ABSTRACT

Perceptions of Hurricane Risk Among North Carolina's Coastal Residents:

A Case Study of Hurricane Irene

By

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The perception of risk to natural hazards is a very complex topic and there are multiple factors that influence it. However, two factors have generally been overlooked. Through the use of mail-out surveys of residents in Beaufort County and Dare County, North Carolina, this research explores how risk perception varies with location and addresses how changes in the characteristics of a hurricane influence the perception of their risk to hurricanes. Location is addressed using two definitions. The first definition used the physical location of the resident (either Inner Banks or Outer Banks), while the second definition used the anticipated impacts from the hurricane (flooding, storm surge, wind damage). This created three locational factors that were tested for their association with risk perception. Hurricane Irene provides an interesting case study because of the change in track and intensity prior to landfall.

Using the Chi Square Test for Association, the results show a significant difference in risk perception with location. Based on location on either the Inner Banks or Outer Banks, risk perception varies with respect to the issued advisories. Based on residing in one of the damage areas, risk perception varies with hazards associated with hurricanes. Results also show that track

change and intensity change influence the perception of risk. Based on track change, Inner Banks residents believed they were at greater risk and had increases in their perceptions of personal risk. However, based on intensity change, Outer Banks residents perceived themselves to be at more risk than did Inner Banks residents. Overall, a majority of respondents believed that the track change increased the hazards associated with hurricanes, while the intensity reduction decreased them. While both location and damage area show their own associations with risk perception, combining location with damage area presents a broader picture of how risk perception varies with location.

Perceptions of Hurricane Risk Among North Carolina's Coastal Residents:

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CHAPTER 1 : INTRODUCTION

1.1. Introduction

It is widely known that in order for people to react to a hazard they need to perceive that they are at risk. Risk perception affects the response to hazards for better or worse. There are a number of factors that affect a person's perceptions of risk and many of these factors have been the focus of research that stretches back to the 1960's. While these studies have contributed to the current knowledge of risk perception, there are still aspects that are not well understood and thus there is a great deal more to learn.

Hurricanes are one of nature's most powerful natural hazards. They can devastate coastal communities and require mass evacuation as they make landfall. For these reasons, hurricanes have been the subject of multiple studies to examine the factors that influence individuals' perceptions of risk and their subsequent decisions. The factors that have been studied range from the perception of meteorological hazards (Brommer and Senkbeil 2010) to the various socio-economic factors that affect evacuation decision-making (Dash and Gladwin 2007). However, one key factor in risk perception that has generally been overlooked is residential location.

Hurricanes are also a very dynamic hazard, and throughout their life cycles, they can experience changes in their physical characteristics including their tracks and intensity. Since 1970's, major improvements have been accomplished in the prediction of the physical characteristics of hurricanes (Sorensen 2000). However, these improvements have not been equal across the board. Forecasting a hurricane's track has seen significant improvements from the 1970's (Franklin et al. 2003; Aberson 2001). Yet, forecasting intensity has not seen the same improvement and scientists are continuing to research methods to improve these forecasts

(DeMaria et al. 2005; Rogers et al. 2006). As is the case with location, the influence of changes in the physical characteristics of hurricanes on risk perceptions also has been overlooked.

1.1. Research Questions

The purpose of this study is to examine the ways in which risk perceptions differ between locations as a hurricane evolves, using the Outer Banks and the Inner Banks of North Carolina to differentiate. To do this, this study explores the following questions:

1. Does risk perception differ between the residents of the Inner Banks and the Outer Banks of North Carolina and does it differ if residing in an area affected by storm surge or by wind?
2. Does the change in the track of a hurricane influence an individual's perception of risk and the perception of hurricane related hazards?
3. Does the change in the intensity of a hurricane influence an individual's perception of risk and the perception of hurricane related hazards?

In order to put this study and research into perspective, it is important to review the hurricane history of North Carolina and review what is known about the hazard-related risk perception literature, with a particular focus on hurricanes. The next chapter provides an overview of the hurricane history of North Carolina with the focus on Hurricane Irene. The following chapter addresses the relevant hazard-related literature. The subsequent chapters address the methods, the results, and conclusions of this study.

CHAPTER 2 : HURRICANE HISTORY AND HURRICANE IRENE

2.1. Hurricane History

Prior to 2011, eastern North Carolina experienced several hurricanes and tropical storms. Between 1953 and 2008, 66 storms passed near the North Carolina coast and affected the coastal counties of Dare and Beaufort (Table 2.1).

Name	Year		Name	Year
IRENE	2011		SUBTROP	1982
CRISTOBAL	2008		DENNIS	1981
GABRIELLE	2007		BOB	1979
BARRY	2007		CLARA	1977
ERNESTO	2006		UNNAMED	1976
ALBERTO	2006		HALLIE	1975
OPHELIA	2005		AMY	1975
CHARLEY	2004		AGNES	1972
BONNIE	2004		GINGER	1971
ALEX	2004		DORIA	1971
ISABEL	2003		UNNAMED	1970
KYLE	2002		ALMA	1970
GUSTAV	2002		GERDA	1969
ARTHUR	2002		GLADYS	1968
ALLISON	2001		ABBY	1968
HELENE	2000		DORIA	1967
IRENE	1999		UNNAMED	1965
FLOYD	1999		ISBELL	1964
DENNIS	1999		DORA	1964
EARL	1998		CLEO	1964
BONNIE	1998		ALMA	1962
DANNY	1997		UNNAMED	1961
JOSEPHINE	1996		DONNA	1960
BERTHA	1996		BRENDA	1960
ARTHUR	1996		CINDY	1959
ALLISON	1995		HELENE	1958
EMILY	1993		FLOSSY	1956
DANIELLE	1992		IONE	1955
BOB	1991		CONNIE	1955
ALBERTO	1988		EDNA	1954
CHARLEY	1986		CAROL	1954
KATE	1985		FLORENCE	1953
GLORIA	1985		BARBARA	1953
DIANA	1984			

Table 2.1: List of Storms that Affected North Carolina's Coast. Knapp et al. (2010) and http://www.ncdc.noaa.gov/oa/ibtracs/index.php?name=ibtracs-data

Before Hurricane Irene's landfall in 2011, the last hurricane to have a major impact in the area was Hurricane Isabel in 2003. Hurricane Isabel made landfall near Drum Inlet, North Carolina on September 16 as a Category 2 (Beven and Cobb 2004). Storm surge values on the coast of North Carolina were reported to be 6 to 8 feet above normal tides, 4 to 6 feet on the eastern side of the sounds, and 6 to 10 feet on the western side (Beven and Cobb 2004). Other than storm surge, Isabel produced 4 to 7 inches of rainfall over North Carolina, Virginia, and Maryland and caused an estimated $1.685 billion dollars in property damage (Beven and Cobb 2004). Prior to Isabel's landfall in 2003, eastern North Carolina experienced a number of hurricanes between 1996 and 2000.

In 1999, two hurricanes devastated the eastern portion of North Carolina. Hurricane Dennis was an unusual storm. Between August 31st and September 2nd, Hurricane Dennis stalled over the Atlantic Ocean near North Carolina before making landfall on September 7th (Beven 2000). This created a situation where an intense amount of rainfall was experienced over eastern North Carolina. The maximum rainfall of 19.13 inches was reported at Ocracoke, NC, and between 3 to 10 inches was reported over other portions of eastern North Carolina (Beven 2000). With this heavy amount of rainfall, a situation developed where severe flooding would be experienced when the next hurricane made landfall. Hurricane Floyd made landfall on September 16th near Cape Fear, NC as a Category 2 storm (Pasch et al. 1999). Floyd produced extensive rainfall with amounts as high as 15 to 20 inches reported in North Carolina and Virginia (Pasch et al. 1999). This rainfall, combined with the extensive rainfall from Dennis, caused widespread flooding damage in North Carolina. The storm killed 56 people in the United States with 35 deaths reported in North Carolina; most of these deaths were due to freshwater flooding (Pasch et al. 1999).

Hurricane Floyd is the worst disaster that eastern North Carolina has ever experienced to the present day. The storm caused an estimated $6 billion in insured and uninsured damage and many residents did not have flood insurance (North Carolina Department of Public Safety 2012).

Prior to Floyd's arrival, the state took precautions to protect citizens. More than 62,000 people had sought shelter in one of the 227 emergency shelters that were opened and another 41,000 or more residents sought shelter in inland motels, with family and friends, or at non-state emergency shelters (NCDPS 2012). In the response to a request from then Governor Jim Hunt, then President Bill Clinton declared 66 counties major disaster areas and nearly 30 of those counties were affected by flooding (NCDPS 2012). The storm affected many different areas of society, causing damage to more than 67,000 homes with 8,000 destroyed. Approximately 12,000 businesses reported losses, 1.5 million homes and businesses lost power with some for nearly two weeks, agriculture losses exceeded $830 million, and floodwaters damaged wastewater treatment plants, wells and public water systems, and many dams and roads (NCDPS 2012). These storms highlight the potential impact hurricanes can have on eastern North Carolina.

Compared to other states in the region, North Carolina is more vulnerable to hurricanes because of the barrier islands that extend out in to the Atlantic Ocean. This leads to some of the coastal counties being frequently hit by hurricanes (Wilson and Fischetti 2010). This is particularly problematic with the increases in population on the coast. Overall, North Carolina saw a 105.9% increase in population living along the coast between 1960 and 2008 (Wilson and Fischetti 2010). One county in particular has had a significant increase in population. Dare County saw an increase of 467.9% in population between 1960 and 2008 (Wilson and Fischetti 2010). This increase in puts more property at risk to hurricane related hazards. Between 1960 and 2008, the number of housing units on the North Carolina coast increased by 274.8% (Wilson and Fischetti 2010). This growth continues, thus, more lives and property are at risk to future hurricanes.

2.2. Hurricane Irene

Hurricane Irene was a 2011 Atlantic hurricane that impacted the east coast of the United States in late August. Irene started like most Atlantic hurricanes by the ejection of an African easterly wave off the coast of Africa on August 15 (Avila and Cangialosi 2011). This area of low pressure with thunderstorms traveled across the Atlantic Ocean for the next couple of days where it gained strength and organized. Weather reconnaissance flights on August 21 detected an area of circulation near the island of Martinique with surface winds of 40 to 45 knots (Avila and Cangialosi 2011). These wind speeds are in the range of a tropical storm on the Saffir-Simpson scale (Fanelli and Fanelli 2011). Figure 2.1 illustrates the path of Irene from its formation near Martinique until its dissipation over eastern Canada.

Over the next couple of days, the storm continued to gain strength as it moved closer to the coast of the southeastern United States. On August 22, Irene made landfall on Puerto Rico, where it gained Category 1 hurricane status and caused major flooding on the island from intense rainfall (Avila and Cangialosi 2011; Fanelli and Fanelli 2011). After the initial landfall in Puerto Rico, Irene continued its west-northwest track across the Caribbean and reached its peak intensity of Category 3 on August 24 with 105 knot winds and a central pressure of 957 hpa near the islands of Mayaguana and Grand Inagua in the Bahamas (Avila and Cangialosi 2011). After passing throught the Bahamas, the storm began to weaken as it moved closer to the US coast.

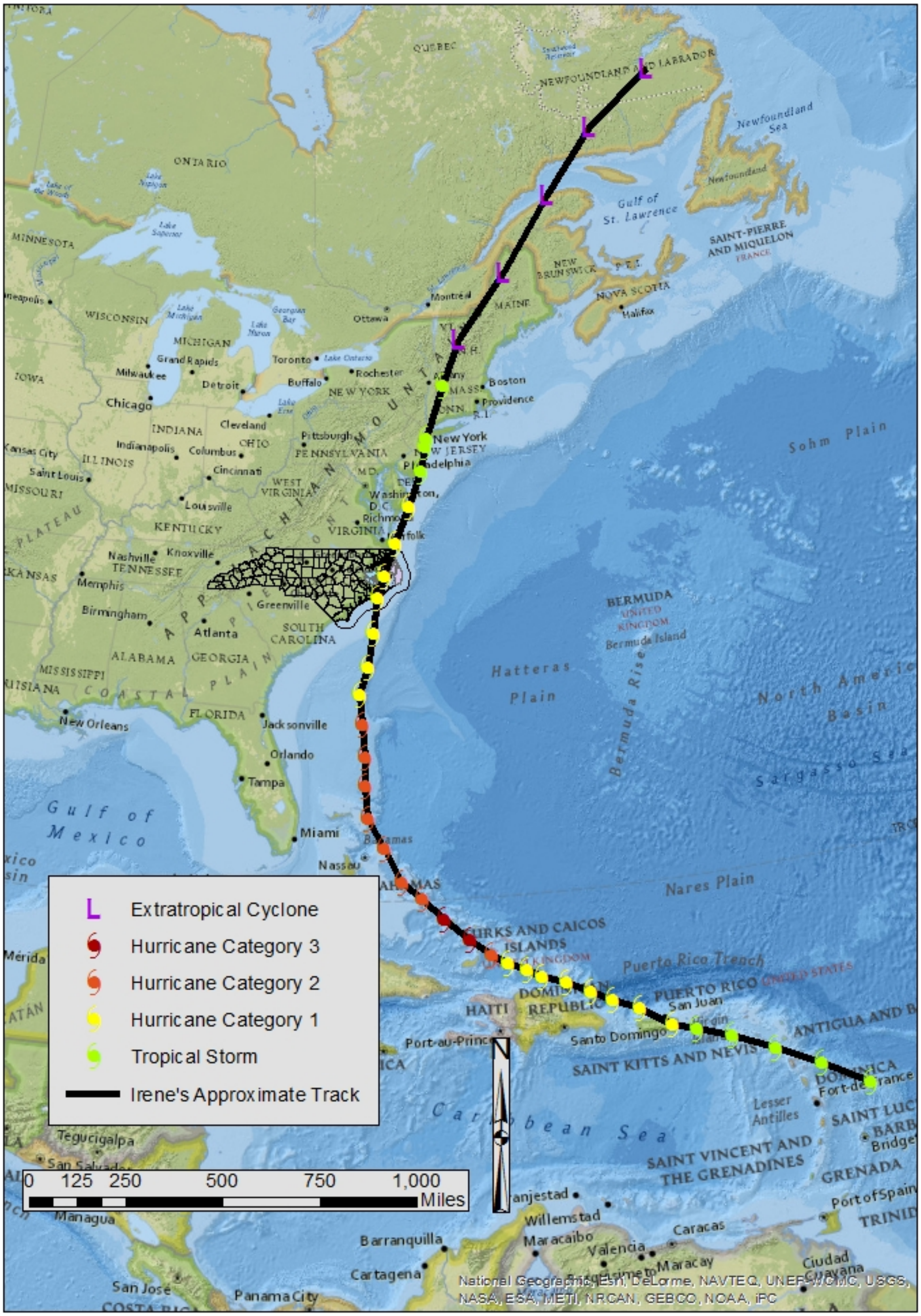

Figure 2.1: Path of Hurricane Irene

Following the first landfall in Puerto Rico, Irene made three more landfalls along the east coast of the US. The first of these was on August 27 between Beaufort and Cape Lookout, North Carolina as a Category 1 storm (Avila and Cangialosi 2011; Fanelli and Fanelli 2011; McCallum et al. 2012). Following landfall in North Carolina, Irene again moved over the Atlantic Ocean before landfalling in New Jersey and New York and then moving over eastern Canada where it was finally absorbed by a frontal system (Avila and Cangialosi 2011). During its US landfalls, Hurricane Irene caused an extensive amount of damage from North Carolina all the way into New England.

2.3. Hurricane Irene Impact

North Carolina was hit especially hard during Irene's landfall and suffered extensive damage from multiple hurricane-related hazards. After landfall, the storm traversed coastal North Carolina for 12 hours as a Category 1 hurricane before re-emerging over the ocean near Norfolk, Virginia (Fanelli and Fanelli 2011). This long duration created many problems. The maximum amount of rainfall was experienced in Bayboro, North Carolina which saw 15.74 inches of rain, and several tornadoes were reported in North Carolina (Avila and Cangialosi 2011). The highest storm surge, 7.09 ft, was experienced at Oregon Inlet Marina, North Carolina, and beaches along North Carolina's Outer Banks were breached, causing damage to Highway 12 (Avila and Cangialosi 2011; Fanelli and Fanelli 2011; McCallum et al. 2012).

Governor Beverly Purdue requested a major disaster declaration on August 28, 2011 due to the effects of Hurricane Irene for the period between August 25th and September 1st (Federal Emergency Management Agency 2011; NCDPS 2012). President Obama declared a major disaster in North Carolina on August 31, 2011 for the counties of Beaufort, Carteret, Craven, Dare, Hyde, Pamlico, and Tyrrell (FEMA 2011; NCDPS 2012). However, due to the extensive damage caused by the storm, more counties were later added. Between August 31st and October 7th, 31 more counties were added to the declaration to receive Individual Assistance, resulting in 38 North Carolina counties receiving assistance (Figure 2.2) (FEMA 2011; NCDPS 2012).

