Respirometry data from corals in high and low nutrient enrichments in a fore reef habitat in Mo'orea, French Polynesia in 2019

Website: https://www.bco-dmo.org/dataset/960144
Data Type: experimental
Version: 1
Version Date: 2025-05-05

Project
» RUI: Collaborative Research: Defining the biogeochemical context and ecological impacts of submarine groundwater discharge on coral reefs (Moorea SGD)

Contributors	Affiliation	Role
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Abstract
This dataset contains respirometry data collected from October to November of 2019 from the study described below. See the "Related Datasets" section or the project page for other data collected as part of this study. Study description: Global- and local-scale anthropogenic stressors have been the main drivers of coral reef decline, causing shifts in coral reef community composition and ecosystem functioning. Excess nutrient enrichment can make corals more vulnerable to ocean warming by suppressing calcification and reducing photosynthetic performance. However, in some environments, corals can exhibit higher growth rates and thermal performance in response to nutrient enrichment. In this study, we measured how chronic nutrient enrichment at low concentrations affected coral physiology, including endosymbiont and coral host response variables, and holobiont metabolic responses of Pocillopora spp. colonies in Mo'orea, French Polynesia. We experimentally enriched corals with dissolved inorganic nitrogen and phosphate for 15 months on an oligotrophic fore reef in Mo'orea starting in October of 2019. We first characterized symbiont and coral physiological traits due to enrichment and then used thermal performance curves to quantify the relationship between metabolic rates and temperature for experimentally enriched and control coral colonies. We found that endosymbiont densities and total tissue biomass were 54% and 22% higher in nutrient-enriched corals, respectively, relative to controls. Algal endosymbiont nitrogen content cell−1 was 44% lower in enriched corals relative to the control colonies. In addition, thermal performance metrics indicated that the maximal rate of performance for gross photosynthesis was 29% higher and the rate of oxygen evolution at a reference temperature (26.8 °C) for gross photosynthesis was 33% higher in enriched colonies compared to the control colonies. Together, our results show that in an oligotrophic fore reef environment, nutrient enrichment can cause changes in coral endosymbiont physiology that increase the performance of the coral holobiont.

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Coverage

Location: Mo'orea, French Polynesia
Spatial Extent: **N**:-17.538144 **E**:-149.896537 **S**:-17.5444 **W**:-149.903445
Temporal Extent: 2019-10-15 - 2019-11-15

Dataset Description

See the "Related Datasets" section or the project page for other data collected as part of this study.

See the Project Page for more data collected as part of the project.

Methods & Sampling

Our study was conducted following 15 months of nutrient enrichment during October 2019 at the control and nutrient-enriched sites on the north shore fore reef habitat in Mo'orea. We collected fragments of Pocillopora meandrina at each site based on morphological characteristics. However, due to recent analyses on the complexity of Pocillopora spp. identification, morphological characteristics are unreliable for species identification. Therefore, the coral fragments will be referred to as Pocillopora spp. for the remainder of the methods. Thirty-two Pocillopora spp. colonies showing no signs of bleaching were haphazardly collected in a block design with four fragments collected from each of four treatment or control blocks from depths of ~ 13 m. The treatment coral fragments were collected within < 0.5 m the nutrient diffusers for the nutrient-enriched treatment (n = 16) and ~ 20 m away from the diffusers for the control (n = 16) on October 15, 2019. Pocillopora spp. fragments were removed with hammer and chisel via SCUBA, placed in clean ziplock bags full of seawater, and returned to the boat.

The coral fragments for physiological assays were transported to the UCB Gump Station in a seawater filled cooler and immediately placed in flow-through seawater tables. Using a stainless steel diagonal cutter, fragments of each sample colony were cut into five replicate dimensions (7.8 cm × 7.8 cm) of multi-branch fragments, which were measured with calipers . Two fragments were used for light and dark respirometry trials, and two fragments were used for endosymbiont and coral response variables, including chlorophyll a content, endosymbiont densities, endosymbiont % nitrogen (N) content, endosymbiont N cell−1, tissue biomass, and coral tissue % N content.

