



Maintaining Marine Ecosystems



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Abstract:

Marine ecosystems such as coral reefs, mangroves and seagrasses are depleting at an alarming rate. The damage being done to these ecosystems is caused by human behavior and environmental changes. Locals and tourists in Puerto Rico often neglect coral reefs, mangroves and seagrasses. Many activities such as anchoring on top of reefs, poaching coral and even simply touching coral can be detrimental to its existence. The goal of our project was to assess the awareness of the public pertaining to these marine ecosystems. In order to do so, we conducted surveys along the coast of the island. We targeted particular areas such as marinas, beaches and local businesses to reach those who come in contact with the reefs. From the survey results and other anecdotal information, our group was able to make recommendations to the Department of Natural and Environmental Resources about how to reach the public and raise awareness about the importance of coral reefs, mangroves and seagrasses.

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Authorship:

Our group worked equally in writing this report. We also all shared in making necessary edits and revisions.

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Executive Summary:

Coral reefs, seagrasses and mangroves all have biological and economic importance. All three ecosystems are key habitats to various recreational and commercial species. They may seem to be three separate ecosystems, but they are all connected in one way or another. Coral reefs are home to nitrogen-fixing bacteria known as cyanobacteria. Some bacteria rely on the coral for survival, while other cyanobacteria surrounding seagrasses rely on the nitrogen produced by the bacteria for survival. This interconnected relationship can be seen in different species of fish and other animals. For example, some fish migrate from the mangrove roots to the seagrass nurseries when they are small. Then as adults, they are mostly found among the coral reef areas. Often, they migrate throughout all three habitats depending on what they are seeking, whether it is shelter, food, or a place for reproduction (personal communication, Aileen T. Velazco, April, 2009).

Coral reefs, seagrasses and mangroves also have economic importance. People flock from all over the globe to visit Puerto Rico. The uniqueness and beauty of coral reefs attract thousands of tourists each year. Thus, tourism is one of the main components in the Puerto Rican economy.

These marine ecosystems are depleting at an alarming rate. This is due to various negative human behaviors and climate change. First, as water temperatures continue to rise, the coral is damaged. The rise in temperature causes the coral to suffer from thermal stress and lose its symbiotic zooxanthellae, thus losing its pigmentation (personal communication, Aileen T. Velazco, April, 2009): a phenomenon known as coral bleaching. Coral reefs are also being adversely affected by human activities. Snorkeling, swimming, boating, kayaking, and fishing are just some of the numerous aquatic activities that prove to have some negative impacts on marine ecosystems. The users of these marine ecosystems continue to participate in these activities in ways that harm the environment primarily due to a lack of awareness regarding the negative impacts of their behaviors. Many people are unaware of the severity of their actions.

The Department of Natural and Environmental Resources (DNER) has been working on conserving these marine ecosystems. Their main focus has been to educate the public about the importance of coral reefs, mangroves and seagrasses. They have produced various forms of educational material, which they have distributed to the public. Also, in 2006 they conducted

nearly 500 surveys to assess the knowledge, behavior, and opinions of the users of coastal marine ecosystems, although the results proved to be inconclusive.

The goal of our project was to assess the effectiveness of the DNER's education and outreach campaign and to make recommendations to facilitate their efforts. We identified three main objectives that enabled us to reach this goal. These objectives were to: (1) assess the quality of the DNER's previous survey that they used in 2006; (2) create an improved survey; and (3) Assess the knowledge, opinions, and behaviors of these marine ecosystem users.

In order for us to assess the quality of the DNER's previous survey, we first analyzed the types of questions that appeared on this survey. After our analysis, we were able to identify areas of improvement that could be made to the survey. These improvements included wording choices and organizational strategies. We tested the first modified survey at the beach in the Condado region of San Juan and again at a marina in Salinas. Upon analysis of the results of these questions, we concluded that some of the questions seemed difficult for the respondents. For example, people would comment on potentially incriminating questions and we were able to tell that they were somewhat timid to answer in a way that may make them look bad. We observed that people were not answering questions truthfully, or were taking awhile to answer a specific question. Also, too many of the subjects had to ask us additional questions during the survey due to confusion and misunderstanding. This confirmed the existence of poorly worded questions along with errors in the format of the survey.

The results from nearly 70 test surveys administered in the Condado region of San Juan and Salinas provided a framework for our new survey. Since we had identified the areas of weakness, we now aimed at improving them. With the help of a social scientist, we put together an improved survey that now needed testing. This survey had four different sections, which inquired about the subjects' demographics, knowledge, behavior, and opinions with regard to marine ecosystems and the DNER's educational efforts. We tested the survey at the DNER vessel registration office. The results from this test run were much improved and we decided that this would be the final format of the survey, which we would use to assess our subjects.

To assess the knowledge, opinions, and behaviors of the users of Puerto Rico's marine ecosystems, we conducted over 300 surveys at various beaches, marinas, and other businesses in coastal communities. First, these surveys provided us with insight as to where the educational gaps exist regarding these marine ecosystems. Also, we were able to identify the level of

popularity among the numerous aquatic activities that adversely affect the environment if conducted improperly. In addition to this, the results allowed us to identify the most efficient means of distribution for the DNER's educational material. Furthermore, we were also able to analyze all of the above results with regard to specific demographic information. This allowed us to further pinpoint trends in education levels, aquatic activities, and publication distribution channels.

During our time spent surveying, we also observed the actions and behaviors of the target users, a technique referred to as "participant observation." This was a very helpful method because it allowed us to obtain information that the surveys may not have been able to retain. For example, as we were surveying at one location, we noticed a kayak resting on shore with poached coral inside of it. In another situation, we observed a user standing on top of coral reef in order to adjust her goggles for snorkeling. All of these types of observations enriched our studies because some of the subjects may not admit to these situations on the survey.

The most valuable set of information that we obtained during our time spent surveying was recorded as anecdotal information. There were numerous occasions in which the survey subject would either comment on specific questions, or tell us stories after the completion of the survey. In most occasions, these conversations lasted for several minutes and seemed like miniature interviews with the subjects. The anecdotal information that we obtained from beach goers, coastal business owners, and many other marine ecosystem users gave us valuable insight into the problems with detrimental aquatic activities. In Fajardo, for example, we spoke with the owner of a dive shop who explained the contradiction that exists between his concern for the environment and his concern for maintaining a prosperous business. Often these goals are conflicting and throughout our time spent in the field this type of qualitative information improved the encompassing problem at hand.

Upon retrieval of the data received from the numerous methods mentioned above, we made recommendations to enhance the DNER's education and outreach campaign. These recommendations primarily existed as creative and inventive suggestions for the DNER to deliver various forms of educational material to the target users. The recommendations were based primarily on two prevailing themes. The first theme is that we feel that stricter laws and heavier fines will be a more effective method for changing the detrimental habits of adults. The

second theme is that we feel education will be the most effective method for targeting younger subjects.

The recommendations will not be able to stop the detrimental byproducts of aquatic activities entirely, but they will be able to facilitate the education of the users of marine ecosystems and raise the consequential awareness of their actions.

Chapter 1: Introduction

Across the globe human behavior is the root cause that negatively impacts the coral reef ecosystems and its counterparts, mangroves and seagrasses. Anecdotal accounts from SCUBA divers and published work of marine scientists state that populations of humans have been damaging marine ecosystems at an unprecedented rate (Hodgson, 1999). As more tourist sites are developed along with growing water traffic, more damage is done to the reefs. The marine corridors are unique animals; they could be forced into extinction.

Despite the ecological and economic importance of the reefs, people have a poor understanding of how this ecosystem responds to human activities, particularly on a global scale (Hodgson, 1999). Humans unconsciously threaten these environments when coming in contact with them and they do not realize how detrimental the contact becomes at a global level. If communities continue to neglect the direct threats they are forcing on the coral reef ecosystems, they will vanish in the near future.

In Puerto Rico, where coral reefs are rapidly depleting, global warming is a major environmental issue that has just recently come to the forefront. For decades, increasing temperatures in the oceans and changes in weather patterns have been negatively affecting coral reefs in not only Puerto Rico but across the globe. Since the early 1980's, episodes of coral reef bleaching and mortality, due primarily to climate-induced ocean warming, have occurred almost annually in one or more of the world's tropical or subtropical seas (Baker, 2008). This environmental change has also been a suspect in coral bleaching. Bleaching refers to the loss of color due to the loss of the symbiotic dinoflagellate algae of the genus *Symbiodinium*, which is present within the tissues of some marine benthic animals such corals (A.E. Douglas, 2003).

The Department of Natural Resources (DNER) in Puerto Rico has been consistently dealing with this environmental menace. Although it may not be plausible to construct a plan to completely inhibit global climate changes, steps must be taken to reduce negative human impact on the coral reef. The DNER has undergone efforts to educate the public on the importance of coral reefs, mangroves, and seagrasses. They have also surveyed the public in an attempt to gauge their knowledge on the subject. Overall, their attempts to project public service

announcements and other various forms of visual aids needed to be tested to see if they are effective in raising awareness.

Assessing the effectiveness of the education and outreach campaign by the Department of Natural Resources was the goal of our project. As our first objective, we evaluated the DNER's surveys to revise any questions that were incriminating, leading, or lacked comprehension. These prior surveys conducted by the DNER provided us with a foundation for new survey ideas. From there, our second objective was to create an improved survey, which we used for the remainder of our study to gather data in sixteen locations targeting tourists (local and foreign), fishermen, boaters, and marinas. These target audiences were chosen based on their location and exposure to the various coral reef environments. Finally our third objective was to evaluate the knowledge, activities, and opinions of the target users. After we collected the data from the sixteen locations, we arranged the data in excel sheets in order to identify any trends and patterns in the underlying data. We discovered that there were trends in the educational gaps, as well as the common activities of the target audiences. Once analyzed, we made recommendations based on the analysis of these educational gaps and activity trends in order to contribute to the DNER's outreach campaign efforts. These recommendations were the foundation for a plan to reduce the harm being done to the coral reef and its associated marine benthic ecosystems in Puerto Rico.

Chapter 2: Literature Review

Coral reefs and other marine ecosystems are quickly depleting all over the globe. Coral reefs, mangroves and seagrasses are all important biologically and economically. This chapter will explain what coral reefs, mangroves and seagrasses are. Their importance and significance will also be discussed. These marine ecosystems are being damaged by a number of different factors. These factors include human behaviors and climate change, both of which will be explained in this chapter. Finally, there has been work done in the past to protect coral reefs, but more effort must be put into these conservation campaigns in order to make them successful.

2.1 Coral Reefs

Coral reefs are large structures that are made up of living organisms known as polyps. They have an exoskeleton composed of calcium carbonate, which gives it a rock-like appearance. Overall, coral reefs are an important aspect of the marine ecosystem and have many functions. First, they act as shelter to hundreds of species of fish, invertebrates and algae (Britannica, 2009). Their three-dimensional structure provides protection for a wide variety of tropical fish from predators and strong tides. In return, the fish provide the reefs with nutrients necessary for their survival (Moberg, 1999).

2.1.1 Coral Reef Survival

Most fish that live in the coral reefs venture to neighboring habitats for food and reproduction. These habitats include mangroves and seagrass beds. It is the connectivity between habitats that provides the coral reefs with nutrients. Some coral reef organisms migrate back and forth between adjacent ecosystems. “Examples of such species that link one ecosystem to another are fish that migrate to mangroves and seagrass beds and use them as nurseries” (Moberg, 1999). The excretion of herbivorous fish provides nutrients to mangroves, seagrass beds, and coral reefs. Within these reefs, the invertebrate species rely heavily on the nutrients excreted for survival. These specific species are scavengers who are unable to travel and hunt their own food. The only way for them to survive is to collect the falling organic matter found in

the feces of fish. Overall, coral reefs provide fish with shelter and protection, gaining nutrition in return (Moberg, 1999).

2.1.2 Contributions of Coral Reefs

Coral reefs do not only function as habitats for marine organisms. They also support life through a process known as nitrogen-fixation. “Reefs typically are surrounded by low-nutrient, low-productivity ocean waters but, paradoxically, the waters of coral reefs often have elevated nitrogen levels” (Larkum, 1988). The increased nitrogen levels in the waters surrounding coral reefs are due to nitrogen-fixing bacteria. Cyanobacteria are nitrogen-fixing organisms known to live amongst coral reefs. They are able to produce nitrogen which is vital in the growth and survival of marine plants. Overall, coral reefs are not only natural habitats for fish, but also for nitrogen-fixing bacteria, which support the surrounding plant life.

Reefs prove to be beneficial to the marine environment, but they are also valuable to the terrestrial environment. One example is their role in protecting the shoreline from waves and erosion. Tourist countries such as Puerto Rico rely on the colorful reefs to support their economy. Coral reefs support recreation and also generate huge amounts of income from the tourism community (Moberg, 1999). Coral reefs are aesthetically pleasing and people come from all over the world to see them. As previously mentioned, these marine corridors are also natural habitats to hundreds of species of fish.

Another major part of the Puerto Rican economy is fishing. “For example, it has been estimated that damages to reefs in the Philippines caused by overfishing and pollution have led to the loss of at least 100,000 fishermen’s jobs” (Moberg, 1999). Without these marine corridors, the Puerto Rican economy will suffer. As they continue to be damaged, people will lose their jobs. Puerto Rico and many marine organisms depend on the survival of coral reefs.

