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Rising Tides and Changing Attitudes: Community Adaptive Planning and Behavior Change in North Kingstown, Rhode Island

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RISING TIDES AND CHANGING ATTITUDES: COMMUNITY ADAPTIVE PLANNING AND BEHAVIOR CHANGE IN NORTH KINGSTOWN, RHODE ISLAND

BY

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ABSTRACT

The consequences of global climate change in the form of sea level rise and more frequent intense storms are likely to cause significant impacts on coastal ecosystems and critical infrastructure in vulnerable coastal municipalities. This could result in major economic losses and social disruption unless these communities proactively plan for the impacts of a changing climate. As a small state with a large coastal population, Rhode Island is highly vulnerable to impacts from climate change, thus the state is positioned to act as a potential leader in a national movement towards proactive adaptation. It is clear that actions must be taken, however implementing effective policy changes requires significant political will as well as the support of decision makers and communities.

This case study assesses municipal officials' perceptions of the risks sea level rise and increased storminess pose to North Kingstown, Rhode Island and analyzes the relationship between town decision makers' understanding of climate change risk and adaptive planning behavior. Evaluation of local decision makers' mental models concerning climate change knowledge and perceptions of risk will provide insights for those working with town decision makers to proactively incorporate adaptation actions in town comprehensive and capital improvement planning.

Results of this research display no correlation between local decision makers' levels of climate change knowledge and their individual preparatory behavior or between personal adaptive behavior and levels of support for proactive municipal adaptation. A strong correlation was found between individuals with

mental models closely matching the expert model of climate change knowledge and levels of support for municipal adaptation planning and actions. Additionally, this study found a moderate correlation between subjects' exposure to climate change information and levels of support for municipal adaptation. Increasing awareness of the risks associated with impacts of climate change through improved communication, educational programs, and public outreach is likely to be an effective way of promoting proactive adaptation in vulnerable coastal communities.

ACKNOWLEDGMENTS

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PREFACE

This thesis is organized in Manuscript Format as described by the URI Graduate School guidelines on thesis preparation. The body of the text corresponds to the journal article format specified by the *Journal of Ocean and Coastal Management.*

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MANUSCRIPT

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Rising Tides and Changing Attitudes: Community Adaptive Planning and Behavior Change in North Kingstown, Rhode Island

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1. Introduction

The consequences of global climate change in the form of sea level rise and more frequent intense storms have the potential to cause significant impacts on vulnerable coastal ecosystems and critical infrastructure in coastal communities around the world (Alley *et al.*, 2007; Ashton, Donnelly, and Evans, 2008; Bender *et al.*, 2010; Douglas, 2001). On October 29, 2012, the devastating power of increasingly severe storms combined with rising sea levels gained national attention when images of Hurricane Sandy's destruction of New York and New Jersey spread across the American media. Waves lapping the steps of the country's economic heartland on Wall Street and the list of Hurricane Sandy's victims published in the New York Times dramatically increased awareness about the immediate impacts of climate change and projections of greater changes in the future. The coastal regions of the United States are densely populated, putting millions of peoples' lives, homes, and properties at risk from sea level rise, storm surge flooding, and extreme weather events (Titus *et al*., 2009; Field *et al.,* 2007; Frumhoff *et al.*, 2007).

As a small state with a large coastal population, Rhode Island is highly vulnerable to impacts from climate change. This gives the state a leadership opportunity in a national movement towards proactive climate change adaptation (Frumhoff *et al*., 2007). The age of Rhode Island's many historic coastal communities means that sea level rise is already impacting some infrastructure and will become an even greater concern as the rate of sea level rise accelerates. It is clear that actions must be taken. However, implementing state-wide and municipal policy changes requires significant political will as well as the capacity to change the behaviors of individuals and

communities. This case study focusing on the coastal community of North Kingstown, Rhode Island, provides insights into the current behaviors and attitudes of municipal decision-makers and suggests methods of increasing proactive climate change adaptation behaviors and actions.

1.1 Objectives of study

Damages incurred from sea level rise and intense storms will cause significant economic losses in local communities unless these communities plan to mitigate the impacts of global climate change (Field *et al*., 2007; Douglas, 2001; Titus *et al*., 2009). In order to start the process of planning for climate change impacts, municipal officials need to make a shift in their beliefs and attitudes and engage in adaptive behavior change (Doppelt, 2008). As decision makers' beliefs and behaviors related to climate change adaptation shift, municipalities can more effectively plan and implement adaptive actions to minimize damages from the impacts of climate change. The objective of this study is to assess local town officials' perceptions of the risks that sea level rise and increased storminess pose to the town of North Kingstown, Rhode Island, and analyze the relationship between town decision makers' perceptions of climate change risk and community adaptive planning behavior. Evaluation of decision makers' knowledge of climate change and behavior related to adaptation and preparation will provide insights for coastal managers and policy makers working to incorporate adaptive actions in town comprehensive and capital improvement planning.

1.2 Research questions

This Rhode Island case study focuses on five core research questions: (1) How do North Kingstown town decision makers conceptualize their town's level of preparedness for climate change impacts? (2) How do their conceptualizations compare to the experts' views of the town's preparedness? (3) Is the stage of adaptive behavior change that town decision makers have reached as individuals related to previous personal impacts from severe weather events? (4) Are town decision makers' individual levels of adaptive behavior change related to their level of willingness to implement adaptive actions at a municipal level? (5) How are the decision makers' conceptualizations of climate change, risk and adaptation related to their level of support for municipal adaptive actions? The combination of these five research questions provides an overview of municipal decision makers' mental models regarding current climate change science, their beliefs and attitudes towards adaptation, and their individual levels of preparation for impacts from sea level rise and extreme weather events.

1.3 Research hypothesis

The research hypotheses for this study are: (1) Individuals whose mental models most closely fit the expert model of climate change and risk will be at a more advanced stage in the five-stage model of personal adaptation behavior change; (2) Individuals whose mental models most closely fit the expert model of climate change knowledge will be more supportive of municipal adaptation planning and actions; (3) Individuals who have attended educational programs or seminars presenting information on climate change impacts and risks will be more supportive of municipal adaptation planning and actions; and (4) Individuals who are at a more advanced stage

in the five-stage model of personal adaptation behavior change will be more supportive of municipal adaptation planning and actions.

This research investigates how much town decision makers in North Kingstown know about projections of climate change risk and how prepared they think their town is for likely impacts of rising seas and increasing storminess. This case study also tests whether moving decision makers through the stages of individual adaptation behavior change is an effective strategy for moving the municipality towards proactive adaptation. The goal of this research is to provide town officials and coastal managers with insight into local decision makers' mental models concerning climate change adaptation and perceptions of risk in order to increase decision makers' knowledge and encourage proactive adaptation actions and planning at the local level.

2. Background

2.1 Location of study

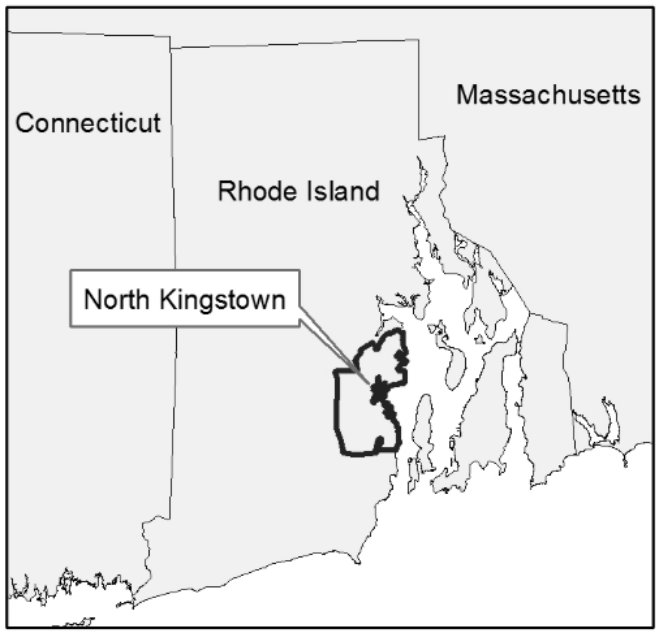

Figure 1. Location of North Kingstown in Rhode Island

North Kingstown, Rhode Island was selected as this study's focus area because it is a coastal community that is already facing the risks and challenges presented by global climate change. The historic village of Wickford provides locals and tourists with a beautiful location for shopping or walking along the harbor followed by lunch at one of the many waterfront cafes and restaurants. The village center is adjacent to the Wickford Harbor, a popular mooring site bustling with motorboats and sailing vessels in the summer. Wickford's historic center is already experiencing impacts from sea level rise: spring tides flood the downtown public parking lot on a nearly monthly basis and during extreme storm events the main bridge through the village center becomes impassable.

Figure 2. The Wickford town parking lot adjacent to the Wickford Harbor flooded during a spring tide without storm surge (photo credit: Teresa Crean)

Figure 3. The Wickford town parking lot with storm surge flooding during "Superstorm" Sandy (photo credit: Melissa Devine)

North Kingstown also contains Quonset Point, the site of the Port of Davisville, the Quonset Airport, a ferry dock with service to Martha's Vineyard, and the Quonset Business Park. The Port of Davisville became North America's fifth largest auto importer in 2009 and had a record breaking year for the number of cars imported by ship in 2012 with more than 172,000 automobiles arriving at the Port (RIEDC, 2009; RIEDC, 2013). The numerous companies with headquarters in the Quonset Business Park as well as millions of dollars of infrastructure at the Port of Davisville are at risk from flooding during high storm surge events and accelerating rates of sea level rise. The risks posed by climate change to the important economic hub at Quonset Point and to the historic village of Wickford place North Kingstown in a highly vulnerable position and necessitate proactive adaptation actions on a municipal level.

The town's previous work with the University of Rhode Island's Coastal Resources Center (CRC) has already engaged part of the community's decision

makers in considering sea level rise impacts on the town's properties and transportation infrastructure (Rhode Island Sea Grant, 2012). Due to its prior meetings and workshops with addressing sea level rise, North Kingstown presents a best-case scenario for community-level adaptation planning (Stake, 1995; Yin, 1994). As a relatively small municipality with a population of approximately 26,600 in 2010, North Kingstown provides an ideal case study for communities working on developing and implementing sea level rise adaptation measures and incorporating adaptation strategies in their town planning process (U.S. Census Bureau, 2010). The Planning Department in North Kingstown has already initiated discussions about ways to incorporate sea level rise and projections for climate change into their Comprehensive and Capital Improvement Plans, however they must overcome numerous challenges and obstacles before definitive proactive adaptation actions may be implemented (Reiner, 2012).

