

RESIDENTS' RECEPTIVITY TO SEA LEVEL RISE ADAPTATIONS ON TYBEE ISLAND

by

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(Under Direction of Jon Calabria)

ABSTRACT

Infrastructure, residences, and businesses on Tybee Island are vulnerable to sea level rise (SLR). Tybee Island is a national leader in climate adaptation planning, and although their 2016 Sea Level Rise Adaptation Plan sought public input for adaptation options, the next step is to specifically assess residents' risk perceptions or adaptation preferences. This is important for planning because it 1) facilitates the development of politically palatable policy and 2) identifies opportunities for targeted outreach. This thesis describes results from a pilot study using Rogers' Protection Motivation Theory as a theoretical framework to assess Tybee residents' perceptions of SLR risks and receptivity to SLR adaptation strategies. Results showed that residents perceived a very high risk from SLR but felt unable to implement adaptation strategies, suggesting a need for Tybee's government to inform residents about SLR adaptations and boost people's confidence in their effectiveness, and the community's ability to undertake them.

Keywords: coastal adaptation, coastal management, coastal planning, individual behavior, managed retreat, risk perception

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DEDICATION

I dedicate this thesis to my family and old friends for their love and support while I was off pursuing my next adventure. I also dedicate this to the wonderful new friends I have made at UGA; I will always treasure our highly-caffeinated late nights and early mornings in Tanner.

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS	v
LIST OF TABLES	viii
LIST OF FIGURES	ix
CHAPTER 1: INTRODUCTION	1
History of Coastal Development and Planning.....	2
Maladaptation in GA.....	4
Jurisdictional Boundaries.....	5
The National Flood Insurance Program and the Community Rating System.....	6
Coastal Planning Practices.....	10
Importance of Public Perceptions in Planning.....	11
Types of Adaptations – Protect, Accommodate, Retreat	12
Tybee Background	13
CHAPTER 2: LITERATURE REVIEW	18
Planning in the Context of Climate Change	18
Importance of Public Perceptions in Implementing Policy	22
NFIP, CRS, and Jurisdictional Issues	23
Environmental Psychology and Ideology	26
Adaptations to Sea Level Rise	27

Protection Motivation Theory.....	29
CHAPTER 3: METHODOLOGY	32
CHAPTER 4: RESULTS AND DISCUSSION.....	35
Protection Motivation Theory.....	36
Responsibility	45
Environmental Ideology.....	47
Selected Crosstabulations	49
Implications for Flood Insurance and Climate Adaptation Strategies	52
CHAPTER 5: CONCLUSIONS	54
REFERENCES	57
APPENDIX 1: COPY OF SURVEY	65

LIST OF TABLES

Table 1. Types of Adaptation Strategies Assessed in Survey.....	34
Table 2. Risk Probability Questions	36
Table 3. Risk Severity Questions.....	37
Table 4. Self-Efficacy Questions	41
Table 5. Adaptation Cost Questions	42
Table 6. Responsibility Questions	45
Table 7. Responsibility Questions continued.....	46
Table 8. Response to Environmental Ideology	47

LIST OF FIGURES

Figure 1. CRS Activities and Rating Scores (Landry and Li 2012)	8
Figure 2. Should the City of Tybee pursue the following SLR adaptations?	39

CHAPTER 1: INTRODUCTION

The National Oceanographic and Atmospheric Institute (NOAA) predicts a global sea level rise (SLR) of eight inches by 2100, though it could potentially rise by 6.6 feet, while the International Panel on Climate Change (IPCC) predicts a likely rise of between one and three feet by the end of the century (Evans et al 2016; IPCC 2014). The sea level at Tybee Island, Georgia, has risen at a rate of approximately 12 inches over 100 years (Parris et al 2012). SLR poses a range of threats, including inundation and displacement of wetlands, shoreline erosion and degradation, increased coastal flooding, and salinization of estuaries and freshwater aquifers (Klein et al 2001). Tybee is already experiencing several of these impacts, such as coastal erosion, tidal flooding, and storm-surge flooding. Coastal erosion is a natural process that has many ecological and social benefits: it maintains beaches and dunes by transporting sediment along the coast, adjusts coastal topography to reduce wave energy impact on the coastline, and provides materials upon which coastal ecosystems depend (Cooper and McKenna 2008). However, it becomes problematic when it increasingly exposes fixed assets, such as developed land and infrastructure, to flooding.

Increased tidal and storm-surge flooding increases the chances of inundation of human development, endangering human health and causing great financial damage. Furthermore, the anticipated increase in intensity, frequency, and duration of hurricanes due to climate change will make SLR impacts even more devastating (NASA 2018). The Tybee Island Sea Level Rise Adaptation Plan (TISLRAP) identified the most visible impacts of SLR on Tybee as frequent closures of US Highway 80 (the only road connecting Tybee Island to the mainland), tidal backup of stormwater drainage systems in low-lying areas, and increased coastal erosion (Evans et al

2016). It suggested pursuing adaptation strategies of retrofitting low-lying stormwater systems, elevating pump well houses, and continuing beach nourishment – forms of accommodation and soft protection, respectively – and recommended against constructing a seawall as it would not be cost-effective (Ibid). Currently the well pump houses have not yet been elevated, as the Water and Sewer Department is waiting on funding (Tybee Island Water and Sewer, private correspondence). This thesis complements the TISLRAP with an assessment of Tybee residents’ receptivity to a wide range of adaptation measures, to inform future planning policy on Tybee Island.

History of Coastal Development and Planning

Several pieces of legislation that govern the management of coastal areas. At the Federal level are the Coastal Zone Management Act (CZMA), the National Environmental Policy Act (NEPA), and the Section 404 of the Clean Water Act. The US Congress passed the CZMA in 1972, in recognition of the necessity to manage continued development in coastal zones. Administered by the National Oceanic and Atmospheric Administration (NOAA), the CZMA aims to “preserve, protect, develop, and where possible, to restore or enhance the resources of the nation’s coastal zone” (Coastal Zone Management Act 1972). The CZMA was intended to provide federal support to the states, so that they could, among other initiatives, effectively protect natural resources within the coastal zone and manage coastal development to “minimize the loss of life and property caused by improper development” in areas prone to flooding, storm surge, erosion, or those likely to be affected by sea level rise, subsidence, and saltwater intrusion, or by the destruction of natural protective features such as dunes and wetlands (Ibid). The CZMA authorized the National Coastal Zone Management Program, which is a voluntary partnership between the federal government and

coastal states that addresses coastal problems through the protection, restoration, and responsible development of that nation's coastline.

The National Environmental Policy Act of 1970 requires detailed environmental impact statements for all major construction projects, including beach nourishment and the building of shoreline structures. Public participation is also required before a plan can be authorized for a construction project. Section 404 of the Clean Water Act governs the disposal of dredge or fill into waters of the United States. The US Army Corps of Engineers (USACE) issues permits under this legislation, which must also comply with NEPA. Section 404 permits are needed for coastal projects like beach nourishment or filling in wetlands (USACE 2018). USACE is also responsible for the authorization and execution of beach nourishment programs. USACE beach nourishment programs began in the 1950s to protect coastal development by widening and restoring beaches depleted by erosion. Such projects typically begin after a local government approaches the federal government for assistance and the federal government determined that there is a federal interest in protecting the area. Some requirements include that the beach being nourished is open to the public, and that the community requesting the project help pay for it (USACE 2007).

At the state level are Georgia's Coastal Marshlands Protection Act, and Georgia's Shore Protection Act. The 1970 Georgia Coastal Marshlands Protection Act (OCGA 12-5-280) protects marshlands, intertidal areas, mudflats, tidal water bottoms, and salt marsh area lying within a tide-elevation range from 5.6 feet above mean high-tide level and below. The Act recognizes the immense ecological value of marshlands, authorizes the Coastal Resource Division to protect tidal wetlands, requires permits for any structures, dredging or filling that occurs in the marsh (Georgia DNR 1998a).

The Georgia Shore Protection Act (OCGA 12-5-230) was passed in 1979 to protect the sand-sharing system that is a vital component of Georgia’s coastal ecosystem. This area is a no-build zone, that comprises sand dunes, beaches, sand bars, and shoals, and acts as a buffer to protect personal property and natural resources from floods, winds, tides, and erosion. Its jurisdiction includes submerged land up to three miles out to sea, the beach, and the “dynamic dune field” that includes all the land between the ordinary high water mark and either the first occurrence of a live native tree 20 feet or taller, or a structure existing on July 1, 1979. Local zoning regulations apply within this jurisdiction (Georgia DNR 1998b).

Local governments have the power to create zoning regulations and other land use policy that must be followed within its own jurisdiction. For example, the City of Tybee has its own zoning map, Beach Management Plan, and Shoreline Protection Project (City of Tybee 2018).

Maladaptation in GA

Despite the intent of these laws, the Georgia coast continues to be developed. Between 2000 and 2010, the number of people living in the coastal floodplain grew from 188,652 to 221,674 – a 15% increase. Meanwhile, 53% of Georgia’s shoreline is rated as moderately to extremely vulnerable to erosion, and between 2006 and 2011, more than 7,000 acres of wetlands were lost (Georgia DNR 2015). Increasing the amount of costly development on the coast while destroying natural protections that could keep people safe is maladaptive. Maladaptations include the avoidance or denial of climate change adaptations, and the pursuit of “bad” responses that actually increase climate risk such as rebuilding or encouraging development in floodplains or coastal zones (Grothmann and Patt 2005). For example, it has been increasingly understood that problems of coastal erosion are caused more by poorly-sited development rather than coastline retreat

(Cooper and McKenna 2008). Reducing maladaptations and decreasing vulnerability will improve coastal communities' ability to adapt to climate change (Klein et al 2001).

Jurisdictional Boundaries

The overlap of Federal, state, and local regulations that govern coastal areas create a complex environment in which to undertake sea level rise adaptations, making them more costly or complicated than if they were subject to a single authority. Jurisdictional overlaps with federal and state governments can increase bureaucratic red tape and the need to deal with potentially conflicting directives (Reiblich et al 2017). In the case of Tybee Island, USACE is in charge of beach nourishment and any shoreline construction, FEMA is in charge of the National Flood Insurance Program (to be discussed in the following section), NOAA is in charge of the Coastal Zone Management Program, the state of Georgia administers the Coastal Marshlands Act and Shore Protection Act, and the City of Tybee is responsible for local land use regulations, infrastructure, and service provision, among other duties. Collaboration is essential.

Wescott's (2004) case study of multi-jurisdictional Integrated Coastal Management in Victoria, Australia, identifies avenues for a more integrated and comprehensive approach. First, clearly stated objectives for state- and national-level coastal planning and a clearly identified lead state agency to coordinate other agencies' activities is necessary. The Georgia Department of Natural Resources Coastal Resources Division could potentially adopt this role. Other factors that contribute to successful ICM at the national level are a clear Government Coastal Strategic Plan and processes that invite the community to participate in direct decision-making at all levels. Such a Plan could be under the auspices of NOAA. Sub-nationally, Wescott recommends one agency to advocate for strategic/statewide issues, and a sub-agency (or agencies) concentrate on building

community support for local plans and tailoring the strategic plan's objective to local conditions via a "linking plan". The linking plan will mediate the balance between heavily top-down policy on one hand and piecemeal local initiatives on the other. Finally, Wescott emphasizes the paramount importance of allowing the community to contribute towards decision-making as much as possible to foster ownership of the coastal policies.

The National Flood Insurance Program and the Community Rating System

The National Flood Insurance Program (NFIP), administered by the Federal Emergency Management Agency (FEMA), was created in 1968 as a means to discourage floodplain development and ensure that property owners could get reasonably-priced flood insurance. The program is voluntary, and participating communities adopt development regulations government the 100-year floodplain – this is also called the 1 percent chance per year floodplain or basic flood elevation (BFE). Premiums are based on federal assessments of flood risk and are meant to make people aware of the risks of having property in a flood-prone area, and take financial responsibility for their choices. The three main components of NFIP are identifying and mapping flood hazards, providing flood insurance, and encouraging floodplain management (Lee and Wessel 2017, Kousky 2018).

Flood Insurance Rate Maps (FIRMs) show base flood elevations, flood zones, and floodplain boundaries of the nation's communities and help homeowners, renters, and insurance companies identify flood risks (FEMA 2002). The most important flood risk zone is the "100-year" or one percent annual chance floodplain. This is also called a Special Flood Hazard Area (SFHA). A house in the 100-year floodplain has a one-in-four chance of being flooded over the course of a 30-year mortgage. (Kousky 2018, Chen 2018). Property owners within an SFHA who

have taken a loan from a federally regulated lender are required to purchase flood insurance. Communities participating in NFIP must adopt minimum floodplain regulations in the SFHA (Kousky 2018). Currently, the entirety of Tybee Island is considered a SFHA (City of Tybee 2016).

The Community Rating System (CRS) is a voluntary incentive program offered through the NFIP that promotes and rewards community floodplain management activities that exceed NFIP's minimum requirements. Its three main goals are to reduce flood damage to insurable property, strengthen and support the insurance aspects of the NFIP, and encourage a comprehensive approach to floodplain management (FEMA 2018). People living in SFHAs are rewarded for participating in the CRS by getting discounts on their flood insurance premiums, with a 5% reduction (up to 45%) for every class rating they move up. For example, a Class 9 community would receive a 5% reduction on their premiums, while a Class 1 community would receive 45% off. CRS participants who do not live in an SFHA can earn up to a 10% reduction on their premium. Creditable activities are organized into four categories: public information, mapping and regulations, flood damage reduction, and flood preparedness. These are detailed in Figure 1.

