Action Plan 18 Planning for a Shifting Shoreline and Coastal Storms

Problem[205]

For millennia, the Buzzards Bay coastline has been subject to the rise in sea level and storms that have continued to erode and shift materials that change the shape, elevation, and position of the shoreline. These processes shift the locations of barrier beaches and alter wetland areas, resulting in the loss of habitat for certain species, and cause the migration of other habitats like salt marshes. Structures built in these hazard-prone areas can not only impede natural processes, but when they are destroyed in storms, they become hazards to public health and the environment. They can also become a financial burden to government. The frequency and intensity of these processes will likely increase in the coming decades due to climate change. Some state and federal programs are creating moral hazards by promoting development in high-risk areas.

The Massachusetts Coastal Zone Management updated its program plan with goals to prevent, eliminate, or significantly reduce threats leading to loss of life, destruction of property, and degradation of environmental resources that result from improper development. They also sought to limit public expenditures in coastal high hazard areas, allow natural physical coastal processes to continue unabated, to the extent feasible, and prioritize public expenditures for acquisition and relocation of structures out of hazardous coastal areas. Unfortunately, current state, federal, and local laws, regulations, and policies are far from achieving these goals.

Goals

Goal 18.1. Protect public health and safety from problems associated with coastal hazards including rising sea level, shifting shorelines, and damage from storms and storm surge.

Goal 18.2. Reduce the public financial burden caused by the destruction of or damage to coastal property.

Goal 18.3. Plan for shifting shorelines and the inland migration of buffering wetlands and shifting sand formations, and the species that utilize these habitats.

Objectives

Objective 18.1. To incorporate sea level rise, increased frequency and intensity of coastal flooding, and shoreline change phenomena into all relevant planning and management programs.

Objective 18.2. To develop a comprehensive strategy for handling existing structures in areas that will be affected by future shoreline changes and other coastal hazards.

Objective 18.3. To adopt regulatory and non-regulatory measures for guiding growth and development in areas that will be influenced by coastal flooding and new shorelines.

Objective 18.4. To encourage continued restructuring of the national flood insurance program to discourage development in flood prone areas.

Objective 18.5. To adopt emergency response plans to reflect additional needs and constraints caused by reduced access and increased flooding potential of developed coastlines.

Approaches

This action plan requires changes in regulations, policies, and actions by all levels of government. Public spending for infrastructure in high risk areas should be avoided, and government should not create incentives for private construction in high-risk zones. The latter problem will require changes in the flood insurance program, and the kinds of actions required by the federal government in the aftermath of disaster relief aid. Municipalities will need to conduct evaluations of new risks caused by rising sea levels. They should adopt hazard mitigation plans, and participate in the FEMA community rating systems. RPAs and CZM should assist in these efforts. They also need to lead by example by not building new public structures in high-risk areas.

Costs and Financing

Much of the expenses associated with this action plan relate to conducting risk assessments, planning, and adopting or amending laws and regulations. These efforts might cost hundreds of thousands of dollars per community and require dedication of staff time. Those measures requiring regulatory or policy changes have nominal costs.

Measuring Success

Because of the rarity of catastrophic storms, and slowness of sea level rise, tracking programmatic actions, like completion of hazard mitigation plans, adoption of changes in the state building code, or adoption of local bylaws, ordinances, and regulations that support climate adaptation, will be the primary measures for tracking success.

[205] This action plan was revised and re-written from the original 1991 CCMP. The first four objectives were in the 1991 CCMP, but have had some minor changes in text. [Goals 1 and 2 were in the 1991 CCMP, but have had some changes in text, including concepts relating to coastal hazards. Goal 3 was changed from planning for loss to planning for inland migration of wetlands.]

Background

Development Pressures and Adaptation

With the tremendous increase of development on the coast and storm damage prone areas in recent decades, human activities to control natural coastal processes have included the filling of tidelands, and the "hardening" of shorelines through the construction of groins, revetments, bulkheads, and other structures. Through direct and indirect effects, there have been wetland losses and impairments, such as restrictions to tidal flow. Hardened shorelines also prevent natural shoreline processes, like coastal sand transport, which in turn may exacerbate coastal erosion rates. These structures also prevent the natural inland migration of salt marshes.

The increasing propensity of private construction in vulnerable coastal areas, particularly residential development, followed by improved public infrastructure of roads, utilities, and bridges, has caused concerns about the economic and ecological costs of this growth. The economic losses due to storm-related damage to the coastal zone have increased, not because of increased storm frequency or intensity, but because of increased development along the coast.[206] In dense urban centers along the coast, the economic value of public and private property and infrastructure is so great that public and private action will result in the continued protection and elevation of existing filled tidelands as has occurred for the past several centuries[207]. In less densely developed coastal areas, particularly residential areas, there is a debate about whether the public (taxpayer) should bear the costs of protecting and rebuilding private property in these vulnerable areas, and whether government should limit new development in these areas.

Since the creation of a federally subsidized National Flood Insurance Program (NFIP) in 1968, there has been an ongoing debate about moral hazards[208] created by the program, and how the program may be encouraging development in high-risk areas. In fact, in the 1991 Buzzards Bay CCMP, an objective of this action plan was "to restructure the flood and hazard insurance programs in threatened areas so that the financial burden on the general public is decreased." The U.S. Congress finally addressed this issue in part with the passage of the Biggert-Waters Flood Insurance Reform Act of 2012. The legislation required the Federal Emergency Management Agency (FEMA) to make a number of changes to the way the NFIP is run. A key provision of the legislation is to require NFIP policy rates to reflect true flood risks and costs. The planned changes, which will be implemented over several years, will raise insurance premium rates appreciably for new construction in the flood plain, and raise the rates for many previously built structures.

Global Climate Change and Sea Level Rise

During the past 750,000 years, the earth has repeatedly cycled between ice ages lasting 70,000 to 100,000 years, and brief warm periods lasting between 10,000 to 30,000 years. We are currently living in one of these warm interglacial periods. Since the peak of the last ice age 21,000 years ago, when Buzzards Bay was covered with a mile thick sheet of ice, sea level has risen roughly 400 feet. During the last interglacial period (130,000 years ago), the earth's climate was warmer than today, Greenland's entire ice sheet melted, and sea level was roughly 15-20 feet higher than today.

Sea level rose rapidly during the rapid retreat of the ice sheet across North America beginning 19,000 years ago, averaging 4 feet per century for thousands of years. About 6,000 years ago, the rate of sea level rise slowed dramatically. During the past 4,000 years, sea level rise in southern New England likely was only 6 inches per century (Engelhart et al., 2011). During the past 3,300 years, relative sea level near Boston was only 3 inches per century (Donelly, 2006). However, the rate of sea level rise is again increasing. Woods Hole tidal records have documented a 10-inch rise during the past century. Due to emissions of greenhouse gases from human activity, the rate of sea level rise may increase by 1.5 feet or more by the 2100. Increased ocean temperatures may also cause coastal storms to become more severe and more frequent. Changes in global temperature will also alter weather and precipitation patterns in both subtle and not so subtle ways.

This action plan is not about climate change or greenhouse gas emissions. Anthropogenic inputs of greenhouse gases will add to an existing trend of rising sea level, and other climate change patterns. However important it is to address and mitigate these human impacts to world climate, this is an international and global scale problem that is beyond the scope of this watershed management plan. Moreover, as noted in the 2007 IPCC report for managers, "anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized." Thus, for the indefinite future, whether or not greenhouse gas emissions are controlled, coastal managers and planners need to promote long-term policies to address the expected continued rise of sea level rise over the next centuries, and society must plan and adapt for future storm damage impacts to minimize the financial and ecological impacts of coastal development.