2.2 *Seagrasses*

Seagrasses are found throughout the world thriving in marine ecosystems in the depths of the ocean. They consist of plant-like structures similar to a blossoming flower that provide various resources to these coastal areas. They supply valuable structures that help support their counterparts, mangroves and the tropical coral reefs. Seagrasses also provide coastal zones with

fishing areas, wave protection, oxygen production, and protection against coastal erosion (personal communication, Aileen T. Velazco, April, 2009). The main function of seagrasses is to constantly maintain the underwater food sources and control several different habitats. These habitats are occupied by shellfish where they reside and also reproduce every year, using these grasses as shelter. The plants provide the sea life with a sufficient amount of nutrients allowing them to dwell in these tropical areas (Wyllie, 1996).

Seagrasses have been around for hundreds of years thriving in marine ecosystems across the continents.

“The importance of seagrasses over the past twentieth century is their key role on the shallow seaward margins of our continents. Seagrasses are now considered one of the most important ‘ecosystem engineers’ given their ability to change significantly numerous aspects of their environments” (Larkum, 2006).



Figure 2.1: Seagrasses (DNER, 2008)

For example, the leaves slow down water currents which increase sedimentation, allowing seagrass roots to stabilize the seabed (personal communication, Aileen T. Velazco, April, 2009).

These organisms provide many services to the water-engulfed environment and each service has a crucial role in keeping the ecosystem stable. The first is that seagrasses have conversion qualities that can convert ordinary sunlight and carbon dioxide into forms of organic substances. Many species rely on these substances for their existence and without them would die. Secondly, these plants allow for a stable sea floor. Having a stable floor allows the plants to grow efficiently and systematically to keep a solid foundation for the rest of the ecosystem. Lastly, grasses provide the underwater habitats with a nursery. Without these grasses there would be no fish in the environment causing an unbalanced food chain and web (Larkum, 2006).

2.3 Mangroves

Mangroves are defined as “any of a genus (*Rhizophora*, especially *R. mangle* of the family *Rhizophoraceae*) of tropical maritime trees or shrubs that send out many prop roots and form dense masses important in coastal land building and as foundations of unique ecosystems” (The Merriam-Webster Dictionary, 2009). Martinez refers to the mangrove forests as “open systems that utilize land-derived nutrients.” There are five different types of mangrove forests, including fringe forests, riverine forests, over wash forests, basin forests, and dwarf forests (Martinez et. al., 1979).

Differences in Puerto Rican mangroves exist primarily between the north and south coastlines. In the north, there tends to be more basin and riverine forests. In the south, there are more fringe and intertidal mangroves. The main difference between the north and south coast mangroves is that the north relies more on nutrients from freshwater sources and it is exposed to harsh and forceful seas. The south coast mangroves rely heavily on the open ocean to provide nutrition, because the water is not as forceful due the south coast’s geographic layout (Martinez et. al., 1979).

2.3.1 Mangrove Functions

Mangroves can serve as an important habitat for fish, just as coral reefs do. These massive root systems are efficient at dissipating wave energy, thus contributing to protecting the coast from erosion (personal communication, Aileen T. Velazco, April, 2009). These habitats not only provide shelter and protection, but the mangroves also give back to the environment



Figure 2.2: Mangroves (Wikimedia, 2006)

by exporting nutrients into the ecosystem (Mumby, 2004). This nourishment is in the form of “microbial protein” particles as the mangrove emissions are broken down by organisms and

released into the ecosystem (Martinez et. al., 1979). These particles play an essential role in the uniquely intricate food chain that exists within this aqueous habitat (Martinez et. al., 1979).

As mangroves help promote healthy fishery environments, coral reefs also serve as an essential ecological component to many fish and surrounding organisms. The depletion of mangroves can have serious negative implications on coral reefs, fish, and other organisms as well as the ecosystem in general (Mumby, 2004).

Coral reefs, mangroves and seagrasses are all vital marine ecosystems. For years they have been damaged by human activity and the environment. The sources of damage range from climate change and pollution to negligence by those who come in contact with these marine corridors.

2.4 Damage by Human Behavior

A significant factor that has been seen around the world correlating with damage to the marine ecosystems is scuba diving. This recreational sport can be found at almost any reef site across the world and is a huge destination for tourism.

However, aside from the profits these sites generate, significant damage is done unknowingly through each contact with the underwater plant and animal life. When divers submerge into the depths of the coral reef environments, they come into direct contact with the



Figure 2.3: SCUBA (Richardson, 1998)

organisms and the surrounding ecosystems. The reef environments are severely damaged by divers with a low awareness of human effects on biology (See Figure 2.3). Divers come into contact with the reef potentially causing a huge risk for depletion of the coral organisms. This includes their handling as well as damage from equipment that continuously breaks apart the

coral and shreds through the reef. The main problem with divers is not that they are simply diving, but that the areas they explore vary in sustainability from location to location. Some reefs simply cannot withstand the high amount of scuba traffic while other reefs can.

Vulnerability depends on the seabed structure, amount, and type of organisms. Scuba diving still has a detrimental impact on the coral ecosystem when not properly conducted in locations unsuitable for diving (Rouphael, 2002).

2.4.1 Fishermen

Fishermen are also damaging the coral reef and the marine ecosystems. Since the early twentieth century, fishing has expanded from the Atlantic Ocean seeping down into the more shallow waters where the rare species of tropical fish are found. Research has proved there is a steady decline in these shallow water species from over fishing in certain territories. A lot of these reefs remain unprotected from the fishing industry and increasingly, major amounts of damage are seen from the boats and equipment alone. Coral is distinctly fragile, so the slightest bulge of an anchor or hull will seamlessly gouge the reef into pieces (Spencer, 2002).

2.4.2 Pollution

Pollution is a third factor, and one of the key components in the depletion of coral reefs, seagrasses, and mangroves. Sedimentation due to runoffs from the terrestrial environment has been caused by construction on Puerto Rico's coast. As the island continues to grow and remove vegetation, marine ecosystems suffer. Sediment deposition degrades coral reefs as it reduces the area of sea floor suitable for growth of new coral. This diminishes the amount of light available for photosynthesis by symbiotic algae that live within individual coral animals, and in extreme cases, buries coral colonies (Larsen, 2004). In recent years, urbanization has increased in Puerto Rico. In turn, this has led to increased runoffs into the oceans and greater degradation of coral reefs, mangroves and seagrasses (Larsen, 2004).

Pollution can also cause diseases that attack the reefs. The four main diseases that attack coral are Apergillosis, Black Band disease, White Band disease, and Plague (Richardson, 1998). Black Band disease, White Band disease, and Plague have all been discovered off the coast of Puerto Rico (See Figure 2.4).



Figure 2.4: Example of Plague Disease (NOAA, 2008)

The most deadly of these diseases has proven to be the white band disease. All of these diseases are caused by the microorganisms that prosper in the nutrient-rich polluted waters. As runoff and pollution continues to rise in Puerto Rico, these diseases will spread and destroy more marine ecosystems (NOAA, 2008).

2.4.3 Tourism

Finally, tourism in Puerto Rico has very serious negative impacts on coastal marine environments. Increased tourism can lead to marine pollution, improper snorkeling practices, incorrect anchor placement, and over-fishing. In addition to this, rising numbers in tourism creates the need for additional coastal attractions and development. All of these practices, which are related to tourism, can have negative implications for mangroves, coral reefs, and seagrass (United States Coastal Reef Task Force, 2006). Beach goers can adversely affect the environments in which coral reefs, seagrasses and mangroves live. Their daily activities which may include fishing, swimming, snorkeling, and partaking in other tourist activities can all have negative by-products. For example, pollution may reach the water from the beach goers in the form of trash and debris. Also, improper snorkeling techniques can lead to coral reef damage and depletion. Lastly, tourist activities such as boat rides and catamaran rides may lead to coral reef destruction in the form of anchoring and propeller damage (United States Coastal Reef Task Force, 2006).

2.4.4 Shoreline Construction

Dredging involves removing some part of land that is submerged or along the coast of water (The Merriam-Webster Dictionary, 2009). This technique is often used in the construction of marinas and other coastal buildings. This usually creates debris or contamination that will make its way to the ocean. In addition to dredging, general construction of marinas or buildings can also lead to pollution of water, thus bringing the water quality down. Due to the fact that seagrasses, mangroves, and coral reefs thrive in healthy coastal marine habitats, any negative implications for these ecosystems can mean negative implications for these coastal environments. This type of coastal construction can cause land erosion which may lead to changes in “turbidity and sedimentation”, both of which have negative implications for coral reefs (United States Coastal Reef Task Force, 2006).

2.5 Climate Change

Human behavior is only one of the causes of coral depletion. Climate change has also played a major role in the destruction of coral reefs, mangroves and seagrasses. Coral bleaching is directly related to climate change. High sea surface temperature (SST), coupled with high irradiance is known to be the primary factor in coral bleaching. Bleaching is the loss of the coral’s pigmentation due to the stress-induced expulsion of the symbiotic unicellular algae commonly known as zooxanthellae (personal communication, Aileen T. Velazco, April, 2009). It often leads to a loss of energy or the partial mortality of the affected organism and, when severe, whole-colony mortality (McClanahan, 2008). If the coral survives a bleaching event, they may be recolonized by the same species of zooxanthellae, or by different species (personal communication, Aileen T. Velazco, April, 2009). As the oceans rise in temperature, the corals are negatively affected. “Over the past 30 years, maximum summer temperature has increased 0.7°C” (Winter, 1998). Overall, climate change has been affecting coral for years.



Figure 2.5: Bleached Coral (ABC, 2009)



Figure 2.6: Healthy Coral (DNER, 2009)

Climate change has also caused fiercer weather patterns in tropical areas such as Puerto Rico. Hurricanes and other tropical storms cause destruction of coral reefs. They wipe out the physical structures of these marine corridors and disrupt the life within them. Coral reefs, mangroves and sea-grasses are generally located in shallow water. This is the main reason tropical storms have such an effect on them whereas ones located in deeper water are generally not affected as much.

Another consequence of climate change and increased concentrations of carbon dioxide is the gradual acidification of the world's oceans, which is likely to reduce the calcifying ability of key organisms such as corals (personal communication, Aileen T. Velazco, April, 2009).

There are negative consequences that come with the depletion of coral reefs, mangroves and sea-grasses. These ecosystems are not only vital to the marine organisms that depend on them for survival, but also to the people of Puerto Rico. The consequences prove to be both biological and economical.

2.6 Economic Consequences

One of the main sources of economy for Puerto Rico is tourism. People flock from all over the world to see the colorful coral reefs. In the Caribbean, tourism increased 4.8% per year between 1985 and 2004. Cuba, the Dominican Republic, and Puerto Rico were among the top of

the list for most popular Caribbean islands to visit (Padilla, 2007). Another key component in the Puerto Rican economy is fishing. Once again, coral reefs, mangroves and seagrasses play a vital role in the economy. These marine ecosystems are critical for the survival of the hundreds of tropical fish that live off the coast of Puerto Rico. Without these ecosystems, the fish would most likely die off or migrate to another area while drastically affecting the fishing industry. Finally, coral reefs have been used in the pharmaceutical industry. “Twenty-five percent of all the world’s medicines are produced in Puerto Rico” (Ramirez, 2007). Research has been conducted on the possibility of using coral in pharmaceutical drugs. Overall, coral reefs are directly related to all three major economic industries in Puerto Rico.

The damage being done to these marine ecosystems has not gone unnoticed. The Department of Natural and Environmental Resources in Puerto Rico has conducted numerous studies in an effort to get to the root of the problem. They have also made an effort to educate the public about the consequences that come along with damaging coral reefs, mangroves and seagrasses.

2.7 Outreach Case Studies

The Department of Natural and Environmental Resources has conducted research in Puerto Rico to gauge the public’s level of knowledge with regard to detrimental forces acting upon the Puerto Rican environment. In conjunction with this research, the DNER produced educational materials which were intended to educate the public on activities that adversely impact coral reefs, mangroves, seagrasses, and the overall environment in general (personal communication, Aileen T. Velazco, January, 2009).

The Department of Natural Resources’ surveys and publications tend to target those who come in contact with the coral reef and the surrounding ecosystem most frequently. These groups include: beach goers, tourists and locals, along with people at marinas.

Studies pertaining to marine ecosystem preservation have been conducted all over the world. In the past few years, Hawaii has worked on protecting its coral reefs. Overfishing, also a problem in Puerto Rico proved to be fatal to marine species in Hawaii. It was the cause of a widespread extinction of the local lobster. In 2006, President George Bush passed a law that forbids fishing in state waters that extended 80 kilometers off the shore of Hawaii. Although

fishing is part of the local economy, this ban was seen as a great achievement due to the fact that coral reefs in the area would be safe again (Science, 2006). Laws like these could be beneficial to the reefs in Puerto Rico as well. The protection campaign in Hawaii is a good example for Puerto Rico to follow. Every attempt to limit damages to these marine ecosystems is a step in the right direction.

A similar project was conducted in the Yellow Sea off the eastern coast of China. The basis of the project was to increase public awareness concerning large marine ecosystems. In order to raise awareness, they had to connect with the public. They did this through various publications in the form of pamphlets that described the benefits of these marine ecosystems as well as the consequences of losing them. The community also conducted eco-tours (UNEP, 2008). This may be a good idea for the DNER to implement. It seems likely that people would be more willing to go on an eco-tour than to go to an awareness seminar. Overall, effectively connecting with the public is crucial when trying to conserve the environment.

