Report Submitted to:
Professor Dominic Golding
Professor John Zeugner
Puerto Rico Project Center

By
Caitlin Macko
Doug Tischer
Kyle Wessling
Eva Zipkin

In Cooperation With

Dr. Craig Lilyestrom - Director of the Marine Resources Division
Puerto Rico Department of Natural and Environmental Resources

Assessment of Chartered Dive and Snorkel Operations in Puerto Rico

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This project report 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 Puerto Rico Department of Natural and Environmental Resources or Worcester Polytechnic Institute.

This report is the product of an education 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 project, sponsored by the Department of Natural and Environmental Resources in Puerto Rico, sought to aid in the transition from an outdated recreational fishing reporting system to a more modern one. A list of all chartered dive and snorkel operators on the island was compiled and information collected on their marine species collection habits, particularly with regard to queen conch and spiny lobster. While nearly all operators have access to the internet from their business, the vast majority of them do not collect any marine species, making frequent internet reporting unnecessary. This report also offers recommendations for improving tense relations between chartered operators and the DNER, with the shared goal of improving marine resources.

Executive Summary

Introduction and Methodology

Traditionally it has been thought that because of its large scale and organization, only commercial fishing activities can have a significant impact on marine stocks. However, studies have shown that recreational fishing can also have significant impacts on marine populations. Governments in the Caribbean realize the importance of protecting their marine resources, as it is a major draw for tourists, who contribute significantly to the area's economy. As a result, regulatory agencies such as the Department of Natural and Environmental Resources (DNER) have taken measures to ensure the ocean's sustainability for both commercial and recreational uses. In Puerto Rico and elsewhere, the Marine Recreational Fisheries Statistical Survey (MRFSS), a survey tool developed by the National Oceanic and Atmospheric Administration (NOAA) in the 1970s, is no longer adequate to effectively monitor recreational fishing activities. A new recreational monitoring program, the Marine Recreational Information Program (MRIP), is being phased in to replace the MRFSS. At its core will be a national registry of recreational fishers, which is divided into three parts: private, shoreline and chartered fishing. This project compiled a list of the chartered portion of this registry in Puerto Rico and collected information about the practices of chartered businesses, particularly with regard to spearfishing and the collection of queen conch and spiny lobster.

The goal of this project was to collect detailed data about chartered diving and snorkeling activities, to help the DNER to complete the National Registry of the MRIP and to determine whether or not monitoring of chartered dive operators is necessary. The first stage of the project entailed locating and surveying chartered fishing operators in order to obtain current information about their business size, vessels, catch by species, techniques used, and customer volume through personally delivered structured inquiries. Once all surveying was completed, the data were analyzed in order to develop a snapshot of the nature and scope of chartered diving and snorkeling business activities on queen conch and spiny lobster. The results of this project will be incorporated into the methodology of a current project at the DNER for monitoring chartered fishing activity.

Results

List of Dive Operators

Through internet research, tourist magazines, and an existing list from a previous study performed by García-Moliner in 2002, a total of 79 chartered dive and snorkeling operators were identified as potential candidates to be surveyed. After making phone calls to verify business locations and visits to listed addresses, most (55) of these initial contacts had to be eliminated because they were no longer in business. Twenty-four (24) operational businesses were identified. Seventeen (17) additional dive operators were identified through snowball references during the surveying process, resulting in a composite listing of 41 dive operators. The project team contacted all 41 operators. Two operators refused to participate and 2 businesses failed to return the questionnaire after repeated requests, resulting in a total of 37 completed questionnaires.

Survey Results

The results of our census provided information about species collection, excursion locations, customer volume, and other details of the chartered diving and snorkeling industry. Of the 37 survey respondents, 19% (7 respondents) allowed their clients to collect marine species during chartered excursions. Of these businesses, only three (3) reported that their customers had collected queen conch and spiny lobster. Fifty-four percent (54%) of dive operators reported a decrease in queen conch and spiny lobster populations over the past 5 years. Eight percent (8%) of chartered operators reported they allow their customers to spearfish during their chartered excursions. The busiest season for chartered businesses was April through June, while the slowest season was October through December. Tourists are the primary customers of chartered businesses (54%), followed by Puerto Rican residents (32%). Fourteen percent (14%) reported that both tourists and Puerto Rican residents are their primary customers. The majority of dive operators (63%) utilized boats for chartered excursions more than 31 feet long. The areas that experienced the greatest amount of diving and snorkeling activity are Humacao, Fajardo, La Parguera, San Antonio, Desecheo Island, southeastern Culebra, and southern

Vieques. Finally, the majority of businesses (77%) indicated that they had convenient access to the internet.

Open Ended Responses

The open ended response question of our survey allowed respondents to make known their opinions of our study and any other aspects of the chartered industry. Their feedback exhibited many trends, including environmental consciousness of the majority of dive operators and firm opinions about the conservation of the marine environment including coral reefs and marine species. Many respondents also demonstrated frustrations with the current state of law enforcement among the fishing industry, both commercially and recreationally. According to several respondents, there is an apparent lack of enforcement of basic laws, such as size limits on conch and lobster and no-take laws for female lobsters with eggs that are in place to protect these marine species.

Conclusions

According to the responses, there is very little collection of marine species by clients of chartered operators. Of the seven operators that indicated they allow clients to collect species, only three allowed the collection of conch and lobster while the rest allowed the collection of species such as reef fish, blue water species, white coral, sponges, sea urchins, and others. As few operators stated that they have had clients collect marine species in the questionnaire, it would most likely be unnecessary, and even counter-productive, to try forcing operators to report landing numbers on a regular basis.

Although there are some respondents who disagreed, the majority of the responses indicated they have noticed a definite decrease in spiny lobster and queen conch populations around the island during the past 5 years. This apparent decline could have been caused by many factors, such as overfishing by other recreational divers (private) or commercial divers. The decreasing populations could also be a result of divers catching these species when they are under the size/length limit or during the breeding season. These perceived decreases are not based on any 'hard' ecological data, however, and further research will be necessary to determine the nature and extent of any population changes, the possible causes, and what conservation efforts may be warranted.

Fifty-eight percent (58%) of surveyed chartered operators have a mostly tourist-based clientele. Many respondents indicated that spiny lobster and queen conch populations may be affected much more by local private divers than by tourists on charter boats.

According to our questionnaire results, a web reporting system as a part of the MRIP would be technically feasible for chartered operators, as an overwhelming majority have access to the internet from their business. Unfortunately, it is difficult to determine just how responsive and cooperative the operators would be if a web reporting system were implemented. Many of the respondents have a negative view of the DNER, believing that the taxes they pay are going into a "central fund" and are not being properly managed to specifically protect and improve the resources their business uses. Since so few operators allow collection of conch and lobster, it would be more practical for the MRIP to focus monitoring efforts on other types of recreational fishing such as private and shoreline fishing. An online reporting system would likely encounter much resistance from chartered operators and provide limited data on the collection of conch or lobster.

Recommendations

1. *All chartered dive operations should be added to the national registry of the MRIP until further investigation can prove that they are not in any way affiliated with the general fishing community.*

It has been discovered through our questionnaire that very few dive operators appear to allow their clients to collect marine species or spearfish. However, it was difficult to gauge the reliability of the responses we received from our questionnaire, since many dive operators claimed that they did not allow their clients to spearfish or collect marine species, yet there were several photographs in dive shops of people holding lobsters, touching marine species, and spearfishing. There were also mounted lobsters and conch shells in the offices of several dive shops. These photos and displays, on the other hand, could have been taken by the dive operators during their own private time, and may not have been taken by clients during chartered excursions

2. *Additional research is necessary to characterize the effects of chartered diving and snorkeling on marine resources. Studies should be performed in the following areas:*
    - *Research on private divers and snorkelers to collect data on their collection habits, locations and landings with regard to queen conch and spiny lobster.*
    - *Dive intercept surveys in popular dive and snorkel locations.*
    - *Official counts of conch and lobster populations.*

Many operators have noticed a decrease in both queen conch and spiny lobster populations in almost all areas chartered operators visit. From the questionnaire responses, many operators noticed a decrease in both conch and lobster populations in Desecheo Island, off the east coast of Fajardo, south of Culebra, south of Vieques and east of Humacao. Special attention should be given to these areas before the decrease in populations becomes irreparable. Some research has already been conducted by the Fisheries Research Lab's SEAMAP (South East Area Monitoring and Assessment Program) to monitor numbers of conch and lobster populations, but it needs to continued and expanded in order to determine the nature and extent of population changes. Dive intercept surveys in popular dive and snorkel locations would also provide further information on how marine resources are affected by charters. The map in Figure I below contains information about the popularity of locations visited by dive and snorkel charters.

Figure I: Map displaying all of the different dive and snorkel sites used by chartered operators. Numbers on the map indicate the average number of visitors per week.

3. *The DNER should strengthen its relationships with chartered dive and snorkel operators through more effective and equitable enforcement of existing regulations.*

Feedback from our questionnaire indicates that many dive operators are displeased with the enforcement of existing regulations. Most dive operators are content with the current regulations and are appreciative that marine habits and species are being protected, but they feel that size and bag limits are not being properly enforced, and that regulations are not well known to the public. Another major concern is the regulation of illegal operations. There are regulations in place including licenses and permits that need to be obtained in order to legally operate, but according to some dive operators there are several businesses that do not acquire licenses, and do not follow regulations because the DNER does not recognize them as legal chartered operators.

4. *The DNER should increase the number of mooring buoys in an effort to demonstrate how tax monies are being utilized for improvements of marine resources.*

Through conversations with dive operators during the questionnaire, two important points emerged that would help the DNER to improve its image. First, dive operators feel that their tax money is being placed into a central government fund rather than being used to improve marine resources. Second, increasing the number of mooring buoys would please many dive operators and demonstrate how their tax money is being utilized. Such buoys would also help to reduce damage to the marine resources, especially coral reefs and sea grass beds. Several operators have stated that there are more boats at popular dive location than there are mooring buoys. Boats, either private or chartered, will sometime circle a buoy waiting for a boat to leave and then race to it in order to moor. This example clearly shows that captains are eager to help protect the reef by using mooring buoys if they are available. However, chartered operators reported being forced to drop anchor when all the buoys are full.

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Authorship Page

All writing, editing and revisions were done equally by all members of the group.

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Introduction

Puerto Rico is known for its clear waters and abundant marine wildlife. However, marine ecosystems are hugely complex and it is a difficult task to monitor all of the interacting components. Overlapping human activities can have serious negative impacts on individual species or the marine community as a whole. Ecological deterioration and declining marine wildlife populations may be due to one or many causes. A cursory glance at the marine ecosystem may overlook species that are in need of protection. Detailed studies of contributing human activities are needed to ensure the lasting health of all marine species and to ensure human beings are good stewards of their natural surroundings.

In the United States, commercial fishing activities land an annual catch of 80.47 million metric tons of marine fish and invertebrates, while recreational activities land 10.86 million metric tons as of 2004 (Cooke, 2004). Because the US recreational catch is on average 10% of the US commercial catch (Coleman, 2004), it is sometimes assumed that recreational fishing is not to blame for declining fishing stocks. But this statistic would overlook that recreational fishing frequently focuses on a handful of accessible species, which are often not targeted by the commercial fishing industry. Figure 1 shows the dominance recreational fishing can exert on a targeted number of marine species (Cooke, 2006). Recreational fishing lands more Striped Bass, Dolphinfish, Red Drum, Bluefish, Spotted Seatrout, Yellowfin Tuna and King Mackerel than commercial fisheries in the United States (Cooke, 2006). There are also striking exceptions where recreational fishing comprises well over 10% of the total catch. In the Gulf of Mexico, recreational fishing outpaces commercial fishing, being responsible for 64% of all fish caught (Coleman, 2004). Figure 2 shows the commanding role recreational fishing has played in the Gulf of Mexico from 1981 -2002 (Coleman, 2004). Although on average commercial fishing overshadows recreational fishing, recreational fishing can have a significant impact on specific marine species in specific areas.

Figure 1: The percent contribution of recreational (grey) and commercial (black) fishing to the top 10 most popular recreational marine species to catch in the United States. (Cooke, 2006).

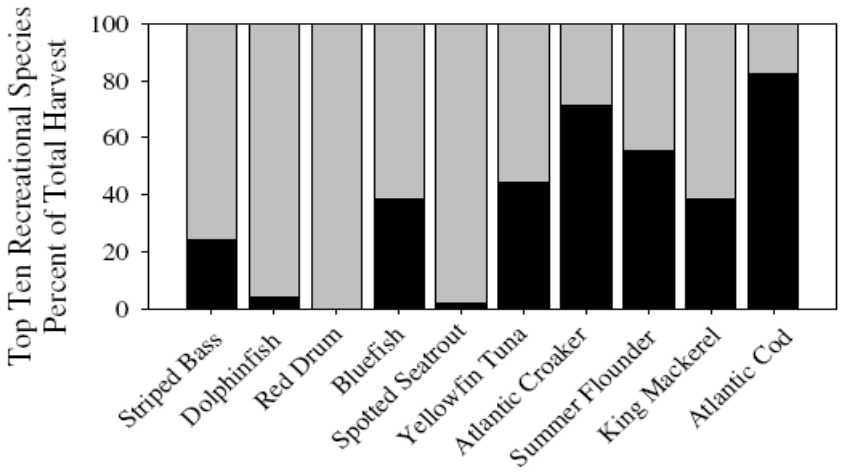
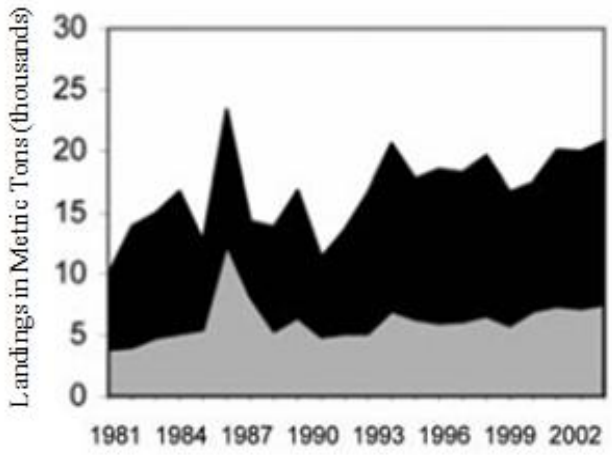


Figure 2: Annual landings in metric tons (MT) of commercial (black) and recreational (grey) fishing in the Gulf of Mexico from 1981-2002 (Coleman, 2004). Please note that shaded portions stack, and represent the percent contribution of each sector to the total landings in the Gulf of Mexico.



The mechanism in which commercial fishing can impact marine habitats is well known. Bottom fishing gear can physically scar the ocean floor, abandoned traps can continue to catch animals and bycatch which can greatly increase the number of individuals harmed or killed beyond reported landings (Cooke, 2006). Although recreational fishing is in general more targeted, it does present its own set of problems.

Left over fishing materials, such as lines and weights, can cause habitat damage. In the Florida Key National Marine Sanctuary, fishing debris caused 84% of the damage to sponges and corals (Cooke, 2006). Catch and release methods are also not as benign as generally believed, and can lead to the permanent injury or death of the released fish. For example, in 2003 it was reported that in the Eastern United States, 12.5 million striped bass were caught with over 90% being subsequently released. Of those, there was a 28% death rate, meaning recreational release activities killed 3.2 million striped bass in one year (Cooke, 2006). Recreational fishing can have a major impact on marine populations, and its effects need to be considered thoroughly in order to develop complete and effective management plans for marine populations.

The Department of Natural and Environmental Resources (DNER) of Puerto Rico is charged with monitoring and managing ocean waters to 9 nautical miles from the coast (Aguilar-Perera, 2006). This is an important duty, as 85% of all fishable waters reside under state control in the US Virgin Islands and Puerto Rico. Fishable waters are defined as waters less than 100 fathoms deep (CMFC Environmental Impact Statement, 2004). While DNER has established a system to track commercial fishing activities in Puerto Rico, there is a dearth of information about recreational and chartered fishing activities (including spearfishing, trapping, and diving) and their impacts on non-fish marine wildlife. More generally, the lack of recreational and chartered fishing information is a problem for the whole Caribbean. The Caribbean Fishery Management Council, which is in charge of regulating federal waters, sums up the current monitoring system by saying, "there is a trivial amount of information on the U.S. Caribbean recreational fishery" (CMFC Environmental Impact Statement, 2004, p.15). This lack of information is in part due to the lack of effectiveness of the current system (Marine Recreational Fisheries Statistical Survey, MRFSS) for recording landings of non-fish marine wildlife by chartered fishing operations. To address these shortcomings, the DNER would like to implement a more effective system known as the Marine Recreational Information Program (MRIP) to help monitor chartered fishing operations in Puerto Rico. (See Appendix A for more information regarding the DNER.)

Preliminary information indicates that populations of many marine species in Puerto Rico are declining, as judged by the decreased harvests reported by fishermen

(CFMC Environmental Impact Statement, 2004). Further research is needed to see if the populations of queen conch and spiny lobster specifically are also declining. Some research has already been done by the Fisheries Research Lab's SEAMAP (South East Area Monitoring and Assessment Program) to monitor numbers of conch and lobster populations, but it needs to continue in order to draw conclusions about exactly how much declining populations are being impacted. Both of these species are regulated, however the DNER would like to be more informed about landings of these species by recreational fishers. In particular, the DNER needs information regarding the spatial and temporal distribution of chartered landings of queen conch, spiny lobster and whelk. If their populations are in fact declining, the group's findings will assist the DNER in determining if chartered fishing businesses are contributing to the trend. Without research, it would be impossible to tell if the chartered impact on conch and spiny lobster is around the national average of 10% of total harvest, or if it represents a case of species targeting where recreational and chartered fishermen could be the dominant influence.

If the impact of chartered fishing is significant, conservation efforts may become essential to the continued existence of these non-fish marine animals. Policies exist to protect non-fish species such as spiny lobster and queen conch, but a complete list of chartered diving operations in Puerto Rico is lacking and is needed to fully implement the MRIP. Information distilled from in-person questionnaires of the dive operators will be necessary to fully inform the DNER about recreational fishing habits for the collecting queen conch and spiny lobster in Puerto Rico. The collected data will give the DNER a better idea about whether or not queen conch or spiny lobster are strongly affected by chartered dive operators and allow them to fulfill their mission of effective marine management.

The ultimate goal of this project will be to collect detailed data about chartered fishing activities, to allow the DNER to enact informed marine resource policy and management plans. The first stage of the project will entail locating and surveying chartered fishing operators in order to obtain current information about their business size, vessels, catch by species, techniques used, and customer volume. Once all surveying is complete, the data will be analyzed in order to develop a snapshot of the impact of

chartered fishing. The results of this project will be incorporated into the methodology of a current project at the DNER for monitoring chartered fishing activity.

The remainder of the report consists of a background literature section presenting background research that is relevant to this project, a methodology section describing how the data will be gathered, a results section presenting the data, and a conclusion section describing the importance of the data. Appendices of lists, procedures, interviews and background information too detailed to include in the report have been added and should complement any reading of the report.

