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Shifting Baselines of Iconic Marine Species in the Caribbean

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ABSTRACT

As the degradation of Caribbean coral reefs occurs, memory of past states is lost so the degraded status is used as a standard in management, a phenomenon known as "shifting baselines." To set restoration targets, marine historical ecology studies are helpful to document baselines of species and understand the past productivity of ecosystems. In this study, I examine the historical ecology of the islands Barbuda, Curaçao, and Montserrat. I analyzed archival materials, including historical maps and other documents from the islands to identify previously abundant or iconic species and understand historical changes. From the archival resources I identified 30 places named after marine species on or near the islands and 22 references to marine species. I interviewed 40 fishermen, divers, and others familiar with the waters of Antigua, Barbuda, and Montserrat about changes in the ecosystem, with an initial focus on species identified as important or iconic from historical materials. My results demonstrate a shifted baseline: interviewees with greater experience in the marine environment view from four to six times as many species, on average, as depleted and were more likely to describe declining species as rare compared to their less-experienced counterparts. I also found disparities between perceptions of abundance, ecological assessments, and the historical material. For example, interviewees described the ecosystem of 20-30 years ago as pristine, when historical documents suggest earlier depletion. Additionally, interviewees perceived key species as more abundant than in-water surveys would suggest and described increases in species that were recently protected by legislation and have not yet had a chance recover, suggesting a "policy placebo" effect. Knowledge of past abundance is critical for policymaking, education and outreach efforts to empower communities to see the potential in the marine environment.

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CHAPTER 1. LITERATURE REVIEW

The Degradation of Coral Reef Ecosystems

Marine ecosystems are globally threatened by a variety of stressors including overfishing, habitat degradation and climate change, which have devastating effects both on the environment and the communities that rely on intact ecosystems. Coral reefs are particularly vulnerable, with losses in coral cover and large vertebrates over century-long time scales (Jackson et al., 2001; Gardner et al., 2003; Pandolfi et al., 2003). Reefs face local impacts, such as destructive fishing techniques, overfishing, nutrient loading, pollution, predation, and disease as well as global threats including ocean acidification and global warming (Cote & Knowlton, 2014). Understanding the resilience of marine ecosystems is critical for future management efforts (Hughes et al., 2003; Cote & Knowlton, 2014).

Caribbean reefs have suffered particularly large declines in coral cover and fish populations from overfishing, pollution, and a large diversity of pathogens (Gardner et al. 2003; Mumby et al., 2007; Cote & Knowlton, 2014). Average hard coral cover in the Caribbean declined by 80% between the 1970s and early 2000s (Gardner et al., 2003). The average coral cover in the region currently is approximately 16% live to dead coral, and coral communities overall have shifted from framework building species to non-framework building species (Hughes, 1994; Gardner et al., 2003; Jackson et al., 2014). The collapse of the sea urchin *Diadema antillarum*, a keystone herbivore, in 1983 resulted in large-scale Caribbean reef mortality from increases in macroalgae (Jackson, 1997; Gardner et al., 2003; Cote and Knowlton, 2014). In Jamaica, Hughes (1994) found that reefs appeared healthy between the 1950s and 1970s, prior to the sea urchin mortality event and series of frequent hurricanes in the 1980s. By the early 1980s, hurricanes, loss of herbivores, and coral disease had reduced Jamaican coral cover to approximately 38% (Mumby et al., 2007). Compared to other reef regions, the Caribbean in particular has numerous pathogens that have historically caused coral die-offs (Jackson, 1997; Cote & Knowlton, 2014).

Anthropogenic factors have combined to make coral reef ecosystems less able to recover from damage (Hughes, 1994). For example, grazing of both parrotfish and urchins is critical for reef recovery, but abundance of both are below critical thresholds required to reduced algal cover and allow coral to expand (Mumby et al., 2007) The mass die-off of urchins in 1983 was so significant because parrotfish grazing had already been substantially reduced by overexploitation (Jackson, 1997; Mumby et al., 2007). In Jamaica, the combined loss of urchins and overfishing of parrotfish prevented coral recruitment and resulted in declines to 5% coral cover by 1993 (Mumby et al., 2007). Likewise, the effects of overexploitation on reef fish populations in the Caribbean have been observable for centuries (Jackson, 1997). However, recently, the implications of habitat destruction on reef fish abundance have also become apparent (Paddack et al., 2009). Paddack et al. (2009) found that Caribbean reef fish density has declined significantly since 1996, in both exploited and non-exploited species across all sub-regions in the Caribbean.

Marine Historical Ecology and the Shifting Baselines Syndrome

Knowledge of past productivity of marine ecosystems is important to assess the current state of the ocean and manage for future recovery. Since long-term ecological data are usually not available for marine species, and fisheries data do not entirely reflect the history of human exploitation, unconventional sources are often necessary to fill knowledge gaps (Thurstan et al., 2015). The field of marine historical ecology has emerged with a growing awareness of the significance of understanding and analyzing the history of the ocean and its use (Lotze & McClenachan, 2014). Surprising results, obtained after examining long-term information about the ocean, may negate current scientific knowledge (McClenachan et al., 2015). By considering historical sources, scientists can better establish baselines for species, understand the past functioning of ecosystems, discern the degree of change to ecosystems, and incorporate past knowledge into current management (McClenachan et al., 2012; McClenachan et al., 2015; Thurstan et al., 2015). Sources have shed light on changes to species abundance resulting from human impacts like overfishing, pollution, invasive species introduction, and habitat destruction (Lotze & McClenachan, 2014; Thurstan et al., 2015). Such awareness of historical conditions is especially significant in setting management targets for restoration and assessing long-term trends (McClenachan et al., 2012; Higgs et al., 2014).

Without acknowledging the long-term history of marine ecosystem exploitation, the phenomenon of shifting baselines may occur, whereby current population levels of species are thought to be the norm, because knowledge of past abundance has been lost (Pauly, 1995). After Daniel Pauly coined the term "the shifting baselines syndrome," numerous studies have documented the phenomenon in marine communities. Dayton et al. (1998) analyzed natural and anthropogenic changes in a kelp forest, concluding that the extinction and reduction of several large species makes it impossible to know the degree of change that has occurred in the ecosystem. Other research has used interviews with resource users to document shifting baselines. Giglio et al. (2015) interviewed Brazilian fishermen about catch abundance: older fishers tended to regard more species as depleted compared to younger fishermen. Similarly, Lozano-Montes et al. (2008) found that Gulf of California fishermen's perception of the ecosystem's degradation varied by age. These studies represent a collective loss of knowledge of how productive ecosystems can be. Accepting the current conditions of ecosystems has lasting implications for management, as there is no motivation to restore the ecosystem to historical conditions (McClenachan et al., 2012). To combat the shifting baselines syndrome, researchers have used a variety of historical ecology techniques to set baselines for past abundance of species.

Recent studies have found that marine ecosystems have a much longer history of degradation and overexploitation than previously realized (Jackson et al., 2001; Pitcher, 2001; Pandolfi et al., 2003). Jackson et al. (2001) examined the effects of overfishing on reef ecosystems, concluding that exploitation of reef fish caused multiple extinctions and loss of key functional groups prior to modern exploitation and global threats (Figure 1). Using a combination of paleoecological, archaeological, historical, and ecological data available in the literature Jackson et al. (2001) found that overfishing ultimately has left marine ecosystems more vulnerable to threats like pollution, pathogens, and invasive species.

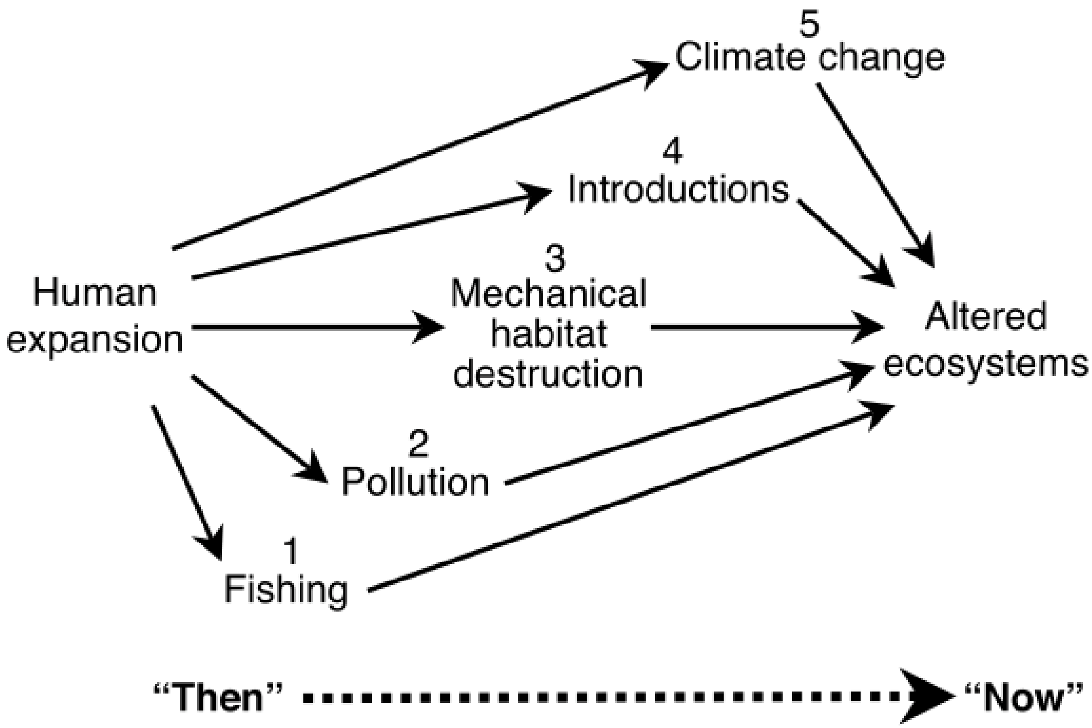


Figure 1. Anthropogenic effects on marine ecosystems: fishing is the first and primary disturbance that degrades the marine environment (From Jackson et al., 2001)

Similarly, Pandolfi et al. (2003) compiled a large number of historical records to analyze anthropogenic effects on the ocean. Though coral bleaching and disease are the large global threats currently, reefs have been threatened for centuries by overfishing and pollution (Pandolfi et al., 2003). The magnitude of decline revealed by historical data in reef ecosystems, particularly in the Western Atlantic, is enormous compared to previous estimates. Even prior to 1900, many high-value species in reefs were overexploited, forcing fishermen to shift effort to more abundant, smaller species, resulting in the sequential depletion of species (Pandolfi et al., 2003). McClenachan and Kittinger (2013) analyzed trends in the fisheries of Hawaii and the Florida Keys by reconstructing historical catch: though Hawaii and the Florida Keys have similar fisheries currently, they had different histories of exploitation and management. Management decisions made in Hawaii historically sustained high populations and heavy exploitation of reef species, demonstrating the possibility for reef fishery sustainability (McClenachan & Kittinger, 2013).

Marine Historical Ecology and Shifting Baselines in the Caribbean

Historical ecology research in the Caribbean has demonstrated that exploitation of the marine species extends much further back than European contact (Jackson, 1997; Fitzpatrick & Keegan, 2007). The first settlement in the Caribbean was between 6,000 and 7,000 years ago, and by 2,200 years ago Arawak groups had populated every island in the Lesser Antilles (Fitzpatrick & Keegan, 2007). Early Lithic (6,000 years before present), Archaic (4,000 years before present, and Ceramic (2,500 years before present) civilizations deforested islands in the Caribbean and heavily exploited marine resources, particularly queen conch and sea turtles (Jackson, 1997; Fitzpatrick & Keegan, 2007).

The colonial era marked a period of continued and, in some areas, accelerated exploitation of Caribbean reef ecosystems. The increase of fishing and land based pollution, from agriculture and deforestation, in colonial times resulted in unprecedented declines in Caribbean reef ecosystems (Jackson, 1997; Fitzpatrick & Keegan, 2007). Jackson (1997) found that substantial degradation occurred prior to 1800 from subsistence fishing, with the loss of large vertebrates like green and hawksbill turtles, manatees, and the Caribbean monk seal. Because these species were more abundant in the past, they had different roles in and effects on the ecosystem. Extinction and reduction of megavertebrates has fundamentally altered grazing behavior, predation, and food chains within marine ecosystems (Jackson, 1997). Turtle populations, particularly, are much more depleted than previously believed (Jackson, 1997; McClenachan et al., 2006). McClenachan et al. (2006) concluded, through analysis of historical sources, that 20% of all historical turtle nesting sites have been lost and 50% of remaining sites are severely reduced. When examining reef fish abundance in Jamaica, Hardt (2009) also found a longer history of decline in the Caribbean than previously believed. Reef fish decline in Jamaica has followed a non-linear pattern, with declines beginning prehistorically from subsistence fishing efforts, followed by slow recovery until further declines resumed in the mid-19th century (Hardt, 2009).

Methods in Marine Historical Ecology

A large variety of data types are available for researchers to learn about the past, including paleontological data, evidence from archaeology, historical reports, scientific surveys, and living memory (Figure 2) (Lotze & McClenachan, 2014). Various challenges exist for analyzing such nontraditional data types (McClenachan et al., 2015). For instance, historical reports and documents may present a language barrier, not be available online, and only exist in local archives (McClenachan et al., 2012). To account for the constraints and specific biases of unconventional data types, it is necessary to integrate historical sources (McClenachan et al., 2015).

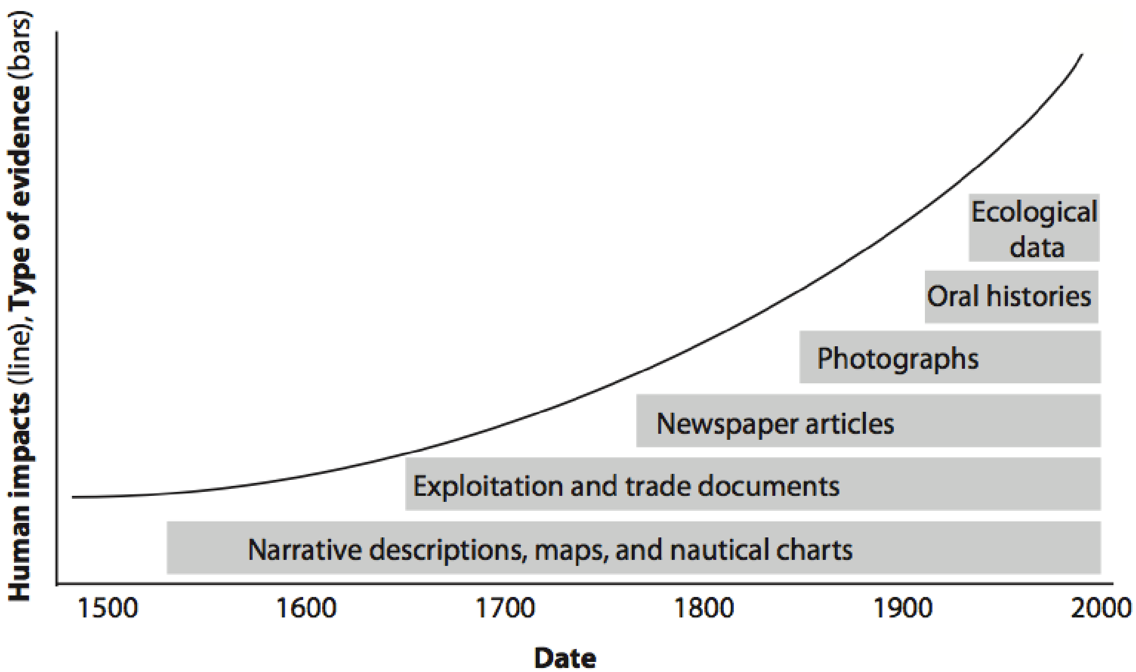


Figure 2. Data types typically used in historical ecology research and length of time each data type captures (From McClenachan et al., 2015)

Data types used in marine historical ecology include middens (Kittinger et al., 2011), historical photographs (McClenachan, 2009), descriptions from privateers, early colonists, and explorers (Saenz-Arroyo et al., 2006), tourist and fishing guides (Saenz-Arroyo et al., 2005b), restaurant menus (Van Houtan et al., 2013), place names (Kittinger et al., 2012), and historical fishing log-books (Rosenberg et al. 2005). Often, historical ecology studies combine archival research with anecdotes from oral histories and interviews to determine more recent perceptions and knowledge of changes (Saenz-Arroyo et al., 2005a; Kittinger et al., 2012).

By identifying historical reference points, studies have been able to quantify large declines in species, occasionally uncover surprising results, and understand the cultural value and perception of species in local communities (Sáenz-Arroyo et al., 2005a; McClenachan & Cooper, 2008; McClenachan, 2009; Kittinger et al., 2012). By synthesizing grey literature and interviews with fishermen, Sáenz-Arroyo et al. (2005b) found that, contrary to fishery data suggesting increases, the Gulf grouper in the Gulf of California has experienced larger declines in abundance than previously expected. McClenachan (2009) discovered a large decline in the weight and composition of trophy reef fish caught in the Florida Keys since the 1950s through analysis of historical photographs. By comparing catches of sharks in the Gulf of Mexico from the 1950s to 1990s, Baum and Myers (2004) found a decline of over 99% in the oceanic whitetip shark and 90% decline in the silky shark. Van Houtan et al. (2013) examined menus to interpret changes in the market availability of seafood in Hawaii and identified shifts in pelagic fisheries as near-shore stocks were overfished.

Other studies have used available historical data to reconstruct populations of once-plentiful species to understand the magnitude of declines (Rosenberg et al., 2005; McClenachan & Cooper, 2008). Kittinger et al. (2012) evaluated historical documents including archaeological reports and descriptive documents in addition to place names and interviews with community-members in Hawaii to determine the historical cultural associations between communities and the Hawaiian monk seal. Engaging community-members, potentially through interviews, but more importantly in the decision making process, is crucial for restoration efforts and better understanding of the marine environment (Kittinger et al., 2012). Insights from interviews supplemented with other nontraditional sources can provide a robust account of the past abundance of species (McClenachan et al., 2015).

Interviews and Local Ecological Knowledge (LEK)

The use of local ecological knowledge from interviews in historical ecology research has recently gained more attention for its ability to include resource users in decisions and tap into the knowledge of locals. When describing local ecological knowledge (LEK), researchers often use the terms traditional ecological knowledge (TEK), indigenous ecological knowledge (IEK), or, for marine systems, fishers' ecological knowledge (FEK). Regardless of the term used, the definition of LEK often includes a detailed system of knowledge gained through continual interaction with and observations of the environment that is learnt and passed on between generations (Huntington, 1998; Davis & Wagner, 2003; Davis & Ruddle, 2010). Increasingly, studies have recognized the value of LEK in better understanding environmental change, and various national and international programs from organizations, including the IUCN, have dedicated projects to the documentation of LEK (Huntington, 1998; Davis & Wagner, 2003).

Concerning marine resources, fishermen often have gathered valuable knowledge over their lifetimes that managers and biologists may not be aware of (Johannes, 2000). This knowledge base is detailed and extensive; fishermen and other resource-users will most likely be the first to recognize changes in the system as they deal most directly with the resources (Johannes, 2000; Murray, 2006). Johannes (2000) commented that, when the Atlantic cod fishery collapsed, it was fishermen who first noticed the low spawning stock levels. Particularly with artisanal fisheries that lack long-term data, fishermen hold valuable information about changes in species abundance and the marine environment (Huntington, 1998; Johannes, 2000). LEK is fluid, and fishermen's knowledge alters as they modify fishing practices, locations, and as the environment around them changes (Murray et al., 2006).

Within the literature, there is not complete agreement concerning the value of LEK research and how the research can benefit communities. Davis and Wagner (2003) argued that LEK can only accurately and justly inform resource management when it empowers communities and recognizes the full range of experiences and priorities of communities. The major issue several studies have with LEK is that it must be translated into a form that can be used in management (Garcia-Ouijano, 2007; Davis & Ruddle, 2010). Such researchers argue that it is impossible for the constraints of Western science to accurately represent the full range of values LEK imparts (Davis & Ruddle, 2010). To better represent LEK in the scientific field, several researchers have set out requirements for research designs with community involvement (Huntington, 1998; Davis & Ruddle, 2010).

Adequately documenting methodology is paramount for using LEK scientifically; research can record LEK using interviews, questionnaires, workshops, or collaborative field-work (Huntington, 1998; Garcia-Ouijano, 2007). The research design must detail how informants are selected and report how and if any experts are identified (Davis & Wagner, 2003; Davis & Ruddle, 2010). Furthermore, all aspects of the information gathering, including the time period, relative weight given to respondents, and any other techniques used must be properly documented and explained (Huntington, 1998; Davis & Ruddle, 2010).

Interviews conducted to gather LEK for use in management decisions often have the goal of community empowerment and should follow recommended ethical guidelines (Bunce et al., 2000; Davis & Ruddle, 2010). Some studies warn that questionnaires are too rigid a format to document LEK, and that open-ended interviews are more desirable, as a respondent will make connections beyond anything the interviewer can predict (Huntington, 1998; Johannes, 2000). However, questionnaires could potentially make respondents more comfortable than open-ended interviews, and be advantageous if the interviewer knows the information they are looking for (Huntington, 2000). During interviews or questionnaires, the use of pictures and maps are invaluable additions to encourage conversation (Huntington, 1998). Daw (2010) cautioned against assuming all information from interviews is true, explaining that due to memory illusions and exaggerations, interviewers must account for biases. To identify and explore any inconsistencies, information gained from semi-structured interviews can be combined with other forms of data to illuminate patterns. Parsons et al. (2000) found a disconnect between LEK from interviews compared to trends from logbooks and stock assessments in the Australia snapper fishery. The inconsistencies identified had implications for shifting baselines in the fishery: resource users could have preferentially recalled years with high catches and not recognized the long-term decline of the snapper (Parsons et al., 2000) One of the most important parts of LEK research is determining how best to apply gathered information to benefit communities and empower better ecosystem management (Davis and Wagner, 2003).

The use of LEK is critical for use in restoration efforts because it both taps into a vast amount of relevant information from local resource users and gives locals a stake in the process of understanding ecosystem changes and goals for restoration (Johannes, 2000). Garcia-Ouijano (2007) interviewed artisanal fishermen in Puerto Rico to analyze LEK about marine resources, finding the fishermen adept at recalling patterns in the environment. By interviewing fishermen in Brazil and categorizing based on experience, Bender et al. (2014) was able to identify depleted fishing grounds and document the shifting baselines syndrome amongst fishermen. Younger fishermen, on average, reported less species and sites as depleted compared to older fishermen. LEK about declines in species like bluefish, grouper, and large parrotfish was supported by available fishery data (Bender et al., 2014). Sáenz-Arroyo et al. (2005a) commented on the rapid speed of shifting baselines amongst fishers in the Gulf of California, with half of the older fishermen naming up to five times as many species (Figure 3A) and four times as many fishing sites as depleted (Figure 3B) compared to half of the younger fishermen. The speed of shifting baselines in marine ecosystems underscores the significance of passing knowledge on to younger generations

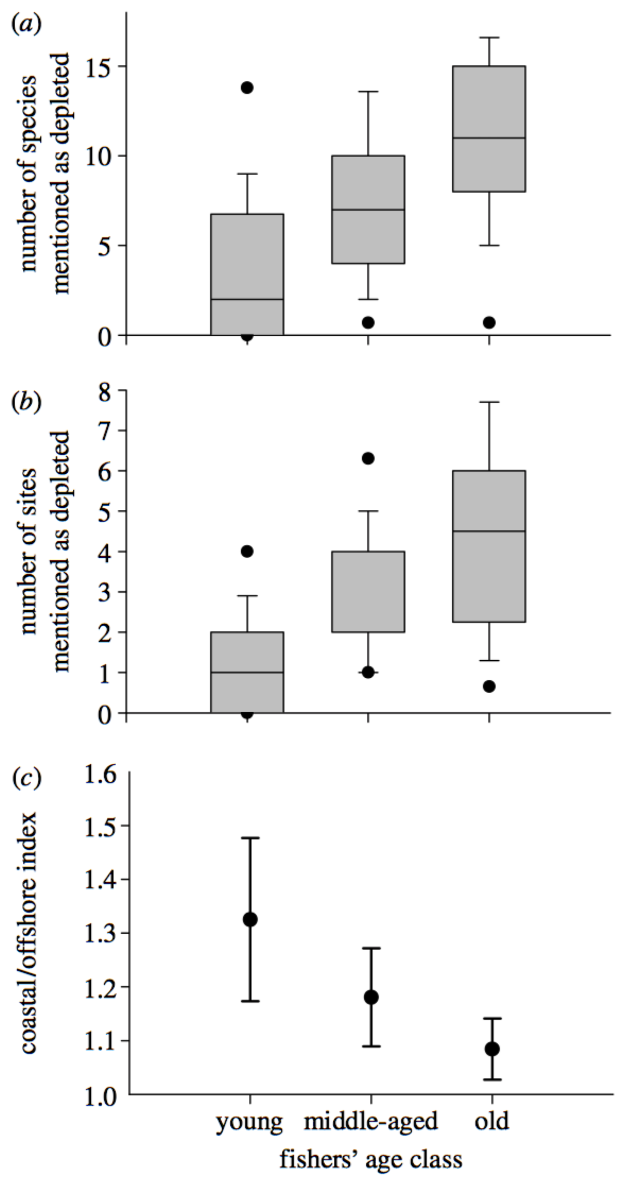


Figure 3. (a) Boxplot showing number of species mentioned as depleted, (b) boxplot showing number of sites mentioned as depleted, and (c) mean value site mentioned by age group of fishers (From Sáenz-Arroyo et al., 2005a)

and empowering restoration efforts (Sáenz-Arroyo et al., 2005a). LEK is a powerful and critical tool to inform marine policy and allow inclusion of the community in resource management decisions.