In conclusion, coral reefs, mangroves and seagrasses are depleting at an alarming rate. They are being damaged through climate change and poor human behaviors. In order to save these marine corridors, the users of these ecosystems must be educated with regard to these damaging behaviors.

Chapter 3: Methodology

The goal of our project was to assess the effectiveness of the Department of Natural and Environmental Resources' coral reef education and outreach campaign. Our project evaluated the public's level of knowledge pertaining to mangroves, seagrasses, and primarily coral reefs. In addition, it also addressed public behaviors regarding these marine ecosystems. Finally, our project obtained public opinions pertaining to effective education techniques. A number of different methods were used to complete our project.

First, we evaluated the DNER's survey. Then we created an updated and revised survey. Finally, we made observations and collected anecdotal information in order to further assess public awareness. While conducting our surveys and collecting anecdotal information, the language barrier proved to be a challenge. To address this challenge, we always came prepared with surveys written in both English and Spanish. Furthermore, we were able to have our liaison gather necessary information from the subjects that only spoke Spanish. Since our new survey was different from those created by the Department of Natural Resources, we were unable to directly compare the results. On the other hand, we ultimately conducted our own study with the revised survey. As a team, we took the data gathered from the surveys and looked for trends and similarities. We also made sure to include questions that helped verify whether or not the public had seen the publications distributed by the DNER. All of this information generated from our survey results was beneficial to the department and aided our team in making helpful recommendations.

3.1 Evaluate the Department of Natural Resource's Surveys

The first objective completed was to evaluate the surveys that were formulated and implemented by the Department of Natural and Environmental Resources targeting tourists, fishermen, boaters, beachgoers, and marinas. In evaluating these previous surveys, we were able to identify questions that lacked important structure or content. These were types of questions that inhibited readability, interest or flow. After looking at the surveys distributed by the DNER, we realized that they used a number of questioning techniques. They had both simple multiple choice questions and open response questions. We evaluated the surveys for potentially

incriminating questions. Incriminating questions included those that led the subject to believe that they may be penalized for a certain response. We also evaluated their surveys for patronizing questions. These types of questions could cause the person being surveyed to feel offended. Finally, we evaluated their surveys for leading questions. These types of questions may skew the results. This is because they trigger the person being surveyed to answer in a fashion that would please the department. When testing a draft of our survey, we realized that this was a major issue. When asked whether or not they knew a certain fact pertaining to coral reefs, the audience was reluctant to say no. Overall, testing different drafts of our survey allowed us to identify these types of questions and make the correct adjustments to our survey.

3.2 Creation of New Survey

Many changes were made in an effort to make the new survey more effective in collecting and analyzing data. Our team felt that more emphasis must be placed on defining our audience, so we added more information to our survey that included where the user was from, occupation, age, and gender. When it came time to make recommendations to the Department of Natural Resources, we felt that this information would be beneficial.

The surveys originally produced by the Department of Natural and Environmental Resources were organized in a manner that made analyzing the data difficult. Consequently, our team decided to split the new survey into different sections according to the types of questions asked. The first section of the survey contained knowledge questions as an introduction for the user to the material in the survey. These questions assessed the knowledge of the subject pertaining to coral reefs, mangroves and seagrasses. Originally, we created the new survey to have questions such as “Are you aware that coral is a living and growing organism?” and had two answers, “Yes” and “No”. After testing this first section with the yes and no combination, we came to realize that people are somewhat forced to answer “Yes” to every questions. It asked if you are aware of a specific fact about coral and it directly tells you in the question what the answer was. Because of this, a majority of the surveys had every answer checked off as “Yes”. At this point we came up with the idea to change the yes and no combination to a true and false combination. In the first section on knowledge, there were a total of eight true or false questions. First, we used excel to create a random number generator between 1-100. It was set up so that

for columns one through eight a random number would be generated and put into each column, one through eight, representing the survey questions respectively. Second, to avoid any bias when creating the true and false order of questions, we designated that any random number generated per each cell that was odd, would be a true question. Any cell that generated a random number that came out as an even number, we designated to be a false question. Lastly, we revised the yes and no questions to be in the correct form for the true and false format.

The next section contained behavioral questions. These questions asked the audience to give information pertaining to personal experience. For example, this section asked whether or not the person being surveyed has ever come in contact with coral. This helped us analyze the amount of contact that is actually being made with the coral and allowed us to make easier connections between amount of contact, location, and activities performed. The third section of our survey contained opinion questions. These questions focused on the educational outreach efforts of the Department of Natural and Environmental Resources. For example, we asked the audience if they had ever seen any of the publications released by the DNER, and if so where they had seen them. This section isolates questions that enabled us to make significant comparisons between the outreach progress and how it had impacted awareness. A positive correlation between the amount of publications seen and the general awareness results from the knowledge section, would tell us that the DNER did a sufficient job at educating the public. However, if there were to be a negative correlation between the same two concepts, it meant that the department made insufficient progress at educating the public. The final section of the survey was vital in analyzing the collected data. It contained demographic questions such as the age, gender and occupation of the audience. The demographic information can be sorted in excel to compare and contrast almost every question from the survey so it was one of the most important sections to include. It told us what information and awareness was the worst and more specifically, by location.

Many drafts of the survey were formulated before obtaining the final product. Before finalizing our survey, we tested a rough draft at the Department of Natural and Environmental Resources. Here we were able to target boat owners who came to the DNER to renew their vessel registrations. This location was crucial to our study because vessel operators in Puerto Rico are mainly composed of local males. We were made aware from the previous surveys that

were conducted, that it would be hard to get males to participate in the surveys. However after visiting dive shops, marinas, and commercial fishing locations we were able to successfully target male participants. Also, by having the vessel registration office in the building where our office is located, we gathered the missing pieces of data that allowed our study to have a balance of male and female respondents. This further ensured that our study was free of any gender bias that could have occurred.

3.3 Assessing Public Awareness

Evaluating the awareness of the target audiences pertaining to coral reefs, mangroves and seagrasses was our third objective. The demographic information obtained from the target audiences enabled our group to make connections between different groups of people and their responses. Our group conducted surveys across Puerto Rico. The locations included marinas such as the largest marina in Puerto Rico, Puerto Del Ray Marina. Also, we surveyed at popular beaches along all of the coasts of the island. These beaches included those in Fajardo, Guanica and Isla Verde. These were all places where our target audiences could be found. Our target audiences included boaters along with locals and tourists that participated in activities near coral reefs, mangroves and seagrasses. The information provided by the surveys allowed our group to find trends and analyze the overall knowledge of target audiences pertaining to these marine ecosystems.

Surveys were not the only form of data collection that we utilized. Although surveys provided our group with valuable insight about our target participants' knowledge, conducting participant observation studies was also essential. Participant observation is necessary because there is often a deviation between the way people are willing to admit they act, and how they actually act. Therefore, this method allowed our group to get a closer look at the actual daily activities of our participants, and allowed us to gauge the accuracy of the information resulting from our survey.

Participant observation played an essential role in our study because there are a lot of conflicting values between the Puerto Rican economy and conservation. Although Puerto Rico relies on its environment to stimulate economic growth, the actions that create this economic growth may tend to deteriorate the environment. Tourist activities such as SCUBA diving,

snorkeling and swimming at the beach can all have negative impacts on the environment, and the coral reefs. Those who depend on activities that negatively impact the environment are very eager to alter the way they are perceived to act when answering a survey or being observed. This illustrates the importance for our group to remain discrete when observing target audiences.

Our group observed both positive and negative activities. When taking a catamaran snorkeling trip, we made sure to observe the steps that the crew took to educate the tourists about the importance of avoiding contact with the reefs. We carefully watched the actions of people who were snorkeling as well. Our group also recorded anecdotal information when conducting our surveys. There is valuable information other than that which can be collected from the survey. Discovering what people like to talk about or experiences that they have had is sometimes more beneficial than analyzing the data collected from the surveys.

In sum, we formulated our own survey that assessed the awareness, activities and opinions of our target users. The surveys provided us with useful data, but were not the only method used. We also conducted participant observation, took photographs, and made sure to record any useful anecdotal information gathered during our study. Together, the methods used allowed us to gather significant data and make useful recommendations to the Department of Natural and Environmental Resources.

Chapter 4: Results and Analysis

This chapter presents findings addressing our objectives: to analyze the Department of Natural and Environmental Resources' previous survey, to create a new survey, and to assess the level of awareness of the marine ecosystem users about coral reef damage. These results and their analyses allowed us to better assess the scope of the DNER's outreach efforts. Finally, we used these results to determine how to approach the main problem of educating people about the importance of coral reefs, mangroves and seagrasses.

4.1 Previous Survey Analysis

In 2006 the DNER distributed over 500 copies of their original survey. We evaluated this survey and determined the successes and failures of those surveys as a whole. As we discussed in our Methods Chapter, we encountered numerous challenges with the original survey. The old surveys included questions that were potentially incriminating. These were types of questions that included any response that would target the user as a criminal or negative stereotype such as a coral poacher and thief. Some of the incriminating questions presented by the DNER were worded in ways that may encourage the participant to answer dishonestly. We also identified potentially patronizing and leading questions in the surveys produced by the DNER.

A second finding, with regard to the previous survey was that there was a general lack of information being collected. The surveys formulated by the Department of Natural Resources consisted of multiple choice questions. Also, most of these questions were based on evaluating the knowledge level of the target audience. The survey's setup and questions did not allow for a feasible input and analysis of the data. Therefore, the results from 500 surveys conducted in 2006 have not been analyzed in full. Due to this, the data is considered inconclusive. In general, after analyzing the original survey, our group concluded that the questions must be formatted in a different manner.

4.2 Creating a New Survey

After analyzing the first survey, we realized that the questions needed to be organized in a specific fashion. They needed to be set up in a manner that allowed the participant being surveyed to have a flow of information and at the same time keep that user interested in the material.

We noticed some trends from a few test runs that we conducted with the old survey, which led us to believe that we needed to create our new survey. First, we found that a lot of the subjects were confused with the way some of the questions were worded. They often would ask us “what does this mean?” or “If I do not participate in this activity, do I still need to answer this question?” Although we could explain the questions to those subjects speaking English, it took a lot of extra time that could have spent organizing clipboards and passing out more surveys to participants. The survey should be simple enough to complete without question. Also, for those subjects who spoke Spanish, we were almost always unable to communicate effectively when they had a question. Sometimes this resulted in such frustration that the subject would give up and hand the survey back.

Another trend we noticed was that some of the questions were potentially incriminating. We had the feeling that a lot of dishonest answers existed on the surveys due to this fact. On a similar note, we tried to implement some knowledge questions in which we told the users a fact, and asked if they already knew this fact. Again, we felt that this technique did not work because too many of the subjects were answering “yes,” that they did know this fact.

With this in mind, we broke the survey down into four separate groups, each with its own set of responses. The four groups were structured with questions based on measuring knowledge, opinions, behavior, and demographics respectively.

4.3 Demographic Findings

Our demographic section contained various questions including the subject's age, gender, residence and occupation. In our demographics analysis, we noticed that the majority of those participants younger than 25 years of age lacked knowledge regarding what coral reefs are made of and how they survive. We also observed that this same age group seemed to observe fewer of the publications set out by the DNER, and those that they have seen usually exist around the beaches. The subjects within this age group tend to be students or young adults just starting a career. We were able to target an even distribution of males and females with a total of 58% of the subjects being male and 42% female. We also compared age groups to the preferences of distribution channels of educational publications. Our survey results showed that younger people would like to see publications on television and on the internet. As the age of the participant increased, the preference for these distribution channels decreased until the oldest. Finally, we compared gender to the preferences of distribution channels of educational publications. Females tended to choose internet, where males did not. On the other hand, males preferred to see these publications in newspapers. This data was essential in making recommendations to the DNER about how to reach the public.

4.4 Assessing Public Awareness

To assess the awareness of the public, we needed data that provided us with both subjective and objective data, as this was imperative in order for us to reach our final goal. Having both sets of data allowed for us to more clearly analyze the two separate concepts in greater detail. In addition to conducting approximately 350 surveys, participant observation and the collection of anecdotal information also proved to be essential steps in reaching this goal.

