Preparing for climate change in three New England coastal communities: Lessons on motivations, approaches, and outcomes

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Abstract
This case study research investigated three coastal communities in New England engaged in climate change adaptation. The research goals were to (1) Identify and describe the factors that prompt communities to plan for climate change impacts, (2) To elucidate the types of approaches taken by communities in planning for climate change impacts, and (3) To identify outcomes that transpire from engaging in climate adaptation. The major factors prompting climate adaptation included experience with extreme weather events, local leadership on climate change, and access to technical assistance. Each adaptation process was largely stakeholder-driven. The approaches varied and included utilizing local stories and experiences, updating a traditional hazard mitigation planning framework, and using a technical modeling tool. Major enduring outcomes included increased capacity for adaptation and other local issues, new collaborations or strengthened partnerships, increased attention to existing vulnerabilities, and a foundation for iterative action on adaptation.

Keywords
Climate Change, Environmental Sciences

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PREPARING FOR CLIMATE CHANGE IN THREE NEW ENGLAND COASTAL COMMUNITIES: LESSONS ON MOTIVATIONS, APPROACHES AND OUTCOMES

BY

CHRIS KEELEY

Environmental Conservation Studies (B.S.), University of New Hampshire, 2010

THESIS

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in
Natural Resources

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October 23, 2012

Date
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ABSTRACT

PREPARING FOR CLIMATE CHANGE IN THREE NEW ENGLAND COASTAL COMMUNITIES: LESSONS ON MOTIVATIONS, APPROACHES, AND OUTCOMES

By

Chris Keeley

University of New Hampshire, December, 2012

This case study research investigated three coastal communities in New England engaged in climate change adaptation. The research goals were to (1) Identify and describe the factors that prompt communities to plan for climate change impacts, (2) To elucidate the types of approaches taken by communities in planning for climate change impacts, and (3) To identify outcomes that transpire from engaging in climate adaptation.

The major factors prompting climate adaptation included experience with extreme weather events, local leadership on climate change, and access to technical assistance. Each adaptation process was largely stakeholder-driven. The approaches varied and included utilizing local stories and experiences, updating a traditional hazard mitigation planning framework, and using a technical modeling tool. Major enduring outcomes included increased capacity for adaptation and other local issues, new collaborations or strengthened partnerships, increased attention to existing vulnerabilities, and a foundation for iterative action on adaptation.
INTRODUCTION

The Problem of Adaptation to Climate Change

The global scientific community has reached consensus that the earth's climate system is changing at an exponential rate, expressing non-linear changes in precipitation, temperature, sea-level, and ecological responses (Intergovernmental Panel on Climate Change 2007). The consequences of these changes are vast and include greater frequencies and extremes in flooding, erosion, heat waves, and droughts; low-lying coastal areas face permanent inundation from sea-level rise and exacerbated storm surge effects; vector-borne diseases will continue to spread (U.S. Climate Change Science Program 2008). Such impacts pose major risks to areas of human health and safety, infrastructure maintenance, ecosystem services, and quality of life. There are three overarching ways to respond to these risks.

The first type of response is to continue with business-as-usual or do nothing. The second response is “climate change mitigation,” which means reducing greenhouse gas emissions in an effort to reduce the amount of climatic change (IPCC 2007). The third response is “climate adaptation,” which is the focus of this research. Adaptation translates to a major planning challenge at all levels of governance, particularly at the local level where impacts are most visible and adaptive strategies are most needed (National Academy of Sciences 2011). As a practice in risk management, climate change adaptation aims to reduce these impacts by balancing the intersection of exposure,
vulnerability, and weather and climate events (Figure 1). The IPCC (2012) defines these terms that underpin subsequent chapters:

- **Vulnerability**: The propensity or predisposition to be adversely affected.
- **Exposure**: The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected.
- **Climate extreme (extreme weather or climate event)**: The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable.

Extremes in weather and climate will continue to increase and become more variable as greenhouse gas emissions rise. The level of exposure and vulnerability to these extremes is therefore largely determined by future emissions and local planning decisions (e.g., land use, hazard mitigation, building codes). The combination of these factors drives the rationale for climate change adaptation (Figure 1).
The facets of climate adaptation span multiple spatial and temporal scales, including the impacts and associated information on observed and projected changes, options for risk management, and the levels of governance needed for action (see Table 1 below). The literature review and the following three case studies illustrate these complexities in how adaptation planning necessitates comprehensive and iterative analysis, broad stakeholder participation, and integrated approaches to risk management.
Table 1. Illustrative examples of options for risk management and adaptation in the context of changes in exposure, vulnerability, and climate extremes. In each example, information is characterized at the scale directly relevant to decisionmaking. Observed and projected changes in climate extremes at global and regional scales illustrate that the direction of, magnitude of, and/or degree of certainty for changes may differ across scales. (Content adapted from IPCC 2012)

<table>
<thead>
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<th>Example</th>
<th>Exposure and vulnerability at scale of risk management in the example</th>
<th>Information on Climate Extreme Across Spatial Scales</th>
<th>Scale of Risk Management</th>
<th>Options for risk management and adaptation in the example</th>
</tr>
</thead>
</table>
| Inundation related to extreme sea levels in tropical small island developing states | Small island states in the Pacific, Indian, and Atlantic Oceans, often with low elevation, are particularly vulnerable to rising sea levels and impacts such as erosion, inundation, shoreline change, and saltwater intrusion into coastal aquifers. These impacts can result in ecosystem disruption, decreased agricultural productivity, changes in disease patterns, economic losses such as in tourism industries, and population displacement—all of which reinforce vulnerability to extreme weather events. | **GLOBAL**  
*Observed:* Likely increase in extreme coastal high water worldwide related to increases in mean sea level.  
*Projected:* Very likely that mean sea level rise will contribute to upward trends in extreme coastal high water levels. **High confidence** that locations currently experiencing coastal erosion and inundation will continue to do so due to increasing sea level, in the absence of changes in other contributing factors.  
Likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged.  
Likely increase in average tropical cyclone maximum wind speed, although increases may not occur in all ocean basins.  
[3.5.5, Box 3-4, 4.3.5, 4.4.10, 9.2.9] | **REGIONAL**  
*Observed:* Tides and El Niño–Southern Oscillation have contributed to the more frequent occurrence of extreme coastal high water levels and associated flooding experienced on some Pacific Islands in recent years.  
*Projected:* The very likely contribution of mean sea level rise to increased extreme coastal high water levels, coupled with the likely increase in tropical cyclone maximum wind speed, is a specific issue for tropical small island states.  
See global changes column for information on global projections for tropical cyclones.  
[Box 3-4, 3.4.4, 3.5.3] | Sparse regional and temporal coverage of terrestrial-based observation networks and limited in situ ocean observing network, but with improved satellite-based observations in recent decades. While changes in storminess may contribute to changes in extreme coastal high water levels, the limited geographical coverage of studies to date and the uncertainties associated with storminess changes overall mean that a general assessment of the effects of storminess changes on storm surge is not possible at this time.  
[Box 3-4, 3.5.3] | Low-regrets options that reduce exposure and vulnerability across a range of hazard trends:  
- Maintenance of drainage systems  
- Well technologies to limit saltwater contamination of groundwater  
- Improved early warning systems  
- Regional risk pooling  
- Mangrove conservation, restoration, and replanting  
Specific adaptation options include, for instance, rendering national economies more climate-independent and adaptive management involving iterative learning. In some cases there may be a need to consider relocation, for example, for atolls where storm surges may completely inundate them.  
[4.3.5, 4.4.10, 5.2.2, 6.3.2, 6.5.2, 6.6.2, 7.4.4, 9.2.9, 9.2.11, 9.2.13] |
| Flash floods in informal settlements in Nairobi, Kenya | **Observed:** Low confidence at global scale regarding (climate-driven) observed changes in the magnitude and frequency of floods.  
**Projected:** Low confidence in projections of changes in floods because of limited evidence and because the causes of regional changes are complex. However, medium confidence (based on | **Observed:** Low confidence regarding trends in heavy precipitation in East Africa, because of insufficient evidence.  
**Projected:** Likely increase in heavy precipitation indicators in East Africa.  
[Table 3-2, Table 3-3, 3.3.2] | Limited ability to provide local flash flood projections.  
[3.5.2] | Low-regrets options that reduce exposure and vulnerability across a range of hazard trends:  
- Strengthening building design and regulation  
- Poverty reduction schemes  
- City-wide drainage and sewerage improvements  
The Nairobi Rivers Rehabilitation and Restoration Programme includes |
<p>| Impacts of heat waves in urban areas in Europe | Factors affecting exposure and vulnerability include age, pre-existing health status, level of outdoor activity, socioeconomic factors including poverty and social isolation, access to and use of cooling, physiological and behavioral adaptation of the population, and urban infrastructure. [2.5.2, 4.3.5, 4.3.6, 4.4.5, 9.2.1] | Observed: Medium confidence that the length or number of warm spells or heat waves has increased since the middle of the 20th century, in many (but not all) regions over the globe. Very likely increase in number of warm days and nights at the global scale. Projected: Very likely increase in length, frequency, and/or intensity of warm spells or heat waves over most land areas. Virtually certain increase in frequency and magnitude of warm days and nights at the global scale. [Table 3-1, 3.3.1] | Observations and projections can provide information for specific urban areas in the region, with increased heat waves expected due to regional trends and urban heat island effects. [3.3.1, 4.4.5] |
| Increasing losses from hurricanes in the USA and the Caribbean | Exposure and vulnerability are increasing due to growth in population and increase in property values, particularly along the Gulf and Atlantic coasts of the United States. Some of this increase has been offset by improved | Observed: Low confidence in any observed long-term (i.e., 40 years or more) increases in tropical cyclone activity, after accounting for past changes in observing capabilities. Projected: Likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged. Likely increase in average | Limited model capability to project changes relevant to specific settlements or other locations, due to the inability of global models to accurately simulate factors relevant to tropical cyclone genesis, track, and intensity evolution. [3.4.4] |
|  | installation of riparian buffers, canals, and drainage channels and clearance of existing channels; attention to climate variability and change in the location and design of wastewater infrastructure; and environmental monitoring for flood early warning. [6.3, 6.4.2, Box 6-2, Box 6-6] | | Low-regrets options that reduce exposure and vulnerability across a range of hazard trends: • Early warning systems that reach particularly vulnerable groups (e.g., the elderly) • Vulnerability mapping and corresponding measures • Public information on what to do during heat waves, including behavioral advice • Use of social care networks to reach vulnerable groups Specific adjustments in strategies, policies, and measures informed by trends in heat waves include awareness raising of heat waves as a public health concern; changes in urban infrastructure and land use planning, for example, increasing urban green space; changes in approaches to cooling for public facilities; and adjustments in energy generation and transmission infrastructure. [Table 6-1, 9.2.1] |</p>
<table>
<thead>
<tr>
<th><strong>Droughts in the context of food security in West Africa</strong></th>
<th><strong>Building codes.</strong> [4.4.6]</th>
<th>tropical cyclone maximum wind speed, although increases may not occur in all ocean basins. Heavy rainfalls associated with tropical cyclones are likely to increase. Projected sea level rise is expected to further compound tropical cyclone surge impacts. [Table 3-1, 3.4.4]</th>
<th>In the context of high underlying variability and uncertainty regarding trends, options can include emphasizing adaptive management involving learning and flexibility (e.g., Cayman Islands National Hurricane Committee). [5.5.3, 6.5.2, 6.6.2, Box 6-7, Table 6-1, 7.4.4, 9.2.5, 9.2.11, 9.2.13]</th>
</tr>
</thead>
</table>
| Less advanced agricultural practices render region vulnerable to increasing variability in seasonal rainfall, drought, and weather extremes. Vulnerability is exacerbated by population growth, degradation of ecosystems, and overuse of natural resources, as well as poor standards for health, education, and governance. [2.2.2, 2.3, 2.5, 4.4.2, 9.2.3] | **Observed:** Medium confidence that some regions of the world have experienced more intense and longer droughts, but in some regions droughts have become less frequent, less intense, or shorter. **Projected:** Medium confidence in projected intensification of drought in some seasons and areas. Elsewhere there is overall low confidence because of inconsistent projections. [Table 3-1, 3.5.1] | **Observed:** Medium confidence in an increase in dryness. Recent years characterized by greater interannual variability than previous 40 years, with the western Sahel remaining dry and the eastern Sahel returning to wetter conditions. **Projected:** Low confidence due to inconsistent signal in model projections. [Table 3-2, Table 3-3, 3.5.1] | **Low-regrets options that reduce exposure and vulnerability across a range of hazard trends:**
- Traditional rain and groundwater harvesting and storage systems
- Water demand management and improved irrigation efficiency measures
- Conservation agriculture, crop rotation, and livelihood diversification
- Increasing use of drought-resistant crop varieties
- Early warning systems integrating seasonal forecasts with drought projections, with improved communication involving extension services
- Risk pooling at the regional or national level [2.5.4, 5.3.1, 5.3.3, 6.5, Table 6-3, 9.2.3, 9.2.11] |
| **Sub-seasonal, seasonal, and interannual forecasts with increasing uncertainty over longer time scales. Improved monitoring, instrumentation, and data associated with early warning systems, but with limited participation and dissemination to at-risk populations. [5.3.1, 5.5.3, 7.3.1, 9.2.3, 9.2.11]** | **Improved monitoring, instrumentation, and data associated with early warning systems, but with limited participation and dissemination to at-risk populations.** | **Improved monitoring, instrumentation, and data associated with early warning systems, but with limited participation and dissemination to at-risk populations.** | **Improved monitoring, instrumentation, and data associated with early warning systems, but with limited participation and dissemination to at-risk populations.** |
Goals and Organization of this Research

This introductory chapter is followed by a literature review that describes projected impacts of climate change in greater detail. The construct of adaptation and adaptation strategies — using traditional planning tools — are then further defined and described. The construct of a "vulnerability assessment" is explained as a means for determining where adaptation strategies are needed. Finally, the literature review describes the major barriers and opportunities for climate adaptation. Collectively, the literature review connects and defines the major constructs of climate adaptation.

The methods chapter then describes the combination of data collection and analysis procedures for investigating three case studies: Bridgeport, Connecticut; the Hampton-Seabrook Estuary, New Hampshire; and Cape Cod, Massachusetts. These cases represent a purposeful sample of approaches to climate adaptation: Data on each case study was collected from semi-structured interviews with individuals involved in adaptation in each case, document data (e.g., municipal plans, news articles), and participant-observation (with the exception of the Cape Cod case, which was analyzed in retrospect).

After the methods chapter, each case study report is presented as a standalone chapter. The organization of each case study report reflects the four questions or research goals that guided this research:

1. What are the factors that led this community to pursue climate change adaptation?
2. How does the approach to adaptation reflect local conditions and actors?
3. What do case study informants perceive as the positive outcomes that transpired from pursuing climate change adaptation?

4. What are the lessons to be learned from those involved in climate change adaptation?

Finally, the closing chapter embodies lessons learned and recommendations. Lessons learned stem from recurrent themes in the findings. These findings, coupled with the experience of the author in this field (described at the end of this introduction), form the basis for recommendations relative to each case and for service providers engaged in adaptation (e.g., regional planners and planning consultants, state and federal agency staff, non-profit organizations). While this research does not attempt to measure the effectiveness of these processes toward achieving action, it does reveal the possible outcomes that indicate progress toward adaptation.

Significance of Research

This research advances the field of climate change adaptation in several ways. First and foremost, it expands the literature by reporting on three emergent cases of adaptation. As enumerated above, the first research goal supports service providers by focusing limited resources on communities that are most primed for adaptation. The second goal supports service providers with a sampling of approaches to adaptation in different community types, scales, and geographic locations. The third goal illustrates the advantages to pursuing adaptation as it relates to risk management and beyond. Finally, given the ‘learning by doing’ nature of this emergent field of planning (Carmin et al.)
2012; Brunner and Nordgren 2012), the final chapter is a synthesis of lessons learned from the three cases. This final analysis is based on a combination of insights from research participants, participant-observation, and personal commentary based on the observations and professional experiences of the author (described below).

Worldview and Origins of this Research

I first immersed myself in the field of climate adaptation in the summer of 2009. At the time, I worked in the Maine Coastal Program at the Maine State Planning Office. In response to an analysis of the past, present, and future climate of Maine by the Climate Change Institute at the University of Maine, the Maine Legislature tasked the Maine Department of Environmental Protection with convening a statewide stakeholder adaptation process to develop recommendations for a state adaptation plan. As a participant in the Coastal Environment and Built Environment workgroups, I was exposed to the challenge and necessity of planning for climate change impacts.

A year later I transitioned into graduate school at the University of New Hampshire to build upon coursework in climate change and adaptive governance. I was introduced to the New Hampshire Coastal Adaptation Workgroup ("CAW") in Spring 2011 and attended several meetings and a workshop. At the same time that I was designing my masters thesis research, Clean Air – Cool Planet announced a summer fellowship to work with CAW to advance adaptation in coastal New Hampshire. I secured the position and spent the summer developing a “climate preparedness data directory” specific to coastal New Hampshire. I also composed The NOAA Roadmap Tool in Context, which provides an analysis of how a vulnerability assessment might be
used in a New Hampshire community. In working on these projects I received invaluable mentoring from what I believe to be a truly innovative, intelligent, collaborative, experienced, dedicated, and supportive group of colleagues.

Although the fellowship ended with the close of summer, I continued my commitment by volunteering my time with the group. I was honored with presenting my summer’s work at the inaugural New Hampshire Climate Summit in December 2011 as one of eleven panelists. In the spring of 2012, I received an unexpected call from New Hampshire Sea Grant offering me a position focused on expanding their role in climate adaptation. I accepted the position. With overwhelming support and encouragement from CAW, I co-lead my first grant-funded adaptation project with a town in New Hampshire (which applied my work on the NOAA Roadmap vulnerability assessment tool).

These experiences provided what I believe to be an essential perspective of “where the rubber meets the road.” In communities throughout New England, I have experienced first-hand how local officials and service providers are grappling with the technical, financial, and political realities of planning for climate change. Given what is at stake and the active learning that I have encountered, I have detected the necessity of inquiry to advance the field of adaptation to climate change. Thus, these experiences shaped my worldview and informed the motivation, design, and conduct of my masters thesis research.
I. LITERATURE REVIEW: LAYING THE FOUNDATION FOR INVESTIGATING CLIMATE ADAPTATION

Preface:

The implications of climate change on local, state, and federal planning have been a widely expanding area of inquiry in the past decade. This literature review describes major organizing constructs of climate adaptation and how they pertain to the municipal level, as this is where climate impacts are felt most and where adaptation is ultimately implemented (Carter and Rapps 2008; Brody et al. 2010; Booz Allen Hamilton 2010; National Academy of Sciences 2011). A growing number of communities are entering into adaptation planning in response to encounters with increasing frequency and severity of extreme weather events (Northeast-Focused Needs Assessment, 2011). In a survey of town officials in southern Maine, nearly 90% felt their municipalities “need to prepare for the effects of changes in the earth’s climate (White et al. 2009).” In a 2010 survey of local, state and federal resource managers, ‘climate change impacts’ and ‘flooding/inundation/storm surge’ were the highest priority areas for coastal hazards
planning in the northeast (NOAA 2010). While extensive research documents barriers and opportunities for planning for climate change (described later), the challenges persist. Hence, communities are increasingly looking to learn from one another through detailed case studies of adaptation (Northeast-Focused Needs Assessment 2011). This research aims to respond to that need.

**Climate Change Impacts: Globally, Nationally, Regionally, and Locally**

“Warming of the climate system is unequivocal, as is now evident from observations of increased ocean temperatures, widespread melting of snow and ice and rising global average sea level (Intergovernmental Panel on Climate Change, Fourth Assessment, 2007.”

Climate assessments available to decision-makers in the northeast include: the *IPCC Fourth Assessment Report* (2007), the *Global Climate Change Impacts in the US* (2009), the *Northeast Climate Impacts Assessment or “NECIA”* (2007), and *Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future* (2011). Respectively, these assessments range in scale from global to regional to local.

The Intergovernmental Panel on Climate Change (IPCC) is an international body that “reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change (IPCC Organization).” The IPCC was established by the United Nations Environment Programme and the World Meteorological Organization in 1988 to “provide the world with a clear
scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts (IPCC Organization)." The IPCC consists of thousands of scientists from around the world who volunteer their expertise in peer-reviewed global climate assessments.

The IPCC (2007) describes many observed and projected changes in the global climate. The observed and projected impacts of climate change are vast and include coral bleaching and ocean acidification, species extinctions and changes in species range, changes in hydrologic regimes including floods and droughts, sea-level rise, warmer annual temperatures, more frequent extreme heat and more frequent and longer heat waves, changes in extra-tropical storm tracts, melting permafrost, and changes in snow cover (IPCC 2007). These impacts will have varying effects upon populations throughout the world.

Due to their serious nature, many of these impacts necessitate action at the state, national and international level to mitigate climate change through actions, policies and agreements to reduce greenhouse gas emissions and/or increase carbon sequestration. Described herein are the impacts of greatest concern to coastal communities to which they need to adapt including sea-level rise, increased precipitation, floodplain changes, and treats to public welfare and health (Northeast-Focused Needs Assessment 2011).

Sea-level rise

Sea levels are rising in response to crustal motion (i.e., land masses are subsiding), thermal expansion, and melting of glaciers, ice caps, and polar ice sheets (IPCC 2007). The IPCC (2007) observed that since 1961, global average sea level has
risen at an average rate of 1.3 to 2.3 mm per year, 3.1 mm per year since 1993. Recent research examining the relationship between observed past temperature and global sea-level suggest sea-level rise could significantly exceed 1 meter by 2100 (Vermeer and Rahmstorf 2009). In Boston Harbor, Massachusetts, sea level has risen about 10 inches over the past 100 years and, as with global trends, the rate of sea level rise appears to be accelerating (City of Boston 2011). In Portsmouth, New Hampshire, relative sea-level\(^1\) has been rising “at about 0.7 inches per decade over the past eight decades (Wake \textit{et al.} 2011),” and also may likely be rising at an increasing rate. The consequences of sea-level rise are extensive:

- "Displacement and loss of wetlands, inundation of low-lying property, increased erosion of the shoreline, changes in the extent of flood zones, changing water circulation patterns, and more salt water intrusion into groundwater and estuaries (Kirshen \textit{et al.} 2007, p. 2).

- Salt marsh habitat may be lost due to sea level rise exceeding the rate at which marshes can naturally migrate inland, or due to upland barriers (e.g., roads, seawalls, coastal real estate). Salt marshes are critical habitat for birds and fish, and provide human communities with a natural buffer against storm surge.

- Increasingly larger areas of coastal communities will be flooded during storms and hurricanes due to increased flood elevations (Wake \textit{et al.} 2011). Storm surge

\(^1\) Relative sea-level describes the effects of both rising sea-levels from more water in the oceans as well as local land subsidence or rebound. This begins to explain why some regions of the world are seeing greater rates of coastal inundation than others. For more information, see the National Oceanic and Atmospheric Administration’s “How Sea Level Changes Affect Coastal Planning” website: \url{http://www.noaa.gov/features/climate/sealevelchanges.html}.\textsuperscript{14}
threatens to damage private properties, claim lives, and inundate wastewater treatment plants and other critical facilities.

Precipitation

Precipitation patterns are changing (IPCC 2007). In recent decades, some regions of the planet (eastern North and South America, northern Europe and northern central Asia) have received significantly more rain, whereas others (Sahel, Mediterranean, southern Africa, southwestern United States, and parts of southern Asia) are experiencing longer and more frequent droughts (IPCC 2007). In the past four decades, precipitation in coastal New Hampshire has increased by 5 to 20 percent and extreme precipitation events have increased across the region (Wake et al. 2011). Overall, the trends indicate a warmer, wetter climate for the northeast with an increase in the annual number of intense precipitation events (Wake et al. 2011). There are a number of impacts associated with changes in precipitation, including:

- Flooded homes and businesses – Real estate can incur high recovery costs and threats to human health via mold and hazardous substances being suspended in floodwaters. In extreme flooding events, lives may be at risk in conjunction with reduced access to emergency services.

- Unprecedented or exacerbated erosion hazards – Undersized culverts or meandering rivers can cause roads to washout or flood, resulting in reduced access to emergency services.
• Increased frequency and duration of power outages, resulting in loss of electric heat, refrigerated food reserves spoiling, and dependency on generators (which if operated improperly can cause illness or death).

