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Don't Rock the Boat: An Analysis of Boat Mitigation Prior to Hurricane Landfall

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DON'T ROCK THE BOAT: AN ANALYSIS OF BOAT MITIGATION PRIOR TO HURRICANE LANDFALL

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ABSTRACT

Tropical cyclones are one of the most destructive and costly natural hazards in the United States. Boat owners and marinas are uniquely impacted by these devastating events. Boats pose a substantial monetary loss to owners unable to evacuate or mitigate damage prior to hurricane landfall, and the time it takes to secure them may impact a household's ability to evacuate in a timely manner. The purpose of this study is to examine the physical and social variables that influence an owner's decision, as well as how this decision affects the household's ability to evacuate and the timing of that evacuation. This was done through quantitative and qualitative methods – specifically, surveying boat owners at a marina in Charleston and Georgetown and semi-structured interviews with Charleston marina and boatyard managers. The survey was a self-administered questionnaire designed by the researcher, and the interviews were based on questions derived from NOAA's manual, "Hurricane Preparedness: Guidelines for Marinas" (2002). Findings indicate that storm magnitude and landfall location significantly influence boat mitigation likelihood, and certain social variables like frequency of boat use and boat type also influence mitigation. Boat mitigation's impact on evacuation timing is quite varied but does not seem to have a substantial impact. Finally, the qualitative data collected from the interviews provided crucial information to help explain the survey data and showed that both expensive and lower-cost marinas have effective hurricane plans. This will be influential to emergency mangers and insurance companies – who are financially invested in the protection of boats and marinas.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Tropical cyclones are one of the most destructive and costly natural hazards in the United States. There have been 31 separate billion-dollar events between 1980 and 2011. These events accounted for 47.4% of the damages from billion-dollar events for this time period (Smith and Katz, 2013). Within the broad category of tropical cyclones, those that reach hurricane status tend to be the most destructive due to higher wind speeds, with 20% of hurricanes accounting for 90% of damages in the United States (Smith and Katz, 2013). On average, about five hurricanes every three years make landfall along the Atlantic or Gulf Coast of the United States, two being major hurricanes (≥ category 3) (Blake et al., 2011).

Due to its Atlantic coastal location, South Carolina often falls victim to these events. Between 1987 and 2016, tropical cyclones accounted for 73.2% of the natural hazard losses in the state (SHELDUS, 2017). Between these years, Hurricane Hugo (1989) stands out as one of the most destructive events. Hugo originated off the coast of Africa before strengthening into a category 5 storm as it headed northwest (NHC, 2017). It passed through St. Croix, the Leeward Islands, and Puerto Rico before making landfall near Charleston, SC as a category 4 event. Hurricane force winds reached far inland with sustained wind speeds of 104 mph and gusts of 120 mph. The winds were coupled by a devastating storm surge of 20ft in some coastal areas (NHC, 2017). The event resulted in $10 billion in adjusted crop and property losses, 420 injuries, and 13 fatalities in the state (SHELDUS, 2017).

Notably, of the 13 people who died during Hurricane Hugo, five died while attempting to bring their boats inland (Bourque et al., 2006). Protecting boats is a serious concern during tropical cyclone events for boat owners, marina operators and crew, and insurance companies. For safety reasons, timing is critical following the issuance of a Hurricane Watch, as boats need to be either evacuated or heavily secured in time for the boat owners and marina crew to fortify their homes and evacuate themselves and their families (NOAA, 2002). While the hurricane evacuation literature is very comprehensive – covering topics such as evacuation logistics, evacuation timing, a household's actual behavior compared to their predicted behavior given a hypothetical hurricane scenario, and the physical and social variables that affect a household's probability of evacuating, the research addressing boat and marina mitigation practices is extremely limited. In particular, the literature has not examined the physical and social variables that affect an owner's decision to take actions to mitigate their boat rather than abandoning it with the hope that their insurance will cover the losses. The research also does not address how boat and marina mitigation affects the ability of owners and marina crew to evacuate effectively. The purpose of this study is to fill the gap in the hurricane evacuation literature by looking specifically at the variables related to the decision of boat owners to mitigate and how this decision affects the evacuation behavior of the owners and their households.

1.1 RESEARCH QUESTIONS

This research aims to determine the variables affecting boat mitigative actions and the extent to which boat owners and marina operators are uniquely affected by hurricane events using surveying and interview methods between December 2018 and March of 2019, this study is shaped by three main research questions.

Q1: What are the physical and social variables that influence the decision to take the time to secure or move a boat prior to hurricane landfall?

Q2: How does owning a boat impact a household's decision to evacuate or affect the timing of the evacuation?

Q3: How well do marinas comply with NOAA's hurricane preparedness guidelines throughout the year and prior to landfall?

1.2 THESIS STRUCTURE

This thesis is divided into 6 chapters that each provide a different facet of information that aids in understanding the totality of the study. Chapter 2 provides a detailed literature review that covers the factors that influence evacuation response such as demographic variables, other social variables, and physical variables; evacuation logistics; special needs populations in the hazards context; and marina procedures and boat ownership. Chapter 3 addresses the materials used in the study; the survey development; the study areas – providing information about the marinas where surveying or interviews took place –; information about the data collection process – including the sampling methodology and a timeline; and it describes the statistical methods used to analyze the survey data. Chapter 4 expands on the previous chapter by including the results of the statistical analyses. Chapter 5 explains the qualitative process and results from the marina operator interviews, and it discusses these findings. Finally, Chapter 6 discusses the results from the quantitative analyses, while bringing in information gathered from the qualitative analysis to tie the results together. It also presents the conclusions to the research questions; introduces the limitations of the study; explains how the study's findings should influence the way the hazards community views boat owners and marina crew during hurricane events; and finally gives suggestions for further research on the topic.

CHAPTER 2: REVIEW OF THE RELEVANT LITERATURE

In 1900, Galveston, Texas experienced one the most fatal natural disaster events in United States history when a hurricane resulted in 6,000 deaths (Baker, 1991). The fatalities from this event are unmatched by any proceeding event due to better warning systems and evacuation procedures (Baker, 1991; Bourque et al., 2006). In fact, no storms occurred between 1959 and Hurricane Katrina that resulted in more than 1,000 fatalities, and while storm surge used to be the major cause of hurricane deaths, it now only causes 1% of the fatalities since people are out of the storm surge zones (Bourque et al., 2006). Despite the life-threatening risk, some people still choose not to evacuate even under a mandatory evacuation order (Baker, 1991). According to Baker (1991), "Evacuation rates vary from place to place in the same hurricane and from storm to storm in the same place" (pg. 291). Extensive research has sought to discover an explanation for the variations in evacuation rates and has revealed a complex intertwining system of physical and social variables that affect evacuation decisions at the household level. Throughout the literature, certain variables emerge as predictors of a household's evacuation response including: specific demographic variables, whether or not the household received an evacuation order, hurricane characteristics, and past experience.

2.1 FACTORS IMPACTING EVACUATION DECISIONS

Demographic variables. Certain demographic variables have been found to influence evacuation response such as having children, gender, owning pets, and income.

Households with children and women are more likely to evacuate than their counterparts (Reininger et al., 2013; Bateman and Edwards, 2002). In contrast, households with pets are much less likely to evacuate (Heath et al., 2001; Edmonds and Cutter, 2008), and the impact of income and education is inconsistent with some studies showing these variables to be positively correlated with evacuation while others show them to be either insignificant or even negatively correlated (Hasan et al., 2011; Smith and McCarty, 2009; Hunt et al., 2012; Bowser, 2013.). These variables are explained in more detail below.

Having children in the household greatly increases the likelihood of evacuation. In fact, some studies have found it to be the largest contributor to complying with an evacuation order – increasing the chance of evacuation by 50% (Hunt et al., 2012). The presence of children augments the perceived risk of the situation because they are a vulnerable population, and parents will take less risks with their safety (Fischer III et al., 1995). Using a binary logistic regression model, Sarwar et al. (2016) determined that having two or more children in the household further increases this phenomenon – since an increase in children equates to a further increase in perceived risk as more children would be subjected to potential harm. In addition, households with children old enough to understand the situation may encourage the household to evacuate out of fear (Drabek and Boggs, 1968). It is important to note that families typically react as a unit during disaster situations (Quarantelli, 1985), and family members are unlikely to leave without the entirety of their family (Dow and Cutter, 2002). This means that children increase the likelihood of evacuation for the whole family, and parents are unlikely to split with one parent evacuating and the other staying behind. However, in a traditional nuclear family, when this phenomenon does occur, the mother usually evacuates with the children, and the father stays behind to protect the property (Drabeck, 1969).

The experiences of women during disaster situations have historically been vastly different than those of men (Bolin et al., 1998), and women are more likely to evacuate from hurricanes and other disasters (Bateman and Edwards, 2002). Understanding this gender discrepancy in evacuation rates is complex and is the result of various intertwining factors including: caregiving roles, a greater perception of risk, and thorough evacuation planning. Since women have been socially constructed to be caregivers, they are more likely to be responsible for taking care of vulnerable populations like small children, the elderly, and special needs individuals. In order to protect the vulnerable groups under their care, women have an increased likelihood of evacuating (Bateman and Edwards, 2002). In addition, women tend to have a more acute perception of risk than men – particularly White men (Slovic, 1987) – making them believe their residence is more at risk, pushing them to evacuate (Bateman and Edwards, 2002). Associated with this factor, women are more likely to have an evacuation plan, so in the event of a hurricane, they are more prepared to evacuate (Bateman and Edwards, 2002). However, it is important to note that some men are caregivers and have a keen perception of risk as well. In these cases, the men are significantly more likely than women to evacuate – leading to the distinction between intention and ability to follow through with that intention (Bateman and Edwards, 2002). This distinction stems from the "gender-based vulnerability" that has been created due to the "sociocultural systems that privilege men" (Bolin et al., 1998 p.41). Men typically have higher incomes, greater access to vehicles, and more independence than women, which increases their ability to evacuate if they intend to do so (Bateman and Edwards, 2002).

Owning a pet has consistently been shown to increase evacuation failure – which is a term used to describe when someone chooses not to evacuate – as people do not want to leave their pets behind and taking them inflates the difficulty of the evacuation process (Heath et al., 2001). In fact, pets are associated with 20% – 30% of all evacuation failures (Heath et al., 2015). The logistics involved in evacuating pets, such as transporting and sheltering them, are major obstacles to evacuation, and these obstacles are augmented for people with multiple pets. Moreover, for childless households, evacuation failure nearly doubles for each additional dog or cat (Heath et al., 2001). Hurricane Katrina was particularly devasting for pets, as many people were forced to abandon them – resulting in between 40,000 and 50,000 lost pets (Hunt et al., 2012). Following this event, President Bush signed the Pet Evacuation and Transportation Standards (PETS) Act, which allocated funds to make pet friendly emergency shelters and evacuation plans for service animals. However, the effectiveness of this act has been questioned, as an informal study, conducted shortly after the Act was passed, revealed that 62% of respondents still reported that they would not evacuate because of their pets (Hunt et al., 2012). In contrast, a study following Hurricane Irene showed no significant differences in evacuation rates among pet and non-pet owners; however, of the pet owners who did not evacuate, most cited pet related reasons for their decision not to evacuate (Hunt et al., 2012). This illustrates that although the PETS Act has decreased the effect of pets on evacuation failure, they are still a strong consideration in making evacuation decisions – indicating that efforts still need to be taken to further reduce this effect.

Notably, local emergency managers need to educate the population about the available pet friendly shelters and provide disposal cat carriers and dog leashes to ease the burden of pet evacuation (Heath et al., 2015). In addition, Edmonds and Cutter (2008) presented a GIS model that estimates the number of pet owners who need assistance in an evacuation area. The model also shows the spatial distribution of these owners, so pet shelters can be strategically placed to maximize their utility (Edmonds and Cutter, 2008). These efforts are crucial to lessening the effects of pet ownership on evacuation failures – saving the lives of both humans and pets.

The impact of income on evacuation decisions varies from study to study. For instance, in a behavioral evacuation mixed logit model, Hasan et al. (2011) found that higher income households and households with members holding a post graduate degree were positively correlated with evacuation. However, since more educated households usually are also higher income households, the researchers were concerned about multicollinearity – leading them to rerun the model, excluding one of the variables. This regression was not significantly different from the model containing both variables, indicating that multicollinearity was not an issue and both variables did increase evacuation (Hasan et al., 2011). While it is logical that higher income households would be associated with higher evacuation rates since they have the financial capability to be temporarily displaced for the duration of the event and would likely have easier access to vehicles, other studies show that income and education are insignificant (Smith and McCarty, 2009; Bateman and Edwards, 2000). Heath et al. (2001) even found that higher educated households had an increased risk of evacuation failure. These inconsistencies are possibly due to the income and education variables being conflated with household type/location. More expensive houses are usually located near the coast (Baker, 1991) – forcing the higher income population to evacuate due to risk from storm surge; however, residents of mobile homes – which are typically part of the very low income population – have an extremely high evacuation rate due to the danger of being in an unstable mobile home during strong wind conditions (Whitehead et al., 2000). This means that income is a poor predictor of evacuation behavior and that household type and household location are far better predictors of response.

Non-demographic social variables. Past experience is one of the strongest predictors of evacuation response; however, whether it increases or decreases evacuation likelihood depends on the intensity and recency of the past experience. In general, the odds of evacuating are higher for households who have experienced a major hurricane in the past compared to those who have not – especially if the experience occurred recently (Baker, 1991). For example, post Hurricane Floyd, Dow and Cutter (2000) looked at the evacuation decisions of coastal South Carolinians with a particular interest in the Horry County residents who had experienced six hurricanes over a four-year period – who they deemed "hurricane savvy." Results show that 83% of the "hurricane savvy" residents (who were surveyed through the mail) evacuated compared to the statewide average of only 64%. Additionally, 17% of all coastal respondents cited past experience as their major reason for evacuating (Dow and Cutter, 2000). In contrast, a household that has not experienced a direct hit from a hurricane but has been on the outskirts of one or weathered a direct hit from a lesser storm may be less likely to evacuate because their previous experience gave them the incorrect idea that hurricanes are not extensively destructive or dangerous (Baker, 1991). This "false experience" distorts the household's view and makes them believe that they have experienced a major hurricane event and do not need to evacuate (Baker, 1991, p.302). According to Windham et al. (1997), the "false experience" leads to the experience adjustment paradox – which is the notion that new coastal residents more likely to evacuate than those who have lived on the coast for years since the new residents would not have had a "false experience" to alter their perception of a hurricane's destructive capabilities (Baker, 1991, p.302). In contrast others believe that the longer a household resides on the coast, the more aware they will be of the destructive nature of hurricanes – resulting in an increased chance of evacuating when compared to newer residents (Baker, 1991). However, research reveals poor support for either theory (Baker, 1991), which makes length of residence an unreliable predictor of evacuation response. Overall, regardless of how long a household has resided along the coast, their likelihood of evacuating will be affected by their most recent past hurricane experience.

Receiving an evacuation order and living in a high-risk area (coastal household with an elevation less than 10 feet above mean sea level) are the two biggest contributors to evacuation, and the two factors are highly linked since the populations who live in these high-risk areas are the people who are ordered to evacuate (Baker, 1991). Following Hurricane Frederick, researchers found that 84% of people who received an evacuation order evacuated compared to only 20% of people who did not receive an order (Baker, 1991). Even more shocking was the discrepancy in evacuation rates following Hurricane David with an 88% evacuation rate for people who received an order versus a minuscule 8% for those who did not (Baker, 1991). Even though all evacuation orders increase response, mandatory evacuations are much more effective than voluntary ones (Whitehead et al., 2000). During hurricane Bonnie, people were three times more likely to evacuate if they received a voluntary evacuation warning; while, they were eight times more likely to evacuate when given a mandatory evacuation order (Whitehead et al., 2000). This is due to the term “voluntary” not promoting the necessary level of risk, which is why mandatory orders need to be issued to generate a strong response.

Physical variables. Unsurprisingly, tropical storm events that are ranked higher on the Saffir-Simpson Wind Scale result in a greater evacuation response because higher magnitude storms elicit a greater perception of risk (Sarwar et al., 2016). A behavioral study by Cutter et al. (2011) found that 76.6% of South Carolinian respondents reported their intention to evacuate for a major hurricane, while only 21% reported their intention to evacuate for a weaker storm. This factor can be problematic as the Saffir-Simpson metric only ranks storms by their wind speeds – not the storm surge or accompanying rainfall, so people may choose not to evacuate but still be faced with life threatening conditions. For example, Hurricane Ike made landfall in Galveston, TX as a category 2 storm; however, the category 2 winds were coupled with the equivalent of a category 5 storm surge (Huang et al., 2012). The storm caused 112 confirmed fatalities, another 300 missing victims in the United States, and $31.7 billion in losses (Huang et al., 2012). When residents were interviewed after the storm, respondents claimed that “even though Ike was officially a category 2 storm, they thought it was higher based on the damage they saw” and that “Ike’s wind speeds or its rating on the Saffir Simpson scale did not accurately reflect the damage it caused” (Morss and Hayden, 2010, p.185). This shows that wind speeds can be a flawed method for making an evacuation decision as a storm's magnitude – or the strength of the storm (Cutter, 2005) – is not always congruent with its intensity – or the "subjective human experience of it" (Cutter, 2005, p.199). Due to this realization, the National Hurricane Center (NHC) began issuing storm surge warnings in 2017 (NOAA, 2017).

