Assessing socioeconomic impacts of climate change on Puerto Rico's coral reef fisheries through a participatory approach

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Introduction

The primary objective of this research is to generate knowledge about important aspects of the socioeconomic impacts of climate change on individuals, households, and communities engaged in various types of fishing activities in and around coral reef areas in Puerto Rico. Climate change and other anthropogenic impacts have greatly affected corals and organisms dependent on these ecosystems in the Caribbean region. These impacts have indirect and direct consequences for people whose livelihoods, nutrition, and overall well-being depend upon the health of these marine resources. This research aimed at assessing the perceptions of different stakeholders, but primarily fishers, about climate change and other anthropogenic impacts affecting the fisheries in Puerto Rico from a socioeconomic perspective. Understanding the perceptions of different stakeholders including natural resource users is crucial for the development of effective strategies for resource sustainability and human adaptation to climate change and other stressors. Policy strategies that are designed to account for and include stakeholder perceptions are more likely to be met with acceptance and compliance. Further, assessing the perceptions of different stakeholders involved in different aspects within the fishery sector allows for the analysis of convergent and divergent viewpoints which can be used to guide policy strategies to focus on areas of agreement and work on areas of discrepancy.

Originally, this project was focused exclusively on achieving the above described objectives. However, the research design was revisited and slightly modified to accommodate for unforeseen events. During the final six months of the original project timeline, hurricanes Irma and, particularly, Maria caused significant damage and severely disrupted the lives of all people in Puerto Rico. As a result, we decided to extend the project timeline and conduct a second data collection effort approximately eight months after Maria made landfall to assess impacts of the hurricane on fisheries and to collect data that allowed us to compare fishers' perceptions of aspects of climate change vulnerability before and after this major natural disaster. This second data collection effort allowed for the unique opportunity to further investigate how natural disasters shape resource users' perceptions and experiences, and affect aspects of their vulnerability to environmental change including climate change. Findings of this second data collection effort provide additional valuable knowledge to help the development of policy strategies aimed at increasing and maximizing the resilience of coastal communities to natural disasters particularly under climate change scenarios in which storms, hurricanes, and sea level rise compound environmental stresses caused by other anthropogenic impacts.

This report includes all major findings of this project and is organized into four sections which follow this introduction. The first section includes the analyses of data collected as part of the original effort before hurricanes Irma and Maria hit Puerto Rico. The second section provides a comparison of the pre- and post-hurricanes assessment of fishers' perceptions of climate change as well as an assessment of impacts of the storms on fishers' fishing activities. The third section describes the outreach components of the project which includes an innovative participatory method of field testing an animated video portraying the major findings of part one. Finally, the fourth section of this report includes our policy recommendations based on the major findings of this research.

Background

Anthropogenic activities have been threatening marine ecosystems and resources worldwide at an increasing rate. In the Caribbean region, economic development and population growth have generally occurred without effective policies to safeguard the sustainability of natural resources, resulting in rapid degradation of coastal waters and critical ecosystems (Valdéz-Pizzini et al. 2012). These ecosystem changes have serious consequences of both ecological and socioeconomic nature, reducing biodiversity, revenues, and the resilience of fishers, their families and communities. Marine fisheries in the Caribbean are also increasingly vulnerable to the impacts of climate change, including warmer sea temperatures, coral bleaching, and more frequent and intense storms, affecting fish and shellfish species of economic and cultural significance, as well fishing infrastructure. Understanding aspects of fisheries and fishers' vulnerability to change and exploring new strategies to address future challenges in fisheries policy is crucial to maximize coastal communities' resilience and adaptation to change, particularly under future climate change scenarios.

Coral Reef Ecosystems

Coral reefs in the Caribbean have been declining for at least the last forty years. Today, 75 percent of the coral reef ecosystems in this region are under medium to highly threatened status (Appledoorn et al. 2009, Burke et al. 2011). Puerto Rico's coastline includes over 5,000 kilometers squared of coral reef ecosystems that are accessible to the public (NOAA 2018). These reefs have been affected by a variety of both global and local stressors. Specific local stressors include land based pollution and runoff, coastal development, overfishing, population increases along the coast, vessel groundings, recreational overuse, coral diseases, bleaching due to increasing sea temperatures, and invasive species. More than 50 percent of the living coral in Puerto Rico has been lost and the rate of loss continues to increase (Morelock et al. 2001).

The degradation of coral reefs and the decline in fishery resources that live in and depend upon these ecosystems have serious consequences of both ecological and socioeconomic nature. Ecological effects include threats to biodiversity, loss of coral reef resilience, degradation of the reef habitat, and disruption of ecological balance (Hoegh-Guldberg et al. 2007, Hughes et al. 2003; 2007, Baker et al. 2004, Mumby et al. 2007). Socioeconomic impacts include negative effects on revenue such as decreases in the total catch and lower catch per unit effort, and also reduced food security, changes in livelihood opportunities, as well as loss of other important ecosystem services provided by coral reefs (Moberg and Folke 1999, Mumby et al. 2014).

Furthermore, the decline of coral reef fisheries can have important social and psychological consequences to many individuals, households, and communities. Extensive research shows that fishers demonstrate a strong attachment to the fishing occupation (Binkley 1995, Pollnac et al. 2008; 2015, Marshall et al. 2007) and, consequently, high levels of job satisfaction and well-being (Pollnac and Poggie 1988, Smith and Clay 2010, Seara et al. 2017a; 2017b). Certain aspects of the occupation of fishing such as "adventure" and "being outdoors," coupled with familial and cultural traditions are important factors influencing fishers to enter and remain in their occupation even when income has declined or become more uncertain (Crawford 2002, Pollnac et al. 2001). Griffith and Valdés-Pizzini (2002) described that Puerto Rican fishers consider fishing as "therapy." Many Puerto Rican fishers who work on land jobs (e.g. farming) during the fishery off seasons, return to the sea, to what they describe as a healthy activity that keeps their minds occupied on useful things and that provide relief from stress (Griffith and Valdés-Pizzini 2002). These sociocultural aspects of the fishing occupation provide further evidence of the complexity of the relationships governing coupled human and natural systems and emphasize the importance of understanding and considering social, economic, and cultural factors in managing and conserving coral reef fishery resources.

Puerto Rico Fisheries

Fishing activities in Puerto Rico are predominantly dependent on nearshore coral reef systems (Appeldoorn 2008) and adjacent ecosystems such as seagrass beds and mangrove forests. Fishers can be found using a variety of gear types along the coasts of Puerto Rico as well as the smaller islands located off the eastern and western coasts (Matos-Caraballo and Agar 2011). Puerto Rico fisheries are organized around fishery centers or associations, "*villas pesqueras*," or along fishing villages and population centers. The fisheries often consist of an owner and operators who use small vessels with limited horsepower. Catches consist of low quantities of a variety of species (Griffith and Valdés-Pizzini 2002) including snappers (Lutjanidae), groupers (Serranidae), and a variety of crustaceans and mollusks that are sold to the *villas pesqueras* and private fish markets (*pescaderias*), or more informally from fishers' houses or directly to buyers or restaurants.

According to Garcia-Quijano (2009) the Puerto Rican small-scale fisheries socioeconomic context can be typified by "heterogeneity and unpredictability of opportunities for employment and for covering the basic needs of subsistence" (2009: 12). According to the latest census of Puerto Rican fishers, approximately 900 individuals engage in the activity throughout the island (Matos-Caraballo and Agar 2011). There is indication, however, that the actual number is higher, ranging between 1,500 and 2,000 as suggested by qualitative data, since many fishers on the island are not fully licensed (Tonioli and Agar 2009). The licensing system in Puerto Rico requires that fishers provide proof of income deriving from fishing in the form of tax documentation in order to be considered eligible for either part- or full-time commercial fishing licenses (Matos-Caraballo 2009). As mentioned above, the fishery sector in Puerto Rico has been historically characterized by occupational multiplicity (Garcia-Quijano 2009, Garcia-Quijano et al. 2015, Griffith and Valdés-Pizzini 2002) which may be in conflict with the current licensing system, therefore unintentionally creating an incentive for unlicensed and, thus, under-or unreported fishing activity.

Puerto Rican fishers typically engage in multiple gear activities including nets, traps, hook and line, and harpoon. In recent years, the percentage of fishers practicing SCUBA diving has increased considerably: from approximately 35% in the mid-90s to between 40 and 50% in 2008 (Matos-Caraballo and Agar 2011). According to Matos-Caraballo and Agar (2011) this reflects a necessity for fishers to become more specialized as a result of declines in coastal catches. Down trends in commercial fish landings in Puerto Rico have been reported since the 1970s (Matos-Caraballo 2009) with an alarming decline of approximately 69% occurring between 1970 and 1990 (Appeldoorn et al. 1992). The species predominantly targeted by SCUBA divers are spiny lobster (*Panulirus argus*) and queen conch (*Strombus gigas*).

Puerto Rico Fisheries Management

Some of the unique characteristics of Puerto Rico coral reef fisheries, such as strong habitat dependence, susceptibility to coastal impacts, diffuse landings sites, intense multispecies and multigear interaction, along with socioeconomic and cultural factors, can pose significant challenges to local conservation and management (Appeldoorn 2008). Puerto Rico state water fisheries are managed by the Puerto Rico Department of Environmental Resources (DNER). Beyond the commonwealth's claimed nine nautical miles, the fisheries are regulated by the NOAA Caribbean Fisheries Management Council (CFMC). Both agencies establish compatible regulations to address fishery conservation goals. The DNER estimates that approximately 70% of all fishing activities occur within their jurisdiction (Matos-Caraballo 2009). In 2004, the DNER passed Regulation 6768, known as Puerto Rico Fisheries Regulations (PRFR). Although the process for implementation of the new code included public hearings and allowed for stakeholder recommendations, the new rules were received with animosity by the majority of fishers (Matos-Caraballo 2009). Puerto Rico fishers thought the rules restrained them from making a living from fishing and focused excessively on overfishing while undervaluing other impacts on mortality such as pollution and habitat degradation (Garcia-Quijano 2009). Conflicts between Puerto Rican fishers and management agencies led to hundreds of fishers ceasing to report their landings statistics and refusing to participate in catch monitoring programs (Matos-Caraballo and Agar 2011). Such resistance practices are common methods for protesting regulations that are seen as unfit and unfair (Garcia-Quijano 2009). Fisheries management is ultimately a trade-off between maximizing yields and achieving social, economic, and cultural goals. Government based management strategies that fail to consider social and community needs, beliefs, and norms of stewardship may result in further conflict, non-compliance, and an increase in illegal practices (Valdéz-Pizzini et al. 2012, Hernández-Delgado 2014). There is strong evidence to support the need for participatory approaches that involve and empower stakeholders (as opposed to *consult*) and take into account local ecological knowledge (LEK) (see Apeldoorn 2008, Garcia-Quijano 2009, Hernández-Delgado 2014). Management strategies that address multiple stressors in a participatory manner convey a sense of fairness to impacted parties, and decisions that are perceived to be fair are more widely accepted by the impacted public (NOEP 2014).

In a census of Puerto Rican fishers conducted in 2008, the majority of participants shared the opinion that the island's fishery resources were worse off then, when compared to "other years" (Matos-Caraballo and Agar 2011). Among the most important reasons cited by Puerto Rican fishers as the cause for declining fish stocks were overfishing, pollution, habitat degradation, regulations, weather and ocean conditions, and climate change. Research conducted on the causes of reef-estuarine ecosystems degradation support the Puerto Rico fishers' opinions that other factors along with overfishing significantly contribute to fish mortality (Mora 2008, Mumby et al*.* 2004, Nellemann et al. 2008).

Climate Change and Coral Reef Fisheries

While it is possible to develop strategies to effectively manage resource use on a local scale, such task becomes more difficult when compounded by multiple stressors, specifically large-scale global threats. Examples of such threats to coral reefs include warmer ocean temperatures and changes in the chemistry of ocean water (Doney 2006). There is a direct correlation between increased greenhouse gases, climate change, and regional-scale bleaching of corals (Hughes et al. 2003, Hoegh-Guldberg 1999). Moreover, changes in ocean chemistry (acidification) due to increased concentrations of carbon dioxide in the atmosphere contribute to the weakening of coral skeletons and may cause death of coral organisms (Doney 2006, Kleypas et al. 1999). Climatic changes can also result in an increase in the frequency and intensity of severe weather events such as storms and hurricanes, which can cause wave damage to corals and increase stress from terrestrial run-off (Heron et al. 2008). Coral bleaching and diseases associated with climate related stressors have already increased greatly in frequency and magnitude over the past 30 years (Glyn 1993, Wilkinson and Souter 2008, Baker et al. 2008, Baker 2014).

Climate change is also considered a major aspect affecting the well-being of coastal communities worldwide (Karl et al. 2009, Melillo et al. 2014). Specifically in fishing resource dependent communities, direct and indirect impacts of climatic changes on commercially important species affect the ability of fishers to harvest them (Sumaila et al. 2011, Pinsky and Mantua 2014, McCay et al. 2011) resulting in declining landings and revenue.

Declines in revenue will not only impact fishers and their families but also local coastal economies at large. Effects of climate change may also influence changes in fishery management (e.g. reduced quotas), compounding the pressures associated with resource scarcity and further affecting fishing communities' socio-economic well-being.

Environmental transformations associated with climate change and specifically the potential impacts of indirect effects (e.g. ocean acidification) on range and productivity of commercially important species require that fishers adopt strategies to respond adaptively. Adaptive responses may include *within-fishing* adaptations, e.g. finding new fishing grounds and exploiting different species, or *outside-fishing* adaptations, i.e. finding alternative income or employment (Pinsky and Mantua 2014, McCay et al. 2011). As described above, a great deal of research suggests that fishers are reluctant to leave the occupation of fishing even under economic hardship due to a combination of socio-cultural and psychological factors (Smith and Clay 2010, Pollnac et al. 2015, Seara et al. 2017a; 2017b). Therefore, seeking alternative employment as a strategy is unlikely and of particular concern for individual, familial, and community well-being (Pollnac and Poggie 2008, Pollnac et al. 2015). Specifically in Puerto Rico, evidence of the significance of fisheries to cultural, psychological, and basic subsistence aspects (Valdéz-Pizzini et al. 2002, Garcia-Quijano 2009, Valdéz-Pizzini et al. 2012, Garcia-Quijano et al. 2015) further exacerbates the challenges associated with fishers' adaptation under climate change.

An extensive assessment of socioeconomic vulnerability to climate change is necessary for understanding long-term scenarios of socioeconomic futures of reef dependent communities engaged in fishing activities in Puerto Rico. Fishing in and around coral reef systems has traditionally had significant economic as well as social and cultural importance while also representing a crucial source of subsistence to many Puerto Rican individuals, households, and communities. The goal of this study is to inform management decisions tightly linked to ecosystem goods and services to address climate change and other important pressures on coral reef fishing systems, while focusing on supporting community resilience at a local scale. This research also focused on the development of a participatory approach, both within the context of the study and more broadly through exploring strategies to further involve stakeholders, particularly fishers, in future decision making and to better communicate research findings to fishers and communities at large. These are necessary steps to maximize acceptance and success of recommended fisheries and climate change policy strategies into the future.

Part I: Assessing Socioeconomic Impacts of Climate Change on Puerto Rico Coral Reef Fisheries

This section of the report includes major findings of the first data collection effort that took place between July 2016 and January 2017. This data collection effort included key informant interviews with different fisheries stakeholders and surveys with fishers in different coastal communities around Puerto Rico. The key informant interviews were used to obtain information that helped the development of the survey questionnaire and also allowed for the collection of important data on perceptions of different stakeholders about critical issues affecting the fisheries in Puerto Rico and an analysis of aspects of convergence and divergence of viewpoints among these different stakeholders. Surveys with fishers were conducted to further investigate aspects of fishers' dependence on the occupation, their well-being and job satisfaction, perceptions on climate change and other anthropogenic impacts on fisheries, and their views on aspects of fisheries governance. This section of the report provides a characterization of the fisheries in Puerto Rico through the analyses of data collected with fishers' surveys and key informant interviews, and it investigates the perceptions of fishers in Puerto Rico communities toward environmental and climate change as well as factors potentially influencing these perceptions and their ability to adapt.

Methods of Data Collection and Sampling

Key Informant Interviews

Key informant interviews were conducted with 20 people involved in different aspects of the fisheries sector in Puerto Rico. Seven interviews were conducted with government officials involved in various aspects of fisheries management of which two were affiliated with the Caribbean Fisheries Management Council (CFMC) and five with the Department of Natural and Environmental Resources (DNER). Six interviews were conducted with people directly involved in the fisheries sector, five of which were experienced fishers including two presidents of fishing associations (*villas pesqueras*), and one was the owner of a major fish market (*pescaderia*). Three key informants were scholars directly involved in research to inform fisheries management decisions in Puerto Rico, three were affiliated with NGOs working directly with the fisheries sector, and one key informant was the head of an institute with indirect ties to the local fishing industry ("other"). Interviews were conducted face-to-face with all informants directly involved in the fishery sector, one of the scholars, one of the NGO members, and with the key informant in the "other" category. Two interviews were conducted over the phone with one of the scholars and one of the government officials. The remaining interviews were self-administered and submitted via email. Although the preferred method for these interviews was face-to-face or over the phone, time constraints created a challenge for many of the key informants, and in order to maximize the total sample, particularly from government officials, the self-administered option was utilized. The sampling method used was a mix of convenience (mostly for the fishery sector) and chain referral sampling starting with our previously established network. The key informant questionnaire included questions on aspects of fisheries dependence, major issues facing the Puerto Rico fisheries sector, opinions on perceptions and impacts of climate change, as well as aspects of fisheries governance. The full questionnaire in both English and Spanish versions can be seen in Appendix 1.

Surveys

A total of 212 fishers were surveyed in ten different municipalities representing the East, Northeast, Southeast, and Southwest regions of Puerto Rico (Figure 1 and Table 1). An intercept sampling method was used, which consisted of approaching fishers at different fishing associations (*villas pesqueras*) and other locations where they were known to land their catches or congregate. This sampling technique was considered the most effective to maximize sampling of the studied universe since no comprehensive list or directory of Puerto Rican fishers is readily available from which to draw a random sample. The questionnaires included questions on demographics, work and fishery attributes, well-being and job satisfaction, perceptions of the status of fishery resources and the environment, perceptions of climate change, and views on aspects of governance and participation in fisheries management. Questions used a combination of dichotomous, Likert scale, and open ended methods to collect data that could be analyzed quantitatively while allowing respondents to elaborate on their views and experiences to aid in interpretation of results. The full survey questionnaire in both English and Spanish versions can be seen in Appendix 2.

Figure 1.Map of Puerto Rico showing municipalities included in the first data collection effort (Adapted from USDA 2012).

Table 1. Survey sample size by region and communities visited by region during the first data collection effort.

Region & Municipalities	**N**
East Coast (Naguabo, Fajardo, Ceiba, Vieques, Culebra)	54
Southeast Coast (Patillas, Guayama)	28
Northeast Coast (San Juan, Cataño)	42
Southwest Coast (Cabo Rojo)	88
Total	**212**

Analyses

Key Informant Interviews with Fishery Stakeholders

Aspects of coastal communities' and fishers' dependence on fisheries were explored during the key informant interviews. Opinions regarding levels of dependence on fishery resources among key informants differed considerably even within the same stakeholder groups. Many key informants stated that dependence is place specific with some communities depending more than others (e.g. Cabo Rojo and Vieques). Informants also pointed out that many coastal communities depend heavily on tourism and, thus, indirectly on fish and shellfish to attend demand for the product by restaurants or recreational fishing tourists. However, another point brought up during the interviews is that the contribution of imported seafood in the Puerto Rican market has increased considerably in the past few years:

> “[M]ore than 90% of our seafood is imported and local fishers have to depend on second jobs to be able to generate additional income to survive. This is in part due to habitat destruction, limited resources, legal and political barriers to the development of a fishing industry with agreements with other countries” (Government).

> “[Coastal communities’] dependency on fisheries is based on how you gage it. Landings and value are not great; in fact, a vast majority of fish are imported. Fisheries are recreationally important to the economy and support the tourism culture. This is important to the communities who depend on tourism” (Research).

One key informant affiliated with the fishing industry expressed concern about the contribution of imported seafood and aspects of government support for the local fisheries:

> “Many fishers retired from fishing and went into other occupations because of the fishing regulations and because the government wants to get rid of the fishers because they prefer the fishery from ‘outside’” (Fishery).

Different key informants across stakeholder groups stated that in general the majority of fishers have other jobs and sources of income and that they rarely depend solely on fishing for their livelihoods. Key informants affiliated with the fishing industry explained that the number of full time fishers has declined considerably in the past few years and that, due to seasonality and market prices, many fishers complement their income with other activities. Some key informants also expressed concern over the decline in fish stocks:

> “In Puerto Rico there is a lot of variety of fish but not quantity and the stocks have been declining in the last 15 years or so. Many fishers in Puerto Rico do not sell or make money out of the fish they catch but rather they fish to eat” (Fishery).

Key informants who believe fishers depend heavily upon fishery resources mentioned lack of alternative employment opportunities and some expressed regard for aspects other than income by mentioning social and cultural components of one’s livelihood such as family ties:

> “There are not too many options for employment on the island [Vieques] and therefore [fishers] depend on the fishery to make a living. They go out everyday fishing.” (Fishery)

> “Most [fishers] fish for a living. This is their full time job. Some don’t know any other job or vocation other than fishing, which many times is a family trade” (Government).

> “Most coastal communities in Puerto Rico still depend of the fisheries industry for self-sustenance or market to local restaurants or shops. Some continuing family traditions, others with no work opportunities or experience” (NGO).

> “Fishers that live in [coastal] communities are very dependent on fishing. A lot of them dedicate only to fishing either because they learned fishing with their parents and inherited the business or because they do not have formal education and have less chances of getting other types of jobs” (NGO).

Overall, perceptions on coastal communities’ and fishers’ dependency on fishery resources differed considerably among individuals and even within the different stakeholder groups. Data to more objectively measure dependence of Puerto Rico coastal communities on fishery resources is needed as one government affiliated key informant explained:

> “There is very little data on fishermen’s dependency on fish resources and we need good objective studies that will provide solid information on this” (Government).

In general, key informants agreed with regard to coastal communities' and fishers' dependence on coral reef ecosystems for their livelihood. Interviewees mentioned the importance of corals to the health of the species fishers depend upon either directly or indirectly:

> "Fisheries in Puerto Rico are mostly coral reef based (although some pelagic species and deep water snappers also are important) so fishers depend on their health to have a steady source of income" (NGO).
>
> "Coastal communities have both tourism and fisheries which both depend on the reefs for livelihood. There is a good deal of overlap between both. Communities seem to be more dependent on the coral reefs than on fisheries" (Researcher).
>
> "Most of the fish here concentrate around the coral: yellowtail snapper, mutton snapper, and grouper" (Fishery).

Key informants involved in the fishery industry also mentioned the higher value of reef and reef dependent species:

> "The reef species are the ones with a better market – they are the ones we can sell" (Fishery).
>
> "Lobster is the number one species that sell in Vieques (conch is also important) and the lobsters live in the reefs" (Fishery).

Aspects of coral reef degradation were also mentioned by key informants. One government affiliated interviewee mentioned the fact that fishers are concerned about pollution and, in another interview, a fisher mentioned their concern for the effects of pollution on corals and the fishery, specifically with regard to pollution from tourism activities:

> "Coral reef health is vital to the health of the fisheries and coral reef degradation due to contamination is the number 1 complaint of fishers" (Government).
>
> "The most important fish we catch are reef species and many of the coral reefs are damaged because of pollution. [Pollution] from [a] nearby resort goes into the water directly and it affects and kills the corals. There are many beautiful reefs but many of them are in bad shape" (Fishery).

One key informant mentioned changes in the local fishery in Puerto Rico that has affected the relationship between fishers and the coral reef habitats:

> "Our fishing efforts have changed from traps deployed at coral reefs to deep ocean fishing and SCUBA. Fishers depend indirectly on coral reefs as habitat for some species but fishing has dramatically changed from what it used to be" (Researcher).

Key informants' views regarding major issues facing Puerto Rican fisheries and challenges affecting the fisheries that they attribute to climate change are summarized in Figure 2. Circles representing different topics mentioned during interviews are spatially organized and colored to illustrate issues that represent convergence and divergence or perceptions between different stakeholder groups[1] (represented by black squares). Issues currently affecting the fisheries mentioned by all four stakeholder groups (pink circles) include: challenges related to lack of enforcement and compliance of fishery regulations, lack of participation from fishers in decision-making, poor relationship and communication between fishers and other stakeholders including government agencies, climate change, coral bleaching and coral damage, and algal blooms. Other important issues which were mentioned by multiple stakeholders including those directly involved in the fishery sector were: lack of concern by fishers with regard to fish stock conservation, fisheries management decisions that are not effective, lack of funding for efforts to deal with fisheries and fisheries management, changes in the

[1] The "other" category containing one key informant was excluded from this analysis.

behavior of fish, more storms, pollution, and warmer water temperatures. Issues common to all other stakeholders except the fishery sector were overfishing, erosion, and lack of or low quality data to make decisions. Issues raised by the fishery sector alone were poor water visibility, change in water color, and statements that say climate change is not a problem or that no changes in climate have been observed. Government and fishery stakeholders were the only two groups to mention that the fishery licensing system in Puerto Rico is a problem currently affecting the fishery (Figure 2).

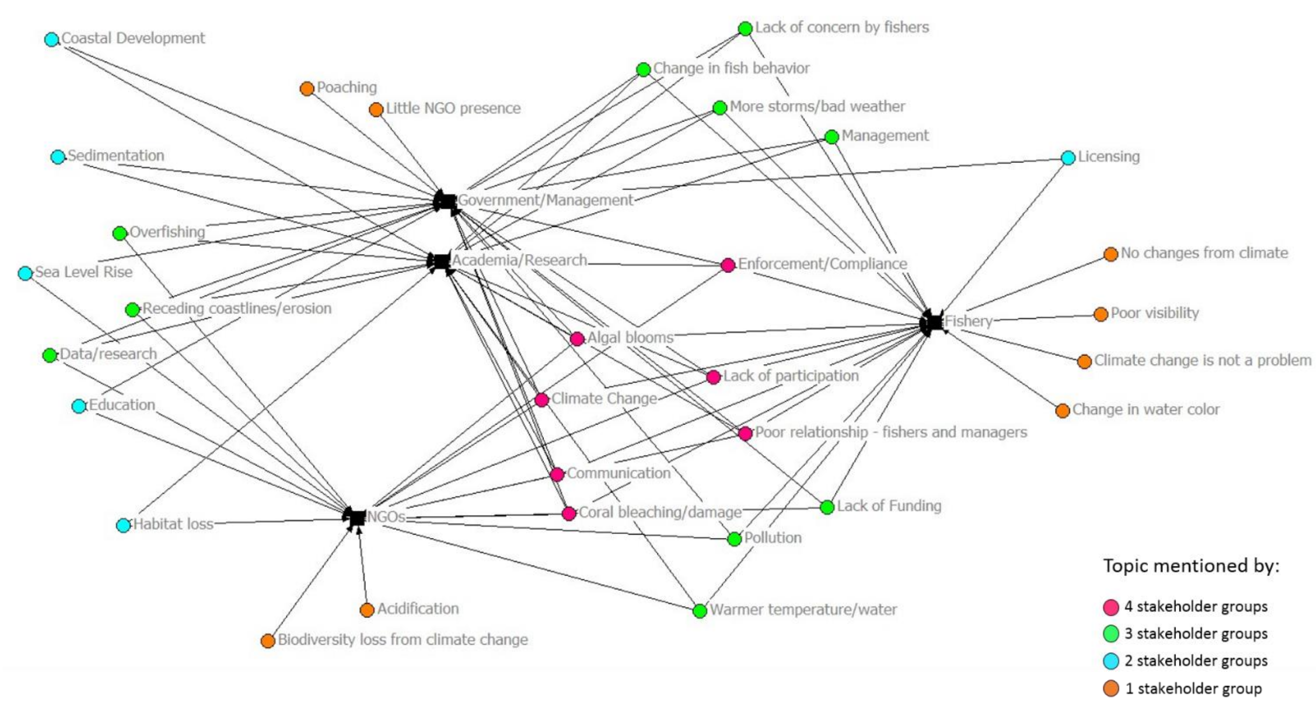

Figure 2. Diagram representing divergence and convergence of opinions between different stakeholder groups regarding issues facing Puerto Rican fisheries and challenges affecting the fisheries that interviewees attribute to climate change.

Although the majority of key informants stated that, in their opinion, fishers are in general concerned about changes in the marine environment that are associated with impacts of climate change, opinions differed with regard to their understanding of the links between changes observed and climate change as the main cause:

> "The fishers are noticing changes but they may not be able to link it to climate change. Fishers lack the knowledge to connect it to climate change. For example, they are aware the water is warmer but use myths to explain why events, like warming, are happening. They see changes in weather patterns. Often, they cannot go out due to weather conditions. Fishers are having to take greater risks" (Researcher).

> "[Fishers] are observing the changes but they do not know why" (Fishery).

Some key informants stated that, although fishers perceive changes related to climate change, this issue is not a priority for them as they are generally more concerned about fishery regulations:

> "Some [fishers] feel times of spawning aggregations are changing. There have been some changes to queen conch regulations associated with changes on spawning behavior – changes that were perceived by the fishers. In general

> I do not get any word from fishers directly regarding concerns about climate change. They are more concerned about the regulations" (Government).

> "Some of them know that climate change impacts the health of the fisheries but the majority of them do not see the correlation. They seem to be more worried about existent regulations that limit them from harvesting fish especially during spawning periods" (NGO).

> "[Climate change is] not a priority [for fishers]. The[ir] priority is catching more fish and not getting regulated" (NGO).

> "I haven't seen many fishers at meetings, symposia, or fora regarding climate change. Nor have I heard them bringing the topic at meetings" (Government).

On the other hand, some key informants mentioned the strong connection fishers have to the marine environment to explain that they are not only aware of the changes but they understand they are occurring due to climate change:

> "Puerto Rican fishers recognize and are concerned about climate change since they are out on the sea every day and are experiencing the changes in temperature, currents, resource degradation and its effects on fisheries" (Researcher).

> "[Fishers] are worried. They see the changes because they go into the water. They talk about changes like the presence of more algae or ones that didn't exist here before" (Fishery).

