Sea-Level Rise Adaptation and Planning:

A Case Study from Tybee Island, Georgia

Photo © Adam Clause

Photo © Steve Padgett-Vasquez

Photo © Adam Clause

Rachel Bormann, Adam Clause, Walker DePuy, Jayanta Ganguly, Rachel Guy, Jonathan Hallemeier, Emily Horton, Sarah McManus, Steve Padgett-Vasquez, Ryan Unks

Center for Integrative Conservation Research

May 2013

Contents Page

INTRODUCTION

Sea-Level Science, Policy, and Planning

One of the potential impacts of global climate change is rising sea levels. The latest Intergovernmental Panel on Climate Change (IPCC) assessment report models sea-level rise of 18 to 60 centimeters (cm) by 2099, based on various emissions scenarios (IPCC 2007). Studies that are more recent model even higher ranges with the inclusion of accelerated ice sheet melt, with mean estimates ranging from 71 to 130 cm and upper range estimates of 54 to 200+ cm (Horton 2008; Rahmstorf 2010; Vermeer & Rahmstorf 2009). Sea-level rise is of great concern to policy makers as approximately 10% of the world's population lives in coastal zones with elevations of ten meters or less (McGranahan, Balk, & Anderson 2007).

Post-Hurricane Sandy in 2012, the U.S. federal government is being forced to consider policy options that will address long-term flood management challenges, including those from sea-level rise (King 2013). Typically, the task of identifying special flood hazard areas (SFHAs), which may be impacted by sea-level rise or other forms of extreme climate events, is the responsibility of the Federal Emergency Management Agency (FEMA). SFHA's in turn inform the National Flood Insurance Program (NFIP), which is the primary instrument available to potential flood victims to protect themselves, outside of post-disaster assistance. However, it has been suggested that vulnerable and disadvantaged groups may still remain exposed to this threat (Martinich, Neumann, Ludwig, & Jantarasami 2013).

Many local coastal communities are themselves preparing for the impacts of increasing coastal vulnerability to climate change. Some are restoring natural storm-surge buffers and incorporating climate change into coastal habitat restoration plans (Kreeger et al. 2010). Models

and guidelines are also being developed for rolling easements to enable natural storm structures like wetlands to migrate inland (Titus 2001). Some states have even developed strategies to promote environment-friendly 'living shoreline' development, as opposed to armoring, to encourage a softer and long-term approach to coastal hazard management among the community (Luscher & Hollingsworth 2005).

Theory for Adaptation, Participation, and Trade-Offs

While adaptation to sea-level rise will include work on many scales, including state and federal actions, in this paper we focus on adaptation at the community (local) level, recognizing that every locality has its own social, economic, physical, and ecological context that will be variably impacted by sea-level rise. The varying contexts and impacts entail that different adaptive strategies will be feasible and practical in different communities (Smit & Wandel 2006; Agrawal 2010). Within the domain of local adaptation to sea-level rise, we focus further on 1) active participation and 2) awareness of trade-offs as important components of successful adaptation processes.

Our attention to active participation is rooted in the goals of supporting more just, legitimate, and informed planning. Participation was explicitly developed as an alternative to top-down models of management and decision making that were criticized as disempowering local actors and as being unresponsive to local conditions and thus ineffective and inefficient (Brett 2003). In the past four decades, participation has been embraced by practitioners in the fields of conservation, development, natural resource management, scientific research, and climate change adaptation (Lyon, Bell, Croll, Jackson, & Gratton 2010; Few, Brown, & Tompkins 2006; Chambers 1992; Cronin, Petterson, Taylor, & Biliki 2004; Reed 2008). In these contexts, participation is seen as 1) a tool for social justice, empowering local and often

disenfranchised people to be heard and have influence on the decisions that affect them (Chambers 1983), 2) a tool of garnering support for processes and legitimizing decisions through involvement with decision making and developing relationships of trust (Lyon et al. 2010; Campbell, Sayer, & Walker 2010), and 3) a tool for more informed planning by including more views and perspectives, including local knowledge and experience of local conditions (Fraser, Dougill, Mabee, Reed, & McAlpine 2006; Wollenburg et al. 2008).

Whether or not participation meets these goals is a matter of debate, and critiques are numerous. Participation may be of a weak form in which local community members are only tangentially involved and have little influence (Brett 2003), it may "empower" people to work within a predetermined set of rules that constrain discussion of their values, or participatory processes may ignore power dynamics and inequities within a local community, thus possibly reproducing or entrenching those inequalities (Cook & Kothari 2010). However, while participation is flawed, it is still a primary tool for attempting to conduct planning processes that are more socially just, more locally legitimate, and more informed by diverse views as well as knowledge of local realities affecting what decisions are feasible and practical in the specific social-ecological context (Few et al. 2006).

Our attention to awareness of trade-offs has roots in the same goals, complementing and supporting participatory processes. As participation developed in response to the problems of top-down models, the focus on trade-offs came in part in response to the flaws of win-win narratives. Particularly in the context of conservation and development, win-win narratives often gloss over real tensions and trade-offs embedded in decisions, leading to a failure to meet expectations and disillusionment (Hirsch et al. 2011; McShane et al. 2011). In the context of adaptation to sea-level rise, community-level choices about adaptation can have variable effects

across a community, thus setting the scene for tensions and trade-offs. Additionally, trade-offs vary among stakeholders, with the values of various individuals and groups differing or even being incommensurable, that is, not comparable in a traditional cost-benefit analysis (Hirsch et al. 2011). Explicit recognition of trade-offs, while making decision making more complex, thus contributes to more informed and socially-just planning through the incorporation of multiple values and to more legitimate decision making through more realistic narratives of decision consequences. Finally, the level to which ideas of trade-offs are shared or not may also influence participatory processes. Shared mental models of how things work and what is important can contribute to better communication and more informed dialogue (Jones, Ross, Lynam, Perez, & Leitch 2011; Otto-Banaszak, Matczak, Wesseler, & Wechsung 2011).

Research Purpose and Goals

Informed by literature on participation and trade-offs, we hope to contribute to current sea-level rise adaptation processes occurring in the city of Tybee Island on the Georgia coast (hereinafter referred to as Tybee Island). In approaching these processes we are asking: Who is participating? Why or why not? How could more active participation be facilitated? What trade-offs do individuals see to particular climate change adaptation choices? How do these locally perceived trade-offs compare with trade-offs acknowledged in the broader scientific literature informing planning? By exploring these questions we hope to identify areas of conflict with respect to potential trade-offs and hurdles to participation and dialogue, gaining insight into how to develop further strategies for facilitating future planning and decision making processes.

In this paper, our objectives are: 1) reviewing current academic literature on social and ecological trade-offs of potential sea-level rise adaptations, focusing on coastal armoring of marsh-facing shoreline, elevating homes above potential flooding, and managed retreat and 2)

analyzing data from interviews with Tybee Island residents about their perceptions of the proposed adaptation strategies and their perceptions of the trade-offs involved in these strategies, as well as their awareness of and perceptions of current community planning processes regarding sea-level rise. We focus our sampling for interviews in the southern Tybee Island area given that region's particular vulnerabilities to sea-level rise.

Study Setting

The site for our study, Tybee Island, Georgia, is the northernmost of Georgia's barrier islands and covers an area of approximately 4.3 square kilometers (Figure 1) (Mendonca 2005). As a barrier island, Tybee Island sits directly on the Atlantic Ocean, but much of the remaining surrounding area consists of salt marshes and small saltwater or brackish rivers and creeks (hereinafter referred to as "marsh"), including much of the area between the island and the nearby inland city of Savannah. The city maintains a sandy beach through renourishment on the Atlantic Ocean side. In 2010, the city's population was 2,990 residents (U.S. Census Bureau 2010). Much of employment on Tybee Island is related to tourism services, including outdoor recreation and ecotourism businesses, and retail businesses catering to tourists (U.S. Census Bureau 2010; Jepson 2005).

The marsh provides a number of benefits to Tybee Island and the surrounding area. In addition to filtering pollutants and providing protection from storm surges, the marsh provides unique habitats for wildlife (Seabrook 2012). The marsh is the primary nursery area for crabs, oysters, shrimp, and other economically important fish and shellfish (Seabrook 2012). Young shrimp and other marine organisms also use salt marshes as shelters and hiding places from predators (Seabrook 2012). Birds, turtles, and adult fish visit the marsh to feed (Seabrook 2012).

The marsh provides the environment for the important fisheries, ecotourism, and bird-watching businesses on the island.

Figure 1 Map of Tybee Island, Georgia

Sea-level rise is of concern to Tybee Island due to its status as a low elevation barrier island and the sensitivity and importance of the surrounding marsh. Data recorded at Ft. Pulaski (Figure 2), a few miles from Tybee Island, shows the Mean sea level (MSL) trend has been increasing at 2.98 millimeters (mm) per year, with a 95% confidence interval of +/- 0.33 mm pre year based on monthly mean sea level data from 1935 to 2006 (NOAA 2013). Figure 2 shows the monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents.

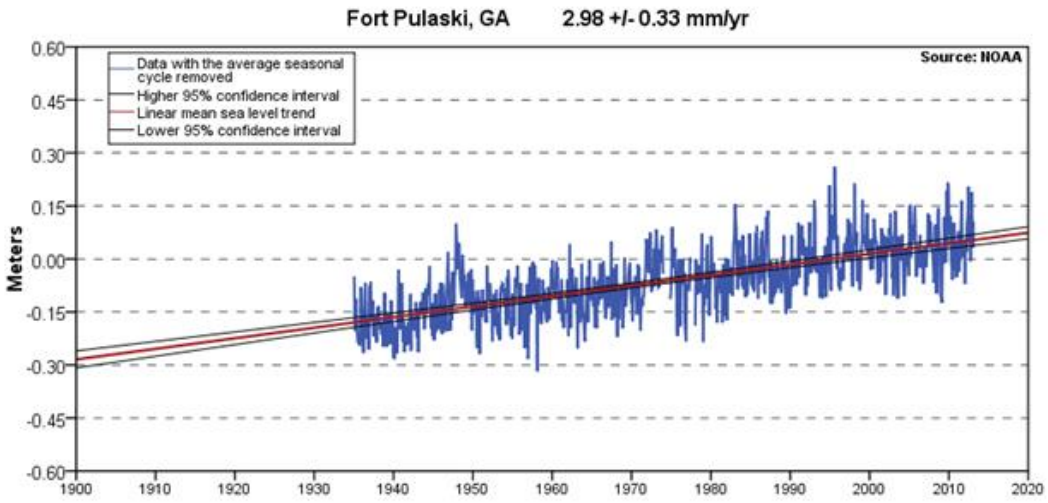
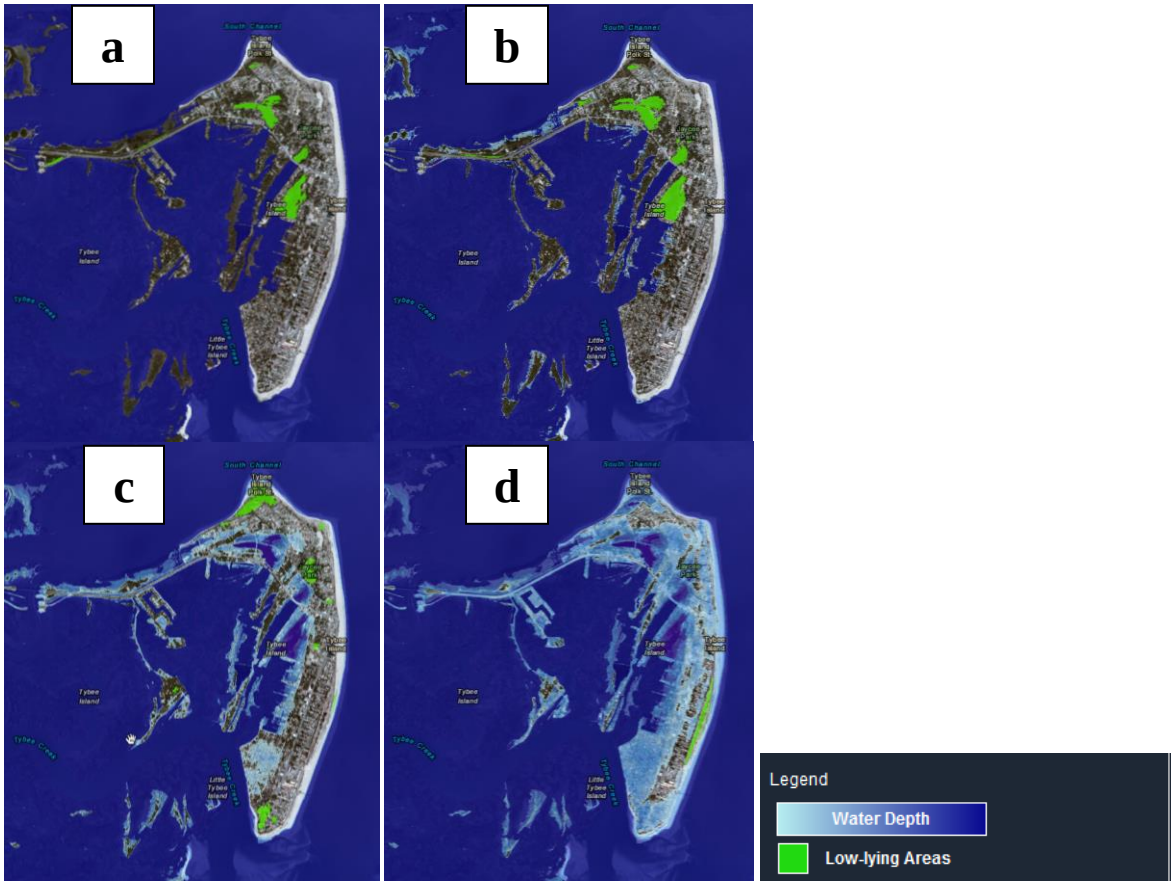


Figure 2 Recorded mean sea level at Ft. Pulaski, GA. (NOAA 2013)

The Ft. Pulaski data shows the trend to date; extrapolating this trend linearly is equivalent to a change of 30 cm in 100 years. However, as discussed above, sea-level rise is expected to accelerate through the end of the century due to accelerated ice sheet melt and thus the impact on Tybee Island is expected to be greater than the linear trend. The National Oceanic and Atmospheric Administration's (NOAA) Coastal Services Center has developed an online tool that models the flooding from sea-level rise using a modified bathtub approach (NOAA n.d.). Figures 3a-d show the potential flooding on Tybee Island using this tool for sea-level rise of one foot (30 cm), 3 feet (91 cm), and 6 feet (183 cm), compared to the current sea-level. Threats posed by this type of flooding form the scientific basis for sea-level rise planning on Tybee Island.

The governing body of Tybee Island is comprised of an appointed manager and council of elected officials ("City of Tybee Island Island, Georgia. City officials," n.d.). The council is legislative and policy oriented, while the manager directs and supervises administration of the city departments. Beyond this local governance structure, Tybee Island, similar to other U.S.

coastal communities, is managed through multiple levels of policy and governance. This complexity of governance is illustrated in Table 1.



Figures 3a-d NOAA modeled effects of sea-level rise on Tybee Island. a) Current sea level, b) one foot rise, c) 3 foot rise, d) 6 foot rise. (NOAA n.d.)

Tybee Island Sea-Level Rise Planning

In terms of adapting to rising sea levels, Tybee Island has already taken action. On a local level, they have raised critical infrastructure like city well pumps, constructed tidal valves to control flooding, and provided citizens with flood hazard information on their website. With the Army Corps of Engineers, Tybee Island is undertaking periodic beach renourishment, and on a federal level, Tybee Island participates in the national flood insurance program.

In terms of adapting to rising sea levels, Tybee Island has already taken action. On a local level, they have raised critical infrastructure like city well pumps, constructed tidal valves to control flooding, and provided citizens with flood hazard information on their website. With the Army Corps of Engineers, Tybee Island is undertaking periodic beach renourishment, and on a federal level, Tybee Island participates in the national flood insurance program.

Table 1 Federal, state, and local policy and governance of coastal communities in the U.S.

	Federal	State	Local
Shoreline (Elfner, September 2005)	Water Resources Development Act, Clean Water Act	Shore Protection Act, Georgia Marshlands Protection Act, GA Land Conservation Act	Storm Water Management (Tybee Island Code 5-4-1), Greenspace (Title 8-3-240)
Wildlife (USACE, 2009, July)	Migratory Bird Act, Endangered Species Act	Georgia Code 27-3-130 to 27-3-133	Ordinances such as: Sea Oats, Section 9-5-1(8)
Disaster (GEMA, 2013)	Disaster Relief and Emergency Assistance Act	GA Emergency Management Act	Damage ordinance, Sec. 5-1-5 Tybee Island Flood ordinance
Agency (GEMA, 2013)	FEMA IV EPA IV	GEMA, G-DNR	Chatham County, Tybee Island

In 2012, as part of the Sea Grant Community Climate Adaptation Initiative, the Tybee Island began collaborating with the University of Georgia's Carl Vinson Institute of Government (Vinson Institute) and the Georgia Sea Grant to implement a rising seas planning project. The aim of this two year project funded by NOAA is to develop a climate adaptation plan in order to prepare for and adapt to rising sea levels through locally suitable mechanisms such as ordinances, improvements in infrastructure, and other municipal action (Georgia Sea Grant

2012). Planning is being carried out through a series of community workshops "in which stakeholders will identify vulnerable assets, such as infrastructure, housing stock and critical facilities, and formulate measures to deal with problems like flooding and more frequent high tides" (Georgia Sea Grant 2012).

Predicted Impacts/Risks of Sea-Level Rise on Tybee Island

Sea-level rise is a global phenomenon, and the large-scale factors driving this process are outside the regulatory control of Tybee Island residents. However, local policies can set precedents for management actions at regional, national, and international levels. Municipalities can collectively tip the decision-making scale, or catalyze the process of innovation through examples from their own community.

Rising seas are predicted to affect the natural and built environments of Tybee Island, even in the absence of specific adaptation actions. However, human interventions may be able to shift these impacts spatially and temporally, or redistribute effects among different subsystems. For example, building a seawall along the southwestern marsh edge could delay erosion of built infrastructure on the inland side for a period of time, while potentially increasing the immediate rate of erosion on the marsh side (Caldwell & Segall 2007; Craft et al. 2009). While this action could shift the destabilizing effects of sea-level rise from property damage to disruption of ecosystem services over the short-term, the long-term consequences are more difficult to predict.

Models have projected that nearly half of Georgia's salt marsh could be lost by 2100, covered by rising seas and converted to "tidal flats and estuarine open water" (Craft et al. 2009). More specifically, Craft et al. (2009) used a model called SLAMM5 (Park, Trehan, Mausel, & Howe 1989; www.warrenpinnacle.com/prof/SLAMM) to simulate the effects of adjusted IPCC sea-level rise estimates on Georgia coastal marshes (Meehl et al. 2007). The model projected

that 20% of Georgia's salt marsh habitat would be gone by 2100 if the sea rises by 52 cm, and 45% would be lost if the sea rises by 82 cm (Craft et al. 2009).

The net change in the extent and types of marsh habitat is determined by several factors, not just the water level. Marsh persistence depends on a balance between accretion and erosion of sediment, or the rates at which mud and sand accumulate and wash away. Tidal marshes in estuaries with high sediment supply may be more buffered against the effects of sea-level rise, while those with less sediment may be more vulnerable (Morris, Sundareshwar, & Nietch 2002; Craft et al. 2009; Kirwan et al. 2010). Tybee Island has experienced significant alterations in sediment flows (compared to historical conditions) as a result of channel deepening and jetty placement associated with the Savannah Harbor Deep Draft Navigation Project (Smith, Stauble, Williams, & Wutkowski 2008). While these activities have increased erosion on the north shore and beachfront, sediment accretion rates has increased on the island's south shore (Smith et al. 2008). This extra sediment input could potentially enable the marsh to rise with sea-level rise, but more modeling work is needed.

Under various sea-level rise scenarios, an area of marsh habitat may persist (given sufficient accretion), convert to open water (submerged due to insufficient accretion), or convert to a different type of marsh. If there is room for a salt marsh to "migrate" inland, this habitat type could potentially "transgress landward and replace tidal freshwater and brackish marshes" (Craft et al. 2009), but built structures such as seawalls or armored shorelines can obstruct this inland migration (Craft et al. 2009).

Craft et al. (2009) project that Georgia will experience a net loss of 184 square kilometers (km^2) of tidal marsh by the year 2100 (with a 52 cm sea-level rise). This result includes the loss or conversion of 226 km^2 of salt marsh, and increases of 41 km^2 and one km^2, respectively, for

brackish and tidal freshwater marsh (Craft et al. 2009). As compared to salt marshes, tidal freshwater and brackish marshes can support higher rates of ecosystem processes per unit area, in terms of biomass production, nitrogen sequestration, and denitrification (Craft et al. 2009). However, the greatest projected decline of marsh ecosystem services on the Georgia coast is associated with the loss of salt marsh, due to its larger total spatial extent.

Under predicted sea-level rise scenarios, total Georgia salt marsh habitat is projected to decline (Craft et al. 2009). However, these effects may be mitigated somewhat by increases in accessible habitat along marsh edges, or perhaps by less-understood feedback mechanisms affecting accretion rate (Morris et al. 2002; Craft et al. 2009; Kirwan et al. 2010).

Human infrastructure on Tybee Island is also vulnerable to the effects of rising sea levels. The maintenance of functional public infrastructure, such as roads and utilities, is a high priority for Tybee Island (Evans & McDowell 2013). Plans are already underway to elevate groundwater pumping stations above projected flood levels, while the economic feasibility of roadbed elevation for U.S. 80 (the highway connecting Tybee Island to the mainland) remains a subject of study and debate (Evans & McDowell 2013).

Two main categories of potential damage are flooding and erosion. Flooding can result from a buildup of stormwater that exceeds the landscape's capacity for transport or infiltration. Without adequate drainage, storm runoff may be retained in low-lying areas, such as the interior of the southwest portion of Tybee Island. Flooding can also be caused by the overland flow of ocean water during extreme high tide events ("king tides") or storm surges. Higher baseline sea-levels are projected to increase the frequency, duration and magnitude of these ocean-related flooding events (Evans & McDowell 2013).

Evans and McDowell (2013) calculated that, in the absence of upgrading the stormwater system, buildings in the low-lying interior of the southern part of the Tybee Island could face millions of dollars in flood-related damage in the coming decades. By 2060, Tybee Island residents in these areas could incur $2.1 million in saltwater flooding damages if sea-level increases by 0.6 feet (18 cm), $3.5 million with a 1.3 feet (40 cm) rise, and $3.3 million with a 2.3 feet (70 cm) rise (Evans & McDowell 2013). These projections are based on depth-damage functions and do not include the effects of freshwater flooding. Evans and McDowell (2013) also calculated annual property flood loss estimates for a one foot (30 cm) sea-level rise scenario, projecting $5.1 million in damages across the island every year. These flooding simulations assume that no adaptation actions have been taken.

Erosion and subsidence pose additional structural risks that may be exacerbated by sea-level rise. Landry, Keeler, & Kriesel (2003) studied erosion management practices and erosion risk valuations for property on Tybee Island. The authors included both oceanfront and inlet-front homes, and found that while abutting the inlet raised property values by $87,620, "presence in the high-erosion zone reduced property value by $9,269" (Landry et al. 2003). These metrics demonstrate that local real estate markets incorporate a certain understanding of erosion risk, though the overall approach to balancing this risk with the reward of prime location has changed dramatically over time. According to Landry et al. (2003), "Historically, residential structures on or near beaches were built with salvaged or inexpensive materials in recognition of storm and erosion risks."

Tybee Island's economy revolves around tourism. On summer weekends, over 25,000 tourists per day may visit Tybee Island, outnumbering residents by almost an order of magnitude (Elfner 2005). This influx of visitors predominantly consists of beachgoers, drawn to the

managed expanses of sand on Tybee Island's eastern shore and the attendant beachfront infrastructure. Another important visitor demographic, however, is seasonal property renters. Over 20% of occupied housing units on Tybee Island are rental properties (U.S. Census Bureau 2010). Visiting fishers targeting finfish and shellfish in marsh and nearshore waters are also key. This community is served by several outfitter businesses based on Tybee Island, or in Savannah. Charters also provide boating tours for another visitor community: wildlife-watching ecotourists (Elfner 2005). Dolphin tours are particularly popular, and several outfitters target their advertising specifically to that interest. Excluding beachgoers, these demographics are especially pertinent to our paper, given their inherent vulnerability to sea-level rise. Many rental properties are located on southern Tybee Island, in low-lying areas that are particularly vulnerable to flooding. Moreover, predicted shifts in marsh ecological dynamics as a result of sea-level rise (Craft et al. 2009) are likely to affect populations of wildlife that are recreationally harvested or observed. In turn, this would set in motion impacts on the Tybee Island tourism sector that relies upon those natural resources.

Adaptation Options and Trade-Offs

Sea-level rise adaptation options for low-lying coastal communities are diverse and context specific (Saroar & Routray 2010, Cooper & Lemckert 2012). Adaptation, in general, inherhently involves social, economic, and environmental cost/benefit trade-offs (Julius & Scheraga 2000; Tompkins, Few, & Brown 2008; Bjornberg & Hansson 2011). Three adaptation options are particularly tractable and relevant to Tybee Island, within the context of our paper's aforementioned objectives. These adaptation options are: coastal armoring, elevating homes, and managed retreat.

Coastal armoring consists of fortifying the sea/land interface through the creation of a linear, rigid structural element (Pope 1997). This structure can be built in a number of different ways. One common form is a seawall (Kamphuis 2010). Regardless of its precise physical form, shoreline armoring is designed with a dual purpose: first, to keep tides, storm surges, and rising sea-levels from causing overland flooding and second, to prevent wave action from eroding away valuable seafront property (Pope 1997).

On Tybee Island, armoring in the form of a seawall has been considered for the island's southwest shore (Evans & McDowell 2013). This shoreline represents the interface between a private residential matrix and salt marsh flats and brackish channels. Numerous private docks interdigitate with this socioecological boundary.

In this context, there are several trade-offs to be considered for adaptation involving a seawall. First is the monetary expenditure. This cost is two-fold: the expense to build the seawall in the first place, and the semi-annual expenses in perpetuity to maintain and repair the seawall's structural integrity (Heberger, Cooley, Herrera, Gleick, & Moore 2009). An important consideration is that the costs will be shared by the broader community; piecemeal construction/maintenance of seawall fragments by individual property owners is not viable (Evans & McDowell 2013). Depending on the selected height of the seawall, it can create aesthetic issues by interfering with scenic waterfront views (Short 2000). This visual obstruction could also lead to lowered value of waterfront property. The presence of many private docks also complicate seawall construction. If left in place, they will contribute to the complexity (and hence, expense) of constructing the seawall (Evans & McDowell 2013). Yet if the docks are removed, property values may decline. Ecologically, the negative effects of the seawall are particularly severe. By preventing salt marsh from migrating inland with rising seas, a seawall

will, over time, cause major declines in this aesthetically and economically important habitat type (Caldwell & Segall 2007; Craft et al. 2009; Hanak & Moreno 2012). Benefits of the seawall are also substantial, however. It is a robust way to create complete or near-complete protection against both overland flooding, and coastal erosion. Existing homes and infrastructure can remain in-place (Hanak & Moreno 2012). Like coastal armoring, elevating homes is an adaptation designed to allow existing human structures to persist on the landscape. It differs in that it does not prevent overland seawater encroachment, but rather accommodates it (Nicholls 2011). Infrastructure elevation is in common use worldwide, at sites where flooding (from any source) is a frequent problem (Chan & Parker 1996; Botzen, Aerts, & van den Bergh 2013). The function of this adaptation strategy is simple: to raise a building and its contents above potential floodwaters, thus avoiding damage.

On Tybee Island, elevation of homes has already been widely implemented. In the island's low-lying south-central part, many homes and rental properties are already elevated. However, more extensive structural elevation remains an important consideration.

As with coastal armoring, there are trade-offs associated with structural elevation as an adaptation technique. Monetary expenditure, again, is significant. Elevating new or existing homes is a costly process (FEMA 2009; Botzen et al. 2013). In many cases, the up-front costs are mitigated over time by reduced insurance fees (FEMA 2009; Pryce & Chen 2011). The benefits of structural elevation are meaningful. For private property owners, it enables self-sufficiency and self-determination in protecting their structures from flooding. Individual adaptation, independent of the community as a whole, is made viable through this approach (Penning-Rowsell & Smith 1987). Ecologically, structural elevation is generally benign. It does not directly impact the biological structure or function of salt marsh habitat.

For situations in which these in-situ approaches are deemed unsuitable, managed retreat is another strategy. This adaptation can take many forms. It can be centralized, dictated by government, and even accompanied by monetary rewards to smooth the transition (Hanak & Moreno 2012). Alternatively, retreat can be decentralized, selected on an individual basis by private property or business owners based on their own risk analyses. It is not an adaptation that is frequently applied. Yet the viability of low-lying coastal communities under the dramatic, long-term effects of sea-level rise may be in serious question (Few, Brown, & Tompkins 2007). Predicted sea-level rise of several feet may make it prohibitively costly for certain elements of these communities to adapt effectively while remaining on-site (Hanak & Moreno 2012).

It is an open question whether Tybee Island, in whole or in part, fits the description of such a community. The cost of in-situ approaches have been shown to increase over time (Abel et al. 2011), as such, managed retreat may make sense as an option for the most vulnerable segments of the community.

The trade-offs of managed retreat are clear. In addition to the substantial monetary costs of moving elsewhere, there may also be significant psychological costs (Evans & Oehler-Stinnett 2006). Translocations can be especially difficult for long-term residents, as they may be linked for generations to a particular property or way of life (Few et al. 2007). If government incentives accompany managed retreat, the costs to society of this adaptation option will be shared in the short-term (Alexander & Ryan 2012). Long-term, however, the benefits to both individuals and broader society can be dramatic, through foregoing repeated private and public expenditures to defend highly vulnerable sites in perpetuity (Abel et al. 2011). By allowing ecological processes (such as salt marsh migration) to reclaim parts of the landscape, this strategy is also beneficial from an environmental perspective.

METHODS

Given our interest in Tybee Island residents' knowledge of the trade-offs of differing sea-level rise adaptations, as well as their awareness and participation in the planning processes currently taking place at the community level, we decided to target resident populations living in the two areas indicated by Carl Vinson Institute models as most vulnerable to inundation and erosion projected from sea-level rise. These two residential areas included the low-lying south-central interior area of Tybee Island and the western marsh edge abutting it (Appendix A1). Such targeted sampling methods have been used in comparable studies, including one concerning farmers' adaptations to climate change in Africa (Mapoyona & Mpandeli 2012).

Using a structured questionnaire (Appendix A2) for analytical clarity and consistency (Bernard & Ryan 2010), we sought to collect a spectrum of quantitative and qualitative information, including demographic and residency data, perceptions of environmental impacts and change from flooding and erosion, perceptions of trade-offs to particular sea-level rise adaptation scenarios (including a marsh seawall, housing elevation, and managed retreat), and awareness and perceptions of the local city sea-level rise planning process.

Questionnaires were given via interview style to residents in both of the residential areas mentioned above by going door-to-door as well as through intercept interview methods at the local pier. Identities of interviewees remained anonymous. Questionnaires were timed to take approximately 15-20 minutes per participant and were executed in teams of two, with one person conducting the questionnaire and the other taking notes. Such methods have been used in similar projects assessing community awareness and attitudes towards environmental issues (Larsen, Beck, Hartnell, & Creenaune 2002; de Barcellos, Krystallis, de Melo Saab, Kügler, & Grunert 2011; Pandve et al. 2011). At the end of each questionnaire, information was voluntarily

provided concerning the goals of our project, as well as our contact information if they had any further questions or desired additional information. All told, 23 Tybee Island residents were interviewed.

Statistical analysis regarding perception of flooding and erosion, trade-offs due to adaptation strategies, and willingness to participate in planning meetings was disaggregated by: 1) full-time vs. part-time residency, 2) location of residence on island, and 3) property owners vs. non-owners. This analysis was performed using contingency analysis (Chi-square) with JMP 9.0.2 software (SAS Institute 2013). Time of residence was compared between aggregates of respondents who answered yes or no to questions regarding perceptions of flooding and erosion using a t-test for unequal sample size (JMP 9.0.2 software, SAS Institute 2013).

RESULTS AND DISCUSSION

Of the 23 Tybee Island residents interviewed, 20 out of 23 (87%) were full-time residents, while three (13%) were part-time residents. They came from around the island, though our sample, as previously noted, was focused geographically in two areas especially vulnerable to sea-level rise. In particular, eight residents lived on the western side of the island directly along the marsh; 11 lived in the low-lying south-central portion of the island; and three lived in other areas of the island. A majority of residents likewise owned property on the island (14 of the 21 who responded, or 66.6%), while 33.3% (7 of 21) rented their residence. Mean time of residence on the island was 15.87 years, with a standard deviation of 15.7 years, suggesting a wide spectrum of residence times. Four residents had lived on the island over 40 years, two between 20-30 years, six for 10-20 years, another six for 5-10 years, one for three years, and four residents had lived on the island for a year or less.

No statistically significant variation was found using a Chi-square contingency analysis in responses related to perceptions of erosion or flooding, or those related to the trade-offs of sea-level rise adaptations, between part-time and full-time residents, based upon where respondents lived on the island, or based upon whether or not they owned property. The subsections that follow describe our summary resident survey findings and tie them back to our driving research questions and concerns.

Respondent Perceptions of Environmental Impacts on Tybee

Impacts of Flooding

Twelve out of 23 (52%) respondents reported being personally impacted by flooding. This is in contrast to 11 out of 23 (48%) respondents who said that they had not been personally impacted. A t-test of residence time showed a significant difference between these two responses ($t=2.258$, $df=14.33$, $p=0.0400$) with a mean residence time of 22.5 years for those that responded yes, and a mean residence time of 9.4 years for those that responded no, suggesting the longer one has lived on the island, the more likely they are to have been impacted by flooding. Ten out of 22 (45%, one respondent refrained from answering) respondents did not know anyone that had been impacted by flooding, while a slightly higher 12 out of 22 (55%) responded that they did know someone that had been impacted by flooding. A t-test of residence time between these two groups was not significant. While such answers reveal two distinct groupings of answers, it is relevant to note that a clear majority of residents either had been personally impacted or knew someone who had been impacted by flooding (18 out of 23, or 78.3%). This suggests that flooding is a recognized issue affecting residents in these vulnerable southern areas of Tybee Island.

Changes in Flooding

Perceptions of changes in flooding varied greatly across respondents, with 12 out of 22 (54.6%, one non-respondent) stating they had not noticed a change in flooding, seven out of 22 (31.8%) noting that they had, and three (13.6%) responding that they were unsure. A t-test of residence time between those who did and did not perceive changes in flooding was not significant. Four of the seven that had noticed a change in flooding stated that it had increased. Two of these respondents that stated flooding had increased attributed it to climate change, and one attributed the perceived increases to tides alone, while one was unsure whether it was due to tides or climate change. Three individuals said that flooding had decreased and that this was due to improved drainage on the island. Of the three individuals that were unsure if flooding had changed, two stated they perceived that it may have increased during heavy rains, while one said that it may have increased during tides. There appear to be no clear patterns as to respondents' perceptions of changes in flooding over time, whether it may be increasing or decreasing, or why such changes might be occurring.

Impacts of Erosion

A majority of respondents, 17 out of 23 (74%), reported not having been personally impacted by erosion, with six out of 23 (26%) responding in the affirmative that they had. Among the causes listed included storm water drainage and topsoil loss due to flooding. Likewise, 16 out of 23 (69.5%) residents did not know anyone personally impacted by erosion, while seven out of 23 (35%) knew someone who had been personally impacted. T-test results showed that mean residence time between these groups of respondents did not vary. These

findings suggest that erosion is not yet an issue of high concern or impact for residents in these areas of Tybee Island.

Change in Erosion

Overall, 16 out of 21 respondents (76.2%, 2 of 23 not responding) thought that the amount of erosion had not changed, while three out of 21 (14.3%) thought that it has, and two out of 21 (9.5%) were unsure. The residence times of respondents that answered yes or no did not vary according to a t-test. Perceptions of and to what causes these changes were attributed over time varied across respondents. Of residents who had no knowledge of anyone being impacted by erosion, one stated that they thought erosion was increasing, and that this was due to climate change, while two others stated they were unsure if erosion was increasing.

Residents also attributed this change to different factors. Of individuals that knew someone who had been impacted by erosion or had themselves been impacted by erosion, three thought that erosion was increasing. One attributed this to tides, one attributed this to wave action, and one attributed this to drainage due to lot development. As with changes in flooding, we see no clear pattern as to resident perceptions of changes in erosion on Tybee Island or possible reasons for it.

Respondent Perceptions of Adaptation Trade-offs

Perceptions of Trade-offs in Building a Seawall

When asked about the potential costs and benefits of a seawall along the marsh, ten residents felt there were mostly negative aspects or no current benefits, seven thought there were mostly positive aspects, and six were unsure as to any costs or benefits or had no opinion. Eight people mentioned that the seawall's monetary cost was a clear negative factor, and three

mentioned a seawall's negative aesthetic impact on the marsh view. Concerning benefits, five residents mentioned that a seawall could positively reduce flooding or be good for people in low-lying areas, and eight mentioned it could prevent erosion or save property. Five people that mentioned property protection or the benefits of reduced flooding or erosion also stated they thought the costs outweighed the benefits. Justification for such feelings was expressed by some in the belief that the economics were not in a seawall's favor, with some noting that "ocean construction always costs five times more than you think" and that it simply "would not be cost effective." Others noted downsides for the larger ecological system, commenting that "homeowners can protect their property, sure, but blockage of tides is no good." Still others spoke of the futility of attempting to hold back the sea, reflecting that "water will eventually enter," and "nature will win in the end."

When asked about impacts to others beside themselves, five respondents said that the benefits to private property would be good for Tybee Island as a whole. Seven responded that the cost would have some negative impact, and three responded that there would be a negative aesthetic impact. One person additionally remarked that a potentially positive impact was that the seawall might actually help during a hurricane.

When asked about potential environmental or ecological impacts, a majority of 14 out of 22 (64%, one not responding) felt there would be negative impacts. Five out of 23 (22%) responded that they did not think there would be negative impacts, and four were unsure. Of those that felt a seawall would have a negative impact, several listed reasons aligned with the literature review, with concerns that "marsh grass might die" and "sea life could be impacted if tides can't move in and out, impacting shrimp breeding." Others more generally felt a seawall would "disrupt the natural order of things," and that it was important to note that "we are all part

of a larger system." One individual, however, thought a seawall might instead have positive environmental impacts, remarking that a seawall "would actually help the marsh by containing fertilizer from yards." Of the 14 individuals who responded that they thought the marsh would be negatively impacted, eight of these residents (57%) felt that the negative impacts to the marsh would affect them personally. Three of these individuals said they make their living in tourism or fishing activities that would be particularly impacted. Other residents expressed concern that a seawall would "reduce" the marsh's "therapeutic value," while one expressed concern of impeding the natural "flux" of the barrier island.

Overall, the various costs or benefits of seawall construction that residents listed paralleled many of the costs and benefits found in the literature review, as a majority of individuals expressed concern about the impacts of a seawall on the marsh, over a third expressed concerns over cost, and a small but notable amount noted the negative aesthetic impacts. Some emphasized a dual concern for these costs and benefits in their personal answers, but frequently those same individuals expressed an overriding concern for financial costs, private property protection, or ecological impacts. This provides insight into not only how individuals may consider these trade-offs on an individual basis, but also how these trade-offs could potentially be balanced in public fora surrounding the decision-making processes related to sea-level rise adaptation.

Perceptions of Trade-offs in Elevating Structures

Of the 23 residents interviewed, respondents were nearly equally distributed between elevated and non-elevated dwellings. Specifically, 12 (52%) lived in non-elevated structures, and 11 (48%) lived in structures that were elevated. Of these 11 residents, five of them personally made the decision to elevate their house. The majority of these (four out of five)

attributed this decision mainly to comply with the law, as well as a desire for flood insurance. Two of these four also attributed their decision to flooding concerns. One resident, rather than mentioning the legal necessity, attributed this decision to both aesthetics as well as the need to protect against flooding. Of the 12 people that did not live in elevated structures, seven owned the property they lived in, and only three answered that they see a need to elevate. Those who responded that they did not see a need to elevate stated multiple reasons, including financial cost, the desire for future additions onto their house, and the belief that it may not flood again.

In terms of trade-offs present in the individual decisions of Tybee residents considering elevating houses compared to a literature review, here we clearly see that the compounded benefits of decreased insurance rates, compliance with the laws for new home construction, and flood avoidance have proved to weight some individual choices toward this adaptation strategy despite the negative aspects of monetary costs and structural building constraints. However, it appears for many that live in non-elevated residences (which we assume were constructed prior to the current building codes) that the monetary costs and structural constraints currently outweigh the benefits present in insurance incentives and flood avoidance.

Such findings suggest that the city council planning process should reflect that a number of individuals on the island live in residences that are not elevated structurally, that they currently lack incentives to elevate, and that this potentially leaves them more vulnerable to future flooding events. While a number of people have indicated that the current laws have mandated that their residence be elevated, it should be noted that these policies aimed at individual adaptations have not evenly decreased vulnerability to sea-level rise throughout the population. Further, because five of the individuals that rented (71% of respondents overall that rented) lived in non-elevated structures, greater knowledge of the demographics of renters that

live in non-elevated structures is needed to gain a better understanding of whether certain individuals or groups may in fact be more vulnerable to sea level rise on the island than others.

Perceptions of Trade-offs in Managed Retreat

Of 17 people that responded whether they had a long-term plan if flooding were to increase, a majority of 11 (65%) answered yes, four (24%) answered no, and two responded they were unsure. Of those 11 that replied yes, five noted leaving as a definite option. Four that said they would stay mentioned various further adaptations such as "marsh filling", levees, raising houses, and improved drainage could be needed, and two individuals claimed to intend to stay but did not express concern, one reflecting that "I have a boat," and the other noting that she will "accept [that change] as is." She and her husband, she noted, "knew the chance [they] were taking" when they moved to Tybee Island. Such findings suggest that people are envisioning scenarios where flooding impacts worsen and weighing considerations as to how to respond.

In considering the trade-offs that respondents have expressed are of main concerns to them, there are clear parallels to the literature we have reviewed. Such sentiments as "I have a boat" imply that some residents are willing to stay until there simply is no other option but to leave, and this implies that the psychological costs of moving from Tybee Island may indeed be great to some individuals. Similarly, for those willing to remain on the island even through changing conditions, the short-term costs of further adaptations clearly do not outweigh the costs, be they psychological or monetary, of moving away from the island. For at least two of the individuals we interviewed, the costs to leaving Tybee Island may not be outweighed by future incentives to move either. However, with five out of 11 respondents open to retreat as a possible adaptation, conversations of managed retreat, while politically sensitive, may have a larger potential audience than previously thought. Based upon our small sample, it does appear

that Tybee residents may be responsive to future incentives to move elsewhere, and that these incentives may outweigh the short-term costs of leaving the island. The short-term costs for society as a whole, however, would still need to be shown to be outweighed by the long-term benefits of people being less vulnerable to coastal hazards, as well as the ecological benefits of unconstrained marsh, a concern which many of the residents we interviewed share.

Respondent Perceptions of Planning Process

Twelve out of 23 (52%) respondents were aware of the city's sea-level rise planning meetings, one was unsure if they had heard of the meetings, and 10 (43%) had not heard of the meetings. The residents who were aware of these meetings listed multiple sources for where they had learned of them, with some sources garnering more mentions than others did. Word-of-mouth and a local email listserv were each mentioned three times, while the Tybee Island TV channel, City Hall and its notice board, and the monthly water bill were each mentioned twice. The Tybee newsletter (Tybee Forever), the Savannah Morning News, one individual's politically-active husband, and Facebook additionally were all listed once.

Four out of 23 (17%) respondents had attended meetings, with two responding that they did so to remain informed. Interestingly, all of these individuals had personally been impacted by flooding or erosion, with two out of the four being personally impacted by flooding and three out of four being personally impacted by erosion.

However, a majority, 19 out of 23 (83%), had not attended meetings. When those who had not attended were asked if they would be willing to participate, six of the 16 who answered said they would be willing to attend. One respondent was unsure. Three individuals willing to attend responded they would go if they are informed about the meetings before, and one said they would attend if changes in FEMA laws were going to be addressed.

Nine respondents, however, said they would not be willing to participate. Of those nine, two explained their lack of willingness by noting that they did not believe sea levels are rising. Six of the nine respondents expressed concerns with the local government political process at some point in the interview. This is contrasted, interestingly, by the fact that those that were willing to participate did not express similar sentiments. Of those unwilling to attend, some bemoaned the "polarization" on the council, while others stated there was "too much local politics" in the process, or that they were put off by all the "infighting." Another simply stated that "politics make you lose the charm of the island." Similarly, it should be noted that one person who had previously attended the meetings called the local government today "too polarized." One individual that was unwilling to attend stated: "they [the city council] don't care about the environment, just money," and another echoed this, reflecting that the main priority of the city council was "bringing more profit into Tybee Island at all costs."

When asked if anything would help them participate, one individual remarked that the opportunity for their "voice to be heard and make an impact" would improve the situation. One person who was unwilling to attend commented that they would attend if there was serious interest and attention given to raising the access road. Another commented that they would be willing to attend "if there were more people willing to do things," continuing that "[the council members] care more about condos and more tourists." One individual expressed similar frustration, noting that Tybee Island city council members "waste a lot of time" focusing on and discussing what in his mind are the wrong things. This individual felt the council should be primarily focused on the oncoming complications regarding flood insurance for Tybee Island residents, positing: "What are we going to do with non-elevated people?" once insurance premiums price them out for coverage as flooding risk forces insurance rates to rise. This

individual also noted that the economic and demographic composition of the island will likely change with rising insurance costs. This sentiment similarly raises concerns of whether individuals that rent their residence will be able to afford to live on the island in the future, and especially given that five out of seven sampled renters lived in non-elevated houses, this indicates a potential lack of representation for these concerns in the sea-level rise planning process.

When asked about barriers to their participation, a majority of respondents (nine out of 15, or 60%) reported none. The remaining six respondents, however, replied in the affirmative and two of their responses display previously voiced sentiments of apathy and frustration with the political process and environment. One respondent noted that they want to avoid the polarized political environment found in the city council, and another expressed difficulty engaging in local politics. This is a pattern that could merit further council consideration. In addition to such sentiments that seem to reinforce a divide seen between some residents and the Tybee Island's local political system, we see five out of the six respondents mention barriers that highlight structural considerations that the council may wish to take into account when scheduling meetings in order to minimize issues of procedural injustice that can limit the range of people able to participate in meetings. In particular, four out of the five respondents mention the possibility of conflicts due to timing, with day-time work and school schedules during the week being the primary considerations. One respondent also noted that medical issues may preclude them from participating as well. Such structural barriers are important to consider, as they point to possible resident populations whose voices may be underrepresented or unheard during planning meetings and processes.

Lastly, related to representation and participation, when asked whether they had watched the sea-level rise planning meetings on TV, a majority of respondents (17 out of 23, or 74%) responded no, while 6 out of 23 (26%) responded yes. Fifteen out of 23 (65%) of those interviewed had watched other city meetings on the Tybee Channel, however, suggesting that it is a popular form of political engagement and participation. Whether it could be translated into greater viewership, let alone participation, for meetings concerning sea-level rise planning is an open question.

CONCLUSIONS AND RECOMMENDATIONS

Participatory Processes

As the Vinson Institute considers how to engage the public of Tybee Island in a more participatory process, our results indicate that the primary hurdles they will encounter involve the perceived polarization of the city council process, a number of social justice issues, and an overall lack of urgency on the part of the public with regard to sea-level rise. The city council environment was the most frequently cited reason for hesitance to engage in planning meetings and appears to present a formidable barrier. Additional social justice issues that have bearing on participation are also conspicuous in that certain groups, especially renters, may not currently be represented in the process. Further, there are social justice concerns regarding some individuals' ability to participate, including meeting times conflicting with work schedules and a mention of a medical condition that prevents one individual from physically attending meetings.

With regard to sea-level rise and perception, it should be noted that all respondents who participated in city meetings had been impacted by coastal hazards, but that overall the results of our survey indicate that perception of these threats shows no clear patterns related to

participation or willingness to participate. The results of our survey indicate that respondents' awareness of flooding and erosion risk was fairly consistent with historical trends and current data, but that residents do not seem to have internalized the severity of projected scenarios. As the impacts of sea-level rise become more apparent, perceptions of personal risk and evaluations of urgency with regard to these impacts may play a larger role in fostering participation.

Opportunities to participate in planning processes were generally advertised, which is important, but our findings suggest that this may not be enough and additional tactics should be used. In the context of anticipatory planning for adaptation to sea-level rise, in which there may be a general lack of awareness or sense of urgency, more effort at initially identifying and directly engaging pertinent stakeholders is important for both informed and legitimate planning. Such direct engagement will by necessity target a subsection of Tybee Island residents, but without a general sense of urgency, and given the time commitment and enthusiasm necessary for robust participation, a smaller corps of participants is to be expected. However, taking the time and effort to identify and engage members of various stakeholder groups could help to mitigate some concerns of under-representation and could go hand in hand with the identification of obstacles to participation that might facilitate the tailoring of meeting times and places to stakeholder needs. Finally, the perceptions of a polarized city council indicate that working purely through the city council and city council meetings eliminated many possible participants from the beginning. Recognition of this obstacle might entail development of more neutral meeting spaces in which the council is one stakeholder among many and in which other Tybee Island residents might feel more efficacy in engaging.

Engagement with Trade-offs

Engaging with trade-offs in planning processes is seen to have multiple distinct yet related benefits. Such benefits begin with the recognition that in any planning decision, there are simultaneous gains and losses for different groups. Grappling with these gains and losses, and including these groups in larger planning decisions, are two critical gains from such a trade-off focused approach. Incorporating such an approach in planning processes is thought to be valuable to create a more informed, participatory, and legitimated reckoning of issues across stakeholders. Hirsch, et al. (2011) reflect that, "[in] the long run, proactive acknowledgement" of trade-offs "may lead to more resilient and sustainable outcomes."

In light of this, we feel there are several valuable examples of trade-off engagement from our research that the Vinson Institute would do well to consider. One such finding was a distinct mismatch between how the Vinson Institute has conceptualized seawall trade-offs for Tybee Island and the broader spectrum of costs and benefits recognized by our respondents. A wide range of values and concerns were brought up by Tybee Island residents, including financial concerns, but also potential costs to visual aesthetics, environmental impacts, and damage to marsh life. Such valuations have not been emphasized quantitatively or qualitatively as of yet in the planning process, suggesting that incorporating wider conceptions of costs and benefits beyond the current envisioning of hotel bed-night tax revenues could engage a larger portion of Tybee Island residents and their values.

Secondly, we find a discrepancy arises in the trade-offs associated with elevating houses. In particular, for many who live in non-elevated structures, financial cost and infrastructural constraints are seen to outweigh the benefits of elevating. Such a trade-off discrepancy highlights the potentially disproportionate impact sea-level rise will inflict on certain Tybee

Island populations. This demographic consideration has an additional component as well, with five of the seven respondents who rented their homes living in non-elevated structures. This also points to a potential need for planning processes to more explicitly engage trade-off considerations of renters' vulnerabilities.

Finally, our findings show five out of 11 respondents with a long-term plan of retreat in case of increased flooding. This suggests the possibility of greater political space in the planning process than perhaps anticipated for discussions concerning managed retreat and corresponding policy and planning options.

Communication

In addition to confronting underlying obstacles to participation and engaging with trade-offs, a wider consideration of communications might also contribute to increased or more effective participation in planning processes. As previously noted, 65% of Tybee Island respondents reported watching city council meetings on the local Tybee TV channel. However, only 26% of respondents reported watching the sea-level rise planning meetings on this channel. These statistics suggest that there may be an opportunity to utilize the Tybee TV channel as a mechanism to increase participation in and awareness of the sea-level rise planning process. Currently, Tybee Island records and posts videos of public meetings online through its municipal website. However, visitors wishing to view meetings specific to sea-level rise planning may have difficulties locating these under the current website structure. Also of interest is that 78% of respondents confirmed accessing the internet for information. Consequently, targeted web-based communication efforts may assist project implementers in accessing a wider online audience. Currently, the Georgia Sea Grant appears to be the principal online clearinghouse for information related to the Tybee Island sea-level rise planning process.

Considering these aforementioned communication dynamics and as a sub-component of this paper's recommendations, a pilot website has been developed in collaboration with the Georgia Sea Grant that attempts to incorporate this report's findings into a strategic, web-based communication plan. The website aims to improve ease-of-access for visitors wishing to view past sea-level rise planning meetings by providing direct links to these videos under an events and planning page. Additionally, viewers will be allowed to provide feedback on how to increase participation and will be given the option to receive email notifications about upcoming sea-level rise planning events.

It should be noted that any communication efforts should be considered within a broader context to identify potential participatory barriers and be responsive to local sensitivities. For example, as previously discussed, several residents chose to actively disengage from planning processes due to the perceived polarization of city council. Thus, while increased dissemination of information may help to increase awareness of planning events, if substantial participatory barriers continue to exist, increased knowledge will likely not translate into increased participation.

BIBLIOGRAPHY

Abel, N., Gorddard, R., Harman, B., Leitch, A., Langridge, J., Ryan, A., & Heyenga, S. (2011). Sea level rise, coastal development and planned retreat: analytical framework, governance principles and an Australian case study. *Environmental Science & Policy, 14*(3), 279-288. doi: 10.1016/j.envsci.2010.12.002.

Agrawal, A. (2010). Local institutions and adaptation to climate change. *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World.* Washington DC, World Bank, 173-198.

Alexander, K. S., Ryan, A., & Measham, T. G. (2012). Managed retreat of coastal communities: Understanding responses to projected sea level rise. *Journal of Environmental Planning and Management, 55*(4), 409-433. doi: 10.1080/09640568.2011.604193.

Bernard, H. R., & Ryan, G. W. (2010). *Analyzing qualitative data : systematic approaches / H. Russell Bernard, Gery Ryan*: Thousand Oaks, Calif. : SAGE, c2010.

Bjornberg, K. E., & Hansson, S. O. (2011). Five Areas of Value Judgement in Local Adaptation to Climate Change. *Local Government Studies, 37*(6), 671-687. doi: 10.1080/03003930.2011.623159.

Botzen, W. J. W., Aerts, J., & van den Bergh, J. (2013). Individual preferences for reducing flood risk to near zero through elevation. *Mitigation and Adaptation Strategies for Global Change, 18*(2), 229-244. doi: 10.1007/s11027-012-9359-5.

Brett, E. A. (2003). Participation and accountability in development management. *Journal of Development Studies, 40*(2), 1-29. doi: 10.1080/00220380412331293747.

Caldwell, M., & Segall, C. H. (2007). No day at the beach: Sea level rise, ecosystem loss, and public access along the California coast. *Ecological Law, 34*, 533–578.

Campbell, B. M., Sayer, J. A., & Walker, B. (2010). Navigating trade-offs: Working for conservation and development outcomes. *Ecology and Society, 15*(2), 16.

Chambers, R. (1983). *Rural development: Putting the last first*. Burnt Mill, Harlow, Essex, England, New York: Longman Scientific & Technical.

Chambers, R. (1992). Rural appraisal: Rapid, relaxed and participatory. *IDS Discussion Paper 311*.

Chan, N. W., & Parker, D. J. (1996). Response to dynamic flood hazard factors in peninsular Malaysia. *Geographical Journal, 162*, 313-325. doi: 10.2307/3059653.

City of Tybee Island, Georgia. City officials. (n.d.). Retrieved April 27, 2013, from http://www.cityoftybee.org/CityOfficials.aspx.

Cooke, B., & Kothari, U. (2001). *Participation: The new tyranny?* Zed Books.

Cooper, J. A. G., & Lemckert, C. (2012). Extreme sea-level rise and adaptation options for coastal resort cities: A qualitative assessment from the Gold Coast, Australia. *Ocean & Coastal Management, 64*, 1-14. doi: 10.1016/j.ocecoaman.2012.04.001.

Craft, C., Clough, J., Ehman, J., Joye, S., Park, R., Pennings, S., . . . Machmuller, M. (2009). Forecasting the effects of accelerated sea-level rise on tidal marsh ecosystem services. *Frontiers in Ecology and the Environment, 7*(2), 73-78. doi: 10.1890/070219.

Cronin, S. J., Petterson, M. G., Taylor, P. W., & Biliki, R. (2004). Maximising multi-stakeholder participation in government and community volcanic hazard management programs; a case study from Savo, Solomon Islands. *Natural Hazards, 33*(1), 105-136.

de Barcellos, M. D., Krystallis, A., de Melo Saab, M. S., Kügler, J. O., & Grunert, K. G. (2011). Investigating the gap between citizens' sustainability attitudes and food purchasing behaviour: empirical evidence from Brazilian pork consumers. *International Journal of Consumer Studies, 35*(4), 391-402. doi: 10.1111/j.1470-6431.2010.00978.x.

Evans, J., & McDowell, R. (2013, March 4). *City of Tybee Island Climate Adaptation Planning and General Overview for Sea Level Rise. Presentation at a City Council meeting*. Tybee Island, Georgia.

Evans, L., & Oehler-Stinnett, J. (2006). Children and natural disasters - A primer for school psychologists. *School Psychology International, 27*(1), 33-55. doi: 10.1177/0143034306062814.

FEMA. (2009). *Homeowner's Guide to Retrofitting, 2nd ed.*

Few, R., Brown, K., & Tompkins, E. L. (2006). Public participation and climate change adaptation. *Tyndall Centre for Climate Change Research Working Paper, 95*.

Few, R., Brown, K., & Tompkins, E. L. (2007). Climate change and coastal management decisions: Insights from Christchurch Bay, UK. *Coastal Management, 35*(2-3), 255-270. doi: 10.1080/08920750601042328.

Fraser, E. D. G., Dougill, A. J., Mabee, W. E., Reed, M., & McAlpine, P. (2006). Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of Environmental Management, 78*(2), 114-127. doi: 10.1016/j.jenvman.2005.04.009.

Georgia Sea Grant. (2012). University of Georgia and Georgia Sea Grant help Tybee Island prepare for potentially rising seas [Press release]. Retrieved from http://georgiaseagrant.uga.edu/article/5_8_12_Tybee/.

Hanak, E., & Moreno, G. (2012). California coastal management with a changing climate. *Climatic Change, 111*(1), 45-73. doi: 10.1007/s10584-011-0295-2.

Heberger, M., Cooley, H., Herrera, P., Gleick, P. H., & Moore, E. (2009). The Impacts of Sea-Level Rise on the California Coast. California Climate Change Center, Sacramento.

Hirsch, P. D., Adams, W. M., Brosius, J. P., Zia, A., Bariola, N., & Dammert, J. L. (2011). Acknowledging Conservation Trade-Offs and Embracing Complexity. *Conservation Biology, 25*(2), 259-264. doi: DOI 10.1111/j.1523-1739.2010.01608.x.

Horton, R. H., C.; Liu, J.; Gornitz, V.; Ruane, A. (2008). Sea level rise projections for current generation CGCMs based on the semi-empirical method. *Geophysical Research Letters, 35*, 1-5.

IPCC. (2007). Intergovernmental Panel on Climate Change (IPCC) Climate Change 2007: Synthesis Report (pp. 1-73). Valencia, Spain.

Jepson, M., Kitner, K., Pitchon, A., Perry, W., & Stoffle, B. (2005). Potential Fishing Communities in the Carolinas, Georgia and Florida: An effort in baseline profiling and mapping. Retrieved April 20, 2013, from National Oceanic and Atmospheric Administration Fisheries Service Southeast Regional Office website: http://sero.nmfs.noaa.gov/sf/socialsci/publications/pdf/SA%20Fishing%20Community%20Report.pdf.

Jones, N. A., Ross, H., Lynam, T., Perez, P., & Leitch, A. (2011). Mental Models: An Interdisciplinary Synthesis of Theory and Methods. *Ecology and Society, 16*(1).

Julius, S. H., & Scheraga, J. D. (2000). The TEAM model for evaluating alternative adaptation strategies. In Y. Y. Haimes & R. E. Steuer (Eds.), *Research and Practice in Multiple Criteria Decision Making* (Vol. 487, pp. 319-330). Berlin: Springer-Verlag Berlin.

Kamphuis, W. J. (2010). *Introduction to Coastal Engineering and Management*. Singapore: World Scientific Publishing Co., Ltd.

King, R. O. (2013). The National Flood Insurance Program: Status and Remaining Issues for Congress. Retrieved from http://www.fas.org/sgp/crs/misc/R42850.pdf.

Kirwan, M. L., Guntenspergen, G. R., D'Alpaos, A., Morris, J. T., Mudd, S. M., & Temmerman, S. (2010). Limits on the adaptability of coastal marshes to rising sea level. *Geophysical Research Letters, 37*(23), L23401. doi: 10.1029/2010GL045489.

Kreeger, D., Adkins, J., Cole, P., Najjar, R., Velinsky, D., Conolly, P., & Kraeuter, J. (May 2010). Climate Change and the Delaware Estuary: Three Case Studies in Vulnerability

Assessment and Adaptation Planning. Partnership for the Delaware Estuary, PDE Report No. 10-01. 1-117 pp. Retrieved from http://delawareestuary.org/pdf/Climate/Climate%20Change%20and%20the%20Delaware%20Estuary_PDE-10-01.pdf.

Landry, C. E., Keeler, A. G., & Kriesel, W. (2003). An Economic Evaluation of Beach Erosion Management Alternatives. *Marine Resource Economics, 18*(2), 105-127.

Larsen, E., Beck, M., Hartnell, E., & Creenaune, M. (2002). Neighbours of the Ku-ring-gai Flying-fox Reserve: Community attitudes survey 2001. *Bat Research News, 43*(1), 16.

Luscher, A., & Hollingsworth, C. (July 2005). Shore Erosion Control, The Natural Approach. Retrieved from ftp://ftp-fc.sc.egov.usda.gov/MD/web_documents/programs/rcd/shore_esrcd.pdf.

Lyon, A., Bell, M., Croll, N. S., Jackson, R., & Gratton, C. (2010). Maculate Conceptions: Power, Process, and Creativity in Participatory Research. *Rural Sociology, 75*(4), 538. doi: 10.1111/j.1549-0831.2010.00030.x.

Maponya, P., & Mpandeli, S. (2012). Climate Change Adaptation Strategies used by Limpopo Province Farmers in South Africa. *Journal of Agricultural Science (1916-9752), 4*(12), 39-47. doi: 10.5539/jas.v4n12p39.

Martinich, J., Neumann, J., Ludwig, L., & Jantarasami, L. (2013). Risks of sea level rise to disadvantaged communities in the United States. *Mitigation and Adaptation Strategies for Global Change, 18*(2), 169-185.

McGranahan, G., Balk, D., & Anderson, B. (2007). The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. *Environment and Urbanization, 19*(1), 17-37. doi: 10.1177/0956247807076960

McShane, T. O., Hirsch, P. D., Trung, T. C., Songorwa, A. N., Kinzig, A., Monteferri, B., . . . O'Connor, S. (2011). Hard choices: Making trade-offs between biodiversity conservation and human well-being. *Biological Conservation, 144*(3), 966-972. doi: DOI 10.1016/j.biocon.2010.04.038.

Meehl, G. A., Stocker, T. F., & Collins, W. D. (2007). Global climate projections. In S. Solomon, D. Qin & M. Manning (Eds.), *Climate change 2007: The physical science basis. Contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press.

Mendonca, A. (2005, June 3). Tybee Island. *New Georgia Encyclopedia.* Retrieved April 20, 2013, from http://www.newgeorgiaencyclopedia.org/nge/Article.jsp?id=h-2967&hl=y.

Morris, J. T., Sundareshwar, P. V., & Nietch, C. T. (2002). Response of coastal wetlands to rising sea level. *Ecological Applications, 83* 2869–2877.

Nicholls, R. J. (2011). Planning for the Impacts of Sea Level Rise. *Oceanography, 24*(2), 144-157.

NOAA (National Oceanic . (2013, March 25). Mean Sea Level Trend 8670870 Fort Pulaski, Georgia [Graph]. Retrieved April 20, 2013, from http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8670870%20Fort%20Pulaski,%20GA.

NOAA. (n.d.). Sea Level Rise and Coastal Flooding Impacts Viewer. Retrieved April 27, 2013, from http://www.csc.noaa.gov/digitalcoast/tools/slrviewer/.

Otto-Banaszak, I., Matczak, P., Wesseler, J., & Wechsung, F. (2011). Different perceptions of adaptation to climate change: A mental model approach applied to the evidence from expert interviews. *Regional Environmental Change, 11*(2), 217-228. doi: 10.1007/s10113-010-0144-2.

Pandve, H. T., Chawla, P. S., Fernandez, K., Singru, S. A., Khismatrao, D., & Pawar, S. (2011). Assessment of awareness regarding climate change in an urban community. *Indian Journal of Occupational & Environmental Medicine, 15*(3), 109-112. doi: 10.4103/0019-5278.93200.

Park, R. A., Trehan, M. S., Mausel, P. W., & Howe, R. C. (1989). The effects of sea level rise on US coastal wetlands. In J. T. Smith, DA (Ed.), *The potential effects of global climate change on the United States. Appendix B – sea-level rise.* Washington, DC: US Environmental Protection Agency.

Penning-Rowsell, E. C., & Smith, D. I. (1987). Self-help flood hazard mitigation: The economics of house-raising in Lismore, NSW, Australia. *Tijdschrift voor economische en sociale geografie, 78*(3), 176-189. doi: 10.1111/j.1467-9663.1987.tb00578.x.

Pope, J. (1997). Responding to coastal erosion and flooding damages. *Journal of Coastal Research, 13*(3), 704-710.

Pryce, G., & Chen, Y. (2011). Flood risk and the consequences for housing of a changing climate: An international perspective. *Risk Management-an International Journal, 13*(4), 228-246. doi: 10.1057/rm.2011.13.

Rahmstorf, S. (2010). A new view on sea level rise. *Nature, 4*, 44-45.

Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. *Biological Conservation, 141*(10), 2417-2431. doi: http://dx.doi.org/10.1016/j.biocon.2008.07.014.

Saroar, M. M., & Routray, J. K. (2010). In situ adaptation against sea level rise (SLR) in Bangladesh: Does awareness matter? *International Journal of Climate Change Strategies and Management, 2*(3), 321-345. doi: 10.1108/17568691011063079.

SAS Institute, Inc. (2013). JMP (Version 9.0.2). Cary, NC.

Seabrook, C. (2012, July 13). Tidal marshes. *New Georgia Encyclopedia.* Retrieved April 20, 2013, from http://www.newgeorgiaencyclopedia.org/nge/Article.jsp?path=/LandResources/GeographyandEnvironment/EcologicalFunctionsofEnvironment/CommunitiesandSystems&id=h-1183.

Short, A. (2000). *Handbook of Beach and Shoreface Morphodynamics*. John Wiley and Sons Ltd.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global environmental change, 16*(3), 282-292.

Smith, J. M., Stauble, D. K., Williams, B. P., & Wutkowski, M. J. (April 2008). *Impact of Savannah Harbor deep draft navigation project on Tybee Island shelf and shoreline*. Vicksburg, Miss.: [US Army Corps of Engineers, Engineer Research and Development Center], Coastal and Hydraulics Laboratory.

Titus, J. G. (June 2001). Rolling Easements. Retrieved from http://water.epa.gov/type/oceb/cre/upload/rollingeasementsprimer.pdf.

Tompkins, E. L., Few, R., & Brown, K. (2008). Scenario-based stakeholder engagement: Incorporating stakeholders preferences into coastal planning for climate change. *Journal of Environmental Management, 88*(4), 1580-1592. doi: 10.1016/j.jenvman.2007.07.025.

U.S. Census Bureau (2010). American Fact Finder, Community Facts, Tybee Island city, Georgia. Retrieved April 20, 2013, from http://factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml.

Vermeer, M., & Rahmstorf, S. (2009). Global sea level linked to global temperature. *Proc Natl Acad Sci U S A, 106*(51), 21527-21532. doi: 10.1073/pnas.0907765106.

Wollenberg, E., Campbell, B., Dounias, E., Gunarso, P., Moeliono, M., & Sheil, D. (2008). Interactive landuse planning in Indonesian rain-forest landscapes: reconnecting plans to practice. *Ecology and Society, 14*(1), 35.

APPENDIXES

Appendix A1
Map Illustrating Low-lying (Blue) and Marsh-edge (Green) Areas

Appendix A2
Resident Questionnaire

INTERVIEW INTRODUCTION SCRIPT

"Hello, my name is _____, and I'm a student from the University of Georgia. I'm conducting a survey for an environmental studies class project. Would you be interested in answering some questions about flooding?"

If they answer "NO":
"Would you like a handout with more information about the project?"

If they answer "YES, but I don't have time right now":
"Here is a handout with more information about the project. Would you like to be contacted later for a telephone survey?"
[If "Yes," take down contact information and best times to call.]

If they answer "YES":
"Thank you. The purpose of this project to determine Tybee residents' attitudes and knowledge of flooding issues and potential adaptations to deal with flooding on the island. One outcome of this project is to develop more effective ways for Tybee residents to interact with their local government concerning flooding issues and adaptation. However, this survey is not necessarily representative of any intended plans for the City of Tybee. Your participation is voluntary and your answers will remain anonymous. This survey should take 15–20 minutes to complete, and you can stop at any time. Would you be interested in answering some questions?"
****
****

INTERVIEW GUIDE **Survey ID#_____**

A) Demographic Information

1) Would you consider yourself a full-time resident, part-time resident, or visitor?
Full-time ____ Part-time ____ Visitor ____ **[If visitor, no need to continue]**

2) We have a map here that divides the island into sections, would you mind showing in which section you live? [Use color-blocked map to identify where]

3) Do you own property on the island?
Yes ____ No ____

4) How many years have you been a resident here? ____

Appendix A2 (cont.)

B) Perceptions of Flooding and Flooding Impacts on Tybee

5) Have you been affected by flooding or erosion while you have lived here? (Note: pay attention to what impact they are referring to and follow-up if they don't cover both)

5a) Flooding: Yes __ No___ (If yes, please describe)

5b) Erosion: Yes __ No___ (If yes, please describe)

6) Has anyone you know been affected by flooding and erosion?

6a) Flooding: Yes __ No___ (If yes, please describe)

6b) Erosion: Yes __ No___ (If yes, please describe)

7) Have you noticed a change in the amount of flooding on Tybee while you have lived here?
Yes __ No__ Unsure __ Other __ (Include any details below)

8) Have you noticed any change in erosion that threatens property on Tybee while you have lived here?
Yes __ No__ Unsure __ Other__ (Include any details below)

Appendix A2 (cont.)

If yes to Questions 7) or 8) ask:

9) Do you have any thoughts on what's causing these changes in flooding and/or erosion? (Interviewer should check if referring to flooding, erosion, or both)

	Flood	Erosion
Global warming		
Sea level rise		
Tides		
Drainage system		
Low elevation		
Areas' dredge-filled origin		

OTHER (Briefly describe):

C) Perceptions of Trade-offs to Adaptation Strategies to SLR

10) Some cities have considered building sea walls along the edges of marsh as a way of adapting to potential flooding and erosion. Is this an idea you have come across?
Yes __ No ___ (Include any details below)

11) Being from Tybee, what costs or benefits do you think such a sea wall would have for those people living on the marsh shore?

Cost ____
Aesthetics ____
Marsh impact ____
Other (Describe):

12) What costs or benefits do you think such a sea wall would have for the other residents of Tybee?

Cost ____
Aesthetics ____
Marsh impact ____
Other (Describe):

Appendix A2 (cont.)

13) Do you think a sea wall would have ecological or environmental effects on the marsh next to it?
Yes __ No__ (If yes, please describe)

14) If so, would those ecological or environmental effects affect you in any way?
Yes __ No__ (If yes, please describe)

15) In coastal areas, elevating houses is often seen as a strategy for dealing with potential problems with flooding. Is this an idea you have come across before?
Yes __ No__ (Include any details below)

16) Is your house elevated? (Skip if standing on porch)
Yes __ No__

17) Did you decide to elevate your house?
Yes __ No__

18) If yes: What factors went into your decision to elevate?

19) If not elevated: Do you see a need to elevate?
Yes __ No__

20) What factors would go into your deciding to elevate?

21) Given the flooding impacts you mentioned earlier, if this flooding were to increase, have you considered how you might respond in the long-term?
Yes __ No__ (If yes, please describe)

Appendix A2 (cont.)

-- At this point thank the interviewee and let them know that you all are almost done --

D) Perceptions and Knowledge of Community Planning Process:

22) Have you heard about the series of city meetings concerning rising sea levels on Tybee?
Yes ____ No ____ Unsure ___

23) If yes, how did you find out about these meetings?
Fill in: _____

24) Have you participated in these meetings?
Yes ____ No____

25) If yes, why did you participate?

26) If no, would you be willing to participate in them?
Yes ____ No ____

27) If no, why would you not be willing to participate?

28) Is there anything that would help you to participate?

29) Are there any obstacles that make it difficult for you to participate?

30) Have you watched any of these meetings about rising sea levels on TV?
Yes ____ No____

31) Have you watched Tybee city meetings in general on TV?
Yes ____ No____

Appendix A2 (cont.)

E) Communications & Media

32) Do you commonly access the Internet for information?
Yes ____ No _____

33) Where are you most likely to get news about Tybee?
(Check all that apply):
Tybee channel ____ City website ____ Neighbors/friends ____
Local radio station (specify) _____
Local/regional newspapers (specify) _____
Other (fill in) _____

34) Where are you most likely to get news about local government events?
(Check all that apply):
Tybee channel ____ City website ____ Neighbors/friends ____
Local radio station (specify) _____
Local/regional newspapers (specify) _____
Other (fill in) _____

35) Can you think of a more useful place or way to find about local government events?
Tybee channel ____ City website ____ Neighbors/friends ____
Local radio station (specify) _____
Local/regional newspapers (specify) _____
Other (fill in) _____

36) Based on our interview today, are there any topics you would be interested in learning more about?
Yes ____ No _____
(If yes, please describe)

37) We are compiling a list of email addresses in case people are interested in receiving more information about these issues on Tybee. Would you be interested in being on this list?
Yes ____ No _____

If yes, provide email address: _____