Vertical temperature data from Little Cayman, Cayman Islands, during the 4th global bleaching event from September 2023 (Molecular and Morphological Coral Adaptation project)

Website: https://www.bco-dmo.org/dataset/964602
Data Type: Other Field Results
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Project
» NSF-BSF: Assessing the mechanisms of molecular and morphological adaptation by corals to extreme environments (Molecular and Morphological Coral Adaptation)

Contributors	Affiliation	Role
Goodbody-Gringley, Gretchen	Central Caribbean Marine Institute (CCMI)	Principal Investigator
Newman, Sawyer	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Coral reefs are increasingly threatened by marine heatwaves, which drive widespread coral bleaching and mortality. Mesophotic coral ecosystems (MCEs) have been proposed as potential thermal refuges due to their greater depth and relative isolation from surface temperature extremes. Yet their resilience to extreme heat events remains uncertain, with location specific conclusions, thus requiring further studies. Here, we investigate the effects of the 2023 marine heatwave in the Cayman Islands, which resulted in prolonged sea surface temperatures exceeding 31°C and 17.5 DHW with extensive bleaching across shallow coral reefs. Utilizing vertical transect surveys from 10m to 50m, we assessed depth-related variations in bleaching prevalence and temperature profiles. Our results indicate a significant decline in bleaching with increasing depth, with a concurrent reduction in temperature. Depth-generalist species exhibited reduced bleaching at greater depths, whereas shallow-water specialists displayed severe bleaching. These findings suggest that while MCEs may provide thermal refuge for some species, their capacity to buffer against climate-driven reef degradation is species-specific. Given the increasing frequency and intensity of marine heatwaves, understanding the role of deeper reef habitats in mitigating coral loss is critical for informing conservation and management strategies. Our study underscores the importance of protecting MCEs as potential thermal refuges while emphasizing the need for continued research on species-specific thermal resilience with depth. Within this dataset, we present the temperature data measured during each survey across depth.

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Coverage

Location: Little Cayman Island, Cayman Islands
Spatial Extent: **Lat**:19.68492 **Lon**:-80.078
Temporal Extent: 2023-09-16

Methods & Sampling

These data were collected from Little Cayman Island at three specific sites: Randy's Gazebo (19.683783, -80.082967), Marylin's Cut (19.684733, -80.079067), and Mixing Bowl (19.684920, -80.078000). Each site features a near-vertical wall that begins at approximately 10 m and extends to depths exceeding 1,000 m.

At each site, a single transect was secured to the substrate at the shallowest point of the vertical wall and extended downward to a maximum depth of 50 m. Seawater temperature was recorded throughout each dive using HOBO ProV temperature loggers attached to the backs of two divers. Depth-specific temperature readings were determined by correlating logger timestamps with depth data from each diver's handheld computer (Shearwater Petrel). All dives were conducted using closed-circuit rebreathers (Hollis Prism 2).

Data Processing Description

Depth-specific temperature readings were determined by correlating logger timestamps with depth data from each diver's handheld computer (Shearwater Petrel).

BCO-DMO Processing Description

- Latitude and longitude of site locations added to the primary data file from dataset metadata.
- Latitude and longitude values were rounded to six degrees of precision.
- Depth column renamed to Depth_ft to more clearly differentiate it from the Depth_m column.

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Parameters

Parameter	Description	Units
site	Colloquial name of dive site.	unitless
Depth_ft	Depth in feet.	feet (ft)
Depth_m	Depth in meters.	meters (m)
Temp	Temperature recorded at measured depth.	degrees Celsius (C)
Site_Latitude	Site latitude; a positive value indicates a northern coordinate.	decimal degrees
Site_Longitude	Site longitude; a negative value indicates a western coordinate.	decimal degrees

