Physiological responses of the coral host and associated endosymbionts measured during two experiments testing the effects of acute and chronic thermal stress on the scleractinian coral, Stylophora pistillata

Website: https://www.bco-dmo.org/dataset/858036
Data Type: experimental
Version: 1
Version Date: 2021-08-10

Project
» EAGER: Collaborative Research: Bleaching phenotypes of acute vs. chronic coral bleaching susceptibility and resilience: towards a standardized coral resilience diagnostic (EAGER-CBASS)

Contributors	Affiliation	Role
Barshis, Daniel J.	Old Dominion University (ODU)	Principal Investigator
Warner, Mark E.	University of Delaware	Co-Principal Investigator
Evensen, Nicolas R.	Old Dominion University (ODU)	Scientist
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Abstract
This dataset describes physiological responses of the coral host and associated endosymbionts measured at the end of the heating hold period and after a recovery period during experiments conducted to test the effects of acute (18 h) and chronic (14 d) thermal stress on the scleractinian coral, Stylophora pistillata. Experiments were conducted in Eilat, Israel in January-February 2019. Methods and results are published in Evensen et al., 2021 (doi: 10.1002/lno.11715).

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Coverage

Spatial Extent: **Lat**:29.55723 **Lon**:34.951579
Temporal Extent: 2019-01-20 - 2019-02-03

Methods & Sampling

Two experiments were conducted to test the effects of acute (18 h) and chronic (14 d) thermal stress on the scleractinian coral, *Stylophora pistillata*. A full description of the methodology is detailed in the published manuscript Evensen et al. (2021).

Multiple ramets of 8 *Stylophora pistillata* genets were used in two experiments: an 18 h acute thermal stress assay using the Coral Bleaching Automated Stress System (CBASS) and a 14 day chronic heat stress

experiment using the Red Sea Simulator (RSS). Experiments were performed in Eilat, Israel in January-February 2019.

In each experiment, corals were exposed to four temperature treatments (27°C (summer ambient), 29.5°C, 32°C, and 34.5°C), with physiological responses of the coral and symbionts assessed at the end of the thermal stress exposure (T1) and after a period of recovery (T2). This dataset represents the physiological response metrics measured at each time point, for each of the acute (CBASS) and chronic heat (RSS) stress experiments.

Physiological responses of the coral host and associated endosymbionts were measured at the end of the heating hold (after 6 h in the CBASS and 6-10 days in the RSS), referred to as T1, and after a recovery period (12 h and 3-7 days post-heat stress in the CBASS and RSS, respectively), referred to as T2. Control/baseline samples were also collected for each genet - a 'field' sample was assessed upon returning from sample collection and a 'T0' sample was assessed after ~ 2 h incubation in the experimental tanks, immediately prior to the start of the experiments, during which time seawater temperatures in the tanks was steadily ramped up from 22°C to 27°C. Experimental tanks were then ramped up to temperature treatments reaching 27°C, 29.5°C, 32°C, and 34.5°C, with each temperature containing two replicate tanks (A and B).

Problem report:
Missing data were samples that were not measured or that are missing due to sample mortality.

Data Processing Description

Data Processing:
Data were organized and plotted using R statistical software (version 4.0.3) or in Prism (v. 8.0; GraphPad Software, Inc.).

BCO-DMO Processing:
- renamed fields to comply with BCO-DMO naming conventions.

The originally submitted GitHub repository https://github.com/BarshisLab/CBASS-vs-RSS-Physiology was forked to https://github.com/BCODMO/CBASS-vs-RSS-Physiology and tagged with release 1.0, which corresponds with this dataset submission. The original repository may have continued updates.