FEMA-4019-DR, North Carolina Disaster Declaration as of 10/07/2011

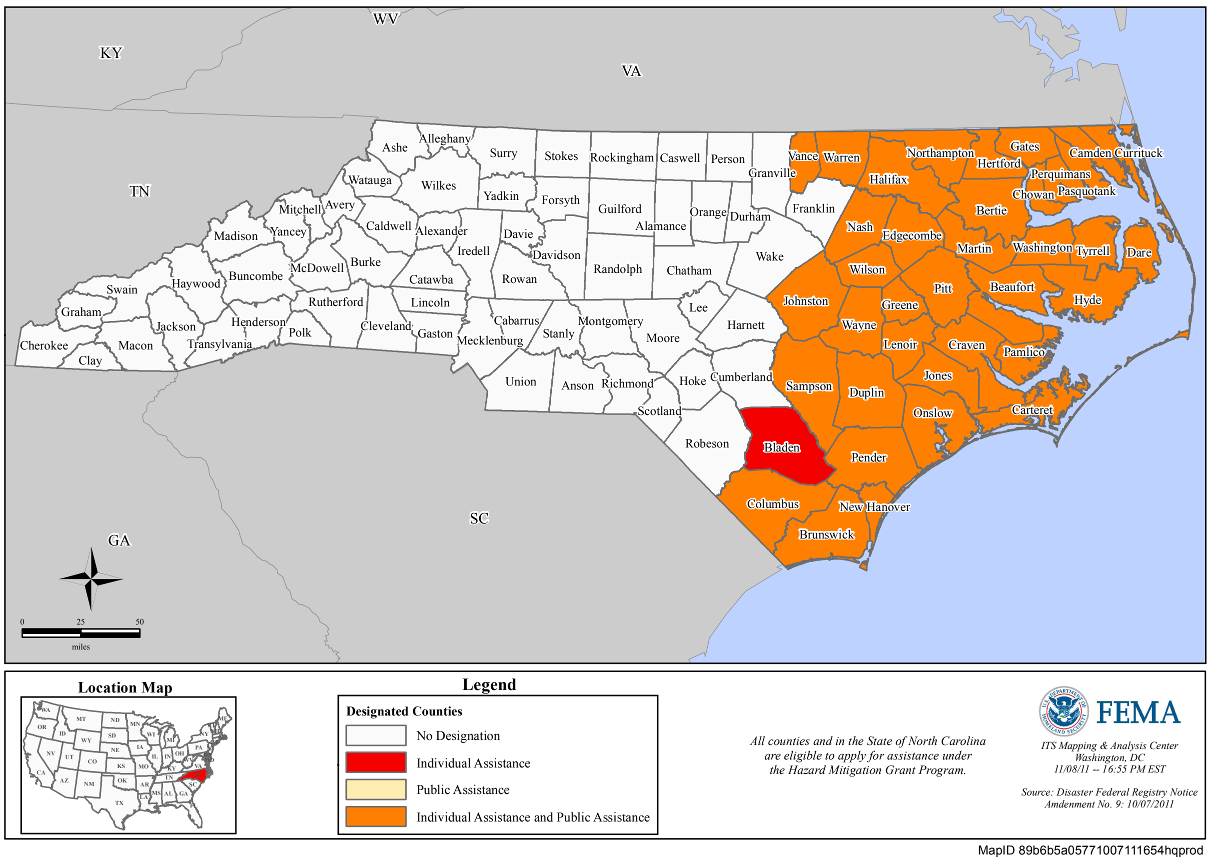

Figure 2.2: Counties with Disaster Declaration. Courtesy of FEMA. http://www.fema.gov/disaster/4019

The impacts from Hurricane Irene in North Carolina were extensive. Seven people were killed, 10,000 people were in shelters, and there were 660,000 power outages (NCDPS 2012). The debris and flooding from the storm caused major problems for the road networks with more than 270 roads and 21 bridges closed (NCDPS 2012). Some 35,000 residents of North Carolina that were affected by the storm contacted the Federal Emergency Management Agency (FEMA) for disaster assistance and received $67 million in state and federal disaster assistance (FEMA 2011). Two of the hardest hit counties were Dare and Beaufort counties. Beaufort County had the most applicants for FEMA assistance with 3,170 filings and $3.38 million in approved assistance (Walker, 2011a). For Dare County, there were 2,443 applications for assistance and were approved for $2.58 million (Walker, 2011a). Dare County also had some of the worst damage associated with the storm. It was second nationwide for hurricane related damage from this storm, with a preliminary estimate of $200 million of insured property damage (Walker, 2011b).

CHAPTER 3 : RELEVANT LITERATURE

The literature that was reviewed for this study can be grouped into four different areas. These include perception literature, locational difference literature, the literature on meteorological hazards, warnings, and information, and the vulnerability literature.

3.1. Perception

The current state of knowledge on risk perception shows that the general public perceives risk differently than professionals and experts (Slovic 1987; Tobin and Montz 1997; Dash and Gladwin 2007). Experts generally judges risk as a measure of probability of occurrence of an event, while the public judge risk based on experiences and many other different factors (Tobin and Montz 1997). Previous research into risk perception also has explored the social variables that influence a person's perception of risk. Such variables that have been studied are race, personal experiences, gender, age, income, education, and length of residence (Peacock et al. 2005; Dash and Gladwin 2007, Lindell and Hwang 2008). All of these variables can contribute to a person's understanding of their risk and they can influence decisions on whether a threat is credible and therefore, whether to evacuate.

Gender was the focus of a study by Bateman and Edwards (2002). They examined why women were more likely to evacuate than men in most situations. Their results suggest that due to socially constructed gender differences, women tend to have a heightened perception of risk by perceiving themselves to be more at risk in general, and they personalize risk warnings more than do men (Bateman and Edwards 2002). These results suggest that risk perceptions differ between men and women. Information and media hype can also influence a person's perception of risk. This is what happened during Hurricane Diana in 1984. Prior to landfall, Hurricane Diana was a strong storm and the media reflected this intensity in their reports. However, just before landfall, the hurricane weakened and did not cause extensive damage. Communities directly impacted by the storm saw the overall extent of the damage through first hand accounts while communities farther away saw only the news and other media reports. This difference in the type of information on the impact of the storm caused residents in communities farther away to perceive themselves to be more vulnerable to future hurricanes than residents near where the storm hit (Beatley and Brower 1986).

Personal experiences can also affect a person's perception. When an event directly impacts a person or the media covers it extensively, the memorability of the event is likely to be increased (Slovic 1986). Memorability is very important because an individual would immediately be able to relate the risk of a hazard if they have previous experience with that type of hazard. Memorability is also crucial in risk judgment and provides feedback on the manageability of hazard, which in turn leads to a better perspective of risks associated with the hazard (Slovic 1986; Kasperson et al. 1988). When people decide if they are at risk from a hazard, the ability of remembering past experience will help individuals make decisions on whether to evacuate or not. However, these personal experiences can be distorted by mass media if the event is unusually memorable (Slovic 1986). Studies have been conducted on determining if personal experiences can predict perception and evacuation for hurricanes but most have concluded that personal experiences cannot predict if a person will evacuate or not (Baker 1979). This suggests that personal experience plays a role in perception but it is not the biggest contributor nor is it a consistent contributor to a person's perception.

Another aspect of risk perception is the ability of a person to identify if their location is at risk. A study by Zhang et al. (2004) found that a majority of the respondents at risk to Hurricane Bret were able to correctly identify their risk area but nearly one-third did not. Another study by

Arlikatti et al. (2006) examined if coastal residents in Texas were able to accurately identify their residence on official hurricane risk maps. However, unlike Zhang et al. (2004), their results show that only 36% of the respondents were able to correctly identify the risk area in which their home resides (Arlikatti et al. 2006). These findings suggest that people can often be unaware of how hazardous their location is and thus can perceive themselves to be at less risk than they actually are or live in a safe area and believe that they are high risk.

Income has been examined in many studies to determine the influence it has on perception and particularly risk perception. In their study to examine a proposed model of household response to different hazards in Texas, Lindell and Hwang (2008) found that household income was negatively correlated with perceived personal risk. This result was also evident in a study by Peacock et al. (2005). The results suggest that as income increases a person's perception of personal risk decreases. However, the Lindell and Hwang (2008) study noted that more research must be done to determine if this is the result of low-income resident's lack of control over their environment or some other factor because of the non-significant correlation of income with hazard adjustment presented in their results (Lindell and Hwang 2008).

3.2. Locational Differences

The current state of knowledge on locational differences suggests that there is a difference in perception based on the distances individuals are from the object of interest. This is shown in a study done by Brody et al. (2004). They attempt to understand the role on environmental risk perception of location and the distance an individual is from two creeks in San Antonio, Texas. Results show that when controlling for socioeconomic factors and other geographic variables, the distance variable is significant in explaining both the familiarity with the creeks and views of pollution levels. People closer to the creeks were more likely to be aware of the creeks' existence and the level of pollution than those who lived further away. This suggests that distance is a general factor for a person's perception of the environment. Another study done by Peacock et al. (2005) also suggests location can play a role in risk perception. Their study showed that perception of hurricane risk in Florida increased from areas of lower wind hazard zones to higher wind hazard zones based on the ASCE 7-89 wind contours from the American Society of Civil Engineers 50-100 peak gusts (Peacock et al. 2005).

While both of these studies show evidence for the role that location can play in a person's perception, previous studies have suggested that location is not a main contributor to perception. In searching for an understanding of why rural residents are less likely to be concerned about environmental issues than urban residents, Lowe and Pinhey (1982) found that the "place of socialization" or the area where people developed their beliefs was a more important contributor to their view of environmental problems than their place of residence. These results suggest that location is not the most significant contributor to perceptions of the environment, but rather that the social interactions of people with shared beliefs have a greater effect on the perception of environmental issues.

3.3. Meteorological Hazard, Warnings, and Information

From the beginning of research into natural hazards, meteorological hazards have been the topic of frequent studies (McPherson and Saarinen 1977; Westgate 1978 are examples). Indeed, weather-related events produce more property damage than any other hazard (Cutter and Emrich 2005). This highlights the importance of studying weather-related hazards because more people are affected by these hazards than any other type. The current state of knowledge about meteorological hazards shows that people will evacuate based on the meteorological hazards perceived as risky. Brommer and Senkbeil (2010) studied the perception of meteorological hazards from Hurricane Gustav by evacuees in Louisiana. Their findings suggest that storm surge was the most important meteorological variable and they also noticed that evacuees inland from the coast were more worried about hurricane force winds than storm surge (Brommer and Senkbeil 2010). This suggests, not surprisingly, that people's perception of their risks associated with hurricanes varies with their location relative to the coast.

A person's perception of hurricane strength can affect his/her perception of risk. A study by Whitehead et al. (2000) found that storm intensity was strong a predictor of evacuation under a hurricane watch and that households were more likely not to evacuate during a weaker storm. According to the Saffir-Simpson scale for hurricane strength, a Category 1 storm is generally not associated with extreme damage beyond the coastline near landfall (Dow and Cutter 2000). While low category storms do have lower wind speeds than the higher categories, they still can contribute to extensive damage resulting from intense rainfall and sustained wind speeds over time caused by slower moving hurricanes. If a person thinks that a lower category storm presents a lower risk to him/her, he/she will most likely not evacuate and therefore might be at higher risk from other meteorological hazards.

The effect of storm information on a person's perception is illustrated by findings that people find several sources of information that are relevant to them. Dow and Cutter (1998) studied the evacuation behavior of South Carolina residents during the 1996 hurricane season, which included several near misses. Their results show that official advisories and warnings declined as the main reason for people to evacuate and that people assessed their risks by a variety of factors and seek information on the storm from varied sources (Dow and Cutter 1998). This shows that people consider diverse sources of information to assess risk. This study also shows that people are now using media more than official warnings to influence their decision to evacuate (Dow and Cutter 1998, 2000). A study by Piotrowski and Armstrong (1998) showed similar results. In their study of mass media preferences during Hurricane Danny, they show that the public relied on local TV and radio coverage for their information on the storm (Piotrowiski and Armstrong 1998). With the widely available information provided on the Internet and people seeking more information to make informed decisions, knowing when people start to access information and what that information is becomes important to understanding risk perception. A study by Sherman-Morris et al. (2011) looks at the search for hurricane information on the Internet during hurricane season. Their results show that coastal communities begin to have a higher search volume index (SVI) for hurricane information when the 3- and 5-day hurricane forecast tracks shift toward their area and decrease when the forecasted track shifts away (Sherman-Morris et al. 2011). This suggests that between three to five days before a forecasted landfall, people begin to seek information because they begin to perceive themselves to be at risk from a landfalling hurricane, and when the forecasted track shifts, the feeling of being at risk diminishes. Thus, the storm's forecasted track appears to play a role in a person's risk perception (Sherman-Morris et al. 2011).

Public responses to warnings have been shown to be the result of perceived risk, the quality and quantity of warning information, and the personal characteristics of the recipient (Mileti and O'Brien 1992). Many studies have attempted to understand the role of hurricane warnings on a person's decision to evacuate. When compared to other hazards, the prediction, forecasting, and warning integration for hurricanes have seen major improvements over time (Sorensen 2000). Such improvement has allowed for the more efficient dissemination of information from experts to the public; however these improvements have generally missed the understanding of how the public interprets and responds to warnings. Increasingly, many researchers have suggested that social scientists should work with meteorologists and physical scientists, through workshops and interdisciplinary research opportunities, to help study the warning process, decision making, and behavioral responses to warnings (Gladwin et al. 2007).

There are many studies that have examined what influences people to take action during a disaster. Christensen and Ruch (1980) attempted to understand how social influence affected the response to hurricane warnings. Their findings suggest that an individual's response to warnings is not necessarily affected by the response of strangers or friends and family (Christensen and Ruch 1980), such that the response to warnings is rooted deeply in the social background of the individual that is receiving the warning. However, recent assessments of hazardous weather events have shown that communication between family and friends has encouraged people to take action during these events (National Weather Service 2009, 2011). Several studies done by Lindell et al. (2005), Burnside et al. (2007) and Lindell and Hwang (2008) also have expanded on the roles peers and local authorities have on decision-making. These studies suggest that while local news media were the most used sources for information, residents rely more on peers and local officials for evacuation decisions (Lindell et al. 2005; Burnside et al. 2007) and that residents closer to the coast or in higher risk areas rely on peers and local authorities for their decisions more than do those in other areas (Lindell et al. 2005; Lindell and Hwang 2008). The study by Lindell et al. (2005) also shows that people in higher risk areas were more likely to rely on local news and Internet sources. These results are consistent with the results from Baker (1991), which suggest that evacuation is not strongly correlated with the primary source of information, the source of initial information, or attention devoted to monitoring the storm (Baker 1991).

Since more people use a variety of sources for information on hurricanes and use public officials and peers as part of their decision-making process to take action, there is some difficulty in transferring hurricane information from weather forecasters to the general public. A study by Demuth et al. (2012) examined how hurricane risk information is communicated from officials at the National Weather Service (NWS) to emergency managers and the news media. They found that, although the process of communicating hurricane risk is successful, there are some difficulties in the process. First, they found that the information that the NWS meteorologists provide, while essential, is voluminous, complex, and has scientific and technical content (Demuth et al. 2012). This provides challenges for individuals using this information because they would have to sift through vast amounts of technical and scientific information that could be difficult for people to understand. Second, the media want better and more accurate information from emergency managers and NWS officials sooner, especially when media coverage increases as the hurricane nears landfall, which is currently difficult to provide (Demuth et al. 2012). Because the media are communicators of hurricane risk, they need the most recent and updated information that can be easily presented to the general public. However, this becomes problematic when NWS officials and emergency managers provide complex information on the storm. Finally, emergency managers prefer to use the onset time of tropical storm force winds to make decisions and to account for uncertainty differently from the NWS (Demuth et al. 2012). This creates a disconnect between the emergency managers and the NWS officials in terms of what information is necessary and useful.

3.4. Vulnerability

Risk and vulnerability are related to each other by the introduction of a hazard. One model of risk that incorporates vulnerability proposed by Blaikie et al. (1994) suggests that risk is the combination of vulnerability and a hazard. The 'pressure and release model' shows that risk (R) equals vulnerability (V) plus a hazard (H) or R = V + H (Blaikie et al. 1994). Currently, the broad definition of vulnerability is the potential for loss. However, vulnerability is very complex, and many other definitions have been developed from various research areas and methodological practices, which view vulnerability as a potential exposure to hazard or as a response to a hazard (Cutter 1996). Cutter (1996) explored the concept of vulnerability as a hazard of place, which combines both the potential exposure to a hazard and the social response to a hazard. Cutter defines risk as the likelihood of occurrence of a hazard and, when combined with mitigation, it creates an overall hazard potential. This hazard potential is then filtered through social factors and a physical geographic context to create both a social vulnerability and a biophysical vulnerability, which combine to create the vulnerability of places (Cutter 1996). This combination of both physical vulnerability from hazards and social vulnerability draws a relatively complete picture of a place's vulnerability because all factors are included.

There is a difference between the biophysical vulnerability and the social vulnerability of a place. Biophysical vulnerability can be viewed as the potential exposure to a hazard, while social vulnerability is the susceptibility of a social group to the impacts of hazards and their resilience to them (Cutter 1996; Cutter and Emrich 2006). This generally means that variation in social vulnerability results from the social inequalities that exist in our society (Cutter and Emrich 2006). This social inequality creates social groups that can have a specific set of characteristics that lead to a community's overall social vulnerability. Groups that are at greater risk for hazards include the poor, the elderly, minority groups, women, and many others (Morrow 1999).

This combination of social vulnerability with the biophysical vulnerability of hazards can reveal the total vulnerability a place has that would otherwise be lost if one dimension of vulnerability, social or biophysical, was studied. An example of the combination of biophysical vulnerability with social vulnerability is the study done by Boruff, Emrich, and Cutter in 2005. The purpose of that study was to examine the differences in the place vulnerability of coastal counties within the United States by using both social and physical factors (Boruff et al. 2005). The results show that different regions of the US have significant differences in both physical and social vulnerability and that different coasts have different important factors of vulnerability, with the physical factors more important on the Atlantic and Pacific Coasts and social factors more important on the Gulf Coast (Boruff et al. 2005). The study illustrates the benefit of combining both social and physical factors to create the vulnerability of places because it highlights how several features contribute to vulnerability. It shows that different places have different factors that embody their vulnerability to hazards.

3.5. Summary

This review of the literature suggests that there are a number of factors that influence perception. Some of these factors are related to the hazard itself, while others are related to characteristics of the individuals at risk. With many studies completed on trying to understand perception, it is clear that there are multiple interrelated factors that combine to influence an individual's perception. Two factors that have not been studied in detail are location and changes in the physical characteristics of a hazard. Previous studies have noted that location can play a role in perception but some studies have also suggested that other social factors have a stronger role in perception than location does.

CHAPTER 4 : METHODS

This chapter describes the design used to complete this study. After explaining the choice of the study areas, the methods used for data collection and analysis are described.

