Empowering Local Action for Coastal Resilience in Massachusetts

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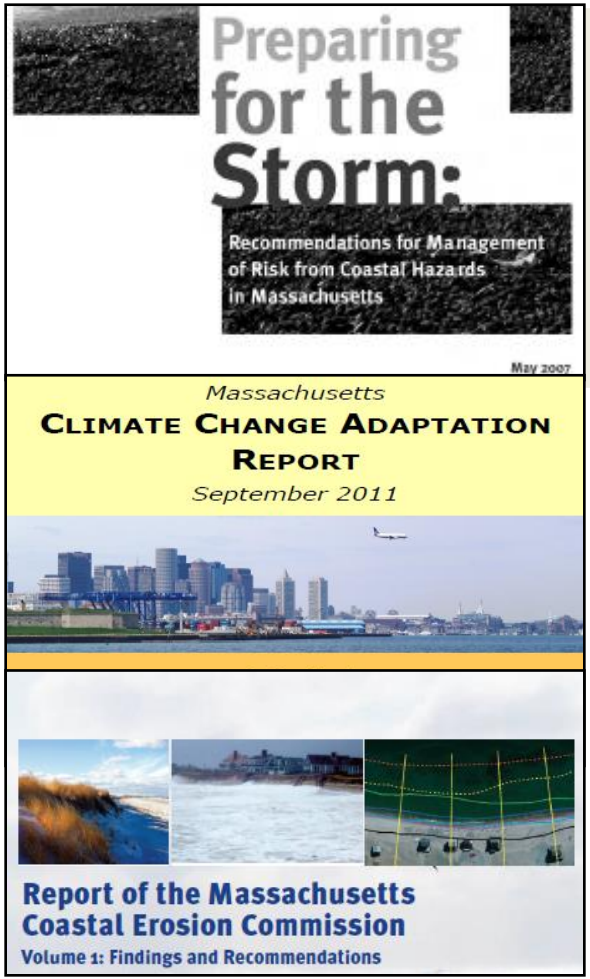
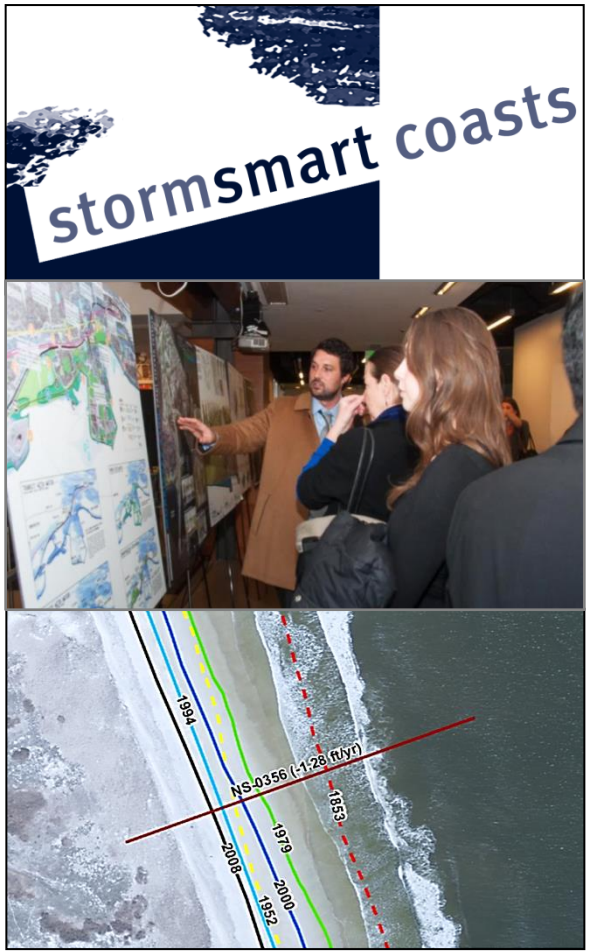
Context

- Coastal communities continue to face both chronic and acute storm surge, erosion, and flooding problems
- Effects of climate change exacerbates and accelerates these problems
- “Home rule”- many land use decisions made at local level
- Focus on providing technical and financial assistance for communities



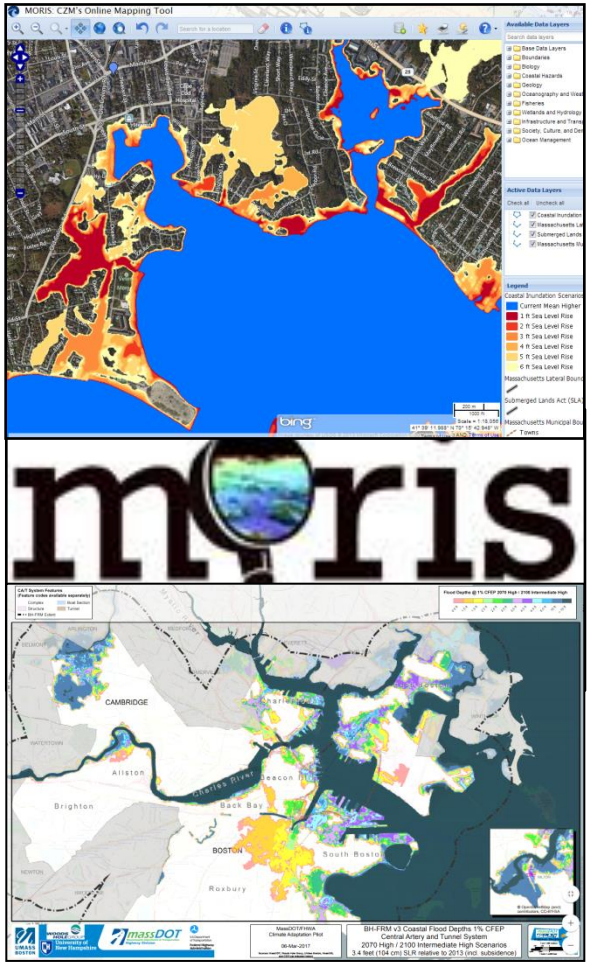
Legislative Initiatives

- State commissions & reports:
  - 2007 Coastal Hazards Commission
  - 2011 Adaptation Advisory Committee
  - 2015 Coastal Erosion Commission
- **Recommendations:**
  - ➢ **Better data & information**
  - ➢ **Strategies connected with & directly support communities**
  - ➢ **Risk & vulnerability assessments**



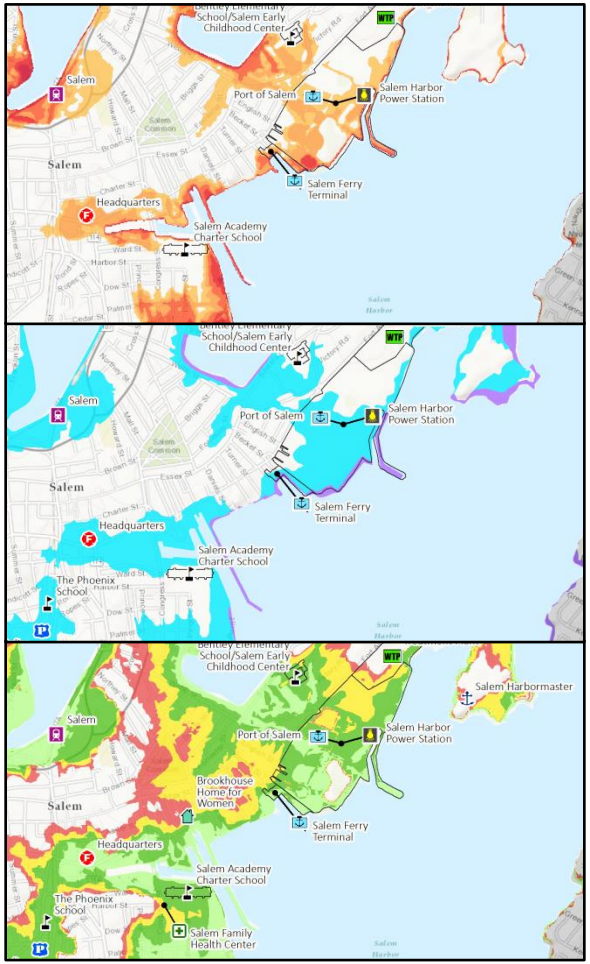
Assistance for communities

- Decision support tools
  - Maps, data and technical information
  - Legal, planning and other guidance
  - Fact sheets
- Hands-on technical assistance
  - Trainings, workshops
  - Advisory role in assessments, plans
  - Case-specific support
- Financial support
  - Coastal Resilience Grants