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Data Files

File	
physio_response_metrics.csv	(Comma Separated Values (.csv), 12.45 KB) MD5:42696a84acf151278ea06acd5cd15839
Primary data file for dataset ID 858036	

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Supplemental Files

File	
CBASS-vs-RSS-Physiology-1.0.zip	(ZIP Archive (ZIP), 10.18 MB) MD5:c0ee937e896b43e0224439a51f6f6358
Code used to analyze and plot data; associated with BCO-DMO datasets 858036 and 858081 and with Evensen et al., 2021 (doi: 10.1002/lno.11715)	
These files are also available in the following GitHub repository: https://github.com/BCODMO/CBASS-vs-RSS-Physiology/releases/tag/1.0	

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Related Publications

Evensen, N. R., Fine, M., Perna, G., Voolstra, C. R., & Barshis, D. J. (2021). Remarkably high and consistent tolerance of a Red Sea coral to acute and chronic thermal stress exposures. Limnology and Oceanography, 66(5), 1718–1729. doi:10.1002/lno.11715
Results

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Related Datasets

IsRelatedTo

Evensen, N. R., Warner, M. E., Barshis, D. J. (2021) **Temperature data measured during two experiments testing the effects of acute and chronic thermal stress on the scleractinian coral, Stylophora pistillata.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-08-10 doi:10.26008/1912/bco-dmo.858081.1 [view at BCO-DMO]
Relationship Description: The Temperature dataset (858081) contains temperature data recorded during the experiments. The Physiological Response Metrics dataset (858036) contains the physiological responses recorded during the experiments.

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Parameters

Parameter	Description	Units
Experiment	experiment: CBASS = Coral Bleaching Automated Stress System; RSS = Red Sea Simulator	unitless
Genet	genet ID number	unitless
Timepoint	timepoint of experiment: Field, T0, T1, or T2 (refer to Acquitision Description for definitions)	unitless
Temperature	temperature	degrees Celsius
Replicate	replicate ID	unitless
Sym_density	symbiont densities measured in each ramet, normalised to the surface area of the ramet	cells per square centimeter (cells per cm2)
Protein_mg_cm2	animal protein concentrations extracted from each ramet, normalised to the surface area of the ramet	milligrams per square centimeter (mg per cm2)
Chla_cm2	chlorophyll a extracted from algal symbionts extracted in each ramet, normalised to the surface area of the ramet	micrograms per square centimeter (ug per cm2)
Chla_cell	chlorophyll a extracted from algal symbionts extracted in each ramet, normalised to number of symbiont cells in each ramet	picograms per cell (pg per cell)
FvFm	measurements of dark adapted maximum quantum yield of photosystem II of the algal symbionts (Fv/Fm) for each ramet	unitless
Resp	measurements of holobiont respiration for each ramet	micromoles O2 per square centimeter per hour (umol O2 per cm2 per hour)
NetPS	measurements of algal symbiont photosynthesis for each ramet	micromoles O2 per square centimeter per hour (umol O2 per cm2 per hour)

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Instruments

Dataset-specific Instrument Name	
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	IceProbe Thermoelectric chillers
Generic Instrument Name	Aquarium chiller
Dataset-specific Description	Temperature control in each tank is achieved using a combination of IceProbe Thermoelectric chillers (Nova Tec) and 150-200 W aquarium heaters linked to a custom-built controller (Arduino MEGA 2560).
Generic Instrument Description	Immersible or in-line liquid cooling device, usually with temperature control.

Dataset-specific Instrument Name	
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	CBASS
Generic Instrument Name	Coral Bleaching Automated Stress System
Generic Instrument Description	CBASS, which stands for "Coral Bleaching Automated Stress System", are portable, field-deployable experimental tanks used to apply rapid, acute heat stress challenges. This system is described in: Voolstra, C. R., Buitrago-López, C., Perna, G., Cárdenas, A., Hume, B. C. C., Rädecker, N., & Barshis, D. J. (2020). Standardized short-term acute heat stress assays resolve historical differences in coral thermotolerance across microhabitat reef sites. Global Change Biology, 26(8), 4328-4343. Portico. https://doi.org/10.1111/gcb.15148

Dataset-specific Instrument Name	MACSQuant Analyzer 10, Miltenyi Biotec
Generic Instrument Name	Flow Cytometer
Generic Instrument Description	Flow cytometers (FC or FCM) are automated instruments that quantitate properties of single cells, one cell at a time. They can measure cell size, cell granularity, the amounts of cell components such as total DNA, newly synthesized DNA, gene expression as the amount messenger RNA for a particular gene, amounts of specific surface receptors, amounts of intracellular proteins, or transient signalling events in living cells. (from: http://www.bio.umass.edu/micro/immunology/facs542/facswhat.htm)

Dataset-specific Instrument Name	Diax 900, Heidolph Instruments
Generic Instrument Name	Homogenizer
Generic Instrument Description	A homogenizer is a piece of laboratory equipment used for the homogenization of various types of material, such as tissue, plant, food, soil, and many others.