4.1. Choosing the Study Area

Because the main focus of the study is to examine the difference in perception between the residents of the Inner Banks and Outer Banks of North Carolina, it was necessary to first determine which counties constitute the Outer Banks and which are the Inner Banks. The Outer Banks have been defined as a string of barrier islands separated from the mainland of North Carolina by a series of sounds and inlets, while the Inner Banks definition was developed to spur tourism to towns not located on the Outer Banks and has been defined as counties around the Albemarle-Pamlico estuarine system (North Carolina Department of Public Instruction n.d.; Smith 2012; North Carolina Department of Commerce 2013). For this study, the Inner Banks are counties that border one of the many sounds and the Outer Banks are the counties that border the Atlantic Ocean and have portions of the counties located on at least one barrier island.

With the establishment of the selection criteria, the two coastal counties chosen for the study area are Beaufort County and Dare County (Figure 4.1). These two counties were chosen for a variety of reasons. Officials at the National Weather Service (NWS) office in Newport, North Carolina, indicated that Hurricane Irene heavily impacted these two counties. A report on the storm surge associated with Hurricane Irene from the US Geological Survey (USGS) also showed that these two counties were heavily affected, as indicated by the location of the high-water marks (Figures 4.2 and 4.3) (McCallum et al. 2012). Further, Beaufort County was chosen to represent the Inner Banks because it borders the Pamlico Sound and Dare County was chosen to represent the Outer Banks because of its border with the Atlantic Ocean.

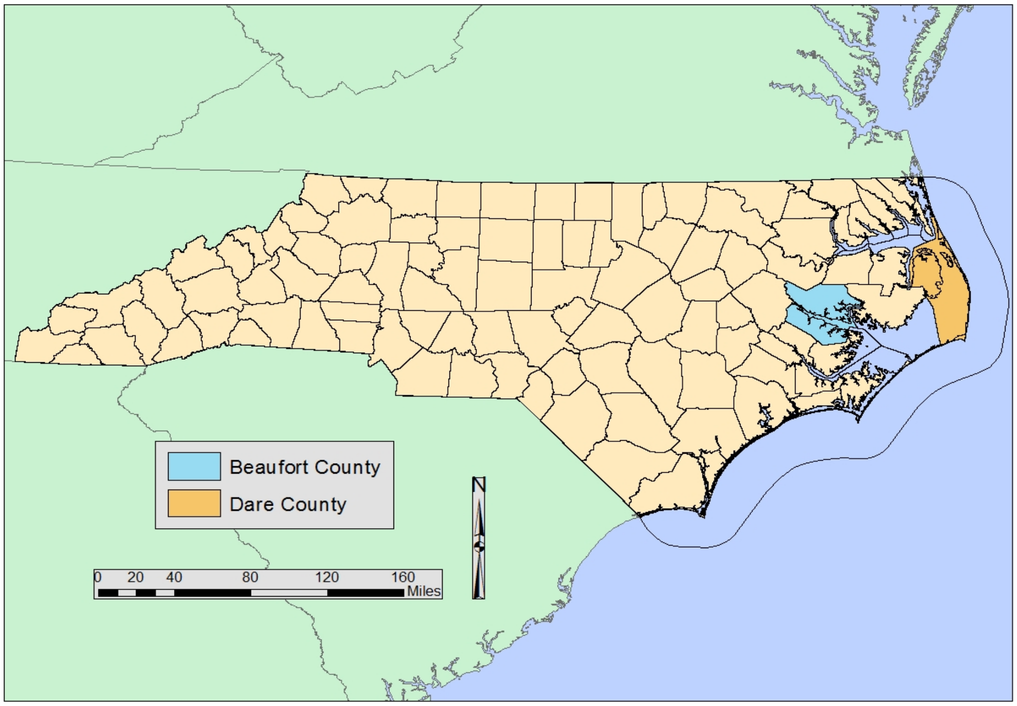

Figure 4.1: Study Area

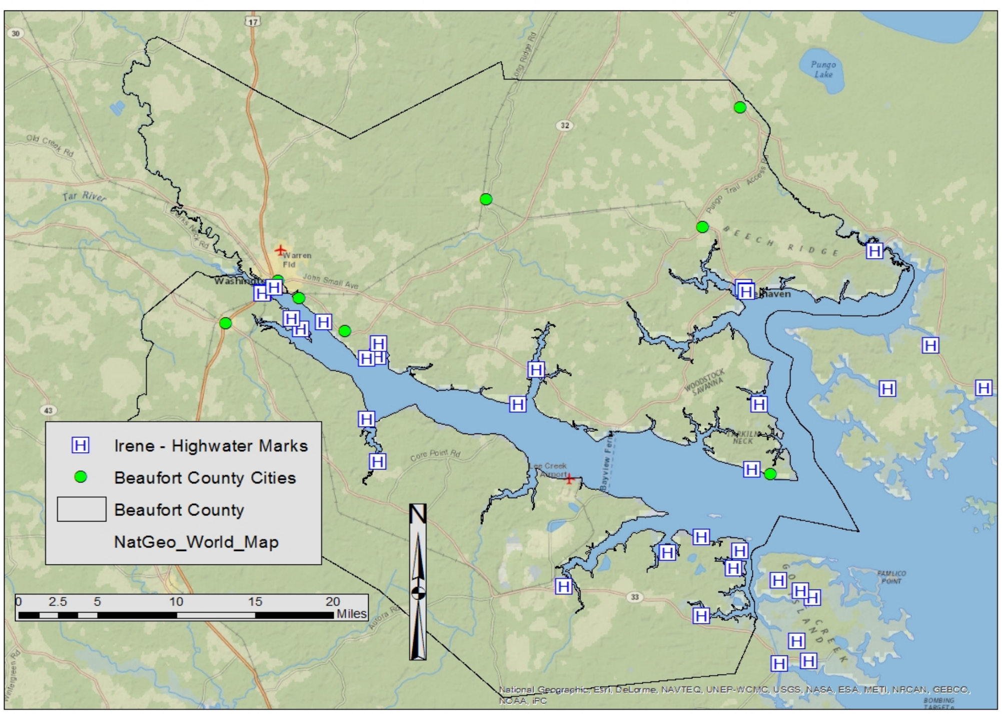

Figure 4.2: USGS High-water Marks in Beaufort County

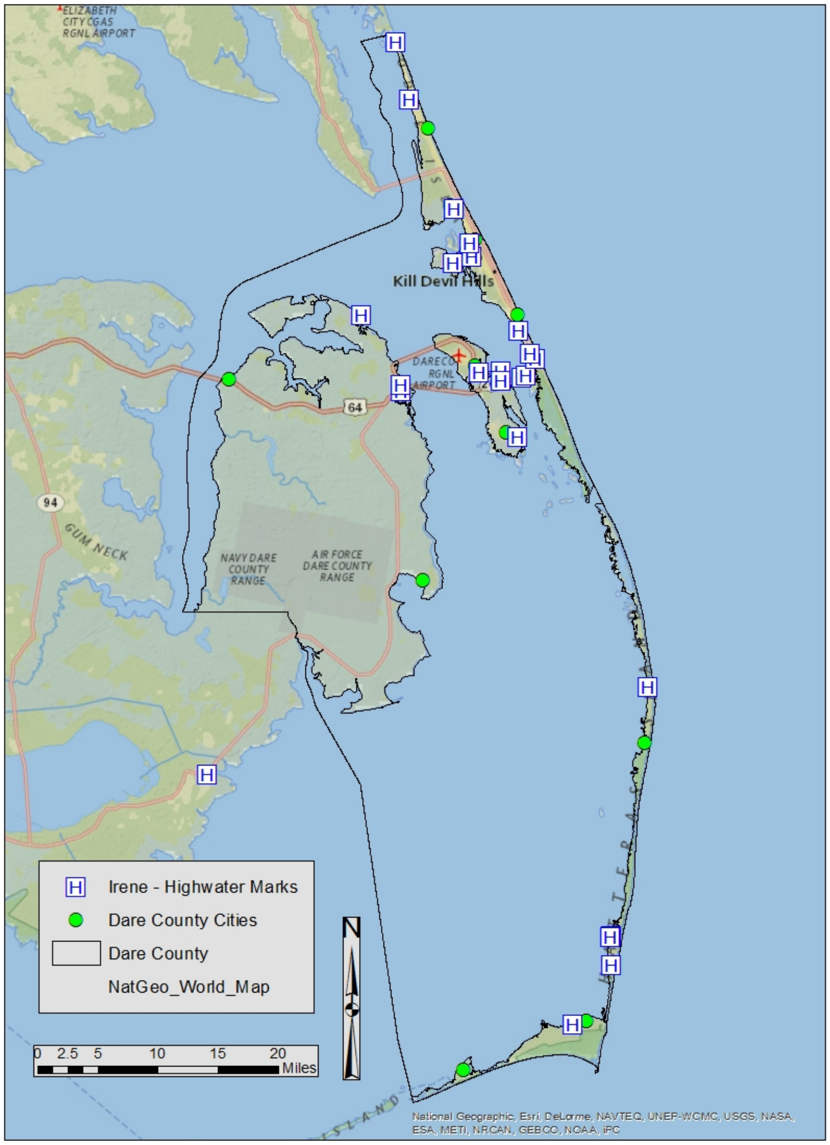

Figure 4.3: USGS High-water Marks in Dare County

With the two counties selected for the study, the next step was to choose different areas within each county for sampling. To do this, the emergency managers for each county were consulted with respect to the areas of the counties that received the greatest damage and the least damage. The emergency manager for Beaufort County, John Pack, indicated that the areas around Aurora, Pamlico Beach, and Belhaven suffered the greatest damage from Hurricane Irene while Washington and Chocowinity received the least damage (Figure 4.4). The emergency manager for Dare County, Sandy Sanderson, indicated that towns south of the Oregon Inlet, such as Avon and Rodanthe, suffered heavy damage associated with the storm while towns north of the Inlet, including Nags Head and Duck, received little to no damage (Figure 4.5). Thus, the areas selected for this project are the areas around Aurora, Belhaven, Washington, and Chocowinity in Beaufort County and the areas between Avon and Rodanthe and between Nags Head and Duck in Dare County.

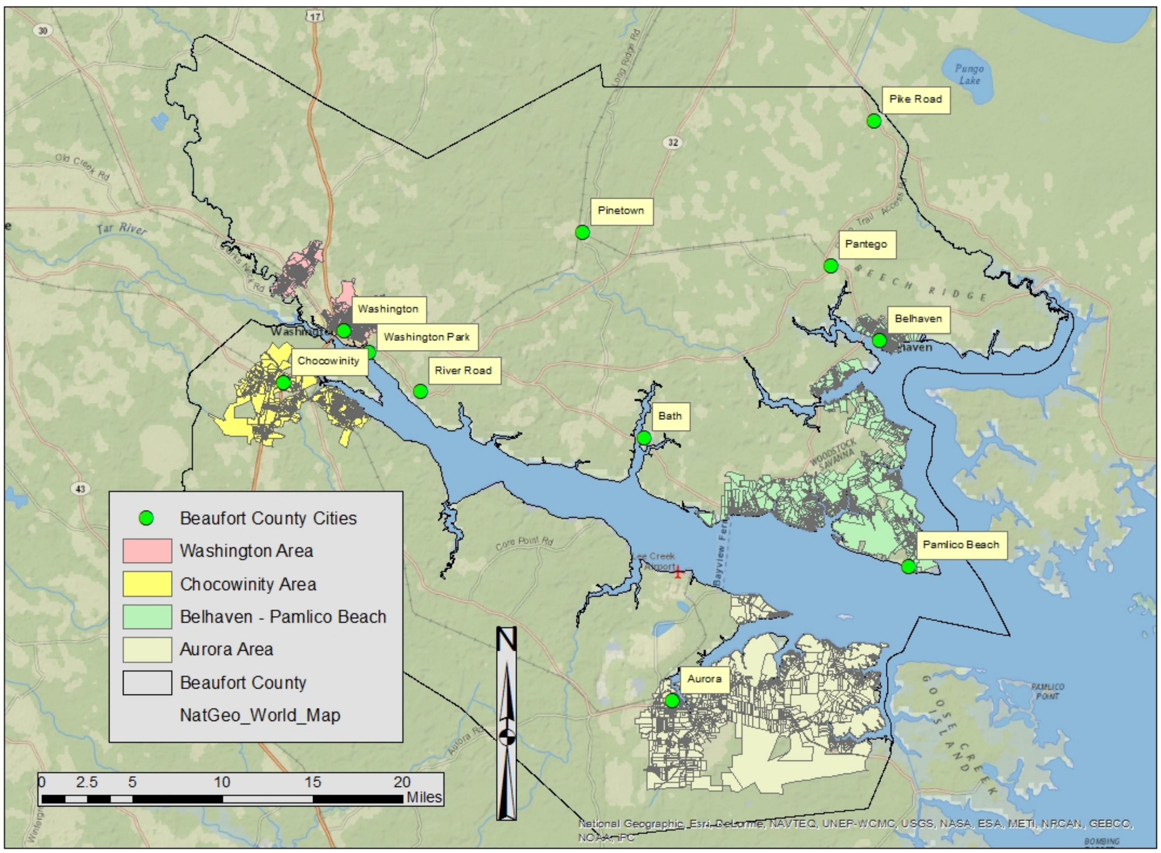

Figure 4.4: Beaufort County Parcels

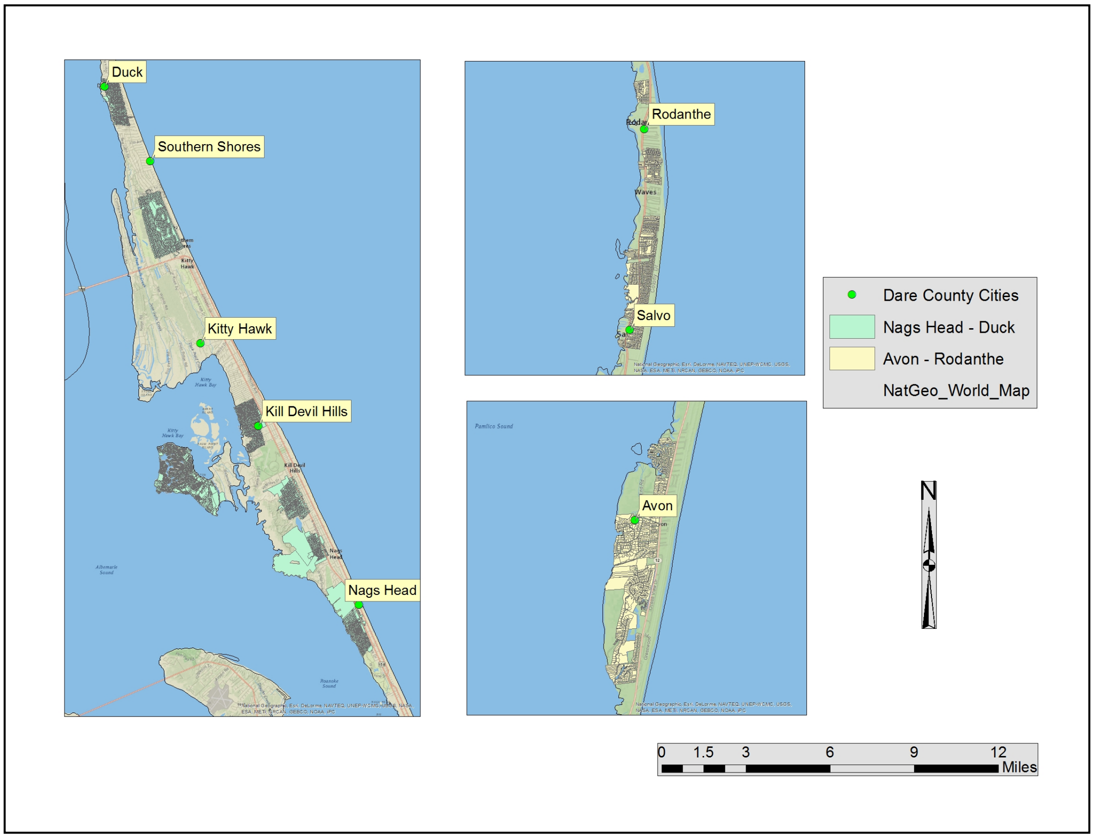

Figure 4.5: Dare County Parcels

4.2. Data Collection

To collect data on the perception of hurricane risk, it was determined that a survey would be the most effective, and previous studies have shown that surveys are capable of revealing perceptions (Baker 1979; Dow and Cutter 1998; Dow and Cutter 2000; Bateman and Edwards 2002; Brody et al. 2004; Beatley and Brower 2008; Lindell and Hwang 2008; Brommer and Senkbeil 2010). Since the study uses human subjects, East Carolina University's Institutional Review Board (IRB) certified all members of the study and approved the study (Appendix A).

The survey was a thirty-three question instrument that included both traditional questions that elicit socio-economic background of the participants and questions to address how their perceptions of risk to hurricanes changed with the change in track and intensity (Appendix B).

To address the perceptions of risk, a Likert Scale was used. This scale was used not only to measure perceived risk to storm surge, flooding, and wind but also changes in risk perception due to changes in the hurricane's track and intensity. To address the effect on perception of the change in the hurricane's track, the survey included three graphics that illustrated the forecasted track and cone of uncertainty, as the storm progressed

Each graphic represents an official advisory from the National Hurricane Center (NHC) and the three advisories were chosen based on official weather briefings from the local NWS office in Newport, NC. The advisories chosen were Advisory 16 issued on August 24, 2011, Advisory 20 issued on August 25, and Advisory 23 issued on August 26. The graphics were created using the geographic information system (GIS) products from the NHC. Data on the forecasted track and cone of uncertainty were downloaded and, through the use of the GIS program ArcMap from ESRI, graphics were created showing the forecasted track from each advisory.

Once the survey was created, a pilot was conducted to address any issues with the survey. After the pilot was completed, the comments and suggestions were used to finalize the survey for distribution.

