Project title: ***Caribbean coral reef health and communities: The effects of global climate change on butterflyfish feeding ecology and associated coral response***

Randi Rotjan, Department of Biology, Graduate School of Arts, Sciences, and Engineering
Collaborators: Dr. Sara Lewis (Biology) and Dr. Marc D'Alarcao (Chemistry)

Background & Objectives: Tropical coral reef communities are home to one quarter of all marine species and one fifth (4,500) of known marine fish species, making them one of the most diverse ecosystems in the world [1]. However, these communities are globally endangered due to the threats of human impact via pollution, overfishing, and global climate change (via increased temperatures and UV radiation). Tropical fishes, corals, and other invertebrate species are disappearing faster than we can study them, making increased understanding of reef ecology a high priority in reef conservation. Butterflyfishes are some of the most conspicuous and charismatic components of tropical reef communities worldwide. Most butterflyfish require healthy coral for their diet and because coral requires very specific conditions for growth and survival, butterflyfish are viewed as bio-indicators of reef health [2]. Few other organisms eat corals, perhaps due to their mechanical and chemical defenses. Thus, butterflyfishes are one of the few fish families that that are trophically dependent on healthy reef corals. More species of butterflyfish eat stony coral than any other reef fish family [3], yet little work has been done on the relationship between butterflyfish feeding and the potential responses of their coral prey [4]. I propose that butterflyfish feeding can trigger coral defenses, and they thus limit their feeding so as not to induce a coral response (i.e. chemical defenses produced by the coral to deter feeding by butterflyfish). The fragility of corals coupled with the growing threat of human impacts has generated much interest in understanding coral reef community interactions. Therefore, the relationship between butterflyfish feeding and coral response is of paramount interest and importance to reef conservation efforts worldwide.

The Caribbean foureye butterflyfish *Chaetodon capistratus* mainly eats stony coral, but is considered to be a more generalist feeder compared to other butterflyfish [5, 6]. One feeding strategy might be to eat highly nutritional and fast-growing coral species [7], yet corals would be predicted to evolve defenses in response. In fact, many corals are chemically and morphologically defended in general. Thus, it might be expected that butterflyfish preferentially feed on corals that have fewer defenses [8]. Thus, I ask the question: does feeding by the foureye butterflyfish trigger chemical and/or morphological defense responses by coral prey? Further, many Caribbean corals have recently suffered due to the effects of global climate change, namely, increased sea-surface temperatures, off-shore pollutants, or increased solar (especially UV) radiation. Given the overall fragility of corals and recent declines of Caribbean reef health, understanding Caribbean butterflyfish and coral interactions is critical to Caribbean reef conservation efforts. Thus, I ask the question: Do butterflyfish predation / coral defense interactions differ between relatively healthy reefs versus reefs suffering from coral health declines?

Field Sites: I will work at two sites in Belize, Central America, which possesses the 2nd largest barrier reef in the world. I plan to compare a relatively healthy reef (Glover's Reef) and a more heavily human-impacted reef (Carrie Bow). Glover's Reef is a United Nations World Heritage Site and hosts a Wildlife Conservation Society research station. The damaged reef site is located on Carrie Bow Caye, which is positioned directly on the Belize barrier reef crest. Carrie Bow hosts a research station operated by the Smithsonian Institution's Caribbean Coral Reef Ecosystems Program. The Smithsonian has already committed to providing me with use of their field and laboratory facilities in addition to room, board, and travel costs. Glover's Reef is near to Carrie Bow and is easily accessible by boat.

