Planning for the Future: Climate Adaptation in Hazard Mitigation Plans and Comprehensive Water Resource Management Plans

An Interactive Qualifying Project submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the Degree of Bachelor of Science

by:

Gregory Bailey

Jacob A. Baril

Jonas A. Bellini

Date: March 6, 2012

Project Advisor:

Seth Tuler

Executive Summary

Coastal Massachusetts, due to its location on the Atlantic Ocean, is an area that is very susceptible to coastal hazards. A common outcome of multiple climate stressors is erosion. With continual erosion, the coastline is receding, causing the ocean to infringe on residents and businesses by the coast. The Massachusetts coastline is eroding at an average of 0.56 feet per year (O'Connell 2011). In addition to this, there has been a steady increase in sea level rise on the Massachusetts coast since 1920 (NOAA 2012) and an increased hurricane frequency and intensity is predicted. Hurricanes and storms increase the damage done by flooding and erosion as well as cause other destruction from high winds. Storm surges cause a rapid increase in the sea level around coastlines and cause flooding. Erosion, hurricanes, and storm surges are already established as coastal hazards, but climate change is predicted to increase the frequency and intensity of these events. On the other hand, sea level rise is a new concern brought on by climate change. If the Massachusetts coastal towns do nothing to prepare for these hazards, the communities will face damaged property, repair expenses, and risk of injury.

To deal with coastal hazards, communities make plans to manage these hazards before they occur. The two types of specific plans used to minimize these potential damages that we are studying are Hazard Mitigation Plans (HMP) and Comprehensive Water Resource Management Plans (CWRMPs). HMPs are a plan that is developed to prepare for known hazards, protect communities, and plan for future hazards. The CWRMP deals with planning for water usage such as drinking water, storm water, surface water, and groundwater. It also deals with waste water management and the public's impact on its water quality (Morris 2011). The purpose of the Hazard Mitigation Plan and the CWRMP is to take a look at the possible hazards and develop a plan so the town's property, resources, and people are safe from the threat of natural disasters.

Our research determined the extent to which coastal communities in Massachusetts are already including climate change information in their HMPs and CWRMPs. To accomplish this we established 3 objectives to guide our research:

Objective 1: Assessing existing Massachusetts coastal community hazard mitigation plans for climate change information

Objective 2: Investigate the opportunities and barriers for climate change information in costal community's comprehensive water resource management plans and hazard mitigation plans

Objective 3: Provide recommendations for possible actions to encourage the implementation of climate change information in hazard mitigation plans

The final product, the list of recommendations, will aid in the future development of HMPs and CWRMPs by providing information that will facilitate integrating climate change adaptation into HMPs and CWRMPs.

Research Methods

The goal of this project was to investigate to what extent hazard mitigation plans are being used to address climate change and its related hazards in Massachusetts. At the same time we examined if climate change information was being incorporated into comprehensive water resource management plans. As suggested by our background sections there are clear benefits to explicit consideration of climate change in planning. Our research data came from reports on climate change adaptation for, interviews with government officials, regional planners, and private sector consultants and 32 town and regional coastal Massachusetts HMPs.

Findings

Through analysis of the hazard mitigation plans and our interviews, we have concluded seven major findings:

1. The majority of Massachusetts coastal communities in our study do not explicitly include climate change information in their hazard mitigation plans.
    - We found that out of the 32 plans we analyzed, 9 were found to include explicit information on climate change.
2. Of the hazard mitigation plans which do include climate change information, there are varying amounts of climate change information being included in each plan.
3. Cape Cod coastal communities are including climate change information in their Hazard Mitigation Plans.

4. Through our research, we found that there is no concrete evidence to prove that coastal communities are using a no-regrets strategy.
    - A no-regrets strategy as related to hazard mitigation is when a community plans or takes an action to prevent damage, assuming the worst possible outcome based on the information they have.
5. Comprehensive Water Resource Management Plans provide opportunities for inclusion of climate change adaptation information.
    - In our interviews one of our goals was to find other mandated planning that would be appropriate for climate change adaptation. In our discussions we found that regional planners and state officials both agree that Comprehensive Water Resource Management Plans are a good place to begin thinking about climate change.
6. Public awareness plays a role in the inclusion climate change information in hazard mitigation plans.
    - Since the only information that regional planners have to go off of are predictions, it is difficult to gain support from the community because they have yet to realize the potential impacts of what is to come.
7. Climate change has not been incorporated into hazard mitigation plans because of a lack of funding.
    - Sources from interviews have indicated that without proper funding, climate change cannot be incorporated into Hazard Mitigation Plans as there is no money for research, or to pay local planning staff to focus on this issue.

Summary

With our project objectives in mind we started our project investigating the hazards which were currently affecting the Massachusetts coastline. Then, we considered how the climate is predicted to change on a global scale and how that might affect Massachusetts' coastal communities. To further aid us in our report, we made our selves familiar with the structure of hazard mitigation plans and comprehensive plans to see how information was presented. Finally, we studied federal and state requirements for hazard mitigation plans.

The research phase of our project involved taking a deeper look into 32 hazard mitigation plans collecting information on hazards, outcomes, and consequences that Massachusetts coastal communities face. We coded information from the plans about climate stressors, outcomes, mitigation strategies, inclusion of climate change information, and consequences of climate stressors. Interviews were used to gather information from regional planners and state officials about the difficulties of considerations being made in HMPs and CWRMPs. The amount of resources that were available to us regarding CWRMPs only allowed us to explore the barriers that it shared with HMPs concerning why climate change was not included.

Our final recommendations reflect the possible measures that can be made to have climate change information be included in hazard mitigation plans and ultimately other mandated local planning activities in the future. By looking at the current hazard mitigation plans and what the regional planners and state officials had to say about them, our group was able to conclude that the topic of climate change is underdeveloped, but has the potential to become more prevalent with more public outreach and demonstration of the potential impacts. We have determined that Massachusetts' coastline is vulnerable to hazards, but with a strong collective effort climate change can become a relevant issue before the full affects arrive.

Abstract

This project investigated whether hazard mitigation plans (HMPs) and comprehensive water resource management plans (CWRMPs) completed by cities and towns in Massachusetts account for the long term effects of climate change. A hazard mitigation plan is documentation created by state officials or planners that states how a specific community prepares for potential hazards. A CWRMP is an assessment of current water infrastructure as well as a plan for future water management. As our group investigated climate change in coastal Massachusetts, we examined if current HMPs included climate change information. We then looked into the opportunities and barriers for climate change information being included in coastal community's CWRMPs and HMPs. Finally, we provided recommendations to improve these plans as a resource for urban and environmental planners interested in planning for future climate change impacts.

Acknowledgments

We would like to thank all of the people who assisted in the efforts of this project. We would like to give a special thank you to our advisor Seth Tuler for the guidance and support he has given us to make this project successful.

The Information and time provided by the following organizations was invaluable to our project and we would like to thank you.

- The Cape Cod Commission
- CDM Smith
- Executive Office of Energy and Environmental Affairs
- GHD
- Massachusetts Emergency Management Agency
- Merrimack Valley Planning Council
- Metropolitan Area Planning Council

Table of Contents

List of Figures

List of Tables

1.0 Introduction

When speaking about climate related hazards we typically speak of hurricanes, winter storms, rain and thunder storms along with their outcomes such as flooding and erosion. Already flooding and erosion of the coast threaten the safety of residents, as well as local economies on a global scale. The flooding in Pakistan in 2011, although an extreme example shows the disruptive nature of this hazard and how it can bring an economy to a halt. Climate change predictions suggest that these hazards and outcomes will increase in intensity (Gourley 2007). The 2007 Intergovernmental Panel on Climate Change (IPCC) has come to the conclusion that due to current warming patterns, the sea level will rise 10-23 inches around the world by the year 2100 (Environmental Defense Fund 2011). This provides evidence that coastal hazards greatly affect residents of coastal communities and they cannot afford for these hazards to become more frequent and of greater magnitude without more substantial planning.

Coastal Massachusetts, due to its location on the Atlantic Ocean, is an area that is very susceptible to coastal hazards. A common outcome of multiple climate stressors is erosion. With continual erosion, the coastline is receding, causing the ocean to infringe on residents and businesses by the coast. The Massachusetts coastline is eroding at an average of 0.56 feet per year (O'Connell 2011). In addition to this, there has been a steady increase in sea level rise on the Massachusetts coast since 1920 (NOAA 2012) and an increased hurricane frequency and intensity is predicted. Hurricanes and storms increase the damage done by flooding and erosion as well as cause other destruction from high winds. Storm surges cause a rapid increase in the sea level around coastlines and cause flooding. Erosion, hurricanes, and storm surges are already established as coastal hazards, but climate change is predicted to increase the frequency and intensity of these events. On the other hand, sea level rise is a new concern brought on by climate change. If the Massachusetts coastal towns do nothing to prepare for these hazards, the communities will face damaged property, repair expenses, and risk of injury.

To deal with coastal hazards, communities make plans to manage these hazards before they occur. The two types of specific plans used to minimize these potential damages that we are studying are Hazard Mitigation Plans (HMP) and Comprehensive Water Resource Management Plans (CWRMPs). HMPs are a plan that is developed to prepare for known

hazards, protect communities, and plan for future hazards. The CWRMP deals with planning for water usage such as drinking water, storm water, surface water, and groundwater. It also deals with waste water management and the public's impact on its water quality (Morris 2011). The purpose of the Hazard Mitigation Plan and the CWRMP is to take a look at the possible hazards and develop a plan so the town's property, resources, and people are safe from the threat of natural disasters.

However, while HMPs and CWRMPs can both provide useful planning information to minimize the effects of natural hazards, they currently do not require explicit attention to hazards or water resources that may be affected by a changing climate. It is unclear as to what extent the topic of climate change is covered in these types of plans.

Our research determined the extent to which coastal communities in Massachusetts are already including climate change information in their HMPs and CWRMPs. This includes indicating which hazards will get worse or arise because of climate change. Another goal of our research was to find out if the developers of these HMPs and CWRMPs are thinking long term or short term. As our group investigated climate change in coastal Massachusetts, we examined if existing HMPs included climate change information. We then looked into the opportunities and barriers for climate change information being included in coastal community's CWRMPs and HMPs. The final product is a list of recommendations which will aid in the future development of HMPs and CWRMPs by providing information that will facilitate integrating climate change adaptation into HMPs and CWRMPs.

2.0 Background

This chapter begins by explaining the coastal hazards of Massachusetts and how they can negatively affect the residents of Massachusetts coastal communities. It then goes on to discuss how the climate is changing globally and how this global change is going to affect Massachusetts. After this, Section 2.3 explains the specific planning process for these hazards called hazard mitigation. This includes 2 types of plans, Hazard Mitigation Plans (HMPs) and Comprehensive Water Resources Management Plans (CWRMPs). This chapter emphasizes the extent to which these hazards affect the coastal communities of Massachusetts and the importance of properly planning for them.

2.1 Massachusetts Coastal Hazards

The Massachusetts coastline is comprised of 78 communities, indicated in Figure 1 (a more detailed map is in Appendix A). Since these areas are near the ocean, they are vulnerable to damage caused by coastal hazards. These hazards include hurricanes, flooding, and erosion.

Massachusetts has islands, like Nantucket and Martha's Vineyard, which are more affected by these hazards. The coast also has barrier islands, such as Plum Island, which dampen the effects of storms, flooding, and erosion. Barrier beaches are geological feature of the Massachusetts coast that helps provide a barricade for the mainland from the full force of incoming storms. Barrier beaches are thin strips of dune and beach separated by a body of water that are parallel to the coastline. Hundreds of barrier beaches that line the Massachusetts coastline offer a natural source of protection against storms and floods just as barrier islands do. Barrier Beaches differ from islands in the fact that these beaches are constantly subject to changing due to over wash, dune movement, and erosion (Massachusetts Office of Coastal Zone Management 2012).

Although Massachusetts natural geology offers protection against climate related hazards, often times it is not enough to dampen the effects of a hurricane or a winter storm.