With the survey in its final form, the next step was to determine the method for distributing the survey. It was decided that the survey would be distributed after September 1st, 2012, in order to avoid surveying vacationers or other non-permanent residents who typically would have not been in the area when Hurricane Irene made landfall. Given the number of surveys to be distributed to residents, the mail-out, mail-back format was used (Dillman 2000). While this was determined to be the best method for the survey distribution, there are notable drawbacks for using this method which include the possibility of low return rates and the year difference between the storm's landfall and the survey, which could affect the ability of residents to recall the event (Bird 2009).

The potential participants of the survey were year-round residents of both Dare and Beaufort Counties. Using GIS parcel data for each county, addresses from each of the six focus areas were selected. Next, the parcels from each area were randomized using the statistical program SPSS. These randomly selected parcels were used to identify year-round residents within each county by comparing the parcel address with the mailing address of the owner. However, some of the selected parcels are located outside of city limits on the state secondary roads. This was evident in the parcel data from Beaufort County, which used the secondary road number for the parcel address instead of the road name. This posed a problem when comparing the parcel addresses with the mailing address because the secondary road numbers use the SR designation followed by a series of numbers and not the name of the road which is found in the mailing address. To address this issue, a database of secondary road numbers and the corresponding road names was downloaded from the North Carolina Department of Transportation (NCDOT) and was used to compare the secondary road numbers with the road names in the mailing addresses (NCDOT, 2012).

With the target audience chosen, the next step was to determine the number of surveys to distribute to the study area. Six hundred and one surveys were sent out to the study areas with 301 surveys mailed out to selected parcels of Beaufort County and 300 surveys mailed to selected parcels of Dare County. Within, each county the selected study areas were divided into two damage categories, one representing the areas damaged from storm surge and one representing areas that were affected only by wind or had no damage at all. This was done to provide another locational factor to examine if residents in those areas had altered perceptions of risk based on the changes in track and in intensity of the storm. Thus three factors are used to address location in this study.

The first is the location of the Inner Banks and Outer Banks. The second is the damage type associate with Irene, either storm surge or wind related damage. The final factor uses the combination of location and damage areas, i.e. Inner / storm surge, Inner / wind, Outer / storm surge, and Outer / wind.

For Beaufort County, the parcels that were selected to represent the storm surge damage areas are located the Belhaven and Aurora areas and parcels in the Washington and Chocowinity areas represent wind damage areas. The 301 surveys in Beaufort were distributed as follows: Belhaven received 78 surveys, Aurora received 72 surveys, Chocowinity received 74 surveys, and Washington received 77 surveys. This was done to distribute the surveys evenly between the two types of damage areas. This same procedure was used for the 300 surveys sent to Dare County. The areas between Avon and Rodanthe represent the storm surge area for Dare County and the areas between Nags Head and Duck represent the wind areas. Three hundered surveys were distributed with 148 surveys mailed to the residents in the Nags Head – Duck area and 152 surveys mailed to the Avon – Rodanthe area.

To identify the location of the returned surveys while protecting the respondents' anonymity, a code was used on the return envelope. The code used letter designations for the location of the survey, the damage type, and the area within the county from which the survey came. Table 4.1 shows the codes used for the return envelopes. It was also necessary during the analysis stage to combine the area codes (A, B and C,W) based on damage type for Beaufort County. This was done so locational differences in risk perception between the storm surge damage areas and wind damage areas for both the Inner Banks and the Outer Banks could be analyzed.

Return Envelope Code					
Location		Damage		Area	
Inner Banks	I	Wind	W	Aurora	A
Outer Banks	O	Storm Surge	S	Belhaven	B
				Chocowinity	C
				Washington	W
				North*	N
				South*	S

Table 4.1: Code for Return Envelopes
* Reference to the Oregon Inlet

Of the 601 surveys that were sent out, 185 surveys were completed and returned to the principal investigator, providing an overall response rate of 31 percent. The response rate for each of the areas is Aurora 34 percent, Belhaven 28 percent, Chocowinity 37 percent, the Nags Head – Duck area 32 percent, the Avon – Rodanthe area 26 percent, and Washington 28 percent. Two areas, the area around Belhaven and the Avon – Rodanthe area, had lower response rates compared to the others. To help generate more responses from those areas, reminder cards were sent out in late October asking potential participants if they were still willing to participate in the study and reminding them to return the completed survey by November 9, 2012. However, reminder cards did not generate additional responses from those areas.

The socio-economic make-up of the survey respondents was compared to the census data for the block groups for the focus areas in each county (Table 4.2). Overall, the respondents were older white males with college degrees and higher incomes. These results suggest that a majority of the respondents were retirees. However, with the exception of race, the characteristics of the survey respondents did not match the socio-economic composition of the areas based on the census data; thus, is not very representative.

Comparison of Demographic Factors						
	Gender	Age	Race	Income	Education	Tenure
Survey (Total)	Male (63.7)	50-69 (62.8%)	White (95.5%)	$100,000+ (28%)	College Grad (31.1%)	6-10 (33.2%)
Survey (Inner)	Male (64.2%)	50-69 (61.1%)	White (92.6%)	$60K-$79k (22.7%)	College/ C. Grad (57.4%)	6-10 (32.3%)
Survey (Outer)	Male (63.2%)	50-69 (64.8%)	White (98.8%)	$100,000+ (37.5%)	Grad/Professional (35.7%)	6-10 (34.1%)
Survey (Surge)	Male (69%)	50-69 (67.1%)	White (94%)	$100,000+ (30.4%)	Some College (28.2%)	6-10,21+ (60.4%)
Survey (Wind)	Male (59.2%)	50-69 (59.2%)	White (96.9%)	$100,000+ (25.8%)	C. Grad/ Grad Deg (70.2%)	6-10 (35.7%)
Survey (IBX - Surge)	Male (64.4%)	50-69 (64.4%)	White (91.1%)	$20k-$79k (66.6%)	Some College (35.6%)	6-10 (23.9%)
Survey (IBX - Wind)	Male (64%)	50-69 (58%)	White (93.9%)	$100,000+ (27.9%)	C. Grad/ Grad Deg (69.4%)	6-10 (40%)
Survey (OBX - Wind)	Male (54.2%)	50-69 (60.4%)	White (100%)	$60k-$79k (26.1%)	C. Grad/ Grad Deg (70.8%)	6-10 (31.2%)
Survey (OBX - Surge)	Male (74.4%)	50-69 (70%)	White (97.4%)	$100,000+ (55.9%)	Grad/Professional (40%)	6-10 (37.5%)
Aurora	Female (58%)	39.6	White (50%)	$38,918	High School Grad (54%)	
Belhaven	Female (51%)	46.9	White (74%)	$38,969	High School Grad (33%)	
Chocowinity	Male (50%)	44.9	White (73%)	$41,884	High School Grad (32%)	
Washington	Female (54%)	42.1	White (64%)	$34,970	High School Grad (36%)	
Avon-Rodanthe	Female (56%)	45.5	White (100%)	$39,050	Graduate Degree (26%)	
Nags Head - Duck	Male (51%)	45	White (95%)	$56,963	Some College (34%)	

Table 4.2: Comparison of Survey Respondents to Census Data: American Community Survey 2006-2010. Minnesota Population Center (2011). http://www.nhgis.org

4.3. Data Analysis

To analyze responses, the surveys were coded into an Excel spreadsheet. This spreadsheet was imported into the statistical program SPSS to test the association between different variables and risk perceptions of hurricanes. Table 4.3 shows the variables used to address the risk perceptions. Demographic variables were tested using discriminant analysis using risk perception as the dependent variable to predict which variables are able to discriminate between the categories of an increase, decrease, or no change in risk perception. Using a stepwise process to select which variables would discriminate between categories, no other variable besides location was chosen for the model that was able to discriminate between the risk perception categories.

Risk Perception Variables	
RSURG	Perception of risk to storm surge prior to Irene
RFLD	Perception of risk to flooding prior to Irene
RWIND	Perception of risk to hurricane winds prior to Irene
RAD 16	Percepton of risk at Advisory 16
RAD 20	Perception of risk at Advisory 20
RAD 23	Perception of risk at Advisory 23
RTRACK	Change in risk due to changes in storm track
LVLPER	Change in risk due to changes in storm intensity
RCHANGE	Changes in risk between Advisory 16 and 23

Table 4.3: Variables Used to Explore Variation in Risk Perception

Within SPSS, Chi Square was used to test the associations between location and the different risk perception variables highlighted in Table 4.3. The Chi Square statistic has been used in other studies to examine perception (Baker 1979; Beatly and Brower 1986; Dow and Cutter 1998, 2000). As mentioned earlier, the locations examined in this study are the Inner and Outer Banks and the storm surge and wind damage areas. During the first attempt to test the association between the risk variables and the location variables, several variables had expected count of less than five. This is a problem since one of the assumptions when conducting a Chi Square test is that the expected count must be greater than five (Michael 2001). To solve this problem, the categories that range from very low risk to moderate risk were combined to form aggregate categories so the expected counts would be greater than five and it would allow for differentiation between individuals who believe they were at “very high” and “high risk” and those who believe they were at “very low” to “moderate risk”. The aggregation of the lower risk categories also helps with the variables on how storm characteristics change individual risk perception.

CHAPTER 5 : RESULTS

This chapter is divided into sections that address the research questions for this study. First, results for how risk perception varies with location are presented. Second, the influence of the physical changes in the hurricane on risk perceptions is addressed to determine if coastal residents' perceptions of hurricane risk were altered by the change in track and intensity of Hurricane Irene. As noted previously, location was assessed in three ways: 1) location on the Inner Banks or the Outer Banks (Location); 2) damage from either storm surge or wind (Damage Area); and 3) a combination of the first two to create, Inner Banks / wind, Inner Banks / storm surge, Outer Banks / wind, and Outer Banks / storm surge (Area).

5.1. Risk Perception

5.1.1. Inner Banks and Outer Banks Locations

Perceptions of risk associated with two of the hurricane advisories (16 and 23) showed significant differences between the Inner and Outer Banks. Table 5.1 shows the results for the Chi Square test for risk perceptions at Advisory 16 (RAD16). Just over 71% of the surveyed residents on the Inner Banks believed that they were at "low to moderate risk" compared to 47% of the Outer Banks. This suggests that, at three days before landfall, residents of the Outer Banks believed that they were at greater risk to the hurricane than did residents of the Inner Banks. The other variable that was significant was risk perception at Advisory 23 (RAD 23). Results show that 74% of the residents of the Inner Banks believed that they were at "high to very high risk" while 49% of the Outer Banks believed this (Table 5.2). Thus the day before landfall, residents of the Inner Banks believed that they were at greater risk from the hurricane than did the residents of the Outer Banks, representing an interesting shift from the Advisory 16 results.

Risk at Advisory 16 (RAD16)				
Location	Moderate - Low Risk		Very High - High Risk	
Inner Banks	69	71.10%	28	28.90%
Outer Banks	40	47.10%	45	52.90%
Total	109	59.90%	73	40.10%

X^2=10.931, df=1, ρ<.001

Table 5.1: Chi Square for Advisory 16 Based on Location

Risk at Advisory 23 (RAD23)				
Location	Moderate - Low Risk		Very High - High Risk	
Inner Banks	24	25.30%	71	74.70%
Outer Banks	43	50.60%	42	49.40%
Total	67	37.20%	113	62.80%

X^2=12.313, df=1, ρ<.000

Table 5.2: Chi Square for Advisory 23 Based on Location

None of the other variables were significant, including perception of risk to storm surge (RSURG), flooding (RFLD), hurricane force winds (RWIND), as well as risk perception at Advisory 20 (RAD20). Results for perceptions of risk to storm surge and flooding, while insignificant (i.e. location did not matter), suggest that respondents from both the Inner Banks and the Outer Banks believed that prior to the storm, they were at "moderate to low risk" with more than 70% indicating this. Thus, regardless of location, respondents believed that they were at low risk to flooding prior to Hurricane Irene. The results for perception of risk to hurricane force winds are somewhat different. In both locations, respondents were equally split between believing they were at "low to moderate risk" and at "high to very risk" to wind, i.e. again no difference between locations.

5.1.2. Wind and Storm Surge Damage Areas

When comparing damage-type areas, there are four significant differences in perception. The results from perceived risk to storm surge (RSURG) indicate that 75% of the residents surveyed in storm surge damage areas and 90% of residents in wind damage areas believed they were at “low to moderate risk” to storm surge (Table 5.3). Only 25% of those in the storm surge damage area rated their risk to storm surge as “very high to high”. The results for perceived risk to flooding (RFLD) show that 70% in the storm surge area and 86% in the wind areas believed they were at “low to moderate risk” to flooding (Table 5.4). It is interesting that a larger percent of those in the storm surge area saw themselves at risk to flooding (30%) than they did to storm surge (26%).

Risk to Storm Surge (RSURG)				
Damage	Moderate - Low Risk		Very High - High Risk	
Storm Surge	64	74.40%	22	25.60%
Wind	87	89.70%	10	10.30%
Total	151	82.50%	32	17.50%

X^2=7.369, df=1, ρ<.007

Table 5.3: Chi Square for RSURG Based on Damage Area

Risk to Flooding (RFLD)				
Damage	Moderate - Low Risk		Very High - High Risk	
Storm Surge	61	70.10%	26	29.90%
Wind	84	85.70%	14	14.30%
Total	145	78.40%	40	21.60%

X^2=6.618, df=1, ρ<.010

Table 5.4: Chi Square for RFLD Based on Damage Area

The results for the Chi Square test for perception of risk to hurricane force winds (RWIND) are shown in Table 5.5. Just over 63% of the residents surveyed in storm surge areas believed that they were at “very high to high risk” to hurricane force winds compared to only 36% of the residents of the wind damage areas. This is troubling in that it suggests that more residents of the storm surge areas believed they were at greater risk to wind than did the residents of the wind damage areas.

Risk to Hurricane Force Wind (RWIND)				
Damage	Moderate - Low Risk		Very High - High Risk	
Storm Surge	32	36.80%	55	63.20%
Wind	63	64.30%	35	35.70%
Total	95	51.40%	90	48.60%

X^2=13.956, df=1, ρ<.000

Table 5.5: Chi Square for RWIND on Damage Area

In contrast to the results for the Inner Banks and Outer Banks, perceived risk at Advisory 20 (RAD 20) showed significant results when tested by damage area (Table 5.6). In this case, nearly 71% of the residents within the storm surge damage areas believed they were at “high to very high risk,” while residents in the wind damage areas were evenly split between risk levels. This suggests that two days prior to Hurricane Irene’s landfall, more residents of the storm surge damage areas believed they were at higher risk to Hurricane Irene than did residents of the wind areas.

Risk at Advisory 20 (RAD20)				
Damage	Moderate - Low Risk		Very High - High Risk	
Storm Surge	25	29.10%	61	70.90%
Wind	50	51.00%	48	49.00%
Total	75	40.80%	109	59.20%

$X^2=9.140$, df=1, $\rho<.003$

Table 5.6: Chi Square for Advisory 20 Based on Damage Area

The other variables tested were perceived risk at Advisory 16 (RAD16) and Advisory 23 (RAD23). A majority of residents in both damage areas believed they were at "low to moderate risk" at Advisory 16 and at "high to very high risk" at Advisory 23, indicating that perception changed, irrespective of location, as the storm developed.

5.1.3. Location and Damage Area

Most of the risk perception variables showed significant associations with this locational delineation. The results for perceived risk to storm surge (RSURG) indicate that more than 70% of all respondents, irrespective of location or eventual damage, believed themselves to be at "low to moderate risk" (Table 5.7). However, comparing the residents of wind damage areas of the Inner Banks and Outer Banks, 95% of the respondents in the Inner Banks wind area believed that they were at "low to moderate risk" to storm surge, while 85% of the Outer Banks wind respondents believed the same. Compared to the respondents in the wind areas in both locations, a larger percentage of respondents in the storm surge damage areas perceived their risk to be "high to very high". Yet, this accounted for only 30% of the respondents in both the Inner and Outer Banks.

Risk to Storm Surge (RSURG)				
Area	Moderate - Low Risk		Very High - High Risk	
Inner Storm Surge	33	71.70%	13	28.30%
Inner Wind	47	94.00%	3	6.00%
Outer Wind	40	85.10%	7	14.90%
Outer Storm Surge	31	77.50%	9	22.50%
Total	151	82.50%	32	17.50%

X^2=9.189, df=3, ρ<.027

Table 5.7: Chi Square for RSURG Based on Area

The results for perceived risk to flooding (RFLD) show, again, the majority of those surveyed believed that they were at “low to moderate risk” to flooding, although the percentages vary with locations (Table 5.8). Respondents in the storm surge damage areas of the Inner Banks and the Outer Banks believed they are at “low to moderate risk” to flooding. When comparing the Inner Banks wind areas to the Outer Banks wind areas, 86% of the surveyed residents in the Inner Banks wind damage areas and 85% of the residents of the Outer Banks wind damage areas believed they were at “low to moderate risk” to flooding. Compared to residents of the wind damage areas, a larger percentage of respondents in the storm surge damage areas in both locations indicated that they perceived their risk to be “high to very high” (30% on the Inner Banks and 25% on the outer Banks). The differences are not so much between the Inner and Outer Banks but rather between damage areas, and these results are significant at the .053 significance level.

Risk to Flooding (RFLD)				
Area	Moderate - Low Risk		Very High - High Risk	
Inner Storm Surge	31	66.00%	16	34.00%
Inner Wind	43	86.00%	7	14.00%
Outer Wind	41	85.40%	7	14.60%
Outer Storm Surge	30	75.00%	10	25.00%
Total	145	78.40%	40	21.60%

X^2=7.665, df=3, ρ<.053

Table 5.8: Chi Square for RFLD Based on Area

The results of the Chi Square test for perceived risk to hurricane force winds (RWIND) are shown in Table 5.9. Almost 64% of the surveyed residents in the Inner Banks storm surge damage areas believed they were at “high to very high risk” to hurricane force winds and similarly, 63% of the residents of the Outer Banks storm surge damage areas believed the same. This suggests that there is no difference in the perception of risk to hurricane force winds between the storm surge areas of the both the Outer Banks and the Inner Banks. In addition, 32% of the Inner Banks wind damage area residents and 40% of the Outer Banks wind damage area residents believed they were at “high to very high risk” to hurricane force winds. Thus, those who reside in the areas that experienced wind damage on both the Inner and Outer Banks did not perceive their risk to be high, while those in the storm surge damage areas did.