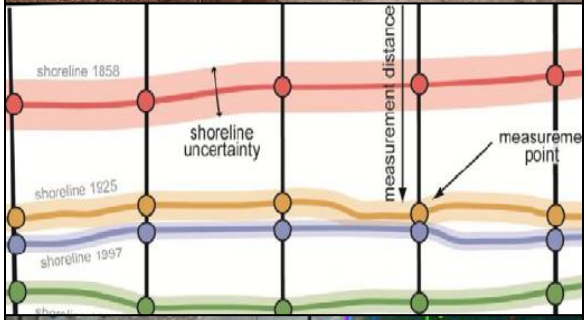
Sea level rise modeling

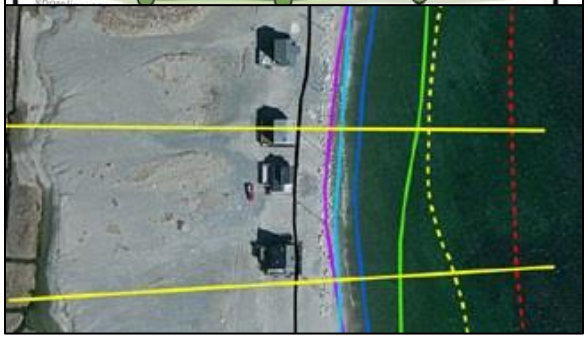
- NOAA model: mapping and visualizing sea level rise
  - Modified “bathtub” approach
  - Depictions of SLR levels (1-6 feet)
  - Access SLR maps with other layers through MA Ocean Resources Information System
- New dynamic flood risk modeling
  - Boston metro - 2015
  - Rest of coast - 2018



SLR and coastal flood viewer

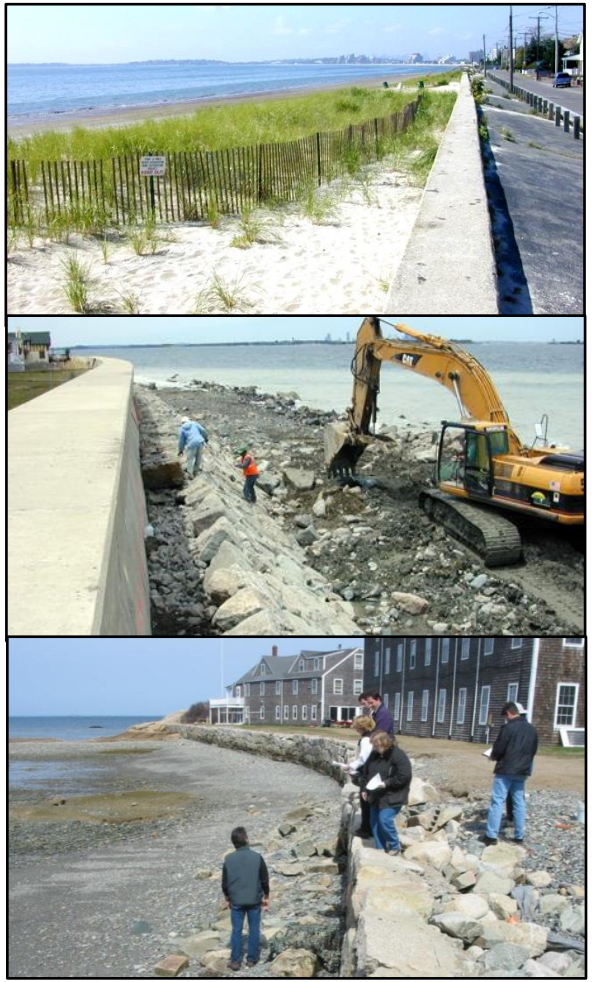
- Interactive maps of flooding extents and water level elevations associated with sea level rise, FEMA flood zones, and hurricane surge areas
- Community facilities & infrastructure:
  - Airports, energy generation facilities, fire stations, health centers, hospitals, landfills, libraries, long-term care residences, subway and rail stations, police stations, prisons, schools, seaports, town halls, USCG bases, & wastewater treatment plants
- Online mapper, website and report





Shoreline change

- USGS Woods Hole Science Center ongoing partnership
- Current and historical shoreline trends, long and short term erosion and accretion rates
- Shorelines: ~ 1846, 1887, 1955, 1978, 1994, 2000, 2009, 2014
- 26,000 transects (50m intervals)
- Data available on CZM's interactive online mapping tool - MORIS

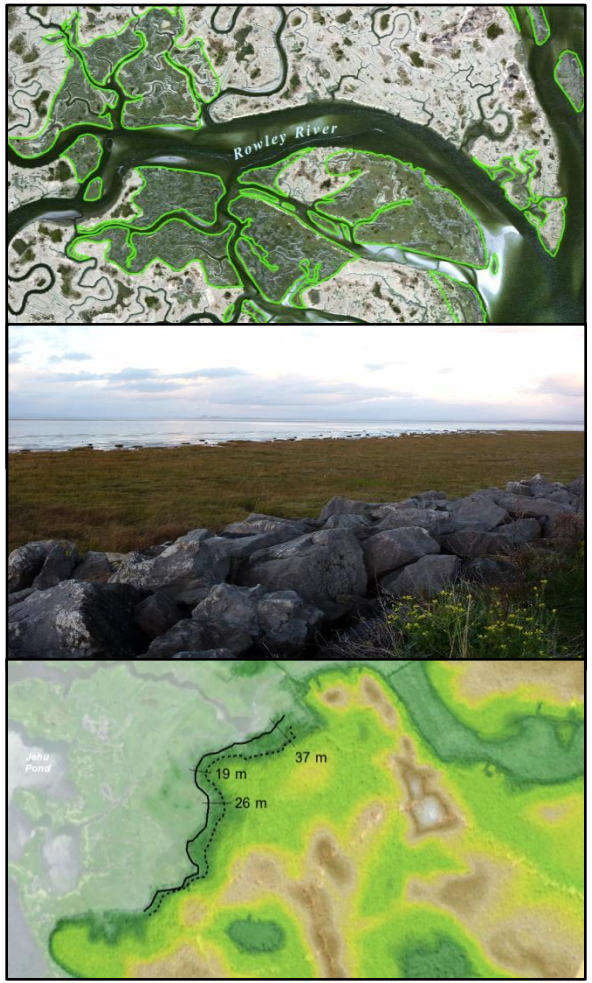


Coastal structures inventory

- Seawalls, revetments, groins, jetties, and other coastal structures
- 2009, 2013, 2015 inventories
  - Location
  - Type
  - Material
  - Height / length
  - Condition ratings
  - Assets protected
  - Estimated repair costs

