



Ecosystem-Based Management in Puerto Rican Communities

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3 May 2006

This project is submitted in partial fulfillment of the degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do not necessarily reflect the positions or opinions of the University of Puerto Rico or Worcester Polytechnic Institute.

This report is the product of an educational program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.

Abstract

This report, prepared for the University of Puerto Rico – Mayagüez, focuses on the process of implementing marine ecosystem-based management in Puerto Rico. We developed steps to implement marine reserves throughout Puerto Rico through the analysis of the Luis Peña Channel Natural Reserve in Culebra, a small island east of Puerto Rico, and the proposed Turrumote marine reserve in Lajas, a municipality in southwestern Puerto Rico. We also conducted an assessment of the different designations for marine protected areas and provided recommendations to simplify the current system.

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Acknowledgements

Our group would first like to thank our liaison, Dallas E. Alston, Ph.D., who provided support and guidance throughout our research project. We especially appreciated his interest in teaching us about marine ecosystems and exposing us to topics outside the scope of our project.

We would like to thank Jeffrey Friedman, Ph.D., who provided living arrangements and transportation while our group conducted research on the western side of the island. His gracious support made it possible to concentrate on the municipality of Lajas and conduct more interviews than originally thought possible.

Along with Dr. Alston and Dr. Friedman, we would like to thank the faculty, staff and students of the University of Puerto Rico who contributed their time, knowledge and experiences to our project: Richard Appeldoorn, Ph.D., Maritza Barreto, Ph.D., Jorge E. Capella, Ph.D., Milton Carlo, Angel David Cruz, Ph.D., Jorge García, Ph.D., Edwin Hernández, Ph.D., Ivan Lopez, Manuel Valdez-Pizzini, Ph.D., Jose Ramos, Yira Rodriguez and Michelle Scharer.

Our team would also like to extend our gratitude to Professors Ann C. Garvin and R. Creighton Peet, Ph.D., for their support and guidance throughout our project. We are grateful for the advice they provided through weekly meetings and continuous revisions. We also appreciate the time and effort put forth by Beatriz Arsuaga and Susan Vernon-Gerstenfeld, Ph.D., who coordinated the logistics of our project.

Finally, we would like to thank the fishermen of Lajas, community members of Culebra and Lajas, and Lajas Mayor Marcos A. Irizarry for participating in this study. Their honesty and willingness to discuss marine reserves increased the validity of our report and was greatly appreciated.

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Executive Summary

The need for management of common resources becomes evident when these resources begin to deteriorate. The ever-present stresses put on coral reef ecosystems in Puerto Rico cause fish populations to decline and eventually require attention. The problems directly affecting the Puerto Rican coral reef ecosystems include global warming, pollution, destruction of juvenile fish habitats, destructive tourism, and over-fishing. We determined that addressing over-fishing would be the most feasible to consider within the timeframe of our project. Over-fishing disrupts the food chain by depleting predatory fish species that thrive on smaller fish, in turn allowing overpopulation of the smaller, herbivorous species and finally destroying the coral reef ecosystem.

The goal of our project was to develop a plan for the successful implementation of ecosystem-based management in Puerto Rican communities. Before developing a plan we needed to first understand marine protected area (MPA) designations, their locations in Puerto Rico, and the regulations pertaining to each. We interviewed individuals who were experienced in working with Puerto Rican marine protected areas and discovered that there are thirty-seven MPAs with eight different designations. The existing confusion regarding the different types of reserves in marine ecosystems stems from the number of different agencies with overlapping jurisdictions. Each agency has its own terms and regulations that apply to similar areas. We therefore recommend that the Department of Natural and Environmental Resources of Puerto Rico develop a list of MPAs and formally define each to clarify existing ambiguities.

We examined the Luis Peña Channel in Culebra, an area with a successfully implemented management plan, and Lajas, an area where a management plan had been proposed but never implemented. In Culebra's reserve we found that many problems existed in its management, however, both coral health and fish populations increased since its establishment in 1999. We also identified reasons for the unsuccessful implementation of the Turrumote reserve in Lajas and found that the major shortcoming of the proposed reserve was that the fishermen of the neighboring town of Papayo had not been involved in the implementation process.

Finally, we determined the feasibility of implementing a marine reserve in Lajas through gathering opinions of community members. Through interviews with individuals from many different backgrounds in the Lajas community we determined that most people were generally in favor of a reserve in the area and therefore they should apply the implementation plan we developed.

Through data analysis, we identified that the four guiding principles of communication, trust, education, and enforcement should underlie all decisions in the creation and management of marine reserves. We identified several steps for the implementation of marine reserves in Puerto Rico, and more specifically in Lajas. The general steps that we recognized in the creation of a reserve are the involving of all stakeholders in the planning of a reserve, decision-making supported by scientific evidence, gathering of necessary funds, and educating the community. We believe that the execution of the steps we have developed

will result in the successful implementation of ecosystem-based management in Puerto Rican communities.

1.0 Introduction

Coastal societies depend greatly on natural resources found within surrounding marine ecosystems. Without careful management, these ecosystems become strained and depleted as the coastal population grows and the accompanying impact on resources increases. The management of marine ecosystems presents a daunting task involving complex links to human actions.

The coral reef ecosystems in Puerto Rico exemplify areas that have not been carefully managed. The decreasing fish populations surrounding these reefs and the decrease in reef area are manifestations of the detrimental impacts of unregulated human activities. Our sponsor, the University of Puerto Rico – Mayagüez, considers this an important issue because the resulting imbalance of marine species puts the ecosystem in a spiral toward collapse, and the impending decline in available resources has serious socioeconomic implications for Puerto Rico. The challenge for any management plan involves providing sufficient protection for the marine ecosystem without depriving local communities of access to resources upon which they so heavily rely. Current methods in Puerto Rico have been insufficient to adequately protect the fragile reef environments.

The approach toward management of marine ecosystems in Puerto Rico consists of a wide variety of strategies ranging from seasonal restrictions on certain species to the designation of marine protected areas. While these measures have been improved, they lack proper documentation and effective enforcement. Several locations throughout the world met more success because

they have taken more aggressive approaches, including the island of Culebra located east of Puerto Rico. A group of reefs off the western coast of Culebra have been designated as a no-take zone in which the removal of any species is prohibited. Other places around the world, such as Belize and Taiwan, have used similar management strategies to address the deterioration of their marine ecosystems.

Although many approaches to ecosystem-based management have been used successfully around the world, including Puerto Rico, it remains to be seen if they could be used elsewhere on the island. Each ecosystem has unique ecological characteristics and is surrounded by communities with distinct economic, social, and political cultures that combine to create a new set of issues in each location.

The uniqueness of each location, however, does not prevent the application of principles and guidelines from one situation to another. By examining locations in Puerto Rico where management plans have been implemented with varying degrees of success, we were able to identify the practices that were generally successful and those which were not. Since these practices were found in locations with similar ecosystems and which operated under the same regulatory framework, we were able to extend them to formulate a general implementation plan that could be used anywhere in Puerto Rico. Applying this plan to marine ecosystems in Puerto Rico will result in healthy coral reefs that will provide a sustainable source of marine resources to future generations.

2.0 Background

Deteriorating coral reefs have become a worldwide problem that requires immediate attention before it becomes irreversible. The following sections focus on the challenges of common-pool resources, the effects of deteriorating coral reefs and several primary causes of this problem that must be understood to appreciate the importance of this study. Previous studies on other coral reef ecosystems provide important information that can be used as a basis for implementing ecosystem-based management in Puerto Rico. Although these studies are useful as a guide, each ecosystem has to be assessed individually due to its uniqueness. We examined the problems that were specific to the marine ecosystems found in Puerto Rico and their governing regulations. Many organizations focus on research and management of coral reefs in Puerto Rico, and these organizations provided important information about current projects regarding the protection of coral reefs.

2.1 Tragedy of the Commons

In 1883 William Forster Lloyd developed a pamphlet in which he described a situation where cattle were raised in a public pasture (Hardin, 1968). Each animal present produces more money for the herdsman; however the overgrazing of the pasture causes depletion of the land resources. He admitted the possibility of sustainability for a period of time but pointed out the remorseless attitudes that develop due to herdsman's efforts to maximize their

gain. Each herdsman looks out for his or her own best interest and the common grounds suffer as a result.

Garret Hardin (1968) developed the concept of the “tragedy of the commons” based on Lloyd’s work, with “tragedy” referring to the “remorseless working of things” (p. 1243). Hardin believed that the overexploitation of resources often reflects the common use of public property with individuals benefiting from exploitation, while costs are divided among each person making use of the area.

According to Elinor Ostrom (2002, p. 5) overexploitation of nonrenewable resources, such as oil, decreases quantities and increases appropriation expenses. Although considered a renewable resource, fisheries suffer from overexploitation as well. Fish stocks are either decreased periodically or become harvested to a point where resource-generating areas are completely destroyed.

The tragedy of the commons theory applied to our study in that unregulated fishing waters would eventually become depleted ecosystems. Without healthy marine ecosystems and a flourishing fish supply for fishermen, waters could enter the state of “tragedy” described by Hardin. Our study sought to assess how similar marine ecosystems, as “commons,” had been managed for productive and sustainable use.

2.2 Causes of Deteriorating Coral Reefs

According to Charles Birkeland (2004), coral reefs degrade due to a lack of fish caused by over-fishing. However issues such as global warming, destruction of juvenile habitats, an increase in human population, pollution, and

careless tourists are also believed to contribute to this undesired outcome. The widespread consequences of deteriorating reefs include a loss of biodiversity, further collapse of reef-associated fisheries, dwindling tourism, and decreased coastal protection during storms.

In terms of the effect on fishermen, those who practice “subsistence [fishing,] and other small-scale fishers who lack mobility and alternatives...and are...dependent on specific fisheries, will suffer disproportionately from changes” (Food and Agriculture Organization of the United Nations [FAO], 2006, *Issues* section). Reefs have often been over-fished to the point that fishermen, even subsistence fishermen, have struggled to make ends meet.

Not only fishermen, but the community as a whole, would benefit from protecting their marine ecosystem. For instance, a protected ecosystem would be much more attractive to tourists because the coral reefs would be flourishing with life instead of struggling to survive.

2.2.1 Global Warming

According to the United States Environmental Protection Agency (2006), the most extreme effects of global warming are “wetland loss, salinity changes, and higher temperatures [which are] ...likely to affect finfish and shellfish in the coastal zone. The most vulnerable species [are] those that either reproduce in coastal wetlands, spend their entire lifetimes in an estuary, or both” (¶1).

According to the FAO (2006), important changes that could occur due to a rise in ocean temperature include changes in growing seasons, reproductive patterns, migration routes, and ecosystem relationships. Temperature increases

cause another dangerous effect known as coral bleaching in which coral reefs become strained and lose valuable algae causing the coral to starve and die.

2.2.1.1 Water Compound Changes

Just as the atomic structures of compounds vary with a change in temperature, properties of water are affected by global warming. According to the FAO (2006), as the temperature of water rises, the amount of oxygen in the water decreases, putting stress on the respiratory habits of fish.

Temperature increases throughout the world affect the salinity level of the ocean. As explained by the EPA (2006), a temperature rise would cause more precipitation and melting of freshwater glaciers, possibly causing the concentration of salt in ocean water to decrease to a point at which fish could not continue to thrive.

2.2.1.2 Coral Bleaching

Coral bleaching represents one of the most critical effects of global warming on the reefs, as shown in Figure 1. Juliet Eilperin (2006) reported the findings of "Avoiding Dangerous Climate Change," a scientific symposium which concluded that a temperature rise of just 1.8 degrees Fahrenheit would likely lead to extensive coral bleaching, "destroying critical fish nurseries in the Caribbean and Southeast Asia" (p. A01). In cases where the bleaching lasts longer than one week, the coral are susceptible to death.

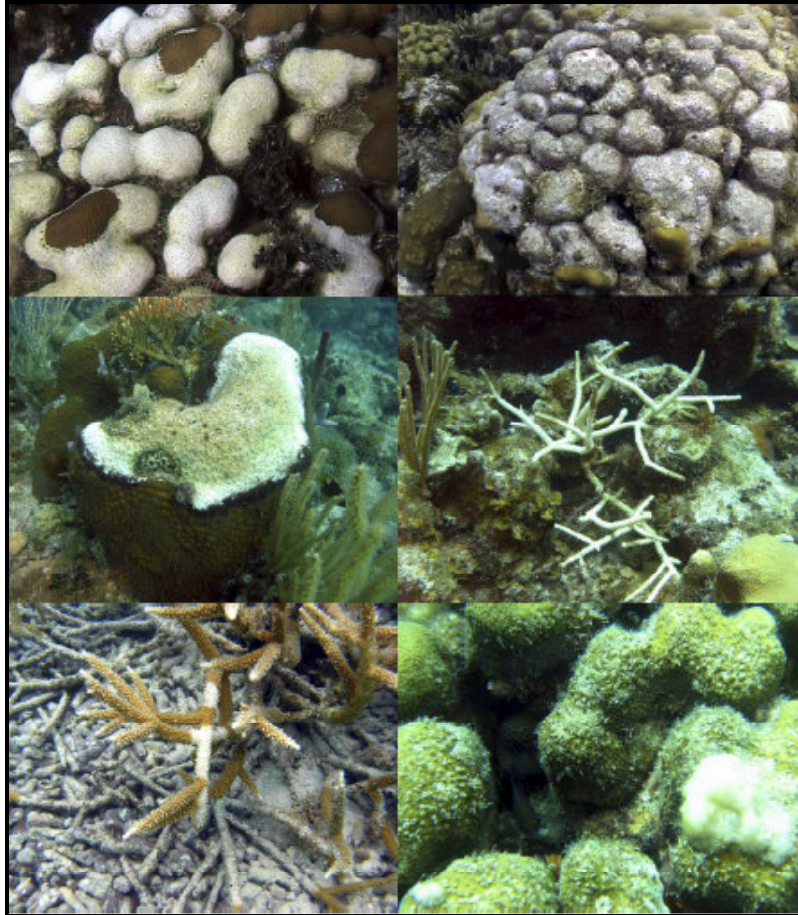


Figure 1: Examples of coral bleaching that caused coral mortality at the LPCNR (Hernández-Delgado, 2004, p. 21).

The El Niño-Southern Oscillation of 1997 consisted of a drop in atmospheric pressure and a rise in water temperature, causing intensive bleaching of the coral reefs in the Southern Pacific. Yap (2000) believed that “the severity of this bleaching [would] accelerate the demise of reefs already under tremendous pressure from other natural and human disturbances, and compromise the ability of other reefs to recover from such perturbations” (section 2).

2.2.1.3 Overall Effects of Global Warming

The Food and Agriculture Organization of the United Nations (2006) stated that “because natural variability is relative to global change, and the time horizon on capital replacement is so short, impacts on fisheries can be easily overstated, and there will likely be relatively small economic and food supply consequences” (*Issues* section) so long as no major fish stocks collapsed. Although these consequences are important for the long-term existence of ecosystems throughout the world, these issues need to be addressed on a worldwide scale and therefore global warming was considered to be outside of the scope of this project.

2.2.2 Increase in Human Population

Some scientists, such as Charles Birkeland (2004), believe there are bigger issues than over-fishing that need to be addressed. He believes research had focused on the proximal causes of reef damage, like global warming, increased atmospheric carbon dioxide, over-fishing, pollution, sedimentation, and disease, while the ultimate causes are an increasing human population and the associated economic demands. While Birkeland acknowledges over-fishing as a large problem, he believes human populations and growing economic pressures cause over-fishing and therefore need to be addressed. Although the issues of economic demand and overpopulation are important, our project focused on the proximal causes because they are more easily addressed by local communities.

2.2.3 Pollution and Sedimentation

Pollution tends to raise the nutrient levels of coastal regions. Thus, in conjunction with over-fishing, pollution can increase the rate at which macroalgae reproduce, causing vital resources such as sunlight to be taken away from the coral. A byproduct of urban sprawl, sedimentation causes problems because it physically covers reef organisms with a smothering layer of sediment (Yap, 2000). As shown in Figure 2, sedimentation obstructs sunlight as it reduces the clarity of water, and this promotes unhealthy levels of macroalgae. We did not research sedimentation as a cause of deteriorating coral reefs because we considered it to be outside the scope of the project.

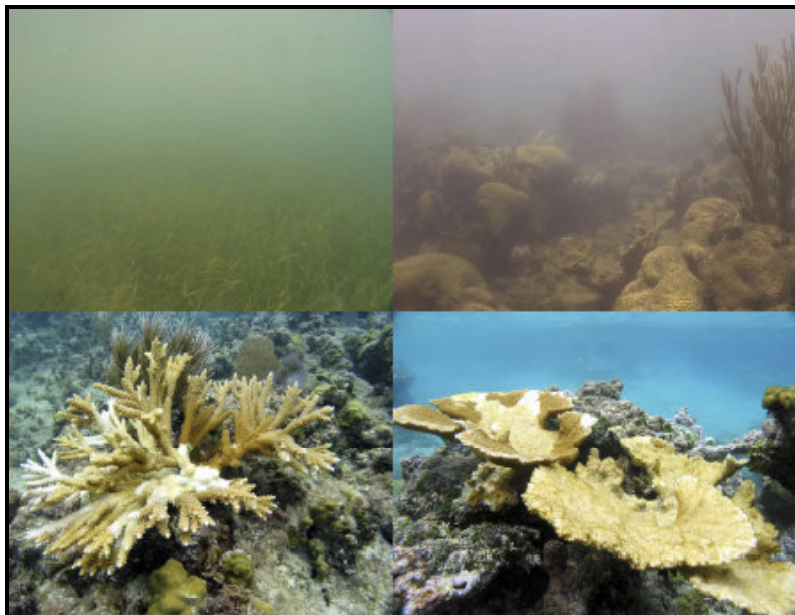


Figure 2: Effects of sediment and nutrient-loaded runoff in Culebra (Hernández-Delgado, 2004, p. 29).

2.2.4 Over-fishing

Coral reef ecosystems rely on a smooth transfer of energy through the trophic levels of the food chain. If fishermen catch excessive quantities of

predatory fish, the prey these fish normally eat will experience a dramatic increase in population, resulting in a cascading effect throughout the subsequent trophic levels of the ecosystem's food chain.

The depletion of predatory fish by the fishing industry in the near-shore coral reefs complicates the restoration of unbalanced ecosystems. Along with decreasing populations of predatory fish within a coral reef ecosystem come abrupt increases in the number of species that would have normally been controlled through predator-prey relationships. Berger et al. (2001) described such a case that occurred in Caribbean reefs in the early 1980's with the long-spined sea urchin *Diadema antillarum*. When predatory fish populations in the reefs decreased, these urchins became overpopulated. This directly increased the rate of transmission of diseases and eventually caused extinction of the species.

Yap (2000) noted that unbearable increases of macroalgae are caused by the imbalance in an ecosystem brought on by over-fishing. The macroalgae consume excessive quantities of oxygen in the surrounding water, killing off some species and thus reducing biodiversity. When herbivorous fish species are eliminated from the coral reefs by over-fishing, the algae begin to spread, competing with hard corals for light and space.

In all coral reef ecosystems, over-fishing continues to be a serious concern. In an article published in the journal *Science*, Berger et al. (2001) identified fishing as the "thread uniting virtually every instance of marine ecosystem collapse" (p. 629). Berger then went on to declare "[h]unting and

gathering in the ocean does more than kill fish[, it] changes ecosystems" (p. 629). In every case studied by this group of scientists, the initial cause of the deterioration of reefs was related to fishing.

Over-fishing not only affects fish populations in the reefs, but it directly affects the fishermen. As these fish species grow scarcer, fishermen are forced to commute to distant fishing spots to attempt to catch their quota of fish (D. Alston, personal communication, January 30, 2006). Since over-fishing promotes the deterioration of coral reefs and directly affects the careers of commercial fishermen on the island of Puerto Rico, fishing on coral reefs needs to be controlled to prolong the existence of the reefs and the livelihood of the fishermen. While many of the other causes of deteriorating coral reef ecosystems need to be dealt with on a global scale, over-fishing is a problem that can be addressed locally through the implementation of management programs.

2.3 Ecosystem-based Management

Ecosystem-based management encompasses different methods, individually designed to protect specific ecosystems. There are many different definitions of ecosystem-based management. The Coastal Information Team of British Columbia (2006) described it as "an adaptive approach to managing human activities that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities" (*Ecosystem-based Management* section). De la Mare (2005) stated that ecosystem-based management considered the "cumulative effects of human activities on the marine environment" and was not restricted to "a piecemeal management of separate human activities" (p. 1).

While the exact wording of the definitions may vary, the overall concept remains the same: scientific, economic, and social factors need to be considered in an integrated manner to achieve a viable plan for managing natural resources.

When applied to oceanic areas, ecosystem-based management could include many different measures such as establishing marine protected areas or controlling the amount of fishing allowed and the specific practices that could be used. Different combinations of these and other measures have been used with varying degrees of success around the world.

2.3.1 Marine Protected Areas

Marine protected areas include any area of ocean in which regulations are in place to prevent certain uses of the ocean areas. These regulations protect natural resources and marine ecosystems. Lauren Mathews, assistant professor of Biology and Biotechnology at Worcester Polytechnic Institute, distinguished the management of the ecosystem as a whole from traditional approaches that have focused on managing a single stock of fish (Appendix G). Many different levels of protection can be implemented within marine protected areas including marine reserves, seasonal closures, and species regulations.

2.3.1.1 Marine Reserves

Marine reserves are areas in the ocean protected from certain human activities and are one of the most popular tools for implementing ecosystem-based management. In these reserves biological organisms and natural resources are protected from fishing. Branch et al. (2006) reported successful

implementation of marine reserves in South Africa and stated that they are “the only effective way of protecting entire ecosystems” (p. 5).

2.3.1.2 Seasonal No-Take Zones

Seasonal no-take zones are fishing grounds that are closed for only a certain period of time. Usually these types of closures are implemented during fishes’ spawning seasons because this is when they are the easiest to catch and they often return to the same spawning grounds every year to reproduce. Researchers Handwerk and Hafvenstein (2003) explained that such was the case off the coast of Belize in the 1970’s when the fishermen of Belize traveled to the spawning grounds of grouper fish. During the ten to fourteen day spawning period, the fishermen caught thousands of fish, and by the late 90’s the spawning beds were nearly empty. An ecosystem-based management plan was implemented in 2002 and regulations were passed to protect the spawning grounds of the grouper. The studies that were conducted showed that this project was successful and the local fishermen were pleased with the progress. Branch et al. (2006) cautioned, however, that seasonal no-take zones may not be enough because “for many species, it makes no difference to reproductive output whether individuals are harvested before, during or after the reproductive season” (p. 5).

2.3.1.3 Fishing Capacity Controls

Another way to address the problem of over-fishing involves the placement of controls on the number of fish caught and the methods used to

catch them. Branch et al. (2006, p. 2) described a system in which users paid for the right to harvest certain species in South Africa. The species were divided into several categories based on how accessible and profitable they were, and different regulations and fees were then applied to each category. These fees discouraged the excessive and irresponsible use of resources and were a means of providing the financial support necessary to fund the reserve. Branch et al. (2006, p. 5) also described two types of quotas that were put in place in South Africa, total allowable catch and total allowable effort. The total allowable catch defined how many tons of fish could be caught annually by the entire industry while the total allowable effort controlled the resources that could be utilized to catch fish, such as the number of boats, quantity of equipment, and size of the crews.

Regulating the methods used by fishermen assisted in controlling the number of fish caught. For example, fishing net mesh sizes were regulated to avoid the problem of by-catch in which immature fish were removed along with the normal catch (Sheffer, 2006).

The fishing practices themselves can also be harmful to the marine ecosystem as a whole. Practices, such as trolling, that disrupt the ocean floor often damage coral and other organisms and generate large amounts of sediment.

2.3.2 Aquaculture

Closing fishing grounds to local fishermen deprives them of their source of livelihood. Aquaculture, which consists of the controlled cultivation and harvest of

aquatic plants or animals, may provide alternative employment for these fishermen. Fish raised in an aquaculture setting need to be fed by humans on a regular basis, something that struggling fishermen may be well suited for (D. Alston, personal communication, January 30, 2006). It remains to be seen whether fishermen are willing to make the transition from the hunter-gatherer lifestyle of fishing to the more predictable lifestyle of aquaculture maintenance.

2.3.3 Lessons Learned in Ecosystem-based Management

Ecosystem-based management has been implemented to different degrees around the world. Slocombe (1998) examined six case studies of ecosystem-based management plans that have been implemented and Keller (2006) detailed the implementation of an extensive ecosystem-based management plan in the Florida Keys. They both outlined several important lessons that have been learned and situations that should be avoided in future ecosystem-based management plans. The first lesson learned related to the management structure that should be used. Management plans should seek to achieve regional support instead of addressing each community individually.

The second lesson pointed out the importance of thoroughly understanding the marine ecosystem. Although gaining this knowledge represents an important first step, the result will be fragmented unless the interactions and interdependencies between different parts of the ecosystem are taken into consideration. Based on this understanding, any management approach should focus on dealing with the ecosystem as a whole rather than on its individual parts (D. Alston, personal communication, April 03, 2006).

Several common flaws of ecosystem-based management were also noted. Some of these problems were site specific such as the size and number of users of the area in question (Keller et al., 2005, p. 21). Others related to the management of the project such as political bureaucracy, short-sightedness, poor use of existing information, and use of vague objectives.

The individual political agendas often found in government organizations make it difficult to accomplish simple tasks, such as obtaining permits, and thus hinder progress toward the creation and success of management programs (L. Feliciano, Appendix G). When communities realize the seriousness of a deteriorating coral reef problem, a desire to find a quick solution can result in the creation of a management plan that has not been thoroughly researched and which has problems that hold it back from long term success (Keller et al., 2005).

Ecosystem-based management is not a new concept and has been implemented in various ways and with varying degrees of success around the world. When the lessons learned from these experiences as well as the relevant scientific data are ignored by the creators of management plans, they put into action a plan that does not have a solid factual basis and set themselves up to repeat mistakes that have already been made. Finally, if a management plan does not have a clear set of objectives that must be met, it is unlikely that it will be able to satisfy the needs of the parties involved (Slocombe, 1998, p. 33).

2.3.4 Models for Ecosystem-based Management

Throughout the world, different forms of ecosystem-based management have been implemented. The successes and failures of these management plans

provided guidelines to implement ecosystem-based management and identified possible social implications.

2.3.4.1 Ecosystem-based Management in Culebra

The island of Culebra, located off the east coast of Puerto Rico, represents one especially significant example of ecosystem-based management. The waters around Culebra had become over-harvested, forcing fishermen to travel further out to sea, where comparable fish populations existed (D. Alston, Appendix G). Alston et al. (2005) reported that the problem had become so severe that many fishermen had been forced to leave fishing and find some other means of employment. In the early 1980's the local fishing community requested that the government create nine different natural reserves around Culebra. The government, however, was unsure of how this would be received and decided to start with one. In September of 1999 the Luis Peña Channel Natural Reserve (LPCNR) was created (E. Hernández, Appendix G).

