Experiment Tank Conditions from a heatwave experiment done September to November 2018 using reef building corals collected in Kāne'ohe Bay, O'ahu, Hawai'i.

Website: https://www.bco-dmo.org/dataset/884417
Data Type: experimental
Version: 1
Version Date: 2023-01-31

Project
» NSFOCE-BSF: COLLABORATIVE RESEARCH: Elucidating adaptive potential through coral holobiont functional integration (Holobiont Integration)

Contributors	Affiliation	Role
Putnam, Hollie	University of Rhode Island (URI)	Co-Principal Investigator
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Abstract
Two common reef-building corals, Montipora capitata and Pocillopora acuta, were collected from six sites in Kāne'ohe Bay, O'ahu, Hawai'i. Fragments were allowed to acclimate in experimental tanks for two weeks prior to exposure to one of the following four treatments: Ambient Temperature Ambient pCO2 (ATAC), Ambient Temperature High pCO2 (ATHC), High Temperature Ambient pCO2 (HTAC), and High Temperature High pCO2 (HTHC). The treatment period lasted for a two month period, starting on September 22nd, 2018 and lasting through November 17th, 2018. Following the stress period, coral fragments were exposed to a two-month recovery period in ambient conditions. This datasets includes experimental tank conditions through the acclimation, treatment, and recovery periods.

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Coverage

Spatial Extent: **N**:21.477194 **E**:-157.786861 **S**:21.429417 **W**:-157.833667
Temporal Extent: 2018-09-22 - 2018-11-17

Methods & Sampling

Sampling locations: Six reefs within Kāne'ohe Bay, O'ahu, Hawai'i:

1.) USA: Hawaii HIMB: 21.436056, -157.786861
2.) USA: Hawaii Reef.11.13: 21.450806, -157.794944
3.) USA: Hawaii Reef.35.36: 21.473889, -157.833667
4.) USA: Hawaii Reef.18: 21.450806, -157.811139
5.) USA: Hawaii Lilipuna.Fringe: 21.429417, -157.791111
6.) USA: Hawaii Reef.42.43: 21.477194, -157.826889

Experiment conducted at the Hawai'i Institute of Marine Biology

Experimental Tank Setup: Treatment conditions (n=3 tanks treatment-1) were randomly assigned to twelve outdoor mesocosm tanks (122 cm x 122 cm x 30 cm; 510 L). Flow rates, measured daily with a graduated cylinder and timer, averaged 84.36 ± 1.20 mL second-1 (n=826), providing full mesocosm tank turnover every ~2 hours. Mesocosm tanks were 60% shaded from full irradiance, and photosynthetically active radiation was measured continuously with the Apex cosine corrected PAR Sensor (accuracy = ± 5%) that was cross calibrated to the Li-Cor cosine corrected PAR sensor (LI-193). Additionally, light values (PAR) from six different positions in each tank were compared to determine spatial differences within each tank. There was no significant difference in light between positions in each tank (n=4 position-1 tank-1). Based on these results, light was measured in the center of the tank ~daily for the duration of the experiment using the Li-Cor 193 spherical underwater quantum sensor. To further reduce any potential position effects with respect to incoming water, heater position, or bubble stream, the positions of the coral fragments in the tank were changed weekly.