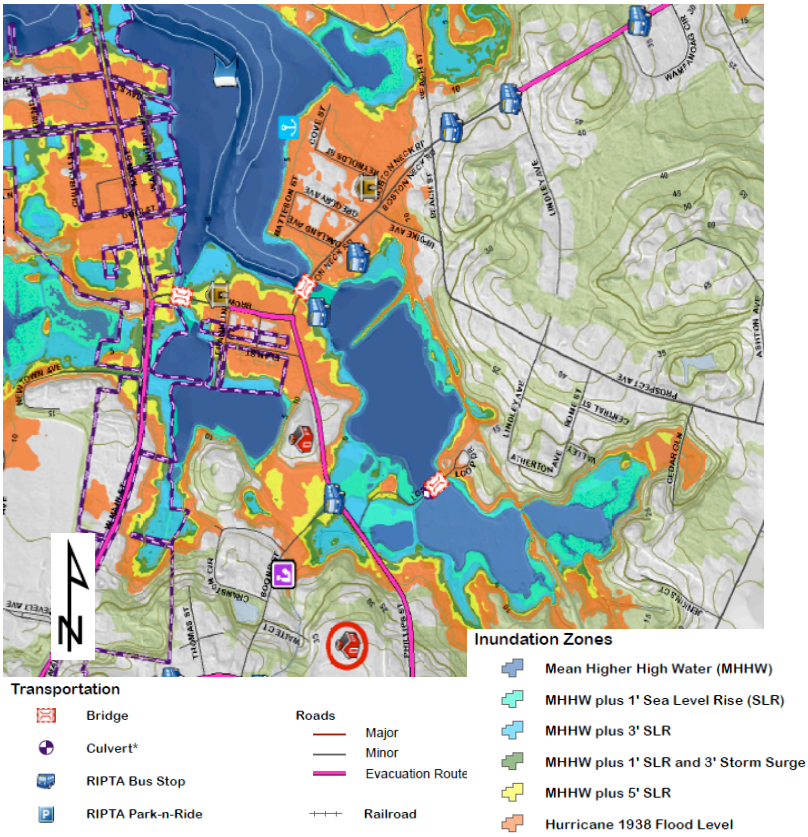

Figure 4. Sea level rise inundation map of Wickford village (map credit: Christopher Damon)

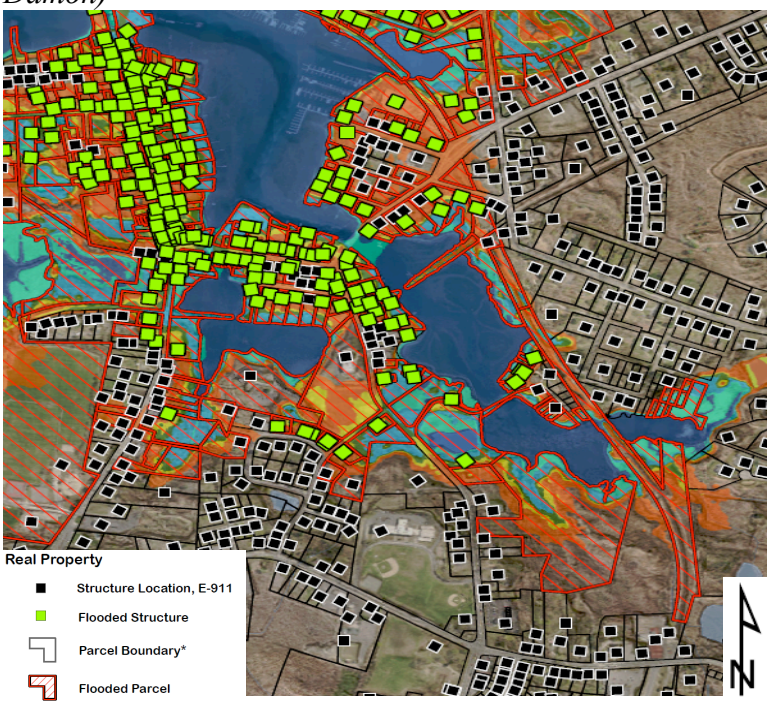

Figure 5. Sea level rise inundation impact on properties and infrastructure (map credit: Christopher Damon)

2.2 Climate Change in Rhode Island

Global climate change presents numerous challenges to Rhode Island's coastal communities, including accelerating sea level rise, increased storminess, and changing ocean conditions (Alley, 2007; Rhode Island Coastal Resources Management Council, 2009; Douglas, 2001; Smith *et al.*, 2010). Inundation of coastal areas caused by increased sea levels and storm surge resulting from more intense storms is a major threat to private and public buildings as well as important infrastructure such as waste water management facilities, power substations, transportation networks, wetlands, agricultural lands, and historic and cultural sites (Douglas, 2001; Field, 2007). Damages incurred from sea level rise and storm surge inundation will cost local communities significant economic losses unless these communities plan for the impacts of global climate change expected in their area (Field *et al.,* 2007; Douglas, 2001; Titus *et al.,* 2009).

The latest report by the Intergovernmental Panel on Climate Change (IPCC) predicts that global mean sea level will rise between 0.18 and 0.49 meters by 2100, however the regional expected sea level rise may vary depending on the particular circumstances affecting a specific location (Alley, 2007; Sallenger, 2012). The IPCC estimates are also arguably conservative as they do not include the uncertain contributions from melting of the Greenland and Antarctic ice sheets (Bamber *et al.,* 2009). Semi-empirical models of sea level rise that include contributions from melting ice sheets predict increases of up to 1.4 meters in global sea level by 2100 (Rahmstorf *et al.*, 2007).

Although predictions of future global sea level vary depending on numerous factors, there is unequivocal evidence that indicates that increases in "global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" will impact vulnerable coastal ecosystems and human infrastructure (Gidley *et al.,* 2009, p. 1). In the last three years Rhode Islanders have experienced first-hand the widespread damage caused by extreme weather events. Terrible floods in March 2010 and Tropical Storm Irene's destruction in August 2011 were followed by massive coastal flooding, erosion, and another long power outage as "Superstorm" Sandy wrought a path of destruction up the East Coast in late October 2012 (Farmer, 2012; Natural Hazards Observer, 2012; Smith, 2013). These three major storms occurring in less than three years provide a possible preview of the type of extreme weather events that many climate models indicate will become more frequent due to global climate change (Seelye, 2010; Cooper, 2011). In order to minimize the risks and costs associated with sea level rise and increasing storm intensity, local communities must begin the process of proactively adapting to the impacts of global climate change through individual and municipal behavior change.

2.3 The Transtheoretical Model of Behavior Change

The Transtheoretical Model of behavior change (TTM) theorizes that behavior change must progress through five stages of change before resulting in a permanent and lasting change in behavior (Prochaska *et al.,* 1997). This research tests whether the five-stage model can be applied to a climate change adaptation scenario, thereby allowing researchers and planners to assess the level of individuals' preparedness for climate change adaptation. Furthermore, this research tests whether an individual

decision maker's level of preparedness at home is correlated to his or her support for community-wide adaptation measures. This information can provide insights to coastal managers and decision makers resulting in the development of more effective outreach and educational materials.

The TTM is based on the theory that change is a process encompassing many steps, not a single event. This model identifies five essential stages that individuals must pass through in order to make a permanent behavior change: (1) Precontemplation, (2) Contemplation, (3) Preparation, (4) Action, and (5) Maintenance. The TTM then uses these stages to develop a stage-based intervention designed to move individuals through the five stages of change, a method that has proven to have a 10 to 15 times greater impact than traditional behavior change models in studies focused on changing health behaviors (Prochaska, 2008). This model is widely used as a leading approach to changing nearly 50 types of risky behaviors in the field of public health and has been used successfully to address smoking cessation and changes in diet, exercise, and medication compliance (Prochaska and DiClemente, 1983). This stage-based approach to changing behavior is frequently used in the field of healthcare and has provided exceptional results for the last twenty-five years, however there is increasing interest in the application of this methodology to the area of environmental and climate studies. Recently the TTM has been identified as a potential tool for implementing change related to environmental and climate change behaviors (Semenza *et al*., 2008; Gertner, 2009; Doppelt, 2008; Doppelt, 2010); however little work has been done yet on these topics. Thus, this

thesis will test the appropriateness of using the TTM for understanding adaptation to climate change.

A recent study conducted by the University of Rhode Island's Cancer Prevention Research Center expanded the use of the TTM model beyond health behaviors, utilizing TTM methods to encourage climate change mitigation behaviors such as driving less, biking to work, and recycling (Mundorf *et al.*, 2013). Although the TTM was developed as a method of changing health behaviors, this thesis hypothesizes that its stage-based approach would have the potential to assist coastal managers and municipal decision makers in evaluating current climate change adaptation behaviors and implementing efforts to promote proactive adaptation behavior changes.

Climate change is often an overwhelming subject for managers and planners to understand and begin adaptation planning for, but the wide success seen through TTM methods in changing high risk health behaviors suggested these same methods might be utilized as a powerful model in understanding and attempting to alter beliefs and behavior related to the risks posed by climate change (Doppelt, 2008). There are numerous challenges in applying health behavior-based methods to climate change adaptation, such as difficulty in identifying concrete and achievable adaptation actions that individuals can take, and uncertainty in gauging when individuals have reached adaptation objectives. However, the TTM's fundamental building block, the stage-based approach to change, provides coastal managers, policy makers, and educators with a new model and tool for altering thinking about climate change risks and

motivating proactive adaptation actions among municipal decision makers (Doppelt, 2008).

2.4 Mental Model Analysis

Analyzing decision makers' mental models and perceptions of their communities' risks from sea level rise and increased storm intensity can provide important insights for guiding adaptation planning and regulation implementation (see, Mozumder *et al.,* 2011; Lowe & Lorenzoni, 2007). Mental models provide insight into an individual's internal understanding and perception of external problems or phenomenon, such as sea level rise and climate change. They are vitally important because they influence the way individuals make decisions and resolve problems (Genter & Stevens, 1983; Jones *et al.*, 2011). Understanding audiences' mental models is thus critical to developing more effective communication and decision-making pertaining to risk mitigation and proactive adaptation planning (Morgan *et al.*, 2002; Steelman and McCaffrey, 2013).

