Data on how nutrient and sediment loading affect coral functionality in a tropical branching coral

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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 examines how nutrient and sediment loading affect coral functionality in a tropical branching coral.

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Coverage

Spatial Extent: **N**:-17.47933 **E**:-149.79272 **S**:-17.49269 **W**:-149.86857
Temporal Extent: 2019-06-17 - 2019-07-31

Methods & Sampling

Study sites and coral collection:
Colonies of *P. acuta* (n = 54) were collected between 0.5 m and 1 m depths from six locations (n = 9 colonies per location) that exhibited a gradient in nutrient loading and sedimentation rates along north shore fringing reefs in Mo'orea, French Polynesia, during the Austral winter of 2019. To ensure that all samples could be processed in the same photoperiod, we separated the six sites into three paired blocks so that thermal performance curve trials (which take ~12 h) could include 4 fragments from each paired site. The three paired site blocks were along the north shore fringing reef sites for sample collection (western: 17° 29' 33.684"S 149° 52' 6.852"W, 17° 29' 25.152"S 149° 51' 1.008"W, central: 17° 29' 4.632"S 149° 50' 23.064"W, 17° 29' 5.532"S , 149° 50' 43.872"W, eastern: 17°28'51.0"S, 149°48'17.8"W, 17° 28' 45.588"S 149° 47' 33.792"W).

P. acuta colonies were removed from the reef with a hammer and chisel on snorkel, placed in clean ziplock bags full of seawater and transported to the University of California, Berkeley Richard B. Gump South Pacific Research Station (UCB Gump Station) in a seawater filled cooler and immediately placed in flow-through seawater tables before being fragmented. Using a stainless-steel diagonal cutter, we cut each colony into four

or five multi-branch fragments (7.8 cm × 7.8 cm), which were measured using calipers. Two of the designated fragments were used for light and dark respirometry trials. The other two fragments were used for endosymbiont and coral host response variables including chlorophyll *a* content, endosymbiont densities, endosymbiont % nitrogen (N) content, endosymbiont N content cell-1, tissue biomass, and coral tissue % N content. A fifth fragment was randomly selected from four colonies per location and used to determine saturating light conditions for the corals. The two fragments delegated for endosymbiont and coral host response variables (one for % tissue N and one for the remaining parameters) were immediately frozen at -20 °C until processing. The two fragments designated for photosynthesis, respiration, and calcification 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 deployed *in situ* to recover from the fragmentation process at their origin reef site for 7 – 14 days. The coral plugs were placed in individual holes on a constructed acrylic sheet with an O-ring placed around the bottom of the plug for stabilization. Each acrylic plate had a cage surrounding it made of 2 cm wide Gutter Guard Mesh (Hallandale, FL, USA) to prevent corallivory. Coral samples were again collected around sunset, ~12 hours before each photosynthesis or dark respiration trial and held in an ambient seawater flow-through system at the UCB Gump Station. The coral samples designated for the dark respiration trials were kept in darkness by wrapping a thick black plastic bag around each tank for ~11 hours prior to measuring dark respiration, while the coral samples for photosynthesis trials were kept in natural light under a shade.

Sampling and analytical procedures:

Sedimentation rates
Sediment traps were deployed in triplicates for ~ 72 h at each of the six sites during the coral recovery period. Traps were constructed with six individual 6 cm diameter (D) x 30 cm height (H) PVC pipes (Storlazzi et al., 2011) that each had a 2 cm D x 4 cm H PVC pipe glued to its side. The smaller PVC pipe slid over an 8-inch long screw that was installed into a cement base. Sediment traps were recovered *in situ* by wrapping the opening of the PVC pipe with parafilm before removal from the reef. The sediment samples were brought back to the lab where the volume of the sediment sample was measured and filtered through a pre-weighed 1 µm pore size, 47 mm Whatman ® polycarbonate filter (Maidstone, United Kingdom). The filters were dried in an oven (Fisher Scientific Isotemp Oven, Waltham, MA, USA) at 80 °C for 24h. Each sample was weighed to the nearest 0.001 grams on an analytical balance to obtain dry mass and normalized to the open area of the trap (mg cm-2 day-1).