Research Partner: The Waitt Institute

This research is part of a larger project, the Blue Halo Initiative, led by the Waitt Institute on the islands of Barbuda, Curaçao, and Montserrat that aims to inform island communities about the past productivity of their waters and empower restoration efforts. The Blue Halo Initiative on Barbuda began in 2012, and by 2014, the Waitt Institute's collaboration with the community and government resulted in the passage of groundbreaking marine policy creating marine protected areas and regulations conserving fish species (Barbuda Fisheries Regulations, 2014). In 2015, The Waitt Institute signed memorandums of understanding with the governments of Curaçao and Montserrat, to expand the Blue Halo Initiative (MOU Curaçao, 2015; MOU Montserrat, 2015). Currently, the projects on Curaçao and Montserrat are in the process of community consultations and surveys, habitat mapping, ecological assessments, policy analysis, education, and outreach.

This project fits into the Waitt Institute's goal of empowering sustainable ocean policy reform by building on past studies that have used both available archival material as well as LEK from interviews to identify shifting baselines and better understand changes to the marine environment (Sáenz-Arroyo et al., 2005a; Lozano-Montes et al., 2008; Kittinger et al., 2012). Though studies in other regions have used similar techniques, LEK from resource users in the Caribbean remains a relatively untapped resource. LEK research and information about past changes is particularly significant for small island developing states (SIDS) within the Caribbean, where global stressors continue to threaten the resilience of communities and the marine ecosystem (Lewsey et al., 2004; Mercer et al., 2012). As ecosystem restoration requires extensive knowledge about past changes, information from this research will be critical for communities to inform marine policy and move forward with restoration efforts. Through use of archival resources and LEK research, this study seeks to document shifting baselines and understand changes in species abundance on the Caribbean islands of Barbuda, Montserrat, and Curaçao (Figure 4).

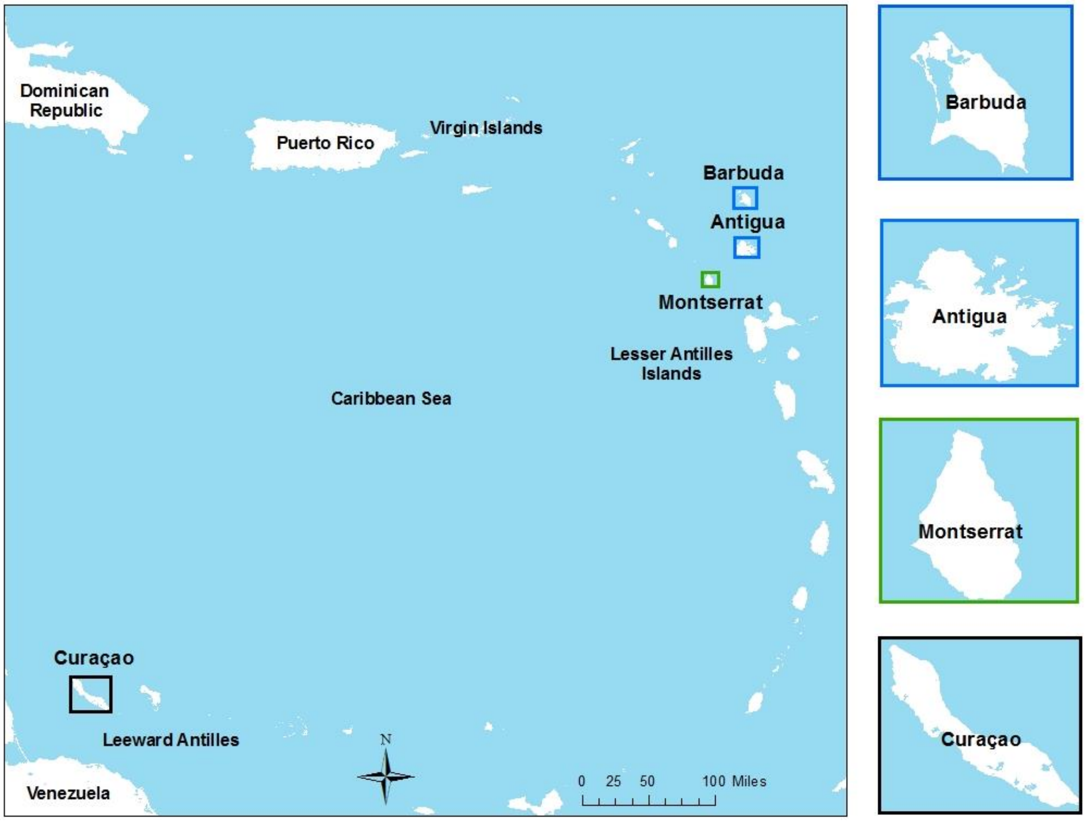


Figure 4. Study area: Barbuda (twin-island state with Antigua), Montserrat, and Curaçao.

Island Historical Background

Barbuda

Barbuda is a 155 square km island part of the twin state of Antigua and Barbuda in the Lesser Antilles of the Caribbean (UN CSD, 2012). The first records of settlements date to 3,500 BCE with Amerindians travelling north from South America. Columbus named Barbuda after sailing by the island on his second voyage through the Caribbean (Barber, 2011). British colonizers arrived in 1632 and established plantations of tobacco, cotton, and sugar, leading to rapid deforestation of virgin forests, with estimates of forest cover loss in Antigua and Barbuda of over 92% from 1632 to the end of the colonial period in the mid-1900s (UN CSD, 2012; Gore-Francis, 2013; Georges et al., 2015). As soils in

Barbuda were less fertile than Antigua, the island was primarily used for raising livestock. The majority of the population was based on Antigua: the population of Barbuda in 1822 was estimated at 1,500 total, while Antigua's total population was nearly 35,740 in 1817 (DLOC, 1822; Georges et al., 2015). Despite the cotton and sugar market collapse in the 1900s, deforestation and overgrazing continued with small-scale food production (Albuquerque & McElroy, 1995). Antigua and Barbuda officially gained independence in 1982 and established an EEZ and Fishery Zone of 200 nautical miles (UN CSD, 2012). Tourism began to develop in the late 1900s and has become the most substantial driver of the economy, in addition to light manufacturing, and services (Gore-Francis, 2013).

Curaçao

Curaçao is a 444 square km island located in the southern Caribbean approximately 40 miles north of Venezuela. The original inhabitants of the island were most likely Arawak Amerindians travelling north from South America. Alonso de Ojeda and Amerigo Vespucci, contemporaries of Columbus, were the first Europeans to document Curaçao, as they sailed toward the South American coast in 1499 (Anderson & Dynes, 1975). Spaniards colonized the island in 1527 and used the land for cattle ranching. In 1634, the Dutch took control of Curaçao as a base for trade, taking advantage of the location and deep-water harbor (CMM, 2015). The town of Willemstad grew around the harbor, and throughout the 17th century, Curacao was a base for Dutch privateers (Barbour, 1911). By 1816, the population was approximately 12,810 on Curaçao, including nearly 6,000 enslaved Africans (Anderson & Dynes, 1975). In the late 1800s, shipping lines between New York, Amsterdam, and Curaçao were established and, with the construction of the Panama Canal and the discovery of Venezuelan oil, development continued. The Royal Shell Oil Company built a refinery on the island, making the country increasingly dependent on oil (Anderson & Dynes, 1975). In 1954, the island became a territory of the Netherland Antilles, with self-governance. In the late 1900s, profits from oil decreased, and the economy became more dependent upon tourism. In 2010, Curaçao became an independent country within the Netherlands (CMM, 2015).

Montserrat

Montserrat is a small (102 square km) island located approximately 27 miles southwest of Antigua with a similar history to that of Barbuda (described above). Like Barbuda, Columbus viewed and named the island on his second voyage in 1493. British settlers and Irish indentured servants arrived on the island in the 1630s and deforested more than two-thirds of the land within 50 years (IRF & MNT, 1993). Labor on cotton, sugar, and tobacco plantations depended on enslaved Africans, with a population of approximately 9,500 by 1805, contributing to a total population size of 10,750 (DLOC, 1822; IRF & MNT, 1993). The slave trade was abolished in 1807, and slaves were freed in 1832, though equal voting rights and status were not achieved until later (Berleant-Schiller, 1996). The sugar economy faltered on Montserrat during the 1800s, as the soil became increasingly degraded and several hurricanes destroyed the land. In 1824, the governor of the Leeward Islands Colony described Montserrat as, "impoverished and ruined" (Berleant-Schiller, 1996). Similar to other Caribbean islands, as agricultural production decreased, tourism development began in the late 1900s on Montserrat. However, while other colonized islands became independent in the 1960s, Montserrat retained British rule and is still a British Overseas Territory (Berleant-Schiller, 1996; CIA, 2015). Hurricane Hugo's center passed directly over Montserrat in September of 1989. The Category 4 hurricane destroyed 20% of the Montserrat's buildings and damaged 98% of island infrastructure in addition to surrounding seagrass beds and coral communities (IRP, 2016). In 1995, a volcanic eruption devastated the island, and nearly two-thirds of the population left within five years, leaving 5,000 residents (CIA, 2015).

CHAPTER 2. ARCHIVAL INFORMATION

Introduction

Historical maps and place names have been used in historical ecology studies to identify species that were abundant in the past (Jackson et al., 2001). Throughout the period of European exploration and colonization, maps were important sources of information for Europeans, and this information can be extracted to make inferences about ecological processes (Pulsipher, 1987). Historical maps contain valuable information that can be used in a variety of applications. For example, Water and Merrits (2008) analyzed historical maps and records of stream-beds in the mid-Atlantic, concluding that the shape of stream deposits has changed since European settlement. Additionally, Kittinger et al. (2012) examined place names in Hawaii to better understand human relationships with the monk seal.

In the Caribbean, place names are commonly indigenous or colloquial names that may be associated with natural flora and fauna or geographical features of the area, providing the opportunity to identify common or iconic species present at the time the location was named (Nicholson, 2002). Jackson et al. (2001) refers to places named after species in the Caribbean like sea turtles, oysters, pearls, and conch, where the populations have all but disappeared. By synthesizing information from historical maps in addition to historical narratives and archaeological records, McClenachan and Cooper (2008) reconstructed the historical distribution of the now-extinct Caribbean monk-seal.

Information from other types of archival resources has also been used in historical ecology research. Previous research including archival resources has used historical photographs (McClenachan, 2009), descriptions from explorers (Sáenz-Arroyo et al., 2006), plantation records (Hardt, 2009) menus (Van Houtan et al., 2013), and log-books from fishermen (Rosenberg et al. 2005) to identify changes in species abundance, distribution, and exploitation rates. For example, given identified historical information, Jackson (1997) determined that sea urchins (*Diadema antillarum)* were much more abundant in the past than previously believed.

By synthesizing information from historical anecdotes and maps, marine historical ecology studies can generate a more robust description of past ecosystems. The goal of this component of the project is to identify places named after marine species and additional marine references from anecdotal accounts on Barbuda, Curaçao, and Montserrat in order to better understand changes in marine species.

Methods

Historical Maps

I reviewed 229 online maps ranging from 1528-1960 depicting Antigua and Barbuda, Curaçao, and other islands of the Lesser Antilles from five online databases (Table 1). I also reviewed 34 maps ranging from 1673-2001 available at museums in Antigua and Montserrat (Table 2). In analyzing these maps, I noted any references to marine species or the marine environment. As maps depicting Curaçao and other holdings of the Netherlands are written in Dutch (Figure 5), I had a Dutch speaker assist with translations of place names where necessary.

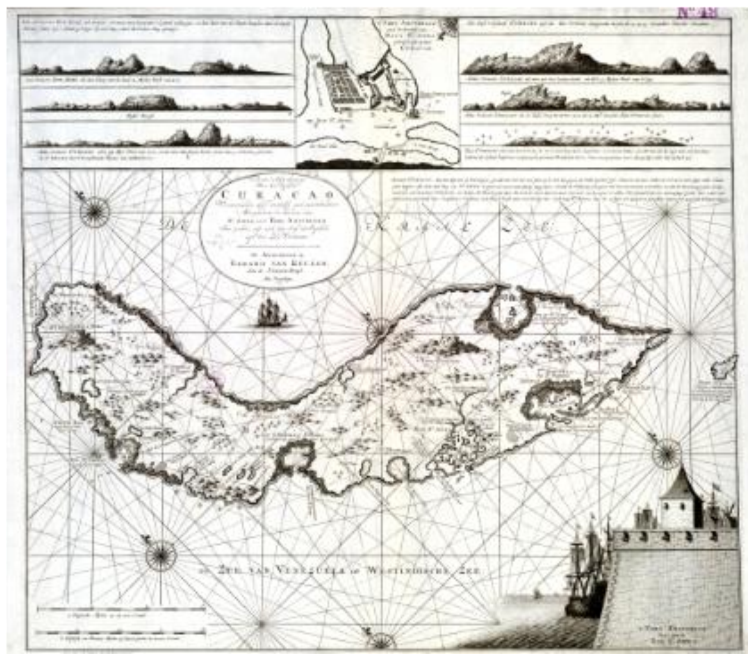


Figure 5. 1728 Map of Curaçao (Caribmap, 1728)

I consulted five online databases with historical Caribbean maps. Caribmap contains approximately 1,800 maps depicting islands of the Caribbean printed between the 16th and 20th century. The Digital Library of the Caribbean provides maps, news, and other archival information about islands of the Caribbean. The University of Alabama has an online historical map archive pertaining to different regions of the world with over160,000 maps. The David Rumsey Map Collection contains over 150,000 maps ranging from the 16th to 21st century. The Library of Congress has an extensive map collection, with maps of the Caribbean area ranging from the 16^{th} - 21^{st} century. After identifying place names, I compiled the data and created maps using ArcGIS of all marine place names in the Lesser Antilles and Curaçao (ArcGIS 10.3.1, projection GCS_WGS 1984).

Table 1. Summary of maps viewed from online collections.

Source	Number of Maps	Date Range	Website
Caribmap	87	1528-1960	www.caribmap.org
David Rumsey Maps	12	1736-1853	www.davidrumsey.com
Digital Library of Caribbean	53	1600-1880	www.dloc.com
Library of Congress	38	1700-1799	www.loc.gov/maps.com
University of Alabama	39	1580-1910	www.alabamamaps.ua.edu
Total	**229**	**1528-1960**	

Table 2. Summary of maps viewed from museums

Source	Number of Maps	Date Range
Museum of Antigua and Barbuda	30	1748-1977
Montserrat National Trust	4	1673-2001
Total	**34**	**1673-2001**

Anecdotal Resources

To locate online archival resources, I reviewed four historical ecology studies (Jackson, 1997; Jackson et al., 2001; McClenachan et al., 2006; Fitzpatrick & Keegan, 2007) that included or focused on the Caribbean and investigated the historical sources used in this previous research. Additionally, I identified individuals, such as missionaries, privateers, and colonists that wrote about their visits to the islands. I reviewed documents, including diaries, ecological descriptions, letters, and trade documents available online from inhabitants and visitors to the islands for mentions of the marine environment (Figure 6). For example, privateer documents from 16^{th} century Caribbean pirates, historical trade documents from the Dutch West India Company's base on Curaçao, and missionary diaries from the Church of the United Brethren on Antigua and Barbuda have all been made available online from studies analyzing Caribbean history (Periodical Accounts, 1814; Jameson, 2008; Butcher, 2012; Curaçao Papers, 2011).

I also identified possible repositories of local archival resources on Montserrat, Antigua, and Barbuda. On the islands, I travelled to three museums: the Montserrat National Trust, the Museum of Antigua and Barbuda, and Nelson's Dockyard Museum. The Montserrat National Trust, located in Olveston, has a series of exhibits describing the history of Montserrat, archived environmental reports, archived copies of local newspapers, and a large reference library. The Museum of Antigua and Barbuda in St. Johns, Antigua, opened in 1985 and is operated by the Historical and Archaeological Society of Antigua and Barbuda. Their collection includes historical maps not available online and exhibits exploring the cultural history of the country. The Nelson's Dockyard Museum in English Harbour, Antigua houses several historical exhibits and serves as an archaeological and environmental research station. Before visiting each location, I contacted museum historians for assistance in locating historical documents and maps.

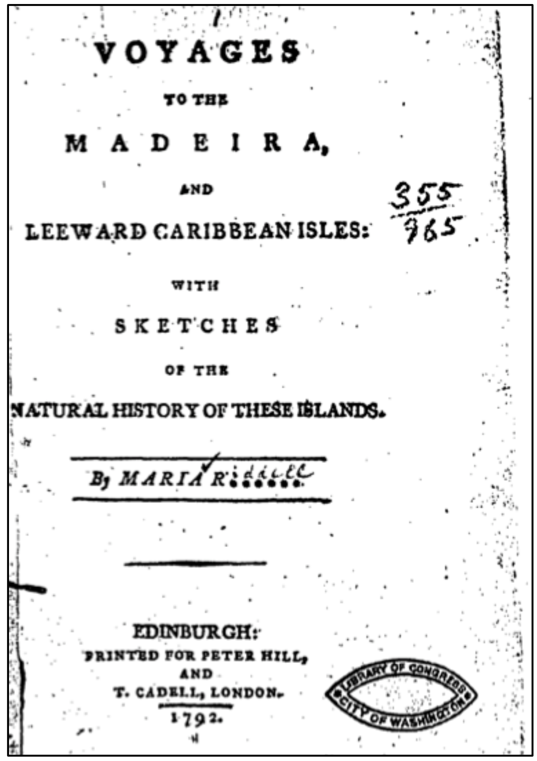

VOYAGES
TO THE
MADEIRA,
AND
LEEWARD CARIBBEAN ISLES:
WITH
SKETCHES
OF THE
NATURAL HISTORY OF THESE ISLANDS.
By MARIA R.......
EDINBURGH:
PRINTED FOR PETER HILL,
AND
T. CADELL, LONDON.
1792.

Figure 6. Descriptions of the Antilles from 1792

Results

Historical Maps

I identified 20 marine references from online historical maps and 10 marine references from maps available at museums of the Lesser Antilles, Curaçao, and nearby islands (Table 3). I included place names from Puerto Rico because it was included on historical maps of the Lesser Antilles and as an example of marine places given by a different colonial power, the Spanish, instead of the Dutch or British (Brás, 2001). Eleven species total were mentioned in place names, including: crab, lobster, man o' war, snapper, turtle, grouper, shark, octopus, sardine, tuna, and oyster. Eight place names did not reference species, but “fish” in general, including the abundance of fish: “much fish is caught” (Caribmap, 1728). While some references were actual place names, such as “Crab Hill,” others referenced a species like, “Groupers,” and others were more descriptive including, “Sharks without number” (Figure 7) (Museum of Antigua and Barbuda, 1748; Museum of Antigua and Barbuda, 1784; Museum of Antigua and Barbuda, 1977).

Table 3. Summary of place name or other marine reference identified**.** References are presented alphabetically by island and chronologically.

Marine Reference	**Location(s)**	**Date**	**Source**
Crab Valley Pt.	Antigua	1716	Caribmap
Fish Pond	Antigua	1716	Caribmap
Crab Hill	Antigua	1748	Museum of Antigua and Barbuda
Lobster Island	Antigua	1748	Museum of Antigua and Barbuda
Man of War Point	Antigua	1748	Museum of Antigua and Barbuda
Snapper	Antigua	1788	Museum of Antigua and Barbuda
Lobster	Antigua	1824	Caribmap
Man o’war	Antigua	1824	Caribmap
Man of War	Barbuda	1813	Museum of Antigua and Barbuda
Fishing Creek	Barbuda	1848	Museum of Antigua and Barbuda
Groupers	Barbuda	1977	Museum of Antigua and Barbuda
Lobsters	Barbuda	1977	Museum of Antigua and Barbuda
Sharks	Barbuda	1977	Museum of Antigua and Barbuda
Fish Trap Bay	Curaçao	1728, 1872	Caribmap, DLOC
Octopus Bay	Curaçao	1728	Caribmap
Much fish is caught	Curaçao	1728	Caribmap
Piscadero Bay	Curaçao	1775	Caribmap
Piscadoris	Curaçao	1775	Caribmap
Coral Sea	Curaçao	1779	Caribmap
Fisher Bay	Curaçao	1779	Caribmap
Crab Point	Dominica	1778	Caribmap
Tortuguero	Puerto Rico	1639	Caribmap
Ensenada Sardinera	Puerto Rico	1898	Caribmap
Punta de la Tuna	Puerto Rico	1898	Caribmap
Groupers	St. Barts	1872	DLOC
Sharks without number	St. Croix/ St. Kitts	1784	Museum of Antigua and Barbuda
Great Turtle Bay	St. Kitts-Nevis	1747	Caribmap
Crab Hole	St. Kitts-Nevis	1824	Caribmap
The fishery	St. Kitts-Nevis	1824	Caribmap
Oyster Pond	St. Martin	1872	DLOC

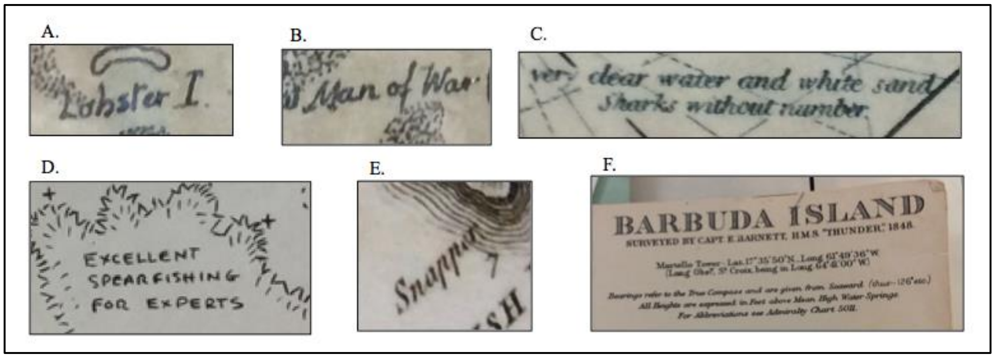


Figure 7. Marine references from (A) Museum of Antigua and Barbuda, 1748, (B) Museum of Antigua and Barbuda, 1813, (C) Museum of Antigua and Barbuda, 1784, (D) Museum of Antigua and Barbuda, 1977, (E) Museum of Antigua and Barbuda, 1788, and (F) an example of a historical map (Museum of Antigua and Barbuda, 1848).

Available maps of Barbuda range from 1528-1977. In total, 175 maps of Barbuda were identified and reviewed. Marine place names identified on Barbuda include “Man of War” (Museum of Antigua and Barbuda, 1813), “Fishing Creek” (Museum of Antigua and Barbuda, 1848), “Lobsters,” “Groupers,” and “Sharks” (Museum of Antigua and Barbuda, 1977) (Figure 7). Names of terrestrial species found on Barbuda include: “Palmetto Point” (Caribmap, 1920), “Goat Reef” (Caribmap, 1902), “Hog Cliffs” (Caribmap, 1893), “Flamingo Pt.”

Figure 8. Historical place names on Antigua and Barbuda

(Caribmap, 1893), and “Pelican B.” (Caribmap, 1893).

Historical maps of Barbuda often also include Antigua, or the entire Lesser Antilles chain of islands. Places named after marine species on Antigua include “Fish Pond” (Caribmap, 1716), “Crab Valley Pt.” (Caribmap, 1716), “Lobster” (Caribmap, 1824a), “Man ‘o war” (Caribmap, 1824a), “Lobster Island,” “Man of War Point,” “Crab Hill” (Museum of Antigua and Barbuda, 1748), and “Snapper” (Museum of Antigua and Barbuda, 1788) (Figure 7). Marine references on maps of nearby islands of the Lesser Antilles are included in the next section (Figure 9).

Available maps of Montserrat range from 1528-2001. In total, 163 maps of Montserrat were identified and reviewed. While no marine place names were identified, places named after species on nearby island include references already described from Antigua and Barbuda (Figure 8), “Groupers” on St. Bartholomew (DLOC, 1872), “Oyster Pond” on St. Martin (DLOC, 1872), “Great Turtle Bay,” “The fishery,” and “Crab Hole” on St. Kitts-Nevis (Caribmap, 1747; Caribmap, 1824b), “Sharks without number” to the east of St. Kitts and Nevis (Museum of Antigua and Barbuda, 1784), “Crab Point” on Dominica (Caribmap, 1778), and “Tortuguero,” “Punta de la Tuna,” and “Ensenada Sardinera” on Puerto Rico (Caribmap, 1639; Caribmap, 1898) (Figure 9).

Maps of Curaçao range from 1728 - 1872. In total, 20 maps of Curaçao were identified and reviewed. As the Netherlands controlled Curaçao, historical maps depicting the island are written in Dutch. A Dutch speaker translated identified marine references and species names. Descriptions on the maps suggest abundance of fish: “a little bay for boats, much fish is caught,” “Piscadero Bay,” “Piscadoris,” (Caribmap, 1775), “Fisher Bay,” (Caribmap, 1779), and “Fish Trap Bay,” (Caribmap, 1728) in addition to references to marine species including “Octopus Bay” and “Coral Sea,” (Figure 10) (Caribmap, 1728; DLOC, 1872).

