Temperature data from short-term heat stress assays performed with with corals collected from sites around Heron Island, southern Great Barrier Reef in Sept and Oct of 2022

Website: https://www.bco-dmo.org/dataset/926905
Data Type: Other Field Results, experimental
Version: 1
Version Date: 2024-05-07

Project
» Influence of environmental pH variability and thermal sensitivity on the resilience of reef-building corals to acidification stress (Coral Resilience)

Contributors	Affiliation	Role
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Abstract
Variable temperature regimes that expose corals to sub-lethal heat stress have been recognized as a mechanism to increase coral thermal tolerance and lessen coral bleaching. However, there is a need to better understand which thermal regimes maximize coral stress hardening. Here, standardized thermal stress assays were used to determine the relative thermal tolerance of three divergent genera of corals (Acropora, Pocillopora, Porites) originating from six reef sites representing an increasing gradient of annual mean diel temperature fluctuations of 1–3°C day-1. Bleaching severity and dark-acclimated photochemical yield (i.e., Fv/Fm) were quantified following exposure to five temperature treatments ranging from 23.0 to 36.3°C (see Related Datasets for photochemical yield). This data set contains the short-term heat stress temperature data.

Table of Contents

Coverage

Location: Heron Island Research Station, Heron Island, southern Great Barrier Reef (23 27°S, 151 55°E)
Spatial Extent: **Lat**:-23.27 **Lon**:151.55
Temporal Extent: 2022-09-27 - 2022-10-09

Dataset Description

See the "Related Datasets" section for other closely related data that was also part of the study published in Brown et al., 2024.

Methods & Sampling

Note: Figure and table references refer to Brown et al., 2024.

Study location

This study was conducted across six sites spanning less than 5 km at Heron Island, southern Great Barrier Reef (23°27' S 151°55' E; Figure 1), which included at least one representative from each geomorphological habitat of Heron Reef (site; depth ± standard deviation): reef slope [Fourth Point (FP; 4.2±0.72 m); Harry's Bommie (HB; 6.1±0.82 m)], reef crest (RC; 0.9±0.59 m), reef flat (RF; 0.7±0.59 m), shallow lagoon (SL; 1.3±0.74 m) and deep lagoon (DL; 2.6±0.59 m) (Phinn et al. 2012) (Figure 1). PAR levels (µmol m-2 sec-1), averaged across the year-long period from August 2015– September 2016, were lower within reef slope habitats (HB: 75.9, FP: 179.4) than within the lagoon habitats (RC: 199.2, RF: 371.7, SL: 201.8, DL: 198.8) (Brown et al. 2023a). Historically, hard coral cover has been greatest within the reef slope (~60%), which is dominated by corals of the family Acroporidae, whereas within the lagoon, sites have peaked around 20% coral cover and are principally composed of *Pocillopora* and massive *Porites* (Connell et al. 1997; Roelfsema et al. 2021; Brown et al. 2023a). Experiments were performed in the austral spring to avoid any potentially confounding thermal stress that is becoming increasingly common during the summer (Marzonie et al. 2022). While absolute thermal tolerance can differ across seasons (Berkelmans and Willis 1999), relative thermal tolerance between individuals across seasons remains consistent (Cunning et al. 2021; Evensen et al. 2022).

Sample collection

Three morphologically distinct coral species with distinct life-history strategies were examined:

Acropora cf. *aspera* (competitive; branching open), *Pocillopora* cf. *damicornis* (weedy; branching closed), and *Porites* cf. *lobata* (stress-tolerant; massive) (Darling et al. 2012) (Figure 3). Coral fragments were collected from 27 September to 6 October 2022 (Table S1). Ten colonies of each genus were sampled from each site except where noted (n = 5–10 colonies per species per site; Figure 3). *Acropora* cf. *aspera* was not collected at the Shallow Lagoon and Deep Lagoon as it was absent or rare. Following collection, corals were transported to Heron Island Research Station (HIRS) and placed in outdoor, flow-through seawater troughs under ambient temperatures (22.86 ± 0.02°C) until experimentation. Each colony was divided into five fragments (i.e., genetic clones) of ~5 cm using bone cutters (*Acropora* and *Pocillopora*) or a brick saw (*Porites*). *Acropora* and *Pocillopora* were then suspended within the experimental tanks using fishing line. *Porites* fragments were placed on plastic grating at the bottom of the experimental tanks. Coral thermal tolerance experiments were initiated within 3–48 hours of collection (Table S1).