Algal tissue nitrogen sampling and water column nutrients
Macroalgal % tissue N content is an integrated measure of nutrient loading for each site. Percent tissue N content for *Turbinaria ornata* was calculated from replicate individuals (n = 3) per site at the same time the corals were collected for fragmentation. Samples were returned to the lab and approximately 1 g (wet mass) of tissue was removed (5 cm from a branch apex) from each individual, rinsed in freshwater (FW) where epiphytes were removed manually with forceps, and dried to constant weight at 80 °C. Dried samples were processed for CHN analysis by the means of high-temperature (1,000 °C) combustion following the Dumas method of samples in an oxygen-enriched helium atmosphere in an elemental analyzer (Control Equipment Corporation: Model CEC 440HA, North Chelmsford, MA, USA) at the University of California, Santa Barbara Marine Science Institutes (UCSB MSI) Analytical Lab. We also collected water column samples to characterize nutrient concentrations in the seawater at the time of collection. Two replicate water samples were collected from the benthos using 60 mL lip-lok tip syringes for dissolved inorganic nitrate (NO3-) + nitrite (NO2-), ammonium (NH4+), and phosphate (PO43-). The samples were filtered through a 0.7 µm GF/F (Whatman ®, Maidstone, United Kingdom) and the seawater samples were placed in a -20 °C freezer immediately upon returning to the UCB Gump Station for later analysis at the UCSB MSI Analytical Lab. Dissolved inorganic nutrients (PO43-, NO3- + NO2-, NH4+) were analyzed using flow injection (QuikChem 8500 Series 2, Lachat Instruments, Zellweger Analytics, Inc., Loveland, CO, USA) at the UCSB MSI Analytical Lab.

Temperature and light
Temperature, accuracy ± 0.21 °C from 0 °C to 50 °C, and light intensity, accuracy ±10% from 0 to 167,731 lux, were recorded *in situ* at all sites with HOBO loggers (Onset HOBO TidbiT v2 Temp Data Logger UTBI-001 and Onset HOBO Pendent Light Intensity Data Logger MX2202, Bourne, MA, USA, respectively) every 15 min during the 7-14 day recovery period. Light loggers were cable-tied to a small acrylic slate before deployment to ensure that the loggers were orientated at a 180-degree angle facing upward and would stay affixed during the experimental period. The light intensity data was converted from luminous flux (lux) to photon flux density (PFD) (commonly referred to as photosynthetically active radiation; PAR; µmol photons m–2 s–1) by using an exponential decay fit (PARLICOR = A1e(–HOBO/t1) + y0).

Algal endosymbiont densities
To quantify algal endosymbiont densities, repeated cell counts (n = 6 - 8) were conducted for aliquoted (1 mL)

coral tissue slurry samples (n = 54) using an Improved Neubauer Haemocytometer (Marienfeld Superior, Lauda-Königshofen, Germany). The endosymbiont cell densities were then normalized to coral surface area (cells cm-2).

Chlorophyll a content
Duplicate 3 mL samples from the tissue slurry were centrifuged (3,450 rpm x 3 min.) (Fisher Scientific accuSpin™ 3R, Waltham, MA, USA) to isolate the algal pellet before 5 mL of 100% acetone was added to extract chlorophyll *a* at -20 °C for 36 h in the dark. The supernatant of the extract was measured spectrophotometrically (λ = 630, 663, and 750 nm) (Shimadzu UV-2450, Kyoto, Kyoto Prefecture, Japan) and concentrations of chlorophyll *a* were calculated using equations specified for dinoflagellates from Jeffrey and Humphrey (1975), after accounting for an acetone blank. The chlorophyll concentrations were then normalized to surface area (µg cm−2) and to endosymbiont cells (pg cell−1).

Tissue biomass
Triplicate 1mL aliquots from each coral tissue slurry were pipetted into pre-burned (450 °C for 5 h) aluminum pans in a muffle furnace (Fisher Scientific Isotemp Muffle Furnace, Waltham, MA, USA), placed in a drying oven (Fisher Scientific Isotemp Oven, Waltham, MA, USA) at 60 °C for > 24 h until they reached a constant weight, and then placed in the muffle furnace at 450 °C for 4-6 h to determine ash-free dry weight. The difference between the dried (60 °C) and burned (4-6 h at 450 °C) masses is the total biomass of the aliquoted tissue slurry and the tissue biomass was expressed as mg cm-2.