Dataset-specific Instrument Name	GalaxyHydro, Roleandro
Generic Instrument Name	LED light
Dataset-specific Description	Tanks were located indoors and received ~ 300 µmol quanta m−2 s−1 from LED aquarium lights (GalaxyHydro, Roleandro) for 12 h per day, as measured via a Li-Cor spherical quantum PAR (Photosynthetically Active Radiation) sensor (LI-192, Li-COR).
Generic Instrument Description	A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons.

Dataset-specific Instrument Name	LI-192, Li-COR
Generic Instrument Name	LI-COR LI-192 PAR Sensor
Dataset-specific Description	Tanks were located indoors and received ~ 300 µmol quanta m−2 s−1 from LED aquarium lights (GalaxyHydro, Roleandro) for 12 h per day, as measured via a Li-Cor spherical quantum PAR (Photosynthetically Active Radiation) sensor (LI-192, Li-COR).
Generic Instrument Description	The LI-192 Underwater Quantum Sensor (UWQ) measures underwater or atmospheric Photon Flux Density (PPFD) (Photosynthetically Available Radiation from 360 degrees) using a Silicon Photodiode and glass filters encased in a waterproof housing. The LI-192 is cosine corrected and features corrosion resistant, rugged construction for use in freshwater or saltwater and pressures up to 800 psi (5500 kPa, 560 meters depth). Typical output is in um s-1 m-2. The LI-192 uses computer-tailored filter glass to achieve the desired quantum response. Calibration is traceable to NIST. The LI-192 serial numbers begin with UWQ-XXXXX. LI-COR has been producing Underwater Quantum Sensors since 1973. These LI-192 sensors are typically listed as LI-192SA to designate the 2-pin connector on the base of the housing and require an Underwater Cable (LI-COR part number 2222UWB) to connect to the pins on the Sensor and connect to a data recording device. The LI-192 differs from the LI-193 primarily in sensitivity and angular response. 193: Sensitivity: Typically 7 uA per 1000 umol s-1 m-2 in water. Azimuth: < ± 3% error over 360° at 90° from normal axis. Angular Response: < ± 4% error up to ± 90° from normal axis. 192: Sensitivity: Typically 4 uA per 1000 umol s-1 m-2 in water. Azimuth: < ± 1% error over 360° at 45° elevation. Cosine Correction: Optimized for underwater and atmospheric use. (www.licor.com)

Dataset-specific Instrument Name	FireSting O2, Pyroscience oxygen probes
Generic Instrument Name	Oxygen Sensor
Dataset-specific Description	Oxygen flux in the chambers was measured at 1-s intervals using oxygen probes (FireSting O2, Pyroscience).
Generic Instrument Description	An electronic device that measures the proportion of oxygen (O2) in the gas or liquid being analyzed

Dataset-specific Instrument Name	Biotek HT Synergy plate reader
Generic Instrument Name	plate reader
Generic Instrument Description	Plate readers (also known as microplate readers) are laboratory instruments designed to detect biological, chemical or physical events of samples in microtiter plates. They are widely used in research, drug discovery, bioassay validation, quality control and manufacturing processes in the pharmaceutical and biotechnological industry and academic organizations. Sample reactions can be assayed in 6-1536 well format microtiter plates. The most common microplate format used in academic research laboratories or clinical diagnostic laboratories is 96-well (8 by 12 matrix) with a typical reaction volume between 100 and 200 uL per well. Higher density microplates (384- or 1536-well microplates) are typically used for screening applications, when throughput (number of samples per day processed) and assay cost per sample become critical parameters, with a typical assay volume between 5 and 50 µL per well. Common detection modes for microplate assays are absorbance, fluorescence intensity, luminescence, time-resolved fluorescence, and fluorescence polarization. From: http://en.wikipedia.org/wiki/Plate_reader, 2014-09-0-23.

