Histological analysis of Caribbean acroporid corals collected in September 2014 before and after exposure to thermal stress in St. Thomas, U.S. Virgin Islands.

Website: https://www.bco-dmo.org/dataset/752550
Data Type: experimental
Version: 1
Version Date: 2019-01-08

Project
» Collaborative research: Is hybridization among threatened Caribbean coral species the key to their survival or the harbinger of their extinction? (Coral Hybridization)

Contributors	Affiliation	Role
Fogarty, Nicole	Nova Southeastern University	Principal Investigator
Biddle, Mathew	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Histological analysis of Caribbean acroporid corals collected in September 2014 before and after exposure to thermal stress in St. Thomas, U.S. Virgin Islands.

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Coverage

Spatial Extent: **Lat**:18.31701 **Lon**:-64.98923
Temporal Extent: 2014-09-20 - 2014-09-22

Dataset Description

A pilot project was conducted in the St. Thomas, U.S. Virgin Islands to examine the effects of thermal stress on the three acroporid taxon.

Methods & Sampling

Two 10 cm fragments (1 for control tank and 1 for treatment tank) from five colonies of each acroporid taxon were collected from Flat Cay the day prior to the experiment and left under ambient temperature conditions overnight. Tissue samples (2cm) were collected immediately prior to and immediately after the experiment and preserved in a Z-Fix Concentrate: seawater (1:4) solution. One fragment (putative genotype) from each taxon was placed in a control tank (n=5) and one was placed in a treatment tanks (n=5). Powerheads that were slightly tilted out of the water to provide aeration and water movement were placed in all tanks. The ambient tanks were placed in a large tank with constant flowing seawater that served as a water bath. The five treatment tanks, each with an individual heater, were place in a neighboring large tank with no running seawater. All tanks were under a covered porch, but exposed to ambient light conditions.

A Hobo temperature logger was placed in each tank and a water temperature measurement was collected every 30 seconds. The control tanks ranged from 27.5 to 29.4C with an average of 28.2C and the heated tanks ranged from 29.1 to 32.7C with an average of 31.3C over the 48 hour experimental period.

Data Processing Description

The semi-quantitative rubric was designed by Dr. Esther Peters for the histological analysis.

Data legend:
ND = No Data
NS = not enough tissue to determine, not seen

Lesion Description:
H = healthy
WBD = white band disease
RTL = rapid tissue loss
BL = bleaching

Bleaching:
0 = none
1 = paling
2 = bleaching

Bleaching Distribution:
1 = focal
2 = multifocal distinct
3 = multifocal indistinct
4 = diffuse

Condition Scores:
0 = excellent
1 = very good
2 = good
3 = fair
4 = poor
5 = very poor

Intensity/Severity Scores:
0 = no change
1 = minimal
2 = mild
3 = moderate
4 = marked
5 = severe

Other:
P = present
A = absent
SI = staining issue
NS = not seen
N/A = not available
N = no

Epidermal mucocytes:
0 = not larger than ciliated columnar cells, uniform distribution
1 = slightly hypertrophied, numerous
2 = many hypertophied, abundant mucus release
3 = uneven, hypertrophied vs reduced
4 = atrophy, necrosis, and epidermal foci lacking mucocytes
5 = atrophy and most mucocytes lacking

Mesenterial Filament (CGB Epithelium) Mucocytes:

0 = none to few
1 = less than 1/2 area, not hypertrophied
2 = about 1/2 area, some hypertrophied
3 = about 1/2 area, all hypertrophied
4 = about 3/4/ area, some vacuolated
5 = much of area vacuolated, necrotic, loss of mucocytes

Calicodermis Condition:
0 = cells squamous but "thick," cover mesoglea
1 = cells slightly atrophied in some foci
2 = 1/2 of cells atrophied
3 = Most cells atrophied, beginning separation from mesoglea
4 = Cells atrophied and loss or sloughing present

Costal Tissue Loss:
0 = none, tissue over costae intact
1 = a few gaps noted
2 = 1/4 of costae exposed
3 = 1/2 of costae exposed
4 = 3/4 of costae exposed
5 = Most costae exposed, tissues attenuated, retracted?