Series	Descriptions	Creditable activities	Points
Public information (300)	CRS will credit those local activities that advise people about the flood hazard, flood insurance, and flood protection measures.	1. Elevation certificates	162
		2. Map information	140
		3. Outreach projects	380
		4. Hazard disclosure	81
		5. Flood protection information	102
		6. Flood protection assistance	71
Mapping and regulations (400)	CRS provides credit to communities that enact and enforce regulations that exceed the NFIP's minimum standards so that more flood protection is provided for new development.	1. Additional flood data	1346
		2. Open space preservation	900
		3. Higher regulatory standards	2740
		4. Flood data maintenance	239
		5. Stormwater management	670
Flood damage reduction (500)	This series of activities addresses flood damage to existing buildings. It complements the previous series that dealt with preventing damage to new development.	1. Floodplain management planning	359
		2. Acquisition and relocation	3200
		3. Flood protection	2800
		4. Drainage system maintenance	330
Flood preparedness (600)	Activities in this series include actions that should be taken to minimize the effects of a flood on people, property, and building contents.	1. Flood warning program	225
		2. Levee safety	900
		3. Dam safety	175

Note: Source is FEMA (2007).

Figure 1. CRS Activities and Rating Scores (Landry and Li 2012)

Tybee Island participates in the NFIP and CRS, and the entire island is located in a SFHA. Tybee is currently a Class 5 community, meaning residents receive a 25% reduction on their flood insurance premiums. Though a list of specific activities undertaken by Tybee was not found, they do have a Flood Damage Prevention Ordinance (Article 8 of the Tybee Island Code of Ordinances) that requires all construction, additions, conversions and/or development to comply with certain minimum standards intended to minimize damage from floods; for example, houses and certain other structures are required to be built one foot above the 100-year base flood elevation (City of Tybee Island 2016). Community Recertification is required annually, and a Cycle Verification is required every few years, to ensure that activities for which a community is receiving CRS credit are being maintained (FEMA 2017). Tybee recertifies yearly and has a Cycle Verification every five years (City of Tybee 2018). The CRS also requires communities to deal with repetitive losses. Repetitive Loss Structures are NFIP-insured structures that have had at least 2 paid flood losses of more than \$1,000 each in any 10-year period since 1978 (FEMA 2018b). Tybee is a Category B Repetitive Loss Community with nine properties on the repetitive loss list (City of Tybee 2018). The cyclical nature of the CRS recertification process and potential for upgrading offer a built-in method for iterative planning. Communities such as Tybee could link their adaptation planning goals to the CRS process, and take advantage of FEMA's regulatory carrot to ensure that local plans actually get implemented rather than languishing on a shelf.

Coastal Planning Practices

Most studies regarding coastal planning and sea level rise have been undertaken in Europe, particularly the UK, and Australia. Investigations into SLR adaptation planning in the United States are remarkably scarce, though a few (e.g. Orland et al 2017, Song and Peng 2017) will be discussed in the literature review in the next section. Coastal planning, like all planning, must account for numerous independent processes and actors that affect each other in cumulative ways. For example, SLR is not the only factor affecting coastal systems. Other contributing factors are resource depletion, pollution, sediment loss, and urbanization. These human-induced stressors decrease the ability of coastal systems to deal with SLR impacts.

Coastal adaptations should, to the greatest extent possible, be appropriate for local environmental and socioeconomic conditions. This can be achieved by framing climate policy issues in culturally sensitive ways, and carefully designing public input processes (Foss 2018). The key to successfully adopting climate policy is extensive community participation as part of a broad-based planning effort. Engaging the community from the onset strengthens a locality's resolve to make meaningful policy change and creates momentum for the planning process, while building local buy-in and support for the new policies (Pitt 2010). Coastal management involves much potential for conflict, mainly between development goals and adaptation needs. Abel et al (2011) identified several planning issues that commonly affect coastal communities in high-income countries: coastal development and population growth are encouraged; naturally protective ecosystems such as wetlands are developed because their value is not formally recognized and their protection does not seem urgent; liability laws favor development; planning ignores cumulative impacts; and as the value of built assets (i.e. development) increases, so does political pressure to protect them. To minimize conflict, all stakeholders must be made aware of the

necessity of reducing coastal vulnerability. Coastal planning should be an iterative process of information distribution and awareness raising, planning, implementation, and evaluation (Klein et al 2001).

Importance of Public Perceptions in Planning

Social acceptability is helpful for adaptation policy decisions because it helps create public buy-in and increases the likelihood of policy compliance (Pitt 2010). Regarding coastal planning, if people do not believe sea level rise is occurring or that human activities have a role in it, they are less likely to encourage public officials to fund mitigation or adaptation activities (Burger and Gochfeld 2017). Successful policy implementation depends largely on public acceptance at the community level and requires not only informing the public to raise awareness, but also involving them in the planning process, which can change peoples' hazard perceptions, trust in authorities, and willingness to take protective action (Klein et al 2001, Wachinger et al 2012).

Adaptation behaviors are motivated by two cognitive processes: threat appraisal and coping appraisal (Rogers 1975). According to Roger's Protection Motivation Theory, people will change their behavior only if they think that they are likely to be harmed; that the harm is severe enough to warrant action; that an adaptation strategy will work; that they can effectively execute the adaptation strategy; and that the benefits of action outweigh the costs. Assessing people's responses in accordance with this theory can reveal where any misunderstandings, misinformation, or other obstacles to receptivity occur.

Flood protection is generally perceived to be the responsibility of the government, rather than of individual householders (Krasovskaia et al 2007, Terpstra and Gutteling 2008). However, Terpstra and Gutteling (2008) also found that about 50% of respondents viewed disaster

preparedness responsibility as shared equally between the government and themselves. Knowing how much responsibility residents are willing to accept for pursuing adaptations can be useful in crafting policy because it may indicate the need for government incentives such as cost-share programs. Environmental ideology (Corbett 2006) is another useful indicator for outreach and policy, because it groups people according to how they view the relationship between humans and the natural environment. For example, people with human-centered ideologies may be less concerned about “nature” and more concerned about economics or human health, and outreach to them should be framed accordingly. Lastly, outreach is most effective when it is tailored towards specific groups, or “audience segments,” rather than made for a generalized public (Maibach et al 2011).

Types of Adaptations – Protect, Accommodate, Retreat

Adaptations to coastal change fall into three categories: protection, accommodation, and retreat (Klein et al 2001; Neal et al 2005; Few and Brown 2007; Abel et al 2011; Alexander et al 2012). Adaptations can be proactive or reactive, public or private. Proactive adaptation is motivated by predicted or potential events, while reactive adaptation occurs after an event has happened. Public adaptation is undertaken by communities or governments, while private adaptation is undertaken by individuals (Grothmann and Patt 2005). Protection is a strategy that attempts to reduce risk by minimizing the chance of a harmful event happening. Accommodation attempts to reduce sensitivity or exposure to SLR, such as raising infrastructure or retrofitting buildings. Retreat involves the relocation or abandonment of buildings and infrastructure under threat (Neal et al 2005; Alexander et al 2012).

Tybee Background

Geographic Context

Tybee Island is the northernmost barrier island off the coast of Georgia, located about 15 miles east of Savannah. It covers an area of about 2.7 miles. It has an average upland elevation of 7.5 feet, while the island's highest elevations can exceed 20 feet and occur on isolated beach dunes adjacent to the Atlantic coastline. The western part of the island is largely comprised of salt marsh, largely dominated by the grass *Spartina alterniflora* (Evans et al 2016). It has a year-round population of approximately 3,000 people (US Census Bureau 2016). This population approximately doubles during the summer, and on summer weekends the island often hosts up to 30,000 visitors (Evans et al 2016). It has a warm, mild climate and receives about 50 inches of rainfall annually (Climate-Data.org 2017).

Current Issues and Impacts of Sea Level Rise

Tybee Island is a barrier island vulnerable to SLR and has already experienced its adverse effects in the forms of increased shoreline erosion, nuisance flooding, and storm surge damage. Tybee Island experiences daily tidal changes of 7.5 feet (NOAA 2016a). During spring tides, the daily tidal range can exceed 9 feet. Flooding is an ever-present concern on Tybee, which experiences both storm-driven and tide-driven flooding. These events are caused by heavy rainfall during high tides, sunny-day flooding from king tides, and storm surge. King tides that cause minor flooding of streets and yards are regarded as “nuisance” tidal flooding; on Tybee a nuisance flood is any rise in water that exceeds 5.2 feet above the North American Vertical Datum of 1988 (NAVD88) located at Ft. Pulaski. The Ft. Pulaski tidal gauge record shows that the frequency of nuisance flooding on Tybee Island has increased considerably over the last several decades – in

2015 alone there were 23 such events (NOAA 2015, Evans et al 2016). The Ft. Pulaski gauge has also recorded a sea level rise of one foot over the last 100 years (NOAA 2016b). Sea level rise appears to be impacting Tybee more strongly than other places on the east coast because Tybee Island is subsiding – so while the sea level is rising, the land is also sinking (Davis 1987).

Tybee Island also experiences hurricanes. Hurricane Matthew in 2016, and Hurricane Irma in 2017, each made landfall and caused damage to structures on the island, mainly from flooding. Hurricane Matthew cost Georgia as a whole \$96,713,268 in damages, while Hurricane Irma cost \$16,088,948 (FEMA 2016, 2017). In the aftermath of Irma, Tybee lost power, and was cut off from the mainland due to inundation of Highway 80 (Brett 2017). Prior to these two storms, a major hurricane (Category 3 or higher) had not made landfall in Georgia since 1898 (Evans et al 2016). As the sea level continues to rise, and Tybee Island continues to sink, storm surge from hurricanes will become an even greater threat.

Tybee Island is also a major tourism hub and one of only four public beach communities in Georgia (Elfner 2005). It receives 1.44 million annual visitors; tourism spending generates \$93 million in on-island business revenue and \$8.7 million in governmental revenue. The tourism sector employs 1,225 people on the island and 1,643 people in Chatham County (Armstrong State University 2015). Resort cities are limited in their adaptation options by the need to retain their defining qualities that attract people to them. Therefore it is important to identify the unique qualities that Tybee residents want preserved, and how they will fare in the face of SLR (Cooper and Lemckert 2012).

Tybee Island's Beach Management Plan and Adaptation Plan

Tybee Island has already undertaken hard and soft protection measures to address the threats of shoreline erosion and coastal flooding. In 1963 the US Army Corps of Engineers initiated a Federal Beach Erosion Project for Tybee Island. 2.3 million cubic yards of sand were placed on the front beach; following this nourishment, the new sand started migrating southward and disappearing off the end of the island. This began a pattern of building groins, placing millions of cubic feet of new sand, and having the sand wash away again. The beach nourishment program is set to expire in 2023 (Elfner 2005). The recent dredging of the Port of Savannah to allow the passage of Post-Panamax ships will likely exacerbate coastal erosion on Tybee Island due to further reductions in sediment transport (Evans et al 2016).

Tybee Island is a national leader in coastal adaptation planning and coastal resilience. It has already undertaken dune restoration and revegetation efforts, and the 2016 Tybee Island Sea Level Rise Adaptation Plan (TISLRAP) identified more adaptation strategies to be implemented in the coming years. Adaptations identified in the TISLRAP included moving pump-well houses to higher elevations and retrofitting stormwater outlets (Evans et al 2016). Both measures both fall into the adaptation category of “accommodation”, indicating that there may be wide public support for other accommodation strategies.

This thesis grew out of the TISLRAP and investigated residents' SLR risk perceptions and receptivity to a variety of adaptation strategies. The purpose of the research is to inform planning policy on Tybee Island for future sea level rise. The rest of the thesis is laid out as follows: Chapter 2 is a literature review discussing the political dimensions of coastal planning, risk perceptions of climate change and sea level rise, natural hazard mitigation and adaptation strategies at the household level, and Protection Motivation Theory, the framework upon which this survey is

based. Chapter 3 describes the research and survey methods. Chapter 4 discusses the survey results, and Chapter 5 is the Conclusion and identifies opportunities for further research.

Limitations of the study include the distribution method and the inherent biases of self-reporting. The survey was administered online, and so people without internet access were not included in the study. However, considering that Tybee Island is a relatively wealthy community within the Savannah metropolitan region, it is likely that internet access is high. The survey depends on self-reporting, which is subject to pitfalls such as social-desirability bias and reference bias. Respondents may feel pressure to give the answer they “should” or that they think researchers want to hear, which could skew results (West 2014). Also, respondents may give more weight to recent or dramatic events and discount more regular occurrences (Dodd-McCue and Tartaglia 2010). Lastly, this study focuses on *proactive* adaptation strategies. Considering that Georgia had not experienced a major hurricane landfall for approximately 100 years prior to the back-to-back hurricane seasons of 2016 and 2017, the “proactivity” of future adaptation measures may be called into question, and it could be argued that it is reactive. However, in Orland et al’s (2017) survey of coastal Georgia residents in the aftermath of Hurricane Matthew, Matthew was framed as a “wake up call” for people who had never experienced a hurricane but would likely experience more in the future. Residents’ intentions were framed as proactive, future-oriented plans. Based on this logic, and since this survey was administered before the 2018 hurricane season, responses will be considered proactive.

