
Generic Instrument Name	Manual Biota Sampler
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.

Dataset-specific Instrument Name	YSI multiparameter meter (YSI 556MPS)
Generic Instrument Name	Multi Parameter Portable Meter
Dataset-specific Description	Temperature and salinity were measured using a YSI multiparameter meter (YSI 556MPS).
Generic Instrument Description	An analytical instrument that can measure multiple parameters, such as pH, EC, TDS, DO and temperature with one device and is portable or hand-held.

Dataset-specific Instrument Name	Titrino Plus 877, Metrohm
Generic Instrument Name	Titrator
Dataset-specific Description	Total alkalinity was measured using an automatic titrator (Titrino© Plus 877, Metrohm) with pH glass electrode (9101 Herisau, Metrohm©).
Generic Instrument Description	Titrators are instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached.

Dataset-specific Instrument Name	Shimadzu model 5050 TOC analyzer
Generic Instrument Name	Total Organic Carbon Analyzer
Generic Instrument Description	A unit that accurately determines the carbon concentrations of organic compounds typically by detecting and measuring its combustion product (CO2). See description document at: http://bcodata.whoi.edu/LaurentianGreatLakes_Chemistry/bs116.pdf

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Project Information

Phenotype and genotype of coral adaptation and acclimatization to global change (Coral Adaptation)

Coverage: Oahu, HI and Hawaii Institute of Marine Biology

Project Summary:
Overview: This study proposes to evaluate the adaptation and acclimatization capacity of eight species of Hawaiian corals to long-term exposure of elevated temperature and ocean acidification (OA) conditions using a two-part approach: 1) a survey of natural corals found across natural temperature and pCO2 gradients and 2) a two-year long mesocosm study which will expose corals collected in part 1 to a range of temperature and pCO2 conditions expected this century. In both approaches, the phenotypic (i.e., physiological and biogeochemical) responses of corals to future climate change will be measured in conjunction with the already funded genotypic (i.e., genomic and transcriptomic) responses of the same corals by Dr. Rob Toonen. This study will address variation at both the population and species level. It will also be the first study to examine the effects of elevated temperature and pCO2 on corals in replicated mesocosms over a multiannual timeframe with a comprehensive suite of physiological, biogeochemical, and genomic tools.

Intellectual Merit: Coral reefs are among the most diverse ecosystems on the planet, housing an estimated 25% of marine species. Yet, they appear to be especially susceptible to the effects of climate change and ocean acidification. To date, the assumption has been that corals will not be able to adapt because the rates of anthropogenically driven ocean acidification and climate change are too high. But there is little experimental evidence to evaluate that assumption. Recent models highlight the critical importance of that assumption in determining coral extinction risk, and several recent studies (including a couple of recent ones from Grottoli's group) indicate that previous studies may have underestimated the potential for corals to acclimatize or adapt to global change. Here, quantitative, empirical estimates of the potential for long-term coral acclimatization and adaptation under global change scenarios will be made. The proposed study includes ~97% of the corals in the Hawaiian archipelago, yielding extensive spatial and biological relevance for the study. Lastly, this research brings together the expertise of Grottoli at OSU (coral physiologist and biogeochemist), Toonen at UH (marine molecular biologist), and McCulloch at UWA (geochemist) in a unique collaboration that blends a large suite of genetic, physiological, and biogeochemical tools to build an unprecedentedly comprehensive picture of coral adaptation and acclimation to global change. Thus, this work has the potential to transform our conceptual and empirical understanding of how corals respond to rapid environmental change.

Broader Impacts: Half of the species in the Hawaiian archipelago are endemic, making Hawaiian coral reefs a high priority for biodiversity conservation. Results from the proposed work will be used for adaptive management plans that collaborator Dr. Toonen is involved in with the goal of preserving Hawaiian coral biodiversity in a UNESCO World Heritage Site -- the Papahanaumokuakea Marine National Monument (PMNM). PMNM encompasses the northwestern Hawaiian Islands, is renowned as one of the most pristine and highly protected coral reefs remaining on the planet, is the single largest conservation area under the U.S. flag, and one of the largest marine conservation areas in the world. This project will provide a bridge between short-term, single-species studies and longer-term, multi-species responses to global change in reef community settings. Findings from this work will be communicated at scientific meetings, through peer-reviewed journal publications, and via press releases. Grottoli will also bring her research and enthusiasm for marine science into her classrooms and onto the podium when giving general audience and professional talks. She has an established track record of recruiting and promoting under-represented students and will continue to do so. This project will recruit 3 undergrads and 2 high school students for supported senior thesis/independent research and provide an environment that will foster their passion and skills necessary to pursue career options in STEM disciplines.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1459536

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