[206] Pielke et al., 2008. Normalized Hurricane Damage in the United States: 1900-2005. sciencepolicy.colorado.edu/admin/publication_files/resource-2476-2008.02.pdf.

[207] Despite a 2.5 foot rise in sea level, between 1700 and 1950, the cities of Boston and New York increased appreciably both in size and elevation as millions of cubic yards of fill were placed on uplands, tidelands, and wetlands.

[208] In economic theory, a moral hazard is a situation where a party may take risks because the full costs that could incur will not be felt by the party taking the risk. The term was defined by the insurance industry more than a century ago. It is also characterized as when an individual, who is insulated from a risk, behaves differently than if they were fully exposed to that risk.

These changes will likely alter future patterns of development along flood-prone coastal areas.

The focus of this management plan is to implement strategies to reduce the severity of impacts of future storms and sea level rise on the coast and on existing and future coastal development. Management agencies call this approach adaptation. Mitigation measures are required to address global climate changes, but these measures are best addressed at the national and international levels of governments, not in this action plan.

Geologic Cycles and Greenhouse Gases

Shorelines have shifted significantly over geologic time. In the 19,000 years since the Laurentian ice sheet began retreating across North America, shorelines everywhere began withdrawing inland as sea level rose in response to melting glaciers and expansion of warming seawater. As recently as 9,000 years ago, Buzzards Bay was a dry-land valley, and the southeastern Massachusetts land mass extended seaward 100 miles encompassing the Elizabeth Islands, Martha's Vineyard, Nantucket, and portions of Georges Bank (Shaw, 2006). As recently as 5,000 years ago, sea level was likely at least 25 feet lower than today[209] (Donnelly, 1998; Engelhart et al., 2011). At this time, the northern boundary of Buzzards Bay was likely defined by a shoreline that ran from Sippican Neck in Marion, to Scraggy Neck in Bourne. All during these millennia, the sandy shores along southern New England continually shifted inland due to erosion in response to major hurricanes and winter storms and rising sea levels.

The rate of sea level rise then lessened dramatically after 5,000 years before present, although with some variability likely related to global temperature shifts. For example, Engelhart et al. (2011) estimated that sea level rise during the past 4,000 years was around 5 inches per century in southern New England. During the past 3,300 years, Donnelly (2006) found the rate to be only 3 inches per century in a Revere, MA marsh[210]. Rates are higher today, and in Woods Hole sea level rise has been 10 inches during the past century (Figure 103). Furthermore, scientists project that the rate of sea level rise and shoreline change will increase appreciably in the next few centuries because of elevated concentrations of greenhouse gases from human activity. The resulting warming is expected to increase the rate of sea level by both raising ocean water temperature (thermal expansion), and by melting glaciers and ice caps in Antarctica and Greenland.

Since colonial times, the two principal ways of measuring coastal changes has been through shoreline mapping and more recently, through the collection of tidal elevation data. A casual examination of old nautical charts shows that some tidal rocky areas, headlands, and tiny islands in Buzzards Bay have disappeared. A more thorough analysis of charts and aerial photographs by Massachusetts Coastal Zone Management has shown that the horizontal migration of shorelines in a few parts of Buzzards Bay has averaged more than 10 feet a century. However, in most of Buzzards Bay, shorelines have been relatively static during the past few hundred years due to the protected natured of most of Buzzards Bay shores, and in a few areas, because of the presence of bedrock.

Tidal data collected around the world documents that during the past century global sea level has been rising at an average rate of approximately 0.3 feet (3.6 inches) per century, consistent with the past few millennia. Actual rates depend on whether a portion of a continent is subsiding or lifting. In Buzzards Bay, like most of the Atlantic seaboard, relative sea level has been rising at a slightly higher rate, approximately 10 inches (0.85 ft) per century during the same period, due to the slow subsidence of the earth's crust along the east coast (Figure 103). Recent models have suggested that sea level rise during the 21st century could range anywhere from 4 inches to 2.5 feet, with a median consensus estimate of 1.5 feet (IPCC, 2007; see also Munk, 2002; Titus, 2000, Titus and Richman, 2000). An additional 0.5-foot increase could result from additional glacial melting predicted by some models.

Atmospheric monitoring and analysis of glacier ice cores show unequivocally that greenhouse gases have increased dramatically in the atmosphere during the past 100 years. There is wide consensus that these increases will further elevate worldwide ocean and atmospheric mean temperatures in the coming decades and centuries. A warmer planet will further raise sea level by expanding ocean water and melting glaciers and polar ice sheets. These changes will not only result in increased coastal inundation, but a warmer climate could result in

[209] Donnelly (1998) concluded (based on radiocarbon dating of buried salt marsh sediments) that 5,000 years ago, sea level was about 39 feet lower in southern New England (=9.4 inches per century increase for the entire period), and 13 feet lower around Boston (=3.1 inches per century average). In 2006, Donnelly revised his Boston estimate (a Revere marsh) to 8.5 feet in 3,300 years, which is still about 3.1 inches per century. Engelhart et al. (2011) estimated an average rate a bit over 5 inches per century during the last 4,000 years in the area New York. When sea level was 39 feet lower, Buzzards Bay would have been defined by a shoreline between Mattapoisett Neck and West Falmouth.

[210] Sea level rise in southern New England may be slightly faster than around Boston. Variability in rates is caused by differing rates of land subsidence and proximity to effects of the Atlantic Gyre (Engelhart et al., 2009). Boston may have also experienced an increase in tidal range. In addition, sea level rise may have varied appreciably during this period as well, as Donelly et al. (2004) also found that during the cold period known as the Little Ice Age, sea level rise in southern New England might have been slowest during the period.

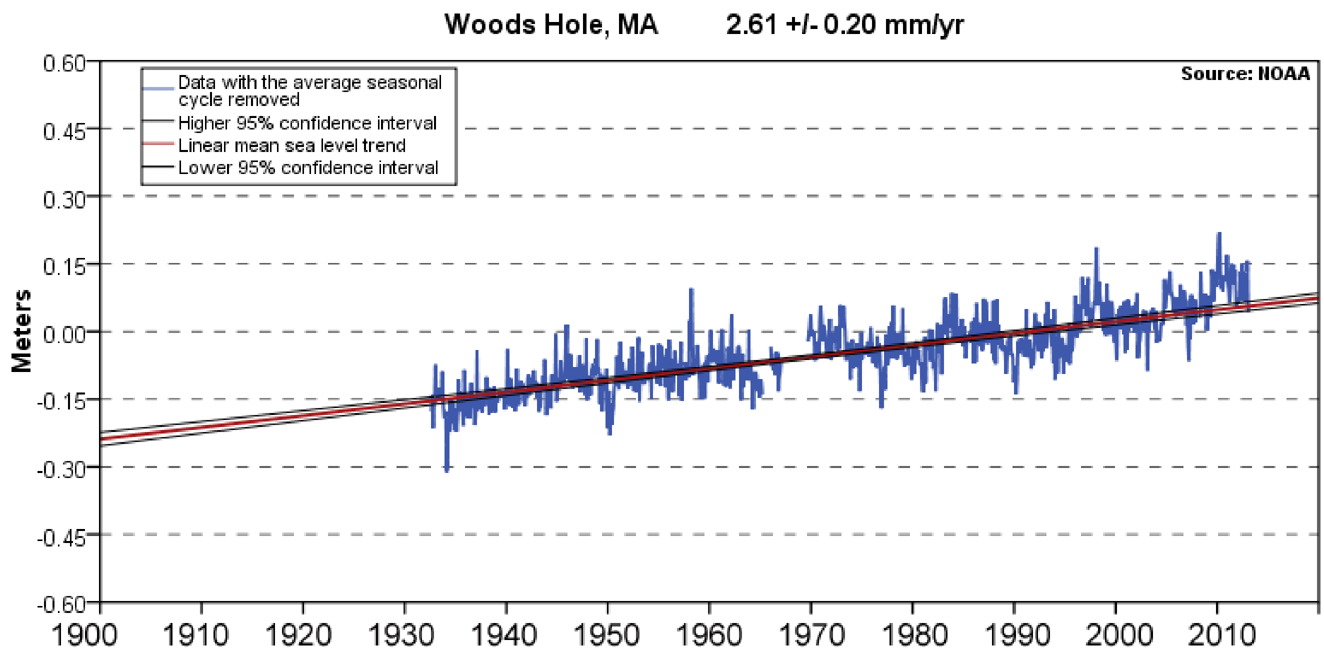

Figure 103. Mean sea level trend at NOAA tidal station 8447930 Woods Hole, Massachusetts.

