



Characterizing harmful behavior of divers
and snorkelers to coral reefs in Puerto Rico
through systematic observation and testing
the effectiveness of pre-trip media-based
interventions: Final Report



The Social and Environmental Research Institute

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PROJECT OVERVIEW

This report summarizes our findings on the recreational misuse of coral reefs by divers and snorkelers in Puerto Rico. There is widespread consensus that recreational misuse is damaging reefs, but the magnitude of the issue is unknown. This is an important issue because tourism is a significant economic force in Puerto Rico and sustenance of healthy reef ecosystems is essential to its productive survival. The ecotourism industry, by in large, recognizes the value and importance of coral reefs to their sustainability as businesses, and have supported our research. Damage to the reefs is usually caused by the inappropriate behavior of individual divers and snorkelers and not the behavior of the industry and is something the tourism industry has a hard time to control. While tour operators give careful and clear instructions for how to behave at the reef, divers and snorkelers don't always listen or act appropriately.

Researchers at the Social and Environmental Research wanted to determine if the latest science on the theory of human behavior with regard to environment would help come up with strategies that the eco-tour operators could put in place to encourage pro-environmental behaviors.

Over the past two years, we made in-water observations of recreational visitors to Puerto Rico's coral reefs. Using a systematic observational protocol, we observed snorkelers and divers at various reef locations and counted the number of contacts visitors made with reefs. Over 300 in water observations of snorkelers were made. We found that during the time snorkelers were over the reef, they had 0.26 contacts per minute with the reef. A subset of the people who were observed also made self-reports of their behavior. We evaluated the accuracy of self-reports and found that snorkelers who completed self-report surveys under reported their harmful behaviors by a factor of seven. Over 150 observations of divers were made. We found that, during the time divers were near the reef, they contacted the reef 0.53 times per minute. SCUBA divers that were both surveyed and observed under reported their harmful behaviors by a factor of seven.

Next, we developed coral reef etiquette messages for divers and snorkelers to view before visiting reefs on a tourist vessel. We evaluated existing messages and found them to be inconsistent with social science theories of behavior and behavior change. Instead we designed and developed a new coral reef etiquette video message based on the Value, Belief, Norm theory of environmental behavior. Since March of 2012, the video message has been shown to hundreds of snorkelers and divers before they boarded a vessel. On board, visitors were also asked to sign a pledge stating commitment to specific behaviors. Post-treatment in-water observations found that snorkelers contacted the reef 0.034 times per minute. That is an 87% reduction in the coral contact rate. Furthermore, the percentage of snorkelers who *never* touched the reef shot up from 64% to 93%. Divers who watched the video also dramatically reduced the number of times they contacted the reef. The rate for divers fell from

0.56 to 0.14 contacts per minute. That is a 75% reduction in the coral contact rate.

This research suggests the pre-trip messaging together with a written pledge can change proximal behaviors, thus improving the ability of eco-tourism operators to help sustain reefs as well as the economic livelihoods of their employees.

BACKGROUND

Specific damaging behaviors by divers and snorkelers include fins hitting coral, impacts caused by equipment, holding on to corals, body brushes, standing on the reef, equipment scratches, stirring up sediment, deliberately touching coral, picking up marine life and collecting. Evidence on interventions to reduce these specific damaging behaviors by divers and snorkelers at coral reefs is weak. SERI researchers designed interventions to modify visitor behaviors at reefs in Puerto Rico by utilizing the social science theories of behavior and behavior change, in particular a strong theory of behavioral change, the Value Beliefs Norm (VBN) theory. VBN theory explains that the drive for individual behavior originates in a commitment to fundamental values but is then modified by information/knowledge, expectations about incentives and punishments, and social expectations or peer pressure. Perceived ability to engage in the behavior effectively is also known to be an important factor. Values, attitudes, expectations of favorable outcomes, and knowledge all stimulate an intention to act. If the proper incentives are in place and/or if there is peer or social pressure to act, the desired behavior may be realized. Our objective was to test the effectiveness of video messages at reducing the frequency of contacts that snorkelers and divers have with the reefs in Puerto Rico.



Photo 1. Snorkelers feeding bread and turkey to fish at Tortugas Reef.