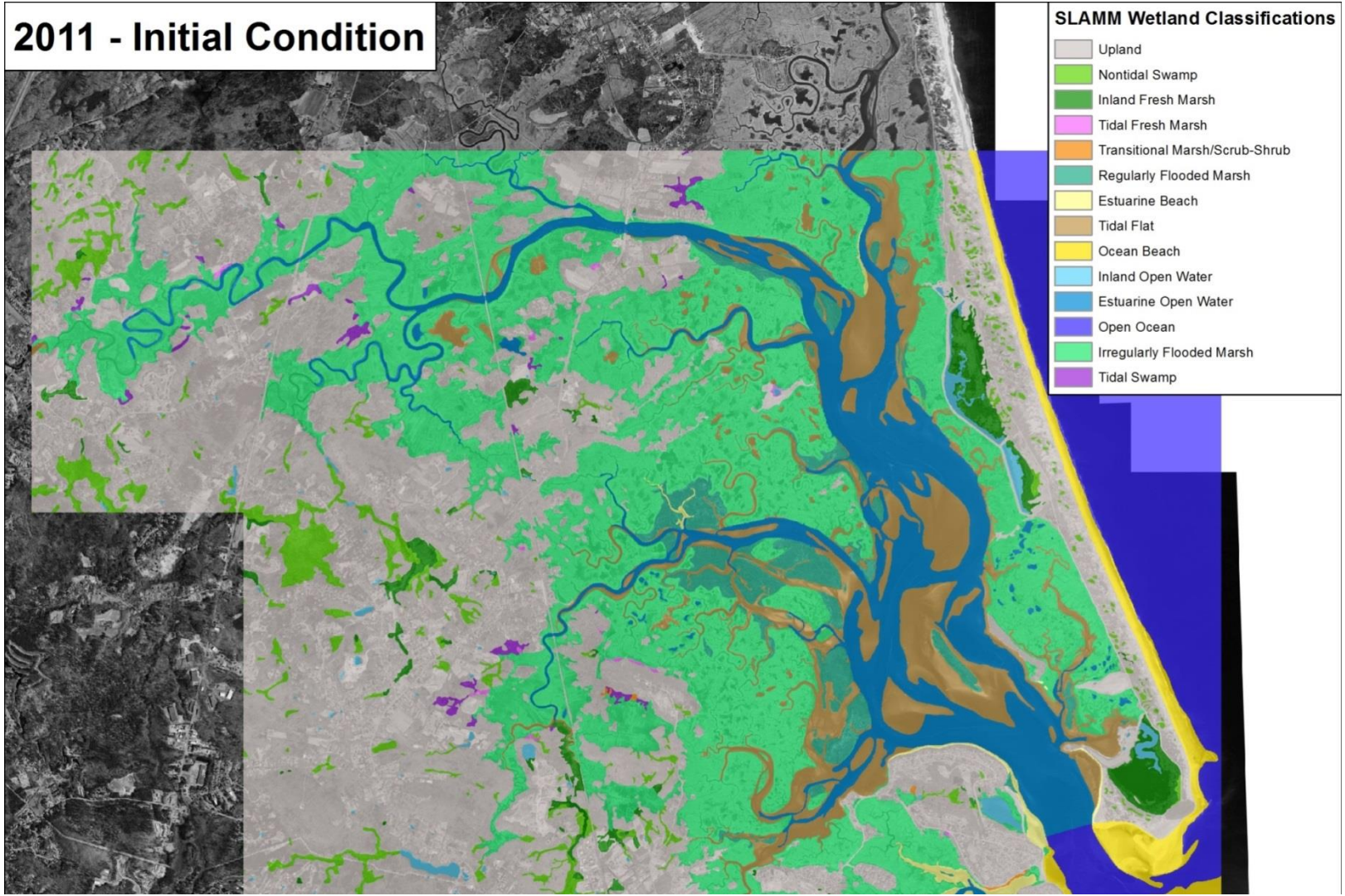
Coastal engineered structures inventory

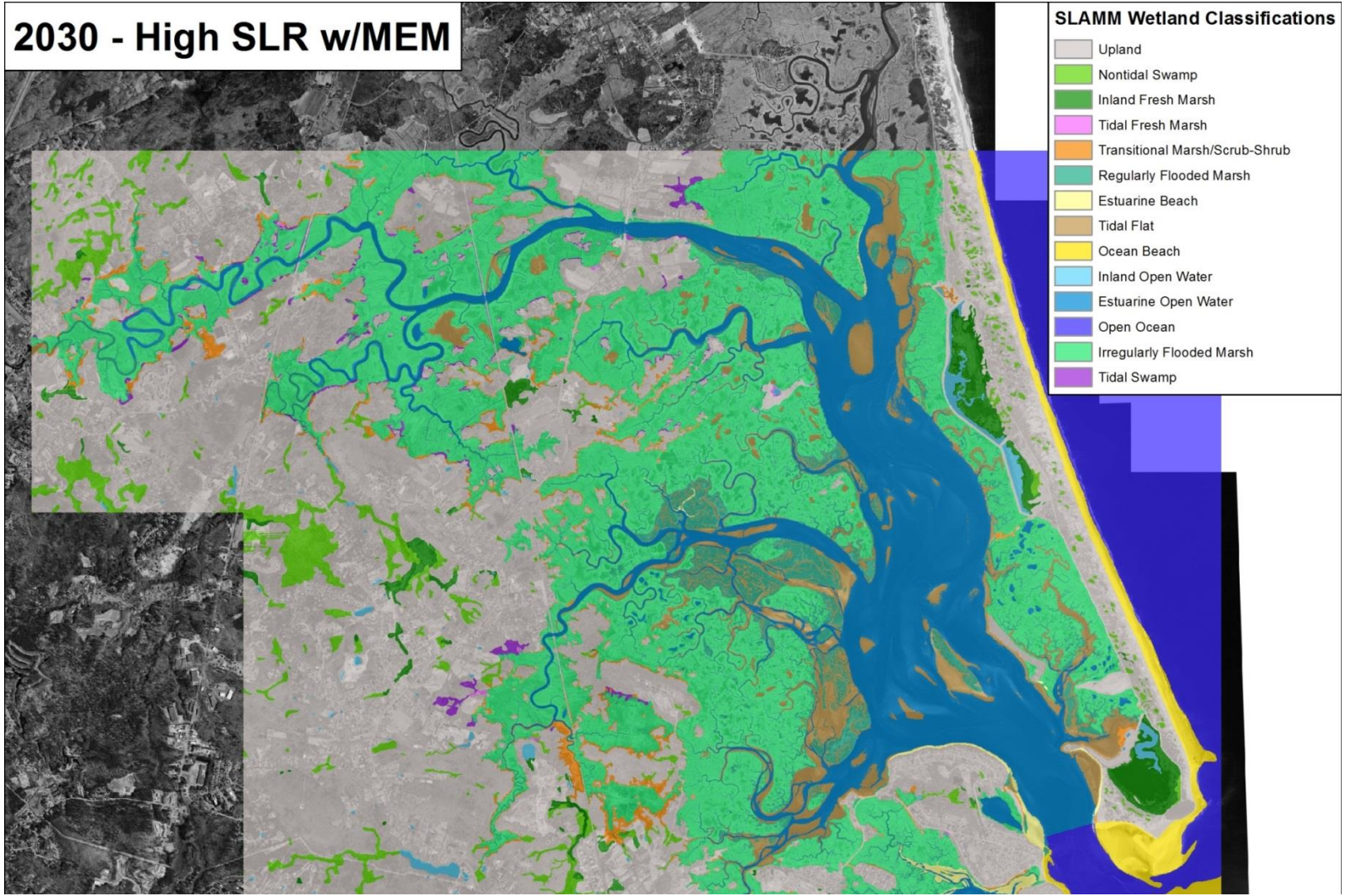
Region	Shoreline Length (miles)	Private Structure Length (miles)	Public Structure Length (miles)	Percent Shoreline with Structure
North Shore	160	50	24	**46%**
Boston Harbor	57	12	21	**58%**
South Shore	129	28	29	**44%**
Cape Cod & Islands	615	66	11	**13%**
South Coastal	154	49	7	**36%**
TOTAL	**1,115**	**205**	**92**	**27%**