To supplement the fishing industry in Culebra aquaculture facilities were put in place, and fishermen were given first priority of maintaining the cages as a source of income (D. Alston, Appendix G). These aquaculture facilities were implemented far away from the reefs in an area where the ocean floor was sandy. This prevented the aquaculture systems from interfering with the coral reef ecosystems.

The creation of the LPCNR was the first instance in Puerto Rican history that local fishermen voluntarily surrendered their fishing grounds. Studying this particular case allowed us to use the Luis Peña Channel Natural Reserve as a

model for fishing villages throughout Puerto Rico. This case study will be discussed in more detail in Chapter 4 of this report.

2.3.4.2 Ecosystem-based Management in Belize

In 2002, the government of Belize implemented ecosystem-based management to protect the spawning grounds of the grouper fish. The Belize government passed regulations that prevented fishing in eleven offshore spawning areas, and they also established a four month closed season for grouper (Handwerk & Hafvenstein, 2003, *Popularity Hurts Nassau Grouper* section).

Belize served as an excellent example of the active role the government could take in ecosystem-based management. In this case the government implemented regulations on a particular species of fish, and the results exceeded expectations. Although the fish populations did not fully recover, they began to flourish again. Based on the increase in grouper and the known connections between one population's success and the health of the ecosystem as a whole, the implementation of regulations proved to be successful (Handwerk & Hafvenstein, 2003, *Popularity Hurts Nassau Grouper* section).

2.3.4.3 Ecosystem-based Management in Taiwan

In Taiwan, the local fisheries group held the rights to the fishing grounds and their management policies until 1993 when they released these rights to the Taiwanese government. According to Sun-Chio Fung (2006), the authorities began enforcing the laws regarding resource conservation by promoting an

investment plan concerning aquaculture. The government also shifted from trying to manage the fishery stocks to properly training and educating fishermen in environmentally sound catch techniques. Beginning in 1993, the government allocated coastal zones to groups of fishermen to optimize and conserve the marine resources. This had been widely accepted and successful, and seventeen of the eighteen coastal counties in Taiwan actively participated in the management of their near-shore areas. Fong also stated that the allocation of coastal zones resulted in easier management and understanding by the government and the fishermen. Local fishermen became territorial with respect to their fishing grounds and have chased away fishing boats from other areas. The survival of fishermen depended on their respective fishing grounds because if they did not conserve their fishing grounds and manage their stocks properly they would be unable to support their families.

2.4 Constraints

Implementing ecosystem-based management requires an understanding of the potential difficulties that can be encountered. The laws and regulations that govern the marine ecosystem dictate what measures can be put into place to promote healthy coral reefs. Environmental policy provides a basis for laws and regulations passed by the U.S. Congress to protect many ecosystems and their inhabitants (National Oceanic and Atmospheric Administration [NOAA], 2002, *Coastal Zone Management* Section). Laws and regulations could be used in conjunction with ecosystem-based management to determine the future of

ecosystems, including coral reefs and the fishing grounds that surround the reefs.

On June 7th, 2005, The National Offshore Aquaculture Act of 2005 was submitted to Congress, and if the bill passes the Secretary of Commerce would have the authority to issue permits for offshore aquaculture in the Exclusive Economic Zone, which grants the rights of the ocean waters up to two-hundred miles offshore to the United States. Although the bill would not displace existing authority, it would allow the Secretary of Commerce to establish and implement a regulatory system for offshore aquaculture (U.S. National Marine Fisheries Service, 1999). The Exclusive Economic Zone includes the waters surrounding Puerto Rico, and this bill could have a profound impact on the feasibility of implementing aquaculture in Puerto Rico. The regulations would require permits to be issued for the implementation of aquaculture, and if communities were unable to acquire these permits, fishermen might be reluctant to close reefs because aquaculture would not provide an alternative and adequate source of income.

2.5 Organizations of Interest

Many organizations around the world agree upon the importance of ecosystem-based management and the role it can play in the repopulation of various marine species. These organizations are an important source of information gathered from research by experts in the field of ecosystem-based management. The most important of these organizations are the National

Oceanic and Atmospheric Administration (NOAA), Sea Grant, CORALations, and the Puerto Rico Department of Natural and Environmental Resources (DNER).

2.5.1 National Oceanic & Atmospheric Administration

The National Oceanic and Atmospheric Administration identifies environmental changes to assist in the protection of life and property. The organization acquires and distributes reliable scientific information and promotes national environmental stewardship. The National Marine Fisheries Service (NMFS), a department of the NOAA, dedicates itself to the conservation, management, and promotion of living marine resources. This organization has extensive resources and documents pertaining to fisheries and the laws and regulations that control them. In Puerto Rico, NOAA has worked in conjunction with the University of Puerto Rico – Mayagüez through the Sea Grant Program to develop habitat maps of selected coral reefs and to monitor these reefs using the maps for tracking of coral reef changes over time (NOAA, 2006).

2.5.2 Sea Grant

Sea Grant, an association of thirty universities throughout the United States, seeks to promote healthy relationships between coastal communities and their environments. The specific goal of Sea Grant at the University of Puerto Rico – Mayagüez is to “promote the conservation and wise use of the coastal and marine resources of Puerto Rico and the U.S. Virgin Islands in ways that benefit the entire population and the Caribbean in general” (UPR Sea Grant College Program, 2006, Funding Opportunity Section). The existence of this

program in Puerto Rico has led to many studies of the ecosystems around the island and drawn the attention of many individuals who are willing to contribute to their well-being.

2.5.3 CORALations

CORALations, a non-profit organization based in Culebra, seeks to maximize limited conservation resources by bringing together government agencies, scientists, and local communities to work on coral reef conservation projects (CORALations, 2006). This organization focuses on conserving resources, nurturing the environment, and educating the people of Culebra. They have donated Reef Ball™ artificial reef systems for use in research projects and for remediation of areas that were severely damaged. CORALations accomplishes its final mission of education by conducting outreach programs in schools and communities throughout Puerto Rico.

2.5.4 Department of Natural and Environmental Resources

The Puerto Rico Department of Natural and Environmental Resources deals with issues affecting ecosystems on the Commonwealth level (Departamento de Recursos Naturales, 2006). Their mission is to protect the resources of the island in an effort to guarantee their existence for future generations. Through promotion of sustainable use of resources, the DNER seeks to improve the quality of life for Puerto Rico as a whole. This organization is involved in the implementation, management and enforcement of marine protected areas throughout Puerto Rico.

2.6 Background Summary

Many interrelated influences have caused the deterioration of the coral reef ecosystems in Puerto Rico. A variety of methods have been proposed to address similar situations around the world, but we had to consider the unique constraints and organizations that existed in Puerto Rico before developing methods to implement ecosystem-based management. The examination of the issues presented in this chapter has provided a foundation of theory and examples that assisted in the completion of our project.

3.0 Methodology

The goal of this project consisted of developing a plan for the successful implementation of ecosystem-based management in Puerto Rican communities. This chapter discusses the methods that we used to accomplish our key objectives of determining designations and locations of marine protected areas in Puerto Rico and identifying the successes and failures of the Luis Peña Channel Natural Reserve in Culebra. We also studied the proposed Turrumote marine reserve in Lajas, a municipality in southwestern Puerto Rico, and determined present opinions of this community regarding marine reserves in this community.

3.1 Determine Puerto Rico Marine Protected Area Designations

Our initial task in Puerto Rico involved documenting the locations of marine protected areas throughout the Commonwealth and the regulations pertaining to each reserve. We completed this objective to provide a better understanding of the current status of marine protected areas on the island.

We interviewed Edwin A. Hernández-Delgado, Ph.D., of the Marine Biology Department at the University of Puerto Rico – Rio Piedras. He was a member of the group responsible for the management and operation of the Luis Peña Channel Natural Reserve in Culebra and has researched marine protected areas in Puerto Rico.

We also interviewed Manuel Valdez-Pizzini, Ph.D., co-author of *Fishers at Work, Workers at Sea: A Puerto Rican Journey through Labor and Refuge*. We contacted him because of his involvement in NOAA's Coral Reef Ecosystem

Studies Program and his knowledge regarding the locations and designations of marine protected areas throughout Puerto Rico.

3.2 Luis Peña Channel Natural Reserve

We identified important aspects pertaining to the management of coral reef ecosystems within the LPCNR in Culebra. Initially, we examined many reports that documented what occurred in the Luis Peña Channel Natural Reserve, looking specifically for techniques identified as particularly successful or areas that needed improvement.

To gain a more in-depth understanding of the Reserve and to help clarify ecosystem-based management concepts found in the literature, we contacted individuals involved in the creation and management of the Reserve. Interviews were used to determine the specific processes involved in the creation of the Reserve, the successes and failures of the Reserve, and its effects on the local fishermen. We were also able to verify the accuracy of each statement through multiple interviews, thus enhancing the validity of our data. Our liaison, Dallas E. Alston, Ph.D., provided us with the contact information for our initial interviewees, and we obtained further contacts through each interview.

3.2.1 Professionals

Edwin A. Hernández, Ph.D., of the University of Puerto Rico – Rio Piedras, produced annual reports focusing on the changes in fish populations and coral reef cover in and around the Reserve. We interviewed him to learn the

history of the LPCNR, which proved useful in completing our objective of determining its successes and failures.

3.2.2 Culebra Fishing Association

We conducted an interview with both Lourdes Feliciano, the secretary of the Culebra Fishing Association, and Carolin Viscarrondo, its manager. This interview focused on the factors that motivated the fishermen to establish the Reserve and how it impacted the fishing industry. We interviewed these members of the Culebra Fishing Association to learn their perspectives on the successes and failures associated with the LPCNR.

3.2.3 CORALations

We also contacted Mary Ann Lucking, director of the Culebra-based community organization CORALations, who played an important role in the development of the Luis Peña Channel Natural Reserve. The knowledge that she possessed proved very useful in understanding the history of the Reserve.

3.3 The Proposed Turrumote Marine Reserve

We achieved our third objective by interviewing members of the scientific community and local fishermen. We interviewed these individuals to learn about the successes and failures of the proposed Turrumote marine reserve. Some of these individuals were identified by our liaison and others were referred to us by other interviewees.

3.3.1 Scientific Community

We interviewed a number of people from the scientific community who played key roles in the process of creating the proposed Turrumote reserve. Jorge García, Ph.D., of the Department of Marine Sciences at the University of Puerto Rico – Mayagüez, studied the feasibility of a reserve based on the scientific data he gathered in the area. Manuel Valdez-Pizzini, Ph.D., of the Social Science Department of the University of Puerto Rico – Mayagüez, was the director of the Sea Grant program at the time that the reserve was being proposed and oversaw the project. Richard Appeldoorn, Ph.D., and Jose Rivera, Ph.D., were also valuable resources because of their familiarity with the Turrumote reserve and their expertise in the field of fisheries management. Many of these people supplemented information from their interviews with useful documents.

3.3.2 Fishermen

We also interviewed a number of local fishermen. The fishing villages of La Parguera and Papayo border each other and represent part of the Lajas coast. Through initial interviews with fishermen from La Parguera, we discovered that the marine reserve proposed in the Turrumote area would have affected both villages; therefore it was important to obtain opinions from both groups of fishermen.

3.3.2.1 La Parguera

We first interviewed fishermen in the Lajas village of La Parguera. There are three commercial fishing markets in La Parguera which represent upwards of forty fishermen. Froilan Lopez owns one of these markets and Romberto Hernández owns the other two. Another prominent member of the fishing community is Luis Moreno, retired owner of one of the markets. We interviewed these and other fishermen in order to understand the successes and failures of the previously proposed Turrumote marine reserve.

The Marine Sciences Department of the University of Puerto Rico – Mayagüez employs researchers Ivan Lopez and Jose Ramos who are members of prominent fishing families in La Parguera. Not only do they have strong fishing backgrounds, but they have become experts in fisheries and understand the biases of each viewpoint. We interviewed them in an effort to gain their views pertaining to the proposed Turrumote marine reserve.

3.3.2.2 Papayo

The village of Papayo consists of approximately twenty commercial fishermen. We interviewed three fishermen in the village to learn why the reserve was not well-received within the village and what could have been done to make it more acceptable to the fishermen.

3.4 Present Community Opinions

In completing our fourth objective, we focused on the opinions of community members throughout the Lajas Valley. Through interviews with

scientists, fishermen, divers, and the mayor of Lajas, we were able to determine the current community attitudes towards marine reserves from the stakeholders.

3.4.1 Professionals

Members of the scientific community of Lajas were interviewed because of their knowledge and experience in regards to the ecological and environmental factors necessary to implement a marine reserve. We conducted several interviews with professors from the Department of Marine Sciences at UPRM to gather the desired data. We also interviewed Valdez-Pizzini, of the Social Sciences Department, who directed the Turrumote marine reserve process for Sea Grant and was interviewed because of his involvement in the process.

We also interviewed Carmen Delia, of the Puerto Rican Department of Natural and Environmental Resources (DNER). Since the DNER is the local government agency responsible for marine protected area designations, it was important to obtain the perspective of a representative of this organization.

We focused on Turrumote and the possibility of establishing a marine reserve at this location, as proposed over twelve years ago. Although current scientific data would be necessary to determine the precise location of any marine reserve, we used Turrumote as an example that allowed us to learn how a marine reserve would affect fishermen. These interviews were conducted to gather important information about not only how a reserve would affect the fishermen of these two villages, but whether they would support it. We were also able to determine if the fishermen of these villages were willing to be involved in the decision making process regarding the management plan.

3.4.3 Tourism Businesses

We interviewed owners and employees of diving and snorkeling businesses in Lajas to learn how marine reserves would affect businesses in the Lajas Valley. We interviewed an experienced dive-master to discuss his opinions regarding the deterioration of the coral reefs and to learn how marine reserves would affect recreational divers. We discussed the impacts that divers have on the coral reef ecosystem and how divers would react to reserves that allowed no recreational activities. We discussed the proposed reserve at Turrumote and how it would have affected businesses if it had been implemented with restrictions on fishing and recreational activities.

3.4.4 Mayor of Lajas

We interviewed Mayor Marcos A. Irizarry, of Lajas, because the support of the local government increases the acceptance of any type of ecosystem-based management plan. This allowed us to determine if the local government was aware that its citizens were concerned about the reefs. We discussed the goals and objectives of the mayor to determine if he supported implementing ecosystem-based management.

3.5 Developing a Plan for Ecosystem-based Management

We used the methods described in this chapter to gather important data that allowed us to meet our objectives. Each of these objectives was a step toward completing our project's goal of developing a plan for the successful implementation of ecosystem-based management in Puerto Rican communities.

4.0 Results and Data Analysis

Through the interviews we conducted and our extensive literature review we obtained a considerable amount of information regarding the development of a plan for the implementation of ecosystem-based management in Puerto Rico. The information presented below explains what we learned about the various types of marine protected areas in Puerto Rico and how each designation has impacted marine ecosystem stakeholders. This chapter also summarizes what we discovered about two specific reserves: the Luis Peña Channel Natural Reserve in Culebra, and the proposed Turrumote marine reserve in Lajas. Finally in this chapter, we present the views of various Lajas community members on the possibility of having a marine reserve in their area.

4.1 Marine Protected Areas in Puerto Rico

This section discusses the different types of marine protected areas and the governing organizations in charge of implementing and managing them in Puerto Rico. This section attempts to clarify the ambiguities and confusion regarding the different types of marine protected areas.

4.1.1 Governing Organizations

We found that Puerto Rico is unique in terms of marine protected areas due to its Commonwealth status. The waters surrounding the island are controlled by both the Puerto Rico DNER and NOAA under the United States Federal Government and therefore designations are unclear and processes are complicated.

The National Oceanic and Atmospheric Administration promotes sustainable economic development, jobs, and prosperity along the nation's coasts. In 1972 the Coastal Programs Division of NOAA developed the Coastal Zone Management Program (CZMP), a partnership between the Federal and State Governments that focused on the management of the nation's coastal ecosystems. This program mandated the creation of management plans for certain coastal ecosystems in Puerto Rico.

In 1996, NOAA created the Caribbean Fisheries Management Council (CFMC) under the Magnuson-Stevens Fishery Conservation and Management Act. The CFMC represents one of eight regional divisions in charge of the management of their respective coastal environments. Each council prepared Fishery Management Plans for areas that needed improvement within the U.S. Exclusive Economic Zone (EEZ), from nine nautical miles to two-hundred nautical miles off shore in Puerto Rico. As a part of Magnuson-Stevens Act, NOAA created three seasonal no-take zones off the western coast of Puerto Rico (Areas 21, 22, and 23 in Figure 3) within the EEZ. Although adjacent marine ecosystems are separated by man-made boundaries, they contain populations that move between ecosystems. Therefore marine protected areas near the nine-nautical-mile boundary of the EEZ contain fish populations that are affected by the rules and regulations of NOAA.

Within nine nautical miles of the shore, the Department of Natural and Environmental Resources joins NOAA in controlling the creation of marine protected areas. Although NOAA has given the DNER exclusive jurisdiction to

manage and operate these areas, it reserves the right to create new management plans in Puerto Rico. Because each of these organizations has jurisdiction in this area there has been confusion among the MPA designations (Michelle Scharer, Appendix G)

4.1.2 Definitions

Because of the overlapping jurisdictions in Puerto Rico, the definitions of marine protected area designations are complicated. The U.S. government created the Marine Protected Areas Center in an effort to clarify these definitions. They defined a number of designations, but not all were considered and differences existed with other organizations. Universal definitions are important to stakeholders of an ecosystem regarding the ease of education and simplicity of applying regulations.

Marine Managed Area (MMA)

The Marine Protected Areas Center (2006) created the term “Marine Managed Area” to refer to “[m]anaged areas in the marine environment that might indirectly, partially, or for a limited duration provide some degree of natural resource or cultural resource protection, and may not include protection for conservation purposes” (section M). Marine Managed Areas are the broadest form of marine protected areas and encompass geological, cultural, or recreational aspects not included in the official U.S. definition of MPAs.

Marine Protected Area (MPA)

As a form of an MMA, the Marine Protected Areas Center (2006) identifies MPAs as “areas of the marine environment that have been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein” (section M).

The Department of Natural and Environmental Resources of Puerto Rico has no formal definition of marine protected areas but at least seven designations could be considered MPAs: natural reserves (NR), commonwealth forests (CF), marine reserves (MR), biosphere reserves (BR), critical habitats (CH), national estuarine research reserves (NERR), and no-take zones (NTZ) (Aguilar-Perera et al., 2005).

Natural Reserves (NR)

According to Jose Rivera, Ph.D., (Appendix G), natural reserves are designated by a planning board on the state or territorial level of government. Natural reserves have a terrestrial as well as a marine component, and can have a variety of restrictions applied to them on a case-by-case basis.

Commonwealth Forests (CF)

According to Rivera (Appendix G), commonwealth forests, also known as insular forests in Puerto Rico, are simply natural reserves that protect mangrove areas.

Marine Reserves (MR)

The National Marine Protected Areas Center (2006) identified marine reserves as “[a]reas in which some or all extractive activities are prohibited” (section M). Marine reserves are simply the aquatic component to a natural reserve.

Biosphere Reserves (BR)

According to Rivera (Appendix G), biosphere reserves are areas recognized by the world as containing unique environmental value, and are designated as such by the United Nations. Restrictions must be applied on a national or local level since these areas do not have any specific restrictions associated with them.

Critical Habitats (CH)

According to Alfonso Aguilar-Perera et al. (2005) critical habitats “were designated by NOAA to protect essential habitats for endangered species, as defined by the U.S. Endangered Species Act” (p.10).

National Estuarine Research Reserves (NERR)

According to Jose Rivera (Appendix G), the Jobos Bay National Estuarine Research Reserve is an example of an NERR. National estuarine research reserves are areas designated for outreach and educational programs funded by NOAA. The legislation under which these areas are established mandates that the local governing agency should develop a management plan to provide protection for Reserve resources to ensure a stable environment for research (Michelle Sharer, Appendix G).

Multiple-use MPAs

According to the National Marine Protected Areas Center (2006), multiple-use areas are “[o]ften employed over larger areas, [and] allow for integrated management of complete marine ecosystems, usually through a zoning process” (section N). Multiple-use MPAs combine more than one designation in a given area, and can be established by either the federal or local government.

Marine Sanctuaries (MS)

“A Marine Sanctuary is a multiple-use MPA under the National Marine Sanctuaries Act” (Aguilar-Perera et al., 2005, p. 10). In Spanish, however, the term “sanctuary” acquires a different meaning due to its religious connotation (M. Scharer, Appendix G). The term “sanctuary” in the Spanish culture often conveys an “untouchable” status, so to the people of Puerto Rico all activities would be prohibited in a marine sanctuary.

No-Take Zones (NTZ)

No-take zones are “[a]reas in which all extractive activities are prohibited” (National Marine Protected Areas Center, 2006, section N). These areas are the most restrictive of the marine protected areas since no marine resources can be taken from them.

Seasonal No-Take Zones

According to Alfonso Aguilar-Perera et al. (2006) seasonal no-take zones “[aim] to protect fish spawning aggregation sites of commercially

important species” (p. 10). The seasonal species restrictions for the grouper are an example of a seasonal no-take zone that is in effect for all of Puerto Rico.

4.1.3 Locations

According to Alfonso Aguilar-Perera et al. (2006) locations of marine protected areas throughout Puerto Rico are numerous. A total of thirty-seven areas designated as MPAs exist, each with a unique management plan. Figure 3 below displays the locations of MPAs throughout Puerto Rico.

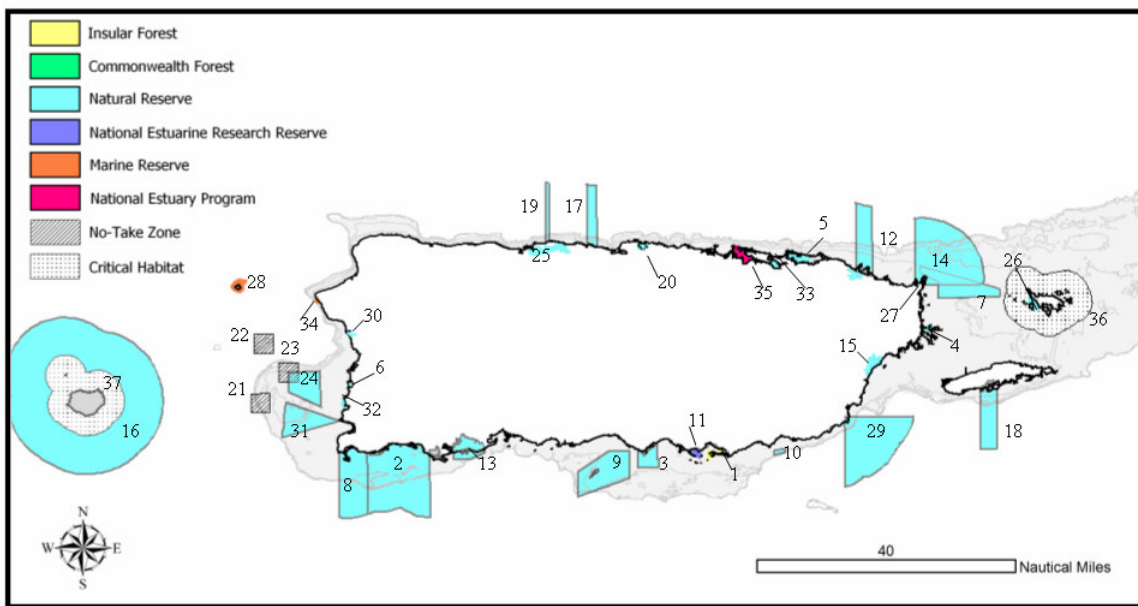


Figure 3: The marine protected areas (MPAs) of Puerto Rico. Refer to Appendix D for zone numeration and associated attributes (adapted from Aguilar-Perera et al., 2005, p. 31). Refer to Appendix C for a higher-resolution map.

Appendix D displays the following information for each MPA:

- MPA name
- Designations
- Establishment Date
- Establishment Mechanism
- MPA composition
- Terrestrial Surface area
- Seafloor Surface area
- Total Surface area

Identifying the eight designations and thirty-seven locations of Marine Protected Areas in Puerto Rico was an important first step in helping us to understand what current strategies are being used to manage marine ecosystems. Our next objectives of examining the Luis Peña Channel Natural Reserve and the proposed reserve in the Turrumote allowed us to get a better understanding of how effective these strategies have been.

4.2 The Luis Peña Channel Natural Reserve

We analyzed the data obtained from our interviews to identify the successes and failures of the Luis Peña Channel Natural Reserve in Culebra. When compared to other situations around the world where fishermen have tended to resist the idea of closing off the waters that they fish in, the voluntary action of the Culebra fishing community was quite unique. The fishermen were motivated by the fact that they saw the fish stocks disappearing and also by the introduction of an aquaculture industry by Snapperfarm, Inc. (Alston et al., 2005). This model of no-take zones implemented voluntarily by the local community in conjunction with aquaculture could be a very promising approach that could be extended to other areas.

4.2.1 Physical Changes

Our interview with Edwin A. Hernández.(Appendix G), from the University of Puerto Rico – Rio Piedras, provided valuable information regarding fish populations and coral reef cover in and around the Reserve. Since the start of the Reserve, Hernández has conducted studies in three sites identified on the

map in Figure 4. During our interview with Hernández, he provided us with his yearly unpublished journal articles, which documented his findings.