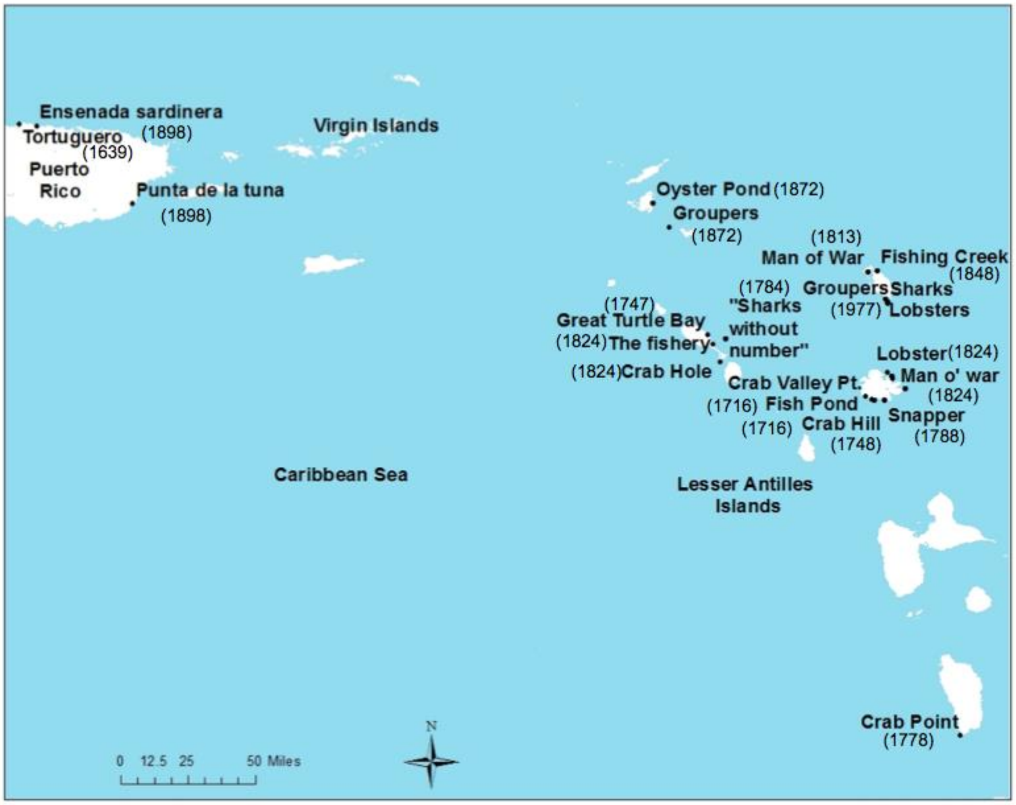


Figure 9. Historical place names on islands of the Lesser Antilles and Puerto Rico

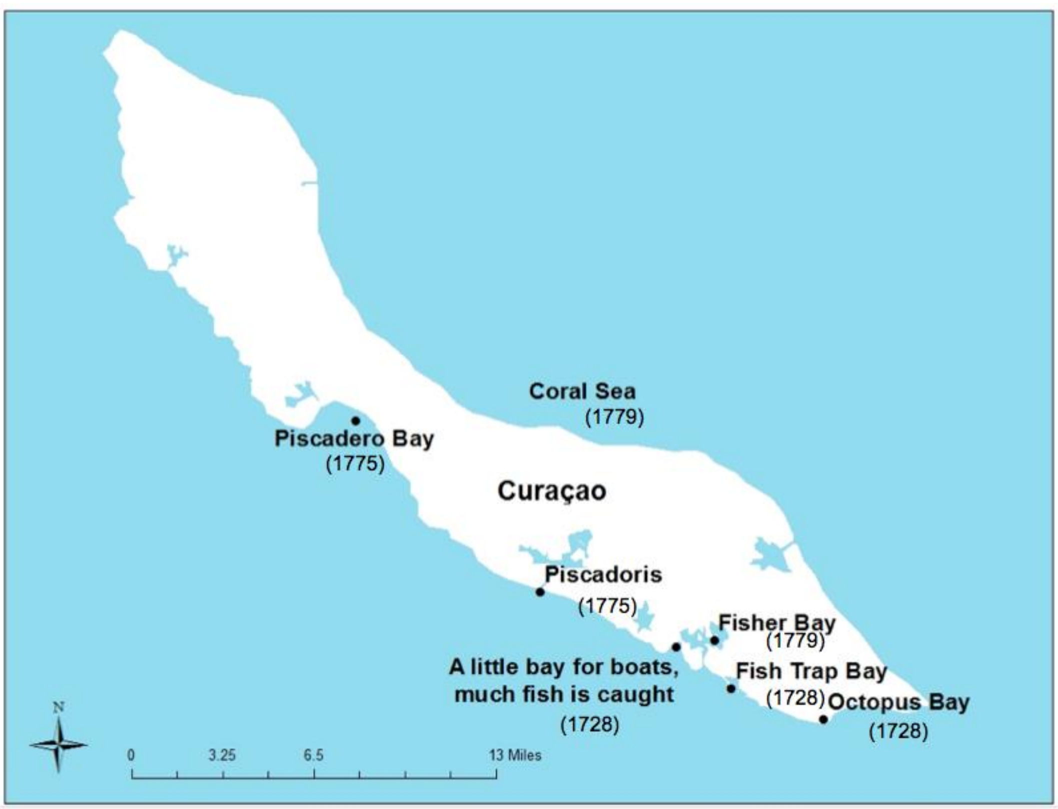


Figure 10. Historical place names on Curaçao identified from maps.

Anecdotal Resources

I identified eight documents with 22 references of 11 marine species from available online resources and with the assistance of museum historians (Table 4). Several of the anecdotal documents contained descriptions of multiple islands, because authors often travelled throughout the chain of Lesser Antilles Islands. For example, Henry Nelson Coleridge, the nephew of the bishop of Barbados, accompanied his uncle on a trip throughout the West Indies and published his book *Six Months in the West Indies* the year after the voyage (Coleridge, 1825).

Species mentioned in the anecdotal accounts in Antigua and Barbuda include: sea urchins (also referred to as sea eggs) (Riddell, 1792; Nutting, 1919), turtles (Lanaghan, 1884 in McClenachan et al., 2006; Riddell, 1792), land crabs (Coleridge, 1825), barracuda (Coleridge, 1825; Riddell 1792), mackerel (Coleridge, 1825), sharks (Coleridge, 1825; Riddell, 1792), kingfish, snappers (Coleridge, 1825), oysters (Riddell, 1792), Portuguese man of war (Riddell, 1792), and sting rays (Riddell, 1792). Urchins were noted specifically due to their abundance, "found almost everywhere in the shallow water" and the pain of their spines (Nutting, 1919 in Jackson, 1997). Turtles are also mentioned because of their abundance, and the "delicacy" of turtle meat is described (Riddell, 1792; Lanaghan, 1884). Both Coleridge (1825) and Riddell (1792) remark upon the danger of barracuda and that, "men…should make a point of murdering…these barbarous brutes." Stingrays are referenced because of their size, "about twelve feet in length and seventeen in breadth" (Riddell, 1792). On Barbuda, specifically, the abundance of oysters in mangroves is described (Riddell, 1792).

Figure 11. Advertisement for lobster from 1973 in Montserrat (Montserrat National Reporter, 1973)

All species references on Curaçao come from the "Curaçao Papers," a series of documents retained by the colonial administrator for the Dutch West India Company between 1635 and 1638, Peter Stuyvesant. Descriptions of the marine species include turtles, manatee, sea urchins, conch, and multitudes of fish, without any reference to specific names. Though authors of the letters often referenced the abundance of fish, the Dutch did not do much fishing because, "the men ruined their shoes more than the fish caught by them were worth…they cannot go fishing barefoot on account of the sharp stones and spiny sea-urchins." Moreover, the men found fishing, "an extraordinary degradation." The Dutch officials described turtle as a food source, and often sent out groups to catch them. Conch is frequently listed on manifests, for trading in the Netherlands and other countries (Curaçao Papers, 2011).

Descriptions of marine species around Montserrat include: turtle (Coleridge, 1826), sailfish, marlin, dolphin, kingfish, sharks, jacks, ballyhoo (Brown, 1945), lobster (Montserrat National Reporter, 1973), and flying fish (Montserrat National Reporter, 1995). Like on other Caribbean countries, turtle is often referred to as a popular dish on the island (Coleridge, 1826). While restaurants in the country's newspaper frequently advertised "Lobster Dinners" in the 1970s newspaper issues, lobster was not advertised in later issues (Figure 11). Only one restaurant consistently advertised fish on their menus: flying fish from the Harbour Court Restaurant (Montserrat National Reporter, 1995). Brown (1945) described the common occurrence of fish poisonings in Montserrat, particularly from barracuda, couvalli, grouper, rock-fish, and snapper (Table 4).

Descriptions from the West Indies, more generally, were found in Fernández de Oviedo y Valdés's "General and Natural History of the Indies" (Branch, 2004). Oviedo supervised actions in Santo Domingo from 1514 until returning to Spain in 1523 as the historiographer of the Indies. Oviedo describes the abundance of shark and turtles in particular in the West Indies, but also mentions mojarra, rays, trout, pompanos, porgies, mullet, octopi, dolphins, shad, lobsters, crabs, and oysters (Branch, 2004).

Table 4. Marine references from Antigua, Barbuda, Montserrat, and Curaçao identified in anecdotal material, presented chronologically. Species of interest or key reference are underlined.

Reference	Year	Location	Source
It has been decided to send a sloop with some soldiers up to the islands of Aves and Rocas to catch some **turtles**…which we have been told come ashore in large numbers during the months of May and June.	1643	Curaçao	Curaçao Papers, 2011
He made a voyage along the mainland of Caraquas towards certain small islands …with the purpose of catching **turtles**, spending about three weeks of his time there in order to supply himself with them…	1657	Curaçao	Curaçao Papers, 2011
Regarding what was supposed to have been such a great assistance to them[the Spaniards] i.e. the **large abundance of fish** which could be caught here in such numbers that it was said to be sufficient to be able to maintain and feed a needy garrison even when meat was lacking...That the Spaniards were able to obtain **enough fish** here in the interior bodies of water as well as in the bays for their own use, is…quite believable…Although there are bays here and there which **abound in fish,** until now I have been unable to attempt much …Just some time ago I dispatched one of the Company's vessels to the bay of St. Cruys [bay on the West shore of Curaçao] with as many men as possible in order to after the net, hoping to catch a quantity of **fish and…turtles.**	1657	Curaçao	Curaçao Papers, 2011
Manifest of goods: 3 barrels of **conch**…manifest: four hundred and **thirty-four conchshells**…manifest: **4 barrels conch, 350 conch**	1659	Curaçao	Curaçao Papers, 2011
Four species of turtle are found on the shores of this island, the **green turtle**, the **hawk's bill**…the **loggerhead,** and the land-tortoise… The green turtle is reckoned one of the greatest delicacies in the West Indies.	1790	Antigua and Barbuda	Riddell, 1792
The **Portuguese man of war**, is often seen floating...near the windward shores.	1790	Antigua and Barbuda	Riddell, 1792

The **<u>echinus</u>**, or sea egg is a round or oval shell … covered with spines on moveable joints.	1790	Antigua and Barbuda	Riddell, 1792
The **<u>sting rays</u>**…about twelve feet in length, and seventeen in breadth, the mouth is four feet wide, the body is about two feet in thickness, the tail is fourteen feet long and tapers to a fine point.	1790	Antigua and Barbuda	Riddell, 1792
The **<u>barracuda</u>**, which is a fish of dreadful voracity, that frequently attacks and devours the men here when they bathe in the open sea. It is more dangerous to encounter the barracuda than even the shark.	1790	Antigua and Barbuda	Riddell, 1792
These mangroves have the thickest foliage imaginable, and a most lovely verdure… Towards the extremities of these branches the **<u>oysters</u>**…twist themselves round the branch…They are found by hundreds at a time, suspended in prodigious clusters, some above, and some below the surface of the water.	1790	Antigua and Barbuda	Riddell, 1792
The coast is beset with shoals and reefs under water…here we have **<u>land crabs</u>**…they are the best in the Windward Islands, and are a most savory and delicate morsel to be sure.	1825	Antigua and Barbuda	Coleridge, 1825
A stray **<u>barracouta</u>**…may occasionally take his pastime therein…all men…should make a point of murdering and exterminating these barbarous brutes by all means in their power…When the net became contracted ….we had chiefly **<u>barracoutas</u>**.	1825	Antigua and Barbuda	Coleridge, 1825
There were **<u>gold and silver fish, snapper, Spanish mackerel, and kingfish… two adolescent sharks</u>**… who would have amputated a baby's arm… and three of four bloody, glutinous, cylindrical beast without head, fins, or tail for which… we caught about a hundred and twenty more fine fellows about a foot and a half in length on average.	1825	Antigua and Barbuda	Coleridge, 1825
I have a grateful recollection of the **<u>turtle</u>** at the Court House…In the West Indies turtle is a generous food certainly, but honest and unsophisticated.	1825	Montserrat	Coleridge, 1825
Plenty of **<u>turtell</u>**	<1884	Antigua and Barbuda	Lanaghan, 1884 in

			McClenachan et al., 2006
No one goes bathing or into the water for any purpose in this region without being warned against the danger of being wounded by the cruel black spines of this ubiquitous **sea-urchin.** It is found almost everywhere in shallow water, both on sandy and rocky bottom. The all too familiar black sea-egg **diadema antillarum** is abundant here, as it is everywhere that I have collected in the West Indies.	1919	Antigua and Barbuda	Nutting, 1919 in Jackson, 1997
Potfishing is the most important method, towing for **kingfish, sailfish, marlin, dolphin, sharks**…	1945	Montserrat	Brown, 1945
There are seines all year round for **jacks and ballyhoo.**	1945	Montserrat	Brown, 1945
Fish poisoning is an issue in Montserrat, the risks are common on the windward coast from **barracuda, horse-eye couvalli, yellow-back, rock-fish, and dog-tooth snapper.**	1945	Montserrat	Brown, 1945

Discussion

Archival information identified in this research covers over 400 years from 1528-1973. Identified historical place names and marine references on maps suggest areas of abundance: “sharks without number,” and “a little bay for boats, much fish is caught,” (Caribmap, 1728; Museum of Antigua and Barbuda, 1784). On Curaçao, five place names are references to fish, though they do not identify any specific species. “Fisher Bay,” “Fish Trap Bay,” and “Piscadoris” indicate that the areas on Curaçao could have been common fishing grounds during the period of time the maps cover, between the early 1700s to mid 1800s (Caribmap, 1775; Caribmap, 1779; DLOC, 1872). Multiple areas on the coasts of Antigua and Barbuda are named after lobsters, crabs, and man ‘o wars, suggesting a multitude of these species or possible fishing areas for the lobsters and crabs. Indications of past abundance of lobster and crabs on historical maps are consistent with current shellfish fisheries on the islands, as Antigua and Barbuda are known for crustaceans, particularly spiny lobster (Horsford et al., 2013). Grouper and sharks are identified near Palaster Reef, which is a common spearfishing area on Barbuda (Museum of Antigua and Barbuda, 1977; Horsford, 2008). On Antigua, the place name, Snapper, is located near English Harbour, a popular base for the British Navy at the time of the map's creation (Museum of Antigua and Barbuda, 1788; English Harbour, 2016). Snapper is one of the preferred species to fish and eat on Antigua, and it could have also been popular in the late 16th century among British colonists (FAO, 2002).

Similar to historical place names, anecdotal records identify species of importance and interest at the time. Coleridge's (1825) narrative of fishing on Barbuda presents a bounty of fish gathered without a large amount of effort. Some of the anecdotes corroborate place names on Antigua and Barbuda, including man 'o war and crabs, which were described as plentiful by Riddell (1792) and Coleridge (1825) around the island. The anecdotes from Curaçao, the "Curaçao Papers," are approximately 100 years older than the historical maps identified of the island. While the maps suggest abundant fishing locations, the "Curaçao Papers" discuss the Dutch colonists disliking fishing in the area and importing large quantities of food instead. However, several manifests in the documents describe exporting large amounts of queen conch, which was traded frequently among Caribbean Islands and colonists (Brownell & Stevely, 1981). Anecdotes from Montserrat describe both fishing techniques and local fish consumption on the island. For Montserratians, fish poisonings are currently an issue with species like barracuda, and early instances of ciguatera are described in historical anecdotes (Brown, 1945; IAMAT, 2016). Restaurants on Montserrat in the 1970s advertised dinners of Caribbean spiny lobster and flying fish (Montserrat National Reporter, 1973). One reason there may not be current advertisements for spiny lobster on Montserrat is because many restaurants on the island have closed since Hurricane Hugo and the volcanic eruption. Restaurants have closed either because they were located in the current Exclusion Zone, the owners emigrated, or due to the decrease in tourism on the island. Spiny lobster populations have also decreased on the island since the eruption, due to reduced habitat from pyroclastic flows (BBC, 2016; Howe, pers. comm., 2016).

Narratives on Antigua, Barbuda, Curaçao, and Montserrat all describe the delicacy of turtle meat, between 1790 and 1884 (Riddell, 1792; Coleridge, 1826; Lanaghan, 1884; Curaçao Papers, 2011). European settlements often grew up around sea turtle nesting areas, as turtle meat was in such high demand throughout the Caribbean during the period of colonization. Europeans brought turtle meat on journeys in the area and even back to Europe to make turtle soup (Swinburne, 2014). According to the narratives, turtle meat was an important part of the Dutch diet in Curaçao, though fishing for turtles usually happened on Aves and Rocas, which are nearby small islands off the coast of Venezuela (Brownell & Stevely, 1981).

Several species were mentioned both in anecdotes and in historical maps, including crab, man of war, lobster, sharks, turtle, oyster, and snapper. Overall, there is a large amount of overlap between the species mentioned in the archival research, with only five species not mentioned on both the maps and in the anecdotes. Historical maps and anecdotes each have different biases that must be considered when gleaning information from the source types. Some animals could be written about more often because they are interesting, charismatic species (McClenachan et al., 2015). The anecdotes used in this research were mainly from visitors to the islands (Riddell, 1792; Coleridge, 1826; Brown, 1945). In describing the environment, such visitors are probably more likely to describe marine life they find engaging and interesting for readers. The colonial administrator for the Dutch West India Company wrote the anecdotes from Curaçao, and most of the documents are official bills or letters to the Company. So, unlike the descriptive narratives from the visitors to the islands, these documents do not often reference specific species. Instead, just saying “fish” suffices, as description is not the goal (Curaçao Papers, 2011). Also, many of the marine references on historical maps of Curaçao did not actually name species, but referenced “fish” in some way. Since early colonists and explorers designed many of the historical maps, they could intend place names to reference areas of species abundance (Pulsipher, 1987). However, descriptions of abundance from both historical maps and in anecdotes could be exaggerations of the actual conditions.

Turtles, lobsters, barracuda, and man of war were referenced often in the archival research. It makes sense for narratives and places names to reference species like lobster often, as they are important for sustenance and could have been fished by early colonists. Though depleted from historical levels, spiny lobster is still significant economically and culturally in the Caribbean, and it is the most valuable fishery on Barbuda (Ruttenberg et al., 2013; Georges et al., 2015). The many names and anecdotal descriptions of the man of war jellyfish, not a species common for consumption, are not as easily explainable as the references to valuable species like snapper or lobster. It could be possible, however, that some of the names are referencing man-of-war, an expression for British warships from the 16^{th} to 19^{th} century (Royal Navy, 2016). Both turtles and barracuda could have been referenced so often because of their abundance, value as sustenance, and their intrigue to explorers or visitors to the area. In different ways, both the species are iconic: the barracuda as a danger and turtle as a charismatic, valuable species. Though barracuda are still perceived to be abundant in the Caribbean and are not threatened, the hawksbill turtle is Critically Endangered and the green turtle is Endangered according to the IUCN (Seminoff, 2004; Mortimer & Donnelly, 2008; Aiken et al., 2015). Historical anecdotes and maps provide a snapshot of what early colonists and explorers perceived to be iconic and abundant species in the Caribbean.

CHAPTER 3. LOCAL ECOLOGICAL KNOWLEDGE

Introduction

A key information source in understanding historical changes in the environment is local ecological knowledge (LEK). Local resource users, especially fishermen, observe key changes to the marine environment such as habitat extent and population abundances of target species, which can help inform restoration efforts (Johannes et al., 2000; Davis & Ruddle, 2010; Parry & Peres, 2015). Information gained from semi-structured interviews combined with other forms of data can illuminate otherwise unnoticed trends in species abundance and other ecosystem changes (Sáenz-Arroyo et al., 2005a). The value of LEK in better understanding environmental change has come under increasing attention, as both marine historical ecology studies and international programs have developed projects documenting LEK (Sáenz-Arroyo et al., 2005a; Lozano-Montes et al., 2008; Kittinger et al., 2012; Bender et al., 2014; Giglio et al., 2015).

Often, LEK interviews in historical marine ecology studies can reveal the shifting baselines syndrome, where memory of past states is lost so the current degraded status is used as a standard in management (Pauly, 1995; Sáenz-Arroyo et al., 2005a). For example, Bender et al. (2014) used LEK alongside fisheries landings data to examine marine species decline in Brazil and found that younger fishermen recognized fewer species as overexploited and fewer sites as depleted compared to older fishermen. By involving the community, LEK also gives locals a stake in the process of understanding ecosystem changes and goals for restoration (Huntington, 2010). LEK is a powerful and critical tool to inform marine policy and allow inclusion of the community in resource management decisions.

The goal of this component of the research is to use LEK from interviews with local resource users, including fishermen, divers, and government officials to identify changes in the marine environment over time on Antigua, Barbuda, and Montserrat. Specifically, it addressed the following research questions:

1. Which marine species are perceived to be increasing or decreasing over the past twenty years?
2. What are the perceived reasons for declines and increases?

3. Is there evidence for a shifted baseline among resource users and other local experts?
4. For the ten key species asked about in interviews, what is the timing and extent of change?
5. Can place names identified by resource users and local experts provide insights into past abundance?

Methods

I conducted interviews on the islands of Barbuda and Montserrat, as these are the English speaking islands that are the focus of integrated conservation efforts by my collaborators at the Waitt Institute. Additionally, I conducted several interviews on Barbuda's twin island state, Antigua. I developed my interview questions based on other interview-based historical ecology studies, with questions most closely resembling those in Sáenz-Arroyo et al. (2005a). The goal of my interview questions was to identify locations named after marine species, changes in the abundance of species, and any observations of shifts in the marine environment over time. This research was deemed IRB exempt by the IRB Chair of Colby College, and interviews on Montserrat were conducted after obtaining a Memorandum of Understanding with the Montserrat Department of Environment. I conducted the interviews by following all ethical and technical recommendations described by Bunce et al. (2000). In addition to explaining how to respectfully inquire about local knowledge and culture in semi-structured interviews, Bunce et al. (2000) describes ways to identify and understand bias in interviews.

First, I asked respondents to identify species that they perceived to be increasing or decreasing and reasons for any changes in abundance. Next, I asked respondents to rank abundances of key species, identified in the historical mapping segment of this research (turtle, lobster, octopus, shark, coral, snapper, and grouper) or considered to be of conservation interest (conch, parrotfish, and barracuda) (The Fisheries Regulations, 2013; Barbuda Fisheries Regulations, 2014). For each species, I asked how abundant the interviewee thought the species was currently, ten years ago, and twenty years ago. On Montserrat, instead of twenty years ago I asked interviewees about abundance pre-volcano, to gauge what changes happened from the natural disaster. The volcanic eruption was 21 years ago (CIA, 2005). Possible responses to, "how abundant is this species?" were absent, rare, common, abundant, or superabundant. I also asked if the interviewee perceived any change in the body size or range of each species over time. Finally I gave each interviewee a map of the island and asked them to identify any location named after any marine species and describe the range of the species.

I traveled to Antigua, Barbuda, and Montserrat in January 2016 and conducted 40 interviews over a three-week period. While on Montserrat, I connected with Waitt Institute staff and created a preliminary list of fishermen, divers, and government officials of varying ages to interview. After each interview, I asked the interviewee if he or she knew of any other fishermen, divers, or government officials with whom I should speak with; a technique known as the snowball sampling method (Goodman, 1961). The goal of snowball sampling is to allow existing participants to identify future participants for a study. On Montserrat I interviewed 20 individuals over a two-week period. On Barbuda, I identified interviewees by locating fisheries officers and waiting by the main fishing dock on Codrington Lagoon for fishermen to return from their daily activities. Over four days on Barbuda, I interviewed 15 fishermen and fisheries officers. On Antigua, I conducted five interviews over two days in a local fish market.

I categorized interviewees into young (≤35, n=14), middle-age (35-55, n=14), and old (≥55, n=12) age categories and low (≤15 years, n=12), medium (15-30 years, n=14), and high (≥30 years, n=12) experience categories. Interviewees answered questions according to their experience level. For example, if an interviewee with low experience level (≤15 years) could not speak to the abundance of a species 20 years ago, I wrote "N/A" as the response. For categorizing interviewee profession, I split the interviewees into "mainly fisherman," who received 75-100% of their income from fishing, and "other," who received less than 75% of their income from fishing.

To address questions of which species are perceived to be increasing or declining in abundance and reasons for the abundance change (questions 1 and 2), I added the number of respondents who viewed each species as increasing, decreasing, or increasing recently after long term declines. I also grouped reasons for decline into categories and added the number of times each reason for change was cited. To determine if there is evidence for a shifted baseline on the islands, my third research question, I first examined correlations between demographic characteristics of interviewees and the number of species they see as declining. I built a linear regression model to predict the number of species an interviewee perceives as declining based on their years of experience fishing or diving. Next, to examine differences among interviewee experience categories, I calculated the average number of species interviewees in each experience category perceive as declining and created boxplots to visualize the data distribution. Finally, I analyzed correlations between demographic characteristics and interviewee's perception of current species abundance. I built linear regression models to predict the rating of abundance (absent, rare, common, abundant, or superabundant) an interviewee indicates based on their age or years experience. For the models, I used the numerical representation of abundance rating (i.e. 1-5). I also conducted t-tests comparing perception of current species abundance between Montserrat and Barbuda to evaluate key differences between the islands. To examine how interviewees perceive the extent and timing of species abundance change (question 4), I compared the percentage of respondents who viewed each species absent, rare, common, abundant, or superabundant across the three time periods. I created plots designed to visualize Likert-type data. Likert scales are rating scales commonly used in survey research (Heiberger & Robbins, 2014. For my analysis and creation of boxplots, Likert-scale data, and regression plots, I used *R*(2015). Finally, to identify places named after marine species and any insights into past abundance (question 5), I used ArcGIS (10.1.3, GCS_WGS 1984) to document all places named after marine species that were mentioned by interviewees.

Results

Interviewee Demographics

Interviewee ages ranged from 19 - 74 years old and years of experience ranging from 2 – 60 (Table 5). The mean age of the interviewees among all three islands was 43 and the mean years experience was 23 (Table 5). Fourteen interviewees were categorized as young (≤35), 14 as middle-age (35-55) and 12 as old (≥55) (Table 6). In terms of experience, 12 interviewees were categorized as low (≤15 years), 14 interviewees were categorized as medium (15-30 years), and 12 were categorized as high (≥ 30 years)

(Table 6). Most interviewees had more than one profession, one of which often included commercial fishing, and most interviewees had experience with recreational fishing. Nineteen interviewees received their income mainly from fishing while 21 had other main sources of income. Three interviewees were female and 37 were male (Table 6).