Key informant opinions differed with regard to aspects of fishers' collaborations within the community as well as with government and decision-makers. Some interviewees affiliated with the government, NGOs, and researchers had a strong opinion that, generally, fishers do not wish to collaborate:

> "Fishers are individualists. If there is a crisis they come together to get the government to fix it and give them more money. Otherwise it is hard to get fishers together" (NGO).

> "Good luck! Fishers are lone wolves and they are infamous for not working together. They are keen on their independence, being their own boss, working alone is one of the reasons they get into the occupation to begin with" (Government).

> "It has been my experience that [fishers] don't unite. Many are just trying to protect their own interest" (Government).

Other key informants acknowledged the importance of fishery industry leadership in the decision making process:

> "When backed by a strong community leader they can and do work together to solve problems. The fishery is their livelihood and they are very well aware of what is at stake" (Government).

> "There are leaders among fishers that could be very important resources dealing with fishery problems and the reduction of its impacts" (Researcher).

On the other hand, key informants in the fishery sector perceive fishers as keen to collaborate amongst themselves and with the government but they do not perceive decision-makers to be facilitating collaborations:

> "It is very difficult and frustrating to work with the government. They open one door and close another" (Fishery).

> "The coop fishers work together to create proposals to help better develop the fishery but the government does not listen to them" (Fishery).

> "The government is always against the fishers. We could work together if the government is willing to reach an agreement with the fishers" (Fishery).

Those in the fishery sector also mentioned lack of assistance and support from the government:

> "Fishers try to talk to the government but they don't trust them. They make promises but do nothing. We pay fees to use the locker rooms, we pay water and electricity and we don't get any help from the government" (Fishery).
>
> "The money comes in but if you don't go directly to them you won't see anything. Now there is no more money for boats, tools, no more help, no more funds" (Fishery).
>
> "Farmers get a great deal of assistance from the government (subsidies, aid to buy equipment) but the fishers do not get any assistance and, in fact, the government poses a number of different obstacles to the development of the fishery in Puerto Rico"(Fishery).

Fishery industry stakeholders also mention the lack of accessibility to and distance of decision-makers as being an impediment to collaboration and a better relationship between fishers and those involved in fisheries management:

> "They make decisions sitting on a chair in their air-conditioned offices. They don't know about the problems. They don't talk to the fishers. When they do, the rules are already made" (Fishery).
>
> "No good communication [between fishers and government]. We have to go there one by one to get information, they don't come here. They are fair to us when we go there, but *we* need to go *there*" (Fishery).

The importance of enabling more collaboration between fishers and decision-makers was brought up by some key informants:

> "There is a wealth of knowledge and information in local ecological knowledge that can be brought to the table by fishers. In turn, there is a lot that fishers can learn from scientists. Combining these two areas of expertise, managers can be given the tools to develop functional, effective and locally targeted management plans. I strongly believe that the only way fishery problems can be solved is by government and fishers working together" (Government).

One NGO key informant expressed concern for impediments to collaboration including issues raised by key informants in the fishery sector:

> "Fishers can and should be more involved in decision making processes regarding fisheries management. However, sometimes it is difficult for fishers to participate as the process becomes too bureaucratic; the way information is conveyed to them is too complex or it gets to them too late in the process and they cannot effectively participate in solving fishery problems. Other times the fishers do not want to participate as they don't trust the authorities in charge of management" (NGO).

Words used by key informants to describe the relationship between fishers and the government agencies involved in decision making in the fishery sector include distant, skeptical, strained, polite, harsh, hostile, complicated, untrustworthy, unreliable, politicized, and unbalanced. Key informants explained that there is lack of communication and understanding between the two parties:

> "Fishers distrust fishery managers/decision makers. They feel like any action managers make is to prevent them from fishing and hence leave them without jobs. They don't understand or don't want to understand that regulations need to be in place in order to have a sustainable fishery in the future. While managers don't put much effort on informing, educating and engaging fishers on the issues being discussed" (NGO).

Key informants expressed their opinion on whether or not they perceived the fishery management process in Puerto Rico to be fair. While many had mixed opinions most in the fishery sector perceived decisions as unfair:

> "So many laws against fishing. Now to fish for different species you need to pay for licenses. It's the law, you can't catch them. They don't give you warnings, like tickets, they fine, they want to wash you away" (Fishery).

> "They are not fair because the fishers are not involved in the decisions" (Fishery).

Other key informants expressed different opinions:

> "The goal is to restore fish populations and in order to do that we can't afford to focus on fishers' incomes. We have to reduce effort" (Government).

> "It cannot be fair. The system is designed to either cut fishers or cut fish" (Research).

One key informant reflected on the impacts that distrust and conflict between fishers and managers can have on the fishery management process:

> "I think one of the biggest problems in fisheries is precisely that conflicts between fishers and managers are not effectively resolved which turns into distrust from the fishers towards the system and in a lot of cases they violate the regulations" (NGO).

Views of key informants on strategies to improve the relationship and resolve conflict between fishers and government and other parties involved in fisheries management in Puerto Rico can be categorized as strategies to improve communication. As summarized by one key informant:

> "When the fishers know the fishery managers directly and can discuss reasons why the policies or decisions are made is when I see less conflicts and disputes with these two groups" (NGO).

Surveys with Fishers

Characteristics of the Sample

The average age of the fishers surveyed was 50.5 years and the average education level measured in years of formal education was 9 years. The majority of fishers (72%, N=152) were married and had an average household size of 3. Fishers had on average 36 years of fishing experience (Table 2).

Table 2. Descriptive statistics of demographic variables.

Variable	N	Min	Max	Mean	St. Dev.
Age	212	18	88	50.46	13.962
Education	210*	0	18	9.13	3.721
Household size	212	1	7	3.01	1.372
Fishing experience	212	2	80	35.92	16.067

*Different sample size due to missing data

Table 3 displays descriptive statistics for demographic variables by region. Statistically significant differences were observed for comparisons between the different regions for all demographic variables except for fishing experience (Table 4).

Table 3. Descriptive statistics of demographic variables by region.

Region	Variable	N	Minimum	Maximum	Mean	St. Dev.
East Coast	Age	54	23	79	52.43	14.766
	Education	54	0	18	8.70	4.133
	Household size	54	1	7	2.78	1.462
	Fishing Experience	54	4	72	36.67	18.306
Southeast Coast	Age	28	18	74	48.96	15.695
	Education	28	6.00	16.00	8.5000	3.71683
	Household size	28	1	5	2.43	1.230
	Fishing Experience	28	7	64	34.21	15.885
Northeast Coast	Age	42	21	88	54.76	13.709
	Education	40	6.00	18.00	11.7000	3.18812
	Household size	42	1	6	2.79	1.298
	Fishing Experience	42	7	80	40.38	16.645
Southwest Coast	Age	88	23	74	47.67	12.451
	Education	88	0.00	14.00	8.4318	3.20128
	Household size	88	1	6	3.45	1.277
	Fishing Experience	88	2	62	33.88	14.069

Table 4. ANOVA comparing demographic variables between regions.

Variable	Sum of Squares	df	Mean Square	F	p
Age	1733.388	3	577.796	3.050	.030
Education	328.016	3	109.339	8.777	.000
Household size	31.877	3	10.626	6.054	.001
Fishing experience	1315.393	3	438.464	1.716	.165

Post-hoc analyses show that age was statistically significantly different only between the Northeast and the Southwest coasts with the former presenting a higher average age (54.8) than the later (47.7) (Figure 3).

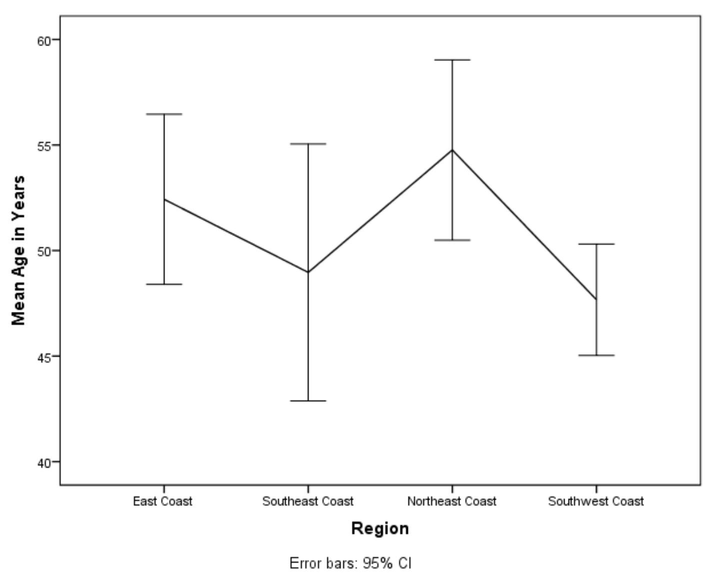

Figure 3. Regional comparison of fishers' average age in years.

The Northeast coast had a statistically significantly higher average of years of formal education (11.7) when compared to all other regions studied (East: 8.7, Southeast: 8.5, Southwest: 8.4) (Figure 4).

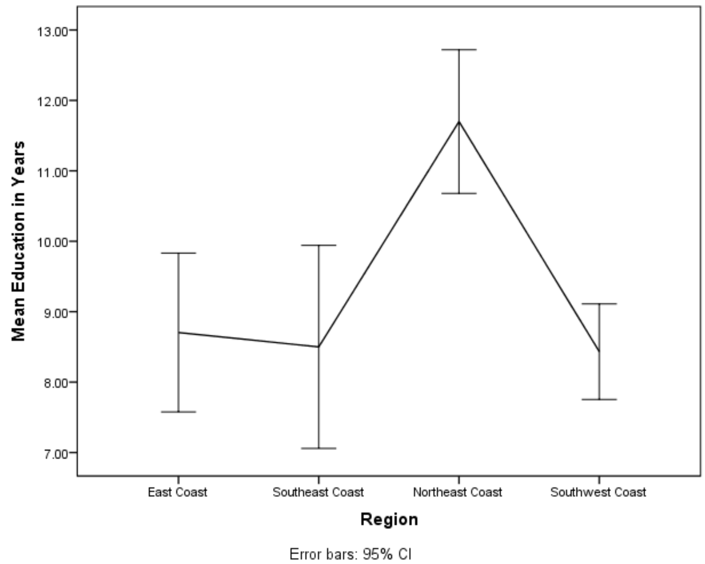

Figure 4. Regional comparison of fishers' average education in years.

The Southwest coast presented higher average household size (3.4) when compared to the other three regions (East: 2.8, Southeast: 2.4, Northeast: 2.8) (Figure 5).

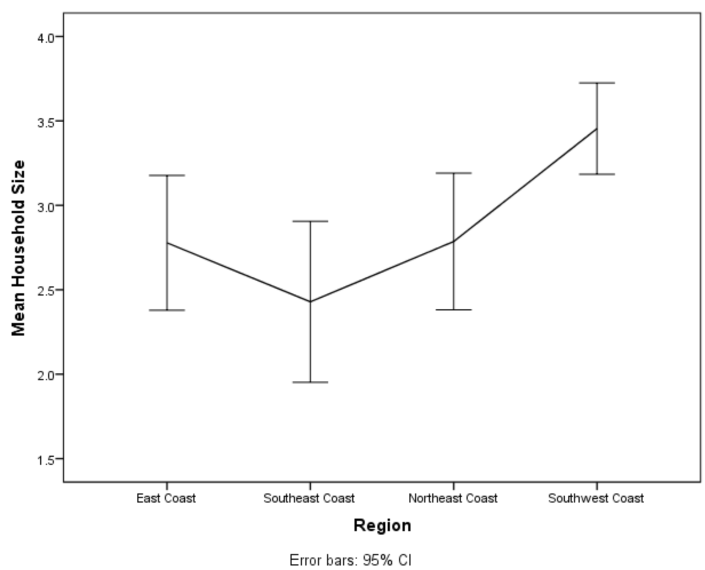

Figure 5. Regional comparison of average fishers' household size.

Frequencies of marital status also differed statistically significantly between the studied regions ($\chi^2 = 23.759$, df = 3, $p<0.001$). The highest frequency of married fishers was observed in the Southwest (87.5%, N = 77) and the lowest in the Southeast (46.4%, N = 13). Frequencies of married fishers were 71.4% (N = 30) and 59.3% (N = 32) in the Northeast and East coasts respectively.

Aspects of Fishery Dependency and Occupational Multiplicity

The majority of fishers in the sample (69.8%, N = 148) said fishing was their only occupation. Twenty four percent (N = 51) of the fishers had other occupations/sources of income and 6% (N = 13) of fishers did not consider fishing an occupation, i.e. fishing was strictly a recreational and/or subsistence activity. The occupations/sources of income most frequently mentioned by those who had an additional occupation or to whom fishing was not an occupation were retired ($16.4\%^{R}$[2], $N^R = 11$), business owner ($10.4\%^R$, $N^R = 7$), and construction ($9\%^R$, $N^R = 6$) (Table 5). The full list of occupations can be seen in Appendix 3.

Table 5. Frequency of responses of fishers' occupations in addition to fishing.

Occupation	**N**	**% of Responses**
Retired/Pension	11	16.4%
Business owner	7	10.4%
Construction	6	9.0%
Farmer	5	7.5%
Government	4	6.0%
Carpenter	3	4.5%
Housekeeping	2	3.0%
Odd jobs	2	3.0%
Handy man	2	3.0%
Retail	2	3.0%
Other (N<1)	23	34.3%

Fishers who stated that they had other occupation(s) in addition to fishing were asked which occupation was more important for their income. For 25% (N = 12) of fishers with additional occupation(s), fishing was their primary source of income. They were also asked to compare occupations with regard to time spent working and preference and 26.1% (N = 12) and 53.3% (N = 24), respectively, said fishing. See Appendix 4 for a table ranking all occupations.

The majority of fishers in the sample (87.1%, N = 182) were the major income providers in their household. The proportion of major householder providers was not statistically significantly different between fishers whose only occupation was fishing (89.7%, N = 131) and those with additional occupations/sources of income (81%, N = 51) ($\chi^2 = .088$, df = 1, $p>0.05$).

The majority of fishers in the sample (81.5%, N = 172) considered themselves *commercial fishers*. Among commercial fishers, 81.9% (N = 140) were currently associated with a fisheries association or *villa pesquera*. The majority of fishers who considered themselves to be commercial fishers stated that fishing was their only occupation (79.7%, N = 137). Of the fishers who did *not* consider themselves to be commercial fishers 33.3% (N = 13) stated fishing was not an occupation, while 25.6% (N = 10) stated that fishing was their only occupation[3].

Commercial fishers with additional occupations/sources of income were most frequently construction workers ($13.5\%^R$, $N^R = 5$), and business owners ($10.8\%^R$, $N^R = 4$). Other occupations/sources of income mentioned by

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[2] $\%^R$ and N^R refer to percent and number of responses as opposed to percent and number of respondents (% and N) and it applies to all questions that allowed multiple responses by individuals.

[3] This apparent discrepancy is likely due to the estimated large number of fishers in Puerto Rico who fish without a commercial license (and thus likely said they are *not* commercial fishers) but do sell their catch for money and may, as suggested by our results, depend entirely upon fishing to make a living.

more than one commercial fisher (N^R = 2, 5.4%^{R}) were retired, housekeeper, carpenter, handy man, and government worker.

Regional differences were observed with regard to aspects of fishery dependence and occupation multiplicity. The frequency of fishers with other occupations in addition to fishing differed between the four regions studied (χ^2 = 129.554, df = 6, p<0.001). The greatest difference was observed between the Northeast and the Southwest coasts. While in the Northeast the majority of fishers either had other occupations/sources of income in addition to fishing (60%, N = 25) or did not consider fishing to be an occupation (31%, N = 13), in the Southwest only one fisher stated to have another occupation in addition to fishing. In the East and Southeast coasts the frequencies of fishers who stated to have other occupations/sources of income in addition to fishing were 26% (N = 14) and 39% (N = 11) respectively. The only region where fishers surveyed stated fishing was not an occupation was the Northeast coast.

A regional difference was also observed with regard to the types of occupations/sources of income fishers had in addition to fishing. In the Northeast coast the most frequently mentioned occupations/sources of income were business owner (15%^{R}, N^R = 4), government worker (11.5%^{R}, N^R = 3), and retired (7%^{R}, N^R = 2). In the East coast the most common occupations were construction worker (23.5%^{R}, N^R = 4), housekeeper and odd jobs (each with 12%^{R}, N^R = 2) and in the Southeast coast the most frequent additional occupation was farmer (36%^{R}, N^R = 4). See Appendix 5 for a complete list of occupations by region.

In the Southwest coast fishing was the only source of income for 98.9% (N = 87) of the fishers surveyed. In the Northeast 9.5% (N = 4) of the fishers stated fishing was their primary source of income while in the East and Southeast coasts the frequencies were 74% (N = 40) and 60.7% (N = 17) (Figure 6).

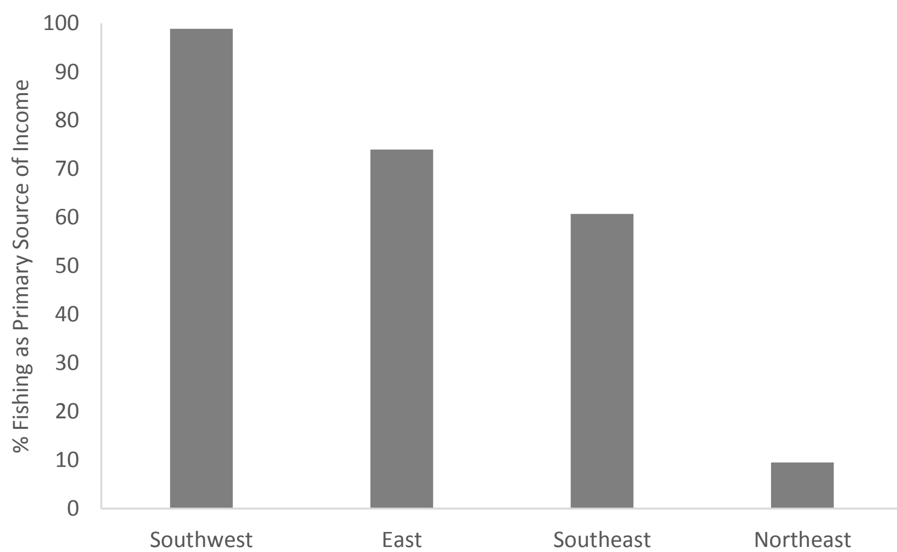

Figure 6. Regional differences with regard to the percentage of fishers for whom fishing was a primary source of income.

While the majority of fishers were the major household providers in all regions, with more than 70% of 'yes' responses, in the Southwest and the Southeast coasts frequencies were statistically significantly higher (89%, N = 85 and 98%, N = 43, respectively, χ^2=19.068, df=3, p<0.001) than the Northeast (72.5%, N = 29) and the East (79.6%, N = 25).

The frequency of fishers who considered themselves to be *commercial* fishers also differed statistically significantly between the four regions studied ($\chi^2 = 34.735$, df = 3, $p<0.001$). While in the Northeast coast 55% (N = 23) and in the Southeast coast 68% (N = 19) of fishers said they were *commercial* fishers, in the East and Southwest coasts frequencies of self-reported *commercial* fishers were 89% (N = 48) and 94% (N = 83), respectively.

Characteristics of the Fishing Activity

The majority of fishers surveyed used a boat to fish (95%, N = 202) and 72% (N = 146) of them owned the boat they used to fish. All boats used by fishers were motorized and average boat length was 20.4 feet (SD. = 3.4). The most frequent fishing methods used were SCUBA diving (*buceo*) (32.5%^{R}, N^R = 114), followed by traps (*nasas*) (14.2%^{R}, N^R = 50), and rod and reel (*caña y carrete*) (12%^{R}, N^R = 41) (Figure 7). See Appendix 6 for a complete list of methods and fishing gears used by fishers surveyed.

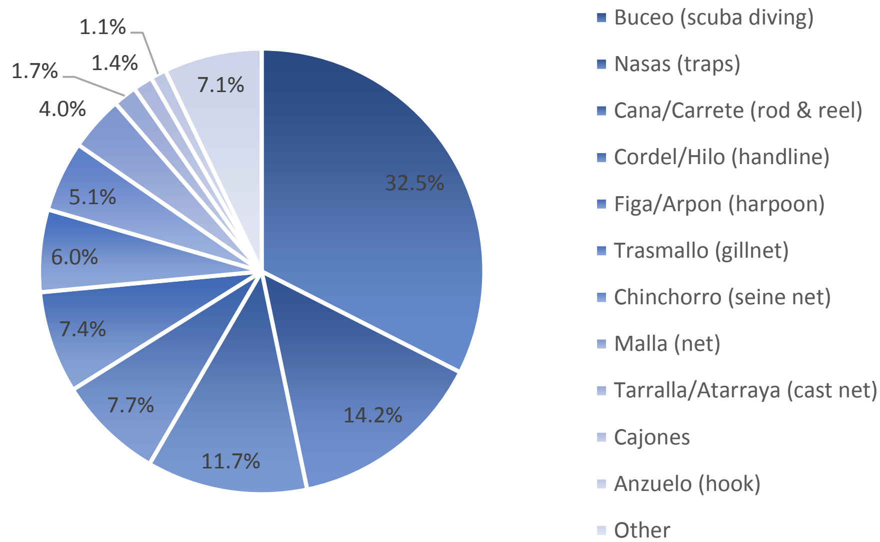

Figure 7. Most frequently used methods and gear types among fishers. Percentages represent frequency of responses since individual fishers may use more than one method/gear type.

The species most frequently targeted by fishers overall were spiny lobster (19%^{R}, N^R = 118), queen conch (14%, N^R = 87), yellowtail snapper (*colirubia*) (10%^{R}, N^R = 62), mutton snapper (*sama*) (7%^{R}, N^R = 43), and snappers in general (*pargo*) (6%^{R}, N^R = 38) (Figure 8). The top species with highest levels of importance to fishers' income were spiny lobster (37%^{R}, N^R = 77), silk snapper (*chillo*) (14%^{R}, N^R = 30), queen conch (9%^{R}, N^R = 19), and yellowtail snapper (*colirubia*) (8%^{R}, N^R = 17). A complete list of target species can be seen in Appendix 7.

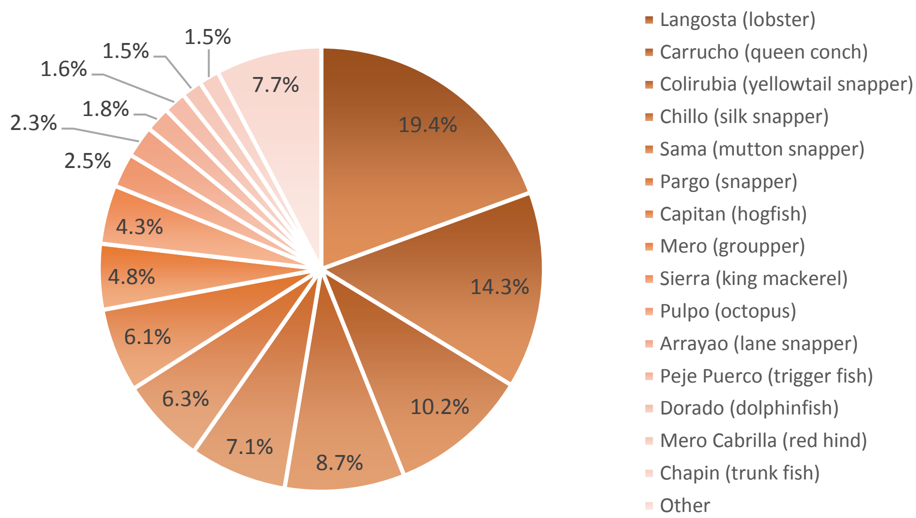

Figure 8. Most frequently species targeted by fishers. Percentages represent frequency of responses since individual fishers could mention more than target species.

Fishers surveyed spent on average 10.9 months a year (SD. = 2.2), 14.9 days a month (SD. = 7.4), and 6.6 hours a day (SD. = 2.1) fishing. Fishers were asked about the approximate size of their catch in pounds on a *good day* versus on a *bad day* of fishing. On average fishers catch 79.8 pounds on a good day (SD. = 79.2) and 12.1 pounds on a bad day (SD. = 17.3). When asked whether they had more *good* or *bad* fishing days in the past year, the majority of fishers (68.9%, N = 142) stated they had more *good* days and 8% (N = 17) said they had an equal amount of *good* and *bad* days.

Characteristics of the fishing activity differed between the regions studied. Results for regional comparisons of boat ownership frequency were statistically significant ($\chi^2 = 11.093$, df = 3, $p<0.05$). The region with the highest frequency of fishers who owned the boats they used to fish was the Northeast (88.9%, N = 32) and the region with the highest frequency of fishers who did *not* own their fishing boats was the Southwest coast (38.6%, N = 34). Regional comparisons for average boat length was also statistically significant (F = 4.966, df = 3, $p<0.05$). Post-hoc analyses show that the largest boats are found in the Northeast coast (22 feet, SD. = 5) in comparison to all other regions (East: 19.9, SD. = 2.9, Southeast: 19.5, SD. = 3.2, Southwest: 20.1, SD. = 2.7) (Figure 9).

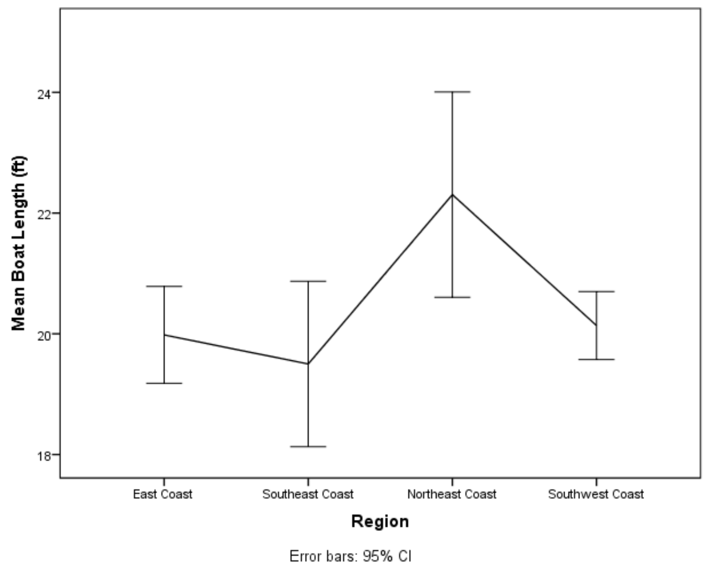

Figure 9. Regional comparison of average fishing boat length.

Primary fishing methods used differed between regions studied. In the East coast, the fishing methods and gear types most frequently used were SCUBA diving ($28\%^R$, $N^R = 27$), traps ($18\%^R$, $N^R = 17$), handline (*cordel*) ($14\%^R$, $N^R = 13$), and harpoon ($13\%^R$, $N^R = 12$). In the Southeast coast the most frequently used fishing methods and gears were traps ($21.5\%^R$, $N^R = 14$), handline ($17\%^R$, $N^R = 11$), harpoon ($9\%^R$, $N^R = 6$), and nets (*malla*) ($9\%^R$, $N^R = 6$). In the Northeast coast, rod and reel ($42\%^R$, $N^R = 33$), gillnet (*trasmallo*) ($16.5\%^R$, $N^R = 13$), SCUBA diving and harpoon (each $10\%^R$, $N^R = 8$) were most common. In the Southwest coast, $68\%^R$ ($N^R = 76$) of fishers used SCUBA diving as a primary fishing method, $12\%^R$ ($N^R = 13$) used seine net (*chinchorro*), and $11\%^R$ ($N^R = 12$) traps (Figure 10). See Appendix 8 for a complete list of methods/gear types by region.

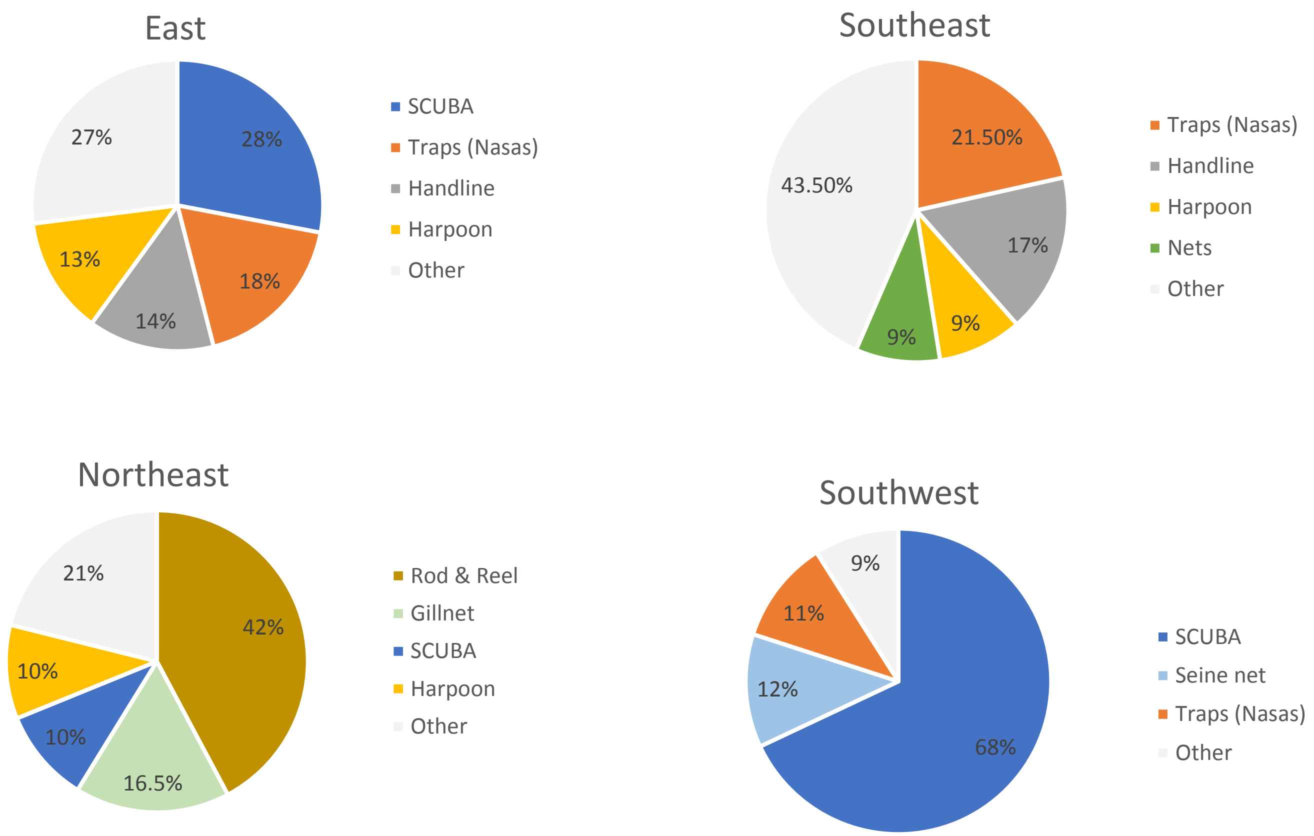

Figure 10. Most frequent fishing methods and gears used by region. Percentages represent frequency of responses since individual fishers may use more than one method/gear type.

