Biomass of fish feeding groups on reefs in Viti Levu, Fiji from 2010-2012 (Killer Seaweeds project)

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Project

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

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Abstract

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Coverage

Temporal Extent: 2010 - 2012

Dataset Description

Fiji MPA vs non-MPA corals, fishes, and herbivory. This dataset describes the biomass of fish feeding groups.

Acquisition Description

The study was conducted from November 2010 through February 2011 and between November 2011 and January 2012 on shallow (~1 m below the surface at low tide, equal or shallower than 2 m at high tide), intertidal fringing reefs platforms (up to 800-m wide) along the Coral Coast (18º 13.05'S, 177º 42.97'E) of Viti Levu, Fiji's main island. Many of the owners of traditional fishing rights along the Coral Coast have established small, customary no-take MPAs to improve and sustain their adjacent fishing grounds. The MPAs in this region are delimited by surface markings and enforced by local villagers, and they have been closed to all fishing activities since their inception (about 10 years). The only exception to this closure was a small experimental hook and line fishing research project that was conducted in the MPAs of Votua and Namada. In the non-MPAs, the main fishing targets are species of Acanthuridae (Nasinae), Epinephelidae, Labridae, Mullidae, and Lutjanidae. Permission for the research was granted by the Fijian Ministry of Education, National Heritage, Culture & Arts, Youth & Sports, which is authorized to approve field studies in Fijian waters. No animal collection or experimental procedures involving animals were conducted during the study, and no endangered species were recorded during our assessments.

To assess the effects of MPAs on fish assemblages, fish feeding group composition, herbivory rates, benthic cover, and coral recruit density, we compared three spatially paired MPA and adjacent, fished, areas (non-MPAs) associated with the villages of Votua, Vatu-o-lalai and Namada. Comparisons of fish assemblages inside and outside of closures are widely used for determining the effects of reserves, but it should be acknowledged that this approach does not reveal the state of an MPA relative to an undisturbed baseline.

The studied MPAs were established in 2002 (Vatu-o-lalai, Namada) and 2003 (Votua), and shortly after establishment, coral cover was low (~7%), and macroalgal cover was high (~35–45%) in both the MPAs and non-MPAs. All surveys and assays were conducted during the same season (austral summer) to minimize seasonal variation in sampling. The reef extends approx. 1 km from shore within each MPA and non-MPA, and all data were collected between 30 and 700 m of the shore (i.e., shoreward of the reef crest) parallel to the shoreline.

Fish feeding groups: The structure of fish feeding groups was assessed using a series of 10-min timed transects, which maximized the distance transversed in search of groups rather than being limited to a 30m transect where there may be no groups. A fish feeding group was defined as any aggregation of two or more fish in which individuals were observed feeding or biting a potential food source.

A total of 30 timed transects (n = 15 MPA; n= 15 non-MPA) were performed at each of the three village sites (n = 90 transects total). Transects were conducted within 2 h of high tide and equally distributed from 10:00 h–14:00 h. A group was counted if at least one individual in the aggregation was inside the transect area. For each feeding group, all individuals were identified to species, their total length (TL) estimated and placed into 5cm size classes. Fish lengths were converted to biomass using established length-weight relationships. For each transect, a snorkeler swam parallel to the reef crest for 10 min at a standard speed and recorded all fish groups within 2 m of each side of the transect. On each sampling day, five transects were deployed on the reef parallel to the shoreline. Adjacent transects were separated by a minimum of 20 m, and small surface floats and reef and shoreline landmarks were used to avoid resampling the same areas.

Processing Description

We used Generalized linear mixed models (GLMM) implemented under a Bayesian framework to test the effect of protection status (MPA vs. non-MPA) on the abundance and biomass of each subcategory of Herbivores and Non-herbivores at the three village sites. We used the same approach to test the effect of protection status on the number of individuals, biomass and diversity of species in the observed feeding groups. The models have a hierarchical structure where the protection status is nested within site. For abundance and biomass of Herbivores and Non-herbivores, we used a muti-response models where each subcategory is a separate response variable. Because we have several samples for the same site, transect and sampling day were included as random factors. For the richness and abundance model, we used a Poisson error structure given the nature of the data. For biomass and diversity data we used a Gaussian error structure. We performed separate analyses for Herbivores and Non-herbivores. We compared model fit against a benchmark model in which protection status was not included as a fixed effect using the Deviance information criterion (DIC). The MCMC used to sample the posterior distributions of effect sizes ran for 106 iterations and was sampled every 100 iterations (thinning = 100) after burn-in (5×105). We considered effect size significant when the 95% credible interval of the estimated posterior distributions of parameters did not include 0. We monitored chain mixing by checking the effective sample sizes (ESS) for fixed and random effects. We used inverse gamma priors for variance components. Exploratory analyses indicate that estimates for fixed effects were robust to prior selection. Outliers were removed prior to the GLMM analyses to reduce overdispersion, although analyses with and without the outliers yielded qualitatively similar results. We used the R package MCMCGLMM for all analyses based on GLMMs.

We compared benthic cover between MPAs and non-MPAs using three-way ANOVA, with village site (Votua, Vatu-o-lalai, and Namada), status (MPA and non-MPA) and year (2010/2011 and 2011/2012) as fixed factors. Separate ANOVAs were used to compare the percentage cover of four different substratum types (scleractinian corals, macroalgae, epilithic algal turfs and others). Benthic cover data were arcsine-transformed, and fish density and biomass data were log-transformed to meet assumptions of normality (frequency histograms). When differences were significant, the test was followed by specific planned comparisons between paired treatments (MPA vs non-MPA) at each village site. P-values were adjusted with the Holm-Sídák method, in which the adjusted p-value is equal to , where k refers to the number of comparisons.

The rates of grazing and browsing and the density of coral recruits were compared between MPAs and adjacent non-MPAs using two-way ANOVA with status (MPA and non-MPA) and village site (Votua, Vatu-o-lalai, and Namada) as fixed factors. Separate analyses were used to compare (1) parrotfish grazing rates, (2) macroalgal browsing rates, and (3) the number of coral recruits per quadrat (log-transformed). Holm-Sídák-adjusted paired comparisons were also used when differences were significant. ANOVAs for benthic cover, grazing and browsing rates, and density of coral recruits, as well as all graph plots in this manuscript, were programmed in R 3.0.1 using base package functions.

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Parameters

Parameter	Description	Units
number	Number of fish observed	count
biomass	Biomass of fish observed	centimeters
status	Status of area where sampling was done; Marine Protected Area (MPA) or non-MPA (NON)	unitless
site	Site name	unitless
g	G error	unitless
day	Day that sampling took place within each years sampling event. A B and C all took place in during year A (Dec 2010 - Jan 2011); D E and F all took place during year B (Dec 2011 - Jan 2012)	unitless
transect	Transect number	unitless

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Deployments

Fiji_2011

Website	https://www.bco-dmo.org/deployment/480730
Platform	Hay_GaTech
Start Date	2010-11-01
End Date	2012-01-01
Description	Studies for this deployment were conducted: November 2010 through February 2011 and between November 2011 and January 2012 on shallow (~1 m below the surface at low tide, equal or shallower than 2 m at high tide), intertidal fringing reefs platforms in Villages of Votua, Vatu-o-lalai and Namada, Coral Coast Viti Levu, Fiji. May–December 2011 on an approximately1.5-2.5 m deep reef flat within a no-take marine reserve at Votua Village, Viti Levu, Fiji.

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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.

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