Table 5. Summary information for age and years experience from 40 interviews conducted on Antigua, Barbuda, and Montserrat. Values are mean years with the range provided in parentheses.

	Antigua	Barbuda	Montserrat	Total
Age	42 (28-64)	41 (20-66)	45 (19-74)	43 (19-74)
Experience	24 (20-30)	22 (3-55)	23 (2-60)	23 (2-60)

Table 6. Summary information for interviewees in each age category, experience category, profession category, and gender.

	Antigua	Barbuda	Montserrat	Total
Interviewees	5	15	20	40
Young (≤ 35 years)	2	5	7	14
Middle-Age (35-55 years)	2	6	6	14
Old (≥ 55 years)	1	4	7	12
Low Experience (≤ 15 years)	0	4	8	12
Medium Experience (15-30 years)	2	6	8	13
High Experience (≥ 30 years)	3	5	4	13
Fisherman (≥75% income)	2	9	7	18
Other Income (≤75% income)	3	6	13	22
Male	5	15	17	37
Female	0	0	3	3

Perceptions of Species Abundance Change

Overall, 80% of respondents perceived that at least one of the 10 species of interest had decreased in the past 20 years. Individual interviewees mentioned between 0 and 11 species as declining. Coral was most often cited as declining, by 21 interviewees, followed by lobster and conch (Figure 12). For species not directly addressed on the survey, grunts were most often mentioned as declining, by seven interviewees, followed by angelfish and seagrass. Overall, all 10 species of interest from the survey (lobster, conch, turtles, grouper, parrotfish, snapper, octopus, barracuda, shark, coral) were described by at least two interviewees as decreasing in abundance. Additional species not included on the survey that were mentioned by respondents as declining were seagrass, jack, grunt, angelfish, striped croaker, sea urchin, mahi mahi, wahoo, mackerel, catfish, trunkfish, whelks, land crabs, rays, tuna, swordfish, needlefish, goatfish, surgeonfish, porgies, triggerfish, pufferfish, and remora (Figure 12).

The majority (80%) of respondents perceived that at least one of the species in the survey had increased in the past 20 years. Individual interviewees mentioned between 0 and 4 species as increasing. Interviewees most frequently mentioned turtles as increasing over the last 20 years. Lionfish, which was not directly addressed in the interview, was the second most cited species as increasing by 17 interviewees (Figure 13). Interviewees mentioned 13 species not included on the interviewee as having increased, including: sargassum, jellyfish, mahi mahi, grunt, seagrass, whelks, helmet shells, jack, surgeonfish, porgies, triggerfish, saltwater catfish, and filefish (Figure 13).

Thirteen percent of interviewees described seeing at least one species that declined in abundance overall, but experienced a slight increase recently. Interviewees mentioned between 0 and 3 species in this category. Species identified as recently increasing but declining overall include lobster, grouper, parrotfish, snapper, and conch (Figure 14).

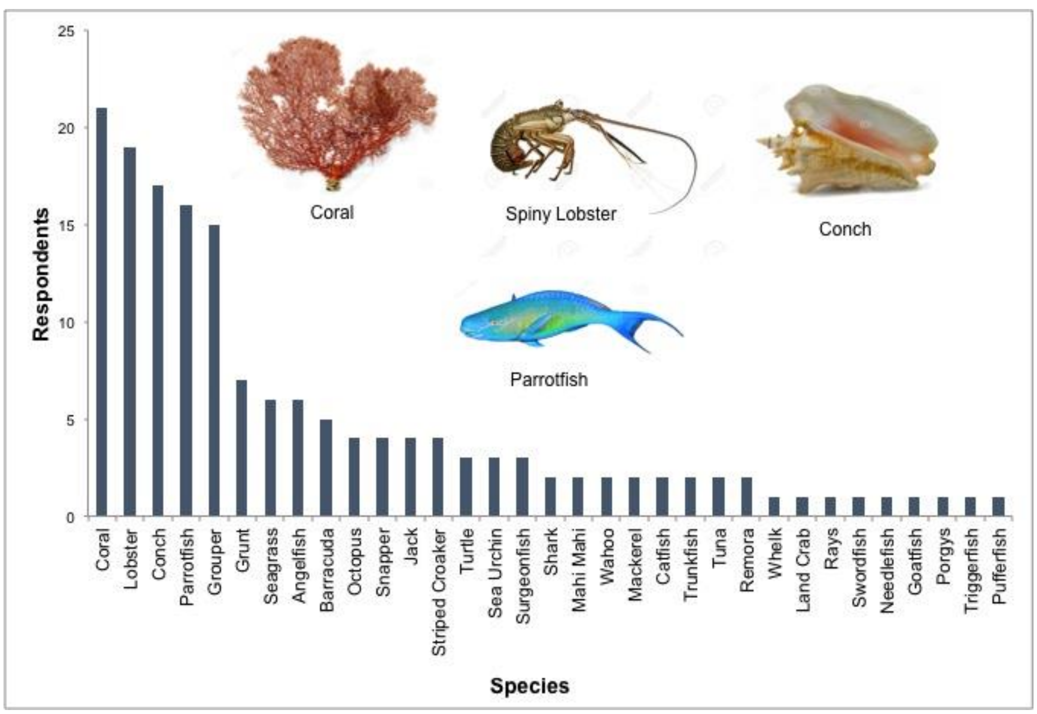


Figure 12. Counts of species perceived to be declining on Antigua, Barbuda, and Montserrat. Images show the top four cited species.

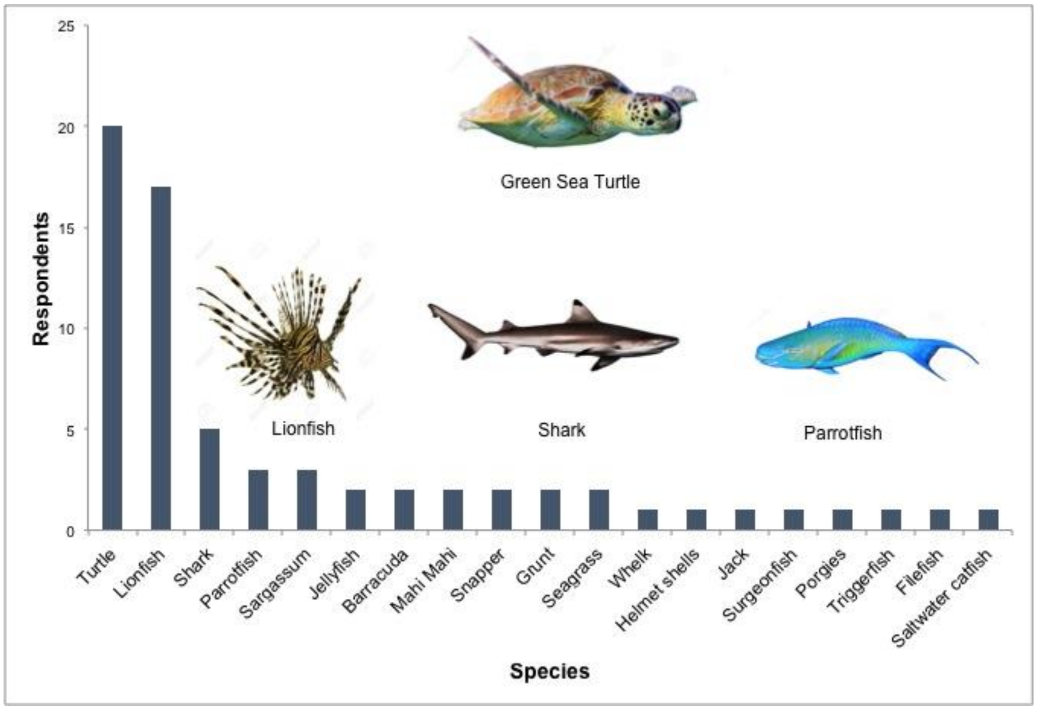


Figure 13. Counts of species perceived to be increasing on Antigua, Barbuda, and Montserrat. Images show top four cited species.

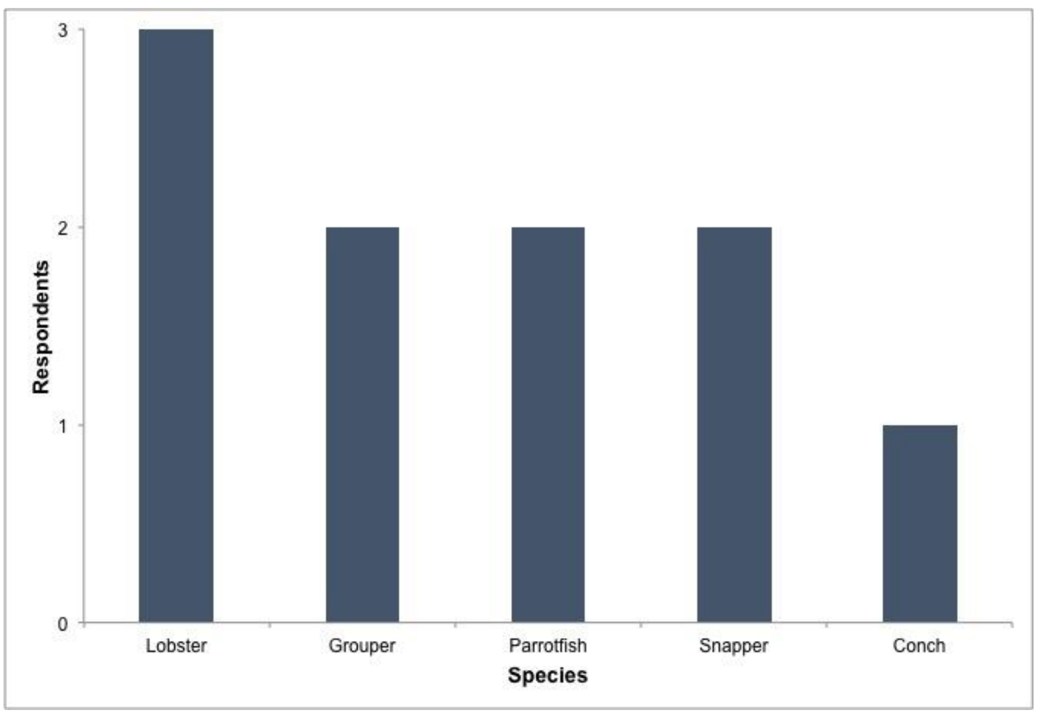


Figure 14. Counts of species perceived to be have increased recently but declined overall on Antigua, Barbuda, and Montserrat.

Interviewees did not only describe changes in abundance of species over time, they also depicted changes in species composition, catch per unit effort, and the size of species. Several interviewees recounted seeing fewer predatory fish than in the past, one Antiguan remembered visiting Spanish Point on Barbuda as a child: “It was massively different. Children would go down and shoot decent sized fish day after day. Now you only see…the smaller fish, not the big predatory fish anymore. Now you see the coneys, the small reef fish, you don’t really see the big grouper at all anymore” (Roberts, pers. comm., 2016). Many fishermen with medium and high levels of experience (≥30 years) interviewed described the need to use more effort and time to catch the same amount or less seafood (including lobster, conch, snapper, grouper, parrotfish) than was possible in the past: “I used to come in by midday and have my total catch. Now it takes more hours to catch what we used to catch. I need to use different gears and go to different locations” (Kelly, pers. comm., 2016). Additionally, fishermen explained the need to go deeper to catch species: “I used to free dive for a long time and [grouper] were always in the shallows, now they have moved out into deeper waters” (Jordan, pers. comm., 2016). Finally, older and more experienced fishermen mentioned how much larger species were in the past: “You just would not believe the size of the fish we used to get here.” (Daley, pers. comm., 2016).

Reasons for Species Abundance Change

The most cited reason on Antigua for decline in species abundance was overfishing, which includes overfishing of juveniles, overfishing of the species’ food source, spearfishing, and net-fishing. Additionally increased demand, particularly from other Caribbean islands, was cited, as well as lack of protection or enforcement, hurricanes and habitat loss (Figure 15). When asked why species populations had increased, Antiguans mentioned reduced fishing, ecotourism, cultural reasons, and legislation. Interviewees perceived legislation as the reason species had recently increased but declined overall.

On Barbuda, interviewees indicated overfishing (including overfishing of spawning aggregations, overfishing of food source, overfishing of parrotfish, spearfishing and netfishing) as the top reason for species decline on Barbuda, in addition to foreign overfishing, illegal fishing, the use of bleach on coral, taking turtle eggs, sedimentation, tourism, habitat loss, and declining water quality as reasons for declining populations. Interviewees also mentioned non-anthropogenic reasons for loss of abundance, including hurricanes, pathogens, and coral bleaching (Figure 16). Legislation, lack of fishing, lack of consumption (for lionfish), and eutrophication were perceived as the causes of population increases. Interviewees perceived that legislation, enforcement, and cultural changes resulted in slight increases in populations that have otherwise declined overall.

In contrast, the top reasons cited for species decline on Montserrat were natural disasters, including both Hurricane Hugo in 1989 and the volcanic eruption of the Soufriére Hills in 1995. Other reasons mentioned were overfishing, including pot fishing, spearfishing, and net fishing, as well as increased demand and lack of regulations. Migration of species away from fishing grounds on Montserrat, predation by the invasive lionfish, habitat loss, sedimentation, declining water quality, and coral bleaching were also cited as reasons for species decline (Figure 17). Interviewees mentioned legislation, a change in customs, less fishing pressure, and beach area increase for turtle nesting as explanations for species increase.

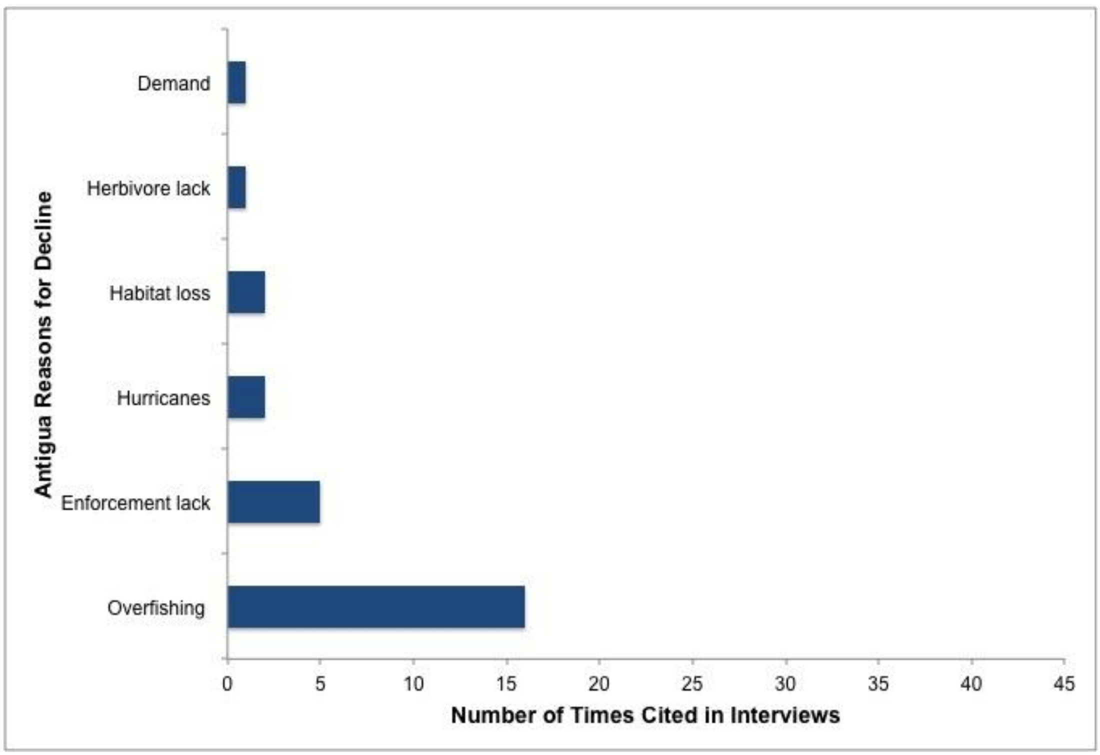


Figure 15. Perceived reasons for species decline on Antigua

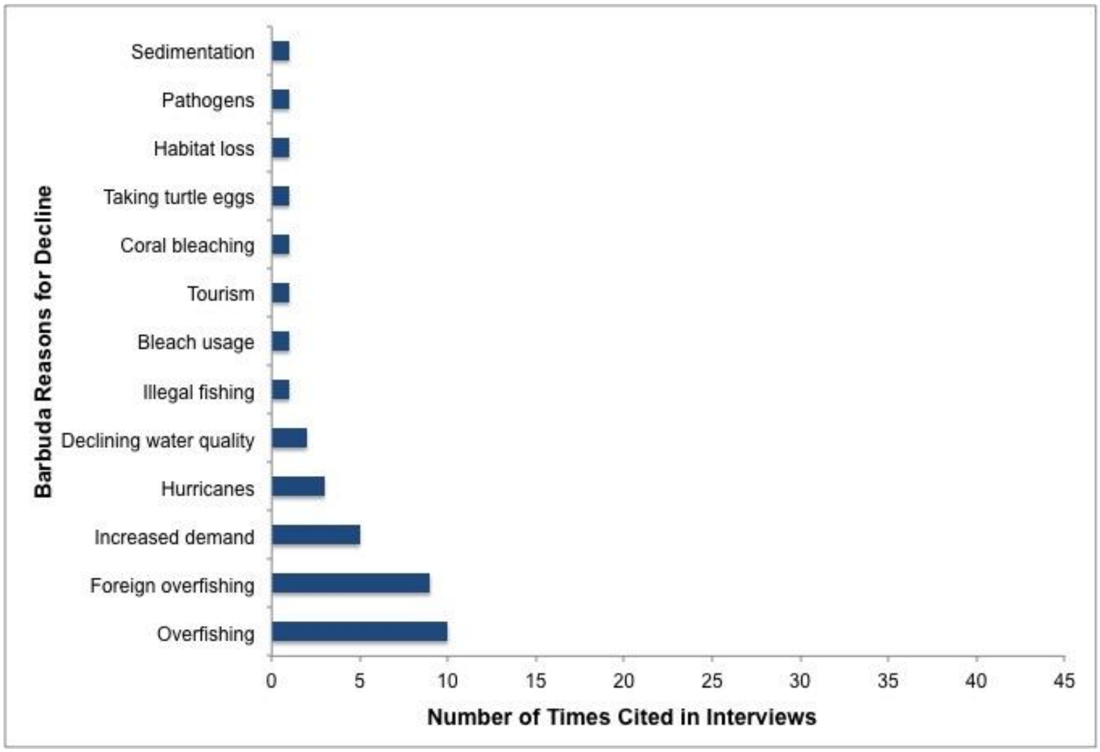


Figure 16. Perceived reasons for species decline on Barbuda

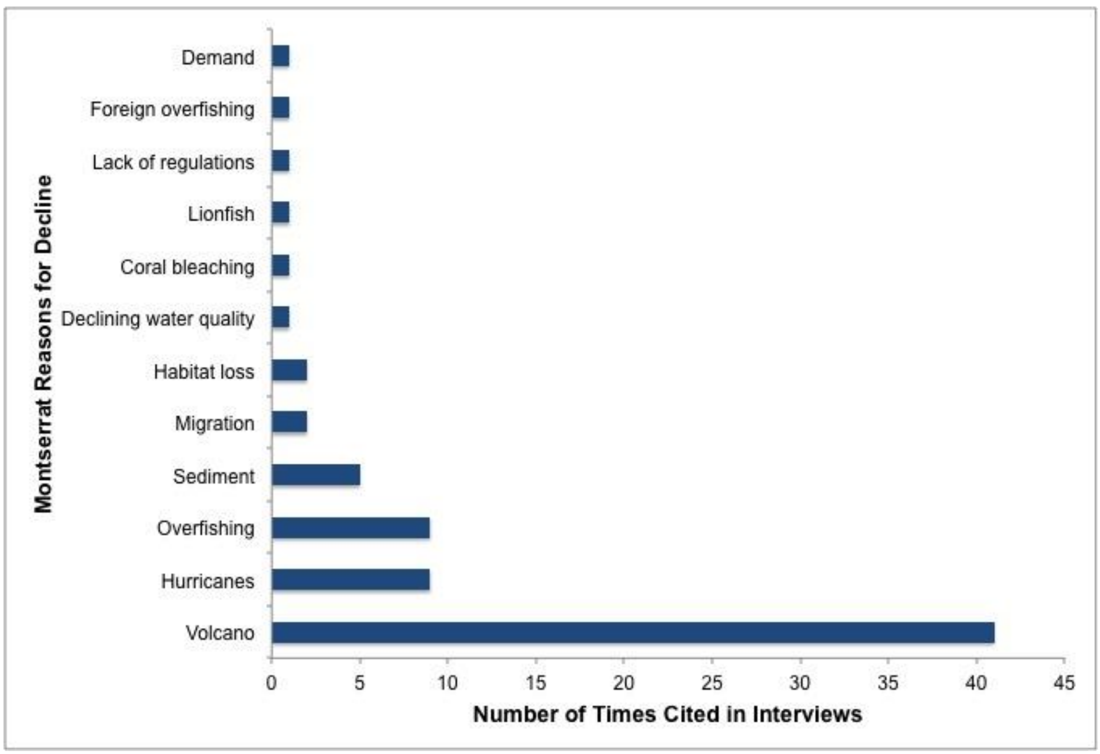


Figure 17. Perceived reasons for species decline on Montserrat

Evidence for a Shifted Baseline

The number of species each interviewee mentioned as declining is correlated with the interviewee's years of experience fishing or diving (Figure 18, P<0.01). The model displays the pattern that with greater years experience, interviewees tend to see a greater number of species as declining compared to younger interviewees. When data are grouped by experience categories, I found that interviewees with high levels of experience (≥ 30 years) perceived 6 species on average as declining in abundance, while those with low levels of experience (≤15 years) saw only 1 species on average as declining. Medium-level experience (15-30 years) interviewees mentioned approximately 4.5 species on average as declining (Figure 19).

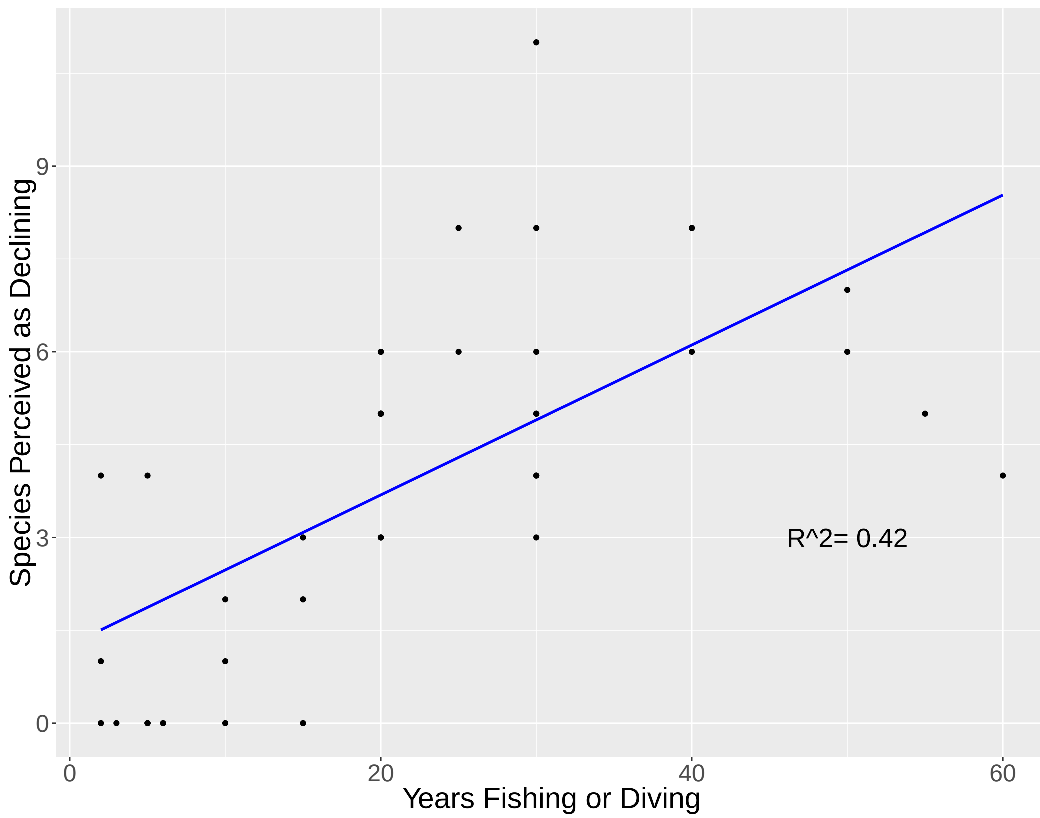


Figure 18. Linear regression model: number of species perceived as declining = 1.26 + 0.12(Years of Experience) (R^2= 0.42, p < 0.01).