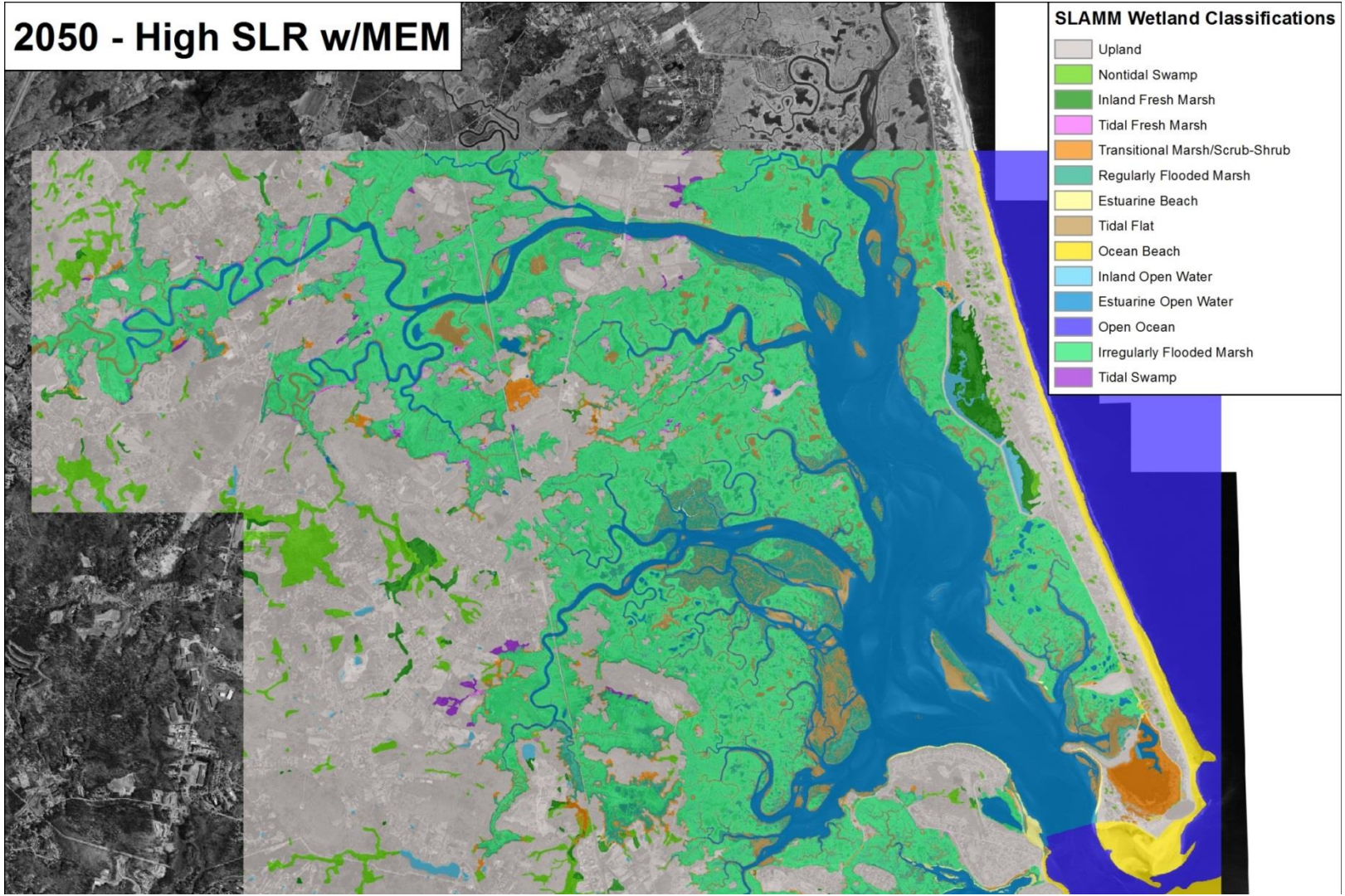


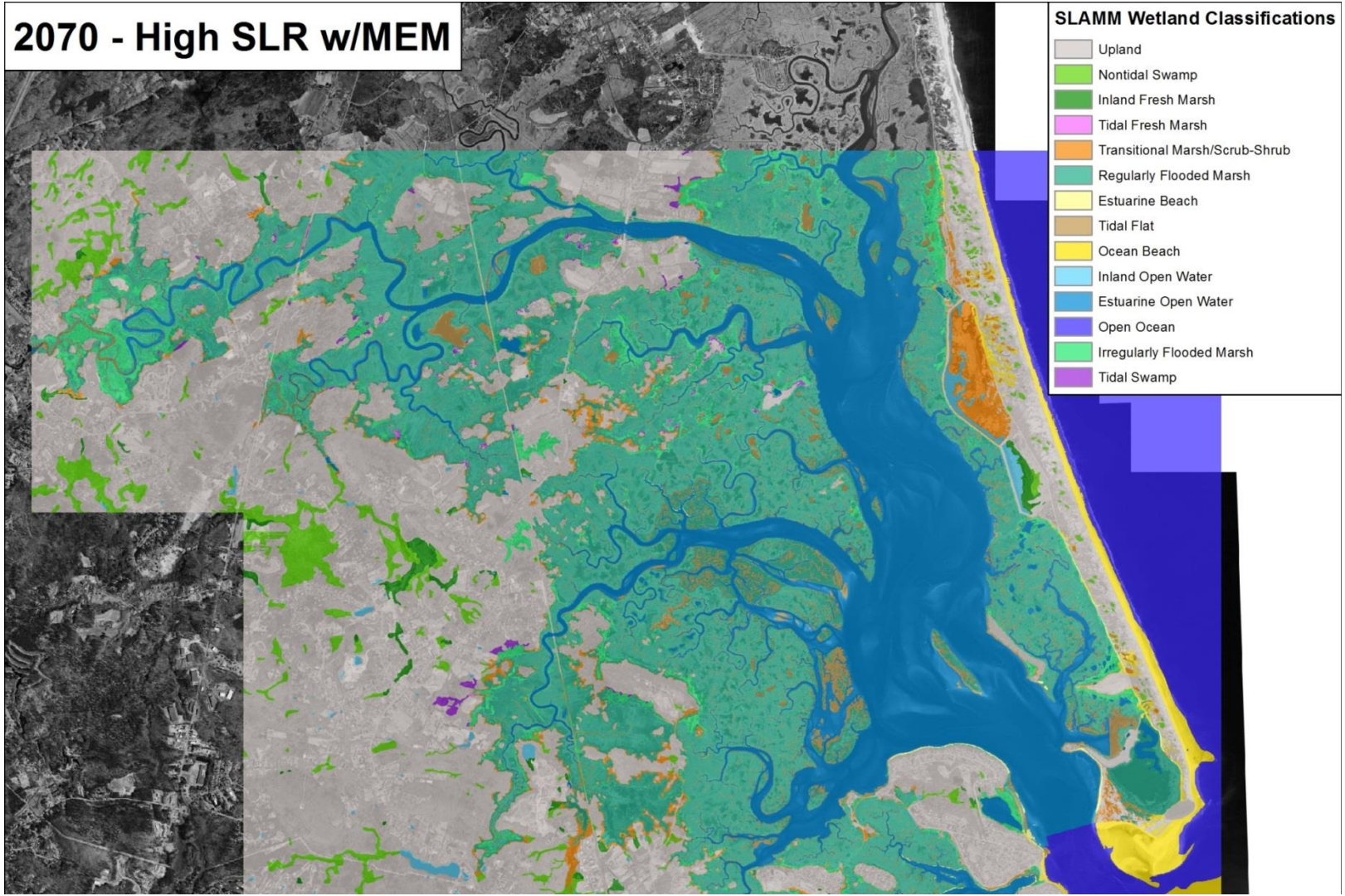
Salt marsh vulnerability

- Model scenarios & forecast effects:
  - Barriers to transgression
  - Transgression areas
  - High vulnerability to loss areas
  - Expected change in wetland type
- Maps depicting SLR changes: 2030, 2050, 2070, 2100
- Establishment of long term transect stations & monitoring network to track biological response


2011 - Initial Condition
SLAMM Wetland Classifications
Upland
Nontidal Swamp
Inland Fresh Marsh
Tidal Fresh Marsh
Transitional Marsh/Scrub-Shrub
Regularly Flooded Marsh
Estuarine Beach
Tidal Flat
Ocean Beach
Inland Open Water
Estuarine Open Water
Open Ocean
Irregularly Flooded Marsh
Tidal Swamp


2030 - High SLR w/MEM
SLAMM Wetland Classifications
Upland
Nontidal Swamp
Inland Fresh Marsh
Tidal Fresh Marsh
Transitional Marsh/Scrub-Shrub
Regularly Flooded Marsh
Estuarine Beach
Tidal Flat
Ocean Beach
Inland Open Water
Estuarine Open Water
Open Ocean
Irregularly Flooded Marsh
Tidal Swamp


2050 - High SLR w/MEM
SLAMM Wetland Classifications
Upland
Nontidal Swamp
Inland Fresh Marsh
Tidal Fresh Marsh
Transitional Marsh/Scrub-Shrub
Regularly Flooded Marsh
Estuarine Beach
Tidal Flat
Ocean Beach
Inland Open Water
Estuarine Open Water
Open Ocean
Irregularly Flooded Marsh
Tidal Swamp