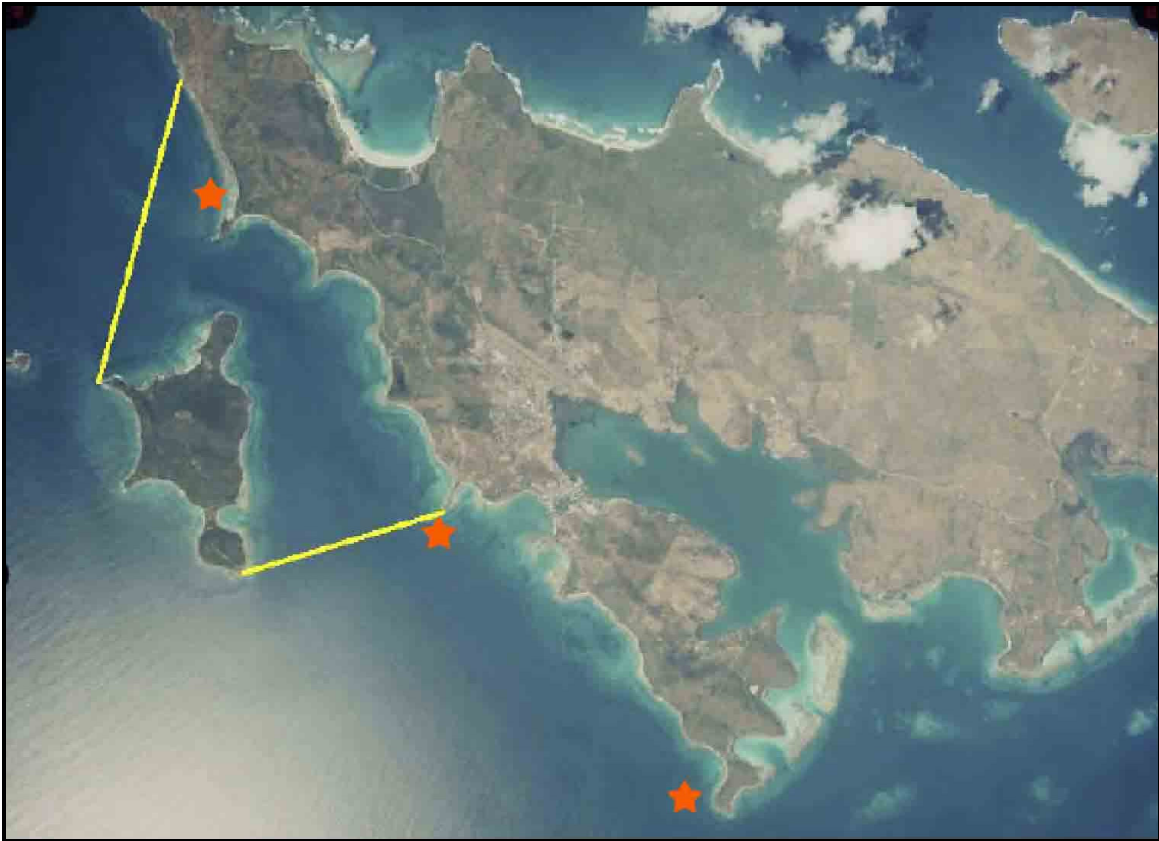


Figure 4: Outline of LPCNR with study sites marked, from north to south: Carlos Rosario, Punta Melones, and Punta Soldado (adapted from Hernández-Delgado et al., 2004)

According to Hernández-Delgado et al. (2004), during the first three years of existence of the LPCNR (from 1999 to 2002), species richness (Figure 5) and total biomass (Figure 6) within the Reserve showed significant improvements. Species richness is a measure of the number of different species in an area, while biomass is the approximated mass of life in a given area.

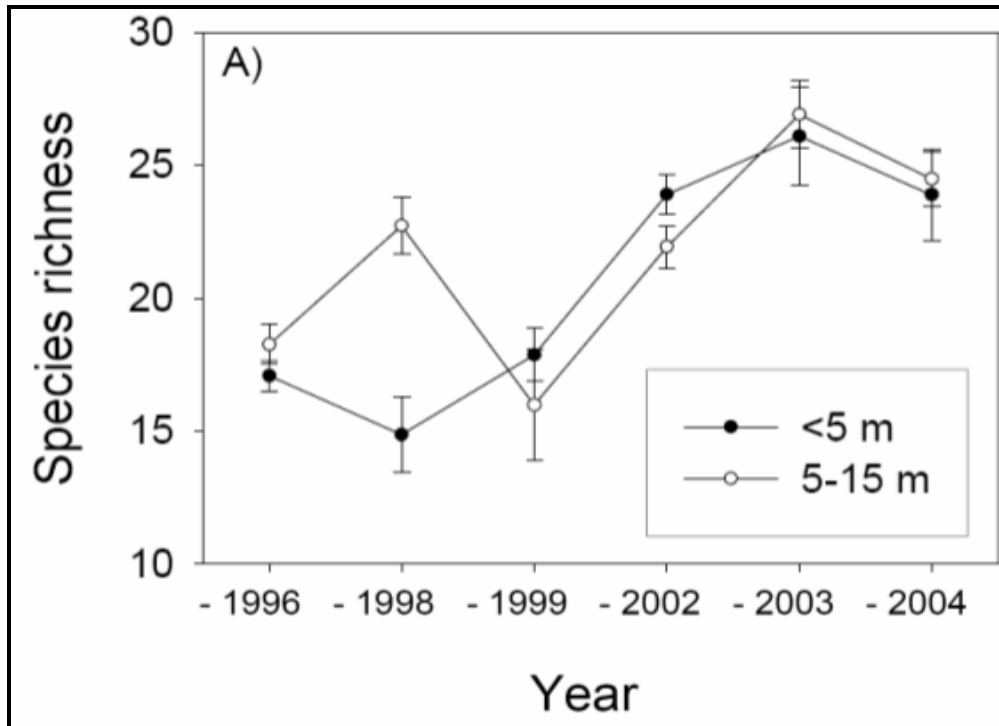


Figure 5: Species richness at Carlos Rosario Beach at two indicated depths (Hernández-Delgado et al., 2004)

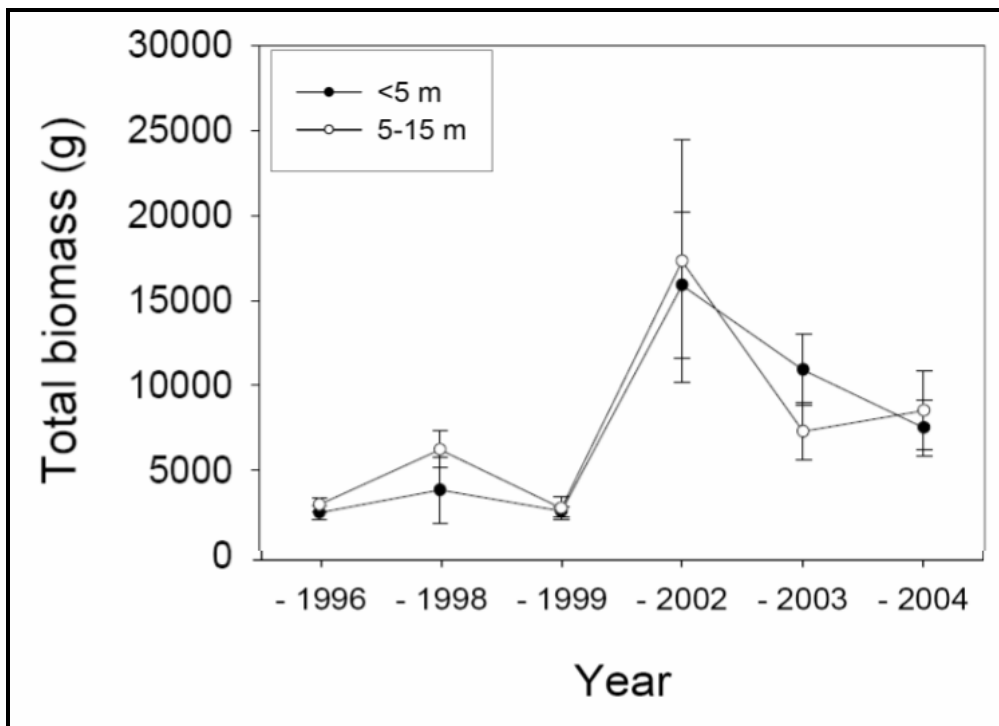


Figure 6: Standing stock biomass at Carlos Rosario Beach at two indicated depths (Hernández-Delgado et al, 2004)

Hernández-Delgado et al. (2004) stated that the relationship between coral and macroalgae greatly affects the health of the reefs. Through measuring the coral-macroalgae ratio, the general health of the coral reef microorganisms could be approximated. While an extremely large coral-macroalgae ratio can exceed the productive range of healthy growth and living, the coral cannot survive when measurements of this ratio drop below 1.0. The coral and macroalgae ratios for Carlos Rosario Beach are shown in Figure 7. In this particular example, the ratios at all depths had dropped below one by 2003 and this contributed to the mortality of coral at this particular location.

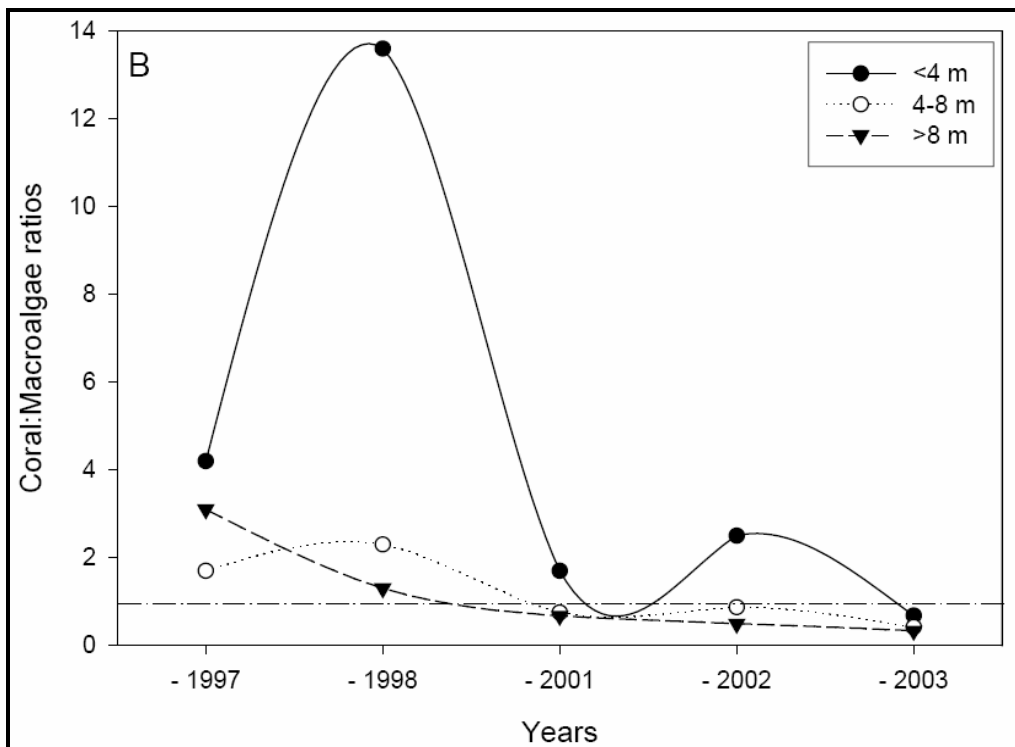


Figure 7: Coral-to-macroalgae ratios at Carlos Rosario Beach (Hernández-Delgado & Sabat, Article in Press)

Mary Ann Lucking, the director of CORALations in Culebra (Appendix G), also identified the Reserve as a great initial success, resulting in nearly 100% coral cover in many areas of the Reserve. Since 2002, however, there has been

a decline in both total biomass (Figure 6) and coral cover, which was thought to be a direct result of a lack of enforcement within the Reserve. Since 2003, the species richness (Figure 5) has declined which is also accredited to delayed effects of a lack of enforcement.

4.2.2 Enforcement Issues

Hernández-Delgado et al. (2004, p. 11) identified the following as failures related to poor enforcement of the Reserve:

- 1) There was only one part-time management officer at the Luis Peña Channel Natural Reserve until 2002, and none since then.
- 2) Boundary buoys that were placed when the Reserve was established were vandalized or dislodged by strong currents and by 2003 they had been missing for an entire year.
- 3) There was no continuous patrolling and law enforcement.
- 4) There was sporadic patrolling by the fishermen, without legal authority.

Hernández-Delgado et al. (2004, p. 11) also identified the following enforcement problems for areas outside the Reserve:

- 1) There was illegal clearing of beach land,
- 2) There was illegal pumping of sediment-loaded waters from public project sites to coastal waters.
- 3) There was illegal raw sewage discharges to coastal waters.

These issues were confirmed in our interviews with Lourdes Feliciano, the Secretary of the Culebra Fishing Association, and Carolin Viscarrondo, the Manager (Appendix G) and Mary Ann Lucking (Appendix G). They agreed that the enforcement issues in the Reserve resulted from the Department of Natural and Environmental Resources (DNER) lacking a full-time enforcement boat patrolling the Reserve. Feliciano and Lucking cited this lack of enforcement as one of the larger struggles facing the LPCNR because without effective enforcement by the DNER, illegal fishing activities would continue without resistance.

4.2.3 Regulation Issues

According to Hernández-Delgado et al. (2004), the regulation issue that faced the LPCNR was that the recreational fishermen outnumbered commercial fishermen for the first time and the Reserve did not address their effects on the environment. Through an interview with Michelle Scharer (Appendix G), we learned that licenses are required for recreational fishermen throughout Puerto Rico, but a system to sell the licenses had not yet been implemented.

Hernández-Delgado et al. (2004, p. 9) also identified regulation issues outside the Reserve that continue to cause problems. The main issue was the development of steep slopes without any erosion control measures.

According to Feliciano and Viscarrondo (Appendix G), fishing has developed into a way of life and the people of Culebra respect the rules governing the Reserve and do not fish within its boundaries. They explained that

the problem arises from outsiders who come from Vieques or other places to fish in the Reserve.

4.2.4 Communication Issues

Hernández-Delgado et al. (2004) believed that communication issues arose because there was “[n]o coordination among enforcing agencies or between agencies and stakeholders” (p. 11).

During the creation of the Luis Peña Natural Reserve, Lucking (Appendix G) identified a lack of communication between the managing agencies and the local fishermen. The fishermen were interested in their own prosperity for the most part, while the managing agencies were acting in the interest of the economic and environmental welfare of Culebra. These differing goals ultimately resulted in a management plan that the fishermen did not entirely support.

4.2.5 Trust Issues

Lucking (Appendix G) believed that there were many breaches of trust between the DNER and the local fishermen. There were several instances in which DNER enforcement personnel were caught fishing in the Reserve, further deepening the local distrust in the DNER. With this distrust in the enforcing agency came an overall lack of obedience for the laws that govern the area.

4.2.6 Educational Issues

Hernández-Delgado et al. (2004) believed that issues existed in the education process of the Marine Reserve. Lucking (Appendix G) developed an

educational outreach program for the children of Culebra, however there has been no program established to educate the fishermen or other adults of the community about the importance of the Reserve and its restrictions. The signs and buoys that mark the boundaries of the Reserve have also been insufficient to inform tourists and fishermen from outside Culebra of the existence of the Reserve and the restrictions that apply in it.

4.2.7 Reserve Summary

The Luis Peña Channel Natural Reserve had been successful in increasing the biomass and species richness inside and outside of the Reserve as documented by Hernández-Delgado et al. (2004). Enforcement issues, however, greatly hinder this process of returning the ecosystem to its original state. Other issues that have been affecting the LPCNR include regulations, communication, trust, and education.

4.3 The Turrumote Reserve in Lajas

We identified the successes and failures of the proposed marine reserve at Turrumote by conducting interviews and reviewing literature. Turrumote is an island surrounded by many intricate reefs, and is similar to many of the islands off the coast of Lajas, a community in southwestern Puerto Rico (see Figure 8).



Figure 8: Satellite image of the Lajas shoreline including the location of the proposed Turrumote reserve (adapted from www.maps.google.com, 2006)

4.3.1 Feasibility Study of Proposed Turrumote Reserve

Jorge R. García, Ph.D., of the University of Puerto Rico – Mayagüez conducted a feasibility study in the early 1990's for a marine reserve in Lajas. There were three main objectives that he accomplished to complete this study. The first objective included determining the level of support that would come from Lajas fishermen. Through extensive interviews with important members of the fishing community in the town of La Parguera, García learned that the fishermen had several concerns, but for the most part they were in support of the idea. García then gave all of the fishermen criteria for what would make an ideal site for a marine reserve. Based on those criteria, the fishermen decided on three sites in the Lajas area for further consideration. The second objective of selecting sites for consideration of closure resulted in the fishermen choosing Turrumote, Media Luna, and San Cristobal reefs. Finally, transects to collect fish population

data (Appendix E) for the three sites were used to meet the third objective of gathering baseline data to justify choosing one of these sites for closure. Not only did the data indicate that Turrumote would be the best site for implementation of a marine reserve, but the fishermen voted and reached the same decision.

Although the fishermen of La Parguera supported the reserve, they had several concerns that García identified in his feasibility study. The fishermen were concerned that after closure of one site, the DNER would close more sites in Lajas without fishermen's approval, that some fishermen would continue to fish inside the reserve, and that the DNER would not provide surveillance and enforcement for the reserve (García, 1994, p. 11).

4.3.2 Community Involvement

Several different aspects of the Turrumote reserve feasibility study were successful. García (Appendix G) noted that the "bottom-up" establishment of an ecosystem-based management plan such as the approach this study took is the best way to meet the needs of the greatest number of users. Had the DNER created the Turrumote reserve without consulting the fishermen, divers, or other affected community members, acceptance and adherence to the new regulations would have been significantly less. Through involving the fishermen in the process from the beginning, they felt as though the reserve was in part their creation and were more willing to participate and set an example for how a marine reserve could be effectively implemented.

4.3.3 Surrounding Communities Involvement

Although García's study included the fishermen of La Parguera, he did not consider the opinions of fishermen from the adjacent fishing village of Papayo. According to Froilan Lopez (Appendix G), fish market owner in La Parguera, this furthered the tension between the two communities, especially since the proposed reserve at Turrumote was in the waters directly offshore from Papayo, not La Parguera.

Manuel Valdez-Pizzini, Ph.D., (Appendix G), of the University of Puerto Rico – Mayagüez, directed Sea Grant for the proposed creation of the reserve at Turrumote. According to Valdez-Pizzini, the DNER was willing to support the Turrumote reserve, but he decided to terminate the project on account of the political hesitancy and indecision. Valdez-Pizzini also confirmed that many of the problems between the communities of La Parguera and Papayo arose because the fishermen interviewed for García's study were only from La Parguera. Ivan Lopez (Appendix G), technician in the Marine Sciences Department of the University of Puerto Rico – Mayagüez and La Parguera fisherman, told us that these fishermen did not fish in the Turrumote area and therefore suggested this reef for closure because it would have the least affect on them.

4.3.4 Reserve Access

Ivan Lopez's background made him an excellent source of information that bridged the gap between the scientific and fishing communities. Ivan (Appendix G) explained that if the reserve was to be implemented, only scientists collecting

data should be allowed within the reserve because recreational divers would disrupt the delicate reef ecosystem. Many fish eggs laid in the Turrumote coral reefs are spread to other nearby reefs by the southeast currents. Froilan (Appendix G) agreed that if a section of water is to be closed for fishing, it should also be inaccessible to divers, snorkelers, and other recreational activities.

Luis Moreno (Appendix G) has been fishing for over thirty years, and until recently was the owner of another fish market in La Parguera. Through interviewing him, we gained supplemental information regarding the fishing community's opinions regarding the reserve. He said that the majority of fishermen know why reserves are important, and that the Turrumote reserve would be particularly significant because of the rare birds and turtles that nest on the island. He explained that fishermen know not to travel to Turrumote during these nesting months because walking on the beach may crush the fragile eggs. Many recreational fishermen and tourists are unaware of this situation and inadvertently damage the eggs during the two-month nesting seasons.

4.3.5 Reserve Attempt Summary

The successes and failures of the proposed reserve at Turrumote that appear in this section can be applied to other locations in Puerto Rico if understood completely and taken in an appropriate context. We obtained a comprehensive collection of data outlining the actions taken by key stakeholders as well as their opinions of the proposed reserve in Turrumote. Such successes included:

- The initial involvement of the fishermen in the planning process helped to develop a positive outlook towards the reserve in the fishing community. Involving key stakeholders promotes trust because they all impact the establishment of a reserve.
- Baseline fish population data for the three possible implementation sites were gathered. Population data allow scientists to determine where reserves should be established and they allow scientists to compare data samples from before and after the implementation of a reserve. This comparison determines if the reserve has accomplished the goals that the stakeholders initially identified.
- The proposed location, if implemented, would protect many species' offspring, including turtles, birds, and fish. Establishing reserves protects juvenile species that typically develop within the reserve and leave once they reach maturity.

The areas in which the proposed reserve in Turrumote failed or had problems are listed below:

- The fishermen and the scientific community did not trust each other, leading to further complications. A lack of trust between stakeholders prevents progress and hinders the establishment of a reserve. Community members and relevant stakeholders must trust each other and work together towards a common goal.
- Indecision due to poor communication between the governing agencies resulted in continued distrust from the fishing community. The planning

process must be repeated for all new reserves to ensure the support of those supporting previous reserves. If relevant stakeholders support one reserve, other agencies must understand that they may not support the establishment of future reserves by different agencies.

- Interviews conducted for García's study were only carried out with fishermen from the La Parguera community and not Papayo, which furthered the tension between the neighboring towns. All relevant stakeholders must be involved in the decision-making process because marine reserves need to be agreed upon and managed on a regional basis, not just a local basis.

4.4 Lajas Community on Reserves

By looking at the Lajas community's attitude toward a possible marine reserve we were able to identify some of the key issues that must be considered when seeking to implement marine reserves anywhere in Puerto Rico. This section will give details regarding the opinions of experts from the scientific community, fishermen, enforcement personnel, and dive shop owners regarding the current situation in Lajas, reserve implementation, and the challenges of living with a marine reserve in the area.

4.4.1 The Current Situation

The personnel that we interviewed at the DNER provided useful insights into the management considerations that must be made when planning marine reserves. Carmen Delia, manager of the La Parguera DNER office (Appendix G),

described how a lack of sufficiently trained and qualified administrative staff had hindered her ability to perform meaningful work to assess the status of the La Parguera MPA. Manuel Torres, one of the DNER rangers in La Parguera (Appendix G), told us that fishing regulations were frequently breached. These deliberate violations of set laws posed regulatory challenges for any future reserves to be created.

We interviewed Graciela García of NOAA (Appendix G) regarding fish catch trends over time in the greater Lajas area. She provided data for the eastern coast of Puerto Rico from 1987 to 1997. Figure 9 displays the monthly reported commercial fish harvest in pounds for the region containing Fajardo, Ceiba, Naguabo, Humacao, Yanucua, Maunabo, Culebra, and Vieques.

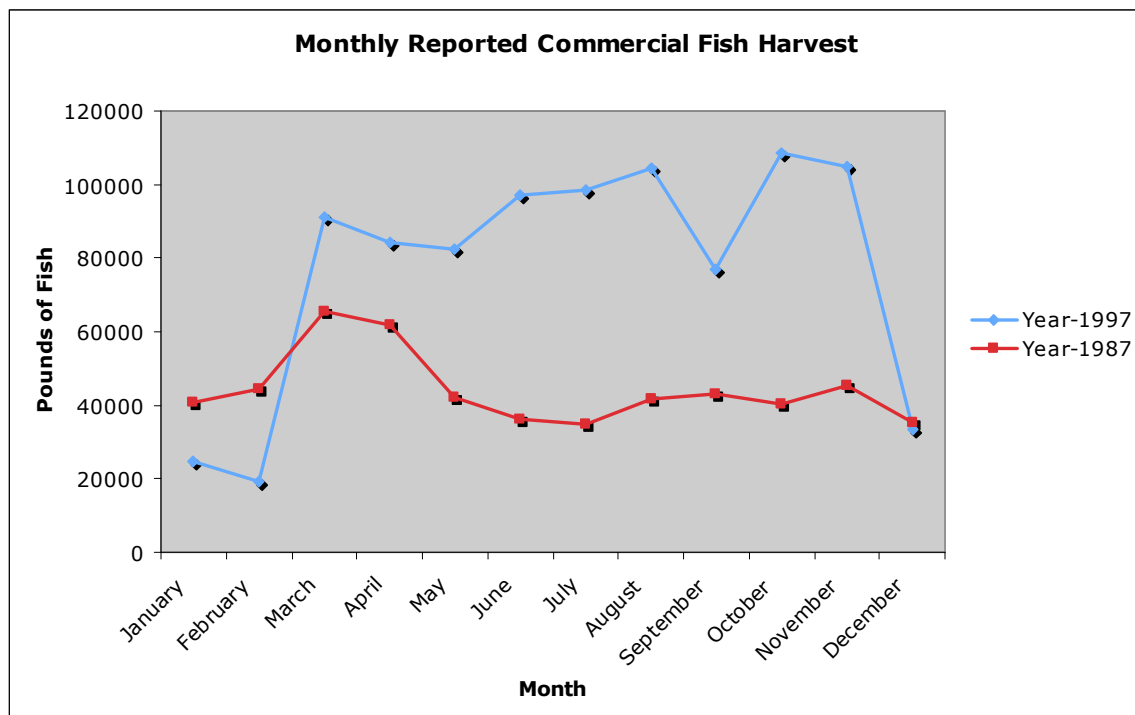


Figure 9: The monthly reported commercial fish harvest for the years 1987 and 1997 (based on G. García, personal communication, April 10th, 2006).

Figure 10 displays the number of reported fishing catches each month for the same area.

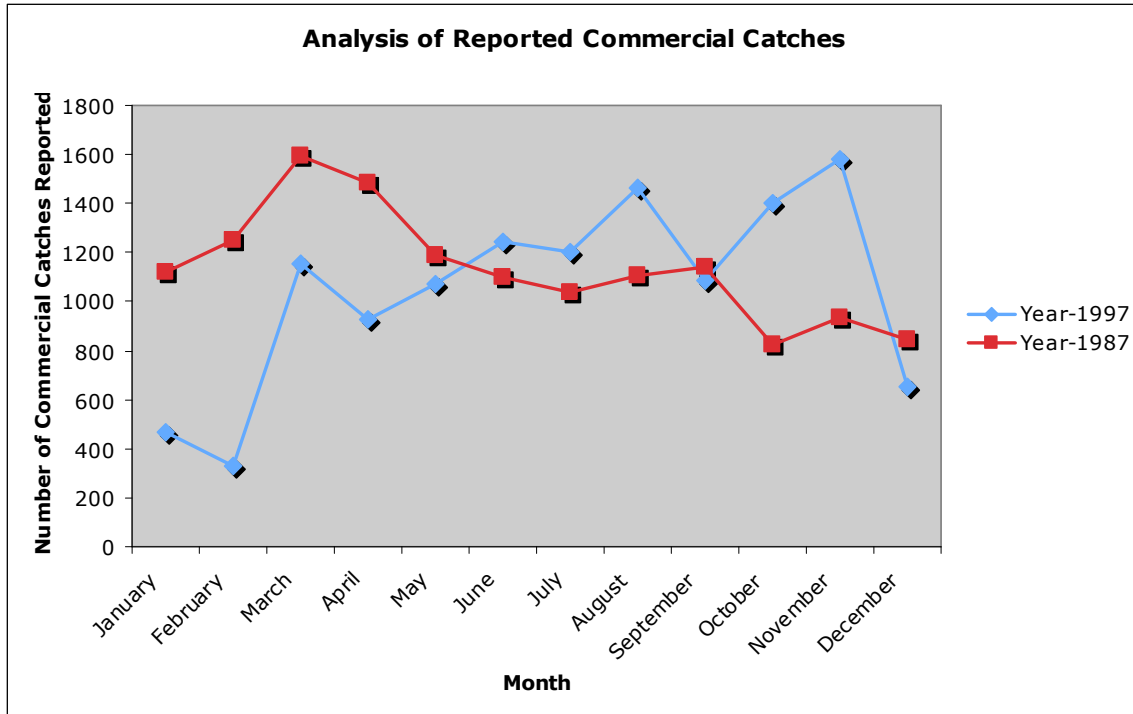


Figure 10: The number of reported commercial catches per month for the years 1987 and 1997 (based on G. García, personal communication, April 10th, 2006).