Risk to Hurricane Force Wind (RWIND)				
Area	Moderate - Low Risk		Very High - High Risk	
Inner Storm Surge	17	36.20%	30	63.80%
Inner Wind	34	68.00%	16	32.00%
Outer Wind	29	60.40%	19	39.60%
Outer Storm Surge	15	37.50%	25	62.50%
Total	95	51.40%	90	48.60%

X^2=14.535, df=3, ρ<.002

Table 5.9: Chi Square for RWIND Based on Area

With respect to Advisory 16 (RAD16), the results suggest that there is a significant difference in risk perception between the damage areas based on location (Table 5.10). For the residents surveyed in the storm surge areas of the Inner Banks, 66% believed that they were at "low to moderate risk", while only 39% of the residents of the Outer Banks storm surge areas believed the same. This result reinforces the finding from the Chi Square test on the Inner Banks and Outer Banks variable because it suggests that a majority of the Inner Banks respondents believed themselves to be at lower risk than the residents of the Outer Banks three days before Irene's landfall. When examining the wind areas for both locations, the results are a little different. Unlike the difference in risk perception for the storm surge areas of the Outer and Inner Banks, a majority of the residents of the wind areas of the both the Outer and Inner Banks believed they were at low to moderate risk. Some 76% of the residents surveyed in the wind damage areas of the Inner Banks believed they were at "low to moderate risk" while 54% of the Outer Banks residents believed the same. Thus, while a majority in both areas believed they were at low risk, more residents of the Outer Banks (46%) believed that they were at "high to very high risk" three days before landfall than did those in the Inner Banks (25%). These results are significant at the .003 significance level.

Risk at Advisory 16 (RAD16)				
Area	Moderate - Low Risk		Very High - High Risk	
Inner Storm Surge	31	66.00%	16	34.00%
Inner Wind	38	76.00%	12	24.00%
Outer Wind	35	54.30%	21	45.70%
Outer Storm Surge	15	38.50%	24	61.50%
Total	109	59.90%	73	40.10%

X^2=14.165, df=3, ρ<.003

Table 5.10: Chi Square for Advisory 16 Based on Area

Table 5.11 shows the results of the Chi Square test for damage area for each location and risk at Advisory 20 (RAD20). While residents of the storm surge areas of the Inner Banks and Outer Banks believed they were at greater risk two days before Irene's landfall, the same cannot be said for those in the wind damage areas. On the Inner Banks, 46% of the wind damage area residents perceived themselves to be at "high to very high risk" compared to 52% of the wind damage area residents of the Outer Banks. These results, which are significant at the .028 level, suggest that the residents of both locations perceived themselves to be at higher risk as the event progressed, but that there are differences in perceptions of storm surge and wind area residents.

Risk at Advisory 20 (RAD20)				
Area	Moderate - Low Risk		Very High - High Risk	
Inner Storm Surge	14	29.80%	33	70.20%
Inner Wind	27	54.00%	23	46.00%
Outer Wind	23	47.90%	25	52.10%
Outer Storm Surge	11	28.20%	28	71.80%
Total	75	40.80%	109	59.20%

X^2=9.537, df=3, ρ<.028

Table 5.11: Chi Square for Advisory 20 Based on Area

A significant difference, at .002, is seen between the damage areas and the Inner and Outer Banks, as the storm neared landfall (Table 5.12). With Advisory 23, the residents of both damage areas of the Inner Banks believed they were at greater risk to the hurricane than did the respondents on the Outer Banks. This was especially the case with the storm surge damage areas, reflecting perhaps the recognition that the track had shifted toward the Inner Banks. This is addressed more specifically in the next section.

Risk at Advisory 23 (RAD23)				
Area	Moderate - Low Risk		Very High - High Risk	
Inner Storm Surge	8	17.40%	38	82.60%
Inner Wind	16	32.70%	33	67.30%
Outer Wind	25	54.30%	21	45.70%
Outer Storm Surge	18	46.20%	21	53.80%
Total	67	37.20%	113	62.80%

X^2=15.284, df=3, ρ<.002

Table 5.12: Chi Square for Advisory 23 Based on Area

5.2. Risk Perception and Track Change

To examine the influence of track change on risk perception, several questions were asked regarding whether the respondents were aware of the track change, how much did it change their perception of risk, and how the track change would influence the hazards associated with hurricanes (i.e. wind, flooding, storm surge). Most respondents, nearly 95%, reported that they were aware of the change (ATRACK) (Table 5.13). Of course, this percent could be the result of the respondents seeing the track change on the images provided in the survey, though no mention was made of the track changes with respect to the Advisories. Even with this, there are some differences in perceptions, based on location variables, as shown in the next sections.

Aware of Track Change (ATRACK)	
Answer	Percent
No	2.70%
Yes	94.50%
Don't Recall	2.70%

Table 5.13: Percentage of Response to ATRACK

5.2.1. Inner Banks and Outer Banks Locations

The results of risk perception based on track change (RTRACK) show that 100% of the residents surveyed in the Inner Banks believed they were at least at "somewhat greater risk" due to the track change while this was reported by only 58% of the residents of the Outer Banks (significant at the .000 significance level) (Table 5.14). This is not a surprising finding because, as the storm moved closer to land, the track shifted from being more centered on the Outer Banks at Advisory 16 to the track moving over the Inner Banks at Advisory 23. Thus, the changes in perception at both locations make sense.

Risk Perception based on Track Change (RTRACK)								
Location	Less Risk		Somewhat More Risk		More Risk		Much More Risk	
Inner Banks	0	0.00%	23	25.00%	39	42.40%	30	32.60%
Outer Banks	33	41.80%	12	15.20%	23	29.10%	11	13.90%
Total	33	19.30%	35	20.50%	62	36.30%	41	24.00%

$X^2 = 48.684$, df = 3, ρ<.000

Table 5.14: Chi Square for RTRACK Based on Location

As described in the Methods Chapter, overall change in risk perception was measured by subtracting the score on the Likert scale for Advisory 16 from Advisory 23. This shows a distinct and significant (at .000) difference between the Inner Banks and the Outer Banks (Table 5.15), with 65% of the respondents in the Inner Banks having an increase in risk perception between advisories 16 and 23, and 78% of the residents of the Outer Banks either having a decrease or no change in risk perception. These results are not surprising and are also supported by the change in track over the course of the official advisories because, over time as the track shifted to the west, the residents of the Inner Banks perceived themselves to be at more risk from the storm than did the residents of the Outer Banks.

Change in Risk Perception (RCHANGE)						
Location	Increase		No Change		Decrease	
Inner Banks	62	65.30%	33	34.70%	0	0.00%
Outer Banks	18	21.70%	41	49.40%	24	28.90%
Total	80	44.90%	74	41.60%	24	13.50%

X^2=48.476, df=2, ρ<.000

Table 5.15: Chi Square for RCHANGE based on Location

The respondents were also asked about how they thought the track change would influence the various hazards associated with the storm. Based on the track change, a majority of the residents of the Inner Banks (over 80%) believed that there would be more storm surge, while the residents of the Outer Banks were equally split between more and less storm surge (Figure 5.1). When looking at the anticipated effect of track change on wind, respondents from both the Inner Banks (100%) and the Outer Banks (over 60%) believed the track change would lead to an increase in wind speed (Figure 5.2). With respect to flooding, residents of both the Inner Banks (over 80%) and the Outer Banks (over 60%) believed that there would be more flooding with the change in track (Figure 5.3). Overall, then, respondents on both the Inner and Outer Banks anticipated an increase in wind and flooding as the track changed. The results were different for storm surge, where those on the Outer Banks believed it would be less of a hazard. Also, the different response for flooding and storm surge suggests that the respondents were able to differentiate between the two hazards.

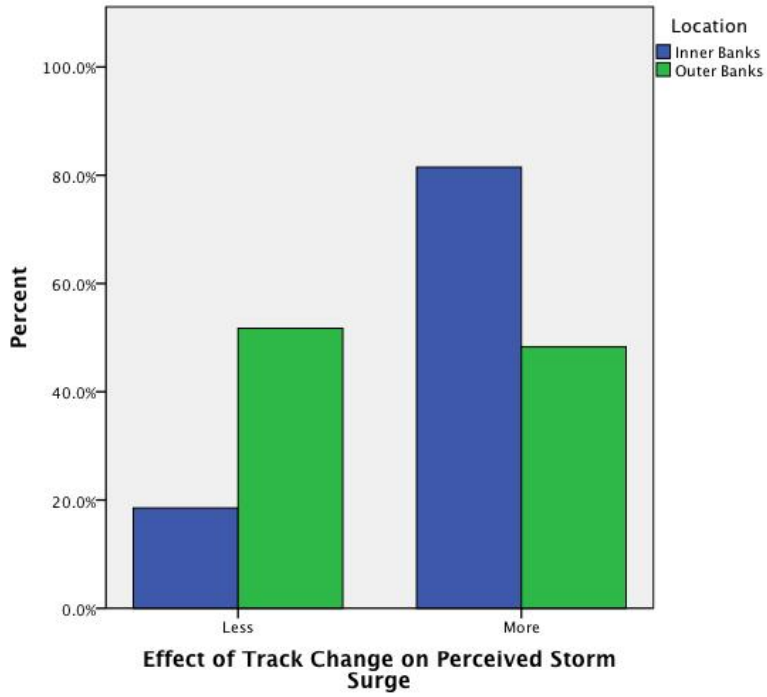

Figure 5.1

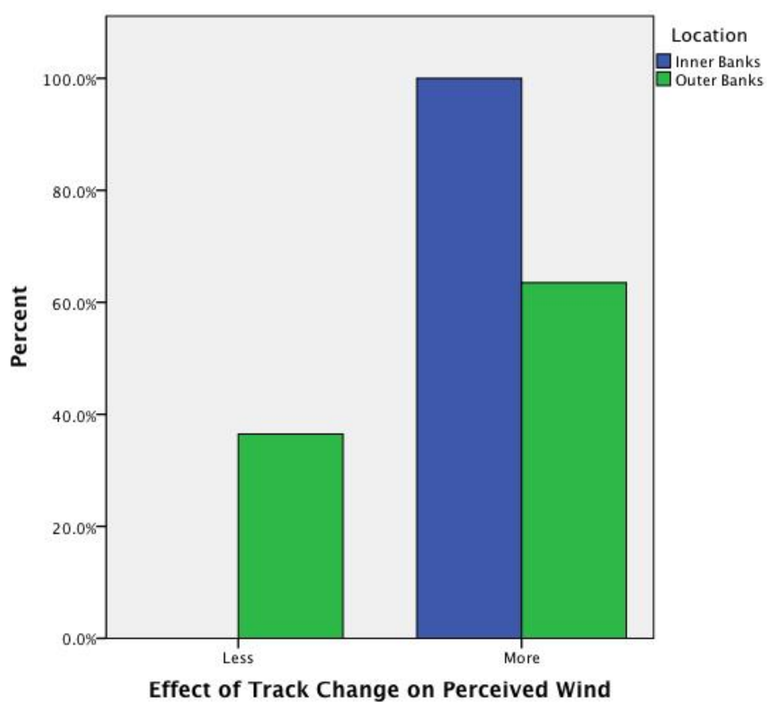

Figure 5.2

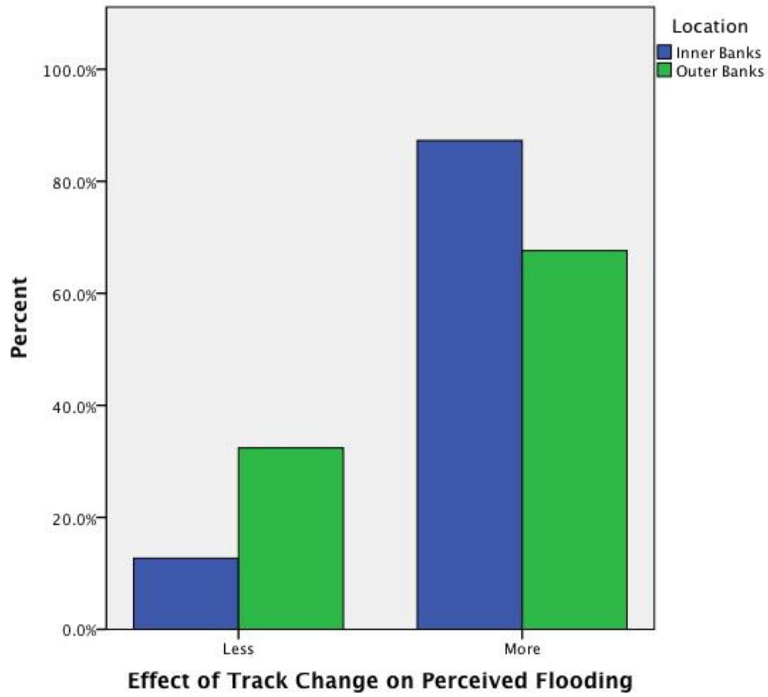

Figure 5.3

5.2.2. Storm Surge and Wind Damage Areas

No significant difference was found when testing for an association between damage area and risk perception, track change, or change in risk perception. More than 80% of all respondents perceived themselves to be at least at "somewhat more risk" and some 85% showed an increase or no change in perceived risk.

When asked about how much the change in track would affect storm surge, a majority of the respondents believed that there would be an increase in storm surge (Figure 5.4) as indicated by over 65% of the residents of the storm surge areas and 60% of the residents of the wind areas. There is little difference between the damage areas when addressing the anticipated effect of track change on wind (Figure 5.5) or on flooding (Figure 5.6). Overall, a large majority of respondents from both damage areas anticipated greater storm surge, wind, and flooding with the change in track.

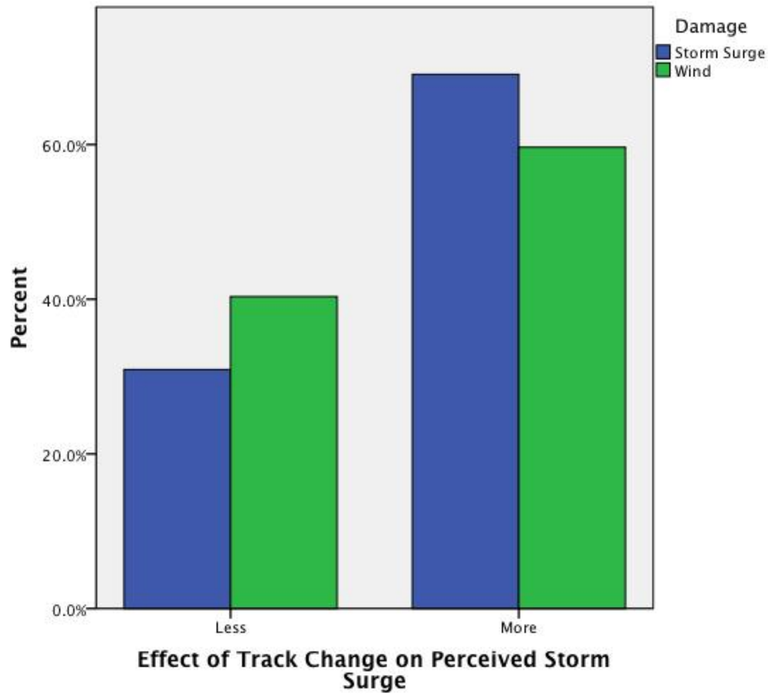

Figure 5.4

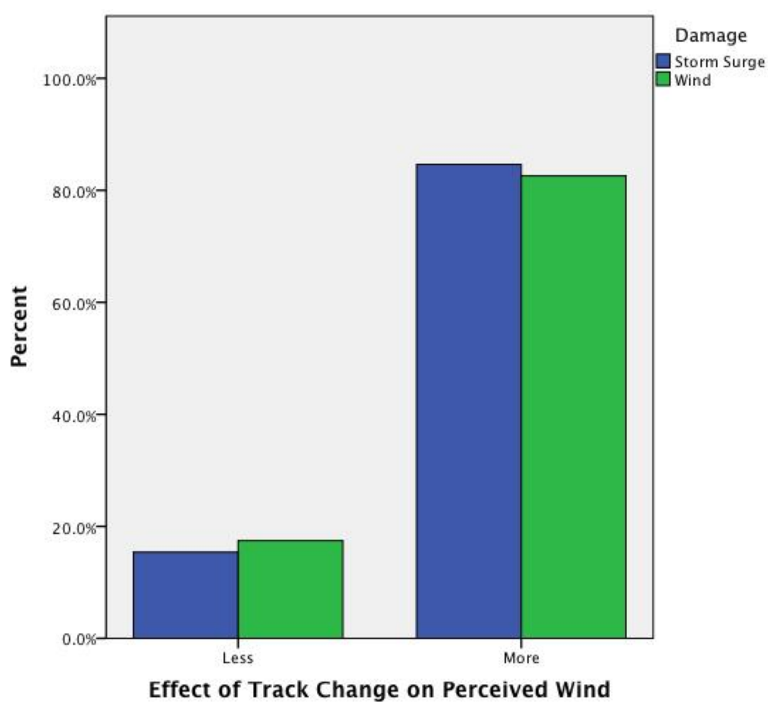

Figure 5.5

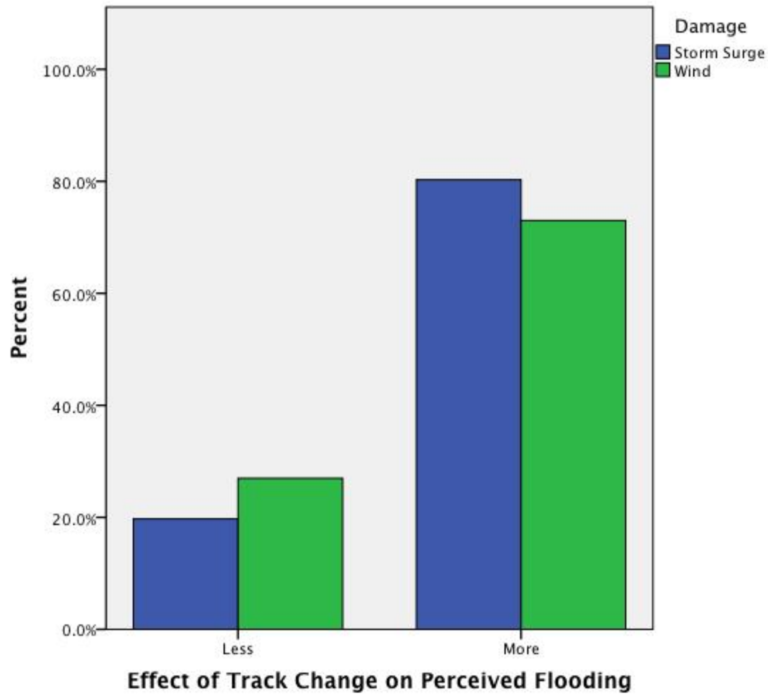

Figure 5.6

5.2.3. Location and Damage Area

The Chi Square tests for risk perception based on Track Change (RTRACK) show a distinct difference between the storm surge and wind areas of the Outer Banks and the Inner Banks (Table 5.16). The results show that 100% of the respondents in the storm surge area of the Inner Banks believed they were at least at "somewhat more risk" due to the track change, while only 57% of the respondents in the storm surge area of the Outer Banks indicated the same. When comparing the wind damage areas of both the Inner and Outer Banks, similar results are found. Again, the results show that 100% of the respondents of the Inner Banks wind areas believed they were at least at "somewhat more risk" based on the track change, while nearly 56% of the respondents in the Outer Banks wind area believed the same.