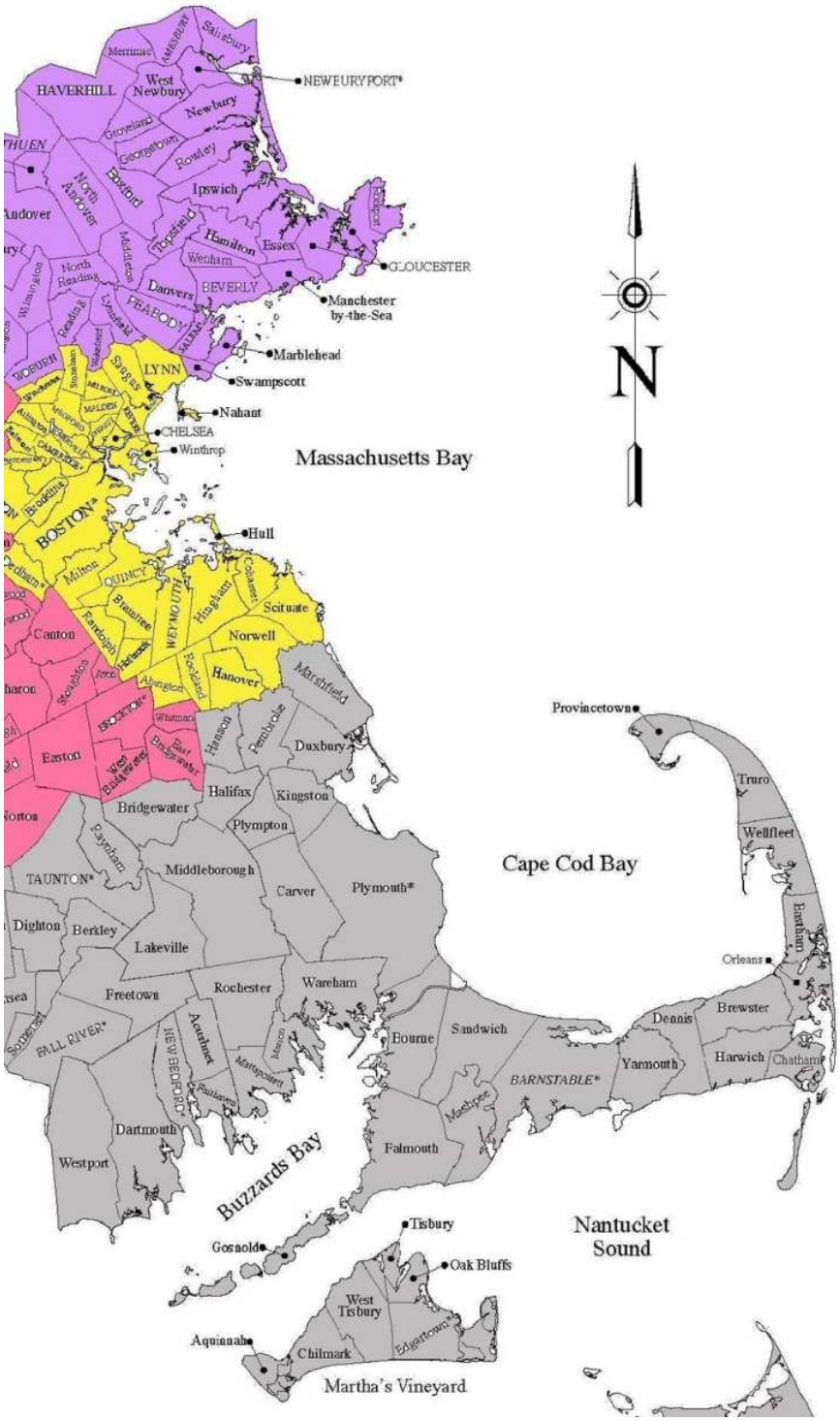


Figure 1: Massachusetts Coastal Communities

Courtesy of: Massachusetts Cities and Towns from the Secretary of the Commonwealth

2.1.1 Types of Coastal Hazards in Massachusetts

Hurricanes inflict damage due to their excessive wind speed, extreme levels of precipitation and their ability to generate storm surges (The Northeast States Emergency Consortium-Hurricanes 2011). Hurricanes can cause extensive amounts of damage to buildings as well as create a hazardous environment for the residents seeking shelter. The typical hurricane season on the eastern coastline is from June to November. Storm surges cause the sea level to rise dramatically in a short time due to the low pressure system pushing down on the ocean's surface. The infrastructure developed by coastal communities is not designed to completely withstand the effects of hurricanes, so this hazard can impact the coastline greatly.

Another type of storm that occurs frequently on the Massachusetts coast is called a Nor'easter. These are classified by large amounts of precipitation, high winds, and large waves that cause erosion (Massachusetts Office of Coastal Zone Management 2011). One to two Nor'easters hit per year during October and April and cause shoreline erosion, flooding, and property damage (Massachusetts Office of Coastal Zone Management 2011). These storms are seen during these times because the transition of the seasons causes a disturbance in weather patterns. Although these storms are not as powerful as a hurricane, their consequences are similar, but of lesser magnitude.

A common outcome of hazards in Massachusetts is flooding, which occurs in a variety of ways. Although most coastal flooding occurs from the heavy precipitation during hurricanes and tropical storms (storms with sustained wind speeds of 39-79 mph), other flooding can occur through dam failures, storm surges, or overflow of river banks and seawalls. Flooding is dangerous as it often causes property damage, economic instability, and even sometimes death (The Northeast States Emergency Consortium-Floods 2011). Unfortunately, damage from flooding is very common due to the fact that coastal communities have many buildings and structures close to bodies of water.

Erosion is a risk that is just as pertinent as flooding. There are "350,000 structures located within 500 feet of the nation's 10,000 miles of coastline" (O'Connell 2011), but about one quarter of these are predicted to be lost within sixty years. The Massachusetts coastline is eroding at an average of 0.56 feet per year (O'Connell 2011). Figure 2 illustrates the varying rates of erosion for different areas of the California coast. These differences are determined by

substrate type (soil and stone), weather patterns and intensity of wave, and in more recent years, sea level rise and storm severity and frequency (Center for Ocean Solutions 2012).

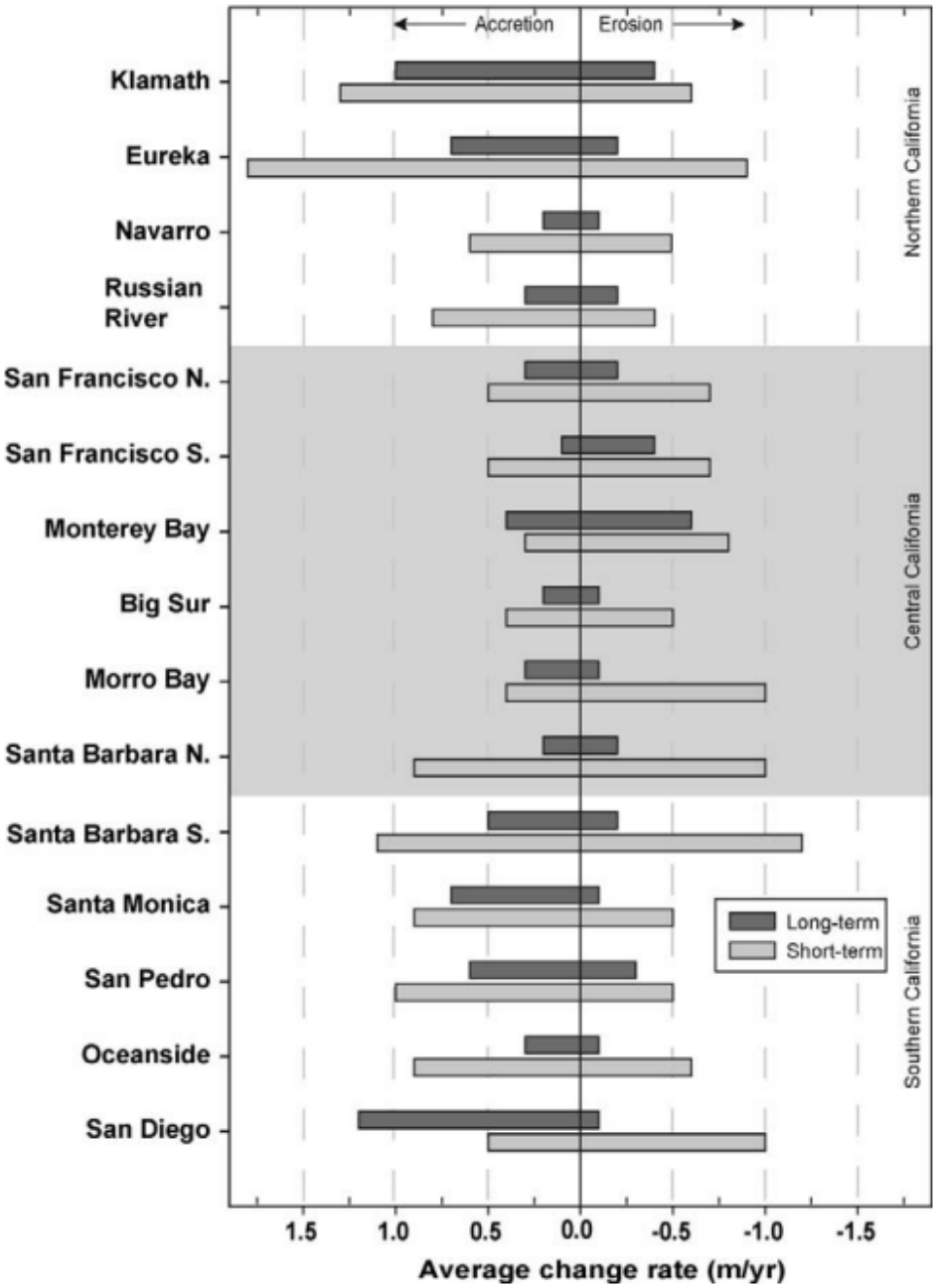


Figure 2: Accretion and Erosion Rates for California

Courtesy of the Journal of Coastal Research

2.1.2 Impacts from coastal hazards in Massachusetts

The coastal hazards of Massachusetts have economic, environmental and social implications. Coastal hazards affect the economy with not only the damage they cause to public and private property, but the lack of revenue generated by businesses as a result of building damage. Flooding is the most expensive hazard to communities due to damage of buildings and private property. Since 1978 there has been over $197 million paid in flood insurance claims in Massachusetts, and an estimated $108 million worth of damage to public property due to flooding (Massachusetts Department of Environmental Management 2003). Luckily, in the case of a major disaster, the federal government will give assistance to towns in need (MassDEM 2003). In most cases, towns have to repair the damage of these storms which will use money from the town budget.

From a public health standpoint, environmental problems can occur from an eroding coastline. As erosion affects land, it exposes bodies of water to various contaminants. Pollution in water ways causes widespread harm to the environment, especially the ecosystems which serve as the habitat for wildlife. Once contaminants have entered a water system, it is extremely hard to remove them. The difficulty of eliminating pollution from the environment makes this a difficult impact to eliminate (Zezima 2010). The only solution is to minimize it from happening in the first place. The endangerment of human lives is another health issue brought about by coastal hazards. To give an idea of the extent of damage caused by coastal hazards it is important to note that in the most recent hurricane Irene, there were at least 44 deaths (MSNBC 2012). Coastal hazards endanger lives causing social and emotional devastation (MassDEM 2003). It is important to recognize the impacts of coastal hazards and the costs associated with them so that the citizens of coastal communities have a greater understanding of what can be done to minimize damage.

2.2 Climate change on a Global Scale

Before understanding the climate change that affects the Massachusetts area, it is important to understand the climate change on a global scale. The Intergovernmental Panel on Climate Change (IPCC) created by the United Nations put out a report in 1995 stating that it is very likely with a ninety percent certainty that emissions caused by humans have a heat

trapping effect which is the cause of global warming (Houghton 1995). The burning of fossil fuels has been proven to produce carbon dioxide emissions, which trap solar radiation from being reflected from the earth causing a raise in temperature of the earth (Frumhoff 2007). The impacts of climate change vary, but all these impacts will dramatically change the way of human life.

2.2.1 Rising Temperature

On a global scale, the temperatures have had a net rise on average. Satellites are used to identify temperature measurement stations that are located in both urban and non-urban areas (NASA 2011). This allows for a variety of temperature findings which can be used to compare the difference in climate between urban and non-urban areas. Between 1880 and 1970, it has been discovered that there was a net global warming of 0.4 degrees Celsius (NASA Analysis 2012). Figure 3 displays average temperature trends from 1880 to 2010.