The mean sea level trend is 2.61 millimeters/year (0.86 feet/century) with a standard error of 0.20 mm/yr based on monthly mean sea level data from 1932 to 2012. Figure generated at tidesandcurrents.noaa.gov/sltrends on 19 April 2013. IPCC (2007) consensus estimate predicts a 1.4-foot increase during the 21st century. An additional 1-foot increase could occur during the same period because of glacial melting.

more severe storms, which in turn accelerates ongoing changes to the coastline.

The greenhouse gases of greatest concern are carbon dioxide, largely derived from the combustion of fossil fuels, and methane, which are increasing because of increased farm animal production, increased areas of rice production, and deforestation of tropical forests. While methane is in much lower concentrations in the atmosphere than carbon dioxide, it has 16 times the heat trapping effect of carbon dioxide, so its release into the atmosphere is also of concern.

Climate change is receiving significant scientific and public attention in national and international forums, and scientific models to predict future conditions have improved. Some previous predictions of sea level rise during the 21st century were unrealistically high (IPCC 2001), and consensus estimates now predict a 60% increase over the current rate. To most individuals, the rise in sea level will seem gradual and imperceptible during their lifetime. Furthermore, even if governments immediately curtailed greenhouse gases, climate change patterns and sea level rise will continue for centuries (IPCC, 2007).

While these facts may generate complacency in some (and alarm in others), policy makers, regulators, and lawmakers must recognize that irrespective of potential future conditions, coastal storms and erosion will continue to shape the shores of Buzzards Bay and affect residents. These individuals must establish a course of action to plan for both the effects of coastal storms, and the effects of sea level rise, and to regulate coastal development in a way to minimize costs to property owners, municipalities, and the environment.

For the 1991 Buzzards Bay CCMP, the Buzzards Bay NEP funded two studies about the potential impacts of rising sea levels (Giese and Aubrey, 1987; Giese, 1989). These studies evaluated the potential loss of upland areas due to sea level rise in the 11 communities directly abutting the bay. Loss of "upland" included both potential shoreline loss and conversion of dry land to wetlands from rising groundwater. The study evaluated three rates of sea level rise: 0.45, 1.3, and 2.1 feet per century (the middle rate is close to the current 2007 IPCC consensus best estimate).

Results showed that under this scenario, several municipalities bordering Buzzards Bay would experience significant losses in area of their coastal uplands by rising waters. Effects from these losses would include increased occurrences of floods at higher elevations, loss and erosion of wetland resource areas, elevated groundwater levels, and potential saltwater intrusion into groundwater near shore. Although some changes, like elevation of groundwater levels will appear as a gradual and continuous change, most sea level rise shoreline change effects would be manifested as dramatic shoreline changes caused by major coastal storms, followed by gradual redistribution and migration of coastal sediments during more quiescent periods.

Managers must also address the inland migration of wetlands, particularly salt marshes, which is an im-

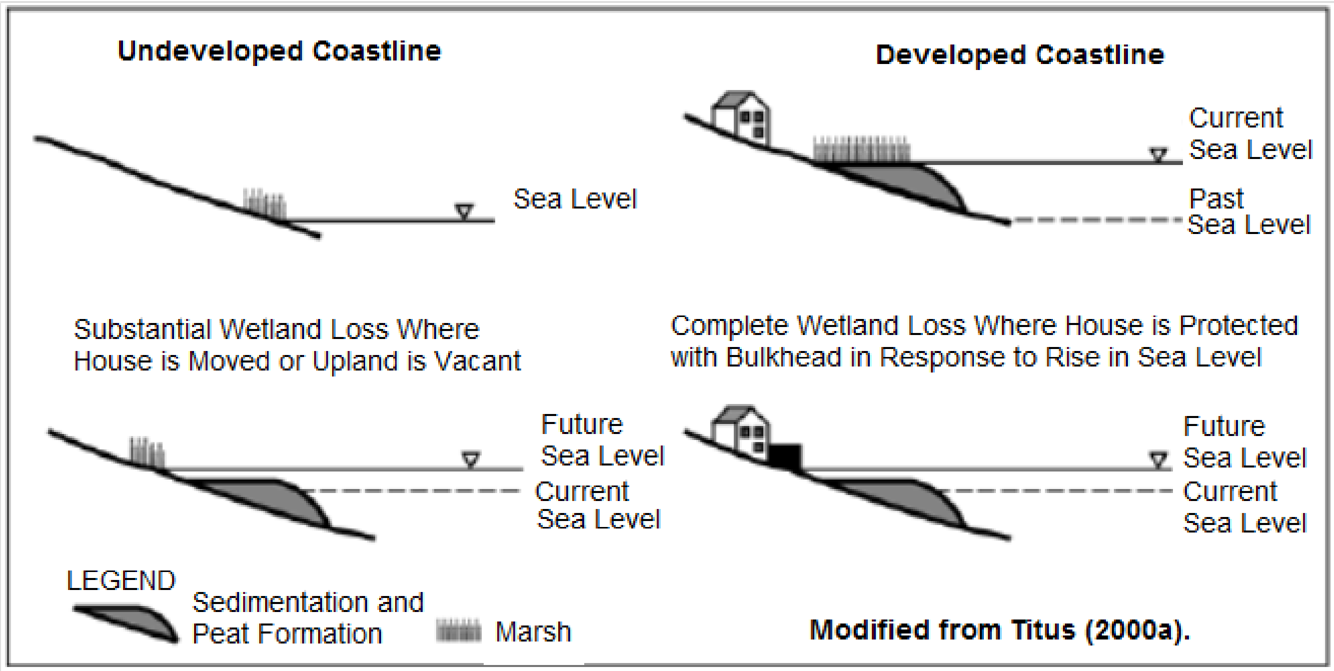

Figure 104. Salt marshes having been migrating inland for thousands of years as illustrated by the figure on the left. Construction of bulkheads and other structure prevent this inland migration, resulting in loss of salt marsh (right).

portant collateral environmental impact of sea level rise. Sediment cores of coastal bays and estuaries show a natural inland migration of nearshore freshwater cedar swamps converting to salt water systems, first as salt marshes, then salt ponds. Barrier beaches migrate inland. Some areas of coast lose sediment, and sediments may build up elsewhere. Construction of bulkheads, sea walls, and revetments interrupt this inland migration and consequently the frontward eroding edges of salt marshes are often not replaced on their backside (Figure 104). Preserving the ability of salt marshes to migrate, and the restoration of tidally restricted salt marshes altered in the past, remain priority actions for the Buzzards Bay NEP.