REEF LOCATIONS

We have observed divers and snorkeler at coral reefs found in several different geographic locations in Puerto Rico. Within the La Cordillera Nature Reserve we made observations at: Icacos Island, Tortugas Reef, Palomino Island, Cayo Lobos, Palominto Wall, Sandslide and Cayo Diablo. Other reefs include Taino Wall (Mayaguez), Black Wall, Cayo Aqua Rock, Tamarindo Grande (Culebra), Playa Flamingo (Culebra) and Tres Palmas Marine Reserve in Rincón.

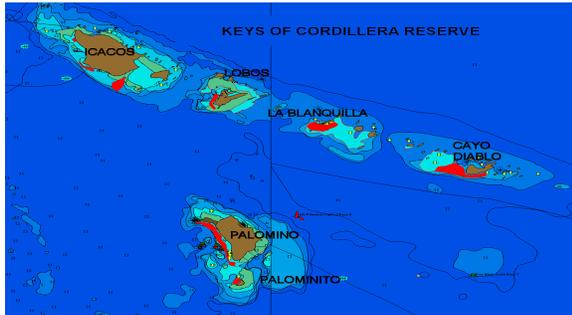


Figure 1. Map of the Keys of Cordillera Reserve.

OUTREACH/AWARENESS EFFORTS

- Dr. Thomas Webler gave a presentation/webinar for NOAA staff about this project in July of 2012. After hearing this presentation about our work in Puerto Rico, staff from the Florida Keys National Marine Sanctuary requested our input on a video message they were designing to promote positive behavior by recreationalists at reefs within the Sanctuary. We suggested changes to their script and suggested adding a pledge. We also suggested the value added in collecting data before and after showing the video in order to document its effectiveness. We proposed a project under the National Marine Sanctuary Foundation, but just learned that project would not be funded. We continue to look for funding to work with FKNMS in the near future on evaluating the effectiveness of their messaging.
- Research assistant, Karin Jakubowski presented results at the Center for Tropical Ecology and Conservation's Ecotourism Symposium at Antioch University in Keene, New Hampshire on November 3, 2012.
- We have proposed to present our project and results to the annual meeting of the International Society for the Study of Resource Management in Estes, CO June 2013.
- Jakubowski presented preliminary results at the International Society for the Study of Resource Management annual meeting in Minnesota in 2011.

- Thomas Webler presented results of the snorkeler treatment to the public conversation on coral reefs in San Juan in September 2011.
- Proven effectiveness has been inspiring to the tour operators that we have worked with. We are continuing to work with many individuals in the tourism industry and in the field of coral reef conservation in Puerto Rico to develop a procedure for implementing strategies to utilize these materials. Individuals include the tourism department, scientists, resource managers, graduate students, tour operators, vessel captains, scuba instructors, dive masters and boat staff. Specific companies working with us include those listed in Table 1.

Tour Operator	Website
Casa del Mar PADI Dive Center	www.scubapuertorico.ne
East Island Excursions	www.eastislandpr.com
Scuba Dogs	www.scubadogs.net
Sea Ventures Dive Center	www.divepuertorico.com
Spread Eagle II	www.snorkelpr.com

Table 1. List of tour operators who have been supportive of this research in Puerto Rico.

EDUCATION MATERIALS

We produced and developed two, three-minute videos on coral reef etiquette, one for snorkelers and one for Scuba divers. Table 2 provides information on what messages were delivered by the video and how these messages have been developed to meet the criteria of the VBN (value, belief, norm) theory of environmental behavior.

Message	VBN Component
Snorkelers come to Puerto Rico to experience its remarkable coral reefs.	Asserts positive environmental attitude toward reefs
Of course, we would never deliberately do anything to hurt marine life. And we all want to practice responsible behaviors underwater.	Reinforcement of benevolence. Appeal to benevolence
However, even experienced snorkelers can accidentally impact the reef. Here are a few things you need to know about how snorkelers can affect coral reefs and suggestions for practicing good reef etiquette.	Awareness of consequences

