The Future of Marblehead Harbor:

Climate Adaptation: Themes and Concepts

Town of Marblehead, MA

Kirk F. Bosma, P.E.
kbosma@woodsholegroup.com
State Street Landing and Harbormaster
Marblehead Municipal Light Department
Ocean Ave. Causeway and Devereaux Beach

Previous Discussion:
https://vimeo.com/393491717

Sea Level Rise Projections:
Align with State Standards in terms of both SLR and Storm Conditions

Focus Areas:

• Little Harbor and Fort Beach
• State Street Landing and Harbormaster
• Marblehead Municipal Light Dept.
• Ocean Ave. Causeway; Riverhead and Devereaux Beach
Marblehead Harbor Conceptual Adaptations

What they are...
- Identification of critical assets and locations at risk
- Conceptual options and ideas for planning purposes
- Flexible and adaptive
- Determination on when actions may need to be taken
- Education, dialogue starter, and expand possibilities
- Individual elements that can be assembled in different ways

What they are NOT...
- A final recommendation on how to proceed
- Design plans

What they Ignore...
- Present day permitting regulations
- Public and private property restrictions
<table>
<thead>
<tr>
<th>PURPOSE</th>
<th>GOALS</th>
<th>SCENARIOS &amp; STRATEGIES (THEMES)</th>
<th>ADAPTATION ACTION EXAMPLES</th>
</tr>
</thead>
</table>
| Develop short-term, mid-term, and long-term strategies to increase the coastal resiliency of at risk areas around Marblehead Harbor. | Preserve, restore, and enhance coastal and marine ecosystems to improve coastal resiliency and promote healthy ecosystem functions. | **NATURAL RESOURCES**  
Emphasize ecosystem health and resilience | • Beach/dune nourishment  
• Provide salt marsh migration corridors and/expand salt marsh areas  
• Integration of nature-based features and living shoreline approaches  
• Living breakwaters/reefs |
| Improve resiliency of infrastructure along coastline to protect current use and operations. | **PROTECTION**  
Emphasize protection and maintenance of infrastructure and current use | • Improve existing seawalls  
• Construct new coastal protection structures  
• Elevate roadways/causeways  
• Protect/elevate homes  
• Floodproof and/or elevate critical infrastructure (e.g., lift stations, pump stations, etc.) and buildings  
• Wave attenuation features |
| Balance the use, access, and enjoyment of coastal resources and public infrastructure, while accounting for geologic and ecosystem shifts in response to sea level rise. | **TRANSFORM**  
Emphasize a balance of uses now with a vision of potential transformation of future flood prone areas. | • Road abandonment  
• Usage swapping  
• Relocation of facilities and parking  
• Retreat and buyouts  
• Adopt bylaws that limit future development in areas  
• Targeted and focused areas of living with water and allowing seawater advance |
Adaptation Definitions

- Building Level Adaptations
- Modular Seawalls
- Terraced Protection
- Living with water
### Flexible, Phased Adaptation and Implementation Plan

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>Adaptation Measures</th>
</tr>
</thead>
</table>
| **Near-Term** (Now - 2030) | - Evaluate Risk of Gas House Lane Capped Area  
- Enhance and expand Gas House Beach  
- Initial Planning for Building Level Adaptations  
- Design and Permit Modular, Vinyl, and Terraced Seawalls  
- Protect Pump Station |
| **Mid-Term** (2030 - 2070) | - Construct Phase I of Modular, Terraced, and Vinyl Seawalls  
- Design and Build Groundwater Adaptation for Gas House Lane Capped Area  
- Implement Building Level Adaptations  
- Construct New Floating Dock Systems  
- Design and Permit Elevated Boardwalk |
| **Long-Term** (2070 +) | - Abandon Gas House and Shantee Beaches  
- Construct Phase II of Modular Seawalls  
- Install Elevated Boardwalk to Gerry Island |
Building Level Adaptations (Storm proofing)