Species most frequently targeted by fishers were also compared by region. In the East coast the most frequently mentioned species were spiny lobster ($16\%^R$, $N^R = 33$), yellowtail snapper ($14\%^R$, $N^R = 28$), mutton snapper ($12\%^R$, $N^R = 25$), hogfish (*capitan*) ($11\%^R$, $N^R = 23$), and queen conch ($11\%^R$, $N^R = 22$). In the Southeast coast the most important target species were silk snapper ($14\%^R$, $N^R = 13$), mutton snapper ($11\%^R$, $N^R = 10$), spiny lobster ($11\%^R$, $N^R = 10$), and yellowtail snapper ($10\%^R$, $N^R = 9$). In the Northeast, snappers in general ($22\%^R$, $N^R = 26$), yellowtail snapper ($21\%^R$, $N^R = 25$), and bluefish (*sierra*) ($14\%^R$, $N^R = 16$) were the most frequently mentioned species. And in the Southwest, spiny lobster ($35\%^R$, $N^R = 68$), queen conch ($30\%^R$, $N^R = 58$), and silk snapper ($13\%^R$, $N^R = 26$) were the most frequently mentioned species (Figure 11). See Appendix 9 for a complete list of target species by region.

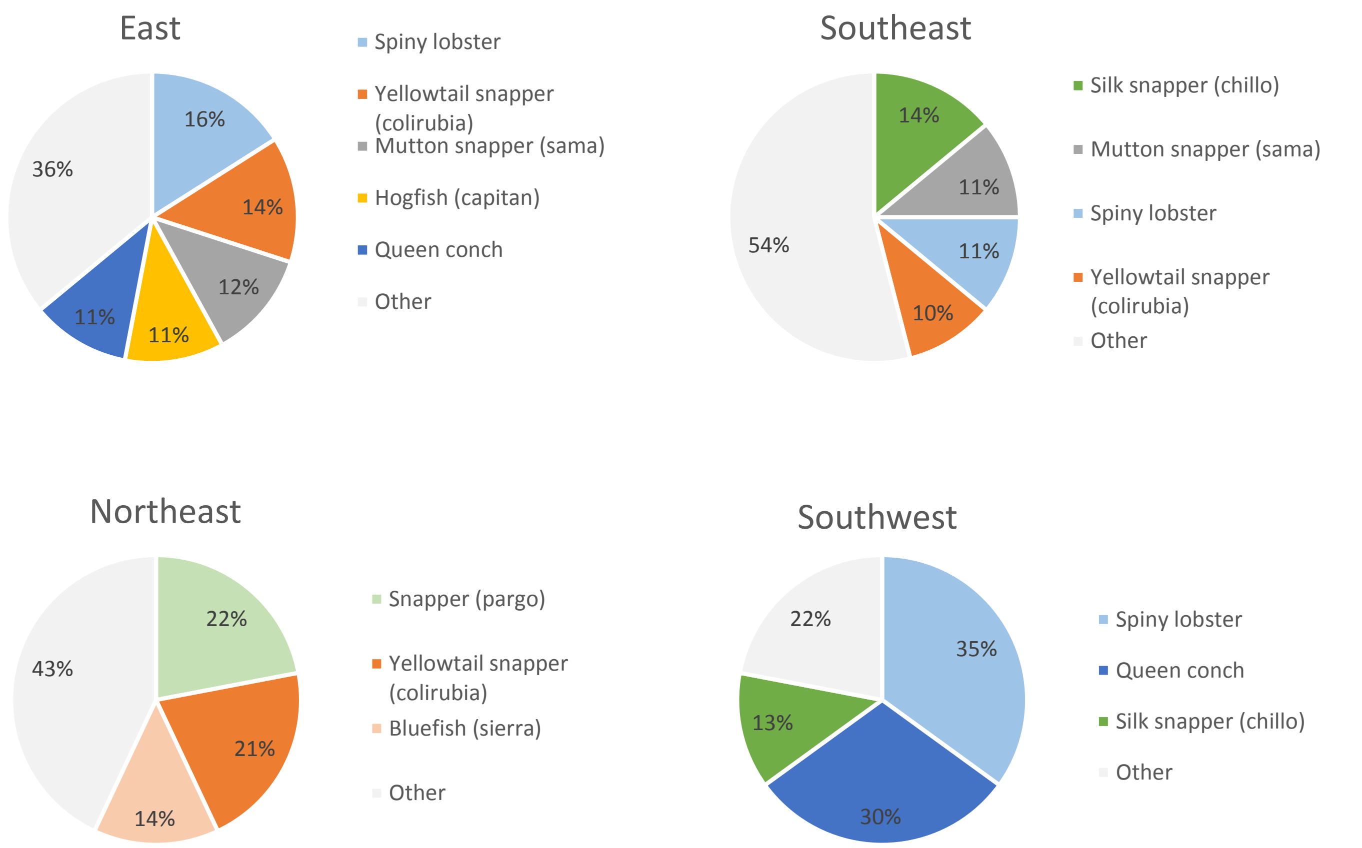

Figure 11. Most frequent target species by region. Percentages represent frequency of responses since individual fishers may use more than one method/gear type.

Target species were also compared by region for species most frequently mentioned as the most important for fishers' incomes. In the East coast the top species were spiny lobster ($28\%^R$, $N^R = 15$), queen conch ($22\%^R$, $N^R = 12$), and yellowtail snapper ($18.5\%^R$, $N^R = 10$). In the Southeast coast the top species contributing to fishers' incomes were silk snapper ($32\%^R$, $N^R = 9$), queen conch, lane snapper (*arrayao*) and whitemouth croaker (*corvino*) (each at $11\%^R$, $N^R = 3$). In the Northeast the most valuable species were snappers in general ($32\%^R$, $N^R = 13$), and bluefish and yellowtail snapper (each at $17\%^R$, $N^R = 7$). In the Southwest the top species most frequently mentioned as the most important for fishers' income were spiny lobster ($67\%^R$, $N^R = 58$) and silk snapper ($21\%^R$, $N^R = 18$).

Regional comparisons regarding fishing effort in terms of months a year, days a month, and hours a day fishing were all statistically significant (Table 6).

Table 6. ANOVA comparing fishing effort between regions.

Fishing Effort	**Sum of Squares**	**df**	**Mean Square**	**F**	**p**
Months/Year	539.389	3	179.796	85.069	.000
Days/Month	2495.454	3	831.818	19.074	.000
Hours/Day	267.552	3	89.184	26.920	.000

With regard to the number of months a year fishers go out fishing, post hoc analyses show that statistically significant differences were found between all regions except between the East (11.2, SD. = 2.1) and Southeast (11.4, SD. = 1.7) coasts. The Southwest coast had the highest average (11.9, SD. = 0.45) and the Northeast coast the lowest (7.6, SD. = 1.7) (Figure 12).

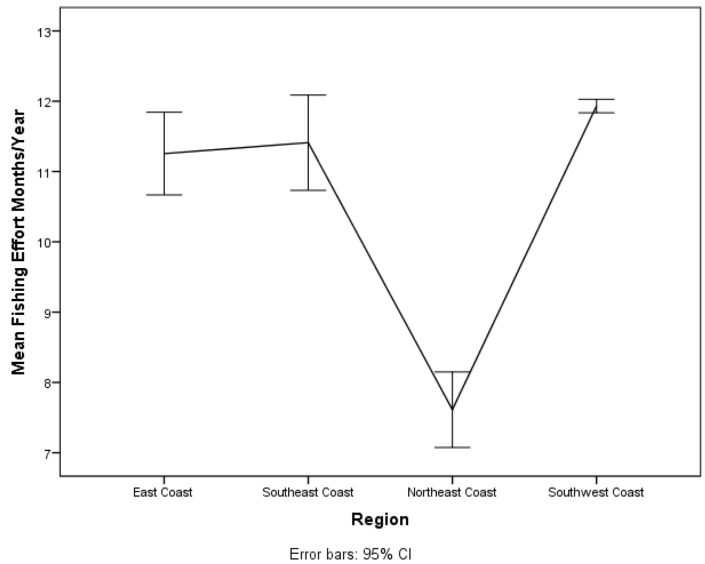

Figure 12. Regional comparison of average fishing effort in number of months per year.

Post-hoc analyses comparing average number of days a month fishing was statistically significant for differences between the Southwest coast (18.6, SD. = 5.5) and all other regions and also between the East (13.9, SD. = 8.7) and the Southeast (9.5, SD. = 7.8) coasts. The Southwest coast had the highest average of days a month effort and the Southeast coast has the lowest average. In the Northeast the average was 11.8 days a month (SD. = 4.5) (Figure 13).

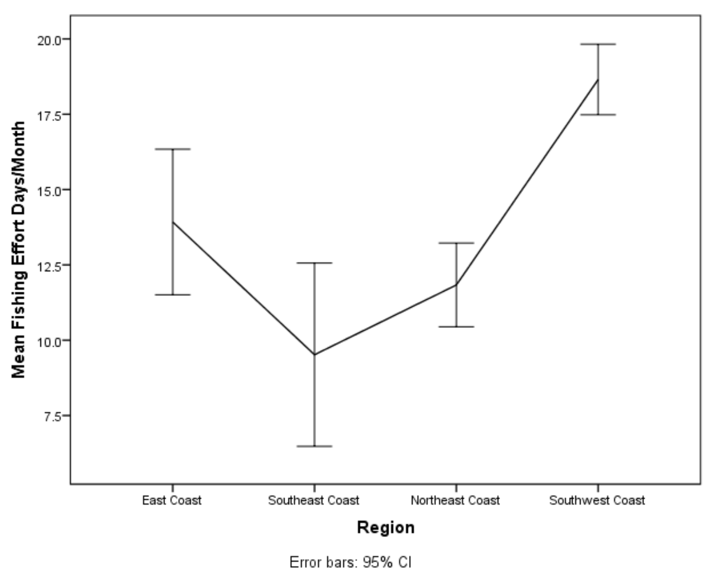

Figure 13. Regional comparison of average fishing effort in number of days per month.

Post-hoc analyses of fishing effort in terms of hours a day spent fishing was statistically significant for comparisons between all regions except when the East (6.7, SD. = 2.1) and Southeast (6.9, SD. = 1.6) coasts were compared. The highest average for hours spent fishing a day was found in the Northeast (8.5, SD. = 2.7) and the lowest average was found in the Southwest (5.4, SD. = 0.95) (Figure 14).

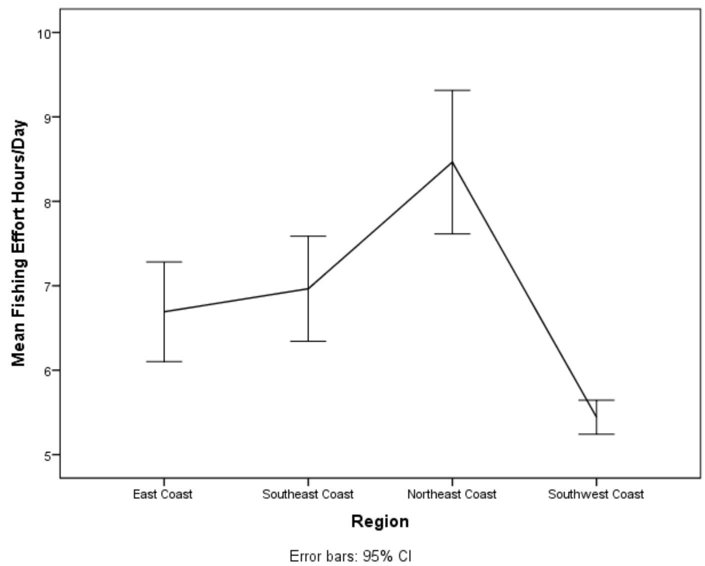

Figure 14. Regional comparison of average fishing effort in hours per day.

Analysis of variance (ANOVA) comparing the approximate amount fishers reported catching on a *good day* and on a *bad day* by region were statistically significant. Post-hoc analysis of the amount caught on a good day show that differences are found between the Southwest coast (50.4, SD. = 20.9) and all other regions except for the Northeast (82.6, SD. = 57.5). The lowest average was found in the Southwest coast and the highest in the Southeast (115.7, SD. = 105.5). Analysis for amount caught on a bad day shows statistically significant differences between the Southwest coast (4.8, SD. = 4.5) and all other regions. The Southwest coast had the lowest average while the East coast had the highest average of pounds landed on a bad day (20 lb, SD. = 26). Averages in the Northeast and Southeast were 14.1 (SD. = 17.3) and 16.2 (SD. = 12.7) respectively (Figure 15).

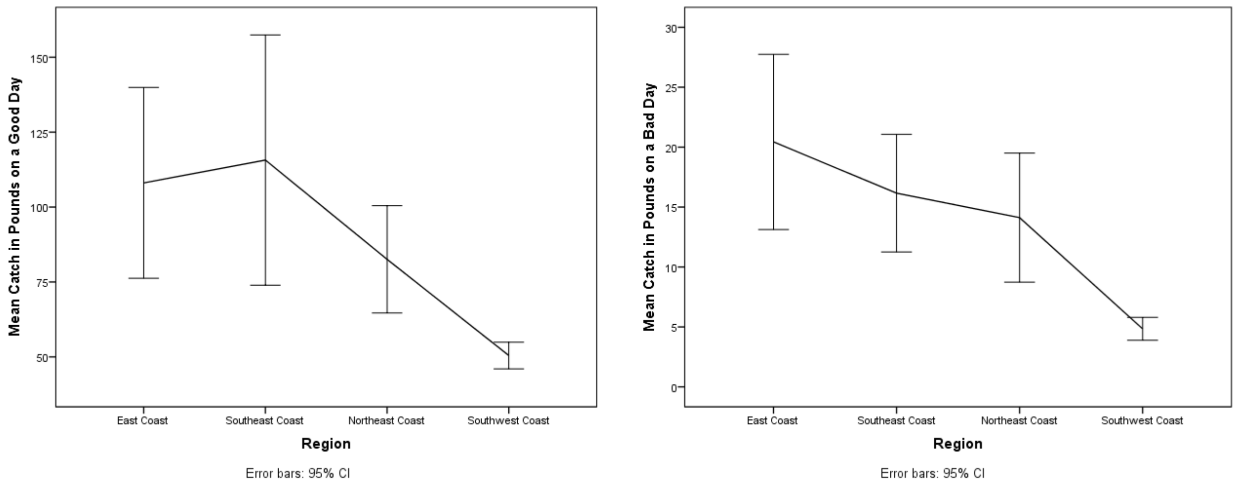

Figure 15. Regional comparisons for average amount reported to be caught on a good day (left) and on a bad day (right) of fishing.

Regional comparisons regarding whether fishers had more *good or equal* versus *bad* days fishing in the previous year were statistically significant ($\chi^2 = 19.781$, df = 3, $p<0.001$). Fishers in the Southwest coast had the highest relative frequency of more *good or equal* responses (89.5%, N = 77) when compared to all other regions (East: 74.5%, N = 38, Southeast: 50%, N = 14, Northeast: 73.2%, N = 30) (Figure 16).

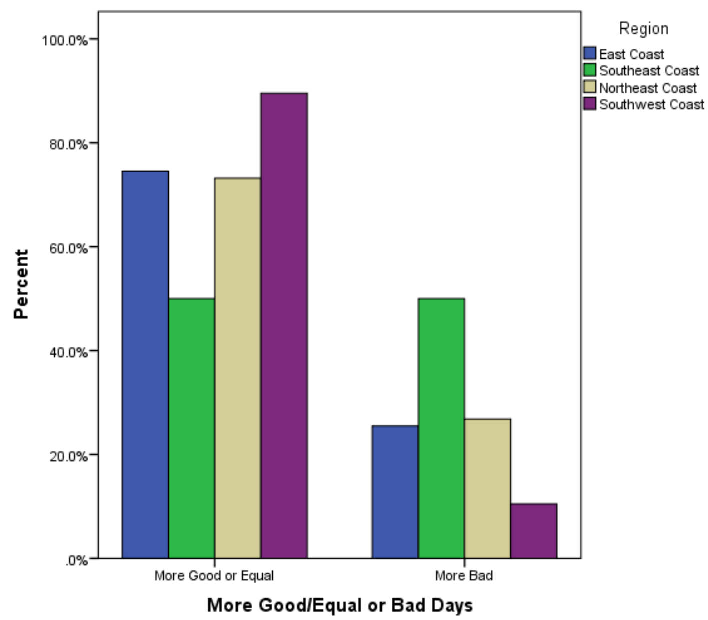

Figure 16. Regional comparison of the frequency of fishers who reported more good or equal versus bad days fishing during the previous year.

Well-being, Job Satisfaction, and Social Capital

Job satisfaction was measured using a 9-item scale (Table 7) derived from a 22-item scale developed by Pollnac and Poggie (1988). The 9-item scale was developed by using a principal component analysis (PCA) from a geographically diverse data set and selecting the three items with the highest loadings on each of the three components commonly derived from the PCA. In the present sample, mean values for all job satisfaction variables, measured on a Likert scale of 1 (*very dissatisfied*) to 5 (*very satisfied*), are above 3.7 suggesting that, in general, fishers present high levels of job satisfaction. Aspects of the job with which fishers are most satisfied relate to independence and adventure (Table 7).

Table 7. Job satisfaction variables with mean values and standard deviation measured on a 5-point Likert scale ranging from 1 = 'very dissatisfied' to 5 = 'very satisfied.'

Item	Mean	St. Dev.
Opportunity to be own boss	4.64	0.624
Adventure	4.45	0.528
Time spent fishing	4.34	0.676
Challenge	4.25	0.606
Earnings	4.08	0.843
Safety	3.97	0.737
Healthfulness	3.92	0.735
Predictability of earnings	3.83	0.759
Fatigue	3.70	0.752

The job satisfaction items were reduced using factor analysis (varimax rotation) which resulted in the three components seen in Table 8. Analysis of the scree plot suggests the number of components is appropriate (Figure 17). The components are similar to job satisfaction components used in several previous studies (see Seara et al. 2017b).

Table 8. Results of Principal Component Analysis using job satisfaction items.

Item	Basic Needs	Self-Actualization	Health
Earnings	**.874**	.039	-.065
Predictability of earnings	**.826**	.127	.210
Time spent fishing	**.464**	-.116	.386
Opportunity to be own boss	**.416**	.317	.105
Adventure	-.043	**.810**	.086
Challenge	.231	**.706**	.218
Safety	.054	**.698**	.017
Fatigue	.263	.054	**.838**
Healthfulness	-.053	.337	**.789**
% Variance Explained	*31.35*	*17.18*	*11.93*

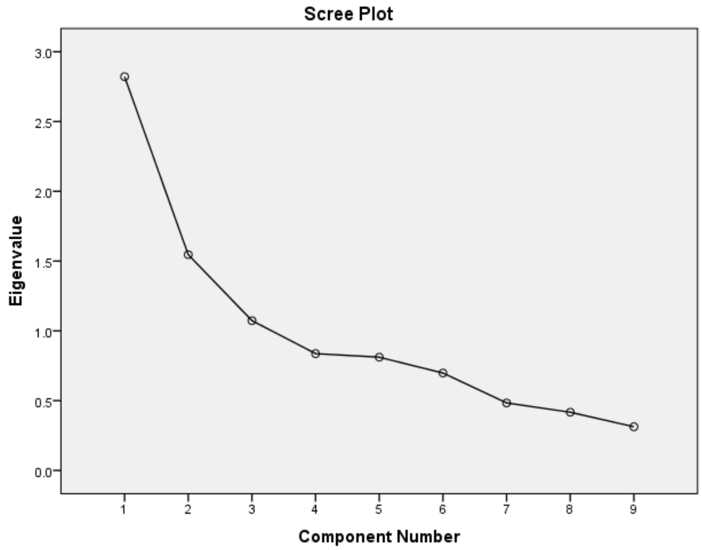

Figure 17. Scree plot of Principal Component Analysis using job satisfaction variables.

Fishers were asked about their level of happiness measured on a Cantril self-anchoring 10-point scale (1 = not happy at all and 10 = very happy), which resulted in an overall mean value of 9.3 (SD. = 1.3). Fishers were also asked if they could count on help from friends and family to deal with any problems they might encounter and 95% (N = 202) of the fishers said 'yes.'

Regions were compared based on their scores on the three job satisfaction components. Results were statistically significant except for the *Health* component (Table 9).

Table 9. ANOVA comparing scores on the job satisfaction components between regions.

Job Satisfaction Component	**Sum of Squares**	**df**	**Mean Square**	**F**	**p**
Basic Needs	53.242	3	17.747	24.220	.000
Health	6.609	3	2.203	2.246	.084
Self-actualization	94.178	3	31.393	60.955	.000

Regional averages for the job satisfaction components are averages of the standardized scores for each individual factor resulting from the PCA (Table 10). Post-hoc tests for the component *Basic Needs* show that the only statistically significant results were for comparisons between the Northeast coast and all other regions. The overall mean scores for the Northeast coast were the lowest when compared to all other regions (Figure 18).

Table 10. Standardized averages for the three job satisfaction components by region.

Region	Job Sat. Component	N	Minimum	Maximum	Mean	St. Dev.
East Coast	Basic Needs	54	-3.39205	1.73004	.1140399	1.08563067
	Self-Actualization	54	-1.98586	2.32003	.6405468	.93309496
	Health	54	-2.04470	2.43479	-.0592850	1.29431535
Southeast Coast	Basic Needs	25	-1.85948	1.72456	.1445115	1.12236774
	Self-Actualization	25	-.57965	1.73704	.8244474	.70796428
	Health	25	-2.71998	2.18016	.4467095	1.32947350
Northeast Coast	Basic Needs	28	-2.81027	.38225	-1.2589591	.88881844
	Self-Actualization	28	-1.90807	1.85179	.3797809	1.00902820
	Health	28	-1.15461	1.16757	-.2232605	.54778632
Southwest Coast	Basic Needs	85	-1.85516	1.27266	.2997637	.53150551
	Self-Actualization	85	-2.20340	.69037	-.7745245	.36445921
	Health	85	-2.79749	1.78389	-.0201771	.73258310

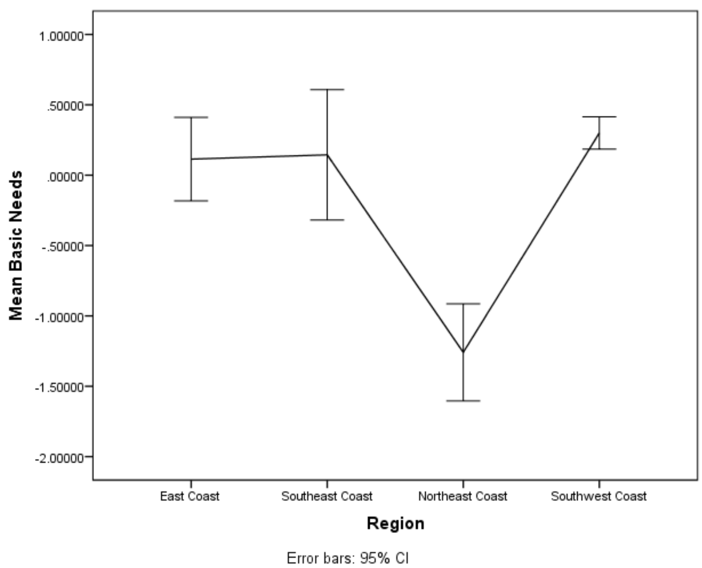

Figure 18. Regional comparison of average score on the job satisfaction component Basic Needs.

Post-hoc analysis for the component *Self-Actualization* shows that the only statistically significant comparisons were between the Southwest coast and all other regions. The overall mean scores for the Southwest coast were the lowest when compared to all other regions (Figure 19).

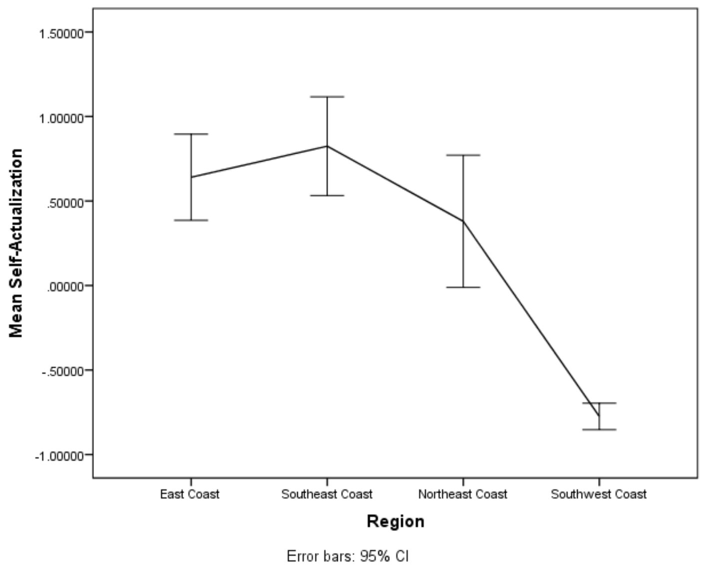

Figure 19. Regional comparison of average score on the job satisfaction component Self-Actualization.

Regions were also compared with regard to scores on the well-being (happiness scale) and results were statistically significant (F = 5.355, df = 3, $p<0.01$). Post-hoc analyses show that statistically significant differences were found between the Northeast (8.6, SD. = 1.4) and both the East (9.7, SD. = 0.8) and Southwest (9.3, SD. = 1.4) coasts. The average score in the Southeast coast was 9.3 (SD. = 1.3) (Figure 20).

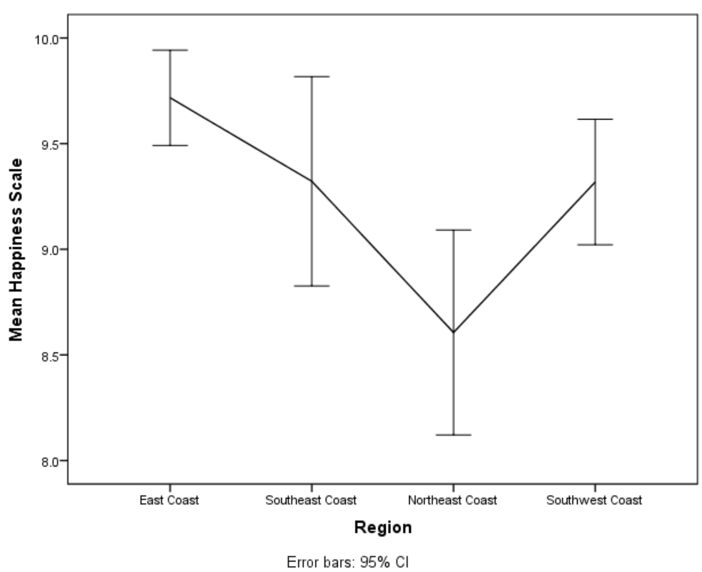

Figure 20. Regional comparison of average score on the well-being (happiness) scale.

Results comparing regions on the frequency of responses with regard to whether or not fishers had friends and family who they could count on to help in times of need (social capital) were not statistically significant (χ^2 = 3.561, df = 3, $p<0.05$). Frequencies of 'yes' responses for all regions were 96.2% (N = 51) in the East, 100% (N = 28) in the Southeast, 97% (N = 32) in the Northeast, and 92% (N = 81) in the Southwest coast.

Perceptions of the Health of Fishery Resources and Environmental Awareness

Results indicate that, in general, fishers perceive the fishery resources in Puerto Rico to be healthy. On a scale of 1 (*very bad*) to 5 (*very good*), responses on the status of fishery resources averaged 3.51 (SD. = 0.84), with 57.9% (N = 122) of the fishers indicating resources to be in *good* or in *very good* shape (Table 11). When asked if resources are currently in worse, equal, or better shape (scale of 1 to 3) when compared to 10 years ago, the average was 1.70 (SD. = 0.63), with 51.7% (N = 109) of the fishers stating resources are *equal* and 39.3% (N = 83) stating they are *worse*. The most frequent reasons stated by fishers for resources to have worsened during the past decade belong to the following topics: pollution (40.4%^{R}, N^R = 42), overexploitation (19.2%^{R}, N^R = 20), changes in climate (15.4%^{R}, N^R = 16), government regulations (6.7%^{R} N^R = 7), and environmental degradation (5.9%^{R}, N^R = 6). See Appendix 10 for a detailed list of responses.

Table 11. Fishers perceptions on the current status of fishery resources asked on a Likert scale ranging from 1 = 'in very bad shape' to 5 = 'in very good shape.'

Status of Fishery Resources	**N**	**%**
In very bad shape	0	0.0
In bad shape	31	14.7
In neither good nor bad shape	58	27.5
In good shape	106	50.2
In very good shape	16	7.6
Total	*211*	*100.0*

A list of 10 items (Table 12) were used to assess aspects of environmental awareness among fishers by asking their level of agreement with each item on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), reversed for negatively worded items. Mean scores were above three for all items with the exception of the item concerning whether or not fishers agreed that the presence of houses near the coast had an effect on the fishery. Items with the highest scores concerned the need to take care of the land and sea to safeguard sustainability and the impacts of coral death on fishing (see Table 12 for all mean scores). A *Total Environmental Awareness* scale ranging from 10 to 50 was created by summing up the responses to all 10 items.

Table 12. Environmental awareness variables with mean values and standard deviation measured on a 5-point Likert scale ranging from 1 = 'strongly disagree' to 5 = 'strongly agree' except for items marked with an asterisk for which scale was reversed.

