Chatham East-Facing Shoreline: Coastal Resiliency and Management Assessment

June 27, 2019





# **Project Overview**

- **1. Historical Analysis to Inform Future Conditions** 
  - Cyclical morphology of barrier beach/inlet system
- 2. Future Configuration
  - "2045" Inlets

# 3. Comparing Past/Present/Future Conditions

- Daily and storm conditions
- Hydrodynamics, tidal flows, wave patterns
- Reviews results presented in Feb public meeting

# 4. Chatham Mainland Assessment Areas

Developed based on 2018 and projected 2045 inlet configurations and management issues

# 5. Management Strategies by Assessment Area

Focus on alternatives that improve coastal resiliency and are adaptable to the rapid geomorphic changes



### **Barrier Island Systems: A Primer**

- Barrier Islands develop parallel to mainland
- Separated from land by a small body of water
- Connected to the ocean via tidal channels/inlets



# **Documented Cyclical Morphological Patterns**



#### **Patterns:**

- 1. "Boomerang" shape of barrier remnants
- 2. Westward migration of barrier remnants and welding onto mainland
- Southerly Elongation of North Beach and North Beach Island

# The Estuary in 1910

# Aunt Lydia's Cove and the initial formation of Tern Island

**Connection between Stage** and Chatham Harbors



### **Previous Projections**



From Giese et al 2009

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# **Previous Projections**



courtesy of the Center for Coastal Studies

### Bathymetry Evolution 2007 to 2018: Setting Up Cycle Similar to the One Initiated in 1846



**1. Historical Analysis to Inform Future Conditions** 





Inlet Evolution: 2007 to 2018 Westward Migration and Southerly Elongation of North Beach Island

### Barrier Beach Evolution: 2007 to 2018



2007

2018

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### Barrier Beach Evolution: 2007 to 2018



2007

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Inlet Evolution: 2007 to 2018



North Inlet 2018



South Inlet 2018

### **Future Configuration: 2045 Inlets**



### Future Configuration: Historic Analysis of Charts



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**3.** Comparing Past/Present/Future Conditions

# Model Development: Tidal Data Collection and Adjustment





2045 Tides were adjusted for Sea Level Rise of 0.5 feet from present 3. Comparing Past/Present/Future Conditions

# Model Development: Bathymetry Data Collection



This could then be compared to the 2007 LiDAR data

# Model Development: Hydrodynamic Grid, Daily Conditions



**3.** Comparing Past/Present/Future Conditions

# Model Development: Wave Grid, Storm Conditions





### **Future Configuration**



### Analysis of Coastal Processes: 2007 Hydrodynamics



#### 2007 Modeled Velocity



### Analysis of Coastal Processes: 2018 Hydrodynamics



#### 2018 Modeled Velocity



### Analysis of Coastal Processes: 2045 Hydrodynamics



### 2045 Modeled Velocity



### Analysis of Coastal Processes: Comparing Ebb Flow at Same Model Timestep



### Analysis of Coastal Processes: Comparing Flood Flow at Same Model Timestep



Hydrodynamic Conditions: Compare by Location



**3. Comparing Past/Present/Future Conditions** 



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**3. Comparing Past/Present/Future Conditions** 



model hours

**3. Comparing Past/Present/Future Conditions** 



3. Comparing Past/Present/Future Conditions





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3. Comparing Past/Present/Future Conditions





**3. Comparing Past/Present/Future Conditions** 



Analysis of Coastal Processes: 2018 Storm Wave Patterns Video



Analysis of Coastal Processes: 2045 Storm Wave Patterns Video



3. Comparing Past/Present/Future Conditions

# Wave Heights during Storm Conditions during Incoming Tide





### **Current and Future Shoreline Management Concerns**

Assessment Area	Location	Current	Future to 2045
1	Minister's Point to Linnell Ln Beach	Severe	Moderate
2	Linnell Ln Beach to Thayer Ln	Moderate	Moderate to Severe
3	Thayer Ln to Chatham Lighthouse	Minimal	Minimal
4	Little Beach/Outermost Harbor	Severe	Severe
5	Quitnesset Barrier Beach to Morris Island	Moderate	Moderate to Severe
4. Assessment Areas