Temperature

At the time of publication of the IPCC’s Fourth Assessment in 2007, eleven of the previous twelve years (1995-2006) were among the warmest twelve years in the instrumental record of global surface temperature since 1850 (IPCC 2007). Looking forward, “increases in annual maximum and minimum temperature ranging from +4.5°F to +9.0°F (Wake et al. 2011, 23)” are likely in New Hampshire’s coastal watershed over the next 100 years. The NECIA (2007) describes the possible future climate of New England states in terms of the present-day equivalent climates of states to the south (Figure 2). The likely consequences of warmer annual temperatures in the northeast are vast and include:

• Expansion of infectious disease vectors (e.g., ticks and Lyme disease, mosquitoes and West Nile Virus) (Wake et al. 2011)

• Alterations in disturbance regimes of forests due to fires and pests (IPCC 2007).
• Changes in agricultural practices – longer, warmer growing seasons that enable earlier plantings, yet an increased likelihood of short- and long-term droughts. Also, changes to the traditional types of crops that can be grown in certain regions (NECIA 2007).

• A northward migration of temperate species, such as sugar maples.

• Less snow and ice – decreased opportunities for winter recreation such as skiing, snowshoeing, snowmobiling, and ice skating (NECIA 2007; Scott et al. 2007).

• Warmer winter temperatures resulting in “more precipitation falling as rain (as opposed to snow), earlier lake ice-out dates, and a decrease in the number of days with snow cover (Wake et al. 2011, p. 24).”

In addition, consequences of more frequent extreme heat as well as heat waves that are longer, hotter, and more frequent include:

• Reduced air quality from increased ozone concentrations, causing greater respiratory stresses for infants, elderly, and those with respiratory ailments, as well as damage to sensitive plant species such as white pine and sugar maple (NECIA 2007).

• An increased need for “cooling centers” where vulnerable populations (infants, elderly, disadvantaged) can escape the heat.
Climate Adaptation and Adaptive Governance – Planning for a Changing Climate

The IPCC (2012) defines climate adaptation separately in terms of human systems and natural systems:

“In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.”

In contrast, the National Academy of Sciences (2010) links human and natural systems as a coupled socio-ecological system. They describe adaptation as:

“Changes in social-ecological systems in response to actual and expected impacts of climate change in the context of interacting nonclimatic changes. Adaptation strategies and actions can range from short-term coping to longer-term, deeper transformations, aim to meet more than climate change goals alone, and may or may not succeed in moderating harm or exploiting beneficial opportunities (2010).”
A fundamental difference in this interpretation of adaptation is that it does not assume effectiveness in adaptation. This view runs parallel to the construct of adaptive governance (Brunner and Lynch 2010), wherein decisions use the best information available and may or may not be immediately conducive to achieving a desired state. However, by monitoring systems and evaluating decisions over time, and incorporating new information as it becomes available, adaptation and adaptive governance can ultimately succeed in reaching the desired outcomes.

The National Academy of Sciences (2010) also identifies three inherent components to any form of adaptation: actors, governance, and the object of adaptation. Actors refer to the people involved in making adaptation-related decisions (e.g., resizing a culvert or relocating a capital improvement project). Adaptation decisions are made by a wide range of institutions ranging from homeowners to the business community to local, regional, state and federal decision-makers. However, as the impacts are felt locally, adaptations are always made regionally and locally (Carter and Raps, 2008). In local governments (the focus of this research) there are many actors including: town/city planners and planning boards, conservation commissions, department of public works staff, road agents, zoning boards, town managers or mayors, police and fire chiefs, emergency responders, hazard mitigation committees, homeowners; virtually anyone involved in their community can be an actor in adaptation.

"Dealing with climate adaptation not only demands a rethink of how we arrange our social-ecological or socio-technical systems but also how we govern them (Nieuwaal et al. 2009)."

"It is facing new challenges with the end of climate stationarity and the need to meaningfully engage people in governance issues (Bradley and Plummer 2011)."
Governance refers to the context in which decisions are made. The National Academy of Sciences (2010) describes governance as, “the timing of certain opportunities to make changes in budgeting, planning or infrastructure replacement schedules.” Lastly, the object of adaptation refers to the socio-ecological system to be managed or altered, such as a road or a building (National Academy of Sciences 2010).

There are many elements of adaptive governance inherent to climate adaptation, namely because the tenets of this emerging governance structure define the ambiguous and challenging nature of climate adaptation. As described below in ‘barriers,’ climate adaptation often requires planning in an atmosphere of uncertainty. Hence, akin to adaptive governance, adaptation requires using the best information available (ranging from local, stakeholder-based expertise to peer-reviewed research), making decisions, monitoring and evaluating the affects of implementation, and modifying actions over time as better information becomes available whether from research or system response.

As with adaptive governance, climate adaptation draws on broad stakeholder engagement. Many reasons are referenced later under ‘opportunities.’ A central reason is that adaptive governance lends climate adaptation the construct of ways of knowing. In a seminal resource from the Wells National Estuarine Research Reserve, “The Collaborative Learning Guide,” ways of knowing is described as the confluence of knowledge from ecological, governance, land use, educational practices, science, technology, and local expertise. This knowledge sharing becomes particularly important when identifying how changes in climate will affect – or are already affecting – a community. For example, a road agent, a town planner, a fire chief, and a lifelong
resident can all bring different experiences to the table culminating in a more comprehensive assessment of local vulnerabilities.

Classifying Adaptation Actions

Multiple approaches are available to reduce the risks of climate extremes and disasters (Figure 3). Furthermore, effective risk management often demands an integrated approach of hard infrastructure-based responses and soft solutions such as growing institutional capacity (IPCC 2012). The approach or approaches taken at the local level will largely be a matter of local ideologies, beliefs, values, resources, vulnerabilities, exposure, and adaptive capacity. Merrill et al. (2008) summarized this succinctly in that, “While planners help to point out the nature of the risks, the ranges of solutions, and the types of processes that can lead to solutions, the answers and their implementation have to come from communities themselves.” Approaches must be accepted by communities given their role in implementation and their vested interest in the outcome. Several of these approaches can necessitate multi-jurisdictional planning. For example, an upstream community with a dam could need to collaborate with downstream communities on flood-related issues.
Adaptation to sea-level rise: retreat, protect, accommodate, or do nothing

All of the approaches in Figure 3 have implications in responding to sea-level rise, which is one of the most concerning issues of climate change for communities in the Northeast (NortheastFocused Needs Assessment, 2011). Sea-level rise adaptation strategies fall within four categories: *do nothing, protect, retreat, or accommodate*. The process that leads a community to choose among these actions can rely heavily on comparisons of the costs and benefits of adaptation strategies, either as changes in policy or implementing specific projects (Yohe, Knee, and Kirshen 2010).
Protect. Building a seawall to prevent storm surge from reaching and damaging a real estate is an example of protection (Figure 4). Protection is likely to be a common approach in population centers along the Atlantic coast due to extensive development (Titus et al. 2009). Other examples of protection include dikes, riprap, beach nourishment and dune restoration.

Accommodate. To retrofit existing structures or to design them to withstand specific flooding scenarios is to accommodate. A common accommodation strategy is to implement freeboard requirements, whereby building codes are amended to require structures to be elevated above a certain flood elevation (essentially putting a building on stilts, shown in Figure 5). The Town of Hull, Massachusetts implemented this approach in 2009. The Board of Selectmen unanimously passed an incentive program awarding builders a $500 credit in building permit fees in return for elevating new structures at least two feet above the highest federal or state requirement (Massachusetts Office of Coastal Zone Management 2011).
Retreat. The third response, retreat, means to relocate or phase-out development in hazardous areas. Imposing limits on armoring or redevelopment in hazardous areas, or preserving natural habitat to buffer storm surge and accommodate landward marsh migration, are examples of retreat strategies. Retreat is the most forward-thinking and long-term solution. However, retreat can also be the most costly and contested option.

Implementing Adaptation – Regulatory Tools and Non-Regulatory Approaches

Planning for climate change is an emerging issue, “even if based on established practices (Brunner and Nordgren 2012, 1).” The Georgetown Climate Center published the Adaptation to Sea-Level Rise Toolkit in 2011 to help technical assistance providers and local decision-makers understand how to apply conventional tools for climate adaptation. The Toolkit provides a comprehensive evaluation of the range of adaptation strategies and implementation mechanisms. It also describes the host of tradeoffs among the three classes of adaptation strategies (protect, accommodate, or retreat) relative to economic, environmental, social, administrative, and legal criteria.
Finally, the Toolkit also expounds the legal authority of local governments to use conventional planning tools to address sea-level rise. Their analysis positions governments to “determine which tools to employ given their unique socio-economic and political contexts (Georgetown, 1).” Since diverse local conditions rule out the existence of a one-size-fits-all adaptation response strategy, “Individual towns have to create individual solutions to meet their own constraints and opportunities without compromising the strategies of adjacent communities (Merrill, Sanford and Lapping, 2008).”

As an overarching planning tool, communities can use comprehensive planning or master planning (including hazard mitigation planning) to address sea-level rise. Numerous regulatory tools are also available including zoning and overlay zones, floodplain regulations, building codes, setbacks/buffers, conditional development and exactions, rebuilding restrictions, subdivisions and cluster development, hard-armoring permits, soft-armoring permits, and rolling coastal management/rolling easement statutes. Spending tools for adaptation include capital improvement programs, acquisitions and buyout programs, traditional conservation easements as well as rolling conservation easements. Tax and market-based tools include tax and development incentives (e.g., freeboard incentives as mentioned earlier in Hull, MA), transferable development credits, and real estate disclosures.
Vulnerability Assessment – Determining where action is needed

Local decision-makers are often familiar with the common tools described above. However, a climate change vulnerability assessment is largely an unfamiliar construct for which Northeast communities have voiced a need for technical assistance (Northeast Focused Needs Assessment 2011). A vulnerability assessment entails identifying how a community or a region’s assets are likely to be impacted by the effects of climate change. It provides the framework for determining the “who, what, where, when, and how” of taking action, and thus is a fundamental step in climate adaptation.

The National Academy of Science affirms the amorphous nature of vulnerability assessments stating that, “There is currently no widely accepted approach for conducting vulnerability assessments (America’s Climate Choices 2010, 64).” Vulnerability assessments range along a continuum from qualitative and participatory-based to more quantitative and expert-driven. Described below are two frameworks that capture the essence of this construct from both ends of this continuum.

NOAA Roadmap for Adapting to Coastal Risks: Largely qualitative, and emphasizes anecdotes of the community’s experiences with extreme weather. The Roadmap is a stakeholder-driven, participatory process commonly conducted over several workshops with community members and relevant state or federal agency staff. Presented in detail in the Bridgeport, Connecticut case study.
Coastal Adaptation to Sea-Level Rise Tool (COAST): A GIS-based analysis tool for estimating the cost-benefit basis of different adaptation strategies for selected assets under varying sea-level rise and storm surge scenarios. COAST uses local data such as assessor databases and parcel maps, local flood data, Light Detection and Ranging (LiDAR), the U.S. Army Core of Engineer's depth-damage functions, and NOAA hurricane models. *Presented in detail in the Hampton-Seabrook Estuary case study.*

**Barriers and Opportunities for Climate Adaptation**

Climate adaptation can be a challenging planning issue for municipalities regardless of size or geography. As an emergent planning challenge, climate adaptation has been likened to “building a bike while riding it (Brunner and Nordgren 2012, 1).” Throughout the world there is a “great deal of experimentation taking place” in crafting approaches to adaptation and determining planning priorities (ICLEI 2012). From a planning perspective, “dealing with new or even ‘fringe’ topics is what planners have always done; it is their job to articulate pathways and opportunities that may arise from events and changes not routinely recognized (Merrill 2008, 149).” Hence, the literature is increasingly being populated with new and diverse insights on adaptation as to what has worked, challenges that communities have faced, and lessons on working around those challenges. Summarized below is a current perspective on challenges and opportunities for adaptation. However, many of these lessons are not unique to climate change but are inherent to the principles of deliberative democracy (Dryzek, 2001). Headwaters
Economics (2012) and Brunner and Nordgren (2012) are cited extensively below as a current resource, and because their syntheses of climate adaptation processes span all regions of the United States. In addition, ICLEI (2012) is cited because the organization collected survey responses from nearly 500 cities worldwide in 2011 (including 300 US cities) on a range of adaptation topics, including challenges and benefits.

Opportunities

Collaboration, trust and relationship-building.

- Encourage collaboration within and across groups to find common ground for implementation. Collaboration often requires translating information across community groups, disciplines, agencies, and levels (Brunner and Nordgren 2012).

- Build personal relationships, credibility, and trust. Human capital is the foundation of effective communication and community action (Brunner and Nordgren 2012).

  - Rely on sequencing to “Build relationships with the right people, then take it public, rather than blowing the trumpets and beginning a public process right away. Find the local champions first (Brunner and Nordgren 2012, p. 5).”

- Bring the right people to the table, such as: vulnerable populations, local champions who have trust and connections, scientists, lawyers and other experts, businesses, and local, state and federal officials (Brunner and Nordgren 2012; Headwaters Economics 2012).
• Bring in outside expertise that (1) has a good track record of providing services to local elected leaders, (2) understands community organizing, and (3) provides technical expertise such as climate science, ordinance writing, or cost-benefit analysis (Headwaters Economics 2012).

Frame climate change pragmatically.

• Make climate change a present-day issue. For example, begin with intriguing questions such as, “Are you ready for the next storm? (Wake 2011, Presentation in Greenland, NH).” Furthermore, focus on an immediate, recognizable threat or a recent natural disaster or extreme weather event that people can relate to (Brunner and Nordgren 2012; Headwaters Economics 2012).

• Use maps, photos, and anecdotes to make the abstract concrete.

• Emphasize the target community’s recent experiences with natural disasters and extreme weather events.

• The term “climate change” and “climate adaptation” can sometimes be ambiguous, invoke debate or contention, or be an off switch for engagement. Analogous phrases can be used instead, such as “extreme weather,” “climate preparedness,” “climate protection,” “resilience planning,” “natural disaster planning,” or “hazard mitigation planning.”

• “Framing should entail selecting those issues with the greatest potential enhancement or threat to public health and welfare (Merrill, Sanford, and Lapping

“Framing climate change in terms of public health and/or national security may make climate change more personally relevant and emotionally engaging (Myers et al. 2012).”
Moreover, stakeholders need to be engaged through the areas of common interest such as sustaining local economic vitality, maintaining "quality of place," preparing for impacts of storms and other extreme weather events (Stephenson et al. 2012).

- Present the community with the economic, environmental, and social benefits of hazard resiliency planning (Booz Allen Hamilton 2010).

**Leadership.**

- Cultivate, identify, and work with local champions – local officials and activists who keep climate change a priority in their community and can lead a local adaptation effort by recruiting community participation (Headwaters Economics 2012; ICLEI 2007, Stephenson et al. 2012).

- "Build an open, inclusive alliance that benefits community members and engages them on their own terms (Brunner and Nordgren 2012, 6)." In other words, identify influential local stakeholders who can effectively reach across the isle. Such leadership may be found in unexpected places, such as public safety workers or water managers (Headwaters Economics 2012, 2).

- Make use of regional compacts. Regional compacts link municipalities with state and federal resources (Headwaters Economics, 2012). They also ensure that state and federal authorities are engaged and aware of the context for local action such that they can provide the enabling conditions.

**Integrate climate adaptation with existing initiatives.**
- Start with an existing process – Integrate adaptation into hazard mitigation planning, water resource plans, master plans, etc. This helps to institutionalize adaptation via familiar tools, rather than standalone adaptation plans that require new means for implementation (Headwater Economics 2012).

- Link adaptation with mitigation. “Sometimes mitigation actions, such as signing the U.S. Mayor’s Climate Protection Agreement, is the first step leading to adaptation planning and actions (Headwaters Economics 2012).” For example, Mayor Finch of Bridgeport, Connecticut signed the Act in 2007 and an adaptation planning process began five years later, building on the shoulders of the City’s sustainability plan.

- Utilize regular master plan updates (or development) as an opportunity for resiliency planning (Booz Allen Hamilton 2010).

**Know the community.**

- Hone in on local priorities – Be responsive to a community’s concerns and use them as entry points into adaptation (Headwaters Economics 2012). For example, if a community is particularly concerned about the state of an estuary, conservation strategies that accommodate salt marsh migration could provide an entry for adaptation.

> “Public/town officials are very busy, have limited financial resources, and do not hear a sense of urgency to take action from those who assign or influence their work,” was a major theme from a Maine Sea Grant (2009) survey of town officials in southern coastal Maine.
Barriers to pursuing climate adaptation

The literature also documents common challenges to adaptation at the community level. ICLEI (2012) organized global challenges into four overarching categories: resources, commitment, communication, and information. This framework is embraced below and supplemented with additional sources.

Resources.

- ICLEI (2012) found that funding for adaptation work is a major challenge for 85% of cities in responding to a worldwide survey.

Commitment.

- There are many priorities that compete or take precedent over hazard planning (Booz Allen Hamilton 2010).
- Communities often have a bias in favor of growth over restricting development (Association of State Floodplain Managers 2011).
- Mandates for planning for climate change impacts are absent at federal and state levels, yet land use planners state that mandates have major influences on land use planning decision-making (Booz Allen Hamilton 2010).
• Though commonly unbeknownst to town officials, local governments in fact have clear legal authority to plan for climate change (Georgetown Climate Center 2011; Harvard Law School 2011; Vermont Law School 2012 *publication pending*). In fact, planning for climate change is embedded in the very essence of local governments’ responsibilities to make “basic land-use decisions needed to protect the health, safety, and welfare of their citizens (Georgetown Climate Center 2011, p. 9).”

**Communication.**

• Of the 500 cities participating in ICLEI’s survey, about 270 say that communicating the nature of adaptation problems (and the need to address them) to elected officials is a major challenge (ICLEI 2012).

• “Nationally-organized political opposition to climate adaptation,” namely in the form of disrupting municipal meetings and undermining scientific research, remains a major challenge due to its backing for local opposition (Brunner and Nordgren 2012, 5).

• Some, but not all, of the perceived or real benefits of adaptation may not be realized for decades, which can render adaptation a low funding priority (Smith and Lenhart 1996).

• There are many concurrent issues – often with more near-term or visible benefits – on the basis of which citizens elected their officials. In 2010 NOAA initiated a survey and series of focus groups with land use planners around the country to document local barriers to hazard resiliency planning. Land use planners said,
“generally speaking, communities are pressured to deal with issues that are in the 6-month to a year horizon (Booz Allen Hamilton 2010, p. 15).” Furthermore, “a lot of master plans say 20 years, but it’s not really, they can’t grasp that far into the future (Booz Allen Hamilton 2010, p. 15).”

- Emergency planners and land use planners, among other diverse partnerships, need to be integrated. Traditionally, these groups work in isolation (Godlewski, personal communication, 2011; Booz Allen Hamilton 2010).

Information.

- Uncertainty in climate projections can function as a justification for inaction (Gifford 2011). Therefore, discussions of uncertainty run the risk of losing your audience (Brunner and Nordgren, 2012). This thread ties back to the notion of risk management: make decisions that reduce the risks stemming from inaction. On the flipside, there is actionable knowledge given the fact that sea-level is rising, temperatures are increasing, and precipitation patterns are changing.

- Don’t wait for perfection (Headwaters Economics 2012). Recognize that adaptation is an evolutionary process, and that plans will need to be revisited as priorities change or more information becomes available (Heinz Center 2009; Brunner and Lynch 2010).

- Adaptation can be a long-term issue without a universal response strategy. “The metrics are not simple (Brunner and Nordgren, 2012).” Thus, it is important to draw from adaptive governance (Brunner and Lynch 2010) by observing the effects of actions as they are taken (Brunner and Nordgren 2012).
Conclusion

While climate modeling continues to improve, the greatest uncertainty of future climate conditions is due to the inability to predict future emissions of heat-trapping greenhouse gases and the response of the Earth’s climate system to human-induced change (Wake et al. 2011). Nonetheless, climate assessments of all scales affirm there are existing and emerging climate change impacts to which societies around the world must adapt. To reduce the consequences of climate impacts upon people, infrastructure, and the environment, effective decision-making must integrate information about current and future climate. The factors that lead communities to pursue adaptation, the various approaches that they take, and the perceived outcomes of doing so remains a significant area of inquiry. This research aims to cast new light upon these facets of adaptation from three recent cases in the Gulf of Maine rooted in diverse geopolitical environments, community size, process design, local history, and actors involved. It also provides a synthesis of lessons learned on adaptation from people in the field as well as from the point of view of the author.

“Most communities are still operating with decades-old information. Watersheds and floodplains are dynamic based on development/climate change, and maps must reflect this.” – Association of State Floodplain Managers (2011).
II. METHODS & CASE STUDY PROTOCOL

Introduction

The purpose of this case study protocol was to guide systematic data collection and analysis across multiple cases. A case study protocol keeps a research project focused on the topic of a study, aids in anticipating and planning for a range of research obstacles, and provides a means to backcast through developing an outline for the case study report (Yin 2009). With the latter in mind, the audience for this research was technical assistance providers engaged in climate adaptation.

The line of inquiry for this research emerged from several years of experience in working with technical assistance providers and communities pursuing climate adaptation in Maine and New Hampshire. My involvement with the New Hampshire Coastal Adaptation Workgroup (“CAW”) has provided an informative lens to the conditions, actors, and challenges commonly associated with adaptation. Hence, this brief introduction begins to illustrate the context for this investigation. My experiences and review of the literature have directly informed the selection of cases and case informants as well as the procurement of document data (described below).

Objectives

This research set out to advance the field of climate adaptation through a multiple case study investigation with three specific objectives. These objectives were applied to
each case study with a set of substantive questions guiding the inquiry (See Section IV). The three specific objectives were:

1. To identify and describe the factors that prompt communities to plan for climate change impacts.
2. To elucidate the types of approaches taken by communities in planning for climate change impacts.
3. To identify outcomes that transpire from engaging in climate adaptation.

Finally, a fourth and overall objective was to advance the field of climate adaptation by unifying these three objectives into lessons learned and recommendations ready for dissemination to professionals engaged in climate adaptation.

Case Study Overview

The cases selected for this research constitute maximum variation, a popular approach in qualitative research (Creswell 2006). That is, each case presents a different approach to climate adaptation. The cases also differ in scale ranging from a mid-sized city (150,000) to an estuary (three semi-rural communities) to an entire county (15 communities ranging in size and wealth). The conveners and sources of technical assistance vary in each case, and the approaches and substantive foci are diverse. In this light, using maximum variation increases the likelihood that findings will reflect different perspectives, which Creswell (2006) calls “an ideal in qualitative research (126).” As every community will follow a different path toward adaptation relative to local
conditions, maximum variation positioned this research to equip technical assistance providers (the primary audience) with an array of insights into climate adaptation.

**Bridgeport, Connecticut.** The City of Bridgeport is one of the first medium-sized coastal cities (150,000 residents) on the eastern seaboard to begin climate adaptation planning (Whelchel, personal communication, 2012). Emerging from a boom and bust in industry, the City’s tax-base is mired by 1/3 of land parcels being tax-exempt and 11% of the land left vacant (BGreen 2020). Beginning in the mid-2000s, the mayor committed the City to sustainability by joining the International Coalition for Local Environmental Initiatives (ICLEI), signing the Mayor’s Climate Protection Agreement, and directing the development of the City’s BGreen 2020 Sustainability Plan. Clean Air-Cool Planet and The Nature Conservancy convened and facilitated the City’s adaptation process in a modified version of the “NOAA Roadmap for Adapting to Coastal Risks.”

**Hampton-Seabrook Estuary, New Hampshire.** With assistance from the New Hampshire Coastal Adaptation Workgroup and the New England Environmental Finance Center over 2011-2012, three NH communities of the Hampton-Seabrook Estuary (combined 2010 population: 26,300, US Census) approached climate adaptation through a cost-benefit analysis of scenario planning for storm surge and sea-level rise. This project built upon existing engagement efforts of CAW, as well as a study commissioned by the Town of Seabrook to the regional planning commission for guidance on integrating climate adaptation into hazard mitigation planning.
Cape Cod, Massachusetts. In the late 2000s the Cape Cod Commission, the Waquoit Bay National Estuarine Research Reserve, and the Adaptation Network convened the fifteen communities of Barnstable County (referred to as Cape Cod with a combined 2010 population of 288,000, according to US Census 2010) to update the county-wide Pre-Disaster Mitigation Plan (PDM). The update extended the term hazards to include sea-level rise, increased intensity of coastal storms and hurricanes, and increased precipitation in the form of heavy downpours. The intent was to empower local climate adaptation planning by engaging the region’s decision-makers in a joint process. Moreover, the regional plan serves as a template from which localities can draw.

Data Collection Procedures

Extensive review of document data preceded contact with key informants to gain contextual understanding and to further inform questioning. Document data included hazard mitigation plans, town/city master plans, sustainability plans, newspaper articles, and municipal and nongovernmental organizational websites. This review of document data provided an initial context for understanding the three substantive lines of inquiry as identified under Objectives, as well as helped to identify key informants for interviews.

The New Hampshire and Bridgeport case studies provided an opportunity to visit the sites gain a sense of the communities’ layout, character, infrastructure, and vulnerabilities. Various photos of stakeholder working sessions and community assets provided additional context to the researcher and reader.
Listed below are the initial key informants identified for each case study community. An asterisk (*) indicates additional informants that participants expressed held important insights. This referral process is termed “snowballing” by Yin (2009).

