Coral colony sizes and distribution on the Coral Coast of Viti Levu, Fiji in 2013 (Killer Seaweeds project)

Website: https://www.bco-dmo.org/dataset/564397
Version: 1
Version Date: 2015-08-12

Project
» Killer Seaweeds: Allelopathy against Fijian Corals (Killer Seaweeds)

Contributors	Affiliation	Role
Hay, Mark E.	Georgia Institute of Technology (GA Tech)	Principal Investigator
Gibbs, David	Georgia Institute of Technology (GA Tech)	Contact
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Experimental results testing Janzen-Connell hypothesis in brooding corals: whether juvenile corals experienced distance-dependent mortality near adult conspecifics.

Table of Contents

Coverage

Spatial Extent: **N**:-18.191 **E**:177.713 **S**:-18.215 **W**:177.62
Temporal Extent: 2013-08-13 - 2013-10-09

Dataset Description

Experiment testing Janzen-Connell hypothesis in brooding corals - whether juvenile corals experienced distance-dependent mortality near adult conspecifics.

To determine the spatial distribution of P. damicornis and S. hystrix at smaller scales, we conducted 2 m radius circular surveys around focal P. damicornis and S. hystrix colonies that i) were the largest colony of that species within 4 m (to reduce the effects of conspecifics), and ii) occurred where >75% of the substrate within 2 m was suitable habitat for P. damicornis and S. hystrix, again to equalize the likelihood of colonies occurring everywhere in the survey.

Related Datasets:

64 m^2 grid survey
survival experiments
survival replacement tiles
array information

Methods & Sampling

Study site characteristics

This study was conducted on reef flats within no-take marine protected areas (MPAs) adjacent to Votua, Vatuo-lailai, and Namada villages along the Coral Coast of Viti Levu, Fiji. These reserves are scattered along 11 km of fringing reef and are separated by ~3-8 km. The reserves have high coral cover (38-56%), low macroalgal cover (1-3%), and a high biomass and diversity of herbivorous fishes (Rasher, Hoey, and Hay 2013; Bonaldo and Hay 2014). The reef flats range from ~1-3 m deep at high tide, extend ~500-600 m from shore to the reef crest, and are typical of exposed reef flats occurring throughout Fjii.

Except during low tides in calm weather, waves push water over the reef front, and water then flows laterally across the reef flats to discharge through channels bisecting the flats. This creates a relatively predictable current direction at most locations.

Distribution surveys

We characterized the spatial distribution of P. damicornis and S. hystrix in the reef flat MPAs of Namada, Vatuo-lailai, and Votua villages at two scales (August through October 2013). For our larger-scale survey, we mapped each colony within 8 x 8 m plots (N=5, 5, and 10 for Namada, Vatuo-lailai, and Votua, respectively). Each plot was divided into 256 0.5 x 0.5 m cells and each coral >1 cm across mapped into a cell. The location of each survey plot was determined by randomly choosing a point on shore, swimming 100, 200, or 300 kicks directly away from shore at that point, and surveying the closest bommie large enough to fill more than three quarters of an 8 x 8 m plot. In four of 10 surveys at Votua and in all five surveys at Vatuo-lailai and Namada, we also measured the largest diameter of each P. damicornis colony. We did not measure S. hystrix colony size because individual colonies were more frequently discontinuous. To avoid confounding biotically-driven spatial distribution with patterns caused by patchiness of suitable substrate, we also recorded which cells were comprised primarily of unsuitable habitats such as sand-scoured pools or channels and bommie tops covered in rubble.

We analyzed these data using the neighborhood density function O(r) in the point pattern analysis program Programita (Wiegand and Moloney 2004). This analysis identifies distances at which individuals are aggregated, randomly spaced, or overdispersed compared to a specified null model. Unlike the more frequently used Ripley's K(r) statistic, each distance category is not affected by those inside it; expected aggregation at each distance is compared to the observed value independently of nearer distances. Each concentric ring centered on an individual coral is separately placed on the aggregated-overdispersed continuum and displays the spatial pattern within a different distance category. Ring width was 0.5 m extending up to 4 m. The null model for this analysis was complete spatial randomness (CSR). Because the variance in substrate types violated CSR's assumption of uniform likelihood of coral placement, we conducted the below analyses once using the entirety of all 8 x 8 m plots and a second time excluding cells of unsuitable habitat (which should better meet CSR's assumption of uniform likelihood).

To determine whether the observed spatial pattern was random, significantly aggregated, or overdispersed, Programita simulated placement of each plot's colonies 999 times using CSR, calculated O(r) for each simulation, then combined replicate O(r)'s from each reef and from all three reefs. This generated a distribution of simulated O(r)'s from which we established the significance of the observed spatial patterns. The distance(s) at which significant aggregation or overdispersion occurred were determined by the distances at which the observed pattern fell above or below the 95% simulation envelopes, respectively. This analysis does not parse aggregating and overdispering processes; it shows the net resulting pattern.