# Minister's Point to Linnell Lane Beach, Assessment Area 1



Linnell Lane Beach facing north, showing the low-lying overwash area, continuous revetment at Minister's Point, and eroded beach face and exposed marsh peat layer Existing Engineered Structures Assessment Area 1



4. Assessment Areas

Active Tidal Channel to Pleasant Bay Assessment Area 1



### Severe Flooding: Assessment Area 1



Storm Wave Heights: Assessment Area 1



Present: Severe 2040: Minimal

Management Strategy: Minister's Point to Linnell Lane Beach Assessment Area 1



Minister's Point Revetment

## **Assessment Area 1: Stabilize Revetment Toe**

<ul> <li>Pros</li> <li>Direct protection of dwellings on Minister's Point</li> </ul>	<ul> <li>Cons</li> <li>Potential increased scour due to tidal currents</li> <li>Cost</li> </ul>
<ul> <li>Challenges</li> <li>Potential regulatory concerns regarding seaward encroachment on resource areas, etc.</li> </ul>	

## **Assessment Area 1: Offshore Structures to Re-Direct Currents**

<ul> <li>Potential increased scour at other locations</li> <li>Cost</li> </ul>

### Challenges

 Likely significant regulatory concerns regarding encroachment on resource areas, potential impacts on other resources by re-directing currents, etc. 5. Management Strategies

Management Strategy: Minister's Point to Linnell Lane Beach Assessment Area 1



~32,000 cubic yards

# **Assessment Area 1: Linnell Lane Beach Nourishment**

Pros	Cons
<ul> <li>Prevent storm-induced overwash into salt marsh and Linnell Lane area</li> <li>Provide sediment supply to downdrift beaches</li> </ul>	<ul> <li>Increased sediment supply will make maintaining inlet to the salt marsh difficult (may require a culvert)</li> <li>Maintenance costs until North Inlet migrates further south</li> </ul>

### Challenges

• Need to maintain and/or improve salt marsh.



4. Assessment Areas



# Linnell Ln Beach to Thayer Ln, Assessment Area 2

Cow Yard Public Access, facing east at low tide, Tern Island and Flats visible in the distance.



Cow Yard Public Access, facing south at low tide, Fish Pier visible in distance.



Existing Engineered Structures Assessment Area 2



Wave

**Storm Wave Heights: Assessment Area 2** 





5. Management Strategies

Management Strategy: Linnell Lane Beach to Thayer Lane, Assessment Area 2



6' NAVD88 top 150' Wide Crest 2,700' long

~150,000 cubic yards



Tern Island Flats Nourishment Status Quo With N





## **Assessment Area 2: Tern Island Flats Nourishment**

Pros	Cons
<ul> <li>Reduce storm wave energy along shoreline until</li> </ul>	Cost (including maintenance)
North Inlet migrates further south	Will not provide complete protection of the shoreline
<ul> <li>Provide sediment supply to nearshore area</li> </ul>	during severe storm events

### Challenges

- Impacts to nearshore resource areas (fisheries concerns)
- Impacts to endangered species habitat on Tern Island (although could be a net benefit)

Management Strategy: Linnell Lane Beach to Thayer Lane, Assessment Area 2



- Series of temporary wooden groins constructed landward of existing MHW line
- Berm nourishment of upper beach to prevent overwash during moderate storms
- Anticipated construction sequence from north-to-south, as needed
- Removed when no longer needed

Management Strategy: Linnell Lane Beach to Thayer Lane, Assessment Area 2



Management Strategy: Linnell Lane Beach to Thayer Lane, Assessment Area 2



**Example Wood Groin** 

## **Assessment Area 2: Temporary Groins and Nourishment**

### Pros

- Direct protection to upland properties
- Provide sediment supply to downdrift shorelines (if designed properly)
- Temporary groins can be removed when no longer needed

#### Cons

- Will not provide complete protection of the shoreline during severe storm events
- Potential impacts to nearshore salt marsh resources

## Challenges

- Impacts to downdrift shorelines if groin cells are not kept filled
- Private property issues that can make a contiguous management approach problematic

4. Assessment Areas



## Thayer Lane to Chatham Lighthouse, Assessment Area 3

Looking north from Chatham

Lighthouse towards Watch Hill



#### Chatham Fish Pier, facing east

Existing Engineered Structures Assessment Area 3



- Much of shoreline is already protected by coastal engineering structures
- Many revetments were improved following the 1987 formation of South Inlet
- In recent years, storm damage to this area has been relatively minor

Conditions in 2045 Assessment Area 3





- Remnants of North Beach Island will continue to protect the shoreline
- Hydraulic separation of system will reduce tidal currents along much of the shoreline
- Based on existing and anticipated future conditions through 2040, no significant shore protection efforts likely will be needed

4. Assessment Areas



# Little Beach/Outermost Harbor, Assessment Area 4

Little Beach, low elevation marsh seaward of sandbag levee temporary fix, view facing east.