Risk Perception based on Track Change (RTRACK)								
Area	Less Risk		Somewhat More Risk		More Risk		Much More Risk	
Inner Storm Surge	0	0.00%	9	19.60%	18	39.10%	19	41.30%
Inner Wind	0	0.00%	14	30.40%	21	45.70%	11	23.90%
Outer Wind	17	40.50%	8	19.00%	13	31.00%	4	9.50%
Outer Storm Surge	16	43.20%	4	10.80%	10	27.00%	7	18.90%
Total	33	19.30%	35	20.50%	62	36.30%	41	24.00%

X^2= 54.721, df=9, ρ<.000

Table 5.16: Chi Square for RTRACK Based on Area

The Chi Square results for change in risk perception (RCHANGE) are presented in Table 5.17. It can be seen that 67% of the residents in the storm surge damage area of the Inner Banks had an increase in risk perception, while only 13% of the residents in the storm surge damage area of the Outer Banks had an increase. When comparing the wind areas of both the Inner and Outer Banks, the results are similar. In this case, 63% of the respondents in the wind damage areas of the Inner Banks showed an increase in risk perception, while only 30% of the respondents in the wind damage areas of the Outer Banks had an increase. This again suggests that residents of the Inner Banks had an increase in perceived risk between advisory 16 and advisory 23. In addition, more residents of the wind damage areas of the Outer Banks (30%) had an increase in risk perception than did the residents of the Outer Banks storm surge damage area (13%). These results are significant at the .000 significance level (Table 5.17).

Change in Risk Perception (RCHANGE)						
Area	Increase		No Change		Decrease	
Inner Storm Surge	31	67.40%	15	32.60%	0	0.00%
Inner Wind	31	63.30%	18	36.70%	0	0.00%
Outer Wind	13	29.50%	20	45.50%	11	25.00%
Outer Storm Surge	5	12.80%	21	53.80%	13	33.30%
Total	80	44.90%	74	41.60%	24	13.50%

X^2=51.365, df=6, ρ<.000

Table 5.17: Chi Square for RCHANGE Based on Area

When asked about how much the category would affect storm surge, over 70% of the respondents of the Inner Banks wind damage area and over 80% of the respondents in the Inner Banks storm surge damage area believed there would be more storm surge based on track change (Figure 5.7). In contrast, residents of both the Outer Banks wind and storm surge damage areas were equally split (both around 50%) in believing that there would be more or less storm surge.

When examining the influence of track change on wind, all areas indicated that they believed there would be increased wind associated with the track change (Figure 5.8). Both the Inner Banks wind and storm surge damage areas had 100% of the respondents reporting that they believed that there would be more wind. Over 60% of the respondents in both the wind and storm surge damage areas of the Outer Banks indicated the same. The results show that while all areas believed there would be more wind, more respondents on the Inner Banks believed this would be the case than did those on the Outer Banks.

All areas also responded that that there would be more flooding based on the track change (Figure 5.9). The results show that nearly 100% of the respondents in the Inner Banks storm surge damage area, nearly 80% of the respondents in the Inner Banks wind damage area, nearly 70% of the respondents of the Outer Banks wind damage area, and over 60% of the respondents in the Outer Banks storms surge damage area indicated this. This suggests that all areas believed there would be more flooding, with more residents of the Inner Banks storm surge damage areas and fewer of the Outer Banks storm surge damage areas indicating they anticipated more flooding.

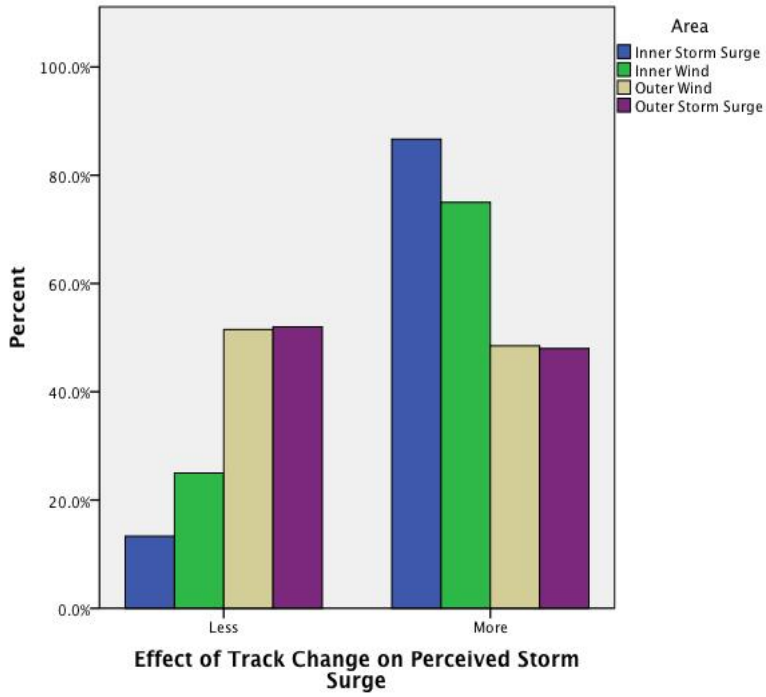

Figure 5.7

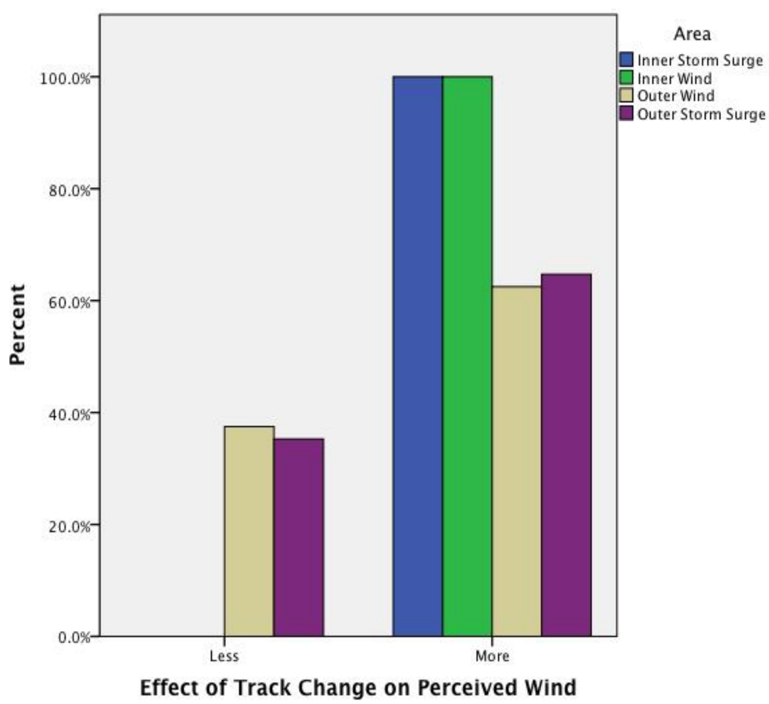

Figure 5.8

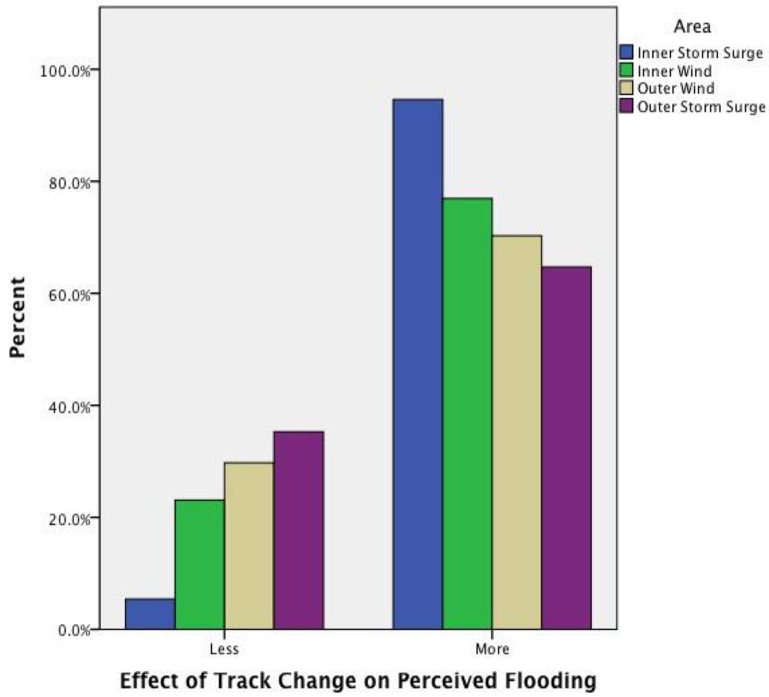

Figure 5.9

5.3. Risk Perception and Category Change

To examine the influence that the change in category has on risk perception, several questions asked if the respondent was aware of the category change, how much the category change influenced their perception of risk, and how the category change would influence the other hazards associated with the hurricane (i.e. storm surge, flooding, wind). When asked if residents were aware of the category change (PERCAT), 59% of the respondents said that they were (Table 5.18).

Aware of Category Change (PERCAT)	
Answer	Percent
No	33.90%
Yes	59.40%
Don't Recall	6.70%

Table 5.18: Percentage of Response to PERCAT

5.3.1. Inner Banks and Outer Banks Location

Table 5.19 shows the results on how the downgrading in category influenced risk perception (LVLPER). Just over 75% of the respondents on the Inner Banks indicated that the category change either changed their risk perception “somewhat” or “very much”. For the Outer Banks, 91% of the respondents believed that the category change influenced their risk perception either “somewhat” or “very much”. These results suggest that while both locations believed the category change influenced their risk perception either somewhat or very much, more respondents of the Outer Banks than the Inner Banks believed this. These results are significant at the .056 significance level.

Change in Perception based on Category Change (LVLPER)						
Location	A little		Somewhat		Very Much	
Inner Banks	14	24.60%	30	52.60%	13	22.80%
Outer Banks	5	9.30%	39	72.20%	10	18.50%
Total	19	17.10%	69	62.20%	23	20.70%

X^2=5.751, df=2, ρ<.056

Table 5.19: Chi Square for LVLPER Based on Location

When asked about how respondents believed the change in category influenced storm surge, 80% of the respondents in the Inner Banks and 90% of the respondents in the Outer Banks responded that the category change would produce less storm surge (Figure 5.10). When asked about the effect of category change on wind, 80% of the respondents of the Outer Banks and 60% of the respondents in the Inner Banks said they believed there would be less wind (Figure 5.11). Similar results were found with respect to the influence of category change on flooding. Over 70% of the respondents in both the Inner and Outer Banks believed there would be less flooding (Figure 5.12). Overall, and not surprisingly, respondents anticipated less impact from hazards associated with the hurricane as it weakened.

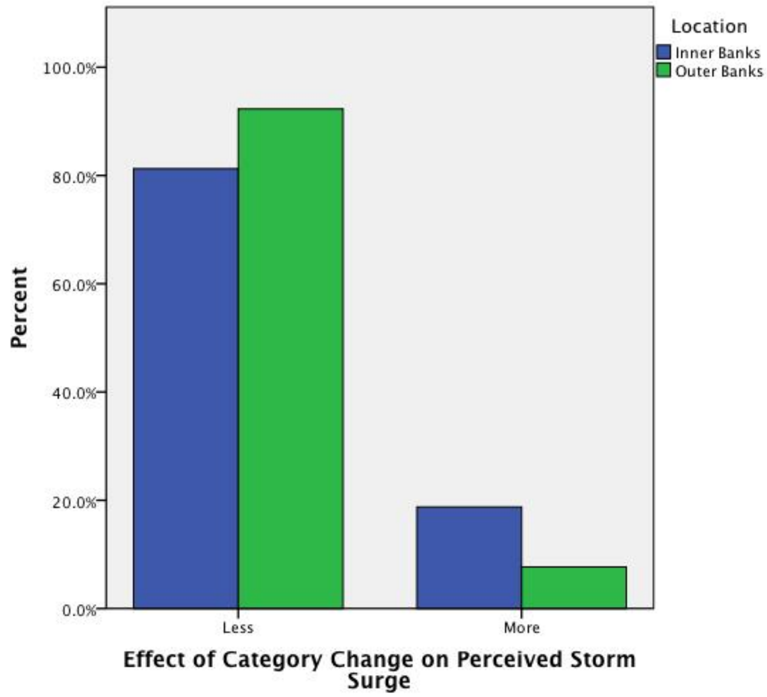

Figure 5.10

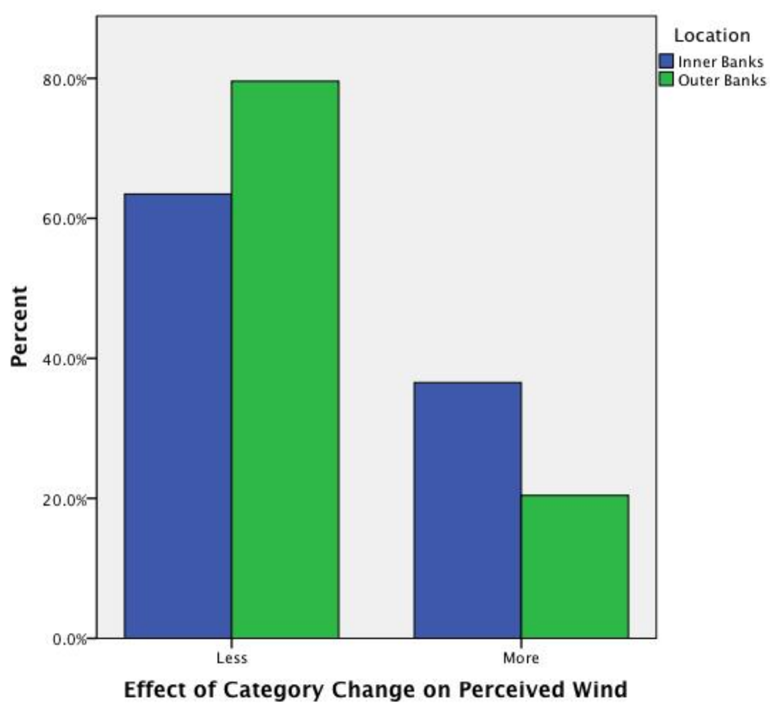

Figure 5.11

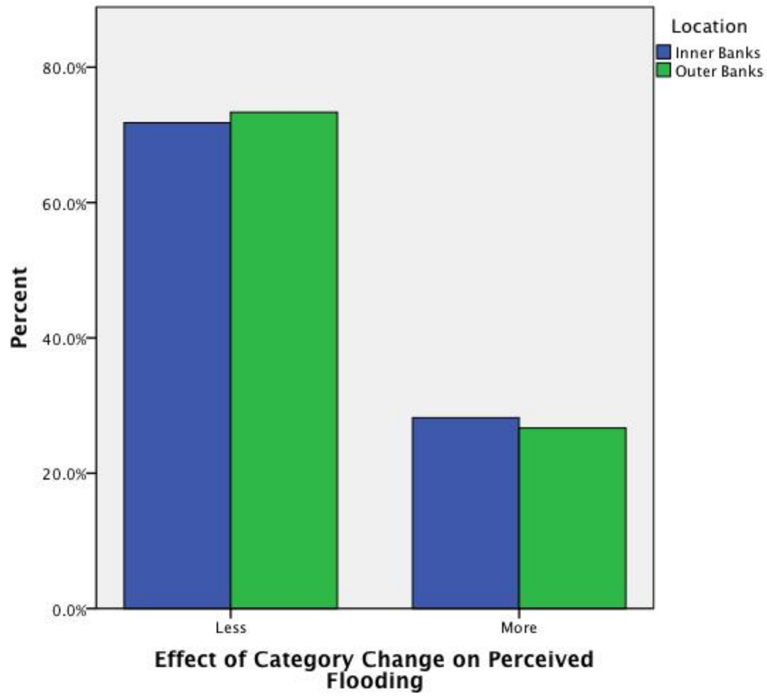

Figure 5.12

5.3.2. Storm Surge and Wind Damage Areas

No significant results were found when comparing the influence of category change on risk perception between damage type areas. It is important, however, to understand in what direction perceptions changed. A majority of the respondents in both the storm surge and wind damage areas believed that there would be less storm surge (Figure 5.13), wind (Figure 5.14), and flooding (Figure 5.15) associated with the change in category of the storm. This is not a surprising finding, but a concerning one, which is discussed in the next chapter.