Coral and endosymbiont tissue N content
To calculate coral and endosymbiont tissue N content, a 7 mL aliquoted tissue slurry containing coral host tissue and endosymbionts from each coral fragment were filtered through a 20 µm nylon net filter (Wildco®, Yulee, FL, USA) (Maier et al., 2010) to remove skeletal carbonates from each sample. The remaining host tissue and endosymbiont cells were separated by centrifugation (3,450 rpm x 3 min.) (Fisher Scientific accuSpin™ 3R, Waltham, MA, USA) with 3-4 seawater rinses. Between each seawater rinse and centrifugation, microscopic inspections using a Leica Binocular Microscope (DM500, Feasterville, PA, USA) were completed to ensure separation efficiency between the coral tissue and endosymbionts. Tissues were filtered onto weighed pre-combusted 25 mm GF/F filters (Whatman ®, Maidstone, United Kingdom) (450 °C, 4h), dried overnight (80 °C), weighed, and placed in microcentrifuge tubes (Wall et al., 2018). Tissue N content for the coral hosts and algal endosymbionts were determined by the means of high-temperature (1,000 °C) combustion following Dumas method of samples in an oxygen-enriched helium atmosphere in an elemental analyzer (Control Equipment Corporation: Model CEC 440HA, North Chelmsford, MA, USA) at the UCSB MSI Analytical Lab. Algal endosymbiont % N content and coral tissue % N content were calculated by normalizing the N (mg) to the weight of the dry tissue mass (mg) on the filter and multiplied by 100. The N per algal endosymbiont cell (pg N cell-1) was also calculated.

Net photosynthesis and respiration
Replicate coral fragments from each colony were assigned to light (n = 48) or dark (n = 48) and underwent light net photosynthesis or dark respiration heat ramping experiments. For respirometry measurements, fragments were placed in 10 individual closed-system acrylic respiration chambers (650 ml) (Australian Institute of Marine Science, Townsville, Australia) with rotating stir bars (200 rpms) to measure net photosynthesis (NP) and Net Calcification (NC) in the light, and respiration was measured in the dark. Filtered seawater (pore size ~ 100 µm) was used for all experimental assays. Replicate seawater-only chambers were used as controls (n = 2) for background normalization during each trial (n = 6 light trials, n = 6 dark trials). Each of the heat ramping experiments began at approximately 06:30 (dark trials kept in complete darkness over experimental assays). Eight experimental coral fragments were moved from their ambient seawater flow-through tanks and randomly assigned to one of the 10 respirometry chambers. During each light ramp trial, the coral fragments were exposed to eight temperatures for 60 mins (20 C, 24 C, 28 C, 30 C, 31 C, 32 C, 35 C, 37 C) at saturating light. The dark respiration ramp trials were conducted at eight to twelve temperatures from 20 C to 40 C for 20 minutes. Preliminary data collected in January 2019 showed no difference between Rd calculated over 60 minutes versus 20 minutes at 9 different temperatures. Longer incubation periods were necessary in the light trials to detect a reliable difference in total alkalinity (TA) to calculate NC rates (Silbiger et al. 2019).

Temperature was controlled in an insulated reservoir using a thermostat system (Apex Controller, Neptune Systems, Morgan Hill, CA, USA) to maintain the assay temperature (±0.1 °C) with paired heaters (Finnex 800W Titanium Heater, Finnex 300W Titanium Heater, Burnaby, British Columbia, Canada) and chillers (Aqua Logic Delta Star, DS-4, San Diego, CA, USA). 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 the same methods described above. GP was calculated as NP

plus the absolute value of Rd. 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 hr-1).

Net light calcification
NC was measured simultaneously during the light trials using the total alkalinity anomaly technique. Before the start of each assay temperature in the light trials, triplicate 125 mL water samples (n = 3) were collected from the temperature-controlled seawater designated to fill the chambers to provide the starting TA value. Following the 60-minute incubation period for each assay temperature, 125 mL water samples were collected from each coral (n = 8) and blank (n = 2) chamber. Conductivity and temperature measurements were taken for each individual water sample using a Thermo Scientific™ Orion Star™ A222 Conductivity Portable Meter (Waltham, MA, USA) and a Traceable® digital thermometer (Control Company 5-077-8, accuracy = 0.05 °C, resolution = 0.001 °C) (Webster, TX, USA). Within 30 minutes of collection, the water samples were preserved with 50 µL of 50% saturated mercuric chloride (HgCl2) in deionized water.