Interestingly, the correlation between the storm's wind speed and evacuation rate is stronger between the storm's maximum wind speed rather than its wind speed at landfall (Dow and Cutter, 2000). For instance, when Hurricane Floyd made landfall as a category 2 storm, there was an 84% evacuation rate for Horry County, SC – which is much higher than the response rate for past category 2 storms. This response stems from Floyd having almost been a category 5 storm while it passed through the Bahamas, with a maximum wind speed of 155 mph (Dow and Cutter, 2000). Table 2.1 illustrates the relationship between the maximum wind speeds of the six hurricanes, including Floyd, that affected Horry County between 1996 and 2000 and the evacuation rate in the county for each event – further showing this phenomenon.

Table 2.1: Horry County Evacuation Survey Responses

Horry County longitudinal survey hurricane evacuation responses

Strength at landfall	Dennis	Irene	Bertha	Floyd	Bonnie	Fran
	Tropical Storm 8–9/99	Tropical Storm 10/99	Category 2 Hurricane 7/96	Category 2 Hurricane 9/99	Category 2/3 Hurricane 8/9	Category 3 Hurricane 8–9/96
Max. wind speed (mph)	104	109	115	155	115	121
Evacuated	17%	7%	38%	84%	44%	46%
Did not evacuate	82%	93%	62%	16%	56%	54%

Source: Dow and Cutter 2000 pg. 149

In addition to wind speed, location of landfall influences household evacuation decisions, as people who believe their household will receive a more direct hit from the storm have an increased likelihood of evacuating (Dow and Cutter, 2000). Hurricane tracks complicate this variable, as they are often misinterpreted and can change rapidly – leading to both evacuation failures and unnecessary evacuations (Bowser and Cutter 2015). In a meta-analysis of 49 hurricane evacuation studies obtained from Google Scholar, Huang et al. (2016) found that location at landfall was a consistent and significant factor in evacuation decision making; however, by averaging the correlation coefficients from the 49 studies, it was determined that the variable only makes a moderate impact.

2.2 EVACUATION LOGISTICS

In addition to affecting the decision to evacuate, past experience also plays a role in certain evacuation logistics, such as evacuation timing and route planning. In regard to evacuation timing, there are many steps that must be completed prior to a household evacuation and predicting the amount of time each step will take is often difficult. These steps include the time it takes to prepare to leave work, travel from work to home, gather household members, pack travel items, protect property, and securing the home to leave (Kang et al., 2007). People's ability to accurately predict how long it will take to complete each step varies significantly between steps. For instance, people are poor predictors of how long it will take to protect their house prior to evacuating; however, they can accurately estimate the amount of time it would take to pack travel items and secure the home (Kang et al., 2007). This discrepancy stems from people being able to compare packing and securing their home to going on a family vacation; whereas, people who have not experienced a hurricane in the past would not have a basis for estimating the amount of time it would take to fortify their homes with sandbags, shutters, etc.

(Kang et al., 2007). This illustrates that people use their past experiences to estimate how long it will take to evacuate.

In terms of evacuation routes, a study by Wu et al. (2012) suggests most evacuees rely on their personal knowledge to pick the most time efficient, safe, and convenient route based on their past driving experiences instead of listening to recommendations from officials or using a navigation system. These findings are based on a survey of Hurricane Katrina and Hurricane Rita evacuees that was conducted in 2006 by the Texas A&M University Hazard Reduction & Recovery Center (Wu et al., 2012). The study revealed that respondents who chose to rely on their past experience were less likely than other groups to accept outside route information to aid in their decision making, and demographically, White respondents were less likely than other groups to use any information in their decision making other than personal experience. Surprisingly, those who relied on past experience to choose their evacuation routes also reported shorter travel times than the other respondents – with those relying on official channels actually reporting the longest travel times (Wu et al., 2012). The overall reliance on past experience is leading to the routinization of evacuation routes and "suggests that repeated hurricane evacuations within a given area can begin to produce the development of the equilibrium traffic conditions associated with routine traffic patterns" (pg. 458). This is not to say that people will evacuate using the exact same route for every tropical storm event, but rather that people learn from each evacuation and use their past experience as the basis for choosing a route while still adapting to each specific storm. It is also important to note that these findings are the result of an individual study, so they should be viewed conservatively since they have not been verified by additional research.

Where people stay during the duration of the displacement is another heavily examined topic. In general people either stay with friends/family, go to a motel/hotel, or stay at a shelter – with friends/family being the most common lodging type (Smith and McCarty, 2009). For instance, in the Hurricane Bonnie evacuation, 70% of respondents reported staying with friends/family (Whitehead et al., 2000) and later during the 2004 hurricane season, around 60% of Floridian evacuees stayed in this type of lodging (Smith and McCarty, 2009). Staying in motels/hotels is the second most common lodging type and was the choice for almost 16% of the Hurricane Bonnie evacuees (Whitehead et al., 2000). Choice of lodging is related to certain demographic variables including income, gender, and length of residence (Whitehead et al., 2000; Smith and McCarty, 2009). Higher income populations are more likely to choose to stay in a motel/hotel, and every income increase of $10,000 corresponds with a 2% increase in the likelihood of choosing to stay in a motel/hotel. Supporting this result is the finding that mobile home residents – who are a lower income population – are twice as unlikely than other groups to stay in a motel/hotel (Whitehead et al., 2000). These results are unsurprising since staying at a motel/hotel for multiple days can be expensive. Similarly, people who choose to stay in shelters are typically lower income populations, and White and more educated populations are unlikely to choose to stay in them (Whitehead et al., 2000). Women and pet owners are also a little more than one and a half times less likely to choose to stay in a shelter (Whitehead et al., 2000). As for choosing to stay with friends/family, people who have lived in an area for a longer period of time are more likely to choose this form of lodging (Smith and McCarty, 2009).

2.3 SPECIAL NEEDS POPULATIONS

The evacuation logistics, decisions, and experiences of special needs populations vastly deviate from those of the total population. In the hazards context, the special needs population is a broadly defined subset of people that includes groups that are typically thought of as special needs – such as individuals with disabilities – and other groups that are impacted differently than the rest of the population. These additional groups include, the elderly, tourists, college students, and small business owners, as each of these groups have evacuation impediments that do not affect the rest of the population.

The elderly. The elderly population is considered a vulnerable subgroup of the population (Bowser, 2013); however, the literature is inconsistent about whether age is associated with evacuation response or evacuation failure (Bowser and Cutter, 2015). Much of these inconsistencies are likely due to the elderly being an ill-defined category. As noted in Bowser (2013), "[W]hat it means to be elderly has changed dramatically. The distance between the ends of an individual's working life and their natural life has expanded, creating a considerably larger and more diverse group than had been initially considered by government planning in all aspects" (pg. 7). The experiences of the "young-old," people between the ages of 65 and 74, will likely be quite different from individuals who are 75 and older. For instance, Bowser (2013) found that having an evacuation plan did not affect evacuation likelihood for those ages 75 and older, but it was still a strong predictor for the "young-old" population. This is likely because the 75 and older portion of the elderly needs to rely on another source to evacuate, such as their family or a caregiver; while, the "young-old" still have the capability to take charge of their evacuation behavior (Bowser, 2013). It is also important to note that the frail elderly have an increased chance of evacuation failure since evacuation lodging and transportation may not appropriately accommodate their needs (Bowser and Cutter, 2015). This can also lead to an elderly individual's caregiver choosing to stay behind to protect them (Bowser and Cutter, 2015) – placing both the elderly individual and the caregiver at risk from the storm. The elderly population is continuously growing, which makes understanding the evacuation experiences of this group particularly important and an area where further research is necessary.

Tourists. According to Cahyanto and Pennington-Gray (2015), "Tourists are an at-risk group during a crisis because of insufficient knowledge to decipher communication messages and are typically in unfamiliar places and lack support systems accessible to them at home" (pg. 329). Examining the evacuation decisions and experiences of tourists is a relatively new phenomenon – with most of the past literature focusing on the impacts of a disaster on the tourism industry (Drabeck, 1995). In response to this gap in the literature, a group of researchers administered a series of surveys to Florida tourists between 2009 and 2011 (Matyas et al., 2011; Cahyanto et al., 2014, Cahyanto and Pennington-Gray, 2015). Each survey used a variation of the same questionnaire that was altered to target the different research objectives of each study. These studies produced a great deal of valuable information about the physical and social variables that influence a tourist's decision to evacuate (Matyas et al., 2011; Cahyanto et al., 2014) and the information sources most used by tourists to seek advice and evacuation instructions (Cahyanto and Pennington-Gray, 2015).

The factors affecting tourists' evacuation decisions mostly align with the factors that influence the evacuation decisions of residents. For instance, tourists were more likely to evacuate from larger magnitude storms (Matyas et al., 2011); tourists with hurricane experience were less likely to evacuate (Matyas et al., 2011); and female and higher income tourists were more likely to evacuate than their counterparts (Cahyanto et al., 2014). The study also revealed that tourists with children perceived a significantly higher level of risk, but their likelihood of evacuation did not significantly increase (Matyas et al., 2011). Having a personal vehicle, rather than relying on a rental vehicle or air travel, was associated with increased evacuation (Matyas et al., 2011; Cahyanto et al., 2014). This finding agrees with previous studies that found evacuees mostly rely on their personal vehicles, rather than carpooling or public transportation, and that not having a personal vehicle is a strong predictor of evacuation failure (Bowser and Cutter, 2015). Finally, international tourists were much more likely to evacuate than domestic tourists, likely since they would feel the least certain of their situation – resulting in a higher perceived risk (Cahyanto et al., 2014).

International tourists also had vastly different opinions about information sources (Cahyanto and Pennington-Gray, 2015). They considered newspapers to be a more credible source of information than their domestic counterparts and were the most likely to use social media for their information (Cahyanto and Pennington-Gray, 2015); however, the use of social media as a credible news outlet is continuously growing in the United States, so this finding may no longer hold true. In regards to domestic tourists, television was the most popular information source, with both men and women ranking the Weather Channel as the most credible source (Cahyanto and Pennington-Gray, 2015). However, although this was seen as the most credible source, using it as the primary source of evacuation information did not affect evacuation decisions. Rather, evacuation decisions were influenced by local authorities, the tourism office, and hotel staff – with the latter source decreasing evacuation and the former two sources increasing evacuation (Cahyanto and Pennington-Gray, 2015).

Overall, tourists are in a unique position during a disaster since they are in an unfamiliar environment without a support system or knowledge of evacuation routes and procedures. Many tourists do not speak the language of the place they are visiting – putting them in an even worse position, as it is difficult to understand complex evacuation instructions with a language barrier. Tourists also may not have access to a personal vehicle – further decreasing their capability of evacuating. Although tourists have a variety of information sources, ranging from the Weather Channel to hotel staff, their lack of hurricane knowledge may hinder them from accurately deciphering the information and making an informed decision.

College students. College students face many of the same challenges as the tourist population. For instance, they often are residing in an unfamiliar place, are away from their families, lack extensive hurricane knowledge, and in the case of international students, face language and cultural barriers (Van Willigen et al., 2005). Likewise, many college students do not keep cars on campus – forcing them to rely on public transportation (Bowser and Cutter, 2015), which as explained in the previous section, is a predictor of evacuation failure. Diverging from the tourist similarities, college students are known to live in low-rent areas – which tend to be more hazard prone –, and students usually do not have much disposal income – making evacuation a financial burden (Van Willigen et al. 2005).

The increased evacuation difficulty that arises from these factors is augmented by a lack of preparation on the part of colleges and universities. For example, during the Hurricane Katrina evacuation, 50,000 students were forced to evacuate, and post-evacuation studies showed that 60% of surveyed students received no assistance from their educational institutions (Auletta, 2012). One student reported, “The evacuation process is one bad memory as a whole and was incredibly frustrating for most students on campus. More organization among the campus administrators and communication with students would have made this a less negative experience” (Ladd et al., 2007, pg. 55). Since students are away from their social networks, they really need the support of their college or university during a crisis; however, students are not receiving the support they need – making evacuation even harder.

Small business owners. In the face of crisis, small business owners have added concerns and preparations that affect their evacuation decisions and behavior (Morss and Hayden, 2010). Not only do small business owners have to secure their homes but also their livelihoods. This is a strong deterrence of evacuation because in addition to storm damage, many people fear “looting” of their homes and stores during disasters – even though rampant looting is just a myth perpetuated by the media (Tierney et al., 2006). In order to protect their businesses, owners often decide not to evacuate (Morss and Hayden, 2010) – putting their lives and the lives of first responders at risk.

In addition to being more likely to not evacuate, business owners have many factors to contend with post-storm that do not affect the rest of the population (Piotrowski et al., 1997). These owners need to get their businesses – their source of income – up and running in chaotic circumstances. The businesses often “lack electrical power, telephone service, transportation access, and employees" (Piotrowski et al., 1997, pg. 1390). Most of these factors can be worked around through generators, cell phones, and other adaptations; however, the lack of employees cannot be avoided, as they need time to get their households back in order and focus on the well-being of their families. Another major problem is an inadequate number of customers (Piotrowski et al., 1997). Like the employees, customers need time to recover from the event, and they will not be patronizing shops and restaurants until they can get their affairs back in order. The lack of customers can be a prolonged problem if the business mostly caters to tourists, as the tourism industry is heavily affected post-disaster. For example, in Nepal – where 8.9% of its 2014 GDP relied on tourism – 90% of international trips were cancelled immediately following the 2015 earthquake, and throughout the next year, there was a 40% decrease in tourist activity (Hajibaba et al., 2017). This can be detrimental to small business owners since they cannot generate sufficient revenue without customers, and they are already financially strained from having to rebuild during the recovery phase of the disaster cycle.

Boat owners. Boats pose a substantial monetary loss to owners unable to mitigate damage prior to hurricane landfall – leading many to take extensive actions to either evacuate or secure their boat. These actions take a considerable amount of time, which may contribute to evacuation delays. Currently, there is no research addressing this question other than one sentence in Baker (1991), which states, "No other factors which have been tested have had much success [in predicting evacuation behavior]. Boat ownership, church attendance, operating home weather instruments, and total number of emergency preparations taken are some of the variables tested" (pg. 308). Although this statement does not support the idea that boat ownership affects evacuation behavior, no research was cited after the statement, and since so many demographic variables affect evacuation inconsistently, it is important to dive deeper into this topic – especially since the article was looking at evacuation rates rather than evacuation timing. However, in the case of owners who use their boats for economic purposes, the likelihood of evacuation failure may be increased, since, like business owners, they may risk their lives to protect their livelihoods (Bourque et al., 2006). Ultimately, boat owners are more directly impacted by hurricanes, and they have experiences strictly unique to them – giving argument that they are a special needs population in the hurricane context.

2.4 MARINA PROCEDURES AND BOAT OWNERSHIP

Despite the comprehensiveness of the evacuation literature, research has not looked at how mitigating boats and marinas affects evacuation behavior. In fact, the mitigative actions themselves have not been well researched. For example, if FEMA's website is searched for "marina mitigation," an extensive list of titles appears; however, each title is simply a link to a brief paragraph about funding being allocated to rebuild a marina, and there is nothing about the actual mitigative actions or procedures (https://www.fema.gov/). While there are some pieces of grey literature about these actions, NOAA (2002) is the only academic source that comprehensively examines the guidelines and procedures necessary for a marina to successfully prepare for a hurricane. The manual goes through every stage of preparation, beginning with mitigating impacts by designing the marina to withstand hurricane winds and storm surge. The manual stresses the importance of educating boat owners on the preparation procedures and having practice sessions to make owners comfortable with evacuating their boat to a “safe haven” and anchoring it in the safe location. The manual also stresses the importance of working quickly and starting preparations 72 hours in advance of landfall, so owners and employees can have time to prepare their homes for evacuation. Insurance and liability claims are also covered in the manual but not in great detail (NOAA, 2002).

Mercante (1993) explains the intricacies of admiralty law, insurance claims, and the instances in which a boat owner or marina would be held liable for the damage to boats or other property. Mercante focuses on the “act of God” defense and the “force majeure” or “inevitable accident” defense. The “act of God” defense is invoked when “[a]ny accident [is] due directly and exclusively to natural causes without human intervention, which by no amount of foresight, pains, or care, reasonably to have been expected could have been prevented” (pg. 1055). Hurricanes are strong enough storms to be included in this category; however, in the case of damage to a third party – say if a boat comes loose due to high winds and collides with another boat – one must establish lack of fault unless the “act of God” is considered catastrophic enough that the damage would have happened even if the necessary precautions would have been taken. If the event is not deemed catastrophic, the “inevitable accident” defense must be invoked. This defense means that the boat owner took every necessary precaution to secure and protect the vessel, but the damage still occurred despite these efforts.

Mercante (1993) provides examples of court cases in which the courts deemed the boat owners liable due to their lack of preparation, while other cases ruled in favor of the owners due to their efforts. It should also be noted that these court cases seem rather subjective because the court often determined the decision based on the owner’s marine experience and how much that owner would be expected to know about boat preparation given their level of experience. Other possible liabilities include wreck removal and pollution charges due to leaking oil from wrecked vessels.