2070 - High SLR w/MEM
SLAMM Wetland Classifications
Upland
Nontidal Swamp
Inland Fresh Marsh
Tidal Fresh Marsh
Transitional Marsh/Scrub-Shrub
Regularly Flooded Marsh
Estuarine Beach
Tidal Flat
Ocean Beach
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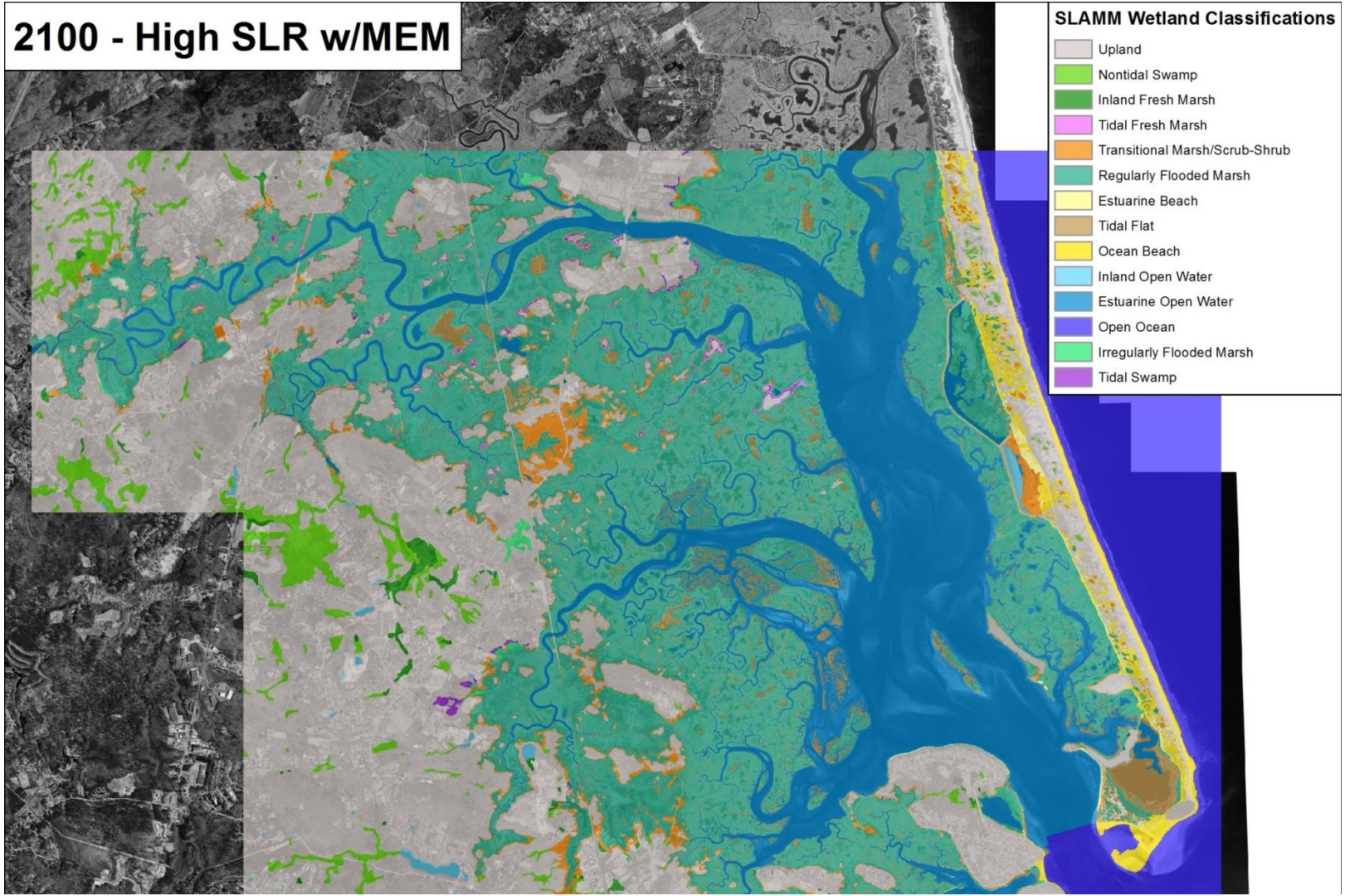
Irregularly Flooded Marsh
Tidal Swamp


2100 - High SLR w/MEM
SLAMM Wetland Classifications
Upland
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Inland Fresh Marsh
Tidal Fresh Marsh
Transitional Marsh/Scrub-Shrub
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Estuarine Beach
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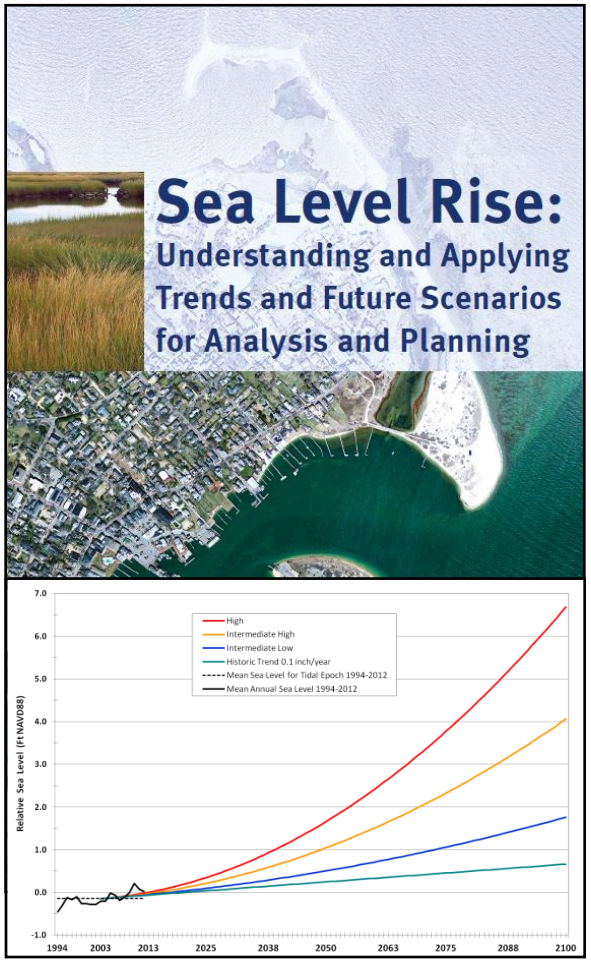
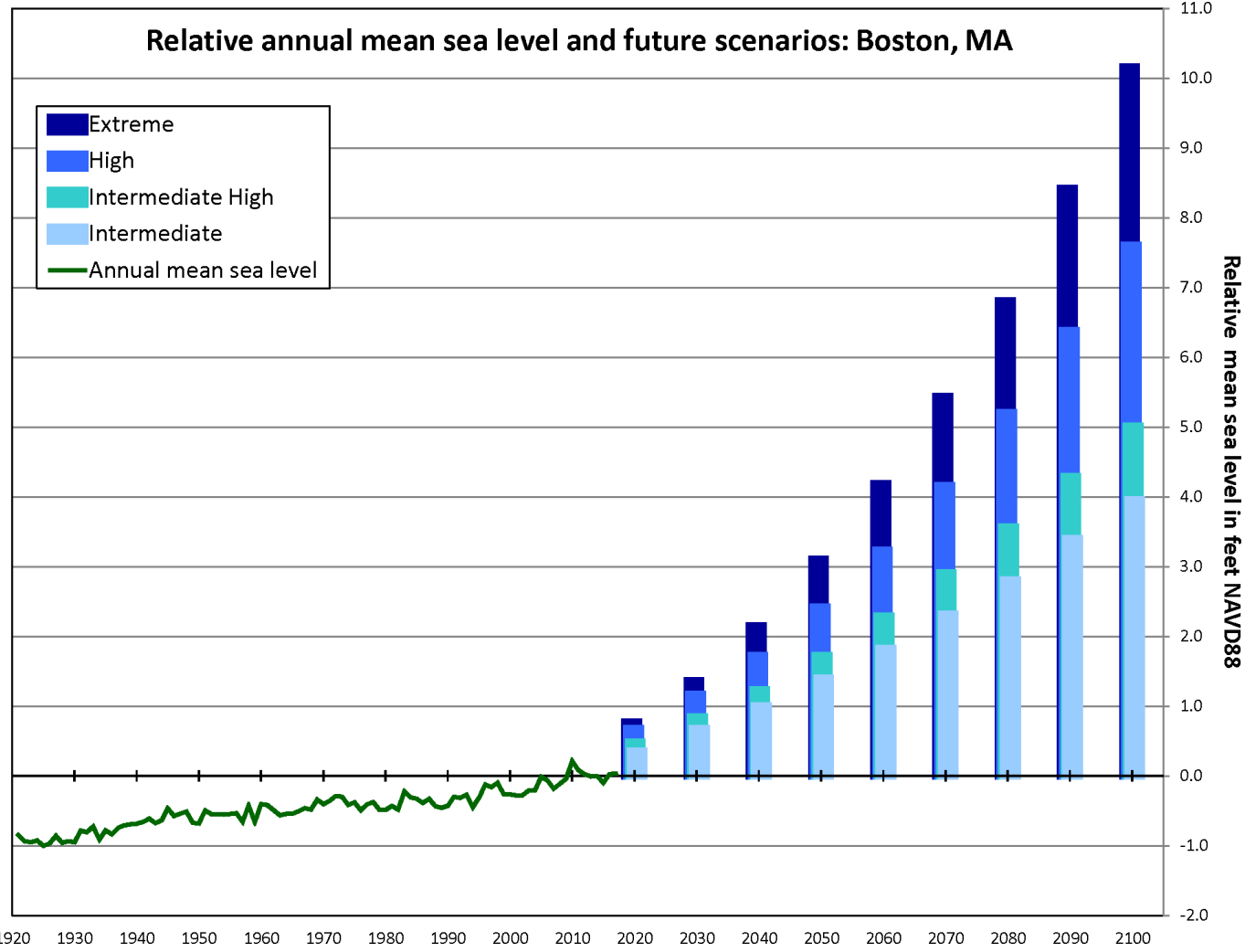


