Cross Depth Coral Transplantation Experiment in Little Cayman, Cayman Islands from 2022 to 2023 (Molecular and Morphological Coral Adaptation project)

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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
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Abstract
In November 2022, colonies of the coral Porites astreoides were collected from two sites off Little Cayman, Cayman Islands, at two depths: shallow (10 m) and mesophotic (45 m). Each colony was bisected, and a cross-depth transplantation experiment was conducted in which one half of each colony was returned to its native depth, while the other half was transplanted to the alternate depth. At each site, light (PME miniPAR) and temperature (HOBO ProV) loggers were deployed to monitor environmental conditions. After a 9-month period, all fragments were recovered and evaluated for survival and overall health status. This dataset represents the survival data for all colonies that were cross-transplanted, providing insight into the adaptive capabilities of corals to differing environmental conditions.

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Coverage

Location: Little Cayman Island, Cayman Islands
Temporal Extent: 2022-11-29 - 2023-07-09

Methods & Sampling

Corals were collected by hand using a hammer and chisel, then bisected with a chisel. Each coral fragment was secured onto a terracotta tile using a mixture of Portland cement and plaster of Paris. Tiles were arranged on racks of six, which were anchored to the reef using 10-inch nails at each corner. PME miniPAR loggers were deployed upright on the benthos at each depth and site, oriented toward the surface. Each logger was equipped with an automated wiper to prevent overgrowth. A HOBO ProV2 temperature logger was mounted next to each PAR logger. Physical data associated with this project are provided in a separate data file. After a 9-month deployment, corals were retrieved and assessed for survival, categorized as either healthy (H) or dead (D).

Parameters

Parameter	Description	Units
Treatment	Depth of origin followed by depth of transplant; i.e., SD = shallow origin transplanted to deep, and DD = deep origin transplanted back to deep.	unitless
Site	Colloquial name for the dive site.	unitless
ID	Individual coral identifier which is the site name_depth of transplant_colony tag id number.	unitless
Status	Health status where H is Healthy and D is Dead.	unitless

Instruments

Dataset-specific Instrument Name	HOBO ProV2 temperature loggers
Generic Instrument Name	Onset HOBO Pro v2 temperature logger
Dataset-specific Description	HOBO ProV2 temperature loggers were mounted on the benthos at each site and depth to monitor thermal conditions. Each HOBO logger was positioned adjacent to a PME miniPAR light logger.
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	PME miniPAR loggers
Generic Instrument Name	PME miniPAR logger
Dataset-specific Description	PME miniPAR loggers, each equipped with an automated wiper system to prevent overgrowth, were deployed upright on the benthos at each site and depth, oriented toward the surface.
Generic Instrument Description	A submersible instrument that logs PAR (Photosynthetically Active Radiation), temperature and tilt measurements. Data are recorded on an internal SD card. The sensor is a LI-192 Underwater Quantum Sensor, manufactured by LI-COR. The sensor uses a silicon photodiode and glass optical filters to create a uniform sensitivity to light wavelengths in the 400-700nm range. It measures PAR from all angles in one hemisphere. An anti-fouling wiper is available. The instrument can be configured to record at intervals between 1 and 60 minutes. It is submersible up to 100 metres. PAR measurement accuracy is dependent upon the stability of the sensor pointed towards the water surface.

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.

Funding

Funding Source	Award
NSF Division of Integrative Organismal Systems (NSF IOS)	IOS-1937770