Finally, the article discusses when a marina would be held liable compared to when the boat owner would be liable, and it explains the concept of the “safe haven hurricane clause” (Mercante, 1993) – which is included in some marina contracts. This states that when a hurricane warning is issued, owners must move their boats to a “safe haven,” or they will be held liable for all damages to boats, docks, etc. (Mercante, 1993). However, NOAA (2002) discourages marinas from having mandatory wet slip evacuations due to safety concerns – as it would be dangerous and unethical to force an owner to evacuate their boat if wind conditions were already unfavorable.

2.5 CHAPTER CONCLUSION

As can be ascertained from the length and breadth of topics covered in the previous section, there is a vast array of research relevant to the thesis topic; however, most is not overtly relevant since research covering boat and marina mitigation or the effect this has on evacuation is poorly represented in the literature. However, even though there is a lack of previous research specifically on the topic, all the research presented in the previous section contributes to the background for the thesis. For instance, the social and physical variables affecting evacuation are extremely important to formalizing the question of how boat ownership interacts with these previously well researched variables to affect evacuation response. Evacuation logistics are important because they broaden the concept of evacuation behavior from simply “evacuate or fail to evacuate” to evacuation timing and the differences in how people evacuate in terms of lodging, transportation, and route. Timing is key to the thesis topic, as owning a boat may not increase evacuation failure, but it may increase evacuation delays, as owners have the added burden of securing their boat prior to evacuation. Finally, understanding the term special needs population in the hazards context is critical to reaching the conclusion that the unique experiences of boat owners may make them an affluent special needs population during hurricanes.

CHAPTER 3: METHODOLOGY

This study used a mixed methods design that included quantitative and qualitative data and analysis. The materials for this study included a brief questionnaire created by the researcher and an outline of questions for semi-structured interviews that were conducted with marina and boatyard operators. A variety of parametric and nonparametric statistics were used to examine the quantitative data. The survey design, study areas, data collection, and statistical analyses will be explained throughout this chapter.

3.1 SURVEY DESIGN

The questionnaire was designed for the surveying of boat owners with the goal of understanding the variables that significantly influence the decision to mitigate boat damage prior to hurricane landfall and examining boat mitigation's impact on evacuation timing (Appendix A). The questionnaire includes a series of fixed categoric responses including binary (yes/no), ordinal, and nominal questions. It also has two open ended questions, and a series of Likert scale questions that are mainly used for the hypothetical scenarios. Questions 1-10 address general boating questions like how long a participant has owned a boat (Q1), boat size (Q5), how the boat is used (Q8), etc. Questions 11-18 begin to address boat mitigation – with question 11 directly asking how likely the participant is to take actions to secure their boat. Questions 19-30 ask whether the participant believes they would take mitigative actions given different hypothetical hurricane scenarios that vary in hurricane wind speeds and landfall location – with the purpose of discovering the hurricane characteristics that influence mitigation decisions. Questions 31-41 ask questions about the boat owners' past behavior and whether they took actions to mitigate boat damage in the past (Q33). The section includes questions about what specific actions the participants took to secure their boats (Q34), how many hours before landfall they began these actions (Q35), and how these actions affected their evacuation (Q37-Q41). The next five questions are general demographic questions that were used to examine the demographic variables that affect the decision to mitigate. The demographic variables, other social variables related to boat ownership, and storm characteristic variables from the hypothetical scenario section, were analyzed for their significance in impacting the decision to take mitigative actions – covering the first research objective. The final question asks, "Is there anything else you would like me to know about your experiences as a boat owner during tropical cyclone events?" This question is designed to allow owners to share specific experiences and information that may be important but are not covered through the structured questions.

The survey was developed during the spring and summer of 2018, and it was pre-tested at the Columbia Sailing Club on July 26, 2018 The pre-test was crucial to identifying problems with the survey's flow and questions. The original survey was similar to the final version (Appendix A); however, a couple major changes were made. First, the original design included three different landfall locations for the hypothetical scenarios: Charleston, Myrtle Beach, and the Outer Banks. The pre-test showed that the last location was too far north for anyone to really consider mitigating, and it added too much time to the survey – leading to this section being removed from the final design.

The original survey also only offered answer choices for one boat, which caused confusion, as most of the pre-tested participants had multiple boats. To remedy this issue, the final survey offers answer choices for three boats – allowing participants to answer each boating question for up to three of their boats. Finally, the other major difference between the two surveys was not in the design itself but rather the administration. The pre-tested survey was administered by the researcher. This proved problematic for the Likert scale questions because participants tended to answer on the extremes (1 or 7); however, the few participants in the pre-test who filled out the questionnaire themselves were better about answering the Likert scale questions in the appropriate manner. Based on this observation, the researcher tried to have the participants in the final study self-administer the survey. Some of the participants still requested to have the survey administered by the researcher because they were working on their boat; however, the majority took the survey themselves.

3.2 INTERVIEW MATERIALS

To explore the final research objective, the researcher conducted semi-structured interviews with the marina operators. A basic outline for the topics covered can be found in Appendix B. The topics included general marina procedures during tropical storm events – specifically focusing on the timing of preparations (Q2), owner responsibility (Q3), crew safety (Q7), etc. These interviews also addressed the mitigative actions that are taken during the rest of the season such as anchoring training (Q6), hurricane drills (Q5), and owner preparedness surveying (Q7). The questions asked were framed around the guidelines and procedures suggested in the "Hurricane Preparedness: Guidelines for Marinas" manual (NOAA, 2002) in order to assess how closely the marina operators are following these guidelines and thus assess how effectively they are preparing the marinas.

3.3 STUDY AREAS

Boat owner surveys. The surveys for this study were collected at the Cooper River Marina in Charleston, SC and the Belle Isle Yacht Club and Marina in Georgetown, SC. The Cooper River Marina is a public marina run by the Charleston County Parks Department (“Cooper River Marina,” 2019), and it can be seen in the aerial photo in figure 3.1. The marina was originally founded as a part of the Charleston Naval Base’s recreational facilities, but in 1995 it was acquired by the Charleston County Parks and Recreation Commission and turned into a public marina (“Cooper River Marina Project,” 2019). The 25-acre park site is conveniently located 15 minutes from downtown Charleston and 2 miles north of the Arthur Ravenel, Jr. Bridge (“Cooper River Marina Project,” 2019 and “Cooper River Marina,” 2019). The marina currently offers deep

Figure 3.1: Cooper River Marina Overhead View ("Slip Fees," 2019)

water slips to both long term and transient boaters, and it has an on land boat storage area for trailered boats ("Cooper River Marina Project," 2019). Long term slips range from 20 ft to 40 ft, while the transient dock can accommodate boats up to 150 feet ("Slip Fees," 2019). The marina offers daily, weekly, monthly, and yearly leases at affordable rates ("Slip Fees," 2019).

Belle Isle Yacht Club and Marina is located just south of Georgetown, SC along the Winyah Bay ("Welcome to Belle Isle Yacht Club," 2019). Unlike Cooper River, which, as previously mentioned, is a public marina, Belle Isle is a private, gated community featuring a yacht club, marina, condominiums, pools, and tennis courts ("Welcome to Belle Isle Yacht Club," 2019). The community aspect of Belle Isle made it an ideal surveying location because almost every resident is a boat owner – providing a large population for sampling.

The marina (which can be seen in fig. 3.2) features 80 slips, a ship store, and utilities, with the slips ranging from 30-50 feet ("Belle Isle Marina Amenities," 2019).

Figure 3.2: Belle Isle Marina ("Belle Isle Mariana Amenities," 2019)

Notably, the marina was once considered premier due to it being the "closest full service marina location to the gulf stream in South Carolina" ("Welcome to Belle Isle Yacht Club", 2019), however, the marina has been negatively affected by increased silt from flooding and Hurricanes Matthew and Irma. This has created a need for dredging, but the U.S. Coast Guard has decided not to take any more of these efforts, which has resulted in reduced hours for the marina as residents must "[access] the water around the tidal cycle." The marina is currently undergoing a redevelopment plan that should reduce the need for dredging and restore the marina to a premier boat docking facility ("Welcome to Belle Isle Yacht Club," 2019). Due to this factor, the surveying took place within the gates of the condominium community, which is where the yacht club is located.

Marina interviews. The interviews were with a manager from Charleston City Marina, Charleston City Boatyard, and Cooper River Marina. The first two locations will be discussed below, as the third was discussed previously.

Charleston City Marina is a high-cost marina located in downtown, historic Charleston that includes many transient and permanent boaters, as the marina offers slips for nightly, weekly, monthly, seasonal, and annual leasing (United Landmarks Associates (ULA), 2013). It is the premier marina of Charleston featuring 19,000 feet of linear dock, covering 40 acres of water. It is home to the longest free standing floating fuel dock in the Southeast and was named the 2005 marina of the year by *Marina Dock Age Magazine* (ULA, 2013).

Charleston City Boatyard is owned by the same company as the marina; however, it is located north of Charleston along the Wando River. The boatyard primarily offers repair services including fiberglass, welding, electrical, mechanical, and woodwork, however, the boatyard also runs a hurricane haul program ("Welcome to the City Boatyard," n.d.) which is a membership program that allows boat owners to have their boats hauled out of the water and tied down prior to a named storm. Figure 3.3 shows a sailboat being hauled out of the water at the boatyard.

Figure 3.3: Hauled Sailboat ("Welcome to the City Boatyard," n.d.)

Overall these three interviews provide a comprehensive look at the marina hurricane preparedness process in Charleston, as the Cooper River Marina and the Charleston City Marina can be compared since the former is a public, lower cost marina and the latter is a premier facility – which could present differences in how the marina preparedness is handled. As for the final interview, although the boatyard is not a marina, understanding the hurricane haul program is crucial to understanding the boat mitigation practices in Charleston. This interview ties the other two together, and the hurricane haul program was actually cited many times by boat owners at the Cooper River Marina for why they could or could not protect their boat during a storm – depending on their opinion of the program –, so this interview helps with analyzing the surveys, as well. Figure 3.4 shows a map of the all the study area locations.

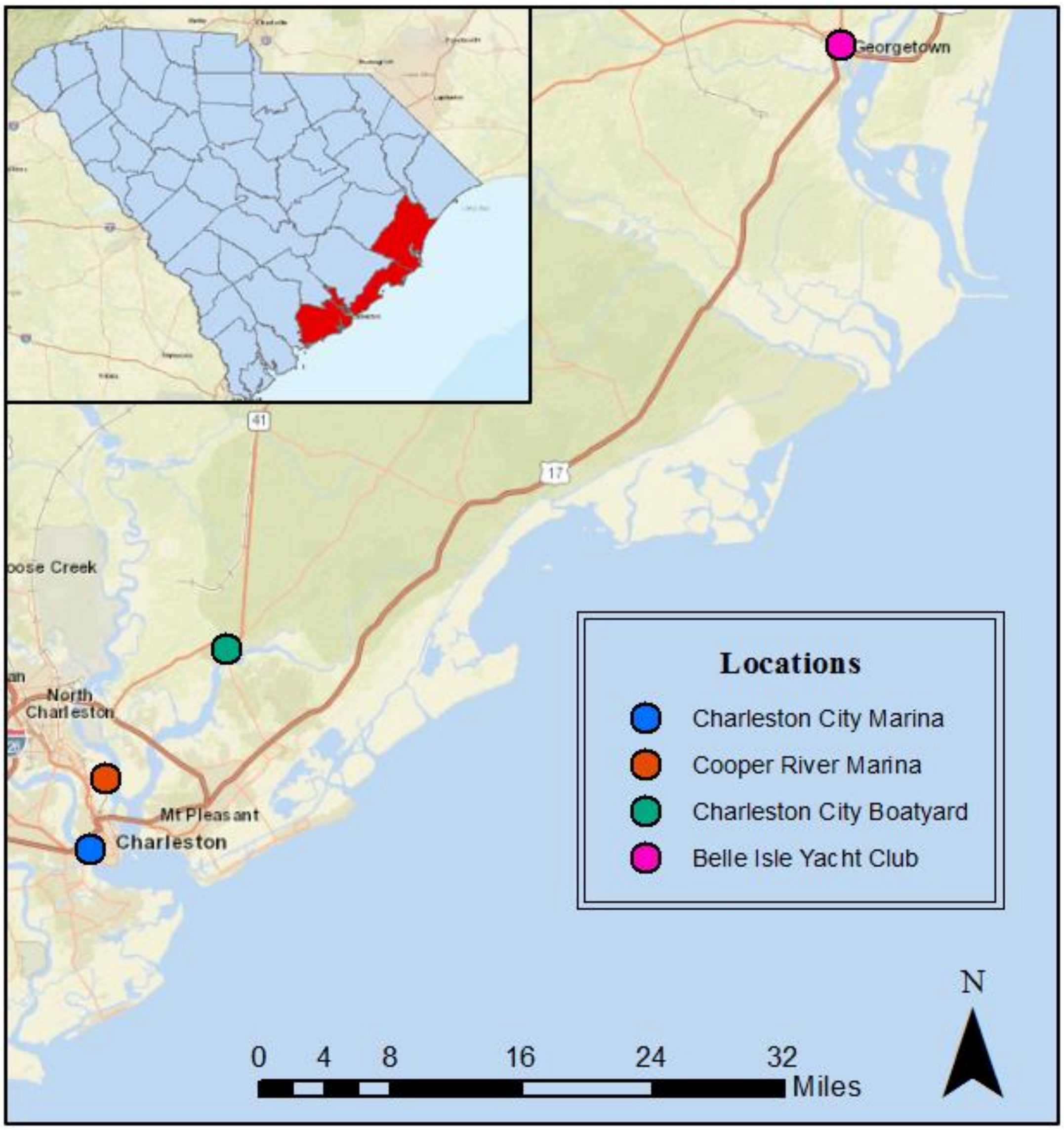

Figure 3.4: Map of the Study Areas

3.4 DATA COLLECTION

The researcher gained approval from the USC Institutional Review Board (IRB) on October 10, 2018 (approval number Pro00083091) before collecting the data between December 2018 and March of 2019. For the survey portion of the study, the researcher walked around both locations requesting boat owners to participate in the study by completing the questionnaire either by the researcher reading the questions aloud and marking the answers or having the participant fill it out themselves – depending on which the participant preferred. The participants were selected randomly by a convenience sample and their willingness to participate in the survey, and the researcher gained informed consent before administering the survey. Most people who were approached were very willing to take the survey, resulting in about a 90% response rate. However, there were not many people at the locations, particularly the Cooper River Marina, so the process only resulted in 64 completed surveys (33 from the Cooper River and 31 from Belle Isle). The interviews were conducted either in person or over the phone and were audio-recorded, in order for them to be easily transcribed later. All the results were kept anonymous, and all ethical guidelines were followed.

3.5 STATISTICAL ANALYSIS

Descriptive statistics. The survey data was first analyzed using descriptive statistics in order to understand the makeup of the respondents in terms of traditional sample statistics such as age, race, gender, etc.; boating statistics such as length of boat ownership and boat type; and past mitigation and evacuation information. Much of the data is nominal, so percentages were used to describe the proportion of participants who chose each answer. This is particularly true for many of the boating questions and those dealing with past hurricane experiences. In terms of sample statistics, the number of minors living in the household and age are the only ratio data; however, both of these variables were not normally distributed, so nonparametric statistics were still a better choice descriptively.

Composite Scores. Notably, other than the descriptive statistics, composite scores were used throughout the rest of the statistical analyses to compare the two landfall locations, storm magnitudes, and to correlate mitigation likelihood to a variety of different variables. These scores were created by summing the hypothetical hurricane scenario responses (Q19-Q30, Appendix A). Specifically, 9 different composite scores were created. Table 3.1 displays each composite score's identifying name – which is how each score will be referred to throughout the rest of the document – and the questions whose responses were summed to create each score. For each score, the term likelihood refers to mitigation likelihood.

Table 3.1: Hypothetical Scenarios Composite Scores

Identifying Name	Responses Used
Charleston Nonmajor Likelihood	Q19+Q20+Q21
Charleston Major Likelihood	Q22+Q23+Q24
Myrtle Beach Nonmajor Likelihood	Q25+Q26+Q27
Myrtle Beach Major Likelihood	Q28+Q29+Q30
Nonmajor Likelihood	Q19+Q20+Q21+Q25+Q26+Q27
Major Likelihood	Q22+Q23+Q24+Q28+Q29+Q30
Charleston likelihood	Q19+Q20+Q21+Q22+Q23+Q24

Myrtle Beach Likelihood	Q25+Q26+Q27+Q28+Q29+Q30
Composite Likelihood	Q19+Q20+Q21+…+Q28+Q29+Q30

Non-Parametric Statistics. A variety of non-parametric comparative tests were used throughout the analysis of the survey data including: the Mann-Whitney U Test (Mann-Whitney), the Wilcoxon Signed Rank, the Sign Test, and the Kruskal Wallis. The Mann-Whitney is the non-parametric version of the independent t-test, so it was used whenever a condition was tested for differences between two independent groups – such as the two survey locations or participants who evacuated and those that failed to evacuate (Q38). The Wilcoxon Signed Rank and the Sign Test are non-parametric alternatives to the one-sample t-test and were used to test for differences within a sample under two different conditions. For example, these tests were used to check for significant differences between the Charleston likelihood and the Myrtle Beach likelihood scores and the nonmajor likelihood and major likelihood scores. The Kruskal Wallis is the non-parametric version of the Analysis of Variance (ANOVA), so it was used to test for significant differences when there were more than two groups.