Item	**Mean**	**St. Dev.**
We have to take care of the land and the sea or they will not provide for us in the future.	4.43	.496
If the corals die it will make a difference for fishing.	4.41	.628
If our community works together we will be able to protect our resources	4.23	.704
Tourism around/near the coast can have an effect on the fish.	3.38	1.105
Agriculture around/near the coast can have an effect on the fish.	3.11	1.036
Industry around/near the coast can have an effect on the fish.	4.04	.897
Houses around/near the coast can have an effect on the fish.	2.91	1.142
*If we throw our garbage on the beach, the ocean takes it away and it causes no harm.	4.34	.848
Unless mangroves are protected we will not have any fish to catch.	4.17	.766
*There are so many fish in the ocean that no matter how many we catch, there will always be enough for our needs.	3.44	1.255

Regional analysis of variance comparing fishers' perspectives on both the status of fishery resources and change in the state of resources in the past decade (Table 13) were statistically significant (Table 14).

Table 13. Descriptive statistics for fishers' perceptions of current status of fishery resources and change in state of resources in the past decade.

Region	Resource Status Variable	N	Minimum	Maximum	Mean	St. Dev.
East Coast	Current Status of Resources	54	2	5	3.39	.920
	Change in Resource Status	54	1	3	1.54	.693
Southeast Coast	Current Status of Resources	28	2	5	3.32	1.156
	Change in Resource Status	28	1	3	1.39	.567
Northeast Coast	Current Status of Resources	42	2	5	3.05	.854
	Change in Resource Status	41	1	2	1.29	.461
Southwest Coast	Current Status of Resources	87	3	5	3.86	.408
	Change in Resource Status	88	1	3	2.08	.435

Table 14. ANOVA comparing regions with regard to fishers' perceptions of the current status of fishery resources and change in resource status over the past decade.

Resource Status Variable	Sum of Squares	df	Mean Square	F	p
Current Status of Resources	21.549	3	7.183	11.877	.000
Change in Resource Status	23.552	3	7.851	27.528	.000

For both variables, post-hoc analyses show that the only statistically significant results are for comparisons between the Southwest coast and all other regions. Fishers in the Southwest coast had on average a more positive perception of the current status of the resource and had more moderate to positive views on resource changes in the past decade (Figure 21).

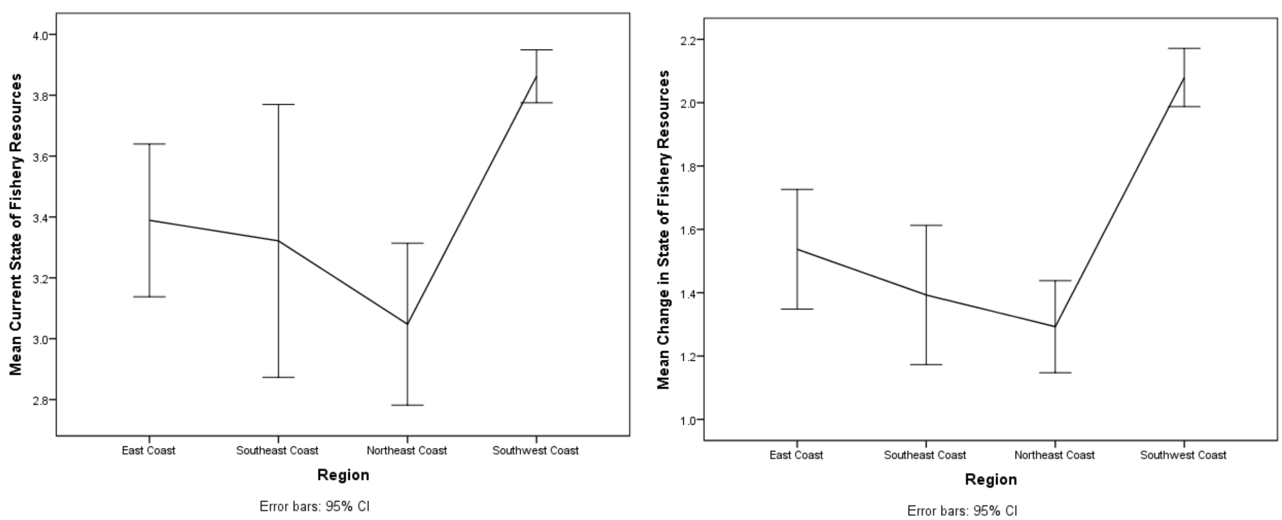

Figure 21. Regional comparisons of fishers' perceptions of the current state of fishery resources and change in resource status over the past decade.

Scores for the *Total Environmental Awareness* variable created as a sum of the items in the environmental awareness scale (Table 12) were also compared between regions and the results were statistically significant ($F = 6.784$, $df = 3$, $p<0.001$). Post-hoc analyses show that statistically significant differences were found between the Southwest coast (37.3, SD. = 2.1) and both the Northeast (39.2, SD. = 2.9) and Southeast (40.6, SD. = 4.8) coasts.

The Southwest coast presents the lowest overall scores on the Total Environmental Awareness variable (Figure 22). The average for the East coast was 38.5 (SD. = 5.0).

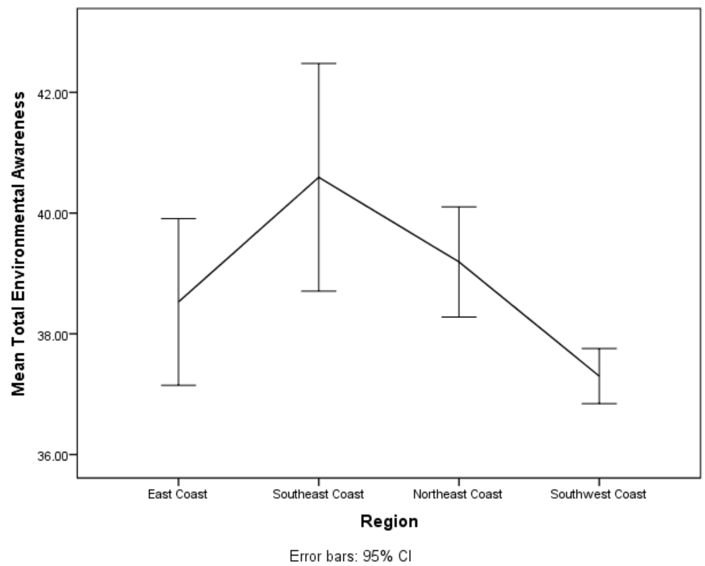

Figure 22. Regional comparison of average score on the Total Environmental Awareness variable.

Perceptions and Local Knowledge of Environmental and Climate Change

Ninety three percent of fishers interviewed (N = 197) were familiar with the term 'climate change' and the majority of them (73%, N = 154) believed the local climate to be changing. Fishers who said they experienced changes in the local climate were asked whether they thought the changes were good or bad on a Likert scale ranging from 1 (*very bad*) to 5 (*very good*). The mean value was 2.35 (SD. = 0.76), between *bad* (2) and *neither good nor bad* (3).

Overall, fishers' level of concern with climate change can be categorized as moderate to high, averaging 6.67 (SD. = 2.50) on a Cantril self-anchoring 10-point *Concern over Climate Change* scale (1 = not worried at all and 10 = very worried).

Just under half (46%, N = 97) of fishers said they have observed changes to the fish, shellfish, and/or local marine environment they believe are related to climate change. The most common changes observed were fishery resource decline (35.7%^{R}, N^R = 44), habitat shifts (15.4%^{R}, N^R = 19) which includes perceptions of species moving into deeper waters or to areas farther away from the coast, change in composition of fish species (10.6%^{R}, N^R = 13), and changes in water temperature (6.5%^{R}, N^R = 8) (Table 15). See Appendix 11 for a complete list of responses.

Table 15. Frequencies of fisher's' responses regarding changes observed in the marine environment as a result of climate change.

Changes	N^R	$\%^R$
Fishery resource decline	44	35.70%
Habitat shifts	19	15.40%
Change in composition of fish species	13	10.6%
Change in water temperature	8	6.5%
Increased fishing effort	7	5.70%
Invasive species	6	4.80%
More bad weather conditions	4	3.3%
Dead/Bleached Corals	4	3.30%
Change in currents	3	2.4%
Other (<2%)	15	12.34%

Fishers who said they have noticed changes in the marine environment they believed to be a result of climate change were asked if they had to change any aspects of their fishing activity to adapt to the changes observed. The majority (62.5%, N = 60) said 'yes.' The most frequent adaptations mentioned by fishers were changing fishing grounds (42.5%^{R}, N^R = 34), gear changes (15%^{R}, N^R = 12), and fishing in deeper waters (11.3%^{R}, N^R = 9) and farther away from shore (8.8%^{R}, N^R = 7) (Table 16). See Appendix 12 for a complete list of responses.

Table 16. Adaptations strategies adopted by fishers in response to changes observed in marine resource and environment.

Adaptation strategy	N^R	$\%^R$
Change fishing grounds	34	42.5
Change/Diversify gear	12	15.0
Fish in deeper water	9	11.3
Fish farther away from shore	7	8.8
Change time of day to fish	4	5.0
Change target species	3	3.8
Use better equipment/Technology	2	2.5
Increase effort	2	2.5
Other (N<1)	5	8.8

The majority of fishers (81%, N = 170) said they were not familiar with any regulations in Puerto Rico to address climate change. Regulations most frequently mentioned by fishers include laws to address pollution (41.3%^{R}, N^R = 19) and fishery closures (39.1%^{R}, N^R = 18). Fishers who stated they were aware of regulations to address climate change impacts in Puerto Rico were asked if they agreed with them and 74.3% (N = 31) said 'yes.' The majority of fishers (80%, N = 37) believed people to generally comply with these regulations.

Fishers were asked about their opinion on whether or not a series of different factors associated with anthropogenic impacts and climate change are a threat to fisheries. The factors with the highest frequency of 'yes' responses were pollution (92.9%, N = 197), coral bleaching (84.4%, N = 178), and increase in sea temperature (59.7%, N = 126). The factors with which fishers were least concerned about as far as how they might affect their fishing activity are increase in air temperature (21.8%, N = 46) and droughts (17.5%, N = 37) (Table 17 and Figure 23).

Table 17. Frequency of ‘yes’ responses to climate change and anthropogenic factors fishers believe are affecting their fishing activity.

Factors	**% ‘yes’ Responses**	**N**
Pollution	92.9	197
Coral Bleaching	84.4	178
Increase in Water Temperature	59.7	126
Overfishing	36.8	78
Increase in Frequency of Storms	34.4	73
Increase in Seaweed	32.9	69
Sea Level Rise	31.9	67
Change in Animal Behavior	30.0	63
Increase in Air Temperature	21.8	46
Increase in Droughts	17.5	37

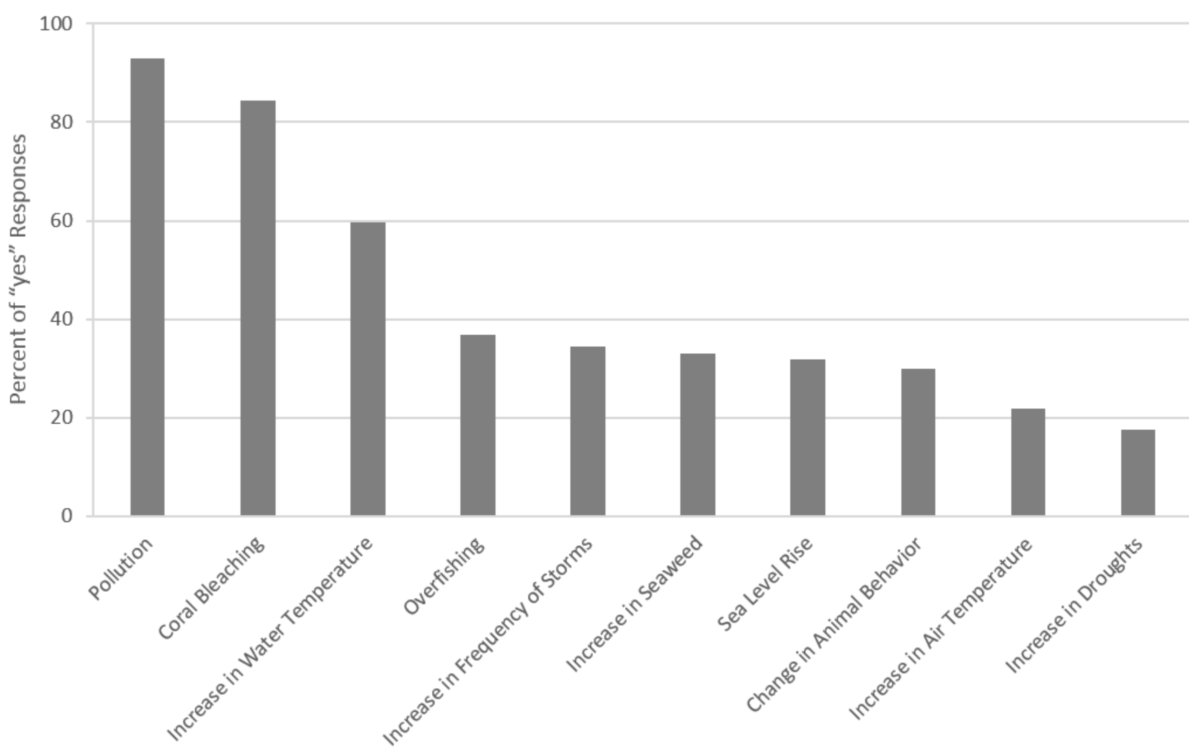

Figure 23. Frequency of ‘yes’ responses to climate change and anthropogenic factors fishers believe are affecting their fishing activity.

The sum of dichotomous responses (no = 0 and yes = 1) to the 10 factors in Table 17 were used to create a scale of perceptions on *Anthropogenic Impacts* ranging from zero to 10. The overall mean value was 4.4 (SD. = 2.4), i.e., individual fishers on average perceive 4.4 out of 10 anthropogenic and climate change factors to be affecting their fishing activity.

The different regions studied were compared with regard to fishers’ perceptions on whether or not the local climate has been changing. Results were statistically significant with the greatest difference in frequencies occurring between responses for the Southwest coast when compared to the other regions which share similar distribution of positive and negative responses. In the Southwest coast almost half of the fishers (47.7%, N = 42) said they have not experienced changes in climate, representing 72.4% of the total number of fishers in the sample who said they are not experiencing changes in climate. In the other regions this frequency ranges between 7 and 17% (Table 18).

Table 18. Regional frequencies of fishers' perceptions of the local climate changing.

Local Climate Change	East	Southeast	Northeast	Southwest
No	16.7%	14.3%	7.1%	47.7%
Yes	83.3%	85.7%	92.9%	52.3%

$\chi^2 = 32.522$, $df = 3$, $p<0.001$

The opinions of fishers who experienced changes in climate on the status of these changes (5-point Likert scale from *very bad* to *very good*) were compared between regions and results were statistically significant ($F = 8.598$, $df = 3$, $p<0.001$). Post-hoc analyses show that statistically significant differences were found between the Southwest coast and all other regions. Southwest coast fishers present the highest mean scores, meaning they present the most positive of the negative perceptions of the observed climatic changes (between *bad* and *neither good nor bad*) (Table 19 and Figure 24).

Table 19. Descriptive statistics of fishers' views on climate change status by region.

Region	N	Minimum	Maximum	Mean	St. Dev.
East Coast	44	1	4	2.09	.772
Southeast Coast	24	1	4	2.13	.900
Northeast Coast	40	1	3	2.30	.564
Southwest Coast	46	1	4	2.78	.629

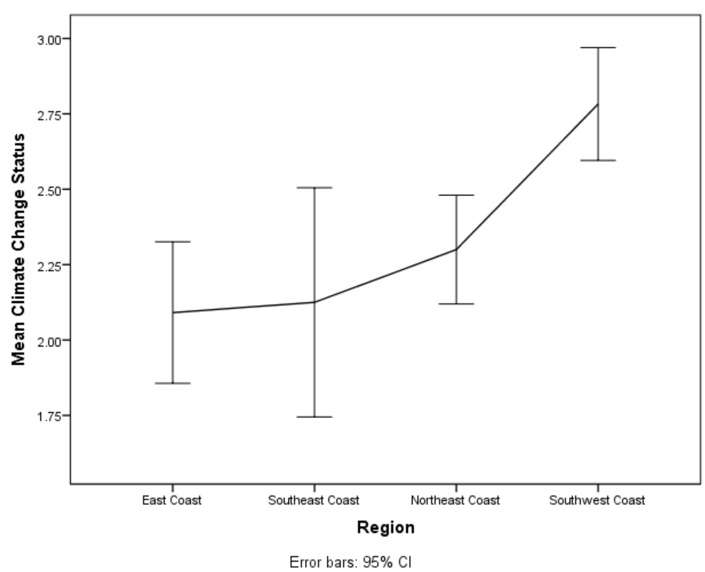

Figure 24. Regional comparison of perceptions in climate change status.

Regional comparisons of fishers' level of concern with climate change, measured on a 10-point scale, were statistically significant ($F = 7.413$, $df = 3$, $p<0.001$). Post-hoc analyses show that concern in the Southwest coast was statistically significantly lower than the East coast and in the Northeast coast concern was statistically significantly lower than both the East and Southeast coasts (Table 20 and Figure 25).

Table 20. Descriptive statistics of fishers' level of concern about climate change by region.

Region	N	Minimum	Maximum	Mean	St. Dev.
East Coast	53	1	10	7.66	3.000
Southeast Coast	28	1	10	7.39	2.699
Northeast Coast	42	1	10	5.55	2.132
Southwest Coast	84	1	10	6.37	1.931

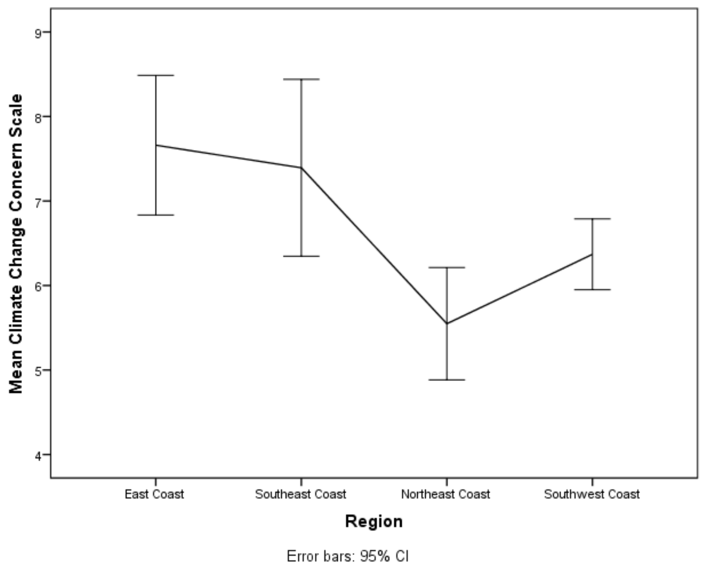

Figure 25. Regional comparisons of average scores on the climate change concern scale.

The regions studied were compared with regard to fishers' responses to whether or not they have observed environmental changes that can be attributed to climate change. Results were statistically significant (χ^2 = 86.497, df = 3, p<0.001) with the highest frequencies of 'no' responses found in the Southwest (89.8%, N = 79) and East (41.5%, N = 22) coasts. The lowest frequency was found in the Southeast coast (7.1%, N = 2). The Southwest coast accounted for 69.3% of all 'no' responses in the sample. In the Northeast coast 73.8% (N = 31) of fishers said they observed changes they believe are a result of climate change.

Fishers who observed changes in the marine environment were asked if they had to change any aspects of their fishing activity to adapt to these changes. Regional comparisons with regard to fishers' adaptations were statistically significant (χ^2 = 12.321, df = 3, p<0.01). In the Northeast 75% (N = 24) of fishers said they had to change their fishing activity to adapt to environmental changes. In the Southeast 68.2% (N = 15) of fishers who observed changes said they adapted, in the East coast 50% (N = 15), and only one fisher in the Southwest gave a similar response.

Awareness of regulations to address climate change in Puerto Rico differed statistically significantly among the different regions (χ^2 = 64.669, df = 3, p<0.001). The Northeast region had the highest number of fishers who were familiar with regulations (61.9%, N = 26) and the regions with the lowest numbers were the Southeast (0%) and East (3.8%, N = 2). In the Southwest 31.7% (N = 13) of fishers said they were aware of regulations to address climate change. The types of regulations most frequently mentioned by fishers in the Southwest coast related to fishing regulations (fishery and area closures) (100%, N = 14), and in the East and Northeast to pollution control (100%, N = 1 and 83.9%, N = 26, respectively). Analyses comparing fishers' opinion on whether or not they agreed with regulations were statistically significant ($\chi^2 = 29.966$, df = 2, $p<0.001$). The majority of fishers in the East and Northeast (100%, N = 1 and 96.2%, N = 25, respectively), and none (0%) of the fishers in the Southwest said 'yes.' Regional comparisons regarding fishers' perceptions on level of compliance with regulations were not statistically significant ($\chi^2 = 7.053$, df = 4, $p>0.05$).

Responses regarding fishers' perceptions on the different anthropogenic and climate change factors affecting the fishery were compared between regions. Results were statistically significant for all factors with patterns of responses between regions differing for each factor (Figure 26 and Table 21). Pollution and coral bleaching were important factors for the majority of fishers in all regions.

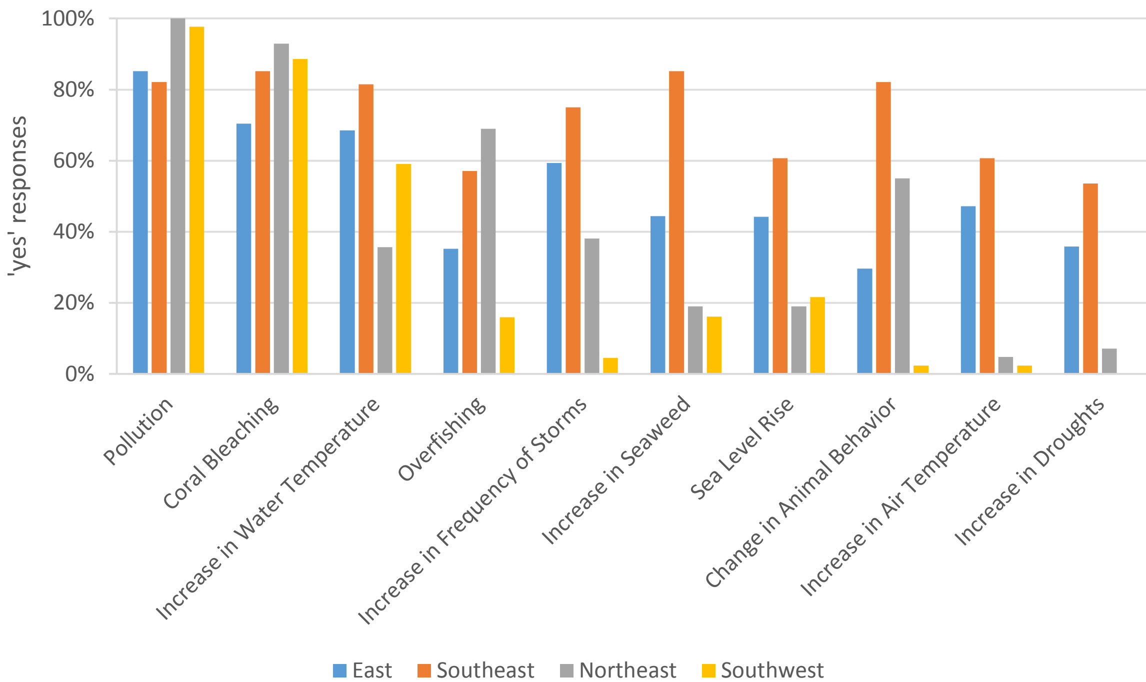

Figure 26. Regional comparisons of frequencies of anthropogenic and climate change factors fishers mentioned as affecting the fishery.

Table 21. Frequency of 'yes' responses and chi square results of regional comparisons of frequencies of anthropogenic and climate change factors fishers perceive as affecting the fishery.

Impacts/Factors	**East**	**Southeast**	**Northeast**	**Southwest**	**χ^2**	**df**	**p**
Pollution	85.2%	82.1%	100%	97.7%	16.155	3	<0.01
Coral Bleaching	70.4%	85.2%	92.9%	88.6%	11.542	3	<0.01
Increase in Water Temperature	68.5%	81.5%	35.7%	59.1%	20.116	6	<0.01
Overfishing	35.2%	57.1%	69.0%	15.9%	40.339	3	<0.001
Increase in Frequency of Storms	59.3%	75.0%	38.1%	4.5%	70.219	3	<0.001
Increase in Seaweed	44.4%	85.2%	19.0%	16.1%	51.514	3	<0.001
Sea Level Rise	44.2%	60.7%	19.0%	21.6%	21.838	3	<0.001
Change in Animal Behavior	29.6%	82.1%	55.0%	2.3%	80.376	3	<0.001
Increase in Air Temperature	47.2%	60.7%	4.8%	2.3%	71.715	3	<0.001
Increase in Droughts	35.8%	53.6%	7.1%	0.0%	59.286	3	<0.001

Results comparing the different regions studied with regard to averages on the anthropogenic scale scores were statistically significant (F = 31.389, df = 3, p<0.001). Post-hoc analyses show that differences were statistically significant between all regions except between the East (5.1, SD. = 2.9) and Northeast (4.5, SD. = 1.5) coasts. Average scores were 7.2 (SD. = 2.6) in the Southeast coast and 3.1 (SD. = 1.1) in the Southwest coast (Figure 27).

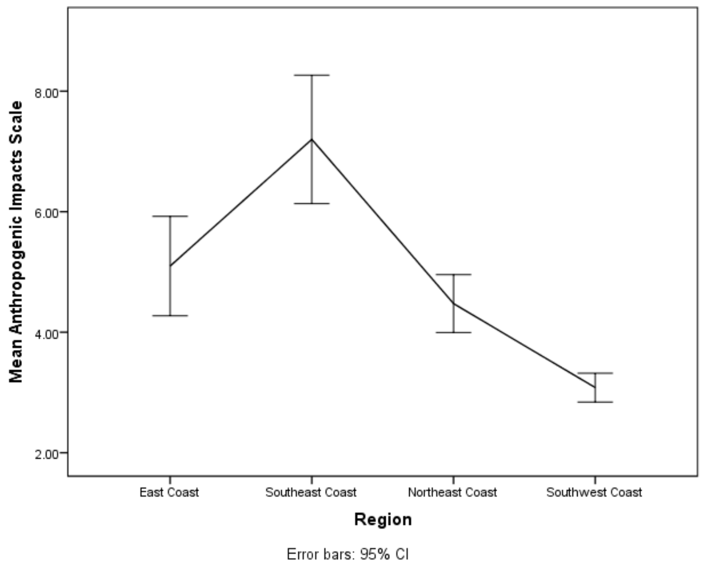

Figure 27. Regional comparisons of average scores on the Anthropogenic Impacts Scale.

Perceptions on Governance and Participation on Fisheries Management

The majority of fishers interviewed (71%, N = 151) did not perceive the government to be fair in the decisions they make with regard to fishing regulations. When asked whether or not they understood the decisions made by the government, i.e. if they think the government decisions are clear, 58.5% (N = 124) said 'yes.'

Fishers were asked to evaluate on a Cantril self-anchoring 10-point scale both their level of participation (1 = no participation and 10 = high level of participation) on decisions regarding fishing regulations and their opinion on the level of compliance with regulations currently in place (1 = no compliance and 10 = high level of compliance). While the average level of participation was approximately the mid-point of the scale (5.46, SD. = 2.38), the compliance scale showed a higher average of 8.28 (SD. = 2.44) (Figure 28).

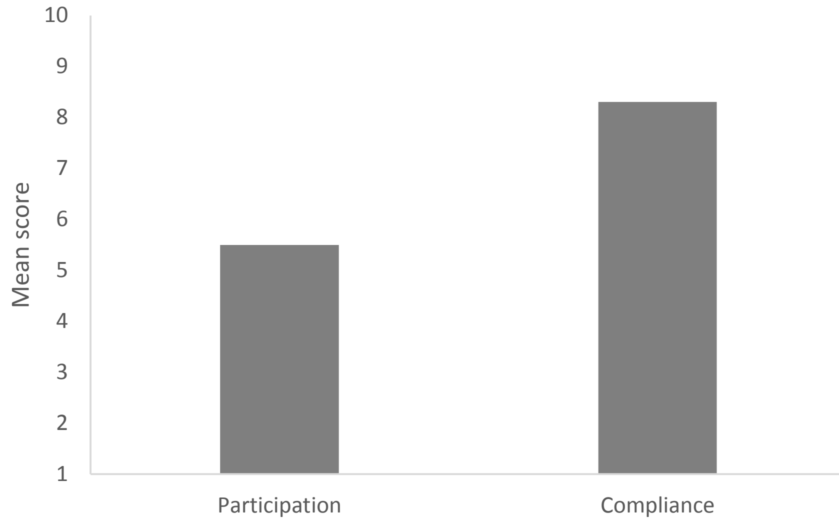

Figure 28. Average levels of participation on fishery management decisions and compliance with fishing regulations measured on a 10-point self-anchoring scale.

Fishers' opinions were virtually equally split with regard to whether or not they believed stricter enforcement of the current fishing regulations is needed (50.2%, N = 106 of the fishers said 'no').

The majority of fishers said that the local community and the fishers can work together to solve problems in the community and in the fisheries (94%, N = 197 and 90%, N = 190, respectively). Eighty four percent (N = 175) of fishers believed the fishers and government should work together to solve fishery related problems.

Differences in responses concerning aspects of fisheries governance were analyzed between the different regions studied. The great majority of fishers (93.2%, N = 82) in the Southwest coast and the majority in the East and Southeast coasts (79.2%, N = 42 and 77.8%, N = 21, respectively) perceived the government as unfair in the decisions they make regarding fisheries management. In the Northeast, the majority of fishers (85.7%, N = 36) perceived the government to be fair. These differences were statistically significant ($\chi^2 = 90.618$, df = 3, $p<0.001$).

Regarding fishers' opinion on whether or not regulations are clear, i.e. if they understand the decisions made by the government, the majority of fishers in the Northeast (81%, N = 34) and Southwest (71.6%, N = 63) coasts responded 'yes' while the majority of fishers in the East (71.2%, N = 37) and Southeast (64.3%, N = 18) coasts said 'no.' These differences were statistically significant ($\chi^2 = 39.632$, df = 3, $p<0.001$).