Intertidal/Offshore Boulder Field

Emphasize ecosystem health and resilience

Flexible, Phased Adaptation and Implementation Plan

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>Adaptation Measures</th>
</tr>
</thead>
</table>
| Near-Term (Now - 2030) | - Evaluate Risk of Gashouse Lane Capped Area  
                         - Beach and Dune Creation and Enhancement  
                         - Seawall Raising, Repairs, and Toe Protection Enhancements  
                         - Initialize Design and Permitting for Perched Living Shoreline and Intertidal/Offshore Boulder Field  
                         - Initial Planning for Building Level Adaptations  
                         - Protect Pump Station |
| Mid-Term (2030 - 2070) | - Design and Permit Elevated Boardwalk  
                         - Design and Build Groundwater Adaptation for Gas House Lane Capped Area  
                         - Construct Fort Beach Adaptations (perched Living shoreline and offshore boulder field)  
                         - Implement Building Level Adaptations  
                         - Planning for Marsh Creation and Living with Water Zone; Phase I of Marsh Creation and Living with Water Zone |
| Long-Term (2070 +)    | - Install Elevated Boardwalk to Gerry Island  
                         - Phase II of Marsh Creation and Living with Water Zone |
Emphasize a balance of uses now with a vision of potential transformation of future flood prone areas.

### Flexible, Phased Adaptation and Implementation Plan

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>Adaptation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Near-Term</strong>&lt;br&gt;(Now - 2030)</td>
<td>- Evaluate Risk of Gas House Lane Capped Area&lt;br&gt;- Design and Permit Modular Seawall&lt;br&gt;- Initial Planning for Building Level Adaptations&lt;br&gt;- Protect Pump Station</td>
</tr>
<tr>
<td><strong>Mid-Term</strong>&lt;br&gt;(2030 - 2070)</td>
<td>- Construct Phase I of Modular Seawall&lt;br&gt;- Design and Build Groundwater Adaptation for Gas House Lane Capper Area&lt;br&gt;- Implement Building Level Adaptations&lt;br&gt;- Design and Permit Elevated Boardwalks&lt;br&gt;- Planning for Waterfront Park and Islands; Phase I of Waterfront Park (Berm and buyouts)</td>
</tr>
<tr>
<td><strong>Long-Term</strong>&lt;br&gt;(2070 +)</td>
<td>- Construct Phase II of Modular Seawall&lt;br&gt;- Install Elevated Boardwalk to Gerry Island and new Island&lt;br&gt;- Construct offshore Islands&lt;br&gt;- Phase II of Waterfront Park and Berm (water and beach)</td>
</tr>
</tbody>
</table>
Building Level Adaptations
Perched Living Shoreline and Offshore Boulder Field
Discussion / Questions
State Street Landing
**Emphasize protection and maintenance of infrastructure and current use**

**Flexible, Phased Adaptation and Implementation Plan**

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>Adaptation Measures</th>
</tr>
</thead>
</table>
| **Near-Term**        | ▪ Evaluate geotechnical and sub-surface conditions at seawall and bulkheads  
                        ▪ Planning for seawall/bulkhead improvement and repairs  
                        ▪ Construction of new concrete floating dock system with wave attenuation  
                        ▪ Improve Fishing Access                                                                                                                    |
| (Now - 2030)         |                                                                                                                                                                                                      |
| **Mid-Term**         | ▪ Repair subsurface conditions under parking and State St. Landing areas.  
                        ▪ Design and construct new modular industrial seawall and floating dock systems                                                              |
| (2030 - 2070)        |                                                                                                                                                                                                      |
| **Long-Term**        | ▪ Add modular sections to seawall and bulkhead systems to provide added protection under climate change conditions                                                                                 |
| (2070 +)             |                                                                                                                                                                                                      |
### Flexible, Phased Adaptation and Implementation Plan

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>Adaptation Measures</th>
</tr>
</thead>
</table>
| **Near-Term**    | - Evaluate geotechnical and sub-surface conditions at seawall and bulkheads  
                    - Planning for seawall/bulkhead improvement and repairs and integration of open space  
                    - Construction of new concrete floating dock system with wave attenuation  
                    - Improve Fishing Access                                                                                                                                 |
| **Mid-Term**     | - Repair subsurface conditions under parking and State St. Landing areas.  
                    - Design and construct new modular industrial seawall and floating dock systems  
                    - Construction of open space and observation dock area  
                    - Design of berm around edge of park / open space                                                                                                                                 |
| **Long-Term**    | - Add modular sections to seawall and bulkhead systems to provide added protection under climate change conditions  
                    - Integration of berm to reduce elevated seawall in areas                                                                                                                                                         |
Emphasize a balance of uses now with a vision of potential transformation of future flood prone areas.