Figure 105 clearly illustrates this phenomenon in the aerial photograph of Great Sippewissett marsh. This photograph shows the extent of the existing salt marsh, as well as old salt marsh peat offshore showing the extent of salt marsh centuries ago when the barrier beach was more than 100 feet shoreward. This salt marsh peat is now habitat for juvenile lobsters and other invertebrates. The photograph also shows a railroad track and bed constructed in the 19th century. This railroad track isolated areas to the east from tidal exchange. While some culverts were installed under the railroad, to permit tidal exchange, over the years many culverts collapsed or filled in. The net result of this construction was the conversion of salt marsh to freshwater wetlands at many sites, and prevention of the natural inland migration of the salt marsh in response to sea level rise.

Storm Damage and Storm Frequency

Hurricane frequency appears somewhat cyclic over roughly a 30-year period (Figure 106). Because most coastal development in the U.S. occurred during the relatively quiescent period between 1970 and 2000, if a hurricane equivalent to the Hurricane of 1938 (estimated to be a Category 3 hurricane with a tidal surge of 14 feet in portions of Buzzards Bay) were to strike Buzzards Bay today, property damage would be far more extensive.

Figure 105. Aerial photograph of Sippewissett Marsh showing salt marsh peat offshore, remnants from a period, hundreds of years ago, of lower sea level and a more westward barrier beach.

Table 49. National Flood Insurance losses in the Buzzards Bay watershed since 1978 and policy values.

Data from FEMA as of 02/28/2009. From www.fema.gov/policy-claim-statistics-flood-insurance/policy-claim-statistics-flood-insurance/policy-claim-13 as of January 31,2009.

Loss Statistics Massachusetts Since 1978 as of 02/28/2009						NFIP Policy Statistics for Massachusetts as of January 31, 2009.				
Community Name	**Total Losses**	**Paid Losses**	**Unpaid Losses**	**Total Payments**	**Dollars per Paid Claim**	**Policies In-force**	**Total Insurance Coverage**	**Annual Premiums Paid**	**Hazard Mitigation Plan**	**CRS partic. (2013)**
ACUSHNET	1	1	0	$14,622	$14,622	11	$2,863,800	$7,992	no	no
BOURNE	459	377	82	$5,435,069	$14,417	1143	$240,108,100	$1,677,292	yes	no
CARVER	9	6	3	$24,692	$4,115	5	$1,400,000	$1,711	no	no
DARTMOUTH	122	76	46	$778,988	$10,250	516	$113,612,000	$539,568	2013 draft	no
FAIRHAVEN	395	314	81	$3,273,025	$10,424	725	$140,240,500	$908,250	no	no
FALMOUTH	619	472	147	$9,091,549	$19,262	2092	$502,122,200	$2,783,527	no	no
GOSNOLD	1	1	0	$2,215	$2,215	7	$2,055,700	$7,895	county	no
MARION	174	131	43	$2,877,321	$21,964	408	$103,432,000	$615,097	no	no
MATTAPOISETT	468	380	88	$6,754,052	$17,774	692	$156,627,700	$968,386	no	no
MIDDLEBOROUGH	16	11	5	$81,802	$7,437	28	$6,582,300	$31,349	yes	no
NEW BEDFORD	51	27	24	$635,184	$23,525	224	$65,282,400	$325,253	yes	no
PLYMOUTH	348	254	94	$4,127,976	$16,252	445	$100,790,800	$429,518	yes	yes
ROCHESTER	0	0	0	$0	$0	1	$350,000	$388	no	no
WAREHAM	835	721	114	$11,500,072	$15,950	1803	$323,510,900	$2,051,640	no	no
WESTPORT	107	78	29	$1,112,631	$14,265	293	$71,013,400	$316,012	no	no

This is because in the 1930s, most of the population lived in cities like New Bedford (which actually had a higher population than today), with a smaller portion of the population in the 100-year flood zone. Surrounding communities were more rural, and the structures built closest to shore were often summer cottages, built to be expendable in the face of coastal storms. With improved roads and infrastructure, and with government subsidized flood insurance programs that de facto promoted residential growth near shore, development within the flood zone of Buzzards Bay increased dramatically. Even in the face of relatively minor storms, Buzzards Bay communities have seen tens of millions of dollars in claims under the National Flood Insurance program since 1978 (Table 49).

The effects of another direct hit of a category 3 hurricane in Buzzards Bay will be immediate and dramatic compared to the gradual effects of sea level rise.

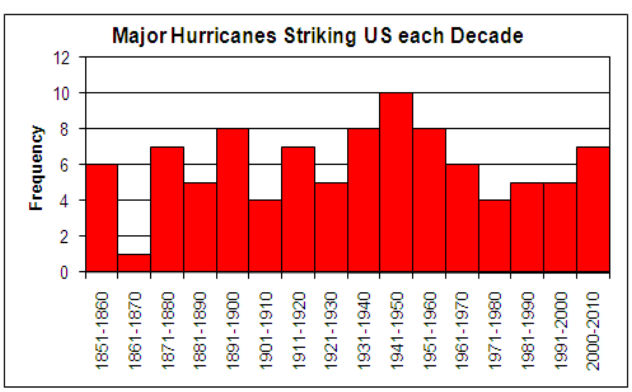

Figure 106. Frequency of major hurricanes (greater or equal to category 3) striking U.S. during the past 150 years.

The frequency of severe hurricanes striking seems to be cyclic, but future trends are less certain. Data from Blake et at. 2005, modified to include 2005 (severe year) and 2006 (hurricane free year) and 2007 and 2008 data. See also: www.nhc.noaa.gov/pastdec.shtml.

Management Opportunities

From a planning point of view, shoreline dynamics occur broadly within three hydrologic regions: flood-prone areas, surface-water areas, and groundwater areas. Issues to be considered include loss of uplands, increased flooding impacts, loss of wetlands, accelerated shoreline changes, saltwater intrusion, and elevated groundwater levels. For currently developed areas, two basic management strategies are available: retreat from the rising water or attempt to protect threatened areas, with varying combinations of both. For undeveloped areas, avoidance is another possibility. However, political, legal, and economic considerations will probably override the scientific issue. Although we know that changes are occurring now, and cannot be reversed, the issues of property rights and equity will probably dominate how the problem is managed. The challenge is to incorporate existing scientific information, even with its uncertainties, into a rational and equitable management scheme.

An example of this can be found in the 1991 Buzzards Bay CCMP. The Buzzards Bay NEP recommended that rising nearshore groundwater levels could be addressed through DEP regulations requiring a five-foot separation to groundwater for septic system leaching fields (instead of the current 4-foot separation required). DEP addressed this issue indirectly by tackling another issue simultaneously. In their 1996 regulations, they required a five-foot separation in very fast perking soils (as might be found near coastal beaches). The strategy was imperfect, for while this regulatory change addressed groundwater separation in most coastal areas, it did not capture all near shore areas, and this recommendation has been revised in this updated action plan.