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Project Information

EAGER: Collaborative Research: Bleaching phenotypes of acute vs. chronic coral bleaching susceptibility and resilience: towards a standardized coral resilience diagnostic (EAGER-CBASS)

Coverage: Red Sea, Thuwal, Saudi Arabia, Eilat Israel

NSF Award Abstract:
The past few years have seen an unprecedented amount of coral bleaching across the globe. Global bleaching events in 2015-17, severely impacting iconic coral reefs in places such as the Great Barrier Reef, Micronesia, Hawaiian Islands, and Caribbean, were the worst recorded in recent human history. When ocean temperatures rise, the symbiosis between reef-building corals and their photosynthetic algae deteriorates, many times resulting in widespread coral die-offs as corals can starve without their symbiotic partners to supply food. These widespread events can have drastic impacts on ocean health and biodiversity, as well as the communities that depend on reefs for fishing, tourism, and protection from storms. Importantly, some corals resist or recover from bleaching better than others. Such variability in coral response to ocean warming could be critical to reef survival in the future, yet the scientific community lacks any standardized diagnostics to rapidly assess bleaching tolerance limits. Here, we plan to: 1) develop a standardized, short-term exposure to assess bleaching limits (analogous to cardiac stress tests for humans), 2) design an experimental system capable of delivering a range of thermal treatments as an open-source, low-cost, highly-portable device that can be readily adapted for bleaching tests in a wide variety of coral habitats, and 3) disseminate the results, instructions, and technologies to the reef research and conservation community through a combination of hands-on workshops, online outreach materials, press releases, and open-access research publications. Widespread dissemination of project products will be achieved via hands-on demonstrations and workshops in

key geographic areas (Middle East, Caribbean, and Indo-Pacific), with a focus on the assembly of the system and operation of the experimental assay using local corals. This project will train both graduate students and a postdoctoral researcher, and brings together a team of national and global researchers in a collaborative investigation to address the international problem of coral bleaching.

With each passing year, coral bleaching has shifted from an issue of serious sporadic concern to a critical widespread threat to reefs across the globe that is increasing in frequency and severity. However, during widespread bleaching events, some scattered corals and reef sections are able to survive better than others. Whether this is due to acclimatization or adaptation in thermal stress tolerance, this variability in response is critical to coral resilience to climate impacts. Currently, the scientific community lacks a standardized approach to rapidly assess coral thermal limits and identify resilient individuals or populations. Present day approaches range from observational surveys of natural bleaching and mortality, to multiple weeks of controlled chronic thermal exposure, to rapid, single or multi-day acute heat shocks. To what degree bleaching response varies across short-term versus longer-term experiments and how these responses compare to natural bleaching patterns is largely unknown. Using a group of coral species representative of a historical range of bleaching susceptibility (e.g., Acropora hemprichii, Pocillopora meandrina, and Porites lobata), research will address this important knowledge gap by experimental evaluation of the bleaching response to acute (0 - 2 day) versus chronic (>4 week) thermal stress. The overarching questions for this study are: how are the acute and chronic coral bleaching responses related, and can investigators predict ecologically relevant bleaching outcomes from the response to a short-term, acute heat-stress? To answer these questions, the research team will: 1) objectively compare acute versus chronic heat-stress exposures and synthesize a variety of response metrics based on core physiological measurements to develop a standardized, short-term thermal assay and diagnostic approach to rapidly assess bleaching, 2) operationalize an experimental system built around an open-source, cost-effective, easily transportable temperature control technology, and 3) distribute the results, experimental procedures, and temperature controlling technologies to the reef research and conservation communities. This project will produce an affordable experimental system and short-term diagnostic capable of determining coral thermal limits in just a few days in almost any location with reliable access to seawater and electricity or a portable generator. The research fills a critical knowledge gap through the development of a standardized set of diagnostic tools to assess coral thermal vulnerability before widespread bleaching events actually occur, so that proactive conservation and management strategies can be implemented ahead of widespread impacts to reef ecosystems.

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-1833215
NSF Division of Ocean Sciences (NSF OCE)	OCE-1833201

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