Literature Review

The tropical waters of Puerto Rico and the Caribbean attract diverse populations of fish and marine invertebrates. In turn, these bountiful resources attract the attention of commercial and recreational fishermen. Unfortunately, the fishermen and marine resources do not always exist in harmony, and it is becoming increasingly clear that a greater understanding of their relationship is needed. In the Caribbean and Puerto Rico, the growth of tourism and chartered fishing may be straining queen conch, spiny lobster, and whelk populations. This review focuses on the history and current state of both commercial and recreational fishing, their environmental impacts, efforts at regulating fishing activities and gaps in existing methods of monitoring that need to be addressed.

Types of Fishing

There are three main types of fishing that are examined in this review: commercial fishing, recreational fishing, and chartered fishing. Commercial fishing includes all fishing activities that are done for profit, while recreational fishing consists of individuals who fish for the enjoyment of the sport and do not profit from their yields. Chartered fishing is a subset of recreational fishing in which a customer pays to be taken to fishing locations, often inaccessible from land. Equipment may or may not be provided. Currently in Puerto Rico, there are laws that regulate the commercial fishing industry, and commercial fishers are required to hold licenses in order to operate. There is also a monitoring system in place for commercial fishers to report their landings. Prior

to 1999, there was no existing system for monitoring the catch of recreational fishers in Puerto Rico. Since then, recreational fishers have participated in the Marine Recreational Fishing Statistics Survey (MRFSS), a federal program which collects data about recreational fishing practices nationwide, including Puerto Rico. However, this survey only gathers information about finned fish landings. The DNER is currently working on a project to collect more specific information than the MRFSS is capable of collecting. Licenses are not required for customers of dive operations, because they only fish intermittently and are frequently tourists. The following review will evaluate the nature and impacts of these three types of fishing.

Commercial Fishing

In 2001, there were approximately 2,023 commercial fishers in Puerto Rico, which increased from 1,973 in 2000 (CFMC, 2004). Each of these fishers is required to have a fishing license according to local laws. Landings of commercial fishers have been monitored by the Fisheries Research Lab, better known as el Laboratorio de Investigaciones Pesqueras (LIP) in Puerto Rico, since 1969.

Commercial fishers can use many methods to catch fish and the popularity of each method has changed over time. Just over a decade ago, traps were the primary fishing method. In 2001, the census recorded 15,481 traps; the majority of them were fish traps and 28 percent were lobster traps. Through the years, there has been a major decrease in the use of traps, which is likely due to the efficiency of other types of gear such as fishing lines, trammel nets, gillnets, and diver-based fishing (Griffith and Valdés-Pizzini, 2002). Seventy-seven percent (77%) trap fishers target reef fish and spiny lobster, 13% of trap fishers target only reef fish, and 10% target only lobster (Scharer *et al.*, in press). Between 1998 and 2001, port samplers recorded 13,620,481 pounds of fish and shellfish that were caught by commercial fishers in Puerto Rico. Spiny lobster accounted for 9% of all catch totals by weight, which was more than any other species examined. Queen conch was a close second at 8%. Individually each species was nearly double the total tuna catch of 5% (Matos-Caraballo, 2002; CFMC, 2004).

The United States Virgin Islands (USVI) requires all commercial fishers to report catches in order to obtain or renew their fishing licenses. In contrast, "Commercial fishers report their catches voluntarily in Puerto Rico, although the government does

provide economic incentives to encourage reporting" (CFMC, 2004). Puerto Rico faces the additional problem of foreign vessels operating within its jurisdiction, which extends nine nautical miles from shore. The DNER is not aware of whether or not commercial fishers from other islands are also fishing in Puerto Rican waters, which could potentially skew collected data to make it seem as if Puerto Rican commercial fishers are having a larger impact than they really are (CFMC, 2005). This lack of knowledge is another contributing factor to the difficulty of maintaining accurate catch data in Puerto Rico.

Recreational Fishing

For several decades, commercial fishing was considered to be the primary cause of declining fish populations (NOAA, 2007). Recent studies have shifted the focus to all forms of fishing, however, including recreational fishing. Marine recreational fishing effort in the United States has increased by over 20% in the past 20 years (Coleman, 2004). It has also been estimated that recreational fishers harvest approximately 10.86 million metric tons annually while the combined harvest of commercial inland and marine finfish fisheries is approximately 80.47 million metric tons annually (FAO, 2003; Cooke and Cowx, 2004). It is becoming increasingly clear that efforts to sustain and conserve natural and marine resources should be implemented by all types of fishers.

The DNER defines “recreational fishing” as a “person who does not fish for profit, but for recreation such as sport, or for purposes of competition or for personal consumption and possesses a license to that effect given by the Secretary [of the DNER]” (DNER, 2004). Dive operating companies all over the island make a living by taking tourists to prime fishing spots and helping them participate in the recreational sport. The last count of year-round charter fishing operations in the Caribbean, conducted in 2000, verified that 19 were based in Puerto Rico (García-Moliner 2002). As the dive operators continue to encourage recreational fishing, the fish population in Puerto Rico will continue to be at risk. Without having an up-to-date and definitive number of dive operators in Puerto Rico and information about their catches, the DNER will not know the extent of the impacts nor be able to make informed policy decisions regarding the marine environment and its management.

According to the National Oceanic and Atmospheric Administration’s (NOAA) Marine Recreational Fisheries Statistics Survey (MRFSS) in 2001, Puerto Rico had

222,128 licensed recreational fishers, with 13% of these fishers not from Puerto Rico. The survey also included data from chartered fishing operators. Although the survey does not provide an explicit definition for "recreational fishing," this review takes recreational fishing to mean any fishing activity in which the catch is not sold for profit. The number of boats being used is known from the survey, but very little information regarding efforts and catches is identified. Different from commercial fishers, clients of chartered fishing businesses are not required to have a recreational fishing license, as long as the vessel operator has a part-time commercial fishing license. As a result, it is more difficult to keep track of catch size information for these businesses. Based on what is reported, in 2000, the spiny lobster catch count by recreational fishers totaled 128,000 and increased by 15,000 the following year (Council Draft SFA document- CFMC, 2004). Also in 2000, the queen conch catches of recreational fishers reached 140,000 but decreased by 15,000 in 2001 (Council Draft SFA document- CFMC, 2004).

Spearfishing and its Impacts

Spearfishing is a technique used by recreational and chartered fishers, in which spear-guns are used to hunt individual fish. The guns range from a spear launched from a tube by an elastic loop to pneumatic air powered guns. The sport can be considered to be less harmful than commercial fishing because it targets individual fish as opposed to mass amounts such as commercial fishing. Despite the specificity of spearfishing, there has still been significant damage to populations of marine species attributed to spearfishing in parts of the world. An article written by Jon Nevill calls attention to many incidences in which he believes spearfishing has caused a negative impact on populations of marine species. Nevill gives the example of the grey nurse shark in New South Wales, Australia, where the species' population was decimated by spearfishing activities during the 1960s. Grey nurse sharks are particularly vulnerable because of their territorial nature and their preference for shallow reef waters. The species is now considered to be endangered under the New South Wales Fisheries Management Act of 1994, and a threatened species under the Queensland Nature Conservation act of 1992. Although legislation has been put in place to protect the grey nurse shark, the population of the southeastern Australian coast has not recovered. There are only about 300-400

adult individuals left in the area, raising concerns about possible extinction (Otway *et al*., 2004; Nevill, 2006).

Population size is not the only indicator of the impact of spearfishing. Sport spearfishers tend to target the largest individuals in their fishing efforts, leaving only the smallest individuals to populate areas that are open to fishing. On the other hand, areas where spearfishing is prohibited have populations consisting of much larger individuals, which indicates a healthier population overall. Nevill cites an article from Oakley (1983) comparing the sizes of individual groupers in areas of the eastern Red Sea with both high and low pressure due to spearfishing[1]. Large fish were six times more abundant and medium sized fish were three times more abundant in areas that experienced high pressure from fishing when compared to low pressure sites. In the low pressure sites, small groupers were twice as abundant as in high pressure sites, indicating that there was much less competition with large and medium sized fish for the small fish to contend with (Neville, 2006). The same results were found in the Barbados Marine Reserve where spearfishing is only allowed outside the reserve; many more large fish were found inside the reserve than outside (Chapman and Kramer, 1999; Nevill, 2006). Overall, there is a very stark difference in individual sizes of fish between Marine Protected Areas (MPAs) and non-protected areas. In his article, Neville suggests implementing laws in Australia prohibiting spearfishing right outside of MPAs, to produce a buffer that could even out the distribution of targeted species (Nevill, 2006).

Competition spearfishing probably inflicts the largest amount of damage on fish populations when compared to smaller, non-competitive spearfishing excursions. When individual or small groups of fishers go on spearfishing expeditions, they tend to cause much less damage to target species' populations. When large groups of spearfishers go out at once, however, with the goal of competitively hunting as many fish as possible, fish populations are often devastated (Nevill, 2006). Nevill interviewed former Australian Spearfishing Champions Ron and Valerie Taylor, who remarked that they had seen an entire coral reef destroyed in only three days during one spearfishing competition. He also stated that once resources were exhausted by competitions in shallower waters,

[1] The term "pressure" refers to the amount of fishing experienced in an area. "High pressure" refers to areas that are heavily fished, while "low pressure" refers to areas with lower amounts of fishing activity.

where target species should naturally reside, fishers began using SCUBA to access the remaining fish in deeper waters (Nevill, 2006).

Existing Regulations

Regardless of the type of fishing performed, many regulations have been established in Puerto Rico and all over the world to protect the marine species. Ongoing problems include depleting species populations, coral reef damage, and pollution. Puerto Rico has set many restrictions to continue to preserve their natural resources and may also be able to adopt regulations similar to those existing in other areas of the world.

According to regulations set forth by the DNER, all commercial fishers must carry a full or part-time fishing license on them at all times while fishing. Permits are required to fish for particular species, such as common lobster, conch, and common land crab. There are specific bag limits for conch collection by commercial fishers; there is a limit of 150 conches per person per day or 450 per vessel per day, whichever is less. The DNER requires that commercial fishers turn in forms each month that report important statistics about their businesses such as catch, size, and frequency. These forms are to be mailed in at the end of each month. There are also many limitations on what types of equipment are allowed (DNER, 2004). All of these regulations, including the data collection forms, provide a relatively accurate representation of the impacts of commercial spearfishing.

Some regulations are in place for recreational fishers, although not nearly as many as those for commercial fishers. According to the DNER, recreational fishers are defined as "all persons dedicated full or part-time to the capture, importation, exportation, and possession in captivity of aquatic or semi-aquatic organisms for purposes of scientific investigation, education, exhibition, aquaculture, marketing, and possession of aquarium or ornamental organisms" (DNER, 2004). Recreational fishers over the age of 13 must obtain either a freshwater or saltwater fishing license to fish in the waters off of Puerto Rico. Licensed recreational fishers must obtain permits to fish for some specific species including spiny lobster and queen conch, similar to commercial fishermen. However, clients of rental boat owners, such as charter boats, do not require a fishing license as long as they are fishing with the owner of the vessel, who is understood to have a part-

time commercial fishing license and a registered vessel. These clients are required to obtain one day permits to fish for the species indicated by the DNER regulations, which will be acquired by charter boat operators. When fishing for conches, there are much smaller bag limits for recreational fishermen than commercial fishermen: 3 per person per day or 12 per vessel per day. There are also size limits when fishing for spiny lobster, queen conches, and whelk. The minimum carapace size for lobsters is 3.5 inches. Legal conches must have a shell length of at least 9 inches and a lip thickness of at least 3/8 of an inch. Whelks must have a shell diameter of at least 2½ inches. For recreational fishers, the use of equipment other than rod-and-reel or hook-and-line is illegal, except when fishing for conch, lobster, or crab (DNER, 2004). Therefore, the use of equipment such as spears and traps are permitted when fishing for conch, lobster, and crab.

Spearfishing is a method that is used primarily by recreational fishers, although commercial fishermen occasionally spearfish as well. There are very few regulations pertaining specifically to spearfishing, but the use of SCUBA equipment is prohibited for recreational spearfishing. However, recreational spearfishing with snorkeling gear is permitted (DNER, 2004).

Marine Protected Areas in Puerto Rico

There are 37 Marine Protected Areas (MPAs) in Puerto Rico, with most of them under the control of the DNER (see Figure 3). The MPAs not only extend off shore into the ocean, but may include some land components under the influence of the ocean, such as mangroves and lagoons (Aguilar-Perera, 2006). Unlike other states, the MPAs in Puerto Rico must also meet federal guidelines, as set forth by executive order 13158 in 2000 (National Marine Protected Areas Center, 2008). This sometimes causes confusion over the proper designation of a reserve and the rules that govern it. Since the DNER does not have a definition of a "marine protected area," Aguilar-Perera *et al*. (2006) use the US federal definition as "any area of the marine environment that has been reserved by federal, state, tribal, territorial, 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, 2008) to define the 37 MPA found in Puerto Rico. The term marine protected area is a general definition and does not constitute an absolute ban on all aquatic activities, as some may think from the name. Marine protected areas in Puerto

Rico are subcategorized based on allowed activities and geographical features. Critical habitats (CH), marine sanctuaries (MS), No Take Zones (NTZ), and the National Estuary Program (NEP) are designated by US federal law. The other subcategories of MPA are Natural Reserves (NR), Marine Reserves (MR), biosphere reserve (BR), insular forest (IF), commonwealth forest (CF) National Estuarine Research Reserve (NERR) (see Table 1). The authority to establish No Take Zones is derived from the Magnusun Stevenson Act, and they are jointly managed by the DNER and the Caribbean Fishery Management Council (CFMC). No Take Zones are established to implement a seasonal ban on fishing commercially significant species to help prevent overfishing (Aguilar-Perera, 2006).

The DNER is responsible for managing most of the MPAs, while the external organization Puerto Rico Conservation Trust manages some of the sites. Unfortunately, the DNER only has management plans for two of the MPAs and is drafting management plans for two more, as of 2006 (Aguilar-Perera, 2006).

Figure 3: Marine protected areas in Puerto Rico. The numbers on the map correspond to the numbers in Table 1 (Aguilar-Perera, 2006).

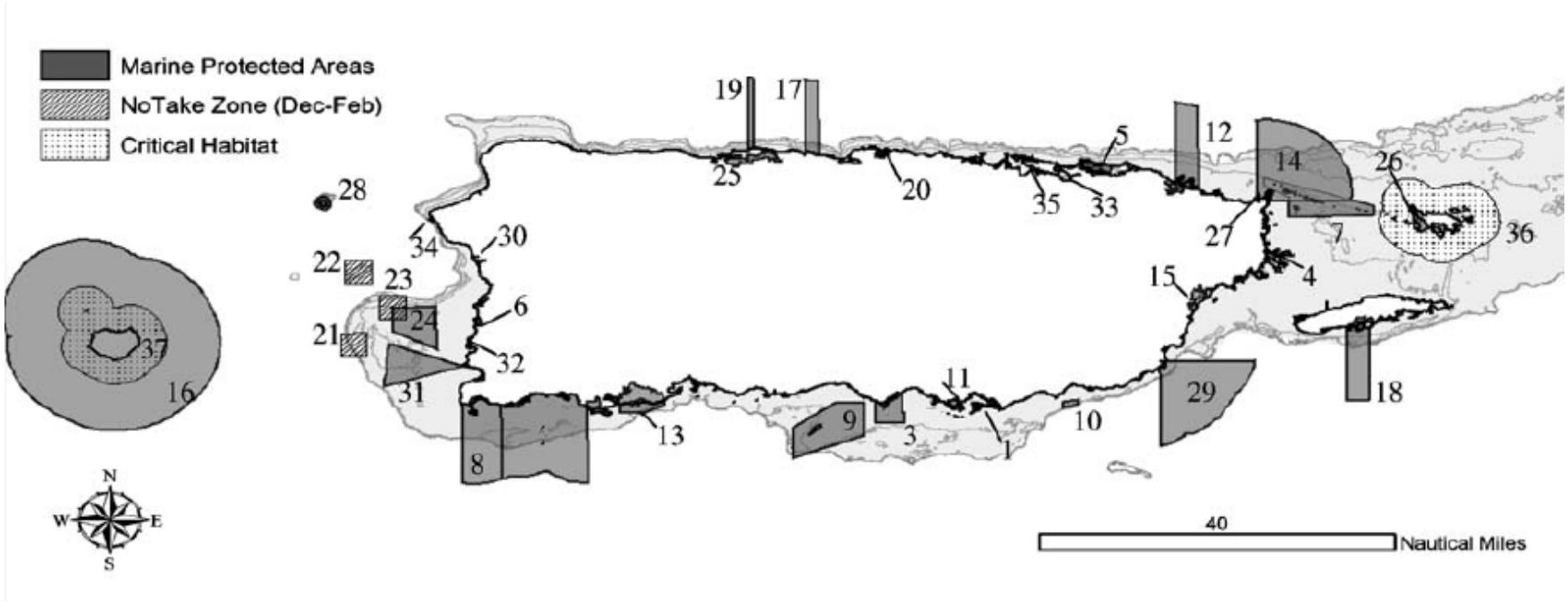


Table 1: The 37 marine protected areas of Puerto Rico (Aguilar-Perera, 2006)

#	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	32,642	32,724
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
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	10,083	10,083
8	Boquerón	IF, CF, NR	22-Jan-80	PRPB Resolution	Mixed	3	15,481	15,484
9	Caja de Muertos	NR	22-Jan-80	PRPB Resolution	Mixed	185	12,550	12,735
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
14	Cabezas de San Juan	NR	29-Jan-86	PRPB Resolution	Mixed	178	30,669	30,847
15	El Pantano, Bosque de *Pterocarpus* 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	15,1995	15,7575
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
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	26,244	26,369
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	11,681	11,681

#	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	24,200	24,200
36	Culebra Island	CH	2-Sep-98	NOAA	Submerged	NI	34,827	34,827
37	Mona Island	CH	2-Sep-98	NOAA	Submerged	NI	26,619	26,619

Problems with Existing Regulations

Most of the regulations on recreational fishing are implemented by the DNER, which only has the power to regulate Puerto Rican waters. Commonwealth waters extend from the coast to 9 nautical miles offshore. At first this may seem like a limited range, but 85% of fishable waters are contained in this area (Aguilar-Perera, 2006). Fishable waters are generally considered to be less than 600 feet deep. Much of the essential juvenile habitat is located in shallow waters close to shore. For example, juvenile spiny lobsters first seek shelter in costal mangrove tangles before transitioning to seagrass beds for territory and food (Marx, 1986). Besides juvenile territory, shallow and coastal waters provide better habitats for whole populations of marine animals, considering fishable waters are generally shallower than 600 feet. By this measure, only 15% of fishable territory is located in federal waters while most is located in state waters (CFMC, 2005). It is important to note that commonwealth regulations extend 9 nautical miles offshore, and federal regulations apply from 9 to 200 nautical miles offshore. An anticipated consequence of this uneven distribution by the CMFC is that federal regulations will have little impact on preserving threatened marine species. For instance, the spiny lobster received federal protection in 1987 but is still heavily fished, presumably mostly in state waters (CFMC, 2005). Even if state regulations are put in place, they need to be at least as strict as the federal guidelines. Otherwise fishermen can state upon returning to shore that their landings were caught in state waters, when in fact they were illegally poached in federal waters (CFMC, 2005). It would cost too much to have consistent and effective on-the-water enforcement to sustain differences in federal and state regulations.