Oocytes:
0 - none present
1 - single cells in mesoglea
2 - early oocytes
3 - mid-development
4 - mature
5 - spawned

Spermaries:
0 - none present
1 - clusters of single cells in mesoglea
2 - few, early spermaries
3 - numerous spermaries, spermatocytes
4 - mature, spermatozoa
5 - spawne

BCO-DMO Processing Notes:

- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- added lat, lon columns

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Data Files

File
coral_histology.csv (Comma Separated Values (.csv), 19.65 KB) MD5:64bd6394ee50ac010254b832215fe616 Primary data file for dataset ID 752550

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Parameters

Parameter	Description	Units

Lab	Academic affiliation	unitless
Histo_Number	Sample number	unitless
Study	Study title	unitless
Collector	PI on project	unitless
Species	A.cerv = Acropora cervicornis; A.pal = Acropora palmata; A. pro = Acropora prolifera	unitless
Sample_Location	Collection location (18.31701 -64.98923)	unitless
Field_or_Lab_Number	assigned coral identifier	unitless
Date_Collected	coral collection date in MM/DD/YY format	unitless
Sample_Type	location within coral colony	unitless
Lesion_Description	Healthy (apparently) (H); White band disease (WBD); Rapid tissue loss (RTL); Bleaching (BL)	unitless
Bleaching	0 = No; 1 = Paling; 2 = Bleaching	unitless
Colony_Bleaching_Distribution	1 = Focal; 2 = Multifocal Distinct; 3 = Multifocal Indistinct; 4 = Diffuse	unitless
Tissue_Loss	Is the skeleton void of tissue? (Y or N)	unitless
In_situ_Photo	Was a photograph taken during the experiment? (Y or N)	unitless
Gross_Photo_Fixed_Sample	Was a photograph taken after the sample was preserved? (Y or N)	unitless
Collection_Notes	anything notable about photographs	unitless
Sample_Number	The assigned unique identifier	unitless

Piece_Number	Pre= collected before experiment; Post= collected after experiment	unitless
Number_of_Blocks_Made	The number of samples embedded in paraffin to be sectioned and mounted on slides	unitless
Fixation	preservative used (Zfix:seawater in 1:4)	unitless
Enrobing	Was the sample enrobbed in agarose gel to preserve the oritentation of cells and tissues while processing and embedding the sample? (Typically required if there is tissue sloughing on the sample)	unitless
Decal	The solution used to decalcifiy the coral skeleton	unitless
Embed	Medium used to embed tissue sample	unitless
Number_of_Slides_Made	Number of slides made from each block	count
Number_Stained_with_H_E	Number of slides stained with hematoxylin and eosin (H&E) stain	count
Other_Stains	Additional stains used on samples (Yes = Stain specified or N = No)	unitless
General_Condition_10x	Observed tissue condition at 10x maginfication. Combines all parameters into a general score- 0=Excellent; 1= very good; 2= good; 3 =fair; 4 = poor; 5= very poor	unitless
Zooxanthellae_10x	Observed symbiont (zooxanthellae) condition at 10x magnification. 0=Excellent; 1= very good; 2= good; 3 =fair; 4 = poor; 5= very poor. Scores related to the number of zooxanthellae present and their overall apperance (atrophy or hypertrophy).	unitless
Epidermal_Mucocytes_Condition	Observed condition of the unicellular secretory gland cells that secrete mucus through an apical pore to aid in protection; sediment removal; and feeding. Epidermal mucocytes are those found in the epidermis; the outermost tissue layer in corals. Condition of mucocytes; 0 - not larger than ciliated columnar cells; uniform distribution; 1 - slightly hypertrophied; numerous; 2 - many hypertophied; abundant mucus release; 3 - uneven; hypertrophied and/or reduced in number; 4 - atrophy; necrosis; and epidermal foci lacking mucocytes; 5 - atrophy and most mucocytes lacking	unitless