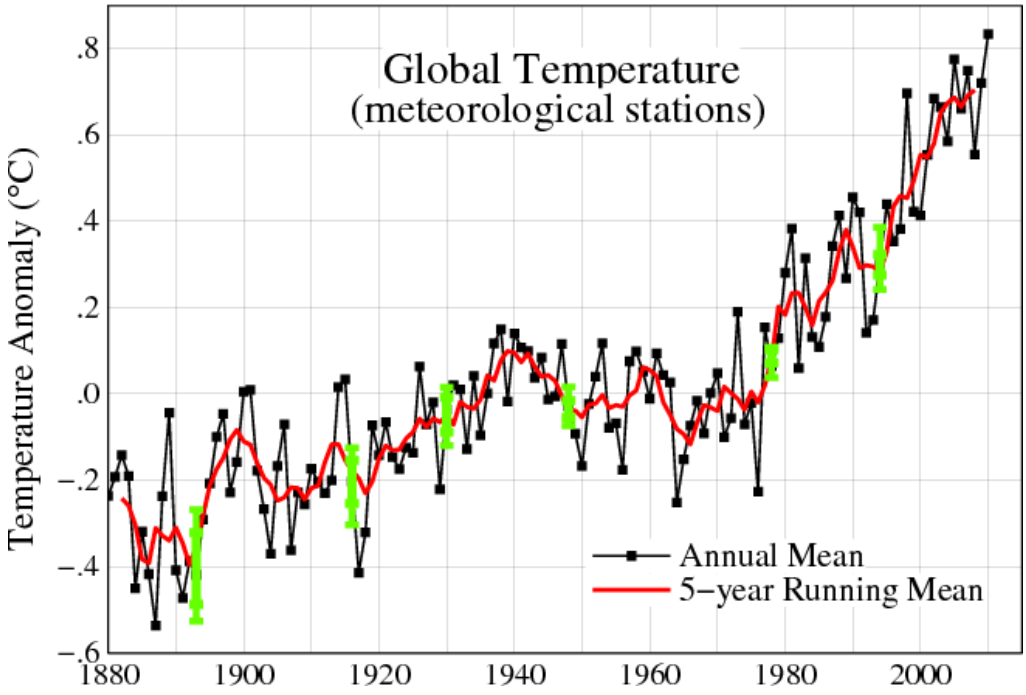


Figure 3: Global Temperature Trends

Courtesy of Goddard Institute for Space Studies (2011)

2.2.2 Warming Oceans

The trend of increasing ocean water temperatures has been linked to global warming (Levitus 2009). The ocean heat content was gathered over a course of fifty years by using

instruments to measure the temperature of the upper seven hundred meters of oceans. These instruments called bathythermograph instruments are expendable floating data collecting devices used to gather temperature readings (Levitus 2009). Figure 4 shows the average heat content of the worlds oceans over a 55 year period. It is important to find what the temperature of the ocean is because it shows a more accurate measure of the temperature of the world than land or air temperatures can. The capacity to store heat of the ocean is about one thousand times greater than the atmosphere (Connor 2011).

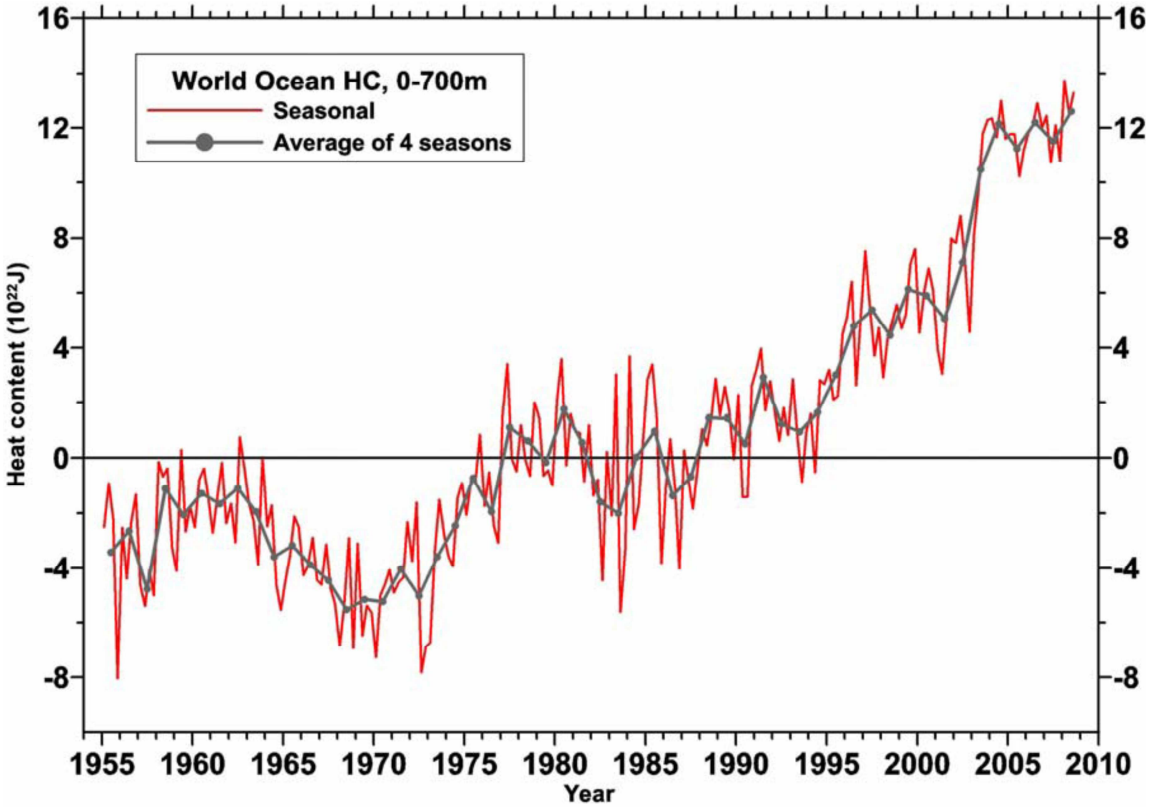


Figure 4: World Ocean Heat Content

Courtesy of National Oceanic and Atmospheric Administration (2011)

2.2.3 Changes in Weather Patterns

As the global climate warms over time it will cause a disruption in normal weather patterns. This rise in temperature can have a variety of effects, one of which is sea level rise. Rising sea levels could mean future category 2 and 3 storms would be able to cause much more

severe flooding (Gourley 2007). It is predicted to precipitate more often due to the increase in water from the melting of the glaciers. Tropical hurricanes are predicted to be less frequent, but more severe (Gourley 2007). Yet, several areas will experience drier weather due to the climate change such as western United States (Enloe 2011). Figure 5 uses data for the United States and relates it to climate extremes.

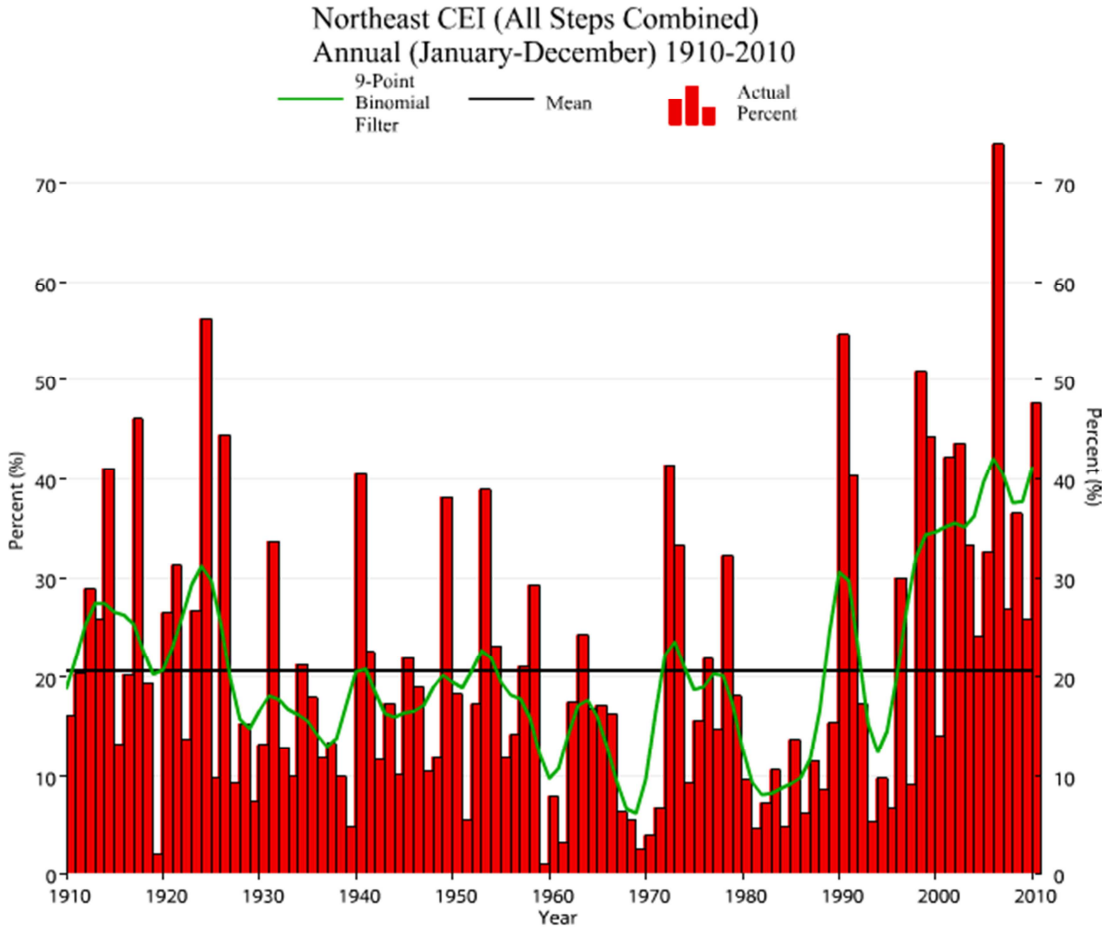


Figure 5: Climate Extreme Index for the Northeast United States

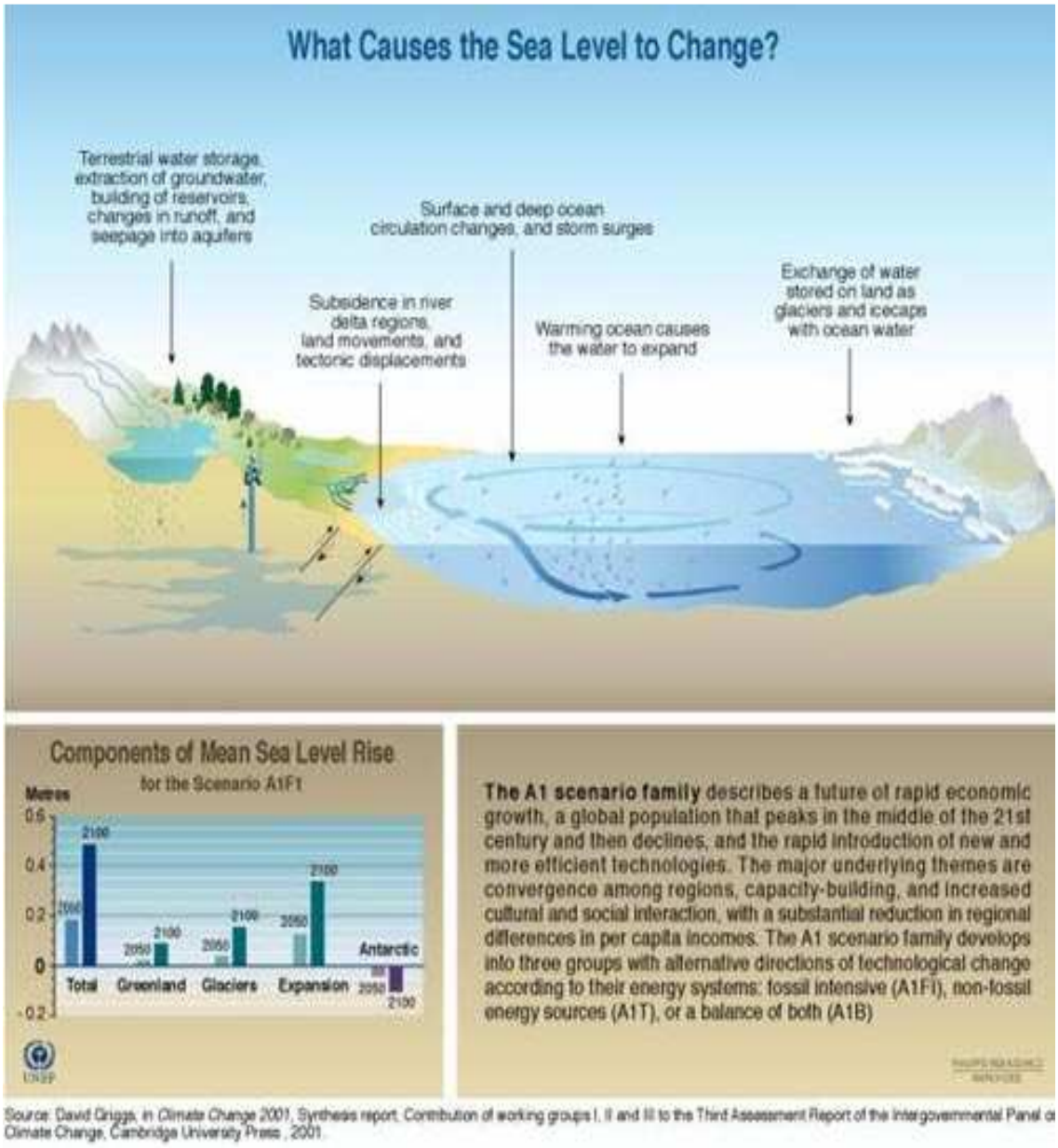
Courtesy of Climate Science Watch (2011)

Precipitation data was gathered from daily rain stations. The National Climatic Data Center climate division precipitation and temperature databases are used (Enloe 2011). Moisture was categorized in increasing order of intensity as near normal, mild to moderate, severe, or extreme for droughts and wet periods (Enloe 2011). The data about the

tropical storms and hurricanes came from the National Hurricane Center's North Atlantic Hurricane Database (Enloe 2011).