CFMC and CITES

The Caribbean Fishery Management Council (CFMC) has recognized the need for regulation enforcement as well as collecting and keeping current data about catch totals and sizes. In the early 1980s there were no restrictions for the harvest of queen conch. Through a study conducted by the CFMC, it was determined that queen conch catches were consistently declining. These data were used to determine how over fishing was affecting the general health and growth of the queen conch populations. Visual surveys were conducted on the fishing grounds where queen conch were captured to further identify how the habitat and populations were affected by the fishing, and eventually meat samples of the conch were collected to identify the quality and health of harvests. In response to the data collected by the CFMC, the DNER implemented laws that required fishers to record the shell length, shell lip thickness, total weight, and meat weight, of all catches (Queen Conch Stock Assessment and Management Workshop, 1999).

Furthermore in 2005, the CFMC amended the Fishery Management Plan that was implemented by the Magnuson-Stevens Act. The amendments made regulated fishing techniques and locations in the Exclusive Economic Zone (EEZ) off Puerto Rico and the Virgin Islands. The implementation of these amendments demonstrated that the CFMC recognized the need for regulations and restrictions for particular areas and species and that catch estimates and surveys need to be improved upon.

Another important organization involved in the regulation of wild animal trade is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES operates as an international agreement of governments, which are referred to as parties. The goal of CITES is to ensure the trade of wild animals does not endanger the survival of the species. CITES policies are legally binding on all parties involved, and CITES policies must be implemented into the national legislature of each party (www.cites.org). In 1994, queen conch was listed as a commercially threatened species. Although this status has since been removed, it is still clear that CITES realizes the prevalence of insufficient monitoring and reporting of conch catches in Puerto Rico.

Limitations of CFMC Data

One of the largest problems facing regulation is a lack of accurate data, particularly with regard to recreational fishing. Although the reporting of recreational landings is required to obtain fishing licenses every year, landings are reported only by broad groups of species, not the specific type (CFMC, 2005). With up to eleven species within each category, reporting by groups is relatively non-informative. In deciding policy, large and inaccurate approximation must be made to generate the most basic of data, such as distribution of fishing locations and number of each species caught. Much of their "species specific" data for Puerto Rico are generated from extrapolations from the few places in the US Virgin Islands where such specific data do exist (CFMC, 2005). Also, due to a lack of information on the ocean locations where fish are caught, the CFMC is forced to make the oversimplification that fish are caught equally throughout their range. This assumption overlooks the fact that fishermen have favorite spots to fish where populations tend to cluster. Regulation and enforcement of these locations may be more realistic than regulating the entire range and could be done if such special fishing information existed. The CFMC is aware of the shortcoming of their approximations, but feel it is the only reasonable way to track fishing trends given the lack of better data. When hard information is available, it usually comes from tournaments that target dolphin fish and marlin. However, chartered boats are not required to record or report their catch (CFMC, 2005). The CFMC sums up the lack of information by saying "there is a general absence of any regional stock assessments for species managed by the Caribbean Council," (CFMC, 2005, p.15) emphasizing that "there is a trivial amount of information on the U.S. Caribbean recreational fishery" (CFMC, 2005, p.15). These shortcomings show the clear need for detailed and continuous data on recreational fishing activities.

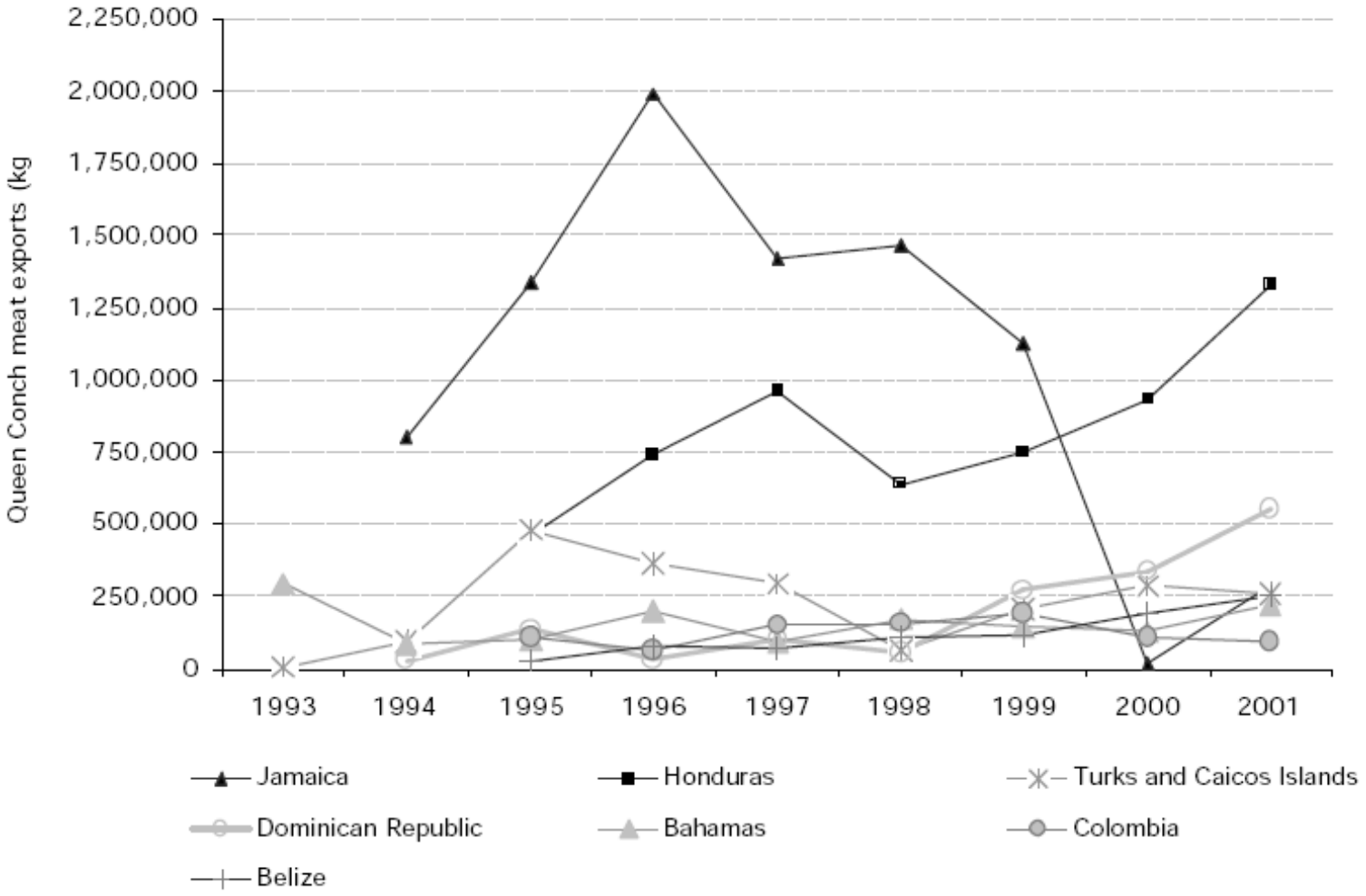
Case Study: Growth and Regulation of Jamaica Conch Industry

Commercial and recreational fishing can devastate certain marine species. Some countries are learning how to help their stocks recover by balancing marine use and conservation. Jamaica is one such country that has effectively protected its queen conch

population while still allowing commercial use through the adoption of the International Trade in Endangered Species (CITES) treaty.

In 1988 Jamaica discovered that it had one of the world's largest conch populations on the Pedro Bank off its shores. Because of its edible meat and potential for export, a conch fishing industry quickly developed and dominated conch exports from 1994-1996. The sudden decrease in Jamaican exports beginning in 2000 is due the closing of the conch season due to legal battles between the government and commercial fishers (see Figure 4). With such a fast development, there was little time for the government to react and establish regulations to ensure the conch population would not be overfished and collapse. Typically, conch fishermen would operate from large boats that would go to sea for several weeks at a time. Daily dive operations were launched from the boat in small dinghies with a handful of divers. The divers collected the conch meat by gutting the animal and leaving the shell on the seafloor. Besides the obvious impact of overfishing, this practice was thought to be especially detrimental to the conch because the living conch retreated from otherwise healthy habitats that were strewn with empty conch shells left by the divers. The live conches were thought to be repulsed by chemicals given off by the conch meat remnants that rotted in the discarded shells (Aiken, 2006).

Figure 4: Graph showing the export of conch meat (kg) of the seven leading countries from 1993-2003 (CITES, 2003)



Conch fishing in Jamaica became more successful over the years. Fisheries in neighboring countries began to take notice and began to illegally fish in Jamaican waters. While video recording documented foreign commercial dive boats operating illegally in Jamaican waters, the coast guard did not have enough resources to properly enforce its borders. Although a conch fishing season was in place, illegal fishing continued in the off season to supply the year round demand (Aiken, 2006).

In 1992 Jamaica adopted the Convention on International Trade in Endangered Species (CITES), a treaty regulating the international trade of threatened or endangered species and their products (Aiken, 2006). Queen conch was listed in CITES Appendix II, designating it a threatened species. This was an effective and appropriate measure because the demand for conch is driven by outside countries rather than internal demand. Currently the US is the number one world consumer of conch meat followed by France, as can be seen in Table 2.

Table 2: Net import of conch meat (kg) broken down by country between 1992-2001. "Note: No trade in Queen Conch meat was reported in 1992. Meat reported in other units e.g. boxes or cases, or in number of specimens is not included" (CITES, 2003).

Exporter	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*Total*	*% of Total*
US	293,097	197,434	1,743,660	2,249,353	2,365,595	2,177,318	2,397,437	2,028,358	2,786,308	16,238,560	75
Puerto Rico					44,001	279,685	317,199			640,885	3
Subtotal US	293,097	197,434	1,743,660	2,249,353	2,409,596	2,457,003	2,714,636	2,028,358	2,786,308	16,879,445	78
France	11,235	805,322	908,534	1,245,652	107,436					3,078,179	14
Martinique		61,236		13,200	547,313		60,000			681,749	3
Guadeloupe					213,432				241,494	454,926	2
Subtotal France	11,235	866,558	908,534	1,258,852	868,181		60,000		241,494	4,214,854	19
Netherlands Antilles			10,896		678	7,491	10,920	25,689	250	55,924	< 1
Netherlands		95		2,268	2,385	10,896			13,000	28,644	< 1
Aruba						10,000				10,000	< 1
Mexico			2,928		13,608	18,640			15,000	50,176	< 1
Haiti								9,453	10,000	19,453	< 1
Sant Lucia								7,539		7,539	< 1
Barbados						5,557	454			6,011	< 1
British Virgin Islands						5,227				5,227	< 1
Trinidad and Tobago						45	2,274	1,862		4,181	< 1
Honduras								1,700		1,700	< 1
Other States	59,089	51,360		7,045	10,663	170,619	29,363	16,209	21,804	366,152	0
Total	363,421	1,115,447	2,666,018	3,517,518	3,305,111	2,685,478	2,817,647	2,090,810	3,087,856	21,649,306	100%

International pressure primarily drives compliance with CITES. In 1993, a large export of conch meat was held up by US officials because it didn't have the proper CITES paperwork prior to leaving the Jamaican dock. By the time the paperwork had been sorted out, the meat had spoiled. There have been no issues of paper work since then. Conch fisheries also know the consequences of overzealous fishing. If conch were to become and endangered species in the eyes of CITES, all international trade would be stopped.

Since 1999, several policies have been put into place. Conch licenses, based on the national total available catch (NTAC), are given out only to a small number of qualified companies. Conch trade during the off season is prohibited in an effort to reduce the demands that tempts fishing during the off season. Companies are required to declare all stocks of conch meat and random inspections are carried out to ensure compliance. Additionally, conch collection in waters greater than 30 meters has been prohibited to preserve a separate breeding stock.

Although these regulations have helped, problems still exist. The two biggest problems are underreporting of landings by fishermen and continued poaching by foreign fishing companies. Underreporting is serious, as it is thought to have caused the collapse of the Peruvian anchoveta fishery. In a self reporting system, participants need to be made aware of the future harm they could do by intentionally underreporting landings to avoid regulation. In Jamaica, prosecution has been slow and resulted in weak punishment. For instance, in 2003, two boats were returned to poachers after being seized and prosecuted by Jamaica. Permanent loss of boats and equipment would send a clear message that illegal fishing will not be tolerated. Poaching highlights the need for adequate resources for enforcement and prosecution.

Marine Conservation Trends in the Wider Caribbean Region

Marine species are not always protected because of their economic importance. Governments choose to protect their marine resources because of the need to maintain pristine environments to attract tourists. This is especially true in the Caribbean, where tourism accounted for 25% of some state's gross domestic product (GDP) in 1996, and is projected to account for 36% GDP by 2012 (Colmenares, 2002). These are powerful statistics fueling conservation efforts by Caribbean governments.

The Caribbean is known for its sparkling water, pristine wildlife and lush forests. This environment makes it a popular draw for tourists. In 2002, the Caribbean drew in some 50% of the world's cruise ship passengers (Colmenares, 2002). Colmenares estimated that tourists

annually supply US$3 billion in revenue, which supports approximately 2.4 million jobs on the Caribbean (Colmenares, 2002). The expansion of tourism in the Caribbean has been impressive. From 1990-2004, the number of tourists visiting the Caribbean has more than tripled (see Figure 5) (One Caribbean 1999 & 2004). In Puerto Rico, tourism has been on a steady rise during the 1990s and tourism spending has been steadily increasing from 2002-2004, with visitors spending over US$3 billion in 2004 (see Figures 6 and 7) (One Caribbean 2001 & 2004). Compared to the 2004 GDP of Puerto Rico, tourism expenditures represent 3.8% of all goods and services produced that year (Puerto Rico's total GDP for 2004 was $84.5 billion (United Nations Statistics Division, 2007). With the prospect of a new trans-oceanic canal, the tourism industry only appears to be growing.

Figure 5: Number of cruise ship passengers visiting the Caribbean per year. [Note that totals were compiled from data specific to each island. Because cruise ships stop at more than one location, the totals given overestimate the actual number of tourists.] (One Caribbean, 1999 & 2004)

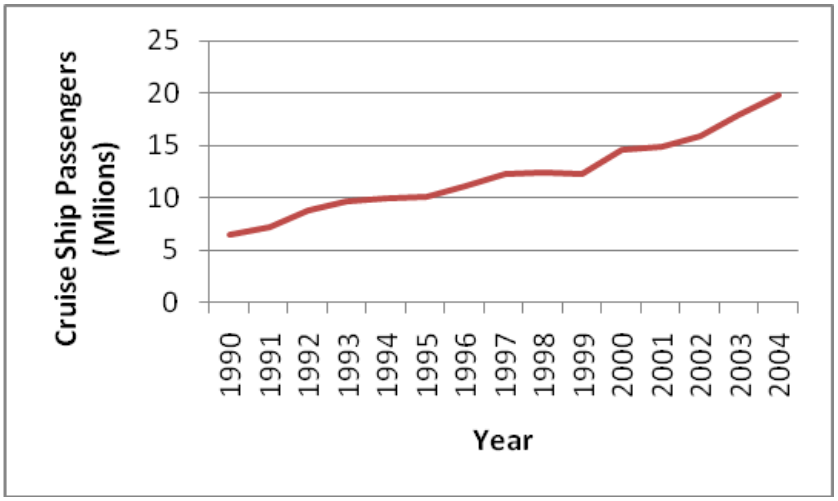


Figure 6: Number of visitors to Puerto Rico from 1991-2001 (One Caribbean, 2001)

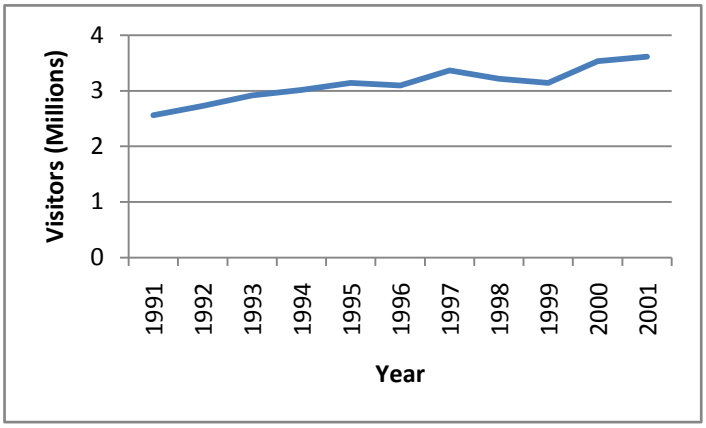
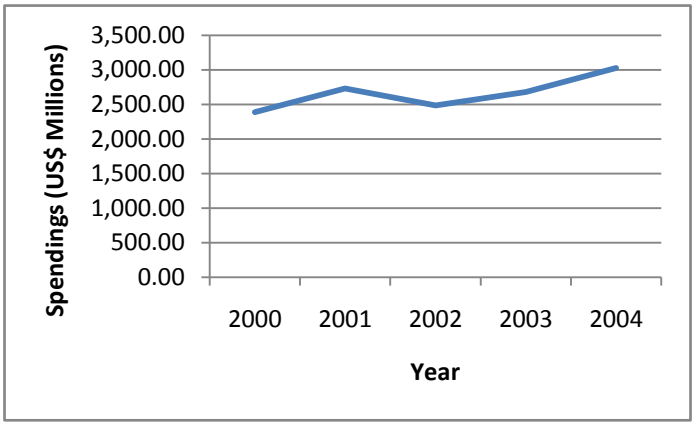


Figure 7: Visitor spendings in Puerto Rico from 2000-2004 (One Caribbean, 2004)



Caribbean governments realize the importance of protecting their natural resources because of their heavy dependence on tourism. In 1981, the United Nations helped Caribbean states to better manage coastal resources through the establishment of the Caribbean Action plan (Colmenares, 2002). Its goal was to create a regional framework to allow states to collectively or independently assess and regulate coastal urbanization, pollution, water quality and fishing. The plan has resulted in successes in some countries. For example, Colombia assessed the effects of tourism, excessive fishing and land runoff in Rosario Islands' National Park and received recommendations to improve these areas (Colmenares, 2002). In the Rosario Islands in Moreau and Tobago Keys a survey of the current conditions of corals reefs was conducted and identified areas that need further protection (Colmenares, 2002). In the Lagoon of Terminos on Campeche, Mexico, highly productive marine areas were protected from overfishing (Colmenares, 2002). This protection was accomplished with significant support and cooperation from the local

community. As of 2002, guidelines for the identification and establishment of marine protected areas, as well as for the monitoring of coral reefs have been established (Colmenares, 2002). Environmental impact assessments have been carried out for the future establishment of small craft marinas in southwest Tobago and training for managing the effects of tourism have been carried out in Jamaica, Mexico, St. Lucia, Barbados and Puerto Rico (Colmenares, 2002).