The target population for this survey is residents of Tybee Island. Visitors were not surveyed as their responses would likely require a different set of questions. However, since Tybee’s economy depends heavily on tourism, city planners will have to factor that in to any future policy. The focus of adaptation strategies is on mitigating the flooding impacts of climate-change

induced sea level rise – impacts from wind damage, marsh dieback, and other hazards are not investigated here. Specific household adaptation measures (i.e., the use of sandbags to prevent water intrusion into the home, moving power sources to upper floors) are also not included in this study because that is too fine-grained an approach; the intent is to assess residents' receptivity, in general, to the various suites of adaptations, what kinds of policy they would likely support, and their willingness to take individual action in the future.

CHAPTER 2: LITERATURE REVIEW

A review of the urban planning and coastal management literature reveals that coastal adaptation as a response to climate change is confounded by issues of scale and the number of actors, as well as disconnect between general concerns about climate change and the adaptive capacity of local institutions (Few and Brown 2007; Abel et al 2011). While urban planning can lead to socially and environmentally sustainable responses to SLR, it must be done in a way that facilitates local ownership of adaptation responses, builds collective action within and between local communities and levels of government, and is fairly applied over space and time (Hurlimann et al 2014). Cooper and McKenna (2008) also recommend that social justice considerations be added to the traditional cost-benefit decision-making process of coastal erosion management.

Planning in the Context of Climate Change

Planning is an inherently political activity. It is funded largely through taxpayer dollars, affects large numbers of people through the shaping of their built environments, requires public input and the coordination of many public and private entities, and must reconcile multiple competing priorities. Planning for sea level rise on Tybee has added difficulties of effectively communicating the risks of SLR to the public, addressing threats that are on far larger spatial and temporal scales than people can easily comprehend, and the inherent uncertainty of when and to what degree its impacts will be felt. Much of the literature on SLR discusses people's perceptions of SLR as a general concept, the merits of adaptation strategies, managed retreat feasibility, planning best practices, management frameworks, and the sociological and economic effects of

SLR impacts on demographic groups. There is a notable gap in the literature regarding individuals' preferences for and receptivity to specific SLR adaptation strategies.

Coastal management requires the recognition of the perspectives of many different public and private stakeholders who, through their choices regarding the use and defense of their property, as well as their ability to give public input in decision-making meetings, can influence coastal policy (Alexander et al 2012, Few et al 2007). Competing priorities in coastal management can cause social injustices, for example, when protecting private property at public expense, one party bears a high cost for the benefit of the other party (Cooper and McKenna 2008). Policy intended to mitigate natural hazards must translate into specific physical actions designed to prevent, accommodate, or retreat from flooding and erosion. Regional studies in the UK have noted a need for a balanced approach of protection, accommodation, and retreat in areas of coastal risk (Few et al 2007).

Planning in the context of climate change is difficult because it requires financing and executing actions in responses to changes that may or may not happen, that are of unknown magnitude, and may take many years to manifest (Few et al 2007). Coastal erosion management decisions are determined mainly through cost-benefit analyses (Cooper and McKenna 2008). The mismatch between the time scales of climate change (decades, centuries) and planning horizons, often restrained by funding and election cycles, makes it difficult for planners and elected officials to make decisions regarding climate change adaptations (Abel et al 2011, Alexander et al 2012, Few et al 2007). Most existing adaptations, such as seawalls, revetments, and beach nourishment, have been based on a "hold the line" premise that existing property and land use patterns should be protected – a perspective that appears to be deeply entrenched within public and institutional bodies in the UK (Few et al 2007). Given the importance of individual property rights

in the United States, it is likely that the same attitude is prevalent here. US attitudes present challenges for enacting policies such as rolling easements or managed retreat, as indicated by the prevalence of lawsuits initiated by coastal property owners against local governments enacting various policies that diverge from the traditional protection regime (Novak 2016, Roberts 2013).

In recent years there have been several studies assessing people's general perceptions of climate change at the community level (Few et al 2007, Alexander et al 2012), risk perceptions of climate change-induced hazards (Peacock 2005, Akerlof 2015, Burger and Gochfeld 2017) as well as studies into flood-mitigation behaviors at the household level (Harries 2012, Lo and Chan 2017, Soetanto et al 2017). Most of these studies were performed in developed countries in Europe, or Australia. Studies in the United States are relatively rare (Song and Peng 2017). This is likely due to the lack of political will in the United States and climate change's low priority as a threat (Nagel 2011, Gallup 2010). However, Akerlof's (2015) statewide study of Maryland residents found that the majority of Marylanders believe that protecting coastal areas should be a high priority for the state government, and that they support SLR adaptation policies such as new zoning laws and set-back distances for building, long-range planning, incentivizing property owners to take protective actions, and using government funds to purchase natural areas as protective buffers. The state of Maryland has experienced a sea level rise of roughly one foot in the last 100 years (Akerlof 2015) – approximately the same as Tybee Island.

Important studies on individuals' motivations to proactively adapt to climate change include those done by Grothmann and Patt (2005), Koerth et al (2013), Akerlof (2015), and Zheng and Dallimer (2016). Studies of individual receptivity to SLR adaptation measures in the United States are few. This literature review found only four surveys investigating individual climate-related adaptation actions in the United States – Akerlof's (2015) survey of Maryland residents;

Song and Peng's (2017) survey of residents of Panama City, Florida, about SLR risks; Orland et al's (2017) survey of coastal Georgia residents in the aftermath of Hurricane Matthew; and Bukvic and Owen's (2017) survey of households affected by Hurricane Sandy. This thesis contributes to the SLR adaptation literature by assessing American attitudes towards protection, accommodation, and retreat in the context of SLR.

There have been few studies to date specifically studying American's perceptions of sea level rise, so studies on perceptions of "climate change" or "global warming" must be used as proxies. Current attitudes appear to be mixed, but lean towards seeing these phenomena as a threat. In America, 63% of people believe global warming is happening, 49% of people believe global warming is caused by human activities, 51% are at least "somewhat" worried about it, and approximately 43% believe global warming will harm people in their community, their family, or themselves (Leiserowitz et al 2013). Low-income communities affected by Hurricane Sandy largely believed that stronger and more frequent storms are caused by climate change, storms will occur more often, increased flooding was due to SLR, and that SLR is largely due to human activity; however they also expressed fatalistic opinions such as that storms are "God's will" and "there have always been storms" (Burger and Gochfeld 2013, 1269). Leaders in conservative communities may avoid incorporating climate change into planning policy for fear of raising political opposition or deterring economic development (Foss 2018). The perception of risk is directly related to environmental behavior, with perceived high risk corresponding to pro-environmental behavior (Soetanto et al 2017). Also, perceptions of personal experience with global warming heighten people's perceptions of its risks (Akerlof et al 2013). However, high risk perception does not necessarily lead to adaptation action (Wachinger et al 2012).

Most of the existing work related to hurricane response focuses on methods for reducing the impacts of future storms, with little research into the connections between attitudes, perceptions, beliefs, and migration decisions in response to hurricanes (Orland et al 2017). However, a few such as Bukvic, Smith, and Zhang (2015) and Bukvic and Owen (2016) assessed the willingness of households affected by Hurricane Sandy to relocate. While these studies are valuable for learning how people may act in the aftermath of a natural hazard, these are studies of *reactive* behavior. This thesis aimed to understand public receptivity to *proactive* adaptation measures, along the lines of Koerth et al (2013), Akerlof (2015), Zheng and Dallimer (2016), and Song and Peng (2017).

Importance of Public Perceptions in Implementing Policy

Community involvement and support is essential in planning because it can avoid major delays (Ledoux et al 2005). Surveys assessing psychological indicators and demographic data can be used to plan effective, targeted, capacity-building interventions. “Psychological indicators” are personal attributes such as hazard experience, knowledge of adaptation measures, perceived personal risk, perceived protection responsibility, and perceived relative cost. They are useful for local decision-makers because there is a strong link between them and an individual’s decision to take protective action. Also, psychological indicators can be influenced by local governance strategies and are relatively easy to change in a short amount of time (Werg et al 2013). Furthermore, engaging the public in participatory processes can change people’s perceptions of natural hazards, their amount of trust for local authorities, and their willingness to adopt protective behaviors (Wachinger et al 2012). High levels of trust in governments, and reliance on public adaptations such as flood insurance or seawalls, discourages private adaptation (Harries 2012,

Koerth et al 2013, Zheng and Dallimer 2016). The public must be engaged early in the planning stages both as a way to “sell” them on the proposed strategies and to avoid delays in the later stages (Ledoux et al 2005). Raucher (2014) found that 88% of Americans view their community water provider as a trustworthy source of climate information, and 92% want their water provider to take a lead role in planning for climate change. This level of trust could potentially be translated to other public utilities and governmental organizations on Tybee Island, to act as points of contact for climate information.

NFIP, CRS, and Jurisdictional Issues

Studies such as that by Sadiq and Noonan (2015) have shown that the tiered rating system can produce disincentives to pursue a higher rating, or to be more flood-ready. Many communities adopt more “passive” CRS activities to achieve the next rating class. These passive activities are typically less effective at reducing flood risk, leaving communities exposed to greater losses. Furthermore, this could undermine the overall efficacy of the CRS program and hamper local capacity-building. Brody et al (2009) found in a Florida study that most CRS communities a small fraction of the available points. They focus on public information and mapping (passive) while neglecting damage reduction and flood preparedness (active) activities. Koursky (2018) suggests that this is true nationwide, noting that flood loss claims are lower in communities that participate in the CRS, but that certain CRS activities (the passive ones) are more prevalent in loss claims than others.

The CRS is unique among federal environmental policies in that it bypasses state governments and directly engages local governments to promote a local, common good (Sadiq and Noonan 2015). However, Shively (2017) says that due to issues of scale and trust, FEMA is likely

not the best entity to seek direct community engagement, which is best left to state- and community-based floodplain managers who help communities implement NFIP through local development codes. Similarly, Berke et al (2014) argue that local mitigation planning is not valued enough under the current CRS credit system, which results in a fragmented, project-based approach that ignores holistic planning. They advocate for a heavier weighting of preventative land-use actions over other categories of credit actions, pointing to land-use planning's essential function in mitigating the buildup of urban development. Most importantly, they call for local governments to be awarded substantial CRS credits for coordinating local mitigation strategies with local comprehensive plans, pointing to Burby's (2006) findings that insured losses from hazards are drastically reduced when mitigation efforts are integrated into local comprehensive planning efforts. These changes will counteract the preference of "passive" activities that many communities adopt, and improve flood readiness.

They also point out that the federal focus on project-based initiatives has led to a disjointed mitigation approach, and that state policy has a much stronger influence on local land use policies than federal policies do even if state policy does not guarantee support for land use initiatives. Thus, the federal government should require states to give preference to land use policy and recognize land use planners as leaders in local adaptation programs. Considering that land-use policy solutions are more complex and context-specific than other mitigation activities, such solutions are most effective when local governments are allowed flexibility to set policy most appropriate for their community.

Social Justice and Flood Readiness

The CRS, and hazard adaptations in general, are often constrained by financial realities. This can cause different protective outcomes for communities of disparate wealth and resources, potentially entrenching climate-hazard inequality. For example, in post-Sandy New York City, the redrawing of FIRM maps will affect tens to hundreds of thousands of people. Many of them are lower income, and will not be able to afford the new premiums even if they sign up early to get grandfathered in at a lower rate (Chen 2018). Shively (2017) points out that in light of the new FIRM maps affecting new populations, expecting low-to-moderate income households to pay NFIP premiums without financial assistance or policy change would only increase climate injustice.

Sadiq and Noonan (2015) found that among participating communities with more flood mitigation actions, the communities with more resources (higher property values and income, bigger government budgets) received bigger subsidies than less resource-rich communities with equal flood risk. They assert that a self-selecting mechanism is at play that favors communities that are already better-equipped to identify and pay for the upgrading activities. At the same time, participating communities at the lower levels of mitigation adopt far more passive activities such as information sharing, which leaves them at greater risk of flood damage. This is in line with the findings of Landry and Li (2012) that financial capacity is a major determinant of mitigation actions, and that vulnerability may be higher in poorer communities with lower property values. They recommend a proactive approach in which state and federal agencies create a better system for aid grants, low-interest loans, and technical assistance that builds resilient communities before disasters, rather than focusing resources on post-disaster cleanup.