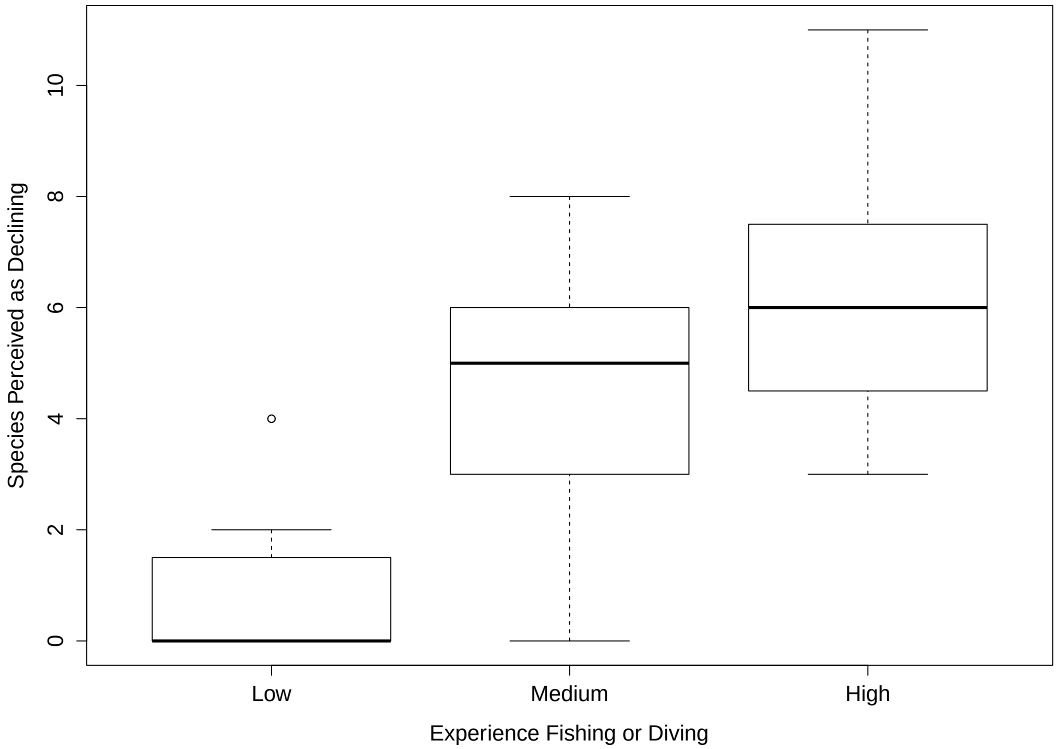


Figure 19: Experience categories of interviewees (Low: ≤ 15 years, Medium: 15-30 years, High: ≥ 30 years) and the number of species perceived as declining.

In examining how respondents describe the current abundance of all species of interest, I found that age is a predictor of the perception of abundance (p=0.03). Experience level fishing or diving is not a significant factor affecting perception of current abundance of all species of interest (p=0.12). While the median response for older (≥ 55 years) and middle-age (30-55) interviewees was “common” (a rating of 3), the median for younger interviewees (≤30) was “rare” (a rating of 2) (Figure 20). The average abundance rating for the 10 species of interest for respondents in the old age category was 3 and the average in the young age category was 2.7.

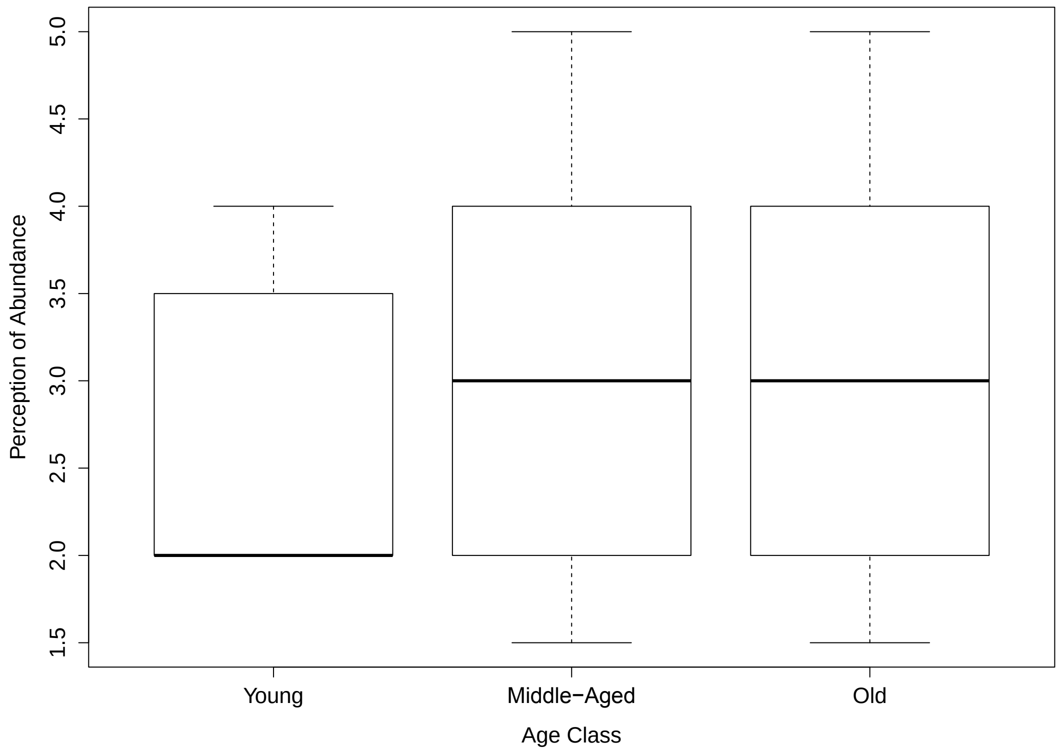


Figure 20. Age categories of interviewees (Young: ≤ 30 years, Middle-age: 30-55 years, Old: ≥ 55 years) and interviewee's perception of current species abundance for the five most cited species as declining. Ranking, 1: absent, 2: rare, 3: common, 4: abundant, 5: superabundant.

When only considering the five species most often cited as declining (coral, lobster, conch, parrotfish, and grouper), interviewee's years of experience was a significant predictor of perception of current abundance (Figure 21) ($p<0.01$). Interviewees with more experience described species as rare (rating of 2) more often than those with medium or low levels of experience who described species more often as common (rating of 3) (Figure 22). The average rating given for high levels of experience was 2.52 (between rare and common) compared to 3.07 (between common and abundant) for low levels experience.

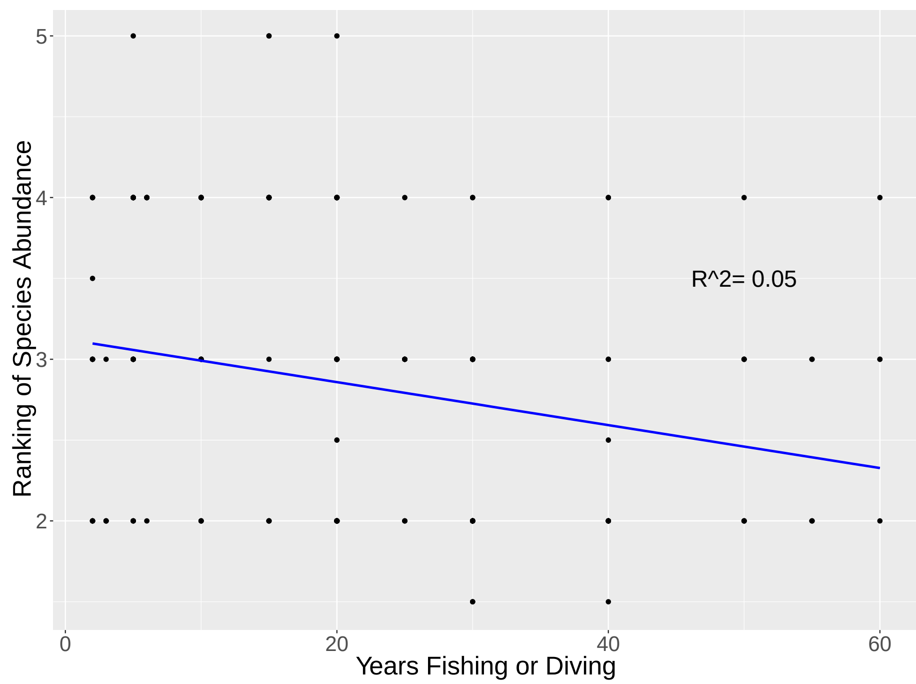


Figure 21. Linear regression model: ranking of species abundance = 3.12 – 0.013(Years experience). Only the top 5 species cited as declining (lobster, conch, grouper, parrotfish, and coral) are included.

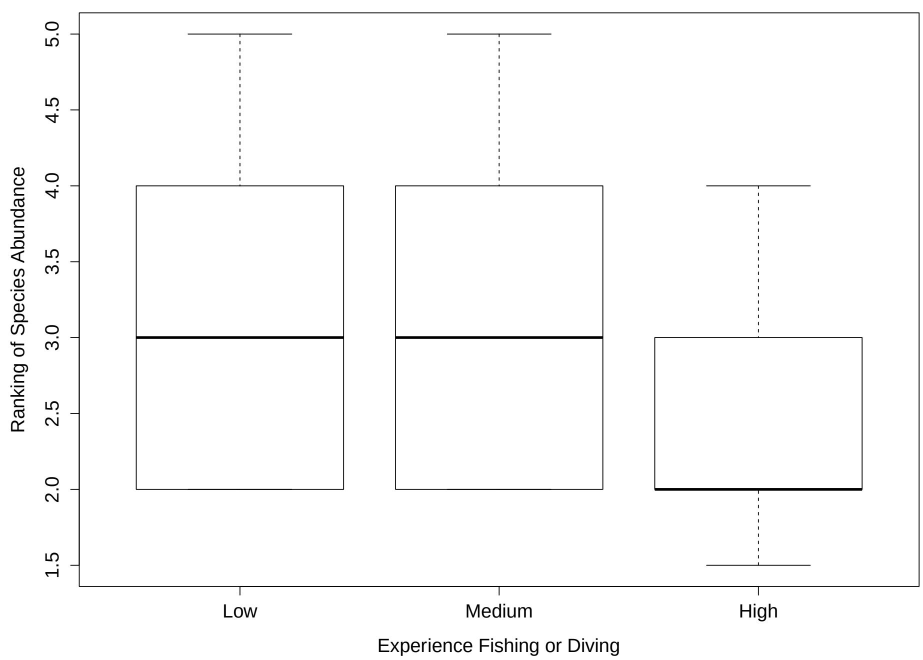


Figure 22. Experience categories of interviewees (Low: ≤ 15 years, Medium: 15-30 years, High: ≥ 30 years) and interviewee's perception of current species abundance for the five most cited species as declining. Ranking, 1: absent, 2: rare, 3: common, 4: abundant, 5: superabundant.

Respondents who received more than 75% of their income from fishing did not perceive a significantly different number of species declining compared to those who received less than 75% of their income from fishing (2-sample t(df) = 0.034 , p=0.97). Between Montserrat and Barbuda, there is not a significant difference between the number of species perceived as declining (2-sample t(df) = -0.67, p=0.51). However, there is a significant difference between the perception of species abundance on Montserrat compared to Barbuda currently (2-sample t(df)=304.87, p<0.01), 10 years ago (2-sample t(df)=235.05, p<0.01), and 20 years ago (2-sample t(df)=162.99, p<0.01. Throughout all time periods, Montserratians perceived species as less abundant, on average, compared to Barbudans.

When I examined the number of species interviewees see as increasing compared to age, there was no association (R^2=0.002, p=0.78). There was also no correlation between the number of species interviewees see as increasing compared to years experience fishing or diving (R^2=0.04, p=0.2).

Timing and Extent of Change for Key Species

For each species of interest, I examined perceptions of the timing and extent of changes, current abundance, and reasons for change in species abundance. As I conducted five interviews on Antigua and it is not a main focus of this research, I only included interviewee perceptions from Barbuda and Montserrat in this section. Overall, interviewees perceive species as most abundant twenty years ago and describe declines from twenty to ten years ago and further declines from ten years ago to present-day. The exceptions are turtles, which have increased according to most interviewees, and barracuda, sharks, and octopus, which the majority of interviewees believe have not changed considerably in abundance. For certain species, interviewees on Montserrat describe a more drastic reduction in abundance from the period pre-volcano (twenty years ago) to ten years ago compared to the declines in abundance from ten years ago to present day.

Coral

Most interviewees (55%) from the islands perceived a decline in healthy coral cover in the last twenty years, and no interviewees mentioned any increases in cover. On Barbuda and Montserrat, over 80% of interviewees perceived healthy coral as abundant or superabundant 20 years ago (Figure 23A). Several interviewees discussed how “pristine” and “really beautiful” the coral was 20 years ago, with “many different kinds” of coral species and “fish everywhere” (Beazer, pers. comm., 2016; Mussington, pers. comm., 2016). A Barbudan said he has seen the largest decline of fish species and coral within the last 15 years (Burton, pers. comm., 2016). A marine biologist on Barbuda mentioned the decline in coral was “between 85% and 95% since the early 1980s” (Mussington, pers. comm., 2016). One interviewee from Barbuda highlighted Hurricane Hugo (1989) as the first year when hurricanes had major impacts on the reefs (Morris, pers. comm., 2016). Montserratians mentioned that the coral cover currently is between 40%-60% of the cover pre-volcano and pre-Hurricane Hugo (Daley, pers. comm., 2016; Sheldon, pers. comm., 2016). The perception of abundance ten years ago is extremely different, with the majority of Montserratians (55%) describing healthy coral cover as rare and Barbudans mainly (73%) perceiving it as common: no interviewees described healthy coral as superabundant. The perceived decline from ten years ago to present day is not as striking as the decline from twenty years ago to ten years ago. On Barbuda, the majority (64%) of interviewees currently perceive healthy coral as rare, opposed to common ten years ago: “the coral is not doing well, it is dying, the areas I used to fish I can’t fish at all anymore” (DeSouza, pers. comm., 2016). On Montserrat, one diving company employee discussed how the coral, “varies drastically…some looks good, strong, and healthy, and others are broken…and covered in ash” (Bartlett, pers. comm., 2016).

Despite the general pattern of decline, several interviewees did not see any change in coral cover in the last ten to twenty years. On Barbuda, of the four fishermen who saw no decline in coral cover, half were in the young age category and the others were middle-aged. One of the fishermen who perceived an increase mentioned, “The coral is good right now” especially compared to other Caribbean Islands (Thomas, pers. comm., 2016). While Montserratians often mentioned the destruction of the volcano, pyroclastic flows, and ash, several believed the coral was healthy, saying “we…do have a good diversity of coral" and "it seems healthy from what I see" (Aston, pers. comm., 2016; Ryan, pers. comm., 2016).

Interviewees described ecological shifts that have occurred as coral cover has declined. Several interviewees mentioned a shift from hard to mainly soft coral, with large growths of algae: "in the early 1980s, there were elkhorn and staghorn…today those are all dead and overlaid with algae" (Morris, pers. comm., 2016; Mussington, pers. comm., 2016).

Barbudans and Montserratians both described a variety of reasons for loss of coral cover around the islands. Several Barbudans mentioned the damage of hurricanes in addition to coral bleaching. On both islands, overfishing and destructive fishing, with pots, nets, and spears, was mentioned as a reason for declines in coral. Particularly on Barbuda, interviewees described the loss of parrotfish as a major factor resulting in the decline of coral (Burton, pers. comm., 2016). On Montserrat, almost every interviewee who could describe conditions twenty to thirty years ago mentioned how the destruction of the volcanic eruption, continued activity from the volcano, and Hurricane Hugo destroyed corals and covered large portions of the reefs in ash and sediment. Interviewees also mentioned anthropogenic effects on the reefs, including fishermen dropping pots onto the reefs and pollution from land-based sources as factors affecting the marine ecosystem.

Lobster

Across the three islands, over half of interviewees perceived a decline in Caribbean spiny lobster within the last twenty years, while several saw no change in the population or a slight increase but overall decline. About 90% of Montserratians interviewed described spiny lobster pre-volcano as abundant, while nearly 90% of Barbudans interviewed described lobster twenty years ago as superabundant (Figure 23B). On Montserrat, the major perceived change in abundance occurred in 1995 from the volcano, "when I spearfished twenty years ago and more there were definitely more lobster, but since the volcanic crisis it's not the same (Boatswain, pers. comm., 2016; Francis, pers. comm., 2016; Murphy, pers. comm., 2016). However, one naturalist on Montserrat mentioned that he recognized declines in the spiny lobster population as early as the

1970s (Daley, pers. comm., 2016). Barbudans described population changes happening within the last 25 years, and several fishermen mentioned larger abundance of lobster in the 1980s (James, pers. comm., 2016; Mussington, pers. comm., 2016). Several interviewees cited a change in catch per unit effort since the 1980s: “we used to snorkel…with a noose and get hundred of pounds. Now…we….use deep pots, and we will still not get the same amount” (Mussington, pers. comm., 2016). Another fishermen recognized ten to fifteen years ago as when he started having to go into deeper waters for lobster (DeSouza, pers. comm., 2016). Overall, Montserratians perceive a greater decline in lobster abundance than Barbudans, with a large decline in perceived abundance from twenty to ten years ago and continued decline from ten years ago to present (Figure 23B).

Interviewees also perceive lobster to be more abundant on Barbuda than Montserrat currently. One Montserratian mentioned, “There is not much lobster being caught right now on Montserrat, we get most of [it] from Antigua and Barbuda” (Meade, pers. comm., 2016). However several divers on Montserrat mentioned seeing areas of lobster abundance in deep waters and large numbers of juveniles (Aston, pers. comm., 2016; Bartlett, pers. comm., 2016). While most Barbudans have perceived a decline in the population, over half of interviewees still described the current population status as abundant or superabundant: “there is no problem with lobster right now, they are very abundant” (Burton, pers. comm., 2016). Others acknowledged the decline but mentioned that the species, “is still abundant and a major source of income” as “900 pounds is shipped out twice a week from the island” (DeSouza, pers. comm., 2016; Mussington, pers. comm., 2016).

While interviewees cited the volcano and hurricanes as the main reasons for lobster declines on Montserrat, Barbudans described the effects of a recent 2-month closed season on increasing abundance. Several Barbudans, who have substantial experience fishing on the island, reported seeing a “dramatic increase” in lobster populations due to the legislation (Beazer, pers. comm., 2016; Elton, pers. comm., 2016; Henry, pers. comm., 2016.) According to one fisherman, there are also fewer fishermen setting out pots for lobster, which has allowed recovery of the species (Henry, pers. comm., 2016). Several Barbudans mentioned that the abundance of lobster is dependent on the demand from other islands (Beazer, pers. comm., 2016; Burton, pers. comm., 2016). Despite an increase in demand for spiny lobster, Barbudans did not describe the species as overfished from domestic efforts, but did mention there were issues with illegal fishing of spiny lobster.

<u>Grouper</u>

Grouper populations, including Nassau grouper, red hind, Goliath grouper, butterfish, and graysby, were perceived by 40% of interviewees as declining, though 30% of interviewees believed there had been no change to the populations and 5% of interviewees saw the populations as recently increasing but declining overall. Montserratians described grouper as less abundant twenty years ago than Barbudans: all interviewees described grouper as superabundant or abundant on Barbuda twenty years ago compared to less than 50% on Montserrat (Figure 23C). On both islands, the largest perceived decline happened between twenty and ten years ago. One Montserratian fisherman remembered, “in the earlies when I was spearfishing, grouper was what I really enjoyed shooting…they are so scarce now,” and others described seeing or hearing about more Goliath and Nassau grouper in earlier years (Aston, pers. comm., 2016; Daley, pers. comm., 2016; Steed, pers. comm., 2016). One interviewee said he had seen declines in the last ten years on Montserrat, as there was more grouper on the market in the early 2000s (Mendes, pers. comm., 2016). On Barbuda, interviewees described large declines in the last fifteen years: 50% of interviewees perceived grouper as superabundant or abundant ten years ago compared to 100% twenty years ago (Henry, pers. comm., 2016; Kelly, pers. comm., 2016) (Figure 23C). A Barbudan interviewee described the abundance in the 1980s: “at every head reef there would be groupers…now you hardly see any of them” (Mussington, pers. comm., 2016).

Interviewees cited grouper most frequently of all species included in the interview as having declined in size. Fishermen with medium or high experience levels on both islands mentioned catching less large grouper currently than in the past (Evans, pers. comm., 2016; Howe, pers. comm., 2016). A Montserratian fishermen recalled, “a long time ago, I would see the big ones, the 190 pound ones, now I get the smaller ones and sometimes the medium ones” (Wallace, pers. comm., 2016).

Currently, approximately half (47%) of Montserratian interviewees describe grouper as rare, while the majority of Barbudan interviewees (40%) perceive the species as common. Like lobster, fishermen on Barbuda report a change in catch per unit effort of grouper: “it is harder to fish and it takes more time” (Henry, pers. comm., 2016). Additionally, fishermen reported having to move to deeper water to catch grouper, particularly for larger grouper. Several divers on Montserrat reported seeing many juvenile, common species of grouper on the reefs.

Similar to other species, Montserratians mainly mentioned the volcano and hurricanes as affecting grouper, while Barbudans cited overfishing. On Montserrat, the volcanic ash and hurricanes destroyed grouper habitat. Additionally, one Montserratian mentioned that lionfish were hurting the population by eating juvenile grouper (Howe, pers. comm., 2016). Barbudans described overfishing of breeding populations of grouper, particularly by foreign fleets, as the major factor leading to the species decline. However, several Barbudans mentioned a recent closed season for grouper as leading to species recovery, “they are really coming back” (James, pers. comm., 2016).

Conch

Most interviewees (40%) perceived a decline in conch populations, 35% saw no change, and 2.5% saw a recent increase but decline overall, and three interviewees on the islands mentioned a decline in the size of conch. Abundance of conch twenty years ago was perceived similarly between the islands, with about 70% of participants describing the species as superabundant or abundant (Figure 23D). Like with other species, Barbudans perceived greater abundance than Montserratians, with more participants describing conch as superabundant twenty years ago on Barbuda compared to Montserrat. On Montserrat, one interviewee mentioned, “I noticed conch start changing after Hugo [1989]…we used to see maybe 40 to 50 conch in 30 feet of water” (Daley, pers. comm., 2016). A Barbudan interviewee described, “fishermen used to go out at…six or seven in the morning…they would come in at nine or ten with 500 conch…today you could spend an entire day or week doing it and not get that same amount” (Mussington, pers. comm., 2016). The majority of Montserratian interviewees perceived the decline in conch abundance occurred between twenty and ten years ago with a smaller decline between ten years ago and present day: about 70% of Montserratians described conch as rare ten years ago compared to about 70% abundant or superabundant twenty years ago. When asked when declines in conch populations began on Barbuda, some interviewees said about ten years ago, while others believed it was more recent: " it was very abundant until about four to five years ago (Beezer, pers. comm., 2016; Kelly, pers. comm., 2016). Barbudan fishermen also perceived a change in catch per unit effort and the need to go further into water to get conch, "I do remember a time when it was certainly easier to get, you could walk out on the shore and get them" (Elton, pers. comm., 2016; James, pers. comm., 2016).

Currently, Montserratians perceive conch as much more rare than Barbudans: 80% of interviewees on Montserrat see conch as rare, and the majority of Barbudans see conch as common (47%) or abundant (40%). One interviewee said the depth of water is an issue on Montserrat for conch: "you would be diving in almost 60 feet of water to get maybe one conch" (Howe, pers. comm., 2016; Mendes, pers. comm., 2016). Another Montserratians mentioned that because conch is so rare, he usually buys it from St. Kitts or Antigua (Meade, pers. comm., 2016). However, several divers on Montserrat report seeing areas with thousands of conch, but that other sites are extremely depleted (Bartlett, pers. comm., 2016; Murphy, pers. comm., 2016). On Barbuda, several fishermen said that conch is definitely depleted, but the abundance of the species also depends on the time of year.

Interviewees described similar reasons for conch decline as for other species, namely natural disasters and overfishing. Hurricanes and the volcano on Montserrat destroyed habitat for conch by ripping up sea-grass, harming reefs, and burying reefs in ash (Sweeney, pers. comm., 2016). Only one Montserratian mentioned overfishing as a potential effect on conch populations because, "people used to go out and take a lot" (Wade pers. comm., 2016). On Barbuda, interviewees mentioned heavy exploitation from foreign fishing fleets, starting about 10 years ago, as the major reason conch have declined. One interviewee noted, however, that the recent 2-month closed season on conch has helped, and the population is starting to recover (Beezer, pers. comm., 2016).