Spearman's Rho (ρ) and Kendall's Tau (τ) were used for a series of correlations that mostly sought to identify variables that were related to mitigation likelihood by correlating the various variables to the composite likelihood score. The correlations were run for continuous variables – such as number of children (43) – and ordinal variables – such as boat size (Q5), since these statistical methods are appropriate for both and none of the continuous variables were normally distributed. A correlation was also run between the composite likelihood score and question 11 – which if the first survey question to address boat mitigation. It asks the participants to rank their likelihood of taking actions to mitigate damage to their boat prior to a hurricane without offering any storm characteristics. Correlating these two scores shows how well participants' responses to a blanket question predicts their responses once the same question is broken into different scenarios.

Multiple Linear Regression. The variables found to be related to the composite likelihood score, either through correlation or a difference in variance found through comparative testing, were combined to form a multiple linear regression model used to predict participants' likelihood to mitigate through the proxy of the composite likelihood score. "Linear regression analysis is the most widely used of all statistical techniques: it is the study of linear, additive relationships between variables," (Nau, 2018a, pg.1). It is represented by the following equation (eqn. 1), with Y denoting the dependent variable, X_1-X_n denoting the independent variables, b_1-b_n denoting the slopes of the variables' independent relationships with Y, and b_0 denoting the intercept.

$$Y = b_0 + b_1X_1 + b_2X_2 + \ldots + b_nX_n \quad (1)$$

Binary logistic regression models are commonly used in hurricane evacuation studies to calculate a household's probability of evacuating, so this study originally wanted to change that model from yes (evacuate) to yes (mitigate) or no (do not mitigate); however, after evaluating the data, it became clear that multiple linear regression is the better choice because combining the responses from each of the hypothetical scenarios provided a continuous dependent variable – the composite likelihood score. Also, multiple linear regression does not recommend quite as large a sample size as logistic regression – furthering its betterment for this study. In particular, logistic regression requires 100 participants at the absolute minimum, and the minimum is often much larger, depending on the number of independent variables (Long, 1997). The sample size increases with the number of independent variables in multiple linear regression as well; however, the minimum is only 50 for testing the multiple correlation (VanVoorhis and Morgan, 2007). The suggested rule for calculating the needed sample size is illustrated in the equation below (eqn. 2), with m representing the number of independent variables (VanVoorhis and Morgan, 2007). Notably, a different rule only

$$N > 50 + 8m \qquad (2)$$

suggests at least 20 cases per independent variable – which means that the model is robust to a smaller sample size ("Assumptions of Linear Regression," 2019).

When dealing with multiple linear regression there are more assumptions to consider than in logistic regression. While both require little to no multicollinearity between the independent variables ("Assumptions of Linear Regression," 2019), linear regression also assumes a linear relationship between the dependent and independent variables, no auto-correlation, homoscedasticity of the residuals, and normality of the residuals (Nau, 2018b). If these assumptions are violated, the results of the regression model must be viewed conservatively, as the model will be subject to bias (Nau, 2018b).

3.6 CHAPTER CONCLUSION

This chapter detailed the method used to craft the study. It explained the study materials – focusing on the survey design and development. It also provided insight into the marinas and boatyard that were used for surveying or interviews and briefly discussed the data collection process. Finally, the chapter described the statistical analyses used to examine the survey data and expounded on why those analyses were chosen. The results of these tests can be found in the following chapter.

CHAPTER 4: RESULTS

This chapter will present the results of the statistical analyses explained in the previous chapter. It provides the results of the descriptive, comparative, and correlational statistics before detailing the creation of the final multiple linear regression model. It defines the independent variables, provides the model summary, explains why two regression models were run, and validates the model through checking the assumptions. The chapter ends with a brief conclusion that summarizes the major results.

4.1 DISCRIPTIVE STATISTICS

Sample demographics. The study accrued a sample of 64 participants. Thirty-three of the surveys were collected from Cooper River Marina, and 31 were collected from Belle Isle. Eighty-four percent of the participants are male (Q45, Appendix A, n=64), and the few female participants are evenly split between the two locations, with 4 from Cooper River and 6 from Belle Isle. The participants are 98.4% White (Q46, n=64), with only one participant from Cooper River being Hispanic. The minimum age for the data set is 18, and the maximum is 79 (Q42). The mean age is 55; however, since the dataset is negatively skewed with more participants falling above the mean age than below, the median of 58 is a better representation of the central tendency. Seventy-seven percent of the participants did not have any minors living in the household (Q43, n=64), and the sample was very affluent with 50% of the dataset having an annual household income above $100,000 and only 26% of the dataset made below $60,000 (Q44, n=60) –

which is notable since, according to the US Census Bureau (2018), the median household income in South Carolina is $48,781.

Boating statistics. A majority of the boaters in the sample are experienced boat owners – in fact, 56% of whom have owned a boat for over 15 years (Q1, n=64). Figure 4.1 shows the distribution of the years of boat ownership amongst the sample. In the dataset, it is also most common to own only one boat; however, 37.5% owned multiple (Q2, n=64). Figure 4.2 illustrates the distribution of the number of boats owned, ranging from one to eight. Motorboats are also the most common type of boat within the dataset with 45 participants owning at least one motorboat (Q4, n=64). Sailboats are more popular among the Cooper River participants since 21 of them own at least one sailboat compared to only 10 at Belle Isle. Figure 4.3 illustrates the number of sailboat owners to the number of motorboat owners and those that own both, and figure 4.4 divides the

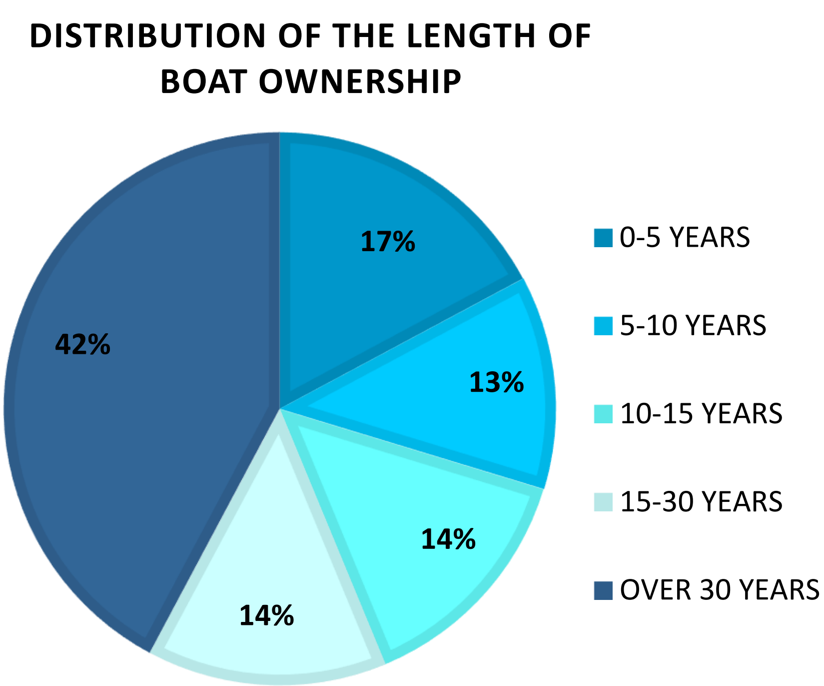

Figure 4.1: Distribution of the Length of Boat Ownership

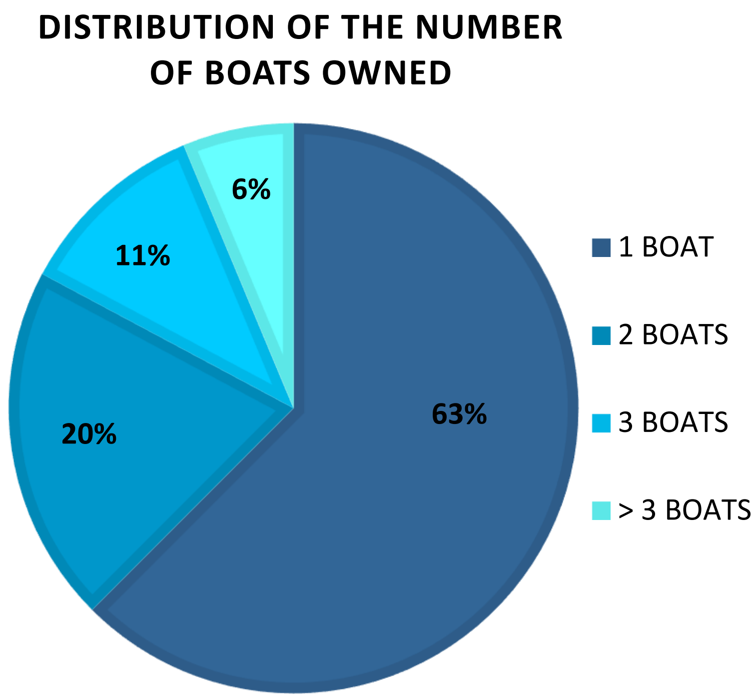

Figure 4.2: Distribution of the Number of Boats Owned

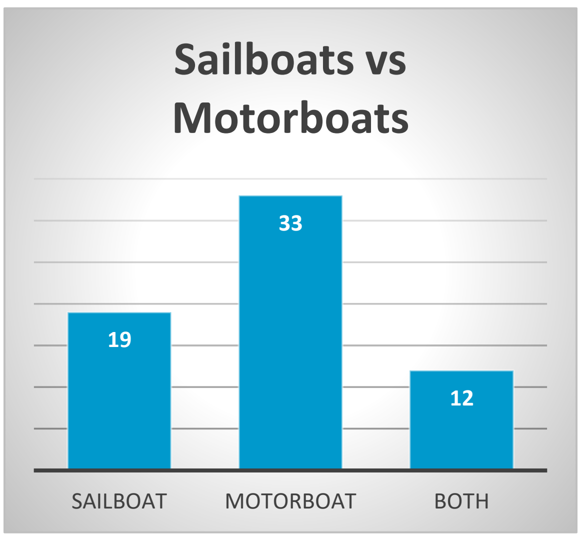

Figure 4.3: Sailboats vs Motorboats

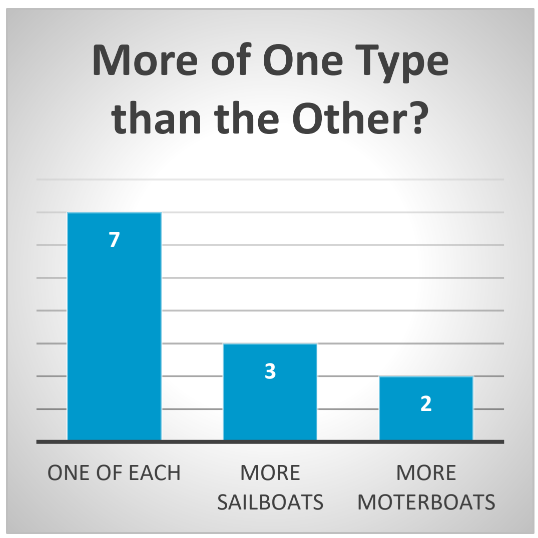

Figure 4.4: Breakdown of those who Own Both

participants who own both into those who have one of each and those who have more of one over the other. Leisure and recreational fishing are the most common reasons for boat ownership in this dataset (Q8, n=64), with 39 participants claiming at least one of their boats is primarily used for leisure and 25 participants claiming at least one of their boats is used for recreational fishing. There are also four liveaboards in the sample whose primary use for their boat is a house. Finally, there are two participants who use one of their boats for racing, and one participant who commercially fishes. More than two-thirds of the participants reported that at least one of their boats has sentimental value (Q10, n=64).

Past mitigation. Since much of the sample consists of longtime boat owners, it is unsurprising that 90.6% of the participants said their boat has been through a tropical storm or hurricane in the past (Q31, n=64). All but three claimed they took actions to mitigate boat damage for the storm (Q33, n=58). Out of the 55 participants that did take actions, securing the boat in its wet slip with ropes was the most reported answer with 51% of the participants claiming to use this method (Q34, n=55); however, when you take out the participants who own motorboats, taking down the sail was cited the most with 86% of sailboat owners reportedly removing their boat's sail in the past (Q34, n=28). Figure 4.5 shows the actions in terms of decreasing popularity, with securing the

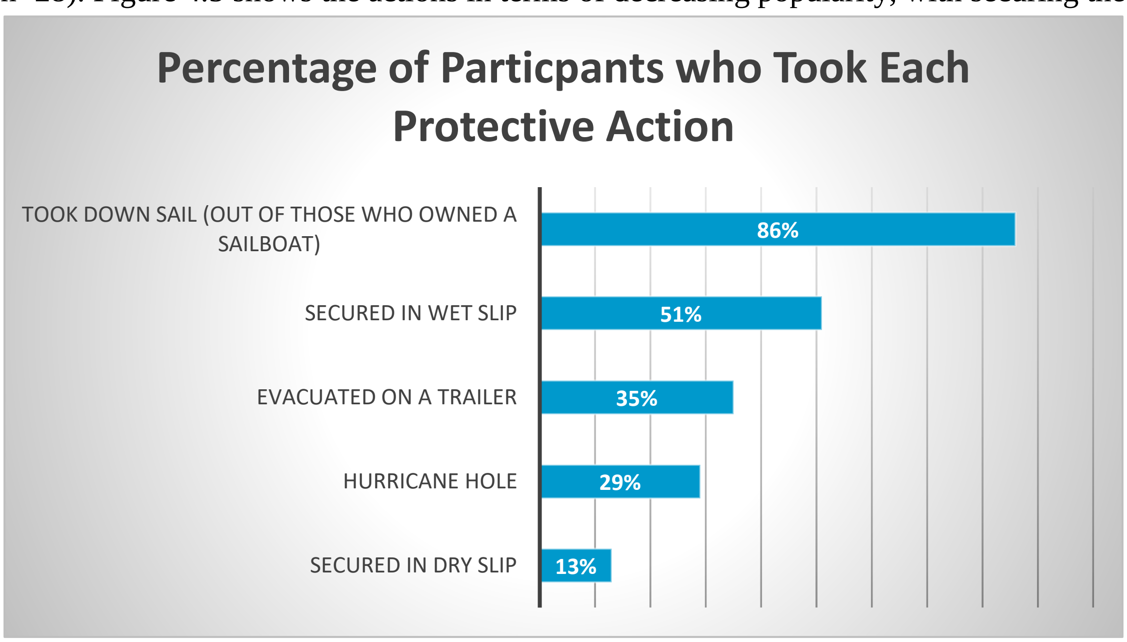

Figure 4.5: Breakdown of Protective Actions

boat in a dry slip with ropes being the least reported answer. It is important to note that the percentages do not add up to 100% since many participants marked multiple methods. Some participants also wrote additional practices such as having their boat hauled out; removing canvases, covers, and other miscellaneous items; and specifying that they use double lines and fenders when securing their boat in its wet slip.

In regard to the timing of these past mitigative actions, 35% of participants started preparing their boats over 72 hours before hurricane landfall and only 9% waited until less than 24 hours to begin (Q35, n=55). Table 4.1 specifies the percentage of the participants who began taking protective actions for each of the time periods available on the questionnaire, and table 4.2 juxtaposes those percentages with those obtained from the whole sample when the survey asked about future storms (Q13, n=64). It is important

Table 4.1: When Participants Started Mitigating in the Past

How Long Before Landfall?	
> 72 HOURS	34.54%
48-72 HOURS	23.64%
36-48 HOURS	20.00%
24-36 HOURS	12.73%
< 24 HOURS	9.09%

Table 4.2: When Participants think they will Start Mitigating in the Future

How Long Before Landfall?	
> 72 HOURS	37.50%
48-72 HOURS	29.69%
36-48 HOURS	20.31%
24-36 HOURS	6.25%
< 24 HOURS	6.25%

to note that question 13 will be referred to as the perceived level of procrastination in future analyses since its measuring how long participants think they will wait to begin mitigative actions.

One of the three participants that did not mitigate damage in the past explained that he had been unaware of the approaching storm and was 300 miles out when the storm hit. There was nothing he could do but ride it out, even though he claimed the waves were over 20 feet high. Interestingly, another participant who was caught at sea during a hurricane said he sought safe haven in a mangrove forest. They were the only two participants who reported ever having to ride out a tropical storm or hurricane on their boats.

Evacuation. In addition to past mitigative actions, past evacuation behavior was also examined. Forty-one percent of the participants have evacuated for a hurricane in the past, 52% failed to evacuate, and 7% were on vacation when a tropical storm or hurricane approached, so they left the area but did not evacuate in the traditional sense (Q38, n=61).

These evacuation rates can be compared to how participants think they will respond for future evacuations. This can be done through analyzing question 17 – which addresses how long participants think taking boat mitigative actions would delay future evacuations. For this question, only 6.25% of participants reported they would not evacuate (Q17, n=64), which is a stark contrast to the 52% who failed to evacuate in the past (Q38, n=61). When looking at the 57 participants who answered a time range (Q17), 89.4% claimed taking boat mitigative actions would delay their evacuation less than 24 hours. Figure 4.6 displays the distribution of perceived time delays due to taking actions to reduce boat damage (Q17, n=57).