Environmental Psychology and Ideology

People's understandings of their environment can be described by their environmental ideologies. Corbett (2006) defines an environmental ideology as "a way of thinking about the natural world that a person uses to justify actions toward it," framing how we relate to the land and its nonhuman inhabitants, and influencing our actions toward them (Corbett 2006, 26). Corbett claims that ideologies run deeper than mere opinions, and are not easily swayed by external events. Corbett orders environmental ideologies on a spectrum. At one endpoint is an anthropocentric outlook, in which humans are at the top of a pyramid, separate from and superior to the natural world. Nature exists solely to serve humanity. At the opposite endpoint is an ecocentric outlook, in which humans are situated in a circle or web along with the rest of the biotic and abiotic elements of the world. In this interdependent arrangement, there is no hierarchy and nobody, not even humans, at the top. Between these two endpoints lie several other ideologies – Unrestrained Environmentalism, an anthropocentric view that natural resources exist solely for unlimited human use; Conservationism, which values natural resources insofar as they are useful to humans; Preservationism, which values natural resources for human use and enjoyment beyond their instrumental value; Ethics and values-driven ideologies, which recognizes that nonhuman entities have intrinsic value and humans have moral and ethical duties towards them; and Transformative Ideologies, which seek to transform anthropocentric worldviews into more ecocentric ones, and pursue new social institutions that recognize the effect of human dominance on the natural world. Corbett cautions that environmental attitudes are only moderately successful at predicting environmental actions. However, knowing where respondents fall on this spectrum, and identifying them as belonging to one of the above groups will enable planners to tailor outreach materials to specific audiences.

Adaptations to Sea Level Rise

Historically, protection has been the preferred adaptation method, especially at the individual property level in the United States. The focus for protection on barrier islands has typically been the high-tide shoreline, rather than taking a holistic view of the entire island or chain of islands (Neal et al 2005). Existing regulatory methods like building codes and land use controls may lessen the impact of storm events but do not recognize or account for coastal retreat (Ibid). Development and adaptation often work at cross-purposes in that costly investments of development are protected with hard structures such as seawalls, bulkheads, and revetments, which then encourage further development.

Increased awareness of the negative effects of hard protection on erosion and sedimentation patterns has increased interest in soft protection measures (Klein et al 2001). Soft protection utilizes more natural approaches such as restoring dunes and wetlands, and adding sand through beach nourishment. Beach nourishment, however, is a soft-stabilization technique that is equivalent to the engineering fix of “holding the line” and has drawbacks such as ongoing costs, diminishing sand supplies, shorter half-lives of nourished beaches, and environmental impacts from dredging and sand placement (Neal et al 2005). Tybee Island and the US Army Corps of Engineers have a beach nourishment program in place, although it is set to expire in 2024. In recent years, the protection strategy of “living shorelines” has gained popularity and proven its effectiveness. Living mimic nature and stabilize marsh and stream banks with native plants, rocks, and oyster shells (UGA Sea Grant 2018). They are more resilient against storms than bulkheads, and allow marsh migration and the growth of plants and animals (NOAA 2017). In Georgia, the permitting process for living shorelines is identical to the permitting process for a bulkhead. The Georgia Coastal Resources Division’s experience with living shorelines is limited to those that

promote oyster reef growth (Jones 2015). This type of living shoreline is considered an “eco-armoring” technique and so it legally treated as hard protection, because if it fails to grow, the hard substrate has the same detrimental environmental effects as a bulkhead (Christopher Wisener, personal communication).

Accommodation is the process of improving a community’s resilience and ability to cope with the effect of a hazardous event. This typically involves alterations to the built environment such as retrofitting buildings and infrastructure to withstand flooding, elevating structures, elevating and curving roads, and improving drainage systems (Neal et al 2005). Other accommodation measures include improved emergency planning, modification of land use practices, and the strict regulation of hazard zones (Klein et al 2001).

Managed retreat, or “managed realignment” as it is called in the EU, encompasses a range of regulatory strategies that include abandonment, relocation, avoidance, setbacks, and land acquisition (Neal et al 2005). Managed retreat is a proactive adaptation strategy that can be implemented over many years. It is expected to be cheaper in the long term than protection or accommodation strategies and is a viable response for low-lying coastal communities that cannot afford to keep investing in protection or accommodation (Abel et al 2011). Though managed retreat has many benefits for communities, it places a disproportionately large burden on some property owners. However, the expectation that publicly-funded structures will be used to protect private property is burdensome to those who do not own coastal property (Cooper and McKenna 2008). Two prominent obstacles to managed retreat are a lack of public support – especially in cases of losing an existing defense – and a lack of adequate financial compensation to landowners (Ledoux et al 2005).

Protection Motivation Theory

The theoretical framework of this research is modeled on Rogers' (1975) Protection Motivation Theory. Protection Motivation Theory (PMT) describes how people are driven to act in response to fear and has been translated into a more general theory of persuasive communication to effect behavior change (University of Twente 2017). In the PMT process, an individual is presented with a fear stimulus as well as recommendations of ways to avert the danger. The decision to act is reached after two cognitive processes have occurred: the threat appraisal and the coping appraisal. Threat appraisal is the assessment of the fear appeal, and its two components are *probability* and *severity* (Rogers 1975). First a person must decide how likely the threat is to occur if not action is taken, and then determine the degree to which the threat will impact them. If they believe that the threat will occur and that the consequences will be dire enough, they move to the process of coping appraisal. Coping appraisal has three parts – beliefs about an action's efficacy, beliefs about one's ability to successfully execute the action, and a weighing of the costs (e.g. money, time, effort) that the action will require (Rogers 1975, Grothmann and Patt 2005, Zheng and Dallimer 2016). If a person believes that the action will be effective, that they can successfully carry out the action, and that the costs of action will not outweigh the benefit, then they will form an intent to act (Zheng and Dallimer 2016, Koerth et al 2013). In the climate change literature, the terms "threat appraisal" and "coping appraisal" are more commonly called "risk appraisal" and "adaptation appraisal" (Koerth et al 2013, Song and Peng 2017, Zheng and Dallimer 2016).

Similar to PMT is Ajzen's Theory of Planned Behavior (TPB). These two frameworks appear to have been developed concurrently yet independently. While Orland et al (2017) was the only survey reviewed to explicitly utilize this framework, it is worth mentioning for its potential to explain climate adaptation behavior. TPB grew out of Ajzen and Fishbein's (1975) Theory of

Reasoned Action, which predicts a person's behavior in situations wherein they have complete control (Ajzen and Fishbein 1975). TPB applies to situations when a person's behavior is influenced by factors over which they have only limited control, and states that a person's decision to act depends on their probability of success or failure, the consequences of success or failure, normative beliefs regarding attitudes of their peers, and the desire to comply with these norms (Ajzen 1985). Put another way, perceptions motivate intentions, and intentions determine behaviors (Soetanto et al 2017).

Also building on PMT is Grothmann and Patt's (2005) Model of Private Proactive Adaptation to Climate Change (MPPACC). The MPPACC distills the cognitive steps that lead from perception to action in order to detect where in the process people lose their motivation to act. Their particular focus is on perceptions of risk and adaptive capacity. Applying this model to two case studies in Germany and Zimbabwe, Grothmann and Patt determined that the most important factors in deciding to undertake adaptation behaviors are the perceived efficacy and perceived costs of the adaptation (Grothmann and Patt 2005).

To reiterate, the purpose of this research is to evaluate Tybee residents' SLR perceptions, determine which adaptation measures they would most be willing to have the local government pursue, and identify where outreach would be helpful in changing residents' perceptions. It does not focus strictly on individual householder action, though this component is included in the suite of measures. The theories of PMT, TPB, and the MPPACC are applicable frameworks because they assess people's risk and adaptation perceptions and how they may be willing to act, and it makes sense that individuals' desires should be communicated to and reflected by local policy. The questions in this survey were chosen in accordance with PMT's categories of threat/risk appraisal (perceived probability, perceived severity) and coping/adaptation appraisal (adaptation

efficacy, self-efficacy, and adaptation cost). The survey also includes questions regarding perceived responsibility, to determine the desired role of government in adaptation planning policy. Taken together they should indicate what residents believe should be done, and who they think should do it.

To date there seems to be little in the literature that assesses individual perceptions of sea level rise adaptations, and fewer that explicitly do so using PMT as a theoretical framework. Furthermore, the majority of studies using PMT for adaptation planning have focused on flooding mitigation at the individual, household level. This thesis focused on individual perceptions of adaptation strategies at both the individual and community level, and seeing if people with similar adaptation preferences or opinions share similar characteristics. The reason for using PMT was used as a guiding framework in an attempt to identify the points at which Tybee residents decide not to support a certain adaptation strategy. For example, adaptation appraisal is an important predictor for adaptation behavior, thus outreach should enhance residents' confidence in undertaking adaptation measures (Koerth et al 2013). Knowing the point in the process at which this breakoff occurs can help coastal managers tailor outreach or engagement program for target audiences.

CHAPTER 3: METHODOLOGY

This thesis evaluated residents' understanding and awareness of SLR risk, their receptivity to various adaptation strategies, and to what degree these attitudes are related to cognitive factors and demographic characteristics. This information was given to the City of Tybee so that the local government can assess the need for more targeted outreach and education, develop politically palatable approaches, and prioritize locations for adaptation interventions.

Survey Design

The survey questionnaire was developed after a review of sea level rise adaptation strategies (protect, accommodate, or retreat) and a review of similar surveys, particularly Koerth et al (2013, 2017), Orland et al (2017) and Song and Peng (2017). Questions were grouped in accordance with Rogers' Protection Motivation Theory, assessing respondents' risk appraisal and adaptation appraisal. The questionnaire was crafted according to Dillman et al's (2009) Tailored Design Method (TDM). TDM is a scientific approach to conducting surveys that focuses on reducing the four sources of survey error – coverage, sampling, nonresponse, and measurement. Coverage error occurs when not all members of the population have a known, nonzero chance of being selected for the survey. A potential source of coverage error is that this survey will be administered online, and it is possible that not all residents have internet access; however, this error is expected to be minimal. Sampling error is the extent to which the precision of the survey is limited because not every person in the population is sampled, and results from surveying only some rather than all members of a population. Nonresponse error stems from not getting everyone

who was sampled to respond to the survey, and occurs when the people selected for the survey who do not respond are different from those who do respond in a way that is important to the study. Nonresponse error is unavoidable, but can be mitigated using personalization, sending reminders, or adopting an alternate survey mode, such as the telephone. Measurement error occurs when a respondent's answer is inaccurate or imprecise. This is often due to poor question wording or survey design. To reduce measurement error, questions will be kept short and specific, and use simple, familiar words. They will also be grouped by theme to provide consistency for the respondent: demographic questions, personal experience on Tybee Island, Risk Appraisal, Adaptation Appraisal, and two vent questions.

Analysis

Crosstabulations are a method for showing relationships between variables. They are best conceptualized as a set of related frequency tables combined into one, with the X-axis as the independent variable and the Y-axis as the dependent variable; the greater the difference in value between columns in the same row, the higher the likelihood that the variables are related and that the relationship is not a matter of chance (De Vaus 2002). Crosstabulations are not always appropriate, especially when the sample is small, such as in the results of this research. To mitigate this problem, categories of variables can be collapsed or reduced (Ibid.), as has been done in this analysis. For ordinal scale questions with five answer categories, the two on either end were combined – for example, “Definitely agree” and “Somewhat agree” were counted as “Agree.” In addition to crosstabulations to detect relationships between variables, respondents' overall risk appraisal, adaptation appraisal, and allocation of responsibility were assessed.

Distribution

The survey was made available online. Recruitment was conducted through snowball or convenience sampling, wherein known contacts were selected to take the survey and then asked to recruit their acquaintances, and so on. The survey link was distributed to key Tybee residents as well as coastal researchers. They were then asked to provide email addresses for other potential respondents, or to forward the survey to other residents.

The survey began with demographic questions regarding residency, property ownership, and flood hazard awareness, followed by qualitative questions about Tybee Island. Respondents were then asked about their perceptions of sea level rise and if they thought they would be personally affected. They were also asked to rate a range of SLR adaptation strategies for their perceived effectiveness, their personal ability to implement them (self-efficacy), and indicate whether or not they would support their implementation by the local government. Lastly, they were asked to identify an area on Tybee in need of intervention, and to select an adaptation strategy to address it. A copy of the survey is included in Appendix 1.

The survey was open for 14 days, after which time the responses were analyzed using Qualtrics and JMP. The data revealed residents' perceptions of risk and their own adaptive capacity, their receptivity to a broad range of adaptation strategies, and their opinions on responsibility for SLR adaptations. The data will be used to make recommendations for city officials going forward.

CHAPTER 4: RESULTS AND DISCUSSION

This survey assessed Tybee residents' receptivity to proactive adaptation strategies. Considering the nearly back-to-back devastation caused by Hurricanes Matthew and Irma after nearly a century without direct landfall of a major hurricane, the results could be skewed in that some respondents were in a reactive frame of mind. However, there is a period after a disaster wherein people can answer questions about future storm impacts from a position of direct experience (Orland et al 2017). This suggests that this survey can also be considered to measure "proactive" adaptation measures.

Grothmann and Patt's (2005) Model of Private Proactive Adaptation to Climate Change (MMPACC) explains why some people exhibit adaptive behaviors but others do not. Based on PMT, it traces peoples' risk and adaptation appraisal processes to their response of either adaptation (preventing harm), or maladaptation (actions that either avoid or exacerbate the threat). An avoidant maladaptation would be adopted when a person's risk perception is high, but perceived adaptive capacity is low. Socio-cognitive indicators (i.e. risk and adaptation appraisal) are important for assessing individual adaptive capacity because they offer better predictions about future adaptation and vulnerability than demographic indicators (i.e. age or education level) (Muller et al 2011, Werg et al 2013, Koerth et al 2013). Furthermore, psychological/cognitive indicators can be influenced by local governance strategies in the short to medium term, making them more immediately impactful than traditional demographic factors (Werg et al 2013). Koerth et al (2013) found that personal experience of a natural disaster is the main driver of adaptation

behaviors, however other studies (Peacock et al 2005, Soetanto et al 2017) have found that personal experience of a hazard is not a good predictor of future protective behavior.