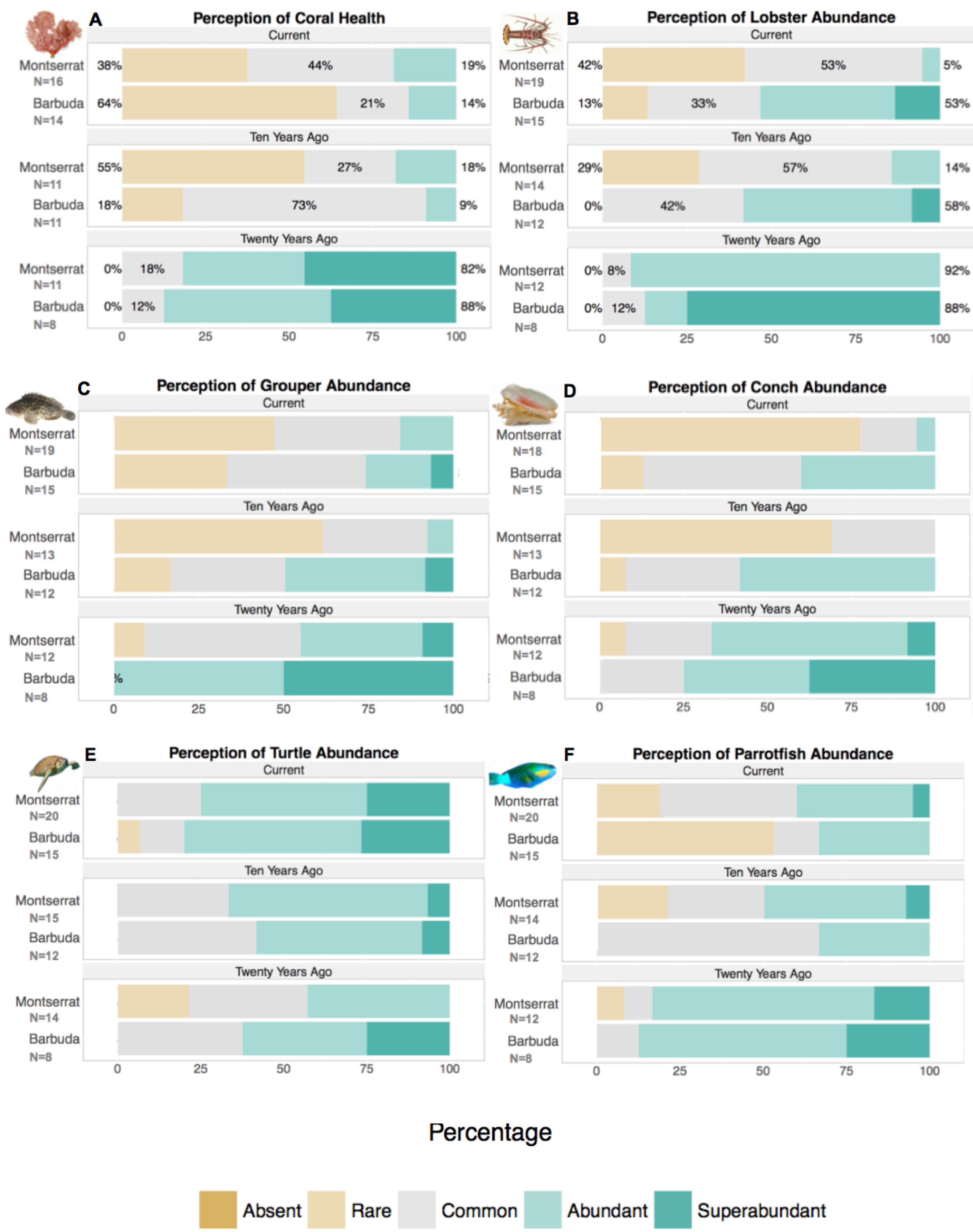
Turtle

Half of interviewees mentioned an increase in turtle (mainly green turtle and hawksbill populations) though 25% of interviewees said there had been no change, and 7.5% perceived a decline in the last 20 years. On both islands, the percentage of interviewees who perceive turtle as abundant or superabundant increased between twenty years ago and currently (Figure 23E). On Montserrat, 20% of interviewees perceived turtle as rare twenty years ago, as they were hunted more often. One fisherman remembered,"30 to 40 years back they were being harvested so much that you would basically never see a turtle…people used to make a living off of harvesting" (Sweeney, pers. comm., 2016). Similarly in Barbuda, interviewees recalled the popularity of turtle meat, "turtles used to be a delicacy, they used to be exported in the past" (Beezer pers. comm., 2016). Interviewees described seeing increases in the species either ten years ago or in the last five years (DeSouza, pers. comm., 2016; Sweeney, pers. comm., 2016). However, on Barbuda, three interviewees mentioned the turtle population had declined in the last fifteen years.

Currently, over 75% of interviewees on both islands perceive turtles to be superabundant or abundant. Fishermen commented on this abundance: "I have never seen so many turtles in Montserrat" and "there are too many turtles, and there keep being more" (Sweeney, pers. comm., 2016; Thomas pers. comm., 2016). On a single half-hour dive in Montserrat, one diving group saw eight turtles (Bartlett, pers. comm., 2016).

On both islands, interviewees attributed the increase in turtle populations to conservation programs, legislation (a closed season for harvesting), a cultural shift, and the value of the species for ecotourism. Though turtle meat used to be popular, there is little to no demand for it anymore, so very few people are harvesting turtles, even when it is in season: "I don't remember the last time I saw someone hunting for a turtle" (Ryan pers. comm., 2016). Several respondents on Montserrat mentioned that the volcano was ultimately beneficial for turtles, because it increased beach size for nesting (Howe, pers. comm., 2016). Additionally, Montserratians mentioned leadership of conservationists in developing programs and policies to help rebuild turtle populations, including a hatchery on the island (Mendes, pers. comm., 2016; Ryan, pers. comm., 2016). One Barbudan interviewee mentioned that he has seen people illegally take the eggs occasionally

(Christian, pers. comm., 2016). Another fisherman on Barbuda mentioned that since turtles are so abundance, more locals should harvest them, since Barbudans are sustainable fishermen (Burton, pers. comm., 2016).



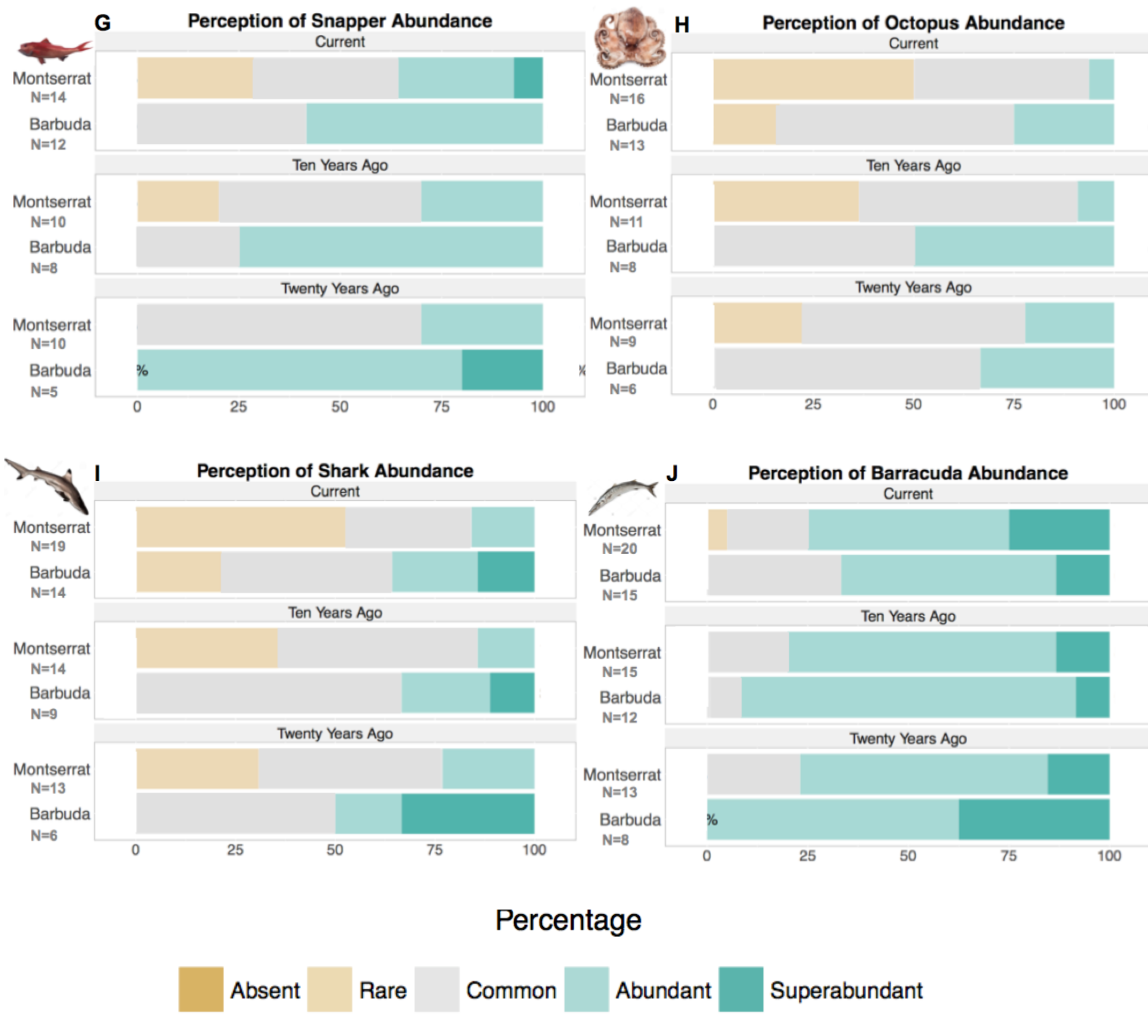


Figure 23. Answers to abundance questions on survey of: coral (A), lobster (B), grouper (C), conch (D), turtle (E), parrotfish (F), snapper (G), octopus (H), shark (I), and barracuda (J). On Montserrat, the “Twenty Years Ago” time period corresponds with pre-volcanic eruption (1995).

<u>Parrotfish</u>

Slightly less than half (42.5%) of interviewees perceived parrotfish populations as declining, 22.5% saw no change, 7.5% saw an increase, and 5% saw recent increases but overall declines. Three participants noticed a decrease in the body size of parrotfish. Twenty years ago, over 80% of interviewees from both islands perceived parrotfish as either abundant or superabundant (Figure 23F). Before the volcano (1995) on Montserrat, one interviewee mentioned, “you couldn’t go out snorkeling without seeing a ton of them” (Sheldon, pers. comm., 2016). On Montserrat, parrotfish used to be a more common target for spearfishing (Boatswain, pers. comm., 2016. A Barbudan described the abundance of parrotfish, called chub on the island, in the 1980s and earlier, saying "fishermen used to be able to shoot the fish from the shore, one foot and larger" (Mussington, pers. comm., 2016). On Barbuda, perception of parrotfish abundance declines greatly between twenty and ten years ago (from 88% abundant or superabundant to nearly 70% common). Fishermen remembered both a greater abundance and larger size of parrotfish in the past, "the population was very high back in the 1980s and 1990s…we used to get them so much bigger" (James, pers. comm., 2016). While several Barbudan interviewees recognized decline as early as the 1980s, others say the decline happened within the last fifteen years. Barbudans also perceived a large decline between ten years ago and present day: one fisherman said that he noticed the decline within the last five years.

Overall, Montserratian interviewees saw a less drastic decline and perceived greater parrotfish abundance currently than Barbudans, with 40% of respondents perceiving parrotfish abundant or superabundant currently on Montserrat. One Montserratian mentioned, "there is no problem with the parrotfish…it is a species that can look after itself" (Ryan, pers. comm., 2016). However, other interviewees on Montserrat mentioned that there is "just less of everything now" on the island, and it is only common to see smaller parrotfish (Bartlett, pers. comm., 2016; Wallace, pers. comm., 2016). Over half of Barbudan interviewees perceive parrotfish as rare and no one described the group as superabundant currently. Several fishermen said that parrotfish are the most depleted of all species on Barbuda. Despite the documented declines, one younger fisherman commented, "There are too many parrotfish right now, and they keep increasing because of the ban" (Thomas, pers. comm., 2016).

Similar to other species, Barbudans mainly cited anthropogenic factors leading to parrotfish decline, while Montserratians cited natural disasters. Volcanic activity and hurricanes destroyed a large amount of parrotfish habitat on Montserrat. Barbudans also mentioned hurricanes as depleting parrotfish populations, but the main factor recognized was overfishing from foreign fishermen from the other Caribbean islands. Interviewees explained that parrotfish were never a main target for Barbudans, but foreign fishermen had decimated the stocks (Beezer, pers. comm., 2016). Barbudan regulations in 2014 banned the harvesting of parrotfish, and several fishermen said that this has allowed the population to increase (James, pers. comm., 2016). Other interviewees said, "we are not seeing the increases yet," but there is hope for more recovery in the next five years (Beezer, pers. comm., 2016; Kelly, pers. comm., 2016).

Snapper

Twelve percent of interviewees described a decline in snapper populations (including mangrove snapper, mutton snapper, dog snapper, cubera snapper, and queen snapper, 32.5% saw no change, 5% saw an increase, and 5% saw a recent increase but an overall decline. Though most people either did not comment on a size change, 12.5% of interviewees noticed a decline in the body size of snapper. Montserratian and Barbudans have very different perceptions of snapper abundance overall. Twenty years ago, 100% of Barbudans interviewed saw snapper as abundant or superabundant, while the majority of Montserratians (70%) interviewed described snapper as common (Figure 23G). One Montserratian recalled, "As a boy I would go on the dock and throw a line in the water and catch a snapper in 2-3 hours, now that just would not happen" (Howe, pers. comm., 2016). Perception of snapper abundance on both islands declined between twenty and ten years ago: several Barbudans described snapper ten years ago as common and none said superabundant and several Montserratians (20%) said snapper was rare. One interviewee on Barbuda said the decline in snapper populations had happened in the last fifteen years: "It used to be easier to catch them, there just aren't as many as before" (Beezer, pers. comm., 2016; Evans, pers. comm., 2016). Between ten years ago and currently, interviewees perceived a slight decline in snapper, with more Montserratians describing snapper as rare (29%), and more Barbudans describing snapper as common (42%) instead of abundant compared to ten years ago. One Barbudan fisherman mentioned, "I do remember about five years back when [snapper] were easier to get than now" (Thomas, pers. comm., 2016).

Interviewees on both islands described snapper as an important fishery, but depleted from the past. Several Barbudans said they still see golden-eye and mangrove snapper, as well as red snapper in deeper waters. Montserratians perceived a decline in the size of snapper, and several divers said it is common to see smaller snapper in the shallow water

(Ryan, pers. comm, 2016). Other Montserratian interviewees said snapper is "one of the only stable populations" and "snapper is the main catch on Sundays" (Daley, pers. comm., 2016; Meade, pers. comm., 2016). Another fisherman said the changes in snapper abundance are seasonal and the population is not changing overall (Boatswain, pers. comm., 2016).

Habitat destruction from the volcano on Montserrat and increased foreign fishing on Barbuda were mentioned as key reasons for snapper decline on the islands. However, one Montserratian said that the population increased after the volcano, because there was less fishing immediately following the volcano, allowing population recovery. A few years later, when fishing commenced again, the species was overexploited (Ryan, pers. comm., 2016). Barbudans and Montserratians mentioned how habitat destruction, particularly of mangroves, has affected snapper. On Barbuda, interviewees described increased demand in snapper because of its value, which led to unsustainable exploitation from foreign fishermen. Due to overfishing of the species, Antigua and Barbuda has implemented a closed season for snapper.

Octopus

Many participants could not comment on the abundance of octopus due to lack of knowledge or experience with the species, but 20% noticed a population decline and 40% saw no change. One interviewee mentioned a decline in the body size of octopus. Perception of octopus abundance has not changed drastically, though interviewees did perceive a slight decline in the populations on both islands (Figure 23H). Montserratians described octopus as less abundant than Barbudans throughout all time periods. Twenty years ago, the majority of participants on both islands (Montserrat 56% and Barbuda 67%) described octopus as common, though 22% of Montserratians perceived octopus as rare. Several fishermen described noticing octopus only because they get stuck in fish traps. One Montserratian fisherman mentioned, "in the earlies…they were around more" we "used to catch them in the fish pots…we used to see them more when we went spearfishing" (Jason, pers. comm., 2016; Lee, pers. comm., 2016). Interviewees on both islands recognized a slight decline between twenty and ten years ago, with more Montserratians describing octopus as rare and Barbudans as common compared to twenty years ago. The perception of abundance also declines slightly between ten years ago and currently, where half of Montserratians interviewed describe octopus as rare and several Barbudans mentioned octopus was rare. A Montserratian fisherman noticed that he had not seen as many octopi in his fish traps as in the past (Boatswain, pers. comm., 2016). On Barbuda, over half of interviewees perceive octopus to be common and 25% found octopus abundant currently. Interviewees noted that octopi are abundant currently because there is no demand for them, so no one is fishing for them. Overall, interviewees perceived octopus as a nuisance because they get in the fish pots. Most interviewees did not know of any reasons why the octopus population could be changing, but a Barbudan explained that the population is most likely declining because their food source is declining. Most Barbudans and Montserratians, however, thought the population had stayed the same and is not threatened because it is not a target for fishermen.

Shark

Most interviewees (47.5%) thought that shark populations on the three islands (including nurse shark, lemon shark, tiger shark, reef shark, and the hammerhead) had not changed, though 7.5% believed there was a decrease, and 12.5% saw an increase. One interviewee cited a decline in shark body size. Overall, Montserratians perceived shark as less abundant than Barbudans over the last 20 years (Figure 23I). Montserratians did not describe a major change in shark populations, though interviewees perceived a slight decline in abundance between ten years ago and currently, where over half (53%) of interviewees mentioned the population to be rare compared to 36% ten years ago. One interviewee from Montserrat described the popularity of shark harvesting in the past, “People used to love catching and eating the sharks” (Meade, pers. comm., 2016). Montserratians differed in the perception of whether the population has increased, not changed, or decreased. Some commented that the population has slightly declined, “not a major reduction, but definitely a reduction,” however, one diver saw large increases, “when I go to snorkel I am always seeing sharks, that never used to happen twenty years ago” (Daley, pers. comm., 2016).

Half of Barbudans twenty years ago described shark as superabundant or abundant. Interviewees perceived a slight decline between twenty years and ten years ago, with over half of interviewees (67%) citing sharks as common ten years ago opposed to abundant. The decline in perceived abundance continued between ten years ago and currently, where 21% of interviewees said shark is rare and the majority (43%) said common. Despite the overall perceived decline, several fishermen described increases in the population: “sharks everywhere, even at the shore,” and “too many sharks…I will see fifteen footers out there” (James, pers. comm., 2016; Thomas, pers. comm., 2016). Barbudans described seeing lemon, black tip, tiger, and nurse sharks commonly in the water.

Interviewees on both islands described similar reasons for slight declines in the shark population and, alternately, reasons why the population is stable. Those who believed the populations had declined cited poor water quality and less food available for sharks. Interviewees who saw no change or an increase in populations recognized the low demand for shark meat and lack of fishing for sharks on the islands as reasons for population stability. One Montserratian said that the population has increased because they are no longer harvested, though they used to be exploited heavily (Daley, pers. comm., 2016). A Barbudan commented that the population is so strong that there could be a fishery for sharks (Burton, pers. comm., 2016).

Barracuda

Barracuda populations on the three islands were generally perceived to have not changed (62.5%), though several (15%) participants saw a decline in populations, and 5% believed there had been an increase. Two interviewees thought the size of barracuda had decreased. Between twenty years ago and currently, interviewees on both islands did not describe a large change in barracuda populations. However, Barbudan interviewees perceived a larger decline than Montserratians, as 100% of Barbudan interviewees found barracuda superabundant or abundant twenty years ago compared to about 70% currently (Figure 23J). In describing perceived declines, interviewees said, “There were a lot more barracuda in the earlies” and “there has been a large decline” (Henry, pers. comm., 2016; Mussington, pers. comm., 2016). On Montserrat the percent of interviewees who perceived barracuda as superabundant or abundant only decreased slightly (77% to 75%) between twenty years ago and today. However, currently, 5% of Montserratian interviewees find barracuda rare currently, and no Barbudans described barracuda as rare. Two interviewees from Montserrat saw declines within the last two to five years, one saying the population currently is about 75% of what it used to be (Bartlett, pers. comm., 2016; Boatswain, pers. comm., 2016). Overall, the majority of interviewees on both islands portrayed the current population as healthy: approximately 70% of interviewees perceived barracuda as superabundant or abundant currently. Barbudans said, “the numbers have not dwindled” and “the population is huge, and there are big ones” (Beezer, pers. comm., 2016; Jordan, pers. comm., 2016). On Montserrat, barracuda is a popular fish for consumption, but fish poisoning (ciguatera) is common in species caught north of the island: some fisherman have been poisoned over 16 times (Aston, pers. comm., 2016; Howe, pers. comm., 2016). Interviewees from Montserrat described seeing large barracuda over two feet commonly and in large schools (Howe, pers. comm., 2016; Ryan, pers. comm., 2016). One Montserratian used to trick people that he took deep-sea fishing by saying they would get a tuna bite “right now” and he would snap his fingers, and they would get a bite, but it was always a barracuda (Howe, pers. comm., 2016).

In describing reasons for population declines or the stability of the population, interviewees on both islands either said the species is overfished or it is not harvested in abundance. A Barbudan fisherman commented that barracuda seem depleted, which could be a result of overfishing, but others said there is not a large market for the species on the island or for export (Evans, pers. comm., 2016). On Montserrat, several divers said that overfishing has harmed the population, but others perceived less consumption of the species because of the prevalence of ciguatera. One diver also said the species has increased because they are concentrated in an area within the volcanic exclusion zone where there is less fishing, so breeding is able to occur uninterrupted (Wade, pers. comm., 2016).

Place Names

Overall, 32.5% of interviewees identified locations named after a marine species. Antiguans identified “Barracuda Point,” (N=1), “Snapper,” (N=1), and “Turtle Bay,” (N=2) as places named after marine species (Figure 24). Of the locations named after marine species identified in Chapter 2 from historical maps, one place name was corroborated by an interview. An Antiguan fisherman referenced the place name "snapper" near English Harbour, which was identified on a historical map of the island (Museum of Antigua and Barbuda, 1788). One fisherman remarked that other fishermen probably have named many additional places after species that are abundant there, but fishermen keep that kind of information protected.

On Barbuda, interviewees mentioned "Whelks," (N=1), "Oyster Bay," (N=1), "Lobster Point," (N=4), Barracuda Rock (N=2), and "Snapper Hole," (N=1) as places named after marine species (Figure 24).

Figure 24. Places named after marine species identified from interviews on Antigua and Barbuda

Though no places named after marine species were discovered on Montserrat in the historical mapping section of this research (Chapter 2), interviewees indicated several locations named after species, including: "Shark Hole," (N=1), Turtle (N=2), Shark

(N=1), Barracuda (N=1), Turtle Bay (N=1), and Sprat Bay (N=1) as places named after marine species (Figure 25).

Figure 25. Places named after marine species identified from interviews on Montserrat

Discussion

Oral histories collected on Montserrat, Antigua, and Barbuda present information about changes in marine species abundance that occurred within living memory. Perceived patterns from interviews about species were often similar. However, some perceptions of changes in species abundance and current status were different from each other or from other sources of information, which raised questions such as: is the barracuda population actually healthy, or is it threatened by overfishing on Montserrat and Barbuda? How abundant is coral on Montserrat and how did the volcano change coral cover? Have conch, lobster, snapper, and grouper populations already increased on

Barbuda because of recent conservation measures? And has the abundance of turtles on both islands increased as much as interviewees perceive? Disparities in the collection of oral histories are not unusual, and several themes found in this research were common among marine historical ecology studies that use LEK.

A pattern throughout the oral histories was interviewees describing changes to the marine system beyond species abundance changes. Fishermen, in particular, mentioned changes in catch per unit effort, the size of species, and overall changes in species composition. These observations have been found in other historical ecology studies, and are a result of the spatial expansion, temporal acceleration, and serial exploitation of fisheries (Lotze & McClenachan, 2014). Exploitation occurs in convenient areas, with low technology, of desirable and abundant species until the species and area is overharvested, wherein technology advances and fishermen move to more abundant grounds and more common species. This pattern could also explain why foreign fishermen have increasingly come to Barbudan waters in the last ten to fifteen; they may have already exploited their own waters. The LEK interviews highlighted trends in perception of resource use, species abundance, and identified possible reasons for alterations in the marine environment.

Perceived Reasons for Change in Abundance

Reasons cited for change in species abundance varied between the islands. On Barbuda and Antigua, interviewees often described legislation as a reason for species increase or recent increase (Table 7). In addition to conserving marine species, the 2014 legislation in Barbuda created marine sanctuaries that protect 33% of the coastal area (Barbuda Fisheries Regulations, 2014). All species that were perceived as recently increasing on Barbuda are protected by legislation implemented either in 2013 or 2014 ranging from bans to minimum size limits and closed seasons for lobster, grouper, parrotfish, snapper, and conch (Fisheries Regulations, 2013; Barbuda Fisheries Regulations, 2014). While the ecosystem could have seen some recovery in the last two to three years since the policies were implemented, this perceived increase could present a "policy placebo effect," where interviewees believe the situation has improved as a result of the legislation prior to recovery actually taking place. More time for recovery and rebuilding of populations will most likely be necessary to see larger improvements in the ecosystem. Several Barbudan and Antiguan fishermen did mention that they have not seen large changes yet, but they expect to see increasing populations of parrotfish and other protected species in the next five to ten years.

Table 7. Conservation measures regarding marine species and year implemented in Antigua and Barbuda (The Fisheries Regulations, 2013; The Barbuda Fisheries Regulations, 2014)

Jurisdiction	Species	Year	Conservation Measure
Antigua and Barbuda	Lobster	2013	Closed season: May 1 – June 30 Minimum size limits No take when molting or with eggs Only catch with pot, trap, hand, or loop
Antigua and Barbuda	Parrotfish	2013	Closed season: May 1 – March 31
Antigua and Barbuda	Conch	2013	Closed season: July 1 – August 31 Minimum size limits No take from vessels
Antigua and Barbuda	Turtle	2013	No take unless an open season is declared
Antigua and Barbuda	Grouper (Nassau, red hind, coney)	2013	Closed season: January 1 – March 31
Antigua and Barbuda	Cockle, whelk, sea egg	2013	Minimum size limits
Barbuda	Parrotfish	2014	Ban
Barbuda	Urchins	2014	Ban
Barbuda	Coral	2014	No nets within 20 meters
Barbuda	Sharks	2014	Only traditional take allowed No exports

Table 8. Conservation measures protecting marine species on Montserrat and the year implemented.

Species	Year	Conservation Measure
Turtles	2002	Size limit: no capture under 20 lbs Closed season: June 1 – September 31
Coral	2010	Montserrat Reef Project: artificial reef ball project
Turtles	2012	Turtle hatchery

On Montserrat, there is no comparable legislation protecting species, other than turtle conservation measures, as the Waitt Institute is in the process of building marine policy with the Montserratian government and community (MOU Montserrat, 2015) (Table 8). Montserratians overall perceived fewer increases and recent increases in species, which could be a result of the absence of conservation policies on the island. While several interviewees described the recent increase of snapper, this is not comparable to the descriptions of recent increases on Barbuda. Montserratians discussed how the snapper population fluctuates, and this year it seems to be more abundant than in previous years, not that they believe this increasing pattern will continue.

On both islands, turtle population increases were explained as not only a result of legislation, but also a cultural shift towards respecting turtles and caring for them for ecotourism purposes. Turtle conservation programs on Antigua, Barbuda, and Montserrat have been active in raising awareness of turtle nesting and protection (EAG, 2009; GOM, 2013). Outreach efforts have led to a shift away from harvesting turtles. Several fishermen who reported catching turtles when they were younger mentioned that even when it is in season currently, they would not want to harvest the turtles now (Murphy, pers. comm., 2016; Sweeney, pers. comm., 2016). However, restoration efforts are fairly recent on both islands, and due to the long generation length of turtle species, the populations will need a longer time for recovery (Seminoff, 2004; Mortimer & Donnelly, 2008).