An additional consideration pertaining to the mental models analysis of North Kingstown town officials is that individuals participating in team decision-making function more effectively as a team and have better team processes when they share task-based mental models (Cannon-Bowers *et al.,* 1990; Mathieu *et al.,* 2000). Mental model analysis has previously been used in numerous studies conceptualizing how people understand coastal management problems, ocean and coastal processes, wildfire mitigation, and the risks of sea level rise and storm surge (Kempton and Falk, 2000; Thompson, 2005, 2007; Stocker and Kennedy, 2009; Marcucci *et al.*, 2012; Champ *et al.*, 2012; Hulst, 2012). Analysis of the mental models of North Kingstown

town decision makers will build on these previous studies and will be useful to foster convergence in their understanding of climate change science and their approach to adaptation, leading to more effective team decision-making.

3. Methods

3.1 Selection of Research Subjects

Research subjects for this case study were selected from the pool of municipal officials, town employees, town council members, and numerous board members in North Kingstown. "Purposive sampling" in which interview subjects are chosen based on the purpose of the research is a good method of sampling for intensive and critical case studies as well as when focusing on a specific population, such as decision-makers in a particular municipality (Bernard, 2011). Fifteen individuals ultimately participated in this case study including three Planning Commission members, one Town Planning staff member, three members of the Town Council, one Zoning Board member, one member of the Town Manager's office, two members of the Conservation Commission, one member of the Emergency Response office, one member of the Public Works Department, and two members of the Land Conservancy of North Kingstown. All subjects were involved in municipal decision-making in North Kingstown and thus contributed to the purpose of this case study, specifically evaluating decision-makers' mental models pertaining to climate change risk and adaptation.

Research subjects were initially identified by reviewing public listings of board and council members on the municipal government website. I contacted potential

subjects by email and by phone, introduced and explained my general field of inquiry, and invited them to participate in the research through an interview.

3.2 The Expert Model

The "expert model" in this case study consists of the knowledge base against which all subject mental models were compared. Comparison between the expert model and subjects' mental models demonstrates the municipal decision-makers level of climate change knowledge. The study also determined the disparity between experts' perceptions of North Kingstown's risk of climate change impacts and town officials' perceptions, as this discrepancy is an important factor to consider in developing and implementing proactive adaptation planning on a municipal level. The mental models methodology used by Morgan et al. (2002) contains four distinct steps: "(1) developing an "expert model"; (2) conducting mental model interviews; (3) coding and analyzing the interviews; and (4) evaluating the differences and gaps between the expert model and the mental models of the interview subjects" (Smythe, 2011). I created the "expert model" used for mental model comparison in this case study based on current relevant literature on climate change, impact risk, and hazard mitigation and interviews with five coastal management experts currently working in the fields of climate change science, community adaptation, and hazard mitigation planning in Rhode Island. This case study's focus on a specific coastal community necessitated the use of an expert mental model that included a wider variety of factors than simply the most current scientific information pertaining to climate change in New England; thus the specialized local knowledge of coastal managers working in the area constituted an essential component of this study's expert model.

The five coastal management experts interviewed during the development of the expert model were asked a series of questions pertaining to their perceptions of North Kingstown's risk from climate change impacts, specifically sea level rise and increased storminess, what features, assets, or resources in North Kingstown were at risk, and how prepared they thought the town was for potential damage from various impacts of climate change. Creation of the expert model also included the coastal management experts' opinions of the immediacy of the risk posed by climate change impacts and the likelihood of various impacts occurring over defined periods of time. The semi-structured interview method used in developing the expert mental model was a departure from Morgan et al.'s (2002) funnel design interview methodology, but the semi-structured method was chosen in order to determine experts' views on specifically defined topics including climate change impacts and risks.

This case study utilized the general mental model methodology outlined by Morgan et al. (2002), however I also used an innovative manner of coding responses using numerical values to represent expert and subject answers. The experts' answers to each question were coded and each answer was given a numeric score, then the "expert model" value of each response was determined based on the mean value of the five experts' responses. For example, the experts were asked how likely they thought it was that the town of North Kingstown would experience any impacts from future climate change on a scale of 1 to 10 with 1 representing "highly unlikely" and 10 representing "highly likely." Each expert then answered by identifying a number within the 1 to 10 range and the mean of the five responses was recorded as the expert model value of that specific question. During the interviews the experts were also

asked numerous open-ended questions, such as "What risks are there to North Kingstown from extreme weather?" and their responses were incorporated in the development of the final survey instrument used in conducting subject interviews.

The finalized expert mental model consisted of the numerical sum of the mean score of all the questions asked during the coastal management experts' interviews. This quantitative score describes the knowledge base and mental model of experts pertaining to the topic of climate change and coastal risks and provides a base for comparison with the mental models of municipal decision makers.

3.3 Interviews

Data for this research was collected through interviews conducted with municipal decision-makers in North Kingstown using a semi-structured interview script consisting of a combination of closed- and open-ended questions (Bernard, 2011). I chose to use a semi-structured interview format due to time limitations, which necessitated only meeting once with each subject, and because the case study consisted of interviews with professionals and municipal officials accustomed to efficient use of time in meetings (Bernard, 2011). The mix of closed- and open-ended questions was used in order to obtain subjects' responses to nearly identical questions while retaining aspects of a mental models survey approach (Bernard, 2011; Morgan *et. al.*, 2002). The semi-structured interview format used open-ended questions to determine interviewees' current beliefs regarding climate change and adaptation in general combined with closed-ended questions to ascertain interviewees' understanding of the likely impacts and risks posed by climate change. Open-ended questions designed to elicit subjects' initial reactions and perceptions were asked first,

followed by multiple choice and closed-ended questions to determine subjects' responses to specific queries. Prior to interviewing subjects, academic advisors and experts in the field of coastal zone management reviewed the interview questions and suggested changes and improvements, resulting in alterations to improve the clarity and flow of the questions. Review of the interview instrument by experienced researchers and experts in the field prior to subject interviews served as a form of pretesting and was vital to ensuring the interview instrument used clear, concise wording and format and did not contain questions that were too broad or misleading (Bernard, 2011). Interviews with subjects were conducted between June and September 2012 at a convenient location of his or her choosing, usually a home, office, or nearby coffee shop. The duration of interviews varied from approximately half an hour to over an hour. I conducted all interviews in person and recorded all interviews for later transcription.

The interview instrument used for data collection followed a "funnel design" beginning with general questions concerning coastal zone management issues and narrowing to focus on climate change impacts (see Appendix 1) (Bernard, 2002). This manner of interviewing developed by Morgan *et al.* (2002) for use in risk analysis allows the researcher to determine the subject's understanding and perception of the general topic of inquiry without influencing the interviewee's answers, thus determining what is most important to the interviewee. The semi-structured design of the interview instrument started with broad questions to assess the subjects' level of agreement with statements regarding the severity and likelihood of local impacts from sea level rise and increased storm intensity (Mozumder *et al*., 2011). Subjects were

then asked through structured questions how concerned they are about local risks posed by these climate change impacts, narrowing the interview to address the specific topic of local climate change risk. Following these questions, subjects were asked if their town, committee, or board is considering adaptive planning in their decision-making. For the purposes of this study I defined "adaptive planning" to mean plans and preparatory actions developed and/or implemented by town decision makers in order to minimize or reduce damages from projected future sea level rise and increased storminess (Lausche, 2009). Depending on the subjects' answers to initial questions, they were asked follow-up questions pertaining to why their decision-making body was not considering adaptive planning and what impediments or obstacles they face to including sea level rise adaptation in their future planning. During the interviews I recorded whether responses were prompted or unprompted, which contributed to the development of each subjects' mental model score during the analysis stage.

Interviewees' mental models were explored through the interview in order to determine their perceptions and understanding of sea level rise and climate change risks in their local area (Jones *et al*., 2011; Morgan *et al*., 2002). Initial questions in the interview instrument were purposefully broad and open-ended in order to elicit the interviewees' most important thoughts and responses to the subject matter, per the methods used to elicit a subject's mental model (Morgan *et al.*, 2002). These initial interview questions (Questions #1-14, see Appendix 1) were used in the development of the Municipal Adaptation Level and Individual Behavior Change metrics, described in detail below. Later questions focusing more specifically on climate change allowed

me to determine the interviewees' mental models more precisely as well as gauge their knowledge and understanding of current climate change science and projections of future risks and impacts. Using mental model methods, I also determined what topics were most important and significant to interview subjects as opposed to simply what information they knew or were familiar with. The responses from subjects obtained through individual interviews were collected and analyzed, as will be explained in detail below, in order to determine the mental models and climate change knowledge of North Kingstown's municipal decision-makers. This data was then compared through statistical analysis of quantitative scores to the "expert model" of knowledge pertaining to projected climate change impacts, coastal risk from sea level rise and storm surge, and current adaptation projects in North Kingstown.

3.4 Data Preparation

All interviews were recorded and transcribed in preparation for analysis of the data collected. Responses to the open-ended questions were transcribed verbatim while responses to the closed-ended quantitative questions were transcribed, coded as a numeric value of the subjects' responses directly into a Microsoft Excel spreadsheet. The design of the quantitative interview questions asked subjects to choose a number on several 1 to 5 and 1 to 10 scales as their answer. The subject responses to these closed-ended questions were already in numerical form; coding the quantitative responses consisted of simply transferring the numerical answers into an Excel spreadsheet in order to develop two scores for each subject: their Individual Behavior Change Score and Mental Model Score. Prior to development of the subjects' Municipal Adaptation, Education, and State Involvement Scores, described fully

below, qualitative open-ended questions were transcribed and organized for coding. These five metric scores obtained from each subject's interview responses were then coded and analyzed in order to answer each of the four primary research questions.

3.5 Metric Development and Scoring

The first step in the analysis of this case study's collected data was the development of five separate metrics designed to represent each subject's behaviors, knowledge, and perspectives concerning different aspects of climate change science and adaptation behaviors. Each subject's answers during the interview were separated into five different categories corresponding to these five metrics: Individual Behavior Change, Mental Model, Municipal Adaptation, Education, and State Involvement. Scoring rubrics were determined for each metric such that subjects received five final numerical scores that quantitatively represented their understanding of climate change and perspectives regarding adaptation actions on a personal and municipal level.

3.5.1 Development of the Individual Behavior Change Score

Each subject's Individual Behavior Change (IBC) score was determined by coding responses to three questions:

1. Have you taken any measures to prevent or minimize future damages to your own property from storms?
2. If so, what measures have you taken?
3. If you have taken previous actions, are there any follow-up actions you will make in the future?

