The effects of nutrient enrichment and predation on coral health and microbiomes from June to August 2013 in Key Largo, FL (small grazers facilitating fungal disease project)

Website: https://www.bco-dmo.org/dataset/717034
Data Type: Other Field Results
Version: 2017-09-26

Project
» Small Grazers, Multiple Stressors and the Proliferation of Fungal Disease in Marine Plant Ecosystems (small grazers facilitating fungal disease)

Contributors	Affiliation	Role
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Dataset Description

To assess how predation and nutrients affect corals and their microbiomes, we exposed colonies of A. cervicornis to a fully factorial field experiment from June to August 2013. This coral species is currently listed as ‘threatened’ under the US Endangered Species Act (NOAA Fisheries 2015) and ‘critically endangered’ under the IUCN Red List (Aronson et al. 2008); therefore, this experiment could not be conducted in natural reef settings or with already-restored colonies. Thus, we conducted this experiment in the Coral Restoration Foundation’s coral nursery in Key Largo, FL, USA in an open sand flat (30-ft depth) using corals grown through established propagation techniques (Johnson et al. 2011).

Related References:

Aronson, R., Bruckner, A., Moore, J., Precht, B. & E. Weil. 2008. Acropora cervicornis. The IUCN Red List of Threatened Species 2008: e.T133381A3716457. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T133381A3716457.en.
Meaghan E. Johnson, Caitlin Lustic, Erich Bartels, Iliana B. Baums, David S. Gilliam, Elizabeth Anne Larson, Diego Lirman, Margaret W. Miller, Ken Nedimyer, and S. Schopmeyer. 2011. Caribbean Acropora Restoration Guide: Best Practices for Propagation and Population Enhancement : 1 -64. http://nsuworks.nova.edu/occ_facreports/71.
Shaver, E. C., Shantz, A. A., McMinds, R., Burkepile, D. E., Vega Thurber, R. L. and Silliman, B. R. (2017), Effects of predation and nutrient enrichment on the success and microbiome of a foundational coral. Ecology, 98: 830–839. doi:10.1002/ecy.1709

Methods & Sampling

We collected coral fragments using wire cutters from visually healthy (e.g., non-diseased) colonies of two genotypes (Upper Keys 2, 'U-2'; Upper Keys 8, 'U-8') due to possible genotypic variation in disease susceptibility. All coral fragments were ~10 cm long to approximate coral transplant sizes used in restoration activities and due to limits in using nursery corals. Using All Fix Marine Epoxy, we secured each coral fragment to an individual structure consisting of a concrete slab with attached vertical PVC pipes, with corals attached to the top of one PVC pipe. Structures were placed 3 meters apart in all directions and were cleaned of all fouling organisms prior to experimentation.

After a one-week acclimation period, we subjected corals to one of four treatments: 1) snail + nutrient; 2) snail-only; 3) nutrient-only; and 4) no snails or nutrients (control). Each treatment consisted of 10 replicates per genotype for a total of 80 colonies. To ensure variation in environmental conditions did not affect treatment results, we evenly distributed genotypes and treatments throughout the experimental site. For nutrient addition treatments, diffusion tubes were secured to PVC tubes ~5cm below coral colonies and replaced every 2-3 weeks. Diffusion tubes consisted of a 6-inch long x 1-inch wide PVC pipe with 16, 3/8-inch holes drilled into the side, covered in mesh screen. Tubes were filled with 70 g Osmocote 19-6-12 Smart-Release Plant fertilizer pellets following the methods of Worm et al. 2000. To ensure nutrient diffusion tubes were effective in releasing nutrients, we analyzed inorganic nitrogen and phosphorus spectrophotometrically from water samples taken within ~3 cm of 5 control corals and ~1 cm from 5 nutrient diffusion tubes once during the experiment a few days after fertilizer pellets were placed in diffusion tubes (UV-2450, Shimadzu; Southeast Environmental Research Center, Miami, FL). Inorganic nutrients were significantly higher in water immediately adjacent to the nutrient tubes (N = 1.474 ppm; P = 0.4211 ppm) relative to controls (N = 0.007 ppm, PN = 0.012; P = 0.007 ppm, PP = 0.006). Though samples were not directly next to corals, we believe this suggests corals received heightened levels of nutrients throughout the experiment.