Experimental pCO2 conditions: Experimental pCO2 treatment conditions were based on measurements of conditions in Kāneʻohe Bay, Hawaiʻi (Drupp et al. 2011) and projected future lower pH conditions in embayments, which can have lower mean pH and higher diel fluctuations due to calcification, photosynthesis and respiration of the benthic community and increased residence time in the embayment (Jury et al. 2013); (Shaw, Hamylton, and Phinn 2016). The daily fluctuating pH levels in the high pCO2 treatment tanks were maintained between 7.6-7.7 with an independent pH-stat feedback system in each tank and ambient conditions fluctuated between 7.9-8.0. In order to generate the high pCO2 treatment, two 99.99% food-grade CO2 cylinders were connected to an automatic gas cylinder changeover system (Assurance Valve Systems, Automatic Gas Changeover Eliminator Valves #6091) to prevent an abrupt shortage of CO2 supply. CO2 was brought into the system on-demand through gas flow solenoids (Milwaukee MA955), based on the pH reading of a probe (Apex pH lab grade probes, Neptune Systems) in each tank via airlines plumbed into a venturi injector (Forfuture-go G1/2 Garden Irrigation Device Venturi Fertilizer Injector), which was connected to a water circulating pump (Pondmaster Pond-mag Magnetic Drive Water Pump Model 5). Gas injected into the system was either CO2 or ambient air and bubbling was constant due to the pressure driven pump moving water and gas through the Venturi injector. An Apex AquaController (Neptune Systems) environmental control system with a wifi base unit (Apex Controller Base Unit, Neptune Systems) was linked to 12 individual monitoring units (Apex PM1 pH/ORP Probe Module, Neptune Systems) with Apex pH Probes (accuracy = ±0.01 pH, Neptune Systems), which were used for microprocessor-control of a power strip (Apex Energy Bar 832, Neptune Systems) containing 12 individual solenoids. This pH-stat feedback system constantly monitored seawater temperature and pH conditions.

Experimental temperature conditions: Temperature treatment conditions were programmed to mimic the natural daily fluctuations (0.75 °C ± 0.06) of the environment at the collection sites in Kāneʻohe Bay, Hawaiʻi (NOAA Moku o Loʻe Buoy data from September 2018). Based on these data, high temperature treatment fluctuated between ~29-30°C to reflect previous marine heatwaves in Kāneʻohe Bay, Hawaiʻi (+2°C above ambient temperature). Temperature was monitored with Apex Extended Life Temperature Probes (accuracy = ± 0.05 °C, Neptune Systems) and temperature loggers (HOBO Water Temp Pro v2, accuracy = ±0.21°C, resolution = 0.02°C, Onset Computer Corp) that were placed in each tank at the same height as the coral fragments for the duration of the experiment and logged temperature at 10 minute intervals. Temperature was separately controlled by submersible heaters (ProHeat D-1500 Heater Controllers, precision ± 1°C) due to the electrical demand of the heaters. Ambient temperature treatments were not controlled, and thus reflected the natural conditions of Kāneʻohe Bay.

Total Alkalinity and Carbonate Chemistry: Tank parameters (temperature °C, total scale pH, and salinity in psu) were measured ~twice daily using a handheld digital thermometer (Fisherbrand Traceable Platinum Ultra-Accurate Digital Thermometer, accuracy = ±0.05 °C, resolution = 0.001°C) and a portable multiparameter meter (Thermo Scientific Orion Star A series A325). A pH probe (Mettler Toledo InLab Expert Pro pH probe #51343101; accuracy = ±0.2 mV, resolution = 0.1 mV) and conductivity probe (Orion DuraProbe 4-Electrode Conductivity Cell Model 013010MD; accuracy = 0.5% of psu reading, resolution = 0.01 psu) were used with an Orion A Star meter to measured pH and salinity (psu), respectively. pH (total scale) was calculated from standard curves of pH (mV) across a range of temperature (°C) in a tris standard (Dickson Laboratory Tris Batch T27 Bottle 269, 236 and Batch T26 Bottle 198). 125 mL water samples were taken from each tank twice a week to measure carbonate chemistry using the total alkalinity method. An automated titrator (Mettler Toledo T50) was used to titrate water samples with salinity adjusted 0.1M hydrochloric acid (Dickson Laboratory Titrant A3, A14). A non-linear, least-squares procedure of the Gran approach (SOP 3b; Dickson et al. 2007) was used to calculate total alkalinity (TA; μmol kg−1 seawater). Accuracy was determined using certified reference material (Dickson Laboratory CO2 CRM Batch 132, 137, 176). Carbonate values, including aragonite saturation, carbon dioxide, carbonate, dissolved inorganic carbon, bicarbonate, pCO2, and pH, were calculated using SEACARB with total pH and total alkalinity given (flag=8; v3.2.16, Gattuso et al. 2015) in R Studio.