4.4.1 Behavioral Findings

The behavioral question responses (see survey in appendix D) indicated that the majority of the target users participate in swimming, boating, and kayaking. More than 70 percent said that they swim and more than 40 percent said that they boat or kayak. Scuba diving, snorkeling,

fishing, and surfing were less common activities and they all existed within the range of 9 to 29 percent. These results are depicted in figure 4.1:

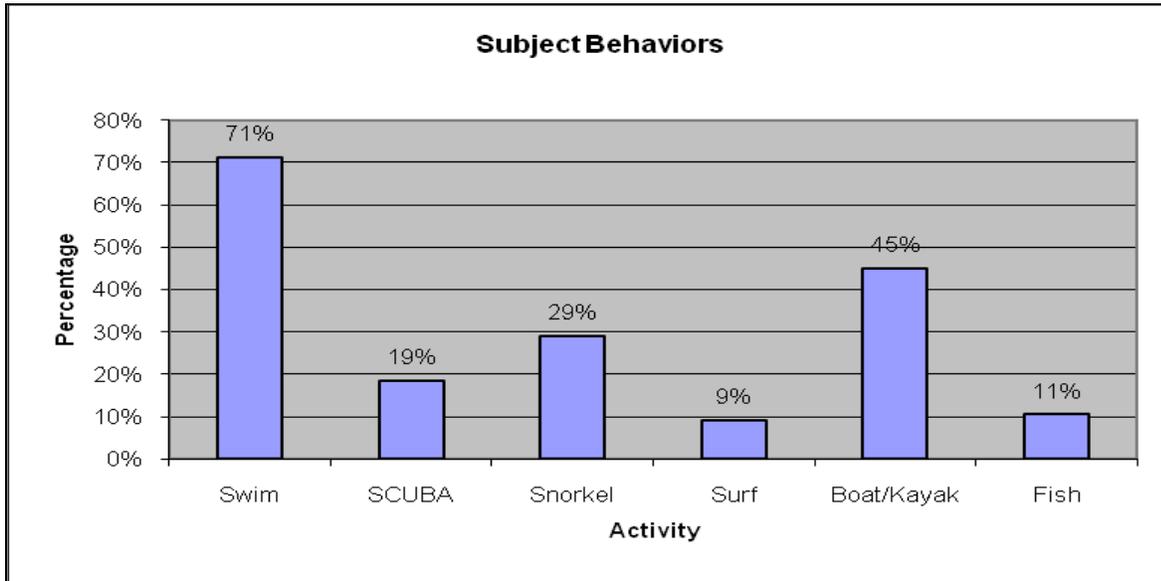


Figure 4.1: Subject Behaviors

4.4.2 Opinion Findings

Our main focus for the opinion questions was to discover which distribution channels would be best for conveying the DNER’s publications to the users. We noticed that at least 80 percent of the target users said that television advertising would be an effective way to convey this information. The remainder of the distribution channels received somewhat equal input aside from direct mail, which only 21 percent of the subjects felt would be effective. The results are depicted in figure 4.2:

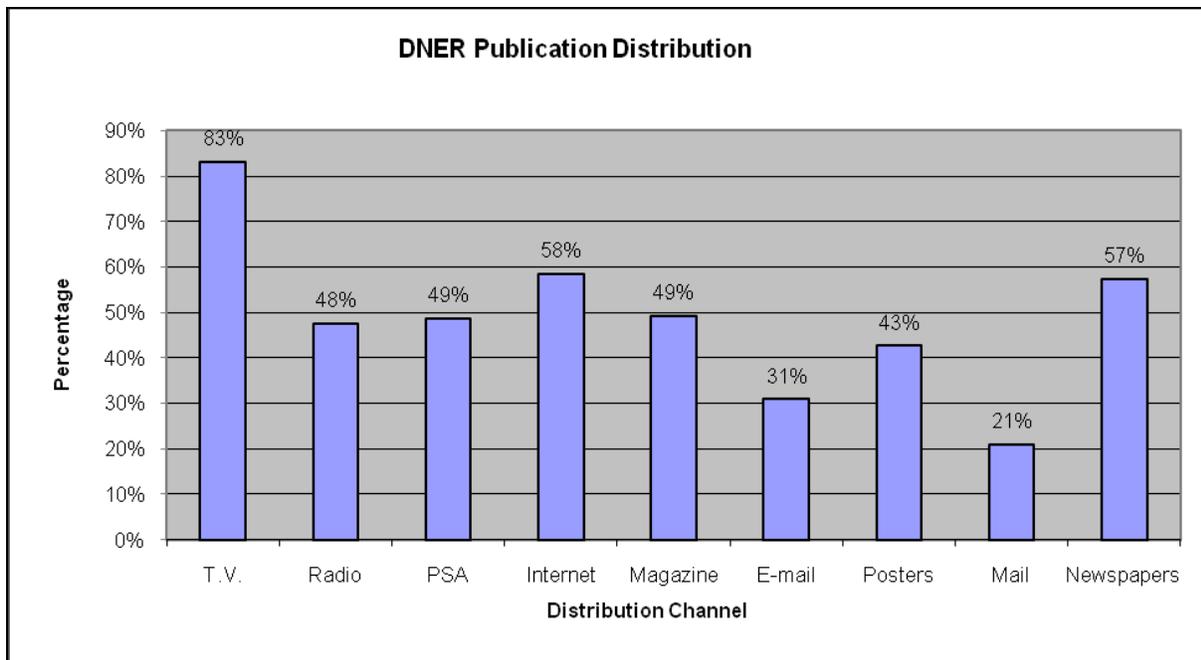


Figure 4.2: Distribution of Publications

We noticed that most people prefer to watch the publications on television. Also from the demographics versus distribution channel we discovered that as the age decreases, the number of people that prefer television increases. We used this data after analyzing, to make recommendations for the Department of Natural Resources.

Another important trend that we noticed with regard to the opinion questions was that only 23 percent of the subjects felt that there are enough mooring buoys placed in the waters of Puerto Rico. This is a very important piece of information because the lack of mooring buoys may encourage boaters to drop their anchors in these waters. The dropping of anchors near coral reefs and seagrasses is damaging these marine ecosystems.

4.4.3 Coral Reef Facts Findings

We analyzed our survey section that measured respondents' basic understanding of marine ecosystems, which we refer to as the "knowledge section". 80 to 90 percent of the users were able to answer six of the eight knowledge questions correctly. As for the remaining two, the results were very poor. Only 26 percent of the users were aware that coral reefs are not

plants that use light from the sun for nutrition. Also, only 34 percent of the users knew that a coral reef is not formed by a conglomerate of rocks.

An interesting trend that may be responsible for some of the poor results to the knowledge questions is the fact that only 40 percent of the subjects have ever seen a DNER educational publication pertaining to coral reefs. Furthermore, we noticed that the younger subjects (less than 25 years of age) had seen the material the least. Figure 4.2 depicts this analysis:

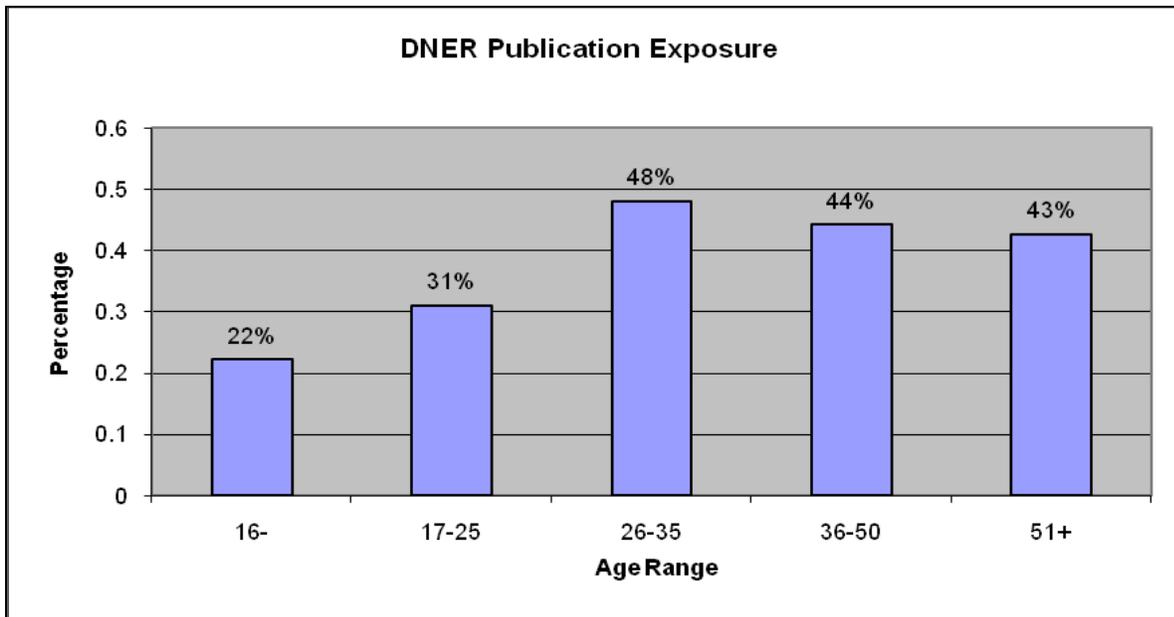


Figure 4.3: Subjects Awareness of DNER publications

As the graph shows, fewer than 25 percent of the subjects less than 17 years old have been exposed to the DNER’s publications. On a similar note, approximately 31 percent of the subjects aging 17-25 were aware of these publications. Contrary to this trend, the age groups 26-35, 36-50, and 51+ have a more extensive exposure to these publications as their approximate percentages are 48%, 44%, and 43% respectively.

4.4.3 Participant Observation

Being in Puerto Rico for the first time, we were fortunate enough to have the opportunity to explore the coral reefs from a tourist perspective. Our team went out on a snorkeling cruise that was chartered by a large catamaran vessel. This vessel took us to two separate areas on a small island off the coast of Puerto Rico to snorkel. Upon arrival, we approached the area where

the anchor was located on the catamaran to watch the anchoring procedure. The anchor was carried down a flight of docking stairs to the sand and was placed deep in the beach by the tour guide. The boat then reversed slowly until the anchor line showed tension and then turned off all power. This practice was very different from some of the other catamarans that we observed in the area. One of the boats simply tossed the anchor into the water, which seemed destructive since we were surrounded by coral reef and seagrass. Most of the remaining boats also had their anchors deeper into the water, but they had already anchored before we arrived so we were unable to observe their actual procedure.

Next, before anyone was allowed to put on any type of gear or to go into the water, the tour guide had a quick five minute talk on the coral reef environment. This talk included instructions not to touch any kind of coral as well as to not take coral of any kind as souvenirs. The guide actually pointed out areas to avoid, due to the overwhelming amount of coral reef. He also pointed out areas in which coral reef existed, but not in amounts large enough to make contact unavoidable.

We also observed detrimental behavior while we were on the excursion. While standing on shore looking out into the open sea, there was a woman snorkeling about one hundred yards offshore. We watched her proceed to take off her mask and stand atop of the coral reef structure. We also observed a woman poaching coral. Off the coast in deeper water terrains, coral reefs thrive. We witnessed a woman blatantly tear off a piece of coral. Tourists, like those on this trip, must be targeted by the DNER in order to limit the damage being done to coral reefs, mangroves and seagrasses.

While conducting surveys in Boquerón, we were walking along one of the beaches as we came across a kayak in our path. As we approached the kayak, simply to cross over it, we noticed some sort of rock-like collection inside. As we looked closer, we noticed that this collection was actually coral that had been poached from the ocean. The poaching of coral is a detrimental source of depleting coral reef in Puerto Rico.

On a similar note, as we were visiting a dive shop, we noticed what we thought was coral for sale. Upon analysis of this object, we determined that it actually at one time, was living coral, which was now preserved and on display for sale at this shop. As we walked around the shop, we noticed that there was also a beautiful marine plant, which had also been preserved and

was now for sale. As the owner of this shop was filling out one of our surveys, he commented about the question regarding anchoring on coral reef and seagrass areas. He stated that he has anchored a boat in these areas on more than one occasion because he can rarely find unused buoys to latch his boat onto. He explained how he uses buoys when they are available, but he explained how he has to worry about his business first and the environment second. “I have to worry about the money,” he stated. We were very disappointed to see a dive shop, whose business relies solely on a beautiful and healthy environment, destroying that same environment. Observations such as these reinforce the notion that it is important for there to be stricter rules and regulations on these types of actions. If money is what is most important to some people, then we must use that to scare them out of their bad habits. If they know that they will be heavily fined for such detrimental activities, surely they will think twice before performing such actions.

4.4.4 Anecdotal Information

With every excursion and trip to the islands, beaches, or marinas, we always encountered information that could not be recorded within the margins of our survey. This anecdotal information was kept in a journal that our team organized to include the location and date of each event.

Our first extensive conversation was with a boater from a marina. This man suggested how and what to do about the general lack of awareness that exists in the public. At marinas specifically, he claims that before boaters go out into the water they must be made aware of coral reefs and their marine counterparts. He suggested creating a large billboard, much like that of one seen off of a highway, which would be constructed in bright fluorescent colors. This structure would be placed at the end of a pier so that before these boaters even leave the marina they are aware of the environment surrounding them.

In another situation, a member of our group was out on a snorkeling and kayaking adventure in Vieques, where she received some very unfortunate information from the tour instructor. After being extensively aware of the damage being done to coral reefs from numerous presentations performed by our team, this member decided to gather some insight. She approached the tour guide and posed the question of whether or not it is prohibited to come

in contact with the coral reef. The guide simply answered that the people on the tour are allowed to do whatever they want. This is the main problem that relates to our project and it directly shows the root causes of the destruction.

While surveying people in the DNER vessel registration office, our group had an interesting conversation with one of the boat owners waiting in line to register his boat. He commented that he has seen some of the publications put out by the DNER, but too few. Mainly, he observed these publications in the DNER offices, and at some marinas. His suggestion was that it would be very beneficial to place publications not only in the coastal marinas, but also in the offshore marinas that act as storage facilities for boaters. He stated that when the boaters take their boat out of the water, they pay a fee to rent out an area to store their boat on land. He claimed that he had not seen any publications in these areas and he felt that it would be a useful reminder to all boaters if educational material existed there.

As we were out surveying on the coast of Boqueron one day, we approached two women and asked them to each take our survey. As they finished with their surveys, they commented on how they were very excited to see efforts being put towards the conservation of coral reefs. They stated that they had grown up in the area and moved away as they began to work professionally. Now, they come back every year and visit the same places that they used to when they were kids. They commented that over the years they have noticed that the level of pollution has definitely increased, and that the shoreline has diminished. This was evident as we were able to observe that much sedimentation had occurred to the area. Their suggestion was that because we were in an area in which tourists are able to rent out small houses on the beach, these tourists should be forced to sit through an educational awareness presentation. The two sisters recommended that this should be a mandatory part of registering for the rental of one of these houses. In addition to this, they suggested that large posters be set out in the beach area to reinforce the information given in the presentation. Due to the fact that these tourists do not live in the area, the sisters feel that they have less of a respect for this environment.