Results of regional comparisons concerning fishers' opinions on whether or not more enforcement of fishing regulations is needed were also statistically significant ($\chi^2 = 67.802$, df = 3, $p<0.001$). All fishers (100%, N = 28) in the Southeast and the majority of fishers in the East (74.5%, N = 38) coasts said more enforcement is needed and the majority of fishers in the Northeast and Southwest coasts said additional enforcement is *not* needed (83.3%, N = 35 and 65.9%, N = 58, respectively).

When averages for both the participation and compliance scales were compared between regions, results were statistically significant for the latter (F = 37.961, df = 3, $p<0.001$) but not the former (F = 1.107, df = 3, $p>0.05$). Post-hoc analyses show that comparisons are statistically significant except between the Northeast and Southwest coasts and between the East and the Southeast coasts. The Northeast and the Southwest coasts scored higher than the East and Southeast coasts on average on the compliance scale meaning Northeast and

Southwest coast fishers in general believe most fishers comply with rules and regulations (Figure 29 and Table 23).

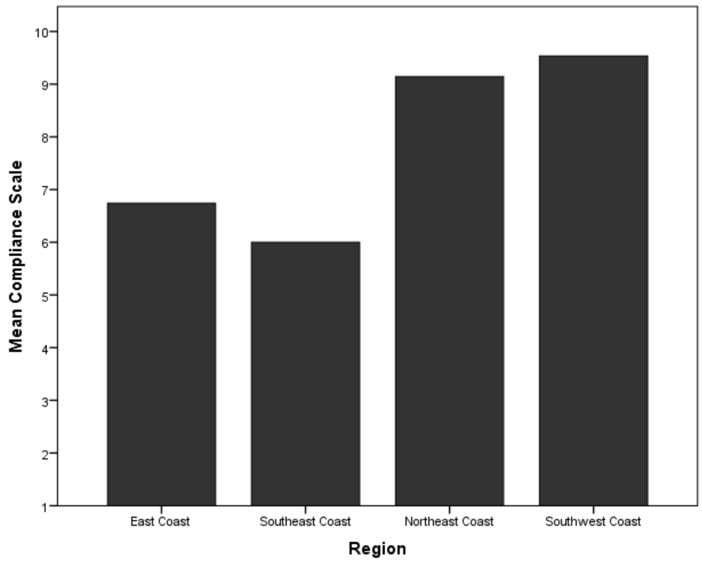

Figure 29. Regional comparisons of mean scores of fishers' perceptions on levels of compliance by fishers measured on a 10-point self-anchoring scale.

Table 22. Descriptive statistics for participation and compliance levels (measured on 10-point scales) by region.

Region	Variable	N	Minimum	Maximum	Mean	St. Dev.
East Coast	Participation Scale	52	1	10	5.75	3.283
	Compliance Scale	54	1	10	6.74	2.700
Southeast Coast	Participation Scale	28	1	10	5.82	2.495
	Compliance Scale	28	1	10	6.00	2.611
Northeast Coast	Participation Scale	41	2	10	4.95	1.788
	Compliance Scale	42	5	10	9.14	1.201
Southwest Coast	Participation Scale	88	1	10	5.42	1.898
	Compliance Scale	88	3	10	9.53	1.438

Results of comparisons between regions regarding whether or not fishers believe the local community can work together to solve local problems were not statistically significant ($\chi^2 = 7.105$, df = 3, $p>0.05$). The great majority of fishers in all regions said the communities can work together (East: 96.3%, N = 52, Southeast: 85.7%, N = 24, Northeast: 90.5%, N = 38, Southwest: 97.6%, N = 83).

Regarding regional comparisons of fishers' opinions on whether or not fishers can work together to solve problems in the fishery were statistically significant ($\chi^2 = 26.634$, df = 3, $p<0.001$). A higher relative percentage of fishers in the Northeast coast (28.6%, N = 12) and a very small percentage of fishers in the Southwest coast (1.2%, N = 1) said fishers are unable to work together (Table 23).

Table 23. Regional comparisons of the frequency of 'yes' responses to whether or not fishers can work together to solve problems in the fishery.

Region	% 'yes'	N
East Coast	94.40%	51
Southeast Coast	89.30%	25
Northeast Coast	71.40%	30
Southwest Coast	98.80%	84

Results of the regional comparisons regarding fishers opinions on whether or not fishers and the government should work together to solve problems in the fishery were statistically significant ($\chi^2 = 11.500$, df = 3, p<0.01). A relative higher incidence of Southwest coast fishers do not believe fishers and government should work together (Table 24).

Table 24. Regional comparisons of the frequency of fishers' responses to whether or not fishers and government should work together to solve problems in the fishery.

Region	% 'yes'	N
East Coast	92.60%	50
Southeast Coast	82.10%	23
Northeast Coast	92.90%	39
Southwest Coast	74.10%	63

Discussion

Results of surveys with 212 fishers in different communities in Puerto Rico representing the East, Southeast, Southwest, and Northeast coastal regions suggest that levels of dependency on fishery resources among Puerto Rican fishers is significant, as a large portion of the sample either depended entirely on fishing for a living or derived most of their income from fishing. The great majority of fishers were also the major household providers suggesting that income and nutrition from fishing are important to support Puerto Rican families and coastal communities at large.

Regional analyses suggest that the socio-economic impacts of fishing differ between fishing communities in different parts of the island. In the Southwest coast fishers tended to be more dependent on fisheries for income and also said more frequently they were the major household providers for larger households on average when compared to the other regions. While these results suggest higher levels of fishery dependency among Southwest coast fishers, this region had the majority of fishers who did not own their fishing boats but rather worked as crew for local *pescaderias*, thus, having less control over the means of production and being more vulnerable to losing access to their livelihood. This could explain the lower scores on the self-actualization component of job satisfaction in this region when compared to all others. Nonetheless, Puerto Rican fishers, in general, presented high levels of job satisfaction and scored high on the happiness scale suggesting that fisheries are not only important as a source of income and nutrition but it is also significant for fishers' social and psychological well-being. Qualitative data collected during this study provide insight into the aspects of the occupation that drive this significant attachment:

> "When I get under water and I see all the beautiful colorful fish I have no worries, no problems. It all goes away" (Naguabo fisher).
>
> "Fishing is like my therapy. If I stop fishing it will be bad for my health" (La Parguera fisher).

Our findings suggest that Puerto Rican fishers have relatively high levels of environmental awareness and many are concerned about the impacts of climate change and other anthropogenic impacts on the marine environment and the fishery resources. While the overall perception of the current status of fishery resources is that stocks are in somewhat good shape, most fishers perceive the resources to have declined in the past decade. Fishers believe that the most important reasons for this decline are pollution, overexploitation, changes in climate, and the negative effects of regulations. Regional differences also influenced fishers' views on the health of the resources. On the Southwest coast, fishers tended to have more positive views on the state of the fishery resources. Fishers in this region target mostly spiny lobster and queen conch and generally do not target reef fish species more commonly targeted in the other regions. This difference in target species may have driven the regional differences observed in fishers' perceptions of the health of the resources. However, the Southwest region also presented the lowest levels of environmental awareness and lowest scores on the anthropogenic impact scale when compared to the other regions. These findings suggest that fishers' overall perceptions of the effects of human activities on the environment are likely tied to their perceptions of the health of the fishery resources. In the Southwest, fishers were also the least concerned about overfishing when compared to the other regions. This potential link between fishers' environmental awareness and their perceptions of the health of the resources provides potential opportunities for outreach and education strategies to further sustainability goals by focusing on increasing environmental and anthropogenic impact awareness in general among fishers.

Although regional differences were found with regard to fishers' perceptions of the impacts of different anthropogenic and climate change related factors, fishers in all regions were overwhelmingly concerned about the impacts of pollution and coral bleaching affecting their fishing activity. One of the items with the highest scores on the environmental awareness scale relate to fishers perceptions of the importance of coral reefs for the health of the fishery resources. Fishers were also generally concerned about warmer sea temperatures. Fishers in Puerto Rico depend greatly on reef and reef dependent species and the majority of them dive into these habitats to fish, allowing them to observe and closely experience changes and impacts to the reefs and surrounding areas.

Environmental impacts most frequently associated with climate change by fishers were fish stock decline, habitat shifts including fish and shellfish moving farther from the coast and into deeper waters, change in composition of species, and increase in water temperature. Although it is difficult to differentiate fishers' perceptions of the different causes of the changes observed, e.g. climate change impacts versus overfishing, changes observed by fishers are in line with observed and predicted climate change impacts on marine ecosystems and organisms. Thus, our findings suggest that many fishers have an understanding of and are able to link changes in climate to changes in the marine environment affecting the fisheries.

These changes experienced by fishers have led to adaptations such as changes in fishing grounds, specifically having to fish in deeper water and farther away from the shore. Fishers also mentioned the need to change or diversify gear to increase productivity and target different species. Adaptations that involve traveling farther from the coast and fishing in deeper waters present potential risks especially for SCUBA divers, and in particular the risk of decompression sickness. It is interesting to note that aspects of the job relating to safety, healthfulness, and fatigue were generally the job satisfaction items with which fishers had the lowest scores, possibly reflecting concern over risks associated with the activities that could be further accentuated by the adaptations mentioned. Considering that most fishers are major household providers, these increased risks to fishers' safety and health further compound the vulnerability of their families and communities.

Findings of this study regarding aspects of fisheries governance suggest that in general fishers perceive their participation levels in decision-making as moderate, and most fishers believe more collaboration between fishers and government authorities is needed to improve fishery management strategies. The region where fishers had the most negative perceptions of the potential for fishers and government collaborations was the Southwest. Anecdotal data collected during the course of this study from conversations with fishers and other fishery stakeholders from the Southwest region provide some insight that help explain these findings. According to the information obtained, fishers in the region have negative perceptions of past interactions with government agencies which, in their view, used information obtained from fishers but did little to give continuation to collaborations and to involve fishers in future management decisions. Although we do not have enough information to infer on these mentioned past events, it is important to point out that the negative perceptions and overall distrust of the fishers was sufficient in this case to create barriers for future collaborations. This is particularly important since the overall majority of fishers interviewed do not perceive the fishery management decisions in Puerto Rico to be fair indicating that fishers may be less inclined to agree or accept regulations adopted.

Findings from the surveys conducted with fishers provide insight into issues raised during the key informant interviews. Although our data does not provide information on the overall dependence of Puerto Rican coastal communities on fisheries, it suggests that for individual fishers fishing is an important source of income, nutrition, and well-being in general despite the perceptions of some stakeholders that fishers do not depend on the activity for a living. Although previous research has shown that occupational multiplicity is an important characteristic of Puerto Rican fishing communities, there is enough evidence to suggest, including our findings, that fisheries and coastal-based resource extraction constitute important components of the cultural and socio-economic context of most coastal communities (see Garcia-Quijano et al. 2015). It is also important to point out, that diversity of livelihood and income is an important aspect linked to increased resilience of natural resource users in the face of natural seasonal changes and long-term environmental transformations.

Results of the survey effort also suggest that environmental and especially climate change awareness among fishers is higher than as perceived by some of the key informants representing government and other institutions working directly and indirectly with fisheries management. These findings, coupled with fishers overall willingness to collaborate with decision-makers in management decisions, suggest that opportunities exist for collaborative strategies focused on addressing challenges in the fisheries, particularly those challenges that are prioritized by all or most stakeholder groups. Our findings suggest that pollution, impacts of climate change, coral reef degradation, and improving communication between fishers and fisheries management authorities constitute common priorities among all stakeholders. These convergent topics provide opportunities to initiate and further increase collaborations and strategies to conserve and safeguard the sustainability of coral reef and fishery resources and the well-being of Puerto Rican coastal communities.

Part II: Impacts of Hurricanes Irma and Maria on Puerto Rican Fisheries and Fishers' Perceptions of Climate Change

This section of the report includes the major findings from the second data collection effort that took place between May and June 2018. This second effort was developed after hurricanes Irma and Maria devastated Puerto Rico, and it had as a major objective to assess impacts of the natural disasters on the fishers and fisheries on the island and also to collected similar data collected during the first period of the project to allow for comparative analysis. Similar questions pertained to fishers' perceptions of changes in climate and the environment and their concern over these changes, and aspects of job satisfaction and well-being. In addition to these topics, the second questionnaire included questions to assess direct impacts of the hurricanes on fishers, their families, and communities. The second questionnaire also included questions on demographics and fishery attributes similar to those asked during the first data collection effort. The full questionnaire can be seen in Appendix 13.

Methods of Data Collection and Sampling

The sample size for the post-storm period was 75 fishers from 11 municipalities, including the same ones visited during the first data collection effort with the exception of Culebra and with the addition of Arroyo and Lajas (Figure 30 and Table 25). The sampling method used was identical to the one used during the first phase of the project: an intercept method that consisted of approaching fishers at different fishing associations (*villas pesqueras*) and other locations where they were known to land their catches or congregate. Often times a networking sampling technique was used when fishers approached would mediate contact with other fishers.

Figure 30. Map of Puerto Rico showing municipalities surveyed in the second data collection effort (Adapted from USDA 2012).

Table 25. Sample sizes by region for the pre-storm (T1) and post-storm (T2) time periods showing communities grouped under each region.

Region & Municipalities	T1 N	T2 N
East Coast (Naguabo, Fajardo, Ceiba, Vieques, Culebra*)	54	26
Southeast Coast (Patillas, Guayama, Arroyo**)	28	12
Northeast Coast (San Juan, Cataño)	42	18
Southwest Coast (Cabo Rojo, Lajas**)	88	19
Total	**212**	**75**

*Community surveyed only in T1
**Communities surveyed only in T2

Analyses

Due to the smaller sample size of this second data collection effort, regional comparisons were not reliable for some complex variables and, thus, not presented for most analyses conducted in this section.

Characteristics of the Sample

The average age of the fishers surveyed during the post-storms data collection effort was 51.4 years and the average education level measured in years of formal education was 11.3 years. The majority of fishers (64%, N = 48) were married and had an average household size of 3.3. Fishers had on average 37.4 years of fishing experience (Table 26).

Table 26. Descriptive statistics of fishers' demographics for the post-storm period.

Variable	N	Minimum	Maximum	Mean	St. Dev.
Age	75	17	87	51.37	13.971
Education	75	0	16	11.35	3.419
Household Size	75	1	7	3.32	1.377
Fishing Experience	75	6	85	37.45	14.850

Aspects of Fishery Dependence and Occupation

Fishers were asked about their uses for the fish they catch. Individual fishers could mention more than one use. The most frequent uses were for income (76.1%^{R}, N^R = 67) and personal consumption (13.6%^{R}, N^R = 12). Other uses mentioned were to give away (8%^{R}, N^R = 7), barter, and pleasure (both 1.1%^{R}, N^R = 1).

For the majority of fishers (88%, N = 66) fishing was their only occupation. Out of the nine respondents who said fishing was not an occupation, seven were retired, one was a mechanic and one an electrician. The most frequent other occupations/sources of income mentioned by those who considered fishing an occupation were retired (23.3%^{R}, N^R = 7), and construction (13.3%^{R}, N^R = 4). See Appendix 14 for a complete list of occupations. Fishing was the most important source of income for the majority of the sample (66.7%, N = 50). Among those for whom fishing was not their primary source of income, four said sources of income were equal, 11 derived most their income from other occupations, and 10 from retirement pensions.

The majority of the fishers interviewed (86.5%, N = 64) were the major providers of their household. Most fishers said they give away some of the fish they catch to friends and family. The frequency in which they did so varied, with 61.3% (N = 46) giving fish to others 'sometimes,' 25.3% (N = 19) 'frequently,' and 10.7% (N = 10) 'all the time.'

Characteristics of the fishing activity

The most important fishing methods and gear types used by fishers surveyed in the post-storm period were SCUBA diving (26.9%^{R}, N^R = 36), handline (22.4%^{R}, N^R = 30), and traps (11.2%^{R}, N^R = 15) (Figure 31). See Appendix 15 for a complete list of methods/gear types mentioned by fishers in the post-storm period.

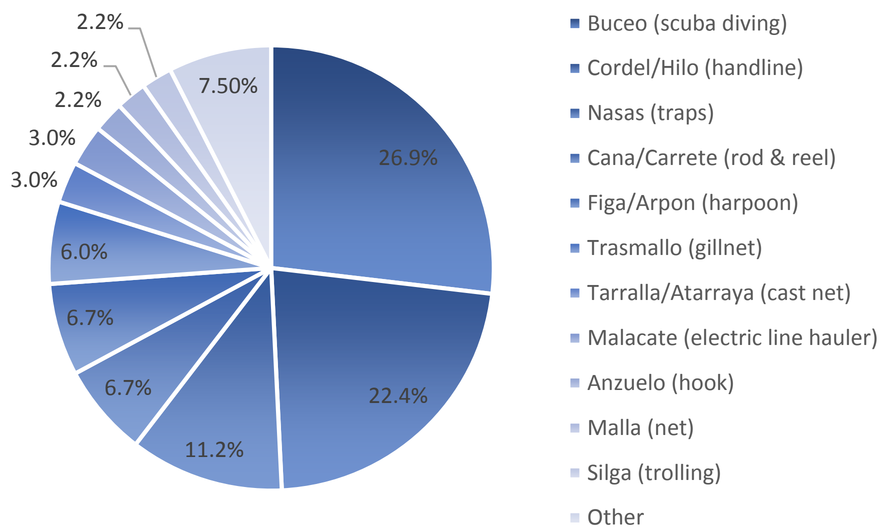

Figure 31. Most frequently used methods and gear types among fishers interviewed in the post-storms period. Percentages represent frequency of responses since individual fishers may use more than one method/gear type.

Target species most frequently mentioned by fishers were spiny lobster (12.8%^{R}, N^R = 41), queen conch (11.5%^{R}, N^R = 37), mutton snapper (9.3%^{R}, N^R = 30), and yellow tail snapper (9%^{R}, N^R = 29) (Figure 32). In terms of importance to fishers' income the top three species were yellowtail snapper (20%, N = 15), spiny lobster (18.7%, N = 19), and queen conch (16%, N = 12). See Appendix 16 for the complete list of species mentioned by fishers in the post-storm period.

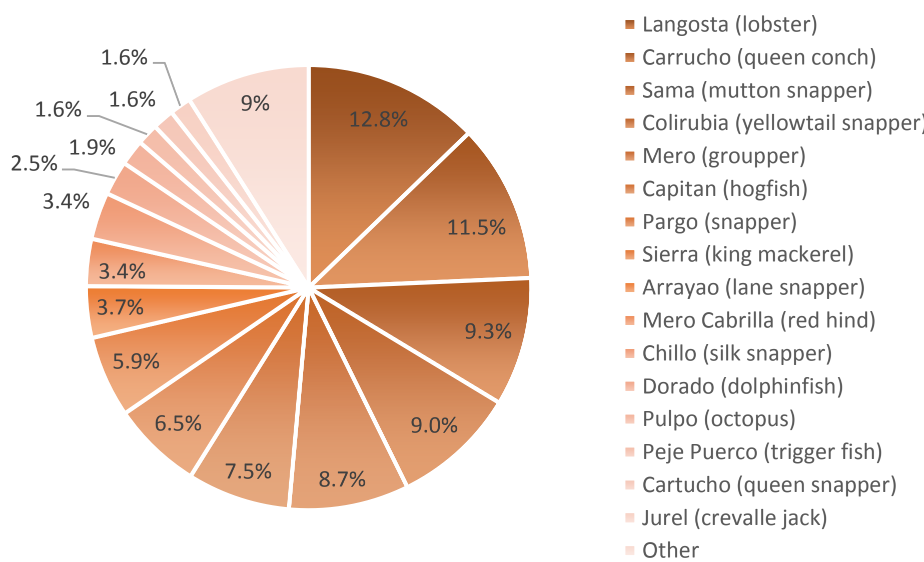

Figure 32. Most frequently species targeted by fishers interviewed in the post-storms period. Percentages represent frequency of responses since individual fishers could mention more than target species.

Average length of boats used by fishers was 20.2 feet (SD. = 3.0). The majority of fishers interviewed (66.2%, N = 49) owned the boat they use for fishing. Those who did not own their fishing boats were asked if the boat owners had more than one fishing boat and the majority (68%, N = 17) said 'no.'

Fishers were asked about their perceptions on the impacts of human activities on the environment and the climate by asking their agreement on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), reversed for negatively worded items, with the three statements seen in Table 27 along with mean values of responses to each variable. Mean values over 3 indicate that, for the most part, fishers believe that human activities influence the environment and climate.

Table 27. Perceptions on the impacts of human activities on the environment and the climate measured on a 5-point Likert scale ranging from 1 = 'strongly disagree' to 5 = 'strongly agree' except for items marked with an asterisk for which scale was reversed.

Human Impact Variable	N	Minimum	Maximum	Mean	St. Dev.
Human activities influence the coastal and marine environment.	75	1	5	3.85	1.171
Human activities influence the climate	75	1	5	3.37	1.271
There is no point in planning for the future; what happens, happens and we cannot do anything about it*	75	1	5	3.68	1.164

Impacts of Hurricanes Irma and Maria on Fishers and Fisheries

With regard to hurricane damage, respondents were asked whether their house, fishing gear, boat, or other personal items were lost or damaged. If there was loss or damage they were asked to rank the level of damage on a 4-point Likert scale with the levels minor, moderate, severe, or complete, respective scores being 1 through 4, with no loss or damage scored as zero.

Overall, a little over one half of the respondents reported damage to their house or fishing gear (both 52%, N = 39). Almost half (49.3%, N = 37) reported loss or damage for other personal items, and about one-fourth (24.7%, N = 18) said their boat was damaged or lost. Mean values for damage level reported for each item is in Table 28. The belonging with the highest overall damage level was gear.

Table 28. Mean value of damage level for different personal belonging measured on a scale of 1 to 4 from minor to complete damage.

Belonging Damaged or Lost	N	Minimum	Maximum	Mean	St. Dev.
House	39	1	4	2.26	1.093
Gear	39	0	4	2.87	1.196
Boat	18	1	4	2.56	1.199
Other Personal Belongings	37	1	4	2.27	1.146

Two scales were constructed based on the questions concerning loss and damage. The first (scale 1) is the total number of the four evaluated items (house, gear, boat, other) resulting in a score ranging from 0 to 4 (Cronbach's alpha = 0.54), and the second (scale 2), composed of the sum of the severity ranks for the items with a scale with a possible minimum value of zero and a maximum of 16 (Cronbach's alpha = 0.68). Between regions differences for these two scales were statistically significant with fishers in the East and Northeast coasts scoring higher than the other two regions (Table 29).

Table 29. Between region differences in total number and severity level indices of damages and losses from the hurricanes.

Region	**Scale 1**	**Scale 2**
East Coast	2.200	6.040
Southeast Coast	1.545	4.364
Northeast Coast	2.222	4.722
Southwest Coast	0.947	2.211
Kruskal-Wallis	*12.927*	*11.233*
p	0.005	0.011

There was also a question concerning physical injury to the interviewee or his/her family. Fortunately only three interviewees reported injury: one from the East coast and two from the Northeast coast. Finally, only three family members were reported to have received injury from the storm: two from the Northeast and one from the Southwest coast.

Those who reported any loss, damage, or injury were asked if they received any help or assistance and from whom. Sixty fishers answered this questions and 36% (N = 22) of them said they received assistance. The most frequently mentioned source of assistance by fishers interviewed was FEMA/DUA[4] (53.1%^{R}, N^R = 17). Some fishers (21.9%^{R}, N^R = 7) mentioned that they sought assistance from the government (e.g. FEMA) but at the time of the interview had not yet received it. Other sources of assistance mentioned were government in general (N^R = 5), NGOs (N^R = 2), and other people (N^R = 1).

Respondents who reported losses and damages were asked to rate their current level of recovery from the storms on a Cantril self-anchoring 10-point (1 = not recovered at all and 10 = completely recovered). The overall average was 5.54 (SD. = 3.1) indicating medium (a little over 50%) level of recovery. When asked about what factors or people had been most important for their recovery, ‘friends’ and ‘family’ combined accounted for 29.5%^{R} (N^R = 18) of responses. Other frequent responses were ‘myself’ (19.7%^{R}, N^R = 12), i.e. the respondent’s self-sufficiency was the most helpful aspect for their recovery, and ‘no help received’ (18%^{R}, N^R = 11). See Appendix 17 for a complete list of responses.

Fishers who reported damages and losses were also asked if there were any impediments to their recovery, and if there were, they were asked to list the impediments. Sixty four individuals responded to this question, and 34% (N = 22) said they experienced impediments. The most frequently mentioned impediments to recovery were no access to or lack of materials (25.8%^{R}, N^R = 8), inability to fish or damage to fishing infrastructure, and damage to infrastructure in general (e.g. no electricity) (both 22.6%^{R}, N^R = 7). Other impediments to recovery mentioned were lingering bad weather (N^R = 4), personal issues (N^R = 3), and no access or lack of money (N^R = 2).

The majority of fishers interviewed (68.9%, N = 51) said they did not consider leaving Puerto Rico after the storms. The most frequent reasons provided for staying were “don’t want to leave” (44.9%^{R}, N^R = 22) or “there is no need to leave” (18.4%^{R}, N^R = 9). For those who considered leaving Puerto Rico after the storms, reasons were mostly idiosyncratic (see Appendix 18 for a complete list). Reasons mentioned by more than one fisher were lack of electricity (N^R = 4), and not being able to fish (N^R = 2) or no income after the storms (N^R = 2). Three fishers said they left Puerto Rico right after the storms and returned.

Many of the fishers interviewed (42.5%, N = 31) had friends and/or family who exited the fishery after the hurricanes. They were asked about what these former fishers were currently doing for a living and the most

[4] Disaster Unemployment Assistance

frequent responses were that they emigrated (43.6%^{R}, N^R = 17) or are working in construction (17.9%^{R}, N^R = 7) (Table 30).

Table 30. Current status or jobs of people known to fishers who have exited the fishery occupation after the hurricanes.

Current status/job	N^R	% of Responses
Emigrated	17	43.6%
Work in construction	7	17.9%
Don't know	4	10.2%
Odd jobs	2	5.1%
Retired/Social security	2	5.1%
Farming/Animal husbandry	2	5.1%
Other	2	5.1%
Looking for jobs	1	2.6%
Work for private sector	1	2.6%
Landscaping	1	2.6%

Fishers were asked to rate their perceptions on the status of the fishery resources on a scale of 1 to 5 (1 = in very bad shape and 5 = in very good shape). Almost half of the fishers (45.5%, N = 34) said the resources are in bad or very bad shape (Table 31). They were also asked to compare the status of resources before the storms and at the time the interview occurred. The majority of fishers (70.3%, N = 52) said the resources were in worse shape than before the hurricanes (Table 32).

Table 31. Fishers' perceptions on the current status of fishery resources asked on a Likert scale of 1 (very bad shape) to 5 (very good shape).

Current Status of Resources	N	%
In very bad shape	14	18.667
In bad shape	20	26.667
In neither good nor bad shape	26	34.667
In good shape	12	16.000
In very good shape	3	4.000

Table 32. Fishers' perceptions comparing the status of resources before and after the hurricanes.

Status of Resources	N	%
Worse	52	70.270
Same	19	25.676
Better	3	4.054

Almost half of the fishers interviewed (48.6%, N = 36) said they go out fishing less frequently since the hurricanes (Table 33). The most frequently mentioned reasons affecting fishers' ability to go out after the storms were weather conditions in general (30.2%^{R}, N^R = 13), and bad ocean conditions (*marejadas*) (11.6%^{R}, N^R = 5). A complete list of reasons for changes in fishing frequency can be seen in Appendix 19.

Table 33. Percent of responses about frequency with which fishers go out fishing since the storms.

Frequency	N	Percent
Less	36	48.6
Same	29	39.2
More	9	12.2
Total	74	100.0

The majority of fishers interviewed (80.8%, N = 59) said they did not change target species nor gear type (90.4%, N = 66) as a result of the hurricanes. For the few fishers who had to change target species the reasons mentioned by more than one fisher were because there is less fish (N = 3) and not catching land crab (*jueyes*) since the storms (N = 2). Reasons for changing gear type were particular to each individual interviewed. Lists of all reasons given for changing target species and gear types after the storms can be seen in Appendix 20.

Some of the fishers (31.5%, N = 23) had to change the locations where they fish after the hurricanes. Explanations and reasons most frequently given by fishers were the need to fish farther from the coast (31.3%, N = 10), fishing in deeper waters (21.9%, N = 7), and changes in ocean bottom (tossing of "stones," damage to corals and seagrass) (18.8%, N = 6). A complete list of explanations and reasons for changing fishing grounds are in Appendix 21.

The hurricanes affected the amount of fish that fishers give away to family and friends for 43.8% (N = 32) of the fishers interviewed. Three fishers said they gave more fish away after the hurricanes. All others said the hurricanes reduced the amount of fish they give away for various reasons including being unable to go out as often to fish or because they needed the money more. A complete list of reasons can be seen in Appendix 22.

Fishers' Perceptions of Environmental and Climate Change Before and After Hurricane Impacts

Comparisons between the pre- and post-storms periods with regard to fishers' perceptions of the health of the fishery resources at the time each survey took place were statistically significant (U = 4183, p<0.001). In the post-storms period, fishers perceived the resources to be in worse shape on average (Table 34).

Table 34. Comparisons of fishers' perceptions on the health of the resource (scale of 1 to 5) before and after the storms.

Period	N	Minimum	Maximum	Mean	St. Dev.
Pre-storms	211	2	5	3.51	.836
Post-storms	75	1	5	2.60	1.090

Changes in perceptions on whether or not fishers experienced changes in climate were observed between the two time periods studied. A higher relative percentage of fishers said they experienced changes in climate during the post-storms period (89.3%, N = 67) when compared to the pre-storms period (72.6%, N = 154) (χ^2 = 8.717, df = 1, p<0.01).

Perceptions of the status of climatic changes observed as well as levels of concern about changes observed were also statistically significantly different between the two time periods studied (Table 35). In the post-storms period, fishers perceived climatic changes as worse and were more worried about changes when compared to the pre-storms period.

Table 35. Comparisons of fishers' perceptions on the status of climatic changes observed (scale of 1 to 5) and concern about changes (scale of 1 to 10) in the pre- and post-storms periods.