For predator addition treatments, we collected C. abbreviata snails from non-diseased corals in nearby corals reefs and starved snails in an aquarium for one week to ensure that any potential pathogens were not transmitted through fecal matter. We placed two snails at the base of each snail-only and snail + nutrient coral, which approximated naturally high snail densities on surveyed A. cervicornis colonies harboring C. abbreviata when corrected for colony height (see Results). Every 2-3 days, we examined corals for predation scars indicated by white coral skeleton (Figure 1a from Shaver et al. 2017) and removed snails from colonies when a large portion of tissue (~30% of colony surface area) was consumed. We recorded colony mortality, tissue loss, and disease signs (e.g., tissue sloughing; Figure 1b and c from Shaver et al. 2017) for all treatments every 2-3 days during the study. To assess coral growth, we measured the total linear extension (e.g., additive length of all branches, TLE) of corals at the beginning and end of the experiment. As we noticed colonization of turf algae on open coral skeleton caused by snail feeding scars, we additionally measured algal colonization on coral colonies at the end of the experiment. This was done by visually estimating the percent cover of algae within snail feeding scars and on live coral tissue to the nearest 5%.

Coral fragments that went missing due to roaming turtles and storms were removed from statistical analyses (snail + nutrient: n=3; snail-only: n=2; nutrient-only: n=0; control: n=3). Colony mortality was defined as a total loss of living tissue from the coral fragment and was analyzed using a generalized linear model (GLM) with a binomial distribution due to uneven sample sizes between treatments. Tissue loss was only observed on snail addition colonies during our experiment; therefore, we examined the effects of nutrients on tissue predation. To do this, we estimated the area of tissue predation using the equation for the area of an ellipse ($A = \pi ab$) to approximate the natural shape of Coralliophila abbreviata feeding scars. We used measurements of the maximum height and width of scars taken at the end of the experiment or before tissue sloughing was observed on corals. When predation scars extended across the circumference of the coral, we averaged the maximum and minimum scar height and multiplied it by the circumference measured at the base of each individual coral. Tissue loss data were square root transformed to meet the assumptions of parametric statistics and Analysis of Variance (ANOVA) was used to analyze the effect of nutrient enrichment and coral genotype on tissue predation. Coral growth was measured as the difference between the coral TLE at the beginning and end of the experiment. Corals that suffered full colony mortality or were broken and reattached in the middle of the experiment were excluded from this analysis. Growth data were analyzed using a GLM (nutrients x predation + genotype). Algal colonization was measured as the percent cover of filamentous algae on coral colonies and was analyzed using beta regression with the betareg package in R (Cribari-Neto and Zeileis 2010), as beta regression is used to model continuous sample proportions.

Related References:

Cribari-Neto, F., & Zeileis, A. (2010). Beta Regression in R. Journal of Statistical Software, 34(2), 1 - 24. doi:http://dx.doi.org/10.18637/jss.v034.i02

Shaver, E. C., Shantz, A. A., McMinds, R., Burkepile, D. E., Vega Thurber, R. L. and Silliman, B. R. (2017), Effects of predation and nutrient enrichment on the success and microbiome of a foundational coral. Ecology, 98: 830–839. doi:10.1002/ecy.1709

Data Processing Description

All analyses were conducted in R version 3.2.1 (R Core Team 2015).

BCO-DMO Processing Notes:
added conventional header with dataset name, PI name, version date
modified parameter names to conform with BCO-DMO naming conventions
blank values replaced with no data value 'nd'
replaced spaces with underscores

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Data Files

File
coral_consum_nuts.csv (Comma Separated Values (.csv), 3.67 KB) MD5:3b7dffaa67c034d88bcaea947716cc7d Primary data file for dataset ID 717034

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Related Publications

(2008). Acropora cervicornis: Aronson, R., Bruckner, A., Moore, J., Precht, B. & E. Weil. IUCN Red List of Threatened Species. doi:10.2305/iucn.uk.2008.rlts.t133381a3716457.en
https://doi.org/10.2305/IUCN.UK.2008.RLTS.T133381A3716457.en
Related Research

Caribbean Acropora Restoration Guide: Best Practices for Propagation and Population Enhancement
http://nsuworks.nova.edu/occ_facreports/71
Methods