Mesenterial_Filament_Mucocytes	Observed mucocyte condition in the cnidoglandular band area of mesenterial filaments. These are the internal longtiduinal partitions of tissue that provide structual support and increase surface area within the gastrovacular cavity. These regions aid in digestive processes and gonad development. 0=Excellent; 1= very good; 2= good; 3 =fair; 4 = poor; 5= very poor	unitless
Degeneration_Cnidoglandular_Bands	Observed condition of the free edge or middle ridge of the mesentary in the gastrovascular cavity. Scores related to reduction in cell height or number of cells; and atrophy of the epithelium in the cnidoglandular band. 0=Excellent; 1= very good; 2= good; 3 =fair; 4 = poor; 5= very poor	unitless
Dissociation_of_Mesenterial_Filaments	Observed condition of cells in the mesenterial filaments. Scores related to loss of cells and atrophy of cells. 0 - none to few; 1 - less than 1/2 area; not hypertrophied; 2 - about 1/2 area; some hypertrophied; 3 - about 1/2 area; all hypertrophied; 4 - about 3/4/ area; some vacuolated; 5 - much of area vacuolated; necrotic; loss of mucocytes	unitless
Calicodermis_Condition	Observed condition of the basal surface lining epithelium which contains calicoblasts- cells responsible for secreting a matrix to promote crystallization of calcium carbonate; thus assiting in the formation of coral skeleton. 0 = cells squamous but "thick;" cover mesoglea; 1 = cells slightly atrophied in some foci; 2 = 1/2 of cells atrophied; 3 = Most cells atrophied; beginning separation from mesoglea; 4 = Cells atrophied and loss or sloughing present; 5 = Multifocal necrosis or sloughing of atrophied cells or absent on mesoglea	unitless
Calicodermis_Repair	Is there evidence of repair of the calicodermis? Are there columnar calicoblasts with extensions of plasmallema present? (Present = 1; Not Present = 0)	unitless
Costal_Tissue_Loss	Observed condition of tissue over the costal ridges (extensions of the septa of the corallite); 0 = none; tissue over costae intact; 1 = a few gaps noted; 2 = 1/4 of costae exposed; 3 = 1/2 of costae exposed; 4 = 3/4 of costae exposed; 5 = Most costae exposed; tissues attenuated; retracted	unitless
Necrotic_Cell_Spherules	Are there signs of necrotic (dying) cell or group of cells present? (Present = 1; Not Present = 0)	unitless
WBD_Bacterial_Aggregates	Number of bacterial aggregates associated with white band disease observed.	count
Epidermal_RLOs	Number of Rickettsia-like organisms observed in the epidermal tissue layers.	count

Filament_RLOs	Number of Rickettsia-like organisms observed within the mesentary filaments.	count
Gastrodermal_RLOs	Number of Rickettsia-like organisms observed within the gastrodermis.	count
Surface_Bacteria	Number of bacteria present on the outer epidermal layer.	count
Coccidia	Number of single-celled intracellular parasites belonging to apicomplexans observed.	count
Zooxanthellate_Ciliates	Are single-celled protozoans with hair-like organelles called cilia observed with zooxanthellae? (Present = 1; Not Present = 0)	unitless
Non_zooxanthellate_Ciliates	Are single-celled protozoans with hair-like organelles called cilia present in other locations of sample? (Present = 1; Not Present = 0)	unitless
Oocytes_Stage_in_Development	Egg cells found in the mesentaries: 0 - none present; 1 - single cells in mesoglea; 2 - early oocytes; 3 - mid-development; 4 - mature; 5 - spawned	unitless
Spermaries_Stage_in_Development	Location of developing spermatozoa in the mesentaries. 0 - none present; 1 - clusters of single cells in mesoglea; 2 - few; early spermaries; 3 - numerous spermaries; spermatocytes; 4 - mature; spermatozoa; 5 - spawned	unitless
lat	latitude coordinates with North positive	decimal degrees
lon	longitude coordinates with East positive	decimal degrees

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Instruments

Dataset-specific Instrument Name	Hobo Pro v2 data logger
Generic Instrument Name	Temperature Logger
Dataset-specific Description	A Hobo temperature logger was placed in each tank and a water temperature measurement was collected every 30 seconds.
Generic Instrument Description	Records temperature data over a period of time.