The coding format for this metric followed the methodology of the Transtheoretical Model of behavior change in which each subject was identified as being in one of the

five stages of behavior change based on their responses: (1) Pre-contemplation, (2) Contemplation, (3) Preparation, (4) Action, and (5) Maintenance (Prochaska and Velicer, 1997). IBC responses were assigned points according to this predetermined scoring rubric.

Points	Stage of Behavior Change	Subject Response
1	Pre-contemplation	Has not previously considered taking measures to prevent damage to home or property from storms.
2	Contemplation	Has considered taking measures to prevent damage to home or property from storms but has not started to take action yet.
3	Preparation	Has decided on what measures they will take to prevent damage to their home or property from storms; is conducting research or consulting professionals but has not taken definitive actions yet.
4	Action	Has taken definitive actions (such as trimming trees, re-grading yard, installing a sump pump) to prevent damage to their home or property from storms.
5	Maintenance	Has previously taken definitive actions to prevent damage to their home and property from storms and is actively maintaining their actions (such as continued tree trimming) while planning for future protective actions.

Each subject's IBC score was recorded in conjuncture with their identifying number so that a subject's scores on each of the five metrics could be compared. The mean score of the fifteen subjects was also determined for comparison with the experts' mean score on the same Individual Behavior Change metric.

3.5.2 Development of the Mental Model Score

In order to determine the subjects' quantitative Mental Model score for comparison with the Expert Model, responses to ten interview questions (Questions

#15-25, see Appendix 1) were given numeric values based on a scale measure the subjects' level of agreement with an Expert Model. The ten questions in this section of the interview instrument pertained to the likelihood of North Kingstown experiencing various impacts from climate change over differing periods of time, what critical infrastructure in North Kingstown would be at risk from such impacts, and the town's level of preparation for ten identified impacts. The question designed to obtain subjects' understanding of the risks North Kingstown faces from extreme weather was scored based on whether a subjects' answers were prompted or unprompted. Unprompted answers that agreed with the Expert Model were each given 1 point and prompted answers received 0.5 points. Several subjects responded that specific risks "might" be a problem for North Kingstown and these "maybe" answers were given 0.5 points if unprompted and 0.25 points if prompted.

Three questions asking subjects about the likelihood that North Kingstown would experience impacts from climate change in general, and sea level rise and increasing storm intensity specifically, were designed on a ten-point scale with 1 representing "highly unlikely" and 10 representing "highly likely" (Questions #17, #21, #24, see Appendix 1). These questions' points were awarded 1 through 10 for each question according to the subject's response. For example, a subject that responded with a 7 on the 1 to 10 scale concerning likelihood of sea level rise impacts would receive 7 points for his answer.

Two questions (Questions #20 and #23, see Appendix 1) concerning sea level rise and future municipal planning were scored based on whether a subject's response fell within a range established by the Expert Model. The sea level rise question asked

how high subjects thought sea level rise would be by 2050 and 1 point was awarded for a response falling within the Expert Model range and no points were given for answers outside the defined range. Similarly, the future planning question asked subjects how far into the future they though the town needed to look when planning for climate change with 1 point awarded for responses within the Expert Model range and no points given for answers outside the defined range. After subjects' responses were coded with numerical values based on the predetermined rubrics each subject's responses were summed and the result was used as that individual's Mental Model score.

The use of numerical scoring to evaluate interviewees' mental models was an independently developed approach that departed from typical mental model analysis as outlined by Morgan et al. (2002) and Jones et al. (2011). In order to facilitate quantitative statistical analysis of interviewees' responses, I used defined scoring rubrics to assign numerical values to the subjects and experts' answers. Interviewees' responses were coded and calculated to determine their scores for each of the five metrics, which were compared using statistical analysis methodology. Through the development and use of quantitative scores I was able to determine the statistical correlations and significance of relationships between interviewees' responses as displayed by the five metrics. This statistical approach provides a quantitative overview of the correlations between decision makers' mental models and the four other metrics.

3.5.3 Development of the Municipal Adaptation Score

The Municipal Adaptation score was obtained through analysis of six questions (Questions #2, #4, #7, #17, #20, #26, see Appendix 1) designed to elicit subjects' level of preparedness for undertaking climate change adaptation actions on a municipal level, and to determine how important they considered proactive planning and actions. Subjects' qualitative responses were coded and assigned quantitative values between 1 and 5 based on defined scoring rubrics corresponding to each question. Questions and their scoring rubrics are as follows:

- *Are there any issues that North Kingstown faces because it is a coastal community? What are some coastal management issues in North Kingstown?*

Points	Subject Response
0	Subject does not know of any coastal management issues.
1	Subject lists issues related to the state of Rhode Island, not specifically North Kingstown
2	Subject thinks there are issues but cannot name any specifically coastal problems.
3	Subject mentions sea level rise and/or climate change in their answer at some point
4	Subject lists sea level rise and/or climate change as the second concern on their list
5	Subject identifies sea level rise and/or climate change as their first listed concern

- *What is currently being done, if anything, at the municipal level to address the risks that sea level rise and climate change may pose to North Kingstown?*

Points	Subject Response
0	Subject is not aware of any current planning efforts or discussions in North Kingstown
1	Subject thinks there "might" be general plans in development.
2	Subject is aware the planning department is working with URI/CRC but does not know they are working on sea level rise and/or climate change planning
3	Subject is aware that some offices and councils in town are thinking about sea level rise and/or climate change
4	Subject is aware of specific sea level rise and climate change planning efforts
5	Subject is aware of current planning efforts and gives specific informed details about planning efforts, initiatives, and projects occurring in North Kingstown

- *How likely do you think it is that the town of North Kingstown will experience any impacts from future climate change on a scale of 1 to 10 with 1 representing "highly unlikely" and 10 representing "highly likely"?*

Points	Subject Response
0	Subject responds with a #0
1	Subject responds with #1 or #2
2	Subject responds with #3 or #4
3	Subject responds with #5 or #6
4	Subject responds with #7 or #8
5	Subject responds with #9 or #10

- *How far into the future do you think the town needs to look when planning for climate change?*

Points	Subject Response
0	Subject believes there is no need to plan for future climate change
1	Subject believes the town should plan 3-5 years in advance
2	Subject believes the town should plan 5-10 years in advance
3	Subject believes the town should plan 11-20 years in advance
4	Subject believes the town should plan 21-50 years in advance
5	Subject believes the town should plan 50-100 years in advance

- *What changes should the town decision makers implement to minimize North Kingstown's risk of damage from climate change-driven impacts?*

Points	Subject Response
0	Subject does not think that any changes should be made
1	Subject has no clearly conveyed ideas of changes decision-makers should implement
2	Subject has at least one idea but it is off topic and/or not related to the question
3	Subject has vague ideas but does not clearly convey ideas for specific changes
4	Subject conveys specific ideas for changes that are related to minimizing impacts
5	Subjects conveys specific and detailed ideas for changes to minimize damages

After all subjects' responses were assigned values based on these five rubrics, the average value of each subject's answers was determined by adding the values of all five questions and dividing by five. The resulting mean of each subject's responses determined their Municipal Adaptation score.

3.5.4 Development of the Education Score

Subjects' Education scores were obtained through responses to two questions (Questions #29, #30, see Appendix 1) concerning their previous participation in any conferences, symposiums, meetings, or educational programs that involved climate change or sea level rise information. Subjects who had not participated or attended any discussions or meetings concerning climate change or sea level rise received a score of 0. Subjects who had participated in general discussions or meetings involving climate change around the state of Rhode Island were given a score of 1. Subjects who had attended discussions or meetings specifically in North Kingstown regarding local sea level rise and climate change initiatives or problems as well as other meetings on the subject in the state received a score of 2.

3.5.5 Development of the State Involvement Score

The State Involvement metric represents subjects' perspectives concerning the level of guidance and oversight the state should have over towns in regards to developing and enforcing regulations, policies, and programs designed to assist towns in climate change adaptation. Subjects' transcribed responses were evaluated and divided into four categories based on the level of state involvement each subject preferred. Each category was then assigned a numeric value between 0 and 3 according to the following rubric:

Points	Subject Response
0	• The state should stay out of the town's business, the state should leave the town alone and have no involvement with municipal planning of this kind • The state's current level of involvement is fine, they do not interfere much and their only role should be to provide information
1	• The state should assist towns in climate change planning but towns should take primary role • The primary role the state should play is in providing funding for adaptation planning that is developed and decided on by the town
2	• The state should take the lead in developing policy and regulations with the consultation and assistance of towns
3	• The state should take full responsibility for climate change adaptation planning and should issue more mandates and regulations to the towns

The numerical value of each subject's response determined their State Involvement score with a possible range between 0 and 3. This score was recorded along with the scores for each of the other four metrics for comparative and statistical analysis in order to answer the four initial research questions that are the focus of this case study.

This metric was developed to address the question: How involved should the state be in determining and implementing municipal-level adaptation actions? The Mental Model metric was designed to gauge decision makers' level of knowledge pertaining to climate change impacts and risks while the State Involvement metric assesses their beliefs regarding the role of the state in climate change adaptation. By evaluating the Mental Model metric and State Involvement metric, coastal managers and policy makers can gain a better understanding of municipal decision makers views on what role the state should play in developing and enforcing adaptive rules and regulations.

3.6 Statistical Analysis of Metrics

Several statistical methods were used to test this case study's hypotheses and research questions. The statistical analysis software Minitab, R, and Microsoft Excel were used to calculate descriptive statistics for each of the five metrics including the sample size, mean, variance, standard deviation, and coefficient of variation. I used the F-Max Test to determine if groups of data had equal variances (Zar, 1996). Inasmuch as the data collected in this case study did not uniformly have equal variances (as determined by the F-Max Test) or show normal distributions (as determined by the Shapiro Wilks Test), I used the non-parametric statistical tests Spearman Rank Correlation and the Mann-Whitney Two Sample Test for hypothesis testing. Correlation analysis was used to test the null hypothesis that $r = 0$; i.e., that there was not a linear correlation between specific metrics as identified in the following hypotheses:

a) Individuals whose mental models most closely fit the expert model of climate change and risk will be at a more advanced stage in the five-stage model of personal adaptation behavior change (testing correlation between Individual Behavior Change and Mental Model scores).
b) Individuals whose mental models most closely fit the expert model of climate change knowledge will be more supportive of municipal adaptation planning and actions (testing correlation between Mental Model and Municipal Adaptation Level scores).
c) Individuals who have attended educational programs or seminars presenting information on climate change impacts and risks will be more supportive of

municipal adaptation planning and actions (testing correlation between Education and Municipal Adaptation Level scores).

d) Individuals who are at a more advanced stage in the five-stage model of personal adaptation behavior change will be more supportive of municipal adaptation planning and actions (testing correlation between Individual Behavior Change and Municipal Adaptation Level scores).