In comparing the two graphs, one can see that 1997 had a significant increase in the number of pounds of fish caught, while the number of reported fishing catches remained relatively the same as 1987. The exception is during the first two months of 1997 when there were fewer reported catches, but this could explain the lower total harvest weights for those months. These data show the increasing demand on marine ecosystems and further emphasize the importance of marine reserves. Marine reserves promote the preservation of natural resources, and they can be used as an effective tool to manage fish populations in the ocean.

One theme that was mentioned repeatedly by the fishermen was their complaint about the current seasonal restrictions that existed on certain important species. Ivan Lopez (Appendix G) explained that there was a ban on catching red snapper, wahoo, Spanish mackerel, king mackerel, dorado, and tuna during their spawning seasons. This was the time during which the fish would bite almost anything and were easiest to catch in large quantities. Jose Ramos (Appendix G), a fisherman from La Parguera, expressed how much harder the current regulations made fishing for the fishermen to land adequate catches and make a living. Froilan Lopez (Appendix G) joined Ramos in the belief that these seasonal species restrictions were too restrictive and the fishermen should have been able to catch at least some of the banned fish. Both of these fishermen also felt that the government should have given them some financial support during the times that the seasonal closures were in place to help make up for the difficulty that these restrictions caused them.

The fishermen were also frustrated by the inconsistency between regulations for commercial and recreational fishermen. According to Michelle Scharer (Appendix G), the Puerto Rican government passed a law two years ago requiring both commercial and recreational fishermen to obtain fishing licenses. However, only a system for selling commercial fishing licenses was put in place. Ivan Lopez (Appendix G) expressed the opinion of many fishermen that it was the recreational fishermen and not the commercial fishermen who were responsible for the over-fishing of marine areas. Table 1 **Error! Reference**

source not found. below displays the views of specific stakeholders from the Lajas area.

Table 1: Compilation of Lajas stakeholders' views on specific topics.

Green indicates an affirmative response to the question asked, red indicates a negative response, and white indicates that the topic was not discussed in the interview.

		Would you support a marine fishing reserve in Lajas?	Have you noticed a marine fishing reserve in coverage?	Have you noticed decreasing coral reef the reefs?	Are there trust issues between fish populations in fishermen?	Are there communication issues between scientists and fishermen?	Are there enforcement issues between proposed reserves?	Are there education issues with existing or protected areas?	Do you support the current seasonal species regulations?	Do you believe it is unfair that fishermen are required to have licenses and recreational fishermen aren't?
Scientists:	Richard Appeldoorn	+	+	+	+	+	+	+		
	Jorge Garcia	+	+	+	+	+				
	Manuel Valdez Pizzini	+	+	+	+	+	+	+		
	Jose Rivera	+	+	+	+	+	+	+		
	Michelle Scharer	+	+	+	+	+		+	+	
	Jorge Capella			+					+	
Fishermen:	Froilan Lopez	+	+	+	+	+	+	+	-	+
	Ivan Lopez	+	+	+	+	+	+	+	-	+
	Jose Ramos	-	+	+	+		+		-	+
	Luis Moreno	+	+	+	+	+		+	-	+
	Ranberto Hernandez		+	+					-	+
Divers:	Milton Carlo	+	+	+	+		+	+	+	
	Pilar Mendez	+	+	+		+		+	+	
	Luis Duitteau	+	+	+						
Management:	Carmen Delia	+			+	+	+	+	+	
	Manuel Torres	+		+	+		-		+	
Government:	Mayor Marcos Irizzary	+			-	-		+	-	+

This table shows that Lajas stakeholders were generally in favor of the implementation of a marine reserve. Jose Ramos (Appendix G) did not support a marine reserve in Lajas because he believed that the lack of trust that exists between the scientists and the fishermen would make it impossible. While most stakeholders recognized communication and trust as areas that needed improvement, the mayor did not believe that these were issues. It is also important to note that the Lajas fishermen and the mayor of the municipality did not support the seasonal species restrictions. Fishermen believe that the

regulations are unfair and should be shortened and the mayor supports the fishermen because of their political importance.

4.4.2 Implementing a Reserve

Richard Appeldoorn, Ph.D., (Appendix G) identified La Parguera as an ideal location for such a reserve because it had one of the biggest and most complicated shelf areas in Puerto Rico.

One of the main obstacles identified by the experts whom we interviewed was the animosity that existed between the scientific and government communities and the fishermen. Appeldoorn expressed his opinion that while it was probably not possible to obtain a compromise between these opposing groups, it was important to at least recognize the problems that existed between them and identify measures that could have been taken to remedy these problems. One of the best ways to do this was to involve the fishermen in the decision making process, something that had not been done effectively in the past.

The fishermen also doubted that “temporary” regulatory measures would have actually remained temporary. They did not trust the government because of a history of unfulfilled promises. One such example that Jose Ramos (Appendix G) mentioned was the ban on catching sea turtles that was imposed in the 1970’s and was intended to last only five years. However, at the end of the five years there was substantial international pressure not to lift the ban and so it has remained in effect ever since. The fishermen remembered this and other similar

instances and were reluctant to agree to measures such as temporary no-take zones.

The possibility of incorporating aquaculture facilities into a management plan as an alternative means of livelihood for the fishermen was not supported for several reasons. Manuel Pizzini, Ph.D., (Appendix G) described fishing as “more than just a job description; it’s a way of life.” According to Jorge Capella, Ph.D., (Appendix G) and Ivan Lopez (Appendix G), further studies must be done to determine if the ocean conditions in the La Parguera area would be adequate for aquaculture.

4.4.3 Impact of a Reserve

Jorge García (Appendix G) mentioned the possibility of government subsidies for the fishermen as another measure that could have helped to make new regulations such as no-take zones more appealing to them. He noted that the cost of paying the fishermen would have been insignificant compared to the benefits that would have been gained through a healthy ecosystem and increased tourism in the area.

Manuel Torres (Appendix G), a DNER ranger in Lajas, believed that a marine reserve would be relatively easy to enforce since it would be a simple matter of whether the fishermen were in the designated area or not. This positive assessment by a ranger in the area showed that a potential reserve would have been supported by those in charge of enforcing the regulations set forth.

The representatives of the dive shops that we spoke with helped us to understand the impact that a marine reserve containing a no-take zone would

have had on this segment of the tourism industry. Luis Doitteau of Paradise Scuba & Snorkeling Center (Appendix G) took his customers to the reefs of Caracoles, Mata la Gata, and Enrique. Doitteau noted that he did not take tours to Turrumote because it was too far out and customers often became seasick. In general, the representatives of dive shops that we interviewed were in favor of the creation of a marine reserve. Milton Carlo, the dive master on Magueyes Island (Appendix G), commented that most of the divers that he worked with would not have a problem avoiding certain coral reef areas.

The results that we obtained from our interviews were analyzed, which allowed us to develop conclusions and make recommendations for future ecosystem-based management plans.

5.0 Conclusions and Recommendations

The goal of this project was to develop a plan for the implementation of marine ecosystem-based management in Puerto Rico. The results that we presented in the previous chapter regarding the system for designating marine protected areas in Puerto Rico enabled us to recommend several steps that should be taken to improve the current process. By examining the Luis Peña Channel Natural Reserve in Culebra we found that while the Reserve was successful in restoring the marine environment, the lack of enforcement needs to be addressed in order for it to operate at its fullest potential. We then investigated the process that was used in the attempt to establish a marine reserve off the coast of Lajas. We found that the lack of trust between government agencies and local fishermen, as well as failure to communicate with surrounding communities were major factors that caused the reserve never to be established. Finally, we determined the present attitudes of members of the Lajas community towards a reserve and found that it was generally approved.

5.1 MPA Designations

The confusion surrounding marine protected area designations proves to be troublesome for organizations involved in the creation or management of such areas as well as the individuals who use these areas. The U.S. government created the Marine Protected Area Center in an effort to organize designations; however they have neglected to fully describe them. Some reserves identified by the Department of Natural and Environmental Resources of Puerto Rico have not

been identified by the Marine Protected Area Center and vice versa, or they have been defined differently. In order for different types of MPAs to be accurately implemented and managed, the DNER must identify all terms currently being used and redefine them for use throughout Puerto Rico.

5.2 MPA Practices

By comparing an implemented ecosystem-based management plan to a failed implementation attempt, we were able to identify several successful and unsuccessful practices. The four underlying principles of successful practices are communication, trust, education, and enforcement. Effective communication among the fishing community, the scientists, and those in charge of enforcing reserve regulations is important to avoid confusions and discrepancies. In addition to communication, a sense of trust between the various stakeholders must be established in order to produce the best results for all involved parties. Beginning at an early age, community members need to be educated about the importance of marine ecosystems, so that they will be able to make environmentally smart decisions. Once a reserve is implemented, adequate enforcement of the established regulations is needed to ensure the safety of the marine ecosystem. Marine reserves in Puerto Rico should incorporate these principles into their management plans to preserve the natural resources found in the environment while supporting those who make a living from these resources. The next sections will outline practical steps that can be taken to develop

management plans that incorporate these principles and identify how this plan could be used in Lajas specifically.

5.2.1 Steps for Implementation of Marine Reserves

When creating a management plan for a marine ecosystem, a specific development strategy should be used. Below is the list of steps we created that we believe should be followed in creating a marine reserve in Puerto Rico.

1. Identify stakeholders.

Obtain the support of stakeholders such as fishermen, government agencies, businesses, and community members. Be sure to include stakeholders from surrounding communities that may be affected. One problem with the proposed Turrumote marine reserve in Lajas was that Jorge García failed to consider surrounding communities that used the area when he conducted his feasibility study. In a second attempt at implementation, all neighboring villages that utilize the potential site, including Papayo, should be consulted.

2. Select a site.

Base the site selection on stakeholder input in order to ensure their support and cooperation. García included fishermen in his feasibility study of a marine reserve in Lajas. By doing this, the fishermen felt involved in the process and were more willing to accept a reserve.

3. Collect scientific data to support marine reserve establishment.

Data should be collected before and after the establishment of the management plan to evaluate its effectiveness. To obtain the best data, samples should be taken inside, on the border of, and outside of the marine reserve. As a part of his feasibility study, García collected data through transects of the Turrumote, Media Luna, and San Cristobal reefs. If stakeholders in Lajas were to select one of these sites for a marine reserve, comparison to past transect data could provide scientific evidence regarding the condition of reefs.

4. Identify a steering committee.

The steering committee should be involved with the implementation of the reserve, the management of the reserve once it is established, and the resolution of conflicts between different stakeholders. The committee should include six to eight elected representatives from surrounding communities. In the implementation of a marine reserve one must remember that a consensus among a group of individuals is very rarely reached. Instead, we recommend that decisions are reached based on two-thirds majority of the steering committee. This decision-making system must be implemented immediately after the establishment of the committee before any decisions are required to avoid biases.

Be sure to include one of each of the following:

- i. One commercial fisherman from each community
An elected fisherman from each community will represent their community as a member of the steering committee in order to obtain viewpoints from all affected fishermen.
- ii. Environmentalist
This individual will provide environmental impact information and possible solutions to various situations.
- iii. Local government member
A mayor's representative will provide municipality-level logistical information and act as an influential figure.
- iv. Concerned citizen
One possibility is a local educator that will act as a liaison between the scientific community and the school system thus enhancing the level of community education.
- v. Marine Biologist/Ecologist
This individual will provide the scientific data necessary to support the creation of a reserve and will study its effectiveness.
- vi. DNER representative
A representative of the DNER will provide commonwealth-level logistical information and inform the committee on changes in Puerto Rican legislation.
- vii. Tourism Industry representative
One possibility is a dive shop representative that will attest to the deterioration of the reefs and identify affects to the tourism industry.

The steering committee overseeing the management of the Tres Palmas Marine Reserve in Rincón can be used as a model. In Lajas, a fisherman elected from the fishing village of Papayo should be a member as well as one from La Parguera.

5. Obtain necessary funds.

Money is needed for initial startup costs, such as buoys and enforcement boats, enforcement officer salaries, and education. Funds can be obtained through grants from organizations such as NOAA or through the DNER of Puerto Rico. The UPRM Department of Marine Sciences is located in Lajas and could participate in the collection of funds through governmental research grants.

6. Educate.

Local schools should develop educational programs to provide children with a basic understanding of the fragile marine ecosystems in Puerto Rico. These educational programs should teach children the importance of protecting and managing ecosystems to ensure their existence for future generations. Educational programs for the general public should be considered as well. This issue affects the fishing and tourism industries most significantly, so these communities should be specifically targeted for education. In Lajas, the scientific community is largely represented through the presence of the University of Puerto Rico which would allow for extensive education of the community as a whole.

The relationship of adjacent steps can be seen in Figure 11, and in some cases different procedures must be followed depending on the outcome of the previous step. The feedback loops that exist may force the process to return to an earlier stage depending on the outcome of some steps.

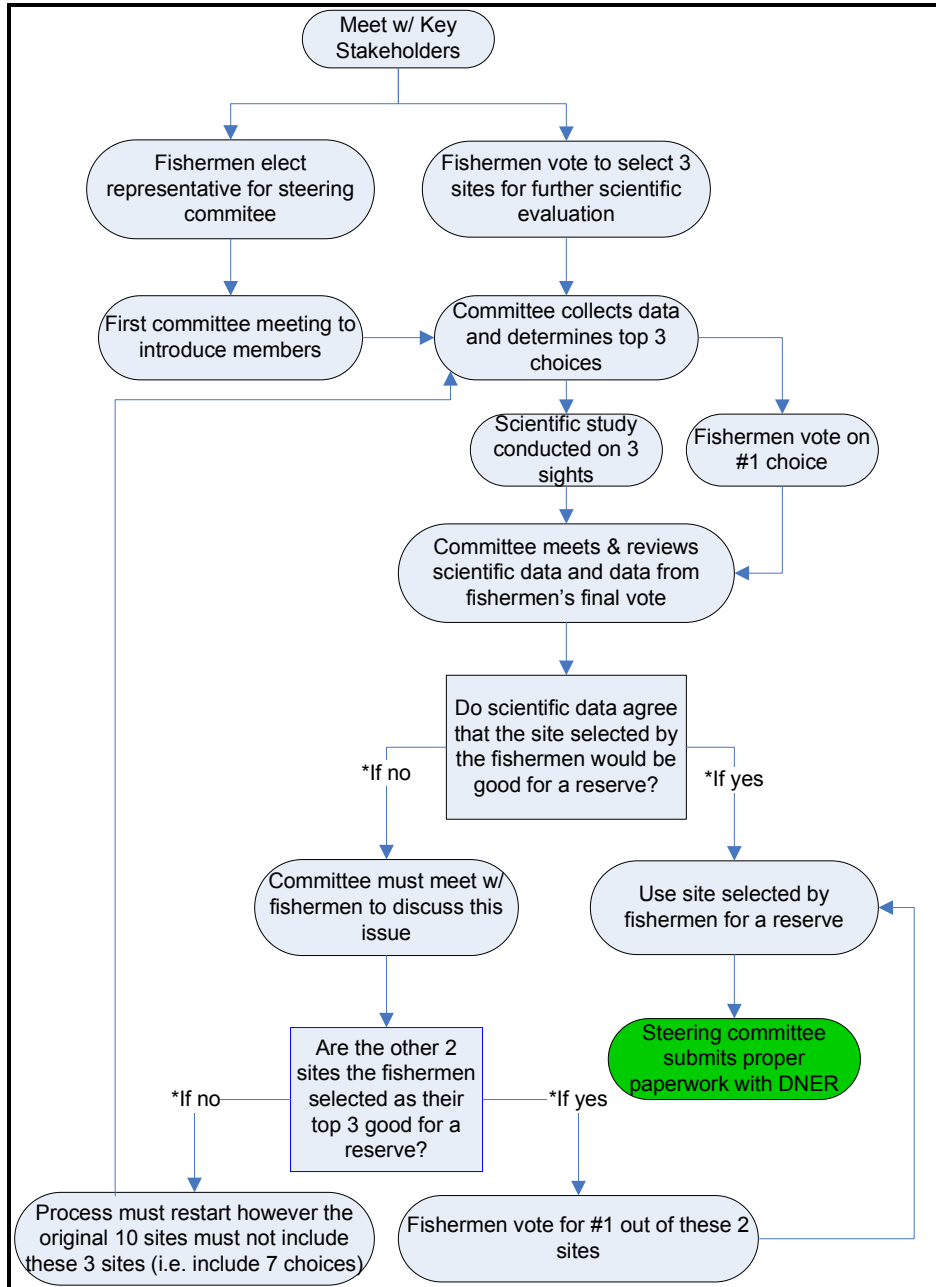


Figure 11: Flowchart showing the different steps that should be followed when establishing a marine reserve

Through the application of these steps and with consideration given to communication, trust, education, and enforcement, a management plan for any location in Puerto Rico can be adequately implemented. Lajas is just one

example of a location where the general steps that we have developed can be used to successfully implement marine reserves. The application of these steps to other locations around Puerto Rico will be an important step towards reducing the effects of deteriorating coral reef ecosystems. In an attempt to implement other marine protected area designations, such as commonwealth forests, steps similar to the ones that we have described could be used to develop management plans.

5. 3 Regulations and Restrictions

We recommend that the DNER enforce the law requiring recreational fishermen to obtain fishing licenses. Everyone we discussed this topic with believed it was unfair that only commercial fishermen were required to obtain licenses and that the DNER should purchase and install the equipment needed to sell recreational licenses. Requiring recreational fishermen to purchase a license will generate revenue and provide additional funding for DNER sponsored projects that currently lack funding. For example, if a one-year recreational license costs twenty-five dollars and there are approximately 100,000 recreational fishermen throughout Puerto Rico, the DNER could generate two-and-a-half million dollars in annual revenue. As well as providing funding, the selling of licenses would decrease the number of recreational fishermen and in turn minimize destructive fishing techniques.

We also recommend that the Puerto Rican government appoint a committee to review the seasonal closure regulations. Although these restrictions have been successful in other areas around the world, all of the fishermen we

spoke to expressed their frustration with these restrictions. They understood their importance, however they felt the restrictions could be shortened to allow fishing for part of the spawning season. Because this project did not focus on this issue we believe that a committee should review these restrictions to determine if they should remain the same or be changed.

In addition to reviewing the seasonal closures, the committee should review the fish length restrictions. Many interviewees expressed the opinion that the fish length restrictions are not adequate because at the minimum allowable length some species are unable to reach reproductive maturity. The committee should review this because the purpose of the restrictions is to promote the reproduction of fish and it is believed that the current length restrictions fail to accomplish this and are therefore ineffective.

5.4 Aquaculture

Our liaison, Dallas E. Alston, of the University of Puerto Rico – Mayagüez, identified aquaculture as a possible economic alternative for fishermen in Puerto Rico. We discovered, however, that fishermen are not normally content with changing their lifestyles.

Alston stated that a water depth of sixty to one hundred feet would be necessary for the size of the cage. He also believed that a water current of approximately twenty centimeters per second was necessary to distribute concentration of waste from the cages. He mentioned that the current can be slower with larger distances from the bottom of the cage to the sandy bottom, as shown in Figure 12.

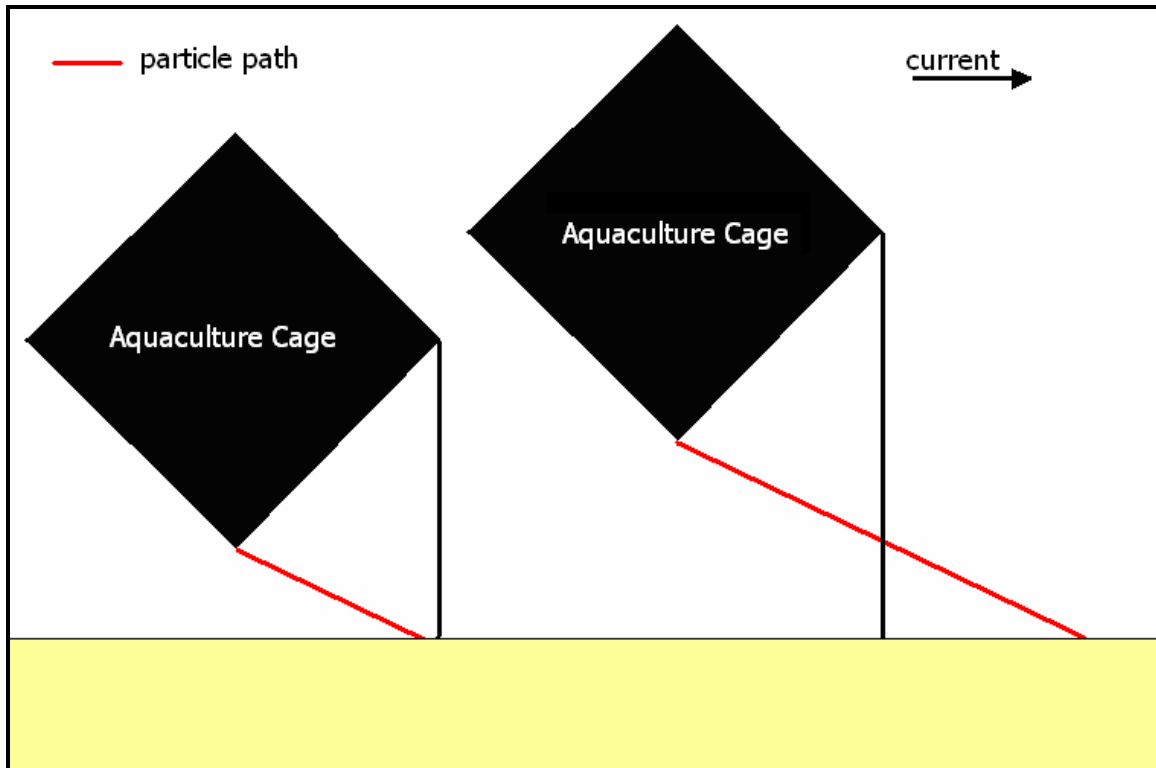


Figure 12: Diagram of aquaculture and particle distribution. As the height of the cage increases, the distance of particles from the cage increase.

Using the depth and current restrictions, we gained initial logistical information on the possibility of aquaculture in the waters surrounding Lajas. We discovered that there is a location on the border of Lajas and Cabo Rojo where aquaculture could potentially be implemented. At this location there is a southeast current that leads out into the Gulf of Mexico. Alston identified a drawback of this location as being its distance from a viable port because as this distance increases, the cost of cage operation also increases. We recommend that the feasibility and effectiveness of aquaculture be evaluated in this area.

5.5 Conclusions & Recommendations Summary

Upon the completion of this project, we identified a number of topics that need to be addressed. The DNER needs to resolve the confusion regarding the

marine protected area designations in Puerto Rico. The implementation plan we developed and the four guiding principles we identified should be applied to communities seeking to implement ecosystem-based management. Using ecosystem-based management in Puerto Rico will result in healthy coral reef ecosystems which will positively affect the surrounding communities.

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Appendix A – Glossary of Acronyms

EBM	Ecosystem-Based Management
EPA	United States Environmental Protection Agency
FAO	Food and Agriculture Organization of the United Nations
IQP	Interactive Qualifying Project
LPCNR	Luis Peña Channel Natural Reserve
NCRI	National Coral Reef Institute
NMFS	National Marine Fisheries Service
NOAA	National Oceanic & Atmospheric Administration
UPR	University of Puerto Rico
UPRM	University of Puerto Rico – Mayagüez
UPRRP	University of Puerto Rico – Rio Piedras

Appendix B – Glossary of Terms

Aquaculture: “The farming of aquatic organisms, including fish, mollusks, crustaceans and aquatic plants. Farming implies some form of intervention in the fish-growing process to enhance growth and survival, such as regular stocking, feeding, protection from predators, etc” (Oceans Alive, 2006).

Commonwealth: “Democracy: a political system in which the supreme power lies in a body of citizens who can elect people to represent them” (WordNet, 2006).

Coral Bleaching: “A phenomenon in which corals under stress (eg, by elevated water temperature) expel their mutualistic algae (zooxanthellae) in large numbers, or the concentration of algal photosynthetic pigments decreases. As a result, the corals’ white skeletons show through their tissue and they appear bleached” (Oceans Atlas, 2006).

Exclusive Economic Zone (EEZ): “The assertion of jurisdiction under the EEZ (3 nautical miles to 200 miles offshore) provides a basis for U.S. economic exploration and exploitation, scientific research, and protection of the environment. While coastal states have primary jurisdiction and control over the first three miles of the EEZ and the federal government has primary jurisdiction over and controls the remaining 197 miles, the Coastal Zone Management Act

provides coastal states with substantial authority to influence federal actions beyond three nautical miles” (National Marine Protected Areas Center, 2006).

Fishery: “i) Place where fish are caught or reared, ii) the occupation or industry of catching or rearing fish” (Marine Institute of Memorial University of Newfoundland, 2006).

Fishery Closure Area: “A fishery closed or restricted by a government entity. Such closure prohibits fishing for commercial, recreational, or subsistence purposes” (National Marine Protected Areas Center, 2006).

Magnuson-Stevens Fishery Conservation and Management Act: “Calls for assessment and consideration of ecological, economic, and social impacts of fishing regulations on fishery participants and fishing communities in marine fishery management plans” (National Marine Protected Areas Center, 2006).

Marine Managed Area: “Managed areas in the marine environment that might indirectly, partially, or for a limited duration provide some degree of natural resource or cultural resource protection, and may not include protection for conservation purposes” (National Marine Protected Areas Center, 2006).

Marine Protected Area: “Areas of the marine environment that have been reserved by federal, state, territorial, tribal, or local laws or regulations to provide

lasting protection for part or all of the natural and cultural resources therein”
(National Marine Protected Areas Center, 2006).

Marine Reserve: “Areas in which some or all extractive activities are prohibited”
(National Marine Protected Areas Center, 2006).

Marine Sanctuary: “As defined by the U.S. government: Multiple-use marine protected areas, protected under the National Marine Sanctuaries Act, that may include breeding and feeding grounds of whales, sea lions, sharks, and sea turtles; significant coral reefs and kelp forest habitats; and the remains of historic shipwrecks. Some sanctuaries are zoned to include no-take areas” (National Marine Protected Areas Center, 2006).