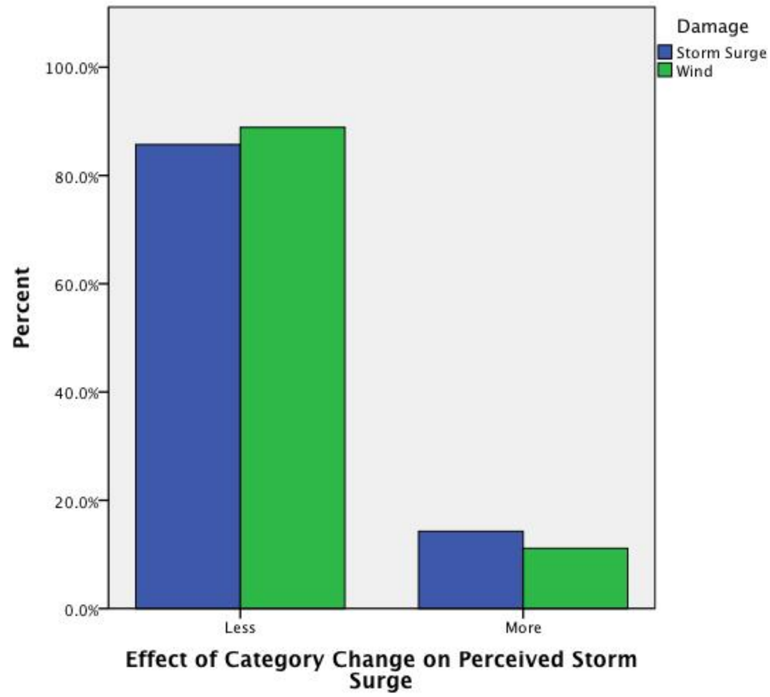

Figure 5.13

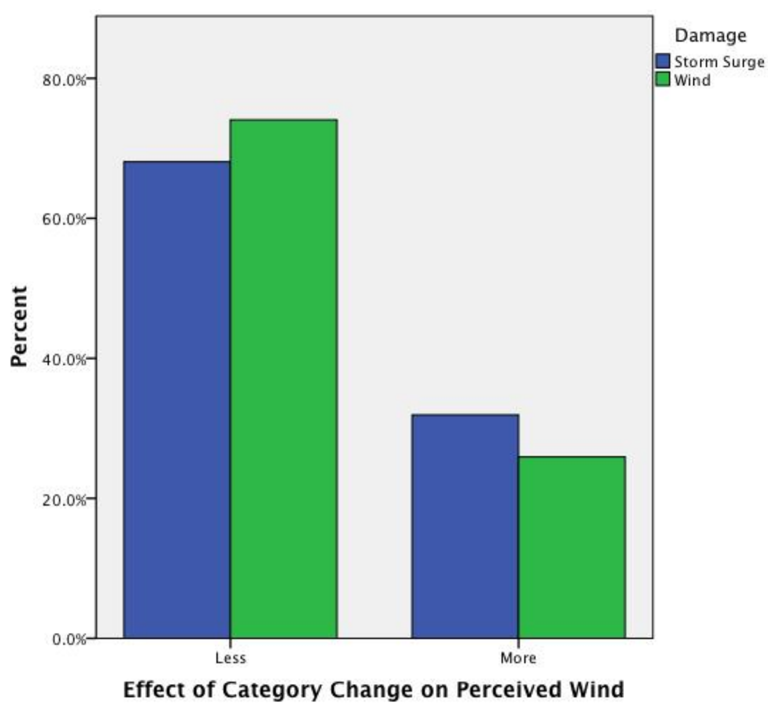

Figure 5.14

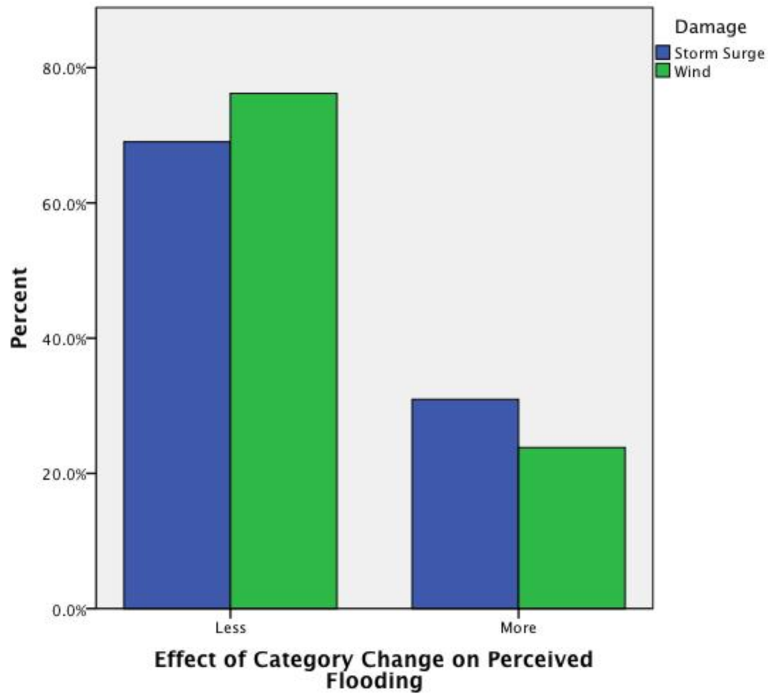

Figure 5.15

5.3.3. Location and Damage Area

The Chi Square test of the Inner and Outer Banks damage areas and change in risk perception showed no significant difference. However, more respondents in both damage areas on the Outer Banks indicated that their perceptions changed "somewhat" or "very much" (93% wind and 89% storm surge), compared to respondents in the damage areas on the Inner Banks (75% wind and 75% storm surge) (Table 5.20). This result suggests that regardless of the damage area location, the majority of the respondents believed that the category change influenced their perception of risk at least somewhat.

Change in Perception based on Category Change (LVLPER)						
Area	A little		Somewhat		Very Much	
Inner Storm Surge	6	25.00%	10	41.70%	8	33.30%
Inner Wind	8	24.20%	20	60.60%	5	15.20%
Outer Wind	2	7.40%	21	77.80%	4	14.80%
Outer Storm Surge	3	11.10%	18	66.70%	6	22.20%
Total	19	17.10%	69	62.20%	23	20.70%

X^2=9.508, df=6, ρ<.147

Table 5.20: Chi Square for LVLPER Based on Area

When examining the anticipated effect of the downgrade in category on storm surge, respondents in all the damage areas in each location believed that there would be less storm surge associated with Hurricane Irene's category change (Figure 5.16). When examining the different areas, the results show that over 70% of the respondents in the Inner Banks storm surge damage area, over 80% of the respondents in the Inner Banks wind damage area, over 80% of the respondents in the Outer Banks wind damage area, and over 90% of the respondents in the Outer Banks storm surge damage areas believed there would be less storm surge. Thus, more respondents of the Outer Banks storm surge damage area believed there would be less storm surge than did respondents in the Inner Banks storm surge damage areas.

When examining the anticipated influence of category change on wind, a majority of the residents in all damage areas of both locations believed there would less wind due to the category change (Figure 5.17). The results show that close to 60% of the respondents of the storm surge damage area of the Inner Banks, over 60% of the respondents of the wind damage areas of the Inner Banks, 80% of the respondents of the Outer Banks wind damage area, and over 70% of the respondents in the Outer Banks storm surge damage area believed there would be less wind. This suggests that more respondents in the damage areas of the Outer Banks believed there would less wind than did the respondents in the damage areas of the Inner Banks.

As seen with storm surge and wind, a majority of the respondents believed there would be less flooding associated with Hurricane Irene's downgrading (Figure 5.18). More residents in the Outer Banks storm surge damage area believed there would be less flooding than did the respondents of the storm surge damage area of the Inner Banks. In addition, more respondents of the Inner Banks wind damage area believed there would be less flooding than did the respondents of the Outer Banks wind damage area.

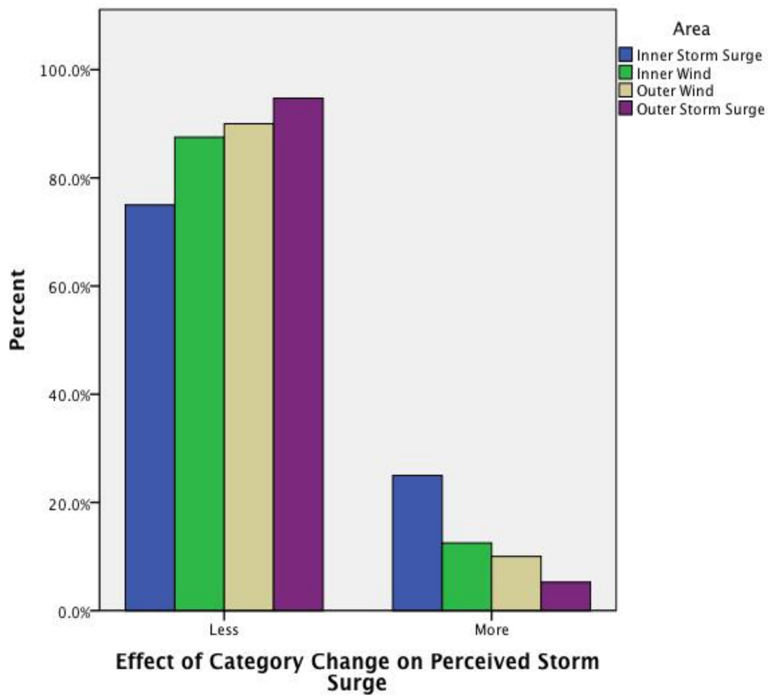

Figure 5.16

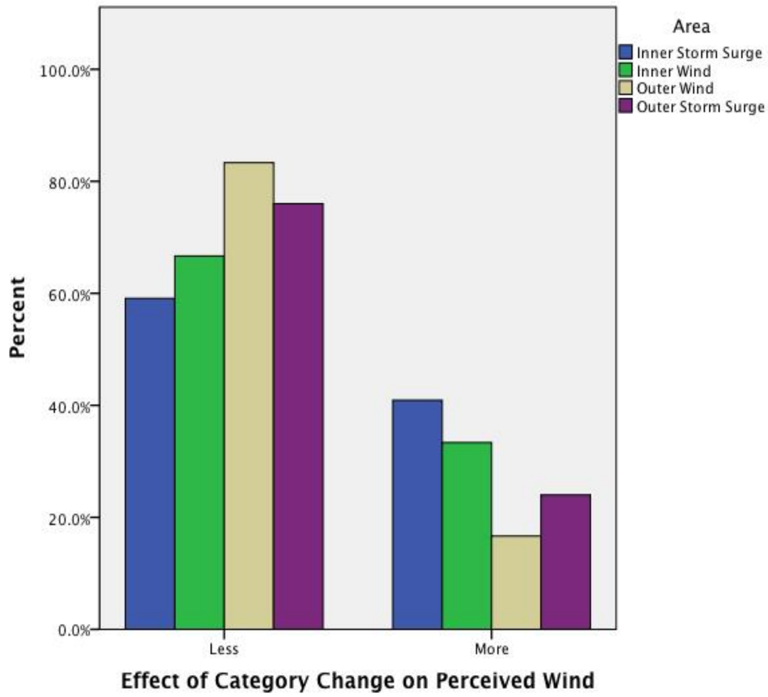

Figure 5.17

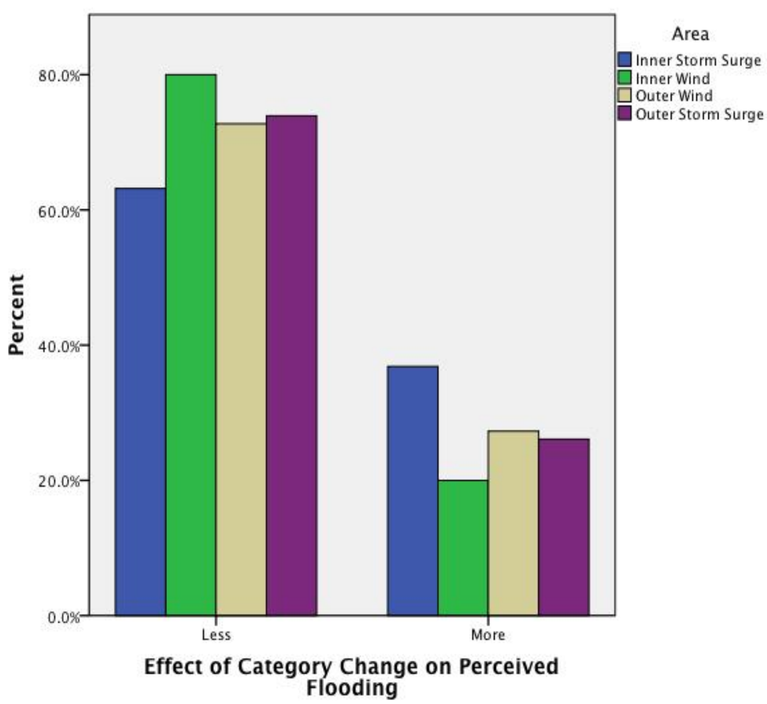

Figure 5.18

5.4. Summary

The results show some significant differences between the respondents in the Outer and Inner Banks of North Carolina. Changes in the storm produced changes in perceptions. As the track moved west, respondents on the Outer Banks indicated that they believed themselves to be at less risk while those on the Inner Banks believed the opposite. At the same time, the decreased category gave both areas the sense that the risk had decreased.

CHAPTER 6 : DISCUSSION AND CONCLUSIONS

6.1. Discussion

This study is designed to build on research with respect to how risk perception varies with location. The results from this study show that location makes a difference. Along with addressing the differences in risk perception with location, this study also examines how physical changes in the characteristics of a storm influence perceptions of risk. The changes in both track and in intensity were found to have an influence on the perception of overall risk and risk to specific hurricane-related hazards. The implications of these findings are discussed below.

6.1.1. Risk Perception and Location

With respect to the first research question, the findings from this study indicate that each of the locational factors that was explored had a strong association with various risk perception variables. Risk perception varied. When looking at risk perception between the Inner and Outer Banks, the variables that showed a significant difference were perceived risk at Advisory 16 and Advisory 23. At Advisory 16, more residents of the Outer Banks believed they were at more risk, while at Advisory 23, more residents of the Inner Banks believed they were at greater risk. This finding is not surprising because at Advisory 16, the forecasted track was over the Outer Banks, while the forecasted track at Advisory 23 was over the Inner Banks. This finding is similar to the results that Brody et al. (2004) and Peacock et al. (2005) found, where residents closer to the forecasted track believed they were more at risk than did the residents that were farther away.

When location was defined based on damage area, significant associations were found with respect to specific hazards associated with hurricanes and risk perception at Advisory 20. Residents from the storm surge areas believed they were at greater risk from both the hurricane-related hazards at Advisory 20 than did residents of the wind damage areas. Interestingly, more residents of the storm surge damage areas believed they were at greater risk from hurricane force winds than any other hazard associated with hurricanes. This result seems to contradict findings from Brommer and Senkbeil (2010) who found that storm surge was perceived as the greatest risk for evacuees. However, while the storm surge residents felt more at risk to hurricane winds than any other hurricane related hazard, residents might still use the threat of storm surge to make evacuation decisions.

While individually the “location” and “damage area” factors illustrate how risk perception differs with location, combining the two factors produces a better understanding of this association. The location and damage area factors showed significant associations between location and risk perceptions. Specifically, there are significant differences in risk perception between the damage areas on both the Inner and Outer Banks with more residents in the storm surge areas on both the Inner and Outer Banks believing they were at greater risk than did the residents of the wind damage areas.

6.1.2. Risk Perception and Track Change

The findings relating to the association between track change and risk perception also showed significant results. It was noted earlier that 95% of the respondents were aware of the track change, although this result may have been influenced by the images provided in the survey of the forecasted track and not the recall of the event. However, given that almost 60% of respondents were aware of the intensity change, it can be assumed that the respondents learned of the track change from the increase in media coverage that typically occurs before landfall (Demuth et al. 2012) and because people rely on a wide variety of information sources to make decisions (Dow and Cutter 1998, 2000).

When examining the influence of the track change on risk perception, the findings show a significant difference between the Inner and Outer Banks. Inner Banks residents believed themselves to be more at risk due to the change in track and their perceptions of their risk increased from Advisories 16 and 23. In contrast, residents of the Outer Banks had an opposite effect due to the track change. While damage areas show no significant difference, the combination of location and damage areas show similar results to the location only factor, suggesting that perhaps location is the influential variable. In addition, the analysis that combined location and damage areas found that risk perception differs between damage types on both the Outer and Inner Banks. It was shown that more respondents in the wind damage areas on both the Inner and Outer Banks believed they were at “more risk” or “much more risk” than did the respondents of the storm surge areas, who believed they were at “somewhat more risk” or “more risk”. These results complement the findings from Sherman-Morris et al. (2011) who observed a spike in hurricane related internet searches as the track shifted closer to landfall, which indirectly addresses the influence of risk perception because people use a variety of information sources to assess their risk (Dow and Cutter 1998).

The findings from this study also suggest that the track change had an effect on people’s perceptions of the hazards associated with hurricanes. It was found that respondents from both the Inner and Outer Banks believed there would be more wind and flooding associated with the track change. When examining the damage areas, the findings show that both areas believed that there would be more storm surge, flooding, and wind associated with the track change. Finally, the analysis that combined location and damage areas produced similar results to the location only factor. These results, with the exception of storm surge for the Outer Banks, are likely due to the storm moving inland which would then impact many people in both locations and damage areas.

6.1.3. Risk Perception and Category Change

When examining the influence of intensity change on risk perception, the findings show that intensity change had a modest influence on people's perceptions of their risk. The only locational factor that showed a significant difference was between the Inner Banks and Outer Banks locations. Results showed that both locations believed that the intensity change influenced their perceptions at least "somewhat."