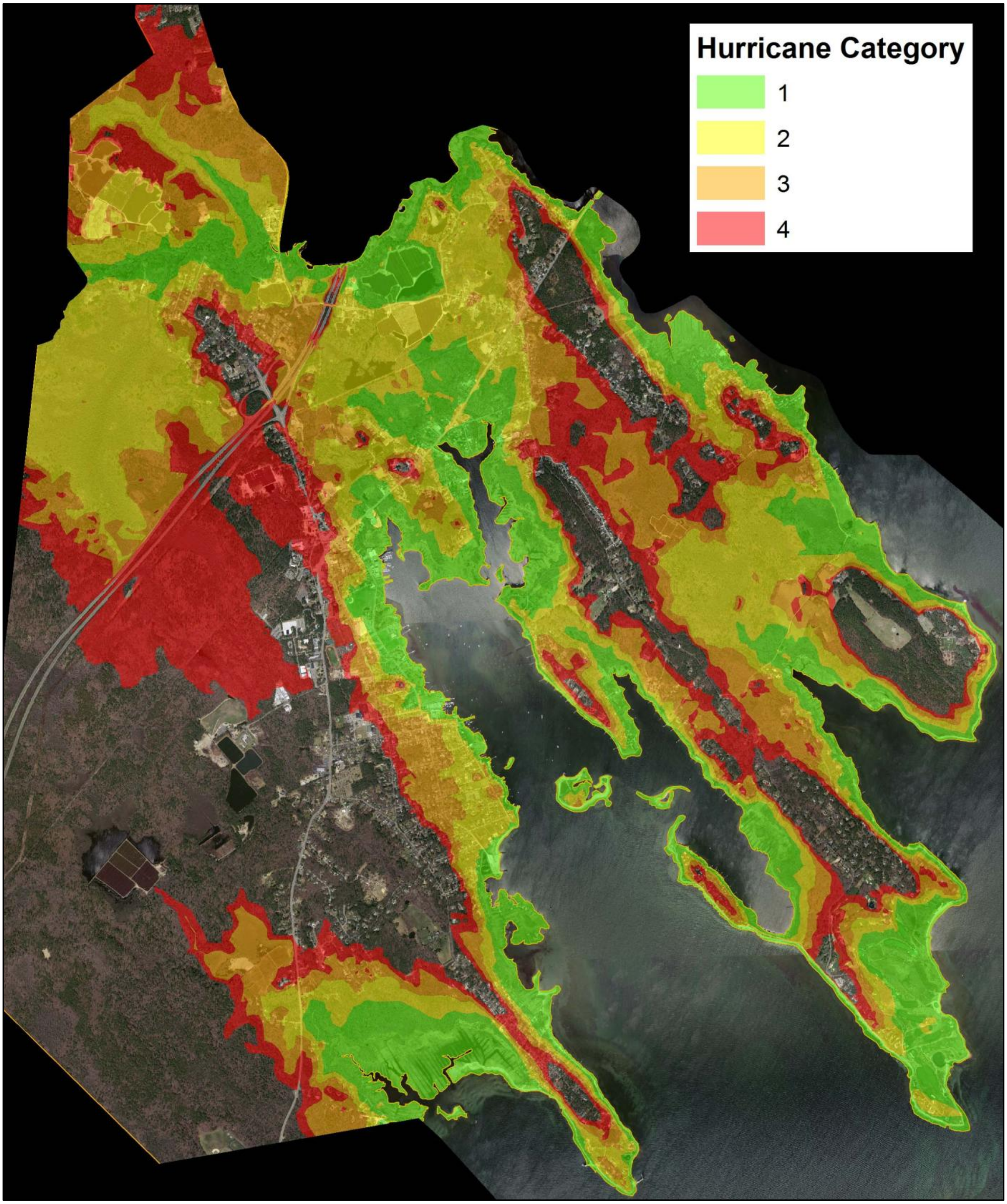

Figure 107. 2013 updated SLOSH flooding model map of Marion, MA produced by the U.S. Army Corps of Engineers.

Shows the current "sea, lake, and overland surges from hurricanes" model for coastal flooding developed by the U.S. Army Corps of Engineers for the Town of Marion. The model shows the worst-case flooding scenario for Category 1-4 hurricanes striking Buzzards Bay. Marion is one of several Buzzards Bay communities with extensive areas within the flood zone. The Buzzards Bay NEP has estimated the assessed value of structures within the FEMA floodplain (nearly the Category 2 storm boundary here) to be 93.5 million dollars.

For three decades, the Massachusetts Coastal Zone Management Office (CZM) has tried to tackle broader sea level rise and coastal erosion issues across Massachusetts. Besides the various guidance documents, policies, and regulations that were developed by CZM staff, the agency, with funding from NOAA, began conducting a GIS analysis of historic maps and aerial photographs.

This effort culminated in two important shoreline change reports that identified the most erosion prone coastal areas of Massachusetts (Thieler et al., 2001; O'Connell et al., 2002). The reports helped towns and regulatory agencies formulate policies and regulations that account for the threats to infrastructure and the environment posed in these dynamic areas. In 2002, CZM updated its program policies to address sea level rise issues in their review of projects. For example, in the 2011 Massachusetts CZM Policy Guide, it is noted that "relative sea level rise should be factored into the design life, elevation, and location of buildings and other structures within the coastal floodplain," and "non-structural alternative approaches to coastal hazards reduction are preferred over structural alternatives."[211]

Massachusetts joined the National Flood Insurance Program (NFIP) in 1978, the first year of the program. Today, more than 95% of Massachusetts' 351 communities participate in the NFIP program. In 1986, Massachusetts also was one of the first states to receive FEMA approval for its State Hazard Mitigation Plan. In 2007, the State Hazard Mitigation Team comprised of staff from the Massachusetts Emergency Management Agency and Department of Conservation and Recreation, together with other state and federal agencies, prepared the most recent State Hazard Mitigation Plan. This document, organized differently than past plans, addressed a number of additional laws and requirements, and for the first time attempted to include priorities contained in local plans.

The 2007 state plan recognized the importance of local government in defining patterns of development and redevelopment, and placed an increased emphasis on the creation of local mitigation plans, with the state providing funding to regional planning agencies to achieve those goals. At the time of the writing of this report, only 25% of the communities in Massachusetts had a local hazard mitigation plan.

While the state was updating its 2007 State Hazard Mitigation Plan, a parallel effort was underway to evaluate coastal hazards. This effort began in February 2006, when the governor created the Massachusetts Coastal Hazards Commission. The charge to the commission was to review existing coastal hazards practices and policies, identify data and information gaps, and draft recommendations for administrative, regulatory, and statutory changes. In May 2007, the commission released its final report. The report contained 29 specific recommendations, most of which were directed to state and federal agencies, and most of these recommendations revolved around improving databases, resources, and local and regional plans to better respond to disasters.

Both these reports touched on the importance of local hazard mitigation planning and better understanding the role of local government and the fact that the development and approval of the local plans creates increased opportunities of funding and technical assistance to local government. One of the more important of these opportunities is the eligibility for hazard mitigation grants. Equally important is that municipalities become eligible to participate in the Community Rating System (CRS). The CRS program provides two key local benefits. The first of these is that it reduces flood insurance policy rates for homeowners in the flood zone. Second, it results in a higher rate of municipal reimbursements in the event of natural disasters. The key disadvantages from the town's point of view are that the town must first dedicate resources to help develop the local hazard mitigation plan. Second, the town must dedicate staff to comply with annual reporting requirements and activities to meet annual CRS certification.

While municipalities may participate in the CRS to reduce threats to human life and property, and for additional political or financial benefits that participation convey, from an environmental policy perspective, many activities that achieve high CRS scores will also reduce environmental impacts from new development, or reduce environmental impacts resulting from natural disasters[212] (see Table 50). For this reason, local participation in the CRS is a high priority in this action plan.

In 2008, in an effort to better increase public awareness and local government action to plan for sea level rise and future storm and coastal erosion impacts, CZM launched the StormSmart Coasts initiative. The effort consisted of a mix of outreach materials, an information exchange StormSmart Coasts website, and workshops directed toward planners and local government officials. As such, it became a logical extension of the state's efforts to place more emphasis on local government actions to manage development. The website was established to provide an accessible collection of ideas, strategies, and case studies to help communities improve efforts to manage coastal floodplains and support local efforts to improve the management of coastal floodplains in Massachusetts.