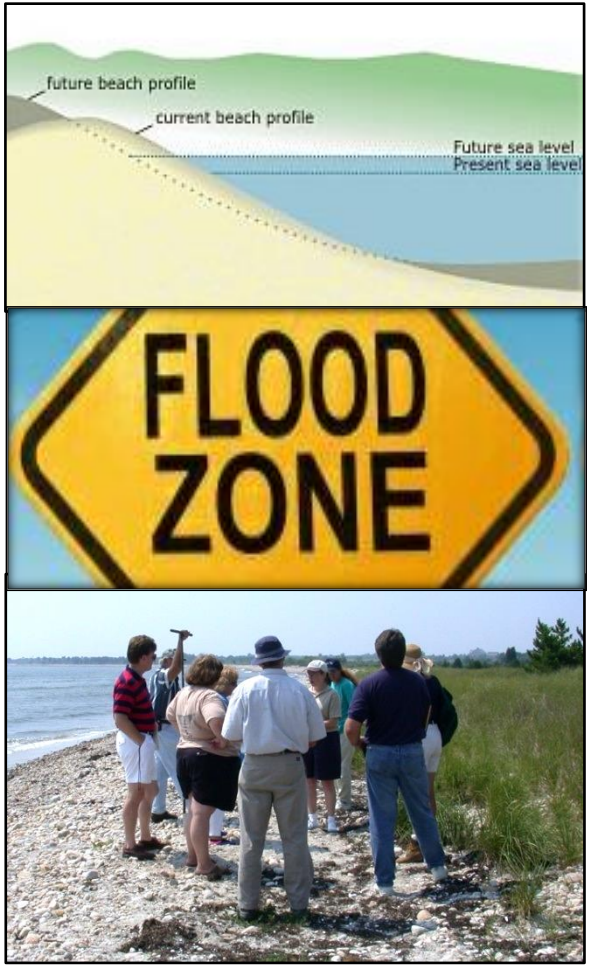
CZM sea level rise guidance

- Provide straight forward guidance on understanding sea level rise
- Background information on local and global sea level rise trends
- Summarizes best available sea level rise projections
- Scenarios for local stations
- Understanding risk and vulnerability
- 2018 update to reflect state of science

- Climate impact down-scaling work done by NE CSC and UMass 2017
- Probabilistic assessment of future relative SLR (DeConto and Kopp, 2017)
- Updated SLR projections for MA (4 stations)



NE CSC Northeast Climate Science Center



Training and outreach

- Workshops and webinars to improve understanding and application of maps and information; introduce new tools:
  - Understanding and interpreting flood and storm surge
  - Mapping future coastal inundation with latest sea level rise projections, elevation data, and other variables
  - Local forums for exploring and discussing adaptation options, best practices, case studies, and community plans

Living shorelines in NE

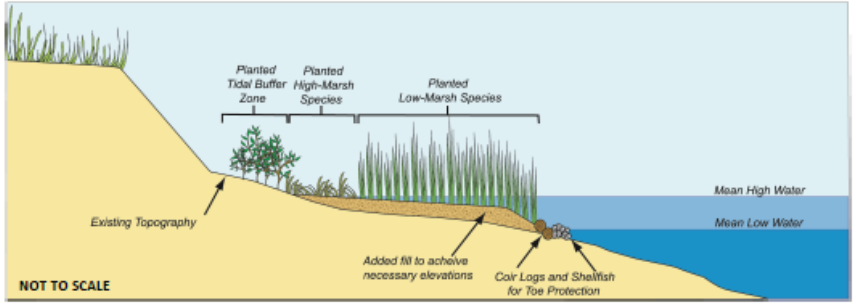
- New England coastal programs and The Nature Conservancy
- *State of the Practice* report
- Fact sheets: Benefits, siting and design considerations, case studies
  - Dunes – Natural & Engineered Core
  - Beach Nourishment
  - Coastal Bank – Natural & Engineered Core
  - Natural Marsh Creation/Enhancement
  - Living Breakwaters

Marsh Creation/Enhancement w/Toe Protection

Marsh vegetation that is planted along the shoreline often benefits from toe protection to assist with marsh stabilization. Toe protection materials may include natural fiber rolls, shell bags or, in some cases, stone. The toe protection may also allow the design to achieve the appropriate grade in lieu of seaward fill, thereby decreasing the project footprint.

Objectives: dissipates wave energy, habitat creation, shoreline stabilization

Design Schematics



Case Study

North Mill Pond, Portsmouth, NH

This project involved restoration of low and high marsh along North Mill Pond, with about half of the area consisting of new marsh creation, and the other half of the area consisting of restoration of degraded low and high marsh through sediment addition (thin layer deposition).

North Mill Pond Marsh Restoration, Portsmouth, NH
Photo courtesy of David Burdick (UNH)

Project Proponent	City of Portsmouth, Stantec (wetlands consultant), UNH (assisted plan development)
Status	Construction complete May 2016. Beginning year two of monitoring in 2017.
Permitting Insights	NHDES and USACOE permits needed for drainage outfall into pond. Project impacted 600 sf of coastal wetland. Salt marsh restoration was compensatory mitigation.
Construction Notes	Imported fill to raise 12,060 sf to suitable elevation for salt marsh (low marsh); planted 3,055 sf of high marsh area. Created micro-topography and interior drainage channels. 12-in diameter coir logs staked at seaward edge of marsh to stabilize toe. Placed large boulders to break-up winter ice sheets.
Maintenance Issues	Long term monitoring and maintenance efforts are scheduled. Survival of low marsh plants is good; survival of high marsh salt hay is fair to poor. Survived 2016-2017 winter well.
Final Cost	$60,000 (construction, monitoring & maintenance)
Challenges	Construction did not have a provision for within plot drainage; many plants were washed out by runoff gullies in the first year. More time needed for filled sediment to settle before planting.

Design Overview

Materials	Native marsh plants appropriate for salinity and site conditions. Plugs of marsh grass can be planted to augment bare areas.[11] Sediment may be necessary if area needs to be filled to obtain appropriate elevations. Toe protection materials may include natural fiber rolls, oyster/mussel shells bags, or in some cases, stone. Filter cloth placed prior to added fill and/or sill materials.[16] Bird exclusion fence to avoid predation while plants develop.[16]
Habitat Components	Salt marsh; Tidal buffer landward of the salt marsh; Coastal beach; Mud flat.
Durability and Maintenance	Plants that are removed or die during the early stages of growth must be replaced immediately to ensure the undisturbed growth of the remaining plants. The removal of debris and selective pruning of trees is also a good maintenance practice to ensure that sunlight reaches plants. After significant growth has occurred only periodic inspections may be necessary. Protection measures, such as fencing, can keep water-fowl from eating the young plants. Toe protection materials should also be replaced or re-installed if they are moved by a storm.[6] Coir logs must be securely anchored to prevent wave and tidal current-induced movement.[11] Ongoing maintenance of invasive species and runoff issues will be important to the long-term success of the project.[10]
Design Life	It is important to recognize that design life may be shorter in the future given changes in sedimentation rates, accelerating sea-level rise and other climate change impacts.
Ecological Services Provided	Increases water infiltration, uptake of nutrients, filtration, denitrification and sediment retention.[2,3] The extensive root systems of marsh vegetation help to retain the existing soil, thus reducing erosion while plant stems attenuate wave energy.[11] Marshes provide habitat for many species of plants and animals, and maintain the aquatic/terrestrial interface.[2] Sill mitigates erosive waves and stabilizes shoreline.[10] Marine animals can access the marsh through gaps in the sill.[12] Marshes also provide better water quality, recreation and education opportunities, and carbon sequestration (blue carbon).[12]
Unique Adaptations to NE Challenges (e.g. ice, winter storms, cold temps)	Including roughened surfaces, such as logs, stones or emergent vegetation can break up ice sheets.[4,10] Fringing marsh projects will respond better to ice if designed with gentler slopes (6:1-10:1) and by incorporating shrubs.[9,13] Planting in the spring will allow vegetation to become established before it has to withstand ice.[8] Hardy, salt-tolerant shrubs are well-suited shorelines that are affected by ice.[13] Need to consider where in the tidal range oysters will be placed if they're used: too high may result in freezing.

Marsh Creation/Enhancement w/Toe Protection

A toe protection structure holds the toe of an existing, enhanced or created marsh platform in place, and provides additional protection against shoreline erosion. A gapped approach to the toe protection structure allows habitat connectivity, and greater tidal exchange. Toe protection is particularly important where there is higher wave activity or threat of boat wakes.