Of those who evacuated in the past, only three reported feeling they did not have enough time to prepare their home prior to evacuation (Q40, n=25), and the dataset indicates that taking boat mitigative actions does not impact the amount of time one has to secure their homes (Q41, n=45), as the mean for the 7-point scale is a 2.76 with a standard deviation of 1.76. Notably, only 24% of participants who mitigated boat damage in the past prepared their homes before preparing their boats (Q37, n=55), and this is very consistent with the 25% of participants who planned to prepare their home before their boat for future storms (Q16, n=64).

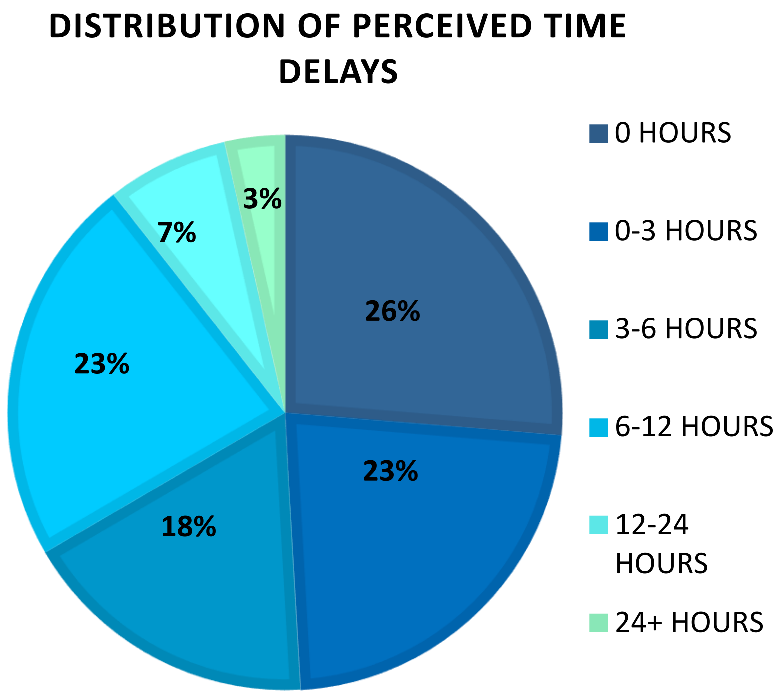

Figure 4.6: Perceived Evacuation Delays from Boat Mitigative Actions

4.2 COMPARATIVE ANALYSIS

The hypothetical hurricane scenarios served to identify the physical variables that impact boat mitigation – particularly location and magnitude (Q19-30). Through the nonparametric, comparative analysis testing discussed in the methods section, it became apparent that both variables significantly influence mitigative actions. The Charleston nonmajor likelihood score was compared to the nonmajor Myrtle Beach likelihood score – as were their major hurricane counterparts. This revealed a significant difference at the

.01 level – with participants being more likely to mitigate for storms hitting near Charleston for both nonmajor and major events. When the storm categories' scores were compared independently, rather than in the nonmajor/major composites, the Wilcoxon and Sign tests showed significant differences at the .01 level between the mitigative action scores at every storm category other than Cat 4 and Cat 5. For Cat 4 hurricanes, the Wilcoxon test showed a significant difference at the .05 level vs .01, although the sign test still indicated a significance at the .01 level. As for Cat 5 hurricanes, both tests showed no significant difference between the likelihood of taking mitigative actions between a storm predicted to make landfall near Myrtle Beach and one below Charleston. The tests also indicated a significant difference (p-value <.01) between the nonmajor likelihood score and the major likelihood score. This was also found true at the more deconstructed level when the Charleston nonmajor likelihood was compared to the Charleston major likelihood and the Myrtle Beach nonmajor likelihood was compared to the Myrtle Beach major likelihood.

The Mann-Whitney test revealed no significant differences between the likelihood to mitigate between the two survey locations. This was tested for storms predicted to land near Charleston and those predicted to land near Myrtle Beach, and both nonmajor and major hurricanes were tested– using the composite scores. This test was also used to test for differences in composite likelihood scores of men and women (Q45). The test revealed that women are more likely to mitigate; however, the test was not significant at the .05 level, but was at the 0.1 level. Since it was significant at the 0.1 level, the test was run for the Charleston likelihood score, the Myrtle Beach likelihood score, the nonmajor likelihood score, and the major likelihood score in order to see if the significance was higher at a downscaled level. Each of these tests showed women being more likely to mitigate, but there was only a significant difference (p= .034) when looking at the major likelihood score. However, it is important to note that since there was only a sample size of 10 for women, these tests need to be viewed very conservatively.

The Kruskal-Wallis test was used to compare the differences in the composite likelihood score between participants who owned sailboats, motorboats, or both (Q4). The test was statistically significant at the .01 level for differences between the median composite likelihood score across boat type and at the .05 level for differences between the distributions of composite likelihood score across boat type. The Dunn-Bonferroni post-hoc test was run to compare the differences between each category. Figure 4.7 shows a box and whisker plot comparing the median composite likelihood scores for each group. The only significantly different groups were sailboat and motorboat owners, with sailboat owners being significantly more likely to mitigate. Interestingly, participants

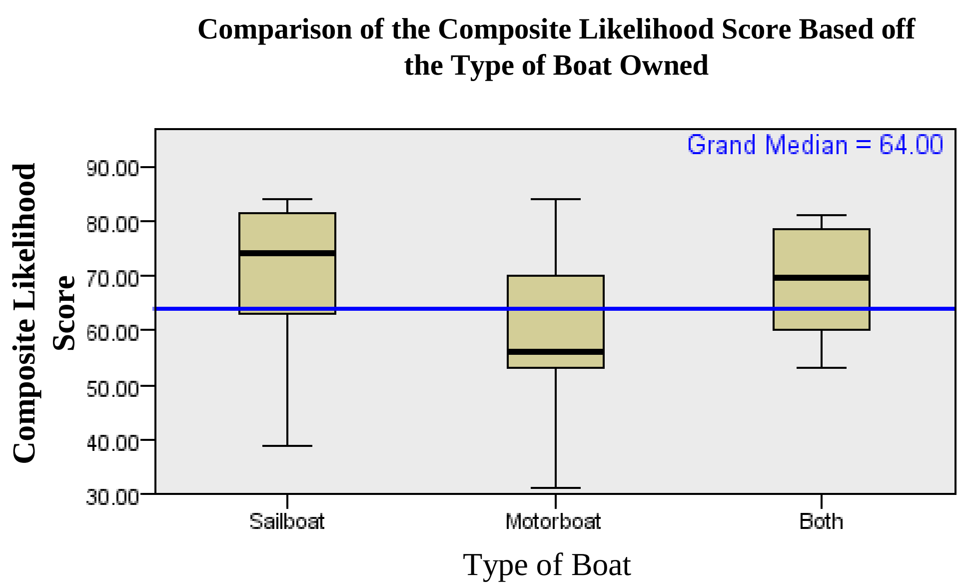

Figure 4.7: Likelihood to Mitigate by Type of Boat – Box and Whisker Plot

who own both type of boats were still more likely to take actions than those that just owned motorboats – just not significantly so.

4.3 CORRELATIONS

The composite likelihood score was correlated with a variety of continuous and ordinal variables in order to check for significant relationships. None of the traditional demographic variables showed any correlation, with age having a ρ= -.029 and a τ= -.045 (Q42), number of minors having a ρ= .001 and a τ= .000 (Q43), and income a ρ= .106 and a τ= .151 (Q44). In regard to boating questions, there was a weak relationship between the composite likelihood score and frequency of boat use (Q9, ρ= .349, $p<.01$). Surprisingly, there were only very weak relationships between the composite likelihood score and boat size (Q5, ρ= -.128; τ= -.092), sentimentality (Q10, ρ= .154; τ= .129), or length of ownership (Q1, ρ= -.122; τ= -.094), and none were statistically significant.

Other variables associated with hurricane mitigation in particular were also tested. Question 12 dealt with the level to which the cone of uncertainty impacts respondents' mitigation decisions, yet it had no correlation to their composite likelihood score (ρ= -.038 and τ= -.042). There was a weak, positive correlation between the composite likelihood score and question 11 – the first question asking respondents to rank their likelihood of mitigating (ρ= .318 and τ= .384, $p<.01$). The correlation measures the relationship between the perceived likelihood of mitigating without knowing storm characteristics (Q11) and the likelihood of mitigating given context (Composite Likelihood Score), and a scatterplot illustrating the relationship is shown in figure 4.8. The level of perceived procrastination (Q13) is also weakly related to the composite likelihood score, as participant's who think they would wait until closer to landfall to start taking mitigative actions are less likely to mitigate (ρ= -.349, p= .005).

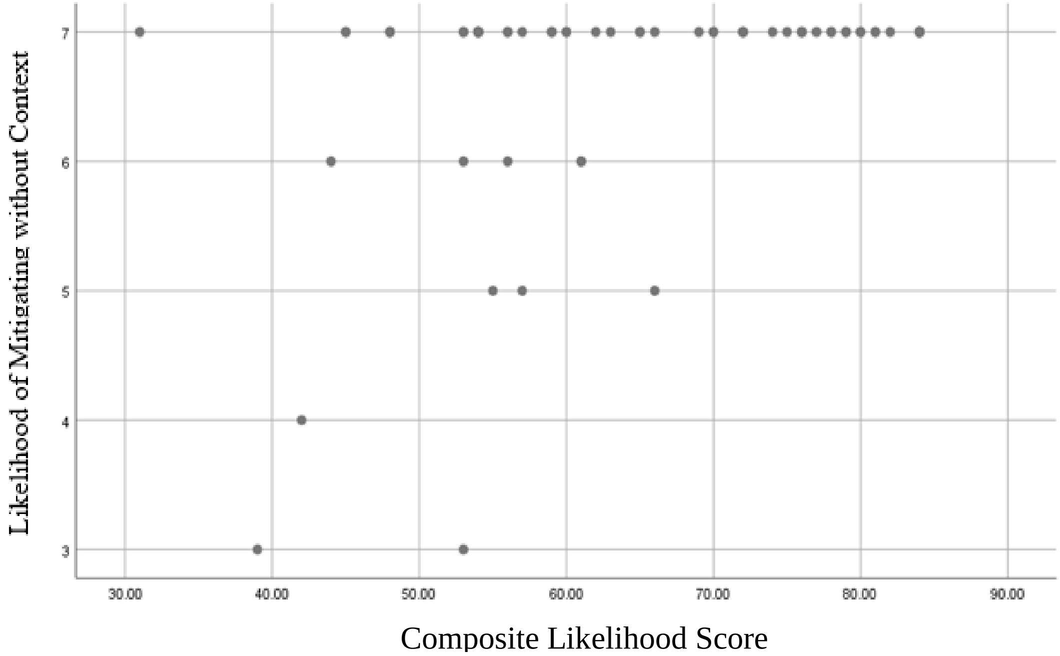

Figure 4.8: Relationship between the Composite Likelihood Score and Mitigation Likelihood without Storm Context

4.4 MULTIPLE LINEAR REGRESSION

Dependent and independent variables. The dependent variable for the regression model is the overall likelihood to mitigate – which is measured by the composite likelihood score. The independent variables are a combination of social and physical variables that were found to significantly relate to the dependent variable in the tests and correlations explained in the previous sections of this chapter. It took the analyzation of two regression models to decide the specific independent variables to include in the model.

Only a few variables have a significant relationship with the dependent variable, so the number of independent variables in the model is low; however, since the sample size for this study is rather small, keeping the number of independent variables to a minimum helped the model be less biased. The independent variables used in the final regression model are type of boat owned (Q4), frequency of boat use (Q9), perceived procrastination level (Q13), and impact of location (Q19-30). The variable for type of boat was changed from sailboat, motorboat, or both to a binary variable – comparing participants who only owned motorboats to those who own at least one sailboat. This was done based off the Kruskal-Wallis post-hoc test that indicated that participants who owned both type of boats were not as likely to mitigate as those who only owned sailboats but were more likely than those that only owned motorboats. The impact of location variable was created by subtracting each Myrtle Beach category scale from Charleston's corresponding scale; taking the absolute value of the differences; and summing those values to create a location level of impact score. This score indicates how much location played a role in participants' answers to the hypothetical scenario questions.

It is important to note that originally a similar measure to the impact of location variable was created for impact of magnitude, with the nonmajor likelihood score being subtracted from the major likelihood score to create an impact of magnitude value – as low scores indicated people who did not drastically change their likelihood to mitigate for stronger storms and high scores indicating people who did. When correlated to the dependent variable, this measure had a ρ= -.828 and a τ= -.699, basically indicating that if magnitude was a variable that a respondent considered when deciding whether or not to mitigate before an approaching storm, it played a major role in that decision. This variable was included in the first regression, resulting in an $R^2 = .796$ and the F-statistic was 57.455. (p=.000). This shows how much magnitude impacts the mitigation decision;

however, this regression violated the assumptions of linear regression in terms of the normality and homoscedasticity of the residuals, so it had to be removed from the final regression.

The independent variables included in the final regression model can be seen in the correlation table below (table 4.3). The collinearity statistics included with the SPSS regression output show all the Variance Inflation Factor (VIF) values to be between 1.00 and 1.10 – meaning multicollinearity is not a problem in this model, as the lowest a VIF value can be is 1.

Table 4.3: Correlation Table

	Mitigation Likelihood	**Type of Boat**	**Perceived Level of Procrastination**	**Frequency of Use**	**Impact of Location**
Mitigation Likelihood	1.00**	.371**	-.305**	.340	-.428
Type of Boat	.371**	1.00**	-.010	.201	.098
Perceived Level of Procrastination	-.305**	-.010	1.00	-.044	.285*
Frequency of Use	.340**	.201	-.044	1.00	-.115
Impact of Location	-.428**	.098	.285*	-.115	1.00

*p<.05, **P<.01

Model Summary. The final regression model explains 42.9% of the variance in the likelihood to mitigate (R^2 =.429). Although this seems like a low R^2, it should be considered that human behavior is very hard to predict (MiniTab, 2013). The F-statistic was 11.078, which is significant (p= .000). To visualize the model, the unstandardized predicted values created by the regression equation were plotted against the overall mitigation likelihood score – creating a scatterplot showing the predictability of the model (fig. 4.9).

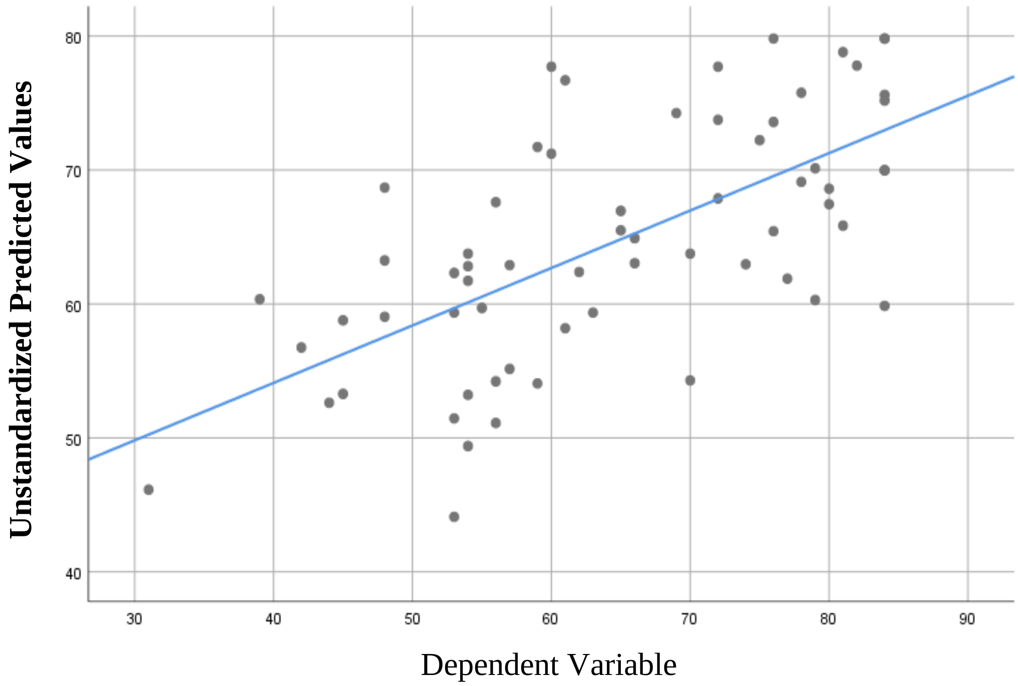

Figure 4.9: Model R Depicted as a Scatterplot

To account for possible sampling bias in the model, a very basic bootstrapping technique was used. Ten different regressions were run – each with 50 random cases from the dataset. Table 4.4 displays the summary statistics for each regression. The median R^2 for the 10 trials is .437, which is slightly larger than the R^2 for the whole dataset. To provide a confidence interval, the value of at the 25^{th} percentile is .423 and the value at the 75^{th} percentile is .464, meaning that 50% of the possible R^2 values for this dataset will fall between these two numbers. These results indicate that the sample may be slightly biased as the R^2 for the dataset is closer to the value of the 25^{th} percentile than the median; however, it is important to note that only 10 trials were run for the bootstrapping, which is much lower than normal and may have skewed the results.