Hampton-Seabrook Estuary, New Hampshire.

- Julie LaBranche, Senior Planner, Rockingham Planning Commission
- Derek Sowers, Piscataqua Region Estuaries Partnership
- Steve Miller, Great Bay National Estuarine Research Reserve
- Sherry Godlewski, New Hampshire Department of Environmental Services
- Sam Merrill, New England Environmental Finance Center
- *Amanda Stone, UNH Cooperative Extension/Natural Resources Outreach Coalition

Cape Cod, Massachusetts.

- Tonna-Marie Surgeon-Rogers, Coastal Training Program Coordinator, Waquoit Bay National Estuarine Research Reserve
- Ryan Christenberry, Planner and Energy Specialist, Cape Cod Commission
- Lynn Carter, Climate Specialist, Adaptation Network
- Paul Lagg, Chatham Town Planner
- *Sara White, Massachusetts Emergency Management Agency/FEMA Liaison

Bridgeport, Connecticut.
Data Management and Analysis

Case study evidence was stored on the password-protected computer of the researcher. During the interviews, responses to interview questions were typed into data collection forms (below). This data was then imported into NVivo software for coding and analysis. Each sentence was coded in a “line by line coding” fashion. The purpose of coding was to identify, rapidly retrieve, and compare themes in participant responses and document data. Special attention was placed on bracketing preconceived codes to keep an open stance toward what the data said. Codes were organized in numerous subnodes under four overarching nodes: Concern to Action, Process, Outcomes, and Lessons Learned. Examples of additional sub-nodes included:

- Concern to Action – Available and trusted technical assistance, recent extreme weather event, funding, good scale, local champion, local interest, momentum from recent actions, leadership;

- Process – Actor, barrier, recruitment, framing, leverage trust and relationships;
• Outcomes – Long-term, short-term, improved capacity, collaboration, expanded trust and relationships, momentum, tool for discussion, identified hazards, identified information needs;
• Lessons Learned – Collaboration, relationships and trust, communications, integrate with existing activities, identify movers and shakers, everyone plays a role, know the community.

Developing the individual case study reports was a key step in developing the cross-case comparison and the final chapter, Lessons Learned & Recommendations. This general sequence is summarized in Figure 6 (adopted from Yin 2009). It is worth underscoring the iterative processes in case study research, particularly in the form of crafting more informed lines-of-questioning within each case study to better meet the overall aims of the research.
Finally, construct validity or the integrity of conclusions was addressed in three ways as advocated by Yin (2009). First, multiple sources of evidence were used including participant observation as well as interviews and document data (as described above). Secondly, a chain of evidence was developed that linked the case study questions, case study protocol, and case study reports. This chain of evidence is visible in the citations to interviews and documents throughout the case study reports. Lastly, and perhaps most importantly, *member checks* tested the overall conclusions in each case study. Prior to any public release of the results of this research, and before the cross-case analysis, key informants from each case study reviewed their respective individual draft case study report and transcripts to ensure that (1) the case study was reported accurately, (2)
participants were comfortable with how they were cited and that it was done accurately, and (3) that the reports were not missing any major themes or outcomes.

Outline of Case Study Report

This outline reflects the three analytic objectives inherent to each case study. The format for this case study report stems from what Yin (2009) describes as the 'multiple-case question-and-answer format.' He asserts that there are potentially enormous advantages to this format:

- Readers can examine the answers to the same questions within each case study to begin making her or his own cross-case comparisons (in addition to the cross-case synthesis).

- As each reader may be interested in different questions, the entire format facilitates the development of a cross-case analysis tailored to the specific interests of its readers.

The case study reports were constructed using the following outline:

Community characterization

- Social, environmental, and/or geopolitical contexts

Transitioning from concern to action on climate adaptation

- Synthesis of interviews
The approach to climate adaptation

- Synthesis of interviews and observations
- Major actors and their expertise, skills, and roles
- The nature of community participation – who participated and how, and how they were recruited
- The nature of the approach including:
  - How concerns were identified
  - Determining what to do or protect
  - Deciding how to do it

Outcomes of pursuing adaptation

- Synthesis of interviews
- What actions – if any – have been taken to date?

Lessons learned from this case study

- Synthesis of interviews and observations including:
  - What worked or didn’t work and why?
  - What could have been done to better the process?
  - What advice would informants offer to other service providers on climate adaptation?
Case Study Questions

The open-ended interview questions enumerated below embody the research instrument. These are the general types and structure of questions posed to informants, recognizing that they were adapted slightly for each interview given growing familiarity with the case (i.e., identification of actors or initiatives for further inquiry). They also provided a guide for reviewing document data. The instrument question for the interviews were organized in presented in the following manner:

Stimuli for Adaptation.

I am interested to learn about what led [case study] to transition from concern to action.

1. Based on your involvement in climate adaptation in [case study], what do you believe were the conditions and/or events that gave rise to climate adaptation in your community?

Approach, Engagement, and Process for Adaptation.

Next, I would like to understand the process or approach to adaptation in [case study].
2. Could you please describe who was involved, how they were recruited to participate, and what their role was? *This includes identifying a lead party or actor for the adaptation initiative.*

3. Could you please describe the general process or approach to adaptation? *This includes details around a particular methodology for assessing climate vulnerabilities and project timeline(s).*

4. How were the community’s concerns identified, and what were they?

**Outcomes.**

5. What actions related to climate adaptation have been taken, if any?

6. How did [case study] determine what action to take? For example, was there a prioritization process?
   
   i. Were there other areas of concern that were not acted upon? If so, why? And how might these concerns be addressed in the future?

7. How have these strategies been implemented (if they have been)?
   
   i. What plans or policies were amended?
   
   ii. Were structures reengineered or relocated? If so, please describe how they were reengineered or relocated and how the community handled the cost of doing so.

   iii. Can you connect with me any documents to learn more about these actions?
iv. Could you share any lessons learned about implementation, including what worked and what has not worked?

Closing.

8. In reflecting on your experiences and the answers provided, what additional advice would you offer to technical assistance providers working on climate adaptation?

9. Before we close, is there anything you would like to share about [case study]'s experience with adaptation that we may not have covered?

10. Do you have any questions for me?

11. Are there any additional people you recommend I speak with about adaptation in [case study]?
III. CASE STUDY #1: A CLIMATE PREPAREDNESS ASSESSMENT IN BRIDGEPORT, CONNECTICUT

Figure 7. Stakeholders participating in the climate preparedness assessment of Bridgeport, Connecticut, April 2012. Photo credit: Adam Whelchel/The Nature Conservancy.

Overview

The case of climate preparedness and adaptation in Bridgeport, Connecticut is focused around the City’s stakeholder-driven vulnerability assessment in Spring 2012. Five key informants involved in the community assessment provided insights and document data about the City’s experience with extreme weather, and other climate-related issues. Key informants from City staff included Mike Nidoh (Planning Director), Ted Grabarz...
(Sustainability Director), and Scott Appleby (Emergency Operations Coordinator). Also interviewed were two key technical assistance providers who helped design and facilitate the climate preparedness assessment: Adam Whelchel (The Nature Conservancy) and Patrice Gillespie (Clean Air – Cool Planet). Herein, quotations indicate statements directly from interviews with informants. In addition, personal observation of the second stakeholder workshop enabled a more informed and complete description of the process and a chance to experience the community of Bridgeport.

Community Profile

Geographic context: The City of Bridgeport is located in the southwest corner of Connecticut along the northern shore of Long Island Sound. New York City lies just 55 miles to the southwest, Boston 140 miles to the northeast. With a population of approximately 150,000, Bridgeport is the largest city in Connecticut. To the east and west are Fairfield and Stratford, the second and third most urbanized communities in the Greater Bridgeport planning area (GBRPA). Neighboring inland communities of Easton, Monroe and Trumbull are more rural with a greater amount of residential land use (Master Plan of Conservation & Development 2008). The City is bisected by Interstate 95, CT Routes #8/25, and the Metro North/Amtrak rail line (Figure 8), thus serving as a regional transportation hub for bus, train and ferry routes. The City also has a regional airport.
Environmental characteristics. The City of Bridgeport is the largest metropolis of southern Connecticut. Referred to as “The Park City,” there are dozens of parks of all sizes in Bridgeport. Seaside Park, Beardsley Park, and Pleasure Beach Park are the larger parks and two of them are located in the heart of Bridgeport’s harbor. There are also dozens of parks along the Pequonnock River and smaller tributaries to Long Island Sound.
that meander through Bridgeport. As for the remaining lands, nearly 90% of the City is covered in impervious surface or building footprints (BGreen 2020, 2010).

The City’s 22-mile shoreline along its rivers and Long Island Sound encompasses barrier islands, beaches and parkland (Master Plan of Conservation & Development, p. 67). However, less than two miles have been recaptured from industrial and commercial uses and only three to five miles are publicly accessible (Master Plan of Conservation & Development, p. 45). The Bridgeport waterfront contains a mix of uses including transportation, residential, recreational, commercial, industrial, and energy facilities. Educational facilities near the water include the University of Bridgeport (5,000 students), Bridgeport Regional Vocational-Aquaculture Center, Housatonic Community College, and Bridgeport City Education Department.

The City has two wastewater treatment plants: the East Side Plant and the West Side Plant. Both plants discharge treated effluent into Long Island Sound via Bridgeport Harbor and Cedar Creek. The Harbor Management Plan (2008) states that both facilities are “vulnerable to exceeding biological treatment capacity” during high-rain events (although the document does not quantify such events). Bridgeport is categorized as a medium-sized, MS4 city under the National Pollutant Discharge and Elimination System of the Clean Water Act. As an artifact of the City’s early development, stormwater and wastewater merge in the older southern portion into a combined sewer overflow (CSO) system. Implementing the separation of storm and sanitary sewers within these CSOs remains an ongoing challenge for the City. Planning Director Mike Nidoh suggested that given current funding and time required to design, permit, and construct these phased
plans, the City is somewhere around 70-80 years away from completely separating the two lines.

Social and economic context. Bridgeport’s history lends a number of present-day social and economic challenges. Up until World War II, the City was an industrial hub and a maritime commercial center (BGreen 2020, 2010). However, after the war much of the City’s population migrated to the suburbs, buildings were abandoned, and lands were left vacant (BGreen 2020, 2010). Of the remaining 10% of lands that are undeveloped in the City, over 80% are smaller than the minimum lot size required by zoning, or lack street frontage, and are therefore undevelopable (Master Plan of Conservation & Development 2008). About a third of the parcels are owned by nongovernmental organizations or government agencies and therefore tax-exempt (BGreen 2020, 2010). Thus, City planning is juxtaposed with development and redevelopment to raise local tax revenue while opportunities abound for conservation or recreation.

The size and diversity of Bridgeport also provides a number of social and economic challenges. Of the 76,000-person workforce, 30,000 commute to work outside of the city due to a shortage in local jobs (BGreen 2020, 2010). About 21% of residents lived below the poverty level in 2008, a rate 7% higher than national statistics of the 2006-2010 period (US Census Quick Facts). One third of Bridgeport residents were born outside of the United States and over 30 languages are spoken locally (BGreen 2020, 2010).
The primary industries in the City are shipping, education, banking, and medical care (GBRPA). One of three deep-water ports in the state is located in Bridgeport’s harbor, as well as four marinas and six yacht clubs. The City’s top five major employers include the Bridgeport Hospital, Bridgeport Health Care Center, People’s Bank, Sikorsky Aircraft, and St. Vincent’s Medical Center (Connecticut Economic Resource Center, Inc., 2011). Finally, as the judicial seat of Fairfield County, Bridgeport is home to the Federal, State, and County Courthouses (GBRPA).

Transitioning from Concern to Action on Climate Change

Informants described Bridgeport’s transition from concern to action as multifaceted. Three major themes emerged from informant interviews: recent experiences with extreme weather events, local leadership on climate preparedness, and synergy from existing sustainability initiatives.

Experience with extreme weather events. When informants were asked, “Based on your involvement in climate adaptation in Bridgeport, what do you believe were the conditions and/or events that gave rise to the City pursuing climate adaptation?,” every informant promptly pointed to Bridgeport’s encounter with a tornado in 2010. Each informant described it as a major event that raised concern amongst the City’s staff and residents about being prepared for extreme weather events, however unlikely or unforeseen.
The City had not previously seen a tornado since 1876 (NOAA 2010). It touched down on Bridgeport’s Main Street (Figure 9) on Tuesday afternoon, June 24, 2010. It was 100-yards wide with winds over 100 mph (National Weather Service). The P.T. Barnum Museum, a landmark building to the City, incurred such extensive damage that it only reopened nearly two-years later (Connecticut Post, 2012). The planning director described that several other buildings were immediately condemned. “I’ve never seen a storm do so much damage in such a short period of time (Connecticut Post, 2010),” said Mayor Bill Finch. United Illuminating and Connecticut Light & Power reported a combined 28,800 power outages following the tornado (WTNH, 2010). By comparison, that’s twice the number of outages of Hurricane Gloria in 1985 (CT Post 2011, “Mallory: Irene Bigger Event than Hurricane Gloria”). Approximately 50 families were left homeless (WTNH, 2010).

Despite the unexpectedness of a tornado, the City was prepared. “The City’s emergency response plans were readily amenable to the circumstances,” said the planning director. The emergency management director attributed ‘all-hazards planning’ as part of the success of the City’s response to the event. The City has utilized ‘all-hazards planning’ for the past 18 years, wherein all the components of a disaster – actors, responsibilities, resources, etc. – are taken into account to ensure that they are functioning regardless of the source of the disturbance.
The planning director described that the City has also sustained significant damages from intense rains and the occasional hurricane, such as Hurricane/Tropical Storm Irene in 2011. In that particular storm, the University of Bridgeport — located close to the shoreline — had to be evacuated to Sacred Heart University (Figure 10) because they were cut off from emergency services as the surrounding road system became flooded.

Bridgeport officials described how recurring annual damages on the order of $50-$100,000 from coastal storms at Seaside Park (Figure 11) have inspired the City to look for both short- and long-term solutions, to shift away from a tradition of repair and maintenance toward proactive hazard mitigation. During Hurricane Irene in 2011, “City officials reported broken sidewalks, roads and seawalls,” and that Long Island Sound waters reached the top steps of the park bandshell (Hearst Connecticut Media Group 2011). In response, the sustainability director described how the Parks Master Plan (2011) plans to integrate
more streamside buffers, reduced road-width, and gate valves for tides at
Seaside Park and others.

The snowstorm of Halloween 2011 was also described as a major
event raising awareness about the need
to be prepared for extreme weather.

While the City did not receive as much snow as elsewhere in the state, distant impacts
were felt locally. Widespread power outages compromised the State for nearly a week.
One informant described that when communication systems' reserve batteries were
depleted, people reportedly could not use their cell phones.

Local leadership on climate change. Leadership
amongst City staff was widely cited as a key factor
leading the community to pursue climate adaptation.

“There are pretty progressive, forward-thinking,
watchful elected officials,” said one respondent, a widely shared sentiment among
informants. Mayor Finch, described as “a connector” and “a standout,” is viewed as being
instrumental in the City’s action on climate change in both mitigation and adaptation.
Bill Finch has a longstanding connection to the City of Bridgeport. He grew up in Bridgeport, graduated from the University of Connecticut, served on the Bridgeport City Council for nine and half years, and was elected Mayor in November 2007 (Mayor’s Bio). He signed the City to the U.S. Mayor’s Climate Protection Agreement. Signatories commit to (1) meet or beat the Kyoto Protocol targets in their own communities, (2) lobby state and federal government to enact policies and programs to do the same, and (3) urge U.S. Congress to establish an emission trading system (U.S. Mayor’s Agreement). That same year, Bridgeport also joined ICLEI’s Cities for Climate Protection Campaign (CCPC).

Momentum from sustainability planning. An array of climate protection actions ensued in the years following Mayor Finch’s leadership on climate change mitigation.

The City contracted with the Regional Plan Association (the regional planning organization to the NY-NJ-CT metropolitan area) in 2008 and completed a greenhouse gas emissions inventory. Local legislation later established an Energy Improvement District. In 2008, Mayor Finch issued an Executive Order for sustainability planning. This led to the appointment of Ted Grabarz as the City’s first sustainability director and the 2010 launch of the BGreen 2020 Initiative. BGreen 2020 is the City’s 10-year sustainability plan, developed with the Regional Plan Agency and over 100 local businesses and community members (RPA spotlight article).
Beginning in the late 2000s, local planning documents highlighted the City’s awareness of the need for adaptation planning. An early assessment of climate vulnerabilities identified “portions of the Amtrak railroad, entrances to Connecticut Turnpike interchanges and bridges, the University of Bridgeport, the Navy Reserve Center, the Heliport, sewage disposal plants and the oil tanks at Johnson Creek” as being vulnerable to sea-level rise (Environmental Defense Report, cited in the Bridgeport Harbor Management Plan, 2008).” The BGree 2020 plan explicitly acknowledges climate change impacts stating that, “Climate change is already affecting Bridgeport (p. 8)” through sea-level rise, warmer ocean and air temperatures, and changes to local ecology.

Each of the five informants suggested a linkage between BGree 2020 and inclusion of adaptation planning. For example, Grabarz proffered that the City’s robust sustainability program is actively addressing many of the impacts related to extreme weather events. Upon engaging the City, Whelchel noted that there was local interest to “integrate the framework and intent of the BGree 2020 Plan with climate adaptation.” While the BGree 2020 Plan is focused on sustainability planning (including climate mitigation), the literature confirms that mitigation efforts can seed adaptation initiatives (Headwaters Economics, 2012).

The BGree Initiative led Bridgeport to contract the Regional Planning Association to provide sustainability training for City staff. After an initial climate preparedness workshop in November, 2011 led by TNC, CA-CP, and GBRC, it was determined a more effective approach for the City would be to synchronize the sustainability training from RPA with additional climate preparedness workshops (March
and April, 2012). Informants described that the result has been greater awareness of not only mitigation but adaptation as well amongst a broad suite of stakeholders in the City.

The Connecticut Sea Grant program worked with the City in 2010 on a rain garden/stormwater bioretention project, referred to as Stormwater Management as a Climate Change Adaptation Strategy. In a final report to National Sea Grant, the principal investigators affirmed local interests in adaptation. “In our discussions with City of Bridgeport officials,” wrote the Sea Grant project leaders, “not only are they supportive of Sea Grant activities through this Coastal Communities Climate Adaptation Initiative project, but they are also interested in further discussion of climate change adaptation strategies (Sea Grant Project Report – CCCAI 2010).”

Several informants described the City’s Waterfront Recapture Initiative (WRI) as a mechanism for advancing adaptation planning. The WRI seeks to reclaim lands under industrial uses located in riverine, estuarine, and Long Island Sound frontage in Bridgeport and reorient them for public access. The BGreen Initiative motions to remove existing buildings from the waterfront and to get property into public hands for public access, which is embodied in the WRI. This is likened to a “retreat” in terms of climate adaptation, a long-term strategy for relocating development out of coastal areas vulnerable to sea-level rise and storm surge.

Assistance from trusted non-governmental organizations. Since 2007, The Nature Conservancy has been very active in adaptation throughout coastal Connecticut and New York. The organization has largely focused on developing the Coastal Resiliency Tool supported by a sustained engagement process to assist municipalities in addressing
climate impacts. The Coastal Resilience Tool (www.coastalresilience.org) is available online as a free geographic information system-based decision-support interface. The Nature Conservancy has worked closely with municipalities in developing the tool and workshop process, given that adaptation and land use policies are carried out at the local level.

The Nature Conservancy’s early work with the South Shore of Long Island revealed that economic and social information must be integrated with natural resource data. Social, built and natural environment issues are inextricably linked. Municipalities requested a wide range of information such as: locally-specific sea-level rise projections with and without storm surge (CAT-2 and CAT-3), critical infrastructure and facilities, estimates on economic impacts using HAZUS – FEMA’s GIS-based model for estimating potential losses from natural disasters, social vulnerability, and existing/future natural resource information such as salt marsh advancement zones to accommodate migration.

In the late 2000s The Nature Conservancy facilitated a series of workshops with Connecticut communities and conducted individual interviews to identify municipalities with a good track record, and the willingness and capacity to take address climate preparedness. As a result of working closely with the Greater Bridgeport Regional Council, Bridgeport surfaced as a community ready to take on adaptation. In many respects, “Bridgeport is considered the centerpiece of the region and lent itself to providing a viable example of what is possible for other municipalities in Connecticut and the nation,” said Whelchel.
Bridgeport’s Climate Preparedness Assessment – Actors, Roles & Process

Major Actors and Roles. Planning for the vulnerability assessment was a joint effort between City staff and four non-governmental organizations. Mayor Finch, Mike Nidoh (Planning Director), Ted Grabarz (Sustainability Director), the GBRC and RPA identified for CA-CP and TNC the City’s movers and shakers – neighborhood leaders, community groups, social service providers, utility companies, etc. The result was a list of 140 people within or connected to Bridgeport with keen local insights and institutional knowledge, and who were likely to be involved in implementation.

Outreach to those individuals was initiated several months before the first of the two vulnerability assessment workshops. The Nature Conservancy and Clean Air — Cool Planet used several recruitment approaches including flyers, emails, personal phone calls, and in-person visits. Mayor Finch sent an email to City department heads directing them to participate in the workshops. “We would have been there anyway,” admitted one informant, “but he got his point across that this was important.”

Whelchel described that a fundamental part of this initiative included communicating the availability and applications of the Coastal Resiliency Tool. In addition to planning and recruiting participants, TNC, CA-CP, GBRC, and RPA provided the workshops with trained facilitators and recorders.

Clean Air – Cool Planet’s mission is, “To accelerate the transition to sustainable communities through climate mitigation, adaptation planning, and effective climate policies.”

“The mission of The Nature Conservancy is to conserve the lands and waters on which all life depends.” – The Nature Conservancy
The Vulnerability Assessment Workshops. The workshop process was based on the *NOAA Roadmap for Adapting to Coastal Risks* framework with several important advancements. The key reason for using the Roadmap was that it requires a comprehensive consideration of the issue across the entire community. The Roadmap traditionally employs a strategy called 'storyboarding,' wherein stakeholders create visual representations of a sector’s vulnerabilities (e.g., infrastructure) using maps, photos, news articles, and graphs. While storyboards can provide an effective discussion tool, Whelchel described that the process was modified to instead utilize a risk matrix developed by TNC that is linked with a basemap via a participatory mapping approach. The intent was to make the process more pragmatic for participants by constructing a concise list of vulnerabilities and strengths across planning sectors, cross-walked against prominent hazards. The result is a draft list of prioritized actions with a relative assignment of cost that the community can advance by integrating into key action plans.

**Workshop 1 – Defining the Community and the Hazards**

**Monday, April 2, 2012 (8:30 AM – 12:30 PM) at City Hall**

The primary purpose of the first workshop was to set the stage for the vulnerability assessment by highlighting local hazards and introducing key climate adaptation concepts, namely hazards, vulnerability, and risk. The climate adaptation overview then segued into an introduction to the Roadmap process (See Appendix B, Item 2 for agenda).
Several weeks prior to the first workshop, the NGO team released a survey to the community members that collected initial insights about existing concerns, vulnerabilities and priorities. The NGO team summarized and presented the results to attendees. In small groups (Figure 13), participants worked collaboratively to construct a profile of the community's exposure to hazards and key issues or concerns. The workshop concluded with a critical open dialogue designed to strengthen awareness and interest in the issue. This was followed with an opportunity for participants to fill out an evaluation of the first workshop.

Workshop 2 – Vulnerability Assessment

Tuesday, April 10, 2012 (8:30 AM - 12:30 PM), City Hall

Introduction. About 50 people from throughout the City came together again at City Hall. There were five roundtables composed of strategic blends of expertise and experience. Working groups were kept small to ensure everyone an opportunity to participate in discussion. Following a brief opening from the sustainability director highlighting the need for this forum, TNC's lead facilitator outlined the goals of the day:
1. Identify vulnerabilities and assets (vulnerability assessment)

2. Develop actions (adaptation strategies) to be taken by the city, local organizations, businesses, and community groups of the region

3. Identify opportunities for advancing these actions (mechanisms for implementation)

Working groups. TNC assigned participants to working groups according to their expertise (Table 2). Due to the large turnout, two tables worked on all three sectors and constituted a blend of expertise. Each table was staffed with a facilitator and a recorder from CA-CP, TNC, or RPA. The conversation was recorded on a large flipchart beside the table. The facilitator’s role was to guide the table in populating the 4’ x 3’ risk matrix (Appendix B, Items 4 and 5) in this general order:

1. Identify 3-4 climate impacts of concern relative to their sector, recorded at the top.

2. Identify vulnerabilities and strengths on the left.

Figure 14. Stakeholders identifying locations of the City’s climate change vulnerabilities. Photo credit: Adam Whelchel/The Nature Conservancy.
3. For as many of these as possible, record the location, ownership, action(s) relative to each climate impact, priority for action (high, medium, or low), and timeframe for action (near or long-term).²

Table 2. Workgroups at Second Workshop.