Cribari-Neto, F., & Zeileis, A. (2010). Beta Regression inR. Journal of Statistical Software, 34(2). doi:10.18637/jss.v034.i02
Methods

Shaver, E. C., Shantz, A. A., McMinds, R., Burkepile, D. E., Vega Thurber, R. L., & Silliman, B. R. (2017). Effects of predation and nutrient enrichment on the success and microbiome of a foundational coral. Ecology, 98(3), 830–839. doi:10.1002/ecy.1709
Results

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Parameters

Parameter	Description	Units
id	identifier	unitless
genotype	genotype of corals (Upper Keys 2, ‘U-2’; Upper Keys 8, ‘U-8’)	unitless
predation	Treatment 1: predation (snail; no snail)	unitless
enrichment	Treatment 2: nutrients (nutrients; no nutrients)	unitless
mortality	coral colony mortality [dead (1);alive(0)]	unitless
growth	coral colony growth	centimeters (cm)
tissueloss	tissue loss/mortality	square centimenters (cm^2)
algae	Algal colonization on corals	percent cover (%)
notes	General notes about whether colonies were lost (broken at base) or a branch broke	unitless

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Instruments

Dataset-specific Instrument Name	spectrophotometrically
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	To ensure nutrient diffusion tubes were effective in releasing nutrients, we analyzed inorganic nitrogen and phosphorus spectrophotometrically from water samples taken within ~3 cm of 5 control corals and ~1 cm from 5 nutrient diffusion tubes once during the experiment a few days after fertilizer pellets were placed in diffusion tubes (UV-2450, Shimadzu; Southeast Environmental Research Center, Miami, FL).
Generic Instrument Description	An instrument used to measure the relative absorption of electromagnetic radiation of different wavelengths in the near infra-red, visible and ultraviolet wavebands by samples.

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Project Information

Small Grazers, Multiple Stressors and the Proliferation of Fungal Disease in Marine Plant

Ecosystems (small grazers facilitating fungal disease)

Coverage: Coastal Plant Ecosystems in North and South America.

In terrestrial communities, grazer-facilitation of fungal disease in plants has been studied for over a century. Despite the prevalence of this interaction in terrestrial systems, it was not considered relevant to the structure of marine plant communities until the investigator's recent work in salt marshes. By manipulating both grazer and fungal presence, he demonstrated that snail grazing and subsequent fungal infection in live grass led to drastic reductions in plant growth and, at high grazer densities, destruction of canopy. If grazer promotion of fungal disease in marine plants is not limited to marshes (as suggested by preliminary data from a world-wide survey of 4 marine plant ecosystems) then small grazers that take small bites out of plants could be exerting similarly strong, but undetected control over marine plants globally. In addition, since physical stress commonly reduces plant immune responses, intensifying multiple stressors associated with marine global change could intensify and destabilize these unstudied grazer-disease-plant interactions. To test the global generality of this potentially keystone ecological interaction, this project will answer the following questions with a combination of multi-site surveys and manipulations across 4 ecosystems spanning 2 continents: 1) Is grazer facilitation of fungal disease in marine plants a common but overlooked interaction? 2) What is the resultant impact of grazer-facilitated fungal infection on marine plant growth? 3) How do multiple stressors impact the strength of grazer facilitation of fungal disease in marine plants? The work represents a transformative step forward in our understanding of plant-grazer interactions in marine ecosystems as it fills a > 100-year intellectual gap in our understanding of top-down control in marine plant ecosystems: Do small grazers commonly facilitate fungal disease in marine plants and does this interaction suppress plant growth? Evidence for this cryptic, yet powerful mechanism of grazer regulation of marine plants will compel marine ecologists to reevaluate our understanding of top-down control and lead to widespread integration of disease dynamics in marine food web ecology.

The consequences of marine plant ecosystem health are far-reaching for humans, since these communities provide many essential services. Results from this study will allow managers to better predict effects of disease and global change on marine plant systems and formulate effective strategies for conservation. To help integrate plant disease dynamics into marine ecology and conservation, the investigator will: (1) produce an edited volume on Food Webs and Disease in Marine Ecosystems and (2) work closely with The Nature Conservancy to incorporate findings into their global marine learning exchanges. In addition, an integrated educational plan will increase student: (1) understanding of disease and food web dynamics in marine ecosystems and (2) consideration of marine science careers.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1445834

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