Table 4.4: Bootstrapping Trials

Trial Number	R2	F-Statistic
1	0.427	8.377
2	0.419	8.129
3	0.446	9.052
4	0.400	7.499
5	0.461	9.61
6	0.439	8.796
7	0.531	12.712
8	0.424	8.279
9	0.435	8.651
10	0.472	10.052

Assumptions of Linear Regression. As mentioned in section 3.5 of the study, five main assumptions must be met for this linear regression to be valid – no multicollinearity, the independent variables must have a linear relationship to the dependent variable, no autocorrelation, homoscedasticity of the residuals, and normality of the residuals. Multicollinearity was assessed earlier in this section, when the VIF values were analyzed, and the independent variables were checked for a linear relationship, by examining their scatterplots, before they were ever included in the regression model – meaning autocorrelation and the residual assumptions are the only ones left to examine.

The model was checked for autocorrelation by running the Durbin-Watson test – producing a value of 1.905. This value is very good because a Durbin-Watson value of 2 indicates no autocorrelation. The last two assumptions are checked by analyzing plots created in the SPSS output, and these are the assumptions the first regression failed to pass. Normality of the residuals is analyzed using the P-P Plot, which plots the observed cumulative probability against the expected cumulative probability. In a perfect P-P plot, the observations are plotted in a diagonal line without many deviations – indicating a normal distribution of the residuals. In the plot for this model (fig. 4.10), the observations are in a line for the most part, other than one deviation in the middle. Although the plot is not perfect, data is hardly ever perfectly normal, so this assumption can also be upheld.

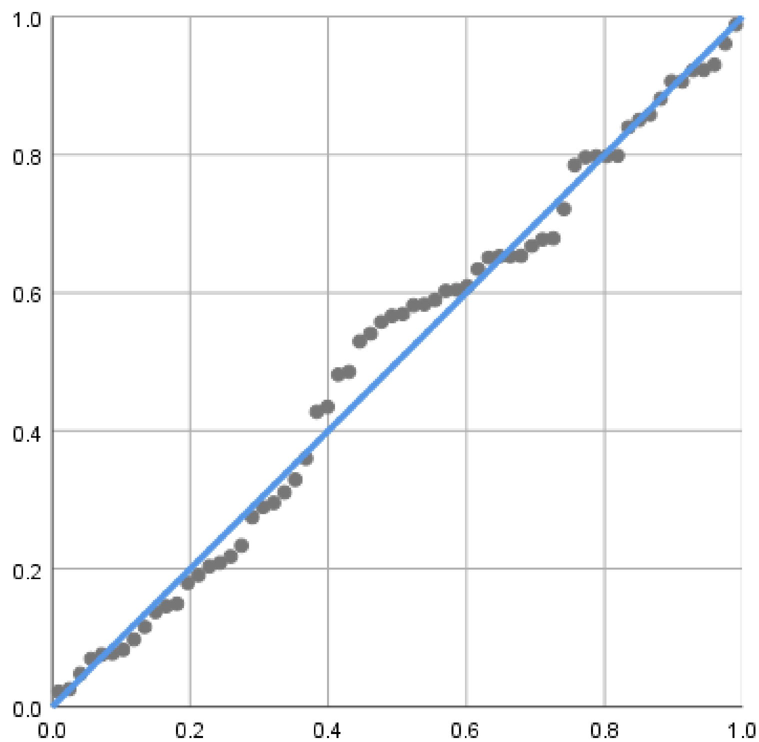

Figure 4.10: P-P Plot

Finally, the test for homoscedasticity involves analyzing a scatterplot of the regression standardized predicted values against the regression standardized residual values. This plot is supposed to show no relationship, with observations being evenly dispersed around the center horizontal and vertical lines. The plot for this model is shown below in figure 4.11, and the observations appear random and evenly spread – meaning this assumption can also be upheld.

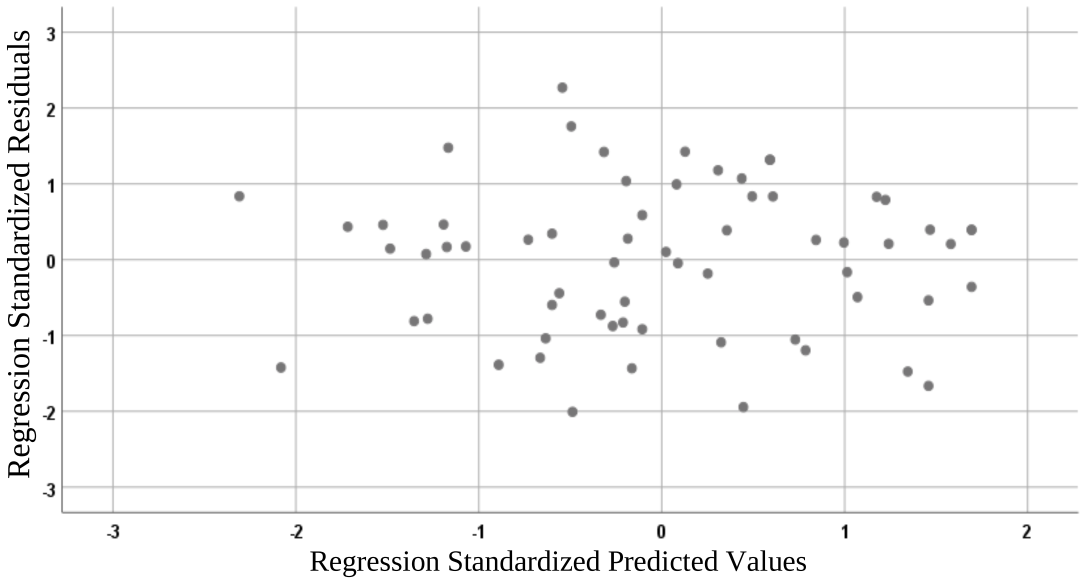

Figure 4.11: Standardized Residuals vs Standardized Predicted Values

4.5 CHAPTER CONCLUSION

This chapter presented all the results from the analysis of the survey data. Some of the major findings include the relationship between type of boat owned and mitigation, with sailboat owners being more likely to take mitigative actions. The findings also showed relationships between the frequency of boat use and the level of perceived mitigation procrastination to the likelihood to mitigate. Surprising variables like boat size and sentimentality were not related to mitigation, and unsurprising, location of landfall and storm magnitude did have a significant influence. The created regression model was able to explain 42.9% of the variance in mitigation likelihood, and the results of this model, as well as the other results from the statistical analyses, will be discussed and interpreted in the discussion and conclusion chapter of this study.

CHAPTER 5: QUALITATIVE ANALYSIS

This chapter goes through the entirety of the qualitative analysis portion of the study. It briefly explains the interview methods and how the interviews were analyzed before detailing the results of the analysis. The chapter also discusses the results and draws conclusions that will later be used in the discussion of the overall study.

5.1 METHODS

Three 15-minute semi-structured interviews were conducted with marina and boatyard managers in Charleston, SC in order to form a comprehensive view of the marina hurricane preparedness procedures in the area. The interviews for the Cooper River and Charleston City marinas were compared – looking particularly at their hurricane plans. The interview with the manager of the Charleston City Boatyard was especially enlightening, as it shows the business side to hurricane preparedness in the area, and it ties the two marina interviews together. All of the interviews were based off questions created from NOAA's Hurricane Preparedness Guidelines for marinas and sought to examine how closely the marinas' hurricane plans aligned with the guidelines present in this manual (2002). Anecdotal evidence is also presented that helps to understand the marina preparedness process and helps put the study, as a whole, in context.

5.2 RESULTS

Charleston City Marina. The interviewee at this marina actually allowed the researcher to have a copy of their formal hurricane plan, which can be found in Appendix C. The plan is very comprehensive and specific. It is broken down into the tasks and procedures that need to be implemented once a hurricane watch is issued and those that need to be implemented once they move into a hurricane warning. The manager updates and reviews the plan with the staff every March.

During the hurricane watch period, the staff sends out an email via MailChimp to all the tenants – informing them of the approaching storm, providing them a checklist of what they need to do to secure their boat, either in its slip or through evacuation, and asking them to let them know if they plan to evacuate their boat. They also send them the contact information for the three boatyards in the area, in case the owner will want their boat hauled out. Larger vessels are sent a questionnaire, requesting the owner or captain to inform the marina about the plans for that vessel. The emails also include the date and time that utilities to the marina will be shut off, and signs are also placed around the marina with this information. During this time, the marina also closes to transient boaters because it is common for boaters from other marinas to try and move their boat to more protected marinas when a storm is approaching – which the interviewee says, "can cause a lot of problems." They also do a lot of miscellaneous tasks such as securing trashcans, carts, flags, signs, and other loose objects; fueling all vehicles and equipment; and stopping the bus that usually runs between the marina and downtown.

The procedures allocated to the hurricane warning time period are much more extensive and are divided into marina, marine fuels, sea store, parking, and office (see

Appendix C). It continues with a lot of the procedures from the hurricane watch period, in regard to securing loose objects, but this is extended – with benches being moved inside; golf carts and company vehicles being moved to a parking garage; and the happy hour tent being completely taken down. Electronics are moved away from windows and computers are moved to an upper level and placed on the floor. Inventory is raised; sandbags are placed in front of doors; and storm shutters are installed in the office. The marinas' boats are taken to the City Boatyard to be hauled out; fuel tanks are topped off; and dispenser nozzles are zip tied, before the power and water is shut off to the docks.

The boaters are not required to evacuate their vessels from the marina, although it is highly recommended. This is consistent with the NOAA guidelines (2002), as it can be very dangerous to force boaters to leave before an impending storm. According to the interviewee, years ago at a marina conference, he heard a story about a couple who died trying to move their boat. "[The] hurricane was coming, and the marina forced them to leave, and they really didn't have a safe haven to go to and ultimately they got caught up in some of the storm. The boat capsized and sank, and they died." The marina was found responsible for their deaths, and a maritime law was created which prevented marinas from forcing owners to evacuate their boats. This anecdote was further researched and found to be true; however, the law is exclusive to Florida and was passed after Hurricane Andrew, when many boaters were placed in harm's way by marina contracts (Brais, 2010).

The marina has a tiered program for marina staff in regard to when they are allowed to leave and reenter before and after the event. For the majority of the staff, they are allowed to leave whenever a mandatory evacuation order has been issued; however, there is an executive team that stays until the marina is completely secured. The marina pays for that team to stay in a hotel, and they have a letter from the governor – allowing them to come back to the city before the evacuation order has been lifted to start accessing damages and reopening the facility.

Cooper River Marina. Charleston City was the only marina that provided a copy of their materials, so the tasks and procedures explained in this section are slightly less specific since all the information comes from the interview; however, the plan is very thorough, and preparations are started way in advance of landfall – making it very effective.

The plan is segregated into five levels of preparedness. The marina stays in level five year-round, and it involves normal maintenance like stocking up on extra 25-foot lines and maintaining the equipment. The interviewee also reviews the plan with the staff at the beginning of each hurricane season, and emails are sent out to patrons reminding them that the season has arrived. Ninety-six hours in advance of a storm, the marina moves to level 4. At this point, all the staff is made aware of the threat, and another email is issued – informing the patrons. According to the interviewee, “Honestly, lots of customers don’t pay attention to the news or the weather, so they have no idea something’s out there until we tell them.” The fuel tanks are topped off, and the staff checks to make sure the facility is draining correctly – to mitigate flood risk. Within 72-48 hours of predicted impacts, a third email is sent – telling patrons to really watch the storm and start preparing. During this time, all loose objects such as fire extinguishers, benches, food, merchandise, and other park equipment are secured inside the dock office.

Level 3 begins when a hurricane watch is initiated. Patrons are reminded that they are not allowed to stay on their boats after the park is closed; all hazardous materials are locked up; and the pump boat is taken out of the water and secured on land. The marina also ties down boats that have not been mitigated with 25-foot lines. Level 2 is 24 hours before the staff leaves, which is earlier than 24 hours before landfall – since the marina closes with county parks. This level involves final checks, bringing in trashcans, and leaving. All of the staff is gone more than 24 hours before landfall. Finally, level 1 is their re-entry protocol. The marina reopens with county parks – which basically is as soon as the storm passes, since they are considered essential personnel.

The marina does not provide any information to boaters about local hurricane holes – which are protected coves or inland creeks/lakes where a boat can be anchored during a hurricane – and most of the boaters choose to secure their boats in their wet slip. According to the interviewee:

> "You can go up the Cooper River to the lake or up the Wando River, but you have to call way in advance to get the bridge lifted. Some of the smaller boats who can sail under the bridge will do that… There is [also] a hurricane haul program but it's so expensive and moving the boats is so time consuming, so most people, who actually do something, just tie them with double lines and take off the sails and canvasses. I think it's partially due to our marina being at the lower end of the price range for marinas in the area."

As previously mentioned, the marina will tie down boats for the owners that did not take any mitigative actions; however, they tell the patrons that they will not in order to encourage more owners to take actions themselves. The interviewee explains, "[M]ost people who use their boats regularly will take actions, but some people have had their boats here for over two years, and I have never seen them. Those people never do anything." The interviewee proceeded to tell a story of a patron he had never seen who called and complained before Hurricane Irma because he did not think the marina had informed him of the threat in enough time to secure his boat. The marina secured the boat for the patron with double lines, and today those double lines are still there because the patron has not been to the boat since Irma in 2017.

Charleston City Boatyard. During normal operations, the boatyard is responsible for repairing boats; however, when a named storm is approaching, the facility shuts down normal operations and focuses on their hurricane haul program. The interviewee compares the program to insurance – saying, “Basically, the first payment [initiation fee] is like your premium, and each time there is a named storm, you pay your deductible for other things.” Specifically, each year boat owners can sign-up and pay a fee to be put on a list of boats that can be hauled out in the case of a named storm. If someone is not on the list, they cannot get hauled out. Once on the list, members pay for a haul block and launch each time they are hauled out for an event. They are also charged lay days, while their boats are on the land – specifically a dollar per foot per day. The hauled boats are tied down with straps attached to helical anchors that are imbedded 4-feet in the ground with an auger. The boatyard is located up the Wando River, so wind is the main concern rather than surge, so the straps keep the boats from knocking into each other, as they are all packed in tightly, or from falling over. Figure 5.1 and 5.2 show the boatyard during Hurricane Mathew in 2016, with the former providing a close-up view of the hauled boats, and the latter providing an aerial view of the yard.

In order for a member to have their boat hauled, they must have the boat to the boatyard’s dock before a hurricane watch has been issued for Charleston. If the boat hits the dock after the watch has been announced, the boatyard is not obligated to haul the

Figure 5.1: Boats at Charleston City Boatyard during Hurricane Matthew (Charleston City Boatyard Interviewee, 2018)

Figure 5.2: Aerial View of the Charleston City Boatyard during Hurricane Matthew (Charleston City Boatyard Interviewee, 2018)

boat. The staff tries to be proactive and begins calling members as soon as there is a chance of a storm coming towards the East Coast. They try to get members to start thinking about the storm early because "any two, three, five boats that [the staff] can get out early before the rush is helpful." The yard can haul between 35 and 40 boats, and the process takes about 40 hours, longer if there are many larger vessels. Once the yard stops normal operations and shifts only to hurricane hauls, the yard is working 24 hours a day. Light plants are brought in, and the staff is divided into shifts – some of which is more structured than others. For instance, the employees running the lift have very structured hours since they are operating heavy machinery, and they can make mistakes that cost serious money. Most of the employees are on 8-10 hour shifts; however, they are allowed to put in as much overtime as they want – meaning if someone wants to work 16 consecutive hours, they can. The interviewee says he "usually ends up working about 20 hours in a row." The whole staff is usually able to leave 24-30 hours before any tropical force winds.

The boatyard also calls the patrons whose boats are already at the facility being serviced and offers to tie down their boat with the straps and anchors for a cost. They also offer to remove canvases from these boats, but that work can get overwhelming, so they prioritize the boats of regular customers and those with a lot of canvas. More dilapidated boats are typically left to the end, but the staff still offers to strap them down to keep them from falling on other boats.

Finally, the interviewee also provided some information about hurricane holes in the area and common practices amongst boat owners in regard to mitigation. The interviewee reiterated that "many people pay their insurance and walk away;" however, he also said, "[A] lot of people make the extra effort when they can't get hauled out to make their boats safe" by "[tying] eight extra lines on their boat, put[ting] out extra fenders, and tak[ing] off sails and canvass." He also explained that historically there have not been many hurricane holes around Charleston, but the bridge crossing the Wando

River was raised this year from about 20 feet to 55 feet – meaning boats can now go up the Wando River to many creeks and anchorages that used to not be accessible.

5.3 DISCUSSION AND CONCLUSION

The information provided by this analysis shows that both the Charleston City and the Cooper River marinas have very effective hurricane plans; however, neither offer any educational programs to boat owners about local hurricane holes, as suggested in the NOAA manual (2002). Although, the Charleston City Marina does provide their customers with the contact information for the three boatyards in the area – in case the customer wants to have their boat hauled out. It is important to note the marina did not only provide the information of the boatyard it is affiliated with – indicating a desire to actually educate the patrons on their options rather than simply sending them to the boatyard it would profit from. Neither of the marinas mentioned having hurricane drills, but since there has been a storm every year for the last few years, it would not seem necessary to have drills anyways.