Corals build a strong skeleton but their “skin” is fragile. Even the lightest touch with your hands or fins can damage sensitive coral.	Awareness of consequences
Keeping a little distance from coral reefs and sea life helps ensure your safety and protects the reef!	Self efficacy
<ul style="list-style-type: none"> ○ Some corals can burn. Keep your distance. ○ Some animals that live in the reef can bite or sting. ○ Waves and currents can push you into reefs resulting in scrapes, bruises, and cuts. 	Awareness of consequences (to value of security)
For all these reasons, it’s a good idea to keep a little space between you and the reef.	Prescriptive norm to protect oneself
Coral is not like grass, it will die if you stand on it.	Awareness of consequences
If you need to adjust your mask, swim away from the reef first.	Self-efficacy
If you want to talk with your friends, swim away from the reef first.	Self-efficacy
When treading water, be aware of where your fins are, so you don’t accidentally kick the coral.	Ascription of responsibility
Any silt your fins kick up can land on coral, smothering it over time.	Awareness of consequences
When you are near the reef, it’s a good idea to float horizontally at all times.	Prescriptive norm
Photographers can get clear and colorful pictures without holding onto the reef. Calm and slow movements are less likely to startle fish and result in great pictures.	Self-efficacy
Leave sand, empty shells or bits of dead coral. Coral reefs need these non-living resources to remain vibrant.	Prescriptive norm
Remember: there are no policemen here. If you choose to break, collect, or stand on the coral, it will harm the reef and people who come after you will not be able to enjoy what is here for you today.	Affirm widely held value of self-direction
We have the choice to make a positive impact on the underwater world. Be aware of your movement in the water and keep a safe distance!	Ascription of responsibility Prescriptive social norm

Table 2. Snorkel video messages based on the VBN (value, belief, norm) theory of environmental change.

Snorkelers and Scuba Divers were also asked to sign a pledge stating commitment to specific behaviors while recreating around coral reefs. By signing a pledge, a snorkeler or Scuba diver commits to carry through with the intention to be responsible at the reef. Table 3 and 4 provide the pledge scripts for both snorkelers and divers.

Pledge for Snorkelers
<p>Most visitors to coral reefs never touch, kick, or stand on the coral. They are careful not to stir up the sand near the coral with their fins. Coral are fragile and, if injured, are slow to recover. Keeping a safe distance from the reef is the best way to ensure these beautiful reefs are here for future generations. If you need to fix your mask or snorkel, it is best to swim away from the reef first.</p> <p>I pledge to be a responsible visitor to the reef by:</p> <ul style="list-style-type: none"> • Being aware of where my fins are at so I don't kick the coral • Treading water instead of standing on the reef • Not stirring up silt near the reef • Keeping a safe distance from all marine organisms

Table 3. Pledge snorkelers were asked to read and sign before boarding tour operator vessel.

Pledge for Scuba Divers
<p>Most visitors to coral reefs never touch, kick, or stand on the coral. They are careful not to stir up the sand near the coral with their fins. Coral are fragile and, if injured, are slow to recover. Keeping a safe distance from the reef is the best way to ensure these beautiful reefs are here for future generations. If you need to fix your mask or snorkel, it is best to swim away from the reef first.</p> <p>I pledge to be a responsible visitor to the reef by:</p> <ul style="list-style-type: none"> • Being aware of where my fins are at all times so I don't kick the coral • Practicing good buoyancy control instead of holding onto the reef • Securing dangling equipment • Not stirring up silt near the reef • Keeping a safe distance from all marine organisms

Table 4. Pledge Scuba divers were asked to read and sign before boarding tour operator vessel.

Finally, we also developed a field guide that contains pictures of common species of fish and corals that are found in Puerto Rico along with a few characteristics to assist with identifying these organisms. Included in the guide are images that serves as reminders on how to behave while snorkeling or diving. This guide has been passed around on each trip that a researcher has participated in.



Photo 2. Photo utilized in field guide for snorkelers.



Photo 3. Image included in field guide that serve to remind divers how to behave around the reef.



Photo 4. Diver kneeling on coral to take a photograph at Sliding Sands reef.



Photo 5. Snorkeler standing on reef and touching coral at Tortugas reef.

DATA COLLECTION METHODOLOGY

For Snorkelers: We designed a systematic and scientific approach to collecting data in the water and showing the video to guests during the experimental treatment phase of our research. Researchers arrived before guests to set up. The video was prepared on two portable DVD drives. As small groups of guests arrived at the dock, they would check in with the vessel crew. After checking in, the researcher would approach a small group of snorkelers and explain that, before boarding the vessel, they needed to watch a short video on how to behave around coral reefs while snorkeling. A majority of snorkelers agreed to watch the video since they assumed that the video was part of the check in procedure. Two portable DVD players were utilized to reach as many snorkelers as possible. After watching the video, the DVD player was returned to the researcher who then asked the snorkelers to read and sign the pledge. The researcher would approach as many snorkelers as possible before it was time to embark on the vessel. The researcher noted key identifying features of those who watched the video and signed the pledge, in order to assist with identifying these individuals later when snorkeling.