The two fragments designated for photosynthesis and respiration trials were affixed to pre-labeled acrylic coral plugs (Industry, CA, USA) using hot glue around the base of the coral skeleton while the fragment was submerged. After coral fragments were affixed, they were placed into one of two flow-through holding tanks (either control or nutrient-enriched) with filtered (pore size ~ 100 µm) seawater to recover from the fragmentation process for 7–12 days. The coral plugs were placed in individual holes on an acrylic sheet with an O-ring placed around the bottom of the plug for stabilization. The acrylic bases had 4 small 15-cm tall PVC pipes on the four corners of the base to keep the corals from being in contact with the bottom of the tank. Holding tank conditions were designed to mimic temperature and light regimes found at the collection sites.

Holobiont metabolic response variables

Acute heat ramping experiments were used to assess net photosynthesis (n = 32) or dark respiration (n = 32) of replicate fragments from each coral colony. To measure net photosynthesis (NP) and dark respiration (Rd), coral fragments were placed in individual closed-system acrylic respiration chambers (650 ml) (Australian Institute of Marine Science, Townsville, Australia) with rotating stir bars (200 rpm) (Fig. 1j). Filtered (pore size ~ 100 µm) seawater was used for all experimental assays. Eight experimental coral fragments were moved from their ambient and nutrient-enriched seawater flow-through holding tanks (4 enriched and 4 control) and randomly assigned to one of the 10 respirometry chambers. Replicate seawater-only chambers were used as controls (n = 2) for background subtraction during each trial (n = 4 NP trials, n = 4 Rd trials). Each of the Rd heat ramping experiments began at approximately 05:30, and corals were kept in complete darkness by a black tarp cover and black trash bag covers on all windows or doors. The Rd corals were exposed to ten sequential temperatures (20, 22, 24, 28, 30, 32, 34, 36, 37, and 38 °C) for 20 min. Following the same experimental design, the light ramp trials began at approximately 13:00 and ended before sunset. During each light ramp trial, the coral fragments were exposed to nine sequential temperatures (20, 22, 24, 28, 30, 32, 34, 36, and 37 °C) for 20 min at saturating light. One less temperature ramp was required for the light trials because corals exhibited near zero oxygen production at 37 °C.

To maintain the assay temperature (± 0.1 °C), temperature was controlled in an insulated reservoir and holding tank using a thermostat system (Apex Controller, Neptune Systems, Morgan Hill, CA, USA) paired with aquarium heaters (Finnex 800 W Titanium Heater, Finnex 300 W Titanium Heater, Burnaby, British Columbia, Canada) and chillers (Aqua Logic Delta Star®, DS-4, San Diego, CA, USA). An air stone diffuser (Growneer, Shanghai, China) was added to the holding tank where the chambers were filled before each temperature ramp to provide circulation and oxygenation. Further, fresh seawater changes were conducted between each temperature ramp. Once the seawater in the insulated reservoir reached a stable temperature, the respirometry chambers containing both the coral fragments and controls were added and measurements started immediately. NP and Rd rates were quantified through oxygen production/consumption measured by fiber optic oxygen sensors using Presens Oxygen Meter (OXY-10 SMA (G2) Regensburg, Germany) system with temperature correction for each channel separately. Temperature (°C) and oxygen concentrations (µmol L−1) were measured using Presens Temperature (Pt1000, Regensburg, Germany) and Presens Oxygen Dipping Probes (DP-PSt7, Regensburg, Germany) (company two-point calibration with oxygen-free environment [nitrogen, sodium sulfite] and air-saturated environment), respectively, at a frequency of 1 Hz. Gross photosynthesis (GP) was calculated as NP plus Rd (as a positive value). After each incubation, we removed all coral tissue, dried the coral skeletons, and measured the surface area of each coral using the paraffin wax dipping technique described above to normalize the rates (µmol cm−2 h−1)

Organism Life Science Identifiers (LSIDs):
Pocillopora meandrina, urn:lsid:marinespecies.org:taxname:206964
Pocillopora spp., urn:lsid:marinespecies.org:taxname:206938

Data Processing Description

All data and code are available at https://github.com/daniellembecker/Chronic_low_nutrient_enrichment_benefits_coral_thermal_performance_fore_reef_habitat (Release: v1.0.0 archival copy doi: 10.5281/ZENODO.5013255).