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<th>Workgroup Table/Sector</th>
<th>Participant Affiliation</th>
<th>Affiliation Category</th>
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<td>Port Authority City</td>
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<td>City</td>
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<td></td>
<td>Public Facilities City</td>
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<td>Finance Department (Utilities) City</td>
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<td>Societal</td>
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<td></td>
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<td></td>
<td>Environmental Health Department City</td>
<td>City</td>
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</table>

² Each table was provided with a regional basemap encompassing Bridgeport and the immediate neighboring communities. Participants were also provided arrow-shaped color-coded sticky notes (infrastructure, natural resources, societal, and hazard) to record specific locations of vulnerabilities.
Report outs. At the conclusion of the small working groups, a reporter from each
table shared with the larger group what their group identified as the impacts of concern to
their sector(s), the highest priority vulnerabilities and strengths, possible actions to take,
and the general nature of their discussion. Some participants also described how they
arrived at their conclusions – e.g., based on personal experiences or the knowledge they
bring from their discipline.

Open discussion. The TNC convener facilitated a full-group discussion about the
information gathered from the report-outs. Questions included:

• What are the common concerns about impacts and vulnerabilities?
• Who is missing from this dialogue?
• What was your favorite adaptation strategy?
• What surprised you?
• What did you like in your discussion?

Workshop 3 – Results and Next Steps

Wednesday, June 13, 2012, City Hall
Over 50 participants and stakeholders attended a public presentation of the preliminary results. Attendees had an opportunity to choose from a list of action items that they could help implement within their respective roles in the community. Following this third workshop, a summary report was sent out to all municipal staff and participants in August 2012.

Outcomes of the Vulnerability Assessment

The Big Picture. By conducting a stakeholder-driven vulnerability assessment, the City of Bridgeport progressed in climate adaptation in several fundamental ways. First, stakeholders established a comprehensive list of observed and potential climate impacts, community strengths or sources of resilience, and prioritized actions. This inventory provides a vision for how the City can direct its attention on climate preparedness moving forward. While policy changes remain to be implemented, the groundwork has been laid in identifying the issues and engaging the actors necessary for action.

Moreover, the list from this comprehensive assessment provides a framework to overlay with planning documents (e.g., land use, harbor management, parks master plan, emergency management plan, hazard mitigation plan, etc.). In essence, it begins to resolve the questions of "what can be done, where, how, when and by who?" Such answers are a precursor to relocating or protecting critical infrastructure or other vulnerable assets, modifying build codes, and other adaptation actions. Clean Air – Cool Planet is analyzing City plans in summer 2012 to identify specific opportunities to integrate action items.
Attention to focus areas. The heightened awareness, while difficult to measure, is inherent to the community dialogue generated from the stakeholder-driven approach. The vulnerability assessment provided a forum for the community to raise attention to existing issues while planning for emerging impacts. The preliminary findings (Appendix E) suggest a few major themes in the City's existing and future vulnerabilities.

Transportation. Participants identified access issues citywide. In specific coastal and low-lying areas, stakeholders pinpointed compromised evacuation routes and accessibility of emergency services. Given Bridgeport's role as a regional transportation hub, stakeholders recognized that the airport, rail, ferries, bus, highways, local roads, bridges, and viaducts are all vulnerable to climate impacts yet integral to the regional transportation network.

Stakeholders voiced that clearance between roads and the railroad viaducts becomes sufficiently narrow during flooding events and blocks emergency vehicles from accessing certain neighborhoods. The planning director described that elevating and widening railroad viaducts superstructure was a desirable short-term action for increasing the City's resiliency to flooding.

Increased focus on conservation. Participants identified specific tidal marshes (East End, Ash Creek) for conservation as an adaptation strategy. Given that stakeholders have recognized the key role that conservation can play in adaptation, the City gained from an increased rationale for conservation. Expanding the breakwater to protect the barrier beaches, such as at Pleasure Beach, was deemed a high-priority action for preserving and advancing dunes. City parks were recognized as an opportunity to limit development and facilitate stormwater retention and filtration.
Explicit concern of coastal infrastructure. An extensive amount of critical infrastructure, including gasoline and oil storage facilities, electrical utilities, two sewage treatment plants, and many privately owned assets, are located immediately on the coastline. The sewage treatment plants’ ability to treat current levels of intake from CSOs has already been demonstrated to be under capacity (Harbor Management Plan, 2008). The vulnerability assessment draws greater attention to the vulnerability of these assets. There will likely be major costs involved in preparing the coastal infrastructure for climate impacts, and the vulnerability assessment provided a forum to initiate that dialogue.

Communications. During the workshop, several participants voiced concern over the impacts of communication systems being compromised. The Bridgeport Office of Emergency Management encourages residents to have a disaster kit and contingency plan, particularly for individuals with special needs. Moving forward, the concerns raised in the vulnerability assessment may provide leverage for further developing the City’s communications infrastructure (both social networks and physical installations).

Heightened attention to vulnerable populations. Participants recognized the proportion of low-income residents and those with special needs (e.g., hospital patients, seniors) as a major societal vulnerability. In an emergency, these people need access to transportation and communication. Thus, the sense of community in Bridgeport has called out the need to protect vulnerable populations.

Food security. The Societal Workgroup (Table 2) pointed out that Bridgeport is very vulnerable to food shortages during emergency events because so little of its
population gets food from local sources. As a result, Bridgeport relies heavily on surrounding transportation networks to bring food into the City. If transportation were severely compromised, "the grocery store shelves would be bare in a day or two," said a stakeholder. Meanwhile, a City staff person has been working with Mayor Finch to identify parcels in the City that could be used for urban agriculture. This forum provides an elevated need for the additional plans for urban gardening that are in the works.

Lessons Learned on Climate Adaptation from Bridgeport, Connecticut

The story of adaptation in Bridgeport offers a range of insights into process design, participant recruitment, organizing participation, and potential outcomes. These insights were collected and reported from first-hand accounts of informants in concert with personal observation of the vulnerability assessment and analysis within the context of the City. Of the dozen interview questions in the instrument, two were directly targeted on collecting this information:

1. In reflecting on your experiences and the answers provided, what additional advice would you offer to technical assistance providers working on climate adaptation?

2. Is there anything you would like to share about Bridgeport’s experience with adaptation that we may not have covered?
Personal observation lent itself to close analysis of the design for an adaptation process, recruiting participants, and utilizing participants experiences and institutional knowledge. Many of these sentiments are reflected in the literature and in informants’ experiences from working with communities in the Northeast and elsewhere (as cited in several text boxes herein).

Gauging community readiness for adaptation

Know the community. “First and foremost,” said Whelchel, “know your community.” It is important to have a clear sense of the geopolitical boundaries, and how the community is positioned in the state context. Technical assistance providers need to be aware of past conflicts and resolutions between a municipality and higher levels of government. State and federal agencies can play an important role in near- and long-term actions.

However, agencies can dramatically change the dynamic of community dialogue, so technical assistance providers need to make an informed decision as to what stage in the process is most appropriate to include them. Nonetheless, they must eventually be included so that they are aware of the context and can assist with enabling the conditions necessary for action. Whelchel described that identifying commonalities in local, state, and federal perspectives has been a successful approach to fostering implementation in previous TNC workshops.

In testament to Whelchel’s comment regarding longevity in municipal staff, Mayor Finch has been involved in the City his entire life. Appleby has worked in the City’s emergency management office for 18 years, and the Planning Director has worked for the City for nearly 30 years.
It is also important to investigate screening questions to be sure a municipality is ready and willing to plan for climate change. What kind of stakeholder process have they used in the past on large issues? Who are the movers and shakers in the community? What is the community’s track record on change and controversial issues? “Longevity in municipal staff can be a positive sign,” said Whelchel. He continued, “Subtle details such as the relationship between the town planner and elected officials, or the community’s debt rating, are all important factors.”

Finally, where on the spectrum is the community with regards to considering climate change in master planning, hazard mitigation, natural resource management, etc.? Has the community made any formal reference to sea-level rise? Are there existing initiatives to build upon? In Bridgeport’s case, the BGreens 2020 Sustainability Plan provided a major launching pad for adaptation with its resulting partnerships and attention to increasing climate change awareness.

Well-planned and structured participation

Framing recruitment. Conveners need to clearly convey to stakeholders how their institutional knowledge is relevant to climate adaptation. In-person visits were said to be particularly effective. Sometimes it was only, “when they heard it over the phone or in person that they understood why they were being invited,” said Gillespie. For example, social services staff were unsure why they needed to be involved, but they understood when she explained to them that, “their institutional knowledge was an important ingredient of Bridgeport’s public safety and future.”
The sustainability director explained that Public Works staff and Fire and Police Chiefs need to be involved, but they sometimes fail to see the connection. “Convert climate change into language that they understand in the emergency management world,” he said. Doing so will help to bring in the people most affected by climate change.

Finally, several informants described that part of the messaging around recruitment was that “Bridgeport is setting an example.” Bridgeport was one of the first medium-sized cities on the eastern seaboard to take on such a project, they said. Participants were encouraged to take a role in something that is not part of their day-to-day jobs. “They made time in their day, and contributed their expertise because they felt like they were akin to pioneers in some ways,” said Gillespie.

Comprehensive recruitment. As seen in Bridgeport, a comprehensive analysis benefits from an equally broad range of stakeholder participation. However, interviews with conveners and feedback from participants indicated that several stakeholders were missing from the original dialogue including school officials, GIS experts, land-use lawyers, and religious groups. School boards can also play a key role. Twelve or more of the City’s public schools are designated as emergency shelters, yet the Board of Education was absent from the first two workshops.

Religious institutions may encompass broad social networks key to communication before, during, and after disaster events. The City’s GIS staff person was invited to the April and May workshops, but was unable to attend. Had he been there, facilitators could have pinpointed assets vulnerable to sea-level rise and storm surge scenarios in concert with small and large group discussions. Given that climate
adaptation strategies such as rolling setbacks and limits to development can raise legal controversy, land use lawyers need to be part of the discussion. Finally, “Commercial real estate brokers seem to know everything there is to know about a municipality,” said Gillespie. She suggested that they can help inform discussions about coastal real estate values and business development plans, which need to be part of the logistical strategies.”

Comprehensive assessment. Several participants gave feedback that Bridgeport’s focus is largely on infrastructure and people. Meanwhile, there are many environmental impacts that necessitate attention. “We’re focusing a lot on holding water back, as with tide gates,” said Grabarz, but “changes in ecology need to be looked at more deeply.” To this end, local knowledge and ecological expertise are important for such analysis.

Participation logistics in vulnerability assessment

Focused participation. Based on the results of the profile-focused tables, facilitators noticed that participants at the mixed tables had a difficult time tackling all three sectors simultaneously. Instead, stakeholders might focus on a single sector while making note of overlaps with other areas of concern. Climate adaptation presents a lot of variables and information to consider. By narrowing the focus of working groups, participants can better drill down into specifics, rather than be stretched thin across multiple substantive areas.

Consider the logistics of roundtable work. The 3’ x 4’ risk matrix was laid on the table in front of each facilitator. Instead of being most visible only to the

“it's all about building awareness, consensus, and community around this issue. As long as you provide a thoughtful, professional process - it'll only enforce the community building piece,” said Whelchel.
facilitator, and upside down to the rest of the group, post the matrix as well as the basemap up on a wall or easel. Arrange participant seating in a semicircle so everyone can see the materials and one another.

Utilize experiences and stories. “Anecdotal stories can be exceedingly powerful,” said Whelchel. In this light, technical assistance providers need to know the community and who holds what types of insights. Linking the decision-makers with the local experiences can be very effective, he added.

Facilitating action. Conveners explained that there was an implicit strategy to closing the workshop with an open discussion. “In order to motivate a community to take action,” Whelchel outlined a few steps. First, you have to ensure that people are aware that there is an issue. Hence, the facilitated discussion at the close of the second workshop sought to emphasize commonalities amongst participants’ concerns. Second, it is important for people to talk about what the issue(s) mean to them personally. This provides an opportunity for participants to voice their concern and to be heard. Finally, the open discussion also provides exposure to different perspectives, and to understand ways that climate change impacts are felt locally beyond the purview of the individual.

Report-outs are “a really important ingredient” in forums such as this, Whelchel added. It is a rare stage where a community dialogue is facilitated by neutral, external non-governmental organizations. Rarely do such broad stakeholders come together, particularly around the issue of planning for the impacts of climate change. Making new connections while talking about this issue begins to forge the necessary networks for future action in the community, both on adaptation and beyond.
Make adaptation manageable

Itemized planning. “Break it down into things that can be easily done in the near-, medium- and long-term,” suggested the planning director. There is great uncertainty around resources available for implementation.

Low hanging fruits – Raise resilience where relocation is not practical. Begin with the most reasonable solutions. “Let’s not try to relocate private residences,” said the planning director. “Instead, look at how you can make ‘this section of the city’ more resilient.” For example, he suggested increasing the height of the viaducts to allow for evacuation/emergency vehicles to access certain neighborhoods.

Focus on the concerns that citizens identify with and buy-in to taking action.

Measuring success. Indicators of success can manifest outside of changes to plans and policies, particularly in the short-term. Conveners identified a heightened awareness about sea-level rise during and immediately following the workshop. For example, Gillespie described how after the workshop a participant removed seaside parcels from land procurement plans for agriculture upon seeing sea-level rise scenario maps. In another instance, a coastal real estate broker at the workshop voiced his concern about sea-level rise during the report-outs. He exclaimed that he now understands that certain developments he had envisioned and was trying to sell will need to be modified due to low elevation.

“Success might not be defined as an adaptation plan, but in the way managers incorporate climate change in the back of their mind and into smaller day-to-day decisions, which add up (Kresge Foundation, 2012).”
IV. CASE STUDY #2: EXPLORING ECONOMIC OPTIONS TO PROTECT HAMPTON-SEABROOK ESTUARY COMMUNITIES FROM COASTAL FLOODING DAMAGES

Overview: This case study of adaptation is focused on three neighboring communities in New Hampshire engaged in a stakeholder-driven investigation of the impacts of sea-level rise and storm surge upon public and private real estate. The process was centered on a GIS-based cost-benefit analysis of adaptation vs. no action. Case study analysis was based on participant-observation, interviews, and document data. Participant-observation provided insight into project design and community engagement as well as the objectives the three stakeholder working meetings through 2011-2012. Interviews collected insights from six technical assistance providers: Derek Sowers (Co-Principle Investigator and Conservation Manager, Piscataqua Region Estuaries Partnership), Sam Merrill (Co-Principle Investigator and Technical Modeler, New England Environmental Finance Center), Julie LaBranche (Senior Planner, Rockingham Planning Commission), Sherry Godlewski (NH Department of Environmental Services), Steve Miller (Great Bay National Estuarine Research Reserve), Amanda Stone (UNH Cooperative Extension). Finally, major document data included local planning documents, meeting agendas, economic model outputs, news articles, and demographic data.
Community characterization

Regional characteristics. The Hampton-Seabrook Estuary spans six towns of southern New Hampshire and one in Massachusetts. Of the six New Hampshire communities, Hampton, Hampton Falls and Seabrook cover the greatest extent of the
estuary's 4,000 acres of tidal marsh (Table 3). Outside the marsh, New Hampshire's coastline is described as predominantly rocky with sandy beaches and some sand dunes (Hampton Master Plan, 2009).

Three primary roads run parallel to the coast and serve the estuary's communities. Route 1A is nearest to the shoreline and narrowly divides the beaches from coastal residences and businesses (though it does not reach Hampton Falls). About five miles inland is Interstate 95, and between the two is Route 1. Both of these roads are designated as major evacuation routes in the event of an emergency at the Seabrook Nuclear Power Plant, which also extends into local emergency operations plans (NH Department of Safety).

With regards to municipal services, all three communities have full-time police, fire, and emergency medical services with the exception of emergency medical services in Hampton Falls, which is operated by volunteers (NH Economic & Labor Market Information Bureau, 2012). All three communities have a board of selectmen and hold annual town meetings. Finally, Seabrook is the only community with a town manager.
See Table 3 below for additional insights and comparisons in the three communities.

<table>
<thead>
<tr>
<th></th>
<th>Surface Water &amp; Wetlands</th>
<th>Forest</th>
<th>Residential</th>
<th>Business</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hampton</td>
<td>36% (3,305)</td>
<td>19% (1,720)</td>
<td>26% (2,355)</td>
<td>4% (367)</td>
<td>15% (1,341)</td>
<td>100% (9,088)</td>
</tr>
<tr>
<td>Hampton Falls</td>
<td>4% (357)</td>
<td>53% (4,251)</td>
<td>13% (1,020)</td>
<td>1% (70)</td>
<td>19% (1,535)</td>
<td>100% (8,078)</td>
</tr>
<tr>
<td>Seabrook</td>
<td>39% (2,445)</td>
<td>18% (1,114)</td>
<td>23% (1,385)</td>
<td>8% (485)</td>
<td>12% (730)</td>
<td>100% (6,159)</td>
</tr>
</tbody>
</table>
Hampton Falls. Hampton Falls is located on the inland northwestern extent of the estuary. The Town Master Plan (2002) describes the land use pattern as “basically rural.” As shown in Table 3, overall land use differs relatively little across the three communities with a few exceptions. Hampton Falls has the largest proportion of forest cover (53%) and lowest proportion of surface water and wetlands (4%). While Hampton Falls is the smallest community in terms of population, it is also the most affluent with an average per capita income of $53,371 from 2006-10 (US Census reports $31,422 as New Hampshire’s average during the same period). About 86% of the town is in 2005 FEMA-designated flood hazard areas (Hampton Falls Master Plan 2006). These areas span four sub-watersheds, demonstrating that flood hazard management is inherently a multi-jurisdictional issue.

Seabrook. Seabrook is the southernmost community and borders Salisbury, Massachusetts. The town is “relatively flat with 95% of the land area under 60’ above sea level (Hazard Mitigation Plan 2005, 7).” Due to flat topography coupled with extensive wetlands, the Hazard Mitigation Plan (2005) identifies flooding and coastal storms as major threats to the town.

The population in Seabrook was 8,693 in 2010, which represents a 9% increase from about 8,000 in 2000 (Economic & Labor Market Information Bureau, 2012). While residential uses dominate 64% of currently developed lands (Hazard Mitigation Plan 2005), Seabrook’s low tax environment has welcomed over 250 industrial, commercial, and retail companies (Town of Seabrook Website). The town’s largest employer is also the only nuclear power plant in the state: the NextEra Seabrook Station (NH Economic &
Labor Market Information Bureau, 2012). It is located on the western edge of the salt marsh.

Hampton. Hampton’s population totals just over 15,000 and is the largest community of the three. It has twice the population of Seabrook (8,693) and about seven times the population of Hampton Falls (2,236). One research participant highlighted that Hampton is heavily developed and close to full buildout of developable lots. The Hampton Master Plan (2009) states the town has approximately 5.4 miles of sandy beach and rocky shores. A concrete seawall (Figure 16) between the beaches and Route 1A spans approximately four miles of the coast from Hampton’s North Beach to the Seabrook-Hampton town border, which coincides with the estuary’s single surface drainage point to the sea. There are three public beaches in Hampton: Hampton Beach State Park, Hampton Beach, and North Beach.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Hampton Falls</th>
<th>Hampton</th>
<th>Seabrook</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (2010)</td>
<td>2,236</td>
<td>15,430</td>
<td>8,693</td>
</tr>
<tr>
<td>Average per capita income (2010 inflation adjusted $)</td>
<td>$53,371</td>
<td>$37,680</td>
<td>$29,907</td>
</tr>
<tr>
<td>Families below poverty level</td>
<td>4.6%</td>
<td>5.8%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Population density (persons per square mile of land area)</td>
<td>183</td>
<td>1,196</td>
<td>977</td>
</tr>
</tbody>
</table>

| Government & services | | |
|-----------------------|-----------------|-----------------|-----------------|
| Government | Selectmen | Selectmen | Selectmen/Town Manager |
| Emergency Services | Fire: Full time chief, volunteer firefighters | Police: Full time officers and sheriff's dept. | Emergency medical: Full time |
| | Fire: Municipal | Police: Full time | Emergency medical: Full time |
| Capital Improvement Plan | Yes | Yes | Yes |

| Utilities | |
|-----------|-----------------|-----------------|-----------------|
| Wastewater Treatment | None | Municipal WWT plant | Municipal WWT plant |
| Electric supplier | Unitil | Unitil | Unitil, PSNH |
| Natural Gas | Northern Utilities (Rt. 107 only) | Unitil | Unitil |
| Water supply | Private wells | Aquarion Water Company NH | Municipal |
| Tax base (2010 Percent of Local Assessed Valuation by Property Type) | | |
| Residential Land and Buildings | 89.1% | 83.6% | 31.9% |
| Commercial Land and Buildings | 8.7% | 13.4% | 11.8% |
### Land Use (as % of developed lands)

<table>
<thead>
<tr>
<th>Public Utilities, Current Use, and Other</th>
<th>2.2%</th>
<th>3.0%</th>
<th>56.2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total housing units</td>
<td>867</td>
<td>9,708</td>
<td>4,640</td>
</tr>
<tr>
<td>Land use (as % of developed lands)</td>
<td>Not available.</td>
<td>Not available.</td>
<td>Residential: 64% Commercial: 18% Industrial: 11%</td>
</tr>
</tbody>
</table>

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**Transitioning from Concern to Action on Climate Adaptation**

Research participants described a diversity of local and external factors that led the communities to pursue climate adaptation. Action on adaptation in the Town of Seabrook was a large driver for the project, while the ecological boundaries of the estuary naturally led to the inclusion of Hampton and Hampton Falls.

**Support from technical assistance providers.** The New Hampshire Coastal Adaptation Workgroup (henceforth, “CAW”) formed in early 2010 in response to impacts on communities from recent storm events and as a recommendation from the State’s Climate Action Plan to form an adaptation workgroup. Hence, there was a local body of service providers that recognized the need for this type of project. They were personally and professionally motivated to help communities reduce and prevent damages from climate impacts.

The Hampton-Seabrook Estuary adaptation project was one of 11 projects funded by the Environmental Protection Agency’s Climate Ready Program.

CAW is an ad-hoc workgroup of about 20 local, state, and federal organizations involved in climate adaptation in coastal New Hampshire. The mission of CAW is to help coastal watershed communities develop and implement climate adaptation strategies and policies, and to expand local capacity for adaptation planning.
Estuaries (CRE) program in 2011 (EPA 2011 CRE Progress Report). The Casco Bay Estuary Partnership of Maine and the Piscataqua Region Estuaries Partnership of New Hampshire/Southern Maine applied for and split $70,000 to conduct similar projects by contracting with the New England Environmental Finance Center (NEEFC). The goal of the Hampton-Seabrook Estuary project was to work with Hampton, Seabrook, and Hampton Falls, the three towns bordering the Hampton-Seabrook Estuary, to examine the potential economic impacts from sea-level rise and coastal storms and the potential economic benefits of implementing adaptation measures to reduce community vulnerabilities.

**Existing action and leadership on climate adaptation.** Every participant highlighted the influence of Seabrook’s momentum in planning for climate change impacts. A local champion was widely cited for catalyzing action on climate change in the community. She was actively involved in her community as Conservation Commission chair, Planning Board chair, and chair of the Master Plan Steering Committee. The senior planner described her as instrumental in initiating the Rockingham Planning Commission’s 2009 study, *Adaptation Strategies to Protect Areas of Town at Risk from Coastal Flooding Due to Climate Change*. Since that time, the Seabrook Planning Board has used the report to inform discussions of coastal land use and planning.

"It's a tool to facilitate discussion... They reference that report as a benchmark. It also gives them validity to their discussion... a series of maps help to illustrate the vulnerability of the coastal area."

— Senior planner
Regional significance. There was enthusiasm amongst service providers to extend the focus of the project to include all three New Hampshire communities of the Hampton-Seabrook Estuary as a natural system. The estuary is a highly valued system amongst natural resource managers as it includes the greatest extent of the state’s salt marsh habitat (Eberhardt and Burdick 2009). Along with the Great Bay Estuary, it is also recognized by the Environmental Protection Agency as an estuary of national significance. While the Great Bay Estuary is the focus of considerable research and stewardship, a service provider explained that PREP has an interest in “elevating the awareness” of the Hampton-Seabrook Estuary. In addition to the ecological significance, the service providers highlighted that it was an opportunity to foster multi-jurisdictional collaboration and planning.

Demonstrated awareness. The Hampton Master Plan’s Natural Resources Chapter (2009) includes a dedicated section identifying awareness of climate change impacts and the need to plan accordingly. It states, “Climate change and sea-level rise are factors to consider in the long range planning for Hampton’s natural resources (p. 4).” In addition to recognizing economic impacts resulting from changes in winter and summer tourism and agricultural production, the plan also suggests awareness that “coastal real estate values may also be affected (4).” The lone recommendation in the Coastal Resources section is to “conduct an adaptation planning study to identify existing and potential measures to mitigate the effects of sea level rise and storm events (40).” The senior planner, who was involved in developing that master plan, explained that local officials
generally felt strongly about putting climate change language in as a component, but not as a focus.