Variable	Period	N	Min.	Max.	Mean	St. Dev.	Mann-Whitney U	p
Climate Change Status	Pre	154	1	4	2.36	.756	3914.000	p<0.01
	Post	68	1	3	2.00	.691		
Climate Change Concern Scale	Pre	207	1	10	6.67	2.500	4718.000	p<0.001
	Post	75	1	10	8.31	2.661		

Fishers' perceptions of different climate change and anthropogenic factors affecting the fishery also differed when the pre- and post-storms periods were compared (Figure 33). The only factor that presented a statistically significant decrease in the post-storms period with regard to the frequency of fishers who stated that it affects their fishing activity was coral bleaching. However, the total frequency of fishers who said coral bleaching to be affecting the fishery in the post-storms was close to 70%. Factors that presented a statistically significant increase in the post-storms were increase in frequency and severity of storms, increase in seaweed, sea level rise, increase in air temperature, and droughts (Figure 33 and Table 36). Analysis comparing the overall score on the *Anthropogenic Impact* scale of 1 to 10 created by summing the factors in Table 36 shows a statistically significant increase in average scores in the post-storms when compared to the pre-storms period (Table 37).

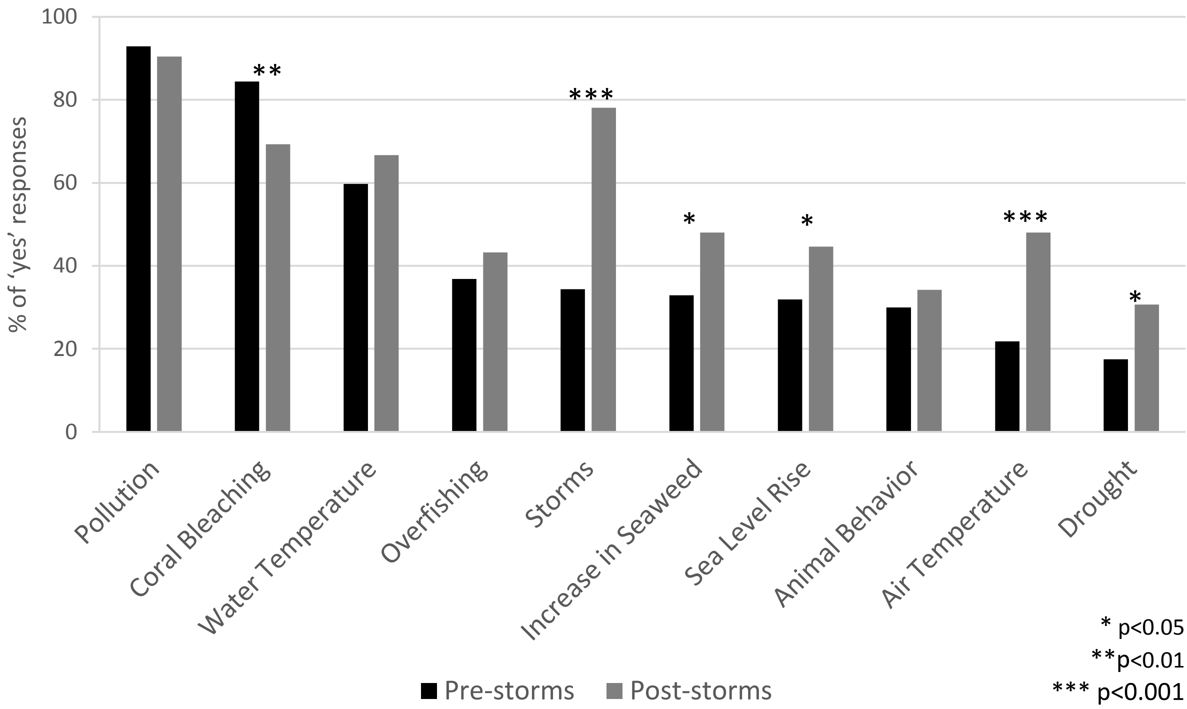

Figure 33. Comparisons of frequencies of anthropogenic and climate change factors fishers mentioned as affecting the fishery before and after the hurricanes.

Table 36. Frequency of 'yes' responses and chi square results of comparisons of frequencies of anthropogenic and climate change factors fishers perceive as affecting the fishery before and after the hurricanes.

Impacts/Factors	Pre-storm	Post-storm	χ^2	df	p
Pollution	92.9	91.7	0.124	1	>0.05
Coral Bleaching	84.4	69.3	7.935	1	<0.01
Increase in Water Temperature	60.0	66.7	1.040	1	>0.05
Overfishing	36.8	43.2	0.964	1	>0.05
Increase in Frequency of Storms	34.4	78.1	41.702	1	<0.001
Increase in Seaweed	32.9	49.3	6.287	1	<0.05
Sea Level Rise	31.9	45.2	4.194	1	<0.05
Change in Animal Behavior	30.0	34.2	0.456	1	>0.05
Increase in Air Temperature	21.8	48.6	19.269	1	<0.001
Increase in Droughts	17.5	31.1	6.048	1	<0.05

Table 37. Comparison of scores on the Anthropogenic Impact scale (1 to 10) between the pre- and post-storms period.

Period	N	Minimum	Maximum	Mean	St. Dev.
Time 1	202	0.00	10.00	4.3663	2.40117
Time 2	66	0.00	10.00	5.5455	2.17101
U = 4481, p<0.001					

Analyses comparing pre- and post-storms periods with regard to the job satisfaction components and happiness scale values can be found in Table 38. Comparisons were statistically significant for the *Basic Needs* and *Health* components, with fishers scoring lower on both components during the post-storms when compared to the pre-storms period.

Table 38. Comparisons of pre- and post-hurricanes job satisfaction and happiness mean scores.

Variable	Period	N	Mean	St. Dev.	t	df	p
Basic Needs	Pre	192	0.175	0.897			
	Post	66	-0.520	1.106	5.103	256	<0.001
Self-actualization	Pre	192	-0.038	0.968			
	Post	66	0.185	1.077	-1.566	256	>0.05
Health	Pre	192	0.087	0.949			
	Post	66	-0.364	1.073	3.218	256	0.001
Happiness Scale	Pre	202	9.307	1.291			
	Post	74	9.459	1.435	-0.843	274	>0.05

Discussion

Surveys with 75 fishers in different communities in the Northeast, East, Southeast, and Southwest regions of Puerto Rico eight months after hurricane Maria made landfall (May – June 2018) provided valuable information regarding the impacts of the storms (Irma and Maria) on fishers and fisheries on the island and allowed for comparisons between the two time periods that reveal important information about the effects of coastal hazards on coastal communities' perceived vulnerability to change.

Similar to findings in part one of this report, most fishers in the sample depended heavily on fisheries as a source of income and nutrition for themselves and their families, and for the majority of them fishing was their only occupation. In addition to their direct dependence on fisheries, findings suggest that fisheries is also an important source of nutrition for members of the coastal communities at large, as most fishers interviewed said they frequently give away fish to friends and family.

Although spiny lobster and queen conch were also the most significant target species among fishers interviewed during the second data collection effort, the relative contributions of other species of finfish including many species of reef fish were higher. This may be explained by different relative contributions of fishers from different regions between the first and second time periods as well as seasonality.

While the environmental awareness indicators used in the pre-storms period were not replicated during the second data collection, aspects of fisheries perceptions of the human impacts on the environment and the climate were assessed. Results indicate that, overall, fishers present moderate to high levels of awareness regarding the impacts of human activities on the marine environment and the climate.

In terms of the direct impacts of the hurricanes on the fishers and fisheries of Puerto Rico, the most significant possessions to sustain damage or loss were fishers' houses and fishing gear. Gear losses were most significant in terms of severity with a high number of fishers reporting moderate to severe damage on average. Qualitative data obtained during the second data collection effort suggests that the most frequent gear damage or losses occurred to fishers who lost their traps during the storms. Trap fishers in Puerto Rico typically place their traps on the ocean bottom and dive to them to retrieve fish and shellfish as opposed to lifting them out of the water. Thus, even in the event of a hurricane, traps are not removed and secured, increasing the risk of damage and losses. Direct impacts of the storms in terms of frequency and severity of damage and losses were higher among fishers in the East and Northeast coasts. This makes sense since communities in these regions were more directly exposed and sustained more force from the hurricanes in general when compare to other parts of the island.

Even eight months after hurricane Maria, levels of recovery reported by fishers can be characterized as moderate. Although many fishers said they received assistance from FEMA/DUA, when asked about the most important factors helping in their recovery, most fishers said that friends and family as well as their own self-sufficiency were most significant. Fishers interviewed reported that some of their fellow fishers left Puerto Rico after the storm. For those who stayed and did not consider leaving the most important reason for doing so was their attachment to their homeland and communities as opposed to external impediments.

About half of the fishers interviewed said the storms affected the frequency with which they go out fishing as well as their ability to give fish away to family and friends. Those fishing less after the storms said that lingering bad weather and ocean conditions were the main reasons preventing them from going out as frequently. Analysis of meteorological conditions could be used in future analyses of this data to test whether these findings reflect objective or subjective perceptions of the impacts of the storms on the ability of fishers to go out at their desired frequency.

Fishers in general reported no changes in target species or methods and gear types used. The most frequently mentioned changes in the fishery after the storms were changes in fishing location. Fishers said they had to shift fishing grounds to farther and deeper areas and many attributed location changes to the impacts of the storms on the ocean bottom such as corals and seagrass beds destruction. Although results of the pre-storms data collection suggest that fishers were already changing fishing grounds into farther and deeper waters to adapt to change, it is possible that the impacts of the storms on coastal reefs and resources further contributed to the issue.

Fishers interviewed during the post-storms period generally perceived the fishery resources to be in worse shape when compared to before the impacts of the hurricanes. Data collected before and after the hurricanes asking fishers to rate the health of fishery resources at the time the survey took place support this perception as results show that fishers in the pre-storms period rated the fishery resources to be statistically significantly healthier when compared to the post-storms period.

Other aspects of fishers' perceptions of environmental and climatic changes differed significantly between the pre- and post-storms periods. Overall perceptions that the climate is changing, changes to the marine environment and species related to climate change, as well as concern for these changes all increased between the pre- and post-storms periods. Specific factors related to anthropogenic and climate change impacts, especially increase in frequency and intensity of storms, also became more important as factors affecting the fisheries in the post-storms period. These findings suggest that fishers' experiences during the recent natural disasters had a significant effect on aspects of their perceived vulnerability to climate and environmental change in general.

Comparisons between the pre- and post-storms assessments suggest that the hurricanes impacted fishers' levels of satisfaction with the *Basic Needs* and *Health* components of job satisfaction. Reported storm impacts on fishers' ability to fish and obtain income likely explain the decrease in satisfaction with *Basic Needs*, which relates to income and independence. Lower scores on the *Health* component, which includes aspects of healthfulness and fatigue, may be explained by the reported changes in fishing grounds, which is likely to increase travel time, and potential changes in fishing effort to adapt to changed conditions. Despite the significant impacts of the storms on fishers and fisheries in Puerto Rico, results of this study show that aspects of the occupation relating to self-actualization as well as fishers' happiness levels were not affected by these natural disasters. These findings emphasize the notion that fishers derive a great deal of social and psychological well-being from fisheries and this aspect of the occupation is likely to contribute positively to their resilience to change and adversity.

Outreach Strategies

Introduction

Research has shown that successful communication strategies utilized to increase stakeholder and community understanding consist of a range of dissemination tools and include research summaries, policy briefs, electronic and web-based outreach tools, and oral presentations (Mitton et al. 2007). This section of the report focuses on the communication strategies utilized to share results of this study in order to increase stakeholder and community understanding and support for coral reef fisheries health and well-being. In addition to the more traditional methods of dissemination which included presentations at scientific conferences[5] and the submission of manuscripts, results of this project have also been shared more directly with Puerto Rico and Caribbean community and fishery stakeholders through invitations to present at the Climate Change Summit organized by Vice-President of the Senate Larry Seilhamer at the Puerto Rico Capital Building[6], and at the Caribbean Fisheries Management Council general meeting[7]. This report is also presented in a format favorable for the dissemination of findings to different stakeholders, more specifically the scientific community and policy makers. One particular concern we have had from the start of the development of this project regards communication and outreach directly to the fishers in a format also appropriate for reaching the general public. In this section of the report, the strategy we used for communicating findings with fishers is emphasized, since there is not much information available on the best methods for communicating research findings to fishers. It was discovered early in this research that traditional means such as written material, oral presentations, and formal meetings were not the most effective strategies and, therefore, we decided to utilize a visual strategy, via video format, as the primary dissemination tool.

A video format was selected because it is considered a powerful communication tool and can present information that may be difficult to communicate in traditional format. Videos can provide messages about issues of value to stakeholders in a more accessible format and reach a more diverse audience. Video formats can prevent missed opportunities to share information when only print-based materials or scheduled presentations are provided. Videos can also incorporate infographics, defined as a visualization of data, as a method to communicate information to a targeted audience in a format that is easier to comprehend (Smiciklas, 2012). We also wanted to incorporate a participatory approach to the development of this outreach tool. To accomplish that, we developed a method of ground truthing the video prior to its finalization by visiting different fishing communities and sharing the initial draft of the video. During this process we asked fishers to provide input and feedback that could be incorporated into the final version of the video. The details of the methodology used to develop and ground truth the video outreach strategy is outlined below.

Methodology

The video script was developed to specifically communicate with fishers and the general public as the target audience. The script included: an introduction to the project, results for attributes of the fishers interviewed including major species targeted and gear utilized, fishers' perceptions of climate change and aspects of fisheries

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[5] Including to date oral presentations at: The Society for Applied Anthropology Annual Meeting, Santa Fe NM (2017), The Coastal & Estuarine Research Federation Biannual Meeting, Providence RI (2017), The Tenth International Conference on Climate Change: Impacts & Responses, Berkeley CA (2018), The 7th International Conference on Environmental Future: Humans and Island Environments, Honolulu, HI (2018), and The Society for Applied Anthropology Annual Meeting, Philadelphia PA (2018).

[6] San Juan, June 2018.

[7] US Virgin Islands, August 2018.

governance, and a conclusion. The video script in English is presented below in full. The video was also created and made available in Spanish.

The Script

Introduction: Coral reefs are considered one of the most diverse and productive ecosystems on Earth. Healthy coral reefs are essential to the people of Puerto Rico. Many generations of fishers have depended on coral reef organisms to provide income and household nutrition. However, the coral reef ecosystems in Puerto Rico are under threat due to a number of human impacts including climate change. Our changing climate has resulted in warmer ocean temperatures which cause coral bleaching and potential coral death. The loss of coral affects other species that depend on the reef, and also the fishers, their livelihoods, and way of life.

Attributes of fishers: To gain knowledge about Puerto Rico fishers' perceptions of environmental change, specifically about our changing climate, researchers spent the summer of 2016 interviewing 212 local fishers. Individuals interviewed lived and fished in different geographic regions and included 54 from the East coast, 28 from the South coast, 42 from the North coast, and 88 from the West coast. 3.5 out of 5 fishers interviewed considered themselves to be full-time commercial fishers, 1.2 out of 5 were part-time fishers, and less than 1 out of 5 were recreational fishers. The average age of the fishers interviewed was 50 and the average fishing experience was 36 years.

*Major species targeted and gear used***:** In order to determine if the fishers felt their occupations were being impacted by climate change, the researchers asked a number of questions about their professions including questions about targeted species, gear utilized, and the geographic areas where they fished. In the West, target species fishers said most frequently to be the most important for their incomes were spiny lobster and silk snapper, and fishers most frequently used scuba diving, seine nets, and traps to capture these species. In the North, the most valuable species were snappers in general, specifically the yellowtail snapper, and king mackerel and the most important gear types were rod and reel, gillnet, scuba diving, and harpoon. Along the East coast, the most valuable target species for income were spiny lobster, queen conch, and yellowtail snapper, and the most frequent gears used were scuba diving, traps, handline, and harpoon. Along the South coast the top species contributing to fishers' incomes were silk snapper, queen conch, lane snapper, and whitemouth croaker and fishers most frequently used traps, handline, and nets to capture these species. Researchers consulted with coral reef fishery biologists who suspect that warming waters may extend the spawning seasons for some species, specifically conch and red hind.

Perceptions of climate change: 3.6 out of 5 fishers believe that the climate in Puerto Rico is changing, and their concern with climate change is considered moderate to high. Some fishers reported that they had to make changes in their fishery because of climate change. Such changes include: changing fishing grounds, changing the type of gear or species they target, fishing in deeper water or fishing further away from the shore, having to change the time of day they fish, needing better equipment, and having to increase their effort. The fishers interviewed also felt that the fisheries were at risk due to other environmental stressors. 4.6 out of 5 of the fishers feel that the fishery is at risk due to pollution, 4.2 out of 5 of the fishers think coral bleaching is a threat, and 3 out of 5 believe increasing sea temperatures are affecting the fishery. A majority of fishers also felt that if corals die, it will be bad for fishing.

Governance: The majority of the fishers (4.2 out of 5) believe that fishers and government authorities should work together to manage the fishery resources. However, fishers feel that currently they are not able to participate and provide their input when decisions are made.

Conclusion: Climate change is a serious threat to coral reefs and marine organisms. Fishers are concerned about climate change because this threat can affect their jobs and their livelihoods. The fishers we interviewed have a strong passion for what they do and they are aware that threats such as pollution and coral bleaching must be addressed. Scientists and managers are also concerned about these threats. Solutions will require collaboration between fishers, government agencies, and scientists and also other stakeholders and members of the community. Each one of these parties have important knowledge that must be shared and used to create better strategies to protect the coral reef ecosystems and conserve and manage fishery resources. By working together, we can all contribute to a healthier future for the environment and the people of Puerto Rico.

Video Design

A collaborative approach was taken with the graphic design department at the University of New Haven in Connecticut, who supported the project and agreed to incorporate a video assignment as a major term project for an upper level course. Student groups were given the charge to develop custom graphics, infographics, and animations to complement the script. Other parameters included minimal text and a five-minute time frame. After viewing all preliminary projects at the end of the 2017 spring term, one senior student was selected to complete the final project to be piloted in Puerto Rico during the summer of 2017. University faculty members, both native Puerto Ricans, agreed to translate the script and narrate in Spanish.

As part of our outreach effort and participatory approach, we returned to Puerto Rico for 14 days during the summer of 2017, visiting the four different regions and v*illas pesqueras* sampled during the first data collection phase and piloted the animation video with the aid of a tablet computer. The objective was to obtain fishers' perceptions and feedback on the video content as well as their reception of this method as a means of information dissemination and a tool for generating discussion. The video was shown face-to-face to individuals and sometimes in a focus group format. Based on discussions with fishers, the video script and graphics were modified to incorporate some of the necessary changes identified from the feedback received. A final version of the video is available here.

Results

Participatory Approach

A total of 32 fishers watched the video, 13 individually and 19 in a focus group format, including 8 in the Northeast, 10 in the East, 7 in the Southeast, and 7 in the Southwest. The video was well received by every fisher who viewed it. Words used by fishers to describe the video include truthful, good, and powerful (*muy fuerte*). Several fishers stated it was an effective way of communicating information. Fishers commented that it was important and interesting to learn about fishers in other regions, targeted species, and gear utilized. Fishers stated that viewing the video made them feel connected to a larger community of fishers, many who expressed similar concerns. For instance one fisher stated "*the video gives us a voice.*" A sense of pride was observed when, for instance, a fisher pointed at the screen to indicate his region, and others shared pictures or personal videos of an impressive catch afterwards. A common recommendation expressed by several fishers was the need to include other stakeholders in the video segment about collaboration. While the fishers and the government are often considered key stakeholders, there are many others to consider, including the people who want to eat fresh fish at a restaurant. A fisher stated:

"*They all should be included in the video. We all love to eat fresh fish but nobody wants to let us fish*."

Another indicator of video approval was fishers who enthusiastically gave their e-mail addresses so that they could receive a link and share the video with other fishers, friends, and family. This happened with fishers who held high committee positions (vice president, president, secretary) within the *villa pesqueras* as well as those who did not.

Ground Truthing

The process of showing the video initiated discussion about the findings and other issues and concerns the fishers had. The video script was designed to report the findings of fishers' perceptions of climate change and several agreed that this was the most important aspect of the video. Fishers that SCUBA dive reiterated that they see a lot of dead, dying, and bleached corals. The fishers felt the video validated their local ecological knowledge by sharing how long and how often they are around the coral reefs:

"*I have seen the changes in the environment in the last ten years*."

"*We see the changes out there every day*."

"We have knowledge but they are not interested.""

A majority of fishers also expressed concern about the impacts of pollution affecting the local ecosystems, specifically the reefs, and how this impacts their livelihoods. Pollution was characterized as litter, chemicals released during dredging (in the Northeast), sewage, and engine oil. Increased *Sargassum*, the invasion of lionfish (*Pterois volitans* and *Pterois miles*), and the use of gillnets were other concerns. These concerns were perceived as having a negative effect on the coral reefs and fisheries. Other stakeholders (e.g. boaters) were discussed including damage from individuals who anchor recreational vessels at reefs:

"*Too many pleasure boats in the water polluting and damaging the corals with their anchors*."

Tension between commercial and recreational fishers was another concern mentioned by several fishers who viewed the video. These two "communities" are considered separate and while several fishers stated they did not believe there was a great deal of conflict between the two, there is, at times, animosity. Recreational fishers do not need to obtain a license, pay for permits, or provide information about their catches (statistics). While licensed commercial fishers have to adhere to limits and regulation, recreational fishers do not. Recreational fishers may sell their catch, even when they know they are not supposed to. A few fishers mentioned that when recreational fishers sell the catch for less than the market price, it has a negative effect on the commercial fishers. Some fishers also mentioned tensions between the tourism sector, fishers, and government interests, especially in the East where there is conflict over coastal land use.

Fishers expressed a willingness to collaborate with decision-makers in management decisions. One fisher commented this was the most important aspect of the video. Several fishers stated it was difficult to deal with the government. Changes in government staff, strict regulations, and regulations that change every few years were reasons expressed. Fishers also commented on the commercial licensing system which magnifies the challenges faced because it is bureaucratic and can be difficult to obtain. Regulations, especially fishery closures were considered positive and helped the resource, especially for conch and spiny lobster limits. However, regulation limits on incidental catch (bycatch), especially for deep water fish that were discarded dead, were considered unfair.

Conclusions

Communicating information between stakeholders in a relatable format can inform, generate important discussion, and result in stronger stakeholder relationships. Results of the video effort indicate that fishers are supportive of visual learning methods as a strategy for information sharing. In fact, a majority of fishers expressed an interest in learning the results of this interview and survey data. This method of information sharing may be met with higher acceptance and compliance by fishers, thus resulting in more effective management for increasing sustainability and well-being in fishing communities.

Policy Recommendations

A socioeconomic assessment of individuals engaged in fishing activities in Puerto Rico's coral reef areas was completed in order to obtain information valuable for addressing the challenges associated with fisheries management and coral reef conservation under climate change. This section of the report provides management and policy recommendations that focus on supporting resilience and well-being at the local scale while safeguarding the sustainability of coral reef fishery resources. We utilized a participatory approach to conducting this socioeconomic assessment, therefore ensuring that stakeholders' major priorities and concerns were effectively considered and addressed. While we have addressed policy considerations and provided information useful for the application of our findings into fisheries policy and management throughout our final report and other outreach materials, the following represent some of our specific recommendations:

A. Maximize involvement of fishers in the policy decision making process. Stakeholders' involvement should be participatory and take into account local ecological knowledge.

Fishers have expressed a willingness to collaborate with decision-makers in management decisions, but find it difficult. As evidence by conversations with our stakeholders, fishers feel they do not have a voice when decision-makers are identifying problems and developing solutions. When a group of stakeholders expect their voices will be ignored, they may be less likely to be involved in the planning process. We recommend implementing strategies to increase involvement and meaningful engagement of the individuals most affected by these issues. Strategies should be put in place to reach the fishing communities more broadly as opposed to those individual fishers who already attend meetings and are more vocal in the decision-making process. While those individuals can be important leaders in the policy process, it is important not to alienate others. During key informant interviews and conversations with fishers, it became clear that many of them view decision makers, managers, scientists, and government agents as *distant* and *removed*. Increasing involvement includes:

- Creating opportunities for face-to-face communication with fishers from each region. We recommend that more face-to-face communications should take place at the *villas pesqueras*.
- Developing strategies to allow fishers to share their knowledge and concerns. Periodic interactions through annual surveys and interviews, informal meetings, and the establishment of a more direct line of communication for fishers would increase opportunities to engage in active participation.

B. Develop strategies to increase collaboration between stakeholders by focusing on unifying concerns identified as important issues by different groups of stakeholders.

Interactions between policy makers, scientists, government officials, and fishers typically occur to address issues that are *fishery* related. Yet, as evidenced by our key informant interviews, different stakeholder groups share concerns about a number of broader environmental issues including algal blooms, pollution, and coral bleaching. When opportunities arise, we recommend utilizing common issues of concern to increase collaboration among various stakeholders. Measures that focus on areas of agreement can facilitate communication, help build trust, and lead to circumstances more favorable to address issues of more divergent nature.

C. Develop a plan to increase adaptation and resilience of Puerto Rico's fishers and coastal communities to climate change.

Environmental and especially climate change awareness among fishers is higher than perceived by some of the key informants we interviewed who represent government and other institutions working directly and indirectly with fisheries management. Fishers are aware of and concerned about the impacts of environmental change on their overall well-being. One of our key informants, a president of a fishing association, stated that very little has been done to understand the impacts of climate change on fishers and fishing communities and that Puerto Rico and the Caribbean at large are in urgent need of a plan for adapting to the impacts of climate change. Other stakeholders shared concerned about the lack of preparation and designated adaptation strategies in place for fishers and coastal communities. For these reasons, we recommend that a strategic plan for climate change adaptation, that is specific to fishing and coastal communities, is developed in collaboration with fishers and fishery stakeholders.

D. Reassess the fishery licensing system to better reflect local fishing practices.

Fishers do not perceive the current licensing system to be adequate and in line with their actual practices. The current licensing system in Puerto Rico requires that fishers provide proof of income deriving from fishing in the form of tax documentation in order to be considered eligible for either part- or full-time fishing licenses. As shown by previous research (see Garcia-Quijano et al. 2015, Griffith and Valdés-Pizzini 2002) and evidenced by our findings, the fishery sector in Puerto Rico has been historically characterized by occupational multiplicity with many fishers practicing the activity to complement their income and overall well-being. This practice may be in conflict with the current licensing system, therefore unintentionally creating an incentive for unlicensed and, thus, under- or unreported fishing activity. Further, recreational fishers currently do not need a license to fish in Puerto Rico. Commercial fishers are aware that many unlicensed fishers often sell their catch. During interviews, some stakeholders in the fishery sector stated that, although they perceive this system as unfair, they understand that some people need to fish and they are often unable to obtain a license either because they are unable to document their activities or because they do not fish frequently enough to qualify for a commercial license. One owner of a fish market we interviewed stated that about half of the fishers selling fish to his market do not have licenses, but he said he knows that they depend on this income and therefore he accepts it.

One of the most significant challenges previously identified as hindering the adequate management of fisheries in Puerto Rico (Garcia-Quijano 2009) is the lack of trust between fishers and government agencies responsible for managing the fisheries. Friction between the two parties can lead to lack of support and non-compliance by resource users which consequently affects the quality of the data provided which, in turn, impacts the effectiveness of the management strategies implemented. Reassessing the licensing system to better account for local practices and occupational multiplicity would be an important step to improve the relationship between fishers and management authorities and will likely also better reporting and statistics, thus improving fishery management strategies in Puerto Rico.

E. Incorporate more diversified strategies to share knowledge with fishers on a regular basis.

During the course of this study we talked to many fishers who expressed willingness to share more information with researchers and managers. However, many perceive that, when they do, outcomes of this process are not adequately shared with them. We encountered instances in which this perception led to fishers believing that the government authorities use the information shared by fishers to create rules and regulations to hurt them and, thus, many no longer wish to partake in collaborations with managers or researchers. We believe implementing better and more consistent strategies to communicate and report findings to fishers is important for the development and maintenance of a more trustful and fruitful relationship. For instance, in this research we used a video format as the primary dissemination tool and we found this to be an adequate way to communicate results and initiate conversations about such results with the fishers. Different communication tools can help present information that may be difficult to communicate in more traditional format. Strategies that can provide information about issues of value to stakeholders delivered in an accessible format help prevent missed opportunities to share information.

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Appendix 1

Questionnaires used to interview key informants in English and Spanish:

Name (optional):
Occupation/Affiliation:
Years of Experience in Occupation/Field:
Community/Area/Location:

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1. Describe your involvement with Puerto Rican fisheries.
2. In general, how would you rate Puerto Rico coastal communities' dependency on fisheries for their livelihood?
   1. Very Dependent; 2. Somewhat Dependent; 3. Not Dependent
   2.1. Describe (e.g. In what ways? Why do you think that is?).

3. In general, how would you rate Puerto Rico coastal communities' dependency on coral reefs for their livelihood?
   1. Very Dependent; 2. Somewhat Dependent; 3. Not Dependent
   3.1. Describe (e.g. In what ways? Why do you think that is?).

4. What would you say is(are) the major problem(s) facing fishing communities in Puerto Rico? (If more than one please rank them in order of importance).

5. Have you observed any changes to the fishery, environment, or other natural resources in Puerto Rico that you think can be attributed to climate change? Describe.

6. In your opinion, are Puerto Rican fishers concerned about climate change? Why or why not?
7. In your opinion, are Puerto Rico fishery manager/decision-makers/researchers concerned about climate change? Why or why not?

8. Do you think people in this community can work together to solve community problems? Why or why not?

9. Do you think fishers could work together to solve problems in the fishery? Why or why not?
   9.1. Can you think of any examples of this kind of community action occurring now in Puerto Rican fisheries? Describe.

10. Do you think the government and fishers could work together to solve problems in the fishery? Why or why not?
    10.1. Can you think of any examples of this kind of participatory action occurring now in Puerto Rican fisheries? Describe.