In 2013, the Buzzards Bay NEP created a similar subdomain website climate.buzzardsbay.org to present storm smart planning and climate ready assessments for

[211] Available at www.mass.gov/eea/agencies/czm/about-czm/czm-policy-guide/, last accessed October 22, 2013.

[212] According to FEMA CRS guidance documents, participation will help "reduce the risk of erosion damage, and protect natural and beneficial floodplain functions." FEMA 2006. CRS Coordinators manual. 130 pp.

Buzzards Bay. This website consolidate information, data, and assessments undertaken by the Buzzards Bay NEP and others, about the potential impacts to Buzzards Bay and its watershed from storms, shifting shorelines, rising sea level, and changes in climate and precipitation. This information, along with potential adaptation strategies, is meant to inform and guide government officials, researchers, local managers, and the public.

The Buzzards Bay National Estuary Program has established this website to consolidate information, data, and assessments undertaken by the Buzzards Bay NEP and others, about the potential impacts to Buzzards Bay and its watershed from storms, shifting shorelines, rising sea level, and changes in climate and precipitation. We are providing this information, along with potential adaptation strategies, to inform and guide government officials, researchers, local managers, and the public.

Major Issues

Even though the magnitude and timing of future storms and shoreline changes is not known, the fact that shorelines erode and migrate is incontrovertible. More importantly, hurricanes are certain to cause more economic damage in the future, not because storms will be more intense, but because there is so much additional development, infrastructure, and residences built in coastal storm damage prone areas than in past decades. Pielke et al. (2008) found that between 1900 and 2005, increases in economic damage caused by hurricanes were the result of patterns of development, and not increased storm frequency or intensity.

It is often argued that the National Flood Insurance Program creates moral hazards[213] by undercharging for actual risks and even funding those who failed to pay for government flood insurance (Kriesel and Landry, 2004). As noted earlier, the U.S. Congress finally addressed this issue with the passage of the Biggert-Waters Flood Insurance Reform Act of 2012. A key element of the legislation is to require the NFIP to charge flood insurance policy rates that reflect true flood risks and program costs. These higher costs will discourage new development in flood prone areas. These changes (to be phased in over several years) will affect existing property owners, and will eliminate grandfathering of insurance rates after a property is sold. Concerns have been raised about financial impacts to existing homeowners. These concerns have prompted attempts to pass new legislation to curtail or delay elements of the act and possibly undermine the climate adaptation benefits of the law[214].

Table 50. Selected Community Rating System activities that may benefit the environment.

Listed by CRS program category number; from FEMA, 2006.
410 (Additional Flood Data) Develop new flood elevations, floodway delineations, wave heights, or other regulatory flood hazard data for an area that was not mapped in detail by the flood insurance study; or have the flood insurance study's hydrology or allowable floodway surcharge based on a higher state or local standard.
420 (Open Space Preservation) Encourages communities to keep hazardous areas open and undeveloped;
420 (Open Space Preservation) Extra credit is provided for open space areas that are preserved in their natural state, have been restored to a condition approximating their pre-development natural state, or have been designated as worthy of preservation for their natural benefits, such as being designated in a Habitat Conservation Plan.
430 (Higher Regulatory Standards) Require freeboard; require soil tests or engineered foundations; require compensatory storage; zone the floodplain for minimum lot sizes of 1 acre or larger; regulate to protect sand dunes; or have regulations tailored to protect critical facilities or areas subject to special flood hazards (e.g., alluvial fans, ice jams, or subsidence).
430 (Higher Regulatory Standards) Regulations that protect natural areas during development or that protect water quality are credited.
450 (Stormwater Management) Regulate new development throughout the watershed to ensure that post-development runoff is no worse than predevelopment runoff.
450 (Stormwater Management) erosion and sediment control and water quality requirements for projects that affect stormwater runoff are credited.
520 (Acquisition and Relocation) Acquire and/or relocate flood prone buildings so that they are out of the floodplain.
540 (Drainage System Maintenance) Conduct periodic inspections of all channels and retention basins and perform maintenance as needed.

In 2011, Massachusetts Coastal Zone Management updated its program plan with these goals: "(1) prevent, eliminate, or significantly reduce threats to public safety, property, and environmental resources resulting from hazards such as erosion, flooding, and storm damage; (2) allow natural physical coastal processes to continue while allowing appropriately sited coastal development and economic growth and promote the use of nonstructural alternatives for shore protection where appropriate and to the extent feasible; (3) limit, prohibit, or condition public expenditures in coastal high hazard areas to ensure that increased exposure to coastal hazards is not encouraged; and (4) prioritize public expenditures for acquisition and relocation of structures out of hazardous coastal areas." Collectively, state, federal, and local policies, laws, and regulations, as currently implemented, are not yet adequate to meet these goals.

Despite the harsh reality of increased development in storm prone areas, most regulations at all levels of government currently assume a static sea level, static shorelines, static nearshore groundwater elevations, or inade-

[213] In legislation proposed by Congress in 2010, the authors wrote, "The Congress finds that.... phasing out flood insurance premium subsidies currently extended to vacation homes, second homes, and commercial properties would result in significant average annual savings to the national flood insurance program.... In addition, we are concerned by provisions that delay the phase out of subsidies and the phase in of risk-based rates. There is an inherent moral hazard when any premium rates are subsidized, and we believe these reforms are urgently needed. Charging less than full-risk rates by the NFIP maintains a system of financial incentives backed by the federal government for individuals to live and build in high-risk flood zones."

[214] There are many benefits of the law for climate adaptation beyond restructuring flood insurance policy rate changes. A good summary is provided by the Georgetown Climate Center (Grannis, 2012).

quate estimates of coastal inundation. Therefore, flood prone areas could expand along the coast as sea level rises

Management Approaches

This action plan requires changes in regulations, policies, and activities at all levels of government, especially public spending for infrastructure in high risk areas, and public spending and program polices that promote development in high risk areas by creating moral hazards. The latter problem will require changes in, and rethinking of flood insurance programs and the kinds of actions required by the federal government should require in the aftermath of disaster relief aid.

With respect to regulations, DEP should amend its wetlands regulations for the resource area "Land Subject to Coastal Storm Flowage" (100-year floodplain) to include performance standards to create a seawall exclusion area 1 vertical foot above the upper salt marsh boundaries. This would allow for salt marsh migration for at least the next 50 years. Such regulatory change could be accomplished in less than a year if desired.

CZM should prepare and post online a Coastal Hazards Characterization Atlas for Buzzards Bay to assist area planning boards, conservation commissions, and other relevant local boards to create plans and regulations to better plan development in coastal areas prone to storm damage and shifting shorelines. They completed such an atlas in 2005 for Massachusetts South Shore communities. Municipalities need such reports to help justify changes in zoning and general bylaws, and to develop and update local land use plans.

Similarly, CZM and USGS could develop a Risk and Vulnerability Assessment Map for each coastal municipality using a standardize methodology and recent LiDAR data. This map series should include scenarios of sea level rise and storm surge. Most of the LiDAR data needed for such an effort was acquired by the federal government for 2011[215]. Much of the GIS work could be conducted in house. The Buzzards Bay NEP is currently undertaking such inundation maps for 1-, 2-, and 4-foot sea level rise scenarios for both the expansion of the flood zone and high tide line for Buzzards Bay.

The Federal Emergency Management Agency should update and maintain Flood Insurance Rate Maps for Buzzards Bay to ensure they are based on the best available LiDAR data. For example, FIRMS for Bristol County in 2009 did not appear to incorporate correctly the latest FIRM data[216].