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Data Files

File
heatwave_tankconditions.csv (Comma Separated Values (.csv), 212.84 KB) MD5:f05494953e4a5c048defeff71e880d43 Primary data file for dataset ID 884417

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Related Publications

Dickson, A.G.; Sabine, C.L. and Christian, J.R. (eds) (2007) Guide to best practices for ocean CO2 measurement. Sidney, British Columbia, North Pacific Marine Science Organization, 191pp. (PICES Special Publication 3; IOCCP Report 8). DOI: https://doi.org/10.25607/OBP-1342
Methods

Drupp, P., De Carlo, E. H., Mackenzie, F. T., Bienfang, P., & Sabine, C. L. (2011). Nutrient Inputs, Phytoplankton Response, and CO2 Variations in a Semi-Enclosed Subtropical Embayment, Kaneohe Bay, Hawaii. Aquatic Geochemistry, 17(4–5), 473–498. https://doi.org/10.1007/s10498-010-9115-y
Methods

Gattuso, J.-P., Magnan, A., Billé, R., Cheung, W. W. L., Howes, E. L., Joos, F., Allemand, D., Bopp, L., Cooley, S. R., Eakin, C. M., Hoegh-Guldberg, O., Kelly, R. P., Pörtner, H.-O., Rogers, A. D., Baxter, J. M., Laffoley, D., Osborn, D., Rankovic, A., Rochette, J., … Turley, C. (2015). Contrasting futures for ocean and society from different anthropogenic CO 2 emissions scenarios. Science, 349(6243). https://doi.org/10.1126/science.aac4722
Methods

Jury, C., Thomas, F., Atkinson, M., & Toonen, R. (2013). Buffer Capacity, Ecosystem Feedbacks, and Seawater Chemistry under Global Change. Water, 5(3), 1303–1325. https://doi.org/10.3390/w5031303
Methods

Shaw, E. C., Hamylton, S. M., & Phinn, S. R. (2016). Incorporating benthic community changes into hydrochemical-based projections of coral reef calcium carbonate production under ocean acidification. Coral Reefs, 35(2), 739–750. https://doi.org/10.1007/s00338-016-1407-2
Methods

Station MOKH1 https://www.ndbc.noaa.gov/station_page.php?station=mokh1
Methods

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Related Datasets

IsRelatedTo

Strand, E., Putnam, H. (2023) **Carbonate Chemistry Parameters from a heatwave experiment done September to November 2018 using reef building corals collected in Kāne'ohe Bay, O'ahu, Hawai'i.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-01-31 doi:10.26008/1912/bco-dmo.884411.1 [view at BCO-DMO]
Relationship Description: Dataset is part of same experiment.

Strand, E., Putnam, H. (2023) **Coral growth rate measured during a heatwave experiment done**

September to November 2018 using reef building corals collected in Kāne'ohe Bay, O'ahu, Hawai'i. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-01-31 doi:10.26008/1912/bco-dmo.884530.1 [view at BCO-DMO]
Relationship Description: Dataset is part is same experiment.

Strand, E., Putnam, H. (2023) **Coral physiology parameters acquired during a heatwave experiment done September to November 2018 using reef building corals collected in Kāne'ohe Bay, O'ahu, Hawai'i.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-01-31 doi:10.26008/1912/bco-dmo.884544.1 [view at BCO-DMO]
Relationship Description: Dataset is part of same experiment.

Strand, E., Putnam, H. (2023) **Coral survivorship tracked during a heatwave experiment done September to November 2018 using reef building corals collected in Kāne'ohe Bay, O'ahu, Hawai'i.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-01-31 doi:10.26008/1912/bco-dmo.884551.1 [view at BCO-DMO]
Relationship Description: Dataset is part of same experiment.

Strand, E., Putnam, H. (2023) **Photosynthetic irradiance capacity of coral fragments measured during a heatwave experiment done September to November 2018 using reef building corals collected in Kāne'ohe Bay, O'ahu, Hawai'i.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-01-31 doi:10.26008/1912/bco-dmo.884537.1 [view at BCO-DMO]
Relationship Description: Dataset is part of same experiment.

Strand, E., Putnam, H. (2023) **Physiology color score extracted from pictures taken during a heatwave experiment done September to November 2018 using reef building corals collected in Kāne'ohe Bay, O'ahu, Hawai'i.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-11-23 doi:10.26008/1912/bco-dmo.884208.1 [view at BCO-DMO]
Relationship Description: Dataset is part of same experiment.

Strand, E., Putnam, H. (2023) **Temperature data measured during a heatwave experiment done September to November 2018 using reef building corals collected in Kāne'ohe Bay, O'ahu, Hawai'i.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-01-31 doi:10.26008/1912/bco-dmo.884738.1 [view at BCO-DMO]
Relationship Description: Dataset is part of same experiment.

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Parameters

Parameter	Description	Units
Date	Date of measurement	unitless
PAR_Time	Time of the light measurement	unitless
Tank	Tank ID number	uniless
PAR_Position	Position in the tank where light was measured	unitless
PAR	Measured light value	nm (nanometers)
PAR_Instrument	Instrument used for that light measurement	unitless
PAR_Measure_Type	Sixpoint or one point to indicate how many light measurements were taken at that time	unitless
Flow_Rate	Flow rate calculated for that day	mL per second
Calibration_date	Date of calibration for the tris calibration	unitless
Discrete_measurement_time	Time of the discrete measurement (Temperature, pH.MV, Salinity)	unitless
Treatment	Treatment condition of that tank	unitless
Temperature	Temperature	degrees Celsius (°C)
pH_MV	pH	millivolts
Salinity	Salinity	psu

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Instruments

Dataset-specific Instrument Name	Conductivity probe Orion DuraProbe 4-Electrode Conductivity Cell Model 013010MD
Generic Instrument Name	Conductivity Meter
Generic Instrument Description	Conductivity Meter - An electrical conductivity meter (EC meter) measures the electrical conductivity in a solution. Commonly used in hydroponics, aquaculture and freshwater systems to monitor the amount of nutrients, salts or impurities in the water.

Dataset-specific Instrument Name	handheld digital thermometer: Fisherbrand Traceable Platinum Ultra-Accurate Digital
Generic Instrument Name	digital thermometer
Generic Instrument Description	An instrument that measures temperature digitally.

Dataset-specific Instrument Name	portable multiparameter meter Thermo Scientific Orion Star A series A325
Generic Instrument Name	Multi Parameter Portable Meter
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	HOBO Water Temp Pro v2 Onset Computer Corp
Generic Instrument Name	Onset HOBO Pro v2 temperature logger
Generic Instrument Description	The HOBO Water Temp Pro v2 temperature logger, manufactured by Onset Computer Corporation, has 12-bit resolution and a precision sensor for ±0.2°C accuracy over a wide temperature range. It is designed for extended deployment in fresh or salt water. Operation range: -40° to 70°C (-40° to 158°F) in air; maximum sustained temperature of 50°C (122°F) in water Accuracy: 0.2°C over 0° to 50°C (0.36°F over 32° to 122°F) Resolution: 0.02°C at 25°C (0.04°F at 77°F) Response time: (90%) 5 minutes in water; 12 minutes in air moving 2 m/sec (typical) Stability (drift): 0.1°C (0.18°F) per year Real-time clock: ± 1 minute per month 0° to 50°C (32° to 122°F) Additional information (http://www.onsetcomp.com/) Onset Computer Corporation 470 MacArthur Blvd Bourne, MA 02532

Dataset-specific Instrument Name	Neptune systems Apex pH lab grade probes
Generic Instrument Name	pH Sensor
Generic Instrument Description	An instrument that measures the hydrogen ion activity in solutions. The overall concentration of hydrogen ions is inversely related to its pH. The pH scale ranges from 0 to 14 and indicates whether acidic (more H+) or basic (less H+).