For several reasons (safety briefings, music, vessel noise, sea spray), no videos were shown once visitors were onboard the vessel. The researcher took every measure to make sure as many snorkelers as possible watched the video. Often late arrivals were not able to watch the video or sign the pledge.

Observation situations at the reef involve several or, in some cases dozens, of people visiting the reef from several tour operations at the same moment. Therefore, our researchers made sure that we were first in the water and swam immediately to the reef where we watched for snorkelers who received the treatment to arrive. The researcher would start the timer and follow snorkelers in the treatment group, often staying 2-4 meters behind the visitor. Underwater clipboard and data recording sheets were used to count different types of behaviors (simply making a slash in the box for each type of behavior). Observations of the individual ended when either (1) they left the area of the reef, or (2) five minutes were completed. At the end of each observation period, the researcher would search for another snorkeler who received the treatment. Snorkelers usually swim together with their party, so finding another individual who received the treatment was not initially difficult. Researchers also recorded identifying information (color of bathing suit, gender) as well as the fact that the snorkeler observed the video and signed the pledge. The researcher would attempt to observe all snorkelers who watched the video and signed the pledge first and then would randomly observe non-treatment snorkelers from any tour operation; these data comprised a second set of baseline data. Snorkelers who did not have fins and a snorkel were not observed or included in the study.

For SCUBA divers: The researcher would be the first to arrive at the dive shop to prepare treatment materials. Guests would then arrive, often in small groups to check

in. After checking in, dive shop staff would inform these guests that they needed to watch a short video on diving etiquette around coral reefs. To date, almost every guest participating in a dive trip has watched the video and signed a pledge. A majority, assume this is part of the check in procedure. Once at the reef, the first diver immediately in front of the researcher was observed. Observations were made from 1- 4 meters behind the diver and lasted for five minutes. The researcher would then seek out a different member of the trip to observe, trying to observe everyone who watched the video/signed pledge once before making a second observation on any individual.

SNORKELER DATA ANALYSIS

Between January 2011 and June 2012 we collected data on snorkelers who did not watch the video and sign the pledge. We made 328 observations of snorkelers for a total of 1720 minutes. 67% of the observations lasted for exactly five minutes. A total of 445 behaviors were observed around the corals. A majority of the contacts were the result of fin kicks (39%), followed by sitting, standing or kneeling (22%) siltation (14%), touching coral (13%), touching other organisms (4%), picking up marine life (4%), brushing up against the coral (2%), and collecting (2%).

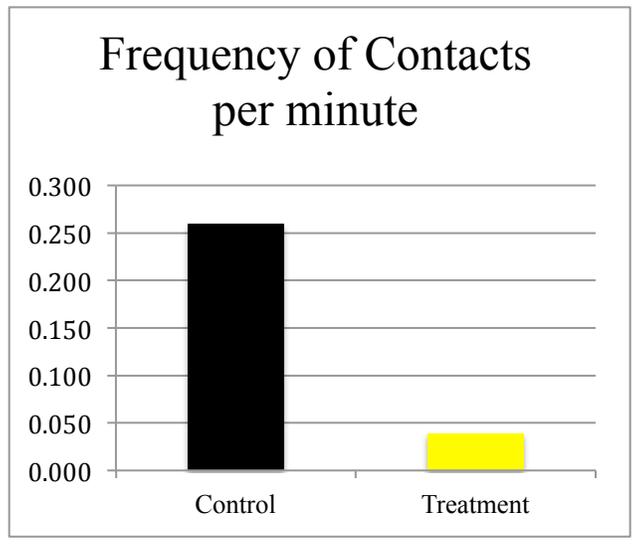
We computed the frequency of contact behaviors for the snorkelers observed. Frequency is merely the number of contacts divided by the amount of time that the visitor was observed. We have found that the frequency of potentially damaging contacts to living corals is 0.26 contacts per snorkeler per 1 minute.