A similar observation was made by a local entrepreneur we surveyed in Isla Verde. This man explained how he has lived in the area all of his life, and every year he and his family have a local snorkeling excursion. He informed us that over the years, he sees fewer fish and less “beautiful colors” in the ocean. By this he was referring to the colors of the grasses, fish, and

coral. One thing that he does see an increasing amount of is pollution. This man stated: “the last time my family went snorkeling, we spent the day bringing Medalla (a local beer) cans and other trash up from the water just to clean the area, you know?” This man suggested that there needs to be more emphasis on beaches that not only explains the damage that is associated with littering, but also to create very strict littering fines and to actually enforce them heavily. This man felt that even if people are educated on the problems, most of them will still litter, so another route to take is to penalize them for littering and do a much better job of catching people who litter. He also suggested that the DNER be more proactive. Having rangers patrolling the beaches would limit pollution and other detrimental activities.

In conclusion, our team has come across a lot of interesting and compelling information that says a lot about Puerto Rico presently. We have noticed that there are two different flaws with most of the people we encountered: 1. they either lack education and unawareness of the fragility of Puerto Rico’s marine ecosystems; and/or 2. regardless of whether or not they are educated, they simply have higher priorities that come before environmental preservation. Therefore, we have produced some recommendations that are aimed at addressing both of these flaws.

Chapter 5: Conclusion

Upon reviewing the data that we have collected, we discovered several different trends and patterns. As stated earlier, it appears that the younger population of Puerto Rico, less than 25 years of age, seems to be less educated on what coral reefs are made of and how they function. This was a surprising discovery to our group. To address this problem we recommend that the Department of Natural and Environmental Resources offer annual educational presentations in the local school systems. These presentations could be given right before Easter weekend, or right before summer starts. These presentations should address the proper way to perform aquatic activities, and illustrate how these activities can harm the environment if practiced improperly. Also, the students should be made aware that Puerto Rico is a unique place and that the environment here is very rare. The presentations should make the students feel as if it is special to live where they are, and hopefully this will instill a feeling of pride and make them want to protect the environment. These presentations could also slightly touch upon the fact that their environment is essential to the economy with regard to tourism. Many of the students may have aspirations to make money out of high school and their jobs may be contingent upon the clean existence of the beautiful Puerto Rican environment. We feel that that it is very important to instill this educational information in the children while they are young so that they grow up with these notions and hopefully have a better respect and understanding for the environment.

According to our data, approximately two thirds of all subjects less than 25 years of age have never seen a DNER publication pertaining to coral reefs. This is a very important demographic group to target because it is the younger generations that have the most power to change the future treatment of Puerto Rico's environment. These young adults need to be educated in order for them to bring up their children with the notion that preserving the environment is an essential part of life. We've noticed that most of these children and young adults said that they would like to receive educational material via the television and internet. Therefore, aside from television commercials, we feel that there may be use in exploring social networking. One of our recommendations is for the DNER to make a DNER group on Facebook

and post news, events, and educational material on that group page. A similar idea could work with another social network known as MySpace.

Another important trend that we noticed was that the vast majority of subjects said that they swim in the waters of Puerto Rico. We feel that this would be a perfect place to reach the majority of the marine ecosystem users. As we visited many of the beaches, we rarely saw educational materials promoting the preservation of marine ecosystems. When we did see these materials, we had to look hard for them. Therefore, our next recommendation would be to place large and attractive posters, or even have children paint wall murals, by the entrances to as many beaches as possible.

A similar suggestion would be to do the same thing at Marinas, both on and off shore. These recommendations are not only ideas that our group feels should happen, but also recommendations from numerous subjects that we spoke with. The idea of having large, attractive signs at the entrance of marinas would definitely serve as an educational reminder to all outgoing boats.

Hotel lobbies and rental properties would be another area in which more educational material could be put. While people are waiting in line to check in, or just relaxing in the lobby, it would be nice to have posters or pamphlets for them to read. They would be apt to read this material because they are simply waiting around and it would pass time, and it would also serve the purpose of educating them as well.

Another way to distribute these educational materials is television advertisement. Due to the fact that 85 percent of the subjects felt that television advertising is a viable means of education, our group would like to see more effort put into this distribution channel. Again, due to the fact that most adults and working professionals have priorities that they rank higher than ecosystem conservation, we feel that the commercials will primarily target the younger generations. Hopefully targeting the youth will allow them to grow up with a respect for the environment, which they will pass on to the generations to come.

As our group went on numerous excursions, we often hired a transportation service that had a television promoting the beautiful scenery of Puerto Rico. We would like to see if the DNER would be able to work out some sort of contract with agencies such as this in order to play a short video aimed at educating the tourists on these types of transportation services. As all

of the viewers are amazed with the scenery on the television, it would be nice to follow up that video with a DNER publication to remind those tourists that the need to respect the environment.

Lastly, our group not only talked to people who have observed much littering, but we have noticed littering first hand at some of the beaches. As littering and pollution are extremely harmful to marine ecosystems, we would like to see higher penalties cast upon those who litter. To take this even further, there should be some sort of undercover DNER officers observing at the beaches and writing tickets on the spot for anyone who does not properly dispose of their waste.

Throughout our project, we have observed and gathered a lot of information pertaining to the conservation of marine ecosystems. Upon analysis of this information, we were able to pinpoint specific trends and patterns in education, behavior, and public opinion. This allowed us to identify strengths and weaknesses within the DNER's education and outreach campaign. The trends and patterns also provided us with a foundation for recommendations that will aid the DNER's education and outreach campaign. These recommendations promote the education of local youths, stricter law enforcement for local adults, and a combination of both strategies for tourists. We feel that these recommendations will truly help the public become more aware of the fragility of these marine ecosystems and promote their conservation either out of true admiration and respect, or in fear of penalty.

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Glossary

- **Corals**- Marine animals consisting of polyps. Polyps are invertebrate animals that remain stationary. They are dependent on other marine organisms for nutrition. Corals have a symbiotic relationship with single-celled organisms called zooxanthellae, which are found within the polyp tissues. These cells carry out photosynthesis and produce excess organic nutrients that are then used by the coral polyps with the consequent faster growth in clear waters. They gain their majority of their nutrition from the excretion of marine organisms. In return, coral supports nitrogen-producing bacteria known as cyanobacteria.
- **Coral Bleaching**- Loss of pigment due to the expulsion from the coral polyps' tissues of the symbiotic unicellular algae commonly known as zooxanthellae, which is directly related to climate change and increased water temperature. Coral bleaching leads to loss of energy and mortality of coral species.
- **Dredging**- Dredging involves removing some part of land that is submerged or along the coast of water. This technique is often used in the construction of marinas and other coastal buildings. This usually creates debris or contamination that will make its way to the ocean
- **Mangroves**- any tropical tree or shrubs of which are mostly low trees growing in marshes or tidal shores, noted for their interlacing above-ground adventitious roots.
- **Reefs**- Rocks, coral or sand generally located in shallow water where there is an ample amount of sunlight. Generally, reefs are composed of calcium carbonate.
- **Seagrasses**- any of various seaweeds that grow underwater in shallow beds that provide a protective environment in which young fish can develop.
- **Sedimentation**- Usually caused by runoff from heavy rainfall. Sedimentation causes foggy, turbid waters, which can be detrimental to marine ecosystems. This is because too much sediment in the water does not allow enough sunlight to reach the marine organisms that need it for photosynthesis.

74% Yes 25% NO 1% blank

If you responded NOT to the previous question, thank you so much for to participate of our survey. I hope you enjoy the rest of your day on the beach.

If you responded YES to the previous question, please answer the following questions:

8b. Which of the following activities do you practice in the sea and how many times each year?

Activity	1-5	6-10	11-15	16-20	20+
Take a Bath in Beach	226	84	37	15	48
Swimming	101	40	17	4	24
Snorkeling	58	11	3	3	11
Scuba Diving (SCUBA)	25	6	2	3	2
Surfing	27	3	8	1	4
Fish from Land	65	6	4	2	2
Fish from a Boat	39	7	6	2	1
Kayaking	34	8	4	1	4
Ride a Jet Ski	76	14	4	5	7
Ride a Boat	95	14	5	2	7
Others: Clean the beach, dance and walk ob beach	14	3	2	0	1
Specify					

9. Do you touch the coral when you dive? 8% Yes 60% NO 32% N/A

10. If you touch them: (Select an answer please)

- 11% to see them better
- 7% carry them
- 2% stop and rest on them
- 5% take as souvenir
- 75% blank

Are you a frequent user of embankments?

11. Do you throw the anchor on top of coral reefs?

12. If yes, do you do it in a way so that:

- 3% boat remains well anchored
- 13% accidently and paid a fee
- 84% blank

13. If not on the reef where is the anchor dropped?

- 2% marine seabed
- 17% sand
- 1% without harming environment

80% blank

14. Does anchoring in coral affect it?

33% YES 6%NO 13% Do not know 48% blank

15. Do you utilize the buoys to hitch on to:

14% YES 17% NO 14% DO not know 55% blank

16. Do you wish more buoys were in installed to hitch on to?

34% YES 12% NO 54% Blank

DEMOGRAPHIC INFORMATION:

SEX ___M ___F

AGE _____

Thank you so much for your valuable information and for contributing to the conservation of our marine resources.

Appendix B: Revised Survey

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.
 True False
 2. Corals are plants that use light from the sun for nutrition.
 True False
 3. A coral reef is formed by a conglomerate of rocks.
 True False
 4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.
 True False
 5. Touching or grabbing coral is not harmful unless pieces of the coral break.
 True False
 6. Anchoring on top of coral reefs and seagrasses can damage them.
 True False
 7. Sedimentation can damage coral reefs.
 True False
 8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.
 True False
-

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

Swimming Snorkeling SCUBA Boating/Kayaking
 Surfing Fishing Other (please specify) _____

10. Do you ever come in contact with coral?

Yes No

11. Have you ever broken coral?

Yes No

(Please continue on the other side)

12. If you answered yes to the previous question, why have you broken coral? _____

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

Yes No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

Yes No

15. If you answered yes to the previous question, do you utilize these buoys?

Yes No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

Yes No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

Yes No

18. If you answered yes to the previous question, where have you seen these publications? _____

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

Television Radio Public Service Announcements
 Magazines/Pamphlets E-mail Public Posters
 Mail Newspapers Internet

_____ Other (please specify) _____

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:
www.drna.gobierno.pr

Location: _____ Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

Appendix C: Survey Results by Location

Seven Seas

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.
86% True 14% False
 2. Corals are plants that use light from the sun for nutrition.
73% True 27% False
 3. A coral reef is formed by a conglomerate of rocks.
68% True 32% False
 4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.
95% True 5% False
 5. Touching or grabbing coral is not harmful unless pieces of the coral break.
36% True 64% False
 6. Anchoring on top of coral reefs and seagrasses can damage them.
95% True 5% False
 7. Sedimentation can damage coral reefs.
95% True 5% False
 8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.
86% True 14% False
-

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

68% Swimming 27% Snorkeling 14% SCUBA 81% Boating/Kayaking
14% Surfing 5% Fishing _____ Other (please specify) _____

10. Do you ever come in contact with coral?

59% Yes 41% No

11. Have you ever broken coral?

9% Yes 91% No

12. If you answered yes to the previous question, why have you broken coral? _____

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

5% Yes 95% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

55% Yes 65% No

15. If you answered yes to the previous question, do you utilize these buoys?

14% Yes 86% No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

18% Yes 82% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

27% Yes 73% No

18. If you answered yes to the previous question, where have you seen these publications? _____

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

86% Television 50% Radio 55% Public Service Announcements
45% Magazines/Pamphlets 23% E-mail 41% Public Posters
27% Mail 59% Newspapers 50% Internet
_____ Other (please specify) _____

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:
www.drna.gobierno.pr

Location: Seven Seas _____ Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

Puerto Del Rey Marina

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.
91% True 9% False
 2. Corals are plants that use light from the sun for nutrition.
74% True 26% False
 3. A coral reef is formed by a conglomerate of rocks.
43% True 57% False
 4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.
100% True 0% False
 5. Touching or grabbing coral is not harmful unless pieces of the coral break.
17% True 83% False
 6. Anchoring on top of coral reefs and seagrasses can damage them.
100% True 0% False
 7. Sedimentation can damage coral reefs.
91% True 9% False
 8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.
83% True 17% False
-

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

83% Swimming 57% Snorkeling 39% SCUBA 52% Boating/Kayaking
22% Surfing 17% Fishing _____ Other (please specify) _____

10. Do you ever come in contact with coral?

57% Yes 43% No

11. Have you ever broken coral?

13% Yes 87% No

12. If you answered yes to the previous question, why have you broken coral? _____

Accident, anchoring boat

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

26% Yes 74% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

77% Yes 23% No

15. If you answered yes to the previous question, do you utilize these buoys?

84% Yes _____ No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

17% Yes 83% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

39% Yes 61% No

18. If you answered yes to the previous question, where have you seen these publications? _____

Marina, internet, marina stores

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

87% Television 26% Radio 35% Public Service Announcements
35% Magazines/Pamphlets 30% E-mail 39% Public Posters
17% Mail 26% Newspapers 61% Internet

