Benthic community composition from Heron Island, southern Great Barrier Reef determined from 2015 to 2020

Website: https://www.bco-dmo.org/dataset/918134
Data Type: Other Field Results
Version: 1
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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
Increasing ocean temperatures threaten coral reefs globally, but corals residing in habitats that experience high thermal variability are thought to be better adapted to survive climate-induced heat stress. Here, we used long-term ecological observations and in situ temperature data from Heron Island, southern Great Barrier Reef to investigate how temperature dynamics within various thermally variable vs. thermally stable reef habitats change during a marine heatwave and the resulting consequences for coral community survival. This data set includes the benthic community composition data across eight sites at Heron Island, southern Great Barrier Reef.

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Coverage

Location: Heron Island Research Station, Heron Island, southern Great Barrier Reef
Spatial Extent: **N**:-23.4395 **E**:151.98 **S**:-23.4598 **W**:151.929
Temporal Extent: 2015-01 - 2020-09

Methods & Sampling

Study location:
This study was conducted across eight sites at Heron Island, southern Great Barrier Reef (23°27' S 151°55' E), previously characterized in detail (Brown et al. 2018, 2020). Briefly, sites included each geomorphological habitat of Heron Reef: reef slope, reef crest, reef flat, shallow lagoon, and deep lagoon (Phinn et al. 2012) (Fig. 1 of Brown et al. 2023). The geomorphological habitats of Heron Reef are distinguished by diverse benthic communities, with hard coral cover higher within the reef slope and macroalgae cover greater within the lagoonal habitats (Brown et al. 2018; Roelfsema et al. 2021). Reef-wide coral cover in 2015 and 2016 was amongst the highest observations in the past 60 years (Connell et al. 1997; Brown et al. 2018; Roelfsema et al.

2021) (e.g., ~75% within the south-west reef slope and ~20% within lagoon), making these years optimal as a recent baseline record.

Within the reef slope habitat, four sites were established: two within the north-east section of the reef (Fourth Point, 4.2 meters (m) and 8 m) and two within the south-west (Harry's Bommie, 6.1 m and 8.2 m) (Fig. 1 of Brown et al. 2023). The northeast of Heron Reef is the exposed side, subject to extreme wave forces during cyclones, whereas the south-west is sheltered from waves generated by both the south-east trade winds and extreme wave action of cyclones (Connell et al. 1997). One site was established in each other geomorphological habitat, with each site sharing its name: Reef Crest (RC; 0.9 m), Reef Flat (RF; 0.7 m), Shallow Lagoon (SL; 1.3 m) and Deep Lagoon (DL; 2.6 m) (Fig. 1 of Brown et al. 2023). Inside the lagoon, semidiurnal tidal fluctuations result in higher variability in temperature and pH than reef slope sites (Brown et al. 2018; Cyronak et al. 2020) (Fig. 2, Fig. S1 of Brown et al. 2023). Photosynthetically active radiation (PAR; µmol quanta $m^{-2}s^{-1}$) is lower within reef slope habitats (HB5: 75.9, HB8: 72.8, FP5: 179.4, FP8: 58.9) than within the lagoon habitats (RC: 199.2, RF: 371.7, SL: 201.8, DL: 198.8), due to differences in depth (Brown et al. 2018; Cyronak et al. 2020). Mean depth and PAR were determined by use of Conductivity Temperature Depth (CTD) units that continuously recorded between July 2015 and November 2016 (SBE 16plus V2 SEACAT fitted with an auxiliary PAR sensor, Satlantic/ECO-PAR sensor) (see Brown et al. 2018 for more detailed methodology).

Benthic community composition:
Benthic community composition was recorded in August 2020 using the method described by Brown et al. 2018. During each survey, three replicate 15-meter (m) transects were laid north, east, and west from a permanent reference point. Quadrats (0.25 square meters (m^2)) were alternated right and left every 0.5 m along the transect line, totaling 30 quadrats per transect. Percent cover of each quadrat was recorded in situ from 22 specific categories. The four main categories were hard coral, other invertebrates (including soft corals and sponges), algae, and substrate. Hard corals were differentiated into family and growth form: Acroporidae- tabular/corymbose/digitate (ARC-TCD), Acroporidae- branching (ACR-BRA), Acroporidae-plating/encrusting (ACR-PE), Pocilloporidae (POCI); Poritidae-massive (POR-M); Poritidae-encrusting/plating varieties (POR-PE); Poritidae-branching (POR-BRA); Faviidae-Lobophyllidae (FAV-LOB); and other hard corals (including non-scleractinian corals). Bleaching status was recorded to family and growth form for all live corals and due to low bleaching prevalence across sites (Fig. S2 of Brown et al. 2023), combined as 'bleached hard coral' for analyses. Macroalgae were separated as: fleshy macroalgae, calcifying algae of the genus Halimeda, articulate/crustose coralline algae (ACA/CCA), and turf algae/cyanobacteria. Substrate was divided into sand/sediment, coral rubble, and recently dead hard coral (i.e., coral skeletons with epithetic algal community with turf height <3 millimeters (mm)). Recently dead hard coral was also recorded to family and growth form where possible (Fig. S2 of Brown et al. 2023).

Benthic community composition in 2020 was compared to data collected in July 2015 and August 2016 along the same transects (Brown et al. 2018). All surveys were conducted within the same season (austral winter) because macroalgae display significant shifts in composition and abundance across seasons (Brown et al. 2018). The relative changes in hard coral (including bleached coral), algae, and hard substrate (including coral rubble and recently dead coral) were determined by subtracting the mean between years and dividing by the initial cover.