The road to success, however, has been mixed. Although the rewards for marine conservation are clear for countries that rely heavily on tourism, realizing those goals runs into many practical obstacles. The first is that environmental impacts on land are more visible than those at sea and so are at the front of public consciousness and national policy (Colmenares, 2002). The second is that marine conservation is interdisciplinary and requires experts in science, public policy and government enforcement to work together. Often multiple organizations specializing in one aspect of marine conservation are working on the same problem without effectively communicating with each other. A lack of communication results in duplication of studies and wasted effort. Colemares argues that one national organization charged with organizing and overseeing the diverse tasks of marine management is needed to fix the problem (Colmenares, 2002). A lack of communication between conservation groups and local residents can also cause problems (Colmenares, 2002). At its base, conservation efforts rely on technical scientific studies to direct their efforts. People within the organization may be able to interpret the significance of a new study, but the general public may not. Without an active dialogue, locals do not get feedback from the sponsoring organization, causing frustration and a loss of interest. Local support is becoming more important to marine conservation efforts because locals often have first-hand knowledge of what resources are in danger, and have the greatest ability to effect change (Colmenares, 2002).

The last problem is limited duration of new programs. New policies are frequently put into place, but little effort is put toward their continued support (Colmenares, 2002). In many cases sporadic support is due to a lack of money and man power. Often times what makes the difference is continued public support. Reflective of the importance of public support is the fact that the most effective conservation efforts protect areas that are especially scenic or of high cultural value. Continued support is essential because it allows for standardized and continuous monitoring systems that are able to track changes over time. With continual feedback, policies are able to adapt to better meet the goals of the project. Successful programs have started out small and focused and then gradually expanded to take on a broader scope (Colmenares, 2002).

MRFSS sampling methods

Puerto Rico currently uses the Marine Recreational Fisheries Statistical Survey (MRFSS, pronounced "murphs"), a federal system used to collect salt water catch data. It was designed in the 1970s with the purpose of collecting information about where, how often, and what species are being fished. Regulatory agencies then take the data to implement laws and regulations. In the MRFSS, both on-site and off-site methods of sampling angler catch and effort are performed. On-site sampling often refers to intercepting anglers while they are fishing or at landing points, while off-site sampling usually implies contacting anglers after they complete their trips (National Research Council 2006). Both suffer from weaknesses that may lead to biases in catch and effort estimation.

By establishing a comprehensive sampling frame with nationwide coverage, a survey is much more likely to accurately portray the reality of a particular situation while a more restricted sampling frame could leave information gaps. Gaps in the list, due to unlicensed dive operators, could result in a biased and inaccurate survey. In order to avoid using a restricted sampling frame, a complete list of chartered vessels from the fishing licensing programs could be utilized (National Research Council 2006).

In most cases, the best way to guarantee catch and effort reporting is to require all charter boat and other for-hire recreational fishing businesses to keep an updated and verifiable logbook of the number of fish caught and the number of fish kept. If a business does not report this information, they are prohibited from operating until it is done so (National Research Council 2006). In any case, honesty of the business' operator is still an issue to consider when analyzing the accuracy of the reported data.

Recreational fishing surveys could greatly benefit from implementing web-base surveys for fishers to report data due to the relative simplicity, electronic documentation, and speed of delivery. The only major difficulty of a web-based reporting system would be that many fishers may not have convenient access to the internet (National Research Council 2006). The MRFSS worked, but has many weaknesses. It uses intercept surveys, which are surveys conducted at public marinas of anglers when they return from a fishing excursion. The surveys collected information from anglers such as catch per trip and fish size. This is useful information, but this type of survey does not include factors such as night fishing, or anglers who operate from private marinas or private properties. Under the MRFSS, phone interviews were also conducted, but the response rate was only about one in every 15. The phone interviews only included coastal countries, and did not incorporate inland anglers who travel to salt water destinations. The

information collected by the MRFSS has been determined too inadequate to be useful because it does not properly represent the entire fishing community. According to the National Research Council, the MRFSS also "fails to provide a valid and reliable method of adequately accounting for fish caught and not brought to the dock (including fish released alive or dead). This shortcoming affects estimates of catch and total removals" (National Research Council, 2006). Table 3 (below) is a sample of MRFSS chartered fishing data in Puerto Rico from 2006. The percent standard error (PSE) shown in the table is consistently high for all of the species measured, indicating the large amount of error existing in the survey results.

Table 3: Marine Recreational Fisheries Statistics Survey Query Results for chartered fishing in Puerto Rico (NOAA, 2008).

Year: 2006

Species	TOTAL CATCH (TYPE A + B1 + B2)	PSE
BARRACUDAS		
BARRACUDAS	2,656	62.6
-- Species Group Subtotal --	2,656	62.6
CARTILAGINOUS FISHES		
OTHER SHARKS	499	46
SKATES/RAYS	258	81.6
-- Species Group Subtotal --	757	41.2
DOLPHINS		
DOLPHINS	4,075	46.1
-- Species Group Subtotal --	4,075	46.1
EELS		
EELS	129	100
-- Species Group Subtotal --	129	100.0
GRUNTS		
OTHER GRUNTS	387	100
WHITE GRUNT	129	100
-- Species Group Subtotal --	516	79.0
HERRINGS		
HERRINGS	29,123	94.4
-- Species Group Subtotal --	29,123	94.4

As a result congress is requiring a new data collection system to be implemented to replace MRFSS, and have decided to use the Marine Recreational Information Program (MRIP). The key difference between the MRFSS and MRIP is the development of a national registry. The national registry will keep a complete record of all anglers without discriminating against where they live, where they fish, or how they fish. This registry will give managers a complete record of people to survey and monitor, and will be an accurate representation of the recreational fishing community.

Traditionally it has been thought that because of its large scale and organization, only commercial fishing activities can have a significant impact on marine stocks. However, studies have shown that recreational fishing can also have significant impacts on marine populations. Governments in the Caribbean realize the importance of protecting their marine resources as it is a major draw for tourists, who contribute significantly to the area's economy. As a result, regulatory agencies have taken measures to ensure the ocean's sustainable use for both

commercial and recreational uses. In Puerto Rico and elsewhere, the MRFSS, a survey tool developed in the 1970s, is no longer adequate to effectively monitor recreational fishing activities. A new recreational monitoring program, the MRIP, is being phased in to replace the MRFSS. At its core is a national registry of recreational fishers, which is divided into three parts: private, shoreline and chartered fishing. The project described in this report aims to compile a list of chartered dive and snorkeling operators in Puerto Rico and collect information about their practices, particularly with regard to spearfishing and the collection of queen conch and spiny lobster.

Methodology

Currently monitoring systems are in place to track commercial fishing operations in Puerto Rico. However, little was known about the activity of recreational and chartered fishing operations until the MRFSS survey was implemented in 2000 in Puerto Rico. Due to many flaws in the MRFSS survey, the MRIP has been developed as a new system of monitoring chartered operations to replace the MRFSS. Before this new method could be implemented in Puerto Rico, the DNER needed to know more information about chartered operators on the island.

The ultimate goal of this project is to collect detailed data about chartered diving activities, to allow the DNER to enact informed marine resource policy and management plans. The first stage of the project entailed locating and surveying chartered dive operators in order to obtain current information about their business size, vessels, catch by species, techniques used, and customer volume. The findings from this project will assist the DNER as the agency develops a system to monitor chartered fishing activity in Puerto Rico.

The table below displays the sequence of events that led to the completion of our study. After the first two weeks of settling into the DNER office and adjusting the proposal, the group spent one week conducting pre-test surveys and editing the questionnaire as necessary based on the events that occurred during the pre-tests. The following three weeks were then spent traveling to every dive shop that was discovered through the internet and outdated lists, including those on the islands of Vieques and Culebra, to survey chartered boat operators and make observations based on the responses. Lastly, the final two weeks were spent writing the final report and presenting the group's findings to the DNER representatives and WPI IQP advisors.

Table 4: Timeline during study

Activity	Week 1 3/9-3/15					Week 2 3/16-3/22					Week 3 3/23-3/29					Week 4 3/30-4/5					Week 5 4/6-4/12					Week 6 4/13-4/19					Week 7 4/20-4/26					Week 8 4/27-5/1			
	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R
Meet with DNER																																						
Review questionnaire and proposal																																						
Conduct Pre-tests																																						
Conduct Interviews																																						
Coding/ analyzing data																																						
Write report/findings																																						
Final Presentation																																						

Describing the current situation

Current Information on Chartered Fishing Operations

In order to collect data about chartered fishing businesses in Puerto Rico, a questionnaire was created, intended for dive operators that run chartered businesses for tourists in Puerto Rico. This study defines chartered dive operators as any company that takes paying customers to nearby ocean waters to observe marine habitats, and possibly engage in the capture or release of any marine animal by any means. Customers must fish for personal use only and must not sell their catch for monetary gain. Activities, such as tournaments, have been included as recreational fishing, as long as the dive operator is involved in sponsoring it in some aspect. This sponsorship could have included but is not limited to money, time, people, boats, equipment or space. In 2002, García-Moliner estimated there are 19 dive operators in Puerto Rico, but our group's goal was to expand upon the previous study to develop a more complete and up-to-date list of contacts for interviewing purposes. It was expected that most of the operators are small, as the majority in the census had only one boat. Previous methods to track all of the dive operators included the use of local yellow pages, tourist agencies, government offices, newspapers and magazines. However, these tracking methods did not include any information on their geographic distribution.

List of current dive operators

Our choice in operators to interview was determined by several sources. This included a tentative list that was provided to us by the DNER from the Office of Licenses and Permits for Forestry, Fishing and Hunting, as well as websites and the list of the dive operators surveyed in a previous study (García-Moliner, 2002). A snowball interview method was used to expand this initial list by asking dive operators for cross references of other local operators that we could interview. The goal was to conduct a census of all of the dive operators in Puerto Rico that allow

the collection of queen conch and spiny lobster in order to include them in the electronic survey system for the DNER.

Due to the rather small number of dive operators, we performed a census with a questionnaire to record information on business practices, trip habits and the amount of marine invertebrate catch. Random sampling would not have been inappropriate for such a small group.

Census Procedure

Before carrying out the interviews, a brief description of the intentions of our project was given to the interviewees in order to explain that the survey is purely for gathering data for research rather than enforcement purposes. A written letter explaining that our survey received approval from the WPI Institutional Review Board (See Appendix B) was readily available to show a participant that doubted the validity of our assurance. In order to be sure that our survey respondents were treated in an ethical manner, they were informed prior to the interviewing process that the feedback they provide to us would remain confidential. To ensure that the hardcopy of the completed questionnaire would remain confidential, only a random number that was assigned to each operator appeared on papers. The file with the key linking dive operator's name to their numerical code was password protected. They were also told that they had the option of skipping any question, terminating their participation at any time for any reason, or not participating in the study at all. Respondents were given the option of completing the questionnaire themselves or having it read out load by one the students researchers.

Questionnaire Design

The questionnaires used for the dive operators were 7 pages long and consisted of a cover page, preamble, and 19 questions. The cover is important to the success of the survey because it forms the subject's first impression. The front cover included a title, graphic of a queen conch, and the WPI logo. A brief preamble preceded the questions and clearly stated that participation in the questionnaire is voluntary, participants can withdraw at any time, and that responses will be kept anonymous. Consent was implied if the questionnaire was completed. We did not use written Informed Consent Forms; implied consent was assumed by those who agree to participate after the survey preamble had been discussed. There are two reasons why we did not seek written consent. First, we believe that seeking such consent could have deterred the participation of our target participants and thereby inhibit our ability to collect the information we were seeking. Second, the risks to participants may have been reduced by not having the

subject sign a document that would link the subject to the information gathered. The surveys were conducted in a variety of settings (an office, on a dock, or on a boat), depending on the busyness of the environment. When consent was sought in a public space, we steered the potential participants to quieter, more private spaces where possible.

The final page consisted of one open ended question allowing the subject to provide any comments on the survey. This section was included in order to allow the subject to vent frustrations about the DNER and their policies, as well as provide information the survey might have overlooked. Following this open ended question was a brief thank you message at the bottom. More sensitive questions were placed towards the end of the survey in order to obtain as much information as possible without discouraging the participant.

The questionnaire was formatted to have the questions in bold, while keeping the answers unbolded. Each thematic grouping of questions had a brief header above it to keep an organized flow to the questions. The questionnaire was directly completed by the respondent rather than read aloud by a researcher. Originally, one of the researchers was going to read the questions aloud and record the responses on a standardized questionnaire form. However, the altered survey method allowed for the respondent to visually comprehend the questions and resulted in less confusion. In all, the questionnaire was completed in roughly 10-15 minutes which helped keep the dive operators interested and focused on their responses. The cover letter, preamble, and questionnaire can be found in Appendix D.

Travel Itinerary

Upon arrival in Puerto Rico, the initial list of dive operators was reevaluated to make sure that the companies were still in business. The location and contact information of each operator were verified by making phone calls. Once this task was complete, it was imperative that the locations of the businesses were mapped out in order to create an organized travel itinerary with convenient times and days to conduct the questionnaires. The objective of this task was to visit companies who are located near each other on the same day to avoid excessive travelling around the island.

Refining questionnaire and Pre-tests

Refining of the survey was carried out in two parts. First, Dr. Craig Lilyestrom and Zulena Cortes from the DNER reviewed the questionnaire in order to verify that the questions were focused on the most important issues. This task was important because it allowed our

sponsor to see if the survey would produce the necessary information and gave them confidence in our efforts. By working closely with the DNER, we were able to select and develop the most suitable survey questions and follow the necessary protocols. It was also helpful to confirm that there were no factual mistakes or misrepresentations within the questionnaire or interview questions.

The second part of refining the survey involved pre-testing with various dive boat operators that were known *not* to allow the collection of conch or lobster. This was done because pre-tested surveys could not be included in the final data set. The pre-testing process was utilized in order to ensure that the questions did not cause any confusion, as well as to obtain feedback and make certain that the questions are clear and neutral. Initially, a pre-test of the survey was going to be given to a fellow IQP group from WPI, however, the group decided that pre-testing a dive operator would be much more valuable. Instead, the group traveled to three dive boat operators to get firsthand experience of conducting surveys in the field. This turned out to be a great way for the group to recognize various misconceptions among the respondents and discuss any underlying issues with Dr. Lilyestrom that had not been previously anticipated.

Conducting census

The surveying procedure took place between March 31st and April 18th. To administer the questionnaire, two members of the team met in person with the dive operator captain, manager, or owner. The interviewers' dress was casual and typical of student researchers in order to make the potential respondent feel at ease. At each location, the interviewers approached the captain, manager, or owner of the dive boat business and explained the purpose of our survey through casual conversation and the questionnaire preamble. The potential respondents were told that their participation is entirely voluntary and they could stop at any time. As previously stated, implied consent was assumed by those who agreed to participate after hearing the survey preamble. The respondents then completed the questionnaires while the student researchers stood by to clarify any questions and observe body language. By having direct contact between the researchers and respondents during the surveying process, the response rate was expected to be higher than if the survey was conducted by telephone, mail, e-mail, or drop box.

As a form of incentive to participate in the survey, we offered posters supplied by the DNER to each dive operator. It also served as an expression of gratitude for taking the time out of their busy days to help us in gathering data for our research.

Code and data analysis

Once the questionnaires were filled out, the responses were entered into a Microsoft Excel spreadsheet that allowed us to organize the information gathered. Notes from the interviews, including any unusual facial expressions or body language of the respondent, served as a tool to extract qualitative data through keywords and compare various common and unique opinions. Depending on the nature of the question, the responses in the additional comments box and multiple choice questions were categorized and counted in a consistent fashion among all surveys. The majority of the data we collected was quantitative and essentially already "coded."

Limitations

Our survey results were dependent upon the answers provided by the dive operators. There is no way to determine the honesty and accuracy of the dive operators' responses. Out of fear of getting in trouble or possibly using illegal techniques, it is possible that dive and snorkel operators were not entirely honest when answering our surveys. These operators may have wanted to keep some of their prime snorkel and dive locations a secret to maintain a competitive edge on their rival operators. Without a proper introduction, the operators could have assumed that the goal of the survey is to impose regulations and become unwilling to participate. For this reason, it was important to create a sense of trust with the dive operators as soon as we met them. Clearly explaining our motives and goals were key steps to winning their participation, as well as presenting ourselves as personable and genuinely interested in their feedback.

Although Spanish is the dominant language of the Commonwealth, all of the dive operators, who deal primarily with tourists, spoke fluent English. Because of their language capability, we did not create or need a Spanish version of the survey.

Identify feasibility of internet system from questionnaire

Once the information was collected from chartered fishing operations, the group was able to determine the feasibility of implementing an internet data reporting system for chartered catch. Our questionnaire helped to collect information from dive operators about whether or not they have convenient access to the internet. These data collected allowed us to suggest what type of reporting system to the DNER should use for implementation as well as the practicality of a web-based system.

Summarize and distribute findings

During the last three weeks of the project, the group worked together with DNER staff to develop and refine our recommendations based on our findings. Also during this timeframe, a final draft of the report was prepared and completed with the group's conclusions and recommendations. At the end of the seven weeks, a formal presentation based on the final report was given to the DNER liaison and team. Following the completion of the report, a summary of the results was sent to the participating dive operators via e-mail, and the IQP file was cataloged in the electronic database system at the WPI Library.

Results & Analysis

List of dive operators

As described in the Methodology section, the first objective of the project was to compile a list of dive and snorkel operators in Puerto Rico. The list was created using several different resources including the internet, tourist guides, local hotel information booths, and a study completed in 2002 by García-Moliner. Our goal was to obtain the name, phone number, address, and web site of each chartered dive and snorkel operator in Puerto Rico. This basic contact information allowed us to learn a little about their business and how they operate. Once the list was completed, each operator was contacted by telephone to verify their address and phone number, and to certify that they are still operative businesses. During this time period we also obtained contact information for several new operators to add to our list, as several operators informed us of other chartered dive and snorkel businesses in their area. Through internet research and an existing list from a previous study performed by García-Moliner, a total of 79 chartered dive and snorkeling operators were initially identified to be surveyed. After making phone calls to verify business locations and visits to listed addresses, several operators (55) had to be eliminated due to the fact that they were no longer in business. Twenty-four (24) operational businesses were identified for surveying. Seventeen (17) additional dive operators were identified through snowball references during the surveying process. Of all of the attempted questionnaires, thirty-seven (37) were completed. There were also two (2) refusals to participate and two (2) businesses failed to return the questionnaire form. After completing the census, a total of 41 operational chartered dive and snorkeling businesses were identified and submitted to the DNER for the MRIP national registry.