In addition to analyzing all P. damicornis and S. hystrix colonies, we analyzed P. damicornis <5 cm, >5 cm, >10 cm, and >15 cm in diameter to see if spatial patterns changed with colony size.

The <5 cm and >5 cm categories were mutually exclusive but because there were not enough colonies between 5 and 10 cm and between 10 and 15 cm to analyze as mutually exclusive groups, larger size categories were subsets of smaller ones.

The 8 x 8 m quadrat surveys could not resolve spatial patterns below the cell size of 0.5 x 0.5 m, meaning that patterns occurring at less than 0.252 m could be undocumented. To determine the spatial distribution of P. damicornis and S. hystrix at smaller scales, we conducted 2 m radius circular surveys around focal P. damicornis and S. hystrix colonies that i) were the largest colony of that species within 4 m (to reduce the effects of conspecifics), and ii) occurred where >75% of the substrate within 2 m was suitable habitat for P. damicornis and S. hystrix, again to equalize the likelihood of colonies occurring everywhere in the survey.

The distance to each surrounding (radial) P. damicornis and S. hystrix colony was the average of the distance to that colony's near and far sides (N=45 focal colonies for P. damicornis around P. damicornis, 10 for S. hystrix around P. damicornis, and 24 each for P. damicornis and S. hystrix around S. hystrix). We analyzed radial colony counts in 10 cm concentric rings using a generalized linear mixed effects model with Poisson errors and the canonical log link function in R (lme4 package, Bates et al. 2013). Distance was a fixed effect and focal colony with distance nested inside was a random effect, with the log10 of the ring sizes as an offset to control for unequal area sampled at each distance (i.e. ring area increased with distance from the focal colony). We repeated this analysis with just the closest 0.5 m and 1 m of the circles in case radial colonies beyond those distances were masking short-range effects of the focal colonies.

We also analyzed the P. damicornis data from the 8 x 8 m plots in the same manner as we did the circular surveys. To convert the plot data, an R script identified every surveyed P. damicornis colony >2 m from all edges of its plot and equal to or larger than a specified diameter (either 15 or 20 cm) as a focal colony (N=38 and 19 focal colonies, respectively). In order to have an appreciable sample size, we did not restrict focal colonies to those that were the largest within 4 m. The script then calculated the distances to all P. damicornis colonies less than the specified diameter within 2 m and placed them into 10 cm concentric rings as above. We used generalized linear mixed effects models as described for the circular surveys.

Data Processing Description

BCO-DMMO Processing:

- added conventional header with dataset name, PI name, version date
- renamed parameters to BCO-DMO standard
- reformatted date from m/d/yyyy to yyyy-mm-dd
- replaced spaces with underscores
- removed trailing blanks
- sorted by species_focal, species_counted, village, survey, dist_foc_col_near
- corrected lat 18.207 to -18.207
- corrected the date 8/28/1930 to 8/28/2013 (Votua 3)
- corrected the date 9/21/2012 to 9/21/2013 (Namada 4)
- moved contents notes from loc_in_quad to comment column and changed loc_in_quad to N/A
- in P_dam_diameter column, replaced blank cells with N/A

[table of contents | back to top]

Data Files

File
2m_circles.csv (Comma Separated Values (.csv), 271.00 KB) MD5:823e02127971ccf55404e5de5d3f7944 Primary data file for dataset ID 564397

[table of contents | back to top]

Related Publications

Bates, D., Maechler, M., & Bolker, B. (2013). lme4: Linear mixed-effects models using S4 classes. R package version 0.999999-2.
Software

Bonaldo, R. M., & Hay, M. E. (2014). Seaweed-Coral Interactions: Variance in Seaweed Allelopathy, Coral Susceptibility, and Potential Effects on Coral Resilience. PLoS ONE, 9(1), e85786. doi:10.1371/journal.pone.0085786
Methods

Rasher, D. B., Hoey, A. S., & Hay, M. E. (2013). Consumer diversity interacts with prey defenses to drive ecosystem function. Ecology, 94(6), 1347–1358. doi:10.1890/12-0389.1
Methods

Wiegand, T., & A. Moloney, K. (2004). Rings, circles, and null-models for point pattern analysis in ecology. Oikos, 104(2), 209–229. doi:10.1111/j.0030-1299.2004.12497.x
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
species_focal	species of interest	unitless
village	village name	unitless
survey	survey number or letter	unitless
lat_approx	approximate latitude; north is positive	decimal degrees
lon_approx	approximate longitude; east is positive	decimal degrees
date	survey date	yyyy-mm-dd
species_counted	the species counted	unitless
focal_colony_dim	focal colony dimensions	cm
focal_colony_area	focal colony area	cm^2
dist_foc_col_near	nearest distance from focal colony	cm
dist_foc_col_far	furthest distance from focal colony	cm
dist_foc_col_near_corr	nearest corrected distance from focal colony	cm
dist_foc_col_far_corr	furthest corrected distance from focal colony	cm
dist_foc_col_avg	average distance from focal colony	cm
dist_bin	distance category	10 cm bins
flag_present	present = 1; absent = 0	unitless
length_col	colony length	cm
comments	notes	unitless

[table of contents | back to top]

Deployments

Fiji_2013

Website	https://www.bco-dmo.org/deployment/564474
Platform	Hay_GaTech
Start Date	2013-08-13
End Date	2013-10-09
Description	Studies of corals and seaweed were conducted on reef flats within no-take marine protected areas (MPAs) adjacent to Votua, Vatuo-lailai, and Namada villages along the Coral Coast of Viti Levu, Fiji in 2013.