In addition, scatter plots of the metric scores were used to qualitatively evaluate relationships between variables. The Mann-Whitney test was used to test the null hypothesis that there was no difference in means between the two groups for each metric.

4. Results and Discussion

4.1 Research Questions 1 and 2: Municipal Preparedness for Climate Change Impacts

The first two research questions explored how town decision makers conceptualize their town's level of municipal preparedness for climate change impacts and compared their conceptualizations to the experts' views of the town's preparedness.

The views of experts and subjects regarding North Kingstown's level of preparedness for impacts from severe weather related to climate change were markedly different. Experts and subjects were asked to rank the town's current level of preparedness for ten different impacts on a scale from 1 to 5 with 1 representing "not prepared" and 5 representing "very prepared." The overall current preparedness level was determined by obtaining the mean of the ten different impacts. The same process

was followed to determine the optimal preparedness score from responses to the question of how prepared North Kingstown *should be* for the same ten impacts as the previous question. Although treating each of the ten impacts as equally important for preparedness presents issues regarding the weight of each impact's severity and potential for damage, developing weighted variables for the ten impacts was beyond the scope of this case study, so for simplicity the impacts were all treated as having an equal weight. Future research in this area would benefit from using weighted variables that may provide greater insight into decision makers' understanding of the importance of different impacts and the potential risks they pose.

Experts viewed North Kingstown as currently ranking (mean $\pm$ SD) 2.7 ± 0.7 out of 5 on the preparedness scale and believed that the town should optimally be 4.5 ± 0.7 out of 5 for the listed severe weather impacts. In contrast, subjects viewed the town as currently ranking 3.1 ± 1.0 out of 5 and thought that they should rank 4.4 ± 0.7 out of 5 in a best-case scenario. These initial results indicate that subjects consider North Kingstown currently to be better prepared than the experts believe it is and that the subjects do not think they need to improve the town's preparedness level as much as the experts do. However, the results of a Mann Whitney test used to compare the differences in the experts' and subjects' responses did not show statistically significant disparity between the two groups (Mann Whitney Test, $W = 151$, $p < 0.6$). This non-significant result indicates that the Mann Whitney test is likely not valid in this case due to the small sample size of experts (n=5). The low sample size of experts does not provide great statistical power for comparison, thus the results of the Mann Whitney

test analyzing the disparity between experts and subjects are not a reliable indication of the true relationship between the two groups.

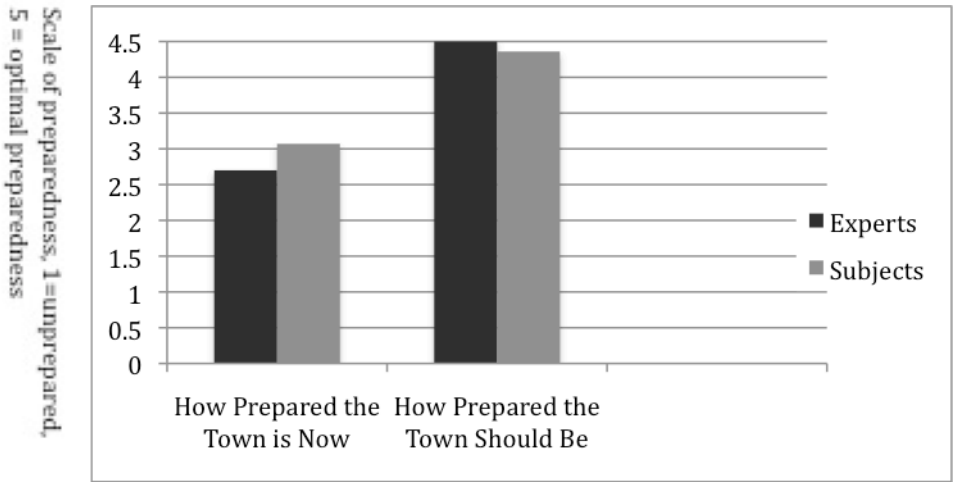

Figure 6: Experts' and Subjects' scores pertaining to North Kingstown's current and optimal levels of preparedness for climate change impacts. The scores are based on a 1 to 5 scale with 5 representing optimal preparedness.

The disparity between experts and subjects regarding North Kingstown's current and optimal levels of preparedness is an important factor to take into consideration when working on municipal preparation and adaptation goals in the town. This disparity indicates that in order to encourage town decision makers to place high priority on increasing municipal preparedness they must first recognize that their understanding of their current level of preparedness does not coincide with experts' views of the town's preparedness. Furthermore, experts believe the town needs to be more prepared than the town decision makers think it does, thus the decision makers are likely to cease preparation efforts before reaching the experts' perceived optimal preparedness level.

4.2 Research Question 3: Decision Makers' Behavior Change Correlation to Severe Weather Events

The third research question explored whether the stage of adaptive behavior change that town decision makers have reached as individuals related to previous personal impacts from severe weather events. Results from the 15 subjects interviewed indicate that 93.3% (14/15) of the subjects sustained some form of damage to their home or property from storms in the last ten years including flooding, loss of power for extended periods of time, and damage from falling trees. Among the interviewees, 1 subject was in Pre-contemplation, 1 was in contemplation, 2 were in action, and the remaining 11 subjects were in the Maintenance phase of behavior change regarding taking measures to prevent or minimize future damage to their home and property from storms.

Stage of Change	Number of Subjects	% of Sample	% Sustained Damage
Pre-contemplation	1	6.7%	100% (1/1)
Contemplation	1	6.7%	100% (1/1)
Preparation	0	-	-
Action	2	13.3%	100% (2/2)
Maintenance	11	73.3%	90.9% (10/11)

Table 1. Subjects' current stages of individual behavior change and percentage of subjects that have sustained damage to their home or property from storms in the past ten years

I was unable to test the correlation between a subject's stage of behavior change and whether he or she was taking measures to prevent future damage because there was insufficient variation with respect to the behavior change variable. Only one subject in the sample did not sustain damage from storms in the last ten years and that individual was in the Maintenance stage of change while both subjects in Pre-contemplation and Contemplation had sustained damage. Thus, I was unable to draw

any definitive conclusions regarding the correlation between decision makers' individual stages of behavior change and whether they had sustained previous damage from severe weather events due to lack of variation in the data collected.

4.3 Research Question 4: Correlation Between Individual Behavior Change and Support for Municipal Adaptation

The fourth question in this case study investigates whether town decision makers' individual levels of adaptive behavior change are related to their level of willingness to support implementation of adaptive actions at a municipal level. This question corresponds to my fourth hypothesis, that individuals who are at a more advanced stage in the five-stage model of personal adaptation behavior change will be more supportive of municipal adaptation planning and actions.

In order to answer this question and test the hypothesis, quantitative scores were developed as described in Section 3.5 for each of five metrics: Individual Behavior Change, Municipal Adaptation Level, Mental Model, Education, and State Involvement. Descriptive statistics were calculated to provide an overview of the five metrics.

Metrics	Mean	SD	CV	n
Subject Individual Behavior Change	4.4	1.2	27.3	15
Subject Municipal Adaptation Level	2.9	1.2	41.4	15
Subject Mental Model	156.7	22.7	14.5	15
Subject Education	1.3	0.7	53.8	15
Subject State Involvement	1.1	0.9	81.8	15
Expert Individual Behavior Change	4.8	0.5	10.4	5
Expert Municipal Adaptation Level	4.6	0.2	4.3	5
Expert Mental Model	180	10.2	5.7	5
Expert Education	2	0.0	0.0	5
Expert State Involvement	2.3	0.5	21.7	5

Table 2. Descriptive statistics of Subjects' and Experts' responses organized within the five metrics: Individual Behavior Change, Municipal Adaptation Level, Mental Model, Education, and State Involvement.

The hypothesis that a positive correlation existed between subjects' Individual Behavior Change score and their Municipal Adaptation Level score was tested using a Spearman rank correlation (r) analysis to test the null hypothesis that r=0 (no relationship). The results of the correlation analysis showed there to be no relationship between the two variables (r=0.08, p=0.77) (Table 3). My fourth hypothesis was disproved due to these results showing no statistical relationship between decision makers' levels of individual adaptive behavior change and their level of willingness to support implementation of adaptive actions at a municipal level.

Metrics	Municipal Adaptation Level	Mental Model	Education	State Involvement
Individual Behavior	0.08 (0.8)	-0.15 (0.6)	0.25 (0.4)	-0.02 (0.9)
Municipal Adaptation Level	-	0.73 (0.002)	0.49 (0.06)	0.63 (0.01)
Mental Model	-	-	0.30 (0.3)	0.45 (0.1)
Education	-	-	-	0.47 (0.08)

Table 3. Spearman Rank Correlation analysis of Subjects' responses to all five metrics with p-values in parentheses.

Individual Behavior Change is also not a good indicator of the other four metrics since it lacked statistically significant correlation with any other metric, as demonstrated by the results of Spearman Rank Correlation analyses conducted on all five metrics (Table 3). These results show no relationship between the Mental Model and Individual Behavior Change metrics, indicating that individual behavior change may not be related to an understanding of climate change impacts and risks as measured by the Mental Model score.

There is a moderately positive correlation ($r=0.49$) between the Education and Municipal Adaptation Level metrics that approaches statistical significance ($p= 0.06$). This correlation indicates that town decision makers who have participated in educational programs or meetings that included climate change topics both within the state and specifically in North Kingstown are somewhat more likely to place municipal adaptation as a higher priority and consider the town to be at risk from climate change impacts. Given this positive correlation, coastal managers and hazard mitigation experts may want to use climate change educational seminars and programs

as a method of increasing municipal decision makers' attention to adaptation needs and promote proactive adaptation through local town-oriented programs as well as state-wide seminars.