_____ Other (please specify) _____

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:

www.drna.gobierno.pr

Location: Puerto Del Rey Marina

Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

Villa Marina

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.
91% True 9% False
 2. Corals are plants that use light from the sun for nutrition.
31% True 69% False
 3. A coral reef is formed by a conglomerate of rocks.
34% True 66% False
 4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.
97% True 3% False
 5. Touching or grabbing coral is not harmful unless pieces of the coral break.
78% True 22% False
 6. Anchoring on top of coral reefs and seagrasses can damage them.
94% True 6% False
 7. Sedimentation can damage coral reefs.
97% True 3% False
 8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.
84% True 16% False
-

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

72% Swimming 41% Snorkeling 28% SCUBA 63% Boating/Kayaking
6% Surfing 16% Fishing _____ Other (please specify) _____

10. Do you ever come in contact with coral?

56% Yes 44% No

11. Have you ever broken coral?

9% Yes 91% No

12. If you answered yes to the previous question, why have you broken coral? _____

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

6% Yes 94% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

47% Yes 53% No

15. If you answered yes to the previous question, do you utilize these buoys?

32% Yes _____ No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

17% Yes 83% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

55% Yes 45% No

18. If you answered yes to the previous question, where have you seen these publications? _____

Beaches, newspapers, marinas, boat ramps, internet

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

81% Television 65% Radio 55% Public Service Announcements
41% Magazines/Pamphlets 29% E-mail 52% Public Posters
16% Mail 65% Newspapers 48% Internet

_____ Other (please specify) Facebook, stores, marinas, schools

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:

www.drna.gobierno.pr

Location: Villa Marina, Fajardo

Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

Luquillo Beach

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.
87% True 13% False
 2. Corals are plants that use light from the sun for nutrition.
65% True 35% False
 3. A coral reef is formed by a conglomerate of rocks.
76% True 24% False
 4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.
93% True 7% False
 5. Touching or grabbing coral is not harmful unless pieces of the coral break.
17% True 83% False
 6. Anchoring on top of coral reefs and seagrasses can damage them.
94% True 6% False
 7. Sedimentation can damage coral reefs.
81% True 19% False
 8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.
87% True 13% False
-

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

63% Swimming 6% Snorkeling 7% SCUBA 20% Boating/Kayaking
0% Surfing 2% Fishing _____ Other (please specify) jetski

10. Do you ever come in contact with coral?

30% Yes 70% No

11. Have you ever broken coral?

7% Yes 93% No

12. If you answered yes to the previous question, why have you broken coral? _____

Accident, curiosity

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

9% Yes 91% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

63% Yes 37% No

15. If you answered yes to the previous question, do you utilize these buoys?

22% Yes _____ No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

31% Yes 69% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

40% Yes 60% No

18. If you answered yes to the previous question, where have you seen these publications? _____

Beach, newspaper, TV

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

89% Television 60% Radio 43% Public Service Announcements
43% Magazines/Pamphlets 42% E-mail 45% Public Posters
32% Mail 62% Newspapers 58% Internet

_____ Other (please specify) _____

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:

www.drna.gobierno.pr

Location: Luquillo

Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

San Juan Nautical Club

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.
94% True 6% False
 2. Corals are plants that use light from the sun for nutrition.
81% True 19% False
 3. A coral reef is formed by a conglomerate of rocks.
56% True 44% False
 4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.
94% True 6% False
 5. Touching or grabbing coral is not harmful unless pieces of the coral break.
12% True 88% False
 6. Anchoring on top of coral reefs and seagrasses can damage them.
100% True 0% False
 7. Sedimentation can damage coral reefs.
100% True 0% False
 8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.
81% True 19% False
-

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

81% Swimming 44% Snorkeling 31% SCUBA 63% Boating/Kayaking
31% Surfing 44% Fishing _____ Other (please specify) _____

10. Do you ever come in contact with coral?

62% Yes 38% No

11. Have you ever broken coral?

13% Yes 87% No

12. If you answered yes to the previous question, why have you broken coral? _____

Accident

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

13% Yes 87% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

75% Yes 25% No

15. If you answered yes to the previous question, do you utilize these buoys?

44% Yes 56% No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

6% Yes 94% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

56% Yes 44% No

18. If you answered yes to the previous question, where have you seen these publications? _____

San Juan Nautical Club (Marina)

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

81% Television 44% Radio 38% Public Service Announcements
56% Magazines/Pamphlets 25% E-mail 50% Public Posters
25% Mail 50% Newspapers 38% Internet

_____ Other (please specify) _____

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:

www.drna.gobierno.pr

Location: San Juan Nautical Club

Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

Playa Santa, Guanica

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.

93% True 7% False

2. Corals are plants that use light from the sun for nutrition.

76% True 24% False

3. A coral reef is formed by a conglomerate of rocks.

83% True 17% False

4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.

100% True 0% False

5. Touching or grabbing coral is not harmful unless pieces of the coral break.

34% True 66% False

6. Anchoring on top of coral reefs and seagrasses can damage them.

93% True 7% False

7. Sedimentation can damage coral reefs.

79% True 21% False

8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.

89% True 11% False

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

69% Swimming 17% Snorkeling 10% SCUBA 28% Boating/Kayaking
0% Surfing 0% Fishing _____ Other (please specify) _____

10. Do you ever come in contact with coral?

38% Yes 62% No

11. Have you ever broken coral?

3% Yes 97% No

12. If you answered yes to the previous question, why have you broken coral? _____

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

0% Yes 100% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

76% Yes 24% No

15. If you answered yes to the previous question, do you utilize these buoys?

24% Yes _____ No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

14% Yes 86% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

41% Yes 59% No

18. If you answered yes to the previous question, where have you seen these publications?

Newspaper, TV, Culebra, DRNA

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

83% Television 52% Radio 48% Public Service Announcements
48% Magazines/Pamphlets 31% E-mail 31% Public Posters
21% Mail 69% Newspapers 79% Internet

_____ Other (please specify) _____

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:

www.drna.gobierno.pr

Location: Playa Santa, Guanica

Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

Puerto Chico Marina

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.
100% True 0% False
 2. Corals are plants that use light from the sun for nutrition.
100% True 0% False
 3. A coral reef is formed by a conglomerate of rocks.
75% True 25% False
 4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.
100% True 0% False
 5. Touching or grabbing coral is not harmful unless pieces of the coral break.
0% True 100% False
 6. Anchoring on top of coral reefs and seagrasses can damage them.
100% True 0% False
 7. Sedimentation can damage coral reefs.
100% True 0% False
 8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.
100% True 0% False
-

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

75% Swimming 100% Snorkeling 50% SCUBA 75% Boating/Kayaking
25% Surfing 25% Fishing _____ Other (please specify) _____

10. Do you ever come in contact with coral?

100% Yes 0% No

11. Have you ever broken coral?

25% Yes 75% No

12. If you answered yes to the previous question, why have you broken coral? _____

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

50% Yes 50% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

50% Yes 50% No

15. If you answered yes to the previous question, do you utilize these buoys?

50% Yes 50% No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

0% Yes 100% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

75% Yes _____ No

18. If you answered yes to the previous question, where have you seen these publications? _____

Marinas, public schools

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

75% Television 50% Radio 50% Public Service Announcements
100% Magazines/Pamphlets 25% E-mail 25% Public Posters
0% Mail 75% Newspapers 50% Internet

_____ Other (please specify) _____ Marinas _____

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:

www.drna.gobierno.pr

Location: _____ Puerto Chico Marina _____

Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

Boqueron

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.
88% True 12% False
 2. Corals are plants that use light from the sun for nutrition.
81% True 19% False
 3. A coral reef is formed by a conglomerate of rocks.
62% True 38% False
 4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.
100% True False
 5. Touching or grabbing coral is not harmful unless pieces of the coral break.
25% True 75% False
 6. Anchoring on top of coral reefs and seagrasses can damage them.
98% True 2% False
 7. Sedimentation can damage coral reefs.
90% True 10% False
 8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.
82% True 18% False
-

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

73% Swimming 35% Snorkeling 12% SCUBA 48% Boating/Kayaking
7% Surfing 58% Fishing _____ Other (please specify) _____

10. Do you ever come in contact with coral?

46% Yes 54% No

11. Have you ever broken coral?

8% Yes 92% No

12. If you answered yes to the previous question, why have you broken coral? _____

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

6% Yes 94% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

62% Yes 38% No

15. If you answered yes to the previous question, do you utilize these buoys?

44% Yes _____ No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

14% Yes 86% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

42% Yes 58% No

18. If you answered yes to the previous question, where have you seen these publications? _____

TV, marinas, newspapers, PSA's

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

87% Television 54% Radio 52% Public Service Announcements
46% Magazines/Pamphlets 38% E-mail 46% Public Posters
25% Mail 58% Newspapers 73% Internet

_____ Other (please specify) _____ Schools, highways, beaches _____

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:

www.drna.gobierno.pr

Location: _____

Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

Isla Verde

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.
87% True 13% False
 2. Corals are plants that use light from the sun for nutrition.
63% True 37% False
 3. A coral reef is formed by a conglomerate of rocks.
77% True 23% False
 4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.
93% True 7% False
 5. Touching or grabbing coral is not harmful unless pieces of the coral break.
20% True 80% False
 6. Anchoring on top of coral reefs and seagrasses can damage them.
93% True 7% False
 7. Sedimentation can damage coral reefs.
83% True 17% False
 8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.
63% True 27% False
-

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

77% Swimming 23% Snorkeling 10% SCUBA 30% Boating/Kayaking
13% Surfing 10% Fishing _____ Other (please specify) _____

10. Do you ever come in contact with coral?

60% Yes 40% No

11. Have you ever broken coral?

3% Yes 93% No

12. If you answered yes to the previous question, why have you broken coral? _____

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

0% Yes 100% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

60% Yes 40% No

15. If you answered yes to the previous question, do you utilize these buoys?

18% Yes 82% No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

46% Yes 54% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

10% Yes 90% No

18. If you answered yes to the previous question, where have you seen these publications? _____

TV

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

87% Television 50% Radio 60% Public Service Announcements
43% Magazines/Pamphlets 40% E-mail 50% Public Posters
20% Mail 63% Newspapers 70% Internet

_____ Other (please specify) _____ schools _____

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:

www.drna.gobierno.pr

Location: _____ Isla Verde _____

Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

Gilligan's Island

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.

97% True 3% False

2. Corals are plants that use light from the sun for nutrition.

72% True 28% False

3. A coral reef is formed by a conglomerate of rocks.

52% True 48% False

4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.

97% True 3% False

5. Touching or grabbing coral is not harmful unless pieces of the coral break.

3% True 97% False

6. Anchoring on top of coral reefs and seagrasses can damage them.

93% True 7% False

7. Sedimentation can damage coral reefs.

76% True 24% False

8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.

93% True 7% False

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

72% Swimming 38% Snorkeling 14% SCUBA 24% Boating/Kayaking
14% Surfing 34% Fishing _____ Other (please specify) _____

10. Do you ever come in contact with coral?

45% Yes 55% No

11. Have you ever broken coral?

0% Yes 100% No

12. If you answered yes to the previous question, why have you broken coral? _____

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

3% Yes 97% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

34% Yes 66% No

15. If you answered yes to the previous question, do you utilize these buoys?

38% Yes _____ No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

48% Yes 52% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

38% Yes 62% No

18. If you answered yes to the previous question, where have you seen these publications? _____

Boy Scouts, Internet and beaches

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

79% Television 41% Radio 48% Public Service Announcements
62% Magazines/Pamphlets 20% E-mail 34% Public Posters
10% Mail 41% Newspapers 69% Internet

_____ Other (please specify) _____

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:

www.drna.gobierno.pr

Location: _____

Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

DNER Vessel Registration Office

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.
90% True 10% False
 2. Corals are plants that use light from the sun for nutrition.
80% True 20% False
 3. A coral reef is formed by a conglomerate of rocks.
71% True 29% False
 4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.
82% True 28% False
 5. Touching or grabbing coral is not harmful unless pieces of the coral break.
14% True 86% False
 6. Anchoring on top of coral reefs and seagrasses can damage them.
98% True 2% False
 7. Sedimentation can damage coral reefs.
96% True 4% False
 8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.
69% True 31% False
-

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

67% Swimming 20% Snorkeling 24% SCUBA 57% Boating/Kayaking
8% Surfing 14% Fishing _____ Other (please specify) jetski/windsurf

10. Do you ever come in contact with coral?

51% Yes 49% No

11. Have you ever broken coral?

4% Yes 96% No

12. If you answered yes to the previous question, why have you broken coral? It was an accident

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

12% Yes 88% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

67% Yes 33% No

15. If you answered yes to the previous question, do you utilize these buoys?

50% Yes 50% No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

13% Yes 87% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

43% Yes 57% No

18. If you answered yes to the previous question, where have you seen these publications? _____
Marinas, TV, boat ramps, beaches

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

73% Television 27% Radio 43% Public Service Announcements
55% Magazines/Pamphlets 22% E-mail 33% Public Posters

14% Mail 57% Newspapers 37% Internet
_____ Other (please specify) Beaches, marinas and schools

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:
www.drna.gobierno.pr

Location: DRNA Vessel Registration Office Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

Appendix D: Total Survey Results

Coral Reef Outreach Survey, 2009

Hello! We are undergraduate students from Worcester Polytechnic Institute in Massachusetts. We are researching the quality of coral reef educational outreach with the Department of Natural Resources (DNER) in Puerto Rico. We would greatly appreciate your help to better understand how we can improve the DNER's coral reef educational outreach campaign. This survey is entirely confidential.