[table of contents | back to top]

Project Information

Killer Seaweeds: Allelopathy against Fijian Corals (Killer Seaweeds)

Coverage: Viti Levu, Fiji (18º13.049'S, 177º42.968'E)

Extracted from the NSF award abstract:

Coral reefs are in dramatic global decline, with reefs commonly converting from species-rich and topographically-complex communities dominated by corals to species- poor and topographically-simplified communities dominated by seaweeds. These phase-shifts result in fundamental loss of ecosystem function. Despite debate about whether coral-to-algal transitions are commonly a primary cause, or simply a consequence, of coral mortality, rigorous field investigation of seaweed-coral competition has received limited attention. There is limited information on how the outcome of seaweed-coral competition varies among species or the relative importance of different competitive mechanisms in facilitating seaweed dominance. In an effort to address this topic, the PI will conduct field experiments in the tropical South Pacific (Fiji) to determine the effects of seaweeds on corals when in direct contact, which seaweeds are most damaging to corals, the role allelopathic lipids that are transferred via contact in producing these effects, the identity and surface concentrations of these metabolites, and the dynamic nature of seaweed metabolite production and coral response following contact. The herbivorous fishes most responsible for controlling allelopathic seaweeds will be identified, the roles of seaweed metabolites in allelopathy vs herbivore deterrence will be studied, and the potential for better managing and conserving critical reef herbivores so as to slow or reverse conversion of coral reef to seaweed meadows will be examined.

Preliminary results indicate that seaweeds may commonly damage corals via lipid- soluble allelochemicals. Such chemically-mediated interactions could kill or damage adult corals and produce the suppression of coral fecundity and recruitment noted by previous investigators and could precipitate positive feedback mechanisms making reef recovery increasingly unlikely as seaweed abundance increases. Chemically-mediated seaweed-coral competition may play a critical role in the degradation of present-day coral reefs. Increasing information on which seaweeds are most aggressive to corals and which herbivores best limit these seaweeds may prove useful in better managing reefs to facilitate resilience and possible recovery despite threats of global-scale stresses. Fiji is well positioned to rapidly use findings from this project for better management of reef resources because it has already erected >260 MPAs, Fijian villagers have already bought-in to the value of MPAs, and the Fiji Locally-Managed Marine Area (FLMMA) Network is well organized to get information to villagers in a culturally sensitive and useful manner.

The broader impacts of this project are far reaching. The project provides training opportunities for 2-2.5 Ph.D students and 1 undergraduate student each year in the interdisciplinary areas of marine ecology, marine conservation, and marine chemical ecology. Findings from this project will be immediately integrated into classes at Ga Tech and made available throughout Fiji via a foundation and web site that have already set-up to support marine conservation efforts in Fiji and marine education efforts both within Fiji and internationally. Business and community leaders from Atlanta (via Rotary International Service efforts) have been recruited to help organize and fund community service and outreach projects in Fiji -- several of which are likely to involve marine conservation and education based in part on these efforts there. Media outlets (National Geographic, NPR, Animal Planet, Audubon Magazine, etc.) and local Rotary clubs will be used to better disseminate these discoveries to the public.

PUBLICATIONS PRODUCED AS A RESULT OF THIS RESEARCH

Rasher DB, Stout EP, Engel S, Kubanek J, and ME Hay. "Macroalgal terpenes function as allelopathic agents against reef corals", Proceedings of the National Academy of Sciences, v. 108, 2011, p. 17726.

Beattie AJ, ME Hay, B Magnusson, R de Nys, J Smeathers, JFV Vincent. "Ecology and bioprospecting," Austral Ecology, v.36, 2011, p. 341.

Rasher DB and ME Hay. "Seaweed allelopathy degrades the resilience and function of coral reefs," Communicative and Integrative Biology, v.3, 2010.

Hay ME, Rasher DB. "Corals in crisis," The Scientist, v.24, 2010, p. 42.

Hay ME and DB Rasher. "Coral reefs in crisis: reversing the biotic death spiral," Faculty 1000 Biology Reports 2010, v.2, 2010.

Rasher DB and ME Hay. "Chemically rich seaweeds poison corals when not controlled by herbivores", Proceedings of the National Academy of Sciences, v.107, 2010, p. 9683.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0929119

[table of contents | back to top]