To determine if pre-trip messaging can reduce the number of potentially harmful behaviors at the reefs, we collected data on snorkelers who observed the video and signed the pledge between January 2012 and June 2012. 120 observations were of snorkelers who received the treatment (watched video and signed pledge) and lasted for a total of 552 minutes of which 71% of these observations lasted for 5 minutes.

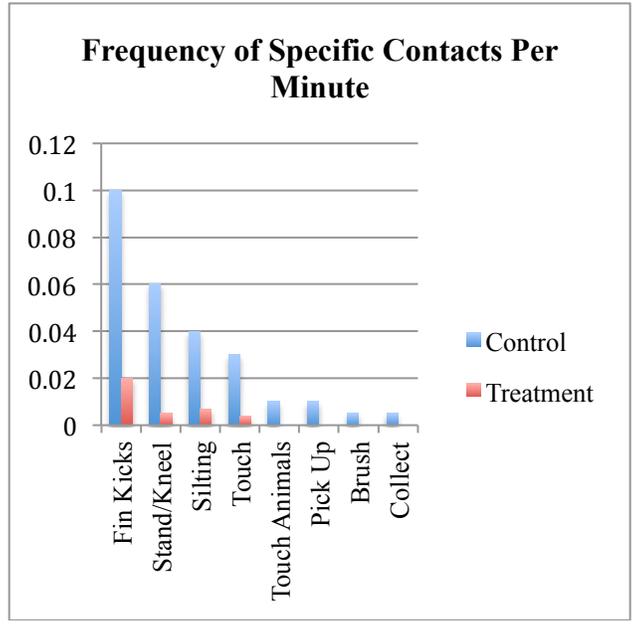
For the experimental group, a total of 19 negative behaviors were observed around the coral reefs. A majority of the contacts were the result of fin kicks (53%), followed by siltation (21%), sitting, standing or kneeling (16%), and touching (10%). No snorkelers were observed touching other organisms, picking up marine life, brushing up against the coral, or collecting.

We have found that the frequency of potentially damaging contacts to living corals is 0.03 contacts per snorkeler per 1 minute for our experimental group. Graph 1 compares the frequency of contacts between the control group and experimental group while graph 2 compares the contact rates between the control group and experimental group for specific behaviors.

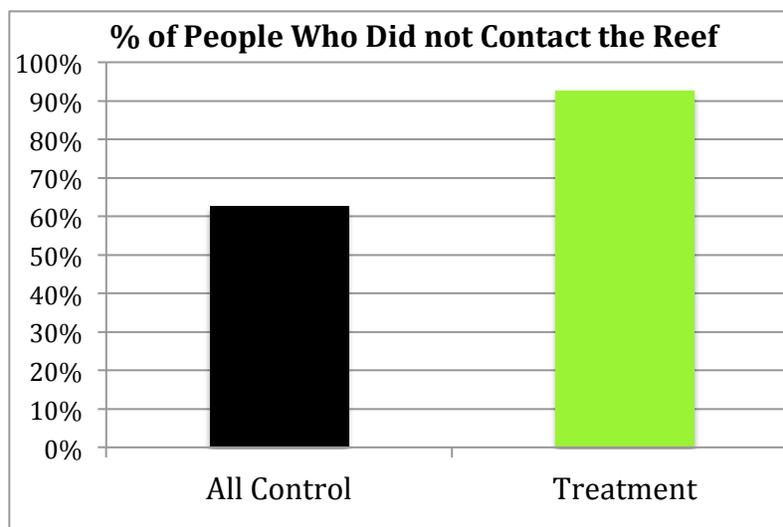
These findings show that a snorkeler who did not watch the video and sign the pledge had 6.5 times more contacts than a snorkeler who did watch the video or sign the pledge. In addition, the percentage of snorkelers who never touched the reef shot up from 64% to 93% (Graph 3).



Graph 1. This graph represents the frequency of contacts per minute in snorkelers who were a part of the control group compared to the experimental group.



Graph 2. Frequency of the different types of contacts we observed in snorkelers who were a part of the control group (did not watch the video or sign the pledge) compared to the experimental group (watched the video and signed the pledge).



Graph 3. The percentage of snorkelers who never touched the reef increased from 64% to 93%.