When the list was completed and all companies were contacted, it was re-organized by location. A travel itinerary was then developed using the list grouped by location to facilitate transportation arrangements. Even after phone calls verified that the businesses are currently operative, several trips into the field proved that some companies no longer exist because we were unable to find the buildings at their listed addresses and other operators in the area specified that such businesses are no longer in operation. These findings, while frustrating and time consuming, have also increased the accuracy of our master list.

Pretest 1: March 18, 2008

The first pretest of our survey was conducted with a dive operator that had been cooperative with the DNER in the past. All four team members were present for the pretest so that everyone could observe firsthand what worked and what did not work. Dress was casual in nature, as the team wanted to be seen more as student researchers rather than employees of the DNER.

The pretest initially seemed unsuccessful; however after reevaluating our current surveying techniques, we recognized the pretest as a key element to the long-term success of our study. At first, we introduced ourselves as working in partnership with the DNER, which made the respondent visibly uneasy. He then vented his frustrations about the DNER regarding recent efforts to collect concession fees, as well as his perception of inefficient regulation enforcement. As we had no prior knowledge of the details of the existing tension between the DNER and chartered operators, we were unprepared to explain that our surveys would not be used for regulatory purposes. As a result, the respondent chose not to participate in our survey. In the successive surveys, a more structured and less formal introduction proved to be more effective. The new introduction contained more background information about our IQP and the other projects carried out in Puerto Rico, which helped to assure respondents that the questionnaire was primarily a university project being sponsored by the DNER. More importantly, respondents felt more comfortable knowing that anonymity was guaranteed.

The second difficulty in administering the questionnaire was the delivery. We had opted for a verbal delivery in which the survey preamble would be delivered verbatim, and then each question read to the respondent. Responses would be filled out on the questionnaire by the student researchers. This approach had initially been chosen because a verbal delivery would likely result in a higher response rate. It was also used to avoid problems where respondents had

limited reading skills. Additionally, standing over a respondent while he/she fills out a questionnaire can be very awkward. However, a verbatim verbal delivery proved to be too constrained and uncomfortable. The participant seemed impatient while the questions were being read and was visibly anxious to read and answer the questionnaire himself.

The third difficulty was the order and content of some of the questions, which ultimately deterred the participant from completing the questionnaire. Since the respondent was already agitated by our affiliation with the DNER, he was especially suspicious of questions about business operations. It had initially been assumed that the most sensitive questions would be about conch and lobster collection, as the dive operators might be fearful of stricter enforcement and the implementation of additional regulations as a result of the study. Because of this assumption, the questionnaire had been designed to begin with easy business-related questions to build confidence and ease into questions about conch and lobster collection. However, it quickly became clear that the business-related questions were the primary point of friction and were perceived as being intrusive with this particular respondent. Ultimately he declined to answer any further questions, and the team thanked him for his time and left. The total encounter lasted approximately 10 minutes.

After talking to our sponsor, Dr. Craig Lilyestrom, it became clear why the business questions had caused so much trouble. Recently, the Office of Licenses and Permits of the DNER enacted a new "concession tax." It states that any private business that utilizes public waters for profit, whether freshwater or saltwater, must pay the DNER a 15% tax on their gross profits. Not only is this widely unpopular, but some operators are contesting its legality in court, claiming that it is a form of double taxation. One chartered dive operator has already been put out of business because of refusal to pay the concession tax.

As a result of this pretest, several modifications were made to the original questionnaire (Available in Appendix C), and the team's protocol for interacting with the dive operators. The questionnaire was changed from an oral delivery to a text handout so that respondents could read each question themselves and mark their own responses. The survey was shortened from 29 questions to 19 questions by eliminating non-essential business questions that could be perceived as intrusive and consolidating overlapping questions about conch and lobster. The questionnaire was organized so that dive and snorkel operators who reported that they did not have clients who collected conch or lobster could skip over any questions that did not directly apply to their business. The business questions pertaining to the number of clients being taken out and the

number and length of the vessels were put at the end so that if the respondent chose not to participate any more, he/she would have already completed the essential questions of the survey. An attractive cover page with a clear title, aesthetic photograph and the WPI seal was added to make the survey look complete and official in its presentation to dive operators. The preamble, which appears on the questionnaire and was also incorporated into our verbal introduction, was reworded slightly to make it friendlier in tone. It more explicitly stated the goal of the project, which was to improve the marine management of queen conch and spiny lobster.

The team's protocol for contact with the dive and snorkel operators was also revised. Only two team members, one male and one female, would be present to talk to the operators and deliver the survey, since that seemed less intimidating than having four researchers surround a respondent. Team members would introduce themselves as being part of a larger group of students from WPI staying in Puerto Rico for 8 weeks, working with a variety of sponsors. Sponsors of other teams, such as Junta de Calidad Ambiental, were mentioned. Providing more background information on the nature and purpose of the program was intended to reassure potential respondents that the purpose of the project was for research and not the enforcement of regulations. Overall, these improvements helped to keep the team's interaction with the operators relaxed in nature and encourage cooperation.

Pretest 2: March 26, 2008

Our second pre-test of the survey went much more smoothly than the first. It took about a half-hour to complete in a casual environment in a public place. The respondent seemed very interested in helping us and hearing about the benefits of our project. Upon arrival, he gave each of us brochures for his sail boat excursions. One student in each pair took the lead in conducting the interview while the second student was able to assist as necessary. Both students present were dressed casually, in order to maintain the appropriate image of student researchers rather than employees of the DNER.

After introducing ourselves in the more discursive, conversational tone noted above, the respondent requested that the questions be read aloud to him instead of filling out the questionnaire himself. During the survey, it was clear that the respondent felt comfortable and confident that his answers would remain anonymous. While he was very friendly with us, it was apparent that there is an underlying sense of frustration with the DNER relating to legal operators being regulated and illegal operators being forgotten and unregulated (similar to that opinion of the first pre-test dive operator). While answering the specific questions, he supplied

further information and opinions and also gave useful feedback about the survey. We noted that he was not aware of size regulations of queen conch and spiny lobster; however, he did mention the law against recreational spearfishing while scuba diving. Following the survey, the respondent suggested that we include questions about whether or not operators are aware of regulations and their feelings about them, as well as their opinions on the efficiency of the DNER's regulation efforts. We are not quite sure if these questions would fit the purpose of our study, but it was helpful to receive his honest feedback. In addition, he supplied us with the names of other chartered dive and snorkel operators to include in the survey.

This pretest also provided much insight into how we could further refine our questionnaire and surveying procedure. During the pretest, the respondent seemed very interested in learning more about our school, the IQP, and our experiences so far in Puerto Rico. Therefore, introducing ourselves as students working on a graduation requirement and sharing information about our trip seemed to be a good way to break the ice with respondents, as well as to encourage them to take part in our survey. Conversely, it was noted that the respondent was not entirely clear on the purpose of our project. Thus it was necessary to more thoroughly explain to future respondents the specific goal of our project, which is to assess whether or not queen conch and spiny lobster, as well as other marine species, are being collected by diving and snorkeling excursions on a regular basis.

Judging from both of our pretests, there was clearly tension existing between the DNER and chartered operators in Puerto Rico. Therefore, it was most likely to be beneficial for us to acknowledge this tension when we introduced ourselves as being sponsored by the DNER. It was also helpful for us to stress verbally that we were not doing our survey for any kind of regulatory purposes and that all answers to the questionnaire would remain completely anonymous. In addition, we had our WPI IRB approval letter on hand as further assurance that the survey would be anonymous, in order to further gain the confidence of the respondents.

First Day's Experience

The first day of actual surveying went very well. All three dive operators agreed to participate in the survey and answered all questions. While respondents still had frustrations with the DNER, they were able to recognize that we were students doing a project and did not allow their frustrations to prevent them from taking the questionnaire. Respondents were generally

positive towards our project, as all of them indicated that they would like to receive the results of our project, once complete.

The modifications that were made as a result of the pretest were successful. Sending in two team members at a time to conduct interviews produced a more relaxed atmosphere. Arriving at each chartered dive shop allowed us to introduce ourselves face-to-face to the operators and express the potential benefits of their participation in our study. We believe it increased the operators' willingness to participate because we were able to reiterate that their feedback would still be very valuable to our study, regardless of whether or not their clients ever collect the specified species or go spearfishing from their boats. We chose not to schedule a meeting time prior to our arrival due to various reasons, such as our inability to guarantee having transportation at specific times and in case our travel schedule needed to be altered for any reason. However, for those operators that were unavailable during our first visit, we arranged meeting times to make sure we had the time and resources to have them complete a questionnaire at another time. The reorganization of business related questions to the end of the questionnaire was also successful, as all dive operators completed them without issue.

Lastly, having more knowledge as to why there is tension between the DNER and chartered dive and snorkel operators (concession fees, restrictions, improvised government) allowed us to sympathize with the dive operators, as well as let them know that we are conducting a school project and are not collecting information as part of a DNER enforcement initiative. This knowledge provided common ground between the research team and the chartered operators, which ultimately made them more willing to participate in our study. Giving the operators more background about our graduation requirement and other students' projects helped to assure them that we are students conducting a bona fide research project.

Questionnaire Data

Prior to visiting the dive shops, it was difficult to accurately predict the outcome of the surveys, because the DNER had very little information about how many dive and snorkel operators are in business and how many of these businesses have served clients who have spearfished or collected marine species from their boats. After the first ten days of surveying, the group had not encountered any dive or snorkel operators that fell into the category that would help answer questions most relevant to our study. For the rest of the surveying period, this

general pattern continued and only a limited number of dive operators have clients who have spearfished or collected any marine species.

This section includes graphs and conclusions extracted directly from the respondents' answers and comments.

Figure 8 shows the number of clients per week serviced by chartered dive operators during the different seasons of the year. These data are compared with the number of hotel bookings of non-residents during the various seasons as an indicator of overall tourist activity in Puerto Rico. Based on the operators' responses, the total number of dive/snorkel clients is estimated to be about 83,000, with April through June being the busiest season and October through December being slowest season. From this graph it was discovered that the number of clients per week of chartered dive excursions do not coincide with the fluctuation of tourist activity. Perhaps the chartered dive business is on the decline, but future research would need to be conducted in order to ratify such a conclusion.

Figure 8: Average numbers of clients per week of dive operators during various seasons of the year (n=34).

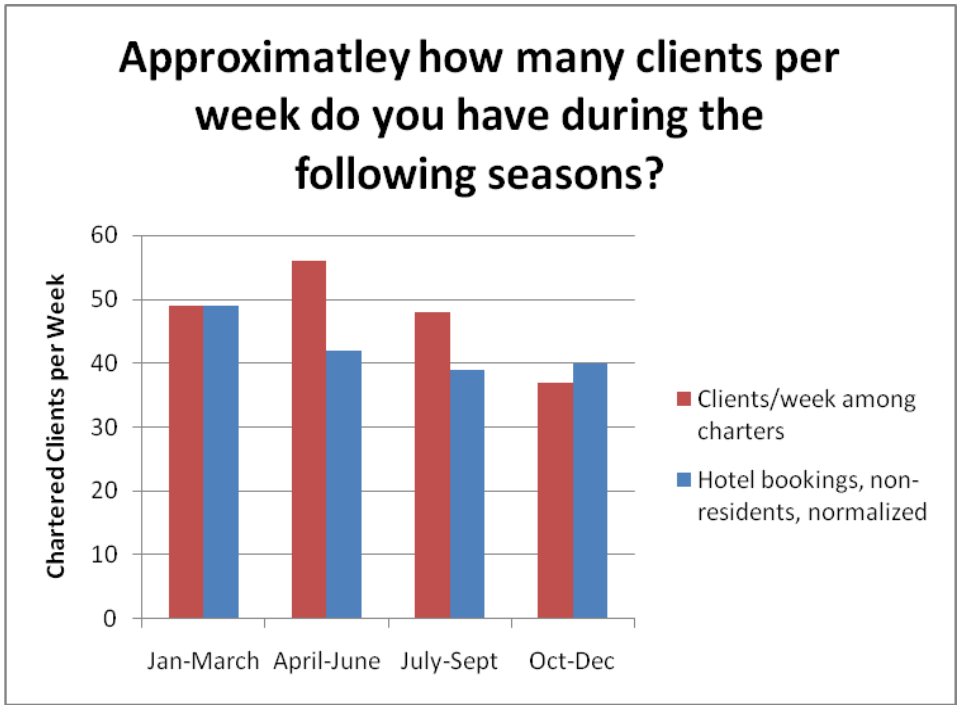
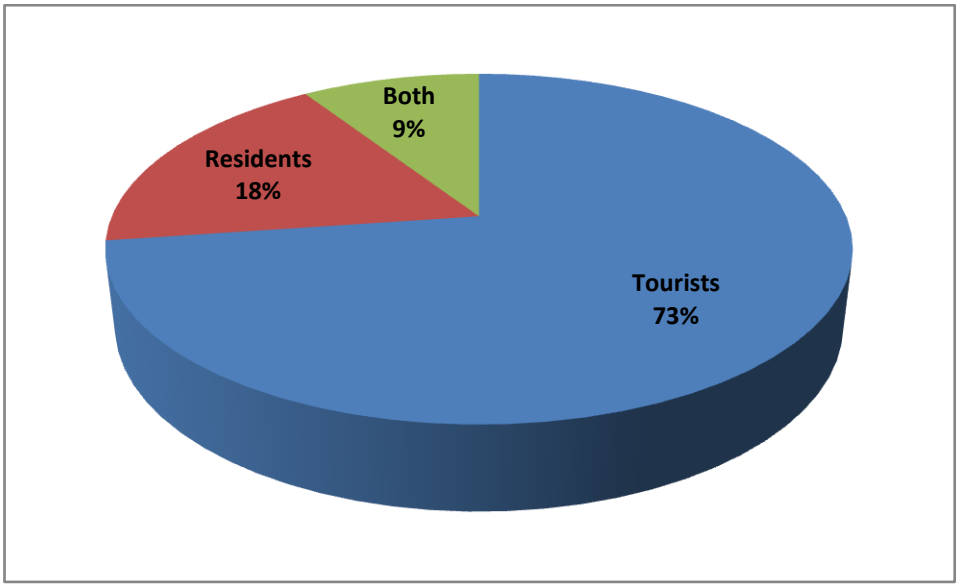
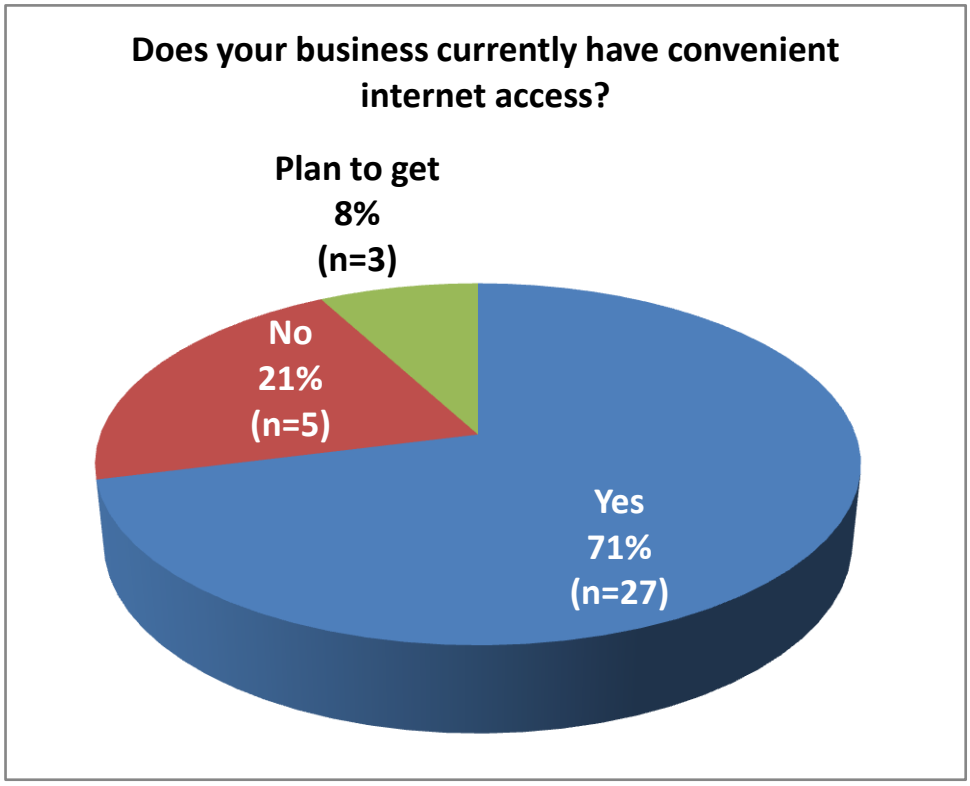


Figure 9: Customer data of dive operations



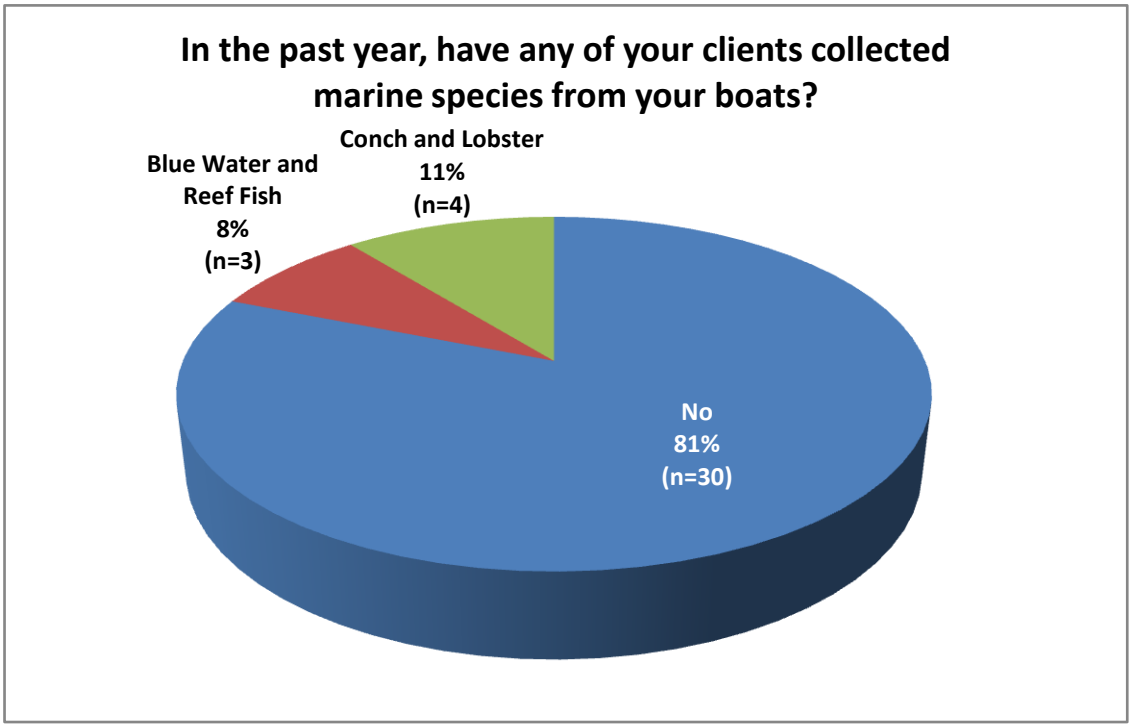
Chartered operators in Puerto Rico serve primarily (54%) tourists, although some (32%) businesses reported that Puerto Rican residents are their primary customers. Several businesses (14%) reported that their client load is composed equally of tourists and Puerto Rican residents. The pie graph above took these responses, and weighted them with the average number of clients each business reported. Thus the percentages in the graph estimate the percent of clients that are tourists or residents of Puerto Rico.