11. Do you feel that fishery management in Puerto Rico is fair in the decisions they make? Why or why not? Be specific.

12. Do you think most fishers understand how managers make decisions? Why or why not?

13. In general how would you describe the relationship between fishers and fishery managers/decision-makers?

14. If they exist, how are conflicts between fishers and between fishers and managers/decision-makers resolved?

Nombre (opcional):
Empleo/Afiliación:
Años de experiencia en el empleo/campo:
Comunidad/Área/Lugar:

1. Describa su involucración con las comunidades y actividades pesqueras puertorriqueñas.

2. En general, ¿podría indicar cuánto dependen las comunidades costeras puertorriqueñas de la pesca para ganarse la vida?
   1. Mucho; 2. Más o menos; 3. Nada
   2.1. Describa (por ejemplo: ¿De qué maneras? ¿A qué se debe esto?).

3. En general, ¿podría indicar cuánto dependen las comunidades costeras puertorriqueñas de los arrecifes de coral para ganarse la vida?
   1. Mucho; 2. Más o menos; 3. Nada
   3.1. Describa (por ejemplo: ¿De qué maneras? ¿A qué se debe esto?).

4. ¿Cuál o cuáles diría usted que es o son los mayores problemas que enfrentan las comunidades pesqueras de Puerto Rico? (Si son más de uno, por favor póngalos en orden de importancia.)

5. ¿Ha observado usted cambios en la pesca, el medioambiente u otros recursos naturales en Puerto Rico que usted le pueda atribuir al cambio climático? Describa.

6. En su opinión, ¿están preocupados los pescadores por el cambio climático? ¿Por qué sí o no?

7. En su opinión, ¿están preocupados los administradores de la pesca/personas que toman decisiones/investigadores por el cambio climático? ¿Por qué sí o no?

8. ¿Piensa usted que la gente de la comunidad puede trabajar colectivamente para resolver problemas comunitarios? ¿Por qué sí o no?

9. ¿Piensa usted que los pescadores pueden trabajar colectivamente para resolver problemas de la pesca? ¿Por qué sí o no?
   9.1. ¿Puede pensar en ejemplos de este tipo de acción comunitaria que estén ocurriendo ahora en las actividades o comunidades pesqueras puertorriqueñas? Describa.

10. ¿Piensa usted que el gobierno y los pescadores pueden trabajar juntos para resolver problemas de la pesca? ¿Por qué sí o no?
    10.1. ¿Puede pensar en ejemplos de este tipo de acción participativa que estén ocurriendo ahora en las comunidades o actividades pesqueras puertorriqueñas? Describa.

11. ¿Piensa usted que los administradores de la pesca en Puerto Rico sean justos en las decisiones que toman? ¿Por qué sí o no? Sea específico.

12. ¿Piensa usted que la mayoría de los pescadores entiendan cómo los administradores toman decisiones? ¿Por qué sí o no?

13. En general, ¿cómo describiría usted la relación entre los pescadores y los administradores/personas que toman decisiones?

14. Si hay conflictos entre pescadores y entre pescadores y administradores/personas que toman decisiones, ¿cómo se resuelven?

Appendix 2

Survey questionnaires used to interview fishers in the pre-storm assessment (time period 1) in English and Spanish:

A. Work & Fishing Attributes

1. Are you a commercial fisher? Yes____ No____
   1.1. If yes: Are you associated with a *villa pesquera* or a fisher cooperative? Yes____ No____
2. How long have you been a fisher?______________________________
3. What fishing methods/gears do you use? ______________________________
4. Do you use boat? Yes____ No____
   4.1. If yes: What is the size of the boat you use for fishing? ______________________________
   4.2. Do you own the boat? Yes____ No____
   4.3. Does the boat have a motor? Yes____ No____
5. How many months a year do you fish? ______________________________
6. How many days a month do you fish? ______________________________
7. How many hours a day do you spend fishing? ______________________________
8. How many pounds of fish do you bring in on a good day? ______________________________
9. How many pounds of fish do you bring in on a bad day? ______________________________
10. Did you have more good or bad days last year? ______________________________
11. Where do you typically fish? ______________________________
12. What are the most important species of fish you catch (if commercial fisher: for your income)? (Which is the most important? Which is second?) ______________________________
13. Is fishing your **only** occupation? Yes____ No____ [Circle: FISHING NOT AN OCCUPATION]
    13.1. If no: What other occupation(s) do you have? ______________________________
    ____
    13.2. Which occupation is more important for your income? (Which is second? Third? Etc) ______________________________
    ____
    13.3. Which occupation do you spend more time with?______________________________
    13.4. Which occupation do you prefer?______________________________
14. Are you the major provider of your household in terms of income? Yes____ No___

B. Perceptions of Resource Status & Individual Well-being

15. At the present time the fishery resources that you use are:
    (5) In very good shape (4) In good shape (3) In neither good nor bad shape (2) In bad shape (1) In very bad shape
16. Are the fishery resources better, worse or the same as they have been over the past 10 years? (Circle)
    16.1. Why do you think that is? ______________________________
17. Job Satisfaction:
    17.1. How satisfied are you with your income from fishing?
    5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied

    17.2. How satisfied are you with the predictability of your income from fishing?
    5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied

    17.3. How satisfied are you with safety on the job?
    5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied

    17.4. How satisfied are you with the fatigue of the job?
    5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied

    17.5. How satisfied are you with the healthfulness of the job?
    5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied

17.6. How satisfied are you with the time you spend away from home fishing?
5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied

17.7. How satisfied are you with the adventure of the job?
5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied

17.8. How satisfied are you with the challenge of the job?
5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied

17.9. How satisfied are you with the opportunity to be your own boss (independence of being a fisher)?
5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied

18. On a scale of 1 to 10 (1 being not happy at all and 10 being very happy), how happy are you with your life?________
19. If you were in trouble do you have relatives or friends you can count on to help you whenever you need them? Yes____ No____

C. Climate change knowledge/perception

20. Have you ever heard of climate change (or global warming)? Yes____ No____
21. Do you think the climate in this area is changing? Yes____ No____
    21.1. If yes, the change is:
    (1) Very bad (2) Bad (3) Neither good nor bad (4) Good (5) Very good
22. On a scale of 1 to 10 (1 being not worried at all and 10 being very worried) how worried are you about climate change? ______________________________
23. Have you noticed any changes to the fish/shellfish or the environment in this area that you believe are related to climate change? Yes____ No____
    23.1. If yes: What? ______________________________
    23.2. Have you done anything or changed anything about your fishing activity as a consequence of these changes? Yes____ No____
    23.3. If yes, what have you changed? ______________________________
24. Are you aware of any regulations in Puerto Rico to address climate change? Yes____ No____
    24.1. If yes, what? ______________________________
    24.2. Do you agree with it/them? Yes____ No____
    24.3. Do you think people comply with it/them? Yes____ No____
25. Do you feel that your fishing activity is currently at risk to:
    a. Air temperature rising Yes____ No____
    b. Sea level rise Yes____ No____
    c. Droughts Yes____ No____
    d. Sea water temperature rising Yes____ No____
    e. More seaweed in the water Yes____ No____
    f. Coral bleaching Yes____ No____
    g. Storms and hurricanes becoming more frequent and violent Yes____ No____
    h. Unusual behavior of marine animals Yes____ No____
    i. Marine pollution Yes____ No____
    j. Overfishing Yes____ No____

26. Environmental Awareness
    26.1. We have to take care of the land and the sea or they will not provide for us in the future.
    5.Strongly agree 4.Agree 3.Unsure 2.Disagree 1.Strongly disagree
    26.2. If the corals die it will make a difference for fishing.
    5.Strongly agree 4.Agree 3.Unsure 2.Disagree 1.Strongly disagree

    26.3. If our community works together we will be able to protect our resources.
    5.Strongly agree 4.Agree 3.Unsure 2.Disagree 1.Strongly disagree

26.4. ______________around/near the coast can have an effect on the fish.

26.4.1. <u>Tourism</u>: 5.Strongly agree 4.Agree 3.Unsure 2.Disagree 1.Strongly disagree

26.4.2. <u>Agriculture</u>: 5.Strongly agree 4.Agree 3.Unsure 2.Disagree 1.Strongly disagree

26.4.3. <u>Industry</u>: 5.Strongly agree 4.Agree 3.Unsure 2.Disagree 1.Strongly disagree

26.4.4. <u>Houses</u>: 5.Strongly agree 4.Agree 3.Unsure 2.Disagree 1.Strongly disagree

26.5. If we throw our garbage on the beach, the ocean takes it away and it causes no harm.

1.Strongly agree 2.Agree 3.Unsure 4.Disagree 5.Strongly disagree

26.6. Unless mangroves are protected we will not have any fish to catch.

5.Strongly agree 4.Agree 3.Unsure 2.Disagree 1.Strongly disagree

26.7. There are so many fish in the ocean that no matter how many we catch, there will always be enough for our needs.

1.Strongly agree 2.Agree 3.Unsure 4.Disagree 5.Strongly disagree

D. Perceptions of Institutional/Organizational aspects

27. Do you feel that the government is fair in the fishing regulations they make? Yes____ No____
28. Do you understand how the government makes decisions? Yes____ No____
29. On a scale of 1 to 10 (1 being no participation at all and 10 being great deal of participation), how would you rate local fishers participation on process of creating fishing regulations? ____
30. On a scale of 1 to 10 (1 being not compliant at all and 10 being very compliant), how would you rate the compliance of local fishers with fishery regulations? ____
31. Do you think there should be more enforcement of the fishing regulations? Yes____ No____

E. Views on Participatory Action

32. Do you think people in this community can work together to solve community problems? Yes____ No____
33. Do you think fishers could work together to solve problems in the fishery? Yes____ No____
34. Should the government and fishers work together to solve problems in the fishery? Yes____ No____

F. Demographics

35. How old are you? ____
36. What was the last grade you completed in school? ____
37. Are you married? Yes____ No____
38. How many people live in your household? ____

A. Atributos relacionados con el trabajo y la pesca:

1. ¿Usted es un pescador comercial? Sí____ No____
   1.1. Si la respuesta es que sí, ¿Pertenece usted a una villa pesquera o cooperativa de pesca? Sí____ No____
2. ¿Con cuántos años usted empezó a pescar?______________________________
3. ¿Qué métodos y artes de pesca usa usted? ______________________________
4. ¿Usted usa un bote para pescar? Sí____ No____
   4.1. Si la respuesta es que sí, ¿De qué tamaño es el bote que usa usted para pescar? ______________________
   4.2. ¿Usted es el dueño del bote? Sí____ No____
   4.3. ¿Tiene motor el bote? Sí____ No____
5. ¿Cuántos meses al año pesca usted? ______________________________
6. ¿Cuántos días al mes pesca usted? ______________________________
7. ¿Cuántas horas al día pasa usted pescando? ______________________________
8. ¿Cuántas libras de pescado pesca usted en un buen día? ______________________________
9. ¿Cuántas libras de pescado pesca usted en un mal día? ______________________________
10. ¿Tuvo usted más días buenos o malos el año pasado?______________________________
11. ¿Dónde pesca usted normalmente? ______________________________
12. ¿Cuáles son las especies de pescado más importantes para usted? (Si un pescador comercial: ¿para sus ingresos?) (¿Cuál es la más importante? ¿La segunda más importante?) ______________________________
13. ¿La pesca es su **único** trabajo? Sí ____ No _____ [Haga un círculo: LA PESCA NO ES UN TRABAJO]
    13.1. Si no, ¿qué otro trabajo(s) tiene usted? ______________________________
    13.2. ¿Cuál es el trabajo más importante para sus ingresos? (¿Cuál es la segunda? ¿La tercera? Etc.) __________
    13.3. ¿En qué trabajo pasa usted más tiempo?______________________________
    13.4. ¿Qué trabajo prefiere? ______________________________
14. ¿Usted es el que más dinero trae a su hogar? Sí____ No____

B. Percepciones del estatus a partir de los recursos y del bienestar individual

15. En el presente los recursos pesqueros (las poblaciones de peces) estan:
    (5) en muy buenas condiciones. (4) en buenas condiciones. (3) ni en buenas ni en malas condiciones.
    (2) en malas condiciones. (1) en muy malas condiciones.
16. ¿Están en (1) peores, (2) iguales o (3) mejores condiciones los recursos pesqueros (las poblaciones de peces) que en los últimos diez años? (Haga un círculo)
    16.1. ¿A qué se debe esto? ______________________________
17. Satisfacción en el trabajo:
    ¿Cuán satisfecho está usted con:

    17.1. lo que gana por sus actividades de pesca?
    5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

    17.2. lo predecible de esas ganancias por sus actividades de pesca?
    5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

    17.3. su seguridad cuando pesca?
    5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

    17.4. el cansancio físico que le causa este trabajo?
    5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

    17.5. el efecto de este trabajo en su salud?
    5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

    17.6. el tiempo que pasa con su familia?
    5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

17.7. el disfrute de la aventura de este trabajo?
5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

17.8. los retos de este trabajo?
5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

17.9. la oportunidad de ser su propio jefe (la independencia que le da el trabajo)?
5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

18. En una escala del 1 al 10 (con el 1 significando no feliz para nada y el 10 muy feliz), ¿cuán feliz está usted con su vida?_____ ____
19. Si usted tuviera un problema, ¿tiene familiares o amigos con los que pueda contar para que lo ayuden en cualquier momento que los necesite? Sí____ No____

C. Percepción o conocimiento del cambio climático

20. ¿Ha oído usted del cambio climático (o del calentamiento global)? Sí ____ No____
21. ¿Piensa usted que el clima de esta área está cambiando? Sí ____ No ____
    21.1. Si la respuesta es que sí, el cambio es:
    (1) muy malo (2) malo (3) ni bueno ni malo (4) bueno (5) muy bueno
22. En una escala del 1 al 10 (con el 1 significando no preocupado para nada y el 10 muy preocupado), ¿cuán preocupado está usted por el cambio climático? _____
23. ¿Ha notado usted cambios en los peces, mariscos o el ambiente de esta área que desde su punto de vista puedan estar relacionados con el cambio climático (o calentamiento global)? Sí ____ No ____
    23.1. Si la respuesta es que sí, ¿qué cambios ha notado?________________________________
    23.2. Si la respuesta (23) es que sí, ¿ha hecho algo o cambiado algún aspecto de sus actividades de pesca como resultado de los cambios de la pregunta anterior? Sí ____ No ____
    23.3. Si la respuesta (23) es que sí, ¿qué cambios ha hecho? ______________________________
24. ¿Sabe usted de algún reglamento en Puerto Rico para responder al cambio climático? Sí ____ No ____
    24.1. Si la respuesta es que sí, ¿de qué reglamento o reglamentos sabe usted? ____________________
    24.2. ¿Está de acuerdo con él/ellos? Sí ____ No____
    24.3. ¿Cree usted que la gente lo/los obedece? Sí____ No____
25. ¿Le parece a usted que la pesca está en peligro debido:
    k. al aumento de la temperatura del aire? Sí____ No____
    l. al aumento de los niveles del mar? Sí____ No____
    m. a la sequía? Sí ____ No____
    n. al aumento en la temperatura del agua del mar? Sí____ No____
    o. al aumento de algas marinas? Sí____ No____
    p. al emblanquecimiento de los corales? Sí____ No____
    q. al aumento en la frecuencia y la violencia de las tormentas y los huracanes? Sí____ No____
    r. a los cambios de comportamiento en animales marinos? Sí____ No____
    s. a la contaminación marina? Sí____ No____
    t. a la sobrepesca? Sí____ No____

26. Ética Ambiental:
26.1. Tenemos que cuidar la tierra y el mar o ellos no nos van a dar sustento en el futuro.
5.Totalmente de acuerdo 4.De acuerdo 3.Ni de acuerdo ni en desacuerdo 2.En desacuerdo 1.Totalmente en desacuerdo
26.2. Si mueren los corales la pesca será afectada.
5.Totalmente de acuerdo 4.De acuerdo 3.Ni de acuerdo ni en desacuerdo 2.En desacuerdo 1.Totalmente en desacuerdo
26.3. Si la comunidad trabaja junta, vamos a poder proteger nuestros recursos naturales.
5.Totalmente de acuerdo 4.De acuerdo 3.Ni de acuerdo ni en desacuerdo 2.En desacuerdo 1.Totalmente en desacuerdo

26.4. _______________ alrededor/cerca de la costa puede afectar a los peces.

26.4.1. <u>El turismo</u>: 5.Totalmente de acuerdo 4.De acuerdo 3.Ni de acuerdo ni en desacuerdo 2.En desacuerdo 1.Totalmente en desacuerdo

26.4.2. <u>Agricultura</u>: 5.Totalmente de acuerdo 4.De acuerdo 3.Ni de acuerdo ni en desacuerdo 2.En desacuerdo 1.Totalmente en desacuerdo

26.4.3. <u>La industria</u>: 5.Totalmente de acuerdo 4.De acuerdo 3.Ni de acuerdo ni en desacuerdo 2.En desacuerdo 1.Totalmente en desacuerdo

26.4.4 <u>Residencias</u>: 5.Totalmente de acuerdo 4.De acuerdo 3.Ni de acuerdo ni en desacuerdo 2.En desacuerdo 1.Totalmente en desacuerdo

26.5. Si tiramos basura en la playa, el océano se la lleva y esto no causa ningún daño.

1.Totalmente de acuerdo 2.De acuerdo 3.Ni de acuerdo ni en desacuerdo 4.En desacuerdo 5.Totalmente en desacuerdo

26.6. A menos que los mangles estén protegidos, no vamos a tener peces que pescar.

5.Totalmente de acuerdo 4.De acuerdo 3.Ni de acuerdo ni en desacuerdo 2.En desacuerdo 1.Totalmente en desacuerdo

26.7. Hay tantos peces en el océano que no importa cuántos pesquemos, siempre habrá suficientes para satisfacer nuestras necesidades.

1.Totalmente de acuerdo 2.De acuerdo 3.Ni de acuerdo ni en desacuerdo 4.En desacuerdo 5.Totalmente en desacuerdo

D. Percepciones sobre aspectos institucionales/organizacionales

27. ¿Le parece a usted que el gobierno es justo en las decisiones administrativas que toman? Sí____ No____
28. ¿Entiende usted cómo el gobierno toma decisiones? Sí____ No____
29. En una escala del 1 al 10 (con el 1 significando ninguna participación y el 10 una participación muy grande), ¿cómo clasificaría la participación de los pescadores locales en la creación de los reglamentos de la pesca? ____
30. En una escala del 1 al 10 (con el 1 significando nada obediente y el 10 muy obediente), ¿cómo clasificaría el nivel de obediencia de los pescadores con respecto a los reglamentos de la pesca? ____
31. ¿Cree usted que es necesario reforzar la fiscalización de la pesca ilegal de Puerto Rico? Sí____ No____

E. Opiniones sobre la acción participativa

32. ¿Cree usted que la gente de esta comunidad puede trabajar colectivamente para resolver problemas comunitarios? Sí____ No____
33. ¿Cree usted que los pescadores pueden trabajar juntos para resolver problemas de la pesca? Sí____ No____
34. ¿Deberían trabajar juntos el gobierno y los pescadores para resolver problemas de la pesca? Sí____ No____

F. Información demográfica

35. ¿Cuántos años tiene?____
36. ¿Cuál es su nivel de educación?____
37. ¿Usted es casado? Sí____ No____
38. ¿Cuántas personas, incluyéndolo/la a usted, viven en su casa? ________________________

Appendix 3

Complete list of occupations mentioned by fishers in period 1:

Occupation	N	% of Responses
Retired/Pension	13	18.8%
Own Business	7	10.1%
Construction	6	8.7%
Farming	5	7.2%
Government	4	5.8%
Carpentry	3	4.3%
Housekeeping	2	2.9%
Odd jobs	2	2.9%
Handy man	2	2.9%
Retail	2	2.9%
Restaurant	1	1.4%
Silk-screening	1	1.4%
Gardening	1	1.4%
Marine electronics	1	1.4%
Refrigeration	1	1.4%
Longshoreman	1	1.4%
Other	1	1.4%
Janitor	1	1.4%
Mechanic	1	1.4%
Teacher	1	1.4%
Department of Agriculture	1	1.4%
Did not want to say	1	1.4%
Sells fruits and eggs	1	1.4%
Recreation and sports	1	1.4%
Musician	1	1.4%
Electrician	1	1.4%
Tire shop	1	1.4%
Housewife	1	1.4%
Plumber	1	1.4%
Captain (private boat)	1	1.4%
Crew (private boat)	1	1.4%
Chef	1	1.4%
Policeman	1	1.4%

Appendix 4

Complete list of occupations mentioned by fishers in period 1 in terms of time spent and preference:

Occupation Time	N	% of Responses
Fishing	12	26.1
Business owner	4	8.7
Equal	3	6.5
Farmer	3	6.5
Carpenter	3	6.5
Works for government	3	6.5
Construction	2	4.3
Other	2	4.3
Restaurant	1	2.2
Gardener	1	2.2
Refrigeration	1	2.2
Longshoreman	1	2.2
Janitor	1	2.2
Teacher	1	2.2
Department of Agriculture	1	2.2
Sells fruits and eggs	1	2.2
Recreation and sports	1	2.2
Electrician	1	2.2
Tier shop	1	2.2
Plumber	1	2.2
Captain (private boat)	1	2.2
Crew (private boat)	1	2.2

Occupation Preference	N	%
Equal	5	11.1
Fishing	24	53.3
Business owner	3	6.7
Gardner	1	2.2
Marine electronics	1	2.2
Farmer	2	4.4
Other	1	2.2
Janitor	1	2.2
Teacher	1	2.2
Carpenter	2	4.4
Works for government	2	4.4
Electrician	1	2.2
Plumber	1	2.2

Appendix 5

Complete list of occupations mentioned by fishers in period 1 by region:

Region	Occupation	N	% of Responses
East Coast	Construction	4	21.10%
	Retired/Pension	3	15.80%
	Housekeeping	2	10.50%
	Odd jobs	2	10.50%
	Restaurant	1	5.30%
	Silk-screening	1	5.30%
	Business owner	1	5.30%
	Gardner	1	5.30%
	Farmer	1	5.30%
	Works for government	1	5.30%
	Recreation and sports	1	5.30%
	Musician	1	5.30%
	N	19	100.00%
Southeast Coast	Farmer	4	36.40%
	Retired/Pension	1	9.10%
	Construction	1	9.10%
	Department of Agriculture	1	9.10%
	Carpenter	1	9.10%
	Handy man	1	9.10%
	Chef	1	9.10%
	Policeman	1	9.10%
	N	11	100.00%
Northeast Coast	Retired/Pension	9	23.70%
	Business owner	6	15.80%
	Works for government	3	7.90%
	Retail	2	5.30%
	Construction	1	2.60%
	Marine electronics	1	2.60%
	Refrigeration	1	2.60%
	Longshoreman	1	2.60%
	Other	1	2.60%
	Janitor	1	2.60%
	Mechanic	1	2.60%
	Teacher	1	2.60%
	Carpenter	1	2.60%
	Handy man	1	2.60%
	Did not want to say	1	2.60%
	Sells fruits and eggs	1	2.60%
	Electrician	1	2.60%
	Tier shop	1	2.60%
	Housewife	1	2.60%
	Plumber	1	2.60%
	Captain (private boat)	1	2.60%
	Crew (private boat)	1	2.60%
	N	38	100.00%
Southwest Coast	Carpenter	1	100.0%
	N	1	100.0%

Appendix 6

Complete list of fishing methods/gear types mentioned by fishers in period 1:

Methods/Gear Types	N	% of Responses
Buceo (scuba diving)	114	32.5%
Nasas (traps)	50	14.2%
Cana/Carrete (rod & reel)	41	11.7%
Cordel/Hilo (handline)	27	7.7%
Figa/Arpon (harpoon)	26	7.4%
Trasmallo (gillnet)	21	6.0%
Chinchorro (seine net)	18	5.1%
Malla (net)	14	4.0%
Tarralla/Atarraya (cast net)	6	1.7%
Cajones	5	1.4%
Anzuelo (hook)	4	1.1%
Trampas (traps)	3	.9%
Lazo	3	.9%
Free Diving/Snorkeling	3	.9%
All of them	2	.6%
Palangre (longline)	2	.6%
Riles Electricos (electric rod)	2	.6%
Cala (vertical longline)	2	.6%
Malacate (electric line hauler)	2	.6%
Cajas (lobster traps)	1	.3%
Silga (trolling)	1	.3%
Cristal	1	.3%
Pesca de Luz	1	.3%
Mallorquin (trammel net)	1	.3%
Barro	1	.3%

Appendix 7

Complete list of target species mentioned by fishers in period 1:

Target Species	N	% of Responses
Langosta (lobster)	118	19.4%
Carrucho (queen conch)	87	14.3%
Colirubia (yellowtail snapper)	62	10.2%
Chillo (silk snapper)	53	8.7%
Sama (mutton snapper)	43	7.1%
Pargo (snapper)	38	6.3%
Capitan (hogfish)	37	6.1%
Mero (groupper)	29	4.8%
Sierra (king mackerel)	26	4.3%
Pulpo (octopus)	15	2.5%
Arrayao (lane snapper)	14	2.3%
Peje Puerco (trigger fish)	11	1.8%
Dorado (dolphinfish)	10	1.6%
Mero Cabrilla (red hind)	9	1.5%
Chapin (trunk fish)	9	1.5%
Cartucho (queen snapper)	5	.8%
Marlin	4	.7%
Vermillion (red snapper)	4	.7%
Atun (tuna)	3	.5%
Corvino (whitemouth croaker)	3	.5%
Loro (parrotfish)	3	.5%
Pescado (finfish)	3	.5%
Salmonete (goat fish)	2	.3%
Muniama (wenchman)	2	.3%
Boquicolorao (white grunt)	2	.3%
Tiburon (shark)	1	.2%
Pez Leon (lion fish)	1	.2%
Sardinas (sardines)	1	.2%
Picua (barracuda)	1	.2%
Negro (blackspot snapper)	1	.2%
Peje Blanco (green turtle)	1	.2%
Cojinua (blue runner)	1	.2%
Mero Pinto (black groupper)	1	.2%
Ronco (grunt)	1	.2%
Bonito (skipjack tuna)	1	.2%
Pluma (porgy)	1	.2%
Pargo Mulato (cubera snapper)	1	.2%
Jarea (white mullet)	1	.2%
Peto (wahoo)	1	.2%
Chicharro (bigeye scad)	1	.2%
Robalo (snook)	1	.2%

Appendix 8

Complete list of fishing methods/gear types mentioned by fishers in period 1 by region:

Region	Method/Gear Type	N	% of Responses
East Coast	Buceo (scuba diving)	27	28.4%
	Nasas (traps)	17	17.9%
	Cordel/Hilo (handline)	13	13.7%
	Figa/Arpon (harpoon)	12	12.6%
	Cana/Carrete (rod & reel)	4	4.2%
	Cajones	4	4.2%
	Trasmallo (gillnet)	4	4.2%
	Lazo	3	3.2%
	Trampas (traps)	2	2.1%
	Tarralla/Atarraya (cast net)	2	2.1%
	Malla (net)	2	2.1%
	Free Diving/Snorkeling	1	1.1%
	Anzuelo (hook)	1	1.1%
	Malacate (electric line hauler)	1	1.1%
	Chinchorro (seine net)	1	1.1%
	Barro	1	1.1%
	N	95	100.0%
Southeast Coast	Nasas (traps)	14	21.5%
	Cordel/Hilo (handline)	11	16.9%
	Figa/Arpon (harpoon)	6	9.2%
	Malla (net)	6	9.2%
	Cana/Carrete (rod & reel)	4	6.2%
	Trasmallo (gillnet)	4	6.2%
	Chinchorro (seine net)	4	6.2%
	Buceo (scuba diving)	3	4.6%
	Anzuelo (hook)	3	4.6%
	All of them	2	3.1%
	Palangre (longline)	1	1.5%
	Cajones	1	1.5%
	Cajas (lobster traps)	1	1.5%
	Cala (vertical longline)	1	1.5%
	Malacate (electric line hauler)	1	1.5%
	Silga (trolling)	1	1.5%
	Cristal	1	1.5%
	Pesca de Luz	1	1.5%
	N	65	100.0%

Region	Method/Gear Type	N	% of Responses
Northeast Coast	Cana/Carrete (rod & reel)	33	41.8%
	Trasmallo (gillnet)	13	16.5%
	Buceo (scuba diving)	8	10.1%
	Figa/Arpon (harpoon)	8	10.1%
	Nasas (traps)	7	8.9%
	Tarralla/Atarraya (cast net)	4	5.1%
	Cordel/Hilo (handline)	1	1.3%
	Trampas (traps)	1	1.3%
	Free Diving/Snorkeling	1	1.3%
	Palangre (longline)	1	1.3%
	Riles Electricos (electric rod)	1	1.3%
	Malla (net)	1	1.3%
	N	79	100.0%
Southwest Coast	Buceo (scuba diving)	76	67.9%
	Chinchorro (seine net)	13	11.6%
	Nasas (traps)	12	10.7%
	Malla (net)	5	4.5%
	Cordel/Hilo (handline)	2	1.8%
	Free Diving/Snorkeling	1	.9%
	Riles Electricos (electric rod)	1	.9%
	Cala (vertical longline)	1	.9%
	Mallorquin (trammel net)	1	.9%
	N	112	100.0%

Appendix 9

Complete list of target species mentioned by fishers in period 1 by region:

Region	Target Species	N	% of Responses
East Coast	Langosta (lobster)	33	16.3%
	Colirubia (yellowtail snapper)	28	13.8%
	Sama (mutton snapper)	25	12.3%
	Capitan (hogfish)	23	11.3%
	Carrucho (queen conch)	22	10.8%
	Mero (groupper)	15	7.4%
	Pargo (snapper)	8	3.9%
	Sierra (king mackerel)	8	3.9%
	Mero Cabrilla (red hind)	7	3.4%
	Arrayao (lane snapper)	6	3.0%
	Peje Puerco (trigger fish)	5	2.5%
	Chillo (silk snapper)	5	2.5%
	Atun (tuna)	3	1.5%
	Dorado (dolphinfish)	2	1.0%
	Salmonete (goat fish)	2	1.0%
	Muniama (wenchman)	2	1.0%
	Cartucho (queen snapper)	1	.5%
	Peje Blanco (green turtle)	1	.5%
	Cojinua (blue runner)	1	.5%
	Mero Pinto (black groupper)	1	.5%
	Ronco (grunt)	1	.5%
	Boquicolorao (white grunt)	1	.5%
	Bonito (skipjack tuna)	1	.5%
	Pluma (porgy)	1	.5%
	Robalo (snook)	1	.5%
	N	203	100.0%
Southeast Coast	Chillo (silk snapper)	13	14.3%
	Sama (mutton snapper)	10	11.0%
	Langosta (lobster)	10	11.0%
	Colirubia (yellowtail snapper)	9	9.9%
	Carrucho (queen conch)	5	5.5%
	Arrayao (lane snapper)	5	5.5%
	Mero (groupper)	5	5.5%
	Pargo (snapper)	4	4.4%
	Dorado (dolphinfish)	3	3.3%
	Peje Puerco (trigger fish)	3	3.3%
	Cartucho (queen snapper)	3	3.3%
	Corvino (whitemouth croaker)	3	3.3%
	Loro (parrotfish)	3	3.3%
	Pescado (finfish)	3	3.3%
	Mero Cabrilla (red hind)	2	2.2%
	Sierra (king mackerel)	2	2.2%
	Pulpo (octopus)	1	1.1%
	Picua (barracuda)	1	1.1%
	Negro (blackspot snapper)	1	1.1%
	Boquicolorao (white grunt)	1	1.1%
	Pargo Mulato (cubera snapper)	1	1.1%
	Jarea (white mullet)	1	1.1%
	Peto (wahoo)	1	1.1%
	Chicharro (bigeye scad)	1	1.1%
	N	91	100.0%

Region	Target Species	N	% of Responses
Northeast Coast	Pargo (snapper)	26	22.0%
	Colirubia (yellowtail snapper)	25	21.2%
	Sierra (king mackerel)	16	13.6%
	Chillo (silk snapper)	9	7.6%
	Sama (mutton snapper)	8	6.8%
	Langosta (lobster)	7	5.9%
	Dorado (dolphinfish)	5	4.2%
	Marlin	4	3.4%
	Vermillion (red snapper)	4	3.4%
	Pulpo (octopus)	4	3.4%
	Mero (groupper)	3	2.5%
	Carrucho (queen conch)	2	1.7%
	Arrayao (lane snapper)	1	.8%
	Capitan (hogfish)	1	.8%
	Tiburon (shark)	1	.8%
	Sardinas (sardines)	1	.8%
	Chapin (trunk fish)	1	.8%
	N	118	100.0%
Southwest Coast	Langosta (lobster)	68	34.7%
	Carrucho (queen conch)	58	29.6%
	Chillo (silk snapper)	26	13.3%
	Capitan (hogfish)	13	6.6%
	Pulpo (octopus)	10	5.1%
	Chapin (trunk fish)	8	4.1%
	Mero (groupper)	6	3.1%
	Peje Puerco (trigger fish)	3	1.5%
	Arrayao (lane snapper)	2	1.0%
	Cartucho (queen snapper)	1	.5%
	Pez Leon (lion fish)	1	.5%
	N	196	100.0%

Appendix 10

Reasons mentioned by fishers for decline in fishery resources in period 1:

Reason Stated	N	% of Responses
Pollution (water)	14	34.1%
Global warming	6	14.6%
Overfishing	2	4.9%
Environmental changes	2	4.9%
Marina pollution	2	4.9%
Overexploitation by foreign fishers	1	2.4%
Human impacts (anchors, tourism, population)	1	2.4%
More boats	1	2.4%
Fishery closures (vedas)	1	2.4%
Government/regulations	1	2.4%
Lack of resources	1	2.4%
Weather conditions	1	2.4%
Lower abundance of resources	1	2.4%
Compliance	1	2.4%
Invasive species	1	2.4%
Fewer fish	1	2.4%
River pollution	1	2.4%
Trash in water	1	2.4%
Algal blooms	1	2.4%
More fish	1	2.4%

Appendix 11

Changes in marine environment and resources attributed to climate change observed by fishers in period 1:

Changes observed	N	% of Responses
Fish population decline	28	22.8%
Decline in fishery	14	11.4%
Change in composition of fish species	13	10.6%
Change in water temperature	8	6.5%
Fish further away from coast	7	5.7%
Fish shifting to deeper water	6	4.9%
Fishing is more difficult/complicated	6	4.9%
Habitat shift	5	4.1%
More bad weather conditions	4	3.3%
Change in currents	3	2.4%
Invasive species	3	2.4%
Lion fish introduction	3	2.4%
Other (pollution, fishery closures)	3	2.4%
Depleted resources	2	1.6%
Dead corals	2	1.6%
Algal blooms	2	1.6%
Change in benthic habitat (bottom habitat)	2	1.6%
Coral bleaching	2	1.6%
Fish weight less	2	1.6%
Change in fishing season	1	.8%
More effort	1	.8%
Siltation	1	.8%
Fish closer to the coast	1	.8%
Pollutants (contaminants in fish that are harmful to human health)	1	.8%
Change in fish behavior	1	.8%
Algae changing color	1	.8%
Regulations	1	.8%

Appendix 12

Changes to fishing activities to adapt to change in environment and resources mentioned by fishers in period 1:

Adaptation	N	% of Responses
Change in fishing grounds	34	42.5%
Change gear/diversify gear	12	15.0%
Fish in deeper water	9	11.3%
Fish further away from shore	7	8.8%
Change time of day to fish	4	5.0%
Change fishery/change target species	3	3.8%
Better equipment/technology	2	2.5%
Increase in effort	2	2.5%
More hurricane (need to be more aware)	1	1.3%
Now there are species that cannot be caught	1	1.3%
Avoid coral reef when anchoring	1	1.3%
Need light for night time fishing because fish are deeper in water	1	1.3%
Change in fishing season	1	1.3%
Study the changes	1	1.3%
Avoid certain fish species in certain seasons	1	1.3%

Appendix 13

Survey questionnaires used to interview fishers in the post-storm assessment (time period 2) in English and Spanish.

A. Work & Fishing Attributes

1. Do you fish? Yes____ No____ (*If no, use community survey*)
2. What do you do with the fish you catch? ____
3. What is your occupation? Fisher____ Other: ____
4. Do you have other occupation(s)?____
5. Which is more important for your income? (Which is second? Third? Etc.) ______________________
6. Or how old were you when you first began fishing?______________________________
7. What fishing methods/gears do you use? ____
8. What is the length of the boat you use for fishing? ______________________________
   - 8.1. Do you own the boat? Yes____ No____
     - 8.1.1. If no, does the boat owner have more than one boat? Yes____ No____
       - 8.1.1.1. If yes, how many? ____
9. What are the most important species of fish/shellfish you catch (if commercial fisher: for your income)? (Which is the most important? Which is second?) ______________________________
10. Are you the major provider of your household in terms of income? Yes____ No___
11. Do you give any fish that you catch to family and friends? (*If already mentioned in question 2, ask: How frequently…*)
    (1) Never (2) Sometimes (3) Frequently (4) All time

B. Perceptions of Resource Status & Individual Job satisfaction and Well-being

12. At the present time the fishery resources that you use are:
    (5) In very good shape (4) In good shape (3) In neither good nor bad shape (2) In bad shape (1) In very bad shape
13. Are the fishery resources (1) worse, the (2) same, or (3) better as they were before hurricanes Irma and Maria?
    - 13.1. If worse or better, why do you think that is? ______________________________
14. Job Satisfaction:
    - 14.1. How satisfied are you with your income from fishing?
      5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied
    - 14.2. How satisfied are you with the predictability of your income from fishing?
      5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied
    - 14.3. How satisfied are you with safety on the job?
      5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied
    - 14.4. How satisfied are you with the fatigue of the job?
      5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied
    - 14.5. How satisfied are you with the healthfulness of the job?
      5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied
    - 14.6. How satisfied are you with the time you spend away from home fishing?
      5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied
    - 14.7. How satisfied are you with the adventure of the job?
      5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied
    - 14.8. How satisfied are you with the challenge of the job?
      5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied

14.9. How satisfied are you with the opportunity to be your own boss (independence of being a fisher)?
5. Very satisfied 4. Satisfied 3. Neutral 2. Dissatisfied 1. Very dissatisfied

15. Would you advise a young person to go into fishing today? Yes____ No___
16. On a scale of 1 to 10 (1 = not happy at all and 10 = very happy), how happy are you with your life?_______________

C. Climate change knowledge/perception

17. Do you think the climate in this area is changing? Yes____ No____ (*If no, go to question 18*)
17.1. If yes, what changes have you noticed? ____
17.2. In your opinion, the fact that the climate is changing is:
(1) Very bad (2) Bad (3) Neither good nor bad (4) Good (5) Very good
17.3. What do you think is causing these climatic changes?____
18. On a scale of 1 to 10 (1 = not worried at all and 10 = very worried) how worried are you about climate change? ____

19. Have you noticed any changes in with regard to the fish/shellfish or the marine environment in this area that you believe are related to climate change? Yes____ No____ (*If no, go to question 20*)
19.1. If yes: What changes? ____
19.2. Have you done anything or changed anything about your fishing activity as a consequence of these changes? Yes____ No____
19.3. If yes, what have you changed? ____
20. Are you aware of any regulations in Puerto Rico to address climate change? Yes____ No____
20.1. If yes, what regulation(s)? ____
21. Do you think legislation to address climate change should be implemented in Puerto Rico? Yes____ No____
21.1. Why or why not? ____
22. Do you feel that your fishing activity is currently at risk due to:
a. Air temperature rising Yes____ No____
b. Sea level rise Yes____ No____
c. Droughts Yes____ No____
d. Sea water temperature rising Yes____ No____
e. More seaweed in the water Yes____ No____
f. Coral bleaching Yes____ No____
g. Storms and hurricanes becoming more frequent and violent Yes____ No____
h. Unusual behavior of marine animals Yes____ No____
i. Marine pollution Yes____ No____
j. Overfishing Yes____ No____

23. Human activities do not influence the coastal and marine environment.
1.Strongly agree 2.Agree 3.Unsure 4.Disagree 5.Strongly disagree

24. Human activities do not influence the climate.
1.Strongly agree 2.Agree 3.Unsure 4.Disagree 5.Strongly disagree

25. There is no point in planning for the future; what happens, happens and we cannot do anything about it.
1.Strongly agree 2.Agree 3.Unsure 4.Disagree 5.Strongly disagree

D. Aspects of Impact and Recovery from Recent Storm Events

26. With regard to your house, was anything damaged or lost due to hurricanes Irma and Maria? Yes____ No____
26.1. If damage occurred, was it: (1) Minor damage (2) Moderate damage (3) Severe damage (4) Complete damage

27. Were any of your fishing gear damaged or lost due to hurricanes Irma and Maria? Yes____ No____
    27.1. If damage occurred, was it: (1) Minor damage (2) Moderate damage (3) Severe damage (4) Complete damage

28. Was your boat damaged or lost due to hurricanes Irma and Maria? Yes____ No____
    28.1. If damage occurred, was it: (1) Minor damage (2) Moderate damage (3) Severe damage (4) Complete damage

29. Were any other personal possessions damaged or lost due to hurricanes Irma and Maria? Yes____ No____
    29.1. If damage occurred, was it: (1) Minor damage (2) Moderate damage (3) Severe damage (4) Complete damage

30. Were you physically injured during the hurricanes? Yes____ No____
31. Was anybody in your family injured during the hurricanes? Yes____ No____
    31.1. If yes, how many? ____________________
32. If any loss, damage, or injury occurred, have you received any assistance or help in your recovery? Yes____ No____
    32.1.1. If yes, who provided the assistance/help? ____________________
33. On a scale of 1 to 10 (1 = not recovered at all and 10 = completely recovered) how would you rate your level or recovery from the hurricanes today? ____________________
34. What or who was most helpful for you recovery efforts? ____________________
35. Were there any impediments to your recovery? Yes____ No____
    35.1. If yes, what? ____________________
36. Did you consider leaving Puerto Rico after the hurricanes? Yes____ No____
    36.1. Why or why not? ____________________
37. Do you go out to fish more or less since the hurricanes? More___ Less___ Same___
    37.1. If more or less, why? ____________________
38. Have you changed target species since the hurricanes? Yes____ No____
    38.1. If yes, how? (What species did you catch before that you do not catch now and vice versa?) ____________
39. Have you changed gear type/fishing method since the hurricanes? Yes____ No____
    39.1. If yes, how and why? ____________________
40. Have you changed your fishing location since the hurricanes? Yes____ No____
    40.1. If yes, how and why? ____________________
41. If answered yes to question 11: Have the hurricanes influenced how much fish you give away to family and friends? Yes____ No____
    41.1. If yes, how? ____________________
42. Do you have any family members or friends who were fishers and had to exit the fishery due to the hurricanes? Yes____ No____
    42.1. If yes, what are they doing now for income? ____________________

E. Demographics

43. How old are you? ____________________
44. What was the last grade you completed in school? ____________________
45. Are you married? Yes____ No____
46. How many people live in your household? ____________________

A. Atributos relacionados con el trabajo y la pesca:

1. ¿Usted pesca? Sí____ No____ (*<u>Si la respuesta es no</u>, use la encuesta de la comunidad)*
2. ¿Qué hace con los pescados que coge? ______________________________
3. ¿Cuál es su trabajo? Pescador____ Otro: ______________________________
4. ¿Tiene otra ocupación además de [____]? ______________________________
5. ¿Cuál es el trabajo más importante para sus ingresos? (¿Cuál es la segunda? ¿La tercera? Etc.) __________________
6. ¿Con cuántos años usted empezó a pescar?______________________________
7. ¿Qué métodos y artes de pesca usa usted? ______________________________
8. ¿De qué tamaño es el bote que usa usted para pescar?______________________________
   8.1. ¿Usted es el dueño del bote? Sí____ No____
      8.1.1. <u>Si la respuesta es que no</u>, ¿el dueño del bote tiene más de un bote? Sí____ No____
         8.1.1.1. <u>Si la respuesta es que si</u>, ¿Cuántos? ______________________________
9. ¿Cuáles son las especies de pescado más importantes para usted? (Si un pescador comercial: ¿para sus ingresos?) (¿Cuál es la más importante? ¿La segunda más importante?) ______________________________
10. ¿Usted es el que más dinero trae a su hogar? Sí____ No____
11. ¿Le das de los pescados que atrapa a familiares y amigos? (Si se mencionó en la pregunta 2, pregunte: ¿con qué frecuencia?)
   (2) Nunca (2) Algunas veces (3) Frecuentemente (4) Todo el tiempo

B. Percepciones del estatus a partir de los recursos y del bienestar individual

12. En el presente los recursos pesqueros (las poblaciones de peces) están:
   (5) en muy buenas condiciones. (4) en buenas condiciones. (3) ni en buenas ni en malas condiciones.
   (2) en malas condiciones. (1) en muy malas condiciones.
13. ¿Están en (1) peores, (2) iguales o (3) mejores condiciones los recursos pesqueros (las poblaciones de peces) que antes de los huracanes Irma y María?
   13.1. <u>Si la contestación fue peor o mejor</u>, ¿qué usted piensa que provocó este cambio?______________________
14. ¿Cuán satisfecho está usted con:
   14.1. lo que gana por sus actividades de pesca?
      5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

   14.2. lo predecible de esas ganancias por sus actividades de pesca?
      5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

   14.3. su seguridad cuando pesca?
      5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

   14.4. el cansancio físico que le causa este trabajo?
      5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

   14.5. el efecto de este trabajo en su salud?
      5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

   14.6. el tiempo que pasa con su familia?
      5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

   14.7. el disfrute de la aventura de este trabajo?
      5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

   14.8. los retos de este trabajo?
      5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

   14.9. la oportunidad de ser su propio jefe (la independencia que le da el trabajo)?
      5. Muy satisfecho 4. Satisfecho 3. Neutral 2. Insatisfecho 1. Muy insatisfecho

15. En este momento, ¿le aconsejaría a un joven a trabajar en la industria pesquera? Sí____ No___

16. En una escala del 1 al 10 (con el 1 significando no feliz para nada y el 10 muy feliz), ¿cuán feliz está usted con su vida?_____

C. Percepción del cambio climático

17. ¿Piensa usted que el clima de esta área está cambiando? Sí ____ No ____ (*Si la respuesta es no, pase a la pregunta 18*)
    17.1. Si la respuesta es que sí, ¿Qué cambios ha notado? ____
    17.2. En su opinión, el hecho de que el clima está cambiando es:
    (1) Muy malo (2) Malo (3) Ni bueno ni malo (4) Bueno (5) Muy bueno
    17.3. ¿Qué usted piensa que está causando estos cambios climáticos? ________________________________
18. En una escala del 1 al 10 (con el 1 significando no preocupado para nada y el 10 muy preocupado), ¿cuán preocupado está usted por el cambio climático? _____
19. ¿Ha notado usted cambios en los peces, mariscos o el ambiente de esta área que desde su punto de vista puedan estar relacionados con el cambio climático (o calentamiento global)? Sí ____ No ____
    19.1. Si la respuesta es que sí, ¿qué cambios ha notado?____
    19.2. Si la respuesta (23) es que sí, ¿ha hecho algo o cambiado algún aspecto de sus actividades de pesca como resultado de los cambios de la pregunta anterior? Sí ____ No ____
    19.3. Si la respuesta (23) es que sí, ¿qué cambios ha hecho? ____
20. ¿Sabe usted de algún reglamento en Puerto Rico para responder al cambio climático? Sí ____ No ____
    20.1. Si la respuesta es que sí, ¿de qué reglamento o reglamentos sabe usted? ____________________________
21. ¿Cree que se debe implementar en Puerto Rico alguna legislación para enfrentar el cambio climático? Sí____ No____
    21.1. ¿Por qué o por qué no? ____
22. ¿Le parece a usted que la pesca está en peligro debido:
    a. al aumento de la temperatura del aire? Sí____ No____
    b. al aumento de los niveles del mar? Sí____ No____
    c. a la sequía? Sí ____ No____
    d. al aumento en la temperatura del agua del mar? Sí____ No____
    e. al aumento de algas marinas? Sí____ No____
    f. al emblanquecimiento de los corales? Sí____ No____
    g. al aumento en la frecuencia y la violencia de las tormentas y los huracanes? Sí____ No____
    h. a los cambios de comportamiento en animales marinos? Sí____ No____
    i. a la contaminación marina? Sí____ No____
    j. a la sobrepesca? Sí____ No____

(Voy a leerle una serie de preguntas y me gustaría saber si está de acuerdo o en desacuerdo con ellas)

23. Las actividades humanas no afectan el medio ambiente costero y marino.
    1.Totalmente de acuerdo 2.De acuerdo 3.Ni de acuerdo ni en desacuerdo 4.En desacuerdo 5.Totalmente en desacuerdo

24. Las actividades humanas no afectan el clima.
    1.Totalmente de acuerdo 2.De acuerdo 3.Ni de acuerdo ni en desacuerdo 4.En desacuerdo 5.Totalmente en desacuerdo

25. No tiene sentido planificar para el futuro; lo que sucede, sucede, y no podemos hacer nada al respecto.
    1.Totalmente de acuerdo 2.De acuerdo 3.Ni de acuerdo ni en desacuerdo 4.En desacuerdo 5.Totalmente en desacuerdo

D. Aspectos de impacto y recuperación de los recientes eventos de tormenta

26. Con respecto a su casa, ¿hubo algún daño o perdida debido a los huracanes Irma y María? Sí____ No____
    26.1. Si la respuesta es que sí, ¿el daño fue: (1) Menor (2) Moderado (3) Severo (4) Completamente dañado

27. ¿Se le dañó o perdió algún equipo de pesca debido a los huracanes Irma y María? Sí____ No____
    27.1. Si la respuesta es que sí, ¿el daño fue: (1) Menor (2) Moderado (3) Severo (4) Completamente dañado

28. ¿Se le dañó o perdió su bote debido a los huracanes Irma y María? Sí____ No____
    28.1. Si la respuesta es que sí, ¿el daño fue: (1) Menor (2) Moderado (3) Severo (4) Completamente dañado

29. ¿Se le dañó o perdió otras posesiones personales debido a los huracanes Irma y María? Sí____ No____
    29.1. Si la respuesta es que sí, ¿el daño fue: (1) Menor (2) Moderado (3) Severo (4) Completamente dañado

30. ¿Fue usted herido físicamente durante los huracanes? Sí____ No____
31. ¿Alguien de su familia resultó herido durante los huracanes? Sí____ No____
    31.1. Si la respuesta es que sí, ¿cuántas personas?____
32. Si algún daño, pérdida o lesión ocurrieron, ¿ha recibido usted alguna asistencia o ayuda en su recuperación? Sí____ No____
    32.1.1. Si la respuesta es que sí, ¿quién dio la asistencia o ayuda? ____________________________________
33. En una escala del 1 al 10 (con el 1 significando no recuperado y el 10 completamente recuperado), ¿cuán recuperado está usted hoy de los daños y pérdidas de los huracanes? ____
34. ¿Qué o quién fue más útil para tus esfuerzos de recuperación? ____
35. ¿Hubo algún impedimento para su recuperación? Sí____ No____
    35.1. Si la respuesta es que sí, ¿cuál impedimento? ____
36. ¿Consideró usted irse de Puerto Rico después de los huracanes? Sí____ No____
    36.1. ¿Por qué o por qué no?____
37. ¿Usted sale a pescar más o menos desde los huracanes? Mas___ Menos___ Lo mismo___
    37.1. Si la respuesta es más o menos, ¿por qué? ____
38. ¿Ha cambiado el tipo de pescado que cogías desde que pasaron los huracanes? Sí____ No____
    38.1. Si la respuesta es que sí, ¿cómo? (¿Que especies solías atrapar antes que ahora no atrapas y viceversa?) __
39. ¿Has cambiado el tipo de arte/método de pesca desde los huracanes? Sí____ No____
    39.1. Si la respuesta es que sí, ¿cómo y por qué? ____
40. ¿Has cambiado tu ubicación de pesca desde los huracanes? Sí____ No____
    40.1. Si la respuesta es que sí, ¿cómo y por qué? ____
41. Si respondió que sí a la pregunta 11: ¿Han influido los huracanes en la cantidad de peces que le regala o da a familiares y amigos? Sí____ No____
    41.1. Si la respuesta es que sí, ¿cómo? ____
42. ¿Tiene usted familiares o amigos que eran pescadores y tuvieron que abandonar este oficio debido a los huracanes? Sí____ No____
    42.1. Si la respuesta es que sí, ¿qué hacen ahora para obtener ingresos?___________________________________

E. Demografía

43. ¿Cuántos años tiene?____
44. ¿Cuál es su nivel de educación?____
45. ¿Usted es casado? Sí____ No____
46. ¿Cuántas personas, incluyéndolo/la a usted, viven en su casa? ____

Appendix 14

Complete list of occupations mentioned by fishers in period 2:

Occupation	N	% of Responses
Fishing	67	63.2%
Retired/Pension	14	13.2%
Construction	4	3.8%
Musician	2	1.9%
Fish scaling/cleaning	2	1.9%
Fish market owner	2	1.9%
Business owner	1	.9%
Gardner	1	.9%
Mechanic	1	.9%
Carpenter	1	.9%
Works for government	1	.9%
Recreation and sports	1	.9%
Electrician	1	.9%
Chef	1	.9%
Tourism boats	1	.9%
Renting truck to FEMA	1	.9%
Insurance company	1	.9%
Waiter	1	.9%
Cruise ship baggage handler	1	.9%
Painter	1	.9%
Marina employee	1	.9%

Appendix 15

Complete list of fishing methods/gear types mentioned by fishers in period 2:

Methods/Gear Types	N	% of Responses
Buceo (scuba diving)	36	26.9%
Cordel/Hilo (handline)	30	22.4%
Nasas (traps)	15	11.2%
Cana/Carrete (rod & reel)	9	6.7%
Figa/Arpon (harpoon)	9	6.7%
Trasmallo (gillnet)	8	6.0%
Tarralla/Atarraya (cast net)	4	3.0%
Malacate (electric line hauler)	4	3.0%
Anzuelo (hook)	3	2.2%
Malla (net)	3	2.2%
Silga (trolling)	3	2.2%
Free Diving/Snorkeling	2	1.5%
Mallorquin (trammel net)	2	1.5%
Trolling	2	1.5%
Trampas (traps)	1	.7%
Lazo	1	.7%
Cajones	1	.7%
Balaju	1	.7%

Appendix 16

Complete list of target species mentioned by fishers in period 2:

Target Species	N	% of Responses
Langosta (lobster)	41	12.8%
Carrucho (queen conch)	37	11.5%
Sama (mutton snapper)	30	9.3%
Colirubia (yellowtail snapper)	29	9.0%
Mero (groupper)	28	8.7%
Capitan (hogfish)	24	7.5%
Pargo (snapper)	21	6.5%
Sierra (king mackerel)	19	5.9%
Arrayao (lane snapper)	12	3.7%
Mero Cabrilla (red hind)	11	3.4%
Chillo (silk snapper)	11	3.4%
Dorado (dolphinfish)	8	2.5%
Pulpo (octopus)	6	1.9%
Peje Puerco (trigger fish)	5	1.6%
Cartucho (queen snapper)	5	1.6%
Jurel (crevalle jack)	5	1.6%
Loro (parrotfish)	4	1.2%
Cojinua (blue runner)	4	1.2%
Robalo (snook)	4	1.2%
Corvino (whitemouth croaker)	2	.6%
Pescado (finfish)	2	.6%
Boquicolorao (white grunt)	2	.6%
Pluma (porgy)	2	.6%
Atun (tuna)	1	.3%
Tiburon (shark)	1	.3%
Salmonete (goat fish)	1	.3%
Pez Leon (lion fish)	1	.3%
Sardinas (sardines)	1	.3%
Picua (barracuda)	1	.3%
Peto (wahoo)	1	.3%
Jueye (land crab)	1	.3%
Carey (hawksbill turtle)	1	.3%

Appendix 17

Factors mentioned by fishers as being most helpful for their recovery from the storms:

Source of Help	N	% of Responses
Myself	12	19.7%
Family	11	18.0%
No help	11	18.0%
Friends	7	11.5%
Government agencies	5	8.2%
God	2	3.3%
Fishing/The fishery	2	3.3%
Savings	2	3.3%
My work	2	3.3%
Hard work	1	1.6%
Crew/kin	1	1.6%
Church	1	1.6%
Community members	1	1.6%
Private organizations	1	1.6%
Restored electricity	1	1.6%
Employer	1	1.6%

Appendix 18

Reasons stated by fishers who said they considered leaving Puerto Rico after the storms:

Reason	N	% of Responses
No electricity	4	13.3%
Left and came back	3	10.0%
Unable to fish after hurricane because of bad weather	2	6.7%
No income/job	2	6.7%
More difficult to obtain necessities	2	6.7%
Economic situation	2	6.7%
For a better quality of life	1	3.3%
General atmosphere	1	3.3%
Wanted to but could not sell house	1	3.3%
Family is here	1	3.3%
The country did not seem like it was recovering	1	3.3%
Never seen anything like it	1	3.3%
Difficult to sell fish during the months after the hurricanes	1	3.3%
Considered but gave up because fishing was good	1	3.3%
Boat was broken/Couldn't go fishing	1	3.3%
Considered but had to endure	1	3.3%
My home is in PR	1	3.3%
No water	1	3.3%
Damages to house	1	3.3%
Family has left	1	3.3%
It would have been too difficult (personal reasons)	1	3.3%

Appendix 19

Factors mentioned by fishers as reasons for fishing less after the storms:

Factor	N	% of Responses
Weather related	13	30.2%
Marejadas/Bad ocean conditions	5	11.6%
Winds/Changes in wind patterns	4	9.3%
Impacts of hurricane on sea bottom	4	9.3%
Boat is/was damaged/lost	3	7.0%
Because there is less fish	3	7.0%
Damage to pier/Fishing infrastructure/*villa pesquera*	3	7.0%
Sales declines because there was less people to buy	1	2.3%
Got hurt after hurricane fixing a tree and cannot fish	1	2.3%
Went to the US after hurricane and back recently	1	2.3%
Has been busy helping family rebuild	1	2.3%
Don't know why	1	2.3%
Impacts of hurricanes on fishery	1	2.3%
Age	1	2.3%
Sargassum	1	2.3%

Appendix 20

Reasons mentioned by fishers for target species and gear changes after the storms:

Species Change	N	% of Responses
Less hogfish and conch	1	6.3%
More conch, colirubia, hogfish	1	6.3%
Use to catch land crab before hurricane and now no longer	2	12.5%
Catches less lobsters	1	6.3%
Used to catch parrotfish and snapper	1	6.3%
Catching less snook and whitemouth craoker	1	6.3%
Instead of deep water fish now fishes coastal species	1	6.3%
Handline fishing has diminished (colirubia, mero, sama)	1	6.3%
Less fish in general	3	18.8%
Not fishing with gillnet anymore (lost)	1	6.3%
Less conch	1	6.3%
Fish has moved to other areas	1	6.3%
Lionfish	1	6.3%

Gear Change	N
Weather	1
Lost traps due to hurricane	1
Not diving because of turbid water (using other gear)	1
Using lazo	1
Used to free dive and now uses tank	1
Used to fish with silga and now fishes with rod and reel from shore (lost boat)	1
Lost gillnet	1

Appendix 21

Reasons mentioned by fishers for changing fishing grounds/areas after the storms:

Reason	N	% of Responses
Has to go further away from the coast	10	31.3%
Go deeper to fish	7	21.9%
Changes in ocean bottom (tossing of stones, damage to corals)	6	18.8%
Changed location because there is less fish in usual spots after hurricanes	2	6.3%
Looked for other places with better fishing (not hurricane related)	1	3.1%
Moved from south to west (the sea in the west coast is calmer)	1	3.1%
Used to fish from a different point on the coast	1	3.1%
Fishes closer than before	1	3.1%
Has to travel farther than before	1	3.1%
Shore fishes now due to lost boat	1	3.1%
Exploring new fishing grounds	1	3.1%

Appendix 22

Changes in amount of fish donated to family and friends and reasons for change mentioned by fishers:

Change and Reason	N	% of Responses
Gives less because needs the money	3	9.4%
Gives less fish away	10	31.3%
Gives less because does not fish as much	6	18.8%
Gives less because not fishing as much due to weather	3	9.4%
Gives less because was in US for some time after hurricane and didn't fish	1	3.1%
Gave more after hurricane because needed food	2	6.3%
Gave less because couldn't go out soon after hurricane	3	9.4%
Gives less because there is less fish	3	9.4%
Gives more because is catching more fish	1	3.1%