Finally, all three communities have a documented commitment to climate change mitigation. Each of them adopted the NH Climate Change Resolution of 2008. Around the state, 162 municipalities signed the resolution proclaiming local commitment to work toward reducing local greenhouse gas emissions through local steps to save energy (Carbon Coalition 2008).

The approach to climate adaptation: A stakeholder-driven process using the Coastal Adaptation to Sea-Level Rise Tool (COAST)

Stakeholder recruitment – September-October, 2011.

The senior planner played a key role in stakeholder recruitment due to her preexisting engagement with them in municipal planning processes. She advised CAW in crafting the engagement plan with the goal being maximum participation. To begin, she engaged several town officials in each community before formal presentations to town boards to describe the value of the project to ensure buy-in and arrange time on meeting agendas. In teams of two, CAW members approached conservation commissions, planning boards, selectmen boards, and emergency management. They delivered a 10-minute presentation and a handout with a consistent message that emphasized:

“We wanted to get buy-in ahead of time so they understood the value of the project.”
– Service Provider
Minimal commitment: three meetings over nine months
The project was focused on economic benefits and improved public safety
The project was to be stakeholder-driven to address specific local concerns

Major Actors and Roles.

- Coastal Adaptation Workgroup. CAW partner organizations provided oversight to the project design and assisted with community engagement and facilitation. While each of the CAW partner organizations contributed skills and expertise to the project, several played a key leadership role including:
  - Piscataqua Region Estuaries Partnership (PREP). Derek Sowers of PREP was the project leader. In addition to applying for and managing the grant money, he coordinated input from CAW and informed the technical modelers of local activities, data and needs. He was also a lead facilitator during the three stakeholder working sessions. Sowers expressed that CAW's technical expertise and support with outreach was critical to the success of the project. The project did not provide funds for outreach and engagement; the majority of funds went to the consultant (NEEFC) for the modeling analysis.

CAW partner organizations:
Carbon Solutions New England
City of Portsmouth
Clean Air – Cool Planet
Great Bay N.E.R.R.
Natural Resource Outreach Coalition
NH Coastal Program
NH Dept. of Environmental Services
NH Sea Grant
NOAA Coastal Services Center
Piscataqua Region Estuaries Partnership
Rockingham Planning Commission
Strafford Planning Commission
The Nature Conservancy
Town of Newington
Town of Seabrook
UNH Cooperative Extension
Thus, CAW’s voluntary role was largely a result of complimentary institutional missions and members’ personal dedication to helping communities.

- **Rockingham Planning Commission**: All three communities of the project are within Rockingham County and contract for services with the planning commission. Hence, staff from RPC – particularly the senior planner assigned to these three communities – coordinated communication to and from the towns by leveraging existing trust and working relationships. She was instrumental in sharing with CAW her expertise in municipal planning processes and her awareness of local dynamics.

Outside of CAW, there were three additional key actors:

- **Municipal officials and community members**: Municipal officials were the primary actors from Hampton, Hampton Falls, and Seabrook. Approximately 3-5 officials from each community were actively involved throughout the process representing planning boards, conservation commissions, emergency management, selectmen, and zoning boards. Several community members joined the project as it got underway.

- **New England Environmental Finance Center (NEEFC)**. Sam Merrill led the analysis at NEEFC and was present with CAW at each of the three community working sessions. The primary role of NEEFC (and their subcontractors) was to conduct modeling of sea-level rise and storm surge scenarios for cost-benefit
analysis of adaptation strategies to protect assets selected by the three communities.

- **Environmental Research Group (ERG).** Based at the University of New Hampshire, Paul Kirshen of ERG led the modeling of the specific adaptation strategies. Kirshen also coordinated with GIS experts and engineering firms to gather conceptual costs to implement adaptation strategies for specific vulnerable real estate assets.

**Kick-off Meeting – Wednesday, October 27, 2011, 6:00-9:00 pm, Hampton Falls Library.**

*See Appendix B, Item 1 for Agenda.*

The kick-off meeting introduced the project in greater detail, and established a core group of stakeholders to inform the direction of the project. Although the stakeholder turnout was lower than anticipated, service providers reflected that the “the group was really interested” and that there was good representation of some key stakeholders such as emergency managers and local government board officials. After stakeholder and project team introductions, CAW member and University of New Hampshire climatologist Dr. Cameron Wake delivered a 20-minute overview of projected climate impacts in coastal New Hampshire focused on sea-level rise and storm surge. Dr. Sam Merrill, the economics expert from the NEEFC, then gave a 30-minute overview of the Coastal Adaptation to Sea-Level Rise Tool.
(COAST). COAST\textsuperscript{3} is the GIS-based cost-benefit modeling tool central to the project. He also summarized the three categories of sea-level rise adaptation strategies (protect, retreat, or accommodate) with several photographs showing examples from around the country. Lastly, he presented the range of possible assets that could be modeled as the focus of the project:

- Lost real estate values
- Lost economic output
- Displaced persons
- Lost natural resources values
- Lost cultural resources values
- Infrastructure (culverts, bridges, roads, utility lines)

Stakeholders were initially very confused about the modeling and what input the project team needed. With guidance from project staff, stakeholders chose to model the vulnerability of public and private real estate. When presented a choice in the range of future climate scenarios to use in the modeling, stakeholders sought council from the project team. Finally, given limited time and technical knowledge of the modeling tool, the modeling team determined a few modeling details on behalf of the group, including:

- A discount rate of 3.5\% for net present value calculations,
- A 1\% increase over inflation in the real value of the modeled assets,

\textsuperscript{3} For more information on the COAST tool: http://efc.muskie.usm.maine.edu/docs/coast.arcuser.pdf
The best available science from Vermeer and Rahmstorf (2009) for four global sea-level rise scenarios: low and high sea-level rise in 2050, and low and high sea-level rise in 2100,

- A compromise estimate of the 100-year flood elevation based on current FEMA Flood Insurance Rate Maps (FIRMs) and local tide gauge analysis (Wake et al. 2011).

Stakeholder Working Session 2, “Reviewing Modeling Results” – February 23, 2012, 6:00-9:00 pm, Hampton Falls Town Hall. See Appendix B, Item 2 for Agenda.

In preparation for the second meeting, the project team met several times with the modeling team to review the material to be presented. In response to participant confusion from the first meeting, a service provider explained, “We applied that learning to the second meeting... to be more clear and concise about what we were asking them [stakeholders] to do.” Several participants expressed that the extra preparation really paid off.

At the second meeting the stakeholders from Hampton, Hampton Falls, and Seabrook reviewed the first round of modeling results. Dr. Merrill used an LCD projector to briefly navigate through Google Earth to highlight the contrasts in the spatial extent...
and range of possible flooding damages throughout the three communities (Figures 20 through 25).

Dr. Merrill also presented a tabulation of the cumulative damages estimates from taking no action across three scenarios out to 2050 (Table 5) and 2100 (Table 6). A major finding was that across all scenarios, the proportion of damages from storm surge far exceeded the costs of permanent inundation from sea-level rise. Moreover, the storm surge damage estimates suggested that action is necessary regardless of the rate of sea-level rise.

The tabulated damages and printed maps were also parsed out and provided separately for each town. GIS-loaded computers were also on hand, though technical difficulties made only one operational. The maps used “extruded polygons,” or parcel-shaped vertical bars with height relative to the damage estimate. A parcel with an asset that was severely affected would have a very tall polygon, whereas a less-affected asset

 Figure 18. Community members discussing vulnerable assets with facilitators. Photo: Chris Keeley/NH Sea Grant.

Figure 19. Participants cataloguing specific concerns and indicated key focus areas. Photo credit: Chris Keeley/NH Sea Grant.
would have a shorter polygon. The relative magnitude of damages from storm surge were shown in blue, and sea-level rise in red (Figures 20 through 25).

As the stakeholders reviewed the modeling results, recorders at each town’s table noted their concerns on a flipchart (Figure 19). At the end of the meeting, each participant applied sticky dots to tally town-specific concerns before entering into a full group discussion to identify commonalities and how to proceed with the modeling.

<table>
<thead>
<tr>
<th>2050 SLR Scenario</th>
<th>Adaptation</th>
<th>Cost (M)</th>
<th>Real Estate Damage</th>
<th>% Damage from SS</th>
<th>% Damage from SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>No SLR</td>
<td>No action</td>
<td>$0</td>
<td>$463,400,542</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Low SLR</td>
<td>No action</td>
<td>$0</td>
<td>$503,504,672</td>
<td>85%</td>
<td>15%</td>
</tr>
<tr>
<td>High SLR</td>
<td>No action</td>
<td>$0</td>
<td>$550,047,454</td>
<td>82%</td>
<td>18%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2100 SLR Scenario</th>
<th>Adaptation</th>
<th>Cost (M)</th>
<th>Real Estate Damage</th>
<th>% Damage from SS</th>
<th>% Damage from SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>No SLR</td>
<td>No action</td>
<td>$0</td>
<td>$1,407,215,562</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Low SLR</td>
<td>No action</td>
<td>$0</td>
<td>$1,952,391,293</td>
<td>75%</td>
<td>25%</td>
</tr>
<tr>
<td>High SLR</td>
<td>No action</td>
<td>$0</td>
<td>$2,859,403,212</td>
<td>62%</td>
<td>38%</td>
</tr>
</tbody>
</table>


Outcomes of Working Meeting #2. The senior planner explained a critical observation made by stakeholders from Seabrook. While certain assets like wastewater treatment and schools showed very high damages (Figure 25), there were many small parcels (private homes) with damages along Seabrook Beach. When lumped together, they represented a major vulnerability to the town’s tax base that could exceed damages to individual major assets. Moving forward, stakeholders requested that damages to these small parcels be accounted for as a single unit when considering appropriate adaptation options.

"There was a much higher level of community engagement at that meeting.”
– Service provider
Maps from Hampton Falls displayed relatively small areas of impact. Participants from their community keyed in on two sections of Route 1 and how flooding affected emergency management and evacuation routes (Figure 24). “They were surprised, thinking it was too far inland to be impacted,” one service provider observed. “But they got it,” he added, “they saw the roads were going to flood… and instantly went to, ‘What can we do about it?’”

After examining town-specific vulnerabilities for 30 minutes, stakeholders reconvened in a full group discussion about next steps. In addition, they completed individual questionnaires aimed at helping the project team understand their preferences for a range of adaptation strategies. From the questionnaires and full group discussion, they decided for the next phase to examine the costs of strategies to protect key public facilities and private real estate. With regards to potential strategies (protect, accommodate, or retreat), participants demonstrated a strong understanding of the value of marshes as natural buffers. “They didn’t want adaptation actions that were detrimental to the estuary,” said the project leader. Thus, subsequent modeling assumed continued efforts in marsh preservation.

Overall, project staff reflected that the second meeting was a major turning point for the participants, that they absorbed the information and felt empowered to discuss taking action. In summary, extent and magnitude of flooding identified in the second stakeholder working session generated four major takeaways (as synthesized by project from participant post-meeting questionnaire):
• Major issues or assets of concern include Route 1 and adjacent homes and businesses, evacuation routes, critical facilities, marsh migration, and loss of coastal beaches.

• Stakeholders voiced that many assets will require collaboration with neighboring towns as well as state and federal agencies.

• There was equal interest amongst stakeholders in adaptation strategies to accommodate (e.g., elevate), preserve (e.g., use natural areas as buffers), and protect (e.g., seawalls, levees) vulnerable assets, but relocating existing assets out of harm’s way was determined a last resort.

• A mix of public and private funds is likely necessary for adaptation.

The final iteration of modeling was determined to examine the cost-benefit of implementing accommodation and protection strategies in the present (i.e., proactive adaptation). A rough sensitivity analysis of when to take action was incorporated into the study for the highest value assets, as the project team agreed that this has a strong influence on a community’s decision about when an adaptation action’s cost is offset by the relative reduction in risk and likely damage costs during extreme storm events. The modeling served in essence as a discussion tool. As evidenced at the third and final meeting, it helped to identify areas for further inquiry.
Figure 20. Lost Real Estate Value for Scenario: Year 2050, Low Sea-Level Rise, 10-Year Storm.

Figure 21. Lost Real Estate Value for Scenario: Year 2050, High SLR, 100-Year Storm.
Figure 22. Lost Real Estate Value for Scenario: Year 2100, Low Sea-Level Rise, 10-Year Storm.

Figure 23. Lost Real Estate Value for Scenario: Year 2100, High Sea-Level Rise, 100-Year Storm.
Figure 24. Compromised Evacuation Routes in Hampton. The tool was also able to demonstrate vulnerabilities in the transportation network from the spatial extent of flooding damages.

Figure 25. Vulnerable critical facilities/public assets in Seabrook.
The third and final stakeholder meeting involved a mix of large and small group discussions to cover several objectives:

1. Overview of October 2011 and February 2012 stakeholder meetings.
2. Review final results for each town’s cost-benefit analysis of taking action to protect real estate.
3. Break into two groups – Public Real Estate and Private Real Estate – to explore challenges, barriers, and opportunities regarding the implications of the model results.
4. As a large group, brainstorm action items to further use or build upon the modeling results, and ways to sustain the dialogue and momentum in adaptation planning in the communities. Actions were categorized separately for stakeholders and CAW.
Cost-benefit analysis – Critical Facilities/Public Assets. Project staff highlighted that adaptation is a long-term process wherein actions are needed at different time periods or ‘thresholds,’ defined as when the lowest-elevation building of the asset will receive any flooding (Table 7). It was noted that many of the vulnerabilities do in fact merit action in the present. For example, the Hampton Sewage Pump Station is located at 6.6’ North American Vertical Datum (NAVD), and thus presently vulnerable to a 100-year flood (9.8 NAVD per FEMA guidelines).

In contrast, the modeling concluded that the NextEra Nuclear Power Plant is safe from flooding into 2100. However, the focus of the modeling is limited to above-ground conditions. Stakeholders recognized that the radioactive waste is stored underground and likely vulnerable to elevated groundwater/saltwater intrusion. While this critical concern could not be addressed within the scope of the modeling, it was openly identified as an area for further inquiry.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Lowest Elevation (ft NAVD)</th>
<th>Present 100-Year Flood</th>
<th>FEMA Guidelines</th>
<th>Threshold for Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hampton Sewage Pump Station</td>
<td>6.6</td>
<td>now</td>
<td>now</td>
<td>now</td>
</tr>
<tr>
<td>Hampton Police Station</td>
<td>8.2*</td>
<td>now</td>
<td>now</td>
<td>now</td>
</tr>
<tr>
<td>Seabrook Wastewater Treatment Plant</td>
<td>9.8</td>
<td>now</td>
<td>now</td>
<td>now</td>
</tr>
<tr>
<td>Hampton Wastewater Treatment Plant</td>
<td>9.8</td>
<td>now</td>
<td>now</td>
<td>now</td>
</tr>
<tr>
<td>Seabrook Middle/Elementary School</td>
<td>14.8</td>
<td>&gt;2100</td>
<td>~2080</td>
<td>&gt;2100</td>
</tr>
<tr>
<td>NextEra Nuclear Power Plant</td>
<td>19.7</td>
<td>&gt;2100</td>
<td>&gt;2100</td>
<td>&gt;2100</td>
</tr>
<tr>
<td>Hampton High School</td>
<td>23.0</td>
<td>&gt;2100</td>
<td>&gt;2100</td>
<td>&gt;2100</td>
</tr>
</tbody>
</table>

Modeling for public assets examined the cost-benefit of a protection strategy in the form of installing a steel floodwall/floodgate around vulnerable assets to reduce damages to
zero (Table 8). This type of structure would be raised out of the ground to protect during storm surge, but not against permanent inundation from sea-level rise. By example, protection of public assets in Hampton resulted in high benefit-cost estimates (Table 7). Results from the Seabrook analysis also revealed the advantages of protection measures: 10:1 to protect to high sea-level rise and 25:1 to protect to low sea-level rise. There were not any critical public facilities of significant vulnerability in Hampton Falls.


<table>
<thead>
<tr>
<th>Low SLR</th>
<th>No adaptation</th>
<th>Protect to 2100 flood and beyond</th>
<th>Protect to 2100 flood and beyond</th>
</tr>
</thead>
<tbody>
<tr>
<td>$78.8</td>
<td>0</td>
<td>$4.9</td>
<td>$73.9</td>
</tr>
<tr>
<td>Protect to 2100 flood and beyond</td>
<td>0</td>
<td>$4.9</td>
<td>$73.9</td>
</tr>
<tr>
<td>Protect to 2100 flood and beyond</td>
<td>0</td>
<td>$7.1</td>
<td>$75.6</td>
</tr>
</tbody>
</table>

Finally, a freeboard accommodation strategy was modeled to explore the costs and benefits to reducing damages to private real estate to zero. The modeling assumed a proactive ordinance change (implemented in the present, prior to damages) that would require vulnerable structures to be elevated by three feet. Once again, this action would be to protect up to the 100-year flood in 2100. The benefit-cost ratio in Hampton and Seabrook was around 2:1 and 3:1, and as high as 10:1 in Hampton Falls. Stakeholders questioned whether this was a result of higher real estate values in Hampton Falls, but the project staff was unsure. The project team offered the following overall conclusions to the stakeholders as they continue to engage in adaptation (Merrill et al. 2012):
• Historic flooding risk is not a good predictor of the level of risk communities will face in the future.
• Actions should, if possible, be compatible with greenhouse gas mitigation.
• Nowhere in the modeling results do the costs of adaptation actions outweigh the benefits. Even under low flooding scenarios, the benefit-cost ratios were 8:1, 3:1, and 10:1 for Hampton, Seabrook, and Hampton Falls respectively – a savings of nearly $260 million by 2100.
• Comprehensive adaptation strategy is needed that includes both “here and now” actions and actions to be taken later but planned for now.
• Adaptation strategies should also consider other regional climate stressors such as increases in extreme rainfall, temperatures, and wind.
• Monitor changes in climate and sea-levels while planning for future actions.

Outcomes

Project staff reflected that by the third and final stakeholder meeting, the community participants had advanced greatly in their understanding of vulnerabilities and adaptation actions. Stakeholders also reached a critical point where they were able to discuss the social infrastructure needed in their own communities to continue toward implementation. Major themes from the final stakeholder discussions of next steps are described below.

"...It started a conversation. The conversation that began was a conversation of, ‘wow, we really have to do something.’"
– Service provider
A foundation for informed discussion. This multi-jurisdictional project provided a unique learning opportunity for local decision-makers, citizens, and the region’s technical assistance providers. This was the first multi-community, stakeholder-driven, economic analysis of potential damages and adaptation strategies in the New Hampshire seacoast region. Prior to this project, CAW was focused mainly on outreach to communities about climate adaptation through public workshops; the workgroup did not yet have the experience of working with specific communities on a climate vulnerability assessment.

Throughout the process, participants asked increasingly informed questions that revealed growing awareness of the limitations of the modeling and the need for further analysis. For example, one participant observed that the modeling did not include the costs of losing supporting services to vulnerable assets (e.g., sewer, roads, and electricity). Thus, one major outcome from this meeting and the process as a whole was that stakeholders have identified subsequent information needs and there is now documented interest in getting that information. This provides a demonstrated rationale to enable service providers to secure funding for projects that meet these needs.

The results can also serve as a reference or baseline assessment for future discussions on adaptation. A Seabrook planning board member highlighted that the Town’s master plan openly states the need to adopt the recommendations in their 2009 sea-level rise study as an action item to minimize storm and flood damage to existing
developed properties. It serves as a guiding document in hazard mitigation, as can a COAST summary report.

**Stakeholder interest in continued collaboration on adaptation.** Many of the impacts and challenges that were identified are common amongst these coastal communities, but need to be addressed within individual town actions (e.g., ordinance change). Moreover, when issues span across town lines, some actions in one town are needed by a neighboring town. A service provider explained, “There has been greater recognition of shared resources, not necessarily specific buildings but roads and accessibility. If ‘this road’ goes out in this town, then ‘we’ can’t get out so we need to pool resources.” In recognition, stakeholders suggested CAW assist with the formation of a ‘climate change workgroup’ to coordinate adaptation-related activities amongst the towns. This highlights that the communities were interested in collaborating moving forward.

**Regional momentum on climate adaptation.** Interviewees described how the project has provided data and momentum for adaptation in other communities. “We are already poised to apply the results of this project to other projects,” said the senior planner, which has “started an iterative process of refining and adding onto these types of studies.”

> “This project serves as a platform for enabling discussion and showing local examples, which is really valuable.”
> - Senior planner

> “...Connecting peers from all different municipalities was so important.”
> - Service provider

In the summer of 2012 the City of Portsmouth contracted the Rockingham Planning Commission to provide analysis and outreach for incorporating climate impacts into the City’s 2012 master plan update. At the same time,
the NH Natural Resources Outreach Coalition is incorporating this experience into their engagement with the Town of Newfields to enhance climate preparedness.

**Expanded trust and relationships amongst service providers and communities.** As stakeholders and service providers interacted throughout the process, research participants suggested that new relationships were developed that augmented trust. The trust factor is visible in the fact that stakeholders requested CAW’s continued support and to convene their community members in future forums. As one participant described, the inherent development of relationships enhanced the undertone of stakeholders’ confidence in seeking assistance from service providers and sharing stories about local issues. This should be considered a relevant outcome in the form of enhanced linkages between community members and service providers to work on adaptation.

**An identified need for wider community engagement.** Stakeholders expressed a need for broader engagement in their own communities about the project’s process and results, and education around sea-level rise and storm surge impacts. They described that community members have not had this level of exposure to sea-level rise nor do they have the deeper understanding that participants gained from this process. Given the importance of support from voters and other local officials in implementing major actions requiring ordinance changes, education and outreach was deemed a priority action to be addressed in the near-term.

"The information reinforces the trust that they know there is someone they can depend on."
– Service provider

"The question is, ‘How do we get other decision-makers, citizens, and taxpayers to feel like this [adaptation] is something we want to do?’"
– Service provider
Stakeholders suggested follow-up presentations about the project to the town boards that were visited in fall 2011, a project slideshow for the local cable access TV channels, and more ‘water cooler talk’ to increase local dialogue. In essence, they rallied around finding opportunities to widen the dialogue to attain a level that is conducive to taking the necessary actions. Decision-makers need citizen support. To this end, a supporting strategy stakeholders suggested was to collect photos, stories, and damage estimates from local storm impacts on a rolling basis as a means to communicate the issue of climate impacts.

**Lessons learned from New Hampshire**

The following is a synthesis of participant insights coupled with participant-observation.

*Create the forum.* Creating a neutral, trusted, and rich dialogue was widely described as the gateway to advancing communities in adaptation. The public meetings were a unique forum for stakeholders to gain new information, to voice their concerns, to feel heard by their peers, and to take part in a solution-oriented discussion. As one project team member described, “All you’re doing is catalyzing the conversation people want to have,” which begins to break down the barriers to action. For example, while the consequences of inaction often appear so distant, information on storm surge brought to this forum demonstrated that serious action is needed now regardless of sea-level rise. In
essence, planning for sea-level rise lends a 'no-regrets' stance by addressing present-day flooding issues.

**Invest in trust and relationships, and know the community.** The nature of the values-laden conversations begs the need for neutral and trusted conveners. Project staff expressed that preexisting relationships with stakeholders was extremely advantageous to the credibility of the conveners and the forum. The senior planner explained, “Having a past relationship with the audience goes toward building trust, that they trust you and recognize your professionalism and have confidence in that you will not only give them information that is useful but that you will listen to their needs, concerns, and priorities.”

Furthermore, to get buy-in and participation from stakeholders, the senior planner suggested that service providers “need to put the time in to get to know them first.” Other project staff highlighted the value of having a senior planner on the team with preexisting connections who could approach stakeholders about the project prior to being engaged by new faces. Her experiences and understanding of local planning issues and processes was also key. Finally, being present at local board meetings as opposed to recruiting participation via mailings was deemed valuable. “I don’t think we would have recruited many more without being there in person,” said the project leader.

“Don’t overwhelm potential end-users with too much methodology and analysis.”
– Senior planner

Focus on the application of results and less on technical processes. Respondents recalled significant confusion amongst stakeholders, particularly at the kick-off meeting. In a very
short amount of time, they were presented with a lot of technical information about climate change and the inner-workings of the modeling tool (particularly at the kick-off meeting). Participants voiced confusion over what their role was and what information the project team needed from them. In reflecting on the process, project staff suggested it might have been more effective to instead begin presentations with modeling results and then explain the analysis (if needed). A great deal of time was invested in technical details that could have been allocated to stakeholder discussion. From this same node, research participants suggested that results be presented by communications specialists, particularly those with a local connection, rather than by external technical experts.