MassGIS, with support from CZM, should continue to expand its online GIS portals (such as Oliver) to make available and distribute coastal hazards information.

EEA should also evaluate the distribution of coastal hazards and emergency management information relating to coastal municipalities to ensure that the public is kept informed with up-to-date and accurate hazard information, and understand the actions that government may ask of the public. FEMA already publishes information on the number of claims filed and paid in each municipality, but maps of claim locations or recurring damage to public structures would help justify local measures to manage growth in hazard prone areas.

EEA should revise and promote policies, regulations, and take actions to promote sand nourishment as the preferred alternative for eroding and shifting shorelines. Some of these policies can be implemented through the MEPA permitting process, much like the way policies on greenhouse gas emission have been implemented[217]. Most federal and local dredging projects still have the largest fraction of dredged materials disposed at sea. This action would also compliment CZM's policies on the beneficial use of dredge materials.

EEA should help fund a standardized benefit-cost analysis model that fully compares the capital, societal, and natural resource benefits and costs of proposed shoreline protection projects and appropriate alternatives. The hidden extra costs of government (and therefore to taxpayers) to provide services to development in hazard-prone areas is not fully appreciated and needs to be explained.

After catastrophic storms, the Department of Fish and Game and the Department of Conservation and Recreation should acquire storm damaged and storm prone properties from willing sellers in fee or through conservation restrictions and easements. This is accomplished by revising current criteria in agency policy (or state regulations) to promote coastal land acquisition, and utilizing federal incentive grant programs. FEMA has a program in place, but state agencies and municipalities must apply. Municipalities should acquire storm prone properties through Community Preservation Act funding. The estimated costs of these acquisitions will total many tens of millions. Besides federal and state grants, local CPA funds could fund purchases. These lands can be acquired by not only purchase in fee approaches, but by conservation restrictions. This approach will take many years, and depends on willing buyers. Adding to the challenge is the fact that these hazard prone properties tend to be very expensive waterfront properties, so there

[215] There is a gap between the 2011 Northeast LiDAR data set and the 2006 LiDAR data acquired by FEMA in the western half of the Buzzards Bay watershed. This data gap can only be filled with the acquisition of new LiDAR data.

[216] See the Buzzards Bay NEP report Discrepancies between recently updated FEMA FIRM base flood elevation boundaries and LiDAR data in Buzzards Bay. Buzzards Bay National Estuary Program and Massachusetts Office of Coastal Zone Management Technical Report SLR13-8 Draft May 3, 2013.

[217] More information is retrieved from the Massachusetts Greenhouse Gas Emissions Reporting Program website.

may be low local interest and capacity to pursue such purchases.

The Massachusetts Emergency Management Agency, the Department of Conservation and Recreation, and the Office of Coastal Zone Management, along with other appropriate planning agencies, should continue to encourage coastal communities to develop, update, and implement coastal hazard mitigation plans. Few Massachusetts communities, and none in Buzzards Bay, have these in place. EEA can provide technical assistance, and possibly the legislature could help by funding.

Municipal planning boards can adopt and implement strict development/redevelopment standards within FEMA A and V flood hazard zones and other areas subject to coastal flooding, erosion, and relative sea level rise. For example, the Marion subdivision regulations prevent new subdivisions in the flood zone. Broader zoning measures will require town meeting approval. Possible supporting legislation may be needed at town meeting.

Through municipal zoning and local wetland bylaws, Buzzards Bay municipalities should establish coastal

1991 Shoreline Action Plan and Outcomes

Goals

1. Protect public health and safety from problems associated with higher waters and shifting shorelines.

2. Reduce the public financial burden caused by the destruction of or damage to coastal property.

3. Plan for the loss of buffering wetlands and shifting sand formations.

Objectives

1. To incorporate sea-level rise and shoreline change phenomena into all relevant planning and management programs

2. To develop a comprehensive strategy for handling existing structures in areas predicted to be affected by future shoreline changes.

3. To adopt regulatory and non-regulatory measures for guiding growth and development in areas that will be influenced by new shorelines.

4. To restructure the flood and hazard insurance programs in threatened areas so that the financial burden on the general public is decreased. [The U.S. Congress finally addressed this issue in part with the passage of the Biggert-Waters Flood Insurance Reform Act of 2012.]

Recommendations and Outcomes

1. DEP will amend its wetlands regulations and adopt performance standards for the resource area "Land Subject to Coastal Storm Flowage" (100 year floodplain).

Outcome: Deemed partially complete through adoption of the Rivers Protection Act and some other changes in 2008.

2. CZM will provide technical assistance to Buzzards Bay area planning boards, conservation commissions and other relevant local committees, commissions and boards in mapping coastal areas that are, or will be, affected by erosion and/or sea level rise

Outcome: Deemed complete through completion of shoreline change maps, Geise study, and other publications and outreach materials. Still ongoing, with communication facilitated through a new Storm Smart Climate Ready Buzzards Bay website.

3. CZM will provide technical assistance to Buzzards Bay communities in developing by-laws, regulations, guidelines, and policies for building in flood zones mapped by the Federal Emergency Management Agency.

Outcome: Deemed complete through adoption of post Hurricane Bob policies, completion of shoreline change maps, Geise study, and other publications and outreach materials.

4. Buzzards Bay communities should pass bylaws increasing the required setback for septic systems from groundwater, water bodies, and vegetated wetlands for areas subject to sea-level rise, erosion, or flooding.

Outcome: Local regulations largely not adopted, but state Title 5 regulations and River Protection Act helped partially chieve this recommendation.

5. Buzzards Bay communities should establish coastal construction setbacks and regulate construction activities more stringently for areas predicted to be subject to sea-level rise, erosion, or flooding.

Outcome: Some communities (like Falmouth) adopted firmer no build set backs from some wetlands, but most towns did not adopt setbacks. Some Title 5 changes helped partially meet this recommendation.

6. Buzzards Bay communities should establish higher flood elevations that exceed the minimum elevations mapped by the Federal Emergency Management Agency.

Outcome: Recommendation cannot be implemented by town; and rejected as written. However, in 2008, the Commonwealth of Massachusetts changed the state building code, requiring freeboard for V-zone properties and required other "storm smart" measures.

construction setbacks and regulate construction activities more stringently for areas predicted to be subject to sea level rise, erosion, or flooding. In particular, these regulations should prohibit the construction of seawalls, revetments, and groins to allow wetland and natural sediment migration processes. Priorities should be set focusing first on the velocity zone and faster eroding coasts.

Municipalities are not allowed to create local building codes. These policies and requirements must be set at the state level. The state Board of Building Regulations and Standards has the ability to update the State Building Code requirements for coastal construction to include requirements for freeboard (the vertical distance between a water level and the top of something that contains or restrains it), and other measures. Such a requirement was implemented in 2008 for properties in the V-Zone (2 feet is now required). Freeboard could also be required for the first floor of properties in the A-Zone. The state also implemented a program to enable local flex code standards. The board should also encourage collaboration between building inspectors and conservation commissions.

Municipalities should prepare and distribute outreach materials encouraging the voluntary adoption of freeboard for new and major reconstruction. Property owners may incorporate freeboard if they recognize the savings in insurance costs. All municipalities should adopt and keep up-to-date their hazard mitigation plan, and participate in the Community Rating System. The CRS not only benefits communities by focusing their planning efforts, and minimizing public storm-related expenses, but also can result in low insurance premiums for residents. CZM, in cooperation with U.S. Army Corps of Engineers, should help implement a program of regional sand management through adoption of state policies, regulations, and activities that promote beach nourishment as the preferred alternative for coastal hazard protection and require beneficial uses of dredged materials, with limited waiver ability from the requirement. Municipalities should consider beneficial uses of dredge materials, even beyond their political boundaries.

