Coral Isotope data from a heating experiment using samples collected from Nikko Bay and Rebotel Reef in Palau in the spring of 2018

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Project
» Collaborative Research: Stability, flexibility, and functionality of thermally tolerant coral symbioses (Thermally tolerant coral)

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Abstract
Coral reefs surrounding Palau, Micronesia are living within a broad range of thermal habitats. Specifically, corals living on the offshore barrier reefs surrounding Palau reside in waters with low temperature variability compared to the much warmer and more acidic waters of near shore environments surrounding the Rock Island habitats. This study was designed to test the differences in thermal physiology among two species of reef corals that reside at both of these locations. Specifically, we examined how short-term elevated temperature influences the uptake and assimilation of carbon and nitrogen isotopes into the symbiotic algae, the coral tissue, and the coral skeleton among these two coral species.

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Coverage

Location: Palau International Coral Reef Center, Koror, Palau.
Spatial Extent: **N**:7.3245 **E**:134.4939 **S**:7.248833 **W**:134.235817
Temporal Extent: 2018-05-21 - 2018-06-03

Dataset Description

This work was conducted in the island nation of Palau. Coral colonies were sampled from an inshore location

(Ngermid Bay, also known as Nikko Bay) and an offshore location on the western barrier reef surrounding Palau (Rebotel Reef). Sampled colonies were returned to land and treated in a thermal experiment at the Palau International Coral Reef Center in land-based aquariums.

Methods & Sampling

Eight colonies of the coral *Psammocora digitata* and *Pocillopora verrucosa* were sampled from the offshore western barrier reef, Rebotel reef (7.248833° N, 134.235817° E) at 5–10 m depth, and from Nikko Bay (also known by Ngermid Bay, 7.3245° N, 134.4939° E) at 5 m depth. Samples were transported to the Palau International Coral Research Center (PICRC), and each colony sample was cut into nine replicate ramets that were placed in flow-through sea water tables and allowed to heal for 48 hours before mounting on labeled PVC tiles with marine epoxy (Splash zone compound A-788).

Temperature experiments were conducted in indoor aquarium systems. Each system used a semi-enclosed design that consisted of a series of 44 L plastic bins connected to a central 220 L sump that was supplied by a continuous slow-feed supply of fresh seawater. The control system (4 bins) was maintained at an average temperature of 28.27 ± 0.33°C by an in-line chiller and titanium heater. The heated system (6 bins) was ramped from 28°C to 31°C (1°C day^{-1}) and held at 31.86 ±0.14°C by an in-line titanium heater. All bins were lighted to an irradiance of 600 µmol photons $m^{-2}s^{-1}$ by LED lights set to daily ramping. At the end of each experiment (day 13), control and treatment ramets were placed in glass beakers containing 400 mL of freshly filtered seawater (0.45 µm) that was enriched with 0.633 mM of $NaH^{13}CO_3$ (99 atom % ^{13}C, Cambridge Isotope Lab Inc., Andover, MA, USA), and 1.5 µM of $Na^{15}NO_3$ (98 atom % ^{15}N, Cambridge Isotope Lab Inc., Andover, MA, USA). Beakers were fitted with false bottoms and continually stirred with magnetic stir bars. All beakers were held for 5 hours at the experimental temperatures under the continuous maximum light level (600 µmol photons $m^{-2}s^{-1}$) used in the experiment. Fragments were then removed, rinsed in filtered seawater, and immediately frozen at -60° C until further processing.