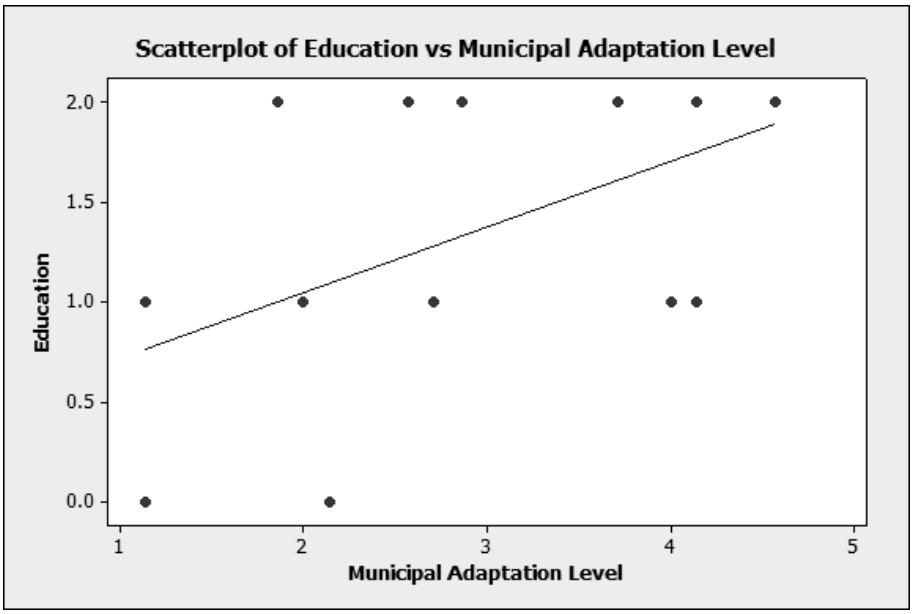

Figure 7. Scatterplot displaying positive correlation between Education and Municipal Adaptation Level metric scores.

There is no correlation (r=0.25, p=0.4) between the Education and Individual Behavior Change metrics, however the small sample size used in this case study and the fact that 73% of the subjects were already in the Maintenance stage means that this lack of correlation may not be a reliable result. Similarly, the lack of correlation (r=0.3, p=0.3) between the Education and Mental Model metrics may be due to the small sample size and the two-point Education metric scale. Future research including more extensive educational background analysis may provide a more accurate understanding of the correlation between education and mental models regarding climate change.

4.3 Research Question 5: Correlation Between Decision Makers' Mental Models and Support for Municipal Adaptation

The fifth research question explored whether the decision makers' conceptualizations of climate change, risk and adaptation were related to their level of support for municipal adaptive actions. This question corresponds to my second research hypothesis, that individuals whose mental models most closely fit the expert model of climate change knowledge would be more supportive of municipal adaptation planning and actions. In order to test this hypothesis Spearman correlation calculations were computed comparing subjects' Mental Model and Municipal Adaptation Level metric scores. The correlation between the Mental Model and Municipal Adaptation Level metrics displays a large positive correlation that is highly significant ($r=0.73$, $p < 0.002$). This is the highest correlation between any two metrics used in this case study. Thus, the combination of the Mental Model and Municipal Adaptation Level metrics is ultimately a far better indicator of decision makers' beliefs and understandings than any combination of the other metrics. From these results it can be determined that decision makers with higher Mental Model scores indicating a better understanding of current climate change projections and likelihood of impacts to North Kingstown are more likely to support proactive municipal adaptation efforts.

Further analysis was conducted to compare subjects' Mental Model and Municipal Adaptation Level metric scores with their responses regarding the likelihood that North Kingstown will experience any impacts from future climate change in general and from sea level rise and increased storm intensity over the next

ten years. Subjects who believe sea level rise and increased storminess are likely to pose a risk to North Kingstown in the near future have higher Municipal Adaptation Level scores, indicating that they are aware of the potential impacts climate change may have on the town and are more supportive of taking proactive adaptation actions at the town level.

Risks	**Mental Model**	**Municipal Adaptation Level**
General Climate Change	0.70 ($p<0.01$)	0.95 ($p<0.001$)
Sea Level Rise Impacts by 2022	0.68 ($p<0.01$)	0.53 ($p<0.05$)
Increased Storminess Impacts by 2022	0.63 ($p=0.01$)	0.47 ($p=0.07$)

Table 4. Spearman correlations between climate change impact likelihood, Mental Model and Municipal Adaptation Level scores of subjects, p-values in parentheses.

Both subjects and experts were asked to estimate the likelihood that North Kingstown would experience impacts from climate change-related sea level rise over a period of years in order to determine whether a variation existed between experts' and decision makers' perceptions of when the town should expect impacts from sea level rise. Experts uniformly believed that North Kingstown should anticipate impacts from sea level rise far sooner than decision makers did. On a 1 to 10 scale with 1 representing "highly unlikely" and 10 representing "highly likely," experts believed that it was "very likely" (7.08 out of 10) that North Kingstown would experience impacts from climate change-related sea level rise in the next ten years (by 2022) while subjects believed it was "possible" (4.82 out of 10) that impacts might occur. Experts unanimously agreed there was "highly likely" (10 out of 10) that sea level rise would impact North Kingstown by 2100, however subjects thought that it was "moderately likely" (7.68 out of 10) that their town would experience impacts in the same time frame. This comparison also reveals that subjects believe that impacts from

sea level rise will pose a greater risk to North Kingstown than increased storminess. Future research is needed to explore why decision makers perceive sea level rise as a greater threat than increased storminess; however, I hypothesize that regular flooding of the downtown Wickford parking lot during spring tides and storm events (see Figures 2 and 3) may have increased municipal officials' awareness of rising sea levels.

The Spearman test results display a highly significant correlation ($r=0.95$, $p<0.001$) between subjects' beliefs regarding the likelihood that North Kingstown will experience impacts from future climate change (Question #17, see Appendix 1) and their level of support for municipal adaptive actions. These statistical results further support my findings that decision makers who perceive climate change impacts such as sea level rise and increased storm intensity as serious threats to North Kingstown are more willing to support proactive adaptation efforts on the municipal level. Thus, in order to increase proactive adaptive planning and actions, coastal managers, educators, and policy makers must make municipalities more aware of the reality and severity of risks posed by climate change impacts in the near future.

By the year…	**Experts mean** (n=5)	**Expert SD**	**Subjects mean** (n=15)	**Subject SD**	**Mann Whitney Test**
2022 (10 years)	7.1	3.3	4.8	2.6	W=66.5 (ns)
2033 (20 years)	8.5	3.0	5.5	2.6	W=73.5 (p=0.07)
2050	9.3	1.3	6.6	2.8	W=72.5 (p=0.09)
2100	10.0	0.0	7.7	2.8	W=69 (p=0.16)

Table 5. Likelihood that NK will experience impacts from climate change-related sea level rise over a period of years. Scores are the average of a 0-10 ranking where 0 = highly unlikely and 10 = highly likely.

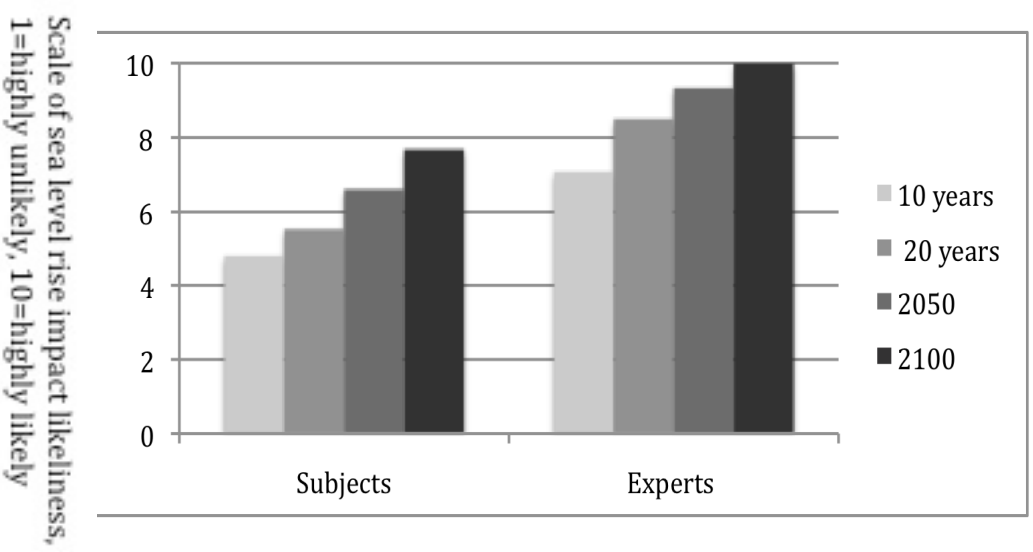

Figure 8. Subjects and Experts' estimates of the time frames in which North Kingstown may experience impacts from sea level rise measured on a 1 to 10 scale with 1 representing "highly unlikely" and 10 representing "highly likely."

This wide discrepancy between experts' and subjects' perceptions of the immediacy of sea level rise impacts in North Kingstown poses a significant challenge to coastal managers and policy makers trying to encourage proactive municipal adaptation. When the municipal decision makers believe that sea level rise and climate change are distant threats that do not pose direct risks to their town in the near future (within the next 10-20 years), they are unlikely to make the difficult, costly, and potentially unpopular decisions that would move the town towards proactive adaptation. This marked difference between experts' and municipal decision makers' perceptions of sea level rise risk must be taken into consideration by policy makers and coastal managers working to improve towns' hazard mitigation and climate change adaptation planning. An additional factor that must be considered is the fact that many municipal decision makers are elected and serve 3- to 5-year terms. These elected officials are often not willing to take unpopular actions that may jeopardize

their political future; planning for climate change impacts that are not currently affecting their town is not a high priority, especially in the current economic environment. As one interviewee stated, "because of the economy and because of financial issues [North Kingstown] is in a pendulum swing causing these political issues [like climate change] to get pushed to the back burner." Planning for sea level rise and climate change necessitates looking farther ahead than the next election cycle and may entail difficult, costly, and unpopular decisions. Coastal managers and policy makers working with municipal officials must be aware of the decision makers' often limited time frames and political cycles. This creates the potential for conflict because long-term planning looking more than 10 or 20 years into the future must include climate change adaptation actions.

4.4 Significance of Study Results

The strongest correlations between metrics in this case study was between Subjects' Municipal Adaptation Levels, Mental Models, and State Involvement metrics. The single strongest correlation was between Municipal Adaptation Level and Mental Model scores with a Spearman correlation of 0.73 (p-value = 0.002). Several results of this case study stand out as particularly important factors for consideration by municipal decision makers, coastal managers, and policy makers.