2.2.4 Sea Level Rise

During the 20th century, the sea level rose about 15-20 centimeters (roughly 1.5 to 2.0 mm/year) (The Climate Institute 2011). There are multiple reasons why the sea level rose. Glaciers account for 75% of the world's fresh water supply. When glaciers melt, the large amount of water stored in them is added to the ocean's supply of water which causes the sea level to rise a total of 2.5 cm in the last century (The Climate Institute 2011). A large portion of the sea level rise is due to the melting of ice in Greenland. Due to its location, it is more susceptible to melting than the Antarctic. The Antarctic has actually caused a decrease in sea level rise for that area due to the increased snowfall. The melting of sea ice causes a reduction of albedo which is the reflective property that the ice has. When the albedo is reduced, the ice will absorb more sunlight which will cause the warming process to increase. This cycle causes the whole warming process to increase rapidly (The Climate Institute 2011). This cycle is illustrated in Figure 6. When the temperature of the ocean rises, the water expands which is a cause of 2.5 cm of sea level rise (The Climate Institute 2011). The rise in sea level in recent years can be seen in Figure 7.



Source: David Griggs, in *Climate Change 2001*, Synthesis report. Contribution of working groups I, II and III to the Third Assessment Report of the Intergovernmental Panel o Climate Change, Cambridge University Press , 2001.

Figure 6: What Causes Sea Level Change

Courtesy of The Climate Institute (2011)

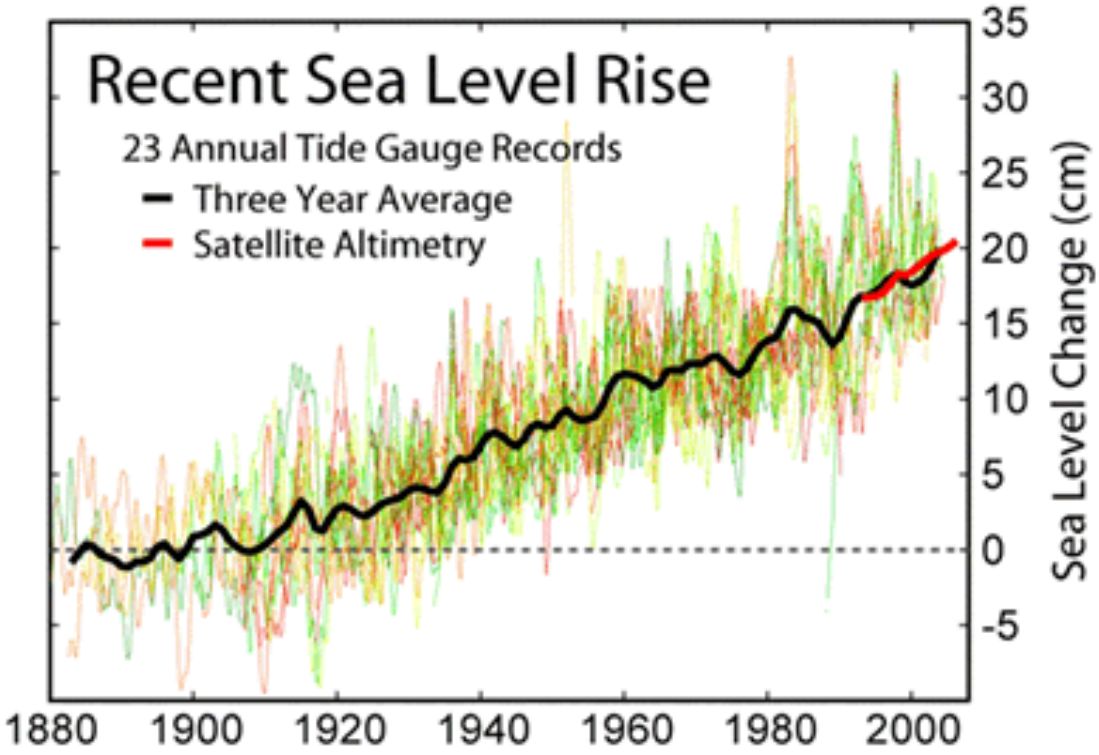


Figure 7: Recent Sea Level Rise

Courtesy of the Climate Institute (2011)

2.2.5 Climate Change affects Massachusetts

Since 1970 the Northeast has been warming at a rate of nearly 0.5 degrees Fahrenheit (°F) per decade (Frumhoff 2007). Winter temperatures have risen even faster, at a rate of 1.3°F per decade from 1970 to 2000 (Frumhoff 2007). Coastal flooding is predicted to occur more frequently. The one hundred year flood, which is the maximum flood elevation that is predicted to occur every century, is expected to occur in Boston every two to four years by 2050 as seen in Figure 8 (Frumhoff 2007). Sea level rise will cause the coastal areas, especially on Cape Cod, to lose shoreline due to erosion. The frequency of Nor'easters and tropical storms is predicted to increase due to global warming during the next century. The predictions which represent the worst case scenarios indicate that temperature rise will cause summers to become as hot as six to fourteen degrees Fahrenheit hotter and winters will get as hot as eight

to twelve degrees Fahrenheit hotter (Frumhoff 2007). Snow cover is predicted to decrease dramatically so that the appearance of Massachusetts winters could change completely.

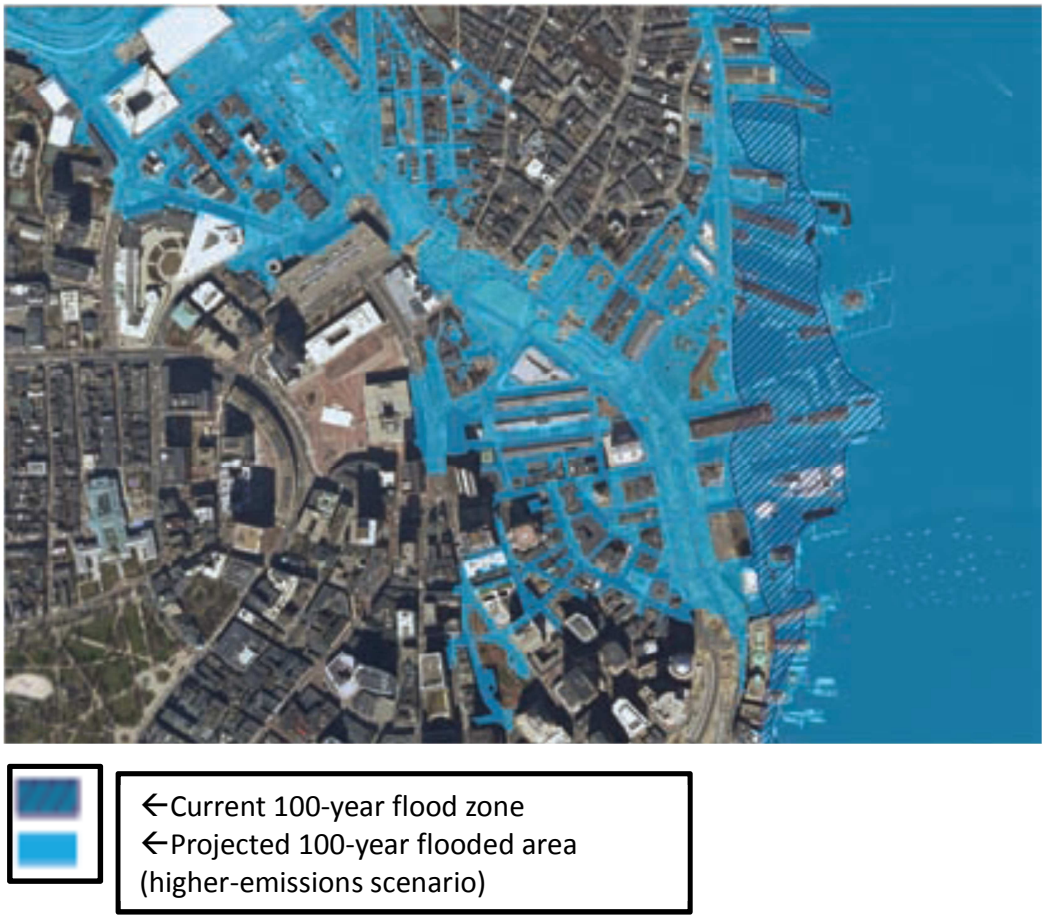


Figure 8: Boston Flood Predictions

Courtesy of Confronting Climate Change in the U.S. Northeast (2011)

Rising sea levels and increased frequency of severe storms does not allow for a confident real estate market (Frumhoff 2007). Extreme heat is projected to occur in the future which can cause health hazards especially for the elderly and children. Global warming could degrade air quality in the Northeast to the point where national air-quality standards cannot always be met (Frumhoff 2007). This could increase the risk of respiratory, cardiovascular, and other ailments as well as increase pollen based allergies due to the increase in carbon dioxide emissions (Frumhoff 2007). Mosquito carried diseases would also increase due to the carbon dioxide emissions.

2.3 Plans for Managing Hazards

With all of the projected hazards that Massachusetts could face, more comprehensive planning is needed to prepare coastal Massachusetts. Coastal hazard mitigation and adaptation plans are a product created on not only the federal level, but the local level as well. Our focus was hazard mitigation and adaptation plans in Massachusetts coastal communities, and how those can be improved as the climate changes. The plans vary on a municipal level as they have been modified to serve the local community's specific needs. The state of Massachusetts uses Hazard Mitigation Plans (HMPs) and Comprehensive Water Resource Management Plans (CWRMPs) to aid in managing coastal hazards and minimize damages and costs that hazards bring.

A large part of hazard mitigation is to stop repetitive loss structures (MassDEM 2003). In the after math of a disaster, people will commonly rebuild to restore damaged property. Although the damage has been repaired to pre-disaster conditions if the same hazard strikes again, in its wake will be similar damage, reconstruction and cost (Executive Office of Public Safety 2012). An example would be a home that has their basement flooded several times due to similar weather events. With simple restoration effort the basement can be repaired, but it is still vulnerable to the same flooding. With a no regrets strategy that is brought about with hazard mitigation, the basement can be repaired, along with measure to minimize or fully prevent flooding damage in the future. A no regrets strategy involves making preparations for possible hazard events in the long term even if the hazards never actually occur (Helsley 2012). This is essentially preparing for the worst but hoping for the best, because in either case you are prepared thus, the no regret. Hazard mitigation often has no regret measures to prepare for possible future events.