**Flexible, Phased Adaptation and Implementation Plan**

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>Adaptation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near-Term (Now - 2030)</td>
<td>- Evaluate geotechnical and sub-surface conditions at seawall and bulkheads</td>
</tr>
<tr>
<td></td>
<td>- Planning for seawall/bulkhead improvement and repairs and integration of expanded harbor</td>
</tr>
<tr>
<td></td>
<td>- Construction of new concrete floating dock system with wave attenuation</td>
</tr>
<tr>
<td></td>
<td>- Improve Fishing Access</td>
</tr>
<tr>
<td>Mid-Term (2030 - 2070)</td>
<td>- Repair subsurface conditions under parking and State St. Landing areas.</td>
</tr>
<tr>
<td></td>
<td>- Design and construct new modular industrial seawall and floating dock systems</td>
</tr>
<tr>
<td></td>
<td>- Construction of new expanded harbor area</td>
</tr>
<tr>
<td>Long-Term (2070 +)</td>
<td>- Add modular sections to seawall and bulkhead systems to provide added protection under climate change conditions</td>
</tr>
</tbody>
</table>
Discussion / Questions
Emphasize protection and maintenance of infrastructure and current use

**Flexible, Phased Adaptation and Implementation Plan**

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>Adaptation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Near-Term</strong></td>
<td>- Initial Planning for self-rising tide gate and Modular Seawall</td>
</tr>
<tr>
<td>(Now - 2030)</td>
<td>- Install self rising tide gate and Phase 1 of Modular Seawall</td>
</tr>
<tr>
<td><strong>Mid-Term</strong></td>
<td>- Construct Phase II of Modular Seawalls (sections)</td>
</tr>
<tr>
<td>(2030 - 2070)</td>
<td>- Install self rising tide gate</td>
</tr>
<tr>
<td><strong>Long-Term</strong></td>
<td>- Construct Phase III of Modular Seawalls (sections)</td>
</tr>
<tr>
<td>(2070 +)</td>
<td>- Abandon Boat Launch</td>
</tr>
</tbody>
</table>
Self Closing (Tide Gates)
Flood Barriers

https://youtu.be/KSa6ENvw1og
Emphasize ecosystem health and resilience

**Flexible, Phased Adaptation and Implementation Plan**

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>Adaptation Measures</th>
</tr>
</thead>
</table>
| Near-Term (Now - 2030) | - Initial Planning for Expanded Park and Modular Seawall  
- Abandon Boat Launch; Install Living Shoreline Element at Parker’s Boat Yard  
- Construct Phase I of Modular Seawall  
- Expanded Boat Access at Commercial St. |
| Mid-Term (2030 - 2070)  | - Construct Phase II of Modular Seawall  
- Construction of Expanded Park  
- Planning for Waterfront Berm addition to Park  
- Construct Improved Fishing Pier and Access |
| Long-Term (2070 +)    | - Construct Phase III of Modular Seawalls  
- Construction of Waterfront Berm |
Emphasize a balance of uses now with a vision of potential transformation of future flood prone areas.

**Flexible, Phased Adaptation and Implementation Plan**

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>Adaptation Measures</th>
</tr>
</thead>
</table>
| Near-Term (Now - 2030) | - Construct upper portion of terraced waterfront with plan for future expansion  
                          | - Develop design layout for entire waterfront                |
| Mid-Term (2030 - 2070) | - Construct waterfront terracing (expands into harbor)       |
| Long-Term (2070 +)     | - Modifications to terracing levels based on sea level rise   |
Discussion / Questions
Causeway and Beaches
Emphasize protection and maintenance of infrastructure and current use

- Salt Marsh Monitoring and Maintenance
- Tide Gate Control
- Floodproofing Pump Station
- Enhanced Beach and Dune System
- Use of Parapet Walls
- Raised Causeway
- Raised, Permeable Parking Area
TRANSFORM

New “Blue Water” Bridge and Approaches for Ocean Ave.