With respect to the influence of intensity change on the perception of hurricane related hazards, the findings from this study show a significant association between intensity change and the perception of hazards associated with hurricanes. It was found that, regardless of location or damage area, respondents overwhelmingly believed that intensity change would bring lesser impacts from hurricane force winds, flooding, and storm surge. This creates a problem for residents because, while Hurricane Irene was a Category 1 storm, the long duration of the storm compounded the effects and created dangerous situations for residents.

6.2. Conclusions

It can be concluded from this study that risk perception varies with location. Risk perceptions differ with location between the Inner and Outer Banks and between the storm surge and wind damage areas. However, each of these locational factors only addresses part of this variation. Combining the location of the Inner and Outer Banks with the damage areas of storm surge and wind provides a better overall picture of how coastal residents' perceptions of risk to Hurricane Irene varied with location. In addition, physical changes in a hurricane's characteristics are found to have influenced risk perception. The findings show that both a change in track and a change in intensity influence a person's perception of risk to hurricanes and his/her perception of hazards associated with hurricanes.

These results have important implications for emergency managers and officials. The physical changes in the storm pose problems for emergency managers who need to persuade people to take action. Even with the shift in track to the west during Irene's landfall, residents still felt that the impacts would be reduced because of the change in category. This could put people at greater risk if they decide to not act, suggesting that emergency professionals need to continue to advise people to take protective action, regardless of hurricane intensity.

6.3. Limitations

There are several limitations to this study. First, the demographics of the respondents to the survey do not match the overall demographic characteristics of the study areas and thus, do not accurately represent the populations of both Dare and Beaufort counties. This, however, could not have been avoided because of nature of mail-out mail-back surveys. Secondly, the images provided of the advisories may have influenced respondents' awareness of the track change. Although it was shown that most respondents were aware of the intensity change before landfall and thus they were able to recall characteristics of the storm, the extent to which participant responses were influenced by the maps cannot be known. The responses could be due to the perceptions of the maps provided in the survey and not actual the recall of the storm. It would be difficult to sort out which is the cause for the responses. At the same time, differences were found between locations, suggesting that factors other the map reading skills led to the responses. However, future research could distinguish between the perception of maps and the recall of an event. Third, with the survey being sent out one year after the storm, there is the possibility that the residents would not complete the survey or that the impacts would have been forgotten. This was apparently not the case with most of the respondents because of the 30% response rate that was achieved. Finally, the study depends on what the respondents believe at the time of the survey. This is, however, a common problem with survey based research.

6.4. Significance and Future Research

These findings show how dynamic risk perception is. It was observed that changes in information on the storm (changes in track and intensity) influence risk perceptions of coastal residents. Further, differences in risk perceptions with respect to location are dependent on how location is defined. Defining location by the physical location and the damage type location produces different results. Combining these two definitions, again, produced a broader view of the variation in risk perception with location that the other definitions have missed.

It might be useful for future research to incorporate a hypothetical hurricane landfall situation in order to examine how changes in information on the storm's track and intensity prior to landfall would influence the risk perception of residents and their decision to take protective action. Further research should use focus groups or door-door methods to deliver surveys. This would help with generating a higher response rate and to focus on participants that would better represent the demographic characteristics of the area that is the focus of the study. Because this study had very homogeneous respondent demographics, it was impossible to explore associations between socio-economic characteristics and risk perception. However, if a study area was chosen with heterogeneous population demographics, future research can examine how risk perception differs with socio-economic characteristics. Finally, similar methods used in this study can be developed for different geographic locations to see how much the influence of location on risk perception can be generalized.

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APPENDEX A: IRB APPROVAL LETTER

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
4N-70 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** · **www.ecu.edu/irb**

Notification of Initial Approval: Expedited

From: Social/Behavioral IRB
To: William Pace
CC:
Burrell Montz Covey
Date: 8/29/2012
Re: UMCIRB 12-001501
Locational difference in hurricane risk perception

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 8/29/2012 to 8/28/2013. The research study is eligible for review under expedited category #7. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

The approval includes the following items:

Name	Description
Draft of Hurricane Irene Risk Survey | History	Surveys and Questionnaires
Perception of hurricane risk among North Carolina's coastal residents: A case study of Hurricane Irene | History	Study Protocol or Grant Application
survey cover letter | History	Additional Items

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

IRB00000705 East Carolina U IRB #1 (Biomedical) IORG0000418
IRB00003781 East Carolina U IRB #2 (Behavioral/SS) IORG0000418 IRB00004973

APPENDEX B: SURVEY

Hurricane Irene – ECU Survey

1. How long have you been living at your current address? (TENURE)
___ 1-5 years
___ 6-10 years
___ 11-15 years
___ 16-20 years
___ 21+ years

2. Before Hurricane Irene, had you previously experienced a hurricane or a tropical storm?
___ Yes (EXPER)
___ No (skip to Question 6)

a. If yes, was it at this address?(HEREEXP)
___ Yes
___ No

3. Which of the following describes your experiences with previous storms? (check all that apply)
___ Loss of home (LHOME1)
___ Damage to home (DHOME1)
___ Loss of Utilities (UTIL1)
___ Major inconvenience (MAJOR1)
___ Minor inconvenience (MINOR1)
___ Loss of structures on your property (LSTRUC1)
___ Damage to structures on your property (DSTRUC1)

4. How did that experience influence how much of a problem you thought Irene would be? (EXPINFL)
___ I was not worried about Irene because of my experiences
___ I was a little concerned, but thought this would be less of a problem
___ I was very worried because I know that any hurricane can be dangerous
___ Other (please describe)

5. Please provide a brief explanation of your experiences?

6. Did you experience damage from Hurricane Irene?
___ Yes (DAMIRE)
___ No (skip to Question 8)

a. If yes, what caused the damage? (CAUSDAM)
___ Surge only
___ Flooding only
___ Wind only
___ Surge and wind
___ All

7. Which of the following describes your experiences? (Check all that apply)
___ Loss of home (LHOME2)
___ Damage to home (DHOME2)
___ Loss of Utilities (UTIL2)
___ Major inconvenience (MAJOR2)
___ Minor inconvenience (MINOR2)
___ Loss of structures on your property (LSTRUC2)
___ Damage to structures on your property (DSTRUC2)

8. What actions did you take in anticipation of Hurricane Irene? (Check all that apply)
___ Gathered supplies (SUPPL)
___ Went to the store for food and water(WSTORE)
___ Took home protection measures like covering windows (HPROT)
___ Checked battery powered radio (BRADIO)
___ Trimmed trees (TTRIM)
___ Secured outside objects (OUTOB)
___ Made evacuation plans (EVAC)
___ None, was not home (NHOME)
___ None, didn't expect any problems (NPROB)
___ Other (please specify): (OTHER)

For the next set of questions, please circle the number that best represents your perception of risk.

9. Prior to Irene, how would you have characterized your risk to **storm surge**? (RSURG)
Very high risk — Moderate risk — Very low risk
5-------------------4-------------------3-------------------2-------------------1

10. Prior to Irene, how would you have characterized your risk to **flooding**? (RFLD)
Very high risk — Moderate risk — Very low risk
5-------------------4-------------------3-------------------2-------------------1

11. Prior to Irene, how would you have characterized your risk to **hurricane force winds**? (RWIND)
Very high risk — Moderate risk — Very low risk
5-------------------4-------------------3-------------------2-------------------1

12. **The map below shows the National Hurricane Center Advisory for August 24, two days before landfall. At this point, how did you rate the risk of your house? (RAD16)**

Very high risk		Moderate risk		Very low risk
5	4	3	2	1

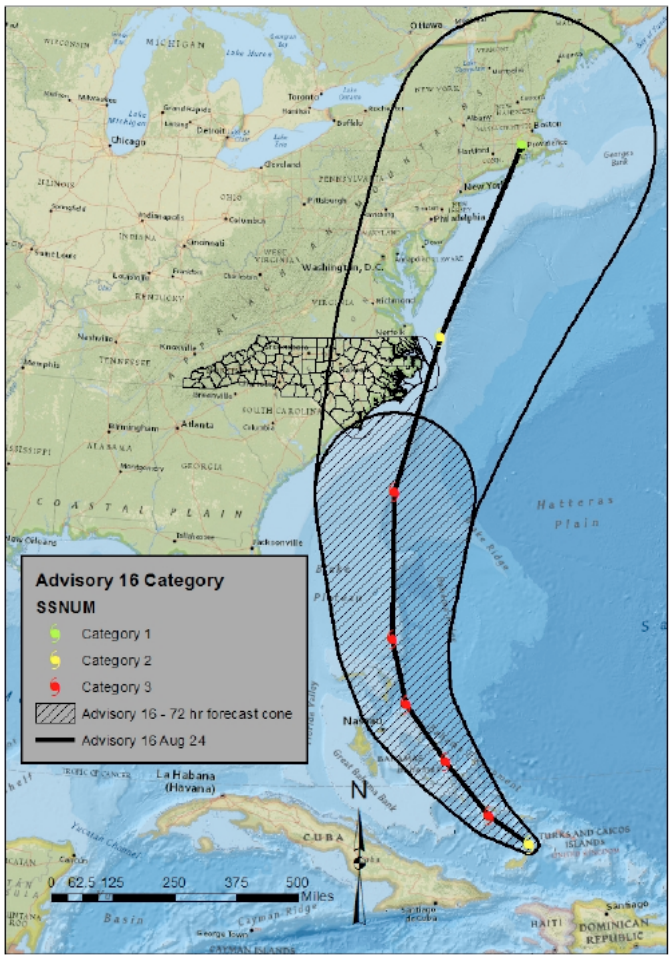

Image 1: Advisory 16 issued on August 24, 2011

13. **The next day the National Hurricane Center issued the advisory below, showing a change in track. At this point, how did you rate the risk of your house?** (RAD20)

Very high risk		**Moderate risk**		**Very low risk**
5	4	3	2	1

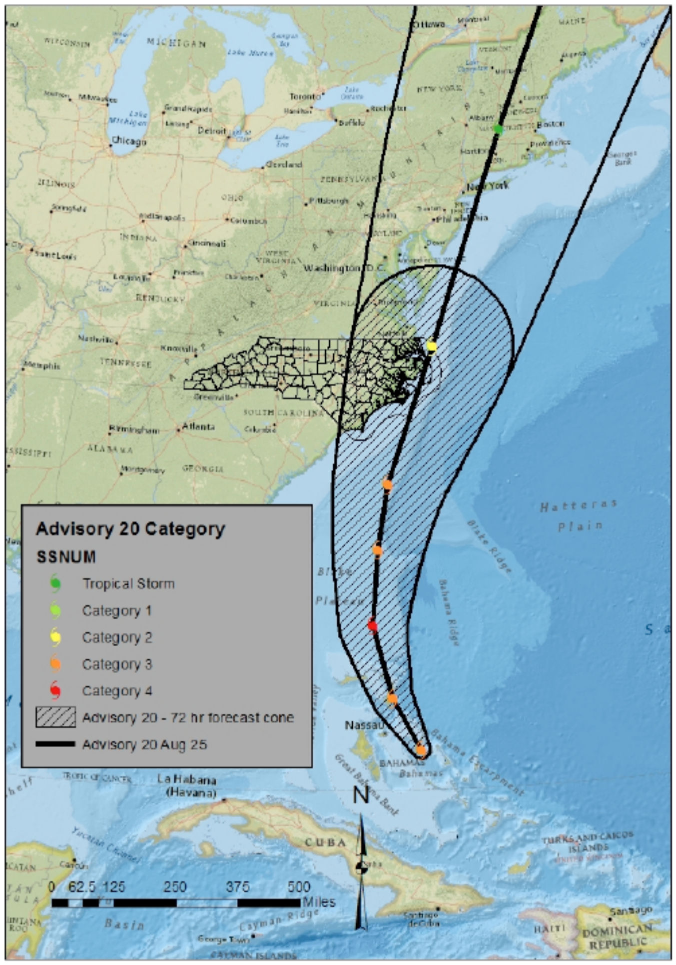

Image 2: Advisory 20 issued on August 25, 2011

14. **The map below shows the National Hurricane Center advisory for August 26, the day Irene made landfall in North Carolina. At this point, how did you rate the risk of your house? (RAD23)**

Very high risk **Moderate risk** **Very low risk**

5------------------4-------------------3-------------------2-------------------1

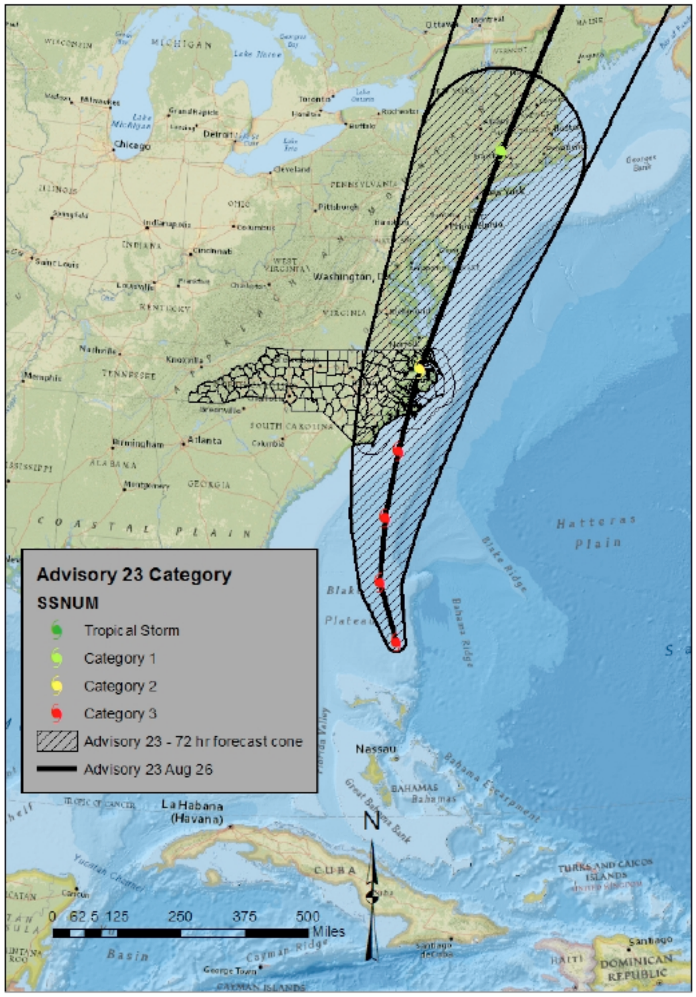

Image 3: Advisory 23 issued on August 26, 2011

15. Each advisory showed the forecasted track shifting more westward than the previous one. Did you pay attention to the change in track as Irene progressed? (ATRACK)
    __ Yes
    __ No (skip to question 18)
    __ I don't recall

16. If yes, which of the following were you thinking about your situation? (RTRACK)
    __ At much more risk
    __ At more risk
    __ At somewhat more risk
    __ At somewhat less risk
    __ At less risk
    __ At much less risk

17. If yes, what did you think would happen?

a.	Storm surge: (SURGE1)	__More	__ Less
b.	Wind: (WIND1)	__More	__Less
c.	Flooding: (FLOOD1)	__More	__Less

18. Hurricane Irene was a Category 3 hurricane, but the storm was changed to a Category 1 hurricane just before landfall. Did this change your perception of the storm? (PERCAT)
    __ Yes
    __ No (skip to Question 21)
    __ I don't recall

19. If yes, how much did it change your perception? (LVLPER)
    __ Very much
    __ Somewhat
    __ A little
    __ Very little

20. If yes, what did you think would happen?

d.	Storm surge: (SURGE2)	__More	__Less
e.	Wind: (WIND2)	__More	__Less
f.	Flooding: (FLOOD2)	__More	__Less

21. Did you evacuate for Irene? (IREEVAC)
    ___ Yes
    ___ No

22. If not, what would prompt you to evacuate?

23. Because of your experiences with Hurricane Irene, how much more likely are you to listen to emergency personnel for future events? (LISTEMP)
    __ Not at all
    __ Much less likely than before Irene
    __ Somewhat more likely than before Irene
    __ Much more likely than before Irene

24. Are you aware that the National Weather Service provided forecasts of storm surge as "feet above ground level measurements" for Hurricane Irene?
    __ Yes (SMEAS)
    __ No

25. How well do you believe you understand "feet above ground level" measurements as an indication of storm surge depth? (UMEAS)

    Extremely well   Poorly
    5-------------------4-------------------3-------------------2-------------------1

26. To what extent do you think using "feet above ground level" in a warning is more effective than "feet above mean sea level" for storm surge? (EMEAS)

    Very great extent   Not at all
    5-------------------4-------------------3-------------------2-------------------1

27. Which, if either, do you think would cause you to take action and why?

28. To what extent does the **category** of a hurricane help you understand the impacts from the following threats?

a) Wind: (CATWD)
Very great extent — Not at all
5-------------------4-------------------3-------------------2-------------------1

b) Storm surge/ Coastal flooding: (CATSUR)
Very great extent — Not at all
5-------------------4-------------------3-------------------2-------------------1

c) Heavy rain/ fresh water flooding: (CATFLD)
Very great extent — Not at all
5-------------------4-------------------3-------------------2-------------------1

d) Tornado: (CATTOR)
Very great extent — Not at all
5-------------------4-------------------3-------------------2-------------------1

29. Gender: (GENDER)
__ Female
__ Male

30. Age: (AGE)
__ 18-29
__ 30-49
__ 50-69
__ 70 & Older

31. With what Race or Ethnicity do you identify?
__ White (RACE)
__ Black
__ Hispanic/ Latino
__ American Indian
__ Asian
__ Native Hawaiian/Other Pacific Islander

32. Approximately what is your household income? (INCOME)
__> $20,000 year
__ $20,000 - $39,999
__ $40,000-$59,999
__ $60,000-$79,999
__ $80,000-$99,999
__ $100,000 or greater

33. What is the highest level of education that you have completed? (EDU)
__ Grade school
__ High school Graduate
__ Some College
__ College Graduate
__ Graduate/Professional Degree

Additional comments: