COMPARING POLICIES FOR ENCOURAGING RETREAT FROM THE MASSACHUSETTS COAST

Michael Graikoski and Porter Hoagland[1]

I. INTRODUCTION

Along the U.S. Atlantic coast, the lands and infrastructure located on barrier islands and beaches and in backbay estuarine environments face mounting threats from king tides, storm surges, and sea-level rise.[2] From the late 19th century to the present, sea-level rise on the United States' Atlantic coast has been more rapid than any other century-scale increase over the last 2,000 years.[3] Even slight increases in sea-level rise now have been hypothesized to significantly increase the risks of coastal flooding in many places.[4]

In New England, some of the most severe northeast storms ("nor'easters") have become notorious for consequent extreme losses of coastal properties. Some of the better known examples are the Blizzard of '78 (February 1978), the Halloween

[1] Michael Graikoski (B.S. 2015, Marine Affairs, University of Rhode Island), Guest Student, Marine Policy Center, Woods Hole Oceanographic Institution & Porter Hoagland (Ph.D. 1999, Marine Policy, University of Delaware), Senior Research Specialist, Marine Policy Center, Woods Hole Oceanographic Institution. This article was prepared under award number NA10OAR4170083 (WHOI Sea Grant Omnibus) from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (Northeast Regional Sea Grant Consortium project 2014-R/P-NERR-14-1-REG); award number AGS-1518503 from the U.S. National Science Foundation (Dynamics of Coupled Natural and Human Systems [CNH]); award number OCE-1333826 from the U.S. National Science Foundation (Science and Engineering for Sustainability [SEES]) to the Virginia Institute of Marine Science; and with support from the J. Seward Johnson Fund in Support of the Marine Policy Center. The authors thank Chris Hein, John Duff, Di Jin, Peter Rosen, Andy Fallon, Billy Phalen, and Sarah Ertle for helpful insights and suggestions and Jun Qiu for help with the map of Plum Island in Figure 1.

[2] James E. Neumann, Kerry Emanuel, Sai Ravela, Lindsay Ludwig, Paul Kirshen, Kirk Bosma & Jeremy Martinich, *Joint Effects of Storm Surge and Sea-level Rise on US Coasts: New Economic Estimates of Impacts, Adaptation, and Benefits of Mitigation Policy*, 129 CLIMATE CHANGE 337 (2015) (presenting a simulation framework, conflating three models of tropical cyclones, storm surges, and economic impacts and adaptation, used to estimate the effects of storm surge and sea-level rise on the U.S. Atlantic coast through 2100; finding a capitalized estimate of impacts of nearly $1 trillion, net of adaptation).

[3] Andrew C. Kemp, Benjamin P. Horton, Jeffrey P. Donnelly, Michael E. Mann, Martin Vermeer & Stefan Rahmstorf, *Climate Related Sea-level Variations Over the Past Two Millennia*, 108 PROC. NAT. ACAD. SCI. 11017 (2011).

[4] David L. Kriebel, Joseph D. Geiman, & Gina R. Henderson, *Future Flood Frequency Under Sea-Level Rise Scenarios*, 31 J. COASTAL RES. 1078 (2015).

Eve Storm of October 1991 (also known as the Perfect Storm), and Winter Storm Juno (January 2015).[5] In coastal Massachusetts, 150 of the 389 "severe repetitive [flooding] loss" properties, which are properties that have had four or more flood loss claims on a policy issued by the U.S. National Flood Insurance Program—are located on the shorefront of Scituate, a town on the state's east-facing South Shore. One Scituate property may have filed claims at least 14 times.[6]

The built environment of coastal communities in Massachusetts comprises residential, business, and government properties, such as homes and other buildings. It also includes public and utility infrastructures, such as roads, electric utilities, water mains, natural gas lines, and sewage systems. This physical capital has become increasingly vulnerable to flooding and erosion due to storm events and possible inundation from sea-level rise.[7] Some of the Commonwealth's most exposed communities are situated on coastal barriers located along its east-facing shores, including Plum Island (Newbury), Nantasket (Hull), Humarock (Scituate), Brant Rock (Marshfield), North Duxbury Beach (Duxbury), and Town Neck Beach (Sandwich).[8] This heightened vulnerability has compelled property owners and municipal officials alike to argue for building either "soft" or "hard" coastal protections (beach replenishments or engineered structures such as seawalls, respectively)[9] as well as adopting strategies for the potential removal of the built environment away from the coast, known as retreat.[10]

---

[5] *See, e.g.*, Duncan M. FitzGerald, Sytze van Heteren & Todd M. Montellot, *Shoreline Processes and Damage Resulting from the Halloween Eve Storm of 1991 Along the North and South Shores of Massachusetts Bay, U.S.A.*, 10 J. COAST. RES. 113 (1994) (finding that, during a strong, prolonged northeast storm, sandy beaches protected by seawalls or revetments experienced greater (erosive) changes than beaches with wide berms or adjacent dunes).

[6] Beth Daley & Shan Wang, *As Storm Flood Damage Swells, a Growing, Controversial Call to Buy Out Homeowners*, NEW ENGLAND CENTER FOR INVESTIGATIVE REPORTING & WGBH (Feb. 8, 2015), http://news.wgbh.org/post/storm-flood-damage-swells-growing-controversial-call-buy-out-homeowners [hereinafter *Call to Buy Out*].

[7] CLIMATE CENTRAL, FACTS AND FINDINGS: SEA LEVEL RISE AND STORM SURGE THREATS FOR MASSACHUSETTS (2012); MASSACHUSETTS COASTAL HAZARDS COMMISSION (MCHC), PREPARING FOR THE STORM: RECOMMENDATIONS FOR MANAGEMENT OF RISK FROM COASTAL HAZARDS IN MASSACHUSETTS (2007), http://www.mass.gov/eea/docs/czm/stormsmart/chc-final-report-2007.pdf [hereinafter PREPARING FOR THE STORM].

[8] MASSACHUSETTS COASTAL EROSION COMMISSION (MCEC), REPORT OF THE COASTAL EROSION COMMISSION (2015), http://www.mass.gov/eea/docs/czm/erosion-commission/cec-final-report-dec2015-complete.pdf [hereinafter MCEC].

[9] PREPARING FOR THE STORM, *supra* note 7.

[10] *See* JAMES E. TITUS, U.S. ENVTL. PROT. AGENCY, ROLLING EASEMENTS (2011), http://papers.risingsea.net/rolling-easements.html [hereinafter ROLLING EASEMENTS]; James E. Titus, *Rising Seas, Coastal Erosion, and the Takings Clause: How to Save Wetlands and Beaches Without Hurting Property Owners*, 57 MD. L. REV. 1279 (1998) [hereinafter *Rising Seas*]; JESSICA

Historically, public policies directed at the problem of coastal erosion in Massachusetts focused on options for modernizing or expanding coastal engineering structures, such as seawalls, revetments, or bulkheads to protect the built environment. The Commonwealth's Wetlands Protection Act (WPA) of 1972 included provisions that were designed to mitigate the unwanted consequences of coastal engineering structures.[11] The grandfathering of some coastal properties (some of which qualify due to their location on "coastal banks") and the continued tolerance of the emplacement of hard structures has resulted in uneven progress, however. Given the widespread use of seawalls and other hard protections prior to the WPA, some recent policies continue to support strategies aimed at maintaining hard protections. For example, the legislative provisions of the 2014 Massachusetts Environmental Bond, include funding for seawall repair.[12]

Hard structural protections can be a costly means of responding to coastal hazards, however. In many situations, seawalls or other coastal engineering structures may offer only short-term solutions to the protection from coastal hazards.[13] Further, when these types of protections are overwhelmed—and catastrophic damage occurs—the costs to federal and state governments resulting from emergency responses and disaster assistance can be significant.[14]

GRANNIS, GEORGETOWN CLIMATE CTR., ADAPTATION TOOLKIT: SEA LEVEL RISE AND COASTAL LAND USE (2011) [hereinafter ADAPTATION TOOLKIT]; Jessica Grannis, *Coastal Management in the Face of Rising Seas: Legal Strategies for Connecticut*, 5 SEA GRANT L. & POL'Y J. 1 (2012).

[11] See the discussion *infra* at notes 37-65.

[12] 2014 Mass. Acts 1, AN ACT PROVIDING FOR THE PRESERVATION AND IMPROVEMENT OF LAND, PARKS AND CLEAN ENERGY IN THE COMMONWEALTH, ch. 286, https://malegislature.gov/Laws/SessionLaws/Acts/2014/Chapter286 [hereinafter ENVIRONMENTAL BOND]. In the Governor's Executive Office of Energy and Environmental Affairs, a program for Dam or Seawall Repair or Removal has been established. EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS, DAM AND SEAWALL REPAIR OR REMOVAL PROGRAM: ANNUAL REVIEW FISCAL YEAR 2015 (2015), *available at* http://www.mass.gov/eea/docs/eea/wrc/2015-annual-review.pdf.

[13] See MCEC, *supra* note 4 for some preliminary estimates of the values of capital infrastructure at risk to coastal erosion in Massachusetts. *See also* Fitzgerald et al., *supra* note 5.

[14] Six of the ten most costly natural disasters in U.S. history have involved coastal storms. NAT'L CENTERS FOR ENVTL. INFO. (NCEI), NAT'L. OCEANIC & ATMOSPHERIC ADMINISTRATION, BILLION-DOLLAR WEATHER AND CLIMATE DISASTERS: TABLE OF EVENTS (2017), https://www.ncdc.noaa.gov/billions/events. As an example, in April 2013, a major disaster was declared for the Massachusetts Severe Winter Storm, Snowstorm, and Flooding (DR-4110) in early February of 2013, resulting in nearly $53 million in public assistance grants for communities to respond to and recover from the storm.

Over the long term, property owners, government agencies at all levels, and the public may need to consider the potential effectiveness of other policies, such as those that encourage retreat.[15] In particular, policies that provide financial incentives for coastal property owners to retreat arguably might be more effective from society's standpoint than regulatory approaches that allow property owners to remain.[16] Comparisons across policy alternatives, market-based or other, could help facilitate the identification and selection of the most effective policies.[17]

Rolling easements are one type of policy that could be employed to influence human responses to shoreline change.[18] A rolling easement moves with the shoreline, either landward, as a consequence of the erosion of land, or seaward, as a consequence of the accretion of land. Typically, a rolling easement requires that shorefront property owners cannot build "hard" protective structures, such as a seawall. Other buildings or infrastructure, including public utilities, must be located landward of a rolling design boundary.

When erosion is the dominant hazard, however, under a rolling easement the owner's property rights may become increasingly compressed.[19] Some properties may even be squeezed out of existence. Consequently, under such a policy, the shorefront property owner who benefits from the waterfront amenities also bears the risks of erosion, entailing damage to or loss of their property. Under unusual circumstances, as discussed below in the case of Plum Island, Massachusetts, the incentives can be large enough to cause property owners and municipalities to

---

[15] Carolyn Karp, *When Retreat is the Better Part of Valor: Analysis of Strategies to Incentivize Retreat from the Shore*, PROC. SHIFTING SEAS SYMPOSIUM (2012); Kenneth J. Bagstad, Kevin Stapleton, & John R. D'Agostino, *Taxes, Subsidies, and Insurance as Drivers of United States Coastal Development*, 63 ECOLOGICAL ECON. 285 (2007) (identification, characterization, and qualitative analysis arguing for the reform of tax, subsidy, and insurance programs affecting coastal development and disaster relief).

[16] The Commonwealth's Environmental Bond does provide for up to $20 million for "buy-outs" of coastal properties from willing sellers (ENVIRONMENTAL BOND, *supra* note 12, at §2B, subsidiary 2000-7060). This amount is regarded by observers as unreservedly inadequate. *Call to Buy Out*, *supra* note 6.

[17] Robert J. Johnston, Mahesh Ramachandran & George R. Parsons, *Benefit Transfer Combining Revealed and Stated Preference Data: Nourishment and Retreat Options for Delaware Bay Beaches*, *in* R.J. Johnston, J. Rolfe, R. Rosenberger, & R. Brouwer (eds.), BENEFIT TRANSFER OF ENVIRONMENTAL AND RESOURCE VALUES: A GUIDE FOR RESEARCHERS AND PRACTITIONERS (2015) (comparing the net costs of alternative responses to shoreline erosion including beach replenishment, planned (strategic) retreat, idiosyncratic (basic) retreat, and doing nothing).

[18] ROLLING EASEMENTS, *supra* note 10.

[19] *Rising Seas*, *supra* note 10.

flout regulatory constraints on the construction of protective hard structures.[20]

Market-based policies could be more palatable for shorefront property owners because they shift onto others some or all of the risks of property losses due to erosion. Such policies might gain political traction, especially if they encourage or facilitate retreat from the coast, thereby potentially reducing the costs of public emergency or disaster responses.

One market-based complement to a rolling easement encompasses conservation easements,[21] where governments, non-governmental organizations, or local community groups could purchase any extant rights from a private landowner to construct hard or soft structural protection.[22] These rights then would remain unexercised.

Two other market-based policies are a buyout, through which a property could be purchased from its owner, or a buyout-leaseback, involving a property purchase and subsequent rental of the property back to its original owner or to another tenant.[23] The latter may have the potential for mitigating some of the fiscal costs of a government program to encourage eventual retreat from the coast.

In this paper, we identify erosion hotspots in coastal Massachusetts that may be leading candidates for policies to encourage retreat. Transferring the results of hedonic pricing approaches,[24] which can be used to estimate the marginal implicit prices of housing attributes that affect the risks of shoreline changes, we develop rough estimates of the fiscal costs to government for implementing these policies.

The budgetary (fiscal) costs of implementing alternative policy approaches are highly relevant to decision-making about protection or retreat, particularly for cash-strapped municipalities and state agencies. A characterization of the scale

[20] See the discussion *infra* at notes 83-93.
[21] *See* Grannis, ADAPTATION TOOLKIT, *supra* note 10, at 50; ROLLING EASEMENTS, *supra* note 10, at 49; and the discussion *infra* at note 70. In Massachusetts, conservation easements are known as conservation restrictions. MASSACHUSETTS DIVISION OF CONSERVATION SERVICES (DCS), MASSACHUSETTS CONSERVATION RESTRICTIONS HANDBOOK (2008).
[22] Other forms of compensation for such transfers might involve various forms of tax relief.
[23] See the discussion *infra* at notes 71-82.
[24] *See, e.g*., Warren Kreisel, Craig Landry & Andrew Keeler, *Coastal Erosion Hazards: The University of Georgia's Results in* THE HEINZ CENTER FOR SCIENCE, ECONOMICS, AND THE ENVIRONMENT (THC), EVALUATION OF EROSION HAZARDS (2000); Di Jin, Porter Hoagland, Donna Au, & Jun Qiu, *Shoreline Change, Seawalls, and Coastal Property Values*. 114 OCEAN & COASTAL MGMT. 185 (2015).

and incidence of potential costs could help to elucidate the incentives and distributional consequences faced by both property owners and governments. We argue that the potential scale of these costs and their likely patterns of incidence across property owners and over different levels of government could render certain policies that encourage retreat from the coast problematic to implement.

In Section II, we review the heterogeneous distribution of shoreline changes and hazards, focusing on Massachusetts as a relevant example. The ways in which the WPA restricts the construction of coastal engineering structures as a protection against erosion are characterized in detail in Section III. Four possible policy approaches to encourage retreat from the coast, including the status quo, are discussed in Section IV.

As a relevant example, we investigate the case of the Plum Island barrier, which comprises a coastal dune resource in the municipality of Newbury, Massachusetts. Plum Island is the location of one of the Commonwealth's 22 recognized coastal erosion hotspots. In Section V, we make estimates of the scales of the fiscal costs of implementing each of the four policy approaches for Plum Island, and we identify some potential sources for funding the alternative approaches. Finally, we conclude in Section VI with a discussion of the incentives, distributional effects, and reasons why market-based policies may not be implemented.

We argue that it is becoming increasingly important to examine alternative policies to encourage the retreat of property owners from a dynamic and ever more hazardous coastline in Massachusetts. Coastal communities are likely to focus on the fiscal costs—and not necessarily the net economic welfare changes—involving a set of feasible policy alternatives that encourage retreat. For the case we examine, estimates of the scales of fiscal costs and their distributions across shorefront property owners and levels of government suggest that market-based approaches to adapt to shoreline change seem unlikely to be implemented soon. As a consequence, retreat from the coast may not be encouraged, thereby mitigating adaptation to shoreline change and increasing the risks of continued human habitation along the coast.

II. THE NATURE OF SHORELINE HAZARDS

The vulnerability of coastal shorefront property and infrastructure has been the focus of numerous recent studies. A general perception exists that the built environment along the U.S. Atlantic coast has become increasingly

vulnerable to coastal hazards, as a consequence of sea-level rise[25], higher high tides[26], storm surges[27], damages from waves[28], and high winds.[29] This perception, abetted by observations of damages from superstorms like Hurricane Sandy in October 2012, suggests that the situation is ubiquitously dire. Recent work suggests, however, that the extent to which coastal communities are vulnerable may depend chiefly upon idiosyncratic factors, such as the local topography or the presence of both soft and hard structural protections.[30]

Risk mapping undertaken by the U.S. Geological Survey paints a complex picture of the risks of shoreline change in Massachusetts, using historical data on the geographic position of shorelines.[31] Nearly one-third of the coastal towns in Massachusetts have experienced net accretion (a gain of material to beaches and an increase in their width) during the last 30 years.[32] The short-term shoreline change data include high levels of uncertainty due to the influence of storms, however, so they may not be fully reflective of a longer-term trend.[33] On the other hand, the long-term shoreline change data may not fully encompass recent nonlinear increases in the rate of sea-level rise induced by climate change and the growing shoreline losses that are likely to result.

---

[25] Neumann et al., *supra* note 2.
[26] Erika Spanger-Siegfried, Melanie Fitzpatrick & Kristina Dahl, ENCROACHING TIDES: HOW SEA-LEVEL RISE AND TIDAL FLOODING THREATEN US EAST AND GULF COAST COMMUNITIES OVER THE NEXT 30 YEARS (2014); Stephanie Kruel, *The Impacts of Sea-level Rise on Tidal Flooding in Massachusetts*, 32 J. COASTAL RES. 1302 (2016).
[27] *See* PREPARING FOR THE STORM, *supra* note 7.
[28] Robert Dolan & Robert E. Davis, *An Intensity Scale for Atlantic Coast Northeast Storms*, 8 J. COASTAL RES. 840 (1992).
[29] Quanwang Lia, Cao Wanga & Hao Zhang, *A Probabilistic Framework for Hurricane Damage Assessment Considering Non-stationarity and Correlation in Hurricane Actions*, 59 STRUCTURAL SAFETY 108 (2016); Daniel R. Petrolia, Joonghyun Hwang, Craig E. Landry & Keith H. Coble, *Wind Insurance and Mitigation in the Coastal Zone*, 91 LAND ECON. 272 (2015); Stephen Farber, *The Value of Coastal Wetlands for Protection of Property against Hurricane Wind Damage*, 14 J. ENVTL. ECON. & MGMT. 143 (1987).
[30] Erika E. Lentz, E. Robert Thieler, Nathaniel G. Plant, Sawyer R. Stippa, Radley M. Horton & Dean B. Gesch, *Evaluation of Dynamic Coastal Response to Sea-level Rise Modifies Inundation Likelihood*, 6 NATURE CLIMATE CHANGE 696 (2016) (using information about coastal elevations, vertical land movements, and land covers, the authors specify probabilistic shoreline response models for the Atlantic coastline, finding that 70% of the coast is able to respond dynamically to sea-level rise, and suggesting that static inundation models over-predict the submergence of coastal lands).
[31] E. Robert Thieler, Theresa L. Smith, Julia M. Knisel & Daniel W. Sampson, MASSACHUSETTS SHORELINE CHANGE MAPPING AND ANALYSIS PROJECT, 2013 UPDATE (USGS OFR 2012–1189) (2013).
[32] MCEC, *supra* note 8, at 3-3 to 3-5.
[33] Thieler et al., *supra* note 31.

Shoreline change within a community is nonuniform, and there are several locations known to be erosion hot spots where erosion occurs more rapidly than elsewhere. There are at least 22 such hotspots that have been recognized in coastal Massachusetts, many of which are located in towns that otherwise have revealed only slow erosion or slow accretion over time.[34]

The work on historical rates of shoreline change undertaken by the U.S. Geological Survey is vital because it highlights a range of coastal vulnerabilities across Massachusetts towns. These vulnerabilities are influenced by the position at any location of the built environment, especially private residences and public infrastructures, and the presence and conditions of protective structures or practices, such as seawalls, revetments, groins, jetties, gabions, coir bags, restored dunes, beach replenishments, and beach scraping.[35] An extensive literature exists on the advantages and drawbacks of these human responses to shoreline change.[36]

The fact that vulnerabilities vary along the coastline implies that locational priorities could be established for implementing approaches to reduce the risks of shoreline change. For example, a policy to compensate coastal property owners (e.g., to acquire their properties or "buy them out") in order to carry out a retreat from the coast could begin at a small scale, focusing on those shorefront properties located at the most vulnerable locations (possibly at the hotspots where erosion rates are highest). As experience accumulates and learning takes place, a successful buy-out program could be expanded, possibly rendering it more effective and thereby mitigating coastal shorefront vulnerabilities over time.

III. LIMITS ON THE POTENTIAL FOR COASTAL PROTECTION

In Massachusetts, private ownership of shorefront property typically extends down to the mean low water mark.[37] On the intertidal lands and seaward

[34] MCEC, *supra* note 8, at 3-5.
[35] James T. Carley, Thomas D. Shand, Ian R. Coghlan, Matthew .J. Blacka, Ronald J. Cox, Adam Littman, Ben Fitzgibbon, Grant McLean & Phil Watson, BEACH SCRAPING AS A COASTAL MANAGEMENT OPTION (2010), http://coastalconference.com/2010/papers2010/James%20Carley%20full%20paper.pdf.
[36] The full range of coastal engineering structures and their levels of effectiveness are introduced, described, and analyzed in J. WILLIAM KAMPHUIS, INTRODUCTION TO COASTAL ENGINEERING AND MANAGEMENT (2nd ed. 2010).
[37] Boston Waterfront Development Corporation v. Commonwealth of Massachusetts, 378 MASS. 629 (1979). *See also* Jack Potash, *The Public Trust Doctrine and Beach Access: Comparing New Jersey to Nearby States*, L. SCH. STUDENT SCHOLARSHIP 738 (2016), http://scholarship.shu.edu/student_scholarship/738

of the mean low water mark, public trust rights exist, including the public's interest in navigation, fishing, fowling, and potentially other public interests.[38] As the shoreline shifts, due to erosion or accretion, the boundary between private and public interests also may shift—or at least become less certain. In Massachusetts, eight public interests that may be impacted by a fluctuating boundary have been articulated explicitly in the language of the WPA. They include public or private water supply; groundwater supply; flood control; storm damage prevention; prevention of pollution; protection of land containing shellfish; and protection of fisheries and wildlife habitat.[39]

A primary objective of the WPA has been to ensure that the actions of private owners to protect their shorefront properties from the hazards of flooding and erosion, such as through the construction of coastal engineering structures, be carried out only if they do not adversely impact these eight public interests.[40] With respect to the public's specific interests in both flood control and storm damage prevention, a leading concern is that the source of supply to the coast of sediments, sand, or other materials from coastal beaches, dunes, and banks remain unhindered.[41] In fact, coastal engineering structures are designed specifically to alter sediment transport processes.[42] Coastal dunes on barrier beaches, the primary frontal dunes along other shorelines, and coastal banks all have been designated in regulations implementing the WPA as *per se* significant to the interests of flood control and storm damage prevention because of their capabilities for supplying sediments, sand, or other materials and their heights relative to storm waves and surges.[43]

Beginning in the late 19th century, but especially during a period of rapid coastal barrier and shorefront development in the mid-twentieth century, many

---

[38] Joseph L. Sax, *The Public Trust Doctrine in Natural Resource Law: Effective Judicial Intervention*, 68 MICH. L. REV. 471 (1970).
[39] MASS. GEN. LAWS. ch. 131, § 40 (1972).
[40] MASS. OFFICE OF COASTAL ZONE MGMT. (MCZM), POLICY GUIDE 15 (October 2011).
[41] *Id*. at 19-24. Massachusetts Coastal Hazard Policy No. 1 holds that it is enforceable state policy to "[p]reserve, protect, restore, and enhance the beneficial functions of storm damage prevention and flood control provided by natural coastal landforms, such as dunes, beaches, barrier beaches, coastal banks, land subject to coastal storm flowage, salt marshes, and land under the ocean." *Id.* at 19.
[42] 310 MASS. CODE REGS §10.28(1) (2014). 310 MASS. CODE REGS §10.23 defines the term "coastal engineering structure" as meaning, but not limited to, "any breakwater, bulkhead, groin, jetty, revetment, seawall, weir, riprap or any other structure that is *designed to alter wave, tidal or sediment transport processes* in order to protect inland or upland structures from the effects of such processes" (emphasis added).
[43] *Id*. §10.28(1), §10.30(1).

significant stretches of the Massachusetts coastline had been armored with coastal engineering structures, including seawalls, revetments, and other hard structures, in order to protect residences or other buildings from flooding during storms and loss of land due to erosion.[44] This infrastructure has been mapped and inspected recently by the Commonwealth, revealing a range of physical conditions—and therefore a range of effectiveness—and a mix of ownership, from private to public to unknown.[45] Much of this infrastructure now is recognized by the Commonwealth to be badly in need of upgrades or replacement.[46]

Under provisions of the WPA, rules were modified with respect to the siting of coastal engineering structures.[47] The WPA was enacted in part to "ensure that development along the coastline [was] located, designed, built and maintained in a manner that protects the public interests in the coastal resources."[48] Under the WPA, specific types of "resource areas" were characterized, and precautionary rules were put in place for siting coastal engineering structures in each resource area (Table 1).[49] These rules require that project proponents show clearly that a proposed structure plays no role in adversely affecting public interests in coastal resources, and it requires an authority issuing permission for siting the structure, which except in rare instances is the relevant municipal Conservation Commission, to make a written determination to that effect.[50]

---

[44] MASS. DEP'T OF CONSERVATION AND RECREATION (DCR), OFFICE OF WATERWAYS, MASSACHUSETTS COASTAL INFRASTRUCTURE INVENTORY AND ASSESSMENT PROJECT (2009) at 4.
[45] MASS. OFFICE OF COASTAL ZONE MGMT. (MCZM), STORMSMART COASTS—INVENTORIES OF SEAWALLS AND OTHER COASTAL STRUCTURES (2016), http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/seawall-inventory/. *See also*, Jeremy Fontenault, Nathan Vinhateiro & Kelly Knee, MAPPING AND ANALYSIS OF PRIVATELY-OWNED COASTAL STRUCTURES ALONG THE MASSACHUSETTS SHORELINE (2013), http://www.mass.gov/eea/docs/czm/stormsmart/seawalls/private-coastal-structures-2013.pdf .
[46] DCR, *supra* note 44.
[47] The WPA was drafted on a foundation of earlier Massachusetts legislation and local zoning efforts to mitigate the adverse effects of constructing coastal engineering structures on wetlands. *See* Alexandra D. Dawson, *Massachusetts Wetlands and Floodplains Revisited*, 4 W. NEW ENG. L. REV. 623 (1982).
[48] 310 MASS. CODE REGS. §10.21 (2014).
[49] *Id.* §10.25-§10.35.
[50] *Id.* §10.02-§10.03.

Table 1: Massachusetts Wetlands Protection Act (WPA) Provisions Regarding the Siting of Coastal Engineering Structures within some of the Relevant Resource Areas

RESOURCE AREA	COASTAL ENGINEERING STRUCTURES	CITATION
Land under the Ocean	Allowed in Designated Port Areas if adverse effects on coastal banks or coastal engineering structures in adjacent resource areas are minimized	310 MASS. CODE REGS §10.26(4)
Tidal Flat	Allowed if clear showing of no role[a]	310 MASS. CODE REGS §10.27(3)
Coastal Beach	Allowed if clear showing of no role[b]	310 MASS. CODE REGS §10.27(3)
Barrier Beach	Allowed if clear showing of no role[b,d]; follows rules for coastal beaches and coastal dunes	310 MASS. CODE REGS §10.28(3)
Rocky Intertidal	Allowed if clear showing of no role[c]	310 MASS. CODE REGS §10.31(1)
Coastal Dune	Not allowed	310 MASS. CODE REGS §10.28(4)
Coastal Bank	Allowed for "grandfathered" properties[d]	310 MASS. CODE REGS §10.30(3)

[a] Does not play a role adversely affecting the protection of marine fisheries or land containing shellfish.
[b] Does not play a role adversely affecting storm damage prevention, flood control, or protection of wildlife habitat.
[c] Does not play a role adversely affecting storm damage prevention, flood control, protection of marine fisheries or wildlife habitat, and, where there are shellfish, the protection of land containing shellfish.
[d] A coastal engineering structure shall be permitted when required to prevent storm damage to buildings constructed prior to August 10, 1978.

The built environment on coastal barriers and other exposed landforms, especially buildings that constitute shorefront residences, occurs in WPA resource areas known as barrier beaches, coastal dunes, or coastal banks.[51] As seen in Table 1, except for coastal banks, the presence of these resource areas in any specific case involving prospective development entails significant restrictions on the extent to which coastal engineering structures can be built or modified.[52]

Here, from a policy-analytic perspective, we interpret these restrictions as encompassing a *de facto* form of rolling easement in Massachusetts, because shorefront property owners may be barred by regulation from protecting their buildings and lands with hard structures from the shoreline changes caused by storms or sea-level rise.[53] As shoreline erosion takes place, shorefront properties may become increasingly compressed between an advancing shoreline and the next row of properties located immediately behind the shorefront.[54] Should buildings be damaged as a consequence of flooding or erosion, property owners desiring to rebuild may be required under the provisions of the Commonwealth's building code or local bylaws to elevate their buildings on pilings or to set the buildings back further away from the shorefront.[55] Eventually, a building may be damaged or lost due to the inundation caused by a storm or higher high tides, or both the building and the land may be lost to erosion during a storm.[56]

Properties located on coastal banks face similar restrictions, except for those properties with buildings that were constructed prior to August 1978.[57] For the latter, the construction and maintenance of coastal engineering structures may be permitted in order to prevent storm damage to buildings perceived to be at risk.[58] The coastal bank grandfathering provision potentially creates

---

[51] Resource areas comprise coastal wetlands, defined in the WPA as "…any bank, marsh, swamp, meadow, flat or other lowland subject to tidal action or coastal storm flowage." MASS. GEN. LAWS ch. 131 §40 (2016). The specific resource areas are further defined in the regulations implementing the WPA at 310 MASS. CODE REGS. §10.04 (2016).
[52] 310 MASS. CODE REGS. §10.28(1), §10.29 (2014).
[53] *Cf.* ROLLING EASEMENTS, *supra* note 10.
[54] *Cf. Rising Seas, supra* note 10, at 1316.
[55] Appendix 120.G of the 7th Edition of the Massachusetts State Building Code "establishes special administrative, design and construction requirements for new and existing buildings and structures located in flood-hazard zones (A Zones); high hazard zones (V Zones) or in coastal wetland resource areas containing coastal dunes that are deemed significant to the public interests of flood control or storm damage prevention." 780 MASS. CODE REGS. App. 120.G (2008).
[56] *Cf. Rising Seas*, *supra* note 10, at 1315-1317.
[57] For any town, the relevant grandfathering date relates to the date of the adoption of town bylaws to implement the WPA. These dates typically occurred well after August 1978.
[58] 310 MASS. CODE REGS. §10.20 (2014).

circumstances where older properties continue to be protected by coastal engineering structures, but more recent downdrift properties or public lands do not—thereby increasing the risks of shoreline change for the latter.[59]

The potential for increased risks depends very obviously upon the dynamics of the geological environment vis-à-vis the location of the human built environment.[60] Notwithstanding the potential for increased risks, WPA rules require that persons applying to construct a coastal engineering structure must determine that there exist no other means of protecting a building and that "…a coastal engineering structure or a modification thereto shall be designed and constructed so as to minimize, using best available measures, adverse effects on adjacent or nearby coastal beaches due to changes in wave action…"[61]

The WPA restrictions on the construction of coastal engineering structures in coastal resource areas have been subject to the threat of litigation by some Massachusetts shorefront property owners concerned with the risks of property losses against which they are unable to protect themselves.[62] One argument that has been put forward is that the WPA restrictions constitute a taking without just compensation in violation of the 5th Amendment of the U.S. Constitution.[63] In the case of the WPA regulations or local zoning decisions restricting the construction of coastal engineering structures, property owners have argued that the restrictions may represent a "passive" taking of private property. They contend that unimpeded encroachment by the ocean, leading to the shoreward movement of public trust lands, is in effect a case of a public taking of private property.[64] While the existence of passive takings remains a theoretical concept,[65] the possibility of litigation over the issue seems very real to both municipal and state government agencies.

---

[59] Porter Hoagland & Lisa Granquist, *Shoreline Change in Urban Massachusetts: Time for Retreat?*, PROC. AAAS ANNUAL MEETING (February 2013), available from the author.
[60] Shoreline change comprises a natural hazard that is jointly determined by humans and nature. *See generally* Clifford S. Russell, *Losses From Natural Hazards*, 46 LAND ECON. 383 (1970).
[61] 310 MASS. CODE REGS. §10.30(3) (2014).
[62] Gabrielle Gurley, *Plum Island at Risk*, COMMONWEALTH (July 7, 2015), http://commonwealthmagazine.org/environment/plum-island-at-risk/.
[63] Todd Gaziano, *Protecting Your Home v. Letting it Crash Into the Sea*, LIBERTY BLOG (Mar. 13, 2015), http://blog.pacificlegal.org/protecting-your-home-v-letting-it-crash-into-the-sea/.
[64] *Id. See also* Christopher Serkin, *Passive Takings: The State's Affirmative Duty to Protect Property*, 113 MICH. L. REV. 345 (2014) (arguing that natural hazards, such as sea-level rise, may compel the government to respond either by protecting property or by compensating property owners for resulting damages).
[65] *Cf.* Robin Kundis Craig, *Public Trust and Public Necessity Defenses to Takings Liability for Sea Level Rise Responses on the Gulf Coast*, 26 J. LAND USE & ENVTL. L.395 (2011) (arguing that, in addition to broad police powers, doctrines of state public trust and public necessity support a type of state regulation of private coastal properties that does not constitute a taking).

IV. POLICY APPROACHES

We compare estimates of the fiscal costs of the status quo and three market-based policies to encourage retreat from the coast. Except for the circumstances of pre-WPA properties located within 100 feet of a coastal bank with permitted coastal engineering structures, we assume that the status quo policy comprises a rolling easement that restricts the emplacement of protective hard structures.[66]

To help substantiate our focus on fiscal costs, we observe that coastal managers regularly make decisions over the choices of policies on the basis of potential impacts to budgets; only rarely are such decisions made on the basis of estimates of changes in economic net benefits. Developing estimates of the latter can be problematic, requiring specific expertise that often can be unavailable at the relevant decision-making levels. In this study, we are not arguing that the costs reflect welfare (economic surplus) losses. Rather, we suggest that these estimates can affect the set of incentives faced by property owners and governments, thereby affecting the ultimate choice of policy.

The potential implementation of alternative policies depends upon the relevant WPA resource area, the physical locations of privately owned shorefront properties and public infrastructures, the presence or absence of historical coastal engineering structures, and the consequent risks of inundation or property loss. For each policy, we characterize the likely distributions of the financial damages of storms or erosion due to shoreline change across stakeholders.

Whether policies of any type should be implemented to help encourage coastal shorefront property owners to retreat from the coast in certain areas is fundamentally a question of the redistribution among private property owners and society of the benefits of property ownership and the costs of damage due to storms or erosion.[67] Arguments could be made that society should step in to encourage retreat, through either regulations or fiscal policies, because of (i) external effects, such as when the shoreline protection of individual properties limits the downdrift supply of sediments, sand, or other materials; (ii) concerns for public health or safety, especially where property owners are in immediate danger during extreme storm events; (iii) the relative costs of bearing the risks of property damages or losses due to erosion; and (iv) the costs of public disaster assistance, embodied in emergency responses and rebuilding efforts.

---

[66] *Cf.* ROLLING EASEMENTS, *supra* note 10.

[67] Often, this issue is framed in terms of the need for government to engage in adaptive planning and management. *See* ADAPTATION TOOLKIT, *supra* note 10, at 8.

We consider the following policies:

a) ***Maintain the status quo***. The *status quo* involves the existing baseline situation in which individual coastal shorefront property owners benefit from their locations along the coast but also bear the risks of shoreline change. Under the status quo, WPA rules regarding the placement of coastal engineering structures are enforced, implying that shorefront property owners would be unable to site hard structures to protect shorefront properties from flooding or erosion due to storm events or longer term sea-level rise. Only owners of pre-WPA properties on coastal banks would be able to construct or maintain hard structures to protect their buildings and land.

Although the risks of property damage or loss are borne by the property owner under the *status quo*, there are situations in which state or federal disaster assistance becomes available to ameliorate some of the costs resulting from severe storms. Thus, even though shorefront property owners bear the costs of the loss of properties due to storm events, there is some likelihood that the federal and state governments also would bear significant costs, including emergency responses, rebuilding or relocation assistance, repair of public infrastructure, including roads and water or sewer lines, or removal and disposal of debris.

In recent memory, the Blizzard of '78 in February 1978 ($200 million) and Hurricane Bob in August 1991 ($250 million) resulted in very significant combined flooding and erosion damage to both private and public properties in coastal Massachusetts.[68] Relying upon historical disaster assistance estimates and including these extreme events, during the 36-year period from 1978 to 2013, statewide average annual damages to private and public properties were on the order of $16 million. Ignoring these extreme events, during the 22-year period from the Perfect Storm in October 1991 though 2013, statewide average annual damages were on the order of $6 million. Based upon these historical damages, which do not include damages resulting from undeclared disasters, a conservative estimate of the capitalized costs to the public of coastal disaster assistance in Massachusetts is on the order of $200-500 million.[69]

b) ***Purchase conservation easements***. The placement of coastal engineering structures in areas where high rates of shoreline change occur likely adds value to a shorefront property. Under WPA rules, shorefront property owners typically may find it difficult to demonstrate that the placement of hard

[68] MCEC, *supra* note 8, at 4-3.

[69] Massachusetts statewide damages of $6 million per year capitalized as a perpetuity using a discount rate of 3% yields an estimate of $200 million. Incorporating disaster assistance for extreme events increases the estimated capitalized damages to more than $500 million.

structures plays no adverse role in affecting downdrift properties. Consequently, these individuals apparently would have no legal basis to protect their properties with hard structures. Nevertheless, some property owners have argued for implementing soft structural alternatives immediately prior to storm arrivals, such as beach scraping, and others have threatened litigation based on inventive legal theories of passive takings in order to permit the siting of hard structures.

One option to preclude beach scraping or the threat of litigation is for a third party, such as a government agency or a non-governmental organization, to recognize an implied legal right to undertake any type of shoreline stabilization project, and to purchase that right through a conservation easement.[70] Once a conservation easement has been consummated, the right to construct or rehabilitate a coastal engineering structure would not be exercised. The purchase of conservation easements for preventing shoreline stabilization may be the most obvious and workable in cases of pre-WPA buildings located on properties situated on coastal banks where hard structures may be allowed.

c) ***Acquire ("buyout") shorefront properties***. An alternative is for a third party, such as the Commonwealth—or even a non-governmental organization to acquire a shorefront property, known as a buyout. The sale of the property by its owners could be voluntary, or the Commonwealth could take the property by eminent domain.[71] Ideally, such a purchase would occur prior to property loss or damage due to shoreline change. Practically, it seems more likely that the purchase of a shorefront property might occur subsequent to significant flooding or erosion damage.[72] After the purchase, the building and any coastal engineering structures could be removed at additional cost.[73] The purchase of shorefront properties has been contemplated by the Commonwealth, which has passed an

[70] *See* ADAPTATION TOOLKIT, *supra* note 10, at 50. *See also* ROLLING EASEMENTS, *supra* note 10, at 49.

[71] The Commonwealth's legislation establishing the buyout program expressly prohibits using buyout funds to take land by eminent domain. ENVIRONMENTAL BOND, *supra* note 12, at §2000-7060 ("…funds from this item shall not be used to compensate land owners for lands taken by eminent domain…"). One possible reason for this prohibition in the legislation is that an exercise of eminent domain over shorefront properties could establish a precedent that the Commonwealth in effect would be recognizing shoreline change as a type of "passive" taking.

[72] This scenario has been suggested for certain shorefront lots on Plum Island, where buildings had been lost to coastal erosion during nor'easters. Christian Wade, *Lots Eyed for State Buyback*, THE DAILY NEWS OF NEWBURYPORT (July 23, 2015), http://www.newburyportnews.com/news/local_news/lots-eyed-for-state-buyback/article_a78b9d00-589c-5636-921f-f0be1f0b54d4.html.

[73] Typical costs of razing and disposal of residential buildings range from $8,000 - $15,000. *See House Demolition Costs*, COST HELPER, http://home.costhelper.com/house-demolition.html.

Environmental Bond authorizing up to $20 million for purchases of high risk shorefront properties. Given the many hotspots and extensive shorefront built environment in Massachusetts, these funds appear to be inadequate.

A Hazard Mitigation Grant Program administered by the Federal Emergency Management Agency (FEMA) includes provisions that allow for the acquisition of coastal properties damaged by floods.[74] In order for the provisions of the FEMA buyout program to be carried out, the state, or regions within the state, must have an approved Hazard Mitigation Plan in place. Where an area has been declared by the President of the United States to be a national disaster, and where the cost of repairing a property is determined to be more than 50% of its value, a willing seller can offer the property to government agencies for sale. Funding for the program is split between FEMA (75%) and state and local sources (25%). Upon its sale, the property cannot be redeveloped and must be used for open space, recreation, or wetlands management.

These provisions of the federal Hazard Mitigation Grant Program capture the intent of a coastal buy-out policy, but they apply only to *flood* losses *ex post*, not to coastal properties that have been or might conceivably be damaged by erosion or high winds.[75] Consequently, a policy to buy-out *ex ante* shorefront properties at risk of erosion remains unsettled.[76]

d) ***Acquire ("buyout") the shorefront property and offer it for rent (or lease it back)***. This approach was suggested more than two decades ago by James Titus at the U.S. Environmental Protection Agency. Under a "buyout-leaseback" policy, a property owner who is a willing seller would be offered a one-time, lump-sum payment for her property at fair market value. If the offer is accepted, then the property would belong to the Commonwealth, but it could be leased back

[74] 42 U.S.C. §5170c (b) (2012).

[75] *See* U.S. GOV'T ACCOUNTABILITY OFF. (GAO), HURRICANE SANDY: AN INVESTMENT STRATEGY COULD HELP THE FEDERAL GOVERNMENT ENHANCE NATIONAL RESILIENCE FOR FUTURE DISASTERS (2015) (finding that most hurricane disaster assistance is available only after a disaster and recommending a program of investments in pre-disaster resilience). There are some very limited federal grant funds available for pre-disaster mitigation, including for the acquisition of properties. FED. INS. AND MITIGATION ADMIN. (FIMA), U.S. DEP'T OF HOMELAND SEC., FY 2016 PRE-DISASTER MITIGATION GRANT PROGRAM FACT SHEET (2016), http://www.fema.gov/media-library/assets/ documents/114667.

[76] *But see* Christine A. Fazio & Ethan I. Strell, *Government Property Acquisition in Floodplains after Hurricane Sandy*, N.Y.L.J. (2013), http://www.newyorklawjournal.com/id=1202590055801 (in the aftermath of Hurricane Sandy, New York Governor Mario Cuomo established a program of incentives, albeit funded with federal hurricane disaster assistance, to encourage homeowners who resided in extremely vulnerable areas to sell their undamaged homes).

to the original property owner—or possibly to another lessee—for a fixed, predetermined period of time. Under a lease agreement, the new lessee would be precluded from redeveloping, maintaining, or altering the property in any manner. A leaseback policy would have the same initial cost as a buyout, but the government could recover some proportion of the purchase cost over time. Such a policy would benefit both the Commonwealth and the lessees; the state would be remunerated in part, and the occupants could continue residing in their formerly owned property and experiencing the benefits of shorefront coastal amenities.[77]

The lease agreement would need to include language pertaining to the terms of the lease and the disposition of the property in the event of significant storm damage. Should a leased property be rendered partially or completely destroyed by a coastal storm or need federal disaster assistance to repair, then the lease should be voided, requiring the lessees to relocate. Because the lease would expire when a property is severely damaged or destroyed, the state would then lose the future stream of rental payments from the property.

A potentially relevant example of a federal buyout-leaseback program concerns the management of inholdings within the boundary of a national park.[78] For example, many of the U.S. National Seashores have implemented programs of life tenancies or life estates, through which private property rights within a park are acquired from their owners and then leased back for the duration of the owners' lives.[79] Another possibility is the acquisition and leasing back of other retained rights for varying terms, also known as tenancies in years.[80] In some instances, the buildings that are acquired and leased are done so for historical interpretive purposes, such as the historical dune shacks located in the Cape Cod National Seashore, Massachusetts, or for recreational purposes, such as the beach

[77] One option is for a lease agreement to include a tenure period of ninety-nine years, expiring at the end of that time or earlier upon the death of the lessee. Katherine R. Candler, LIFE TENANCY AND THE NATIONAL PARK SERVICE—A TOOL FOR CULTURAL RESOURCE MANAGEMENT (2015) (master's thesis, Univ. of Ga., Athens, Ga.).
[78] *See generally* Joseph L. Sax, *Helpless Giants: The National Parks and the Regulation of Private Lands*, 75 MICH. L. REV. 239 (1976). The National Park Service does not have a general authority for acquiring private property, such as inholdings, but the legislation establishing some national parks, such as the national seashores, includes such authority within the boundaries of the relevant park. CAROL H. VINCENT, LAURA B. COMAY, M. LYNNE CORN & KATIE HOOVER, CONG. RESEARCH SERV., RL34273, FEDERAL LAND OWNERSHIP: CURRENT ACQUISITION AND DISPOSAL AUTHORITIES (2012).
[79] *See* Candler, *supra* note 77.
[80] Candler, *supra* note 77, at 2.

clubs at the Gateway National Recreation Area on Sandy Hook, New Jersey.[81] In general, however, programs for acquiring and leasing inholdings are used to defray the costs to the federal government of assembling the lands within a park's boundaries so that they can be managed in a consistent fashion.[82]

V. CASE STUDY: PLUM ISLAND, MASSACHUSETTS

Plum Island is an east-facing, inlet-associated, coastal barrier located on the North Shore of Massachusetts, near the Massachusetts-New Hampshire border, and situated immediately to the south of the Merrimack River delta. Plum Island runs from Newburyport in the north, through Newbury and Rowley, and down to Ipswich in the south. The undeveloped federal Parker River National Wildlife Refuge is located on the barrier and in the salt marsh behind the barrier to the south of Newbury. The barrier protects the extensive Great Marsh wetland ecosystem, which is one of the largest, relatively undeveloped salt marsh systems remaining in Massachusetts.[83]

The dynamic coastal geomorphology of the Plum Island barrier system commonly entails areas of accretion on the barrier beach in Newburyport near the mouth of the Merrimack River and areas of erosion along the shorefront in Newbury to the south. Coastal geologists continue to study the dynamic geology of the barrier, however, and several theories have been posited about the apparent cyclical nature of erosion there. In particular, there is a longstanding debate about the implications for shoreline erosion on Plum Island of two jetties that extend seaward from the mouth of the Merrimack River, which were constructed and are maintained by the U.S. Army Corps of Engineers in order to keep a navigation channel open in the river.[84] One novel geological theory relates the position of an offshore bar proximate to the barrier shorefront in Newbury, which is supplied periodically with sediment from a deposit off the mouth of the Merrimack River, to longterm cycles of erosion and accretion occurring along different Newbury shoreline segments at different times.[85]

---

[81] NAT'L TRUST FOR HISTORIC PRES., HISTORIC LEASING IN THE NATIONAL PARK SYSTEM (September 2013).
[82] Candler, *supra* note 77.
[83] MASS. EXEC. OFFICE OF ENERGY AND ENVTL. AFFAIRS (EEA), GREAT MARSH RESOURCE SUMMARY (2016), http://www.mass.gov/eea/agencies/dcr/conservation/ecology-acec/great-marsh.html.
[84] Gurley, *supra* note 62.
[85] Andrew R. Fallon, Christopher J. Hein, Peter S. Rosen & Haley L. Gannon, *Cyclical Shoreline Erosion: The Impact of a Jettied River Mouth on the Downdrift Barrier Island*, PROC. 11TH INT'L SYMP. ON COASTAL ENGINEERING AND SCI. OF COASTAL SEDIMENT PROCESSES 239-252 (2015).

Beginning in the 1930s, and accelerating rapidly in the post-World War II period, the Plum Island barrier was heavily developed with residential properties in both Newburyport and Newbury. More than 1,200 buildings, comprising mainly private residences, exist currently on the barrier (Figure 1). On the Newbury shorefront, the coastal barrier has been classified under the provisions of the WPA as a coastal dune resource area. Along this portion of the barrier, residential buildings are located adjacent to the shoreline, and they become exposed during severe storms, such as nor'easters and hurricanes.

Figure 1: Map of Plum Island (Newburyport, to the north, and Newbury, to the south, are separated by the diagonal border across the land) showing the housing stock (green dots), the locations of protective structures of different types (red lines), and the geological transects that are used to help measure shoreline changes over time.

Several Plum Island buildings have been lost to erosion in the last few decades, but it is difficult to make a full and reliable accounting of these losses. For example, after two severe nor'easters occurred in February and March 2013, reports described six homes that had to be demolished and seven that were "too dangerous to be occupied," implying that thirteen homes had been lost.[86] Later reports listed the loss of only six buildings.[87] Based on historical data gathered from the Newbury Conservation Commission and from media sources, we assume that eight buildings were lost over the decade from 2006 to 2015, implying that an average of 0.8 shorefront buildings (about one percent of the shorefront housing stock) may be lost to storms each year in Newbury.[88] Thus, on average, Newbury may lose about $0.64 million in residential housing value to shoreline erosion each year.[89]

There are sixty-eight shorefront properties with buildings on the Newbury section of the Plum Island barrier, with an estimated average market value of $800,000 per property.[90] These buildings are located on a coastal dune resource, so the WPA prohibition on emplacing structural protections should be in effect. Notwithstanding the WPA rules, about two-thirds (45) of the Newbury shorefront

[86] Jess Bidgood, *It's Move It or Lose It in Path of a Nor'easter*, N.Y. TIMES, Mar. 18, 2013, at A17.
[87] Dyke Hendrickson, *'Stigma' Gives Plum Island Homeowners a Tax Break*, THE DAILY NEWS OF NEWBURYPORT (Dec. 4, 2013), http://www.newburyportnews.com/news/local_news/stigma-gives-plum-island-homeowners-a-tax-break/article_d611a8b9-c623-5ced-9c05-0e84f1500ce4.html.
[88] We used an estimate of eight shorefront buildings destroyed by coastal storms during the 10-year period from 2006 to 2015 to calculate this rate of loss. Personal communication with Doug Packer, Newbury Conservation Commission via Prof. Peter Rosen, College of Science, Northeastern University (August 16, 2016). For media reports, see Billy Baker, *On Plum Island, Another Punishing Storm*, BOSTON GLOBE (28 December 2012); Billy Baker, *Storm Devastating to Plum Island*, BOSTON GLOBE (March 9, 2013); Dyke Hendrickson, *On Island, 40 homes Deemed 'At Risk'*, THE DAILY NEWS OF NEWBURYPORT (March 12, 2013).
[89] This estimate of lost value includes the "waterfront" premium associated with the location of the properties. Importantly, this premium typically is *not* lost when a building is destroyed; it accrues to the property and building located immediately behind the former waterfront property. Based upon the results of a hedonic pricing model, an average waterfront premium on Plum Island is on the order of $80,000, about 10% of an average shorefront property's value. Andrew R. Fallon, Porter Hoagland, Di Jin, William Phalen, G. Gray Fitzsimons & Christopher J. Hein, *Adapting Without Retreating: Responses to Shoreline Change on an Inlet-Associated Coastal Beach*. 45 COASTAL MGMT. (forthcoming 2017).
[90] The actual number of Plum Island shorefront properties vulnerable to erosion in the near-term is uncertain, and the identities of vulnerable properties depend crucially upon the dynamics of coastal geological changes. Here, we focus on all sixty-eight of the Newbury shorefront properties, although at least one source suggests that the number of properties "at risk" could be as small as forty. Dyke Hendrickson, *Walls built to fight sea*, THE DAILY NEWS OF NEWBURYPORT (March 19, 2013). Shorefront property values were estimated using the online real estate valuation assessment tool at http://www.zillow.com/.

properties are shielded already in part by either private or public structures, including coir bags, riprap, groins, or jetties. Based upon the results of a hedonic pricing model, the capitalized value of structural protections is on the order of 5-8% ($36,000-$67,000) of the value of an average oceanfront property on Plum Island.[91]

Some of these protective structures had been put in place prior to the WPA rules. Many may not have been modified during the last three to four decades. Over the years, a wide range of approaches have been used in an attempt to mitigate flooding and erosion, including beach replenishment, using dredge spoils from the mouth of the Merrimack River or sand "mining" from onshore sources; junked cars and trucks; hay bales; concrete seawalls; sand bags; revetments; emplacement of assorted sizes of rocks ("riprap"); 100-foot long coir (coconut fiber) tubes filled with sand; grass plantings; and others. In recent years, on several occasions, some of the shorefront property owners have engaged in beach scraping to create sacrificial dunes in front of their properties in anticipation of winter nor'easters or immediately prior to severe storm events.

Further, during the late spring of 2013, subsequent to a March nor'easter that caused the loss of six homes and the temporary condemnation of seven others, several of the shorefront property owners put in place massive rock embankments (riprap comprising piles of rocks of various sizes) and symmetric stone walls to forestall erosion along 400 feet of the coastal dune.[92] With the forbearance of Newbury's Conservation Commission and the underlying threat of litigation over a potential passive taking should WPA rules be interpreted and enforced strictly—causing the Massachusetts Department of Environmental Protection to acquiesce—the riprap project moved forward.[93] These actions indicate clearly that the shorefront property owners were behaving as if they possess legal rights, albeit implied ones, to protect their shorefront properties.

We estimated the potential fiscal costs to government agencies of implementing policies to encourage retreat (Figure 2). If implemented, these fiscal costs would involve actual expenditures of public funds for the various alternatives (including the status quo). We argue that the scales of these costs help us to appreciate some of the issues surrounding how the risks of shoreline change are distributed between society and property owners.

---

[91] This estimate was developed using a model of factors contributing to the assessed values of all Plum Island residential properties. Fallon et al., *supra* note 89.
[92] *See* Hendrickson, *supra* note 90.
[93] John Macone, *On Plum Island, Rocky Beach Causing Problems*, THE DAILY NEWS OF NEWBURYPORT (July 21, 2015), http://www.newburyportnews.com/news/local_news/on-plum-island-rocky-beach-causing-problems/article_2fe33c0b-49af-5b75-8bc8-4613ac75182b.html.

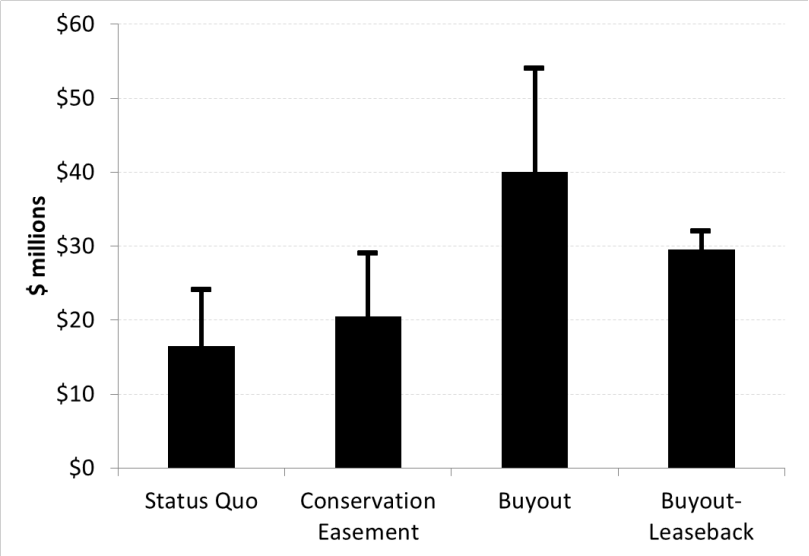

Figure 2: Comparison of the fiscal costs to government of alternative market-based approaches to encourage retreat from the Plum Island shoreline.

Nevertheless, we caution that estimates and comparisons of these costs do not comprise a formal cost-benefit analysis of alternative policies. Undertaking the latter would require incorporating additional information about potential losses in amenities to shorefront property owners and gains to the public of increased access to the shorefront or increases in the economic values of public trust uses and other public interests. In particular, making such estimates would depend critically upon observations or models of the volume of sand on the barrier and the shape and position of shorelines in the future.

a) *Status quo ($9-24 million).* The status quo involves ongoing costs of emergency response and disaster assistance borne by government agencies, including those at local, state, and federal levels. These aggregate costs can be estimated for the entire state, but they are difficult to allocate across specific locations, such as the Plum Island barrier, and to ascribe to different levels of government. Estimates of costs using only declared disasters may underestimate the actual costs to government; such estimates ignore lesser categories of (non-disaster) hazards. On the other hand, estimates of disaster assistance costs using declared disasters may overestimate the costs of shoreline change due only to erosion, as they may also include the costs of disaster due to wind damage and flooding.

Using an estimate of statewide federal disaster assistance, including assistance for disasters as a consequence of flooding, erosion, and wind, and assuming that these damages were spread uniformly across the Commonwealth's twenty-two erosion hotspots, we estimated disaster assistance to Plum Island of $300-700 thousand per year. Capitalizing these costs at three percent, the costs of coastal disaster assistance range from $9-24 million. Note that individual property owners also face costs due to the actual losses of land and buildings, as well as costs of the risks of such losses, which may already be capitalized into home values.[94]

b) ***Conservation easements ($12-29 million).*** Assuming that the implied legal rights to protect a shorefront property could be defended successfully, the implementation of a policy of conservation easements involving the purchase of the rights to protect the heretofore unprotected shorefront properties (23 buildings) would cost the Commonwealth between $0.8-1.5 million.[95] Note that the purchase of conservation easements on only a subset of shorefront properties could lead to a situation in which those properties continue to be deprived of sediments, sand, or other materials for which movement would be constrained by existing protective structures in front of updrift shorefront properties. In order to prevent accelerated erosion of the downdrift properties with easements, conservation easements could be purchased on all 68 of the shorefront properties at a cost to the Commonwealth of $2.5-4.6 million.

We assume further that the costs to government of emergency responses or disaster assistance, as estimated for the Status Quo alternative above, would continue to be incurred.[96] An argument could be made, however, that, with the removal of structural protections, a more natural geological regime would mitigate some of the damages resulting from coastal storms.

Conservation easements should include conditions precluding beach scraping and requiring the removal of existing coastal engineering structures. Some of the protective structures are publicly owned, and therefore they may require public financial or technical assistance in their removal. Regardless of the degree of public assistance, implementing an effective program of conservation easements could be problematic if the program relies upon the voluntary

[94] *See* Kreisel et al., *supra* note 24.
[95] This calculation was made using the results of the hedonic pricing model of the value of oceanfront coastal engineering structures to a shorefront property on Plum Island of between $36,000 and $67,000.
[96] In order to make this calculation, the costs of purchasing the conservation easements on all sixty-eight of the shorefront properties are added to the costs of the status quo.

participation of shorefront property owners. Partial participation is especially concerning if only a subset of property owners choose to offer conservation easements for purchase voluntarily.

c) *Buyouts ($26-54 million).* In order to implement a buyout policy, the purchase of all shorefront properties on the Newbury Plum Island barrier would cost the Commonwealth approximately $54 million. Because we estimated that only 0.8 percent of the shorefront housing stock is lost each year on average, a buyout policy could be arranged so that it is carried out in stages, perhaps focusing on shorefront properties believed to be at the highest risk of erosion and inundation first. To be conservative, assume that the annual risk of the loss of property to the shorefront housing stock is two percent. A plan to acquire properties by purchase over the next 25 years would lead to the acquisition of roughly half of the 68 Newbury shorefront properties on Plum Island and cost the Commonwealth about $26 million.[97]

d) *Buyouts-leasebacks ($28-32 million).* Several of Newbury's shorefront properties could represent viable candidates for a buyout-leaseback policy. Based on a capitalization rate of 3%, the average shorefront property could be rented back to its original owners for $2,000 a month. After a period of twenty-five years, which might be regarded as a typical lease term, and assuming that the average property has not been lost to storm or erosion damage during that period, the Commonwealth would recover 75% (about $600,000) of the original purchase cost. After thirty-four years, the Commonwealth would have recovered the full buyout costs of the average property.

We assume that there would not be a need for disaster assistance subsequent to a damaging event, so we do not include the costs of such assistance. A shorefront property could not continue to be rented after a damaging event occurs, however. Consequently, there is the likelihood in each year that the future stream of rental income would be lost completely from that period forward. It is reasonable to assume that, as erosion occurs and shorefront properties get nearer to the coast, the chances of losing the future stream of rental income would increase. We employ the results of a regional hedonic pricing model[98] to simulate the increased risks of erosion losses to the future stream of rental income (Figure 3).

[97] At an assumed loss of two percent of the sixty-eight shorefront buildings per year (or 1.36 buildings per year), thirty-four buildings (one-half of the total) would be lost over twenty-five years. For heuristic purposes, in estimating the costs of both the buyout and buyout-leaseback programs, we assume that inflation in the real estate market just equals the rate of discount, so there is no need to convert these estimates into present value terms.

[98] *See* Kreisel et al., *supra* note 24.

Our approach suggests that, over the thirty-four year period required to recover buyout costs in the absence of a damaging event, the expected cost to the government is on the order of 12% of the original buyout cost. Thus, we estimate that the risks of lost rental payments through the implementation of a buyout-leaseback policy would cost the Commonwealth approximately $7 million.

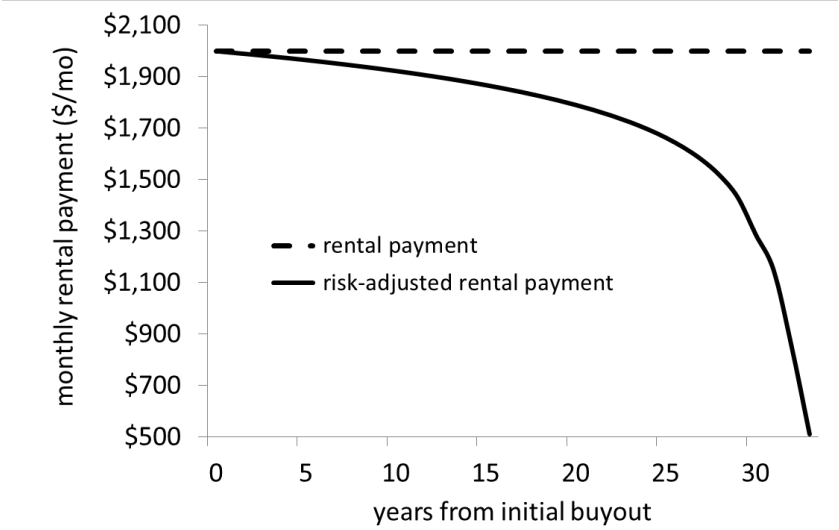

Figure 3: Constant monthly rental payment compared to a risk-adjusted monthly rental payment. The difference between the two curves is a measure of the fiscal cost to the government of implementing a buyout-leaseback policy. The risk adjusted rental payment accounts for the increasing risk over time that a storm event will lead to a discontinuation of future rental payments.

A buyout-leaseback policy also would incur significant costs of property management, which we estimate at 38-45% of the capitalized value of the average property.[99] Consequently, property management costs would add $20-24 million to the total costs of a buyout-leaseback policy. We assume that there are no costs of disaster assistance. There may be costs of demolition and disposal for properties that are lost during the thirty-four year period, however. These costs would increase the policy costs by another $0.5-1.0 million.

[99] Leonard Baron, *Investing 101: Estimating Rental Property Expenses* (Aug. 24, 2012), http://www.zillow.com/blog/investing-101-estimating-rental-property-expenses-94824/.

Although not modeled for this study, the buyout-leaseback policy, like the buyout policy, could be implemented in stages. With a staged approach, the selection of properties to participate in the policy is critical, as those shorefront properties at the greatest risk are those properties for which the future streams of rental income are most likely to be cut short prematurely.

e. ***Potential funding sources***. Two potential sources of funding might be used for implementing the policies described in this study. Further, the FEMA Hazard Mitigation Grant Program, focused on flood damages, also could be used to encourage retreat.[100] The existence of these funding sources suggests that, in principle, policies to encourage retreat through buyouts or buyouts-leasebacks could be feasible. The scale of available funding, however, would greatly limit their effect.

1. ***Massachusetts Environmental Bond***. In 2014, over $2 billion was appropriated through the Massachusetts Environmental Bond[101] to fund projects such as the removal of dams, the repair of seawalls, or the restoration of public parks. 6% ($117 million) of the bond was designated for use on coastal projects.[102] While the general understanding of the Massachusetts legislature was that these monies would be used mainly to repair failing seawalls, in principle, they also could be used to initiate programs to fund buyouts or a buyout-leaseback program. It appears unlikely that the monies would be used to purchase conservation easements, as the position of the Commonwealth is that the rolling easement policy embodied in the WPA is established law. The appropriation includes language to allocate $20 million to be used for voluntary buyouts of coastal properties.[103]

---

[100] See the discussion *supra* at notes 74-76.

[101] *See* ENVIRONMENTAL BOND, *supra* note 12.