4.4.1 Divergence Between Expert and Subject Mental Model Scores

The Mental Model metric in this case served as a measure of experts' and subjects' understanding and knowledge of climate change projections and likely impacts in the state of Rhode Island. This metric was also used as a method of gauging the level of importance subjects placed on preparing and planning for climate change

individually and as a community, as well as indicating what level of risk they anticipate climate impacts pose in North Kingstown. Experts were in close agreement with each other that climate change impacts are a serious threat to the town, particularly the highly vulnerable historic village of Wickford, with a mean Mental Model score of 180 (SD = 10.2). In contrast, municipal subjects' mean Mental Model score was 156.7 (SD = 22.7). These results display a surprisingly wide divergence between experts and subjects, indicating that coastal managers working with towns to introduce climate change adaptation planning are thinking about climate change risks and impacts on a very different level than municipal decision makers. Additionally, there is a large variance within subjects' Mental Model scores which means town officials who need to work together to develop long-term planning goals and adaptive actions also have divergent understandings and perceptions of climate change, potentially resulting in uncoordinated, inefficient, or directly opposing approaches to dealing with the challenges presented by impacts such as sea level rise. In order to develop coordinated, effective planning focused on proactive adaptation in North Kingstown, town decision makers must work together. Coastal managers can assist in this effort by facilitating meetings and presentations and keeping officials up to date on the most current climate change science in an effort to reduce the variance within the decision makers' mental models. Decision makers who share similar mental models pertaining to their common task (in this case study, climate change adaptation) are far more effective at resolving problems, work more cooperatively, and produce better final decisions and plans as well as working as a more effective team. Thus, reducing the wide variability between North Kingstown's decision makers' mental

models regarding climate change must be a high priority (see, Cannon-Bowers *et al.,* 1990; Mathieu *et al.,* 2000)

4.4.2 Variability in Subject Scores

Subjects' responses on all five metrics displayed much higher variance than experts' responses, indicating that decision makers in North Kingstown vary widely in their levels of knowledge, understanding, education, and beliefs concerning climate change impacts. The coefficient of variance values for all metrics clearly shows the differing levels of agreement between Subjects and Experts.

Metrics	**Subject C.V.**	**Expert C.V.**
Individual Behavior Change	28.2	9.3
Municipal Adaptation Level	40.4	4.1
Mental Model	14.5	5.7
Education	54.3	0.0
State Involvement	80.9	19.4

Table 6. Coefficients of Variation for all five metrics

In order to determine whether the level of variance between subjects' and experts' responses was statistically significant, the variance of each group (Subjects and Experts) was calculated for each metric and compared using the F-Max test of equal variance (Zar, 1996).

Metrics	**Individual Behavior**	**Municipal Adaptation Level**	**Mental Model**	**Education**	**State Involvement**
Subject Var.	1.5	1.4	515.8	0.5	0.7
Expert Var.	0.2	0.04	104.1	0.000	0.2
F-max statistic	7.7 (ns)	37.1 ($p<0.005$)	368.1 ($p<0.001$)	Undefined	3.7 (ns)

Table 7. Variance of Subject and Expert responses to all five metrics; not statistically significant results indicated by (ns), p-values shown in parentheses.

The results of the F-Max test of equal variance indicate that there is no statistically significant variance between subjects' and experts' responses on the Individual Behavior Change and State Involvement metric, and the results of the Education metric test are undefined due to lack of variation in experts' responses to this metric. However, there is a highly significant difference in the variance ($p<0.001$) between Subjects and Experts' Mental Model metric and between the two groups' Municipal Adaptation Level metric ($p<0.005$). These results show that subjects are far more variable in their responses than experts in regards to understanding climate change, evaluating the risks climate change impacts pose to North Kingstown, and in their level of readiness for taking adaptive actions.

The variance between the experts and subjects' mean scores for all five metrics was also calculated to determine whether the differences in the two groups' averages were significant. The differences between expert and subject scores on the Individual Behavior Change metric were not significant (Mann-Whitney Test, $W=154$, $p=0.73$), further supporting the F-Max and Spearman correlation test results indicating that this is not a good metric for determining the behaviors and attitudes of municipal decision makers. The divergence between the two groups' mean responses as measured by the Mental Model metric approached statistical significance (Mann-Whitney test, $W=136.5$, $p=0.07$), however the most significant differences between the groups' means were between responses to the Municipal Adaptation Level and State Involvement metrics. The difference in means for the Municipal Adaptation Level (Mann-Whitney test, $W=122$, $p<0.01$) and State Involvement metrics (Mann-Whitney test, $W=124.5$, $p=0.01$) indicates that the most divergence in beliefs and attitudes

between experts and subjects regards the necessity of taking adaptive actions as a municipality, the level of risk that climate change poses to North Kingstown, and what role the state should play in municipal adaptation planning and the implementation of adaptive actions.

Proactive adaptation planning and actions designed to mitigate the risks climate change impacts pose on a municipal level require the cooperation and coordination of the town's major decision makers and officials. However, cooperation between decision-making groups, councils, stakeholders, and state agencies is difficult to achieve in the best of times, and the politically charged topic of climate change makes collaboration even more challenging (Beratan, 2007). North Kingstown's decision makers currently have widely varying attitudes and beliefs regarding the risks posed by climate change impacts, the role the state should play in regulating adaptation actions and policies, and what should be done to prepare for likely impacts. In order to effectively implement proactive adaptive planning efforts and adaptation actions at a municipal level the town decision makers must reach a closer agreement on what the risks are, who should be addressing them, and what needs to be done. Improved communication between the numerous decision-making bodies within the municipal government combined with increased awareness of current climate change science is likely to reduce variation in the town officials' attitudes and beliefs, a necessary first step in movement towards proactive adaptive planning.

4.4.3 Correlation Between Education and Other Metrics

The results of this case study support previous studies' findings that education on a particular issue does not correspond to changes in individual behavior regarding

the problem (Beratan, 2007; Andreasen, 2006; Kotler and Zaltman, 1971; McKenzie-Mohr and Smith, 1999); however, the statistical analysis does indicate a correlation between education and support for municipal adaptation. The Education metric in this study was based on whether a subject had attended any seminars, meetings, or educational presentations about climate change and its impacts to Rhode Island and the town of North Kingstown. Although the results of the Spearman Correlation test indicate a small positive correlation between the Education metric and the Individual Behavior Change and Mental Model metrics, neither of these correlations are statistically significant (p-values equal 0.4 and 0.3 respectively). The correlation between Education and Municipal Adaptation Level was moderately positive ($r=0.5$) and approached statistical significance ($p=0.06$). Only 10 of the 15 interviewed municipal decision makers had attended a program that included any information pertaining to climate change. Attendance at such seminars or programs did not result in significantly higher understanding of climate change science, risks, or potential impacts that North Kingstown is likely to experience. These results indicate that educational programs must improve in effectiveness or coastal managers and hazard mitigation planners must use different methods of communicating North Kingstown's risks from climate change to municipal decision makers. The majority of the interviewees (10 of the 15 subjects) directly stated that they believed education was very important in order to increase public awareness and "get [the public] involved;" the need for "top down" education, starting with the decision makers, was also cited as a way of making decision makers "more receptive to adaptation ideas." The moderately positive correlation between the Education and Municipal Adaptation

Level metrics indicates that improved access to climate change information and educational presentations or programs may result in increased support for municipal adaptation planning and actions among town decision makers.

4.5 Key Findings

The results of this case study indicate that municipal decision makers are largely unaware of current planning efforts in North Kingstown related to sea level rise and hazard mitigation. Although the Planning Department has been working with the URI Coastal Resources Center on a pilot project mapping sea level rise vulnerability and the project is currently entering its second phase, only 6 of the 15 decision makers interviewed mentioned anything related to this pilot project. Since a modified mental model methodology was used in the interview instrument, the fact that less than half of the decision makers mentioned the current planning project indicates either that they are unaware of these efforts or they may be aware of them but do not consider the project to constitute a significant action that the town is already taking towards proactive adaptive planning.

The majority of municipal decision makers also do not believe that sea level rise and increasing storminess pose a serious threat to North Kingstown in the near future and do not think that the town needs to plan more than an average of 30 years in the future. While the experts interviewed in this case study thought North Kingstown should be looking 50 to 100 years (with a mean of 65.5 years) into the future when planning for climate change, subjects' responses varied from 5 to 100 years with a mean of 30 years. These results display the wide divergence between municipal decision makers and coastal management experts regarding the time frame in which

adaptation planning should be taking place. Decision makers believe North Kingstown needs to plan less than half as many years in advance as the experts think they need to, further displaying the wide divergence between experts and subjects regarding climate change beliefs and attitudes towards adaptation. This result also reaffirms previously discussed findings that show a large variability within the decision makers' responses. While experts' responses varied by 50 years (50 to 100 years), the decision makers' answers varied by 95 years (5 to 100 years), indicating that reaching a consensus on how many years into the future North Kingstown should be looking when planning adaptive actions may be challenging.

The statistical analysis of data collected in this case study displays a wide and statistically significant discrepancy between experts and subjects' understanding of climate change and its impacts as displayed by differences in the Mental Model metric scores. This wide division between experts and subjects is also shown in the Municipal Adaptation Level metric scores. These results provide important information to both municipal decision makers and coastal managers working with Rhode Island towns as they indicate exactly how divergent decision makers' and experts' knowledge and understanding of climate change is in two key areas: how differently these two groups conceptualize the risks climate change impacts pose, and the time frame in which adaptive planning should occur.

When determining methods of communicating with and educating municipal decision makers, individual behaviors related to adaptation and preparation should not be used in an effort to enact municipal-level adaptation. This study showed that Individual Behavior Change levels of decision makers displayed no correlation with

their level of Municipal Adaptation readiness or understanding of climate change risks. Thus, encouraging individual adaptive actions will likely have no effect on increasing proactive adaptation beliefs or actions at the municipal level.

In order to effectively implement proactive adaptation at the municipal level, decision makers' mental models concerning climate change risks need to come into closer agreement with currently available climate science information, illustrated by the expert mental model. The current mental models of decision makers pertaining to adaptation and climate change knowledge are so widely variable that reaching consensus on which adaptation actions to take and how such actions should be implemented is likely to be an extremely difficult task. Additionally, coastal managers, hazard mitigation experts, and planners must understand the decision makers' current level of understanding and concern in order to effectively work with decision makers and engage them in the adaptation process.