Markedly, the Charleston City Marina is considered the gold standard in marina preparedness, but this may largely stem from their clientele because Cooper River's hurricane plan is just as comprehensive as the one for Charleston City. In fact, Charleston City does not start preparing for a storm until a hurricane watch (48 hours before landfall) versus Cooper River, which begins preparations 96 hours before landfall. The plans also specify very similar tasks, and both marinas' managers review the plan with the staff annually. Cooper River actually reviews the plan twice – once in February, when every staff member brings a copy of their plan from the previous year with notes about how well the plan worked and what could be improved, and once before the start of the hurricane season to review the revised plan that was updated based off the notes from the staff members in February. The marinas are also similar in the level of communication they have with their patrons in regard to an approaching storm. Both marinas send out emails in advance of the storm; however, Charleston City also sends out a checklist to the owners to help guide them in properly securing or evacuating their boat. In contrast, Cooper River does not send out a similar document, but the staff stays in constant communication with their patrons throughout the process – urging them to mitigate their boats in a timely manner. Overall, the differences in these two marinas lies in their customers. Charleston City's customers can afford to be members of the hurricane haul program – meaning many of the boats in the marina will be evacuated. In contrast, as quoted in the Cooper River section, the hurricane haul program is too expensive for many of Cooper River's patrons – forcing people to secure their boats in their slips, and customers who do not frequent their boat, are unlikely to take any actions at all.

The boatyard interview provided crucial information that helped to understand the differences in boat owner mitigation practices between the two marinas. It also highlighted the industry aspect of the Charleston hurricane scene, as companies are able to charge high prices to offer protective services. The program, while effective at mitigating boat damage, is only really accessible to the wealthy. This is particularly a problem since according to the boatyard and Cooper River interviewees, there are not many hurricane holes near the area; however, now that the Wando River bridge has been raised, maybe more boaters, who cannot afford to have their boats hauled, will be able to move them to safety.

CHAPTER 6: DISCUSSION AND CONCLUSION

This is the final chapter of the document, and it begins by mostly discussing the quantitative results from chapter 4. It is specifically placed after the qualitative analysis chapter because some of the results from chapter 4 can better be explained in context through the information learned in chapter 5. The chapter then addresses the research questions, explains the study limitations, provides suggestions for future research on the topic, and discusses the study's significance to the hazards community.

6.1 OVERALL DISCUSSION

Discussion of descriptive statistics. As was illustrated in figure 4.5, 51% of respondents would secure their boat in their wet slip versus only 29% who cited moving their boat to a hurricane hole. This can better be understood after learning in the interviews that there are not many accessible hurricane holes around Charleston. Notably, of the 26 participants who said they would move their boat to a hurricane hole, 9 specified they would "haul out" or "pull out" their boat rather than anchoring it up river. This accounts for only 14% of the dataset, and five of the nine respondents who claimed they would have their boat hauled were from Belle Isle – which is interesting because there are more accessible hurricane holes around Georgetown. However, the boatyard interview shed light on how expensive it is to have a boat hauled in Charleston, and the Cooper River interview highlighted that many of its tenants cannot afford this expense – which is likely why so few Cooper River respondents use this method.

It is also interesting to examine the timing of when respondents think they will begin taking mitigative actions to when respondents started taking these actions in the past. In table 4.1 and 4.2, the percentage of respondents who said they would begin actions during each possible time period were compared to the percentage of respondents who began taking actions during each period in the past. These tables show that more participants expect to begin taking mitigative actions earlier than what respondents did during their past experiences. This could mean that people perceive their level of procrastination to be less than it actually is, or it could mean that people have learned from their past experiences and realized it is better to start taking these actions earlier.

Similarly, respondents' past evacuation rates did not align with question 17, which asks participants how long mitigative actions would delay their evacuation and offers the option of "would not evacuate." Only 6.25% of the participants chose that option, which is quite different from the 52% of the participants who failed to evacuate in the past. This difference, like with the mitigation procrastination, could be due to participants learning from their past experiences and deciding to evacuate in the future. Response bias – which will be discussed more thoroughly in the limitations section of this chapter – is another possible explanation, as social-desirability – a type of response bias that will also be explained in the limitations section – may have played a role in the respondents' answers.

Still dealing with question 17, 89.4% of the participants thought taking mitigative actions would delay their evacuation less than 24 hours (n=57). The largest proportion of participants (26%) believed taking these actions would not delay their evacuation at all, and another 23% thought it would cause less than a three-hour delay. These statistics would suggest that having a boat does not cause a substantial effect on evacuation; however, a different 33% of the participants thought taking actions would postpone their evacuation by over six hours (23% – 6-12 hours, 7% – 12-24 hours, 3% – over 24 hours, n=57). This is a considerable length of time when considering how hectic and fast-paced hurricane evacuations can be. When a large number of a county's population is leaving an area at around the same time through similar routes, traffic becomes a serious issue, and having a quarter of a day to a full day delay may put boat owning families at a slight disadvantage for getting out of the hazard areas in a timely manner.

Discussion of comparative and correlational analyses. Markedly, respondents' perceived level of procrastination was found significantly correlated to the composite likelihood score through an indirect relationship. This means that respondents are less likely to mitigate, when they plan to wait to the last minute before taking actions.

Another area in which participants' perceptions can be compared is question 11, which directly asks participants how likely they are to mitigate boat damage, and their composite likelihood score. This relationship had a significant positive relationship; however, the $\rho = .318$ is not a particularly strong correlation, especially when one considers that these two values are supposed to be measuring the same construct, likelihood to mitigate. What this correlation really indicates is that people believe they are much more likely to take mitigative actions than they actually are once physical variables are applied to the question. As can be seen in the scatter plot of the relationship in figure 4.7, most participants answered question 11 at the extreme 7 instead of thinking about the question and realizing that not all tropical cyclone events are equal, and they are not going to take the same actions for storms of differing magnitudes and landfall locations. What also can be seen in the scatterplot, however, is a very strong relationship between the composite likelihood score and the question 11 score for participants who contemplated the initial question and answered not on the extreme.

In reality, physical variables significantly impact respondents' likelihood to mitigate, with a significant difference existing between the likelihood to mitigate between nonmajor and major storms and between storms landing near Charleston versus Myrtle Beach. This is not surprising given how much magnitude influences the decision to evacuate (Cutter et al., 2011; Sarwar et al., 2016) and that location of landfall has been found to significantly and consistently influence evacuation as well (Huang et al., 2016). Interestingly, no significant difference was found between the two survey locations in regard to their likelihood to mitigate for either landfall location. This is notable since Belle Isle is located in Georgetown – which is about equidistant between Charleston and Myrtle Beach, so one would think that respondents from Belle Isle may be more likely than those in Charleston to take mitigative actions for storms expected to hit Myrtle Beach. The fact that boaters in Georgetown are not any more likely than Charleston boaters to mitigate for storms hitting Myrtle Beach potentially indicates that boaters understand the heightened impacts of the front right quadrant of a cyclone and know that a storm hitting right below them will likely be more destructive than a storm landing above them. This may suggest that boaters have a greater hurricane knowledge than the general population, which is logical since boaters – especially sailors – must have a basic understanding of atmospheric dynamics.

Notably, sailors had a significantly higher composite likelihood score than motorboaters. This could be due to sailboats being more vulnerable to tropical storm force winds due to their masts and sails; however, it is also possible that there is an inherent difference between sailboat and motorboat owners. As mentioned previously, sailing requires a knowledge of the atmospheric sciences, and it needs a level of physical skill that is not needed to operate a motorboat. This means that even though the sailboat owners in this dataset mostly used their boats for leisure, just like the motorboaters, the sailboat owners needed to put more time into their boat and likely view their ability to sail as a talent – which they would want to preserve and would likely raise their appreciation for their vessel.

There was also a positive correlation between respondents who used their boats more frequently and their composite likelihood score. Again, this is not surprising because – like the explanation for sailboat versus motorboat owners – people who put more time and effort into their boat will have a greater devotion to that boat, and it will be more important to them. As was quoted in the Cooper River subsection of section 5.2, "[M]ost people who use their boats regularly will take actions;" however, when speaking of people who rarely to never frequent their boat, the interviewee claimed, "Those people never do anything." This concept will further be examined in the limitations section of this chapter.

Three rather surprising findings were that boat size, sentimentality, and length of boat ownership all resulted in nonsignificant relationships when they were correlated with mitigation likelihood. This is surprising because larger boats are often more expensive than smaller ones, and one would assume that respondents would be more likely to take actions to protect a greater financial liability. However, smaller boats are much easier and less expensive to secure, which may negate the effects of more expensive boats.

In regard to sentimentality, the lack of correlation is also unexpected, since as explained multiple times previously, caring about the boat should increase the likelihood of taking actions to protect it. The lack of correlation found in this study likely stems from participants overstating their level of affection for their vessels. Only 31% of the participants said none of their boats had sentimental value even though sentimental value is defined by psychologists as value "stem[ming] from an item's intangible link to a cherished aspect of one's life. Specifically, sentimental value is value derived from an emotionally-laden object's associations with significant others, or special events or times in one's life" (Givi and Galak, 2017, pg. 474). This definition implies a strong emotional connection to an object – which is concept the survey question was designed to pinpoint since boats are objects that can be very special to a person; however, for 69% of the participants to claim to have this strong emotional connection, it is unlikely that participants have an accurate understanding of the term and view it more as a surface level emotion.

Finally, it was also surprising that length of boat ownership did not significantly correlate with the composite likelihood score because more experienced boaters would have more hurricane experience, and past experience is consistently shown to influence evacuation (Baker, 1991; Dow and Cuter, 2000), so it would be assumed that it would also influence mitigation, as well. The lack of relationship may be due to boaters' additional understanding of hurricane dynamics – meaning boaters with less experience still have a better understanding of atmospheric conditions than the general population, so they may base their decision making more on this knowledge than their past experiences.

Discussion of the multiple linear regression. A multiple linear regression model was created, with the composite likelihood score as the dependent variable and with type of boat owned, frequency of boat use, level of perceived procrastination, and impact of location, as independent variables. The R^2 is relatively low but acceptable for human subjects' research since it is so difficult to predict human behavior, and R^2 values in this type of research are often below .50 (MiniTab, 2013). The R^2 is also lower because only four independent variables were used in the regression, and each additional variable results in a higher R^2; however, mainly, the R^2 is low because none of the independent variables measured storm magnitude. Magnitude is the major factor in evacuation (Cutter et al., 2011; Sarwar et al., 2016) because it largely forms people's perception of risk which drives their evacuation behavior (Sarwar et al., 2016). As evidence by the strong correlation between the impact of magnitude score and the composite likelihood score, this concept also applies to boat mitigation. People are more likely to take mitigative actions when they perceive a high level of risk which corresponds to larger magnitude storms – meaning the lack of a magnitude variable in the regression severely affects the efficacy of the model. When the R^2 is viewed as the variance explained outside storm magnitude, it seems much more impressive.

6.2 RESEARCH QUESTIONS ADDRESSED

This study sought to examine three main questions: 1) What are the physical and social variables that influence the decision to take the time to secure or move a boat prior to hurricane landfall? 2) How does owning a boat impact a household's decision to evacuate or affect the timing of the evacuation? And 3) How well do marinas comply with NOAA's hurricane preparedness guidelines throughout the year and prior to landfall?

RQ 1: What are the physical and social variables that influence the decision to take the time to secure or move a boat prior to hurricane landfall? The first question can be answered simply based on the multiple linear regression. Participants had higher mitigation likelihood scores when they own a sailboat, use their boats more frequently, and plan to start taking mitigative actions farther from time of landfall. For physical variables, location of landfall and storm magnitude both had significant relationships to mitigation likelihood, with participants being more likely to mitigate for stronger storms. Location was interesting because it appeared that participants took hurricane dynamics into account when deciding on the likelihood to mitigate between the two locations rather than just proximity.

RQ 2: How does owning a boat impact a household's decision to evacuate or affect the timing of the evacuation? The second question is more difficult to examine since there is no way to compare evacuation rates between boat owners and non-boat owners, since everyone surveyed owned a boat. For the dataset, there was a pretty even split between participants who evacuated in the past and those that did not, and these numbers cannot be compared to other hurricane evacuation studies of the general population since the survey did not specify a certain storm. When looking at evacuation timing, a large majority of the respondents reported that taking mitigative actions would delay their evacuation less than six hours; however, some respondents actually think it would cause over a 24-hour delay. Overall, the findings indicate that owning a boat varies in its effect on evacuation; however, most delays will be under 12-hours.

RQ 3: How well do marinas comply with NOAA's hurricane preparedness guidelines throughout the year and prior to landfall? The third question can be answered through looking at the qualitative data gleaned from the interviews. The marinas examined in this study both had detailed hurricane plans that the staff is familiarized with each year. Cooper River starts preparedness procedures 96-hours in advance, which gives the staff plenty of time to have the marina secured and leave well in advance of storm impacts. In contrast, Charleston City does not begin preparations until a hurricane watch has been issued – which is concerning since "[s]ome hurricane observers believe waiting for a watch to be posted also may be too late to adequately prepare boats or marina facilities" (NOAA, 2002, pg.7). Under this plan, most of the staff is able to leave and evacuate once a mandatory evacuation has been ordered, but an executive team still has to stay until the marina is completely secured.

Overall, both marinas effectively prepare for tropical cyclone events and take mitigative actions throughout the year but could improve in some areas. Cooper River tries to keep all their patrons informed about approaching storms, but their staff should provide more educational materials to possibly increase the number of owners who evacuate their boat. Charleston City already provides these materials, and its customers tend to move their boats or thoroughly secure them; however, the marina and its staff would benefit from starting preparations earlier.

6.3 STUDY LIMITATIONS

This study had a variety of limitations that should be considered when viewing its results and merits. Probably the most important limitation is that the participants were surveyed at a marina and a boating community/yacht club. This means that the surveyed boaters were actively either working on or using their boats (Cooper River Marina) or they care enough about boating to live in a boating community (Belle Isle). In addition, none of the surveying took place in the summer, which is when less serious boaters tend to use their vessels. Due to these factors, none of the participants were the type of boat owner who owns a boat but never uses it. This is crucial to understand since, as learned in the interviews, some people do not frequent their boat for years at time, and these are the people who never do anything to mitigate damages.

Another significant limitation is the small sample size. Sixty-four participants is not a large sample, and even though multiple linear regression does not require as large a sample size as logistic regression, the sample size was still less than what is recommended. Based on equation 2 (section 3.5), a linear regression with four independent variables, should have a sample size of 82 – meaning this study was 18 people short of the ideal sample size for this model. The bootstrapping technique indicated that this may have slightly impacted the model, as the median R^2 for this method was larger than the R^2 for the whole dataset, which should be considered when analyzing the results of the model.

Related to the small sample, the lack of diversity amongst the sample is concerning. Almost every participant was a White male, and the dataset was skewed towards an older, affluent population. Much of this lack of diversity can be expected as owning a boat is very expensive; however, at least some racial variation would have been preferable, and it would have been better to have more women so that differences between men and women could be more effectively assessed. With the current sample, women are more likely than men to mitigate but only at the alpha=0.1 level. Since larger samples provide more power and increase the chance of finding significance, having more women could have resulted in a significant finding for this construct – which would have been very interesting since women are historically more likely to evacuate (Bateman and Edwards, 2002).

Finally, when dealing with self-reported data, response bias must be taken into consideration. Response bias occurs when participants "offer biased estimates of self-assessed behavior" (Rosenman et al., 2011, pg.321). This occurs for a variety of reasons such as misunderstanding the question or measure; social-desirability – which is when participants try to make themselves sound better in their answering even though the survey is anonymous (Rosenman et al., 2011); and the observer-expectancy effect – which the American Psychological Association defines as "the effect in which the researcher's belief or expectations unconsciously affects the behavior of those which are being observed" (qtd. in Abernethy, 2015, pg.25). Many of the problems regarding how participants answered certain questions likely stems from one of these types of response bias. For example, the problem with the sentimentality question was probably due to participants not understanding that the question was asking about a deep, emotional connection to their boat rather than it simply being important to them at a surface level. Another example is Question 11, which was the first question asking about mitigation likelihood. Fifty-three out of the 64 participants reported a 7 out of 7 for their likelihood to mitigate. This was likely due to social-desirability because taking mitigative actions to protect an expensive piece of property is a much more socially acceptable idea than leaving it for the marina to deal with or insurance. While response bias is an unavoidable part of self-reported, human subjects research, it is still problematic and needs to be acknowledged.

6.4 FUTURE RESEARCH AND STUDY SIGNIFICANCE

Future studies should work to reduce some of the limitations present in this study – particularly in regard to sampling. This study was seriously limited because everyone surveyed took some interest in their boat since they were either actively at a marina or lived in a boating community with a marina and a yacht club. These people will likely have vastly different answers than boat owners who never frequent their boats, and this assertion is backed-up by the marina interviews. Future studies should also compare evacuation rates of boat owners to the general population; although, the lack of substantial time delays found in this study may indicate that there will not be a difference between the two groups. Last, it would be interesting to perform a similar study only focusing on how boat owners respond to other hazards such as winter weather in the northern coasts of the country.