Though Montserrat does not currently have legislation protecting species except turtles, lack of policies was not cited as a reason for species decline. Overwhelmingly, the volcano and Hurricane Hugo were described as the events that have most affected Montserrat's marine and terrestrial ecosystems. The volcano, in particular, destroyed the marine ecosystem by burying large amounts of coral around the island. Though the eruption was in 1995, volcanic debris is still frequently sent into the water by dome collapses and other activity from the volcano (Myers, 2013). Hurricane Hugo, in 1989, passed directly over Montserrat and destroyed 98% of the country's infrastructure and altered the marine ecosystem (IRP, 2016). Even fishermen who weren't active pre-volcano or pre-Hugo cite the disasters as the main reasons for species decline. However, this emphasis on natural disasters could mask other anthropogenic effects on marine species that have occurred in the last several decades.

Overall, both Barbudans and Montserratians interviewed described the same trends for species abundance over time: all species other than turtles have declined in abundance to varying degrees in the last twenty years. On Barbuda, most reef species, including lobster, conch, and grouper, were described as more abundant than on Montserrat. Barbudans more frequently described species as "superabundant" twenty years ago compared to Montserratians. This suggests either that Montserrat has less abundance of marine species or that the fishermen perceive it this way. On both islands, the perception of coral health has declined more than all other species, followed by reef species like lobster, grouper, conch, and parrotfish. This perception corresponds with the observation of Paddack et al. (2009) that coral decline and reef fish decline have been incongruent in the Caribbean. Though coral reef decline has been documented for decades, there has been a lag in the decline of reef fish species.

On Barbuda, many fishermen cited overfishing as an issue, but specified the overfishing was from foreigners. Interviewees frequently described the sustainability of Barbudan fishermen, compared to fishermen from other Caribbean islands. Interviewees cited tourism, habitat loss, declining water quality, and increased demand as reasons for species decline. The pressure of these factors will increase on Barbuda as a new plan for a resort on the island unfolds. In 2015, Antigua and Barbuda announced plans led by Robert De Niro to build Paradise Found, a luxury resort on Antigua (Glusac, 2016). With Barbuda's small population and tourism industry, increased construction on and visitation to the island will present challenges for continued marine restoration efforts.

Shifting Baselines on Barbuda and Montserrat

This research, like other marine historical ecology studies, found years of experience and age as important predictors of perception of ecosystem degradation in the environment. In the Gulf of California, Sáenz-Arroyo et al. (2005a) found that older fishermen were more likely to name more locations and species as depleted compared to younger fishermen. In Brazil, Bender et al. (2014) categorized interviewees based on fishing experience and found beginner fishermen described fewer sites and species as overexploited and fewer species as target catches. This research found years of experience of fishermen as a significant predictor of perception of species decline. Experience fishing or diving is particularly important on Montserrat, as several interviewees had recently emigrated to Montserrat from other islands. Additionally, experience level affects how interviewees perceived and described the abundance of species that were commonly cited as declining. As interviewees with greater experience saw environmental conditions and populations of species several decades ago, they were more likely to recognize the degraded status of species currently. As conservation initiatives on the islands continue, these findings can inform continued outreach efforts. While the shifting baselines syndrome presents an educational hurtle for restoration, identifying the loss of generational knowledge is a critical step to improve public awareness and presents opportunities for outreach and education.

DISCUSSION

Comparison of ecological assessments, archival resources, and LEK

This research analyzes LEK alongside available archival resources and ecological assessments to gain a more complete view of changes in marine species abundance around Barbuda, Curaçao, and Montserrat. Other marine historical ecology studies that used local ecological knowledge alongside historical and ecological data have unearthed unexpected results that are significant for future management, restoration efforts, and education (Sáenz-Arroyo et al., 2005a; Parsons et al., 2009; Kittinger et al., 2012; Bender et al., 2014). By examining oral histories from fishermen alongside anecdotal research, Sáenz-Arroyo et al. (2005b) discovered that the Gulf grouper was more abundant historically than previously realized in the Gulf of California. Through interviews with fishermen in Australia and analysis of historical information, Bender et al. (2014) found interviewees preferentially recall years where snapper abundance has increased, and largely forget periods of decline. Such results speak to the significance of historical anecdotes and narratives when designing fishery policy; historical information is not only helpful, it is crucial. Conservation efforts for marine species are able to be more robust and effective when historical information and fishermen's experiences are taken into account.

As this research uses LEK from local resources users in addition to historical sources, it is significant to address the biases of each source type when inferring trends about abundance or historical changes in abundance. The full time period of marine exploitation is not covered in this analysis: living memory extends back to the mid 1900s and historical maps and anecdotal accounts extend to the 1500s. Additionally, identified historical data sources for this research are not comprehensive. To utilize historical records in research, it is important to situate the results in a larger historical context and analyze why authors may have wanted to reference a species or specific environmental description (Lotze & McClenachan, 2014). Marine historical ecology studies have acknowledged various forms of bias in historical information including: recording bias, observation bias, sampling effort bias, and preservation bias (McClenachan et al., 2015). Some of the species referenced in my archival research, like turtles or sharks, may have been written about because of observation bias; the author was interested in the species and believed readers would be as well. Additionally, archival research efforts were affected by preservation bias, as my research was limited to online information and documents from island museums, and many documents have been lost from natural disasters. Finally, there are inherently biases in discussing the abundance of resources with resource users. For example, certain fishermen or divers have more knowledge about species they commonly interact with. Additionally, Daw (2010) documented the phenomenon of "memory illusion," where older interviewees can inaccurately recall past conditions and possibly exaggerate the magnitude of changes. However, part of the reason I collected oral histories was to understand perspectives of interviewees, not only to gather information about the marine environment. Thus, inaccuracies and skewness in interviewee perceptions were vital to my research process. Ultimately, I use the historical records to identify iconic and significant species at that time the records were created. As some of the anecdotes suggest abundance or a large size of species, I compare such descriptions to current perceptions of ecological assessments.

To evaluate if interviewee perceptions corresponded to available data, I analyzed LEK alongside scientific assessments. While in-depth assessments of marine species specific to each island are not available, International Union for Conservation of Nature (IUCN) assessments and other available ecological studies provide information on current status. Of the species identified in interview questions, three are Critically Endangered (elkhorn coral, hawksbill turtles, staghorn coral) two are Eendangered (green turtle, Nassau grouper) three are Vulnerable (cubera snapper, mutton snapper, pillar coral), four are Near Threatened (blacktip reef shark, lemon shark, rainbow parrotfish, red grouper), four are Least Concern (barracuda, boulder brain coral, red hind, redband parrotfish), two are Data Deficient (spiny lobster, nurse shark) and two have not been evaluated (octopus, queen conch) (Table 9).

Table 9. IUCN Red List categorizations of species included in interview questions. Categories are: Not Evaluated, Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild, Extinct. For species of coral, four common types in the Caribbean region or mentioned by interviewees were included.

Common Name	Species	IUCN Red List Categorization
Elkhorn coral	*Acropora palmata*	Critically Endangered
Hawksbill turtle	*Eretmochelys imbricata*	Critically Endangered
Staghorn coral	*Acropora cervicornis*	Critically Endangered
Green turtle	*Chelonia mydas*	Endangered
Nassau grouper	*Epinephelus striatus*	Endangered
Cubera snapper	*Lujanus cyanopterus*	Vulnerable
Mutton snapper	*Lutjanus analis*	Vulnerable
Pillar coral	*Dendrogyra cylindrus*	Vulnerable
Blacktip reef shark	*Carcharhinus melanopterus*	Near Threatened
Lemon shark	*Negaprion brevirostris*	Near Threatened
Rainbow Parrotfish	*Scarus guacamaia*	Near Threatened
Red grouper	*Epinephelus morio*	Near Threatened
Barracuda	*Sphyraena barracuda*	Least Concern
Boulder brain coral	*Colpophyllia natans*	Least Concern
Redband Parrotfish	*Sparisoma aurofrenatum*	Least Concern
Red hind	*Epinephelus guttatus*	Least Concern
Caribbean spiny lobster	*Panulirus argus*	Data Deficient
Nurse shark	*Ginglymostoma cirratum*	Data Deficient
Octopus	*Octopus briareus*	Not Evaluated
Queen conch	*Strombus gigas*	Not Evaluated

The comparison of ecological assessments, LEK, and archival information below follows the declining order in the table above, with Critically Endangered species first and ending with Data Deficient and Not Evaluated species from the IUCN.

Coral

Coral was the most cited group by interviewees as having declined on the islands. This perception matches with assessments of several types of coral as Critically Endangered globally and Threatened throughout the Caribbean. On Barbuda, an ecological assessment found coral cover as low as 2.6% in some areas with high algae coverage compared to the Caribbean average of 17% coral cover. The healthiest sites on Barbuda had approximately 10% live coral cover, with few staghorn and elkhorn species (Ruttenberg et al., 2013). A study conducted twenty years ago on Antigua and Barbuda found live coral cover between 5 to 20% on average with one area up to 50% live coral coverage (Goreau & Goreau, 1996). As documented by interviews and ecological assessments, coral cover has drastically declined in the past twenty years around Barbuda. Assessments of Montserrat's coral abundance match with interviewees' perceptions of decline. No terrestrial or marine environment was the same after the volcanic eruption, and coral reefs were particularly harmed on Montserrat. Continued sedimentation from the volcano has buried large portions of the reefs, particularly inshore. Elkhorn and staghorn coral is rare on Montserrat, due both to white band disease, hurricanes, and the volcano (Myers, 2013). Myers (2013) also noted the prevalence of destructive fishing practices on the island that have resulted in losses in coral cover. A project started in 2010, the Montserrat Reef Project, aims to create new reef structures around the island (Myers, 2013; Discover MNI Team, 2015). Coral cover for the area has been estimated at 10-25%, which is somewhat higher for the deeper reefs of the island (Johnson, 2015).

Turtles

On both islands, interviewees perceived turtles currently as superabundant, abundant, or common; however, the hawksbill and green are considered Critically Endangered and Endangered by the IUCN (Seminoff, 2004; Mortimer & Donnelly, 2008). Historical data shows significant exploitation of turtles throughout the Caribbean (McClenachan et al., 2006). Steadman et al. (1984) found evidence of hawksbill turtle exploitation on Montserrat from cultures 2,000 years ago. Most historical narratives describe eating turtle soup in the Caribbean, and in Oviedo's (1526) observations, he mentions that the turtles around Cuba were so large that ten to fifteen men were necessary to pull them from the water (Branch, 2004). As recently as the 1980s, exports of turtle products and sale of turtle meat was a large business on Antigua and Barbuda (Meylan, 1983). Despite the current shift away from catching and eating large numbers of turtles, which is documented in the anecdotal accounts, turtles have faced extensive population declines worldwide (Seminoff, 2004). Recent increases due to conservation efforts are a success, but studies have estimated enormous decline of historic nesting populations throughout the Caribbean, with 20% of historic nesting populations lost and 50% of remaining sites with low populations in the Caribbean (McClenachan et al., 2006). On Barbuda, several fishermen thought the populations were strong enough to reestablish larger turtle fisheries. Though Montserrat is not a major nesting site in the Caribbean, there are over 50 nests annually, with evidence of hawksbill and green nesting, and non-nesting emergences for loggerhead turtles (Martin et al., 2005). Montserratians identified two areas on the island named after turtles and one area was identified by Antiguans. Godley et al. (2005) analyzed populations and current threats to turtles on Montserrat, and noted continued harvesting of green and hawksbill turtles, and described populations of turtles as "critically small." Studies conducted in the 1980s described low abundance of nesting green turtles on Antigua, Barbuda, and Montserrat (Meylan, 1983; Groombridge & Luxmore, 1989). Turtle conservation programs on both islands have had success and raised awareness about the importance of restoring populations, though current populations throughout the Caribbean are still fractions of past abundance (Godley et al., 2004; EAG, 2009).

Grouper

Though historical population sizes are unknown, grouper was documented on a historical map of St. Barts (DLOC, 1872) and a 1977 map of Barbuda near Palaster Reef suggesting abundance and plentiful fishing of the species. Grouper species mentioned in the interviews or species that are common in the region have been assessed as Endangered and Near Threatened, both with declining populations due to overfishing and habitat loss (Cornish & Eklund, 2003; Garcia-Moliner & Eklund, 2004). On Barbuda, grouper is one of the most economically important species and is also a common target species on Montserrat (Ramdeen et al., 2012; Ruttenberg et al. 2013). Grouper was mentioned in Brown's (1945) account of Montserrat fishing as a species that commonly carries ciguatera. A 2013 study observed low abundance of grouper in Barbuda compared to other Caribbean islands (Ruttenberg et al. 2013).

Snapper

The mutton and cubera snapper, mentioned in LEK interviews, have both been classified as Vulnerable by the IUCN (Huntsman, 1996a; Huntsman, 1996b). A historical map of Antigua and Barbuda had "snapper" as a place name in southern Antigua, which was corroborated by a current Antiguan fisherman (Museum of Antigua and Barbuda, 1788). Snapper was described by Coleridge (1825) as one of the species easily caught on a fishing trip in Barbuda. One Barbudan fisherman and conservationist mentioned "Snapper Hole" as a place name in the highly productive Codrington Lagoon. Despite indications of the importance of snapper historically and currently in the area, 2013 surveys of abundance on Barbuda found snapper abundance low compared to other locations in the Caribbean (Ruttenberg et al., 2013)

Sharks

Of the sharks described in interviews, the lemon and blacktip reef shark are Near Threatened and the nurse shark is Data Deficient for a classification (Rosa et al., 2006; Heupel, 2009; Sundstrom, 2015). In Oviedo's (1526) description of the Caribbean, he mentions that the fishermen could only catch small sharks, because the species could become so large they were impossible to lift out of the water (Branch, 2004). A historical map of the Lesser Antilles documents the abundance of sharks, describing "sharks without number" near St. Kitts and Nevis (Museum of Antigua and Barbuda, 1784). Later historical anecdotes on both Montserrat and Barbuda mention the common practice of fishing for sharks (Coleridge, 1826; Brown, 1945). A 1977 map of Barbuda identified an area common for sharks off the southeastern coast (Museum of Antigua and Barbuda, 1977). During an ecological assessment in 2013, scientists only observed two sharks throughout 12 days of surveys of 234 sites (Ruttenberg et al., 2013). Though recent assessments of shark abundance on Montserrat were unavailable, one diver and one fisherman identified two areas on the island named after sharks. Despite the threatened status of sharks and low abundance documented by ecological assessments, the majority of interviewees perceived little change in shark abundance in the last 20 years.

Parrotfish

Of parrotfish common in the region, the rainbow parrotfish is Near Threatened and the redband is considered Least Concern (Choat et al., 2012; Rocha et al., 2012). On Barbuda, parrotfish, which is known locally as chub, is an economically important species (Henry, pers. comm., 2016). Surveys of Barbuda show low presence of larger parrotfish, rainbow, midnight, and blue, with higher concentrations of smaller parrotfish and redbands (Ruttenberg et al., 2013). This finding corresponds with the majority of interviewees' perceptions on both Barbuda and Montserrat that parrotfish populations have declined rapidly and species caught now are smaller overall.

Barracuda

Barracuda are considered a species of Least Concern by the IUCN, with no documented threats (Aiken et al., 2015). The species is described several times in identified historical anecdotes, for the danger of encountering it in the water, fishing for it, and the prevalence of ciguatera in its meat (Riddell, 1792; Coleridge, 1825; Brown, 1945). Most interviewees commented on the abundance of the species, identifying one location on each island named after barracuda. However, several participants perceived a decrease in barracuda populations because of overfishing and some mentioned that the species was much more abundance in the past.

Lobster

Caribbean spiny lobster is Data Deficient for an IUCN classification, though recent assessments have found the current population trend decreasing due to overexploitation and disease (Butler et al., 2013). Two locations on Antigua from historical maps are named after lobsters (Museum of Antigua and Barbuda, 1748; Caribmap, 1824a), lobsters are referenced on a 1977 map of Barbuda (Museum of Antigua and Barbuda, 1977), and four fishermen mentioned "Lobster Point" as an area in Codrington Lagoon, Barbuda.

The amount of references to lobster speaks to the significance of the species for Antigua and Barbuda. Spiny lobster is the most valuable fishery on Barbuda, and forms a critical part of the tourist and export economy (Luckhurst & Marshalleck, 1995; Georges et al., 2015). An assessment of lobster on the island found species only present at half the sites, with most lobsters of sub-legal size (Ruttenberg et al., 2013). Compared to a study in 1974, the average size of lobster on the island has declined (Peacock, 1974; Ruttenberg et al., 2013). Despite the documented decline in lobster, over half the fishermen on Barbuda perceive the lobster population as either abundant or superabundant. On Montserrat, interviewees more often described the population as common or rare, as the drastic effects of the volcano on lobster habitat is well known around the island (Howe, pers. comm., 2016).

Conch

Though queen conch has not been evaluated by the IUCN, an assessment of the conchfish, which has a commensal relationship with the queen conch, mentions that conch has suffered from high exploitation throughout the Caribbean (Gilmore & Fraser, 2015). Conch trade has thrived for centuries, with officials in the Dutch Netherlands describing the trade in the mid-1600s (Curaçao Papers, 2011). Due to overfishing of the species and high levels of trade, the Queen Conch was listed on CITES Appendix II in 1992, and there have been several attempts to list it on the Endangered Species Act (Townsend, 2012). The majority of interviewees perceived a decline in conch, with older fishermen often describing the ease of collecting the species in the “earlies.” This corroborates an analysis of Barbuda’s fisheries that found that fishermen pre-1970s usually gathered conch by free diving. After the late 1970s, however, SCUBA became more common and necessary on the island (Georges et al., 2015). Compared to other Caribbean islands, assessments of Barbuda have found low abundance and small average size of conch (Ruttenberg et al., 2013).

Shifting Baselines on Montserrat and Barbuda

On each of the islands, fishermen and divers with less experience perceived fewer species to be declining compared to older interviewees with more experience.

Furthermore, of the species most commonly cited as depleting, more experienced interviewees perceived the species as less abundant compared to less experienced interviewees. This presents a clear example of the shifting baselines syndrome, where people believe the environmental conditions in their lifetime to be the norm, regardless of past changes (Pauly, 1995). As younger interviewees, or interviewees who recently moved to the islands, do not have experience with the environment prior to fifteen or twenty years ago at most, they perceive the degraded marine condition as a baseline and become more tolerant to species declines.

Furthermore, I found that natural disasters on Montserrat, namely the volcanic activity and Hurricane Hugo, have created a new baseline for the island, where most locals now expect less productivity from the ecosystem. One older interviewee recalled, "in the earlies I would tell my wife I was going to go get fish. I would spend about an hour fishing and come back with fresh fish…then came the volcano and everything was lost" (Daley, pers. comm., 2016). Even those who were not alive or do not remember the pre-volcano conditions know that there have been major changes to the terrestrial and marine ecosystems. The danger in this is that people could accept the current conditions because they feel the ecosystem cannot recover. One interviewee wondered, "Will fishing on Montserrat die?" (Francis, pers. comm., 2016). Additionally, there is a possibility that the major destruction from the volcano has disguised more subtle or recent changes to the ecosystem from other factors. Several Montserratians believe the pre-Hugo and pre-volcanic conditions were pristine because the ecosystem is drastically different now. Historical data has the ability to identify conditions well before the volcanic eruption in the 1990s and determine historical changes to the marine environment caused by past natural disasters. The response of Montserratians to the effects of the volcano also presents an example of how communities can view non-anthropogenic effects on ecosystems. Such observations have implications for the empowerment of communities and success of restoration goals in the face of more global and unknown stressors, such as climate change.

By analyzing LEK and current species status, I also identified discrepancies between local perception and ecological assessments of certain species' abundance. When examining disconnects between science and LEK, it is significant to consider the value of

LEK and the possibility that scientific assessments are incorrect (Johannes, 2000). The interviewees from this research from Antigua, Barbuda, and Montserrat work closely with marine resources and have specific knowledge about species changes and abundance that ecological assessments may not have captured. The discrepancies I noted between the LEK research and ecological assessments included describing species abundance as healthy or pristine several decades ago, perceiving a rare or threatened species as abundant, and equating a conservation policy with recovery of a species.

The first disconnect between ecological assessments and LEK was older interviewees describing the marine environment as “pristine” in the 1980s and 1990s, a time when the ecosystem had been affected by humans for centuries. Archaeological records found on Barbuda and Antigua from nearly 4,000 years ago show evidence of heavy exploitation of marine life like turtles, crustaceans, parrotfish, grunts, and grouper (Fitzpatrick & Keegan, 2007). Furthermore, reconstructed catches from Antigua and Barbuda extending back to 1950 shows higher exploitation rates than previously estimated, with species like conch depleted by the 1970s (Georges et al., 2015). Similarly, catches are underreported on Montserrat, and domestic markets and tourist consumption of seafood resulted in substantial catches as early as the 1950s (Ramdeen et al., 2012). Using the marine conditions of twenty to thirty years ago as a baseline for past abundance could be misleading for future management and could skew restoration targets for species.

Secondly, recent legislation protecting species, including lobster, parrotfish, conch, grouper, and parrotfish on Barbuda and turtle on each island has potentially given some interviewees a skewed perception of abundance and population increase. As the populations of species like parrotfish, grouper, and turtles are so degraded, the knowledge of what a healthy population can look like has been lost. While conservation measures and legislation are a significant step, species populations will need longer to recover.

Finally, interviewees perceived several species as significantly more abundant than ecological assessments have found. Turtle, particularly, presented one of the largest disconnects between local perception and ecological assessments. Despite the cultural shift towards protecting turtles and a decrease in turtle harvesting, the populations of green and hawksbill turtles are still fractions of their historical abundance throughout the Caribbean (McClenachan et al., 2006). On Montserrat, historical extraction, in addition to damage from the volcano, has left nesting turtle numbers at critical low levels (Godley et al., 2004). Because of the long generation length of turtles, the species requires significant time for recovery, and perceptions of large increases and healthy turtle populations on the islands cannot detract from continued conservation efforts.

Implications for Future Restoration

Shifting baselines is a major obstacle for conservation. However, there is a large amount of enthusiasm and knowledge on the islands from fishermen and conservationists alike who want to restore the marine environment. For example, when asked about parrotfish on the island, most Barbudans described how the protection of the species is necessary because it is crucial for reef health and recovery. The Waitt Institute has already achieved success on Barbuda with community-based conservation by helping governments build species-level protection policies in addition to ocean zoning efforts. On Montserrat and Curaçao, the Waitt Institute is in the process of developing new ocean policies with the help of the governments and communities. The challenge on Montserrat will be developing policies and encouraging fishermen and other community members to look beyond the destruction of hurricanes and the volcanic eruption to see the resilience and potential in the marine environment.

To remind communities about the ecosystem's resilience and past productivity, this research and other historical ecology studies can inform education and outreach efforts regardless of the government's stage of policymaking or enforcement. For continued education efforts, including lessons plans in elementary school and later years about the past and present marine conditions around the islands will be crucial for the younger generation to understand the productivity of their waters. One interviewee on Montserrat has organized a program called "Aqua Montserrat," which teaches young Montserratians how to swim, dive, and identify species around the coral reefs of the island (Wade, pers. comm., 2016). Another Montserratian commented on the program, "One of the greatest things happening now is Aqua Montserrat. I can see it as a foundation of life in Montserrat for the future," (Daley, pers. comm., 2016). Such programs are critical to restoration efforts, as they teach the next generation about the ocean and interest them in conservation efforts. Another way to highlight the past productivity of the islands' waters could be through museum exhibits and additional marine historical ecology research efforts. Montserrat and Curaçao both have museums and historical societies active in local communities (Curaçao, 2016; MNT, 2016). While there is not a museum on Barbuda, there are several on Antigua (MAB, 2016). Exhibits at the museums could highlight historical anecdotes and oral narratives from older fishermen and conservationists. Another researcher could also explore photographs on the islands of fishermen's catch and possibly make an exhibit to display past and present sizes of fishing landings. Further research could also focus on collecting oral narratives from more fishermen and divers on the islands, that could be organized into a book or other presentation. With identified archival resources, future research could reconstruct populations of species to better understand historical changes. Despite historical and current declines in marine species abundance, the communities and marine environment of Barbuda, Curaçao, and Montserrat are resilient, and the communities are committed to the restoration of their waters.

Conclusions

Marine resources on Barbuda, Curaçao, and Montserrat have been exploited for thousands of years. There are well known sites on the islands from communities 4,000 years ago that hunted fish, turtles, and invertebrates from the reef and shore (Fitzpatrick & Keegan, 2007). Even before the period of colonization, the marine environment was heavily exploited for parrotfish, grouper, grunts, sea turtles, lobster, and queen conch for subsistence and trade (Jackson, 1997; Fitzpatrick & Keegan, 2007). Archival information identified in this research from historical maps and anecdotes highlight species of interest around the islands and present descriptions of early abundance. In total, I identified 30 marine references from historical maps of the Lesser Antilles and Curaçao, and 22 references of 11 marine species from anecdotal resources. From oral histories gathered on Montserrat and Barbuda, I discovered that more experienced fishermen and divers are more likely to see species as declining in abundance and describe declining species as less abundant compared to their less experienced counterparts. Furthermore, the majority of interviewees perceive certain species, including sharks, lobster, turtles, and snapper, as more abundant than ecological assessments suggest. As the Waitt Institute continues their work on Barbuda, Curaçao, and Montserrat, this research can help identify perceptions of species abundance and inform education efforts. Knowledge of past abundance is empowering, and this research and similar studies can aid continued restoration efforts on islands in the Caribbean.