Snorkel Surveys

For the 131 snorkelers who completed surveys, we have in-water observational data for 41 of them. All of these were during the baseline data collection phase. These 41 individuals reported 39 contacts with the reef in 1850 reef-visit minutes, or an average of 0.15 per 7-minute period. Since we observed these people in the water, we can use their self-report data to compute the degree to which people under report their harmful behaviors. We calculated that the 41 snorkelers that were both surveyed and observed under reported their harmful behaviors by a factor of 7.1.

DIVER DATA ANALYSIS

During the baseline data collection phase, we made 121 observations of divers for a total of 592 minutes with 93% of these observations lasting for exactly five minutes. A total of 316 behaviors around the reef were recorded. The majority of contacts were from fin kicks (39%) following by siltations (21%), hand touches (13%), body brushes (11%), equipment contacts (11%), and touching organisms (3%). Only two divers (0.6%) were observed sitting or standing on coral while three divers (0.9%) actually picked something up from the reef. No divers were observed feeding or collecting marine life.

We have found that the frequency of potentially damaging contacts to living corals is 0.53 contacts per diver per 1 minute for our experimental group. To determine if pre-trip messaging can reduce the number of potentially harmful behaviors at the reefs, we collected data on divers who observed the video and signed the pledge. We made these observations from May of 2012 through January 2013. (We have plans to

continue to collect more data, even though this project has ended.) Our findings show that the frequency of divers who received the treatment (watched video and signed pledge) is 0.14 contacts per diver per 1 minute. These findings show that a diver who did not watch the video and sign the pledge had 3.7 times more contacts than a diver who did watch the video or sign the pledge.

Diver Surveys

Only 32 divers who completed surveys, but we have in-water observational data for 27 of these individuals. These 27 people reported 77 contacts with the reef in 1224 reef-visit minutes, or an average of 0.44 per 7 minute period. Table 5 summarizes these self-report data and the frequency of observed harmful behaviors among the same individuals. We can use these data to compute the degree to which people under report their harmful behaviors. We calculated that the 27 SCUBA divers that we both surveyed and observed under reported their harmful behaviors by a factor of 7.0

SIGNIFICANCE OF FINDINGS

In addition, to these quantitative findings, we have also observed and recorded qualitative information about our observations, the video and pledge.

We found that snorkelers in groups tended to do more damage, because they paused to take their heads out of the water and discuss what they are seeing. During this time, they were vertical in the water and their fins were often kicking the coral, or, worse, they were standing on it.

We have also learned that, for shore-based snorkelers, there is a need and a desire on their part to be more knowledgeable about the best way to enter and exit the water. At two beaches where we worked (Tres Palmas on Rincón and Tamarindo Grande on Culebra) there is only a small sand alley that allows safe access to the deep water. But people who do not know about it try to enter in much more vulnerable places. That's when they contact the reef.

Snorkelers also provided us with comments regarding the video and pledge:

“Thank you for showing me the video. This is my first time snorkeling and there were many things mentioned in the video that I did not know.”

“I live in Puerto Rico and this is the first time I have been told this information. I think this should be mandatory for every snorkeler visiting our reefs.”

We also overheard a female snorkeler getting ready to swim over the reef remind her

family to remember what they learned from the video.

Next Steps

The data reported here are the only known in-water observational data of snorkelers in Puerto Rico. In fact, there is scant data of this type available anywhere in the world. Although we have little understanding of the ecological significance of how these visitor contacts with the reef actually do damage, the number of possible contacts is large enough to warrant concern and consideration of this stressor to the coral reefs. Some of the reefs where tourists frequent are significantly degraded, further allaying suspicion on visitor behavior.

This research points to specific and practical things that we can do right now to reduce impacts from reef visitors, while still supporting valuable ecotourism operations and the human communities that depend on them. We found that we can reduce harmful behavior and that action strategies to create effective messaging are warranted. Tour companies can use pre-trip messaging to dramatically reduce the impacts of tourists to reefs. These findings are also relevant for the following policies:

- Local Action Strategies
- Concessionaire Licensing Process
- Boat Mooring Buoy Locations
- Individual Business Owners
- Marine Reserve Management

Finally, we are aware that a focus on visitor behavior is not an excuse to avoid working on other threats. Coral reefs are incredibly beautiful and valuable ecosystems that must be saved. Hopefully this research inspires others to work to protect these living resources.



Photo 6. Graphic at Luis Muñoz Marín International Airport in San Juan, Puerto Rico.