Figure 10: Internet access availability among dive operators



Internet access is available to the majority of chartered dive and snorkeling operators that took part in our census. "Plan to get" means operators had plans to get internet within the next year. Therefore, an online reporting system as a part of the MRIP would be a feasible possibility for monitoring of chartered operators.

Figure 11: Collection of marine species by clients of dive operations.



These data regarding the collection of marine species will give the DNER an idea of how many chartered operator s actually have customers who collect conch, lobster, and other marine species during diving and snorkeling excursions. We discovered that 19% of dive operators allow the collection of marine species, however this figure can be misleading. While 19% of dive operators allow the collection of marine species, it does not mean that marine species are collected by all 16,000 clients (19% of 83,000 total dive clients) during all dive or snorkeling excursions. The collection of marine species is not something that these operators advocate, but rather they allow it if a client is interested. For this reason an estimate of the number of people who collect marine species cannot be derived from these data.

Of the 37 respondents that completed our questionnaire, a total of seven (7) had clients who collected marine species during diving and snorkeling excursions. Only four (4) of these had clients who collected queen conch and spiny lobster, and only three (3) allowed clients to spearfish during excursions. Two of the three businesses that allowed spearfishing had clients that collected conch and lobster as well. However, since there were so few respondents that claimed to have clients who collected marine species and spearfished, not many correlations can be made about their activities. Of the four businesses with clients who collect conch and lobster, there are large differences in location, clientele demographics, number of boats owned, and internet accessibility.

Figure 12: Opinions of dive operators about whether or not there has been a change in queen conch populations in the past five years.

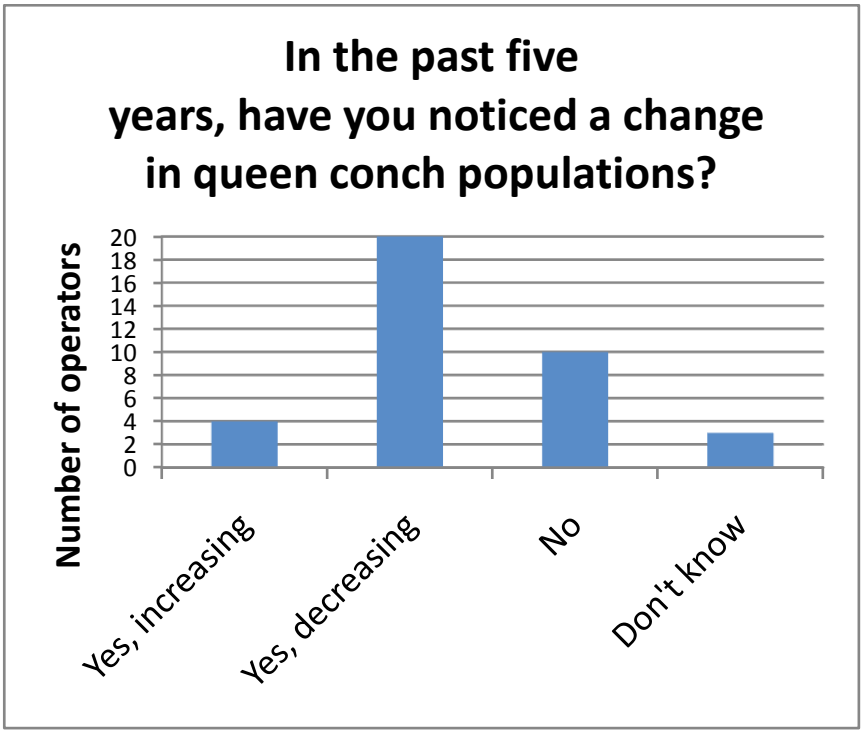


Figure 12 (above) shows the responses of dive operators regarding their perception of any changes in the populations of queen conch, while Figure 13 (below) displays their perception of any changes in the populations of spiny lobster. The common response was that both species have been declining in population over the past five years. These responses are not concrete, but rather display what the dive operators have perceived to be the general change in populations. One particular dive operator based his/her answer on the amount of conch and lobster she noticed being sold from local food stands. Official counts of populations need to be conducted in order to verify the dive operator reportings.

Figure 13: Opinions of dive operators about whether or not there has been a change in spiny lobster populations in the past five years.

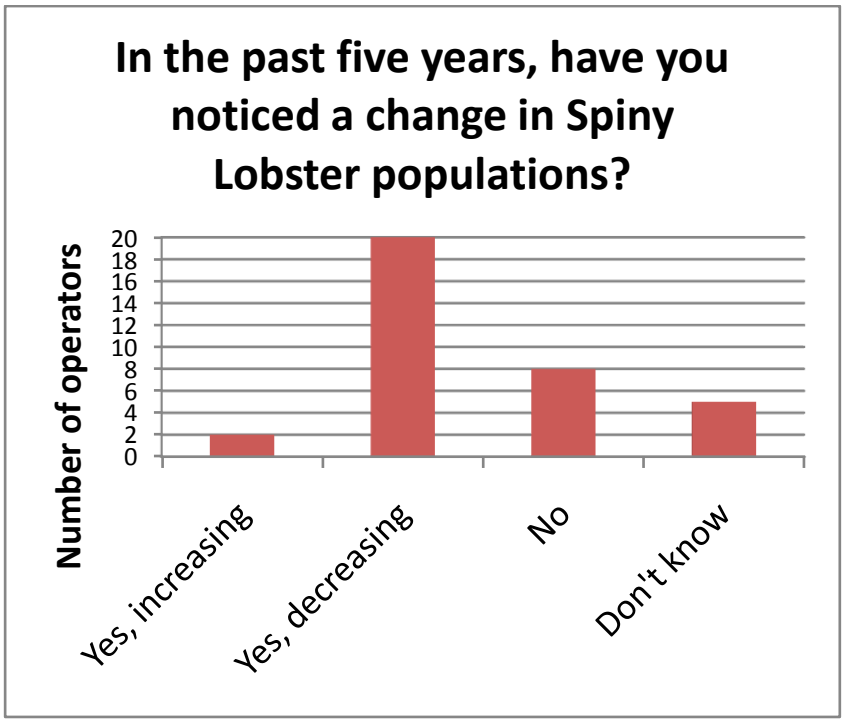
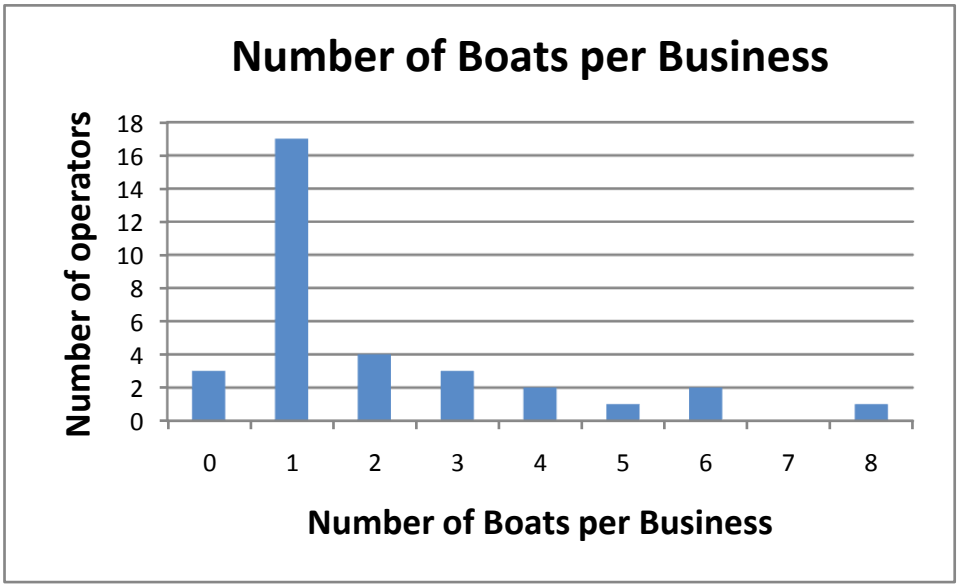
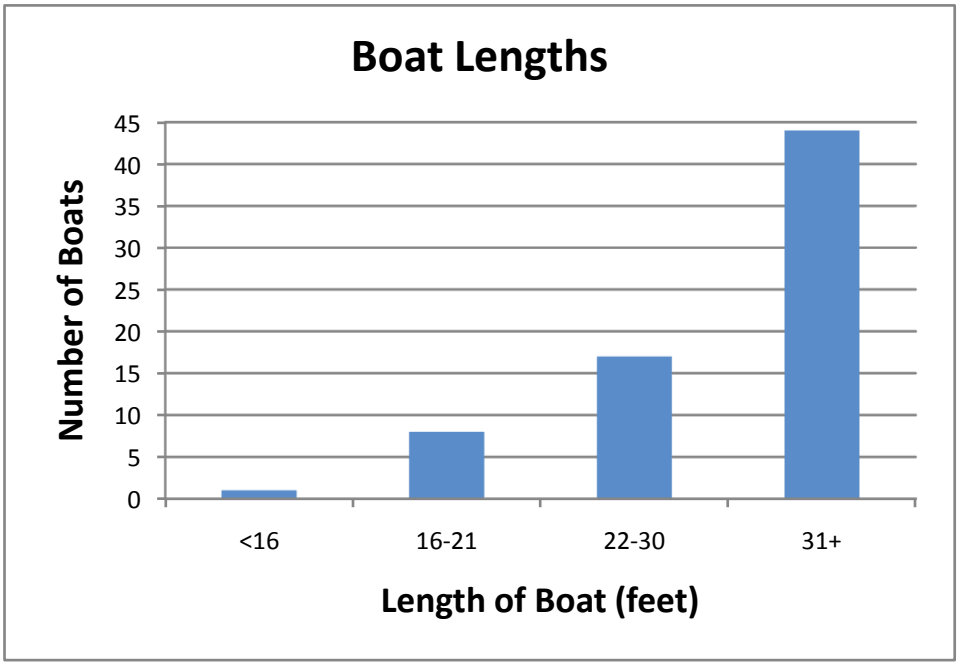


Figure 14: Number of boats used by chartered operators for diving and snorkeling excursions.



While the number of boats that each business owned ranged from 0 to 8, the majority of chartered operators (17) had only one boat to use for diving and snorkeling excursions.

Figure 15: Sizes and number of boats utilized by dive operators for chartered excursions



The majority of chartered operators (21 businesses) use at least one boat larger than 31 feet in length for diving and snorkeling excursions.

Figure 16: Map displaying all of the different dive and snorkel sites used by chartered operators. Numbers on the map indicate the average number of visitors per week.

The grids on this map are five square miles in size. Grids highlighted in yellow represent areas of lower diving activity, orange grids represent areas of moderate diving activity, and red grids represent areas of high diving activity. This map confirms the DNER's original assumption that the most popular dive and snorkeling locations are in the areas near Fajardo, Humacao, Culebra, Vieques, La Parguera, and Desecheo Island. The DNER was previously

unaware of which sites were the most popular dive locations because this is the first study that validates such predictions.

Open-Ended Responses

Several chartered operators suggested improvements that the DNER could make to its operations and regulations. One of the most frequent suggestions has been to increase the number of mooring buoys. Mooring buoys are permanent buoys that are attached to the ocean floor in popular boating locations. Boats dock to the mooring buoys instead of dropping anchor, which causes damage to the ocean floor, seagrass beds and costal reefs. Charters have complained that there are not enough mooring buoys available and that they would use them if more became available. All respondents so far appeared to be aware of the delicate nature of reef systems and expressed a commitment to protecting them. Thus, they dislike having to drop anchor when no mooring buoys are available. Though they try to find sandy areas to set anchor, they feel an increased number of buoys would help them to protect the reefs. Respondents stated that increasing the number of mooring buoys would be an appropriate use of the fees they pay to the DNER and would be a visible sign that the DNER is managing their money appropriately. This buoy expansion would help counter a widespread concern that the money collected from chartered operators is being lost in a central DNER money pot and not being used towards improving the resources on which their business rely.

Another common perception among many chartered dive and snorkel operators is that the DNER should be responsible for cleaning up the trash that surrounds parts of the shore, marinas, and local dive and snorkel shops. Many operators would like to see that the taxes and concession fees they pay to the DNER are used wisely and in a way that directly benefits their business environment. They often have opinions that the DNER, as a government agency dedicated to preserving natural resources, should take more initiative to help maintain a cleaner, less polluted environment. One particular dive operator explained that on several occasions he has had to pay to get trash removed from outside of his building because people are not disposing of it the correct way. As we recognize this request to be a bit challenging for the DNER to handle, increased law enforcement for littering could be a possible solution for the future.

Based on the comments of several respondents, there seems to be a general misconception of the licensing requirements for recreational fishers. One dive operator complained about the complexity of obtaining a private fishing license, which would cover hook

and line, diving, and snorkeling. He explained that having to travel to large cities, such as Ponce, and pay around $50 to obtain a fishing license causes many people to forego this step and simply go fishing without a license. Upon returning from the survey and discussing this matter with the DNER office, the group was surprised to find out that recreational fishing licenses are actually not yet required. While licenses are technically required by two laws and one regulation according to the DNER, no fine will be issued to a recreational fisher for not having a license at this time.

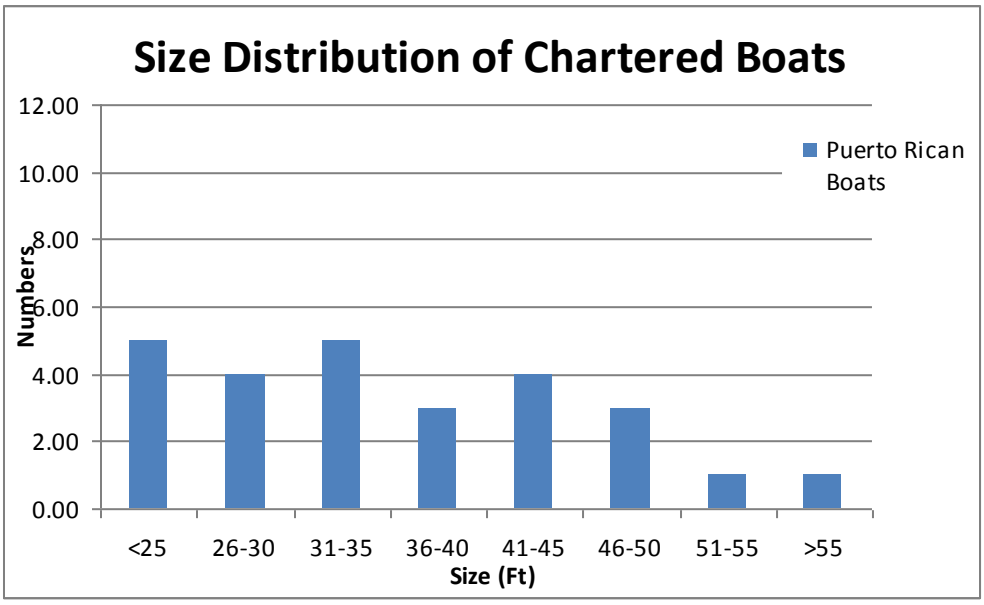
The recreational fishing license system in Puerto Rico has been in development over the past eight years. The DNER has a contract with Central Bank of Missouri to design and implement a modern automated system. The future plans of selling fishing licenses include installing thin touch screen systems in retail outlets that sell fishing gear, as well as telephone and web-based sales. When the DNER is prepared to approve the final steps of implementing this system, a reasonable price (the dive operator suggested $15) and easy accessibility would likely result in increased revenue for the DNER and would provide a more accurate count and record of individuals exploiting the marine resources.

Comparison to 2002 García-Moliner Report

The only other recent investigation involving recreational fishing in Puerto Rico is the García-Moliner report entitled *Recreational Chartered Fishing Activity in the U.S. Caribbean*. García-Moliner's report focused on 19 chartered fishing business of finned fish (blue water species, sport fish, reef fish, etc.), while our study included 37 chartered dive operators and the collection of invertebrate species (queen conch and spiny lobster particularly) and spearfishing. While the two studies contain similarities and differences, it is important to note that they both helped compile a more complete depiction of the entire recreational fishing society which includes all types of recreational fishing (chartered, private, shoreline) and are beneficial to the goal of the MRIP which is to include all types of recreational fishing in its surveys in order to properly represent the entire fishing community.

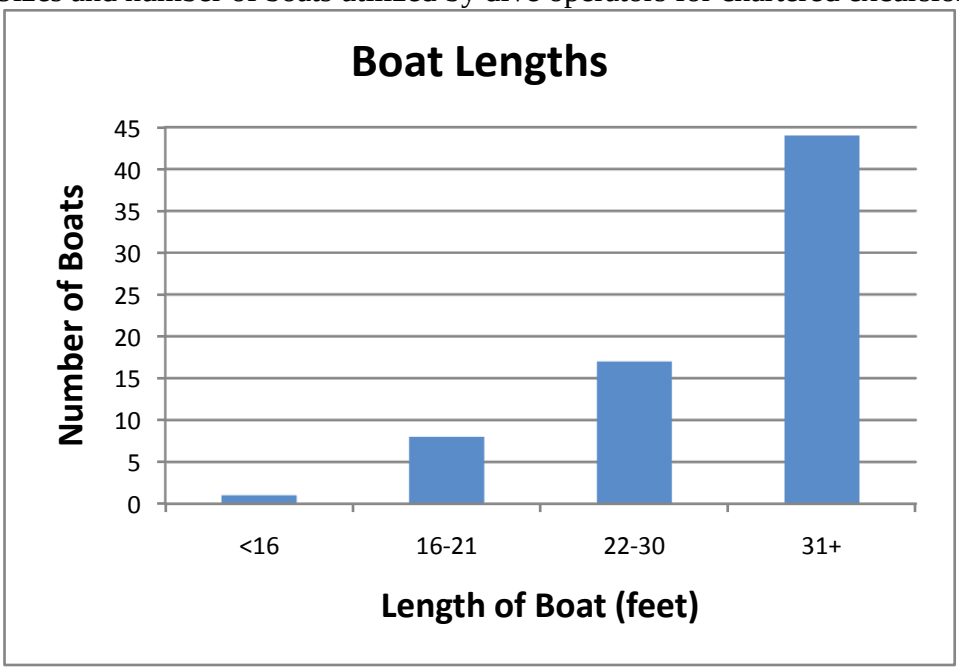
García-Moliner surveyed 19 different chartered fishing businesses, which utilized a total of 26 boats. Figure 17 shows the size distribution of the chartered fishing boats included in her survey. Figure 15 shows the size distribution of the 37 chartered diving/snorkeling boats of our study.