Comprehensive Water Resource Management Plans are the second type of plan we conducted research on. We worked to provide insight on the opportunities and barriers to including climate change in these plans. These plans are often constructed in conjunction with the Massachusetts Water Resources Authority (MWRA), and the Massachusetts Department of Environmental Protection (Mass DEP). Comprehensive Water Resource Management Plans (CWRMPs) are closely related with Integrated Water Resource Management Plans (IWRMPs). IWRMPs are aimed at addressing a community's water infrastructure system as a whole for

current and future needs. Water infrastructure mainly involves the management of wastewater, drinking water, and storm water. Since many towns lack the financial provisions to fund the development of an integrated plan they often opt to create a CWRMP in lieu of it. Comprehensive plans are more practical and cost effective in the sense that it focuses the improvement of one aspect of water infrastructure, instead of the whole system (Morris 2011).

2.3.1 Framework for a Hazard Mitigation Plan

To combat the threat of natural disasters Massachusetts has produced a guide to outline a uniform method for both inland and coastal towns to adopt when creating, and updating hazard mitigation plans. The purpose of this document is to "[identify] actions that can be done now can keep [towns and cities] from becoming a disaster area in the future" (MassDEM 2003). This guide is a response to the Disaster Mitigation Act of 2000, where the aim is to standardize state planning requirements with the requirements in place for FEMA mitigation programs (MassDEM 2003).

Before approaching the step by step planning process, it is necessary to have a community planning team to carry out tasks. Recommended members for the team include a community planner, an elected official, a business community representative, and an emergency manager (MassDEM 2003). The following list, which is directly from the planning guide, provides a complete list of recommended members that should be included in the hazard mitigation planning process (MassDEM 2003).

- A member of the City Council or Board of selectmen
- Community planner or a planning board member
- Conservation Commission member
- Building official
- Town/city engineer
- Community health official
- Public works personnel
- Emergency manager (usually the police chief or fire chief)

- A member of local watershed association
- One or more community residents living in a hazard-prone area
- One or more representatives from local cultural resources
- One or more representatives of the business community
- Representatives of adjoining communities

The hazard mitigation planning process is based on ten different steps outlined in the planning guide:

- The first two steps involve finding out what hazards the community can be exposed to and what are the risks that these hazard bring about.
- Steps three, four and five involve assessing what measures are being taken to protect against these hazards, where the gaps are, and what actions can be taken to fill these gaps in protection.
- In steps six and seven, the most feasible actions are selected, and collaboration takes place with communities who have taken these measures in hazard mitigation in the past.
- The last three steps involve setting priorities, developing a strategy to implement the mitigation actions and monitoring the plan and ensuring its success.

Throughout the whole planning process public opinion is considered to assure that the measures taken will best serve the community. It is important to note that each step includes a checklist of tasks that must be completed before moving on (MassDEM 2003).

Although the planning process supplied by the state of Massachusetts is very thorough, it does not list climate change adaptation as a requirement. Throughout our research, we've worked to discover if communities are planning with this in mind even without state guidance.

2.3.2 Framework for a Comprehensive Water Resource Management Plan

Comprehensive water resource management plans have a basic structure that includes the following steps (Woodard and Curran 2006):

- Assess the current condition of the water infrastructure
- Suggest solutions to improve the current infrastructure
- Evaluate suggestions for feasibility and practicality
- Solutions are further developed and the financial aspects are mapped out

2.3.2.1 Assessment of Existing and Future Conditions

When making an assessment for a CWRMP, the focus is not only on the man-made infrastructure, but is also on the natural environment of the town or region. Reports, data bases and maps are used to provide information on the man-made and natural environment. One aspect of analysis for the man-made environment of a town or region is to study land use patterns and land use regulations. Special attention must be paid to past planning efforts, and the projections for future growth. This information can be attained by contacting planning agencies, zoning commissions, public officials. If applicable, public health issues caused by man-made infrastructure should be noted as well (Morris 2011).

The assessment for the natural environment is a complicated process because of the unpredictability of factors such as climate, hydrology, water bodies, ground water flow, water table depths, surface water, water quality, and unique natural resources (e.g. wetlands). These factors take much more priority for their direct relation to long term water resource protection. Other factors to consider are endangered wild life and fisheries. Acquisition of this data and information can be obtained by Total Max Daily Load (TMDL) reports, Integrated Massachusetts Geographic Information System (GIS), and *Executive Office of Energy and Environmental Affairs* (EOEEA) water asset and water balance studies (Morris 2011).

To establish future conditions, data is collected to project anticipated population and economic growth through a long term planning period; the CWRMP guide calls for a twenty year planning period. Information to make these projections is available from the Massachusetts Institute for Social and Economic Research (MISER), regional planning agencies, and community master plans (Morris 2011).

The state has a “fix it first” concept that involves assessing existing infrastructure and seeing how improvements can be made to ensure its longevity. Comprehensive plans only focus on one of the following water resources: waste water, storm water, or drinking water (Morris 2011).

2.3.2.2 Waste Water

Waste water is any water whose quality has been adversely affected by human, industrial, commercial, and agricultural production of liquid and solid waste. With waste water, many factors of the surrounding environment must be taken into account. To be able to track the risk of ground water contamination soil types, percolation rates, and depth of the ground water table are taken into account. This helps track leaks in septic tank waste and other underground storage tanks (e.g., gas station storage tanks) and whether they are contaminating lakes, ponds, and ground water (Morris 2011).

Analysis of current water treatment plant conditions helps develop an idea of current operations, and projected increases in input and output from the plant. Information on the type of waste water plant, the age, energy efficiency, backup power, and present anticipated effluent limits are described. Also, performance information is required to be provided on how the plant is affected by dry and wet weather flows (Morris 2011).

Sewer systems conditions must be identified to assure that waste water is being drained properly. The pipe size, pipe material, pipe age and pump station features like back up power available are required to be assessed. Sanitary sewer overflows (SSOs) are areas in sewage piping with line brakes and blockages that causes waste water to escape the sewage system and discharge into surrounding soils. Existing SSOs need to be identified to prevent future problems (Morris 2011).

Based on the twenty year planning period, growth projections are used to see how they will affect wastewater flow for residential, commercial, institutional, and industrial uses. If waste water is expected to increase, the source of this increased flow is required to be identified. Then it is essential to determine how the increased flow will be managed whether it be through water conservation efforts or change in infrastructure. Areas in sewer piping where

over flows occur should be studied, and how increased flow rate will affect these areas (Morris 2011).

2.3.2.3 Storm Water

Storm water originates from precipitation events and it either permeates into soils or flows into storm drains that are later discharged into surface body waters. In storm water management it is necessary to identify high priority storm water problems. This entails collecting existing information of storm water discharges from the municipal storm drain system and other nonpoint sources (e.g. run off), and seeing if this water meets state water quality standards. If it does not, the source of water impairment must be determined. In a community the areas where there is an increased risk of pollution loads, like auto salvage yards, and fueling stations must be identified to manage where this water goes (Morris 2011).

Storm water planning has a strong emphasis on public education in CWRMPs because the individuals who live in communities greatly affect the quality of runoff storm water. The general public affects the quality of storm water by fertilizing their lawns, washing their cars, and disposing of trash and pet waste. Public outreach on proper methods for lawn care, care car, and waste disposal can improve storm water quality (Morris 2011).

The development and redevelopment projects that are projected for a twenty year planning period are analyzed and the quality and quantity of peak water flow and total runoff are to be determined. The projects cause an increase in impervious areas so planners and engineers are required to determine how it will affect runoff quality and quantity. Storm water management requirements are to be assessed for effectiveness in upcoming years due to growth and development. The assessment of storm water is important because of the implications of flooding (Morris 2011).

2.3.2.4 Water Supply

The water supply of a community provides clean drinking water for nourishment and provides people with water for sanitary purposes, and is a valuable asset for industrial sectors as well. So assuring that there is enough water to serve communities now and in the future is of the utmost importance. Without proper management of waste water and storm water, a clean water supply is put in danger (Morris 2011).

In assessing the water supply planners must locate the sources a community gets their water from. A list of all ground water and surface water sources, their location and the water quality are to be compiled. Documentation is needed to describe water treatment plants to note what contaminants the plant treats for and the process which need to be used. It is also important to describe the water distribution and storage system. Water use patterns are used to assess the distribution and storage system because water use varies between seasons, and it is important that the distribution system can provide water during peak use times. The age of the system is important to know because older systems still have the use of lead pipes and older pipes are more likely to fail (Morris 2011).

Knowledge of current emergency procedures is vital in the case of events such as supply source contamination, power failures and mishandling of chemicals. The risk of long and short term water shortages must be analyzed, and details for plans against this risk should be described (Morris 2011).

For future planning, it must be determined if current water supply will meet the projected demand. If it is found that the demand is projected to outgrow the supply, additional water sources are needed, along with water conservation measures, wastewater reuse and low impact development practices. In the case of an increase in water supply it must be concluded whether addition water treatment facilities are needed. Areas where current or possible water sources are located, growth and development are required to be limited for preservation and protection (Morris 2011).

2.4 Summary

Using the information from the sections above, our team concluded that it is necessary to take a closer look at the regional planner's point of view and also how coastal communities prepare their hazard mitigation plans. Climate change data and the impacts of how it will affect Massachusetts provided evidence that it would be beneficial to include climate change information in hazard mitigation plans. By identifying the current hazards and impacts in Massachusetts, it gave our team perspective on what was already happening. Next, we explored climate change globally and then related it to how it would affect Massachusetts locally. In order to consider what it would take to implement climate change information, we

explained the general framework for hazard mitigation plans and comprehensive water resource management plans. This allowed us to determine how climate change information could be useful to include in these plans. Given that HMPs and CWRMPS do not require climate change assessment, it was unclear whether they included climate change information. Because of this, our research focus was to determine whether this information was being used in these plans. A more detailed explanation of our research is indicated below.

3.0 Research Methods

The goal of this project was to investigate to what extent hazard mitigation plans are being used to address climate change and its related hazards in Massachusetts. At the same time we examined if climate change information was being incorporated into comprehensive water resource management plans. As suggested by our background sections there are clear benefits to explicit consideration of climate change in planning. Our research data came from reports on climate change adaptation for, interviews with government officials, regional planners, and private sector consultants and HMPs.

We completed our project with three objectives in mind to guide our research. Our first objective was to assess Massachusetts' coastal community HMPs for climate change information. Our second objective was to investigate the opportunities and barriers for climate change considerations being included in CWRMPs and HMPs. Finally we developed recommendations to encourage the implementation of climate change information in HMPs

3.1 Objective 1: Assessing existing Massachusetts coastal community hazard mitigation plans for climate change information

The first step in achieving this objective was deciding which HMPs would be included in our study. The majority of plans in our study were given to us by our project advisor. The rest were tracked down by our project group by getting into contact with town and regional planners. The aim was to obtain as many up to date plans as we possibly could. With an exception of a few, our plans were updated in 2005 or later. For each of these plans we confirmed that each town was classified as a coastal community. We also made sure that each planning council that had communities situated on the coast were properly represented in our sample of HMPs.

Next we created a coding form to collect qualitative data from each of the hazard mitigation plan in our study sample. Our coding form was made from a Microsoft Word Excel spread sheet and contained different categories. The categories were:

- Towns
- Climate Stressors
- Outcomes
- Discussion of Outcomes
- Mitigation Strategies
- Consequences
- Inclusion of Climate Change information

The town category referred to the 28 community and 4 regional hazard mitigation plans we were examining. Climate stressors in our coding form were climate related events such as hurricanes, thunder storms and snow storm. Outcomes referred to events directly caused by climate stressors which include flooding, wind and rain. Depending on the wording in HMPs some outcomes could be placed in the climate stressors category based on the way it was presented in the planning document. The discussion of outcomes category was used to discover how each coastal town spoke of the impacts of outcomes in respect to their community. The mitigation strategies category was used to see if every climate stressor and outcome in each respective plan had a mitigation measure to counteract the event. Consequences referred to how the climate stressor and outcome affected people, building structures, and infrastructure. Climate change information was a black and white category that was used to state whether climate change information on a particular stressor and outcome was present in the document. Figure 9 is an example of a coding form used in our research.

Town	Climate Stressors	Outcomes	Discussion of Outcomes	What strategy is proposed for dealing with the hazard	Consequences	Climate Change	Reference
Braintree	Flooding	Dam Failure	According to Town officials, there is very little risk of dam failures in Braintree. There are four dams in Braintree.	Public Works Operations/Maintenance Activities, Flood Plain Management Plan, Restrictions on Development in Flood-Prone Areas	property damage	No	pg.30-33
Braintree	Hurricane	Wind	The Town is affected by the wind and rain of other coastal hurricanes regardless of the official hurricane track.	Comprehensive Emergency Management Plan (CEMP), State Building Code, Town Hall Emergency Shelter Enhancement		No	pg. 33-34
Braintree	Hurricane	Rain	The Town is affected by the wind and rain of other coastal hurricanes regardless of the official hurricane track.	Comprehensive Emergency Management Plan (CEMP), State Building Code, Town Hall Emergency Shelter Enhancement		No	pg. 33-34
Braintree	Hurricane	storm surge	The Town is affected by the wind and rain of other coastal hurricanes regardless of the official hurricane track.	Comprehensive Emergency Management Plan (CEMP), State Building Code, Town Hall Emergency Shelter Enhancement		No	pg. 33-34
Braintree	Hurricane	sea level rise	The Town is affected by the wind and rain of other coastal hurricanes regardless of the official hurricane track.	Comprehensive Emergency Management Plan (CEMP), State Building Code, Town Hall Emergency Shelter Enhancement		No	pg. 33-34
Braintree	Winter Storms	Flooding	Winter snow storms and extended cold weather are frequent hazards in New England. The impact of heavy snowfall is to impair the flow of vehicles needed for day-to-day commuting, local businesses and public safety response.	Public Works Operations/Maintenance Activities, Flood Plain Management Plan, Restrictions on Development in Flood-Prone Areas	delay in public safety response, closed roads, damage to infrastructure	No	pg. 33-35
Braintree	Winter Storms	Snow Accumulation	Winter snow storms and extended cold weather are frequent hazards in New England. The impact of heavy snowfall is to impair the flow of vehicles needed for day-to-day commuting, local businesses and public safety response.	Public Works Operations/Maintenance Activities, Flood Plain Management Plan, Restrictions on Development in Flood-Prone Areas	delay in public safety response, closed roads, damage to infrastructure	No	pg. 33-35
Braintree	Winter Storms	Wind	Winter snow storms and extended cold weather are frequent hazards in New England. The impact of heavy snowfall is to impair the flow of vehicles needed for day-to-day commuting, local businesses and public safety response.	Public Works Operations/Maintenance Activities, Flood Plain Management Plan, Restrictions on Development in Flood-Prone Areas	delay in public safety response, closed roads, damage to infrastructure	No	pg. 33-35
Braintree	Coastal storms	Flooding	The primary impacts of coastal and winter storms are either related to flooding or to the difficulties of snow removal.	Public Works Operations/Maintenance Activities, Flood Plain Management Plan, Restrictions on Development in Flood-Prone Areas		No	pg. 33-34
Braintree	Coastal storms	Wind	The primary impacts of coastal and winter storms are either related to flooding or to the difficulties of snow removal.	State Building Code		No	pg. 33-34
Braintree	Tornadoes	Wind	Tornadoes are extremely rare in this part of Massachusetts and there have been no recorded tornadoes in the Town of Braintree.	State Building Code		No	pg. 34
Braintree	Wild Fires		State fire officials consider pitch pine, mixed conifer, oak and oak mixed forests to be the forest types at highest risk for wildfires.	Burn permits, Subdivision & Building permit review		No	pg. 35

Figure 9: Example Hazard Mitigation Plan Research Coding Form

3.1.1 Data analysis of coding forms

The end result of our data compiling of hazard mitigation plans was 32 coding forms. Next, a method to organize all of our collected information was needed. For each coding form we developed a data analysis form that was designed to better organize the information suited to be used in our report.

The first section of the form coupled all climate stressors-outcome combinations together (e.g. Hurricane is the climate stressor, and flooding is the outcome of the hurricane). Next was a section to mention which climate stressor-outcome duos were related to climate change, if any mention was made at all. With these combinations the information on mitigation strategies and outcome discussion were analyze to see the quality and quantity of climate change information. Then the page reference associated with this climate stressor-outcome combination was referred to get the full scope of climate change information within the HMP. The next section of the form tracked if each stressor-outcome combination had a mitigation strategy to address the climate event. This was to evaluate if actions were being taken against all hazards listed in these plans. The final section of our data analysis form looked into all the consequences for a particular town. In this section we were looking to compare and contrast consequences between towns and regions. An example of this data analysis form can be found in Appendix C.

3.2 Objective 2: Investigate the opportunities and barriers for climate change information in costal community's comprehensive water resource management plans and hazard mitigation plans

To accomplish this objective we conducted seven interviews with Massachusetts' regional planners, state officials, and private firm consultants. We determined our interviewees by trying to selecting regional planners that had communities in their jurisdiction situated on the coast. We were able to get planners from the Metropolitan Area Planning Council (MAPC), Merrimack Valley Planning Council (MVPC), and the Cape Cod Commission (CCC). We then selected 2 state officials because of their experience working with hazard mitigation plans and

comprehensive water resource management plans. The final two interviewees were with private firm consultants who have worked with communities in developing CWRMPs.

As our coding of HMPs progressed we noticed a trend of hazard mitigation plans within our research sample not including climate change information. When we interviewed regional planners, state officials, and private contractors on their thoughts on climate change information in hazard mitigation plans we kept this in mind. The questions we drafted were guided by our project objectives. The interview guide focused on:

- Why climate information is not in HMPs
- If these considerations would be useful for HMPs
- If other routine or mandated plans (such as CWRMPs) in Massachusetts would be appropriate for climate change considerations
- Barriers to making consideration of climate change a part of HMPs and ways to overcome these barriers

Our interviews asked why climate change information was not included in these hazard mitigation plans because of the trends were seeing in our research. Our group asked if climate change considerations would be useful in HMPs to discover whether planners thought climate change information was necessary in these documents and planning in general. The next focus was on alternative mandated and routine planning that would be suitable for climate change information. Our final question was how to overcome some of the barriers which got in the way of including climate change into HMPs. The order of the questions was optimized to flow from one topic to the next, making our interviews very successful.

Since we were not able to obtain any community comprehensive water resource management plans our main source was strictly interviews. In the previously mentioned interviews we were able to gather useful information through the following question:

- Would other routine or mandated plans (such as CWRMPs) in Massachusetts be appropriate for climate change considerations?

Additionally in our one of our interviews we drafted completely new questions in order to have a stronger focus on comprehensive water resource management plans. We asked about:

- Basic information currently in typical CWRMPs
- Current Barriers to developing CWRMPs and how they can be bypassed
- Climate change in CWRMPs
- Barriers to climate change in CWRMPs and how they can be dealt with
- Alternative routine or mandated planning appropriate for climate change considerations

Because of our lack of knowledge in these plans, we started off our interview asking about the basic requirements for information in CWRMPs. We then asked the current barriers to creating CWRMPs to see what the difficulties were in creating these plans when climate change is not involved. We then asked what barriers the consultant could foresee in developing CWRMPs as well as solutions to these barriers. These questions were designed to provide a contrast as to how the barriers change once the factor of climate change information enters the equation. Then, as we had asked in our other interview guide, asked if there were other routine or mandated planning appropriate for climate change. Copies of each interview guide can be found in Appendix B.

3.2.1 Method for Conducting Interviews

Our interviews were conducted over Voice IP with Skype in conjunction with recording software. When we first got into contact with our interview subjects we provided them with an Institutional Review Board (IRB) form to sign. Their signature gave us permission to ethically interview them and use what was said in the interviews in our report.

In our interviews we had a set number of questions in our guide, but it wasn't intended to be read word for word. It was a guide to make sure that the questions and answers stayed

on topic with our interviewee. For each question focus we would start with a broad question, and follow up with more specific questions to zero in on the topics pertinent to our project.

3.2.2 Analysis of Interviews

To better understand the information gathered from the interviews, transcriptions of each interview were created. Once this was completed we searched each document for the keywords: climate change, hazard mitigation plans, HMPs, comprehensive water resource plans, and CWRMPs. We would then read the text associated with these keywords in the transcription and highlight important information. This information included barriers to HMPs and CWRMPs and how those barriers could be overcome, because this information had strong implications for use in our findings chapter as well as in our recommendations. After skimming over the transcriptions with the use of our keywords, each document was read completely through to collect information that was overlooked initially.

3.3 Objective 3: Provide recommendations for possible actions to encourage the implementation of climate change information in hazard mitigation plans

Recommendations are based on empirical data gathered as part of our research and information presented in the background chapter.

When creating our recommendations we looked for reoccurring trends in data between our interviews, HMP coding forms, and background research. With this data we developed our findings of our research. With our findings we again studied our background, interviews, and coding forms to look for solutions to the gaps we discovered in hazard mitigation planning.

4.0 Findings and Discussion

Through analysis of the hazard mitigation plans and our interviews, we have concluded seven major findings:

1. The majority of Massachusetts coastal communities in our study do not explicitly include climate change information in their hazard mitigation plans.
2. Of the hazard mitigation plans which do include climate change information, there are varying amounts of climate change information being included in each plan.
3. Cape Cod coastal communities are including climate change information in their Hazard Mitigation Plans.
4. Through our research, we found that there is no concrete evidence to prove that coastal communities are using a no-regrets strategy.
5. Comprehensive Water Resource Management Plans provide opportunities for inclusion of climate change adaptation information.
6. Public awareness plays a role in the inclusion climate change information in hazard mitigation plans.
7. Climate change has not been incorporated into hazard mitigation plans because of a lack of funding.

These findings will be discussed in the following sections.

4.1 Finding #1: The majority of Massachusetts coastal communities in our study do not explicitly include climate change information in their hazard mitigation plans

A major part of our research was developing a coding form to collect information from 28 of Massachusetts 78 coastal community's hazard mitigation plans. The analyses of four regional planning council plans were done as well.

We found that out of the 32 plans we analyzed, 9 were found to include explicit information on climate change. Table 1 provides a breakdown of communities that have and have not included climate change information in their hazard mitigation plans.

Table 1: Break down of hazard mitigation plans including climate change information

No Climate Change in Plan	Climate Change in Plan
Chatham	Barnstable
Provincetown	Dennis
Truro	Eastham
Braintree	Cape Cod Regional
Quincy	Gloucester
Beverly	Ipswich
Manchester	Hull
Milton	Salem
Randolph	Marshfield
Rockport	
Cohasset	
Scituate	
South Shore Regional	
Newbury	
Salisbury	
Hingham	
Plymouth	
Kingston	
New Bedford	
Fall River	
Westport	
SRPEDD Regional	

All of the towns, and the one regional plan, all come from either the Cape Cod Commission (CCC) or the Metropolitan Area Planning Council (MAPC). Table 2 lists hazard mitigation plans with climate change and their respective planning council.

Table 2: Hazard mitigation plans including climate change information and their respective planning council

Climate Change Plans	Planning Council
Barnstable	Cape Cod Commission
Dennis	Cape Cod Commission
Eastham	Cape Cod Commission
Cape Cod Regional	Cape Cod Commission
Gloucester	Metropolitan Area Planning Council
Ipswich	Metropolitan Area Planning Council
Hull	Metropolitan Area Planning Council
Salem	Metropolitan Area Planning Council
Marshfield	Metropolitan Area Planning Council

In respect to the MAPC, the reason why five communities have climate change information could be from the fact that Boston is in the MAPC and the state's capitol has a climate change coalition as we learned from a state official. Based on this, there is a possibility that Boston, along with its surrounding communities are beginning to shift their thinking in respect to climate change.

In our interview with a coastal resources specialist at the Cape Cod Commission, it was explained that although there are no mandated federal or state regulations for explicitly addressing climate change in hazard mitigation plans, communities within the region are encouraged to do so. As a result, we see 4 Cape Cod towns including this information. The coastal resource specialist explained that "The Cape is in a pretty unique position here given that it's got so much shoreline, and it's a soft coast not a rocky coast." Since Cape Cod

communities are more exposed to the harsh effects of the ocean, this might explain why these hazard mitigation plans are starting to include climate change.

4.2 Finding #2: Of the hazard mitigation plans which do include climate change information, there are varying amounts of climate change information being included in each plan

Of the nine hazard mitigation plans which we found to include climate change information, the range of information being included varied. In the Barnstable plan it is mentioned that "Recent climate change assessments predict that sea levels will rise three feet over the next 200 years, but caution that this change could occur as soon as the year 2100. A sea level rise of two feet will eliminate an estimated 10,000 square miles of land, including up to 43% of the country's current wetlands (Barnstable Growth Management Department 2010)." Here is a great example of climate change being expressed in a plan and at the same time providing information on the impacts it will have on the community.

In the Ipswich HMP there is only one sentence that gives mention to climate change. In its flooding section it states that "precipitation events have increased in frequency and intensity over the last ten years, most likely the result of global warming trends (Metropolitan Area Planning Council-Ipswich 2011)." This is the extent of climate change considerations made in this report. It is important.

The quality in information is explained in one report due to the fact "that coastal entities most at risk to the adverse impacts of climate change, such as sea level rise, are paying more attention to mitigation and adaptation issues. This interest is, however, even for coastal states, not sustained across all agencies but is focused among a few (Brody 2010)." This is evident due to Barnstable's vulnerable location on the cape, whereas Ipswich is located on the North Shore of Massachusetts and is provided added protection from barrier islands.

4.3 Finding #3: Cape Cod coastal communities are including climate change information in their Hazard Mitigation Plans

Regional planners explicitly included information about climate change in the most recent Cape Cod Regional plan. The physical changes happening now in the environment are "increased air and water temperatures, reduced snow cover and glaciers, increased frequency and intensity of heavy downpours, and rising sea levels (Cape Cod Commission 2010)." Although specific details as to how much these hazards will worsen is not given, it is impressive that the planning committee has already thought about the effects that climate change will have. It is impressive because topic of climate change has very limited publicity, it is not required by FEMA, and the effects as to why are very controversial.

The fact that Cape Cod has already started to put climate change information in their hazard mitigation plan suggests that the topic of climate change is becoming more popular among planners. A regional planner from the Cape Cod Commission thinks that most planners in Cape Cod communities "are aware that for instance that they should minimize the amount of development in the coastal flood zone or elevate buildings above a base flood elevation. Despite the lack of technical data available to planners, it seems that they are beginning to observe physical changes due to climate change.

4.4 Finding #4: Through our research, we found that there is no concrete evidence to prove that coastal communities are using a no-regrets strategy.

A no-regrets strategy as related to hazard mitigation is when a community plans or takes an action to prevent damage, assuming the worst possible outcome based on the information they have. Since our group looked for the inclusion of climate change adaptation information in hazard mitigation plans, we also felt it was necessary to see if coastal communities are doing anything to prepare for the future, such as a "no-regrets" strategy. Our group found references regarding proactive strategies, but not one strategy in any of the hazard mitigation plans we reviewed had the term no-regrets.

A good example to look is Hull because there is evidence that they are proactive about hazards, but do not explicitly state that they have a no-regrets strategy for said hazards. The mitigation plan has identified mitigation strategies such as:

> "infrastructure projects such as continued maintenance and *proactive* identification of improvements for sea walls and the storm drainage system, continuation of the structure elevation program for floodplain properties, actions to protect and restore the beach dune system, and public education efforts relating to flooding and other natural hazards potentially impacting the Town (Metropolitan Area Planning Council-Hull 2011)."

Although none of these strategies are explicitly referred to as no-regrets strategies, the fact that Hull is being proactive with the changes they see in infrastructure such as sea walls suggests that they might be using a no-regrets strategy.

It is important to look for no-regrets strategies in hazard mitigation plans because it shows that communities are beginning to plan for the future. A no-regrets strategy is a proactive strategy which can eliminate some of the damage caused by climate change. Hull is the only town which included proactive strategies to mitigate hazards. By being proactive and observing what features in their community are changing, they are better preparing themselves for the future because they can start to repair or improve upon them as they change.

4.5 Finding #5: Comprehensive Water Resource Management Plans provide opportunities for climate change adaptation information to be included

In our interviews one of our goals was to find other mandated planning that would be appropriate for climate change adaptation. In our discussions we found that regional planners and state officials both agree that Comprehensive Water Resource Management Plans are a good place to begin thinking about climate change. A planner at the Metropolitan Area Planning Council said that "these CWRMPs are another slice of planning around a specific focus of the community which is its water infrastructure." A state official endorsed the idea of climate change in CWRMPs because they "take the common approach to how climate change might influence whatever infrastructure you might be talking about and you would need to adapt it."

Through confirmation from a state official and a project manager at a private firm, we learned that not only are CWRMPs a good platform for climate change information, but some contractors are beginning to incorporate climate change affects into these plans. Although this is progress, the current guidance document for CWRMPs predates climate change becoming a "hot button" issue; therefore this information is not mandated by the state. Through correspondence with a state official we have also learned that the Massachusetts Environmental Protection Agency (MEPA) along with other state agencies do provide information climate change impacts, but are yet to require this information be included in CWRMPs.

The state official also stated that "I do not think hazard mitigation plans are the only appropriate place, they are *an* appropriate place but really, I think the hazards of future climate change impacts should be built into the community's broader based plan, or [master] plan." From this we see a shift of thinking where climate change could eventually become a part of many regulatory plans as well as hazard plans.

4.6 Finding #6: Public awareness plays a role in the inclusion of climate change information in a Hazard Mitigation Plans

Since the only information that regional planners have to go off of are predictions, it is difficult to gain support from the community because they have yet to realize the potential impacts of what is to come. A regional planner from the Merrimack Valley Planning Council stated "In terms of lack of planning locally, or the lack of acceptance of the need to plan locally for climate change, I think that's just primarily just a public education outreach need." Since the effects of climate change are not observed year after year, it is difficult to make the public realize that climate change is a hazard to the community. Another interviewee from the Cape Cod Commission also stated that "with our frequent northeast storms battering the coastline, people start to realize that the shoreline is disappearing, that it's eroding, it's changing, and they begin to think that maybe we need to take some of these things more seriously." If the community does not accept that climate change is real and it is happening, then nothing can be done to be proactive about the issue.

The focus here is not necessarily the residents of the communities, but the planners of the communities, and any organization which aids in the process of hazard mitigation planning. Out of the 6 regional planners and state officials we interviewed, 5 of them said that the one of the reasons why climate change was not included into hazard mitigation plans was because it was not a FEMA requirement to explicitly address it. With more public awareness of the potential effects of climate change, it is more likely that FEMA would require communities to explicitly address climate change in their hazard mitigation plans.

4.7 Finding #7: Climate change has not been incorporated into hazard mitigation plans because of a lack of funding

Without proper funding, climate change cannot be incorporated into Hazard Mitigation Plans as there is no money for research, or to pay local planning staff to focus on this issue. This was expressed by a state official who said that funding these plans was needed to provide resources so communities and consultants to deal with the issue of climate change.

The main problem with obtaining money to complete research related to climate change is that the potential effects and impact are not apparent; there does not seem to be a need for funding the issue. Additionally, the funding that planning departments are currently receiving is often times are just enough to plan for hazards that are already occurring. One state official says that “because climate change isn’t part of their [FEMA’s] standard format, there is no funding to do any of the work that would relate to that [researching climate change]”. This lack of funding prevents communities from explicitly addressing climate change because the information needed to develop mitigation strategies regarding climate change impacts cannot be obtained.

5.0 Conclusion

With our research and developed findings we will provide our recommendations for climate change consideration in coastal Massachusetts planning. These recommendations offer indirect ways to take incremental steps towards better climate change coverage in town planning.

5.1 Recommendations

We have developed five recommendations based on the findings from our research. These suggestions are interrelated with each other. This interdependence shows a need for cooperation between multiple sectors moving forward.

Recommendations:

1. Planning Councils should encourage communities in their jurisdiction to include climate change information/adaptation regardless of the FEMA requirements.
2. Proactive mitigation strategies, such as a no regrets strategy, should be used to minimize impacts of future hazards
3. To increase public awareness, community education is needed to put the potential impacts of climate change into perspective.
4. Climate change information should be included in the risk assessment section of Hazard Mitigation plans.

5.1.1 Planning Councils should encourage communities in their jurisdiction to include climate change information/adaptation regardless of the FEMA requirements

Since FEMA does not require HMPs to explicitly address how hazards might change as a result of climate change there is little incentive for communities to include it. Due to a scientifically observed trend of rising sea levels and increased air/water temperatures in the ocean mentioned in Chapter 2.2, planning councils should encourage communities to include any information they already have regarding climate change into their next draft of their hazard mitigation plans. As seen in Finding #3, not only have changes been seen globally, but Cape Cod has observed these rising sea levels, increased air and water temperatures and even increased intensity and frequency of heavy downpours. Since changes in the environment are already being seen, it would be beneficial for coastal communities to start including climate change information, even if it isn't required. Examples of this kind of data are expected sea level rise, updated building codes based on projected flood maps, and mitigation strategies to deal with hazards which might become worse due to climate change.

5.1.2 Proactive mitigation strategies, such as a no regrets strategy, should be used to minimize impacts of future hazards

If communities are proactive about the effects of climate change, extensive damage to their land, property, and infrastructure can be minimized. As seen in the background Section 2.2, rising air and water temperatures, changes in weather patterns, and sea level rise are being observed globally. As seen in Finding #3, Cape Cod is already including climate change information in their hazard mitigation plan. The fact that Cape Cod has already included some of this climate change information into their hazard mitigation plan indicates that there is some climate change information available to hazard mitigation planners. This information, even if it is not extensive, should be used to develop mitigation strategies for potential future hazards and their impacts. Coastal communities can develop a no-regrets strategy by using the information they already have about current hazards, and comparing it to the information they have about projected changes in the environment. There can still be improvements in current infrastructure, because all of the communities whom we read hazard mitigation plans for still experience damage from year to year. Wendy Carey from the Delaware Sea Grant commented

on the inclusion of a no-regrets strategy in the city of Lewes hazard mitigation plan. She stated, "The result is the city has a win-win, no-regrets strategies that will prepare them for their future flood risk no matter what the cause" (NOAA 2011).

By using a no-regrets strategy, this would ensure that no matter how severe the effects of climate change end up being, the updated infrastructure and mitigation strategies will better protect the community.

5.1.3 To increase public awareness, community education is needed to put the potential impacts of climate change into perspective

Through our research we have learned that the topic of climate change lacks public awareness and its causes are a controversial topic. In Finding #6, it is established that residents and planners need to become more aware of the potential effects of climate change. From background section 2.3.1 it is seen that there are no FEMA requirements for communities to explicitly address climate change. This demonstrates that either there is not enough information to convince both residents and planners of coastal communities that the climate is changing, or the information available on climate change is not easily available. In Finding #3 and background Section 2.2, it is established that there are changes in the environment being observed. Cape Cod's hazard mitigation plan and information regarding sea level rise and air and water temperature increases can be a topic of discussion at public meetings where new hazard mitigation plans are being developed. Local planners and scientist can also organize middle and high school assemblies on climate change and its effects to educate younger generations.

The idea behind public awareness is to make the potential effects of climate change known so that action can be taken against them. By having climate change information in public meetings and school assemblies, it makes it known that there are changes happening, and something must be done. By notifying the public, both residents and planners alike, there is a possibility for the inclusion of a FEMA requirement for hazard mitigation plans to explicitly address climate change. Public awareness is key going forward, as it will go hand in hand with political influence.

5.1.4 Climate change information should be included in the risk assessment section of Hazard Mitigation plans

As it was mentioned in Finding #3, the risk assessment is where the majority of information on hazards and their affects are discussed in hazard mitigation plans. Going forward it will be very beneficial for climate change information to be included in this section as well. Past trends in sea level risk, coastline erosion rate, and air and water temperature changes will be the basis to determine the town's risk and vulnerability for climate change impacts. By using trends in data, it will assist communities to be proactive about the issue of climate change before the major impacts are upon them.

5.2 Project Summary

Our project research objectives were to:

1) Assess existing Massachusetts coastal community hazard mitigation plans for climate change Information,
2) Investigate the opportunities, barriers for climate change information in coastal community's comprehensive water resource management plans and hazard mitigation plans, and to
3) Provide recommendations for possible actions to encourage the implementation of climate change information in hazard mitigation plans.

With these goals in mind we started our project investigating the hazards which were currently affecting the Massachusetts coastline. Then, we considered how the climate is predicted to change on a global scale and how that might affect Massachusetts' coastal communities. To further aid us in our report, we made our selves familiar with the structure of hazard mitigation plans and comprehensive plans to see how information was presented. Finally, we studied federal and state requirements for hazard mitigation plans.

The research phase of our project involved taking a deeper look into 32 hazard mitigation plans collecting information on hazards, outcomes, and consequences that Massachusetts coastal communities face. We coded information from the plans about climate stressors, outcomes, mitigation strategies, inclusion of climate change information, and consequences of climate stressors. Interviews were used to gather information from regional planners and state officials about the difficulties of considerations being made in HMPs and

CWRMPs. The amount of resources that were available to us regarding CWRMPs only allowed us to explore the barriers that it shared with HMPs concerning why climate change was not included.