Frame adaptation as a relevant issue with a positive tone. Participants described several revelations around framing adaptation. For participants to buy-in to the process, “It is useful to frame this discussion or the initial conversations with communities around public safety and economic benefits,” said the project leader. He added that if the project was framed as, “How can we preserve marsh habitat in the face of rising sea-levels?,” conservation groups would have likely replaced emergency managers and the focus on human systems might have been lost. To this end, the process linked environmental conservation strategies with the protection of public health and safety.

Participants also highlighted the importance of maintaining a positive tone. It can be discouraging to confront the immense, long-term economic realities of sea-level rise. “When you feel helpless, you can’t move forward,” said a service provider, who added...
that CAW’s role is to help communities overcome perceived paralysis and empower them to take action. The senior planner stressed the importance of focusing on the applications of the results from a project like this.

"Seeing that information on maps was really powerful."
— Senior planner

Maps and graphics as effective communication tools.
At the kick-off meeting, the examples of extrusion maps and the modeling tool were very hypothetical in the absence of locally-specific examples.

However, when the local data were modeled and presented for the second stakeholder working session, the senior planner reflected that stakeholders were “overwhelmingly excited about seeing results on a map for their town.” Other interviewees agreed that the maps, when thoroughly explained by project staff, were very effective in fueling the discussion and helping stakeholders translate the impacts into actions. “I felt they had a better understanding of what the model could do because of the visual outputs,” said a service provider.
Overview

The case of climate adaptation in Cape Cod, Massachusetts is focused around Barnstable County’s 2009-2010 multi-hazard mitigation plan update. Five key informants involved in the update provided insights and document data about the process and the region’s experience with extreme weather and other climate-related issues. Key informants included Tonna-Marie Surgeon-Rogers (Waquoit Bay National Estuarine Research Reserve), Ryan Christenberry (Planner, Cape Cod Commission), Lynne Carter (Adaptation Network), Sarah White (Massachusetts Emergency Management Agency), and Paul Lagg (Town Planner of Chatham, Massachusetts). Herein, quotations indicate statements directly from these interviews. In contrast to the Bridgeport, CT and Hampton-Seabrook Estuary, NH case studies, this was a retrospective case study and did not afford an opportunity for participant-observation. Hence, there are
inherent variations to the extent and nature of the data collected in relation to the other two case studies.

Community characterization

Societal context. The fifteen communities of Cape Cod are diverse in land area, population, government structure, coastal orientation, and natural and human resources. Barnstable is the only city and operates with a Mayor-Council government. The remaining communities all have Board of Selectmen and either an Executive Secretary or Town Administrator/Moderator/Manager. Finally, all but two (Bourne and Falmouth) rely on Open Town Meetings for purposes such as voting on warrant articles and to approve municipal budgets.

The population of the Town of Barnstable is approximately 41,000 people, whereas there are about 216,000 in all of Barnstable County. However, there is a large flux in population throughout Cape Cod across the landscape and throughout the seasons. Populations are as high as 750,000 in the summer and lowest in the winter (Barnstable County Regional Multi-Hazard Mitigation Plan, 2010). For example, Harwich has 12,677 full-time residents but a summer population of approximately 40,000 (Town of Harwich website).

Environmental characteristics. Cape Cod is primarily a barrier beach system surrounded by Cape Cod Canal, Cape Cod Bay, the Atlantic Ocean, Nantucket Sound, and Vineyard Sound. The Cape Cod Canal effectively renders Cape Cod as an island, and
is recognized as such by the Massachusetts Emergency Management Agency for planning purposes (Barnstable County Regional Multi-Hazard Mitigation Plan, 2010).

The challenges in emergency response planning in Cape Cod are compounded by several factors. The linear orientation of towns throughout the Cape results in a bottleneck for evacuation and in providing emergency services. Two four-lane bridges provide primary access to Cape Cod, and are often “seriously congested, and/or in repair (Barnstable County Regional Multi-Hazard Mitigation Plan, 2010 p. 40). In addition, summer traffic congestion occurs when the threat of tropical storms is highest. Furthermore, the Cape has over 400 freshwater ponds and lakes that “provide myriad potential for flooding (Barnstable County Regional Multi-Hazard Mitigation Plan, 29).”

The extent and combination of hazards across the landscape is high. Many areas full under multiple categories of hazards, hence why the sum of percentages in Table 7 exceed 100 percent. Of the Cape’s 412 square miles, 17% is in a zone of potential sea, lake, and overland surges by hurricanes (SLOSH) (Barnstable County Regional Multi-Hazard Mitigation Plan 2010, p. 26). Within this SLOSH zone are 85 segments of evacuation routes and 179 critical facilities (Barnstable County Regional Multi-Hazard Mitigation Plan 2010, p. 40).

Table 9. Profile of hazardous areas of Barnstable County. Source: Barnstable County Regional Multi-Hazard Mitigation Plan 2010.

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (square miles)</th>
<th>Percent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cape Cod Total Land</td>
<td>412</td>
<td></td>
</tr>
<tr>
<td>Upland</td>
<td>396</td>
<td>96%</td>
</tr>
<tr>
<td>Wildlife Risk Area</td>
<td>198</td>
<td>48%</td>
</tr>
<tr>
<td>Flood Insurance Rate Map (FIRM) Zone</td>
<td>72</td>
<td>17%</td>
</tr>
<tr>
<td>Potential Sea, Lake, and Overland Surges by</td>
<td>72</td>
<td>18%</td>
</tr>
<tr>
<td>Hurricanes (SLOSH)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As of 2003, 44% of the Cape’s land area was developed, 39% was permanently protected, and 17% was available for development (Regional Multi-Hazard Mitigation
Plan for Barnstable County 2010, p. 26). The Cape Cod Commission’s build-out analysis in 2000 suggested that the present growth rates would reach the Cape’s maximum capacity by 2040 (Regional Multi-Hazard Mitigation Plan for Barnstable County 2010, p. 27).

As for land cover, the majority of lands are conserved as large tracts in the two most lightly populated communities, Wellfleet and Truro (2,500 and 1,600, respectively), both located on the outer extent of the Cape (colloquially referred to as ‘the forearm’). The Cape Cod National Seashore, while it has grandfathered residences, covers approximately 61% of Wellfleet’s land area and over 50% of Truro. Also in Wellfleet is a 1,000-acre Massachusetts Audubon Society Wildlife Sanctuary. These conserved lands are primarily beech and salt marsh habitat.

The 2010 Regional Multi-Hazard Mitigation Plan update specifically enumerates “the most likely and most damaging natural hazards to which Cape Cod is vulnerable.” The Plan explicitly notes that these hazards will have increasing adverse impacts from climate change:

- Flood
- Shoreline change
- Wildfire
- Wind
- Snow and ice accumulation
- Drought
- Tornado
- Sea-level rise and increased precipitation
The direction of coastal tides and the landfall patterns of hurricanes makes for a diversity of hazards in both extent and type facing the region's communities. Mean tide range exceeds eight feet along the northern shore of Cape Cod (the "bicep"), while the eastern face experiences four to eight feet and the southern shores see a change less than four feet (Ramsey et al. 2005). There are also notable variations in exposure to the 1-year and the 100-year flood elevation (feet NGVD). The topology of north-facing communities of Cape Cod Bay lends a base flood elevation of 2-6 feet, whereas south-facing communities see a difference from 4.1-8+ feet (Ramsey et al. 2005).

Hence, coastal orientation is a key factor in determining local vulnerabilities and therefore creates a high demand for locally-specific data. Thus, flooding, storm surge, coastal erosion, and sea-level rise are common issues throughout the region, yet present challenges to be addressed on a town-by-town basis.

Transitioning From Concern to Action on Climate Adaptation

Participants offered mixed responses as to what led to planning for climate change impacts. What is particularly unique about this case is that climate change was not the main focus. "...It wasn't really about climate," said one participant during an interview. "We found a way to get climate into it." Some stated that future climate impacts were not a high priority among local planners, while others expressed local awareness of consensus in the scientific community that hazards have been increasing. One respondent was unsure how climate change came to be part of the process, and suggested that it was a requirement by FEMA. Finally, front and center to driving the process was a key
partnership between the Adaptation Network, the Waquoit Bay National Estuarine Research Reserve (Waquoit Bay NERR), and the Cape Cod Commission. It is likely a combination of these factors that gave rise to adaptation planning in Cape Cod.

The timing was right. Dr. Lynne Carter of the Adaptation Network, a key partner and non-profit organization, described that the focus on adaptation was largely a result of activity from about five years earlier. During the first pre-hazard mitigation planning in Barnstable County in 2004, Carter was attending the monthly planning meetings for communities held by the Cape Cod Commission (henceforth, "the Commission"). In preparation for her involvement in the mid-Atlantic regional climate assessment, Carter was observing local planning processes into which communities could incorporate climate change information. As she engaged the planning director of the Cape Cod Commission about bringing climate change information into the process, she sensed that the timing simply was not right – that the communities were not ready. "Maybe the next time around," she was told. Thus, a seed was planted to pick up the process at a later date.

Carter again approached the Commission several years later in preparation for the 2009-2010 planning update. The Commission was transitioning planning directors at the time. Carter described that both the outgoing and incoming planning directors were more prepared and interested in incorporating climate change information into the process. The knowledge base of climate change had since improved and expanded with recent reports from the U.S. Global Change Research Program, which Carter delivered to the process. "I think it had to do with knowing more than just the science, but beginning to look at the
social impacts,” which Carter described was a stronger focus in the 2009 national assessment, “Global Climate Change Impacts in the United States.”

**Key partnerships.** Prior to the update, the Waquoit Bay NERR organized two climate adaptation workshops targeted to coastal communities in Cape Cod and throughout Massachusetts (see Appendices B and C for workshop flyers/agendas). The overall goal of the workshops was to expand local understanding of major climate impacts and the need for adaptation. The workshops were inspired by a 2007 needs assessment conducted by the Waquoit Bay NERR with Cape Cod towns.

These workshops cultivated a key partnership between three organizations with varying skills, relationships, and expertise. Carter was a key partner and presenter in both workshops with her expertise in climate impacts. The Waquoit Bay NERR coordinated the workshops and brought facilitation skills. Thirdly, the Cape Cod Commission brought expertise in hazard mitigation planning and was positioned to connect these two partners with municipal decision-makers.

Following the first workshop in 2007, the coastal training program (CTP) coordinator approached the Cape Cod Selectmen and Councilor’s Association and arranged for a presentation by the Adaptation Network. “The idea was to inform the selectmen of the Cape towns about this concept of linking climate adaptation planning with the hazard mitigation planning process in order to get their buy-in,” said the CTP coordinator. Finally, all three partners agreed that the 2009 workshop would serve as a launching point for linking adaptation with the regional MHMP update. The Cape Cod Commission presented on the rationale and means for making the connection. Extensive
effort was placed on bringing Cape Cod town planners to what participants described as “an instrumental workshop.”

**Institutional motives.** The Commission and the Massachusetts Emergency Management Agency (MEMA) had complimentary institutional missions for incorporating climate change into the process. The Commission received a FEMA grant to convene the Cape Cod communities to update the 2004 pre-disaster mitigation plan. Sara White from MEMA served as a liaison between Barnstable County and FEMA. She highlighted that the RMHMP is required by FEMA to “address all hazards that could affect the planning area.” While there is no mandate for towns or regions to consider climate change as a hazard, “there is nothing preventing it either,” she said. Thus, incorporating climate change into the planning process might be considered as a “middle-down” directive led by the Commission rather than state or federal government. “It is not on the local level that we would have put it in there,” said a town planner.

**Local experiences with a dynamic coastal environment.** The shoreline throughout Cape Cod is rife with erosion hazards and coastal flooding. “…people realized that coastal environments are very dynamic. They are meant to change,” a service provider explained. The Patriot’s Day nor’easter of 2007 was provided as a particular example. “Chatham has a south and north beach,” an interviewee explained. “Water and pressure from the ocean...
during the Nor'easter caused a breach in that sandbar. People used to be able to drive cars across the sandbar and there were houses there." Several houses were destroyed during the storm, as indicated to the left of the red arrow in the lower portion of Figure 29 on the following page.

"The losses of these beach cottages are economic for the owners, but more importantly, the loss of a way of life for Cape Codders in general," reported the Cape Cod Today newspaper. The system change also poses a threat to the Chatham fishing fleet's primary access to the ocean, and mainland properties previously protected by the barrier beach system are now exposed to ocean waves (Woods Hole Group 2007).

Dating back even farther, a nor'easter in the winter of 1987 had similar affects. Large waves and an extreme high tide cut across North Beach. Within a week the channel was 100 yards wide, and by the spring it divided the beach by a quarter mile (FEMA 2009). Finally, informants described that there were lots of smaller events causing local planners to rethink development in the coastal environment. Widespread issues of erosion have historically threatened coastal real estate, as evident in Figures 28 and 29.
Approaching Climate Adaptation through Regional Multi-Hazard Mitigation Planning

All fifteen communities of Cape Cod participated in the regional planning process. Described below are the major actors and their roles, and the format for the update process.

Key actors and roles. The Commission led the coordination of the update process. As the regional planning entity, the Commission was experienced in planning with the communities and had pre-existing connections with decision-makers relevant to multi-hazard mitigation planning. The Commission organized stakeholders in the form of a regional multi-hazard planning team, convened on a monthly and as-needed basis (see Appendix D, Item 1 for 2009-2010 schedule). This provided “a forum for town planners to discuss and focus on hazard mitigation planning (Regional Multi-Hazard Mitigation Plan for Barnstable County 2010, p. 12).” The representation from each community on the team and at the forums was diverse and included:
Town planners and planning board members

• Conservation agents

• Natural resource officers

• Town administrators

• Town GIS coordinator

• Emergency management

• Director of growth management

• Health directors

In addition, the planning team included regional and state representation from:

• Americorps

• County Department of Health & Environment

• Barnstable County Regional Emergency Planning Committee

• Cape Cod National Seashore

• Cape Cod Commission

• Provincetown for Coastal Studies

• MA Emergency Management Agency

• MA Office of Coastal Zone Management

• New England Regional Climate Center

• United States Geologic Survey

• Woods Hole Oceanographic Institute

• Waquoit Bay National Estuarine Research Reserve

The Waquoit Bay NERR and the Adaptation Network both supported the Commission by providing data and interpretation of climate change science and impacts.

"My goal was to help them understand what the major issues were," Carter explained.
She also presented examples of adaptation from elsewhere. "If people know that other people have begun to deal with things and see how they’ve done it, then it stimulates their thinking.” Finally, Carter expressed that the Waquoit Bay NERR was instrumental in involving additional regional partners with relevant expertise, such as Woods Hole Oceanographic Institute and the Northeast Regional Climate Center.

Early in the RHMP process WBNERR and Dr. Carter also worked together to organize a webinar for the town planners involved in the RHMP process on downscaling climate models for Cape Cod. Going into the RHMP process it was hoped that downscaled climate data (e.g. temperature and precipitation) could be produced for Cape Cod that would provide more regionally-specific data for planning. Unfortunately, this process stalled and was not able to be completed during the timeframe of the RHMP and therefore became a data limitation. Nevertheless, more general climate information (the best available then) specific to New England and Massachusetts were incorporated as part of the regional and local plans.

Finally, Massachusetts Emergency Management Agency (MEMA) was also a major actor. A liaison from MEMA (Sarah White) helped to ensure that all local plans were consistent with FEMA requirements. She provided hazards data, such as Risk & Vulnerability Assessment Maps for each town, and “crosswalks” to ensure approval from FEMA. Along with the Waquoit Bay NERR, MEMA also assisted in linking local officials with expertise from research institutions.
Updating the regional multi-hazard mitigation plan. Hazard mitigation planning is a common risk management tool used around the country. The Disaster Mitigation Act of 2000 requires all communities to have a FEMA-approved hazard mitigation plan in order to be eligible for many sources of federal post-disaster funds.

The purpose of the regional multi-hazard mitigation plan update was to “identify new and on-going hazards that are common to the communities of Barnstable County, to understand specific locations where the region is vulnerable to these hazards, and to assess the mitigation strategy developed in the 2004 plan to reduce the risks associated with these hazards and recommend new strategies where necessary (Regional Multi-Hazard Mitigation Plan for Barnstable County 2010, p. 5).”

The hallmark of Cape Cod’s approach to climate adaptation is that the update process provided a unique forum for the region’s hazard mitigation stakeholders to learn from one another in a collaborative setting. At the end of the planning process, “if a town had kept on a course parallel to the regional team they would have generated all of the information needed for a local multi-hazard mitigation plan update (Regional Multi-Hazard Mitigation Plan for Barnstable County 2010, p. 12).” Thus, the process was designed in a way that encouraged communities to incorporate the outputs of the regional plan into local planning frameworks. This design positioned participants to simultaneously work toward local and regional resiliency.

Drawing on the success of the 2004 planning process, local team leaders were again given ‘homework assignments’ between each meeting to stay actively engaged. Tasks included populating a hazard identification matrix, identifying critical facilities, and evaluating or updating mitigation strategies.
A Commission planner and the MEMA liaison both described that topographic data was limited to 3-meter resolution, so they avoided general bathtub modeling (which assumes static shorelines and disregards tidal variability) for fear that it might raise undue concern. Conveners highlighted that they were attuned to recently heightened tension about flooding. The region had just received updated floodplain maps from FEMA. Shortly after the maps were released, FEMA pulled them back for further review in response to local feedback because so many additional parcels were included in the floodplain. One town in particular facilitated a public workshop to refute the updated maps. In the place of outdated floodplain maps, service providers used a Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model to further identify vulnerable areas.

Outcomes

**Strengthened local planning for climate impacts and institutional change.** The regional multi-hazard mitigation planning process resulted in the towns of Truro and Dennis developing pre-disaster mitigation plans for the first time (Regional Multi-Hazard Mitigation Plan for Barnstable County 2010, p. 11). As two of Cape Cod’s smallest towns, this outcome begins to demonstrate the contribution to regional climate resilience. Every other community updated their pre-disaster mitigation plan for the first time.

Following the update process, some communities established specific standards for sea-level rise, as in the case of the Town of Dennis. Their local comprehensive plan established that, “Within the 10-year floodplain, no activity shall impede the landward migration of other resource areas within this area of the floodplain. Relative sea level rise
and the landward migration of resource areas in response to sea level rise shall be
incorporated into the design, construction, and location of structures and other activities
proposed.” In essence, this policy provides directive to facilitate a buffer between
development and coastal waters. There are two notable benefits to this policy. First, it
provides space for natural communities to migrate inland as sea-levels rise. Second, it
reduces the extent of real estate vulnerable to rising sea levels.

Meanwhile, other communities enacted less progressive but nonetheless
fundamental mitigation measures. The Town of Barnstable’s multi-hazard mitigation plan
(2010) has a dedicated sea-level rise section documenting the range of predictions for
permanent inundation, the exacerbation of coastal flooding and beach erosion, and the
conversion of wetlands to open water. It states, “A major challenge for the Town in the
future will be evaluating the ecological and social impacts of sea level rise and
developing planning and adaptation strategies that will address both environmental and
human interests.”

Institutionalizing climate change into local planning should provide a directive for
incoming town officials to carry on with adaptation. In addition, the plan also references
the need to review sea level rise in the context of other plans, e.g., the Three Bays Plan
that focuses on coastal access and development.

**Inter-municipal collaboration.** This case demonstrated diverse, unexpected, and
likely untold benefits to municipalities from engaging in regional collaboration. For
example, by coming together and sharing evacuation plans, one research participant
reflected that two adjacent communities discovered that their evacuation strategies were
conflicting. "They would each end up getting stuck at town lines because one had them going through one way, the other had them going through the other way," recalled a service provider. A town planner affirmed the necessity for inter-municipal collaboration because "this stuff bleeds across town lines." This regional process provided a forum to make those connections that can help to address future challenges.

**Heightened attention to gathering climate data.** Several participants voiced that the climate change language inserted into the local plans was "the weakest part of the plans" and "very general." The lack of locally-specific climate change data was commonly cited as a major challenge. "We struggled with it because there is not a lot of local data," said a town planner, "such as sea-level rise specific to Chatham." Hence, this process provided an opportunity for service providers and towns to jointly identify information needs that can provide deeper analysis in future planning. Participants expressed hope that in the next few years they would have access to more locally-specific, high-resolution sea-level rise data as opposed to bathtub modeling. A town planner echoed this sentiment in that "more local communities will be paying more attention and gathering data" as a result of this process.

**Lessons Learned on Climate Adaptation from Cape Cod, Massachusetts**

**Link climate with existing activities.** The regional multi-hazard mitigation plan provided a platform for integrating climate change within a conventional risk management tool. In consideration of the wide range of responsibilities and decisions that
local officials are tasked with, informants suggested that it is far more efficient and
effective to link climate change with existing activities than to address it as an
independent issue. A service provider explained, “If we ask them to talk about climate
adaptation as if it’s something separate,” then we risk overloading them. She added that
in reality, “it’s all related and we should just be asking the climate question of all of our
activities.”

A town planner went on to explain that big picture challenges like climate change
are not a significant focus at the local level. There are more near-term, identifiable issues
that need to be addressed. “The day-to-day little things, like fixing pot holes, are a
priority,” he said. Hence, service providers described that one of their key roles is to help
decision-makers see the climate connection to conventional planning, and to elucidate the
options for incorporating it into decision-making.

Focus on the impacts: climate change is here and now. As the town planner stated,
“if a section of town has an increase in flooding, we’re
not looking into global warming, we’re just focusing
on mitigation – what we can do to fix infrastructure
and mitigate damage.” This local planning perspective highlights an opportunity for
technical assistance providers to engage people in adaptation. A service provider
described the importance of using local examples of impacts and what is at risk.

Also, focusing on existing issues and planning for them to worsen over time can
help to be more prepared for present and future conditions while sidestepping challenges
posed by lack of information. As a service provider explained, "Help them see the problems that they already have… in most cases, they are likely to get worse."

Invest in communication and use tangible examples of impacts and solutions.

From her experience on this and other projects, the MEMA liaison suggested that a public relations or media relations person who understands communications is really important. People need to hear about the project multiple times, and to be able to access and retrieve information in multiple formats. Moreover, it is important to extend engagement beyond town or city officials working on the issue as required by their jobs. “The more engagement you get from the broader community, the more successful the project will be,” said the MEMA liaison.

Images and stories of vulnerabilities and adaptations, locally and elsewhere, were said to inspire decision-makers and make conceptual risks more visible. Providing examples of what other communities are doing can help to stimulate decision-maker’s thinking about how they can reduce local risks and vulnerabilities. Once decision-makers have a strong understanding of the impacts and options, “they are more likely to talk to others about the issue,” explained Carter from the Adaptation Network.

Regional collaboration. This case illustrates regional collaboration – across sectors and from local to federal government – can provide broad and deep expertise, strong facilitation capacity, and can raise attention to climate change on a broader scale. It also established new working relationships, which may have untold

“I definitely connected regional experts with local experts in fields we don’t typically interact with.”
– Commission planner
benefits in addressing future local or regional issues of adaptation and beyond. Several participants echoed that working on climate adaptation may in fact be better left to regional bodies, such as the Cape Cod Commission or the Pleasant Bay Alliance (Chatham, Harwich, Brewster, and the Cape Cod Commission). A town planner added, “anything that the state and region can do to bolster cooperation amongst towns,” would be a major step forward.

A journey begins with a single step. Some interviewees expressed that the Plan’s climate change language was generic. One participant suggested that current data had provided “conceptual planning” at best (e.g., identifying areas that are potentially at risk). While remembering that climate change was not the main focus of this process, this initial effort can serve as a platform for adaptation in subsequent planning. The regional multi-hazard mitigation plan states that it will “provide a framework for addressing climate change by considering projected climate change impacts on existing hazards in our region under the risk and vulnerability assessment.”

In fact, the RMHMP update was implicitly and explicitly recognized as a starting point adaptation. It goes on to state that, “As better climate change data becomes available, such as LiDAR data to better estimate sea-level rise impacts, the Barnstable County Regional Multi-Hazard Mitigation Plan’s risk and vulnerability assessment is an appropriate place for this information to reside (Regional Multi-Hazard Mitigation Plan for Barnstable County 2010, p. 7).”
Momentum from existing actions. Prior to the update, the Town of Chatham already had stringent regulations on floodplains. The Town’s zoning bylaw includes conservancy districts that encompass the entire historic 100-year floodplain. New construction is prohibited in this flood zone. “We had a lot of this in place before the update,” said the town planner. “Most other towns are trying to emulate this.”

It is unclear whether the intended replication is a result of increased attention to flooding issues due to discussions initiated by the multi-hazard planning process, as a result of seeing the success of these regulations in practice, or other unforeseen factors. However, this suggests that technical assistance providers may seek out and leverage examples of strong local regulations. Such examples of others taking action can reduce the perceived risk of enacting more stringent regulations.

Local champion. When interviewees were asked, “What additional advice would you offer to technical assistance providers working with communities on climate adaptation?,” the necessity of a local champion was often the first thing to come to mind. In this case, participants recognized the Commission as the champion, as opposed to an individual. “They have a lot of proactive programs that push and drive this stuff,” said one interview. Others suggested there were unidentified towns people who hold hazard mitigation as a high priority.