We are going to ask you some true/false questions about coral reefs. Please answer these questions to the best of your knowledge so that we can design the DNER outreach campaign more effectively.

1. Coral reefs help protect the coast from storm damage.
90% True 10% False
 2. Corals are plants that use light from the sun for nutrition.
74% True 26% False
 3. A coral reef is formed by a conglomerate of rocks.
66% True 34% False
 4. Coral reefs, seagrasses and mangroves provide habitats for a variety of plant and animal life.
94% True 6% False
 5. Touching or grabbing coral is not harmful unless pieces of the coral break.
20% True 80% False
 6. Anchoring on top of coral reefs and seagrasses can damage them.
96% True 4% False
 7. Sedimentation can damage coral reefs.
89% True 11% False
 8. Increased temperatures due to climate change causes coral bleaching, damaging coral reefs.
82% True 18% False
-

Please think about your experiences near coral reefs as you answer these next questions.

9. Do you participate in activities near coral reefs? (Check all that apply):

71% Swimming 29% Snorkeling 19% SCUBA 45% Boating/Kayaking
9% Surfing 11% Fishing _____ Other (please specify) _____

10. Do you ever come in contact with coral?

50% Yes 50% No

11. Have you ever broken coral?

8% Yes 92% No

12. If you answered yes to the previous question, why have you broken coral? _____

13. Have you ever thrown an anchor of a boat over a coral reef or seagrasses?

9% Yes 91% No

14. Are you aware that there are permanent mooring buoys in reef and seagrass areas?

62% Yes 38% No

15. If you answered yes to the previous question, do you utilize these buoys?

37% Yes 63% No

16. In your opinion, are there enough buoys along the coast of Puerto Rico?

23% Yes 77% No

The DNER has a public educational outreach program regarding coral reefs. The following questions will allow us to understand the effectiveness of their educational materials.

17. Have you seen any of the publications produced by the DNER concerning the conservation of coral reefs?

40% Yes 60% No

18. If you answered yes to the previous question, where have you seen these publications? _____

19. In your opinion, what do you think would be the most effective way for the DNER to distribute these publications? (Check all that apply):

83% Television 48% Radio 49% Public Service Announcements
49% Magazines/Pamphlets 31% E-mail 43% Public Posters
21% Mail 57% Newspapers 59% Internet

_____ Other (please specify) _____

Demographic Information

Sex: M _____ F _____

Age: (Please circle one): 16 or younger 17-25 26-35 36-50 51+

Where do you live? _____

What is your occupation? _____

Approximately how many times do you visit Puerto Rico's beaches per year? _____

Thank you for your time. If you would like a copy of our report, please visit:

www.drna.gobierno.pr

Location: _____ All _____

Date: _____

Department of Environmental and Natural Resources
Bureau of Coasts, Reserves, and Refuge
Coral Reef Outreach Survey, 2009

Appendix E: Anecdotal Information

1. Professor Ingrid Shockey's Kayak Trip

3-20-09

Professor Ingrid Shockey shared an interesting experience with us that she had while on a kayaking adventure trip that had snorkeling involved. This was located on the coast off the island of Vieques. She decided to ask the instructor if she was allowed to touch the coral when they arrived at the snorkel location. During that time the instructor advised her that she could do whatever she wanted with the coral. This is not good that tourist companies are not raising awareness on the damaging effects that humans have on coral reefs environments. Surveying and participant observation will be beneficial when trying to assess these different companies and their practices.

2. East Wind Catamaran Trip

3-28-09

During our snorkeling trip on East Winds Catamaran we saw a poster on the wall that outlined dangers to coral. Also, before entering the water, the crew gave a short speech telling us that even the slightest touch can damage the coral. Also, they cautioned us that we should not get too close to the reefs that rise above the water because the current could push us onto the coral damaging both us and the coral.

The crew also made sure to anchor the boat in an appropriate manner. They went up close to the shore and put the anchor on the sandy shore. The other boats around us seemed to be careless about their anchors and the positions where they dropped them. Although, whether or not they had anchored on top of coral, they did not seem to act as cautious.

There were approximately seventy five people on board our catamaran. Our group only saw two people act inappropriately. For example, a member of our group saw a woman about one hundred yards off the shore standing on the coral and her whole body

was exposed out of the water except for her feet. We made her aware of her damage and told her we were from the Department of Natural and Environmental Resources. The woman stated “I was having trouble breathing”. We also noticed she was not using a flotation device which the tour guides suggested using if you have trouble swimming.

The other person was observed by another member of our team. A female snorkeler broke off a piece of plant life attached to the coral reef structure. It was later assumed that she was a tourist and was taking it as a souvenir.

We also noticed that there was a large amount of sedimentation present in our area. This was most likely due to the fact that it was a high traffic tourist area with a lot of constant moving from catamarans and other vessels.

3. Department of Natural and Environmental Resources Vessel Registration

3-30-09

A man talked about the best places to put out publications was in a boatyard in Fajardo. It was an area where people store and keep boats on multi-level storage towers and racks.

One man stated that he does sometimes come into contact with the coral reef because of the current and waves of the ocean. He said that sometimes he will be at an acceptable distance but the water brings him closer and before he knows it he is right on top of the coral reef and is pushed into it. He says he has learned to keep his distance now. He also stated that he thinks the best place to put DRNA publications are at the places on land where boaters pay a low rent fee to store their boats. There is one in Fajardo that he said would be a great place for this. “The one in Fajardo would be a great area to have this information because many of the people don’t know that this is such a serious issue”.

4. Villa Marina

4-2-09

A client at Villa Marina said he is disappointed in the amount and locations of the current mooring buoys. He thinks there needs to be more and especially during the holidays. When there is an abundant number of boats in one area and not enough buoys, the boaters just drop their anchors anywhere, even if there is coral unknowingly below them.

Outside the marina shop, a man recommended a large fluorescent sign that can be seen when boaters leave the marina before they hit the open seas. He also has seen as well as learned from the public service announcements that have been produced on television by the DRNA.

Aileen and the DNR driver also mentioned that “Villa marina is the dumpiest marina in Puerto Rico”

In the SCUBA shop, money is all the people care about. We saw and took pictures of coral that was poached and was being sold throughout the shop. Customers also stated again that there are not enough mooring buoys and that they are forced to anchor on the weekends in unknown waters that could possibly have coral beneath the boats.

5. Puerto Chico Marina

4-2-09

Frances Torro, the owner of the marina, makes care packages for new members of the marina. Within these care packages are the publications that have been distributed by the DNR. She also stated that she needs more publications to distribute because she is running out. She says that they are very important, especially for the new boating members of the marina who do not know a lot about coral reef ecosystems”. Also she requested more mooring buoys be placed in the reef areas and her marina offers free boat inspections on the first of every month.

Frances also offers free clinics for kids and adults that educate them on the coral reef and plants. Also offered is a GPS course that teaches the boaters how to find and locate the mooring buoys.

6. San Juan Bay Nautical Club

4-6-09

The captain of a fishing boat wants Fish Attraction Devices (FAD's) to be placed in the ocean which will take boaters away from the coral areas where the fish are currently swarming. He noticed that the area between Fajardo and Dorado was all damaged and bleached. Less people would be anchoring on the reefs if there were FAD's because they would be anchoring in areas away from the coral reefs. He also admitted that he drops his anchor on the seagrass all the time, but never the coral.

Another boater shared with us, the fact that he has been hearing stories about how people, especially as lately, have just been dropping anchors on coral reefs and damaging them.

The shop owner says that sedimentation from rivers and buoys are the main cause for reef damage. He mentioned that San Juan Bay is the most polluted on the whole island but is getting a lot better recently.

7. Isla Verde

4-8-09

A man told us that the coral reefs are dying around the Isla Verde beach and are washing up all over the shoreline recently.

8. Boquerón Beach

4-9-09

A woman suggested that with all the condominium rentals on the coast, there should be a rules and instructional video that people should watch before they get the keys to their condominium rental. She also stated that every year for the past fifteen years the shoreline has been decreasing by the year.

9. Fajardo Catamaran Charter Docking Area

4-17-09

The tour guides are noticing that even after they give a verbal presentation before taking the people out to the reefs, they still touch and poach the coral. They also are noticing that they are all trampling over the coral when out snorkeling over the coral reefs. Their boats have plastic signs that have coral reef awareness information hooked onto the side of the boat for the snorkelers to see. They recommend that there needs to be some kind of enforcement for these actions. Also recommended were there needs to be more rangers out at these locations and marine patrol ticketing these damaging users. “The crew does all they can”, the captain stated, but they need additional help to enforce the damage being conducted. When we were leaving the captain requested that they be given a poster for their docking station so when people are waiting to get aboard the catamaran for their snorkeling trip, they are aware of the damages done to coral. Finally, he suggested that before people book their trips, that they are required to watch an instructional video on coral reefs so they are aware of the dangers before they even get into a bus and leave for the trip.

Appendix F: Educational Marine Publications

UNITED STATES CORAL REEF TASK FORCE

In 2002, the U.S. Coral Reef Task Force identified the need for action at the local level to reduce key threats to coral reefs and called for the development of Local Action Strategies (LAS) in each of the seven states and territories which possess significant coral reef resources.

PUERTO RICO Local Action Strategy

In Puerto Rico, local and federal agency representatives were identified as leads in the development of individual LAS for each focus area. On April 30 and May 1, 2003, a kickoff meeting was held to develop draft LAS to address issues affecting coral reefs in Puerto Rico. A core group of people was convened to help draft the Puerto Rico LAS document, which will serve as the backbone for a long-term Puerto Rico Coral reef management plan. The LAS currently proposed build on the experience of many different stakeholders, and strengthen Puerto Rico coral reef management efforts through increased coordination between state and federal partners and local agencies.

LACK OF AWARENESS ...

Puerto Ricans consider the sea as an integral part of their daily lives and many people have a basic knowledge of marine coastal ecosystems. However, increased education is needed about the direct relationship between human activities and their impacts on the marine environment. This focus area aims to promote awareness on the extent of these interrelationships and the consequences of different human activities.

Goals and Objectives

- Promote public awareness of the importance of coral reef ecosystems to Puerto Rico's economy
- Improve communication and promote participation of coastal communities and other stakeholders in planning efforts and protection of coral reefs

Project Examples

- Design and produce and educational and interactive CD or DVD on coral reefs
- Install signs in coastal areas to educate users on the different marine ecosystems and ways to protect them
- Identify, produce, and distribute educational information to coastal businesses about the importance of coral reefs to Puerto Rico's economy

Anticipated Outcomes

- Series of public education campaigns created and used to reach various interest groups
- Improved communication between all coral reef stakeholders

LAND-BASED SOURCES OF POLLUTION ...

Rapid rates of human population growth and density in Puerto Rico have led to increased deforestation for agriculture, and increased discharge of sewage and industrial waste. Knowledge of the functions and processes controlling reef environments is currently limited, which confounds appropriate management actions that could be taken. This focus area addresses management options to control land-based pollution sources and to improve enforcement of and compliance with protection measures.

Goals and Objectives

- Reduce loss of live coral reef cover through the promotion and implementation of integrated watershed and land use management practices in at least two watersheds associated with coral reef communities
- Improve compliance and enforcement of laws, rules, and regulations related to construction and land development permits in order to prevent deterioration of coral reef habitats.



ESTIMATED LAS PROJECT IMPLEMENTATION COSTS

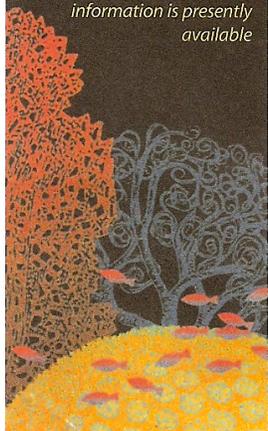
Lack of Awareness
\$625,000

Land-based Sources of Pollution
\$980,500

Overfishing
\$1,285,000

Recreational Misuse/Overuse
\$1,020,000

Estimated costs derived from projects for which cost information is presently available



STAKEHOLDERS

Boat operators

Caribbean Fisheries
Management Council

Department of Natural
and Environmental
Resources

Dive instructors

Dive shop representatives

Environmental Planning
Board

Environmental Quality
Board

Marine ornamental
fishers

NGOs

NMFS

NOAA

Puerto Rico Sea Grant

Puerto Rico Tourism
Company

State water and power
agencies

University of Puerto Rico

U.S. Coast Guard
Auxiliary

USDA, Natural Resources
Conservation Service

USEPA

USFWS

contact

Project Examples

- *Implement best management practices to reduce pollution from agriculture*
- *Conduct training workshops for marina operators and the agricultural community on ways to reduce coastal pollution*

Anticipated Outcomes

- *Fully trained and knowledgeable enforcement staff*
- *Reduction in number of non-compliance reports for construction and land development activities*

OVERFISHING ...

Reef fisheries in Puerto Rico's coastal waters have plummeted during the last two decades. It is important to take action in order to revive and attempt to sustain a healthy fishery for the future. Effective fisheries management directed towards restoring coral reef health and the fisheries supported by these reefs is the aim of this focus area.