This study fills a gap in the hazards literature which did not address boat owners or marinas in a detailed manner. The conclusions of the study indicate that the same physical variables that influence evacuation behavior also influence mitigation actions, and that a variety of social variables are also related to mitigation likelihood. These variables are important for insurance companies to understand since they affect whether boat owners will be proactive in reducing damage or will leave their boats and rely on insurance to mitigate their monetary loss. The study's conclusions regarding evacuation timing are relevant to emergency managers because they show that boat owners will likely not have any substantial evacuation delays due to securing their boats in advance of storms. Finally, this research is very important to marina managers as they are responsible for protecting the boats and docks within their facilities. Ultimately, they need to understand that providing informational materials to their patrons is critical, as many less affluent boaters are unaware of where and how to evacuate their boats; the importance of starting preparations early since it takes a considerable amount of time to properly secure boats and marinas; and boaters are much less likely to take actions for nonmajor hurricanes – meaning there may be more potential damage to docks during these events, as less boats will be tied properly or evacuated.

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APPENDIX A: SURVEY INSTRUMENT

PART 1: Boating Questions

1. **How many years have you owned a boat?**

0-5=11	5-10=8	10-15=9	15-30=9	30+=27

2. **How many boats do you own?**

Mean=1.69	Median=1	n=64

3. **Do you have boat insurance?**

Yes=57	No=5	No Response=1

4. **What type of boat do you have?**

Boat 1: Sail=29	Motor=35	Other=0
Boat 2: Sail=9	Motor=14	Other=0
Boat 3: Sail=1	Motor=8	Other=1 – Kayak

5. **What is the size of your boat?**

Boat 1:	< 15 feet=4	15-20=16	20-30=12	30-40=26
	40-50=5	50-75=1	75+ feet=0	
Boat 2:	< 15 feet=7	15-20=5	20-30=10	30-40=0
	40-50=0	50-75=1	75+ feet=0	
Boat 3:	< 15 feet=0	15-20=0	20-30= 2	30-40=2
	40-50=0	50-75=0	75+ feet=0	

6. **Do you keep your boat in the water?**

Boat 1: Yes=43	No=21
Boat 2: Yes=8	No=15
Boat 3: Yes=3	No=7

7. **If so, how long do you keep it in the water?**

Boat 1:	All the time=42	During the summer=2	On the weekends=1
	Never=19	Other=0	
Boat 2:	All the time=8	During the summer=1	On the weekends=3
	Never=11	Other=0	
Boat 3:	All the time=3	During the summer=0	On the weekends=0
	Never=7	Other=0	

8. How do you use your boat?

Boat 1: Leisure=38 Recreational fishing=20 Racing=1
Commercial fishing=1 Commercial tourism=0
Liveaboard=4

Boat 2: Leisure=14 Recreational fishing=8 Racing:1
Commercial fishing=0 Commercial tourism=0
Liveaboard=0

Boat 3: Leisure=6 Recreational fishing=4 Racing=0
Commercial fishing=0 Commercial tourism=0
Liveaboard=0

9. How often do you use your boat/s?

~ Every week=23 A couple times a month=21 ~ Once a month=11
Every few months=6 A couple times per year=3

10. Does your boat have sentimental value?

Boat 1: Yes=40 No=24
Boat 2: Yes=11 No=10
Boat 3: Yes=5 No=5

11. How likely are you to take actions to reduce or minimize boat damage before a hurricane?

7-Point Scale:
1=Not Likely at All
7=Very Likely
Mean=6.66 Median=7 n=64

12. How likely is the cone of uncertainty to affect this decision?

7-Point Scale:
1=Not Likely at All
7=Very Likely
Mean=5.08 Median=6 n=64

13. How many hours before landfall do you think you would begin to take these actions?

+72 hours=24 48-72=19 36-48=13 24-36=4
< 24 hours=4

14. What actions would you take?

Move the boat to a hurricane hole:
Yes=26 No=38

Evacuating the boat on a trailer:
Yes=27 No=37

Securing the boat in its wet slip w/ ropes:
Yes=32 No=32
Securing the boat in its rack w/ ropes:
Yes=9 No=55
Took down the sail:
Yes=26 No=38
Other:
Take off canvas, covers, loose objects, etc.
Double lines and fenders
Hauled out

15. If you plan to evacuate your boat, where would you move it?
House, backyard, driveway, etc.
Columbia
Up River

16. Will you prepare your boat before or after securing your home?
Before=39 After=16 Not Applicable=9

17. If you planned to evacuate from the storm, how many hours do you think securing your boat would delay your evacuation?
0=15 0-3=13 3-6=10 6-12=13 20-24=4 24+=2
Wouldn't evacuate=4
Vacationing (will leave the area but didn't "evacuate")=3

18. If your household planned to evacuate from the storm, would securing your boat delay their evacuation as well?
Yes=32 No=26 Wouldn't evacuate=2
Vacationing (will leave the area but didn't "evacuate")=4

PART II: Hypothetical Hurricane Scenarios
Please answer the following questions based on the Saffir-Simpson Wind Scale:
Tropical storm: 34-64 knots
Cat 1: 65-83 knots
Cat 2: 84-95 knots
Cat 3: 96-113 knots
Cat4: 114-134 knots
Cat 5: ≥ 135 knots

Hypothetical Scenario I: Tropical system making landfall below Charleston within 72 hours.
How likely are you to take actions to reduce or minimize boat damage based on the following wind-scale categories?

7-Point Scale:
1=Not Likely at All
7=Very Likely

19. <Cat 1 (tropical storm)

Mean=3.33 Median=2 n=64

20. Cat 1

Mean=4.78 Median=5 n=64

21. Cat 2

Mean=5.91 Median=7 n=64

22. Cat 3

Mean=6.75 Median=7 n=64

23. Cat 4

Mean=6.80 Median=7 n=64

24. Cat 5

Mean=6.83 Median=7 n=64

Hypothetical Scenario II: Tropical system making landfall near Myrtle Beach within 72 hours.
How likely are you to take actions to reduce or minimize boat damage based on the following wind-scale categories?

7-Point Scale:
1=Not Likely at All
7=Very Likely

25. <Cat 1 (tropical storm)

Mean=2.67 Median=1 n=64

26. Cat 1

Mean=3.70 Median=4 n=64

27. Cat 2

Mean=4.84 Median=5 n=64

28. Cat 3

Mean=5.81 Median=7 n=64

29. Cat 4

Mean=6.58 Median=7 n=64

30. Cat 5

Mean=6.70 Median=7 n=64

PART III: Past Behavior

31. Has your boat ever been through a tropical system?
(If you answer no, skip to question 38.)

Yes=58 No=6 Don't Know=0

32. How strong was that storm (Based on the Saffir-Simpson Scale)?

< 1=3 1=17 2=25 3=5 4=4 5=4

33. Did you take any actions to protect your boat?
(If you answer no, skip to question 38.)

Yes=55 No=3 Don't Know=0

34. If so, what actions did you take?

Move the boat to a hurricane hole:
Yes=16 No=39
Evacuating the boat on a trailer:
Yes=19 No=36
Securing the boat in its wet slip w/ ropes:
Yes=28 No=27
Securing the boat in its rack w/ ropes:
Yes=7 No=48
Took down the sail:
Yes=24 No=31
Other:
Take off canvas, covers, loose objects, etc.
Double lines and fenders
Hauled out

35. How many hours before landfall did you begin these actions?

+72 hours=19 48-72=13 36-48=11 24-36=7
< 24 hours=5

36. How many hours did it take to secure the boat?

1-2 hours=16 2-5=18 5-7=12 7-10=6 10-15=2
15-20=1 20+ hours=0

37. Did you prepare your boat before or after preparing your home?

Before=34 After=14 Not Applicable=9

38. Did you evacuate from the hurricane?

Yes=25 No=32 Vacationing (left the area but didn't "evacuate")=4

39. Did the rest of your household evacuate?

Yes=29 No=28 Vacationing (left the area but didn't "evacuate")=4

40. If so, do you feel you had enough time to prepare your home prior to evacuating?

Yes=30 No=3 Not Applicable=29

41. If you took actions to secure your boat, do you feel that securing your boat influenced the amount of time you had to prepare your house? (If you did not take actions, skip this question.)

7-Point Scale:
1=Not Likely at All
7=Very Likely

Mean=2.73 Median=3 n=64

PART IV: Demographic Questions

42. What is your age?

Mean=55 Median=58 n=64

43. How many minors (< 18) live in your household?

Mean=0.49 Median=0 n=64

44. Which of the following best describes your annual household income?

< $20,000=3 $20,000-$40,000=6 $40,000-$60,000=7
$60,000-$80,000=8 $80,000-$100,000=5 $100,000-$150,000=9
$150,000-$200,000=12 $200,000+=10

45. What is your gender?

Male=54 Female=10 Other=0

46. What do you consider your racial background?

White =63 Hispanic or Latino=1 Black or African American=0
Native American=0 Asian/Pacific Islander=0

47. Is there anything else you would like me to know about your experiences as a boat owner during tropical cyclone events?

Every storm is different
Preparation depends a lot on forecast – which direction
Prepare/move boat early to avoid danger

APPENDIX B: OUTLINE OF INTERVIEW QUESTIONS

1. Does the marina have a formal marina hurricane preparedness plan?
    a. What procedures are included in this plan?
2. How long before predicted hurricane impacts does the marina start taking actions to secure the marina?
3. Does the marina require wet slip evacuations in the rental contracts?
4. Does the marina ever have hurricane drills to test the preparedness plan and to increase the crews' familiarity with the procedures?
5. Does the marina offer any educational programs for boat owners such as anchoring clinics or tours to the local hurricane holes?
6. How long before predicted hurricane impacts is the crew allowed to leave the marina to prepare their households and evacuate if needed?
    a. Is there a schedule for crew members to take turns leaving to secure their homes before returning to continue the preparations?
7. Does the marina survey boat owners using a "Boat Owner's Hurricane Readiness Questionnaire" throughout the year to find out the owners' plans and preparations for their boats given a hurricane – including absentee owner provisions, license to move, etc.?

APPENDIX C: CHARLESTON CITY MARINA HURRICANE PLAN

Source: Charleston City Interviewee

Hurricane Tasks & Operational Guidelines
SAFETY FIRST
<u>Hurricane Watch Tasks</u>

- Keep the customer informed of Hurricane Plan/Schedule
    a. Send out impending weather email to prepare vessels
    b. Send TCBY Hurricane Haul/Help email
    c. Send notice of closing hours and the date/time of utilities shut down
        i. Post signs in office, restrooms, laundry, gates, and sign on van
- Stop taking transient reservations (decide on date and relay to staff)
- If evacuation is announced or flooding expected, stop running van downtown and post a sign at van stop
- Pull most trash bins off mega dock, place at containers and tie down
- Email slip holders (have City Boatyard's Mobile Service Contact available) including monthlies and nightly vessels
- Fuel all vehicles and equipment to include work truck, TCM van, fire cart equip, jerry jugs for generators,
- Fender work float on back side of K-dock
- Have Safety-Kleen empty oil totes in Enviro Trailer
- Round up push carts at head of dock and secure
- Secure Cleats to the jet dock and be sure the gas tank is full
- Relocate large vessels from outside wall and Z-dock
- Tie lines from backside of WW-dock to wall
- Pull flags down from Dock Office
- Contact larger vessels' owners/captains and check their plans
- Store signs
- Take down Happy Hour tent top and store in 3 Lockwood

<u>Hurricane Warning Tasks</u>

- Print contact list for annual, monthly and nightly tenants to include phone numbers.
- Print employee hurricane sheets and make sure up to date
- Move benches into dock office
- Drop web cam down to lowest height and pin in place
- Strap dock carts together at the head of the CW
- Bring all major files to main office
- Take company vehicles to Beach Co parking garage
- Place computers on floor in main office

- Pull P/O boats (all but the Alcoa) and take to TCBY
- Pull the MegaPower trailers to the parking lot
- Take golf carts to Beach Co parking garage or if time does not allow tie up together on the gas dock
- Pull remaining trash bins from mega dock and place in the parking lot
- Tie down P/O hoses (coil and tie to cleats)
- Take van to Mary Street parking garage
- Tie off dumpsters
- Forward dock office phones to the van cell phone
- Take electronics from the Dock Office to the TCM Conf Room
- Shut power and water off to the docks
- Remove inventory from transient shed. (Don't stack it will float and topple over)
- Raise boxes in package shed off the floor, call people to pick them up
- Remove t-shirts, baskets, and anything low enough for the water to reach, depending on forecasted storm surge/tide
- Call arrivals through period the marina is closed and update them on marina's plans and ask about their plans to still come in
- Take down Happy Hour tent
- Use Sand bags as chocks for trailers
- Close diesel line valves at top of dock, CW gangway and old gas dock area
- Hit one of the estops and turn TMS machine off

  Diesel Dispenser/Tank Prep
- Top off tanks
- Coil and tie down fuel hoses on the MD to MD cleats
- Turn fuel valves in the main diesel line to the off position at the transition/filter sump and the CW gate
- Zip tie fuel tank caps closed
- Turn off power to tank pumps/dispensers (most likely we will shut down all power to the docks)
- Manual pump is located in 3 Lockwood

Marine Fuels:

- Fill up TCM vessels, generators and fuel containers before shutting down fuel/gas
- Top off both gas and diesel UST
- Shut Gas and Diesel Ball Valves
- Shut power off to fuel system (E-STOP)
- Zip tie UST fuel fill cap shut

Sea Store:

- Try and keep pumps running as long as it is safe to do so
- Try and coordinate traffic when possible and inform of product outage
- Keep staff informed on hours of operation/closing
- Top off fuel tanks (place Cel on alert for short truck if needed – 2800 or 4500 gallon truck)
- Zip tie nozzles to dispensers and wrap with caution tape
- Tie down trash cans or place in the store

- Turn off canopy and store lights
- Sand bag doors
- Be sure to have extra cash on hand to operate the store should the credit card machines go down
- Move any low electronics to the TCM Conf Room
- Have a contact with an organization to remove water from fuel tanks if needed
- Trip breakers off for nonessential equipment to include:
    - Dispensers, coffee burners/maker, sales counter, in-store lighting, canopy lights, veeder root, pricing sign

Parking:

- Keep Staff informed of hours of operation/closing
- Relocate computer, battery backups, power strips, and any other electrical equipment that can be removed to TCM conf room
- Pull parking gate arms as needed and place storage unit

Office:

- Inform staff of hours of operation/closing
- Relocate any computers near windows to the Conf Room
- Contact Beach IT and plan to shut power to the servers off and unplug from wall jacks if needed
- Unplug any equipment not needed (Ex. Copier/Printer/Fax
- Turn off HVAC unit breakers

Post Hurricane City Marina Docks

- Conduct a dockwalk when safe to do so in order to assess damage.
- Create a triage list
- Notify customers of the status of the marina and power/utilities
- Inform staff of modified or regular business hours of operation.
- Place insurance agent on notice of potential damage
- Notify advertisers of our status (Ex. Open/Under Repairs/Closed/Etc)
    - Advertisers to include: Waterway Guide, Salty Southeast Cruisers Net, Marinas.com, MarinaLife, NMMA contact, DockWa

Post Hurricane Marine Fuels

- Conduct a dockwalk when safe to do so in order to assess damage.
- Create a triage list
- Inform staff of modified or regular business hours of operation.
- Check electrical equipment before power equipment back up.
- Place insurance agent on notice of potential damage

Post Hurricane Sea Store

- Check electrical equipment before turning equipment breakers back on
- Create a triage list
- Check food items for inventory loss and record
- Report inventory loss to insurance agent
- Clean/Pump out dispenser sumps
- Blow off concrete area under the canopy and clean up bottles/trash
- Check the gas tanks for gas with water paste

- Inform staff of modified or regular business hours of operation.
- Place insurance agent on notice of potential damage

Post Hurricane Parking

- Open up all fixed parking equipment and let dry out
- Check equipment before powering up the booth
- Bring all equipment back to the booth from the main office and run equipment when known to be safe to do so
- Install gate arms
- Inform staff of modified or regular business hours of operation.
- Place insurance agent on notice of potential damage

Post Hurricane Office

- Check electrical equipment and plug back in as appropriate
- If power is out wait until it is restored and turn HVAC breakers on
- Inform staff of modified or regular business hours of operation.
- Place insurance agent on notice of potential damage

Post Hurricane Diesel Dispenser/Diesel/Gas Tank Prep

- Be aware of any downed power lines that could be energized
- Visually check all equipment before trying to restore power to the system
- Check the wiring and junction boxes along with the rectifier for impressed current cathodic protection systems before restoring power
- Be alert to indications of electrical shorts or failed wiring as you attempt to restart the system
- Check for water in the fuel/gas using a measuring stick and water paste before dispensing any fuel
- Conduct frequent checks of sumps, dispensers, pans, and measure for water in the tank several times during the first couple of days after resuming operations. Check for water after each delivery
- Be alert for unusual operating conditions such as slow dispensing of fuel, frequent alarms, customer complaints or equipment shut downs. Extra filters are in 3 Lockwood if needed