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Project Information

Collaborative research: Is hybridization among threatened Caribbean coral species the key to their survival or the harbinger of their extinction? (Coral Hybridization)

Coverage: Caribbean and North-West Atlantic

NSF Award Abstract:
Reef-building acroporid corals form the foundation of shallow tropical coral communities throughout the Caribbean. Yet, the once dominant staghorn coral (Acropora cervicornis) and the elkhorn coral (A. palmata) have decreased by more than 90% since the 1980s, primarily from disease. Their continuing decline jeopardizes the ability of coral reefs to provide numerous societal and ecological benefits, including economic revenue from seafood harvesting and tourism and shoreline protection from extreme wave events caused by storms and hurricanes. Despite their protection under the U.S. Endangered Species Act since 2006, threats to the survival of reef-building acroporid corals remain pervasive and include disease and warming ocean temperatures that may lead to further large-scale mortality. However, hybridization among these closely related species is increasing and may provide an avenue for adaptation to a changing environment. While hybrids were rare in the past, they are now thriving in shallow habitats with extreme temperatures and irradiance and are expanding into the parental species habitats. Additional evidence suggests that the hybrid is more disease resistant than at least one of the parental species. Hybridization may therefore have the potential to rescue the threatened parental species from extinction through the transfer of adapted genes via hybrids mating with both parental species, but extensive gene flow may alter the evolutionary trajectory of the parental species and drive one or both to extinction. This collaborative project is to collect genetic and ecological data in order to understand the mechanisms underlying increasing hybrid abundance. The knowledge gained from this research will help facilitate more strategic management of coral populations under current and emerging threats to their survival. This project includes integrated research and educational opportunities for high school, undergraduate and graduate students, and a postdoctoral researcher. Students in the United States Virgin Islands will take part in coral spawning research and resource managers will receive training on acroporid reproduction to apply to coral restoration techniques.

Current models predict the demise of reefs in the next 200 years due to increasing sea surface temperatures and ocean acidification. It is thus essential to identify habitats, taxa and evolutionary mechanisms that will allow some coral species to maintain their role as foundation fauna. Hybridization can provide an avenue for adaptation to changing conditions. Corals hybridize with some frequency and results may range from the introduction of a few alleles into existing parent species via introgression, to the birth of a new, perhaps better adapted genetic lineage. The only widely accepted coral hybrid system consists of the once dominant but now threatened Caribbean species, Acropora cervicornis and A. palmata. In the past, hybrid colonies originating from natural crosses between elkhorn and staghorn corals were rare, and evidence of hybrid reproduction was limited to infrequent matings with the staghorn coral. Recent field observations suggest that the hybrid is increasing and its ecological role is changing throughout the Caribbean. These hybrids appear to be less affected by the disease that led to the mass mortality of their parental species in recent decades. Hybrids are also found thriving in shallow habitats with high temperatures and irradiance suggesting they may be less susceptible to future warming scenarios. At the same time, they are expanding into the deeper parental species habitats. Preliminary genetic data indicate that hybrids are now mating with each other, demonstrating the potential for the formation of a new species. Further, hybrids appear to be capable of mating with both staghorn and elkhorn coral, perhaps leading to gene flow between the parent species via the hybrid. Research is proposed to address how the increase in hybridization and perhaps subsequent introgression will affect the current ecological role and the future evolutionary trajectory of Caribbean acroporids. Specifically, this collaborative project aims to answer the following questions: 1) What is the historic rate, direction, and degree of introgression across species ranges and genomes? Linkage block analysis based on genome-wide SNP genotyping across three replicate hybrid zones will answer this question. 2) What is the current extent and future potential of later generation hybrid formation? Morphometric and genetic analyses combined with in vitro fertilization assays will be used. 3) What mechanisms allow hybrids to thrive in hot, shallow waters? A series of manipulative in situ and ex situ experiments will determine whether biotic or abiotic factors favor hybrid survival in shallow waters. 4) Are hybrids more disease resistant than the parentals species? Disease transmission assays in reciprocal transplant experiments and histological analysis to determine the extent of disease will be conducted. A multidisciplinary approach will be taken that combines traditional and cutting edge technology to provide a detailed analysis of the evolutionary ecology of Caribbean corals.

Note: PI Nicole Fogarty's original award OCE-1538469 was issued while at Nova Southeastern University. This was replaced by OCE-1929979 upon moving to the University of North Carolina Wilmington.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1538469

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