Acute heat stress experiment

A standardized temperature profile was used to measure heat tolerance in corals (e.g., (Voolstra et al. 2020; Cunning et al. 2021; Marzonie et al. 2022; Evensen et al. 2023)) with minor modification in temperature profiles. The climatological maximum monthly mean (MMM) of Heron Reef is 27.3°C (Weeks et al. 2008). A pilot experiment with all three genera indicated no difference in Fv/Fm between MMM, MMM+3°C and MMM+6°C, so the latter two treatments were increased to more accurately assess the decline in performance, such that the five treatments used here included ambient, MMM, MMM+4°C, MMM+6.5°C, and MMM+9°C. Generally, experiments began at ~12:00 with a 3-hr ramp to respective treatment temperatures (23°C, 27.3°C, 31.3°C, 33.8°C, 36.3°C), a 3-hr hold, and a 1-hr ramp down to MMM (Evensen et al. 2023) (Figure S1). Lights were turned off at the onset of the 1-hr ramp down to correspond with sunset. Due to experimental constraints (space, equipment, and time), only two treatments (n = 1 tank) were performed per day and each site was done in isolation. Accordingly, a complete assay took two days per site, with treatments tested each day selected randomly (Table S1, Figure S1). A fragment from each coral colony was randomly placed into each treatment, so that all colonies were present in each treatment. Temperatures were controlled using an Apex controller (Neptune Systems). Apex temperature probes were calibrated against a high-precision temperature probe (HANNA HI-98190; accuracy: ±0.4°C at 25°C; resolution: ± 0.10°C) at the onset of the experiment. Temperatures were also recorded using cross-calibrated temperature loggers (HOBO UA-001-64, accuracy: ± 0.29°C at 25°C). Photosynthetically active radiation (PAR) was static and controlled using aquarium lights (NICREW HyperReef LED, Shenzhen NiCai Technology Co.), averaging 250 µmol m-2 sec-1.

Organism identifiers (Genus, Lifesciences Identifier [LSID]):
Pocillopora, urn:lsid:marinespecies.org:taxname:206938
Porites, urn:lsid:marinespecies.org:taxname:206485
Acropora, urn:lsid:marinespecies.org:taxname:205469

Data Processing Description

For more detailed information on analysis and results, please see: Brown, et al. (2024).

BCO-DMO Processing Description

* submitted file "STHS temperature data_revised.csv" was imported into the BCO-DMO data system for this dataset.
** Missing data values are displayed differently based on the file format you download. They are blank in csv files, "NaN" in MatLab files, etc.

* 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]

* DateTime in AEST converted to UTC and added as an additional column in the dataset (timestamp with timezone in ISO 8601 format).

Problem Description

N/A

[table of contents | back to top]

Related Publications

Berkelmans, R., & Willis, B. L. (1999). Seasonal and local spatial patterns in the upper thermal limits of corals on the inshore Central Great Barrier Reef. Coral Reefs, 18(3), 219–228. https://doi.org/10.1007/s003380050186
Methods

Brown, K. T., Eyal, G., Dove, S. G., & Barott, K. L. (2023). Fine-scale heterogeneity reveals disproportionate thermal stress and coral mortality in thermally variable reef habitats during a marine heatwave. Coral Reefs, 42(1), 131–142. https://doi.org/10.1007/s00338-022-02328-6
Methods

Connell, J. H., Hughes, T. P., & Wallace, C. C. (1997). A 30-YEAR STUDY OF CORAL ABUNDANCE, RECRUITMENT, AND DISTURBANCE AT SEVERAL SCALES IN SPACE AND TIME. Ecological Monographs, 67(4), 461–488. https://doi.org/10.1890/0012-9615(1997)067[0461:aysoca]2.0.co;2 https://doi.org/10.1890/0012-9615(1997)067[0461:AYSOCA]2.0.CO;2
Methods