BCO-DMO Processing Description

* Table within submitted file "Respirometrydata.csv" was imported into the BCO-DMO data system for this dataset. Values "NA" imported as missing data values.Table will appear as Data File: 960144_v1_coral-respirometry.csv (along with other download format options).

* BCO-DMO requires each column contain an individual measurement type (and units consistent per column). In order to meet this requirement, the BCO-DMO data manager transformed the data table and worked with the data contributor to review and make any additional changes needed. The original data format "Respirometrydata.csv" provided to BCO-DMO was included as supplemental file 960144_v1_coral-respirometry-alternate-format.csv

Transformation notes (going from the originally provided file "Respirometrydata.csv" to primary data table format 960144_v1_coral-respirometry.csv) :

* A table pivot was performed (transforming columns rate_type, umol_cm2_hr, and Temp_C) to separate sets of columns per rate type.
* To do this tables were separated by filtering on rate_type (R, NP, GP). Then joined to combine all columns using full joins on unique keys ("Fragment_ID", "Temperature_category", "treatment").
** Data were evaluated to determine a unique set of columns corresponding to the rate_type. ("Fragment_ID", "Temperature_category", "treatment") were unique per rate_type and Temp_C was variable for every type of rate measurement so it was included as separate columns R_Temp_C, NP_Temp_C, etc. (See Parameters section for column descriptions).

Missing Data Identifiers:
* In the BCO-DMO data system, missing data identifiers are displayed according to the format of data you access. For example, in csv files it will be blank (null) values. In Matlab .mat files it will be NaN values. When viewing data online at BCO-DMO, the missing value will be shown as blank (null) values.

* Column names adjusted to conform to BCO-DMO naming conventions designed to support broad re-use by a variety of research tools and scripting languages. [Only numbers, letters, and underscores. Can not start with a number]

* Organism names in this dataset were matched to Life Science Identifiers (LSIDs) using the World Register of Marine Species (WoRMS) on 2025-05-06.

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Related Publications

Becker, D. M., Putnam, H. M., Burkepile, D. E., Adam, T. C., Vega Thurber, R., & Silbiger, N. J. (2021). Chronic low-level nutrient enrichment benefits coral thermal performance in a fore reef habitat. Coral Reefs, 40(5), 1637–1655. https://doi.org/10.1007/s00338-021-02138-2
Results

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Related Datasets

IsRelatedTo

Silbiger, N., Putnam, H., Burkepile, D., Adam, T. C., Becker, D. M. (2025) **Bulk physiology data from corals in high and low nutrient enrichments in a fore reef habitat in Mo'orea, French Polynesia in 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-05-05 http://lod.bco-dmo.org/id/dataset/960140 [view at BCO-DMO]

Relationship Description: Data collected as part of the same study of thermal performance of corals in high and low nutrient enrichment in Mo'orea, French Polynesia.

Software

Danielle M. Becker. (2021).
daniellembecker/Chronic_low_nutrient_enrichment_benefits_coral_thermal_performance_fore_reef_habitat: First release of my first manuscript data (Version v1.0.0) [Computer software]. Zenodo. https://doi.org/10.5281/ZENODO.5013255
https://doi.org/10.5281/zenodo.5013255

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Parameters

Parameter	Description	Units
Fragment_ID	Unique Fragment ID	unitless
Temperature_category	Temperature category for thermal performance curve (enriched or control, see methology)	unitless
treatment	Nutrient treatment (enriched = nutrients added; cocntrol = control)	unitless
Temp_C	Temperature in respirometry chamber	degrees celcius (degC)
umol_cm2_hr	metabolic rate	micromoles of O2 per square centimeter per hour (umol O2/cm2/hr)
rate_type	Rate type (R = Respiration, GP = Gross Photosynthesis, NP = Net Photosynthesis)	unitless

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Instruments

Dataset-specific Instrument Name	Presens Oxygen Dipping Probes (DP-PSt7, Regensburg, Germany)
Generic Instrument Name	Oxygen Sensor
Dataset-specific Description	Temperature (°C) and oxygen concentrations (µmol L−1) were measured using Presens Temperature (Pt1000, Regensburg, Germany) and Presens Oxygen Dipping Probes (DP-PSt7, Regensburg, Germany) (company two-point calibration with oxygen-free environment [nitrogen, sodium sulfite] and air-saturated environment) for respirometry measurements.
Generic Instrument Description	An electronic device that measures the proportion of oxygen (O2) in the gas or liquid being analyzed