Marsh Enhancement w/Coir Toe, Chatham, MA
Photo courtesy of Wilkinson Ecological Design

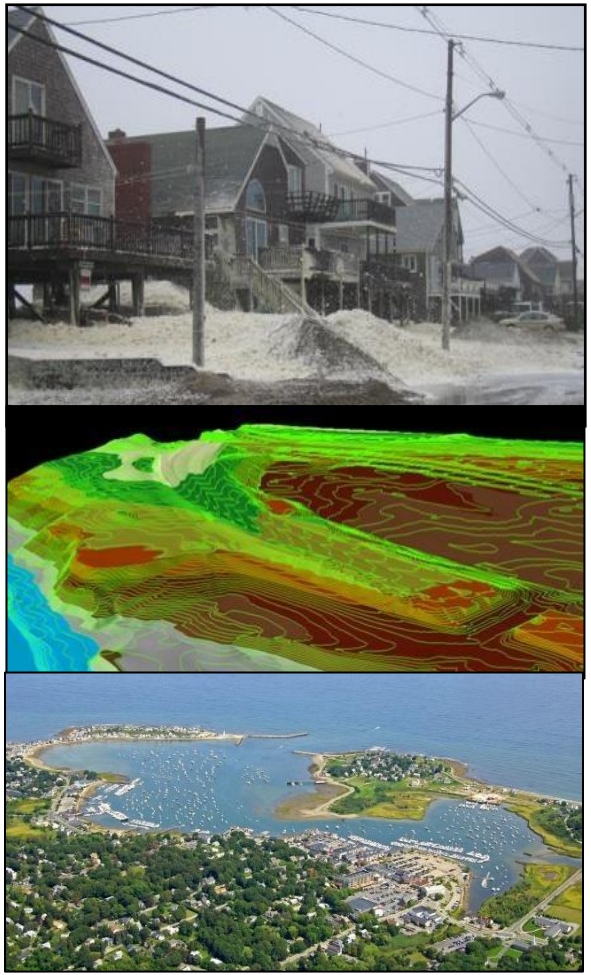
Regulatory and Review Agencies

Maine	Municipal Shoreland Zoning, Municipal Floodplain, ME Dept. of Environmental Protection, ME Land Use Planning Commission, ME Coastal Program, ME Department of Marine Resources, ME Department of Inland Fisheries and Wildlife, ME Geological Survey, and ME Submerged Lands Program.
New Hampshire	Local Conservation Commission, NH Natural Heritage Bureau, NH Department of Environmental Services (Wetlands Bureau, Shoreland Program, and Coastal Program), and NH Fish & Game Department.
Massachusetts	Local Conservation Commission, MA Dept. of Environmental Protection (Waterways and Water Quality), MA Division of Fisheries and Wildlife (Natural Heritage and Endangered Species Program), MA Environmental Policy Act, and MA Office of Coastal Zone Management.
Rhode Island	Coastal Resources Management Program, and RI Dept. of Environmental Management.
Connecticut	Local Planning and Zoning Commission, and CT Department of Energy and Environmental Protection.
Federal (for all states)	U.S. Army Corps of Engineers, National Marine Fisheries Service, U.S. Environmental Protection Agency, and U.S. Fish and Wildlife Service.

Siting Characteristics and Design Considerations

Selection Characteristics	Detail
ES Energy State	Moderate. A sill may be necessary in medium energy sites (2-5 foot waves, moderate currents and storm surge).[3,6]
EE Existing Environmental Resources	Coastal beach; mud flat; salt marsh
SR Nearby Sensitive Resources	Endangered and threatened species. If the project is proposed in or adjacent to habitat for protected wildlife species or horseshoe crab spawning areas, there may be limitations on the time of year for construction.[1] Shellfish beds and essential fish habitats will restrict where a marsh can be extended. Construction may produce short term habitat impacts, but in the long term, the marsh area should provide enhanced wildlife and fisheries habitat.
TR Tidal Range	Low to moderate. Sills are more suited to sites with a small to moderate tidal range, and are intended to be low-crested structures with a freeboard of between 0 and 1 ft above MHW.[7,11,16] However, shellfish sills should have a crest height at or near MLW since oysters and mussels can only remain out of the water for between 2 and 6 hours depending on the weather conditions.[7]
EL Elevation	MLW to MHW; Above MHW. For low marsh, the lowest grade should be MTL and extend up to MHW. High marsh plantings should extend between MHW and MHHW.[3] Tidal buffer should be planted above highest observable tide.
IS Intertidal Slope	Moderate. With slopes between 5:1 and 3:1 (base:height), sills should be added to the toe of the marsh.[3]
BS Bathymetric Slope	Flat to moderate
ER Erosion	Low to moderate

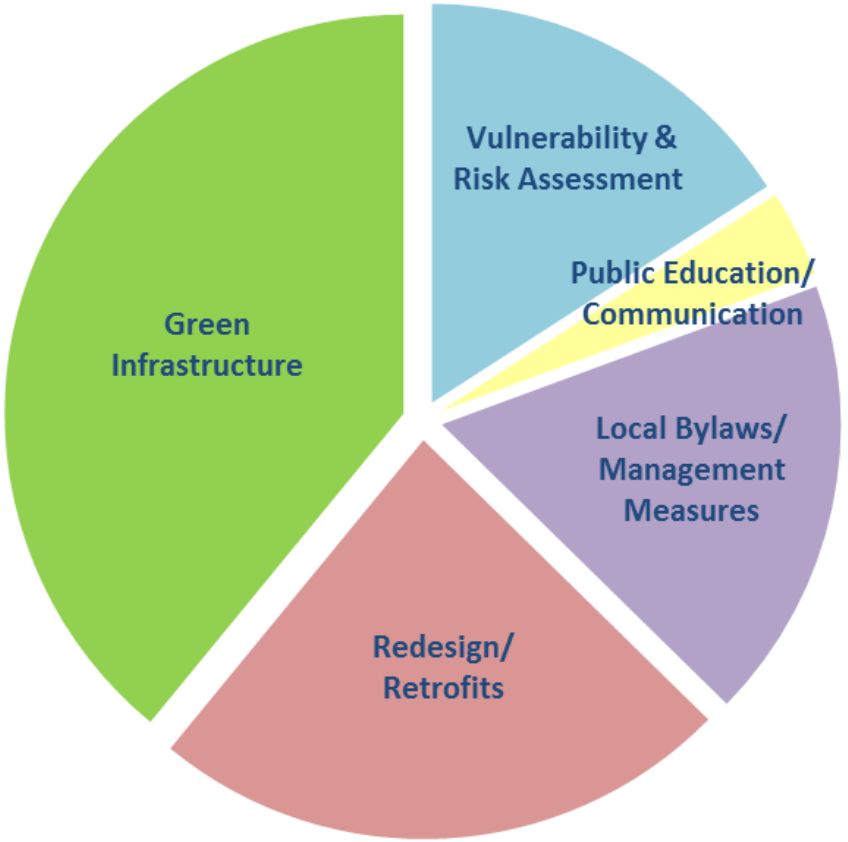
Other Characteristics	Detail
Boat Traffic	If boat wakes are expected to be the dominant force the sill should be designed accordingly.[7]
Ice Sensitivity	Gentle slopes and intermixed shrubs will handle ice the best.[8] Plant in the spring to allow plants to become established well before ice becomes a concern.[8]
Climate Vulnerability	If implemented carefully, this design can allow for inland migration. Planting higher, outside of the normal elevation range for the marsh grasses, may be useful in anticipation of sea level rise. It is important to recognize the uncertainty in future elevations. The effectiveness of a sill will be reduced over time as sea level rise gradually reduces the freeboard of the structure.[7]
Surrounding Land Use	Existing structures on site, like seawalls, may force living shoreline projects to have a steeper slope than desirable. Seawalls will limit the inland migration potential of the salt marsh in the future. Steeper slopes leave little opportunity for wave energy dissipation.[13] Marshes require sunlight to thrive; trees must be pruned or removed to allow for at least four to six hours of sunlight a day;[6] this will increase vegetation growth.[11,15] Although it is possible to create a marsh on most shorelines, marsh creation is not recommended for sites where they are not a natural feature along comparable natural shorelines.[11]



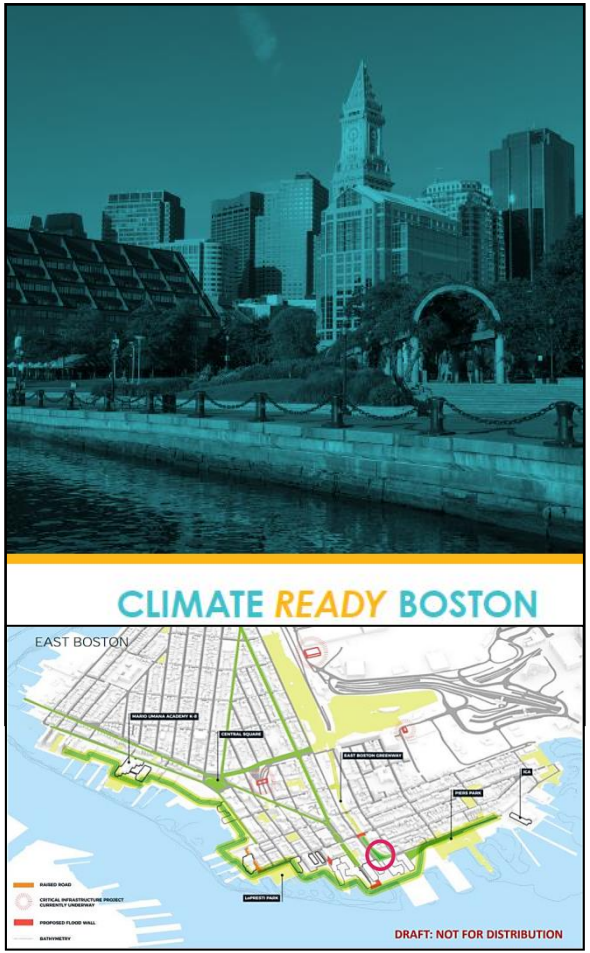
Coastal Resilience Grants

- Increase awareness and understanding of climate impacts
- Map and evaluate vulnerable facilities, infrastructure, and natural resources
- Develop community-based resilience plans, ordinances, bylaws, standards
- Redesign or retrofit vulnerable public facilities and infrastructure
- Implement nature-based (or green infrastructure) approaches to enhance natural resources and provide storm damage protection