Protection Motivation Theory

Risk Appraisal – Probability

The majority of respondents (85.38%) believed that SLR is happening. Of these, over half of respondents reported that they have already been affected by SLR (63.95%) or will be affected by it in the next five years (17.44%). Moreover, 86.29% of residents have noticed an increase in frequency of flood events on Tybee Island. When shown a potential 3-foot sea level rise on Tybee Island by the end of the century, 61.72% of respondents believed that their property would be affected.

Table 1. Risk Probability Questions

Question [Abbreviated descriptor]	Choices [ordinal scale] {#of responses, % }
Have you noticed a change in the frequency of flooding on Tybee Island? [Recent events]	<ul style="list-style-type: none"> a. I have noticed a significant increase [1] {66, 48.53% } b. I have noticed a slight increase [2] {48, 35.29% } c. I have not noticed a change [3] {22, 16.18% } d. I have noticed a slight decrease [4] {0, 0% } e. I have noticed a significant decrease [5] {0, 0% }
Do you think you personally will be affected by SLR? [Personal welfare]	<ul style="list-style-type: none"> a. Yes [1] {91, 65.94% } b. Maybe [2] {36, 26.09% } c. No [3] {11, 7.97% }
When do you think you will be affected by SLR? [Immediacy]	<ul style="list-style-type: none"> a. I have already been affected [1] {57, 63.33% } b. Within 5 years [2] {15, 16.67% } c. Within 10 years [3] {10, 11.11% } d. Within 25 years [4] {7, 7.78% } e. Within 50 years [5] {1, 1.11% }
If the sea level rose three feet by 2100, would your property be affected? [Climate scenario]	<ul style="list-style-type: none"> a. Definitely yes [1] {60, 42.86% } b. Probably yes [2] {23, 16.43% } c. Might or might not [3] {30, 21.43% } d. Probably not [4] {18, 12.86% } e. Definitely not [5] {9, 6.43% }

Risk Appraisal – Severity

Respondents reported being “Very Concerned” about SLR’s impact on both the natural and built environments, indicating that they believed the impacts would be severe. Slightly more people were concerned about impacts to the built environment (95.16%) than to the natural environment (91.05%). They also overwhelmingly believe that SLR will intensify both extreme weather events (91.87%) and regular tidal events (95.93%). This suggests that the majority of respondents view the potential consequences of SLR as very severe.

Table 2. Risk Severity Questions

Question [Abbreviated descriptor]	Choices [ordinal scale] {#of responses, % }
To what extent are you concerned about sea level rise affecting the natural environment? [Priorities]	<ul style="list-style-type: none"> a. Very concerned [1] {86, 63.70% } b. Somewhat concerned [2] {37, 27.41% } c. Neither concerned nor unconcerned [3] {10, 7.41% } d. Somewhat unconcerned [4] {0, 0% } e. Not at all concerned [5] {2, 1.48% }
To what extent are you concerned about sea level rise affecting the built environment? [Priorities]	<ul style="list-style-type: none"> a. Very concerned [1] {81, 59.56% } b. Somewhat concerned [2] {48, 35.29% } c. Neither concerned nor unconcerned [3] {3, 2.21% } d. Somewhat unconcerned [4] {3, 2.21% } e. Not at all concerned [5] {1, 0.74% }
Do you think that sea level rise will intensify extreme weather events such as floods, hurricanes, and storm surges? [Random events]	<ul style="list-style-type: none"> a. Yes, definitely [1] {83, 61.48% } b. Yes, probably [2] {40, 29.63% } c. No, probably not [3] {11, 8.15% } d. No, definitely not [4] {1, 0.74% }
Do you think that sea level rise will intensify regularly-occurring events such as spring or king tides? [Cyclic events]	<ul style="list-style-type: none"> a. Yes, definitely [1] {85, 62.96% } b. Yes, probably [2] {44, 32.59% } c. No, probably not [3] {6, 4.44% } d. No, definitely not [4] {0, 0% }

Adaptation Appraisal – Response Efficacy

Response efficacy is the perception that a potential action will enable someone to successfully prevent or avoid harm. Respondents were presented with a range of adaptation strategies including protection, accommodation, and retreat, and asked if they thought the City of Tybee should pursue them. Responses to these yes-or-no questions will be considered proxies for adaptation efficacy, because it is reasonable to assume that people would not want resources to be spent on approaches they do not think will work. One question (“There is nothing anyone can do about SLR”) was asked to assess a respondent’s degree of fatalism, because as Grothmann and Patt (2005) noted, a fatalist outlook can lead to maladaptive responses such as denial, inaction, or counterproductive actions.

The most popular adaptation by far (98.36%) is the restoration of natural areas, a form of soft protection. The next most-supported adaptations are requiring new development to be able to withstand flooding (96.72%) and discouraging or prohibiting the development of sensitive lands using measures such as zoning (93.39%)¹. Categorically, respondents most favored soft protection strategies (95.92%)², followed by accommodation (87.91%). Retreat strategies were less popular, with 60.09% of respondents in favor of them. Hard protection was not seen as desirable, with only 44.92% in favor

¹ Option 9, “Help vulnerable communities prepare for floods and other impacts”, was excluded post-analysis because it was too vague and was not a concrete action.

² Includes responses from other questions asking about support of beach nourishment and living shorelines

Adaptation	Yes		No	
	Percent	Count	Percent	Count
Incentivize the protection of sensitive lands through measures such as tax breaks	85.47%	100	14.53%	17
Retrofit or elevate development that is at risk of flooding	86.55%	103	13.45%	16
Purchase land that is ecologically sensitive or at risk of flooding to keep it free of development	82.91%	97	17.09%	20
Require new development to be able to withstand flooding	96.72%	118	3.28%	4
Discourage or prohibit the development of sensitive lands through measures such as zoning	93.39%	113	6.61%	8
Permanently remove damaged structures after a disaster	49.57%	58	50.43%	59
Relocate development to less vulnerable areas	71.19%	84	28.81%	34
Eliminate or charge more for flood insurance on structures built in vulnerable areas	53.85%	63	46.15%	54
Plan new communities in nearby cities to help relocate vulnerable populations	32.46%	37	67.54%	77
Restore natural areas such as dunes and wetlands	98.36%	120	1.64%	2
Build seawalls, bulkheads, revetments	44.92%	53	55.08%	65

Figure 2. Should the City of Tybee pursue the following SLR adaptations?

Responses to the questions “Should the City of Tybee pursue the following SLR adaptations?” revealed that at least one third of respondents are hypothetically open to a managed retreat scheme. At least 32% thought that Tybee should plan new communities in nearby areas to help people relocate, and 71% agreed that development should be relocated to less vulnerable areas. More research is needed to determine exactly what should be relocated, and where it should be relocated to. Also, since the vast majority of respondents indicated that they would do what it takes to stay in their home, research is needed to determine what would motivate people to relocate. It is possible that there is an attitude of “everyone else should go, but I can stay”, and this must be assessed. There are several managed retreat strategies listed in the CRS credits, such as open space preservation, higher regulatory standards, acquisition and relocation, and floodplain management planning. Results of this survey show support for these types of activities. If Tybee has not already pursued these avenues for their CRS rating, or there is room for improvement, this is a perfect opportunity to include such adaptation strategies in local planning policy. Linking these strategies to CRS recertification or reclassification would increase their likelihood of implementation.

Adaptation Appraisal – Self-Efficacy

Table 3. Self-Efficacy Questions

Question	Choices [ordinal scale] {#of responses, % }
I feel knowledgeable about sea level rise adaptation strategies [Do I know what to do]	<ul style="list-style-type: none"> a. Completely agree [1] {11, 8.27% } b. Somewhat agree [2] {42, 31.58% } c. Neither agree nor disagree [3] {31, 23.31% } d. Somewhat disagree [4] {39, 29.32% } e. Completely disagree [5] {10, 7.52% }
I feel that I can successfully implement adaptation measures on my own {Can I do it}	<ul style="list-style-type: none"> a. Completely agree [1] {1, 0.75% } b. Somewhat agree [2] {16, 12.03% } c. Neither agree nor disagree [3] {20, 15.04% } d. Somewhat disagree [4] {37, 27.82% } e. Completely disagree [5] {59, 44.36% }
I feel that the government can successfully implement adaptation measures that would protect my home [Can it be done]	<ul style="list-style-type: none"> a. Completely agree [1] {10, 7.52% } b. Somewhat agree [2] {37, 27.82% } c. Neither agree nor disagree [3] {19, 14.29% } d. Somewhat disagree [4] {41, 30.83% } e. Completely disagree [5] {26, 19.55% }

Self-efficacy is the belief that one can successfully execute a behavior that will prevent harm from occurring – in this case, an adaptation strategy. To determine self-efficacy, respondents were asked if they felt knowledgeable about SLR adaptation strategies and if they felt that they could successfully implement strategies on their own. The results show that while 41% of respondents feel at least somewhat knowledgeable about adaptation strategies, only 13.6% feel that they could effectively carry them out. However, 42% of respondents think the government can successfully implement SLR adaptation measures that would protect them. This indicates a need for educational opportunities for residents to learn more about SLR adaptations, in order to increase their knowledge and confidence.

Adaptation Appraisal – Adaptation Costs

Table 4. Adaptation Cost Questions

Question [Abbreviated descriptor]	Choices [ordinal scale] {#of responses, % }
I would do what it takes to stay in my home [Cost of leaving]	<ul style="list-style-type: none"> a. Strongly agree [1] {54, 39.71% } b. Somewhat agree [2] {45, 33.09% } c. Neither agree nor disagree [3] {19, 14.29% } d. Somewhat disagree [4] {9, 6.62% } e. Strongly disagree [5] {9, 6.62% }
Using my own resources, I could not recover from losses or damage to my home [Cost of staying]	<ul style="list-style-type: none"> a. Strongly agree [1] {25, 18.66% } b. Somewhat agree [2] {35, 26.12% } c. Neither agree nor disagree [3] {30, 22.39% } d. Somewhat disagree [4] {25, 18.66% } e. Strongly disagree [5] {19, 14.18% }
I would like to relocate elsewhere to avoid losses or damage [Cost of staying]	<ul style="list-style-type: none"> a. Strongly agree [1] {5, 3.76% } b. Somewhat agree [2] {18, 13.53% } c. Neither agree nor disagree [3] {18, 13.53% } d. Somewhat disagree [4] {29, 21.80% } e. Strongly disagree [5] {63, 47.37% }
My peers think that sea level rise adaptations are important [Social cost]	<ul style="list-style-type: none"> a. Strongly agree [1] {28, 21.71% } b. Somewhat agree [2] {53, 41.09% } c. Neither agree nor disagree [3] {33, 25.58% } d. Somewhat disagree [4] {13, 10.08% } e. Strongly disagree [5] {2, 1.55% }

The final component of Protection Motivation Theory is the cost appraisal: how much will the consequences of action outweigh those of inaction? Costs can be both social and financial. If an individual perceives a high social cost of implementing an action, for example if they think it is not a popular course of action, they are less likely to do it. However, if they feel that their peers would approve of the action, they are more motivated to carry it out. Dollar valuations of SLR adaptations are beyond the scope of this research, so respondents were asked general questions about their financial and social resilience. Over 63% of respondents said that their peers believed that SLR adaptations are important. According to PMT, this should motivate them to also embrace SLR adaptations, so that they can maintain standing in their peer group.

Regarding finances, respondents were asked if they felt capable of recovering from severe storm damage using their own resources – 45% said they could not, suggesting that, for many people, the costs of inaction on SLR would outweigh the costs of action. Moving, however, is not an appealing option for most respondents. While approximately 20% said they would like to relocate to avoid losses or damage from SLR, approximately 72% said they would do what it takes to stay in their homes. Taken together, these responses suggest that residents are open to adaptations as long as they are able to remain in their homes. The fact that “Accommodation” was a popular category of adaptation strategies corroborates this finding.

Discussion of the PMT Component Questions

Residents of Tybee Island are acutely aware of the risks posed by SLR, perceiving that there is both a high probability of a flood occurring, and that the impacts will be severe. However, while high risk perception can lead to the adoption of adaptation behaviors (Lindell and Hwang 2008, Grothmann and Reusswig 2006, Dallimer and Zhang 2016), this is not always the case (Scolobig 2012, Soetanto et al 2017). While awareness of risk is important, it is not enough to inspire action – people must also be aware of actions they can take to avoid harm, believe the actions will be effective, and believe that they can successfully execute the action without too high of a cost.

Approximately 40% of respondents reported feeling knowledgeable about SLR adaptations, yet only 14% thought that they could successfully implement adaptation measures on their own, while 32% believed that the government could successfully do so. Notably, 43% of respondents have already pursued adaptation measures for their property, indicating existing support, or recognition of the need, for household-level adaptations. Common adaptation measures undertaken by residents are elevating their homes to meet or exceed FEMA standards, landscaping

and installing equipment to facilitate drainage, sealing lower levels of homes, structural storm-proofing methods, using the lower levels only for storage, and moving utilities and valuables to higher floors. Since perceived adaptation efficacy and perceived self-efficacy have a positive effect on adaptation actions (Koerth et al 2017), it can be concluded that nearly half of respondents felt confident in these structural, household-level adaptation measures as well as in their personal abilities to implement them.

This suggests that residents may want the government to take the lead in implementing SLR adaptations because residents feel they have done all they can do. It also identifies an opportunity for more public education and outreach regarding SLR strategies. Admittedly, the adaptation strategies featured in the survey were not household-level adaptations such as those reported by respondents in the previous paragraph. Rather, they were larger-scale approaches that will likely require more coordination and capital than individuals can muster. Since the purpose of this survey was to assess residents' receptivity to SLR adaptations so that they could be incorporated into local policy, the focus was on regulatory and capital-intensive approaches that would require government involvement.

This survey has shown that respondents recognize that SLR poses a great risk, but are less confident in their ability to implement adaptation measures. In outreach to residents, Tybee should emphasize possible adaptation strategies and help people feel more confident and comfortable with them rather than focusing merely on the potential impacts of SLR. Communicating just the risks of SLR is insufficient for motivating individuals to act; also, communicating the risks without also educating about possible solutions is likely to cause people to use maladaptive responses (Koerth et al 2017, Gothmann and Pratt 2005). Highlighting the efficacy of adaptations and boosting people's confidence of them can greatly enhance a community's resilience (Soetanto et al 2017).

Responsibility

Table 5. Responsibility Questions

Question	Choices [ordinal scale] {#of responses, % }
It is ultimately the responsibility of an individual to protect their home from sea level rise	<ul style="list-style-type: none"> a. Completely agree [1] { 10, 7.52% } b. Somewhat agree [2] { 37, 27.82% } c. Neither agree nor disagree [3] { 19, 14.29% } d. Somewhat disagree [4] { 41, 30.83% } e. Completely disagree [5] { 26, 19.55% }
It is ultimately the responsibility of local government to protect people's property from sea level rise	<ul style="list-style-type: none"> a. Completely agree [1] { 10, 7.52% } b. Somewhat agree [2] { 37, 27.82% } c. Neither agree nor disagree [3] { 19, 14.29% } d. Somewhat disagree [4] { 41, 30.83% } e. Completely disagree [5] { 26, 19.55% }
It is ultimately the responsibility of the State or Federal government to protect people's property from sea level rise	<ul style="list-style-type: none"> a. Completely agree [1] { 10, 7.52% } b. Somewhat agree [2] { 37, 27.82% } c. Neither agree nor disagree [3] { 19, 14.29% } d. Somewhat disagree [4] { 41, 30.83% } e. Completely disagree [5] { 26, 19.55% }
I am willing to work together with my neighbors to implement adaptation measures	<ul style="list-style-type: none"> a. Completely agree [1] { 10, 7.52% } b. Somewhat agree [2] { 37, 27.82% } c. Neither agree nor disagree [3] { 19, 14.29% } d. Somewhat disagree [4] { 41, 30.83% } e. Completely disagree [5] { 26, 19.55% }

Responses regarding the allocation of responsibility varied widely. While the majority of respondents (56.91%) agreed that individuals are ultimately responsible for protecting their property from SLR, more than 45% thought that local government (45.53%) and the state or federal government (48.78%) are ultimately responsible for protecting people's property from SLR. This same percentage of people (48.78%) also believed that the federal government should do more to help people protect their homes, while slightly less (44.71%) thought that the government of Tybee should do more.

Table 6. Responsibility Questions continued

Question	Choices [ordinal scale] {#of responses, % }
The City of Tybee should do more to protect my home	<ul style="list-style-type: none"> a. Completely agree [1] {18, 13.74% } b. Somewhat agree [2] {41, 31.30% } c. Neither agree nor disagree [3] {36, 27.48% } d. Somewhat disagree [4] {26, 19.85% } e. Completely disagree [5] {10, 7.63% }
The Federal government should do more to protect my home	<ul style="list-style-type: none"> a. Completely agree [1] {25, 19.08% } b. Somewhat agree [2] {39, 29.77% } c. Neither agree nor disagree [3] {33, 25.19% } d. Somewhat disagree [4] {18, 13.74% } e. Completely disagree [5] {16, 12.21% }
The City of Tybee should help me move somewhere safer	<ul style="list-style-type: none"> a. Completely agree [1] {2, 1.53% } b. Somewhat agree [2] {5, 3.82% } c. Neither agree nor disagree [3] {24, 18.32% } d. Somewhat disagree [4] {27, 20.61% } e. Completely disagree [5] {73, 55.73% }
The Federal government should help me move somewhere safer	<ul style="list-style-type: none"> a. Completely agree [1] {6, 4.58% } b. Somewhat agree [2] {5, 3.82% } c. Neither agree nor disagree [3] {24, 18.32% } d. Somewhat disagree [4] {29, 22.14% } e. Completely disagree [5] {67, 51.15% }
Have you personally implemented any adaptation measures on your property?	<ul style="list-style-type: none"> a. Yes [5] {56, 43.08% } b. No [5] {74, 56.92% }

Grothmann and Patt identify a research need for determining the extent to which the MMPACC applies to adaptations carried out by governmental organizations. It is interesting to note the “missing middle” wherein responsibility is assigned to the individual, or the higher levels of government, while less is assigned to the local government. This may be because the federal government is seen as having more resources. However, local government is better able to affect immediate actions and policy, and many climate-related responsibilities were delegated to local governments from higher echelons. This uncovers a potential need for people to be educated about available programs or processes in place at the local level. Or, more straightforwardly, a need for more funding and resources to be allocated to local governments.

It is commonly found that trust in public flood protection, such as flood insurance, government compensation, or infrastructure projects decreases people’s motivation to prepare for floods themselves (Grothmann and Reusswig 2006, Wachinger et al 2012, Dallimer and Zhang 2016, Koerth et al 2017). Tybee residents do not seem to think that owning flood insurance excuses people from taking further adaptation action – indeed, 93.55% disagree that flood insurance alone is sufficient to protect people from SLR. At the same time, fewer respondents (33.60%) think that the government can successfully implement adaptation measures to protect their homes than think it cannot (51.20%). This apparent skepticism may indicate that respondents are willing to implement more adaptations at the household or community level than might otherwise be imagined.

Environmental Ideology

Table 7. Response to Environmental Ideology

Ideological Description	Percentage	Count
Humans are at the top of the hierarchy, separate from and superior to the natural world, and natural resources exist solely for unlimited human use	0.67%	1
Natural resources are valuable insofar as they are useful to humans	2.67%	4
Natural resources should be valued for more than their instrumental use, such as for beauty and enjoyment	11.33%	17
Natural resources and nonhuman entities have intrinsic value, and humans have moral obligations towards them	45.33%	68
Humans are situated in a web of relationships with the living and nonliving elements of the natural world, there is no hierarchy	40.00%	60

The most prevalent ideologies of respondents are Ethics and Value-Driven, and Transformative ideologies. The only statistically significant relationship between environmental ideology and demographics was whether a respondent was a full-time resident of Tybee or not. Respondent's environmental ideologies revealed statistically significant correlations through crosstabulation. Environmental ideology was most related to Risk Appraisal, showing a relationship with four different components. People with Ethics/Value-Driven and Transformative (EVD&T) ideologies were more likely than those with Instrumentalist, Conservationist or Preservationist ideologies to believe they would be affected by SLR; to be concerned about SLR's impact on the natural environment; and to believe that SLR will intensify both extreme weather events and regular tidal events. There is also a strong correlation between people with EVD&T ideologies and support for regulatory measures such as discouraging development of sensitive lands through zoning. They also were more likely to agree with the statement "The federal government should help me move somewhere safer", although very few respondents of any ideology showed a desire to relocate.

It must be acknowledged that these results are less than reliable because there were less than five values in each crosstabulation cell. Ideologies of respondents are overwhelmingly EVD&T, which could skew the results.

Selected Crosstabulations

Responsibility by Risk Severity

There are strong correlations between the belief that one could not recover from a natural disaster using their own resources, and to whom respondents assign responsibility for SLR adaptations. Those who agree that they could not recover on their own are far more likely to assign responsibility to the local, state, or federal government. Among these scenarios, the most responsibility was assigned to the State or Federal government.

Responsibility by Self-Efficacy

Similarly, respondents who believed that government could successfully implement adaptation strategies indicated that government is ultimately responsible for protecting people's property. More responsibility was assigned to the state or federal government rather than local government. This is in accordance with the literature which states that trust in government institutions decreases individuals' motivation to undertake adaptations on their own (Krasovskaia et al 2007, Grothmann and Reusswig 2006, Terpstra and Gutteling 2008, Koerth et al 2017).

Responsibility by Personal Adaptation Attempts

No correlation is seen between those who believe that individuals are ultimately responsible for protecting their property from SLR and those who have personally attempted to implement an adaptation measure on their property. This runs somewhat counter to Koerth et al's (2017) finding that a feeling of individual responsibility increases the probability of making preparations – one would expect to see those who place responsibility on the individual to be more prepared than those who do not. However, the survey question asked about past attempts, and not

future ones, so this may have excluded some respondents who otherwise might have been planning to pursue household-level adaptations.

Personal Adaptation Attempts by Hazard Experience

There was no correlation between having experienced a severe storm event or flood, and having personally attempted to implement adaptation strategies on one's property. This could be because people have implemented adaptations in anticipation of severe impacts but have yet to be affected. On the other hand, it could be reflective of a maladaptive response in which people feel that there is nothing they can do to prevent adverse impacts from floods and severe storms. This contradicts Koerth et al's (2013) finding that personal experience of a natural hazard is the main impetus for adaptation behaviors.

Adaptation Preferences by Flood Insurance

People who reported not having flood insurance were more supportive of the permanent removal of storm-damaged structures than people with flood insurance. This survey has revealed that a number of respondents are not aware that they live in a FEMA Special Flood Hazard Area and are legally required to have flood insurance. This correlation could suggest a lack of understanding of the question, or, a surprising receptivity to a managed retreat strategy.

Adaptation Preferences by Hazard Experience

A surprising finding was that more respondents who had been directly impacted by a flood or severe storm event thought that Tybee should eliminate or charge more for flood insurance on structures that are built in vulnerable areas. This is notable because the entirety of Tybee Island is designated as a FEMA Special Flood Hazard Area and is within the 100-year floodplain. It is

possible that respondents misunderstood this question or did not think it applied to them. Also surprising was the lack of correlation between having been directly impacted by a natural hazard and a desire to relocate.

Risk and Adaptation Appraisal by Demographics

There was little correlation between demographic factors and perceptions of risk or adaptations. What correlation existed was a result of age or gender, but was considered not significant due to the unevenness of the sample – respondents were overwhelmingly female and in their sixties or seventies. This absence of a significant correlation is in keeping with the literature that emphasizes the predictive power of cognitive factors (risk appraisal and adaptation appraisal) over demographic factors (e.g. Gothmann and Patt 2005). There was also little correlation between demographic factors and Environmental Ideology, which is disappointing because Environmental Ideology was a potential cluster identifier.

Survey Shortcomings

This survey was distributed via convenience sampling. Considering the distribution channels (personal email, community listservs, social media sites) it is possible that the sample was self-selected towards people who are already civically engaged or concerned about environmental issues. Also, out of approximately 3,000 potential respondents (the number of year-round Tybee residents), only 185 responses were gathered, which may not be a representative sample. This small sample size may make crosstabulations that are misleading or statistically less than reliable, such as in the crosstabulations involving Environmental Ideologies. This study

should be considered a pilot study that assessed initial attitudes of Tybee residents towards SLR adaptations, meant to help the City of Tybee to identify future research areas.

Implications for Flood Insurance and Climate Adaptation Strategies

All of Tybee Island is a SFHA, although that may change with the new FIRM maps coming out in August 2018. Due to Tybee's improvements through the CRS, and its ongoing efforts of dune restoration and beach nourishment, most of Tybee will be out of the "V" zone. The V, or velocity zone, indicates areas that are flooded by a combination of rising waters and storm waves that are three feet high or higher, and has higher insurance premiums than other zones. Furthermore, the base flood elevation (BFE) has been reduced in many areas on Tybee. Both of these developments will result in bigger discounts on flood insurance premiums for residents (City of Tybee 2018c).

The stated purpose of the CRS is to improve communities' flood readiness and reduce flood damage to insurable property. Communities, and individuals within them, receive direct financial benefits for participating in the CRS by not only having flood insurance but also by paying less for it. This raises the concern of whether the more communities get higher CRS ratings, the less they will pay into the system, thus depleting the overall funding for the program. However, it could be argued that the higher rating system pays for itself through increased flood-readiness, thus reducing the likelihood of needing a payout.

This thesis used Protection Motivation Theory as a theoretical framework. Though PMT is used to study the protective behavior of an individual, the theory applies here because local government is essentially formalized individual action. People can vote, attend input sessions, meet with their elected officials, and pursue a number of other civic actions in which their personal

preferences can be heard, and incorporated into policy. Individual actions can be scaled up through citizen interest groups, nonprofits, and special committees that can express their preferences to local officials. Survey respondents indicated an overwhelming willingness to work together with their neighbors to implement adaptation strategies, which should signal to the Tybee government that now is an appropriate time for SLR-related action. Local implementation of SLR adaptation strategies demonstrates communities' commitment to climate-change planning. Such local investment can attract much-needed state and federal investment, and if enough localities demonstrate their need for assistance and willingness to take initiative, this could potentially catalyze a regional or national movement.