This case study of North Kingstown decision makers disproved my initial hypothesis that individuals whose mental models of climate change and risk most closely fit the expert mental model would be more advanced in the stages of personal adaptive behavior change. Further research is needed to determine whether this result showing no correlation is due to lack of variance in my sample and the small sample size or if it is indicative of disparity between climate change knowledge and personal behavior on a larger scale. My second hypothesis was verified through statistical analysis, proving that a strong correlation exists between individuals with mental models closely matching the expert model of climate change knowledge and levels of support for municipal adaptation planning and actions. This result indicates that

increasing decision makers' knowledge and understanding of climate change impacts and risks will likely lead to greater support for municipal proactive adaptation planning and implementation of adaptive actions.

The third research hypothesis anticipated that decision makers who had attended educational programs or presentations about climate change would be more supportive of municipal adaptation efforts. The results of this case study display a minor correlation between interviewees' education and level of support for municipal adaptation, indicating that increased climate change education may contribute to greater support for proactive adaptation. However, coastal managers and communicators must be aware of decision makers' current level of knowledge and beliefs concerning climate change and adaptation in order for education and outreach efforts to be effective in raising public awareness of the impacts and risks posed by climate change. My fourth hypothesis was disproved through statistical analysis displaying no correlation between individuals' personal stages of adaptive behavior change and their levels of support for municipal adaptation. However, this result may be caused by lack of variation within the decision makers' stages of personal adaptive behavior change, thus future research using a larger sample size could provide a more definitive answer to this hypothesis. Results gathered from this study do not support the use of advancing individual adaptive behavior change as a method of increasing proactive adaptation on a municipal level. Instead, building awareness of the risks associated with impacts of climate change through improved communication, educational programs, and public outreach is likely to be the most effective way of promoting proactive adaptation in vulnerable coastal communities.

5. Conclusions and Recommendations

The results of this case study provide valuable insight into the attitudes, beliefs, and behaviors of North Kingstown's decision makers. Although nearly all of the interviewees have taken actions to protect their own homes and properties from damage resulting from climate change impacts such as increasing storm intensity, the majority of the decision makers do not believe that climate change poses a serious risk to North Kingstown in the near future and many are not supportive of planning to minimize longer-term risks. As a whole, the group of decision makers interviewed for this study have widely varying conceptualizations of climate change, the risks sea level rise and increasing storminess pose, and the time frames in which adaptive actions should be implemented.

Two potential policy options may be considered in order to address the issues encountered in encouraging proactive municipal adaptation. The first option is to continue efforts to educate municipal decision makers regarding climate change science, the risks posed by likely impacts, and the current science pertaining to the projected time frame of climate changes. While education and outreach are important, this study indicates that there is not currently a statistically significant correlation between education and decision makers' preparedness or willingness to implement adaptive actions on a municipal level. Further research needs to be done on this topic to investigate what forms or methods of education and communication are most effective in increasing decision makers' awareness of climate change impacts and willingness to support proactive adaptive planning and implementation of adaptation

actions. Future studies can also explore in greater depth the relationship between decision makers' education and their beliefs and attitudes towards climate change.

The second policy option is to turn responsibility for implementing municipal climate change adaptation over to the state. The State of Rhode Island has already designated the Coastal Resources Management Council (CRMC) as the agency in charge of managing the state's coasts, and the Council's responsibilities could be expanded to encompass coastal climate change adaptation regulations. Statewide Planning is also involved in developing long-term plans for the state and could take a leading role by incorporating climate change projections in their work. Due to the divergent beliefs and attitudes within the largely elected municipal decision making body, the role of the State in encouraging and mandating adaptation actions should increase in order to provide continuity and free the adaptation process from the political election cycle. The results of this case study show that local decision makers do not have the knowledge (and possibly not the political will) to implement adaptation actions that may be unpopular and impact their ability to get reelected. However, many of the decision makers do not want to turn responsibility for climate change adaptation over to the State because they are opposed to increased regulations and development restrictions. State agencies, such as the CRMC, consist primarily of appointed decision makers, thus they have greater ability to do long-term big-picture planning.

Although members of the CRMC are political appointees, the laws and regulations developed by CRMC provide limits to politics by establishing rules pertaining to the management of coastal resources and presenting policy

recommendations. Municipal decision makers that serve in a short-term elected capacity potentially lack the knowledge, political will, and skill for long-term planning that is necessary for the development and implementation of proactive adaptation actions. Thus state-level decision makers and agencies must play the key role in preparing Rhode Island's coastal communities for the impacts of climate change.

However, it is important to note that a collaborative approach must be used to effectively overcome the challenges posed by climate change. In order for adaptation planning to be effectively implemented and enforced, state agencies and municipal decision makers must build trusting and cooperative working relationships (Beratan, 2007). While the state must be responsible and take the leading role in setting an agenda and providing tools for implementing proactive adaptation, Rhode Island's coastal towns need to be involved in the decision making process to increase community knowledge and understanding of climate change risks and thus improve cooperation and compliance.

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APPENDIX 1

Interview Instrument

1) In your opinion, what are the most important issues facing North Kingstown (NK)?

2) Are there (other) issues that NK faces because it is a coastal community?
   __ Prompted
   __ Unprompted

3) What natural events pose the greatest risk of damage to NK?

4) What are some coastal management issues in NK?
   __Prompted
   __ Unprompted

5) What do you think are the top four issues that deserve the greatest attention? Why?
   - Issue 1:
   - Issue 2:
   - Issue 3:
   - Issue 4:

6) Of all the issues you just mentioned, which do you think is the most important?

   a. What steps would you recommend taking to resolve this issue?

7) What is currently being done, if anything, at the municipal level to address these coastal management issues?

   a. What do you think of these actions or inactions?

8) What challenges or barriers are there to taking action on this issue? [Why isn't this happening? Why is it difficult to think about long-term changes?]

9) Have you personally experienced any damage to your home or property from storms in the last 10 years?

   a. What kind of damage was it?

   b. From what kinds of storms?

10) Have you taken any measures to prevent or minimize future damages to your own property from storms?

a. What measures have you taken?

11) If you have not yet taken preparatory actions, how likely do you think you are to take any actions in the next year?

(Highly unlikely) 1 2 3 4 5 6 7 8 9 10 (Highly likely)

12) In the next 5 years?

(Highly unlikely) 1 2 3 4 5 6 7 8 9 10 (Highly likely)

13) In the next 10 years?

(Highly unlikely) 1 2 3 4 5 6 7 8 9 10 (Highly likely)

14) If you have taken previous actions, are there any follow-up actions you will make in the future?

15) What risks are there to NK from extreme weather? [Prompted/Unprompted]

Flooding (infrastructure)	Destruction of property (public)
Flooding (storm surge)	Destruction of property (private)
Flooding (residential)	Destruction of infrastructure
Flooding (roads)	Drought
Temperature change	

16) What features, assets, or resources in North Kingstown will be exposed to the greatest risk from these impacts?

Residential buildings	Public buildings
Roads	Bridges
Harbor area	Commercial buildings
Infrastructure	Wastewater facilities
Emergency response facilities	

17) How likely do you think it is that the town of North Kingstown will experience any impacts from future climate change?

(Highly unlikely) 1 2 3 4 5 6 7 8 9 10 (Highly likely)

18) What elements of climate change do you think might affect (life in) North Kingstown?

Increased air temp.
Increased water temp.
Increased storm intensity
Increased storm frequency
Drought
Sea level rise
Accelerated Sea level rise
Increased heavy rain events
Increased storm surge

19) For the purposes of the following questions, 1 = not prepared and 5= very prepared.

Impacts	How prepared do you think NK ***is*** for the following impacts?	How prepared do you think NK ***should be*** for the following impacts?
Flooding (rain)	(1) (2) (3) (4) (5)	(1) (2) (3) (4) (5)
Flooding (infrastructure)	(1) (2) (3) (4) (5)	(1) (2) (3) (4) (5)
Flooding (storm surge)	(1) (2) (3) (4) (5)	(1) (2) (3) (4) (5)
Flooding (roads)	(1) (2) (3) (4) (5)	(1) (2) (3) (4) (5)
Flooding (residential)	(1) (2) (3) (4) (5)	(1) (2) (3) (4) (5)
Downed power lines	(1) (2) (3) (4) (5)	(1) (2) (3) (4) (5)
Trees falling	(1) (2) (3) (4) (5)	(1) (2) (3) (4) (5)
Destruction of infrastructure	(1) (2) (3) (4) (5)	(1) (2) (3) (4) (5)
Destruction of property (public)	(1) (2) (3) (4) (5)	(1) (2) (3) (4) (5)
Destruction of property (private)	(1) (2) (3) (4) (5)	(1) (2) (3) (4) (5)

20) How far into the future do you think the town needs to look when planning for climate change? Why _____ years?

21) Now I'm going to ask you how likely you think it is that NK will experience impacts from climate change-related sea level rise over a period of years. For the purposes of these questions 1 = highly unlikely and 10 = highly likely.

a. 10 years: (unlikely) 1 2 3 4 5 6 7 8 9 10 (likely)
b. 20 years: (unlikely) 1 2 3 4 5 6 7 8 9 10 (likely)
c. By 2050: (unlikely) 1 2 3 4 5 6 7 8 9 10 (likely)
d. By 2100: (unlikely) 1 2 3 4 5 6 7 8 9 10 (likely)

22) Have you personally witnessed the impacts of sea level rise (SLR)? How? Where?

23) How high do you think SLR will be by 2050?

24) Now I'm going to ask you how likely you think it is that NK will experience impacts from <u>increased storm intensity</u> over a period of years. For the purposes of these questions 1 = highly unlikely and 10 = highly likely.

    a. 10 years: (unlikely) 1 2 3 4 5 6 7 8 9 10 (likely)
    b. 20 years: (unlikely) 1 2 3 4 5 6 7 8 9 10 (likely)
    c. By 2050: (unlikely) 1 2 3 4 5 6 7 8 9 10 (likely)
    d. By 2100: (unlikely) 1 2 3 4 5 6 7 8 9 10 (likely)

25) Have you personally witnessed the impacts of increased storm intensity? How? Where?

26) What changes should the town decision makers implement to minimize North Kingstown's risk of damage from climate change-driven impacts?

    a. Are these changes possible to make given current institutional structures and regulations?

    b. If not, what would need to be altered?

27) What do you think the top three priorities of the town should be for climate change preparation and adaptation?

28) What changes does the state need to make in regulations, policies, and/or programs to assist towns in climate change adaptation?

29) Have you previously been involved in any conferences, symposiums, meetings, or educational programs about climate change?

30) Have you previously participated in any discussions or meetings about sea level rise or climate change in North Kingstown?