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APPENDIX I: MEMORANDUM OF UNDERSTANDING WITH MONTSERRAT GOVERNMENT

MEMORANDUM OF UNDERSTANDING

Between

DEPARTMENT OF ENVIRONMENT, MINISTRY OF AGRICULTURE, TRADE, LAND, HOUSING & ENVIRONMENT
Government of Montserrat, Brades, Montserrat

And

WAITT INSTITUTE with COLBY COLLEGE

Waitt Institute: 5786 La Jolla Blvd, La Jolla, CA 92037 Colby College: Mayflower Hill, Waterville, Maine, 04901

Concerning

SHIFTING BASELINES OF ICONIC MARINE SPECIES IN THE CARIBBEAN

1. The research will be conducted from 12/01/2016 to 27/01/2016 and the permission is valid for the named researchers only.
2. Fieldwork will be guided by the agreed research methodology and associated protocol.
3. Any deviation from the current research proposal or personnel would require a written request from the leading researcher indicating the proposed changes and the reason for them. No deviation from the current research proposal will be allowed without the written permission of the Director of Environment.
4. The principle of best practice shall be adhered to at all times, including strict adherence to safety for the researcher and interviewees. The researcher must work under the strict supervision of the scientifically competent college advisor and site manager.
5. The DOE shall be allowed to assess research activities at any point during the research period.
6. Upon arrival on Montserrat and prior to the commencement of the research, the visiting researcher must meet with the Director of Environment to discuss the work programme to be undertaken and agree on any opportunities for DOE staff to accompany researchers on field visits.
7. The Director of Environment shall receive all data information submitted to electronically upon completion of the research.

8. At the end of the research, before the researchers leave Montserrat, a debriefing meeting shall be convened between the researchers and the Director of Environment.
9. The researchers must have relevant technical competence and access to sufficient financial resources to undertake and complete the research.
10. Collaboration with other agencies, organisations or individuals on Montserrat, must be done with the concurrence of the Director of Environment.
11. No specimens or materials of any kind shall be collected, harvested or hunted.
12. Interviews with the news media, on aspects of the research, will be undertaken as agreed with the Director of Environment.
13. Upon completion of the research, the researchers will be required to deposit copies of data, photographs, reports and publications with the DOE.
14. The research will facilitate capacity building and technology transfer between DOE staff and researchers, as appropriate.
15. The DOE shall facilitate and support this research to the extent of its capacity to do so.
16. The Waitt Institute/Colby College agrees that they shall effect and maintain insurance in an adequate sum to cover the Researcher for any eventuality including death, accident and personal injury arising out of or in the course of the performance of the research.

    b) The Waitt Institute/Colby College agrees and accepts that the DOE will not be held liable to the Researchers or anyone claiming on behalf of the Researchers, for any death personal injury, loss, medical costs, damage or claim howsoever arising out of or in the course of the performance of the research.

    c) The DOE agrees that the Waitt Institute will not be held liable to the DOE for any death, personal injury, loss, medical costs, damage or claim by or on behalf of any Employee of the DOE howsoever arising out of or in the course of the performance of the research.

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Date: January 19, 2016, Robin Ramdeen, Site Manager Waitt Institute

Date: January 14, 2016, Loren McClenachan, Colby College Advisor

Date: 19 January 2016, Gerard A L Gray - Director of Environment Government of Montserrat

APPENDIX II: INTERVIEW QUESTIONS

Caribbean Shifting Baselines Interview Questions
This survey is meant to identify places named after marine species and perceptions of change in marine species over time.

Demographic information
Name:

Email:

Island of residence:

Gender: ☐Male ☐Female

Age: ☐<20 ☐20-30 ☐31-40 ☐41-50 ☐51-60 ☐>60

Profession:

(If fishermen, what gear)

Number of years in profession:

Percentage of income from marine-related profession:

☐0% ☐1-25% ☐25-50% ☐50-75% ☐75-100%

Interview Questions

Identifying marine place names
This section asks if you know of any areas on the island named after a list of species.

1. Do you know of any areas on the island named after or commonly called lobster?

   ☐Yes (indicate location on map) ☐No

2. Do you know of any areas on the island named after or commonly called turtle?

   ☐Yes (indicate location on map) ☐No

3. Do you know of any areas on the island named after or commonly called grouper?

   ☐Yes (indicate location on map) ☐No

4. Do you know of any areas on the island named after or commonly called octopus?

   ☐Yes (indicate location on map) ☐No

5. Do you know of any areas on the island named after or commonly called conch?

☐Yes (indicate location on map) ☐No

6. Do you know of any areas on the island named after or commonly called barracuda?

   ☐Yes (indicate location on map) ☐No

7. Do you know of any areas on the island named after or commonly called coral?

   ☐Yes (indicate location on map) ☐No

8. Do you know of any areas on the island named after or commonly called shark?

   ☐Yes (indicate location on map) ☐No

9. Do you know of any areas on the island named after or commonly called oyster?

   ☐Yes (indicate location on map) ☐No

10. Do you know of any areas on the island named after or commonly called other marine species names?

   ☐Yes (indicate location on map) ☐No

Names: ____

Identifying observations of change over time

This section asks 8 short questions about species current and past abundance, body size, population size and range.

1. How abundant would you consider lobster currently?

   ☐Absent ☐Rare ☐ Common ☐ Abundant ☐ Superabundant

2. Has the amount of lobster changed in the last 10 years?
   ☐Yes (if so, how?) ☐No
   ☐Absent ☐Rare ☐ Common ☐ Abundant ☐ Superabundant

3. How abundant were lobsters 20 years ago (Montserrat: pre-volcano)?

   ☐Absent ☐Rare ☐ Common ☐ Abundant ☐ Superabundant
   ☐Do not know

4. If the population size of lobsters has changed, why do you think this happened?

5. Have you noticed any changes in the body size of lobster over time?

☐Decrease ☐No change ☐ Increase

6. Have you noticed any changes in the range of lobster over time?

☐Yes ☐No

7. Where (on the map) are lobsters concentrated currently?
   a. Has this changed in the last 10 years? How?
   b. Was this different 20 years ago (Montserrat: pre-volcano)? How?

8. If the range has changed, what do you think caused the change(s)?

[Repeat for conch, turtle, parrotfish, grouper, barracuda, octopus, shark, coral, snapper]

Generating a list of species perceived to be increasing or decreasing
(for species that have not otherwise been mentioned in the survey)

Ex: Tuna, wahoo, urchins, grunts, angelfish, trunkfish, blue tag, flamingo tongues, jack

1. Have you noticed any other populations of marine species increasing? (i.e. lionfish)

☐Yes ☐No

2. If yes, list the species and the reason you think the species may be increasing in abundance.
   Species _______________Reason____
   Species _______________Reason____
   Species _______________Reason____
   Species _______________Reason____
   Species _______________Reason____
   Species _______________Reason____
   Species _______________Reason____
   Species _______________Reason____

3. Have you noticed any other populations of marine species decreasing? (seagrass, urchins)

☐Yes ☐No

4. If yes, list the species and the reason you think the species population may be decreasing in abundance.
   Species _______________Reason____
   Species _______________Reason____

Species ________________Reason____
Species ________________Reason____
Species ________________Reason____
Species ________________Reason____
Species ________________Reason____
Species ________________Reason____

Other perceptions of change (time permitting)

1. Have you noticed any other changes in the marine environment that you would like to talk about? (i.e. prevalence of ciguatera, sea-grass)

Future contacts

1. Is there anyone else that you suggest I should talk to?

APPENDIX III: SUMMARY INFORMATION FROM INTERVIEWS

Table 1. Summary information for all islands: categories of the species, common and scientific names, and the number of respondents who saw a change in the species abundance

Category	Common Name	Scientific Name	Increase	Decline	Recent Increase/ Overall Decline
Invasive	Lionfish	*Ptserois volitans*	17	0	0
Invertebrate	Conch	*Strombus gigas*	0	17	1
Invertebrate	Coral		0	21	0
Invertebrate	Helmet shells	Family: Cassidae	1	0	0
Invertebrate	Jellyfish	*Cassiopea*	2	0	0
Invertebrate	Land crab	*Gecarcinus ruricola*	0	1	0
Invertebrate	Octopus	*Octopus briareus*	0	4	0
Invertebrate	Sea urchin	*Diadema antillarum*	0	3	0
Invertebrate	Spiny lobster	*Panulirus argus*	0	19	3
Invertebrate	Whelk	*Cittarium pica*	1	1	0
Plant	Sargassum	*Sargassum*	3	0	0
Plant	Seagrass	*Thalassia testudinum*	2	6	0
Pelagic fish	Barracuda	*Sphyraena barracuda*	2	5	0
Pelagic fish	Mackerel (king mackerel)	*Scomberomorus cavalla*	0	2	0
Pelagic fish	Mahi Mahi	*Coryphaena hippurus*	2	2	0
Pelagic	Pufferfish	*Sphoeroides nephelus*	0	1	0
Pelagic fish	Rays	Batoidea	0	1	0
Pelagic fish	Remora	*Remora*	0	2	0
Pelagic fish	Saltwater catfish	*Ariopsis felis*	1	2	0
Pelagic fish	Shark (nurse, lemon, tiger, reef, hammerhead)	*Ginglymostoma cirratum, Negaprion brevirostris, Galeocerdo cuvier,*	5	2	0

		Carcharhinus perezii Sphyrnidae			
Pelagic fish	Snapper (mangrove, queen, mutton, dog, cubera, red)	*Lutjanus griseus Etelis oculatus, Lutjanus analis, Lutjanus jocu, Lutjanus cyanopterus Lutjanus campachanus*	2	4	2
Pelagic fish	Swordfish	*Xiphias gladius*	0	1	0
Pelagic fish	Tuna	*Thunnus*	0	2	0
Pelagic fish	Wahoo	*Acanthocybium solandri*	0	2	0
Reef fish	Angelfish	*Holacanthus*	1	6	0
Reef fish	Filefish	Family: Monacanthidae	1	0	0
Reef fish	Goat fish	Family: Mullidae	0	1	0
Reef fish	Grouper (Nassau, coney, red hind, graysby, goliath)	*Epinephelus striatus, Epinephelus guttatus, Cephalopholis fulvus, Cephalopholis cruentata, Epinephelus itajara*	1	15	2
Reef fish	Grunt	*Haemulon*	2	7	0
Reef fish	Jack	*Caranx*	1	4	0
Reef fish	Needlefish	Family: Belonidae	0	1	0
Reef fish	Parrotfish	*Scaridae*	3	16	2
Reef fish	Surgeonfish (blue tang, ocean surgeon, doctorfish)	*Acanthurus coeruleus Acanthurus bahianus Acanthurus chirurgus*	1	3	0
Reef fish	Porgies	Family: Sparidae	1	0	0
Reef fish	Striped croaker	*Bairdiella sanctaeluciae*	0	4	0
Reef fish	Triggerfish	Family: Balistidae	1	1	0

Reef fish	Trunkfish	Family*:* *Ostraciidae*	0	2	0
Reptile	Turtle	*Chelonia mydas, Eretmochelys imbricata*	20	3	0

Table 2. Summary information for interviews from Antigua: species mentioned or asked about, how many respondents saw the species as increasing, declining, recently increasing but declining overall, and reasons for the change in abundance. The table is organized descending by the number interviewees who mentioned a change in species population.

Species	Increase	Decline	Recent Increase/ Overall Decline	Reasons: Increase	Reasons Decline	Reasons: Recent Increase/ Overall Decline
Grouper	1	4	1		Overfishing (3), Lack of protection (n=1)	Legislation (n=1)
Coral	0	4	0		Spearfishing (n=2), Hurricanes (n=2), Net fishing (n=2), Decrease of parrotfish (n=1)	
Conch	0	3	0		Overfishing (n=2), Lack of enforcement (n=1), Increased market in French islands (n=1)	
Lobster	0	3	0		Overfishing (n=3), Overfishing juveniles (n=1), Lack of enforcement (n=2) Lack of protection (n=1), Habitat loss (n=1)	
Turtle	4	0	0	Reduced fishing (n=3), cultural (n=3), legislation (n=2), ecotourism (n=1)		
Parrotfish	0	2	1			Recent legislation (n=1)
Snapper	0	1	0		Overfishing (n=1)	
Octopus	0	3	0		Overfishing (n=1), Overfishing of food (n=1)	
Lionfish	3	0	0			

Barracuda	0	1	0		Overfishing (n=1), Habitat loss (n=1)
Grunt	0	2	0		
Surgeonfish	0	2	0		
Shark	0	1	0		Less food source (n=1)
Mackerel	0	1	0		
Seagrass	0	1	0		
Sargassum	1	0	0		

Table 3. Summary information for interviews from Barbuda: species mentioned or asked about, how many respondents saw the species as increasing, declining, recently increasing but declining overall, and reasons for the change in abundance. The table is organized descending by the number of interviewees who mentioned a change in species population.

Species	Increase	Decline	Recent Increase/ Overall Decline	Reasons: Increase	Reasons: Decline	Reasons: Recent Increase/ Overall Decline
Coral	0	8	0		Spearfishing/ nets (n=2), Parrotfish overfishing (n=2), Hurricanes (n=2), Fishermen using bleach (n=1), Tourist industry (n=1), Coral bleaching (n=1)	
Grouper	0	6	1		Overfishing of spawning aggregations (n=2)	Legislation (n=1), Enforcement (n=1)
Parrotfish	3	8	1	Legislation (n=2)	Overfishing by foreign fleets (n=7), Hurricanes (n=1)	Legislation (n=2), Cultural (n=2)
Lobster	0	7	3		Demand has increased (n=3), Illegal fishing (n=1)	Legislation: 2 month-closed season (n=2)
Conch	0	4	1		Demand has increased (n=1), Overfishing from foreign fleets (n=2)	Enforcement has increased (n=1)
Turtle	6	3	0	Lack of fishing (n=6), Legislation (n=1)	People take the eggs (n=1)	
Lionfish	4	0	0	Lack of consumption (n=1)		

Snapper	1	3	0		Overfishing (n=1), Demand (n=1), Habitat loss (n=1)
Grunt	2	4	0		Overfishing (n=1)
Barracuda	0	3	0		
Shark	2	1	0		Declining water quality (n=1)
Jellyfish	2	0	0	Eutrophication (n=1)	
Octopus	0	1	0		Overfishing of food source (n=1)
Jack	1	1			
Urchin	0	2	0		Pathogen (n=1), Declining water quality (n=1)
Surgeonfish	0	1	0		Overfishing (n=1)
Angelfish	0	3	0		
Seagrass	0	1	0		Sedimentation (n=1)
Whelk	1	0	0		
Porgy	1	0	0		

Table 4. Summary information for interviews from Montserrat: species mentioned or asked about, how many respondents saw the species as increasing, declining, recently increasing but declining overall, and reasons for the change in abundance. The table is organized descending by the number of interviewees who mentioned a change in species population.

Species	Increase	Decline	Recent Increase/ Overall Decline	Reasons: Increase	Reasons: Decline
Lobster	0	9	0		Volcano (n=10), Migration (n=2) Hurricanes (n=1) Sedimentation (n=1)
Conch	0	10	0		Volcano (n=11), Hurricane (n=2), Overfishing (n=1)
Coral	0	10	0		Volcano (n=11), Hurricanes (n=3), Sedimentation from construction (n=4), Potfishing/ spearfishing/ nets (n=2), Declining water quality (n=1), Bleaching (n=1)
Turtle	10	0	0	Change in customs (n=9), Protection by law (n=4), Beach area increase (n=3)	
Lionfish	10	0	0		
Grouper (nassau, goliath, red hind)	0	5	0		Overharvesting (n=2), volcano (n=2), lionfish eating juveniles (n=1)
Parrotfish	0	6	0		Volcano (n=4), Hurricanes (n=1)
Sharks (lemon, nurse, reef, hammerhead,tiger)	3	0	0	Less fishing (n=1)	
Striped Croaker	0	4	0		
Angelfish	1	3	0		Habitat loss (n=1)

Jack	0	3	0	Overfishing (n=1), Lack of regulations (n=1)
Seagrass	2	4	0	Volcano (n=3), Hurricane (n=2)
Snapper (queen, mutton, grey, dog)	1	0	2	Overfishing (n=2) Foreign overfishing (n=1) Loss of habitat (n=1) demand (n=1)
Barracuda	1	0	0	Overfishing (n=1)
Mahi mahi	2	2	0	
Saltwater catfish	0	2	0	
Wahoo	0	2	0	
Tuna	0	2	0	
Sargassum	2	0	0	
Needlefish		1	0	
Triggerfish	1	1	0	
Surgeonfish(blue tang, doctorfish)	1	0	0	
Filefish	1	0	0	
Helmet shells	1	0	0	
Rays	0	1	0	Overfishing (n=1)
Whelk	0	1	0	
Mackerel	0	1	0	
Urchin	0	1	0	
Trunkfish	0	1	0	
Goatfish	0	1	0	
Land crabs	0	1	0	
Remora	0	2	0	
Swordfish	0	1	0	
Trunkfish	0	2	0	
Tuna	0	2	0	
Grunt	0	1	0	

APPENDIX IV: R Script

```
setwd("~/Desktop")
df1 <- read.csv("Survey_Results_Rounded.csv", na.strings = "N/A")

library(dplyr)
library(tidyr)
library (ggplot2)
library(devtools)
library(likert)
library(car)

## Regression, only "other" mentioned species
attach(df1)
detach(df1)
Age.mlr3 <- lm(Decline_other ~ Years_Ex)
summary(Age.mlr3)

ggplot(df1,aes(x=Years_Ex, y=Decline_other)) +
  geom_point() +
  stat_smooth(method="lm", col="red", se=FALSE) +page number
  ylab("Other Species Percieved as Declining") +
  xlab("Years Fishing or Diving") +
  ggtitle("Experience as a Predictor of Species Decline Perception") +
  annotate("text", x=50, y=5, label="R^2= 0.1", size=7) +
  theme(axis.title.x=element_text(size=22)) +
  theme(axis.title.y=element_text(size=22)) +
  theme(title=element_text(size=24)) +
  theme(axis.text = element_text(size=18))

# Regression - look at "other" and explicitly mentioned species as declining
attach(df1)
detach(df1)
Age.mlr3 <- lm(Decline_other_explicit ~ Years_Ex)
summary(Age.mlr3)

ggplot(df1,aes(x=Years_Ex, y=Decline_other_explicit)) +
  geom_point() +
  stat_smooth(method="lm", col="blue", se=FALSE) +
  ylab("Species Percieved as Declining") +
  xlab("Years Fishing or Diving") +
  ggtitle("Experience as a Predictor of Species Decline Perception") +
  annotate("text", x=50, y=3, label="R^2= 0.43", size=7) +
  theme(axis.title.x=element_text(size=22)) +
  theme(axis.title.y=element_text(size=22)) +
  theme(title=element_text(size=24)) +
  theme(axis.text = element_text(size=18))


# Boxplots by years of experience
boxplot(df1$Decline_other_explicit ~ df1$Years_Ex_Class_Num,
        ylab = "Species Perceived as Declining",
        xlab = "Experience Fishing or Diving",
        names=c("Low", "Medium", "High"))
```

```
# means of the age categories

df2 <- df1 %>% group_by(Years_Ex_Class) %>%
  summarize(mean(Decline_other_explicit))

#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~#
# looking at current abundance perception

dat <- read.csv("Current_Abundance.csv", na.strings = "N/A")

attach(dat)
detach(dat)

# perception of current abundance - with all species included, age is significant****
dat <- dat %>% na.omit(Current.Perception)

Age.mlr3 <- lm(Current.Perception ~ Age)
summary(Age.mlr3)

# Boxplots by age - shows nothing....
boxplot(dat$Current.Perception ~ dat$Age_Class_Num,
        ylab = "Perception of Abundance",
        xlab = "Age Class",
        names=c("Young", "Middle-Aged", "Old"))

dat1 <- dat %>% filter(Age_Class_Num=="1") %>%
  na.omit(Perception_Current)

# Looking at the top 5 species that are declining, years experience is more significant***

df3 <- read.csv("Current_Species_Perception.csv", na.strings = "N/A")
attach(df3)
detach(df3)
Age.mlr3 <- lm(Perception_Current ~ Years_Ex)
summary(Age.mlr3)

# look at means
df4 <- df3 %>% filter(Years_Ex_Class_Num=="3") %>%
  na.omit(Perception_Current)

# boxplot to look at differences in perception for key species**
boxplot(df3$Perception_Current ~ df3$Years_Ex_Class_Num,
        ylab = "Ranking of Species Abundance",
        xlab = "Experience Fishing or Diving",
        names=c("Low", "Medium", "High"))

# mean for low: 3.07, median= 3
# mean for middle: 2.92, median= 3
# mean for high: 2.52, median= 2

# plot
ggplot(df3,aes(x=Years_Ex, y=Perception_Current)) +
  geom_point() +
  stat_smooth(method="lm", col="blue", se=FALSE) +
  ylab("Ranking of Species Abundance") +
  xlab("Years Fishing or Diving") +
```

```
  ggtitle("Experience as a Predictor of Species Abundance Perception") +
  annotate("text", x=50, y=3.5, label="R^2= 0.05", size=7) +
  theme(axis.title.x=element_text(size=22)) +
  theme(axis.title.y=element_text(size=22)) +
  theme(title=element_text(size=24)) +
  theme(axis.text = element_text(size=18))


# species by species assessment...
df <- read.csv("Survey_Results.csv", na.strings = "N/A")
attach(df)
detach(df)

# Coral **** significant
Age.mlr3 <- lm(Coral_current ~ Years_Ex)
summary(Age.mlr3)

ggplot(df,aes(x=Years_Ex, y=Coral_current)) +
  geom_point() +
  stat_smooth(method="lm", col="blue", se=FALSE) +
  ylab("Ranking of Healthy Coral Abundance") +
  xlab("Years Fishing or Diving") +
  ggtitle("Experience as a Predictor of Coral Abundance Perception") +
  annotate("text", x=40, y=3, label="R^2= 0.15", size=7) +
  theme(axis.title.x=element_text(size=22)) +
  theme(axis.title.y=element_text(size=22)) +
  theme(title=element_text(size=24)) +
  theme(axis.text = element_text(size=18))

# Grouper *** significant
Age.mlr3 <- lm(Group_current ~ Years_Ex)
summary(Age.mlr3)

# plot
ggplot(df,aes(x=Years_Ex, y=Group_current)) +
  geom_point() +
  stat_smooth(method="lm", col="blue", se=FALSE) +
  ylab("Ranking of Grouper Abundance") +
  xlab("Years Fishing or Diving") +
  ggtitle("Experience as a Predictor of Grouper Abundance Perception") +
  annotate("text", x=50, y=4, label="R^2= 0.11", size=7) +
  theme(axis.title.x=element_text(size=22)) +
  theme(axis.title.y=element_text(size=22)) +
  theme(title=element_text(size=24)) +
  theme(axis.text = element_text(size=18))

# Lobster
Age.mlr3 <- lm(Lobster_current ~ Age)
summary(Age.mlr3)

# Conch
Age.mlr3 <- lm(conch_current ~ Age)
summary(Age.mlr3)

# Turtle
Age.mlr3 <- lm(Turtle_current ~ Age)
```

```
summary(Age.mlr3)

# Parrotfish
Age.mlr3 <- lm(Parrot_current ~ Years_Ex)
summary(Age.mlr3)

# Octopus
Age.mlr3 <- lm(Oct_current ~ Age)
summary(Age.mlr3)

# Shark
Age.mlr3 <- lm(Shark_current ~ Age)
summary(Age.mlr3)

# Snapper
Age.mlr3 <- lm(Snap_current ~ Age)
summary(Age.mlr3)

# Barracuda
Age.mlr3 <- lm(Barr_current ~ Years_Ex)
summary(Age.mlr3)

# look at differences between the islands for current abundance, 10 years ago, and 20 years ago abundance
# Significantly differnt perceptions of species abundance between Antigua and Barbuda
# currently, 10 and 20 years ago. *****
dat1 <- dat %>% filter(!Island=="Antigua")
attach(dat1)
detach(dat1)
t.test(Current.Perception ~ Island)

t.test(X10_Years ~ Island)

t.test(X20_Years ~ Island)

# Likert Plots
# Install devtools if not already installed
if(!require(devtools)) install.packages("devtools")

# Install development version of likert
devtools::install_github('jbryer/likert')

# Load libraries
library(ggplot2)
library(likert)
library(dplyr)
library(tidyr)

# Load data file
df1 <- read.csv("Survey_Results_Rounded.csv", na.strings = "N/A")

# Create vector object of values (in desired order)
lv.ord <- c("Absent","Rare","Common", "Abundant", "Superabundant")

# create lookup table (to link numbers with above values)
l1 <- data.frame(Value = seq(1,5), Code  = factor(lv.ord, levels=lv.ord) )
```

```
# Create long version of table. This enables us to:
#    1/ replace all numbers with values by joining tables
#    2/ fill missing values for all combinations of islands, user ID and questions
df2l <- df1 %>% filter(Island == "Montserrat"| Island == "Barbuda") %>%
  select(Turtle_current,Turt_ten, Turt_twen, Island) %>%
  mutate(ID = 1:n()) %>%      # User ID needed to spread the table later
  gather(key=Year, value=Value, -Island, -ID) %>%
  inner_join(l1, by="Value") %>%
  complete(ID, nesting(Year), fill = list(Code=NA) ) %>%
  select(-Value) %>%
  na.omit(Island) %>%
  data.frame()

# Now create a wide format for use with likert
df2w <- df2l %>% spread(key=Year, value=Code)

names(df2w) <- c(ID           = "ID",
              Island        = "Island",
              Turt_ten      = "Ten Years Ago",
              Turt_twen        = "Twenty Years Ago",
              Turtle_current = "Current")

library(extrafont)
font_import()
fonttable()


# And here you have it

lkt <- likert(df2w[,c(3:5)], grouping = df2w$Island, nlevels=5)

plot(lkt, ordered=TRUE, text.size=7, centered=FALSE, plot.percent.high=FALSE,
     plot.percent.low=FALSE, plot.percent.neutral=FALSE) +
  ggtitle("Perception of Turtle Abundance") +
  theme(axis.text.y=element_text(size=22, family="Times New Roman")) + guides(fill=guide_legend(""))
  +
  theme(strip.text=element_text(size=20)) + theme(plot.title=element_text(size=25, face="bold")) +
  theme(legend.text=element_text(size=16)) + theme(axis.title.x=element_text(size=18)) +
  theme(axis.text.x=element_text(size=20))

# continue for all other species
```