Deveraux Beach and area of old causeway allowed to naturally evolve

Enhanced Beach and Dune System

Park and Open Space

Salt Marsh

Floodproofing Pump Station

Open Water and Recreation

Salt Marsh expansion and enhancement

Raised, Permeable Parking Area

Deveraux Beach and area of old causeway allowed to naturally evolve

New “Blue Water” Bridge and Approaches for Ocean Ave.

Enhanced Beach and Dune System

Park and Open Space

Salt Marsh

Floodproofing Pump Station

Open Water and Recreation

Salt Marsh expansion and enhancement

Raised, Permeable Parking Area

Deveraux Beach and area of old causeway allowed to naturally evolve

New “Blue Water” Bridge and Approaches for Ocean Ave.

Enhanced Beach and Dune System

Park and Open Space

Salt Marsh

Floodproofing Pump Station

Open Water and Recreation

Salt Marsh expansion and enhancement

Raised, Permeable Parking Area

Deveraux Beach and area of old causeway allowed to naturally evolve

New “Blue Water” Bridge and Approaches for Ocean Ave.

Enhanced Beach and Dune System

Park and Open Space

Salt Marsh

Floodproofing Pump Station

Open Water and Recreation

Salt Marsh expansion and enhancement

Raised, Permeable Parking Area

Deveraux Beach and area of old causeway allowed to naturally evolve

New “Blue Water” Bridge and Approaches for Ocean Ave.

Enhanced Beach and Dune System

Park and Open Space

Salt Marsh

Floodproofing Pump Station

Open Water and Recreation

Salt Marsh expansion and enhancement

Raised, Permeable Parking Area

Deveraux Beach and area of old causeway allowed to naturally evolve

New “Blue Water” Bridge and Approaches for Ocean Ave.

Enhanced Beach and Dune System

Park and Open Space

Salt Marsh

Floodproofing Pump Station

Open Water and Recreation

Salt Marsh expansion and enhancement

Raised, Permeable Parking Area

Deveraux Beach and area of old causeway allowed to naturally evolve

New “Blue Water” Bridge and Approaches for Ocean Ave.
## Causeway and Beaches

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>Adaptation Measures</th>
</tr>
</thead>
</table>
| Near-Term (Now - 2030) | ▪ Consider Flood Management Controls for Goldthwait Reservation  
▪ Monitoring Program for Goldthwait Reservation  
▪ Begin Planning for Beach and Dune Restoration Program |
| Mid-Term (2030 - 2070) | ▪ Install Tide Gate Measures or Open channel for Entrance to Goldthwait Reservation  
▪ Design and Construct Floodproofing measures for Pump Station  
▪ Begin Planning for Causeway Raising or Bridge Conversion  
▪ Planning for Beach Parking Raising and Connection  
▪ Phase I Marsh Creation and Expansion, Open water Creation |
| Long-Term (2070 +) | ▪ Raise Causeway and/or Transform to Bridge  
▪ Phase II Marsh Creation and Expansion, Open water Creation |
Discussion / Questions
NEXT STEPS...An Example
DYNAMIC ADAPTION PATHWAYS FOR SURF DRIVE AREA FALMOUTH, MA

KEY:
- **Change in Direction** (can change to a different adaptation action)
- **Adaptation Tipping Point** (Terminal – Adaptation no longer meets goals)
- Natural Resource theme focused pathway
- Connection theme focused pathway
- Protection theme focused pathway
- Managed Retreat theme focused pathway
- Preferred Path