CHAPTER 5: CONCLUSIONS

The purpose of this research was to assess Tybee residents' receptivity to sea level rise adaptations. This was done using Protection Motivation Theory as a theoretical framework. The climate literature shows that cognitive factors, such as risk appraisal and adaptation appraisal, are better predictors of future adaptation behaviors than are the traditional demographic factors such as age, race, gender, employment, and education. Residents rated their perceptions of risk probability and severity, the perceived effectiveness of a range of SLR adaptation strategies, their own ability to execute adaptation behaviors, and the costs of adaptation action versus inaction. Furthermore, they were asked who they thought was responsible for implementing these adaptations.

The majority of respondents perceived sea level rise as posing a great deal of risk to themselves and the environment. However, the majority of respondents also reported that they did not feel knowledgeable about SLR adaptations, and even fewer believed that they could successfully implement SLR adaptations on their own. It makes sense, then, that responsibility for SLR adaptations is attributed to government entities. However, federal funding to local governments, especially for environmental issues, has been decreasing and will likely continue to do so under the current administration. Furthermore, organizations such as FEMA advocate for preparedness at the individual level, encouraging regular people to assume responsibility for flood-mitigation efforts.

Fortunately, the majority of respondents also indicated that they are willing to work together with their neighbors to implement SLR adaptations. This is a promising avenue for the City, who may be able to increase this feeling of camaraderie through events such as awareness-raising festivities, and leverage it into community workdays or volunteer projects. Over 40% of survey respondents have already attempted one or more adaptation strategies on their property. Many have indicated that they would like to learn more about climate adaptations. Recognizing this, as well as the need for adoption of household-level adaptations, Tybee should consider household incentive programs in addition to community-scale efforts. Household-level assistance may be used as a good-faith appeal to the individualistic residents and potentially create buy-in for larger, more “bureaucratic” initiatives.

This survey did not assess how many households implemented SLR adaptations as a result of the NFIP-CRS certification process, but considering that Tybee is a Class 5 community, it is apparent that flood mitigation is a central theme of local initiatives. Indeed, flooding is the major risk posed by SLR. Survey results showed that respondents generally supported SLR-adaptation measures that align with CRS Flood-Damage Reduction credits. Such credits include floodplain management planning, acquisition and relocation, and flood protection. These credits can be pursued as local planning policy, and tied to both a comprehensive plan and the CRS plan to ensure that Tybee continues to move forward in its adaptation efforts.

Existing opportunities for education include better communication about the effectiveness of SLR adaptations and building residents’ confidence in implementing them. Another need is making people more aware of their location in a FEMA Special Flood Hazard Area and what that means for their property. The most pressing future research need is to determine the barriers perceived self-efficacy of adaptation behaviors – is it due to financial costs, or other factors? If the

relatively wealthy population of Tybee feels ill-equipped to deal with SLR, what does that mean for other, less affluent communities? Another research need is for a segmentation analysis, such as Principle Component or Latent Class Analysis, of a larger sample of residents to determine specific audience segments that may need more targeted outreach. Lastly, the vast majority of respondents to this survey were white, middle-aged-to-senior adults who were either employed full-time or retired. While this is generally reflective of the Tybee population, a wider range of residents must be included in participatory planning processes to get a more robust perspective on issues and reach as many people as possible, to bring them safely into the future.

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Residents' Receptivity to Sea Level Rise Adaptations on Tybee Island

Start of Block: Intro

Q1 Dear Resident of Tybee Island,

You are cordially invited to participate in a research study entitled *Residents' Receptivity to Sea Level Rise Adaptations on Tybee Island*. The purpose of this study is to determine residents' receptivity and preferences for sea level rise adaptations that may be undertaken in the future.

Your participation will involve taking an online survey and should take about 20 minutes. Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time without penalty. If you decide to stop or withdraw from the study, the information/data collected from or about you up to the point of your withdrawal will be kept as part of the study and may continue to be analyzed.

All of your responses will remain confidential and will be kept on a secure server. Your responses will not be tied to you through any personally identifiable information. The results of the research study may be published, but your name or any identifying information will not be used. In fact, the published results will be presented in summary form only.

This research involves the transmission of data over the Internet. Every reasonable effort has been taken to ensure the effective use of available technology; however, confidentiality during online communication cannot be guaranteed.

The findings from this project may provide information for the City of Tybee Island's government for future planning and policy purposes. There are no known risks or discomforts associated with this research.

I am a graduate student in the College of Environment + Design at The University of Georgia, working under the direction of Dr. Jon Calabria. If you have any questions about this research project, please feel free to send me an e-mail at catherine.sauer25@uga.edu, or to contact Dr. Calabria at (706) 542-1816. Questions or concerns about your rights as a research participant should be directed to the Institutional Review Board (IRB) Chairperson at (706) 542-3199 or irb@uga.edu.

By reading this letter and proceeding to the survey on the next page, you are agreeing to participate in the above described research project, and confirming that you are 18 years of age or older. Thank you for your consideration! Please keep this letter for your records.

Sincerely,
Catie Sauer

End of Block: Intro

Start of Block: Demographics

Q2 The following questions ask for information about you.

Q3 What category best describes you?

- I own property on Tybee Island (2)
- I am a renter/tenant on Tybee Island (3)

Skip To: Q5 If What category best describes you? = I am a renter/tenant on Tybee Island

Q4 What kind of property do you own on Tybee Island? Please select all that apply:

- I own my residence (1)
 - I own my place of business (2)
 - I own property that I lease out to a different primary user, such as residential or commercial space (3)
-

Q5 Is your residence on Tybee Island located in a FEMA-designated Flood Hazard Area?

- Yes (20)
 - I don't know (21)
 - No (22)
-

Q6 Do you have flood insurance?

- Yes (1)
 - No (2)
-

Q7 During the past year, how many weeks have you spent on Tybee Island?

- 0-4 (less than one month) (1)
 - 5-12 (between one and three months) (2)
 - 13-26 (between three and six months) (3)
 - 27-52 (between six and twelve months) (4)
-

Q8 Would you say that you are:

- A full-time resident of Tybee Island (1)
 - A part-time resident of Tybee Island (2)
 - Not a resident of Tybee Island (3)
-

Q9 How long have you been a resident of Tybee Island?

- I don't consider myself a resident of Tybee Island (1)
 - Less than one year (2)
 - 1-2 years (3)
 - 2-5 years (4)
 - 5-10 years (5)
 - More than 10 years (6)
-

Q10 Do you currently have plans to move away from Tybee Island?

- Yes, within the next 5 years (1)
 - Yes, within the next 10 years (2)
 - Yes, but not within the next 10 years (4)
 - No (5)
-

Q11 What is your age?

Q12 What is the highest level of education that you have completed?

- Some high school (1)
 - High school graduate (2)
 - Some college (3)
 - Associate's degree (4)
 - Bachelor's degree (5)
 - Professional or Masters degree (6)
 - Doctorate (7)
 - Prefer not to answer (8)
-

Q13 In what ZIP Code is your **primary** residence located?

Q14 Which of the following descriptions most closely matches your stance on environmental issues?

- Humans are at the top of the hierarchy, separate from and superior to the natural world, and natural resources exist solely for unlimited human use (5)
 - Natural resources are valuable insofar as they are useful to humans (2)
 - Natural resources should be valued for more than their instrumental use, such as for beauty and enjoyment (3)
 - Natural resources and nonhuman entities have intrinsic value, and humans have moral obligations towards them (4)
 - Humans are situated in a web of relationships with the living and nonliving elements of the natural world, there is no hierarchy (6)
-

Q15 What best describes your employment situation?

- Employed full time (1)
 - Employed part time (2)
 - Unemployed looking for work (3)
 - Unemployed not looking for work (4)
 - Retired (5)
 - Student (6)
 - Disabled (7)
 - Prefer not to answer (8)
-

Q16 Which category best describes you?

- White, not Hispanic (1)
 - Black or African American (2)
 - Hispanic/Latino (8)
 - Asian (4)
 - American Indian or Alaska Native (3)
 - Native Hawaiian or Pacific Islander (5)
 - Other (6)
 - Prefer not to answer (7)
-

Q17 What is your gender?

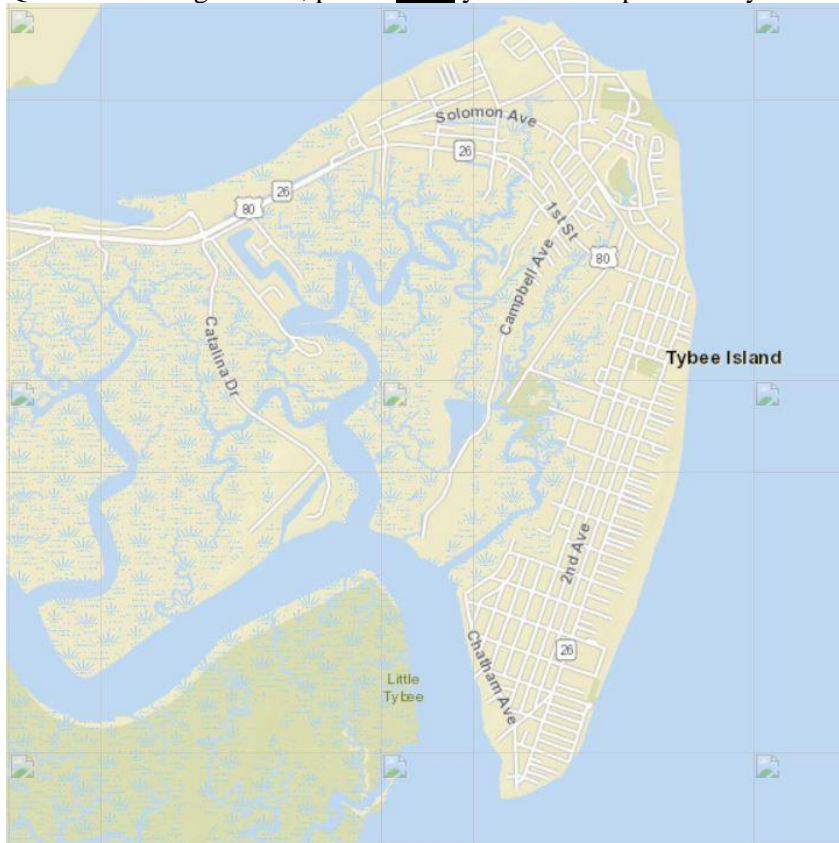
- Male (1)
- Female (2)
- Other (3)
- Prefer not to answer (4)

End of Block: Demographics

Start of Block: Experience on Tybee Island

Q18 The questions in this section ask about your experiences on Tybee Island, and what you enjoy about it.

Q19 On the image below, please **click** your favorite place on Tybee Island.



Q20 Please tell us more about your favorite place and why you think it's special:

Q21 What do you like best about Tybee Island and why?

Q22 In your opinion, what is a defining characteristic of Tybee Island that you would not want to see disappear?

End of Block: Experience on Tybee Island

Start of Block: Risk Appraisal

Q23 The following questions ask about your perceptions of sea level rise.

Q24 Do you believe that sea level rise is happening?

- Yes (1)
- I don't know/not sure (2)
- No (3)

Skip To: Q32 If Do you believe that sea level rise is happening? = No

Q25 Do you think you personally will be affected by sea level rise?

- Yes (1)
- Maybe (2)
- No (3)

Skip To: Q27 If Do you think you personally will be affected by sea level rise? != Yes

Q26 When do you think you will be affected by sea level rise?

- I have already been affected (4)
 - Within 5 years (3)
 - Within 10 years (1)
 - Within 25 years (2)
 - Within 50 years (5)
-

Q27 To what extent are you concerned about sea level rise affecting the natural environment (example: beaches, marshes, barrier islands)?

- Very concerned (1)
 - Somewhat concerned (2)
 - Neither concerned nor unconcerned (5)
 - Somewhat unconcerned (25)
 - Not at all concerned (26)
-

Q28 To what extent are you concerned about sea level rise affecting the built environment (example: buildings, roads, utilities)?

- Very concerned (11)
 - Somewhat concerned (12)
 - Neither concerned nor unconcerned (13)
 - Somewhat unconcerned (14)
 - Not at all concerned (15)
-

Q29 Do you think that sea level rise will intensify extreme weather events such as floods, hurricanes, and storm surges?

- Yes, definitely (20)
 - Yes, probably (23)
 - No, probably not (22)
 - No, definitely not (24)
-

Q30 Do you think that sea level rise will intensify regularly-occurring events such as spring or king tides?

- Yes, definitely (25)
- Yes, probably (28)
- No, probably not (27)
- No, definitely not (29)

Q31 To what extent do you agree with the following statements, regarding impacts from sea level rise and increased storm frequency and severity?