Methods: Coral health at both Glovers Reef and Carrie Bow will be assessed using the non-invasive Pulse Amplitude Modulation (PAM) fluorometry, which measures the fluorescence of chlorophyll produced by essential coral symbionts. Additionally, I plan to use spatial statistics in Geographic Information Systems (GIS, spatial analyst extension) to correlate biological findings with associated environmental factors such as natural versus human impacts. The biological experiments conducted will be to quantify feeding preferences and to assay preferred coral heads for chemical defenses and nematocyst (stinging cell) density. This will allow me to determine whether preferred corals allocate similar induced defenses on relatively pristine (Glover's) and

severely damaged (Carrie Bow) reefs. I will be working with my advisor and collaborator Dr. Sara Lewis in the Department of Biology, on the biological aspects of these questions. I will be working with collaborator Dr. Marc D'Alarcao in the Department of Chemistry at Tufts to analyze chemical samples and characterize potentially novel natural products. I have already collected preliminary data on the foraging behavior of foureye butterflyfish from Southwater Caye, Belize (Summer 2002) in a damaged reef area. I found that most butterflyfish preferred one group of stony corals. Sara Lewis and I will use SCUBA to determine the feeding preferences of foureye butterflyfish (on both damaged and undamaged reefs) by counting the number of bites per feeding bout and flagging preferred coral colonies Small samples of preferred versus non-preferred coral colonies will be collected and assayed for differences in nematocyst density and chemical defense. Colonies of preferred coral species will be transplanted into butterflyfish territories. Of the transplanted coral, some will be left exposed to butterflyfish predation, while others will be protected from predation by cages as a control. Samples will later be collected from these transplanted corals. Following methods by Gochfeld [4], coral samples will be examined to determine nematocyst (stinging cell) density. Also, a feeding bioassay will be used to examine chemical deterrent capabilities of corals [4]. Coral samples will be separated into water- and lipid-soluble fractions, and offered in a food pellet [9] to omnivorous wrasses. Fractions showing deterrent activity will be brought back to Tufts for further analysis with collaborator Dr. Marc D'Alarcao in the Department of Chemistry. Together, we will characterize the natural products stored in these coral fractions with analytical High Performance Liquid Chromatography (HPLC), a technique used to identify and quantify chemical compounds. Because chemical defenses are essential to coral survival and are likely associated with butterflyfish feeding preferences, understanding the compounds involved will help us to better understand corals themselves as well as reef community interactions. Dr. D'Alarcao has previously isolated compounds from other Caribbean corals and has HPLC facilities.

Anticipated Results: I expect that there will be differences in butterflyfish coral preference between Carrie Bow and Glover's Reef. Thus, I hope to show how these essential coral reef community organisms are responding to damage (thought to be caused mostly by the effects of global climate change). I hypothesize that corals respond to predation by butterflyfish, and that butterflyfish in turn respond (by avoidance) if coral defenses rise above their tolerance threshold. I predict that some combination and intensity of defenses are induced depending on the severity of feeding and on the specific coral species. I hope to quantify this threshold for different coral species and understand the consequences of these interactions for the corals, the butterflyfish, and the associated coral communities. This work is likely to result in several publications detailing the biology of fish-coral behavioral interactions, the chemical characterization of coral toxic deterrents, and the comparisons of pristine versus damaged Caribbean reefs.

Qualifications of Applicant: My long-term goal is to head a biological research program targeting the conservation of endangered coral reef ecosystems and to promote conservation efforts world-wide. In addition, I hope to contribute to policy and public education of conservation needs. Given the growing threats of global climate change and the sensitivity of coral reefs to change and human impact, I feel that reef conservation and comprehension is urgent to preserve coral ecosystems for the future. The research proposed here is a major portion of my proposed doctoral thesis in the Biology Department at Tufts.

I have been working with marine chemical defense strategies and fish feeding ecology since I was an undergraduate at Cornell. At Cornell, I explored the chemical defenses of Pacific echinoderm larvae, and monitored the impact of disease on Caribbean soft corals. I also worked at Shoals Marine Laboratory studying invertebrate feeding preferences. Since then, I have participated in fish studies at the University of Georgia as a field assistant. I am currently completing a study in collaboration with a UGA lab studying the paternity of coral reef Hamlets in Florida. Here at Tufts, I have worked with Dr. Jan Pechenik on the invasive slipper shell *Crepidula fornicata* and with Dr. Sara Lewis on a behavioral study of the New England hermit crab. I have also worked on an invasive species in the Costa Rican tropical rainforest with Dr. Colin Orians. Most recently, I conducted studies on the Southwater Caye Marine Reserve in Belize on butterflyfish/coral interactions and fish foraging activity.

References:

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