Figure 17: Size Distribution of Chartered Fishing Boats from the García-Moliner Report



Data from Recreational Chartered Fishing Activity in the U.S. Caribbean. García-Moliner, 2002

Figure 15: Sizes and number of boats utilized by dive operators for chartered excursions



It is interesting to note that the majority of boats used for chartered diving and snorkeling are over 31 feet long, while chartered fishing has a more even distribution of vessel length. García-Moliner also discovered that the number of boats in Puerto Rican waters has been increasing over the years. Our results cannot be directly compared to the report written by

García-Moliner, because our study dealt with different types of chartered vessels. In 2002, García-Moliner discovered 26 chartered fishing vessels in Puerto Rico, while our study identified 70 boats used for chartered diving/snorkeling excursions. These figures show a general increase in the number of boats used in chartered operations, as García-Moliner predicted, and can be compared with future studies.

Another important difference to mention between the García-Moliner report and our study is that García-Moliner conducted phone surveys and we performed in-person questionnaires, which we found to have a very high response rate (approximately 90%). It is also useful to note that both reports attempted to gain specific information about individual chartered businesses. García-Moliner gathered information about vessel size, number of years in business, estimated costs per vessel, and the number of trips per year each business takes. Using this information she made estimates of effort, cost, and potential impacts these chartered operators have had on marine habitat. Specifically by using the number of boats, trips per year, average number of lines per trip, and number of people per trip she estimated that 54,000 lines per year are cast off of chartered fishing vessels, who take approximately 43,200 trips per year. She also attempted to make correlations between boat size and number of years in business, but there was none. Our study was more focused on the collection of marine species, but also tried to gather general information regarding number of vessels, size of vessels, clientele, and seasonality of business. Using these data we estimated that approximately 83,850 people go on chartered fishing excursions each year.

Even though the García-Moliner report and our investigation involve two different types of chartered operators, many similarities about chartered businesses can be derived from the two studies. García-Moliner discovered that by comparing her list of chartered fishing operators to studies completed between 1992 and 2000, there was only one repeat, indicating a "rapid turnover in chartered businesses" (García-Moliner, 2002). Our study discovered very comparable results. We originally identified 79 chartered dive businesses in Puerto Rico through phone books, the internet, tourist stands, and snowball references. After attempting to contact these businesses, and through conducting our questionnaire, our list of chartered dive operators was reduced to 41, showing that the chartered dive industry is constantly changing due to companies joining and withdrawing from the chartered fishing business. Of the 19 chartered fishing businesses surveyed by García-Moliner, the number of years that each were in business ranged from one to 49, with an average of 13 years in business. In order for the MRIP to be successful,

the “national registry,” which will include all dive/snorkel operators as well as chartered fishing, will need to be checked and updated regularly.

Both investigations allotted time for the participants to provide feedback and comments about anything they felt the respected studies should focus on. García-Moliner reported that many of her participants stated a need to manage, both fishing activities and the number of people participating in ocean sports. Many of the participants of our investigation suggested that the laws and regulations currently in place need to be enforced more thoroughly and consistently. These comments show a genuine concern for marine resources by both types of charted operations, and advocate a need for better, firmer regulation and management.

Another comment from participants of García-Moliner’s report was the need to conserve special habitats where juvenile species congregate as well as where certain species migrate to breed. Several participants of our questionnaire mentioned that spiny lobsters with eggs were being collected, and the eggs were being removed before being taken. There were also several comments that people were not following size regulations that are currently in place for queen conch or spiny lobster. It seems that chartered operators of both businesses notice similar illegal practices occurring in Puerto Rican waters. It may be necessary to establish more protected areas where species gather to breed, or where juvenile fish congregate, as well as more strictly enforce the laws that are currently in place to prohibit such activities.

Conclusions

Prior to the beginning of this study, the DNER had no information concerning chartered dive and snorkel operators in Puerto Rico. There was no official up to date list of chartered dive operators, and instead employees kept a binder with business cards as reference. No information existed on the scale of chartered dive and snorkeling, how many people were taken out, where they were taken out, marine species collection habits of the clients and whether or not chartered businesses had access to the internet. The present studies has answered all of these questions, giving the DNER its first look into chartered dive and snorkel operators and how they affect queen conch and spiny lobster populations.

Chartered dive and snorkeling operators have a small impact on queen conch and spiny lobster populations. From the questionnaire, few dive and snorkel operators reported having clients that collect marine species (7 of 37), and even fewer reported having clients that collect queen conch or spiny lobster (4 of 37). The second theme to note is that several dive operators felt that private divers are contributing most to the perceived decline in conch and lobster

populations. However, this second theme should be received with certain skepticism. Since this census was only done among chartered dive and snorkel operators, it is expected that any comments assigning blame for declining conch and lobster stocks would be aimed at any group other than chartered operators. Keeping this in mind, there are still good reasons to believe their comments. According to chartered operators, private divers are not always aware how their individual actions can have a cumulative effect on reef health. Private divers can be sport divers that are only in Puerto Rico for a few days, and so might think that their activities cannot contribute to declining marine stocks. Alternatively, private divers might only be collecting for themselves and their family, and so think that their impact is small compared to commercial collection. What both of these mentalities fail to grasp is that while their individual impacts are small, a large number of private divers can have a big cumulative impact on marine stocks. This is only the opinion of chartered dive and snorkel operators. Further studies would be needed to assess the actual impact of private divers relative to chartered divers.

Based on our questionnaire results, a web reporting system as a part of the MRIP would be technically feasible for chartered operators, as an overwhelming majority have access to the internet from their business. Unfortunately, it is difficult to determine just how responsive and cooperative the operators would be if a web reporting system was in fact implemented. Many of the respondents have a negative view of the DNER, believing that the taxes they pay are going into a "central fund" and are not being properly managed to specifically improve the resources their business uses. Since so few operators allow collection of conch and lobster, it would be more practical for the MRIP to focus monitoring efforts on other types of recreational fishing such as private and shoreline. An online reporting system would likely encounter much resistance and provide little data on the collection of conch or lobster.

According to the responses, there is very little collection of marine species by clients of chartered operators. Of the six operators that indicated they have collected species, only three collected conch and lobster while the rest caught species such as reef fish, blue water species, white coral, sponges, sea urchins, and others. As few operators stated that they have had clients collect marine species in the questionnaire, it would most likely be unnecessary to try forcing operators to report landing numbers on a regular basis.

While there are some respondents who disagree, the majority of the responses indicate that there is a definite decrease in spiny lobster and queen conch populations around the island. This decline could have been caused by many factors, such as overfishing by other recreational divers (private) or commercial divers. The decreasing populations could also be a result of

divers catching these species when they are under the size/length limit or during the breeding season. As these are only hypotheses, further studies would be necessary to determine the true cause of the population decreases and whether or not conservational efforts may be important.

Fifty-eight percent (58%) of surveyed chartered operators have a mostly tourist-based clientele, and many respondents gave feedback indicating that spiny lobster and queen conch populations are affected much more by local private divers than by tourists on charter boats.

Recommendations

1. *All chartered dive operations should be added to the national registry of the MRIP until further investigation can prove that they do not significantly contribute to the collection of marine species.*

It has been discovered through our questionnaire that very few dive operators appear to allow their clients to collect marine species or spearfish. However, it was difficult to gauge the honesty of the responses we received from our questionnaire. As previously mentioned, many dive operators claimed that they did not allow their clients to spearfish or collect marine species, yet there were several photographs in dive shops of people holding lobsters, touching marine species, and spearfishing. There were also mounted lobsters and conch shells in the offices of several dive shops. In order to completely capture business that can potentially collect marine species, all chartered dive and snorkel operators should be added to the MRIP list.

2. *Monthly or yearly surveys of dive and snorkel operators concerning marine species collection may be more appropriate than a weekly survey.*

Only 4 of 37 operators surveyed reported having clients that collected conch or lobster in the past year. Therefore, requiring all chartered operators in Puerto Rico to fill out an online landings reporting system when the vast majority never allow collection of any type may further strain relations between the DNER and chartered operators. Less frequent surveys, perhaps monthly or yearly, should be adequate to capture any changes in collection habits among chartered dive and snorkel operators. If species collection becomes more common in the future, more frequent surveying may then be more appropriate.

Since the impact of chartered dive and snorkel operators on conch and lobster populations is small yet 54% of operators surveyed thought that both conch and lobster populations had decreased over the past five years, this begs the question, what is to account for the perceived decrease in queen conch and spiny lobster? For the purposes of analysis, it was assumed that the dive operators' perceptions of changes in conch and lobster populations were reflective of actual changes in their populations. At the time, no field counts of conch and lobster populations in Puerto Rico were available as a more accurate gauge. This assumption is reasonable because the chartered operators are on the ocean on a near daily basis and can observe population behavior over a long period of time.

Also a monthly or yearly survey would serve to help keep the MRIP national registry updated. We've noticed that the chartered industry is constantly changing and has a very high turnover rate. Some type of survey would need to be implemented in order to maintain a current list of dive operators as well as eliminate companies that are no longer in business.

3. *Additional research is necessary to characterize the effects of chartered diving and snorkeling on marine resources. Studies should be performed in the following areas:*
   A. *Research on private divers and snorkelers to collect data on their collection habits, locations and landings with regards to queen conch and spiny lobster.*
   B. *Dive intercept surveys in popular dive and snorkel locations.*
   C. *Official counts of conch and lobster populations.*

A. Research on private divers and snorkelers is a significantly more challenging task than that of surveying chartered operators. The most obvious difficulty is that private divers are difficult to locate because they do not have a store and do not advertise. They can put into the water from a private residence where it is essentially impossible to conduct a dock-intercept survey, and they can go out early in the morning or return late at night. Private divers are also more transient than chartered operators. For example, they can come to Puerto Rico for a few days to dive for sport or they can be residents that only go out once or twice a year for fun. The sheer number and effort required to track down and interview even a fraction of private divers is daunting. The following two recommendations will make the task of studying private diving more manageable.

B. Dive intercept and dockside surveying of private divers and snorkelers should be focused in popular dive locations, which are shown in the map in Figure 16. Although private divers may launch from many different locations it is reasonable to assume that like chartered divers, they travel to certain hot spots. It is also reasonable to assume that these hot spots are the same for both chartered and private divers, as both are interested in seeing abundant sea life. Here, dive intercept surveys could be carried out to collect the most accurate information on species landings. Based on the questionnaire results, these hot spots would be: east of Humacao, off the east coast of Fajardo, southeast of Culebra, south of Vieques, south of La Paguera, Desecheo Island and north of San Antonio. Figure 16 below shows all of the most popular chartered dive and snorkeling locations.

Figure 16: Map displaying all of the different dive and snorkel sites used by chartered operators. Numbers on the map indicate the average number of visitors per week.

The most obvious advantage of this approach is that it would capture the most accurate landing information, as it directly measures what people catch, not what people *say* they catch. However, the drawback of such an approach is that it takes significant time and effort for a DNER agent to patrol the waters, looking for private boats which tend to be smaller and may only be on the water for a few hours. Although the map in Figure 16 only has a resolution of 5 miles, in reality an agent would not have to comb through all 25 square miles looking for divers. Common sense would limit the possibilities to shallow waters for the collection of queen conch and spiny lobster. It would be harder to locate dive sites for spearfishers because they don't have to stay to coastal waters. Nearly none of the chartered operators reported allowing spearfishing, thus the hot spots in Figure 16 probably do not correlate with hot spots for spearfishing.

Finally, with a dive-intercept or dockside survey, it would be difficult to gauge how much of the private dive population is being reached. One possibility is to survey the same area multiple times on different dates. If the same boats are found each time, then more of the private diving population is being reached. If however new boats are found each time, then it is likely that only a small portion of the private dive population is being reached. The shortcoming of multiple sampling is that it only works well if the same divers go out on a consistent basis, so that there is some overlap between sampling. However, this method could not accurately account for the vacationing diver who only goes out once or twice. Another method should be used in conjunction with dive intercept surveys to track private divers.

C. Formal counts of queen conch and spiny lobster should be taken, to quantify changes in their population and locations where it is occurring. Many operators have noticed a decrease in both queen conch and spiny lobster populations in almost all areas chartered operators visit. From the questionnaire responses, many operators noticed a decrease in both conch and lobster populations in Desecheo Island, off the east coast of Fajardo, south of Culebra, south of Vieques and east of Humacao. Some research has already been done by the Fisheries Research Lab's SEAMAP (South East Area Monitoring and Assessment Program) to monitor numbers of conch and lobster populations, but it needs to continue in order to draw conclusions about exactly how much declining populations are being impacted. Special attention should be given to these areas before the decrease in populations becomes too severe to resolve.

4. *The DNER should create a system to make fishing licenses easily available at a wide variety of locations, such as convenience stores and dive supply shops.*

Diver registration is another method that should be used to track private divers. While there are extensive plans in place for licensing of private SCUBA diving, no law currently requires licensing. Of course this leaves the DNER with no record of the activities of private divers. Implementing a fishing registration program would be an effective way to assess the number of private divers, although with all other recreational fishers.

A successful fishing registration program needs have three points. 1) Licenses need to be made available for purchase in a wide variety of easy-to-access locations such as grocery, drug and convenience stores and dive suppliers. People will be more likely to buy a license if they don't have to make a special trip. 2) Licenses must be made cheaper so as to make private divers more likely to purchase them. One chartered operator suggested $15 for a private diving permit. In terms of revenue, the decreased price will be offset by higher volume. 3) Fines for collecting marine species without a permit must be made higher, so as to encourage proper licensing use. In reality, enforcement always seems to be the shortcoming of any marine regulation. In their comments during the questionnaire, chartered operators were aware of the lack of law enforcement. One can only assume private divers are also aware of the lack enforcement. Higher fines encourage proper licensing use with less man-power than water patrols.

5. *The DNER should improve relations with dive operators to ease future monitoring.*

In a very real sense, this questionnaire and report was only possible because it was conducted by students from a university. Had the DNER tried to conduct the exact same survey themselves, they would likely have failed because they are perceived negatively by chartered dive and snorkel operators. Several of the complaints were over the recently enacted concession fees, which many dive operators consider a form of double taxation. One operator was already shut down over refusing to pay it and others are contesting its legality in court. In all but one case, dive operators were able to separate their feeling for the DNER from our DNER-sponsored investigation and agreed to take our survey. Should the DNER themselves need to conduct a similar survey in the future, they will likely face a much lower response rate which in turn reduces the amount of viable data they can collect and hinders their ability to properly manage marine resources. A positive image among chartered dive operators is important for the DNER to better fulfill its mission to manage marine resources. The following three recommendations are ways in which the DNER could improve its relations with the chartered diving community.

6. *Increase the number of mooring buoys.*

Through conversations with dive operators during the questionnaire, two important points emerged that would help the DNER to improve its image. Increasing the number of mooring buoys would please many dive operators. They stated that there are more boats at popular dive location than there are mooring buoys. Boats, either private or chartered, will sometime circle a buoy waiting for a boat to leave and then race to it in order to moor. This example clearly shows that captains are eager to help protect the reef by using mooring buoys if they are available. However, chartered operators reported being forced to drop anchor when all the buoys are full. While they try to aim for sandy areas, their anchors undoubtedly have an impact on the reefs. In regards to buoy maintenance, chartered operators said it took as long as six months to get a broken buoy replaced, and although the DNER has been looking into ways to remedy this situation, improvements still need to be made. Increasing the number of mooring buoys and expediting their replacement would improve the DNER's image.

7. *Clearly communicate how taxes from chartered dive and snorkel operators are being used to improve marine resources.*

Chartered operators also cited the need for better management of money collected through taxes. Operators said they did not mind paying the money so long as they knew specifically how it was

being used. They worried that their taxes were being lumped into a central DNER pot, and were not being used to specifically improve marine resources. To improve their image, the DNER should make it clear how any marine improvement projects are being funded. Improvements using chartered dive operator money need to be clearly identified. For instance, if a new mooring buoy is installed, it should have a notice saying something to the effect of, "This mooring buoy is funded by chartered operators' fees."

8. *Increase enforcement of regulations to reward dive operators that are complying with current regulations.*

Feedback from our questionnaire indicates that many dive operators are displeased with the enforcement of existing regulations. Most dive operators are content with the current regulations and are appreciative that marine habits and species are being protected, but they feel that size and bag limits are not being properly enforced, and that regulations are not well known to the public. Another major concern is the regulation of illegal operations. There are regulations in place including licenses and permits that need to be obtained in order to legally operate, but according to some dive operators that were surveyed, there are several businesses that do not acquire licenses. Because the DNER has no formal paperwork from the illegal charters and monitoring of illegal activities is lax, the DNER ends up nit picking the legal charters while leaving illegal charters undisturbed. The result is a feeling of resentment among legal charters, who feel they are being punished for doing the right thing, while illegal charters are slipping by without consequence. Consistent enforcement of all regulations will benefit marine habitats as well as create better relationships with DNER and chartered dive operators.

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Appendix A: Organization Overview and Responsibilities of the DNER

The Department of Natural and Environmental Resources (DNER) is a non-profit, public government agency that was founded by law No. 23 on June 20, 1972 and reorganized in 1993 under the Johannesburg Plan of Reorganization. With 54 divisions, including public outreach, conservation, and construction, the DNER lives by the following mission: “To protect, conserve and manage natural resources and environmental aspects of the country in a balanced form, to ensure future generations their enjoyment and foster a better quality of life” (Department of Natural and Environmental Resources [DNER], 2008). Furthermore, the DNER actively follows a clear vision, "to encourage a healthy environment through the promotion of sustainable use of natural resources, environmental management and the transformation of an environmental culture of Puerto Ricans with the participation of all sectors of society to improve the quality of life" (DNER, 2008).

The DNER protects a diverse set of terrestrial and marine habitats. Protected marine reserves and parks are shown in Figure 1. It discharges its duties from a central office located in San Juan, as well as 68 field offices spread throughout the island. The DNER collects data on natural life in order to make informed public policy decisions, as well as educating the public about natural resources. The agency also issues permits and endorsements to encourage the appropriate use of natural resources and manage navigation safety. Some examples include permits for mineral extraction, construction surveying, and tree management.