Cunning, R., Parker, K. E., Johnson-Sapp, K., Karp, R. F., Wen, A. D., Williamson, O. M., Bartels, E., D'Alessandro, M., Gilliam, D. S., Hanson, G., Levy, J., Lirman, D., Maxwell, K., Million, W. C., Moulding, A. L., Moura, A., Muller, E. M., Nedimyer, K., Reckenbeil, B., … Baker, A. C. (2021). Census of heat tolerance among Florida's threatened staghorn corals finds resilient individuals throughout existing nursery populations. Proceedings of the Royal Society B: Biological Sciences, 288(1961). https://doi.org/10.1098/rspb.2021.1613
Methods

Darling, E. S., Alvarez-Filip, L., Oliver, T. A., McClanahan, T. R., & Côté, I. M. (2012). Evaluating life-history strategies of reef corals from species traits. Ecology Letters, 15(12), 1378–1386. doi:10.1111/j.1461-0248.2012.01861.x
Methods

Evensen, N. R., Parker, K. E., Oliver, T. A., Palumbi, S. R., Logan, C. A., Ryan, J. S., Klepac, C. N., Perna, G., Warner, M. E., Voolstra, C. R., & Barshis, D. J. (2023). The Coral Bleaching Automated Stress System (CBASS): A low-cost, portable system for standardized empirical assessments of coral thermal limits. Limnology and Oceanography: Methods, 21(7), 421–434. Portico. https://doi.org/10.1002/lom3.10555
Methods

Evensen, N. R., Voolstra, C. R., Fine, M., Perna, G., Buitrago-López, C., Cárdenas, A., Banc-Prandi, G., Rowe, K., & Barshis, D. J. (2022). Empirically derived thermal thresholds of four coral species along the Red Sea using a

portable and standardized experimental approach. Coral Reefs, 41(2), 239–252. https://doi.org/10.1007/s00338-022-02233-y
Methods

Marzonie, M. R., Bay, L. K., Bourne, D. G., Hoey, A. S., Matthews, S., Nielsen, J. J. V., & Harrison, H. B. (2022). The effects of marine heatwaves on acute heat tolerance in corals. Global Change Biology, 29(2), 404–416. Portico. https://doi.org/10.1111/gcb.16473
Methods

Phinn, S. R., Roelfsema, C. M., & Mumby, P. J. (2012). Multi-scale, object-based image analysis for mapping geomorphic and ecological zones on coral reefs. International Journal of Remote Sensing, 33(12), 3768–3797. https://doi.org/10.1080/01431161.2011.633122
Methods

Roelfsema, C., Kovacs, E. M., Vercelloni, J., Markey, K., Rodriguez-Ramirez, A., Lopez-Marcano, S., Gonzalez-Rivero, M., Hoegh-Guldberg, O., & Phinn, S. R. (2021). Fine-scale time series surveys reveal new insights into spatio-temporal trends in coral cover (2002–2018), of a coral reef on the Southern Great Barrier Reef. Coral Reefs, 40(4), 1055–1067. https://doi.org/10.1007/s00338-021-02104-y
Methods

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
Methods

Weeks, S. J., Anthony, K. R. N., Bakun, A., Feldman, G. C., & Guldberg, O. H.-. (2008). Improved predictions of coral bleaching using seasonal baselines and higher spatial resolution. Limnology and Oceanography, 53(4), 1369–1375. Portico. https://doi.org/10.4319/lo.2008.53.4.1369
Methods

[table of contents | back to top]

Related Datasets

IsRelatedTo

Brown, K., Barott, K. (2024) **Photochemical yield and color score data from short-term heat stress assays performed with with corals collected from sites around Heron Island, southern Great Barrier Reef in Sept and Oct of.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-05-07 http://lod.bco-dmo.org/id/dataset/926887 [view at BCO-DMO]
Relationship Description: This dataset was part of the same heat-assay experiment.

Brown, K., Barott, K. (2024) **Thermal tolerance (ED50) data used to compare previously published regional (Florida Reef Tract, Coral Sea, Red Sea) coral thermal tolerance with Heron Island, Great Barrier Reef values measured in 2022.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-05-07 http://lod.bco-dmo.org/id/dataset/926911 [view at BCO-DMO]
Relationship Description: These datasets were part of the same study published in Brown et al., 2024.