[102] *Id*. §2800-7107. Specifically, these monies are to be directed toward "… the design, construction, reconstruction, improvement or rehabilitation of department or navigable coastal and inland waterways projects including, but not limited to, coastal protection, structures, dredging, river and stream cleaning, coastal structure maintenance, piers, dune stabilization, culvert repair, renourishment, erosion control, waterfront access and transportation improvements and related facilities and equipment."

[103] *Id*. §2000-7060. Specifically, these monies are to be directed toward "… the acquisition of land for the purposes of open space, recreation and conservation, to be protected pursuant to Article 97 of the Amendments to the Constitution, which lands are located near or adjacent to the mean high water mark of coastal areas, on coastal barrier beaches or in coastal high risk flooding zones and which lands or structures thereon suffer repeated damage by flooding or are otherwise impacted catastrophically by severe weather events and pose a high risk to public health, safety or the environment; provided, that funds shall be available to purchase adjoining coastal parcels next to such acquired land which is necessary to protect the environment; and provided further, that funds from this item shall not be used to compensate land owners for lands taken by eminent domain."

2. ***Federal Land and Water Conservation Fund***. A second potential source of funding is the annual appropriation to Massachusetts under the federal Land and Water Conservation Fund (LWCF). Importantly, appropriations from the LWCF go mainly to 50:50 federal-state matching grants for land and water conservation projects, but these monies also could be used for other purposes, which may include private land conservation grants.[104] To the extent that buyouts result in increased public access to coastal areas, the use of LWCF appropriations for shorefront buyouts would appear to be a sensible application of the Massachusetts share of the monies. The LWCF is authorized at $900 million per year, but historically only a small proportion of the annual authorization is appropriated by the U.S. Congress to carry out the Fund's purposes, averaging $40 million per year for the entire United States. Further, the share of total LWCF appropriations that accrues to individual states is uncertain.[105] During the past decade, Massachusetts has received on average only about $1 million per year.[106]

VI. DISCUSSION AND CONCLUSIONS

Our study is an initial attempt at characterizing the fiscal costs of implementing alternative policies to encourage the retreat of property owners from a dynamic and increasingly hazardous coastline in Massachusetts. Under provisions of the WPA, we argue that extant coastal law embodies a *de facto* policy of rolling easements, where shorefront property owners must respond to shoreline change by retreating from and not protecting their property. We note that this form of rolling easement may be weakened in certain exigent circumstances, such as has been the situation on Plum Island.

We focused on Plum Island, which constitutes only one of the Commonwealth's 22 recognized coastal erosion hotspots. We considered three market-based approaches to retreat, including conservation easements, buyouts, and buyouts-leasebacks. We compared the fiscal costs to governments of undertaking these policies to the status-quo. These costs are relevant to decision-makers at all levels of government, but especially for state and municipal agencies, as they weigh alternative approaches for responding to the hazards of shoreline change.

---

[104] CAROL H. VINCENT, CONG. RESEARCH SERV., RL33531, LAND AND WATER CONSERVATION FUND: OVERVIEW, FUNDING HISTORY, AND ISSUES (2014).
[105] Phil Taylor, *Conservation: How States Lost the Battle for LWCF Cash*, ENVIRON. & ENERGY DAILY (Nov. 4, 2015), https://www.eenews.net/stories/1060027408.
[106] SALLY JEWELL, LAND AND WATER CONSERVATION FUND FY2015 REGULAR APPORTIONMENT TO THE "STATES" OF $42,000,000 (Aug. 11, 2015) (the 2002-2015 apportionments are accessible at https://www.nps.gov/ncrc/programs/lwcf/funding.html).

Notably, for the Commonwealth, we found that these alternatives appeared to be significantly more costly than the status-quo. This result suggests that it may be problematic from a fiscal—and therefore political—point of view to put in place market-based policies that could help encourage shorefront property owners to retreat. The status quo constitutes a rolling easement for property owners, backed up by the prospect of emergency or disaster assistance funded mainly at the federal level. Plum Island represents a case that may become increasingly common as sea-level rise accelerates, and property owners refuse to abide a policy of rolling easement.

Importantly, further work is needed to refine our estimates so that more rigorous comparisons can be made of the potential costs of policies encouraging retreat. One possible means of spreading the costs out over time could involve setting priorities over locations where market-based approaches might be implemented. This may become increasingly feasible with an emergent understanding of the geographic distribution of coastal erosion hotspots.

In Table 2, we present a qualitative comparison of these policies, including descriptions of the types of risks and the costs that would be borne by shorefront property owners and government agencies at different levels of government. This comparison may help to clarify the complex mix of motivations faced by a diverse set of stakeholders.

Table 2: Comparison of the Distribution of Impacts of Alternative Policies for Encouraging Retreat from the Coast

	STATUS QUO	CONSERVATION EASEMENT	BUY-OUT	BUY-OUT, LEASE-BACK
PROPERTY OWNER	Enjoys coastal amenity value; bears risks of erosion due to regulatory restrictions on the construction of coastal engineering structures	Enjoys coastal amenity value; bears risks of erosion due to inability to construct coastal engineering structures but is compensated for these risks	Loses coastal amenity value but is compensated for this loss	Enjoys coastal amenity value for a limited period; compensated for loss of coastal property; bears costs of rental payments; bears costs of depreciating living conditions
TOWN	Captures portion of coastal amenity value with property tax; bears some risks of emergency response and infrastructure repair (roads, sewers)	Captures portion of amenity value with property tax; bears some risks of emergency response and infrastructure repair (roads, sewers)	Loses property tax proceeds	Captures portion of amenity value with property tax for a limited period; property tax proceeds may diminish with depreciation; bears some risks of emergency response and infrastructure repair (roads, sewers)
STATE*	Bears some risks of emergency response and disaster assistance costs	Bears some risks of emergency response and disaster assistance costs; bears costs of purchase of conservation easement	Bears cost of purchase of coastal property; bears cost of razing and disposal of structures; bears administrative costs of managing natural areas	Bears cost of purchase of coastal property; bears administrative costs of renting, including making tax payments; bears risk of lost future rental payments due to erosion
NATION	Bears most of the risks of disaster assistance costs	Bears most of the risks of disaster assistance costs		

*In principle, the costs borne by the State under the various alternatives could be shared with non-governmental organizations, the town, or the nation.

For example, under the present system of rolling easements, shorefront property owners are likely to push hard for the right to build coastal engineering structures in order to protect their properties. On Plum Island, the shorefront property owners have been observed both to scrape up sacrificial dunes as coastal storms bear down on the barrier and to emplace massive riprap structures. Coastal property owners also may continue to threaten litigation to enable the construction of even more permanent structures. Local municipalities have a stake in protecting the public services that they own or manage, including roads and water and sewer lines, to ensure that property taxes from high-assessed properties continue to be paid.[107] Consequently, even if they are not required to contribute financially, a buyout policy would not be particularly attractive to the municipalities.

The Commonwealth likely would argue against the need for implementing a policy of conservation easements, as the WPA provisions currently place the risk of shoreline change on the shoulders of shorefront property owners. The Commonwealth might prefer a buyout-leaseback policy, although the property management costs associated with being a landlord are unlikely to be trivial, and, when combined with the risks of the loss of rental payments from damaged properties, could well approach the costs of outright buyouts.

Considering our results, it is difficult to conclude that market-based approaches to rolling easements would be implemented in coastal Massachusetts in the near future. Even more concerning however, and consistent with this conclusion, is there appears to be little evidence of human retreat. A recent editorial in the *Newburyport Daily News* describes the contemporary situation on Plum Island:

> It's a strange dichotomy—in Newburyport City Hall they are discussing how this coastal community will cope with the ravages of rising sea levels and storm surges, while along the fragile coast of Plum Island, a new batch of enormous homes is rising, some on land where homes were destroyed by storms just three years ago… [T]he days when Plum Island was populated by simple cottages are long gone. Now, much of the new construction is enormous and expensive, much taller, and more resilient to the ravages of nature thanks to their impressive anchors—steel pilings driven deep into the ground… Today, engineering has allowed for the construction of buildings that are far larger…and more solid than anything in the past. They are built to withstand the maelstrom. Yet the ground underneath them remains the same, an unpredictably shifting landscape that the best engineering in the world can't tame.[108]

[107] Some of the Plum Island shorefront property owners have argued for property tax abatements due to reduced market values that are the consequence of coastal erosion. Although abatements have been minor for the most part, they reinforce the stake that municipalities have in perpetuating the shorefront properties. *See* Hendrickson, *supra* note 90.

[108] Anonymous, *On Plum Island, a Regretful Decision*, THE DAILY NEWS OF NEWBURYPORT (May 12, 2016), http://www.newburyportnews.com/opinion/editorials/on-plum-island-a-regretful-decision/article_cf67cdb4-46c3-51fb-8536-a6c7daa2de8d.html (arguing that state legal

As has been the pattern in other coastal locations,[109] retreat from the coast seems less likely to take place through careful planning, the adoption of reasoned policies, or even financial incentives. Instead, it may be more likely to occur as the inevitable reaction to future, punctuated occurrences of major natural catastrophes.

requirements to construct water and sewer lines to meet public health and water quality standards on Plum Island unintentionally led to continued or expanded coastal development).

[109] HURRICANE SANDY REBUILDING TASK FORCE, HURRICANE SANDY REBUILDING STRATEGY (Pre-Publication Ed.) 2013). Among other steps, the Task Force "[e]ncourag[ed] homeowners and other policy-holders to take steps to mitigate future risks, such as elevating their homes and businesses above flood levels, which [would] not only protect against the next storm but also make their flood insurance premiums more affordable."