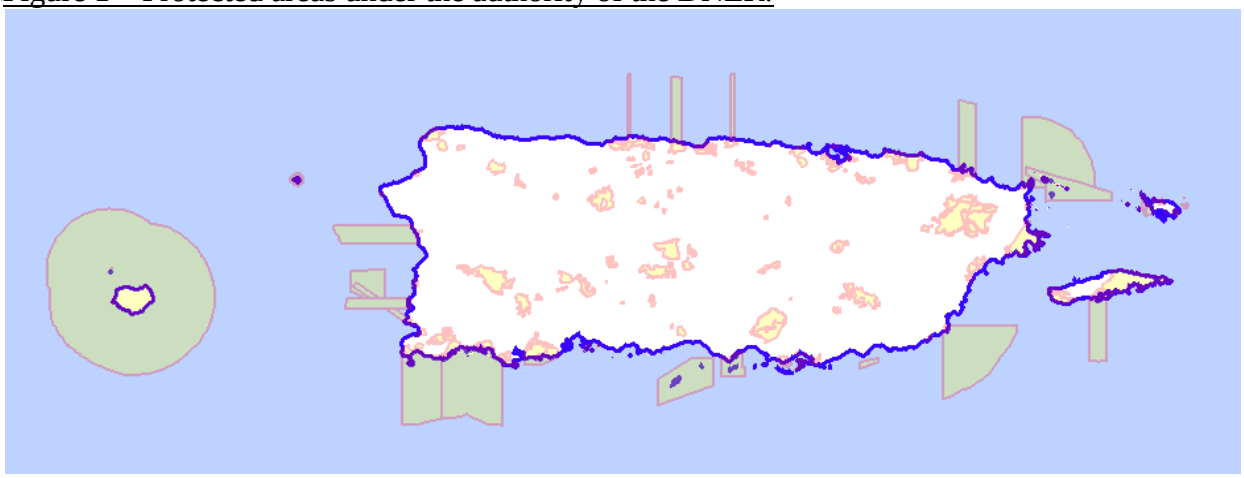
The DNER has a hierarchical structure with a secretary to oversee the company’s operations. The current secretary is Javier Velez Arocho, who supervises and advises various committees controlling environmental policies. He is appointed by the governor to serve on his Consultative Counsel, subject to the approval of the legislature as prescribed by Article IV, section 5 of the Puerto Rican constitution (DNER, 2006). While he is at the head of the department, he is not in charge of its day to day operations, but oversees its long term goals and strategies. The secretary functions as an advisor to the Governor and legislature, providing data and recommendation relating to natural resource use and conservation. This function fulfills the mission statement of the DNER, namely, environmental management and conservation to improve the quality of life for commonwealth members (DNER, 2008). This directly fulfills the stipulation of Article VI, section 19 of Puerto Rico's constitution to "conserve, develop and use

its natural resources in the most effective manner possible for the general welfare of the community" (Rivera, 2008). In addition to his advisory role, the Secretary sits on several committees that ensure the general welfare of Puerto Rico's natural wildlife. These responsibilities leave the secretary little time to run day to day operations, which are instead delegated to the Assistant Secretary. The Assistant Secretary approves all permit requests as well as represents the DNER in any official function.

The DNER is responsible for a wide variety of projects intended to protect plants, wildlife, and habitats, and encourages public visits to protected areas and environmental awareness. For example, in December of 2007, the DNER carried out a project to re-release into wild endangered Puerto Rican parrots that were raised in captivity. These parrots were released into the Rio Abajo State forest in Arecibo, where they continued to be observed and assisted while adjusting to their new environment. The DNER has also recently resumed work on flood prevention projects that had been previously abandoned. Seventeen million dollars have recently been dedicated towards cleaning canals and dams in an effort to prevent flooding in communities such as Ponce, Sabana Grande, Vega Baja, and Humacao. (DNER, 2008)

The DNER also has a history of sponsoring WPI projects. Recently, WPI students have worked on IQPs for the DNER concerning reforestation, public forest management, and creating an inventory of marinas. Our project, concerning the impact of sport spearfishing on marine wildlife, will be carried out in partnership with the Marine Resource Division and its director, Dr. Craig Lilyestrom. The division is part of the Bureau of Fishing and Wildlife, which is one of three bureaus within the Department of Living Resources. The Bureau of Fishing and Wildlife's mission is "to conserve, to protect, and to improve the resources of fishing and wildlife; promoting the sustainable and rational use for the enjoyment of the future and present generations." (DNER, 2008) In 1996, the Bureau of Fishing and Wildlife launched a strategic plan to ensure the efficient use and conservation of local marine wildlife. To accomplish this goal, the Bureau needs accurate, up to date information on marine populations which will help to determine if a species is threatened or endangered and if it needs the protection of the DNER. Particular focus is given to hunted species, such as Queen Conches and lobsters, which are pursued by recreational spearfishermen. The focus of the current IQP will be to monitor these populations to help DNER determine if they are in need of protection. If necessary, a combination of increased public awareness, local private organizations and regulation is used to protect a threatened species (DNER, 2008).

Figure 1 – Protected areas under the authority of the DNER.



Areas under the protection of the DNER have been highlighted in green and yellow. Note both the marine and terrestrial responsibilities of the DNER. (DNER, 2008)

Appendix B: IRB Approval Letter

100 Institute Road
Worcester, MA 01609-2280, USA
508-831-5296, Fax 508-831-5896
www.wpi.edu

Department of
Social Science
and Policy Studies

17 March 2008
File: 2008-007

Worcester Polytechnic Institute
100 Institute Road
Worcester, MA 01609

Re: IRB Approval: #2008-007, "Marine Wildlife Conservation":

Dear Professor Golding,

The WPI Institutional Review Committee (IRB) approves the above-referenced research activity, having conducted an expedited review according to the Code of Federal Regulations 46.

Consistent with CFR 46.116 regarding the general requirements for informed consent, we remind you to only use the oral informed consent script that was proposed as a part of the questionnaire that you intend to use. The requirement for a signed informed consent statement has been waived in this instance.

The period covered by this approval is 17 March 2008 until 16 March 2009, unless terminated sooner (in writing) by yourself or the WPI IRB. This approval becomes immediately null and void if this project receives any federal sponsorship. Amendments or changes to the research that might alter this specific approval must be submitted to the WPI IRB for review and may require a full IRB application in order for the research to continue.

Please contact the undersigned if you have any questions about the terms of this approval.

Sincerely,

Kent Rissmiller
WPI IRB Chair

Appendix C: Original Questionnaire

Survey Preamble:

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting a survey of dive boat operators in Puerto Rico, with the goal of collecting statistical data about chartered fishing activities. This study will provide a better understanding of fishing activities and the status of fish populations. We strongly believe the research will enhance the management of fish stocks and the long-term success and sustainability of chartered fishing in Puerto Rico. This is a collaborative project between the DNER and WPI, and your participation and honesty is greatly appreciated.

Your participation in this survey is completely voluntary and you may withdraw at any time. Also please remember that the results will be anonymous. No names or identifying information will appear on the questionnaires or in any of the project reports or publications. If interested, a copy of our results can be provided at the conclusion of the study.

1. **Which position(s) do you hold at your chartered business? Circle all that apply.**
   a. Captain
   b. Manager
   c. Owner
   d. Other:_____
   e. None of the above

First, we would like to collect some information about your business. Think about when your business is open, how many boats you own and about how many clients you take out.

2. How many years has your chartered operation been in business? _____

3. Which days of the week are you typically open for business? Circle all that apply.

a. Monday
b. Tuesday
c. Wednesday
d. Thursday
e. Friday
f. Saturday
g. Sunday

4. Which months of the year are you open for business? Circle all that apply.

a. January
b. February
c. March
d. April
e. May
f. June
g. July
h. August
i. September
j. October
k. November
l. December

5. How many boats does your business use for chartered diving excursions? ____

6. How long is the boat you use most often for chartered diving excursions? Check the appropriate box.

	Less than 16 feet	16-21 feet	22-30 feet	31+ feet
Boat #1				

7. If you use more than one boat for chartered diving excursions, what are their lengths? Check the appropriate box.

	Less than 16 feet	16-21 feet	22-30 feet	31+ feet
Boat #2				
Boat #3				

8. Do your clients fish or collect any marine species from your boat(s)?

a. Yes
b. No

9. Do your clients spearfish from your boat(s)?

a. Yes
b. No

10. Are your boats used for purposes other than chartered diving?

a. No.
b. Yes, my boat is used for commercial part-time fishing
c. Yes, my boat is used for participation in fishing tournaments

d. Other:_____

Now we would like to ask about the dive excursions. Think about a typical excursion that you bring clients out on. Think about the species your clients may catch, where they catch them and the techniques they use.

11. How many people do you take out on a typical excursion?

a. 1-2 b. 3-5 c. 6-10 d. 10+

12. Do you or your clients catch any of the following species? Circle all that apply.

a. Queen conch
b. Spiny lobster
c. Whelk
d. Reef fish
e. Blue water species
f. Other:_____

13. What type of fishing techniques are used to collect queen conch? Circle all that apply.

a. We do not allow clients to collect queen conch
b. Hand catching with SCUBA equipment
c. Hand catching with snorkeling equipment
d. Other. Please specify:_____

14. What type of fishing techniques are used to collect whelk? Circle all that apply.

a. We do not allow clients to collect whelk
b. Hand catching with SCUBA equipment
c. Hand catching with snorkeling equipment
d. Other. Please specify:_____

15. What type of fishing techniques are used to collect spiny lobster? Circle all that apply.

a. We do not allow clients to collect spiny lobster
b. SCUBA equipment, by hand
c. SCUBA equipment with noose
d. Snorkeling equipment, by hand
e. Snorkeling equipment with noose
f. Lobster pots
g. Mopping
h. Other. Please specify: _____

16. Where do your customers most often catch queen conch? Please check all grids on the map that apply.

17. Where do your customers usually catch whelk? Please check all grids on the map that apply.

18. Where do your customers usually catch spiny lobster? Please check all grids on the map that apply.

19. Have you noticed a decrease in queen conch or spiny lobster populations over the past five years?

a. No significant change has been noticed.

b. Yes. It is occurring in these locations (Mark locations on map)

20. Do you keep records of species & number caught? If yes, indicate all species that you record.

a. Yes. Species tracked: _____
b. No

21. In the past week:

a. How many trips did you make? _____
b. How many clients did you take out on your boat(s), regardless of if they caught any fish? _____
c. What species were caught, if any? _____
_____
_____
_____

22. Have you ever noticed charter vessels of other nations or islands fishing in Puerto Rican waters? If so, please specify where and when if possible.

Finally, we would like to ask about your clients. Think about the times during the year when you are most busy and least busy, and where your clients are from.

23. Approximately how many clients per week do you have during the following seasons?

	Clients per week					
Season	**0-10**	**11-20**	**21-30**	**31-40**	**41-50**	**50+**
Jan - March						
Apr - June						
July - Sept						
Oct - Dec						

24. In general, who are your primary customers?

a. Tourists
b. Local residents
c. Not sure

25. Does your business currently have convenient internet access?

a. Yes
b. No

26. If not, do you plan for your business to have internet access in the next year?

a. Yes
b. No
c. Not sure

27. Do you know of any other chartered businesses that could be of help to our study?

28. Your feedback is important to our study. Is there any important information that you feel our questionnaire may have missed?

29. Are you interested in receiving the results of this study once it is completed?

a. Yes
b. No

Appendix D: Revised Questionnaire

Below is the questionnaire that was used to survey 37 dive operators for this study. It was administered as is, with the only exception that the map in question 9 was enlarged and cropped to more clearly show areas near to the dive and snorkel operators.

Managing Marine Resources

Worcester Polytechnic Institute

Hello! We are students from Worcester Polytechnic Institute in Massachusetts conducting a survey as part of a university project. This questionnaire asks about the collection of queen conch and spiny lobster from chartered dive operators. Please be aware that all of these activities are legal. The purpose of this survey is to collect valuable information from dive operators to enhance the ocean management and the long-term sustainability of chartered diving in Puerto Rico. Our project is being sponsored by the DNER. Because our project team wants you to feel comfortable, all responses are confidential. No names or identifying information will appear on the questionnaires or in any of the project reports, presentations or publications. While your participation is greatly appreciated, please note this survey is completely voluntary and you may withdraw at any time. If you're interested, a copy of our results can be provided at the conclusion of the study. We hope you will join us in improving Puerto Rico's marine resources by taking this brief questionnaire.

This questionnaire has been designed to be completed in 15 minutes.
We thank you for your honesty and completeness.

1. **Which position(s) do you hold at your chartered business? Circle all that apply.**
   f. Captain
   g. Manager
   h. Owner
   i. Other:_____
   j. None of the above

First we would like to ask about some of the activities of your clients. While most of your clients may do the same thing, we are also interested in the activities of your clients that may do different things. For the next questions, think about the activities of both the usual and unusual client.

2. In general, who are your primary customers?
   a. Tourists
   b. Residents of Puerto Rico
   c. Not sure

3. In the past year, have *any* of your clients collected marine species from your boat(s)?
   a. Yes. Please continue to **question 4.**
   b. No. Please skip to **question 9.**

4. If in the past year any of your clients have collected marine species, have *any* of your clients spearfished from your boat(s)?
   c. Yes
   d. No

5. In the past year, have *any* of your clients caught any of the following species? Circle all that apply.
   a. Queen conch
   b. Spiny lobster
   c. Whelk
   d. Reef fish
   e. Blue water species
   f. Other:_____
   g. Our clients have *never* caught marine species.

6. What types of techniques were used to collect queen conch? Circle all that apply.

e. Hand catching with SCUBA equipment
f. Hand catching with snorkeling equipment
g. Our clients have *never* collected queen conch
h. Other. Please specify:_____
i. Do not know

7. What types of techniques were used to collect whelk? Circle all that apply.

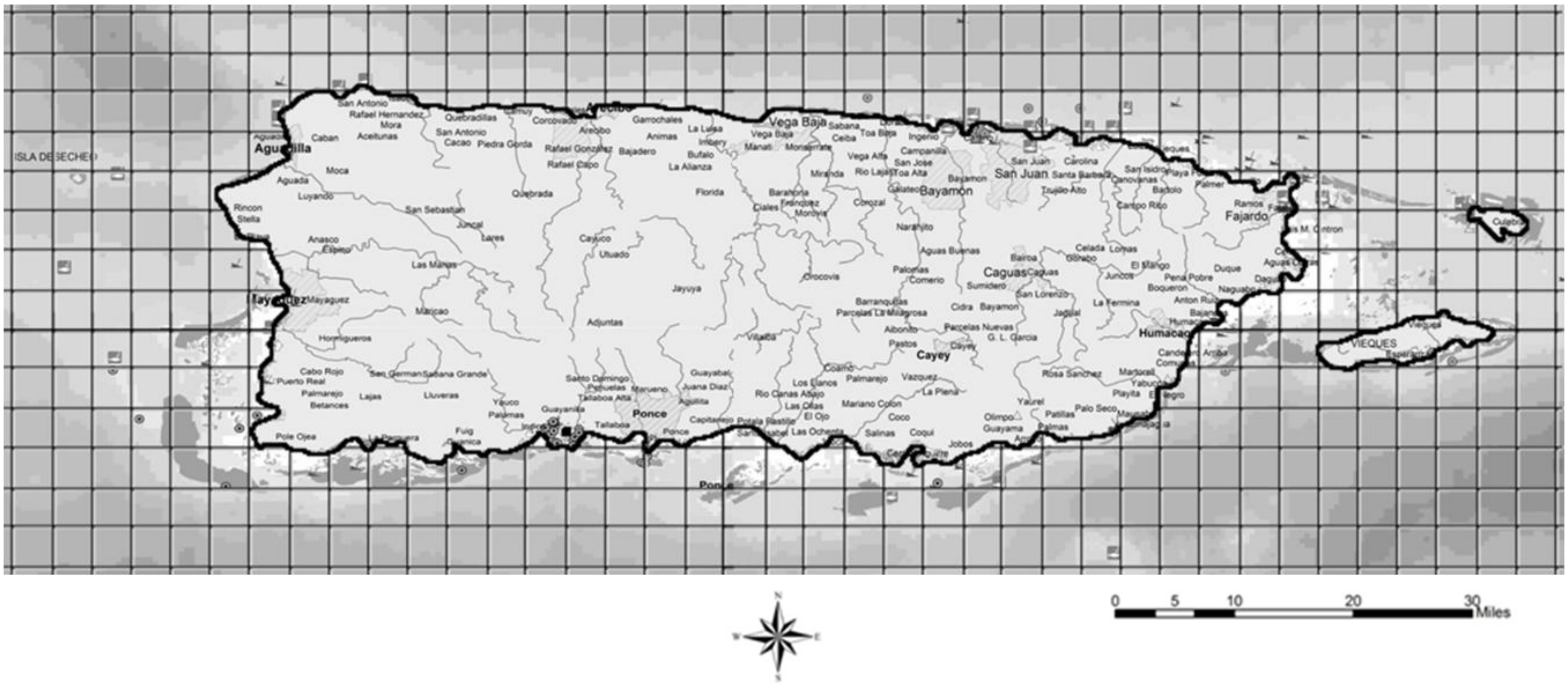
e. Hand catching with SCUBA equipment
f. Hand catching with snorkeling equipment
g. Our clients have *never* collected whelk
h. Other. Please specify:_____
i. Do not know

8. What types of techniques were used to collect spiny lobster? Circle all that apply.

a. SCUBA equipment, by hand
b. SCUBA equipment with noose
c. Snorkeling equipment, by hand
d. Snorkeling equipment with noose
e. Mopping
f. Other. Please specify: _____
g. Our clients have *never* collected spiny lobster.
h. Do not know

9. Where do you take your customers on your trips, regardless if they catch anything? Please put an "X" in the boxes where your clients dive or snorkel on the map on the following page.

9. Please put an “X” in the boxes where your clients dive or snorkel, regardless if they catch anything.



10. Have you noticed a change in queen conch or spiny lobster populations over the past five years?

Queen Conch

c. Yes - increasing
d. Yes - decreasing
e. No change
f. Don't know

Spiny Lobster

a. Yes - increasing
b. Yes - decreasing
c. No change
d. Don't know

11. In the past year, have you ever noticed charter vessels of other nations or islands diving in Puerto Rican waters? If so, please specify where and when if possible.

a. No
b. Yes. Please answer below.

Finally, we would like to know a little bit about your business.

12. Does your business currently have convenient internet access?

c. Yes
d. No

13. If not, do you plan for your business to have internet access in the next year?

d. Yes
e. No
f. Not sure

14. How many boats does your business use for chartered diving/snorkeling excursions? ____

15. How long is/are the boat(s) you use most often for chartered diving/snorkeling excursions? Please write the number of boat in the boxes bellow.

	Length of Boat (in feet)			
	Less than 16 feet	16-21 feet	22-30 feet	31+ feet
Number of Boats				

16. Do you know of any other chartered diving/snorkeling businesses that could be of help to our study? If yes, please list their name, location and telephone number below.

Name	Location	Telephone

17. Approximately how many clients per week do you have during the following months?

	Clients per week						
Months	0-20	21-40	41-80	81-120	121-160	160-200	200+
Jan - March							
Apr - June							
July - Sept							
Oct - Dec							

18. Your feedback is important to our study. Is there any important information that you feel our questionnaire may have missed? Is there anything else that you would like to tell us? Please use the space below.

19. Are you interested in receiving the results of this study once it is completed?

c. Yes
d. No

Thank you for your time. You have successfully completed the chartered diving questionnaire. Please return your completed questionnaire one of the student researchers.