TA was measured using open cell potentiometric titrations following standard operating procedures (SOP 3b; Dickson et al. 2007) using an automatic titrator (Mettler-Toledo T50,Columbus, OH, USA) fitted with a InMotion Pro-sample carousel (Columbus, OH, USA). The titrator had a Mettler pH probe (DGi-115, Columbus, OH, USA) and was operated with certified HCl titrant (Batch #A17, Dickson Laboratory). Certified reference material (Dickson CRM Batch #180) was used to evaluate the accuracy of the TA measurements (SOP 3b; Dickson et al. 2007). A CRM was run before each sample set daily. The error was always less than 0.60% off from the certified value, and precision was <4 µEq. To calculate NC, we used Eqn 2:

$NC = (\Delta TA \times V \times \sigma)/(2 \times t \times SA)$

where ΔTA (µmol kg-1) is the difference between the initial pre-incubation and post-incubation TA value, V (cm3) is the volume of water in the experimental aquaria (chambers), σ(g cm-3) is the density of seawater, t (h) is the incubation time, and SA (cm2) is the surface area of the corals samples determined by the paraffin wax-dipping technique (Stimson et al., 1991; Veal et al., 2010). ΔTA is divided by 2 because 1 mole of CaCO3 is produced for every 2 moles of TA and the values expressed as µmol cm-2 hr-1. NC (µmol cm-2 hr-1) was calculated by subtracting the seawater controls to account for changes in the alkalinity anomaly due to any calcifying organisms in the seawater.

Population Level Response:

Benthic community and P. acuta percent cover
To calculate percent cover of the benthic community and *P. acuta* at each site, 20 0.5 x 0.5 m quadrats divided into 25 equal squares (5 x 5 cm) were randomly placed (using a random number generator) along each of two 40 m transects that were laid parallel to shore starting at the coral recovery locations. The percent cover was visually estimated for *P. acuta* cover, total coral cover (23 genera) excluding *P. acuta*, total algal cover (macroalgae, turf, and fleshy algae), crustose coralline algae (CCA), and substrate (bare rock, rubble, sand, and/or bare space) in each quadrat with the limit of resolution being 4% change in cover. The same snorkeler measured percent cover at all six sites.

Known Problems/Issues:
Two fragments could not be used for coral and endosymbiont processing as the tissue slurries resulting from the airbrushing protocol were not reliable for aliquoting and inspection. They did not homogenize enough so the cell counts and chlorophyll readings were not reliable. Both fragments were not used in the final analyses.

Data Processing Description

Data Processing:
Data were analyzed using R statistical program. All code is available at https://github.com/daniellembecker/Nutrient_sediment_loading_affect_coral_functionality and Zenodo DOI: 10.5281/zenodo.4081813

BCO-DMO Processing:
Data are currently being processed.

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Data Files

File
nutrients_sediments.csv (Comma Separated Values (.csv), 45.46 KB) MD5:4e18c46d1f5de7637c720b912202bb37 Primary data file for dataset ID 860955

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Related Publications

Becker, D. M., & Silbiger, N. J. (2020). Nutrient and sediment loading affect multiple facets of coral functionality in a tropical branching coral. Journal of Experimental Biology. doi:10.1242/jeb.225045
Results

Becker, D. M., & Silbiger, N. J. (2020). daniellembecker/Nutrient_sediment_loading_affect_coral_functionality: First release (Version v1.0.0) [Computer software]. Zenodo. https://doi.org/10.5281/ZENODO.4081813
Software

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Parameters

Parameter	Description	Units
fragment_ID	individual coral fragment ID, Pocillopora acuta (PA)	unitless
site	site, either A or B to distinguish two sites	unitless
rate_type	type of gross photosynthesis (GP), respiration (R), or calcification (C) rate measured	unitless
E	activation energy	electron volts, eV
Eh	deactivation energy	electron volts, eV
lnc	metabolic rate normalized to a reference temperature	micromoles per square centimeter per hour (umol/cm2/hr)
Th	temperature at which half the enzymes are inactivated	K
Topt	thermal optimum	degrees C
site_block	eastern, central, or western sampling site block	unitless
recovery_block	indicating order trials were run for various coral fragments	unitless
site_letter	A-F for six sites sampled	unitless
Pmax	maximal rate of performance	micromoles per square centimeter per hour (umol/cm2/hr)
mean_L	mean of light data across all sites	umol photons/m2/s
var_L	variance of light data across all sites	umol photons/m2/s
qnorm_L	quantile range, 90th percentile of light data across all sites	umol photons/m2/s
mean_T	mean of temperature data across all sites	degrees C
var_T	variance of temperature data across all sites	degrees C