Break the planning process down into manageable pieces. Each town came to the planning process in various phases of pre-disaster mitigation. Some were developing
hazard mitigation plans for the first time (Truro and Dennis), whereas others were focused on regular updates. By breaking the planning process down into manageable goals and tasks, local planning teams that were new to the process were brought up to speed, while those making updates were kept "moving forward in a timely manner (Regional Multi-Hazard Mitigation Plan 2010, p. 12)." The process unfolded over a nine-month period that broke a larger initiative into manageable pieces.
VI. CONCLUSIONS

This final chapter is organized into four parts. Part I is a concise review of the initial aims of the research. Part I is broken down into greater detail in Part II, "Lessons Learned and Recommendations," which is intended to be disseminated to service providers. Part III summarizes the major outcomes in each case study community from engaging in climate adaptation. Finally, Part IV provides several reflections on the research experience and visions that emerged for future research.

Part I: Answers to the research questions, and next steps for future research

This research set out to advance the field of climate adaptation through a multiple case study investigation with three specific aims. The first aim was to identify and describe the factors that prompt communities to plan for climate change impacts. The second aim was to elucidate the types of approaches taken by communities in planning for climate change impacts. Finally, the third aim was to identify the outcomes that transpire from engaging in climate adaptation. Collectively, the goal of the research was to synthesize these findings into Lessons Learned and Recommendations (Part II below) ready for dissemination to service providers engaged in climate adaptation.
The three overarching questions to this research, framed as the “aims” within the research proposal, were:

1. What are the events or conditions that transition communities from concern to action on climate adaptation?

Three enduring themes that contributed to pursuing adaptation emerged across all three case studies: recent experiences with extreme weather events, local champions, and the availability of trusted technical assistance. The relative weight of each of these variables was not investigated. However, several informants highlighted the importance of “timing.” These and other unforeseen factors all play a dynamic role. See Part II for lessons learned and recommendations on leveraging these factors.

2. What types of processes do communities use for climate adaptation?

Common elements to adaptation processes in the case study communities include broad stakeholder engagement, support in facilitation and convening from trusted service providers, and iterative processes that are linked with conventional and current municipal planning activities. This research spanned three case studies ranging widely in geography, scale, technical and financial resources, and vulnerabilities. In light of the case study diversity, the range of approaches varies greatly and the conclusion is that there is no silver bullet. The “right” process is contingent upon local conditions, and this research displays several approaches taken in three different contexts.
Of special note is the role of partnerships in adaptation processes, especially when service providers work collaboratively with communities to leverage diverse expertise, skills, and relationships with community members. One research participant succinctly described the value of partnerships. She explained, “Key partnerships can help to stimulate action… and bring varying levels of expertise to a planning process.” She continued, “regional entities can build off the work each other is already doing to make progress in climate adaptation planning, especially because it is such a cross-cutting issue.”

3. What are the outcomes relative to adaptation as evident in changes to plans, policies, and/or behaviors?

The range of outcomes uncovered during the research expanded the third aim to include “benefits” such as greater local capacity (for adaptation and other issues) and strengthened relationships amongst community members. The Cape Cod case study resulted in the most tangible changes to plans as manifested in their regional and local hazard mitigation plans. In part, this is due to deadlines for submitting hazard mitigation plan updates to FEMA in 2010. In the New Hampshire and Bridgeport cases, it is preemptive to expect changes in plans and policies given that the research fell in step with the vulnerability assessment phase (as opposed to implementation).
In regard to the substantive adaptation responses that were identified in these processes, flooding (coastal, estuarine, and inland) was the most prominent issue. The range of responses included:

- Accommodation strategies, such as elevating private real estate using regulations requiring freeboard, elevating roads and railroad viaducts to enable access for emergency service vehicles, and conserving salt marsh habitat (which reduces storm surge effects, among many other ecosystem services).

- Protection strategies, such as installing retractable floodgates to reduce storm surge damages.

Relocating assets out of harm’s way, so called “retreat” strategies, did not emerge. In fact, community members in the New Hampshire case indicated retreat was the least desirable approach. Additional strategies fell in unconventional categories such as increasing dialogue amongst local officials, institutions, and community members and strengthening the physical communication systems that connect them.

A Note on Major Barriers to Adaptation

Although “barriers to adaptation” was not an explicit focus identified at the outset of the research, the case studies provided a few key insights worth highlighting. Participant-observation in New Hampshire and Bridgeport was particularly revealing given the opportunity to observe the processes in person. Key insights to barriers include:
• **Lack of hard science at the local level.** Community members harbor a suite of stories and experiences of local climate impacts that can help to overcome information barriers. This data bank of local knowledge can both ground truth modeling tools as well as fill in gaps in hard science.

• **Planning for climate change with climate deniers.** Research participants in Cape Cod voiced that in some instances they had to take climate change out of the conversation. To do so, they focused on current climate impacts that needed to be better addressed. Doing so helped to be better prepared for both current and future climate effects. Regardless of the cause of the impacts, one service provider described the need to “help them see the problems they already have... in most cases, they are likely to get worse.”

• **Recognizing climate change as a relevant issue.** Stakeholders often times might not see how climate change affects their responsibilities or daily lives. Service providers need to place special attention to translating how climate change is a relevant issue, and why their participation is important. See Part II for a specific recommendation on overcoming this barrier.

• **Community member (voter) support for implementation.** Solutions that deviate from business-as-usual planning will ultimately necessitate emphasis on gaining voter support. Inclusive processes that engage the fullest extent of community members is a fundamental component to gaining voter support. Additional efforts in education and outreach to non-participants should be built into implementation plans.
For more information on overcoming barriers, see the lessons learned and recommendations in Part II.

Next steps for related research

Much of this research focused on the experiences and lessons learned from the point of view of service providers and municipal staff. An alternative or complimentary line of research would focus data collection more extensively on the perspectives of lay-citizens and elected officials. This would necessitate a different interview instrument and an alternative path through the literature review digging more extensively into areas such as deliberative democracy (e.g., Dryzek 2001) and public participation (e.g., Rubin 2000, Creighton 2005). This would be an intriguing area of inquiry for future research in support of adaptation planning.

Along the way I encountered many philosophical questions about the role of information in decision-making. My observations and experiences in this research and related professional work suggests that information – at least in the issue of climate adaptation – is perhaps a relatively small barrier to communities in transitioning from concern to action. What appear as being more influential are factors such as voter support and concurrent issues/competing priorities given the heavy load that local officials have to deal with (especially those in volunteer positions and/or with multiple positions). Thus, I conclude that an intriguing line of research would be to investigate the role of information in decision-making specifically on the issue of climate adaptation. Such research would ask, “What type and level of information do communities really need to decide to take action?”
Part II: Lessons Learned and Recommendations for Service Providers Engaging Communities in Climate Adaptation

Part II synthesizes the key findings from the three case studies and is organized by three sections: (1) Factors causing communities to embrace adaptation, (2) Engaging Stakeholders and Designing Adaptation Processes, and (3) Outcomes from Embracing Climate Adaptation. For the first two sections, lessons learned appear on the left and the recommendations that stem forth are on the right. The intent is to provide service providers (e.g., planners, state/federal agency staff, non-profit/non-governmental organizations, etc.) with a clear understanding of (1) the lesson learned, (2) which cases generated this lesson and how, and (3) what specific recommendations transpire from these particular lessons. The basis for these recommendations should be highly transferable given the range in each case’s approach, scope, and geography.

Finally, during a cross-case synthesis such as this, case study research authority Robert Yin (2009) advises researchers to integrate “prior, expert knowledge (161)” when analyzing case study evidence. Thus, this cross-case synthesis represents a culmination of data analysis that is informed by practical experience with adaptation.
Factors causing communities to embrace adaptation

Key elements to why the case study communities transitioned from concern to action on adaptation.

Lesson learned

- Participants in each case referenced the role of particular individuals who inspire action on adaptation, so called “local champions.” Champions ranged from the Mayor of Bridgeport to a NH planning board chairwoman down to unnamed concerned citizens in Cape Cod.

- Work on the issue of adaptation can often be deferred given competing demands and the technical nature of adaptation. External technical assistance on adaptation to the case study communities was prevalent. (Examples of providers included regional planning commissions, nonprofit/nongovernmental organizations, state/federal agencies, and research institutions.) Of special note is that planning for climate change impacts necessitates navigating a sea of information and convening a wide range of stakeholders. External assistance begins to expand local capacity to meet such challenges amidst a host of ongoing local challenges and competing priorities.

Recommendations

- Identify and engage local champions at the very outset of an adaptation initiative and cultivate their close involvement. Champions greatly accelerate the pace of local adaptation actions by voicing that the issue is a local priority and by recruiting additional community members to the process. In addition to mobilizing community support, they also serve a key role in sustaining momentum and continuing to drive adaptation once grant funds expire or technical assistance from a particular project comes to an end.

- Engage external technical assistance providers to convene, facilitate, and assist with data interpretation. Providing a competent, safe and trusted process enables communities to bring forth a wealth of local knowledge about impacts and possible solutions. As with other fields of policy, implementation is more likely to succeed when the solutions come from communities themselves and it carries a sense of ownership (See Merrill, Sanford and Lapping 2008).
Lesson learned

- Participants from each case identified varying reasons why “the timing was right” for adaptation in their community. For example, in Cape Cod it took over five years since the first notion of adaptation before official processes for climate change planning took place. Rather than look for a single factor that indicates readiness for adaptation, there are likely a host of interacting factors that inspire the transition from concern to action including the availability of information and interpretation, recent extreme weather events, local champions, and current municipal planning processes.

Recommendations

- Engage the opinion leaders and decision-makers in a community to ensure that the timing is right for adaptation. Despite common factors like extreme weather and local champions, there are other interacting factors that may reduce traction, including critical decision-makers that are opposed to adaptation (e.g., selectmen, town manager). Thus, it becomes critical that service providers take the time to understand local conditions. Adaptation efforts must receive buy-in from the community given the current climate of shrinking fiscal and human resources and the range of local challenges and priorities.
Engaging Stakeholders and Designing Adaptation Processes

Key considerations for service providers (planners, state and federal agency staff, non-governmental and non-profits, etc.) in planning and conducting an adaptation project.

Lessons Learned

- Trust and relationships between service providers and communities were two enduring themes across the case studies. Service providers expressed these were critical conditions to engaging communities in the topic of climate change.

Recommendations

- Leverage existing trust and relationships when engaging communities. This may mean involving an additional partner that has a positive history in the community. For example, the New Hampshire case benefited greatly from the regional planner’s connection with the participants of the three communities and her experience with their planning processes.

- Communicate the outcomes to maximize understanding of how adaptation is relevant to stakeholders. For example, emergency managers might not make the connection between their job and conserving salt marshes in the face of sea-level rise. Instead, make the linkage explicit by engaging emergency managers in the context of buffering storm surge to protect public safety (as in the New Hampshire case); engage municipal finance staff in terms of identifying and appropriating funds for municipal projects (as in the Bridgeport case).

- Climate adaptation can take on many names, ranging from “climate preparedness” in Bridgeport to “hazard mitigation” in Cape Cod to “adaptation to sea-level rise” in New Hampshire. Despite the term used in each case, the outcomes were all related in terms of emergency preparedness, managing flood risk, improving communications, etc. Research participants reflected that stakeholders better understood their role in adaptation when their participation was framed with regard to the outcomes.
Lessons Learned

- Each of the three case studies took a very different approach to adaptation, e.g., a hazard mitigation framework in Cape Cod, roundtable discussions with stakeholders using a cost-benefit modeling tool in New Hampshire, and a two-part city-wide dialogue using a risk matrix in Bridgeport. Thus, there is no single approach to adaptation, but rather great flexibility to match the process to local conditions and actors.

- The New Hampshire case demonstrated how a modeling tool generates rich discussion, but that end-users can easily be overwhelmed with methodology. Avoiding emphasis on the technical components of a model can mitigate the latter. Prior relationships and trust of project staff are important.

Recommendations

- Create an adaptive process that matches the local culture, skills, and knowledge. Service providers should invest the time to know what kind of processes the community has used in the past and what the associated successes or challenges were. Consider the skills and knowledge of the participants in the methods for identifying vulnerabilities (e.g., using local knowledge, modeling tools, or both). In the Bridgeport case, the risk matrix appeared to be well received by the large proportion of technically-minded city staff involved. Observation suggested that lay-citizen participants more easily engaged in the small and large group discussions than compiling their input into the matrix (hence the need for effective facilitation).

- Lightly introduce methodology, but focus on applications of model results. Maps and graphics are exceptionally powerful in communicating how the results will inform decision-making. However, this does not dismiss the necessity of providing stakeholders with a basic understanding of a model’s operations if they are to place trust in the results.
Lessons Learned

- Adaptation is relevant to virtually all sectors and levels of government, as evidenced by the range of stakeholders engaged in each of the case studies ranging from planners and emergency managers to civic groups and homeowners.

- The diversity in stakeholders necessitates multiple methods of recruitment. In New Hampshire and Bridgeport, research participants highlighted the value of in-person project introductions and invitations. Stakeholders were said to have compelling questions that were best answered in person. In addition, the personal contact further contributes to building trustworthy relationships with service providers.

Recommendations

- **Engage the widest possible range of relevant stakeholders.** There are several reasons to seek comprehensive stakeholder involvement. A greater diversity of participants brings more knowledge about locally observed impacts and possible solutions (See “ways of knowing” by Feurt 2008). It also affords an opportunity for implementers to play a role in developing the solutions and positions voters to support the costs of adaptation, thus increasing the likelihood of implementation. Thirdly, as discussed in “Outcomes,” broad engagement also affords an opportunity for strengthening connections amongst community members and outside expertise. This in turn positions communities to be more prepared for future challenges. Finally, broad engagement also leaves an impression upon institutional memory (e.g., the culture of a planning board) by facilitating an exchange of experiences and priorities from current to future memberships.

- **Firstly, recruit stakeholders via multiple avenues.** Face-to-face interactions contribute to developing trustworthy relationships, and convey a sense of commitment on behalf of service providers. Service providers should also consult community leaders to identify local communication streams and which audiences they reach.

- **Secondly, ask whom to engage, and then ask again.** Identify sector leaders in the community by constantly seeking referrals to who else needs to be engaged. Once referrals begin to identify the same key stakeholders, this so-called “snowball” sampling establishes a sense of saturation (i.e., a comprehensive list is established).

- **Thirdly, identify how the community receives information from the media.** In the New Hampshire case, local cable access channels were one means of reaching out to
Lessons Learned

- All three case studies showed how humans and the environment are inextricably linked within a socio-ecological system. For example, actions in Cape Cod and New Hampshire to protect coastal real estate and utilities necessitate conserving salt marsh habitat and landward areas to accommodate inland migration. In Bridgeport, reducing flood risk and improving water quality necessitates managing impervious surfaces.

- The Bridgeport and Cape Cod cases demonstrated how adaptation can be integrated into existing municipal activities, either comprehensively across city plans, projects and policies or focused within traditional hazard mitigation planning (respectively).

Recommendations

- Focus on strategies that enhance the resiliency of socio-ecological systems. Service providers should avoid focusing solely on the built or the natural environment. Rather, they should help communities to aspire for strategies that improve the resiliency of the system as a whole.

- Link adaptation with existing municipal processes. Rather than a standalone adaptation plan with uncertainty in implementing partners, integrate adaptation into existing processes with built-in mechanisms for implementation (e.g., normal job responsibilities). Adaptation is too far reaching to be nested within a single department or the responsibility of a lone stakeholder group.

- Local newspapers, newsletters, flyers, and email lists can also support casting the widest net possible.
Lessons Learned

- While the nature of grants enables service providers to work closely with communities for a predetermined period of time, the reality of adaptation (new information, new questions, and new conditions) demands an iterative process. As of Fall 2012, communities of the New Hampshire case study are meeting four months after the grant closed to continue digging deeper into the questions that arose and seeking to engage a greater extent of the local community members to gain support for implementing solutions. The final stakeholder meeting in NH in June 2012 gathered input from the communities regarding next steps, one of which was to further facilitate meetings with community members to discuss climate impacts. With this information, the service providers are positioned to approach funders with a demonstrated need to continue working with the communities.

- Adaptation does not have to result in increased costs to communities. To the contrary, it can result in significant cost savings. The cost-benefit analysis in the New Hampshire case demonstrated striking cost savings (nearly $250M for the three towns by 2100) with adaptation strategies to reduce flooding damages, even under the most conservative sea-level rise scenarios. In fact, adapting to future conditions is a means to also address present day

Recommendations

- Firstly, anticipate an iterative process that continues beyond grant cycles. With this in mind, service providers should keep an eye on the funding horizon for further assistance to ensure that valuable momentum and results from grant-funded projects do not fall through the cracks.

- Secondly, facilitate a process while preserving the opportunity for champions to rise to a position to drive the community toward implementation.

- When recruiting participants, communicate that the outcomes can include significant cost savings. With evidence from cases like NH, this should alleviate concerns from skeptical stakeholders that adaptation will result in additional costs to the community.
<table>
<thead>
<tr>
<th>Lessons Learned</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>flooding impacts – thus providing short- and long-term savings.</td>
<td></td>
</tr>
</tbody>
</table>
The outcomes described by participants in each case indicated that adaptation has tangible benefits beyond being prepared for a changing climate. The necessary diversity in stakeholders and expertise convenes new assemblages of community members in ways that can forge enduring connections. This integration of scientists, community leaders, local to federal government, businesses, and nonprofits prepares communities for adaptation, as well as for future challenges beyond climate change.

In all three case study communities, it was clear that community members possess a wealth of local knowledge about how climate and extreme weather events impact their community. They have the ability to think creatively and develop solutions to reduce adverse impacts. By providing a well-facilitated and transparent forum, service providers should see their role as empowering stakeholders to bring forth ideas. When possible, locally-inspired solutions should precede solutions imposed by external sources. Strategies that are proffered by local stakeholders carry a sense of local ownership. This local empowerment begins to reduce global climate change to an issue that is manageable at and by the local level – the very level at which impacts are felt most.

In summary, climate adaptation can be a highly advantageous issue for communities to tackle. Some of the more tangible benefits uncovered in the case study communities included reduced risks to flooding, heightened attention to emergency preparedness, strengthened community networks, improved communications across sectors and levels of government, and recognition of how protecting ecosystem services benefits human health and safety. From these outcomes, climate adaptation presents a
mechanism for building stronger communities that are more resilient to environmental, economic, and social changes.

Part IV: Reflections on the Research Experience

Beginning with the literature review provided an informative basis for guiding the development of the research design and interview instruments. However, as the research began it became clear that much of the experiences of the individuals who were interviewed have yet to be widely documented in the written literature. Hence, this was confirmation that both the aims and the participants of this research were at the forefront of an emergent issue, which could be argued as a hallmark of applied research.

Furthermore, case studies seemed to be a particularly relevant form of qualitative research given the need to understand what Yin (2009) would describe as the “what” and “how” of adaptation. The “why” aspect of pursuing adaptation, although inherently difficult to answer within uncontrolled social systems, was approached strategically and solely by collecting the perspectives of the research participants. To test the accuracy of the conclusions from these three questions of “what,” “how,” and “why,” draft case study reports were reviewed by interviewees. Although there were not any major substantive corrections, these “member checks” did help to elucidate what research participants felt were key components within their respective cases.

Open-ended interviews turned out to be an exceptional research tool. Contrived interview questions, however, were a challenge faced head-on in the first few interviews. It quickly became apparent that questions had to be adapted to each case study and each
interviewee, often in the midst of an interview. To maintain consistent data collection despite differing questions, the three aims of the research guided the interviews into three consistent parts: (1) the conditions that led to adaptation, (2) the process for adaptation, and (3) the outcomes from pursuing adaptation. While the questions to answer these were responsive to initial review of document data and preceding interviews, the most revealing question (from a methodology perspective) was, “Can you tell me more about that?” Probing questions such as this routinely unearthed unexpected gems and called forth important details to an “outsider” that participants overlooked.

Another personal discovery about research methodology was the power of line-by-line coding. It helped make sense of large amounts of qualitative data, especially in making comparisons across multiple case studies. The iterative nature of refining and reassigning codes directed a critical thought process about what each piece of data said. This skill transcends academic research into professional settings to “read between the lines” by identifying themes in what people are trying to communicate.

In retrospect, constructing and implementing a research proposal has already had clear implications upon writing grant proposals. While at times the iterative process seemed more torturous than pushing rope uphill, it turned out to be a truly invaluable experience. One of the greatest personal lessons learned was to construct a proposal that is specific yet amenable to unforeseen challenges and opportunities. It was particularly helpful to gain input from the New Hampshire Coastal Adaptation Workgroup who served as both a body of experts and a pool of end-users. This resource made the research more informed and relevant to needs in the user community. I owe tremendous gratitude
for the support, guidance, and encouragement that I received from this group of dedicated and brilliant group of individuals.

Conducting three case studies was very time-intensive and tested my ability to focus the analysis given the extent of data, although the NVivo software was particularly helpful in this regard. Nonetheless, conducting multiple case studies was critical to generating generalizable findings to meet the aims of this research.

At the outset, I had not anticipated the differences in available data from retroactive case studies (Cape Cod) in contrast to those providing opportunities for participant-observation (New Hampshire and Bridgeport). I found that the latter provided a superior opportunity to collect and analyze data, particularly with interviews. The timeliness of the interviews being in step with the processes allowed for strong recall among interviewees as well as more informed questioning. It is my personal impression that some participants from the Cape Cod case study may have forgotten important details about the process that could have enhanced the richness of that case study.

Finally, I found the experience of designing, conducting, and reporting research to be extremely challenging. The unforeseen twists and turns in the iterative process can test one’s resolve. At the same time, research provides profound opportunities for personal and intellectual growth. I have gained skills and knowledge (described above) that carryover into professional settings. On that note, I discovered that research can be a vehicle to unknown destinations. The knowledge, skills and relationships that I developed through this research led me to accept a job with New Hampshire Sea Grant. From this research and recent employment, I now find myself engaged with communities and the New Hampshire Coastal Adaptation Workgroup seeking to help communities address the
very issue of climate adaptation. However, the learning is not over. I believe it has just begun.
BIBLIOGRAPHY

<http://www.seabrooknh.org/Pages/SeabrookNH_WebDocs/about>

Harbor management plan.  


<http://www.floods.org/index.asp?menuID=290&firstlevelmenusitemID=187&siteID=1>


Godlewski, S. New Hampshire Department of Environmental Services, Environmental Health Outreach and Education. Telephone Interview by Chris Keeley. 24 MAR 2011.


Grabarz, Ted. City of Bridgeport, Sustainability Director. Personal interview conducted by Chris Keeley. 8 MAY 2012.


Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.


Mayor's biography. (n.d.). City of Bridgeport. Mayors Page, Background.  
<http://www.bridgeportct.gov/mayorspage/Pages/Background.aspx>


<http://www.springerlink.com/content/b0072m777772k7r/>

Nidoh, Mike. City of Bridgeport, Planning Director. Personal interview conducted by Chris Keeley. 26 APR 2012.


<http://www.erh.noaa.gov/okx/StormEvents/storm06242010.html>


U.S. Census Bureau; State and County Quick Facts. (2012, January 31).  
<http://quickfacts.census.gov/qfd/states/09/0908000.html>

U.S. Conference of Mayors Climate Protection Agreement. (n.d.).  
<http://www.usmayors.org/climateprotection/agreement.htm>


Whelchel, Adam. The Nature Conservancy, Director of Science. Personal interview conducted by Chris Keeley. 25 APR 2012.


APPENDICES
APPENDIX A – INSTITUTIONAL REVIEW BOARD APPROVAL FOR HUMAN SUBJECTS RESEARCH
13-Jan-2012

Keeley, Chris
Natural Resources and the Environment, Nesmith Hall
710 Augusta Road
Jefferson, ME 04348

IRB #: 5340
Study: How Are Small, Coastal Communities with Volunteer-Based Governments Facing Adaptation to Climate Change?
Approval Date: 13-Jan-2012

The Institutional Review Board for the Protection of Human Subjects in Research (IRB) has reviewed and approved the protocol for your study as Exempt as described in Title 45, Code of Federal Regulations (CFR), Part 46, Subsection 101(b). Approval is granted to conduct your study as described in your protocol.

Researchers who conduct studies involving human subjects have responsibilities as outlined in the attached document, Responsibilities of Directors of Research Studies Involving Human Subjects. (This document is also available at http://unh.edu/research/irb-application-resources.) Please read this document carefully before commencing your work involving human subjects.

Upon completion of your study, please complete the enclosed Exempt Study Final Report form and return it to this office along with a report of your findings.

If you have questions or concerns about your study or this approval, please feel free to contact me at 603-862-2003 or Julie.simpson@unh.edu. Please refer to the IRB # above in all correspondence related to this study. The IRB wishes you success with your research.