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Instruments

Dataset-specific Instrument Name	HOBO ProV2 temperature logger
Generic Instrument Name	Onset HOBO Pro v2 temperature logger
Dataset-specific Description	HOBO ProV2 temperature loggers were attached to the backs of two divers and used to record seawater temperature throughout each dive at the three study sites.
Generic Instrument Description	The HOBO Water Temp Pro v2 temperature logger, manufactured by Onset Computer Corporation, has 12-bit resolution and a precision sensor for ±0.2°C accuracy over a wide temperature range. It is designed for extended deployment in fresh or salt water. Operation range: -40° to 70°C (-40° to 158°F) in air; maximum sustained temperature of 50°C (122°F) in water Accuracy: 0.2°C over 0° to 50°C (0.36°F over 32° to 122°F) Resolution: 0.02°C at 25°C (0.04°F at 77°F) Response time: (90%) 5 minutes in water; 12 minutes in air moving 2 m/sec (typical) Stability (drift): 0.1°C (0.18°F) per year Real-time clock: ± 1 minute per month 0° to 50°C (32° to 122°F) Additional information (http://www.onsetcomp.com/) Onset Computer Corporation 470 MacArthur Blvd Bourne, MA 02532

Dataset-specific Instrument Name	Shearwater Petrel handheld dive computer
Generic Instrument Name	Water Depth Logger
Dataset-specific Description	Depth-specific temperature readings were obtained by matching logger timestamps with depth data recorded on each diver's handheld computer (Shearwater Petrel).
Generic Instrument Description	For measuring and recording water levels in rivers, streams, and wells.

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Project Information

NSF-BSF: Assessing the mechanisms of molecular and morphological adaptation by corals to extreme environments (Molecular and Morphological Coral Adaptation)

Coverage: Caribbean, Subtropical Atlantic, Red Sea

NSF Award Abstract

Coral reefs have global ecological, structural, social, and economic importance, are a fundamental component of marine ecosystems, and a major locus of global biodiversity. The recent devastating impacts of global warming and local stressors on shallow-water coral reef communities are expected to increase as oceans continue to warm, leading to more frequent and severe mortality events. In recent years, deeper reef systems have gained considerable interest as they appear to be buffered from impacts affecting shallow-water coral reefs and may, therefore, serve as important areas of refuge for coral survival.

Survival under rapid environmental change relies, in part, on the ability of organisms to adapt to new conditions. Species that exist along broad depth gradients are exposed to a wide range of environmental conditions, requiring a high capacity for adaptation and/or trait-based selection in response to different conditions. In this study, we address two primary research questions: (1) how does coral morphology and physiology differ across depth and (2) are these differences due to plasticity or evolutionary adaptation? Using a multifaceted approach, including advanced molecular and imaging techniques, we will examine the mechanisms that enable corals to thrive across broad depth gradients. As a US-Israel binational project led by two female early career scientists, we will promote diversity and create new international collaborations

through student participation, training workshops and exchange. Ultimately, this study will improve our understanding of coral reef resilience and indicate the potential for deep reefs to serve as refuges.

Although corals often show macromorphological and physiological characteristics distinct for each species, it is also known that these features may vary along environmental gradients among individuals of the same species. Changes in such features often appear to match local conditions in a way that may be beneficial, however, whether these changes result from phenotypic plasticity or trait-based selection remains unclear. Here, we examine the relative influence of plasticity versus selective adaptation on changes to morphology, physiology and gene expression across a depth gradient to determine if these characteristics differ among geographic locations with different environmental conditions, if they are intrinsically or extrinsically controlled, and how they impact recruitment success. Variations in skeletal morphology, calcification, photosynthesis, respiration, symbiotic association, fluorescence, nutrient acquisition, and gene expression will be examined in adult corals from across a depth gradient in the Red Sea and Caribbean. Corals from shallow and mesophotic corals will then be reciprocally transplanted and reassessed for changes in the same key characteristics.

Larvae will also be collected from shallow and mesophotic corals and reciprocally settled in situ, with differences in morphology, ecology, physiology, and gene expression examined across life stages. Finally, differential patterns of recruitment across depths, determined using fluorescent imaging, will determine long-term impacts of adaptation to population resilience.

Together these integrated investigations will provide a comprehensive assessment of the role of light, temperature, and trophic status on the plasticity of corals, as well as the molecular and physiological mechanisms enabling adaptation to environmental conditions experienced in the mesophotic zone. This proposal was cofunded by the Integrative Ecological Physiology Program in the Division of Integrative Organismal Systems in the Directorate for Biological Science and The Biological Oceanography Program in the Division of Ocean Sciences in the Directorate for Geosciences.

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 Integrative Organismal Systems (NSF IOS)	IOS-1937770

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