qnorm_T	quantile range, 90th percentile of temperature data across all sites	degrees C
NH4	ammonium	micromoles per liter (umol/L)
N_N	sum of nitrate and nitrite	micromoles per liter (umol/L)
P	phosphate	micromoles per liter (umol/L)
N_ST	endosymbiont nitrogen content per cell	pgN/cell
per_N_AT	coral tissue percent nitrogen content	unitless (percent)
trap_accumulation_rate	sedimentation rate	mg/cm2/day
N	percent nitrogen	unitless (percent)
per_N_ST	algal endosymbiont percent nitrogen content	unitless (percent)
chlA_ugcm2	pigment content of the coral sample/total number of cells of the coral sample)/surface area of coral sample	micrograms per square centimeter (ug/cm2)
zoox_per_cm2	number of cells: normalized with SA represented by 106	cells/cm2
AFDW_mg_cm2	ash-free dry weight	mg/cm2
N_resid	percent nitrogen residuals	unitless (percent)
trap_resid	sedimentation rate residuals	mg/cm2/day
long	Longitude	Decimal Degrees East
lat	Latitude	Decimal Degrees North
CCA_cover	Crustose Coralline Algae percent cover	unitless (percent)
algal_cover	total fleshy, turf, and macroalgae identified	unitless (percent)
p_acuta_cover	Pocillopora acuta percent cover	unitless (percent)
coral_cover	total coral cover of all species identified	unitless (percent)
substrate_cover	Non-living substrate percent cover	unitless (percent)

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Instruments

Dataset-specific Instrument Name	Aqua Logic Delta Star, DS-4
Generic Instrument Name	Aquarium chiller
Generic Instrument Description	Immersible or in-line liquid cooling device, usually with temperature control.

Dataset-specific Instrument Name	Mettler-Toledo T50
Generic Instrument Name	Automatic titrator
Dataset-specific Description	An automatic titrator (Mettler-Toledo T50,Columbus, OH, USA) fitted with a InMotion Pro-sample carousel (Columbus, OH, USA). The titrator had a Mettler pH probe (DGi-115, Columbus, OH, USA) and was operated with certified HCl titrant (Batch #A17, Dickson Laboratory).
Generic Instrument Description	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	calipers
Generic Instrument Name	calipers
Generic Instrument Description	A caliper (or "pair of calipers") is a device used to measure the distance between two opposite sides of an object. Many types of calipers permit reading out a measurement on a ruled scale, a dial, or a digital display.

Dataset-specific Instrument Name	Fisher Scientific accuSpin 3R
Generic Instrument Name	Centrifuge
Generic Instrument Description	A machine with a rapidly rotating container that applies centrifugal force to its contents, typically to separate fluids of different densities (e.g., cream from milk) or liquids from solids.

Dataset-specific Instrument Name	Thermo Scientific Orion Star A222 Conductivity Portable Meter
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	Traceable digital thermometer (Control Company 5-077)
Generic Instrument Name	digital thermometer
Generic Instrument Description	An instrument that measures temperature digitally.

Dataset-specific Instrument Name	snorkel
Generic Instrument Name	Diving Mask and Snorkel
Generic Instrument Description	A diving mask (also half mask, dive mask or scuba mask) is an item of diving equipment that allows underwater divers, including, scuba divers, free-divers, and snorkelers to see clearly underwater. Snorkel: A breathing apparatus for swimmers and surface divers that allows swimming or continuous use of a face mask without lifting the head to breathe, consisting of a tube that curves out of the mouth and extends above the surface of the water.

Dataset-specific Instrument Name	Fisher Scientific Isotemp Oven
Generic Instrument Name	Drying Oven
Generic Instrument Description	a heated chamber for drying

Dataset-specific Instrument Name	Control Equipment Corporation: Model CEC 440HA
Generic Instrument Name	Elemental Analyzer
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

Dataset-specific Instrument Name	QuikChem 8500 Series 2, Lachat Instruments, Zellweger Analytics
Generic Instrument Name	Flow Injection Analyzer
Generic Instrument Description	An instrument that performs flow injection analysis. Flow injection analysis (FIA) is an approach to chemical analysis that is accomplished by injecting a plug of sample into a flowing carrier stream. FIA is an automated method in which a sample is injected into a continuous flow of a carrier solution that mixes with other continuously flowing solutions before reaching a detector. Precision is dramatically increased when FIA is used instead of manual injections and as a result very specific FIA systems have been developed for a wide array of analytical techniques.

Dataset-specific Instrument Name	Improved Neubauer Haemocytometer
Generic Instrument Name	Hemocytometer
Generic Instrument Description	A hemocytometer is a small glass chamber, resembling a thick microscope slide, used for determining the number of cells per unit volume of a suspension. Originally used for performing blood cell counts, a hemocytometer can be used to count a variety of cell types in the laboratory. Also spelled as "haemocytometer". Description from: http://hlsweb.dmu.ac.uk/ahs/elearning/RITA/Haem1/Haem1.html.