Multiple Use MPAs: “Often employed over larger areas, multiple-use areas allow for integrated management of complete marine ecosystems, usually through a zoning process” (National Marine Protected Areas Center, 2006).

No-Take Zones: “Areas in which all extractive activities are prohibited” (National Marine Protected Areas Center, 2006).

Trophic: “Relates to position of organisms in the food chain of an ecosystem based on type of food supply required” (Australian Department of the Environment and Heritage, 2006).

Appendix C – MPA Locations

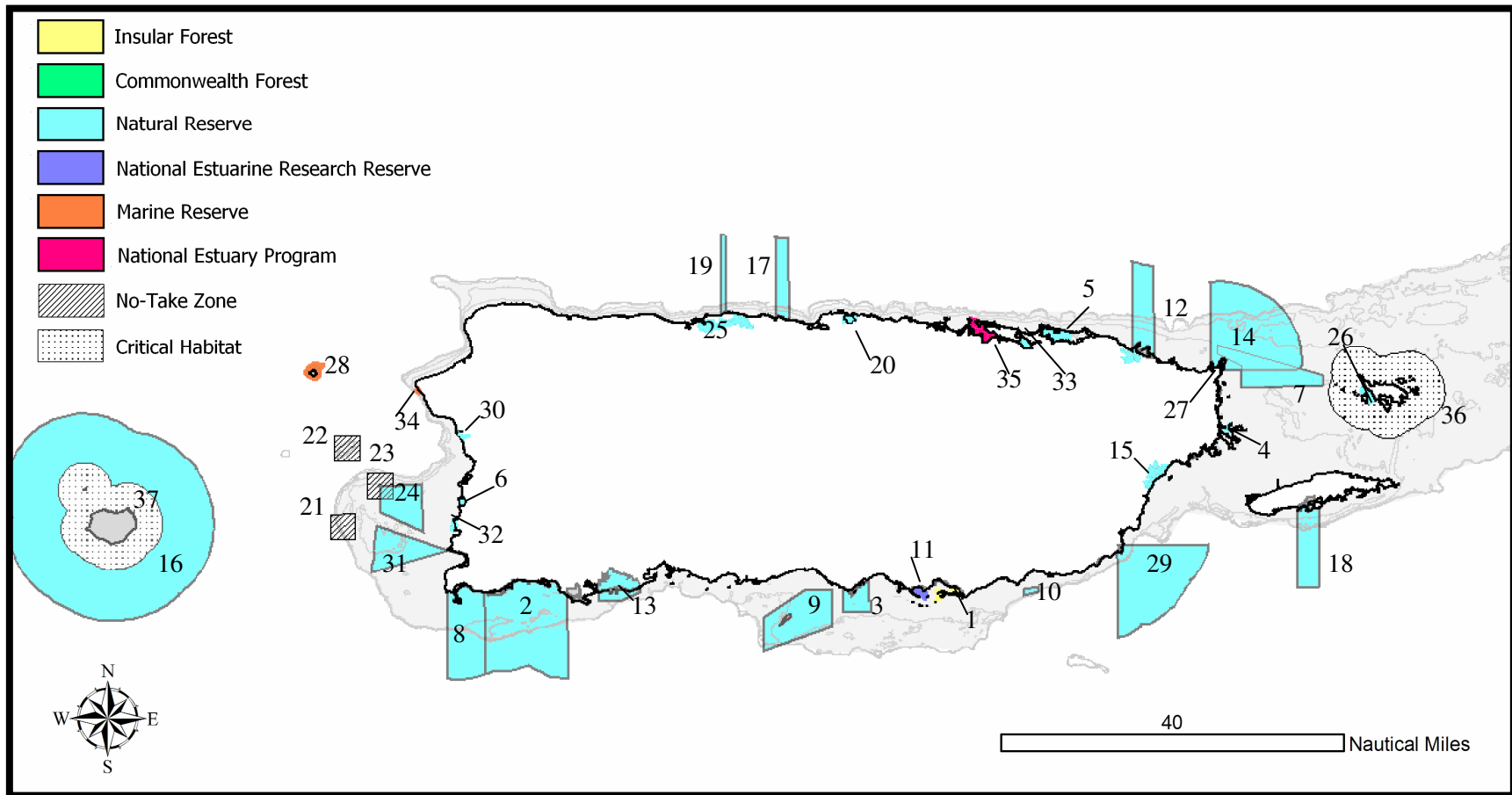


Figure 13: High Resolution MPA Designations (adapted from Aguilar-Perera, 2005).

Appendix D – MPA Designations

Table 2. Marine Protected Areas in Puerto Rico.

Marine protected areas are listed in chronological order of establishment, based on the Puerto Rico MMA Inventory. Categories according to Department of Natural and Environmental Resources are as follow: IF= insular forest, CF= commonwealth forest, NR= natural reserve, MR= marine reserve, BR=biosphere reserve, CH= critical habitat, NERR = National Estuarine Research Reserve, NTZ = no-take zone, NEP = national estuary program. PR = Puerto Rico; EPA = Environmental Protection Agency; NOAA = National Oceanic and Atmospheric Administration; PRPB = Puerto Rico Planning Board; MSFC&M Act = Magnuson-Stevens Fishery & Conservation Act. In Designations, the categories appear sequentially according to first and last designations. Establishment date refers to date of latest designation. Canal Luis Peña (NR, # 26) and Culebra (CH, # 36) are in the same geographic location, with the former including the latter, but their category and governance are different. Similarly, Isla de Mona (NR, # 16) and Mona Island (CH, #s 37) are in the same geographic area with the latter included in the former, but have different designations and governance. Composition refers to characteristics of each area in terms of presence of the following geographic components: Terrestrial = emergent land, wetlands and mangrove forests; Mixed = emergent and submerged lands; Submerged = marine seafloor; Coastal lagoon = land locked under tidal influence. *these areas have been also designated as no-take zones. Surface areas are in hectares. The area is in hectares. N/A = data not available; NI = surface area not included in designation. # identifies the numeration for each MPA referred in Figure 1 (Aguilar-Perera, 2005).

#	MPA name	Designations	Establishment Date	Establishment Mechanism	MPA composition	Terrestrial Surface area	Seafloor Surface area	Total Surface area
1	Aguirre	IF, CF	28-May-18	PR Governor Proclaim	Terrestrial	434	NI	434
2	La Parguera	IF, NR	20-Sep-79	PRPB Resolution	Mixed	82	32642	32724
3	Punta Petrona	NR	20-Sep-79	PRPB Resolution	Mixed	165	3117	3282
4	Ceiba	IF, CF, NR	14-Nov-79	PRPB Resolution	Terrestrial	236	NI	236

#	MPA name	Designations	Establishment Date	Establishment Mechanism	MPA composition	Terrestrial Surface area	Seafloor Surface area	Total Surface area
5	Piñones	IF , CF, NR	14-Nov-79	PRPB Resolution	Terrestrial	885	NI	885
6	Laguna Joyuda	NR	2-Jan-80	PRPB Resolution	Coastal lagoon	NI	179	179
7	Arrecifes de la Cordillera	NR	22-Jan-80	PRPB Resolution	Mixed	0.2	10083	10083
8	Boquerón	IF, CF, NR	22-Jan-80	PRPB Resolution	Mixed	3	15481	15484
9	Caja de Muertos	NR	22-Jan-80	PRPB Resolution	Mixed	185	12550	12735
10	Arrecifes de Guayama	NR	23-Jan-80	PRPB Resolution	Submerged	NI	442	442
11	Jobos Bay	NERR	1981	U.S Coastal Zone Management Act	Mixed	586	2	588
12	Río Espíritu Santo	NR	21-Feb-85	PRPB Resolution	Mixed	1090	8578	9668
13	Guánica	IF, CF, NR	16-Oct-85	PRPB Resolution	Mixed	3617	1785	5402

#	MPA name	Designations	Establishment Date	Establishment Mechanism	MPA composition	Terrestrial Surface area	Seafloor Surface area	Total Surface area
14	Cabezas de San Juan	NR	29-Jan-86	PRPB Resolution	Mixed	178	30669	30847
15	El Pantano, Bosque de <i>Pterocarpus</i> y Lagunas Mandry y Santa Teresa	NR	4-Jun-86	PRPB Resolution	Mixed	885	NI	885
16	Isla de Mona	IF, NR	4-Jun-86	PRPB Resolution	Mixed	5580	151995	157575
17	Hacienda La Esperanza	NR	20-May-87	PRPB Resolution	Mixed	994	5064	6058
18	Bahías Bioluminiscentes de Vieques	NR	1-Jul-89	PRPB Resolution	Mixed	572	7962	8534
19	Cueva del Indio	NR	13-Apr-92	PRPB Resolution	Mixed	6	1558	1564
20	Pantano Cibuco	NR	5-Feb-93	PRPB Resolution	Terrestrial	885	NI	885
21	Abril la Sierra	Seasonal NTZ	4-Dec-96	MSFC&M Act	Submerged	NI	2929	2929
22	Bajo de Sico	Seasonal NTZ	4-Dec-96	MSFC&M Act	Submerged	NI	3119	3119

#	MPA name	Designations	Establishment Date	Establishment Mechanism	MPA composition	Terrestrial Surface area	Seafloor Surface area	Total Surface area
23	Tourmaline Bank	Seasonal NTZ	4-Dec-96	MSFC&M Act	Submerged	NI	3121	3121
24	Arrecifes de Tourmaline	NR	22-Jul-98	PRPB Resolution	Submerged	NI	7269	7269
25	Caño Tiburones	NR	22-Oct-98	PRPB Resolution	Coastal lagoon	NI	1499	1499
26	Canal Luis Peña	NR*	11-Jun-99	PRPB Resolution	Submerged	NI	633	633
27	Seven Seas	NR	12-Aug-99	PR Legislature	Terrestrial	N/A	N/A	N/A
28	Isla de Desecheo	MR*	10-Mar-00	PR Legislature	Submerged	NI	677	677
29	Punta Yegüas	NR	22-Dec-00	PRPB Resolution	Mixed	125	26244	26369
30	Caño Boquilla	NR	21-Aug-02	PRPB Resolution	Coastal lagoon	NI	70	70
31	Punta Guaniquilla	NR	15-Nov-02	PRPB Resolution	Mixed	N/A	N/A	N/A
32	Finca Belvedere	NR	21-Feb-03	PRPB Resolution	Mixed	NI	11681	11681

#	MPA name	Designations	Establishment Date	Establishment Mechanism	MPA composition	Terrestrial Surface area	Seafloor Surface area	Total Surface area
33	Caño Martin Pena	NR	18-Jun-03	PRPB Resolution	Coastal lagoon	NI	81	81
34	Tres Palmas de Rincón	MR	8-Jan-04	PR Legislature	Submerged	NI	83	83
35	San Juan Bay Estuary	NEP	1992	EPA	Coastal lagoon	NI	24200	24200
36	Culebra Island	CH	2-Sep-98	NOAA	Submerged	NI	34827	34827
37	Mona Island	CH	2-Sep-98	NOAA	Submerged	NI	26619	26619

Appendix E – Transect Data from 1993 Feasibility Study

Table 3: Transect survey of fish at the Fore Crest of Turrumote (García, 1994)

	DATES(1993)	18-Feb	18-Feb	
	DEPTH(m)	3.3	3.3	
	RELIEF(m)	1.2	0.7	
	TRANSECT	TC-1	TC-2	MEAN
SPECIES	COMMON NAME			
Acanthurus bahianus	Ocean Surgeon	1.0	3.0	2.0
Acanthurus coeruleus	Blue Tang	1.0	0.0	0.5
Canthigaster rostrata	Sharpnose Puffer			
Caranx ruber	Bar Jack	1.0	0.0	0.5
Cephalopholis cruentatum	Graysby	0.0	1.0	0.5
Chromis multilineata	Yellow Chromis	1.0	25.0	13.0
Haemulon chrysargyreum	Smallmouth Grunt			
Haemulon flavolineatum	French Grunt			
Halichoeres garnoti	Yellowhead Wrasse	2.0	0.0	1.0
Holacanthus ciliaris	Queen Angelfish	0.0	1.0	0.5
Hypoplectrus guttavarius	Shy Hamlet	1.0	0.0	0.5
Lactophrys triqueter	Smooth Trunkfish			
Lutjanus apodus	Schoolmaster	0.0	1.0	0.5
Lutjanus mahogany	Mahogany Snapper			
Mulloides martinicus	Yellowtail Goatfish			
Mycrospathodon chrysurus	Yellowtail Damselfish	3.0	4.0	3.5
Ocyurus chrysurus	Yellowtail Snapper	0.0	1.0	0.5
Ophioblennius atlanticus	Redlip Blenny	1.0	0.0	0.5
Scarus iserti	Stripped Parrotfish	4.0	0.0	2.0
Scarus taeniopterus	Princess Parrotfish	0.0	1.0	0.5
Scarus vetula	Queen Parrotfish	0.0	1.0	0.5
Sparisoma aurofrenatum	Redband Parrotfish	1.0	1.0	1.0
Sparisoma chrysopterum	Redtail Parrotfish	1.0	0.0	0.5
Sparisoma radians	Bucktooth Parrotfish	0.0	1.0	0.5
Sparisoma viride	Stoplight Parrotfish	3.0	2.0	2.5
Stegastes dorsopunicans	Dusky Damselfish	5.0	3.0	4.0
Stegastes partitus	Bicolor Damselfish	6.0	2.0	4.0
Thalassoma bifasciatum	Bluehead Wrasse	23.0	3.0	13.0
Total Individuals/transect =		54.0	50.0	52.0
Total Species/transect =		15.0	22.0	18.5

Table 4: Transect survey of the fish at the Fore Reef Slope of Turrumote

	DATES(1993)	18-Feb	18-Feb	
	DEPTH(m)	7.7	7	
	RELIEF(m)	1.1	2.4	
	TRANSECT	TS-1	TS-2	MEAN
SPECIES	COMMON NAME			
<i>Acanthurus bahianus</i>	Ocean Surgeon	1.0	3.0	2.0
<i>Acanthurus coeruleus</i>	Blue Tang	0.0	1.0	0.5
<i>Autostomus maculatus</i>	Trumpetfish	1.0	0.0	0.5
<i>Caranx ruber</i>	Bar Jack	0.0	1.0	0.5
<i>Clepticus parrae</i>	Creole Wrasse	0.0	2.0	1.0
<i>Chromis cyanea</i>	Blue Chromis	1.0	4.0	2.5
<i>Chromis multilineata</i>	Yellow Chromis	35.0	5.0	20.0
<i>Coryphopterus glaucifrenum</i>	Bridled Goby			
<i>Chaetodon capistratus</i>	Four-eyed Butterflyfish	2.0	2.0	2.0
<i>Diodon holocanthus</i>	Spiny Puffer			
<i>Haemulon plumieri</i>	White Grunt	0.0	1.0	0.5
<i>Halichoeres radiatus</i>	Puddinwife	0.0	1.0	0.5
<i>Hypoplectrus guttavarius</i>	Shy Hamlet	0.0	2.0	1.0
<i>Hypoplectrus unicolor</i>	Butter Hamlet	1.0	0.0	0.5
<i>Lutjanus apodus</i>	Schoolmaster	0.0	3.0	1.5
<i>Malaccoctenus</i> sp	Blenny			
<i>Mycrospathodon chrysurus</i>	Yellowtail Damselfish	1.0	4.0	2.5
<i>Ophioblennius atlanticus</i>	Redlip Blenny	0.0	1.0	0.5
<i>Scarus coeruleus</i>	Blue Parrotfish			
<i>Scarus iserti</i>	Stripped Parrotfish	4.0	6.0	5.0
<i>Scarus vetula</i>	Quenn Parrotfish			
<i>Serranus tigrinus</i>	Harlequin Bass	0.0	1.0	0.5
<i>Scomberomorus regalis</i>	Cero			
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	3.0	0.0	1.5
<i>Sparisoma chrysopteron</i>	Redtail Parrotfish			
<i>Sparisoma radians</i>	Bucktooth Parrotfish	0.0	3.0	1.5
<i>Sparisoma viride</i>	Stoplight Parrotfish	4.0	1.0	2.5
<i>Stegastes dorsopunicans</i>	Dusky Damselfish	8.0	6.0	7.0
<i>Stegastes partitus</i>	Bicolor Damselfish	4.0	3.0	3.5
<i>Stegastes planifrons</i>	Yellow-eyed Damselfish	7.0	3.0	5.0
<i>Synodus intermedius</i>	Sand Diver	0.0	1.0	0.5
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	7.0	21.0	14.0
Total Individuals/transect =		79.0	75.0	77.0
Total Species/transect =		14.0	22.0	18.0

Table 5: Transect survey of fish at the Deep Reef Slope of Turrumote

	DATES(1993)	18-Feb	18-Feb	
	DEPTH(m)	17.5	15.8	
	RELIEF(m)	5.7	6	
	TRANSECT	TD-1	TD-2	MEAN
SPECIES	COMMON NAME			
Acanthurus bahianus	Ocean Surgeon	1.0	0.0	0.5
Acanthurus coeruleus	Blue Tang	1.0	0.0	0.5
Autostomus maculatus	Trumpetfish	0.0	1.0	0.5
Caranx ruber	Bar Jack	0.0	1.0	0.5
Canthigaster rostrata	Sharpnose Puffer	0.0	2.0	1.0
Clepticus parrae	Creole Wrasse	0.0		
Chromis cyanea	Blue Chromis	3.0	4.0	3.5
Chromis multilineata	Yellow Chromis			
Coryphopterus glaucifrons	Bridled Goby			
Chaetodon capistratus	Four-eyed Butterflyfish	1.0	2.0	1.5
Gramma loreto	Royal Gamma	7.0	24.0	15.5
Haemulon aurolineatum	Tomtate	1.0	0.0	0.5
Haemulon flavolineatum	French Grunt	7.0	1.0	4.0
Haemulon plumieri	White Grunt	0.0	1.0	0.5
Holocentrus adsensionis	Longjaw Squirrelfish	0.0	1.0	0.5
Holocentrus rufus	Squirrelfish	0.0	1.0	0.5
Hypoplectrus chlorurus	Yellowtail Hamlet	0.0	1.0	0.5
Hypoplectrus indigo	Indigo Hamlet	1.0	0.0	0.5
Hypoplectrus unicolor	Butter Hamlet	1.0	0.0	0.5
Lutjanus apodus	Schoolmaster			
Lutjanus mahogany	Mahogany Snapper			
Mulloides martinicus	Yellowtail Goatfish	1.0	0.0	0.5
Mycrospathodon chrysurus	Yellowtail Damselfish	1.0	0.0	0.5
Ocyurus chrysurus	Yellowtail Snapper	1.0	1.0	1.0
Odontoscion dentex	Reef Croaker	0.0	1.0	0.5
Pomacanthus arcuatus	Gray Angelfish	1.0	1.0	1.0
Scarus iserti	Stripped Parrotfish	6.0	5.0	5.5
Sparisoma viride	Stoplight Parrotfish	1.0	1.0	1.0
Sparisoma sp.	Unid. Parrotfish (juv)	0.0	1.0	0.5
Stegastes partitus	Bicolor Damselfish	4.0	0.0	2.0
Stegastes planifrons	Yellow-eyed Damselfish	0.0	2.0	1.0
Thalassoma bifasciatum	Bluehead Wrasse	0.0	2.0	1.0
Total Individuals/transect =		38.0	54.0	46.0
Total Species/transect =		16.0	20.0	18.0

Table 6: Transect survey of fish at the Fore Reef Slope of Media Luna

	DATES(1993)	9-Mar	9-Mar	
	DEPTH(m)	10	10	
	RELIEF(m)	1	1.3	
	TRANSECT	TS-1	TS-2	MEAN
SPECIES	COMMON NAME			
<i>Abudefduf sextilis</i>	Sargent Major	2.0	0.0	1.0
<i>Acanthurus bahianus</i>	Ocean Surgeon	1.0	0.0	0.5
<i>Acanthurus coeruleus</i>	Blue Tang	0.0	1.0	0.5
<i>Autostomus maculatus</i>	Trumpetfish	0.0	1.0	0.5
<i>Canthigaster rostrata</i>	Sharpnose Puffer	1.0	0.0	0.5
<i>Clepticus parrae</i>	Creole Wrasse	0.0	2.0	1.0
<i>Chromis multilineata</i>	Yellow Chromis	5.0	0.0	2.5
<i>Holacanthus ciliaris</i>	Queen Angelfish	1.0	3.0	2.0
<i>Hypoplectrus guttavarius</i>	Shy Hamlet	1.0	1.0	1.0
<i>Mycrospathodon chrysurus</i>	Yellowtail Damselfish	1.0	1.0	1.0
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	0.0	1.0	0.5
<i>Pomacanthus arcuatus</i>	Gray Angelfish	0.0	2.0	1.0
<i>Scarus iserti</i>	Stripped Parrotfish	3.0	6.0	4.5
<i>Scarus taeniopterus</i>	Princess Parrotfish	0.0	1.0	0.5
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	1.0	1.0	1.0
<i>Sparisoma viride</i>	Stoplight Parrotfish	2.0	1.0	1.5
<i>Stegastes dorsopunicans</i>	Dusky Damselfish	7.0	5.0	6.0
<i>Stegastes partitus</i>	Bicolor Damselfish	4.0	4.0	4.0
<i>Stegastes planifrons</i>	Yellow-eyed Damselfish	1.0	2.0	1.5
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	35.0	18.0	26.5
Total Individuals/transect =		65.0	50.0	57.5
Total Species/transect =		14.0	16.0	15.0

Table 7: Transect survey of fish at the Deep Reef Slope of Media Luna

	DATES(1993)	9-Mar	9-Mar	
	DEPTH(m)	18	17.9	
	RELIEF(m)	5.3	3	
	TRANSECT	TD-1	TD-2	MEAN
SPECIES	COMMOM NAME			
Acanthurus bahianus	Ocean Surgeon	1.0	0.0	0.5
Acanthurus coeruleus	Blue Tang	0.0	1.0	0.5
Anistotremus surinamensis	Black Margate	0.0	1.0	0.5
Canthigaster rostrata	Sharpnose Puffer	1.0	1.0	1.0
Chaetodipterus faber	Spadefish			
Chromis cyanea	Blue Chromis	2.0	1.0	1.5
Chromis multilineata	Yellow Chromis	3.0	0.0	1.5
Gramma loreto	Royal Gamma	16.0	4.0	10.0
Haemulon aurolineatum	Tomtate	1.0	1.0	1.0
Haemulon chrysargyreum	Smallmouth Grunt	1.0	0.0	0.5
Haemulon flavolineatum	French Grunt	1.0	3.0	2.0
Haemulon melanorum	Cottonwick	0.0	1.0	0.5
Haemulon plumieri	White Grunt	0.0	1.0	0.5
Holacanthus ciliaris	Queen Angelfish	0.0	2.0	1.0
Hypoplectrus guttavarius	Shy Hamlet	1.0	1.0	1.0
Hypoplectrus puella	Barred Hamlet	0.0	1.0	0.5
Lactophrys triqueter	Smooth Trunkfish	1.0	1.0	1.0
Lutjanus analis	Mutton Snapper	1.0	0.0	0.5
Lutjanus apodus	Schoolmaster	0.0	1.0	0.5
Mulloides martinicus	Yellowtail Goatfish	0.0	4.0	2.0
Mycrospathodon chrysurus	Yellowtail Damselfish	0.0	1.0	0.5
Myripristis jacobus	Black-bar Souldierfish	0.0	2.0	1.0
Ocyurus chrysurus	Yellowtail Snapper	1.0	1.0	1.0
Scarus iserti	Stripped Parrotfish	1.0	8.0	4.5
Scarus taeniopterus	Princess Parrotfish	0.0	2.0	1.0
Scarus vetula	Quenn Parrotfish	1.0	0.0	0.5
Sparisoma aurofrenatum	Redband Parrotfish	0.0	1.0	0.5
Sparisoma radians	Bucktooth Parrotfish	0.0	3.0	1.5
Sparisoma viride	Stoplight Parrotfish	0.0	1.0	0.5
Stegastes partitus	Bicolor Damselfish	1.0	0.0	0.5
Stegastes planifrons	Yellow-eyed Damselfish	1.0	3.0	2.0
Thalassoma bifasciatum	Bluehead Wrasse	4.0	5.0	4.5
Total Individuals/transect =		38.0	51.0	44.5
Total Species/transect =		17.0	20.0	18.5

Table 8: Transect survey of fish at the Fore Reef Slope of San Cristobal

	DATES(1993)	29-Apr	29-Apr	
	DEPTH(m)	6.0	6.0	
	RELIEF(m)	1.0	0.9	
	TRANSECT	TC-1	TC-2	MEAN
SPECIES	COMMOM NAME			
Acanthurus chirurgus	Doctor Fish			
Acanthurus coeruleus	Blue Tang			
Anisotremus virginicus	Porgy			
Autostomus maculatus	Trumpetfish			
Chromis cyanea	Blue Chromis	0.0	2.0	1.0
Chromis multilineata	Yellow Chromis	0.0	1.0	0.5
Haemulon aurolineatum	Tomtate			
Halichoeres maculipina	Clown Wrasse	1.0	0.0	0.5
Halichoeres radiatus	Puddinwife	1.0	0.0	0.5
Hypoplectrus guttavarius	Shy Hamlet	1.0	2.0	1.5
Lutjanus apodus	Schoolmaster			
Mycrospathodon chrysurus	Yellowtail Damsel fish	3.0	3.0	3.0
Ocyurus chrysurus	Yellowtail Snapper			
Scarus iserti	Stripped Parrotfish	4.0	0.0	2.0
Scarus taeniopterus	Princess Parrotfish			
Scarus vetula	Quenn Parrotfish	0.0	1.0	0.5
Scomberomorus regalis	Cero			
Serranus tigrinus	Harlequin Bass			
Sparisoma aurofrenatum	Redband Parrotfish	2.0	1.0	1.5
Sparisoma radians	Bucktooth Parrotfish	2.0	0.0	1.0
Stegastes dorsopunicans	Dusky Damsel fish	14.0	9.0	11.5
Stegastes partitus	Bicolor Damsel fish	2.0	4.0	3.0
Synodus intermedius	Sand Diver			
Thalassoma bifasciatum	Bluehead Wrasse	31.0	11.0	21.0
Total Individuals/transect =		61.0	34.0	47.5
Total Species/transect =		10.0	9.0	9.5