[table of contents | back to top]

Parameters

Parameter	Description	Units
index	Row index (serial)	unitless
Date	Date (local AEST, UTC+10)	unitless
Time	Time (local AEST, UTC+10)	unitless
DateTime_Local	Timestamp (local time AEST, UTC+10)	unitless
Temperature	Temperature	degrees Celsius (degC)
day	Day (local AEST, UTC+10)	unitless
Site	Site Code (DL='Deep Lagoon'; FP='Fourth Point'; HB='Harry\'s Bommie'; RC=Reef Crest; RF=Reef Flat; SL=Shallow Lagoon)	unitless
Treatment	Treatment description: amb, T1, T2, T3, T4 (see methodology for treatment code details).	unitless
DateTime_UTC	Timestamp with timezone (ISO 8601, UTC)	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	temperature loggers (HOBO UA-001-64)
Generic Instrument Name	Onset HOBO Pendant Temperature/Light Data Logger
Dataset-specific Description	Temperatures were controlled using an Apex controller (Neptune Systems). Apex temperature probes were calibrated against a high-precision temperature probe (HANNA HI-98190; accuracy: ±0.4°C at 25°C; resolution: ± 0.10°C) at the onset of the experiment. Temperatures were also recorded using cross-calibrated temperature loggers (HOBO UA-001-64, accuracy: ± 0.29°C at 25°C).
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.

[table of contents | back to top]

Project Information

Influence of environmental pH variability and thermal sensitivity on the resilience of reef-building corals to acidification stress (Coral Resilience)

Coverage: Kaneohe Bay, Oahu, HI; Heron Island, Queensland, Australia

NSF Award Abstract:
Coral reefs are incredibly diverse ecosystems that provide food, tourism revenue, and shoreline protection for coastal communities. The ability of coral reefs to continue providing these services to society is currently threatened by climate change, which has led to increasing ocean temperatures and acidity that can lead to the death of corals, the animals that build the reef framework upon which so many species depend. This project examines how temperature and acidification stress work together to influence the future health and survival of corals. The scientists are carrying out the project in Hawaii where they have found individual corals with different sensitivities to temperature stress that are living on reefs with different environmental pH conditions. This project improves understanding of how an individual coral's history influences its response to multiple stressors and helps identify the conditions that are most likely to support resilient coral communities. The project will generate extensive biological and physicochemical data that will be made freely available. Furthermore, this project supports the education and training of undergraduate and high school students and one postdoctoral researcher in marine science and coral reef ecology. Hands-on activities for high school students are being developed into a free online educational resource.

This project compares coral responses to acidification stress in populations experiencing distinct pH dynamics (high diel variability vs. low diel variability) and with distinct thermal tolerances (historically bleaching sensitive vs. tolerant) to learn about how coral responses to these two factors differ between coral species and within populations. Experiments focus on the two dominant reef builders found at these stable and variable pH reefs: Montipora capitata and Porites compressa. Individuals of each species exhibiting different thermal sensitivities (i.e., bleached vs. pigmented) were tagged during the 2015 global coral bleaching event. This system tests the hypotheses that 1) corals living on reefs with larger diel pH fluctuations have greater resilience to acidification stress, 2) coral resilience to acidification is a plastic trait that can be promoted via acclimatization, and 3) thermally sensitive corals have reduced capacity to cope with pH stress, which is exacerbated at elevated temperatures. Coral cells isolated from colonies from each environmental and bleaching history are exposed to acute pH stress and examined for their ability to recover intracellular pH in vivo using confocal microscopy, and the expression level of proteins predicted to be involved in this recovery (e.g., proton transporters) is examined via Western blot and immunolocalization. Corals from each pH history are exposed to stable and variable seawater pH in a controlled aquarium setting to determine the level of plasticity of acidification resilience and to test for pH acclimatization in this system. Finally, corals with different levels of thermal sensitivity are exposed to thermal stress and recovery, and their ability to regulate pH is examined over time. The results of these experiments help identify reef conditions that promote coral resilience to ocean acidification against the background of increasingly common thermal stress events, while advancing mechanistic understanding of coral physiology and symbiosis.

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.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1923743

[table of contents | back to top]