Graduate Research Plan Statement

Catherine Alves | October 2016

Keywords: Coral reefs, conservation, community-based fisheries, sustainability, survey analysis

Proposed Research: Does community-based fisheries management restore ecological function and improve the livelihood of fishers in Belize?

Background: Overfishing is a significant threat to the world's ocean ecosystems (1) that has caused an 80-95% reduction in large predatory fish biomass (2). This not only disrupts ecosystem functioning but threatens invaluable commercial and subsistence fisheries that provide livelihoods and fish protein to nearly 3 billion people annually (3). Marine reserves are one tool designed to mitigate these impacts and to meet both biodiversity conservation and fisheries management goals. Marine reserves function by restricting fishing access with the intention of increasing fish abundances and diversity within no-take zones, ideally with fish spilling over into adjacent non-protected areas (4). However, poaching, lack of enforcement, and limited spillover often limit the broader success of marine reserves (5).

An emerging approach is to more directly involve and incentivize local communities in the restoration and management of overfished stocks. Such "TURFs" ("Territorial User Rights for Fishing") assign local fishers the rights to fish in designated areas in exchange for reporting their catch. These initiatives encourage environmental stewardship in coastal communities by providing effective ownership of fish stocks, further incentivizing sustainable fishing practices (6, 7). TURFs have been implemented worldwide by the Environmental Defense Fund (EDF), but little is known about their effectiveness, particularly in the tropics where implementation is only beginning (6). Research to examine the impact of TURFs from ecological and social perspectives is limited (6, 7), despite catch improvements reported by fishers participating in the program. TURFs have been designed to prevent the "race to fish" oftentimes accompanying small-scale fisheries because they assign catch shares to fishers. Furthermore, by assigning fishers locations to fish, poaching decreases in restricted areas, enabling fish populations to recover (6, 7).

In 2011, the first TURFs in the Caribbean were established by the Belize Fisheries Department and they incorporated The Port Honduras Marine Reserve (est. 2000) and the Glover's Reef Marine Reserve (est. 1993) (7). The Belize Fisheries Department is currently in the process of implementing a nation-wide TURF system, adding seven additional TURFs to pre-existing marine reserves (7, www.fisheries.gov/bz/#). **The purpose of my study is to quantify the efficacy of Belize's newly implemented TURFs in restoring overfished stocks, general biodiversity, and ecosystem functioning as well as in improving the livelihood of fishers. Specifically, I will test the following hypotheses:**

H_1: Fish species richness, density and biomass will be greatest in locations with TURF implementation and lowest in unmanaged control sites.

H_2: TURF implementation will improve the perception, livelihood, and catch per unit effort (CPUE) of fishers who participate in the TURF program versus those who do not.

Study Design: Visual fish surveys will be performed in the nine TURF locations plus nine unmanaged control sites (7, www.fisheries.gov/bz/#). Fish species richness, density and biomass will be quantified via underwater transect surveys using SCUBA. At all sites, I will quantify

ecological factors that could influence coral reef community structure and potentially compromise co-management efforts – such as reef structural complexity, temperature, chlorophyll, macroalgal cover and human population density (Cox et al., *in review*).

The quantitative social science surveys will consist of structured interviews of 100 individuals randomly selected from four stakeholder groups: fishers participating in the TURF program, fishers not participating in TURFs, natural resource managers, and scientists (8). Closed-ended questions will be asked of all survey respondents to collect socio-economic, demographic and perceptions data including income, number of years in profession, gender, and perceived goals of the TURF program. Specifically, fishers will be asked to identify fishing locations on a map, provide CPUE, and share the percent of their income that comes from fishing. I will use the multilevel, nested framework of studying social-ecological systems (9) to build Bayesian hierarchical models to quantify the relationship between covariates. It is crucial to include fishers in management decisions because they become resources of change in their communities (5, 6, 7).

A key component to the success of this project will be my partnership with the Belize Fisheries Department, the University of Belize, and local non-profits like Belize Healthy Reefs – all of whom are currently collecting CPUE data at locations where fishers sell their catch to vendors. During a research trip to Belize this past summer, I began to make connections with individuals at all of these institutions, with intentions to collaborate in the future. My partnership with local contacts is essential for establishing trust among the community because it will increase the likelihood that the fishers, managers, and scientists will consent to the study (5, 9). This collaboration will also enable the survey questionnaire to be implemented in the local languages of English, Spanish, and Belizean Kriol, therefore reaching different communities in Belize. In addition, I will draw upon data collected by my PhD advisor, Dr. John Bruno, who has conducted long-term monitoring research in Belize across 16 sites with varying levels of marine protection.

Broader Impacts: This study will advance the field of community-based fisheries management by providing natural resource managers and fishing associations with insights into the efficacy of the TURF program in Belize from social and ecological perspectives. Information gleaned from this study has the potential to maintain livelihoods of the commercial and subsistence fishers in Belize while preserving coral reef fish biodiversity. I will also incorporate public outreach and education to increase scientific literacy and engagement of the public, both among the public in Belize and in my local community in North Carolina. I will collaborate with local institutions to co-organize public forums, workdays and outreach events for citizens of Belize to educate them about their local marine ecosystems. For outreach within my community in North Carolina, I have already developed a lesson plan for grades 8-12 on marine food webs for the Scientific Research and Education Network (SciREN). I hope to incorporate the findings of this study into a different lesson plan that focuses on marine resource management decision making. Both of these outreach programs will show the public the importance of interdisciplinary conservation science, and encourage environmental stewardship among the next generation. Community-based environmental management techniques are emerging across the globe as some of the most promising ways to combat anthropogenic threats to ecosystems, and I look forward to becoming a part of that endeavor.

References: 1. Jackson, J.B.C., et al. *Science* 293:629-638 (2001). **2.** Valdivia, A., et al. *PeerJ PrePrints* 3:e805v1 (2015). **3.** FAO. *The State of World Fisheries and Aquaculture: Opportunities and Challenges* p. 243 (2014). **4.**

Gaines, S.D., et al. *Proceedings on the National Academy of Sciences* 107(43):18286-18293 (2010). **5** Valdés-Pizzini, M., et al. *Caribbean Studies* 40(2):95-128 (2012). **6.** Barner, A.K., et al. *Oceanography* 28(2):252–263 (2015). **7.** Foley, J.R. *Proceedings of the 12th International Coral Reef Symposium: Evaluating Management Success* (2012). **8.** Bernard, H.R. *Research Methods in Cultural Anthropology* ch. 9 (1988). **9.** Ostrom, E. *Science* 325:419-422 (2009).