Table 9: Transect survey of fish at the Fore Reef Slope of San Cristobal

	DATES(1993)	29-Apr	29-Apr	
	DEPTH(m)	10.0	10.0	
	RELIEF(m)	1.2	1.5	
	TRANSECT	TS-1	TS-2	MEAN
SPECIES	COMMON NAME			
Acanthurus coeruleus	Blue Tang	1.0	1.0	1.0
Chaetodon capistratus	Four-eyed Butterflyfish			
Chromis cyanea	Blue Chromis	0.0	1.0	0.5
Chromis multilineata	Yellow Chromis			
Gramma loreto	Royal Gamma	3.0	0.0	1.5
Haemulon aurolineatum	Tomtate	1.0	2.0	1.5
Haemulon flavolineatum	French Grunt	2.0	0.0	1.0
Haemulon melanorum	Cottonwick			
Haemulon sciurus	Bluestriped Grunt	0.0	1.0	0.5
Holacanthus ciliaris	Queen Angelfish	0.0	1.0	0.5
Holocentrus rufus	Squirrelfish	1.0	0.0	0.5
Hypoplectrus guttavarius	Shy Hamlet	2.0	0.0	1.0
Hypoplectrus unicolor	Butter Hamlet			
Lactophrys triqueter	Smooth Trunkfish			
Lutjanus apodus	Schoolmaster	0.0	1.0	0.5
Mycrospathodon chrysurus	Yellowtail Damselfish	1.0	2.0	1.5
Myrichthys ocellatus	Golspotted Snake Eel	0.0	1.0	0.5
Myripristis jacobus	Black-bar Souldierfish	1.0	0.0	0.5
Ocyurus chrysurus	Yellowtail Snapper	0.0	1.0	0.5
Pomacanthus arcuatus	Gray Angelfish	0.0	1.0	0.5
Scarus vetula	Quenn Parrotfish	1.0	0.0	0.5
Sparisoma aurofrenatum	Redband Parrotfish	0.0	2.0	1.0
Sparisoma viride	Stoplight Parrotfish	1.0	0.0	0.5
Stegastes dorsopunicans	Dusky Damselfish	9.0	4.0	6.5
Stegastes partitus	Bicolor Damselfish	9.0	3.0	6.0
Stegastes planifrons	Yellow-eyed Damselfish	3.0	4.0	3.5
Stegastes vaiabilis	Cocoa Damselfish	0.0	1.0	0.5
Synodus intermedius	Sand Diver	1.0	0.0	0.5
Thalassoma bifasciatum	Bluehead Wrasse	12.0	7.0	9.5
Total Individuals/transect =		48.0	33.0	40.5
Total Species/transect =		15.0	16.0	15.5

Table 10: Transect survey of fish at the Deep Reef Slope of San Cristobal

	DATES(1993)	29-Apr	29-Apr	
	DEPTH(m)	12.7	13.9	
	RELIEF(m)	1.2	1.5	
	TRANSECT	TS-1	TS-2	MEAN
SPECIES	COMMON NAME			
Acanthurus bahianus	Ocean Surgeon	4.0	0.0	2.0
Acanthurus coeruleus	Blue Tang			
Canthigaster rostrata	Sharpnose Puffer	1.0	1.0	0.5
Chaetodon capistratus	Four-eyed Butterflyfish			
Chromis cyanea	Blue Chromis	1.0	0.0	0.5
Haemulon aurolineatum	Tomtate	1.0	1.0	1.0
Haemulon flavolineatum	French Grunt	1.0	8.0	4.5
Haemulon plumieri	White Grunt	2.0	0.0	1.0
Holocentrus rufus	Squirrelfish	0.0	2.0	1.0
Hypoplectrus guttavarius	Shy Hamlet	1.0	1.0	1.0
Hypoplectrus puella	Barred Hamlet	0.0	1.0	0.5
Hypoplectrus unicolor	Butter Hamlet			
Lachnolaimus maximus	Hogfish			
Mycrospathodon chrysurus	Yellowtail Damselfish	1.0	2.0	1.5
Myripristis jacobus	Black-bar Souldierfish	0.0	2.0	1.0
Ocyurus chrysurus	Yellowtail Snapper	0.0	1.0	0.5
Pomacanthus arcuatus	Gray Angelfish			
Scarus iserti	Stripped Parrotfish	7.0	1.0	4.0
Sparisoma aurofrenatum	Redband Parrotfish	0.0	1.0	0.5
Sparisoma viride	Stoplight Parrotfish	1.0	2.0	1.5
Stegastes dorsopunicans	Dusky Damselfish	0.0	3.0	1.5
Stegastes leucosticus	Beau Gregory	1.0	0.0	0.5
Stegastes partitus	Bicolor Damselfish	1.0	2.0	1.5
Stegastes planifrons	Yellow-eyed Damselfish	4.0	7.0	5.5
Thalassoma bifasciatum	Bluehead Wrasse	0.0	6.0	3.0
Total Individuals/transect =		26.0	40.0	33.0
Total Species/transect =		13.0	15.0	14.0

Appendix F – Reef Selection Forms

Form 1 in English (García, 1994):

THIS IS A FORM FOR THE SELECTION OF THE REEFS TO BE EVALUATED IN A FEASIBILITY STUDY FOR THE ESTABLISHMENT OF A FISHING RESERVE IN LA PARGUERA

Initially choose three (3) reefs that will be used in the comparative study during the year. During the next year, the feasibility study has been complete, then we will return with a new list for the selection of one (1) reef and you will choose your favorite location for a fishing reserve.

PLEASE CHOOSE THE THREE (3) REEFS YOU WOULD PREFER

_____ TURRUMOTE

_____ CORRAL

_____ MEDIA LUNA

_____ LAUREL

_____ SAN CRISTOBAL

_____ EL PALO

_____ MARGARITA

_____ MAJIMO-CARACOLES-LA GATA

_____ ENRIQUE

OTHERS: (WRITE THE NAME OF REEFS THAT YOU PREFER THAT WE DID NOT MENTION)

FISHERMAN'S NAME (OPTIONAL) _____

DATE:

Form 1 in Spanish:

FORMULARIO PARA SELECCIONAR LOS ARRECIFES (CAYOS) A SER EVALUADO EN EL ESTUDIO DE VOCABULARIO PARA ESTABLECER UNA RESERVA PESQUERA MARINA EN LA PARGUERA

_____ Inicialmente se escogeran tres (3) arrecifes para hacer un estudio comparativo durante un año. Al final del primer año del estudio de viabilidad nos reuniremos nuevamente para seleccionar uno (1) y proponerlo como nuestro favorito para ser designado una reserva pesquera.

FAVOR DE SELECCIONAR TRE (3) ARRECIFES DE SU PREFERENCIA

_____ TURRUMOTE

_____ CORRAL

_____ MEDIA LUNA

_____ LAUREL

_____ SAN CRISTOBAL

_____ EL PALO

_____ MARGARITA

_____ MAJIMO-CARACOLES-LA GATA

_____ ENRIQUE

OTROS:(ESCRIBA EL NOMBRE SI NO GUSTRAN LOS ARRIBA MENCIONADOS)

NOMBRE DEL PESCADOR (OPCIONAL) _____

FECHA:

Form 2 in English:

(date)

Select the reef to be proposed as a fishing reserve for La Parguera. The Turrumote, Media Luna y San Cristobal are the reefs the fishermen selected as the best alternatives to be further evaluated. The reef with the most votes will be included in a formal proposal endorsed by the fishermen and directed to the Department of Natural and Environmental Resources for the establishment of a marine reserve in La Parguera.

I am a fisherman and my selection is the following:

_____ TURRUMOTE

_____ MEDIA LUNA

_____ SAN CRISTOBAL

signature

Form 2 in Spanish:

(la fecha)

Papeleta para seleccionar el arrecife a ser propuesto como una reserva pesquera para La Parguera. Los arrecifes (cayos) Turrumote, Media Luna y San Cristobal fueron seleccionados por los pescadores como las mejores alternativas a ser evaluadas. El arrecife con mas votos sera incluido en una propuesta formal endosada por los pescadores y dirigida al Departamento de Recursos Naturales y Ambientales para solicitar se establezca una reserva pesquera marina en La Parguera.

Mi selección como pescador es la siguiente:

_____ TURRUMOTE

_____ MEDIA LUNA

_____ SAN CRISTOBAL

firma

Appendix G – Interview Summaries

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Dallas E. Alston, Ph.D.

When: Monday, January 30, 2006

Interviewer(s): Benjamin Cleveland, Daniel Filipe, Jeffrey Pelligrino, Edward Robinson

Methodology: Telephone interview

Background: Dr. Alston is a professor at the Department of Marine Sciences at the University of Puerto Rico – Mayagüez and our project liaison.

Discussion:

- To clarify our understanding of the project, what do you see as the main problems/issues that need to be addressed?

Ben: We understand the project to be implementing ecosystem-based management in PR

Alston: You will not be actually implementing ecosystem-based management; there is not enough time for that. Instead you will be studying the possibilities of implementation in the future.

Ben: Okay, so we will be developing a plan to implement ecosystem-based management.

Alston: Yes, you will be developing a plan.

- How does this project relate to your work?

Alston: Ecosystem-based management is already in use in Culebra, PR, use this as a model. Reefs tend to go out of balance very quickly. The idea is to close the reef because fishing causes a problem with the top predators of the reef. This makes it necessary for fishermen to continue to move further and further out to sea. This causes reefs further and further out to be affected by over-fishing. In reefs there are many different types of species and fishermen are trying to catch all of them. It would not be possible to place regulations on certain types of fish.

- We've looked at some of the work that you've done on mariculture. Does this project fit in at all with that research?

Alston: Take Culebra as a model (as if it has not already been regulated). It is difficult to close a coral reef area, but the mariculture in place is to move species to a barren area (ocean area with sandy bottom).

- Is UPRM currently doing anything to address this issue? If so, what? If not, what would they be willing to do and what resources are available?

Alston: The University of Puerto Rico is studying the environmental effects of underground cages, also known as aquaculture. It is necessary to still be able to catch fish while the reefs are closed. Mariculture is used at barren areas away from reefs, typically over portions of the ocean with sandy bottoms. This is something that is already being done in Puerto Rico. Other solutions would be to try to close parts/all of the reef.

- How is our problem perceived by the local people? In other words are they concerned about this problem? How willing and able would they be to comply to an ecosystem-based management plan?

Alston: With Culebra as the model, this has been the first instance of fishermen voluntarily closing the reefs. They did this in recognition that they are/were over-fishing and are worried about their youth who will need to make a living off of fishing also. Culebra is the 1st and only area in which local people closed a reef.

- We felt that the fishing industry and tourist industry were being affected by this problem. Is anyone else being affected by this problem?

Alston: We do not see tourism as being affected by the fish populations. Tourism agencies would be in favor of a no-take reserve for the reefs. Tourists visit reefs to see the sights, only a few fishermen that visit Puerto Rico.

Ben: So you are saying that it would be more attractive to the tourists to have fish-filled reefs than worry about being able to fish.

Alston: Flamenco Bay in Culebra is largely a tourist area, 90% of tourists visit there.

Ben: You have been referring to Culebra a lot. Will our project concentrate on the island or on Mayagüez?

Alston: Culebra is only acting as a model for our project.

- We've been considering this project mostly in the context of the deterioration of coral reefs. However, we've learned that the fisherman on the western side of the island have more experience with deep sea fishing. Will the fishing grounds that we will be researching involve the coral reefs close to shore or the offshore fishing grounds?

Alston: Fishing in or around the reefs has a much larger effect on the reef ecosystem than the tourists. Tourists could be damaging the reefs but this is not a major concern because it is minimal.

- What are the involved communities like (e.g. population size, economic activities in area, level of education, ability to speak English, what percent are involved in fishing)?

Alston: Many of the fishermen that you will be interviewing or contacting will not be fluent in English. It is a must to prepare questions in Spanish. I may have a grad student that will be willing to act as a translator if necessary.

- Would you like to receive reports about our progress during this term?

Alston: Yes, it would probably help both of us in your project. I would like you to send me major parts of your report and findings and emails of progress so that I can oversee, in a way, and make sure that you are on the right track.

Other Information Discussed:

Alston: For the dates that I am in San Juan we could set up a snorkeling or kayaking trip. Would you all be interested in this?

Ben: We would definitely be interested in such trips with you! We could also do this while in Mayagüez?

Alston: I need to know everyone's weight in order to prepare kayaking equipment. Also, rate yourselves on swimming ability (non-swimmer, non-swimmer athletic, beginner, and swimmer). Make sure to bring mask, snorkel, and fins. I would also like to know if anyone has any snorkeling experience. Eighteen inch fins will be good (about \$30). You will not need to rent kayaks most likely. If you plan on staying in the dorms, it will be about \$10 per night per person. Please let me know in advance if you will need to do this. We can meet up on a Friday and go over the project, Saturday we could do some office/field work, and Sunday we could plan a trip.

Alston: Put 'La Parguera, PR' in Google Earth and you can see the coral reefs that we will be concentrating on. When I come to San Juan, please find out if there is a place that I will be able to sleep in someone's room. I will be arriving on Friday but not meeting my class until Saturday morning.

Richard Appeldoorn, Ph.D.

When: Thursday, April 6, 2006 at 11:00 am

Where: Magueyes Island, University of Puerto Rico – Mayagüez

Interviewer(s): Benjamin Cleveland, Daniel Filipe

Methodology: Semi-structured interview

Background: Dr. Appeldoorn studies fisheries and will be able to give us a broad perspective of the issues.

Discussion:

- *We discussed the current regulations*
The only meaningful regulation is the island-wide species restrictions that exist during breeding seasons. The coral reef and fish populations are down all throughout the La Parguera
- *Dr. Appeldorn gave his opinion on what should be done*
Any plan must operate on an ecosystem scale and Parguera is only a part of the ecosystem. Parguera has one of the biggest and most complicated shelf areas in Puerto Rico and is thus an ideal location. Any plan must take into account all of the factors such as water quality that impact the ecosystem. There is a lot of animosity between the fishermen and the scientific community. A long series of discussions is needed before a productive conversation can be had.
- *Dr. Appeldorn discussed the role of fishermen*
He doesn't think a happy medium can be obtained between the fishermen and the government/scientific community, but there should be a realization of the problems that exist. For the most part, the fishermen have been left out of the decision making process. Fishermen like to complain about the regulations but they need to realize that everybody else in the world has restrictions on many things all year round. The fact remains that they have eliminated fish aggregation near ports. Catching fish during spawning seasons is economically important for the fishermen because it allows them to catch large quantities with very little effort, but this practice cannot be done sustainably. The new people don't know what the problems are and the old people don't care.

Jorge E. Capella, Ph.D.

When: Wednesday, April 5, 2006

Methodology: Structured interview

Background: Dr. Capella is a professor in the Marine Sciences Department of the University of Puerto Rico – Mayagüez

1. What is your background pertaining to ecosystem-based management or coral reef ecosystems?

My background is theoretical, mainly from being a member of the CFMC-SSC, from colleagues doing work in this area and from personal interest in the literature, specially modeling.

2. What types of fish do you normally target?

Mainly offshore and coastal pelagics, occasionally bottom fish and some lobster.

3. What methods do you use to catch fish?

Rod and reel trolling for the most part. Some hand lining for bottom fish and diving for lobster.

4. In what areas of the ocean do you fish?

I rarely fish at La Parguera, most of my fishing is done in Aguadilla (northwest PR).

5. Are you aware of any laws or regulations that govern this area?

Yes both State and Federal regulations.

6. Have you noticed any changes in quantities and types of fish you catch?

Yes. Fewer fish nowadays.

7. Have you had to change your fishing techniques or locations or species of fish caught for any reason? If so, why?

You have to go out further for dorado, dive deeper for lobster. I don't fish commercially.

8. Have you noticed a change in coral reef fish populations? If so, increase or decrease?

Large decrease in big fish.

9. Do you have any ideas on how to reverse this trend? (asked if a negative trend is recognized by interviewee)

Decrease fishing pressure and increase aquaculture production.

10. What is your opinion on closing certain areas of water to fishing in order to protect the ecosystem? Why or why not?

Yes, it has been shown to work. Site selection must be scientifically rigorous.

11. What is your opinion on seasonal closures of fishing areas? Why or why not?

Yes, mainly during spawning.

12. Would you be interested in maintaining a fish farm instead of fishing? Why or why not?

When I was younger. Too much work.

13. What is your opinion on being required to obtain a fishing license? Why or why not?

Don't like it but realize it is necessary.

14. One concept that has been used in other areas of the world involves fishermen owning the rights to certain fishing grounds. What is your opinion on the government granting fishermen ownership of oceanic areas to be managed at their will? Why or why not?

Don't think this idea will work in the PR-USVI as the shelf is too small.

15. Would you be willing to fish to a quota determined by the government and how do you think the commercial fishing industry would feel about this? Why or why not?

There are state quotas in place at the moment so it is not an option. Again, I don't like it but they are necessary.

16. Professor Dallas E. Alston mentioned that you were knowledgeable of the currents in the waters surrounding Puerto Rico. We are interested in the possibility of implementing aquaculture in the fishing grounds of La Parguera near its border with Cabo Rojo. There are a few requirements for this to be possible including a minimum current of 20cm/s. Do you know if the current in this area would meet this requirement?

Do you mean minimum speed, resultant velocity, or average speed?

The minimum speed at most places is zero, the averages vary from site to site. Mean speeds at La Parguera are in the order of less than 10 cm/s, resultant velocities are even lower. Very few places around PR-USVI exhibit mean speeds higher than 20 cm/s. The 20 cm/s value comes from temperate waters, I believe, so it would be a good idea to conduct research to provide optimal speeds for cage aquaculture in our waters.

17. Do you know of any other fishermen who would be willing to talk with us about this issue?

Try Mickey Amador of La Parguera Charters and Marcos Rosado at Magueyes. Almost the entire staff at Magueyes conducts fishing at some level.

Milton Carlo

When: Wednesday, April 5, 2006

Where: Magueyes Island, University of Puerto Rico – Mayagüez

Interviewer(s): Benjamin Cleveland, Daniel Filipe

Methodology: Semi-structured interview

Background: Milton Carlo is the diver master on Magueyez Island and is pursuing his master's degree in Geology.

Discussion:

- *We discussed the trend in fish populations*
Mr. Carlo takes researchers out diving to collect samples of algae, coral, or other things of interest to them and to do transects. He has definitely noticed a rapid drop in the fish population in all of the reefs and on the shelf. For the most part the corals haven't changed much with the exception of Cayo Enrique.
- *We discussed his feelings on making certain reef areas off-limits to divers*
He doesn't have a problem not diving in a certain place and thinks that other divers would agree with him. The places where people go a lot are visibly highly impacted. One such area is Cayo Carracoles.
- *We discussed the species regulations that currently exist*
Fish spawn out on the shelf in very concentrated numbers. They are very hungry and will bite at anything. It is thus very easy to catch a large amount of fish very quickly, but this is not good for the longevity of species. The fishermen don't like the scientific community because they think that they want to take away their fishing grounds. There are only about 4 or 5 fishermen active in this area. Froilan is moody and tends to disrupt public hearings.

LisaMarie Carruba

When: Thursday, March 6, 2006

Methodology: Semi-structured interview

Background: Ms. Carruba works for NOAA

NOAA has been sponsoring the development of management plans in several protected areas around the island and I believe there is already a project to begin the development of a management plan for Parguera. In addition, there is a Special Use Plan already as Parguera is part of the Southwest Special Planning Area. However, the development of management plans MUST be coordinated with and approved by the Puerto Rico Department of Natural and Environmental Resources as the agency responsible for implementing management plans in protected areas. Therefore, I would recommend that you coordinate with the Department through its San Juan office to determine whether a project is already in place in coordination with the NOAA Coral Reef Conservation Program and whether they would be willing to collaborate with your group.

Carmen Delia

When: Friday, April 7, 2006 at 2:30 pm

Where: DNER office, La Parguera, Lajas

Interviewer(s): Benjamin Cleveland, Daniel Filipe

Methodology: Semi-structured interview

Background: Ms. Delia is the director of the local Department of Natural and Environmental Resources (DNER) office in La Parguera.

Discussion:

- *We first talked about the current reserve situation in the general Lajas area*
There is an 1886 Spanish law that protects marine areas. Puerto Rico Law #4860 governs all marine areas in Puerto Rico. There are 2 recreational areas in the Lajas region which is part of the southwestern special planning area comprised of Cabo Rojo, Guanica, and Lajas.
- *We discussed the different types of measures used to protect marine areas*
A “marine reserve” contains a land and sea area and is managed by a planning board which makes the restrictions for the area. An MPA contains only a sea area.
- *We discussed how the current situation could be improved*
The DNR needs more trained personnel. It’s a very political agency. People need to be educated more.

Luis Doitteau

When: Wednesday, April 4, 2006 at 1:30 pm

Where: Paradise Scuba and Snorkeling Center, La Parguera

Interviewer(s): Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Background: Luis Doitteau is the owner of Paradise Scuba and Snorkeling Center in La Parguera.

Discussion:

- *We discussed Paradise Scuba and Snorkeling Center*
Luis Doitteau is the owner of Paradise Scuba and Snorkeling Center in La Parguera. He does daily snorkeling or scuba diving trips to coral reef areas adjacent to Lajas. He identified Caracoles, Mata La Gata and Enrique as the locations to which he brings his groups. His tours consist of going to the bioluminescent bay, shallow diving, scuba diving and sunset snorkeling. His busiest times are Holy Week, June, July, August and Christmas time in the United States.
- *We discussed the possibility of a marine reserve in the Turrumote area*
He believed that fishermen were against the reserve because they needed to catch fish, specifically red snapper, lobster and conch. He believed that young people were anchoring off the island of Caracoles and partying and destroying the environment. He said that he does not take his groups to Turrumote because it is too far out and his customers get sea sick normally.
- *We discussed several other topics*
He mentioned that the current is from the Southeast... In Spanish, "pargo" means "grouper" so because it is known for grouper the named it La Parguera or "grouper town." The office of UPR opposes all negative activities in the environment and they receive aid to do studies on them.

Lourdes Feliciano & Carolin Viscarrondo

When: Monday, March 27, 2006

Where: Culebra Fishing Association, Culebra

Interviewer(s): Benjamin Cleveland, Daniel Filipe, Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Background: Lourdes Feliciano is the Secretary of the Culebra Fishing Association and Carolin Viscarrondo is the manager. They were both influential in the formation of the Luis Peña Channel Natural Reserve in Culebra.

Discussion:

- *Lourdes explained why the people of Culebra fish*
We like to have fresh fish and provide for our families. Most of the fish that are caught get sold to the community. We also fish because it's something that we like to do and it's part of our way of life. This is a small island and fishing is an activity that we do like other people would go dancing. Since we were children we have been fishing and snorkeling; it's been part of our growing up.
- *Lourdes discussed the Culebra Fishermen's Association*
The association was incorporated as a club in 1966. It's a fish co-op where all the fishermen can bring the fish that they catch and sell them there instead of having to go around town offering them to people. Customers come to the coop to buy the fish. The government has seasonal restrictions on what fish species can be caught based on their growing and breeding seasons. The co-op won't buy fish unless it is the right season for them. This effectively enforces the seasonal restrictions.
- *The reserve*
The people of Culebra respect the rules governing the reserve and don't fish there. The problem comes from outsiders who come from Vieques or other places to fish in the reserve. The Department of Natural Resources is the governing body of the reserve.
- *Lourdes explained where the fishermen of Culebra fish*
The fishermen don't go very far out to sea to fish. A special permit is needed to fish in Saint Thomas. The fishermen mainly fish in the circled areas:

The Department of Natural Resources has done a bad job managing the reserve. There is nothing really stopping people from fishing in the reserve.

- *Lourdes discussed the future of the reserve*
At some point in the future she hopes to push for the creation of another reserve in the circled area below:



Jorge García, Ph.D.

When: April 03, 2006 at 2:00pm

Where: Magueyes Island, University of Puerto Rico – Mayagüez

Interviewer(s): Benjamin Cleveland, Daniel Filipe, Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Background: Dr. García is a professor in the Marine Sciences Department of the University of Puerto Rico – Mayagüez. He gathered much of the scientific data to support the formation of the proposed Turrumote Reserve and wrote a proposal for the Reserve.

Discussion:

- *We discussed the work that Dr. García has done to try and form a reserve in the Turrumote area*
He completed the proposal for a visibility study using baseline surveys on 3 different reefs offshore of La Parguera. This study was conducted on territorial and non-territorial fish and assessed their abundance and size.

- *We discussed the condition of the coral reef ecosystems*
Essentially all problems with fish ecosystems comes down to fecundity (reproduction). Over-fishing and other reasons (storms, global warming, environmental factors) cause fish to die before they reach an age where they can reproduce – this is obviously detrimental to their populations and therefore the ecosystem. This is specifically true of coral reef fishes.

- *We discussed the factors that hindered the creation of the reserve that was proposed in the Turrumote area*
A reserve in the waters offshore of La Parguera would help, but adjacent fishermen of Papayo refuse such ideas because supposedly the reefs at which the proposed reserve is centered is “theirs.” Social problems like this are commonly issues when considering any ecosystem-based management. Around the time when the proposed reserve on the reef supposedly owned by Papayo was almost being implemented, Hurricane Jorge hit Papayo hard and destroyed much of the village. In order to reduce additional stresses on their community, the proposed reserve was put on hold again by Sea Grant.

- *We discussed the possibility of subsidizing fishermen to make a reserve more appealing to them*
Basically everything boils down to money, according to Prof. García. In the vote on the reserve, all 14 voters voted against implementation, but not a single one had a fishing license. They all simply fished to subsidize their income. Prof. García suggested the idea of subsidizing the fishermen’s income so that they won’t fish in the reserve if it ever gets implemented.

He expressed an importance of everyone understanding that paying \$10,000/year to fishermen so they won't fish in the reserve was "peanuts" compared to the money made from a healthy ecosystem through tourism, etc.

George Heaton, Ph.D.

When: Friday, February 3, 2006

Where: Social Science Department, WPI

Interviewer(s): Benjamin Cleveland, Daniel Filipe, Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Discussion:

- *Introduction*

Jeff: Can you tell us about your background?

Professor Heaton: I'm a lawyer by training. I did work at MIT on public policy and taught environmental law. I then went on to work on international environmental policy at the World Bank, the World Resources Institute, the EPA, the US-Asia Environmental Partnership, and I am now a professor at both WPI and Clark University.

- *Potential Resources*

Jeff: What are some good ways to find information on this topic?

Professor Heaton: Look at today's issue in the Boston Globe – they talk about a helpful article that was recently published in *Science*.

Professor Heaton: Read the book called "The Lobster Coast"

Professor Heaton: Public hearings are a good source of information. All kinds of people come to talk about a specific policy proposal. To find out about hearings look in agency websites, newspapers, trade journals, trade associations, National Fisheries Institute.

- *Ecosystem Based Management*

Jeff: Do you know of any examples of EBM?

Professor Heaton: The concept/principal of ecosystems management is minimal in the US. The laws that exist are old and unsophisticated. They were made on a medium-by-medium basis, i.e. air, water, etc. They found out what the best available technology was and then just used it to solve a problem. One are in with ecosystem management exists is the endangered species act. If a species is threatened it is listed and it is protected by laws. There are also habitat management acts.