Dataset-specific Instrument Name	Metler Toledo InLab Expert Pro pH probe #51343101
Generic Instrument Name	pH Sensor
Generic Instrument Description	An instrument that measures the hydrogen ion activity in solutions. The overall concentration of hydrogen ions is inversely related to its pH. The pH scale ranges from 0 to 14 and indicates whether acidic (more H+) or basic (less H+).

Dataset-specific Instrument Name	Water circulating pump (Pondmaster Pond-mag Magnetic Drive Water Pump Model 5)
Generic Instrument Name	Pump
Generic Instrument Description	A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps

Dataset-specific Instrument Name	Mettler Toledo T50
Generic Instrument Name	Titrator
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	Apex Extended Life Temperature Probes Neptune Systems
Generic Instrument Name	Water Temperature Sensor
Generic Instrument Description	General term for an instrument that measures the temperature of the water with which it is in contact (thermometer).

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Project Information

NSFOCE-BSF: COLLABORATIVE RESEARCH: Elucidating adaptive potential through coral holobiont functional integration (Holobiont Integration)

Website: https://sites.rutgers.edu/coralbase/

Coverage: Hawaii, Rhode Island, New Jersey, Israel

NSF Abstract:

The remarkable success of coral reefs is explained by interactions of the coral animal with its symbiotic microbiome that is comprised of photosynthetic algae and bacteria. This total organism, or "holobiont", enables high ecosystem biodiversity and productivity in coral reefs. These ecosystems are, however, under threat from a rapidly changing environment. This project aims to integrate information from the cellular to organismal level to identify key mechanisms of adaptation and acclimatization to environmental stress. Specific areas to be investigated include the role of symbionts and of epigenetics (molecular "marks" on coral DNA that regulate gene expression). These aspects will be studied in Hawaiian corals to determine whether they explain why some individuals are sensitive or resistant to environmental perturbation. Results from the proposed project will also provide significant genomic resources that will contribute to fundamental understanding of how complex biological systems generate emergent (i.e., unexpected) properties when faced with fluctuating environments. Broader impacts will extend beyond scientific advancements to include postdoctoral and student training in Science, Technology, Engineering and Mathematics (STEM). Data generated in the project will be used to train university students and do public outreach through live videos of experimental work, and short stop-action animations for topics such as symbiosis, genomics, epigenetics, inheritance, and adaptation. The research approaches and results will be shared with the public in Hawaii through the Hawaii Institute of Marine Biology education department and presentations at Hawaiian hotels, as well as at Rutgers University through its 4-H Rutgerscience Saturdays and 4-H Rutgers Summer Science Programs.

Symbiosis is a complex and ecologically integrated interaction between organisms that provides emergent properties key to their survival. Such is the case for the relationship between reef-building corals and their microbiome, a meta-organism, where nutritional and biogeochemical recycling provide the necessary benefits that fuel high reef productivity and calcification. The rapid warming and acidification of our oceans threatens this symbiosis. This project addresses how relatively stress resistant and stress sensitive corals react to the environmental perturbations of increased temperature and reduced pH. It utilizes transcriptomic, epigenetic, and microbial profiling approaches, to elucidate how corals respond to environmental challenges. In addition to this profiling, work by the BSF Israeli partner will implement powerful analytical techniques such as network theory to detect key transcriptional hubs in meta-organisms and quantify biological integration. This work will generate a stress gene inventory for two ecologically important coral species and a (epi)genome and microbiome level of understanding of how they respond to the physical environment. Acknowledgment of a role for epigenetic mechanisms in corals overturns the paradigm of hardwired genetic control and highlights the interplay of genetic and epigenetic variation that may result in emergent evolutionary and ecologically relevant properties with implications for the future of reefs. Furthermore, clarifying the joint contribution of the microbiome and host in response to abiotic change will provide an important model in metazoan host-microbiome biotic interactions.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1756623

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