Coastal Resilience Grants (2015-2018)

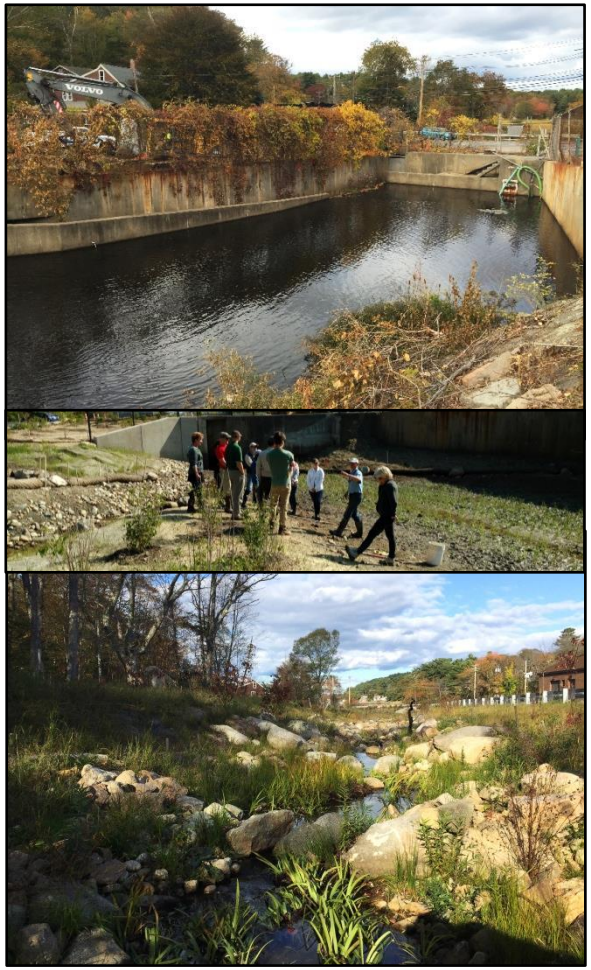


- 119 proposals
- 67 awards
- 43 communities
- $9.1M state funds
- $4.3M in local match



Boston

- Projects: Climate Ready Boston; Priority Flood Mitigation in East Boston and Charlestown
- Review and develop consensus on local climate change projections
- Identify vulnerabilities, characterize potential impacts, develop strategies
- Coastal resilience solutions for East Boston and Charlestown:
  - Coastal protections for flood risk
  - Expand use of green infrastructure



Gloucester

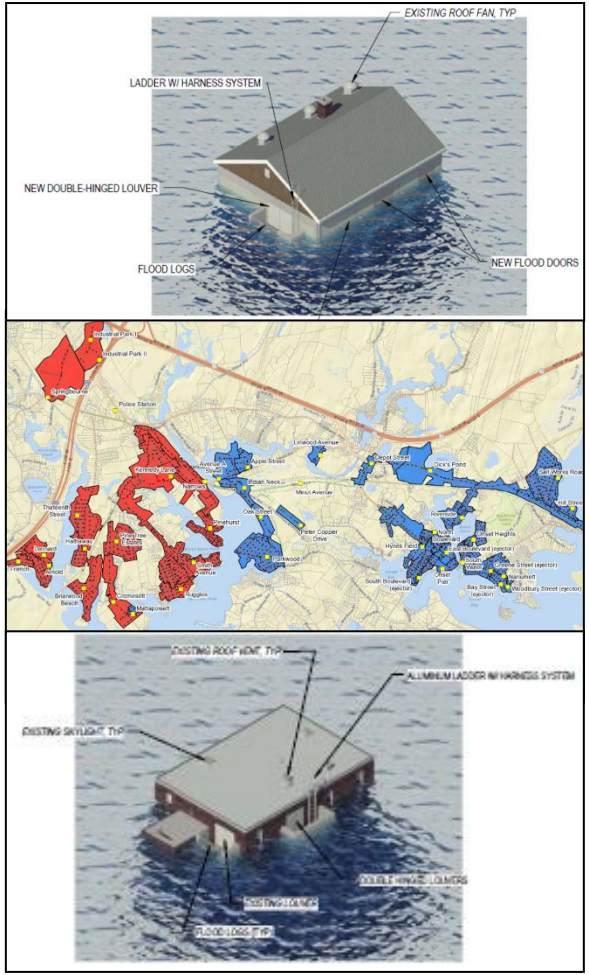
- Project: Little River floodplain and habitat restoration
- Former concrete channel, flood-prone
- Re-establish coastal floodplain, bioengineering techniques
- Flood and storm damage protection
- Restored freshwater and salt marsh wetlands; riparian enhancements
- Large group of partners; cost-sharing and leveraging

Chilmark

- Project: Squibnocket beach restoration
- Managed relocation and nature-based solutions
- Severe storms impact roadway, lot
- Remove rock revetment and asphalt parking lot
- Relocate road onto elevated causeway
- Beach and dune nourishment with harbor dredging, planting
- Town easements, legal challenges

Scituate

- Project: Roadway elevation and dune nourishment
- North Humarock area: ~$6.7 M in FEMA claims last 20 years
- Flooding and significant volumes of sand, gravel, and cobble over-wash after severe storms
- Highest priority area for adaptation
- Elevate Central Avenue above 1% BFE,
- Beach and dune nourishment

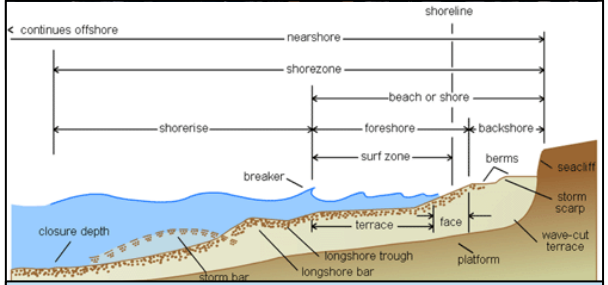


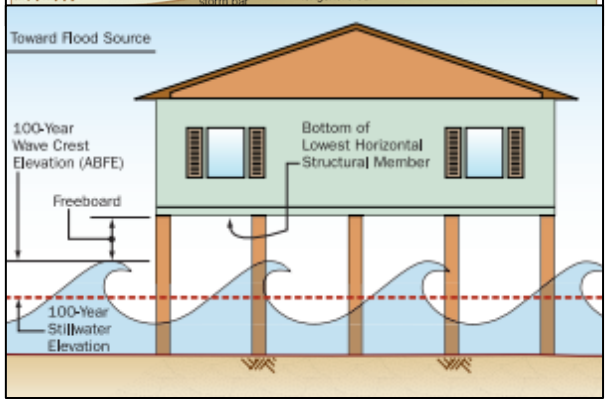
Wareham

- Project: Coastal Resilience Improvements for 3 Priority Pump Stations
- Builds on vulnerability assessment work under prior grant
- 3 most critical pump stations subject to flood and sea level rise inundation
- Design, engineering plans and specs
- Retrofit work account for SLR:
  - 2040 design life mechanical
  - 2070 design life structural

Brewster

- Project: Relocation of Breakwater Beach landing
- Storm damage and erosion have impacted Brewster's town landings and beaches
- Remove pavement, relocate and elevate lot
- Restore beach and dune, vegetated bioretention swale
- Importance of communication and local consensus building process





Next steps….

- Resources
  - Governor’s Environmental Bond Bill and 5-year Capital Investment Plan include significant increases for resilience work
- New and enhanced tools
  - Coastal erosion forecast model – USGS Woods Hole Science Center
  - Continued and new work on regional wave/sediment transport modeling
- Policies
  - Coastal A Zone building code standards
  - Coastal buy-back provisions
  - No/low interest loans for elevating buildings

Thank you

MASSACHUSETTS OFFICE OF

COASTAL ZONE MANAGEMENT