Professor Heaton: Costa Rica 5-6 years ago (look in *Issues in Science and Technology*). The country set aside a large area of tropical forest to be managed by a drug company and the government. The money came from the drug company which did research on the organisms in the area.

Jeff: Have these been successful?

Professor Heaton: The fish are coming back so I guess so. The theory is that if you protect the habitat for one species it is improved for all the other species in the habitat. This may or may not be true.

- *Laws & Regulations*

Jeff: What can you tell us about the MS act?

Professor Heaton: It was a protectionist measure that established a 200 mile fishing zone limit where other countries can only fish by permit.

Professor Heaton: The regulating agencies are CZMA and NMFS. Various regions come up with species specific plans and the NMFS approves them. Find out what plans the region that PR is in has. Laws are statutes made by congress. Regulations are made by government organizations and are found in the CFR. Find out who the regulating agencies in PR are. The framework and funding are established by the federal government and implemented by the individual states.

- *Other Topics*

Jeff: Do you have any other advice for us?

Professor Heaton: Divide the problem statement and synthesize what you find. Demonstrate knowledge of all of the components. Don't have all four people working on everything because then you'll end up being superficial. Each of you should become an expert on a different topic. There are many environmental organizations around the world; find the environmental organizations in PR.

Edwin Hernández, Ph.D.

When: Wednesday, March 15, 2006 at 10:30am

Where: Dr. Hernández' office, Marine Sciences Building, University of Puerto Rico – Rio Piedras

Interviewer(s): Benjamin Cleveland, Daniel Filipe, Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-Structured Interview

Background: Dr. Hernández has worked extensively with the Louis Peña reserve on Culebra.

Discussion:

- *We discussed Marine Protected Areas*
Marine Protected Areas are referred to as natural reserves in Puerto Rico. The general rule is for Marine Reserves that they must extend at least 9 nautical miles off of the coast. There are situations that only 150 meters of coastline are protected making for very long and narrow zones. The islands of Mona and Desecheo also contain MPAs that say you cannot fish closer than one mile to shore. Culebra also has MPAs. He mentioned that areas are “protected” at the federal level but that means nothing. Areas are not marked and fishermen are not aware of their existence.
- *We discussed the history of the Reserve on Culebra*
Luis Pena is the MPA located in Culebra and is 475 hectares. Professor Hernández explained that Culebra was the first no-take reserve in Puerto Rico and was started in 1999. Fishermen tried for two decades to get the government to declare no-take zones. They pinpointed nine different places that it would be possible but the federal government decided that it would be better to start with one. The no fishing law is known as Law 278. These areas that were selected as possible no-take zones were overexploited due to over-fishing and to Naval bombing for many years.
- *We discussed the ecological conditions on Culebra*
In Culebra the area that is protected includes up to the highest point that the water reaches at high tide. But Professor Hernández explained that it should also include mangrove and lagoon areas. Carlos Rosario Beach is located on the island of Culebra and issues such as white plague, coral bleaching, and bacterial blooms threaten the coral. The bacterial blooms generally occur after storms over the island and are consequences of runoff. There are no rivers in Culebra and the soil is very light and soft. Tamarind Bay is also located in Culebra and contains artificial coral farms.
- *We discussed problems that the Reserve is experiencing*
In Luis Pena there is no regular patrolling. Fishermen still fish and lobsters and shrimp are caught because they know that enforcement officers will

never show up. For over a year there were no marking buoys in the Luis Pena reserve.

- *We discussed the possibility of satellite sensing to keep an eye on the fishermen.*
Professor Hernández also mentioned that in Australia fishermen were given GPS and radios so that they could patrol the area themselves and protect the areas. With the GPS it would also be possible to know where the boundaries for fishing reserves were located.
- *Professor Hernández gave us the names of people involved in the MPA in Culebra:*
 - Lourdes Feliciano – 787-742-3371 – Secretary Culebra Fishing Association
 - Ramon Feliciano – Member of fish corporation
 - Anastacio (Taso) Soto – President of fish corporation

Ronberto Hernández

When: Friday, April 6, 2006 at 3:30 pm

Where: Interviewee's fish market, La Parguera

Interviewer(s): Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview (*Ronberto did not speak English but his friend that was there did. The information may have been both the interviewee's and his friend's opinions.*)

Background: Ronberto Hernández is the owner of a *pescadoría* in La Parguera

Discussion:

- *We discussed the current seasonal species restrictions*
He believed that seasonal restrictions should be split. Instead of seasonal closures he mentioned that he would like it better if he could catch five fish and then stop fishing, like in the United States. When you throw a hook you don't know what you are going to catch.
- *We discussed other regulations*
About a month ago, fishermen went to San Juan to discuss with the legislature the closures and required licenses that they must obey. Ronberto was not familiar with the proposed Turrumote Marine reserve and did not seem very willing to give information.

Mayor Marcos A. Irizarry

When: Tuesday, April 18, 2006

Where: Mayor's Office, Lajas, Puerto Rico

Interviewer(s): Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Background: Mayor Marcos A. "Turin" Irizarry Pagan has been the mayor for the municipality of Lajas for 9 years and is currently serving his 3rd term.

Discussion:

- *The Mayor discussed La Parguera*
La Parguera is protected by federal law partially because of the bioluminescent bay. In Lajas new building cannot be more than 3 stories high and there must be special light covers for street lights in Lajas to minimize light pollution because it affects the organisms in the bay. These special laws are not found anywhere in Puerto Rico except Lajas. The primary industries in Lajas are agriculture and tourism.
- *The Mayor discussed the current fishing restrictions*
The fishermen do not agree with the current restrictions that are being imposed. The Mayor and many fishermen, including Froilan Lopez who is the fishing association president, traveled to San Juan to meet with congress to discuss these restrictions 2 weeks prior to our meeting. There will be a committee that will review these laws. The commercial fishermen are the only type of fishermen that are required to obtain a license. There are also size restrictions on certain species of fish. The fishermen believe these size restrictions are unfair because you do not know the size of the fish until it is on your boat and often the fish is dead once it is brought onto the boat. What are the fishermen suppose to do if the fish is dead once it is onboard? They can't throw it back because that would be bad for the environment, but if they keep it they could get substantial fines. The law came from the US and above the law in Puerto Rico.
- *The Mayor discussed the proposed Turrumote reserve and the fishermen.*
They tried to implement a reserve before and they mayor thought it was good, but the fishermen didn't understand why it was important. He still thinks it would be a great idea, but he stressed the importance of obtaining the support from the fishermen. He was unsure if they would support a reserve because there are already so many restrictions.
- *The Mayor discussed the village of Papayo*
Papayo is a sector of La Parguera. There are 8 special communities (Cummunidad Especial) in Puerto Rico, the last governor established them and Papayo represents one of these communities. These communities are very poor and lack good facilities, parks, sometimes don't

have running water or electricity. The village of Papayo is very poor but luckily they have running water and electricity.

- *The Mayor discussed communication between scientists and fishermen*
He believed there was good communication between the different parties.
- *The Mayor discussed the municipality of Lajas*
The municipality is approximately 60 square miles. One thousand acres is an agricultural reserve (Law 277) in which nothing can be constructed unless it relates to the agricultural industry. The area south of the agricultural reserve is a natural reserve where there are strict regulations preventing the development of the land. There are very few areas that can be developed to promote tourism.

Froilan Lopez

When: Monday, April 3, 2006

Where: La Parguera

Interviewer(s): Benjamin Cleveland, Daniel Filipe, Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Background: Mr. Lopez is the owner of one of the three *pescadería's* in La Parguera

Discussion:

- *Froilan discussed aquaculture in Culebra and La Parguera*
The MPA in Culebra was good because it protects the reefs and helps the fish populations. They are able to use the cages to produce many types of fish. The aquaculture would be good to do in La Parguera but most of the platform surrounding La Parguera is not deep enough to do aquaculture. There is one area near Cabo Rojo where the water is deep enough to do aquaculture.
- *Froilan discussed the attempted implementation of an MPA in La Parguera*
The fishermen of La Parguera agreed to make the reserve originally. The fishermen of Papayo did not want the reserve and the two groups argued about the subject and eventually politics prevented the reserve from being implemented. The fishermen of La Parguera also wanted the reserve, which was going to surround the island of Turrumote, to be off limits to everyone except scientists conducting experimental studies. You need to preserve the reserve and not allow any commercial or recreation activities within its boundaries. This was very important to the fishermen. There are approximately 70 fishermen in La Parguera and Papayo.
- *Puerto Rico, its laws, and how they relate to fishermen*
One problem in Puerto Rico is that whenever there are resource problems, they always blame it on the fishermen. Many people don't realize that many things damage their resources. Hurricane David was more than 125 miles away from Puerto Rico and it turned the reefs upside down and many of the reefs died. There are approximately 3500 commercial fishermen in Puerto Rico. Most don't agree with the laws relating to their industry. The laws affect when they can fish certain species. The problem is that many of the fish are protected during their prime fishing season. One species of fish that is protected during its prime fishing season is the redhind grouper. The best time of the year to catch redhind grouper is approximately 2 months in length, and the entire season the fishermen are unable to catch this type of fish. The fishermen would be happy if they could fish for redhind grouper for ½ of this 3-month

period. One possibility is that you could take fish that share similar prime seasons and allow only one of the species to be fished the first half of the season and only allow the other species to be fished the second half of the season. The fishermen are frustrated because they don't get any help based on the problems caused by the laws. The fishermen are also frustrated because people come from Florida and fish 25 miles south of the island. The government and politicians are not doing anything to help the commercial fishermen. The fishermen would like to see restrictions placed on who could fish within 50 miles of Puerto Rico or something like that. La Parguera use to be recognized as a fishing village, it use to be much bigger. Many fishermen no longer are able to provide for their families because of all the laws and regulations. If it continues, there will be no fishermen left in the near future.

- *Froilan explained who buys his fish*
Most of the fish get sold to people in Puerto Rico, people from all over the island come here to buy fish, especially with Holy week approaching. Ten other fishermen also sell to Froilan. There are 3 businesses in La Parguera where people can come and buy fish. Some people sell fish from their homes but they don't sell many fish and they don't sell to people all over the island.
- *Froilan discussed using artificial reefs*
Jose Rivera works for the NOAA and he has discussed the use of artificial reefs. They could be used with aquaculture to create new reefs and expand the current reef system. In Culebra, the aquaculture cages are great areas to fish for yellow snapper. Froilan and his brother found an old sunken ship and there were lots of fish in the area and coral was growing on the ship. It was like a home for the fish. If you stripped boats of most of their parts and removed all the gasoline, you could sink the boats and eventually reefs would grow on the boats.
- *Froilan discussed fishing partners*
He explained that some people work in pairs or small groups, but it doesn't work well unless both people contribute the same amount of equipment, otherwise the split cannot be 50/50. If there is a hurricane and all the equipment gets destroyed, only one person gets hurt because the other has no money invested in the equipment.

Ivan Lopez

When: Monday, April 3, 2006 at 2:00 pm

Where: Magueyes Island, Department of Marine Sciences, University of Puerto Rico – Mayagüez

Interviewer(s): Benjamin Cleveland, Daniel Filipe, Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Background: Ivan Lopez is a researcher in the Marine Sciences Department at the University of Puerto Rico – Mayagüez. He has been a fisherman for most of his life.

Discussion:

- *We discussed the reserve that was proposed several years ago in the Turrumote area*
Turrumote was chosen because turtle nesting occurs in the sand of the island and birds nest within the mangroves. Fishermen believe that if the area becomes marine protected that no one should be there recreationally. People should only be in the area for scientific measures. The idea would be to close Turrumote for five years and then close a different reef to the west. The southeast winds/currents would push fish production (eggs) into other areas closer to shore. The proposal included fishermen patrolling the reefs. The organizations in control of the waters are marine police, DNER and the Coast Guard.
- *We discussed the fishermen's reaction to a possible reserve*
Ivan Lopez believes that it is hard to get fishermen to realize that something needs to be done in La Parguera area. The proposed Turrumote MPA because governmental issues caused the project to stop. The government is said to be too interested in politics and not in projects like this. Fishermen are worried about the restrictions that they are subject to such as being banned from catching certain species. On Friday, March 31st fishermen protested to the government because of the limitations on grouper, mutton, snapper and wahoo.
- *We discussed the difference between commercial and recreational fishing*
Throughout Puerto Rico commercial fishermen are much less populated than recreational fishermen. Dr. Lopez believes that recreational fishermen are where the problem exists. They are not required to have licenses. Fishermen can catch up to 5 fish per person per day or 20 fish per boat per day. It would be better to raise commercial limit and/or lower recreational limit for fishing.
- *We discussed the different types of commercial fishermen*
Artisinal fishermen fish from the coast to the reefs. Regular fishermen fish over the platform into the open water.

- *We discussed the current status of the waters surrounding Parguera*
Parguera is currently a Natural Marine Reserve. The Federal government was thinking about making it a National Marine Sanctuary but the proposal was presented poorly and it became a Natural Marine Reserve which would be run by the local government. Natural Marine Reserves stop the development on the land. There are 12 or 13 Natural Marine Reserves in Puerto Rico. The LPCNR in Culebra is the only Marine reserve in Puerto Rico.
- *We discussed the fishing regulations that are currently in place*
The DNER has all of the fishing regulations in terms of species/dates/locations of MPAs. There are also seasonal restrictions on several target species. “On the platform” there is a ban on Red Snapper (Yellow Tail, Mutton, Ducktail, Grouper) and in the open water there is a ban on Wahoo, Spanish Mackerel, King Mackerel, Dorado and Tuna.
- *Dr. Lopez suggested that we contact several other individuals*
We can contact Roberto Chapparo and Manuel Valdez-Pizzini of Sea Grant in Mayagüez to get interview transcripts and other important information.

Mary Ann Lucking

When: Monday, March 27, 2006

Methodology: Structured interview

Background: Ms. Lucking is the director of the Culebra based community organization CORALations.

1. What is your background pertaining to management of coral reef ecosystems?

Academically: BS Zoology from MSU

Work History includes: Research assistant at university and in industry in:

- Cardiovascular whole animal physiology
- Forensic and environmental toxicology
- GMP/GLP compliance
- NIH funded virology studies.

When I was working in industry I connected with a biochemist who worked in his spare time in Eritrea growing tilapia to try and feed Ethiopia. This made an impression on me. He was not at the time I spoke with him years ago getting anywhere....the politics and tribal wars were impeding efforts. Since I was a kid I was fascinated with marine ecosystems. Since high school, I figured out trips to Florida. When all the kids were headed to Lauderdale or Daytona, I continue on to the keys to dive. I used to hang out at the Long Key Shark Institute and watched growth studies on sharks and saw some of the initial mariculture attempts on different species. In college this usually resulted in me missing the first week of the nine week spring term...but I really loved that stuff and in my senior year, switched my major from biochemistry to zoology... When my husband was relocated to PR, I decided to pursue a different career with a focus on coral reef ecosystem conservation, and it seemed that my academic and work background in whole animal systems was transferable. The first thing I did in Puerto Rico was go to Caribbean Fishery Management Council and raid Miguel Rolon's library of papers. He had a great consolidation of information specific to Puerto Rico. I remember them looking at me like I was nuts. (can't really blame him there) At this time I was waffling about trying to propel some kind of conch or lobster mariculture, but stumbled on all the MPA papers by James Bonshack. ...I did not fully understand the challenges facing the ecosystem at that time. I studied for two months pretty intense and began interviewing old timers inside agencies who worked on coastal issues who were very kind and doused me with information...on Culebra as well. Stuff you probably would never find in any library. I naively thought I could easily get hired by one of the local conservation orgs, but they got a kick out of that. These are all trimly run orgs with little funding and no money for outsiders...understandably. So, with the help of friends at Reef Relief in Florida and set up our own org here...modeled on their grass roots issues approach. Ironic trying to establish a grass roots org in different culture with different language, but biggest challenge was that communities were so disempowered...nobody felt they could effect any meaningful change in the face

of the corruption in government. We formed connections on internet and learned about coastal clean water, coral disease, coral predation, diadema work etc.... Most important thing we learned was that the political problems were more or less the same everywhere. Today our partners also include Reef Ball Development Group for coral restoration jobs and always local commercial fishermen of Culebra After attending some government meetings on balanced fishery management regs and watching all the conflicts at CFMC meetings..... we decided to focus our energies with locals and in two areas:

- 1) making more fish
- 2) coastal clean water initiatives

At this time I was interested in Culebra and began doing historical research. Holy shit, this tiny isolated community got rid of the Navy! The guy who was mayor at the time, was active in the Fish Association. I learned as much as I could about the place on the ground and then went to meet the people. They were proposing an MPA.....They needed mooring buoys... These are both very long stories...but we learned about the history and began establishing a trust with the local fishermen, by letting them know what we knew. If you want more detail on this I can send but they are pretty long stories...and maybe not relevant here.

2. What mistakes have been made in the Louis Peña reserve? What things could have been done better?

If you mean things we could have done better, I would have to say we should have not assumed the agencies understood what goals we were trying to accomplish with the co-management proposal. The agencies move in a different culture and use a different language, almost as distinct as any other society, and I did not appreciate this. When we solicited their help, we should have made the objectives very clear about what we were trying to accomplish with the management plan and not assume they were exposed to the same research we were looking at. Our mistake was that we assumed too much when we engaged their help. There should have been clearly defined goals and an understanding among everyone that without enforcement you need compliance, and with a co-management agreement the point was to create a plan the people felt a part of. This is completely foreign to NOAA and to DRNA...they present stuff at public hearings, the people grumble, and then the plan is done.... This is not what we wanted...so what we wanted conflicted with their objectives and today I am not sure if it will ever be finished. . We made MPA signs in partnership with DRNA and the community so all people felt a part of the reserve. They were wooden, green and white with agreed upon text indicating locals proposed the reserve and asking for people to respect it. Then DRNA went to NOAA and got funding for aluminum international symbol “no” signs and put them everywhere. The people shot their signs and ran them over... If you mean the mistakes the government made, there were many violations of trust. The designation ceremony did not invite the fishermen who proposed the reserve, The demarcation buoys were installed in an area much larger than agreed upon with the agency. Two boats were given for enforcement but never utilized. One went back to big island after press conference. Vigilantes (DRNA enforcement personnel) had an officer who

regularly fished in the reserve. The reserve manager caught him....but they did not punish him, they moved him to better paying job in another gov. agency. DRNA announced on TV the Vigilante was poaching in the reserve and they caught him....validating everything people are afraid of about such a reserve....this will hurt the creation of reserves elsewhere. The reserve designated by administrative order, had no financing or plan for enforcement. This could have easily been done using fines...but financial management of this would perhaps not be possible given agency financial management problems (corrupt). The management plan encountered similar obstacles. It seemed the government did not want or did not understand the goal of co-management as we were looking at it. They fired Edwin, replaced him with political consultants to finish the plan all without consulting the fishermen who were on the steering committee. When I came into the picture the fishermen had already proposed a major conservation effort including protecting offshore cays nursery grounds etc...It was the agency who said no to this more comprehensive approach and due to financial reasons...they said they could not enforce. In the past, the reasons for the lack of enforcement were attributed to Vigilantes being related to the people in the area they patrol, but what I have since discovered is that there is a bit of an underground thing going on here. For example, we file complaints on illegal land clearing all the time....non point runoff has destroyed most of our coral. I reported a violation to DRNA, they approach the violators and explain that DRNA does not have an issue with you....but Mary Ann does...(sometimes this happens for stuff I don't even report). Then they tell the people they will obtain permits needed from regional office....and possibly this involves an exchange of money in a shoe box at some time. If people apply for land clearing permits legitimately their paperwork disappears in the regional office, so someone is working there as well. Permits are obtained, clearing continues and if we are lucky silt fences are improperly installed. We have to go to court! .It is hard to plan anything that has to function in the realm of how things are actually done, instead of how things are supposed to be done.....and right now we are in how things are done "landia"....If we talk to managers about problems they get defensive and insulted....they do not discuss management inadequacies in my opinion on an adult level...and if we don't discuss and resolve problems, it is hard to make any progress. We needed funding and we needed oversight to the process of defining a management plan. We knew it had to be made from the bottom up, and not the top down to be effective. The plan had give ownership to the people for compliance to the reserve to be realized....there also had to be some enforcement. DRNA wanted nothing to do with either of these needs. We did not effectively explain this to NOAA and DRNA. NOAA just wanted to have something defined on paper and DRNA wanted to maintain control of everything. We wanted the people to see their recommendations and solutions in the plan so they would be a part of the process and feel empowered and proud of the reserve. We hoped that this would reduce poaching since we never got enforcement.

3. What was the process for getting the government to create the reserve?

By the time we entered the picture the final reserve had been hashed out with the people and DRNA was telling us there needed to be more public education before it could be designated. What we learned was that the major users of the reserve were power boaters that were undoubtedly politically connected who visited Carlos Rosario on weekends with their families and enjoyed spearing anything that moved, including sea fans. We brought a bi-lingual exhibit from the Smithsonian Tropical Research Institute in Panama and set up 600 gallon touch tank system with sea grass, mangrove and small coral display in 1998. It was up on Culebra for over 3 months and then moved to San Juan. The display was mint...museum quality and then we went to discuss the designation of the MPA with the US coral reef task force in Washington explaining that there was an area proposed by local fishermen....and 20 years ago. In fall of 1999, the reserve was designated. It is my understanding that Vance Vicente started the ball rolling with the fishermen back when he worked for National Marine Fisheries, and Teresa Tallevast, the Refuge Manager, also spent time discussing benefits of an MPA. Don Monchin (Don Ramone Feliciano) came up with first plan very comprehensive. In 1994 I started attending some of the meetings. Quique Canovas was also pushing for a reserve, but as an attraction...or a Park and restricting take was not a concern of his. Three meetings were dedicated to whether it should be proposed as a park or a reserve. Sea Grant helped mentor the meetings....until finally it was agreed that you could not call it a marine park because local law did not recognize that designation.... It seemed a slow process. Some people were looking for Disneyland in the water...and DRNA was looking for *nobody* in the water and fishermen were thinking somewhere in between. People in the water visiting, but no exploitation.

4. What considerations should be made when seeking to implement similar reserves in different locations?

Agencies tend to focus on biological criteria, and indeed this is important, but if people fish in the reserve, you don't have a reserve...biological criterion or not. Social receptivity from multiple user groups, location regarding currents and biological diversity. Also beware of pending water quality concerns like dumps or river mouths even if impact is not evident at that date.

5. What motivated the local fishermen to ask the government to create the no-take zones?

1) personal knowledge and information provided by Vance Vicente and Teresa Tallevast.

2) no fish...at least older fishermen here saw the change...New fishermen have no idea what it used to be.

3) declining corals

6. How well do the local fishermen obey the fishing regulations?

Balanced fishery management regs are difficult to enforce. For the most part I think they all got their cards, albeit with some complaining because of expense etc... Initially, the reserve saw some compliance, but today I believe it is being poached. Locals say it is being poached by off island fishermen, but I know it is being poached by local community.

7. How has the reserve effected the fishing habits or target species for fishermen?

Subsistence fishers head out to Melones because large fish now aggregate around this point, and just outside the reserve. Outside of that, everything is targeted here. They still trap fish and anything goes. Rays, trunk fish, angel fish....everything. Not much left to target. They also spear with tanks...and anything they see. Long lining for sharks is on the increase as well. It seems everything is being taken everywhere which is one of the reasons the reserve was proposed. Fish studies showed that originally there was compliance at the reserve.

8. How has aquaculture affected the fishermen of Culebra?

The on land aquaculture has not really affected the fishermen. The off island cages is a good question. This project was partnered with the local association, but never really partnered as envisioned due to local interest. The fishermen are a bit apprehensive about the diving associated with the nets, it feels too dangerous for them. I am not sure if the project can survive without providing direct economic benefit. Association works with snapper farm in a more project coordinating capacity, which is at least something. Local restaurants still buy everything and snapper farm only produces one type of fish, so it is not hurting the local fishermen by out competing them. They export most of their fish.

9. Has the reserve been successful in revitalizing damaged coral reef areas?

Yes....and No.

Yes initially it stabilized the decline we were seeing. Most recently we saw almost total loss of live coral in an area where only last july had close to 100% live coral coverage in the reserve. This is most likely due to the higher sea surface temperatures caused by global warming and declining water quality from the bay...no waste water treatment plant.... Disease and algae are all that remain as of just a month ago.

Lauren Mathews, Ph.D.

When: Thursday, February 9, 2006

Where: Salisbury Laboratories 209, WPI

Interviewer(s): Benjamin Cleveland, Daniel Filipe, Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Discussion:

1. *What is your background education/research?*

She does research with tropical marine and fresh water ecology relating to one species or a group of species.

2. *How exactly will over-fishing in a coral reef area affect that coral reef's ecosystem?*

It is not an easy prediction, there are lots of possibilities and it depends on the food chain. It is important to understand that increasing coral reefs is not always a good thing too. Communities are very complex and therefore there is no simple answer, you need to look at what responses there are in different situations.

3. *How exactly will over-fishing in a coral reef area affect that coral reef's ecosystem?*

It's important to know that corals don't eat anything, they are known as a primary producer because they are photosynthetic. Fish caught high on the food chain are far from coral and the interactions between various species are extremely complex and it is difficult to understand what happens. It is also increasingly complex because there are so many different species in each coral reef ecosystem and every one is unique.

4. *How should we go about assessing the "damage" level to the ecosystem?*

You can't see what is happening because of over-fishing because it is not a controlled experiment. With the current regulation you probably can't conduct controlled experiments on coral reefs either. This makes it very difficult to assess the damage being done to an ecosystem from anything. It's also difficult to compare one ecosystem to another because every ecosystem is different.

5. *What would be an appropriate method for determining a sustainable fish population for the health and survival of the coral reef ecosystems?*

This question was answered in question 1.

6. *We read an IQP report that you advised last year in Puerto Rico, what do you know about the successes/failures/problems/issues of implementing ecosystem-based management?*

This area was not Prof. Mathews' specialty however she mentioned that the idea of ecosystem-based management is controversial because people don't want to make decisions.

Other items discussed:

We discussed what our problem statement means by determining the "feasibility" of implementing EBM and determined that this is something that we need to discuss with our liaison. We discussed how EBM is very general and she asked us who would own the aquacultures and fish raised if they were implemented.

Pilar Mendez

When: Friday, April 7, 2006 at 2:00 pm

Where: West Divers, La Parguera, Lajas

Interviewer(s): Benjamin Cleveland, Daniel Filipe

How: Semi-structured interview

Methodology: Ms. Mendez worked at a dive shop called “West Divers” in the small town of La Parguera. She was helpful in providing us with the perspective of people who dive in the La Parguera area.

