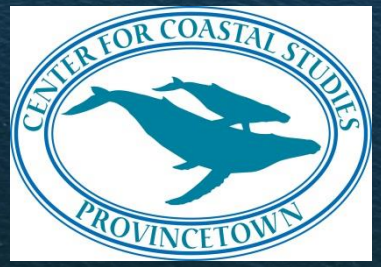
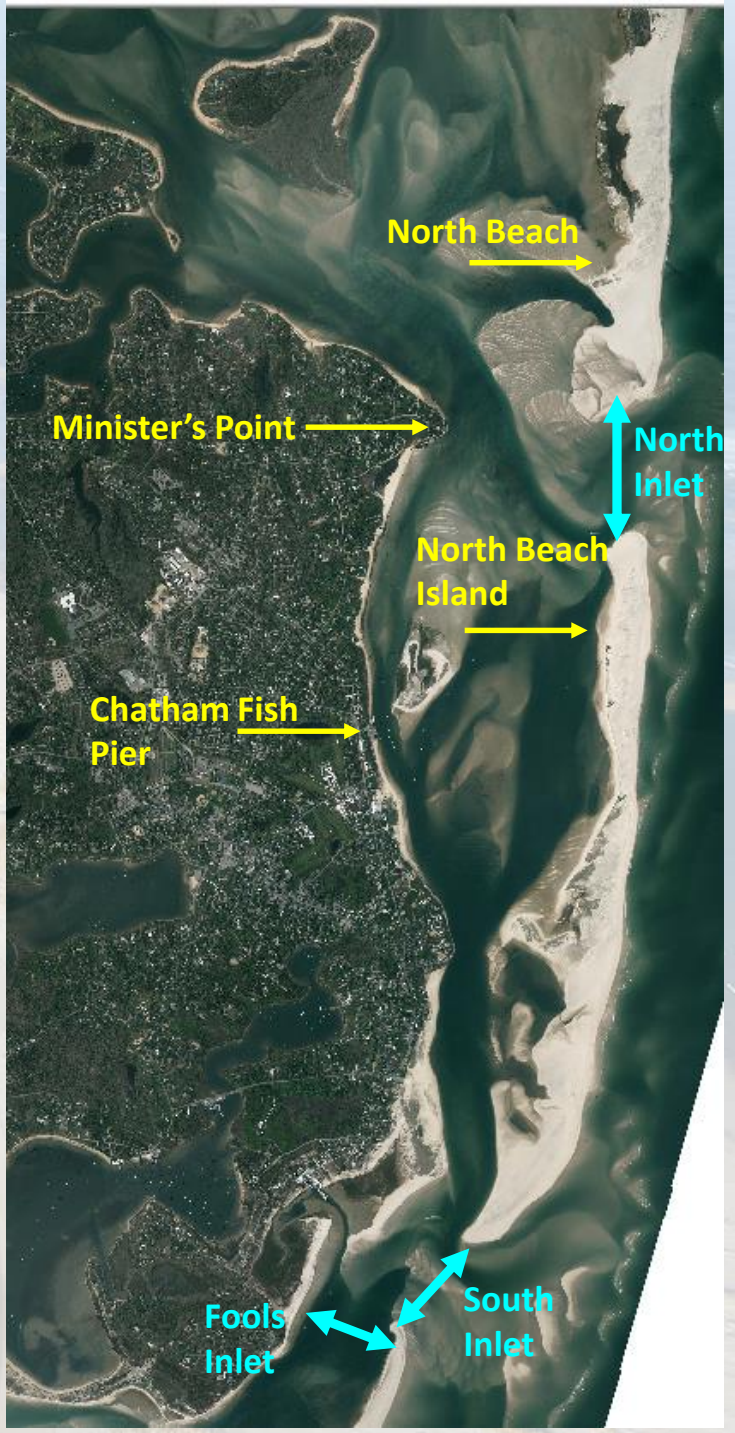
Chatham East-Facing Shoreline: Coastal Resiliency and Management Assessment