Dataset-specific Instrument Name	Finnex 800W Titanium Heater, Finnex 300W Titanium Heater
Generic Instrument Name	Immersion heater
Generic Instrument Description	Submersible heating element for water tanks and aquaria.

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	Leica Binocular Microscope
Generic Instrument Name	Microscope - Optical
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of reflection and absorption of visible light. Includes conventional and inverted instruments. Also called a "light microscope".

Dataset-specific Instrument Name	Fisher Scientific Isotemp Muffle Furnace
Generic Instrument Name	muffle furnace
Generic Instrument Description	A muffle furnace or muffle oven (sometimes retort furnace in historical usage) is a furnace in which the subject material is isolated from the fuel and all of the products of combustion, including gases and flying ash. A type of jacketed enclosure that is used to heat a material to significantly high temperatures while keeping it contained and fully isolated from external contaminants, chemicals or substances. Muffle furnaces are usually lined with stainless steel, making them largely corrosion-resistant.

Dataset-specific Instrument Name	Onset HOBO Pendent Light Intensity Data Logger
Generic Instrument Name	Onset HOBO Pendant Temperature/Light Data Logger
Generic Instrument Description	The Onset HOBO (model numbers UA-002-64 or UA-001-64) is an in-situ instrument for wet or underwater applications. It supports light intensity, soil temperature, temperature, and water temperature. A two-channel logger with 10-bit resolution can record up to approximately 28,000 combined temperature and light measurements with 64K bytes memory. It has a polypropylene housing case. Uses an optical USB to transmit data. A solar radiation shield is used for measurement in sunlight. Temperature measurement range: -20 deg C to 70 deg C (temperature). Light measurement range: 0 to 320,000 lux. Temperature accuracy: +/- 0.53 deg C from 0 deg C to 50 deg C. Light accuracy: Designed for measurement of relative light levels. Water depth rating: 30 m.

Dataset-specific Instrument Name	Onset HOBO TidbiT v2 Temp Data Logger UTBI-001
Generic Instrument Name	Onset HOBO TidbiT v2 (UTBI-001) temperature logger
Generic Instrument Description	A temperature logger that measures temperatures over a wide temperature range. It is designed for outdoor and underwater environments and is waterproof to 300 m. A solar radiation shield is required to obtain accurate air temperature measurements in sunlight (RS1 or M-RSA Solar Radiation Shield). With an operational temperature range between -20 degrees Celsius and +70 degrees Celsius, the TidbiT v2 has an accuracy of +/-0.21 and a resolution of 0.02 degrees Celsius.

Dataset-specific Instrument Name	fiber optic oxygen sensors
Generic Instrument Name	Oxygen Sensor
Generic Instrument Description	An electronic device that measures the proportion of oxygen (O2) in the gas or liquid being analyzed

Dataset-specific Instrument Name	analytical balance
Generic Instrument Name	scale
Generic Instrument Description	An instrument used to measure weight or mass.

Dataset-specific Instrument Name	sediment traps
Generic Instrument Name	Sediment Trap
Dataset-specific Description	Traps were constructed with six individual 6 cm diameter (D) x 30 cm height (H) PVC pipes (Storlazzi et al., 2011) that each had a 2 cm D x 4 cm H PVC pipe glued to its side. The smaller PVC pipe slid over an 8-inch long screw that was installed into a cement base.
Generic Instrument Description	Sediment traps are specially designed containers deployed in the water column for periods of time to collect particles from the water column falling toward the sea floor. In general a sediment trap has a jar at the bottom to collect the sample and a broad funnel-shaped opening at the top with baffles to keep out very large objects and help prevent the funnel from clogging. This designation is used when the specific type of sediment trap was not specified by the contributing investigator.

Dataset-specific Instrument Name	Apex Controller, Neptune Systems
Generic Instrument Name	thermostat
Generic Instrument Description	A device designed to regulate temperature by controlling the starting and stopping of a heating/cooling system.

Dataset-specific Instrument Name	Shimadzu UV-2450
Generic Instrument Name	UV Spectrophotometer-Shimadzu
Generic Instrument Description	The Shimadzu UV Spectrophotometer is manufactured by Shimadzu Scientific Instruments (ssi.shimadzu.com). Shimadzu manufacturers several models of spectrophotometer; refer to dataset for make/model information.

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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
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