For the IRB,

Julie F. Simpson
Director

cc: File
    Becker, Mimi
To: Julie Simpson, Human Subjects Research  
From: Mimi Larsen Becker  
Re: IRB Submission from Chris Keeley  
Date: Dec 8, 2011

Chris Keeley has had his proposal approved by his M.S. committee. He is now submitting his request for IRB Human Subjects Board Review of his research. He will be approaching his interview subjects based upon their professional or official positions in their communities. Thus I would consider it low risk. None of the subjects will be quoted by name unless they give their explicit permission. The collaborators on the project are anxious for Chris to proceed. It is important work and I have confidence that he will conduct it with professional skill and demeanor. Thanks for your help with this review.

Sincerely,

Mimi Becker, Ph.D.,  
Chair of Chris's MS Committee and his advisor.
Item A3 – Informed Consent form provided to research participants

Informed Consent

You are being contacted to participate in research at the University of New Hampshire. The purpose of this research is to capture lessons learned about local conditions that support climate adaptation, approaches to adaptation processes, and insights into implementation and broader outcomes. The intent of this research is to help technical assistance providers in coastal New Hampshire and elsewhere to overcome challenges associated with climate adaptation. Within each case study, the goals are to describe (1) what led the community to move from concern to action on climate adaptation, (2) the approach or process for adaptation, and (3) any enduring outcomes of the adaptation effort.

The research will culminate in a Masters of Science thesis. Individual case study reports may be made available through the Climate Adaptation Knowledge Exchange (CAKE), or through a professional journal.

Approximately 3-5 people involved in climate adaptation will be interviewed at each study site. There will be 3-5 case studies, resulting in individual case study reports as well as a synthesis report.

Please review the following components of informed consent, then reply via email to the researcher (Chris Keeley) to confirm that you have reviewed the consent and agree to participate.

- Participation is entirely voluntary.
- Interviewees may refuse to answer any question and/or terminate the interview at any point.
- There are no reasonably foreseeable risks or discomforts.
- There are no direct benefits to you personally, other than contributing to this knowledge base.
- Your responses will not be attributed to you unless for contextual reasons there is a need to identify you by name and you agree to such identification.
- Data generated from interviews will be accessible only by the research team (graduate student Chris Keeley, and thesis advisor Dr. Mimi Larsen Becker). However, under rare circumstances, other individuals may access the data. For example, in the case of a complaint about the study, the Institutional Review Board and/or UNH administrators may have to review the data.
- Following completion of the research, all data will be deidentified and will be stored on a secure computer in Dr. Mimi Becker’s lab.

For questions about the research, please contact the lead researcher, Chris Keeley, at the University of New Hampshire by phone (207-441-3341) or email (chris.keeley@unh.edu), or Dr. Mimi Larsen Becker by email (mimi.becker@unh.edu). Please contact UNH Research Integrity Services at 603-862-2003 with questions about your rights in participating in this research.

If you agree to participate, please email Chris Keeley (chris.keeley@unh.edu) stating that you have reviewed this consent document and agree to participate in this research project.
APPENDIX B – MATERIALS PERTAINING TO BRIDGEPORT,
CONNECTICUT CASE STUDY
**Item B1 – Community Profile Quick Facts**


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<tr>
<th>Demographic</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Population (2010)</td>
<td>144,229</td>
</tr>
<tr>
<td>Average per capita income (2010 inflation adjusted $)</td>
<td>$19,854</td>
</tr>
<tr>
<td>Persons below poverty level</td>
<td>20.8%</td>
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<tr>
<td>Population density (persons per square mile of land area)</td>
<td>9,029</td>
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</table>

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<tr>
<th>Government &amp; services</th>
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<tr>
<td>Total expenditures (2009)</td>
<td>$486,192,767</td>
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<tr>
<td>Government</td>
<td>Mayor-Council</td>
</tr>
<tr>
<td>Emergency Services</td>
<td></td>
</tr>
<tr>
<td>Police: Full-time</td>
<td></td>
</tr>
<tr>
<td>Fire: Full-time</td>
<td></td>
</tr>
<tr>
<td>Emergency medical: Full-time</td>
<td></td>
</tr>
<tr>
<td>Bridgeport Office of Emergency Management and Homeland Security</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Boards and commissions</th>
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<tbody>
<tr>
<td>Board of Assessment Appeals, Board of Public Purchases, Cable Advisory Board, Civil Service Commission, Ethics Commission, Fair Housing Commission, Fair Rent Commission, Fire Commission, Greater Bridgeport Regional Planning, Greater Bridgeport Transit Authority, Harbor Commission, Historic Commission No. 1, Housing Authority, Parks Commission, Planning &amp; Zoning Commission, Police Commission, Port Authority Commission, Stratfield Historic District Commission, Water Pollution Control Authority Commission, Zoning Board of Appeals</td>
<td></td>
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</table>

| Capital Improvement Plan | Yes |

<table>
<thead>
<tr>
<th>Utilities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastewater Treatment</td>
<td>West Side Treatment Plant, East Side Treatment Plant, both operated by Bridgeport Water Pollution Control Authority</td>
</tr>
<tr>
<td>Electric supplier</td>
<td>The United Illuminating Co.</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Southern Connecticut Gas Company</td>
</tr>
<tr>
<td>Water supply</td>
<td>Aquarion Water Company</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Tax base</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Taxable lands</td>
<td>56%</td>
</tr>
<tr>
<td>Vacant lands</td>
<td>11%</td>
</tr>
<tr>
<td>Tax-exempt lands</td>
<td>33%</td>
</tr>
<tr>
<td>Total housing units</td>
<td>57,012</td>
</tr>
</tbody>
</table>
AGENDA
Greater Bridgeport Community Climate Preparedness
March 30, 2012, 8:30 AM – 12:30 PM
Bridgeport City Hall, Annex A/B

Workshop 1 Objectives
1. Understand connections between ongoing community issues, hazards vulnerabilities, and local planning/decision processes.
2. Evaluate strengths and vulnerabilities of local populations, infrastructure and natural resources to hazard threats.

<table>
<thead>
<tr>
<th>Day 1</th>
<th>ACTIVITIES and OBJECTIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30</td>
<td>Registration – Sign-in, Grab Your Agenda, Coffee, Refreshment</td>
</tr>
</tbody>
</table>
| 9:00  | Welcome, Workshop Overview, and Introductions  
*Objective:* To introduce workshop purpose, objectives, participants |
| 9:20  | Overview Presentation  
*Objective:* Hazards, Vulnerability, Risk - Needs, Information, Tool, Process |
| 9:40  | Roadmap Process Overview  
*Objective:* Introduction to Roadmap process and how the workshop activities will proceed. |
| 10:00 | Community Characterization – Survey Results  
*Objective:* Set the stage for vulnerability assessment by characterizing existing conditions and identifying significant local issues and priorities. |
| 10:20-12:15 | Hazard Profile – Small Group Breakouts  
*Objective:* Develop and report out the Hazard Profile identifying key hazards exposure issues & concerns |
| 12:15-12:30 | Day 1 Wrap-up and Introduction to Workshop #2 (April 10, 2012) |

Thank You!
Item B3 – Workshop 2 Agenda

AGENDA
Bridgeport Climate Preparedness Workshop
April 10, 2012
8:30 AM – 12:30 PM
Bridgeport City Hall, Annex A/B/C

Workshop 2 Objectives
1. Evaluate Vulnerabilities and Assets of infrastructure, local populations and natural resources to hazards.
2. Identify opportunities for adapting to local hazard risk.

<table>
<thead>
<tr>
<th>Day 1</th>
<th>ACTIVITIES and OBJECTIVES</th>
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</thead>
<tbody>
<tr>
<td>8:30</td>
<td>Registration – Sign-in, Grab Your Agenda, Coffee, Refreshment</td>
</tr>
<tr>
<td>9:00</td>
<td>Welcome, Workshop #1 Recap, Workshop #2 Overview and Instructions</td>
</tr>
<tr>
<td></td>
<td><em>Objective: To introduce workshop objectives, process and flow</em></td>
</tr>
<tr>
<td>9:30</td>
<td>Small Group Breakouts – Roadmap Profiles</td>
</tr>
<tr>
<td></td>
<td><em>Objective: Develop Infrastructure, Societal, Ecological Profiles and Actions</em></td>
</tr>
<tr>
<td>11:00</td>
<td>Short Break - Coffee and Refreshments</td>
</tr>
<tr>
<td>11:15</td>
<td>Small Group Report-Outs</td>
</tr>
<tr>
<td></td>
<td><em>Objective: Brief presentation on small group dialogue – Risk Matrix</em></td>
</tr>
<tr>
<td>12:00</td>
<td>Open Facilitated Discussion – Commonalities, Plans, Actions</td>
</tr>
<tr>
<td>12:20</td>
<td>Workshop #2 Wrap-up and Next Steps</td>
</tr>
<tr>
<td>12:30</td>
<td>Thank You! Please complete an evaluation.</td>
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</table>
Capturing actions via cross walk of Vulnerabilities and Assets with Hazards using TNC’s “Risk Matrix”
<table>
<thead>
<tr>
<th>Vulnerabilities and Assets by Hazards</th>
<th></th>
<th></th>
<th>Precipitation</th>
<th>Heat</th>
<th>Wind</th>
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</thead>
<tbody>
<tr>
<td><strong>Vulnerabilities/assets</strong></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Transportation - bridges, rail, ferry, bus, highways, local roads, bridges, viaducts</td>
<td>Coastal Flooding (Surge and SLR)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Citywide</td>
<td>Surf &amp; tide, Harvey Beach</td>
<td>Roadway risk to bridges for evasive action and中小学 for pumping stations, back up generator</td>
<td>High tide and salinity</td>
<td>High tide and salinity</td>
<td>High tide and salinity</td>
</tr>
<tr>
<td>A High Road to Inland Route Route</td>
<td>Coastal City</td>
<td>Improper perimeter control/maintenance</td>
<td>High tide and salinity</td>
<td>High tide and salinity</td>
<td>High tide and salinity</td>
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<tr>
<td>A Metro North Bridges for Evacuation</td>
<td>Coastal</td>
<td>Increased vehicle, high-traffic vehicle (1000 vehicles per hour)</td>
<td>Increased vehicle, high-traffic vehicle (1000 vehicles per hour)</td>
<td>Increased vehicle, high-traffic vehicle (1000 vehicles per hour)</td>
<td>Increased vehicle, high-traffic vehicle (1000 vehicles per hour)</td>
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<tr>
<td>A Communication (Fixed) Sub, Mobile</td>
<td>Coastal Citywide</td>
<td>Underwater line, internet, power</td>
<td>Equipment performance, management</td>
<td>Equipment performance, management</td>
<td>Equipment performance, management</td>
</tr>
<tr>
<td>A Utilities - Tank Plants/Power Plants/Trash to Energy/Water</td>
<td>Coastal</td>
<td>Coastal &amp; low lying</td>
<td>Equipment performance, management</td>
<td>Equipment performance, management</td>
<td>Equipment performance, management</td>
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<tr>
<td>V High Density Public Housing</td>
<td>Coastal Citywide</td>
<td>High rise and elderly</td>
<td>Equipment performance, management</td>
<td>Equipment performance, management</td>
<td>Equipment performance, management</td>
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<tr>
<td>A Air and Police Response/OIC</td>
<td>Citywide</td>
<td>High density &amp; public housing</td>
<td>Equipment performance, management</td>
<td>Equipment performance, management</td>
<td>Equipment performance, management</td>
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<tr>
<td>Ecosystem vulnerabilities/assets</td>
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<td>V Island Marsh</td>
<td>New Haven, Milford</td>
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<td>M</td>
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<td>V Shellfish Beds</td>
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<td>E&amp;S Neighbor</td>
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APPENDIX C – ITEMS RELATING TO HAMPTON-SEABROOK ESTUARY,
NEW HAMPSHIRE CASE STUDY
Item C1 - Stakeholder Meeting #1

A project of the New Hampshire Coastal Adaptation Workgroup (NH CAW)

EXPLORING ECONOMIC OPTIONS TO PROTECT THE HAMPTON-SEABROOK
ESTUARY FROM COASTAL FLOODING: LOCAL STAKEHOLDER GROUP MEETING #1

When: Thursday 6:15-8:30 PM, October 27, 2011
Where: Hampton Falls Public Library Conference Room

6:15 – 6:30 Sign-in, Refreshments, Slides of “King Tide” photos from earlier in the day
6:30 – 6:45 Welcome and Introductions
(Sherry Godlewski, NH Dept. of Environmental Services, Co-Chair of the New Hampshire Coastal Adaptation Workgroup)
6:45 – 7:15 Overview of the Project and the Coastal Adaptation to Sea Level Rise Tool (COAST)
(Dr. Sam Merrill, New England Environmental Finance Center)
7:15 – 7:30 Storm Surge and Sea Level Rise Overview
(Dr. Cameron Wake, Institute for the Study of Earth, Oceans, and Space, University of New Hampshire)
7:30 – 8:25 Group Discussion of Community Asset Vulnerabilities
(Dr. Sam Merrill and Cliff Sinnott, Rockingham Planning Commission)
OUTCOME: Final decision on what assets to model for rest of the study.
8:25 – 8:30 Wrap-up & Adjourn (Cliff Sinnott)

Agenda
Item C2 - Stakeholder Meeting #2 Agenda

Climate Ready Estuaries/COAST Project
Exploring Economic Options to Protect the
Hampton-Seabrook Estuary from Coastal Flooding
Stakeholder Meeting #2
Thursday, February 23, 2012, 6:00-8:30 pm
Hampton Falls Town Hall, NH

Meeting Objectives
- Participants understand their community’s vulnerability to coastal flooding
- Participants identify and prioritize vulnerable areas and assets of concern
- Participants provide input on flood damage reduction options for modeling work

<table>
<thead>
<tr>
<th>Time</th>
<th>Objectives &amp; Process</th>
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<td>6:00pm</td>
<td>Welcome and Introductions by Project Team</td>
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| 6:15pm| **Presentation of coastal flooding and property damage maps for various storm events and sea level rise scenarios**  
        *Session Objective: Participants understand flood and property damage data presented in series of maps. Refer to the “Map Chart” on following page.* |
| 6:45pm| **Participants review map series and identify vulnerabilities in all 3 towns**  
        *Session Objective: Participants examine maps showing the flooding and economic impacts on all three towns for various model scenarios* |
| 6:55pm| **Facilitated break-out group for each of the 3 towns**  
        *Session Objective: Participants identify specific vulnerabilities in their town using map set for their town  
        Facilitators: Hampton (Derek Sowers), Hampton Falls (Steve Miller), Seabrook (Julie LaBranche)  
        ▪ Participants walk through each map scenario with facilitator and note areas and assets of concern  
        ▪ Facilitators will lead group to prioritize their “top 3 concerns”  
        ▪ Participants will identify 1 person from their group to provide a summary/report to the group* |
| 7:30pm| **Facilitated group review of community concerns and discussion of priorities**  
        *Session Objective: Participants share top town concerns with each other to inform hazard reduction strategies  
        ▪ Each town will report to the group sharing their top concerns; participants and facilitators may ask clarifying questions so that all understand each concern  
        ▪ Review the top concerns, note similarity/differences, identify regional issues, and group discussion to gain consensus on priority concerns. Outcome is to help inform the next step in project (see next agenda items about selection and modeling of adaptation strategies/actions)* |
| 7:45pm| **Overview presentation of potential management options (protection, accommodation, retreat, and preservation) to address coastal impacts and vulnerability**  
        *Session Objective: Participants understand management options/philosophies available to address vulnerability concerns  
        Project team will provide a short presentation on management options/philosophies, including examples of management actions, and economic/environmental/social tradeoffs of each strategy* |
| 8:05pm| **Individual stakeholder feedback on flood hazard reduction strategies using a questionnaire**  
        *Session Objective: Participants individually respond to a series of questions in order to guide the identification of coastal flooding hazard reduction actions to be modeled for the remainder of the study.* |
| 8:20pm| **Review of Next Steps in the Project**  
        Project team will review project status, how the group’s work will inform next steps for modeling actions, and review next meeting timeframe |
| 8:30pm| Thank you and Adjourn                                                                |
Item C3 - Stakeholder Meeting #3 Agenda

6:00pm Introductions, overview of previous two meetings, and tonight’s agenda
Derek Sowers, Piscataqua Region Estuaries Partnership

6:40pm Presentation of modeling results for damage reduction strategies and
summary conclusions
Paul Kirshen, University of New Hampshire

7:00pm Break out into two groups to discuss implications of results for public and
private real estate assets
NH Coastal Adaptation Workgroup facilitators

7:45pm Overview of technical resources available to municipalities and group
facilitated discussion of next steps
Julie LaBranche, Rockingham Planning Commission

8:30pm Adjourn
APPENDIX D – ITEMS PERTAINING TO CAPE COD, MASSACHUSETTS

CASE STUDY
Item D1 – Regional Multi-Hazard Mitigation Planning Team Meeting Schedule

Regional Multi-Hazard Mitigation Planning Team Meeting Schedule

June 2, 2009 9:00-11:00 Cape Cod Commission
Kick-Off Meeting; Discussion of Plan Update Requirements and Climate Adaptation

July 7, 2009 9:00-11:00 Cape Cod Commission
Hazards & Vulnerability, Critical Facilities, RVAM Maps

August 4, 2009 9:00-11:00 Cape Cod Commission

September 1, 2009 9:00-11:00 Cape Cod Commission
Attend Local MHM Meetings; Update Goals & Mitigation Strategies

October 6, 2009 9:00-11:00 Cape Cod Commission
Implementation; NFIP

November 3, 2009 9:00-11:00 Cape Cod Commission
Complete Strategy Development; Review Draft Local Plan Updates

November 17, 2009* 9:00-11:00 Cape Cod Commission
Review Regional Draft Plan; Discuss Updated Mitigation Action Items & Climate Change Adaptation; Complete Strategy Development

January & February, 2010
FEMA, MEMA & Public to review Draft Local and Regional Plans
Develop Final Plans to address comments to Draft Plans
Present Draft Regional Plan to County Commissioners and Cape Cod Commissioners

*Regional representatives only

Source: Barnstable County Multi-Hazard Mitigation Plan 2010.
Workshop Agenda

8:30-9:00 Registration and Continental Breakfast

9:00-9:20 Welcome and Opening Remarks
Brendan Annett, Manager and Tonna-Marie Rogers, CTP Coordinator, WBNERR

9:20-10:15 An Overview of Climate Change
Dr. Hugh Ducklow, MBL

Blending lecture and discussion, this session will set the stage for the day and provide an objective scientific overview of the climate debate. Using the latest available research-based climate reports, Dr. Ducklow will examine climate variability and change, human influence on climate, how we deal with uncertainty in climate science, and implications for New England.

10:15-10:30 Coffee Break

10:30-11:15 Sea Level Rise: How Vulnerable is the Cape to this Coastal Threat?
Dr. Rob Thieler, USGS

Drawing on results of a USGS project which uses the coastal vulnerability index (CVI) to rank the likelihood of physical changes to the shoreline as a result of sea level rise, Dr. Thieler will explain how different areas of Cape Cod might be affected by sea level changes. He will also address how societal responses to shoreline erosion may affect what communities can and cannot do with respect to sea level rise.

11:15-12:15 Climate Change Impacts on Coastal Resources
Dr. Jeff Donnelly, WHOI

Dr. Donnelly will examine shoreline impacts of sea level and storms drawing on his historical knowledge of the Cape. The session will also look at impacts to wetlands and implications for restoration activities, as well as some of the socioeconomic and management aspects of dealing with the coastal impacts of global change.

12:15-1:15 Lunch (provided)

1:15-2:00 Impacts on Water Resources and Planning Implications
Dr. David Ahlfield, UMASS, Amherst

This session will address the risks to Cape Cod water supplies produced by a changing climate. Extended droughts, increased evapotranspiration, and increased salt-water intrusion will be examined, as well as adaptation options such as increased water conservation and improved operational management of well fields.

2:00-3:00 Adapting to Climate Change: Planning Approaches and Resources
Dr. Lynne Carter, Adaptation Network

This session will explain what is meant by adaptation in the context of climate change and offer guidance on where and how communities can begin to incorporate climate change information into longer term planning. Dr. Carter will share case studies emphasizing how various communities have tackled adaptation and will also introduce a project that is being developed to help guide municipalities through this planning process.

3:00-3:15 Coffee Break

3:15-4:00 Managing Coastal Hazards In a Changing Climate: Available Tools & Techniques
Wes Shaw, CZM

This session will address specific things communities can do to improve their ability to survive and bounce back from coastal storms. Mr. Shaw will introduce StormSmart Coasts, a new CZM program that will help support local efforts to improve coastal floodplain management. The program offers a menu of options from which communities can choose as well as legal information to help communities regulate land use and avoid legal trouble.

4:00-4:20 Facilitated Discussion

4:20-4:30 Wrap-up and Evaluation

REGISTRATION
Fax: 617-727-5537
Email: laurie.tompkins@state.ma.us

Name __________________________
Title __________________________
Organization ____________________
Address _________________________
City, State, Zip ___________________
Telephone _______________________
Fax _____________________________
Email __________________________

In order to help us use our resources efficiently, registration is required. A limited number of walk-ins will be accepted. There is no charge for the workshop.

For additional information please contact: Tonna-Marie Rogers at 508-457-0495 x110 or tonna-marie.surgeon-rogers@state.ma.us.

Workshop Location

The Cape and Islands Association of REALTORS
Conference Center
22 Mid Tech Drive, West Yarmouth

Directions: Route 6 West to Exit 7 Willow Street. Turn Left onto Willow Street. Left onto Higgins Crowell Road. Through round a-bout then left onto Mid-Tech Drive. The Conference Center is the first Right.
Item D3 – April 2009 Workshop Agenda

Workshop Agenda

8:00 – 9:00 am Sign-in and Continental Breakfast

8:15 – 8:45 am An Overview of Climate Change (Optional)
Dr. Lynne Carter, Director, Adaptation Network
This presentation will set the stage for the day by explaining what is meant by adaptation in the context of climate change.

Morning Sessions (9:00 am – 12:15 pm)

Climate Change Is Here: Adapt or React
Dr. Lynne Carter, Director, Adaptation Network
This presentation will focus on the changing conditions that are setting the stage for more and larger wildfires, and how community decision-makers and residents can use existing tools to plan for and adapt to these changing conditions.

Lunch 12:15 – 1:15 pm (provided)

Afternoon Sessions (1:15 pm - 4:00 pm)

Early Experiences in Climate Change Adaptation: Lessons from the Deer Island Wastewater Treatment Plant
Stephen Estes-Smargiassi, Director of Planning, Massachusetts Water Resources Authority (MWRA)
This case study will explain how the MWRA made adjustments to the design and construction of the Deer Island Wastewater Treatment Plant in Boston to take into account future sea level changes and the long (50 – 100 yrs) expected service life of the plant.

Planning for Sea Level Rise and Shoreline Change at the Local Level
Rob Thieler, United States Geological Survey
This session will present findings of a study examining current and potential future conditions of the Town of Falmouth’s south shore. Problems such as eroding dunes and diminished sand supply to beaches downstream of jetties are expected to be exacerbated by sea level rise. The study recommends actions to restore viability to the coastal system.

Sea Level Rise Adaptation & Response Planning in Maryland
Gwen Shaughnessy, Maryland Department of Natural Resources
Next Steps: Linking Hazard Mitigation and Climate Adaptation Planning on Cape Cod
Stacey Justus, Coastal Resources Specialist, Cape Cod Commission
This session will explain an upcoming opportunity for interested Cape municipalities to receive technical assistance to develop climate adaptation plans. This exercise will be coupled with updating hazard mitigation plans. The planning process will draw on FEMA guidance for hazard mitigation plans, detailed climate model projections for this region, and adaptation planning tools and resources.

Wrap-up and Evaluation – Tonna-Marie Rogers, WBNERR

Workshop Location
Cape Cod & Islands Association of REALTORS Conference Center
22 Mid-Tech Drive, W. Yarmouth
Directions: From Route 6 (Mid-Cape Highway), take exit 7, then left onto Higgins Crowell Road, then left onto Mid-Tech Drive.

ONLINE REGISTRATION
www.waquoitbayreserve.org

Steps to easy on-line registration:
1. Go to the Reserve’s home page
2. Click on FULL CALENDAR
3. Scroll to March 2009
4. Click on the Plan to Protect Workshop
5. FIRST TIME ONLINE REGISTRANTS: please choose “Add me as a user” and fill in the appropriate information.
   Remember to hit SAVE when finished.
   This process will only need to be done once.
6. If you have previously registered for a workshop, just type in your email address and hit LOGON to review your information and register.

Your email address is your User ID

Workshop information please contact:
Tonna-Marie Rogers at 508-457-0495 x110
or tonna-marie.surgeon-rogers@state.ma.us

Registration Information please contact:
Laurie Tompkins at 508-457-0495 x108
or laurie.tompkins@state.ma.us