Dataset-specific Instrument Name	Presens Temperature (Pt1000, Regensburg, Germany)
Generic Instrument Name	Water Temperature Sensor
Dataset-specific Description	Temperature (°C) and oxygen concentrations (µmol L−1) were measured using Presens Temperature (Pt1000, Regensburg, Germany) and Presens Oxygen Dipping Probes (DP-PSt7, Regensburg, Germany) (company two-point calibration with oxygen-free environment [nitrogen, sodium sulfite] and air-saturated environment) for respirometry measurements.
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

RUI: Collaborative Research: Defining the biogeochemical context and ecological impacts of submarine groundwater discharge on coral reefs (Moorea SGD)

Coverage: Mo'orea, French Polynesia

NSF Award Abstract:
Submarine groundwater discharge (SGD) is the flow of water from land through the coastal seafloor into the nearby ocean. Approximately 13,000 cubic kilometers of groundwater is discharged into coastal environments every year, yet the effects of this fresh and often nutrient rich SGD are still poorly understood for coral reefs. This SGD input is driven by changes in precipitation, human land use, sea-level rise, tidal amplitude, and groundwater usage, many of which are rapidly changing with climate and human impacts. This project improves our understanding of SGD effects on coral reefs to better predict how both natural and human-induced changes will affect coastal ecosystem functioning in the future. Working in one of the most comprehensively studied coral reef ecosystems in the Pacific (Mo'orea, French Polynesia, home of the Mo'orea Coral Reef Ecosystem LTER); this project tests the influence of SGD on individual, community, and ecosystem-scale coral reef processes. Using mensurative studies, caging experiments, and a synthetic model, the investigators: 1) characterize SGD gradients and relate it to high resolution coral reef cover data, 2) determine how individual to ecosystem processes are influenced by SGD, and 3) develop a synthetic model to show how changes in SGD fluxes will alter reef ecosystem functioning. As SGD is a common feature on nearshore coral reefs worldwide, the results of this study have global implications for understanding the performance of coral reefs, which are essential economic, cultural, and scientific resources. This project is structured to provide training across multiple career levels, linking 13 undergraduate students, 2 graduate students, 2 senior personnel, 1 postdoctoral researcher, 1 female beginning lead investigator, and 2 senior co-investigators, with a focus on encouraging participation from underrepresented groups (e.g., through the Alaska Native and Native Hawaiian, Asian American and Native American Pacific Islander, and Hispanic-Serving Institutions of California State University Northridge, the University of Hawai'i at Mānoa, and California State University Long Beach). The investigators work with local K-12 students and teachers in Mo'orea and collaborate with an artist-in-residence to communicate science to the broader public through interactive and immersive art experiences in Mo'orea, Miami, and Los Angeles.

SGD is a natural and understudied feature of many nearshore coral reef ecosystems, which can contribute substantial changes to marine biogeochemistry, with impacts for coastal organisms such as reef-building corals, macroalgae, and bioeroders. SGD may play a key role in coral reef ecosystem functioning because it alters key physicochemical parameters (e.g., temperature, salinity, and nutrient and carbonate chemistry) that substantially affect both biotic and abiotic processes on coral reefs. This project (i) characterizes the spatial extent and biogeochemical signal of SGD in Mo'orea, French Polynesia, (ii) identifies how SGD influences microbial processes, benthic organism growth rates and physiology, species interactions between corals, macroalgae, and herbivores, and net ecosystem calcification and production rates, and (iii) quantitatively assesses how changes in SGD fluxes will alter reef biogeochemistry and ecosystem functioning through an integrative modelling effort. Specifically, the hydrogeological, biogeochemical, and ecological data collected in this study are synthesized in a Bayesian structural equation model. This project characterizes and quantifies how SGD directly and indirectly affects ecosystem functioning via changes in biogeochemistry and altered individual to ecosystem responses, thereby providing a better capacity to track and predict alterations in reef ecosystem function.

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-1924281

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