Discussion:

- *We identified Ms. Mendez’s involvement at the dive shop and what the dive shop did for activities in the waters offshore of Lajas*
Ms. Mendez is an employee of the dive shop, but knew a considerable amount about where the dive shop took people out in the water and what they did for activities there. She said that they take people out on numerous snorkeling and scuba diving trips. While snorkeling, they typically visit the reefs known as “Enrique” and “Media-Luna” (half moon), but they are also looking for another reef to frequently take snorkelers to. When they take scuba divers out on trips, they go right to the shelf, what everyone commonly calls “the wall.” She mentioned how there are public-use buoys already on the reefs for boats to attach to when they go on their trips, but that the wall could use a buoy or two because as of now they have to set anchor, which is not good for the reef ecosystems out there.
- *We asked her about marine reserves and protected areas and what she thought about the current situation as well as the possibility of creating one in the area of La Parguera*
She believes that marine protected areas are a great idea for preserving the ecosystem and that this opinion is pretty much carried through the community for the most part. The only problem with possible implementation of a management plan on some of the reefs in the Lajas waters is that so many people use them for all sorts of reasons, from commercial to recreational.

Luis Moreno

When: Wednesday, April 4, 2006 at 1:30 pm

Where: Interviewee's residence, La Parguera

Interviewer(s): Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Background: Luis Moreno was the owner of a *pescadoría* in La Parguera.

Discussion:

- *We discussed Mr. Moreno's background*
Luis Moreno previously owned Rosados fish market in La Parguera. He has been a commercial fisherman for thirty years and continued to fish and sell it locally. He concentrated on Mahi Mahi, Wahoo, Kingfish (King Mackerel) and Tuna all being caught with either reel and rod or a handline. As the owner of Rosados, he had approximately twenty-five fishermen that sold to him and his business included driving to other parts of the island with his catch and theirs.
- *We discussed the marine reserve that was proposed for the Turrumote area*
He was familiar with the proposed Turrumote Marine reserve and said that it was a good project, but it had some problems. In Puerto Rico there were about 2000 licensed commercial fishermen and hundreds of recreational fishermen. In 2004 the law was passed that all fishermen needed licenses but since then only commercial fishermen had been required to get them because there was no process for selling them to recreational fishermen. He identified Turrumote as octopus grounds and no one really fishes there other than that. Turrumote is also the only place where a particular species of birds lays its eggs and they are buried under the sand. This happens in October until November and commercial fishermen know not to walk on the island during that time.
- *We discussed the La Parguera fishing community*
He estimated that 95% of commercial fishermen in La Parguera can't read, write, drive and don't have any schooling.
- *We discussed the current state of the fish populations in La Parguera*
There had been no problems with fish populations in the area. Ten years ago Pescadoria Rosa in Puerto Real was the largest in the Caribbean.
- *We discussed the seasonal closure regulations*
He believed that there should only be a two month closure, instead of three, for the red snapper and one instead of two for the grouper. He also believed that commercial fishermen should have different space than the recreational fishing. His idea was to close areas to fishing but have limited

permits for seasonal opens. The rule for Red Snapper was that it must be larger than 12" in length (about two pounds) and if it is not you need to throw it back. The problem was that you cannot tell the size of it until it is all the way up, and the species is typically at very low depths. In the process of pulling the fish up, the pressure changes so fast that the fish is dead by the time that it hits the surface. Another idea was that the reserves should rotate the reserves, maybe have Turrumote for a couple years and then change it to Caracoles and then Mata La Gata. Fish species restrictions would be good to rotate too and fishermen agree.

- *We discussed the possibility of a advisory board for a marine reserve*
For our potential committee board he suggested having a DNER representative, but mentioned that the DNER is difficult to work with.
- *We discussed the Tarpon fish*
His house was built over the water and there was a hole in his fillet table which he threw unusable fish remains and the Tarpon lived under his house waiting for the food. He said it was like a pet and he could catch them but they do not eat Tarpon in La Parguera. He said that San Juan does eat the Tarpon but he would much rather have it as a pet and garbage disposal.
- *Other contacts*
The son of the man that owns the Paradise Scuba and Snorkeling Center was also there and he agreed that Turrumote is a good location and fish would leave the reserve once they were mature enough.

Manuel Valdez-Pizzini, Ph.D.

When: Tuesday, April 04, 2006 at 3:15 pm

Where: University of Puerto Rico – Mayagüez

Interviewer(s): Benjamin Cleveland, Daniel Filipe

Methodology: Semi-structured interview

Background: Dr. Pizzini was the director of Sea Grant when the Turrumote reserve was proposed.

Discussion:

- *We discussed Prof. Pizzini's background and role at UPR..*
Prof. Pizzini is a social anthropologist and heads the interdisciplinary Center for Marine Studies at UPRM. This is a group made up of students and faculty at UPRM from biology, social science, engineering and many other backgrounds. He is also involved with NOAA's Coral Reef Ecosystem Studies (CRES), which comes up with innovative management strategies for ecosystems. Prof. Pizzini is in charge of the social component of the CRES which involves many interactions with fishermen (he did this for the Luis Peña reserve).
- *Marine Protected Areas*
The conversation then led into an overview of what exactly a Marine Protected Area (MPA) is. He gave us a report on the differences between all of the types of MPAs and the process involved in moving from one status to another. MPA is the general term used internationally and, more specifically, by NOAA. A Marine Managed Area (MMA) is basically the same thing, but with a terrestrial component as well. A marine reserve (or natural reserve) has no official rules or regulations on the activities that take place within them, but the DNER is responsible for creating management plans to permit/prohibit activities that will promote the conservation and protection of the areas. Without specific action by the DNER marine reserves are just "paper parks" that don't really mean much. Finally a No-Take Zone (NTZ) is an MPA with the highest level of restrictions on practices. The creation of a NTZ requires an administrative order from the secretary of the department. Prof. Pizzini expressed the importance of multi-use strategies with in MPAs and marine sanctuaries. Certain zones of the MPA can be NTZs, while others can have other regulations on fishing and/or other activities. There is a lot of confusion about the different types of MPA, and even among researchers the same terms are used to refer to different things. The goals and objectives unique to each location should be reflected in the regulations that are put in place. Each site around the world is created for a different reason, for example there are reserves in Florida that are designed to protect archeological sites. This is an example of a situation that regulations about anchoring

boats would make sense and fishing regulations wouldn't. The overlap of the jurisdictions of the different agencies is complicated

- *Proposed Management Plan for La Parguera*
La Parguera is currently a natural reserve (the government must consider all of the resources that are present). The scientific community wanted to make a marine reserve at Turrumote, the fishermen agreed, and Sea Grant got into the process. At that time Prof. Pizzini was director of Sea Grant and so he oversaw the project. However, by the time Sea Grant got involved political problems had grown up in this area which had a long history of political and social unrest and because there were so many complications the Turrumote reserve was never established. One of the main problems with a smooth process was the neighboring town of Papayo. They own the bioluminescent bay and the Turrumote reef is directly in front of Papayo, so the Papayo fishermen protested the idea of closing the area down for fishing. When the count of where the fishermen were fishing was made there were fishermen from Papayo fishing there but Prof. Pizzini doesn't think they actually fish there much. When the idea was presented to the local fishermen (of both La Parguera and Papayo, as well as other local towns) there was not much fish in the Turrumote area, so the fishermen were willing to close the area at first. But after the fishermen considered the proposed 5 year closure of Turrumote they remembered how (in the case of sea turtle capture banning) a 5-year time ban can quickly turn into forever. In the 1970's the US government instated a 5 year ban on the capture or harvesting of sea turtles, but due to international pressure the ban was never lifted. The fishermen remember this and don't trust the government much. They also feel that La Parguera is a test site for how the government will deal with a variety of issues such as speeding, crowding, stilt houses, etc. The government also questioned the 5 year plan because there was no solid factual basis for this time period and no one really knew if it would work or not. DNER was prepared to sign on the reserve if Sea Grant agreed, but this never happened because there were too many problems between the different groups that were involved. In the end, fishermen were willing, but it was not pursued. Prof. Pizzini believes that if the idea was picked up again now that the fishermen would be willing to consider it again. The overlap of the jurisdictions of the different agencies is complicated
- *We discussed the Marine Sanctuary that proposed for the La Parguera area*
The US dept. of the interior is in charge of protection of the bioluminescent bays of Puerto Rico. Tax law 936, which ended in 1995, provided different types of taxation for US corporations in Puerto Rico and had a profound effect on the economy of the commonwealth. A non-government agency was funded with part of this money and was in charge of the wetlands surrounding the bays. A marine sanctuary was proposed for the greater La

Parguera marine area (from Guanica to the shelf to Cabo Rojo) and would be protected under law (NOAA). The La Parguera sanctuary never happened though, after being proposed in the 1908's. Fishermen didn't know what a "marine sanctuary" meant, even after a base study in Vieques. The proposed management plan was called "The bioluminescent bays of Puerto Rico: a plan for their preservation and use" (1968).

- *We discussed the current status of the waters surrounding La Parguera*
La Parguera is a Special Planning Area which means that the government manages development of the surrounding terrestrial zone. The government has not done anything yet.
- *We discussed the possibility of incorporating aquaculture into a reserve plan*
Finally, Prof. Pizzini stressed the difference between aquaculture workers and fishermen. The difference is more than just a job description, it is a way of life. The fishermen fish because it gives them a sense of identity and freedom. They like being their own boss. One cannot expect the fishermen to simply switch over to working the fish-farm cages. A different type of person with a different set of technical skills is needed.
- *Dr. Pizzini suggested several other people that it might be helpful to speak with*
Talk to Graciella García at the Caribbean Fishery Management Council (CFMC) <http://www.caribbeanfmc.com/>. Contact Juan Agan, PhD (Juan.Agan@noaa.gov) who is an economist at the socioeconomic unit of the National Marine Fisheries Service (NMFS) in Miami. He is coauthoring a paper with Prof. Pizzini and David Griffith called "Entangled Communities" which is a profile of fishing communities in Puerto Rico and may be able to give us a copy of the report. <http://amp-pr.org/blog> is a good source of information. The DNER has the management plans for reserves.

Jose Ramos

When: Friday, April 7, 2006 at 11:00 am

Where: Magueyes Island, University of Puerto Rico - Mayagüez

Interviewer(s): Benjamin Cleveland, Daniel Filipe

Methodology: Semi-structured interview

Background: Jose Ramos works for the University of Puerto Rico and is also a fisherman.

Discussion:

- *We identified Mr. Ramos' background*
He has been fishing in the La Parguera area since the early 1970's, making him an excellent resource for questions pertaining to a history of fishing activities.
- *We discussed what exactly he does in the waters and where*
He mostly trolls around the Turrumote area and hook & line fishes too. When it comes to catching conch (when they are allowed to) it is Turrumote where the best conch are available. He sometimes takes groups of people out for various reasons too, even research. The "Laurel Reef" is also a great place to catch fish.
- *We discussed what he thought the fish and coral reef health/vitality trends have been since he began fishing in the waters decades ago*
He said that he has certainly noticed a decline in fish population and abundance since the start of his fishing career around 1972. He has taken scientists and students out on research trips in the past to collect samples of the coral reefs at Turrumote, these studies have shown that the coral reefs have been suffering as well.
- *We asked him what his/the fishing community's feelings on current fishing restrictions were*
The fishermen feel that the restrictions on mutton snapper, conch, and the other seasonal restrictions during spawning periods were a bit harsh. They are upset because when the restrictions are in place, it is much harder for them to make a decent catch and a living. It was good to learn that the fishermen (he thought) for the most part understood *why* the restrictions were in place, to preserve the population during a key point of the year, reproduction. They feel that if they were allowed to catch *some* of the spawning fish it would be fair.
- *We inquired about what the fishing community thought of the idea of implementing a no-take zone in the area of La Parguera*
He said that obviously money is an issue for fishermen; so if the government could give some sort of support for fishermen during the

restrictive periods in order to care for their families, they would all be in favor of it. Realistically this is not an option to the extent to which he was implying, but it is at least important to have the fishermen involved in the decision-making process. They tend to feel left out and then defensive when restrictions are imposed on them without consultation prior to implementation. We asked him what he felt about a 5-year closure of Turrumote, to all activities including scuba diving and snorkeling, not only fishing. He reminded us of the ban on turtle meet for “5 years” long ago, which was never lifted and is still in effect today. So basically if the fishermen get involved in the process they might feel better about trusting the scientists and authorities and might follow the restrictions more willingly.

Michelle Scharer (1)

When: Friday, April 6, 2006 at 4:15 pm

Where: Magueyes Island, University of Puerto Rico – Mayagüez

Interviewer(s): Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Background: Michelle Scharer is a student in the Department of Marine Sciences

Discussion:

- *We discussed Michelle's background*
Michelle did a project on the impact of fish traps on coral reefs. She looked at the impact and interviewed about fifty fishermen throughout Puerto Rico including Vieques and Culebra. She said that it was important to be straightforward with the fishermen. Her thesis focused on the spawning sites of different species of fish.
- *We discussed the relationship between fishermen and scientists*
She identified the fishermen to professor relationship to be a problem because scientific information is not translated into terms that fishermen can understand it and vice versa.
- *We discussed the current classification of La Parguera*
The keys of La Parguera make up a natural reserve which extends nine nautical miles out to sea. Past nine miles the Caribbean Fisheries Management Council, a part of NOAA is in charge of the waters as a part of the EEZ. A marine sanctuary is implemented under a Federal Act. The word 'sanctuary' means much more in Spanish but a sanctuary is not necessarily no fishing. In fact, in the Florida Keys there is a large marine sanctuary and there are very few no-take zones, instead it is more of a multiuse MPA.
- *We discussed our idea of a community meeting*
She believed that a community meeting is a good idea but it would be very difficult because there had been meetings previously and it was good information but bad confrontation between parties. For our fishing representative, she believed that a fish market "boss" would not be a good choice because a "boss" normally gets his employees to support him even if they do not agree.
- *We discussed the issues that we should focus on*
She said that we needed to explore how they feel about what happened at Turrumote and why, in terms of the fishermen not knowing benefits. Papayo was not consulted in terms of the proposed Turrumote Reserve so they became mad when they were trying to pass it. She also stated that

fishermen can see where the problems are more easily than scientists. For implementing a marine reserve, she mentioned that there are a lot of different perspectives and you need communication, trust and enforcement. Now there are many options for fishermen and it is unlikely fishermen will continue to exist.

- *We discussed the fishermen's response to fishing regulations*
The fishermen did not like fishing restrictions because of the short-term effects and because they do not understand any long term benefits.
- *We discussed other reserves*
She identified the National Estuarine Marine Reserve in Jobos Bay as an approved management plan (www.coralpr.net). Rincón and Desecheo have marine reserves recognized by the legislature and then given to the DNER for approval. This process is rare but it bypasses the initial DNER processes. In the case of Rincón, the reserve did not prohibit fishing.
- *We discussed several other contacts*
Michelle identified Carmen Delia as the manager of the Natural Reserve of La Parguera and she would be in charge of a marine reserve in La Parguera. She was in charge of mangrove pool regulations and Mata La Gata regulations. She identified Marcos Rosato as a fishermen and a researcher that would understand both sides.
- *We discussed current fishing regulations*
She said that fishermen of all types are required to get licenses but at the time of the interview only commercial fishermen could buy them as there was not yet a way to sell recreational fishing licenses. The number of recreational fishermen was increasing rapidly and fishermen were complaining about unequal enforcement of the laws.
- *We discussed sources for further documents*
The DNER office North of Mayagüez had statistics and interview information for projects with the fishermen. The contact there is Grisel Rodriguez. The DNER of San Juan had a template for the information necessary to make a management plan and was used in both Culebra and Rincón. The DNER has a steering committee consisting of a community representative, a local NGO, a university representative, and a municipality representative.
- *We discussed the different categories of reserves*
Marine Protected Area is an area defined by law, with boundaries, that includes ocean or tidal influence by the sea. Under MPAs are sanctuaries, national parks, national estuarine reserves, state or community parks, marine reserves (not necessarily no-take zones), seasonal closures and

multi-use. There are thirty-seven MPAs in Puerto Rico, eleven with staff and some without a budget at all.

- *We discussed the process of setting up a marine reserve*
The process for setting up a marine reserve is for the DNER to send a document to the planning board for approval and then to public hearings for approval, the state department for making the law and then finally the implementation. Without money there is no way to implement the management plan. The money generally comes from the government of Puerto Rico and it is very hard to get. There is money made from the reserve which goes to the DNER and dissolved through the company and does not pay to operate the reserve.
- *We discussed the mayor's opinion on reserves*
The mayor is not in favor of reserves because he would like to develop the land and cannot due to the numerous reserves in the area. She suggested asking him why isn't a reserve good for tourism and to think about the long-term economics.

Michelle Scharer (2)

When: Wednesday, April 26, 2006 at 5:45 pm

Where: Magueyes Island, University of Puerto Rico – Mayagüez

Interviewer(s): Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Background: Michelle Scharer is a student in the Department of Marine Sciences

Discussion:

- *We discussed the differences in marine protected area designations*

Marine Managed Area=The term marine managed area (MMA) encompasses a broader spectrum of management purposes. It includes protection of geological, cultural, or recreational resources that may not fall under the official U.S. definition of MPAs.

Marine Protected Area=Not too different is the definition in Marine Protected Areas Executive Order 13158. This defines an MPA as "any area of the marine environment that has been reserved by Federal, State, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein" (Federal Register, 2000). Under this broad definition, a wide variety of sites could be considered as MPAs. (http://www.mpa.gov/information_tools/archives/what_is_mpa.html#varying)

Multi-use MPA=A marine protected area that is zoned for a variety of uses...

Marine Reserve=A type of MPA which in some cases implies a fishing prohibition

Natural Reserve=Type of MPA in Puerto Rico

Commonwealth Forest=Type of MPA in Puerto Rico

Insular Forest=Type of MPA in Puerto Rico

Biosphere Reserve=Biosphere reserves are sites recognized under UNESCO's Man and the Biosphere Programme which innovate and demonstrate approaches to conservation and sustainable development. They are of course under national sovereign jurisdiction, yet share their experience and ideas nationally, regionally and internationally within the World Network of Biosphere Reserves. There are 482 sites worldwide in

102 countries. (<http://www.unesco.org/mab/BRs.shtml>)

Critical Habitat="Critical habitat" is defined as: (1) specific areas within the geographical area occupied by an endangered species, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation. The National Marine Fisheries Service has designated critical habitat for the threatened green sea turtle to include coastal waters surrounding Culebra Island, Puerto Rico, and the endangered hawksbill sea turtle to include coastal waters surrounding Mona and Monito Islands, Puerto Rico. This Endangered Species Act designation of critical habitat provides explicit notice to Federal agencies and the public that these areas are vital to the conservation of these species. The formal announcement of this designation appeared in the Federal

Register on Sept. 2. (<http://www.epa.gov/fedrgstr/EPA-SPECIES/1998/September/Day-02/e23533.htm>)

Natural Estuarine Research Reserve=The National Estuarine Research Reserve System

is a network of protected areas established for long-term research, education and stewardship. This partnership program between NOAA and the coastal states protects more than one million acres of estuarine land and water, which provides essential habitat for wildlife; offers educational opportunities for students, teachers and the public; and serves as living laboratories for scientists. (<http://ctp.uprm.edu/jobos/>)

Marine Sanctuary=US Federal govt. level (NOAA) type of MPA/The National Marine Sanctuary System consists of 14 marine protected areas that encompass more than 150,000 square miles of marine and Great Lakes waters from Washington State to the Florida Keys, and from Lake Huron to American Samoa. The system includes 13 national marine sanctuaries and the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, which is being considered for sanctuary status. (<http://sanctuaries.noaa.gov/about/faqs/welcome.html>)

No-take Zones=Areas where fishing is prohibited for all species (this may be a zone within an MPA)

Seasonal No-take Zones= Area where the fishing prohibition is not year round, but instead it during a season (here it is the 3 months of grouper spawning on the west coast of PR)

We also had a question on the government organizations that control

MPAs in Puerto Rico= The Department of Natural and Environmental Resources (DNER)(<http://www.coralpr.net/index.php>) has jurisdiction over all MPAs under 9 nautical miles from the coast, NOAA only has jurisdiction further from those 9 nm.

We have found that NOAA or the federal government controls the areas but the DNER also plays a role. = DNER controls and NOAA also plays a role

Which organizations control the process of developing management plans (=DNER) and does the federal government have control over this process (not directly, but in some cases they are funding projects to help in the development of management plans)

Are there jurisdiction issues between the federal and state governments? We think that Puerto Rico is a unique case due to its Commonwealth status and therefore confusion exists between different levels of government. You are correct!!! much confusion exists (on all sides, managers, administrators, scientists, public, etc...) and some issues will never be resolved!!!

Are there any other organizations involved in the creation/management of these areas? the PR Planning Board must finally approve the management plan after it goes to public hearings....

We received a document from Manuel Valdez-Pizzini of which you and Alfonso Aguilar-Perera were involved. We were not sure of Alfonso's or your backgrounds (graduate student, doctor, etc.) and would like to refer to each of you correctly.

Dr. Aguilar Perera is a graduate of UPR-M Dept. of Marine Sciences and is now in Mexico soon to be a professor at the university there.

I am a PhD candidate, and I expect to graduate in about 2 yrs...

I hope this helps and do not hesitate to contact me again if you need to. Good luck

Manuel Torres

When: Friday, April 7, 2006 at 3:15 pm

Where: Magueyes Island, University of Puerto Rico - Mayagüez

Interviewer(s): Benjamin Cleveland, Daniel Filipe

Methodology: Semi-structured interview

Background: Mr. Torres is a ranger for the municipality of Lajas. He was useful in getting input on the enforcement considerations necessary for a successful marine reserve.

Discussion:

- *We first discussed his job as a ranger and what it entailed*
He equated his job to basically a state police for Puerto Rico. He carries a gun and can give tickets just like regular officers of the law, and has been working at this job since 1999. His job description is essentially just law enforcement on the waters. There are a number of restrictions on what and when people can catch on the waters, for both commercial and recreational fishermen.
- *We asked him about any current problems that he had with his job*
He said that people frequently break the laws and restrictions in place that are designed to save certain marine populations during their breeding periods. The conch ban that begins next month, for instance, has a \$500-\$1000 fine *per* individual conch in one's possession during the ban. Ranger Torres said that last season he stopped a boat and found over 150 conchs on it, which was obviously a considerable fine for the fishermen.
- *We asked him if more restrictions, as in a new marine protected area, would mean a big change in his job*
He seemed to think that another reserve would not be a drastic change in what his job entailed. Yes, he would need to patrol more waters if there was another marine protected area, but as in a no-take zone it would be rather black-and-white whether or not someone was breaking the law.
- *We discussed in brief the Luis Pena reserve in Culebra*
We were under the impression that there was no patrolling of the Luis Pena reserve waters since 2002 and that led to a decline in coral reef health and fish populations. Ranger Torres informed us that there is and has been 5 rangers and 1 lieutenant working around the whole island of Culebra, including the waters of the Luis Pena reserve. This was interesting to learn, especially since it completely contradicts what we were under the impression of prior to this interview.

Rafael Vargas

When: Monday, April 17, 2006

Where: Papayo, Lajas

Interviewer(s): Jeffrey Pelligrino, Edward Robinson

Methodology: Semi-structured interview

Background: Rafael Vargas is a fisherman from Playa Santa that has been fishing his whole life in Lajas and is familiar with fishing techniques in Papayo.

Discussion:

- When fishing licenses were first required, Vargas sent in his check to get a license but has still not received it.
- He was familiar with Turrumote but said that people did not fish there. Because no one fishes there already, there would be no problem with a marine reserve there.
- He used to fish with by diving with a spear gun to depths of forty-five feet.
- In the last ten years he has noticed a decline in the number of red snapper and king fish.
- Vargas believed that there were only ten to twelve fishermen from Papayo.

Appendix H – Sponsor Description

The University of Puerto Rico (UPR) school system contains twelve campuses which are located throughout the island (Universidad de Puerto Rico [UPR], 2006). The Board of Trustees, a University Board, and the President of the University of Puerto Rico manage the budget of the entire university system. This group also appoints a Chancellor responsible for the development and financial concerns of each respective campus. The academic procedures and policies of UPR are determined by an Academic Senate comprised of both faculty and students. The mission of the University focuses on two main objectives: transmitting and enhancing knowledge through the arts and sciences and contributing to the development, cultivation, and enjoyment of the aesthetic and ethic values of culture.

The main campus, located in Rio Piedras, employs 1,026 educational staff along with 1,336 regular staff to serve a student body of 12,136 undergraduate and graduate students (University of Puerto Rico – Rio Piedras [UPRRP], 2006). The University at Rio Piedras serves the northeastern Puerto Rico area with technical, theoretical, and practical knowledge and maintains high standards in the education of its students.

The University of Puerto Rico – Mayagüez (UPRM) is located on the western side of the island. In addition to providing higher education to the people of Puerto Rico, UPRM facilitates research and development projects in cooperation with government agencies and private organizations (University of Puerto Rico Mayagüez [UPRM], 2006). These projects address a wide array of

topics ranging from those that are industrial and corporate in nature to those that deal with biological and environmental issues. In conducting these projects, UPRM seeks to improve the quality of life for Puerto Rico's inhabitants and visitors, as well as the people and other organisms living in the surrounding area.

Our liaison, Dallas Alston, Ph.D., works in the Marine Sciences Department at UPRM and understands the importance of protecting coastal marine areas in Puerto Rico (UPRM, 2006). The Department consists of twenty-three faculty members, fifty-one graduate students and thirty-six students pursuing doctorate degrees. Students specialize in the fields of Biological Oceanography, Geological Oceanography, Physical Oceanography, and Marine Chemistry. The main research activities of the Marine Sciences Department occur at the extensive laboratory facility that they operate on eighteen-acre Maguëyes Island, twenty-two miles from the main campus. This facility includes a number of laboratories, hatcheries, and classrooms along with several boats used for research purposes.

As a member of the Sea Grant University system, the University of Puerto Rico – Mayagüez is among the ranks of thirty universities throughout the United States concentrating on the relationship of coastal communities and their environments (UPR Sea Grant College Program, 2006). The goal of the Sea Grant Program at UPRM consists of educating communities about the importance of conserving and wisely using the coastal and marine resources in ways that benefit the entire population and the Caribbean in general. The Program implements research programs concentrating on the effects of coastal

community actions and the related outcomes within the surrounding marine ecosystems.

The University as a whole is in agreement with many other universities and organizations around the world on the importance of ecosystem-based management and the role that it plays in the repopulation of various species (UPR, 2006). Also focusing on the assessment, monitoring, and restoration of coral reefs is the National Coral Reef Institute, as part of Nova Southeastern University in Fort Lauderdale, FL. This organization creates partnerships with universities throughout the United States, including the Commonwealth of Puerto Rico (NCRI, 2006). The U.S. National Oceanic and Atmospheric Administration's involvement with ecosystem-based management includes projects in seventy-two countries worldwide and fifty-four additional projects in the preparation stages (NOAA, 2006).