For more detailed information, please see:
Brown, K.T., Eyal, G., Dove, S.G. et al. (2023) Fine-scale heterogeneity reveals disproportionate thermal stress and coral mortality in thermally variable reef habitats during a marine heatwave. Coral Reefs 42, 131-142. https://doi.org/10.1007/s00338-022-02328-6

Data Processing Description

See Brown et al. (2023) for details of statistical analyses performed using this dataset.

BCO-DMO Processing Description

- Imported the original file "All benthic community composition at Heron Island 2015-2020.xlsx" into the BCO-DMO system.
- Renamed fields/columns to comply with BCO-DMO naming conventions (replaced hyphens, slashes, and spaces with underscores).
- Created columns for Latitude and Longitude using the site locations provided as part of the temperature

dataset metadata.
- Rounded the percent cover columns to a maximum of 3 decimal places.
- Saved the final file as "918134_v1_benthic_comm_comp_heron_isl_2015-2020.csv".

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Data Files

File
918134_v1_benthic_comm_comp_heron_isl_2015-2020.csv(Comma Separated Values (.csv), 11.70 KB) MD5:8a245f06b5d6019a7db5ac634ec64eff Primary data file for dataset ID 918134, version 1

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Related Publications

Brown, K. T., Bender-Champ, D., Kubicek, A., van der Zande, R., Achlatis, M., Hoegh-Guldberg, O., & Dove, S. G. (2018). The Dynamics of Coral-Algal Interactions in Space and Time on the Southern Great Barrier Reef. Frontiers in Marine Science, 5. https://doi.org/10.3389/fmars.2018.00181
Methods

Brown, K. T., Bender-Champ, D., Achlatis, M., Zande, R. M., Kubicek, A., Martin, S. B., Castro-Sanguino, C., Dove, S. G., & Hoegh-Guldberg, O. (2020). Habitat-specific biogenic production and erosion influences net framework and sediment coral reef carbonate budgets. Limnology and Oceanography, 66(2), 349–365. Portico. https://doi.org/10.1002/lno.11609
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
Results

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/10.2307/2963466
Methods

Cyronak, T., Takeshita, Y., Courtney, T. A., DeCarlo, E. H., Eyre, B. D., Kline, D. I., Martz, T., Page, H., Price, N. N., Smith, J., Stoltenberg, L., Tresguerres, M., & Andersson, A. J. (2019). Diel temperature and pH variability scale with depth across diverse coral reef habitats. Limnology and Oceanography Letters, 5(2), 193–203. Portico. https://doi.org/10.1002/lol2.10129
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

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Parameters

Parameter	Description	Units
Year	Year	unitless
Depth	Depth	meters (m)
Transect	Transect ID number. There were 3 replicate transects per site.	unitless
Site	Site name	unitless
Latitude	Latitude of site; negative values = South	decimal degrees
Longitude	Longitude of site; positive values = East	decimal degrees
ACR_TCD	Acroporidae- tabular/corymbose/digitate	percent cover (%)
ACR_BRA	Acroporidae- branching (ACR-BRA)	percent cover (%)
ACR_PE	Acroporidae- plating/encrusting (ACR-PE)	percent cover (%)
POCI	Pocilloporidae (POCI)	percent cover (%)
POR_MASS	Poritidae-massive (POR-M)	percent cover (%)
POR_ENC	Poritidae-encrusting/plating varieties (POR-PE)	percent cover (%)
POR_BRA	Poritidae-branching (POR-BRA)	percent cover (%)
FAV_LOB	Faviidae-Lobophyllidae (FAV-LOB)	percent cover (%)
Other_hard	other hard corals (including non-scleractinian corals)	percent cover (%)
Soft_coral	soft coral	percent cover (%)
Giant_Clam	giant clam	percent cover (%)
Sea_Cuke	sea cucumbers	percent cover (%)
OTH_INV	other invertebrates	percent cover (%)
Macroalgae	fleshy macroalgae	percent cover (%)
Halimeda	calcifying algae of the genus Halimeda	percent cover (%)
Turf_Cyano	turf algae/cyanobacteria	percent cover (%)
CCA_ACA	articulate/crustose coralline algae (ACA/CCA)	percent cover (%)
Sand_Sed	sand/sediment	percent cover (%)
Coral_Rubble	coral rubble	percent cover (%)
Bleached_coral	bleached coral	percent cover (%)
Bare_Rock	recently dead hard coral (i.e., coral skeletons with epithetic algal community with turf height	percent cover (%)
Temperature_mean	Mean temperature by year and site	degrees Celsius
Temperature_max	Maximum temperature by year and site	degrees Celsius
Temperature_min	Minimum temperature by year and site	degrees Celsius
Amplitude	Mean diel temperature amplitude by year and site	degrees Celsius per day
DHW	Degree heating weeks	degrees Celsius per week

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Instruments

Dataset-specific Instrument Name	quadrat
Generic Instrument Name	quadrat
Dataset-specific Description	Quadrats (0.25 m^2) were alternated right and left every 0.5 m along the transect line, totaling 30 quadrats per transect. Percent cover of each quadrat was recorded in situ from 22 specific categories.
Generic Instrument Description	A square or rectangular rigid frame of known area, often home-made, that is placed on the substrate to be sampled to mark a fixed area for sampling flora or fauna.

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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.

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Funding

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

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