	Strongly disagree (18)	Somewhat disagree (19)	Neither agree nor disagree (20)	Somewhat agree (21)	Strongly agree (22)
I would do what it takes to stay in my home (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using my own resources, I could not recover from losses or damage to my home (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would like to relocate elsewhere to avoid losses or damage (14)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q32 Are you aware of the Tybee Island Sea Level Rise Adaptation Plan that was published in 2016?

- Yes (1)
- No (2)

Skip To: End of Block If Are you aware of the Tybee Island Sea Level Rise Adaptation Plan that was published in 2016? = No

Q33 Did you provide input/participate in the public input sessions that were part of the Tybee Island Sea Level Rise Adaptation Plan' development?

- Yes (5)
- No (6)

Skip To: End of Block If Did you provide input/participate in the public input sessions that were part of the Tybee Island... = Yes

Q34 What deterred you from providing input into the Tybee Island Sea Level Rise Adaptation Plan?

- I didn't know I could (1)
- I didn't want to (2)
- I was unable to (3)

End of Block: Risk Appraisal

Start of Block: Hazard Experience

Q35 The following questions ask about your experiences with natural hazards on Tybee Island.

Q36 Have you been directly impacted by a flood or severe storm event on Tybee Island?

- Yes (1)
- No (2)

Skip To: Q38 If Have you been directly impacted by a flood or severe storm event on Tybee Island? = No

Q37 In what ways were you impacted by a flood or severe storm event on Tybee Island?

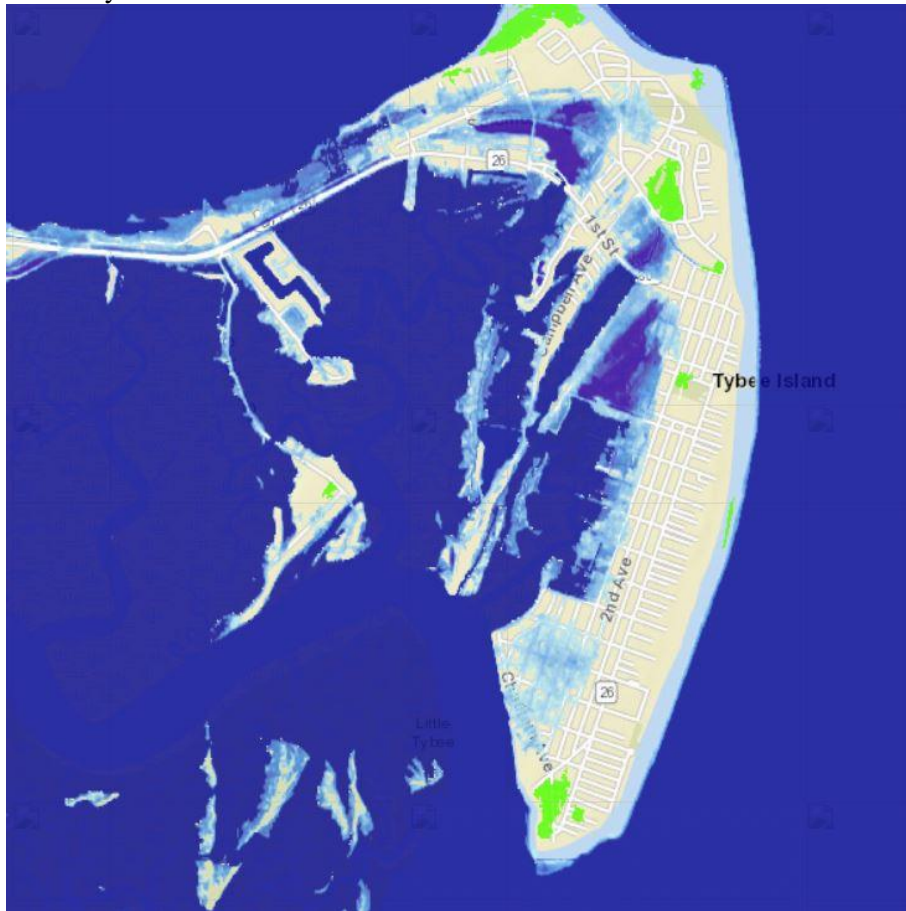
Q38 Have you noticed a change in the frequency of flooding on Tybee Island?

- I have noticed a significant increase (1)
- I have noticed a slight increase (2)
- I have not noticed a change (3)
- I have noticed a slight decrease (4)
- I have noticed a significant decrease (5)

End of Block: Hazard Experience

Start of Block: Inundation

Q39 The global sea level is projected to rise between 8 inches and 6.6 feet by 2100. The image below shows Tybee Island after a three-foot sea level rise.



Q40 In the above scenario, do you think your property will be affected by sea level rise?

- Definitely yes (1)
- Probably yes (2)
- Might or might not (3)
- Probably not (4)
- Definitely not (5)

End of Block: Inundation

Start of Block: Adaptation Appraisal

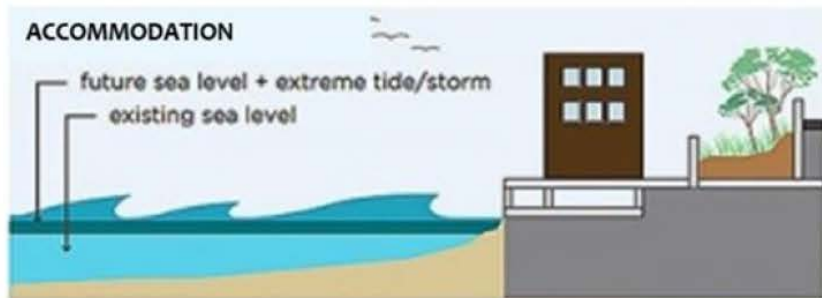
Q41 This section asks about your preferences for different types of sea level rise adaptations, beginning with the general types of adaptations, and ending with more specific strategies. The graphic below illustrates the four main types: hard protection, soft protection, accommodation, and retreat.



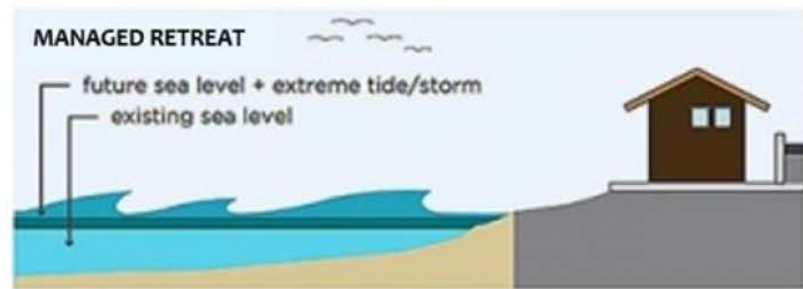
Engineered structures such as seawalls, bulkheads, revetments, and other hard armoring. Hard protection measures are usually implemented on the coastal/ocean side of a land area where wave energy is strong and direct.



Interventions such as dune or wetland restoration that mimic or enhance natural processes. Soft protection measures are usually implemented in areas where wave energy is less strong or direct.



A number of strategies that can include creating elevated, floatable, or floodable development, raising land or building heights, allowing structures to float on the water, designing structures to withstand flooding, or moving vulnerable structures to higher ground.



A suite of regulatory strategies that can include abandoning development in hazard areas, restricting development in hazard areas, fixed or rolling setbacks, not rebuilding damaged structures, and long-term relocation plans

Q43 To what extent do you agree or disagree with the following statements?	Completely disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Completely agree (5)
There is nothing that anybody can do about sea level rise (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel knowledgeable about sea level rise adaptation strategies (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel that I can successfully implement adaptation measures on my own (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
People with flood insurance do not need to take any further adaptation actions (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel that the government can successfully implement adaptation measures that would protect my home (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My peers think that sea level rise adaptations are important (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q44 Please indicate whether or not you think The City of Tybee should pursue the following adaptation strategies to address sea level rise:

	Should a community do this?	
	Yes (1)	No (2)
Incentivize the protection of sensitive lands through measures such as tax breaks (4)	<input type="radio"/>	<input type="radio"/>
Discourage or prohibit the development of sensitive lands through measures such as zoning (5)	<input type="radio"/>	<input type="radio"/>
Retrofit or elevate buildings and structures that are at risk of flooding (7)	<input type="radio"/>	<input type="radio"/>
Purchase land that is ecologically sensitive or at risk of flooding, to keep it free of development (8)	<input type="radio"/>	<input type="radio"/>
Permanently remove damaged structures after a disaster (20)	<input type="radio"/>	<input type="radio"/>
Require new development to be able to withstand flooding (22)	<input type="radio"/>	<input type="radio"/>
Relocate development to less vulnerable areas (9)	<input type="radio"/>	<input type="radio"/>
Eliminate or charge more for flood insurance on structures that are built in vulnerable areas (23)	<input type="radio"/>	<input type="radio"/>
Help vulnerable communities prepare for floods and other impacts (3)	<input type="radio"/>	<input type="radio"/>
Plan new communities in nearby cities to help relocate vulnerable populations (6)	<input type="radio"/>	<input type="radio"/>
Build more hard structures like seawalls or bulkheads (24)	<input type="radio"/>	<input type="radio"/>
Restore natural areas like dunes and wetlands (25)	<input type="radio"/>	<input type="radio"/>

Q45 To what extent do you agree with the following statements, regarding impacts from sea level rise and increased storm frequency and severity?

	Strongly disagree (18)	Somewhat disagree (19)	Neither agree nor disagree (20)	Somewhat agree (21)	Strongly agree (22)
The City of Tybee should do more to protect my home (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The Federal government should do more to protect my home (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The City of Tybee should help me move somewhere safer (12)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The Federal government should help me move somewhere safer (13)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q46 To what extent do you agree with the following statements, regarding responsibility for sea level rise adaptations?

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (5)	Strongly agree (8)
It is ultimately the responsibility of an individual to protect their home from sea level rise (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is ultimately the responsibility of local government to protect people's property from sea level rise (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is ultimately the responsibility of the State or Federal government to protect people's property from sea level rise (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am willing to work together with my neighbors to implement adaptation measures (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q47 Have you personally attempted to implement, or get someone else to implement, any adaptation measures on or around your property?

Yes (5)

No (6)

Skip To: End of Block If Have you personally attempted to implement, or get someone else to implement, any adaptation meas... = No

Q48 What kind of adaptation measures have you pursued for your property?

End of Block: Adaptation Appraisal

Start of Block: Soft protection

Q49 This definition is provided to help you answer the next question:

Dune – a mound of sand or other loose sediment formed by the wind, especially on the sea coast. Dunes protect coastal areas from storms by creating a physical barrier between the ocean and inland, and dissipating wave energy



Q50 Would you support dune restoration as an adaptation strategy on Tybee Island?

- Definitely yes (1)
 - Probably yes (2)
 - Might or might not (3)
 - Probably not (4)
 - Definitely not (5)
-

Q51 This definition is provided to help you answer the next question:

Tidal wetland – tidal wetlands include landforms such as marshes and estuaries, where the land meets the sea and is periodically flooded with seawater during high tides. Wetlands protect coastal areas from flooding by dissipating wave energy and retaining excess water caused by rain or runoff



Q52 Would you support wetland restoration as an adaptation strategy on Tybee Island?

- Definitely yes (16)
 - Probably yes (17)
 - Might or might not (18)
 - Probably not (19)
 - Definitely not (20)
-

Q53 The following definition is provided to help you answer the next question:

Living shoreline – technique that protects against erosion in lower-energy areas by creating or enhancing vegetated shoreline habitats, using the strategic placement of structural or organic materials such as plants, stone, oysters, or sand fill. These are most appropriate in creeks, and areas with lower wave energy.



Q54 Would you support the construction of living shorelines as an adaptation strategy on Tybee Island?

- Definitely yes (16)
 - Probably yes (17)
 - Might or might not (18)
 - Probably not (19)
 - Definitely not (20)
-

Q55 The following definition is provided to help you answer the next question:

Beach nourishment – technique that adds or replaces sand to beaches that have shrunk due to erosion. This creates a larger beach and provides space for recreation.



Q56 Would you support beach nourishment as an adaptation strategy on Tybee Island?

- Definitely yes (1)
- Probably yes (2)
- Might or might not (3)
- Probably not (4)
- Definitely not (5)

End of Block: Soft protection

Start of Block: DIY

Q58 On the image below, please click on a problem area that you think is in need of protection, accommodation, or retreat.



Q59 For the area you identified, choose the specific strategy that you think is most appropriate.

- Build a seawall, bulkhead, or revetment (1)
- Build a jetty or groin (17)
- Build a living shoreline (19)
- Add sand to beach (4)
- Protect/restore dunes (6)
- Protect/restore wetlands (8)
- Retrofit or elevate buildings and utilities (13)
- Relocate buildings or utilities (10)
- Do not rebuild or repair area after damages (12)
- Prohibit development of the area (16)
- Purchase land to keep it free of development (18)
- Other (28)

Skip To: End of Block If For the area you identified, choose the specific strategy that you think is most appropriate. != Other

Q60 What adaptation measure do you think is best for the area you selected?

End of Block: DIY

Start of Block: Almost done! The following questions ask your opinion about Tybee Island.

Q61 Almost done!

Q62 Are there any coastal management topics that you would like to receive more information about? Your answer will help us in assessing the need for further outreach to Tybee residents.

Q63 Please share any additional thoughts you have related to sea level rise:

End of Block: Almost done! The following questions ask your opinion about Tybee Island.