Coral tissue was removed with an airbrush and filtered seawater (0.45µm), followed by the addition of 0.02% (w/v) sodium dodecyl sulfate (SDS) and homogenization for 10 s with a Tissue-Tearor (Biospec Products, Inc). Algae and coral tissue were separated by 2–3 centrifugation washes (550 g for 5 min) with 10 s homogenization steps between each wash. Algal cells were pelleted via centrifugation and frozen at -20°C. Accumulated supernatants (animal portion) were microscopically verified to not contain symbiotic algae or skeletal material and were filtered onto pre-combusted (450°C for 5 h) glass 0.7 µm glass fiber filters (Whatman GF/F) until clogged and then frozen at −20°C. Due to the relatively high concentration of ^{13}C assimilation by the symbiotic algae during the labeling incubations, coral skeletons were placed in 100% bleach for 24h to remove remnant organic material, rinsed in fresh water for 24h, and dried under low heat. Approximately 20 mg of the outermost $CaCO_3$ was sampled from both the corallite and coenosarc regions of the coral skeleton using a Dremel tool with a diamond bit. Skeletal samples were stored at -20°C. Elemental isotope analyses were performed on a Carlo Erba CHN Elemental Analyzer (Model NA1500) coupled to Thermo Finnigan Delta V Isotope Ratio Mass Spectrometer via a Thermo Finnigan Conflo III Interface at the University of Georgia, Center for Applied Isotope Studies.

Instruments:

- Seawater temperature was controlled by an in-line chiller and titanium heater DeltaStar DS-3, and Cygnet Mini (Aqualogic Inc.), and light was supplied to each experimental bin by a custom LED array (XP-G3 Cool White LEDs, Cree) controlled with a digital Storm Controller(Coralux).
- Water was continuously mixed in each bin by a small submersible pump (Sicce Micra, 90 GPH).
- Coral tissue was removed with an airbrush (Paasche VL-3AS) at 100 psi and homogenized with a hand-held homogenizer (Tissue tearor, Biospec Products, Inc).
- Coral homogenates were centrifuged in a clinical centrifuge (IEC)
- Isotope analyses were performed on a Carlo Erba CHN Elemental Analyzer (Model NA1500) coupled to Thermo Finnigan Delta V Isotope Ratio Mass Spectrometer via a Thermo Finnigan Conflo III Interface at the University of Georgia, Center for Applied Isotope Studies.

Data Processing Description

Enriched isotopic data are reported as atom% of the heavy isotope (AP15N & AP13C).

BCO-DMO Processing Description

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Problem Description

Some missing data cells were due to sample loss in transport from Palau to the U.S. and partial thawing of some samples and were not included in the final isotopic analyses.

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Parameters

Parameter	Description	Units
Species	Coral species tested. Psammacora digitata or Pocillopora verrucosa	unitless
Sym	Symbiotic dinoflagellate ID based on ITS2 nomenclature or formal genus and species (when known)	unitless
Treatment	Control (=28 degrees Celsius) or Heated (=32 degrees Celsius)	unitless
Date	Month Day Year as (MDDYYYY)	unitless
Day	Day of measurement from start of experiment (time zero)	unitless
Colony	Colony number (1–8 for each species)	unitless
a_13catom	Atom percent enrichment in 13C in the algae	percent (%)
h_13catom	Atom percent enrichment in 13C in the coral tissue	percent (%)
s_13catom	Atom percent enrichment in 13C in the coral skeleton	percent (%)
a_15natom	Atom percent enrichment in 15N in the algae	percent (%)
h_15natom	Atom percent enrichment in 15N in the coral tissue	percent (%)

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Instruments

Dataset-specific Instrument Name	Carlo Erba CHN Elemental Analyzer (Model NA1500)
Generic Instrument Name	Carlo-Erba NA-1500 Elemental Analyzer
Dataset-specific Description	Elemental isotope analyses were performed on a Carlo Erba CHN Elemental Analyzer (Model NA1500)
Generic Instrument Description	A laboratory instrument that simultaneously determines total nitrogen and total carbon from a wide range of organic and inorganic sediment samples. The sample is completely and instantaneously oxidised by flash combustion, which converts all organic and inorganic substances into combustion products. The resulting combustion gases pass through a reduction furnace and are swept into the chromatographic column by the carrier gas which is helium. The gases are separated in the column and detected by the thermal conductivity detector which gives an output signal proportional to the concentration of the individual components of the mixture. The instrument was originally manufactured by Carlo-Erba, which has since been replaced by Thermo Scientific (part of Thermo Fisher Scientific). This model is no longer in production.