Goals and Objectives

- *Increase the effectiveness of coral reef and fishery laws in promoting the restoration and cleanup of coral reefs impacted by abandoned equipment and fishing gear*
- *Reduce impacts of recreational fishing on coral reefs*

Project Examples

- *Purchase and acquisition of equipment for the designation of no-take reserves*
- *Identify and prioritize indicators and parameters that will designate no-take reserves*
- *Inventory current fisheries status*

Anticipated Outcomes

- *Increased enforcement and compliance of fishery regulations and laws*
- *Formal indication list and parameter guidelines for establishment of no-take reserves*

RECREATIONAL MISUSE/OVERUSE ...

Ocean-related promotional services and attractive marine recreational activities are key to the local tourism industry and fundamental to Puerto Rico's economy. Coral Reefs are an integral part of the recreation and tourism in Puerto Rico. This focus area addresses the management of recreational activities to avoid or minimize negative impacts to coral reefs.

Goals and Objectives

- *Identify high priority coral reef sites*
- *Reduce damage to heavily used coral reef areas in Puerto Rico to ensure healthy and long-lasting coral reefs for the island and tourism industry*
- *Maintain/improve conditions in most heavily visited coral reefs sites to ensure sustainability of resource and long-lasting recreational boating use*

Project Examples

- *Assess damage by anchoring or trampling at target coral reef areas*
- *Install/increase number of buoys at target sites*
- *Revise and update management plans for target reef areas*

Anticipated Outcomes

- *Maps for the general public and boat users, including information on the identification and demarcation of safe anchoring zones at key reef sites*
- *Increased amount and appropriate usage of buoys installed at affected reefs*

AILEEN VELAZCO, avelazco@caribe.net 787.999.2200 x2706



— LAS REGULACIONES — — THE REGULATIONS —

Únicamente 20 peces coralinos y 8 invertebrados pueden ser legalmente capturados para acuarios y requieren permisos especiales con cuotas anuales establecidas para pescadores comerciales.

Only 20 reef fish and 8 invertebrates are permitted for aquarium capture and require special permits with established annual quotas for commercial fishers.

Entre las actividades y métodos de colección ilegal están: la pesca con químicos, romper o voltear los corales para buscar animales, anclar sobre los corales, y utilizar otras artes de pesca que no sean redes de mano, redes de barrera o pistolas de succión.

Illegal activities and methods of collection include: fishing with chemicals, prying apart or overturning corals to find animals, anchoring on reefs, and using fishing gear other than hand nets, barrier nets, or slurrp guns.

Está prohibido pescar con el fin de poseer o de vender muchos animales provenientes del arrecife de coral. Entre los animales que no se pueden capturar están: caballitos de mar, langostas comunes inmaduras, peces mariposas, corales y el carrucho reina inmaduro o juvenil.

Fishing for, possessing, or selling many coral reef animals is prohibited. Some of these include: seahorses, immature lobsters, butterflyfish, corals, and undersized queen conch.

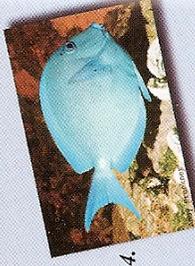
Está prohibida la colección de pedazos grandes de coral muerto. Estos pedazos son importantes para la formación de nuestras playas arenosas, para la formación de nuevas costas y ayudan en la prevención de su erosión, y forman sustrato donde otros organismos inclusive los corales pueden crecer.

The collection of large pieces of dead corals is prohibited. These pieces are important in forming our sandy beaches, building our coastlines and aiding in the prevention of erosion, and forming substrate for other organisms, including corals, to grow.

Pasa la voz — cuéntale a otros como “¡Ayudar a mantener los arrecifes!”



1. Coral columnar - Pillar coral
2. Doncella cabezurita - Blue headed wrasse
3. Cangrejo de flecha - Arrow crab
4. Barbero - Blue tang



4.

Deja los animales en el arrecife de coral en vez de llevarlos al acuario de tu casa. Los animales del arrecife de coral son frágiles y usualmente mueren antes de llegar a tu casa.

Leave animals on the reef rather than bringing them to your home aquarium. Reef animals are fragile and usually die before you can get them home.

Comienza a ser más consciente: pregunta a cerca de lo que estas comprando, pregunta de donde viene y como fue colectado.

Become more aware: ask about what you're buying, where it came from, and how it was collected.

Evita comprar recuerdos hechos de coral u otros organismos marinos manejados, a menos que fueron coleccionados de las playas bajo los permisos apropiados.

Avoid purchasing souvenirs made from coral or other managed marine organisms unless they were collected from beaches under the appropriate permits.

No liberes ningún pez de acuario o algún otro animal a cuerpos de agua del medio ambiente. Especies no nativas pueden perjudicar el arrecife de coral.

5. Esrella de mar común - Cushion sea star
6. Isabellita mediblob - Rock beauty
7. Isabellita negra - French angelfish
8. Langosta común - Spiny lobster

¿QUE PUEDO HACER? WHAT CAN I DO?

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Do not release aquarium fish or other animals into our waters. Nonnative species can harm the reef.



6.

Spread the word: Tell others how to “Help Keep the Reef!”

- Temperaturas cálidas, nunca inferiores a los 21-22° -C
- Buena iluminación
- Alta salinidad
- Baja tolerancia a sedimentos suspendidos
- Oleaje o corrientes
- Baja tolerancia a emersión prolongada

Distribución y tipos de arrecifes



Las condiciones anteriores sólo se dan en algunas áreas de los fondos poco profundos de los mares tropicales. En el Caribe se dan las condiciones muy propicias para el crecimiento de arrecifes de las Antillas, sobretudo en aquellos litorales más secos donde no hay ríos ni aportes de sedimento. En Puerto Rico se encuentran importantes áreas de coral en la costa este, sur y suroeste. La costa norte carece de gran desarrollo coralino probablemente debido a que en ella desembocan ríos de gran caudal que traen grandes cantidades de sedimentos. La plataforma submarina al norte de la Isla también es muy empinada y cae a grandes profundidades muy cerca de la costa. El espacio disponible para el establecimiento de esta comunidad es limitado por esos factores.



En Puerto Rico se encuentran tres tipos o formas de arrecifes, a saber:

- **Arrecifes de franja o marginales**- Este tipo de arrecife bordea un litoral no coralino. Frecuentemente está separado de la costa por una laguna o cuerpo de agua estrecho y poco profundo, cuyo fondo está revestido de arenas calcáreas y yerbas submarinas. Este tipo de arrecifes es uno de los más comunes en Puerto Rico, pero por su proximidad a la propia costa, también es el que más ha sido degradado por la actividad humana.

- **Arrecifes de barrera**- Los arrecifes de este tipo ocurren más separados de la costa. En Puerto Rico este tipo está representado por una estructura arrecifal que se encuentra en el borde de la plataforma insular, a profundidades en el orden de 20 metros (65 pies).

- **Arrecifes de banco**- Los arrecifes de banco están situados en la plataforma, entre los dos tipos anteriores. A este tipo de estructura se le conoce como arrecifes de plataforma o de banco-barrera. Estos arrecifes frecuentemente adquieren formas de media luna, ya que el arrecife crece y se consolida preferentemente hacia el oleaje.

Respuesta de los arrecifes de coral a los disturbios

Los arrecifes de coral son sistemas de gran complejidad y por lo tanto los daños ocasionados por los disturbios naturales o aquellos provocados por el ser humano, pueden tomar muchas décadas para ser remediados. Sin embargo, el conjunto de especies que constituye el arrecife incluye especies de crecimiento relativamente rápido lo que permite el "sanar" los daños que son provocados por disturbios que no dejan acciones residuales. Desgraciadamente, la acción del ser humano sobre estos ecosistemas frecuentemente no permite que actúen estos mecanismos naturales de regeneración, provocando disturbios crónicos que llevan a la eventual degradación y colapso del sistema.

Disturbios naturales

- **Tormentas**- En nuestra región geográfica los huracanes y las tormentas son uno de los disturbios naturales más violentos que actúan sobre las áreas de coral. Estas tormentas generan olas de gran fuerza que rompen los corales y desprenden bloques de roca coralina que a su vez causan daños muy extensos al rodar o deslizarse sobre los fondos.



Paradójicamente estos cambios suelen renovar los procesos vitales del sistema y pueden a la larga ser beneficiosos contribuyendo a un mayor crecimiento y desarrollo de nuevos habitáculos.

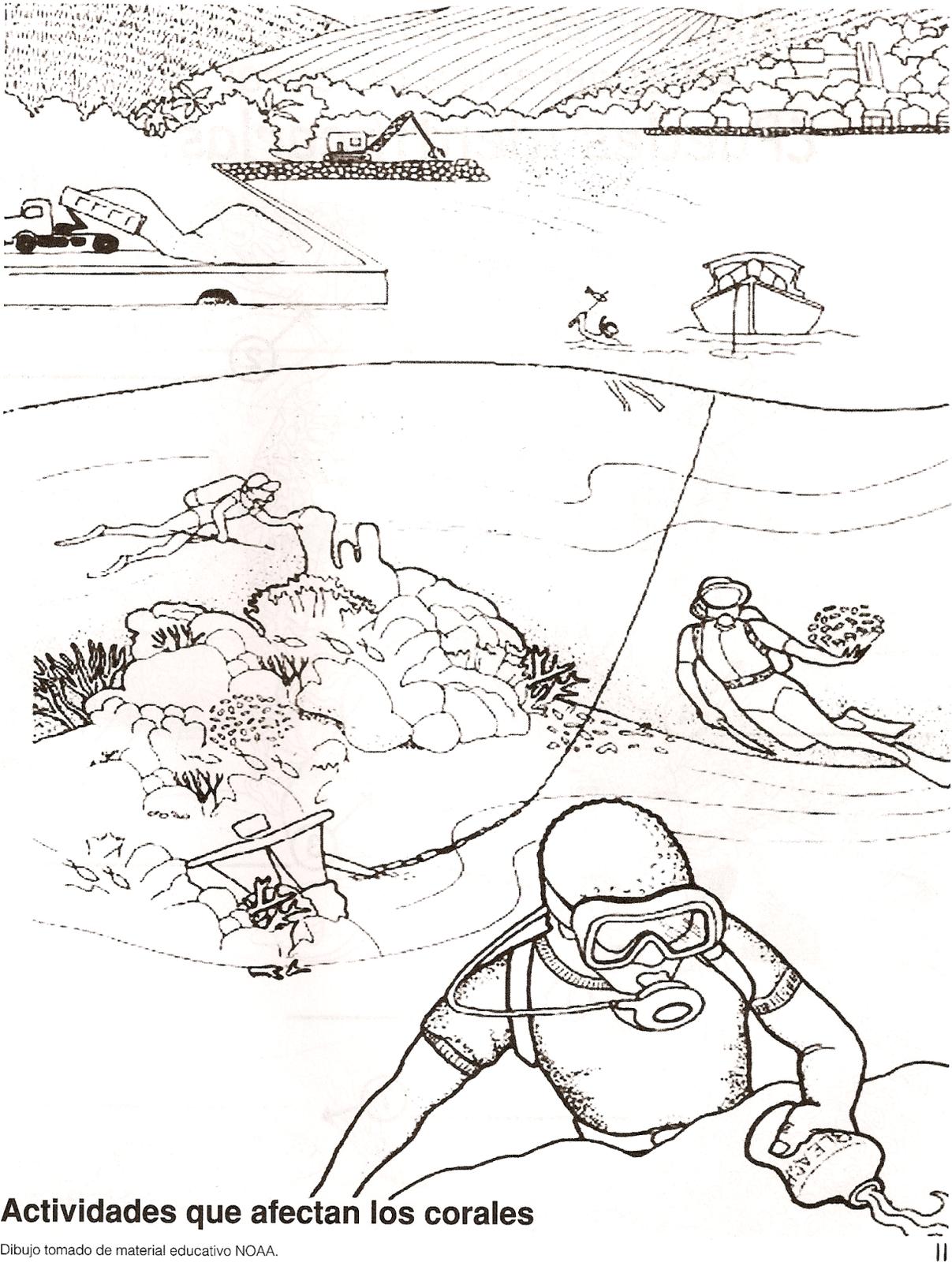
- **Cambios en el nivel del mar**- La comunidad científica ha expresado gran preocupación con relación a los cambios en el nivel del mar que se están experimentando debido al llamado "efecto de invernadero" provocado por las emisiones a la atmósfera de ciertos gases. En el caso de los corales se ha expresado la preocupación de que estos sistemas están sufriendo una degradación muy severa que podría imposibilitarlos de la capacidad para resistir, dada la rapidez de los cambios en el nivel de las aguas que se han pronosticado.

- **Blanqueamiento de corales**- El blanqueamiento de los corales es un fenómeno que se está registrando en muchas áreas del Caribe aunque sus causas se desconocen. El blanqueamiento, que es provocado por la expulsión de las zooxantelas, ha sido atribuido a pequeños aumentos en la temperatura media de las aguas superficiales en el área del Gran Caribe.

Disturbios causados por las actividades humanas

- **Sedimentación y enriquecimiento de las aguas**- En Puerto Rico algunos ríos llegan a transportar anualmente hasta 100 toneladas (200,000 lbs.) métricas por hectárea de sedimentos en suspensión. Estos sedimentos llegan al mar donde son dispersados degradando la calidad de las aguas costeras. Los sistemas arrecifales sujetos a la sedimentación son destruidos o degradados rápidamente. El enriquecimiento de las aguas por nutrientes causa afloramientos de fitoplancton y los organismos (zooplancton) que se





Actividades que afectan los corales

Dibujo tomado de material educativo NOAA.

