Physiological metrics recorded at the end of experiments conducted to examine two coral species' responses to thermal stress

Website: https://www.bco-dmo.org/dataset/858150
Data Type: experimental
Version: 1
Version Date: 2021-08-11

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
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Abstract
This dataset includes physiological response metrics recorded at the end of experiments conducted to examine two coral species' responses to thermal stress. Species examined were Acropora hemprichii and Porites lobata. Experiments were performed in Thuwal, Saudi Arabia in July-August 2019.

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Coverage

Spatial Extent: **Lat**:22.275795 **Lon**:39.113112
Temporal Extent: 2019-07-29 - 2019-08-11

Methods & Sampling

Multiple ramets of five genets of *Acropora hemprichii* and five genets of *Porites lobata* were collected from two sites (protected and exposed) used in two experiments: an 18 h acute thermal stress assay using the Coral Bleaching Automated Stress System (CBASS) and a two-week prolonged heating experiment using the indoor aquarium system at the King Abdullah University of Science and Technology (KAUST) Coastal and Marine Resources laboratory. Physiological responses of the coral host and associated endosymbionts were measured during (Fv/Fm, and phosynthesis and respiration) and at the end of the experiments (Final: symbiont densities, host protein, and chlorophyll a concentrations per cell and per cm2). Experimental tanks were ramped up from the 32°C control treatment to temperature treatments reaching 35°C, 36.5°C, and 38°C over 3h in the CBASS, and temperature treatments reaching 33.5°C, 35°C, and 36.5°C in the prolonged experiment at rates of 0.5 and 1.5°C per day. Each temperature treatment contained two replicate tanks (A and B).

Corals were subjected to short-term (7h) acute thermal profiles with four peak target temperatures (32°C, 35°C, 36.5°C, and 38°C), versus more prolonged heat exposures lasting 7 to 15 days, where temperatures were raised 0.5 and 1.5°C per day to four target temperatures (32°C, 33.5°C, 35°C, and 36.5°C). Physiological response metrics were recorded during and at the end of the experiments.

This dataset includes the final physiological metrics from both experiments.

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 organised using R statistical software (version 4.0.3).

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

The originally submitted GitHub repository https://github.com/BarshisLab/Heating-Duration-vs-Intensity-vs-RampRate was forked to https://github.com/BCODMO/Heating-Duration-vs-Intensity-vs-RampRate 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
final_physio.csv (Comma Separated Values (.csv), 32.69 KB) MD5:746f3ead8adf0bc6f2fbd79922a0f22f Primary data file for dataset ID 858150

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Supplemental Files

File
Heating-Duration-vs-Intensity-vs-RampRate-1.0.zip (ZIP Archive (ZIP), 9.89 MB) MD5:a762f0b8e1419f74653bf7da72a16296 Code used to analyze and plot data; associated with BCO-DMO datasets 858112, 858150, and 858180. These files are also available in the following GitHub repository: https://github.com/BCODMO/Heating-Duration-vs-Intensity-vs-RampRate/releases/tag/1.0

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Related Datasets

IsRelatedTo

Evensen, N. R., Warner, M. E., Barshis, D. J. (2021) **Maximum potential quantum efficiency of**

Photosystem II (Fv/Fm) for two coral species, Acropora hemprichii and Porites lobata, in response to thermal stress. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-08-10 doi:10.26008/1912/bco-dmo.858112.1 [view at BCO-DMO]
Relationship Description: These datasets resulted from the same set of experiments.

Evensen, N. R., Warner, M. E., Barshis, D. J. (2021) **Photosynthesis and respiration data recorded during experiments conducted to examine two coral species' responses to thermal stress.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-08-11 doi:10.26008/1912/bco-dmo.858180.1 [view at BCO-DMO]
Relationship Description: These datasets resulted from the same set of experiments.

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Parameters

Parameter	Description	Units
Species	species: Acropora or Porites	unitless
Experiment	experiment: CBASS = Coral Bleaching Automated Stress System; Prolonged = two-week prolonged heating experiment at the King Abdullah University of Science and Technology (KAUST)	unitless
Ramp	method of ramping up temperature	unitless
Temperature	temperature	degrees Celsius
Treatment	treatment	unitless
Tank	tank ID	unitless
Site	description of coral collection site: exposed or protected	unitless
Genotype	genotype	unitless
Replicate	replicate: each temperature treatment contained two replicate tanks (A and B)	unitless
Sym_density	symbiont densities measured in each ramet, normalised to the surface area of the ramet	cells per square centimeter (cells per cm2)
Pro	animal protein concentrations extracted from each ramet, normalised to the surface area of the ramet	milligrams per square centimeter (mg 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 (pg per cell)
Chla	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)

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Instruments

Dataset-specific Instrument Name	3D scanner (HDI 120, LMI Technologies Inc.)
Generic Instrument Name	3D scanner
Generic Instrument Description	A 3D scan captures digital information about the shape of an object with equipment that uses a laser or light to measure the distance between the scanner and the object.

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	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	flow cytometer (BD LSRFortessa, BD Biosciences)
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. Description from: http://www.bio.umass.edu/micro/immunology/facs542/facswhat.htm

Dataset-specific Instrument Name	Pulse amplitude-modulated (PAM) fluorometer (MINI-PAM, WALZ)
Generic Instrument Name	Fluorometer
Generic Instrument Description	A fluorometer or fluorimeter is a device used to measure parameters of fluorescence: its intensity and wavelength distribution of emission spectrum after excitation by a certain spectrum of light. The instrument is designed to measure the amount of stimulated electromagnetic radiation produced by pulses of electromagnetic radiation emitted into a water sample or in situ.

Dataset-specific Instrument Name	handheld homogenizer (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	fiberoptic oxygen probes (FireSting O2, Pyroscience)
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	SpectraMax Paradigm Multi-Mode Microplate Reader (Molecular Devices)
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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