June 27, 2019



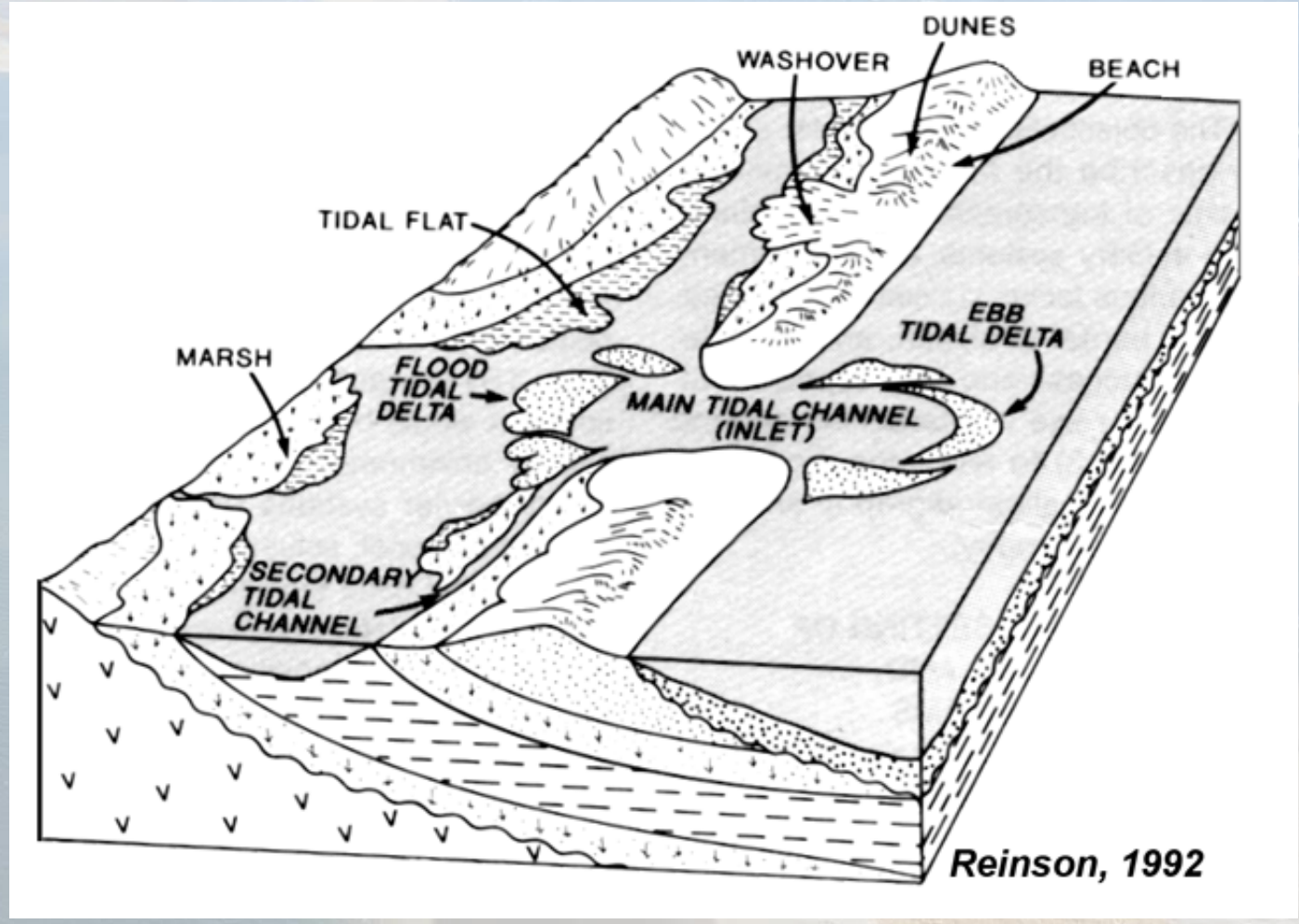
Project Overview

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

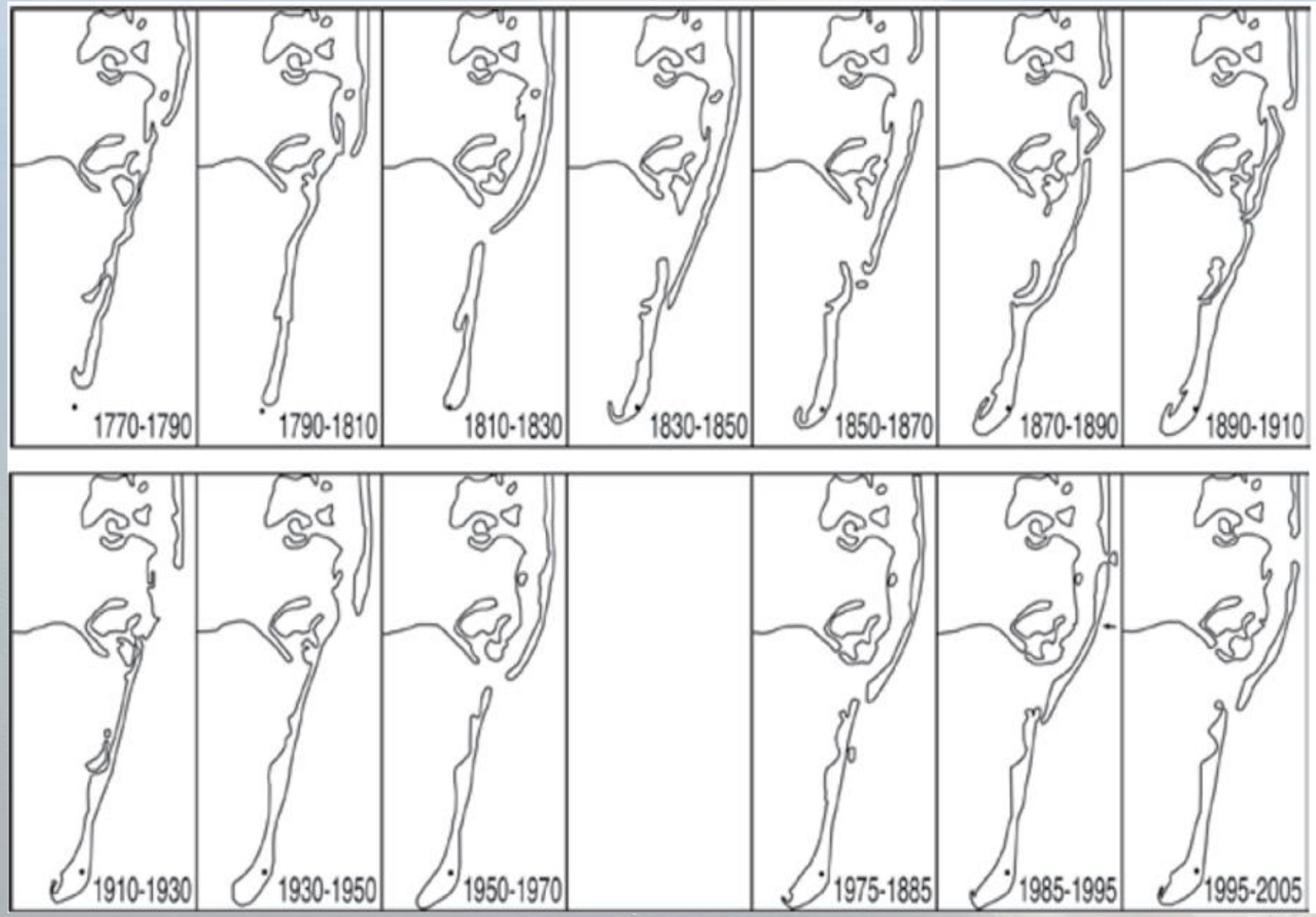