Our final recommendations reflect the possible measures that can be made to have climate change information be included in hazard mitigation plans and ultimately other mandated local planning activities in the future. By looking at the current hazard mitigation plans and what the regional planners and state officials had to say about them, our group was able to conclude that the topic of climate change is underdeveloped, but has the potential to become more prevalent with more public outreach and demonstration of the potential impacts. We have determined that Massachusetts' coastline is vulnerable to hazards, but with a strong collective effort climate change can become a relevant issue before the full affects arrive.

6.0 Works Cited

Barnstable Growth Management Department. (2010). Town of Barnstable multi-hazard mitigation plan.

Brody, S., Grover, H., Lindquist, E., & Vedlitz, A. (2010). *Examining climate change mitigation and adaptation behaviors among public sector organizations in the United States.* Institute for Science, Technology and Public Policy.

Cape Cod Commission. (2010). *Cape Cod regional multi-hazard mitigation plan.*

Center for Ocean Solutions. *Coastal erosion.* Retrieved 2/25, 2012, from http://centerforoceansolutions.org/climate/impacts/cumulative-impacts/coastal-erosion/

Connor, S.*Man-made climate change blamed for 'significant' rise in ocean temperature.* Retrieved 10/1/2011, 2011, fromhttp://www.independent.co.uk/environment/climate-change/manmade-climate-change-blamed-for-significant-rise-in-ocean-temperature-1977669.html

Enloe, J. (2011). *U.S. climate extremes index* Retrieved 10/1/2011, 2011, from http://lwf.ncdc.noaa.gov/extremes/cei/graph/ne/cei/01-12

Environmental Defense Fund. *Climate change impacts* Retrieved 9/24/2011, 2011, from http://www.edf.org/climate/climate-change-impacts

Executive Office of Public Safety. *What is hazard mitigation?* Retrieved 1/28/2012, 2012, from http://www.mass.gov/eopss/home-sec-emerg-resp/hazard-mitigation/planning/what-is-hazard-mitigation.html

Frumhoff, P., McCarthy, J., Melillo, J., Moser, S. & Wuebble, D. (2007). *Confronting climate change in the U.S. northeast.* Retrieved 10/1/2011, 2011,

from http://www.northeastclimateimpacts.org/pdf/confronting-climate-change-in-the-u-s-northeast.pdf

Gourley, B. (2007). *Global warming and climate change: Weather patterns, past, present and future* Retrieved 10/1/2011, 2011, fromhttp://climatechange.ws/weather/

Helsley, J. *No regret strategies to climate change mitigation.* Retrieved, 2012, from http://www.personal.psu.edu/jrh5408/blogs/joshua_helsley/no-regret-strategies-to-climate-change-mitiatigation.html

Houghton, J., Meira, F., Callander, B., Harris, N., Kattenberg, A. & Maskell, K. (1995). *The science of climate change.* Retrieved 2/26/2012, 2012, from http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf

Levitus, S., Antonov, J., Boyer, T., Locarnini, R., Garcia, H. & Mishonov, A. (2009). *Global ocean heat content 1955–2008.* Retrieved 10/1/2011, 2011, from ftp://ftp.nodc.noaa.gov/pub/data.nodc/woa/PUBLICATIONS/grlheat08.pdf

Massachusetts Department of Environmental Management. (2003). Natural hazards mitigation planning: A community guide. 2011. Retrieved from http://www.mass.gov/dcr/stewardship/mitigate/hazguide.pdf

Massachusetts Office of Coastal Zone Management. *Barrier beach management in Massachusetts.* Retrieved 02/26, 2012, fromhttp://www.mass.gov/czm/hazards/beach/barrierbeach.htm

Massachusetts Office of Coastal Zone Management. *The Massachusetts coastal hazards commission final recommendations-chapter 1* Retrieved 10/5/2011, 2011, from http://www.mass.gov/czm/chc/recommendations/chapter1.htm

Metropolitan Area Planning Council. (2011). *Town of hull hazard mitigation plan update.*

Metropolitan Area Planning Council. (2011). *Town of Ipswich hazard mitigation plan.*

Morris, M., Haas, G., Delorenzo, D., Barker, C., Delaney, J., Worrell, E. & Lyberger, R.*Water resource management planning.* Retrieved 10/1/2011, 2011, from http://www.mass.gov/dep/water/laws/iwrmp.pdf

MSNBC. *Hurricane Irene death toll rises to at least 44.* Retrieved, 2012, from http://www.msnbc.msn.com/id/44314551/ns/weather/t/hurricane-irene-death-toll-rises-least/

NASA.*GISS surface temperature analysis (GISTEMP)* Retrieved 10/1/2011, 2011, from http://data.giss.nasa.gov/gistemp/

National Oceanic and Atmospheric Administration. *Mean sea level trend.* Retrieved, 2012, fromhttp://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8443970

National Oceanic and Atmospheric Administration. (2011). *Integrating climate change adaptation and hazard mitigation in Delaware* Retrieved 10/13/2011, 2011, from http://www.csc.noaa.gov/magazine/2011/05/article2.html

O'Connell, J. *Evaluation of coastal erosion hazards.* Retrieved 10/6/2011, 2011, from http://www.fathom.com/feature/122478/

The Climate Institute. *Climate change and sea level rise* Retrieved 10/1/2011, 2011, from http://www.climate.org/topics/sea-level/index.html

The Northeast States Emergency Consortium. *Floods* Retrieved 10/6/2011, 2011, from http://www.nesec.org/hazards/floods.cfm

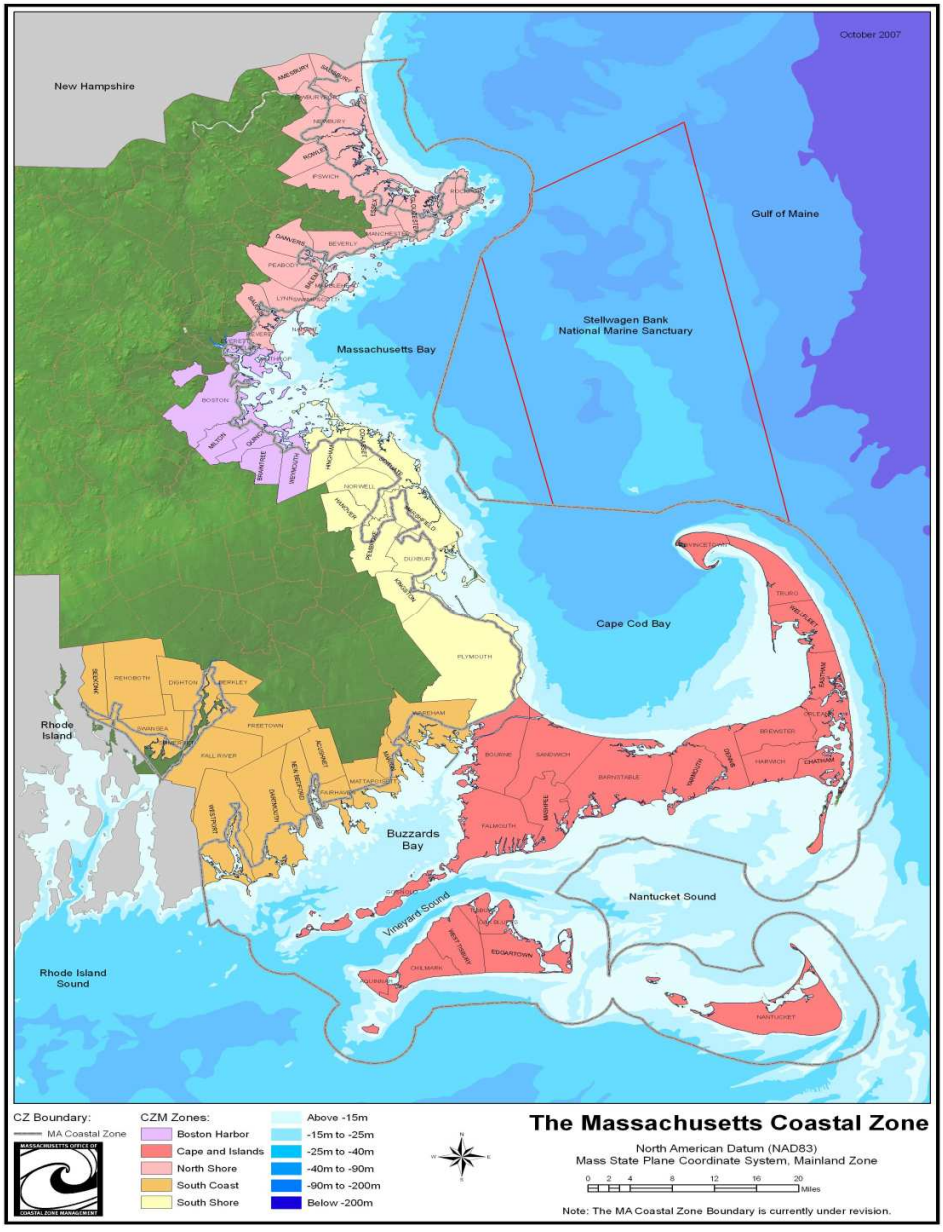
The Northeast States Emergency Consortium. *Hurricanes* Retrieved 10/5/2011, 2011, from http://www.nesec.org/hazards/hurricanes.cfm

Woodard and Curran. (2006). *Comprehensive water resources management plan (CWRMP) – phase 2.* No. 2012). 35 New England Business Center Andover, MA 01810: Woodard and Curran.

Zezima, K. (2010, 08/17/2010). Cape Cod waterways face pollution crisis. *The New York Time,* pp. A13. Retrieved fromhttp://www.nytimes.com/2010/08/18/us/18nitrogen.html?adxnnl=1&adxnnlx=1317873699-hUHVaNf8cNawBJl1RdNWgQ

7.0 Appendices

7.1 Appendix A: Maps



Detailed Coastal Massachussetts Map

Courtesy of Massachusetts Office of Coastal Zone Management (2011)

7.2 Appendix B: Research Guidelines

Coding Form Data Analysis

BARNSTABLE:

HAZARDS and OUTCOMES:
Hurricanes >>>Flooding
Hurricanes>>>Storm surge
Hurricanes>>>Wind
Hurricanes>>>Erosion
Hurricanes>>>Tornadoes
Tornadoes and Waterspouts>>>Wind
Winter storms >>>Flooding
Winter storms >>>Storm surge
Winter storms >>>Wind
Winter storms >>>Snow and Ice Accumulation
Winter storms >>>Erosion
Flooding>>>Dam Failure
Drought>>>Wild Fires
Sea Level Rise>>>Flooding
Sea Level Rise>>>erosion

CLIMATE CHANGE HAZARDS AND OUTCOMES:
Sea Level Rise>>>Flooding>>>Climate Change
Sea Level Rise>>>erosion>>>Climate Change

MITIGATION STRATEGIES:
5/15 do not include strategies.

CONSEQUENCES:
washed out roads, contaminated drinking water, property damage, overwhelmed storm sewers, downed trees, downed power lines, shoreline change, threat to water crafts, loss of life

Hazard Mitigation Plan Interview Guide

1) We've noticed that the majority of communities and planning councils do not include climate change in their HMPs. Why is that?

2) Would it be useful or practical for Hazard Mitigation Plans to include information specifically about climate change and how to manage or adapt to hazards that arise from it?

- Do you think that HMPs are the appropriate place for climate adaptation planning?

3) Are other kinds of routine or mandated planning more appropriate for considering climate change adaptation?

- CWRMP?
- Flood management plans?
- Other?

4) What are the barriers to making consideration of climate change part of HMP?

- Information or data availability?
- Lack of FEMA requirement to do so?
- Lack of interest or knowledge?
- Funding?
- Lack of a local "champion"?
- Other?

5) Are there ways to overcome any of these barriers? Do you see HMPs being useful for climate change planning in the future?

Comprehensive Water Resource Management Plan Interview Guide

1) What basic information can you give us on the information that is currently in a typical CWRMP?
2) In your work with CWRMPs what have been the barriers?
    a. How did you overcome these barriers?
3) We recently learned that CWRMPs are now incorporating information on climate change adaptation. Can you explain what the specific requirements will be?
4) What are some barriers you foresee in implementing these new requirements?
    a. How can these barriers be dealt with?
5) Are other kinds of routine or mandated planning that are appropriate for considering climate change adaptation?