Change in action function
## DYNAMIC ADAPTION PATHWAYS
### SURF DRIVE

### Pathway Scorecard

<table>
<thead>
<tr>
<th>Path Actions</th>
<th>Relative Costs</th>
<th>Target Effects</th>
<th>Side Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managed Retreat</td>
<td>+</td>
<td>Balances present uses with increased costs and risks in the future through a multi-phase retreat plan</td>
<td>Loss of Homes&lt;br&gt;No Connection via Surf Drive&lt;br&gt;Loss of Accessible Beach</td>
</tr>
<tr>
<td>Protection</td>
<td>+</td>
<td>Protects operational capacity of existing Infrastructure and features</td>
<td>Loss of Accessible Beach&lt;br&gt;Aesthetics/Visuals</td>
</tr>
<tr>
<td>Natural Resources</td>
<td>++</td>
<td>Preserves and enhances coastal and marine ecosystem functions</td>
<td>Loss of Homes&lt;br&gt;No Connection via Surf Drive&lt;br&gt;Loss of Accessible Beach</td>
</tr>
<tr>
<td>Connection</td>
<td>+</td>
<td>Maintains important public access, utility Connections and transportation corridors</td>
<td>Loss of Homes&lt;br&gt;Loss of Homes&lt;br&gt;No Connection via Surf Drive&lt;br&gt;Loss of Accessible Beach</td>
</tr>
<tr>
<td>Preferred</td>
<td>++</td>
<td>Balances present uses w/increased costs and risks in the future through a multi-phase retreat plan, while enhancing ecosystems</td>
<td>Loss of Homes&lt;br&gt;No Connection via Surf Drive&lt;br&gt;Loss of Accessible Beach&lt;br&gt;Aesthetics/Visuals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improved maintenance for short-term uses w/a long-term focus on ecosystem restoration</td>
<td>Loss of Homes&lt;br&gt;No Connection via Surf Drive&lt;br&gt;Loss of Accessible Beach&lt;br&gt;Aesthetics/Visuals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coastal habitat restoration in the short term, w/protection of existing infrastructure in the long-term</td>
<td>Loss of Homes&lt;br&gt;No Connection via Surf Drive&lt;br&gt;Loss of Accessible Beach&lt;br&gt;Aesthetics/Visuals</td>
</tr>
</tbody>
</table>
Surf Drive Bathhouse and Parking Actions

Sea Level Rise (ft)

High SLR

2020

2030

2050

2070

2100

1

2

3

4

5

6

7

8

2020

2030

2050

2070

2100

Current Actions

Remove Bathhouse/Parking

Beach & Dune Nourishment (Storms) w/Walkways

Transition to Portable Facilities (w/Beach)

Elevate/Floodproof

Protective Walls

Beach & Dune Nourishment (For Daily Access)

Transition to Shell Parking Lot and Portable Facilities (w/Beach)

Tipping Point if floodproofing. Elevation extends action.
**Pathway Scorecard**

<table>
<thead>
<tr>
<th>Path Actions</th>
<th>Relative Costs</th>
<th>Target Effects</th>
<th>Side Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Managed Retreat</td>
<td>+</td>
<td>Balances present uses with increased costs and risks in the future through a multi-phase retreat plan</td>
<td>No Bathhouse/Parking Loss of Accessible Beach</td>
</tr>
<tr>
<td>2. Protection</td>
<td>+++</td>
<td>Protects operational capacity of existing infrastructure and features into long-term</td>
<td>Loss of Accessible Beach if not coupled with Beach Nourishment</td>
</tr>
<tr>
<td>3. Natural Resources</td>
<td>++</td>
<td>Preserves and enhances coastal and marine ecosystem functions</td>
<td>No Permanent Facilities</td>
</tr>
<tr>
<td>4. Connection</td>
<td>++</td>
<td>Maintains public access to the beach</td>
<td>Loss of Accessible Beach No Permanent Facilities</td>
</tr>
<tr>
<td>5. Preferred</td>
<td>++</td>
<td>Preserves and enhances coastal and marine ecosystem functions, while preserving access</td>
<td>No Permanent Facilities</td>
</tr>
</tbody>
</table>
Next Steps – Community Engagement

• You have been given lots to think about.....

• Barbara Warren will continue holding online stakeholder meetings.
  
  If you want to share your thoughts or join a meeting, call her at 978-741-7900 or email – barbara.warren@salemsound.org.

• Final Presentation in September
  
  Public/Private Partnerships in Marblehead
  to improve community resilience and enable coordination and collaboration

  ▪ Linnean Solutions and Built Environment Coalition
  ▪ September 15th at 7:00pm