Dataset-specific Instrument Name	Thermo Finnigan Delta V Isotope Ratio Mass Spectrometer
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

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Project Information

Collaborative Research: Stability, flexibility, and functionality of thermally tolerant coral symbioses (Thermally tolerant coral)

Coverage: Coral Reefs of Palau, Micronesia

NSF abstract:

All reef-building corals require large numbers of internal symbiotic microalgae (called Symbiodinium) for their survival and growth. These mutualisms have shown considerable sensitivity to changes in the environment in recent decades, especially due to global increases in ocean temperatures. When exposed to severe thermal stress, corals loose their symbionts and often die. However, recent experiments show that some symbionts may be more stress-tolerant. Corals with these heat-resistant symbionts continue to receive high amounts of algal derived nutrients and grow under elevated temperatures. If the global trend in seawater warming continues to increase, these heat-resistant symbioses may become more ecologically prevalent on reef systems around the world and could play a critical role in maintaining healthy and productive coral communities. This project will examine the ecological and physiological attributes of stress-tolerant symbioses from the Indo Pacific where coral communities are the largest, most diverse, and productive in the world. The researchers will conduct a series of experiments to (1) evaluate host and symbiont attributes that contribute to thermal tolerance and (2) characterize the relative flexibility and functionality of various corals and symbionts exposed to typical ambient and stressful temperatures. Broader impacts of the project include the

training of several Ph.D. students, undergraduates, and high school students in the disciplines of physiology and ecology. The researchers will partner with Global Ocean Exploration, Inc. to communicate this research to the general public through short documentary videos, editorials, and podcasts. An interactive K-5 program, "Invertebrates on the Road," will introduce elementary students in Pennsylvania to marine invertebrate diversity. Research results will also be disseminated to the public at the University of Delaware via educational seminars, as well as through hands-on research displays and demonstrations presented at the annual open house "Coast Day" festival in each year of the project.

This project will examine several attributes important to the functional ecology of coral-dinoflagellate symbioses. Specifically, the research team seeks to understand the interplay between coral and symbiont physiologies under different environmental conditions and determine the relative influence of biotic factors crucial to the performance of stress tolerant symbioses. Results from recent experiments on Indo-west Pacific corals found that Clade D (S. trenchii) symbionts are stress-tolerant. These symbionts are able to maintain function and provide nutrients to their hosts under high temperatures that typically elicit the breakdown of symbioses involving many other species of symbiont. A number of questions arise about how enhanced thermal tolerance symbioses may be aided by a combination of factors; for example: Are symbionts physiologically hardier in corals that are routinely feeding? Do host genotypes that are adapted to high temperatures affect the physiology of their symbionts in ways that make the partnership more stress-tolerant? A series of experiments over three years will examine the functionality of different coral-symbiont pairings exposed to ambient and high temperatures. Reciprocal transplants between inshore (stress-tolerant) and offshore (stress-susceptible) reef sites will be used to produce specific host-symbiont parings. Controlled experiments will test the relative importance of coral trophic status (nutrient content) while holding symbiont type constant and how changes in both coral trophic status and symbiont species identity of the resident affect thermal tolerance. Tank experiments on shore will track rates of photosynthesis as well as carbon translocation and assimilation from symbiont to host tissues and skeletons. Long-term growth rates via skeletal density, linear extension, and biomass gain will also be measured. This project will help elucidate how biochemical, physiological and ecological differences among host-symbiont pairings may respond to rising ocean temperatures and enhance the future viability of coral reefs.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1719684
NSF Division of Ocean Sciences (NSF OCE)	OCE-1635695
NSF Division of Ocean Sciences (NSF OCE)	OCE-1636022

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