Little Beach with a temporary sand bag levee to help alleviate flooding



### Existing Engineered Structures Assessment Area 4



Severe Flooding Little Beach/Outermost Harbor, Assessment Area 4







**Recent Storms** 

Storm Surge at Outermost Harbor Marina reached over 7 feet NAVD twice in 2018



### Severe Flooding: Assessment Area 4



5. Management Strategies

Severe Flooding and Loss of Emergency Egress Little Beach/Outermost Harbor, Assessment Area 4



Storm Wave Heights and Wave Setup Assessment Area 4



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**5. Management Strategies** 

Management Strategy: Little Beach/Outermost Harbor, Assessment Area 4



1938 Aerial: Contiguous wide beach in area of Outermost Harbor Marina Management Strategy: Little Beach/Outermost Harbor, Assessment Area 4



#### **HMGP** Design

Management Strategy: Little Beach/Outermost Harbor, Assessment Area 4



Management Strategy: Little Beach/Outermost Harbor, Assessment Area 4



#### **Alternative Design**

## Assessment Area 4: Flood Barrier (Dune/Berm/Bulkhead)

### Pros

- Direct protection to upland properties
- Provide protection for emergency egress route to both Little Beach area and Morris Island

#### Cons

- Will not provide protection of all properties during severe storm events
- Does not address likely accretion of beach that will impact Outermost Harbor Marina
- If open ocean wave conditions persist in the future, dune likely cannot withstand the forces (retrofit/redesign likely required)
- Cost to construct and maintain (frequent inspection)

### Challenges

- Connection between "soft" dune/berm and "hard: bulkhead at marina may cause a weak link in the design
- Drainage landward of protection may be problematic

4. Assessment Areas



# Quitnesset Barrier Beach to Morris Island, Study Area 5

Monomoy Refuge facing south towards Morris Island



### Existing Engineered Structures Assessment Area 5



### Wave Heights and Tidal Currents Assessment Area 5

Level of protection in future dependent on continued growth and landward migration of North Beach Island remnants




## Assessment Area 5: Maintain or Improve Existing Revetments

<ul> <li>Pros</li> <li>Direct protection to upland properties already fronted by revetments</li> </ul>	<ul> <li>Cons</li> <li>May cause end effects if exposed to increased wave energy</li> <li>Does not protect Monomoy National Wildlife Refuge property</li> <li>Cost, if tidal currents cause significant scour</li> </ul>
Challenges	

• Minor concerns regarding environmental impacts of improved structures



## **General Management Strategies by Assessment Area**

#	Location	Present/Future Concerns	Approach
1	Minister's Point to Linnell Lane Beach	Erosion/scour due to current and storm waves, overtopping of barrier beach and flooding	<ul> <li>Stabilize existing structures or re-direct tidal currents (Minister's Point)</li> <li>Enhanced nourishment (Linnell Lane Beach)</li> </ul>
2	Linnell Lane Beach to Thayer Lane	Increased erosion and wave exposure as inlet migrates	<ul> <li>Temporary groins with nourishment</li> <li>Tern Island Flats nourishment</li> </ul>
3	Thayer Lane to Chatham Lighthouse	None	<ul> <li>None; however, maintaining navigation channel could serve as a source for nourishment material</li> </ul>
4	Little Beach/Outermost Harbor	Storm flooding and increased wave activity, emergency egress	<ul> <li>Coastal dune/berm/bulkhead to improve protection against flooding</li> </ul>
5	Quitnesset Barrier Beach to Morris Island	Increased wave activity and tidal currents as inlet migrates, emergency egress	<ul> <li>Maintain and/or improve existing shore protection structures</li> </ul>

## Questions