CZM and DEP should develop a guidance document or revise the Wetland Protection Act regulations to incorporate best management practices or performance standards for land subject to coastal storm flowage (LSCSF). The state's WPA regulations have long lacked clear performance standards for LSCSF.

CZM should conduct a regional sand management study that identifies (1) critically eroding public beaches where access is open to the public, (2) areas most vulnerable to coastal hazards, and (3) potential regional beach nourishment methodology and costs. CZM will need to update and finalize the existing draft document entitled Assessing Potential Environmental Impacts of Offshore Sand and Gravel Mining for the Purposes of Beach Nourishment to include contemporary state of knowledge regarding the potential short- and long-term physical and biological impacts associated with offshore sediment removal.

There are both confusion and confounding technical issues surrounding the real world elevations of the mean high water mark and the high tide line (the latter defined by the annual high tide or "king tide")[218]. Often these elevations are not correctly identified in engineering plans submitted to state and local permitting agencies. These issues can be partly resolved through the presentation of data, maps, and information disseminated on the Buzzards Bay NEP website.

Financial Approaches

Many of the expenses associated with this action plan relate to conducting risk assessments and planning. These efforts might cost hundreds of thousands of dollars per community and require dedication of staff time. The actual costs for changing, implementing, and conforming to any regulations are probably negligible. Specific projects like the CZM Coastal Hazards Characterization Atlas for Buzzards Bay might cost $10,000 or more to produce. The costs of updating CZM and Mass GIS portals would be minimal because both systems are already well established and the agencies can use existing website management staff.

Potential funding sources for planning and assessment include NOAA Coastal Zone Enhancement (Section 309) Grants, and various FEMA grant programs.

Monitoring Progress

Because of the rarity of catastrophic storms, many of the benefits of this action plan might not be assessed for decades. Therefore to evaluate this action plan, programmatic actions must be tracked. Such tracking might include town completion of hazard mitigation plans, adoption of new laws or regulations, participation in FEMA's CRS program, and acquisition of sensitive properties.

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[218] Under Massachusetts Wetland Protection Act regulations, the elevation of the mean high water (MHW) mark is based on the average predicted MHW during the currently adopted National Tidal Datum Epoch (1983-2001). Under federal law, the high tide line (HTL, or highest tide of the year), does not have a specific reference time period defined. This ambiguity has prompted some (like the state of Connecticut Department of Transportation, see Doody 2009) to call for a definition based on predicted highest annual tides during a tidal epoch.

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MA 2007 Coastal Hazard Plan Recommendations (MEMA, 2007)

The following recommendations were included in the 2007 Coastal Hazard Plan for Massachusetts. They are being reviewed for consistency with this action plan and possibly incorporated by reference into this action plan.

Recommendation #3 Develop an RVAM for each coastal community using a standardized GIS methodology.

Lead Agency: Massachusetts Emergency Management Agency (MEMA), DCR, regional planning agencies, and municipalities
Funding Requirement: yes
Potential Funding Source: FEMA Hazard Mitigation Grant, state funds, and municipal funds
Next Steps: form task force of stakeholders to develop the standardized GIS methodology
Project Duration: 5 years

Recommendation #4: Map and model climate change and sea level rise data related to coastal hazards in Massachusetts.

Lead Agency: USGS
Funding Requirement: yes
Potential Funding Source: federal funds and state funds
Next Steps: acquire funds, assess status of current data, and develop plan to collect new data
Project Duration: 5 years

Recommendation #5: Develop a process to capture coastal conditions immediately after major storm events.

Lead Agency: CZM and MEMA
Funding Requirement: no
Next Steps: form task force to identify opportunities, make arrangements with appropriate agencies, and train the Storm Team
Project Duration: 6 months

Recommendation #6: Model potential storm damage based on historical event data to educate decision makers and the public to the magnitude of risk in the coastal zone.

Lead Agency: MEMA, DCR, and CZM for wind modeling; FEMA, USACE, and NOAA for inundation modeling
Funding Requirement: yes
Potential Funding Source: federal funds and state funds
Next Steps: acquire funds and run scenarios using appropriate models
Project Duration: 2-4 years

Recommendation #8: Evaluate the distribution of coastal hazards and emergency management information to coastal communities before and during major storm events.

Lead Agency: MEMA, CZM, and municipalities
Funding Requirement: yes
Potential Funding Source: state funds
Next Steps: acquire funds and develop survey to be distributed to residents and visitors of high-risk coastal areas
Project Duration: 1 year

Recommendation #9 (Priority): Establish a storm-resilient communities program to provide case studies for effective coastal smart growth planning and implementation.

Lead Agency: Massachusetts Executive Office of Energy and Environmental Affairs (EEA)
Funding Requirement: yes
Potential Funding Source: state funds
Next Steps: acquire funds and define the model storm-resilient community
Project Duration: 2-4 years

Recommendation #10: Finalize guidance document for state and local agencies on the implementation of Executive Orders 149 and 181 relative to publicly funded infrastructure projects, and develop guidance for the remaining sections of Executive Order 149.

Lead Agency: CZM and DEP
Funding Requirement: no
Next Steps: update and finalize draft guidance document
Project Duration: 1 year

Recommendation #18: Develop informal local coordination processes or modify bylaws to provide for the coordination of permitting and approval by local departments.

Lead Agency: chief elected municipal officials
Funding Requirement: no
Next Steps: assemble municipal agents to discuss opportunities for coordination
Project Duration: 6-12 months

Recommendation #21: Identify existing culverts and tide gates associated with transportation crossings of coastal wetlands that are priorities for replacement due to flood hazards or environmental resource concerns, and address flooding, wetlands hydrology, and maintenance in the early stages of the design and implementation of new or replacement transportation projects that cross coastal wetlands and waterways.

Lead Agency: Massachusetts Executive Office of Transportation (EOT), CZM, DEP, and USACE
Funding Requirement: yes
Potential Funding Source: state funds
Next Steps: form working group to develop strategy
Project Duration: 1 year

Recommendation #25 Identify and map potential offshore and inland sources of suitable nourishment sediment.

Lead Agency: USGS
Funding Requirement: yes
Potential Funding Source: federal funds
Next Steps: map existing data
Project Duration: 5 years

Recommendation #27: Establish a Technical Advisory Committee, consisting of a broad range of qualified professionals, to evaluate and develop construction and monitoring guidance, and recommend appropriate approval conditions for those protection approaches determined to be new and innovative.

Lead Agency: EEA
Funding Requirement: no
Next Steps: identify members and hold first planning meeting
Project Duration: ongoing

Recommendation #28: Build upon an ongoing study by WHOI Sea Grant and the Cape Cod Cooperative Extension to quantify the inherent values of Cape Cod coastal beaches for storm damage protection, recreation, and wildlife habitat to develop similar values for all Massachusetts beaches.

Lead Agency: Woods Hole Oceanographic Institution (WHOI) Sea Grant and Cape Cod Cooperative Extension
Funding Requirement: yes
Potential Funding Source: WHOI funds and Cape Cod and Islands License Plate Campaign funds
Next Steps: acquire funds and release request for response
Project Duration: 1-2 years

Recommendation #29: Develop a standardized benefit-cost analysis model using an approach adapted from that used by the USACE to justify projects that fully compares the capital, societal, and natural resource benefits and costs of proposed shoreline protection projects and appropriate alternatives.

Lead Agency: EEA and academic or research institute
Funding Requirement: yes
Potential Funding Source: private grants
Next Steps: identify lead researcher and acquire funding
Project Duration: 2 years