Barrier Island Systems: A Primer

- 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



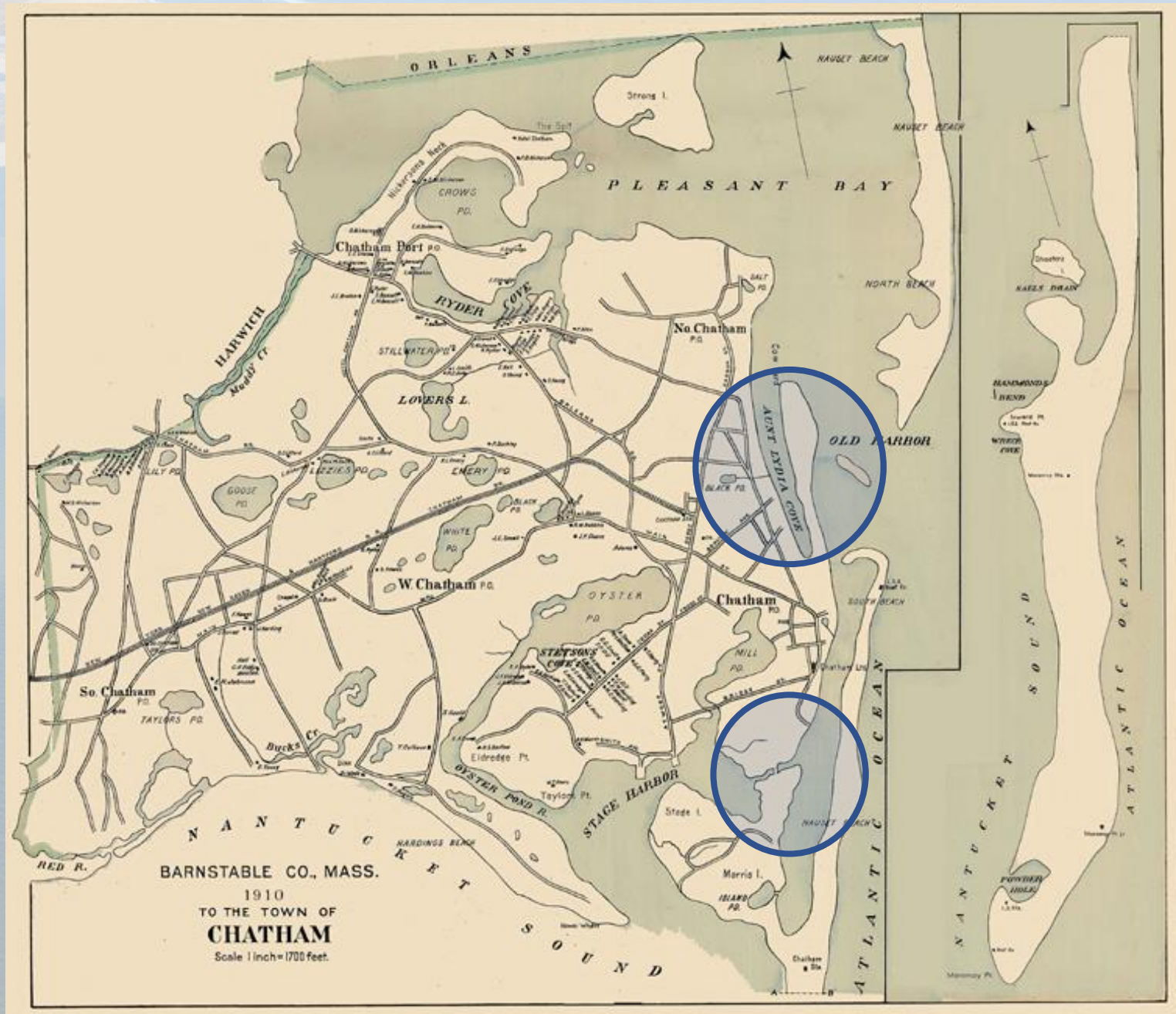
Patterns:

1. “Boomerang” shape of barrier remnants
2. Westward migration of barrier remnants and welding onto mainland
3. Southerly Elongation of North Beach and North Beach Island

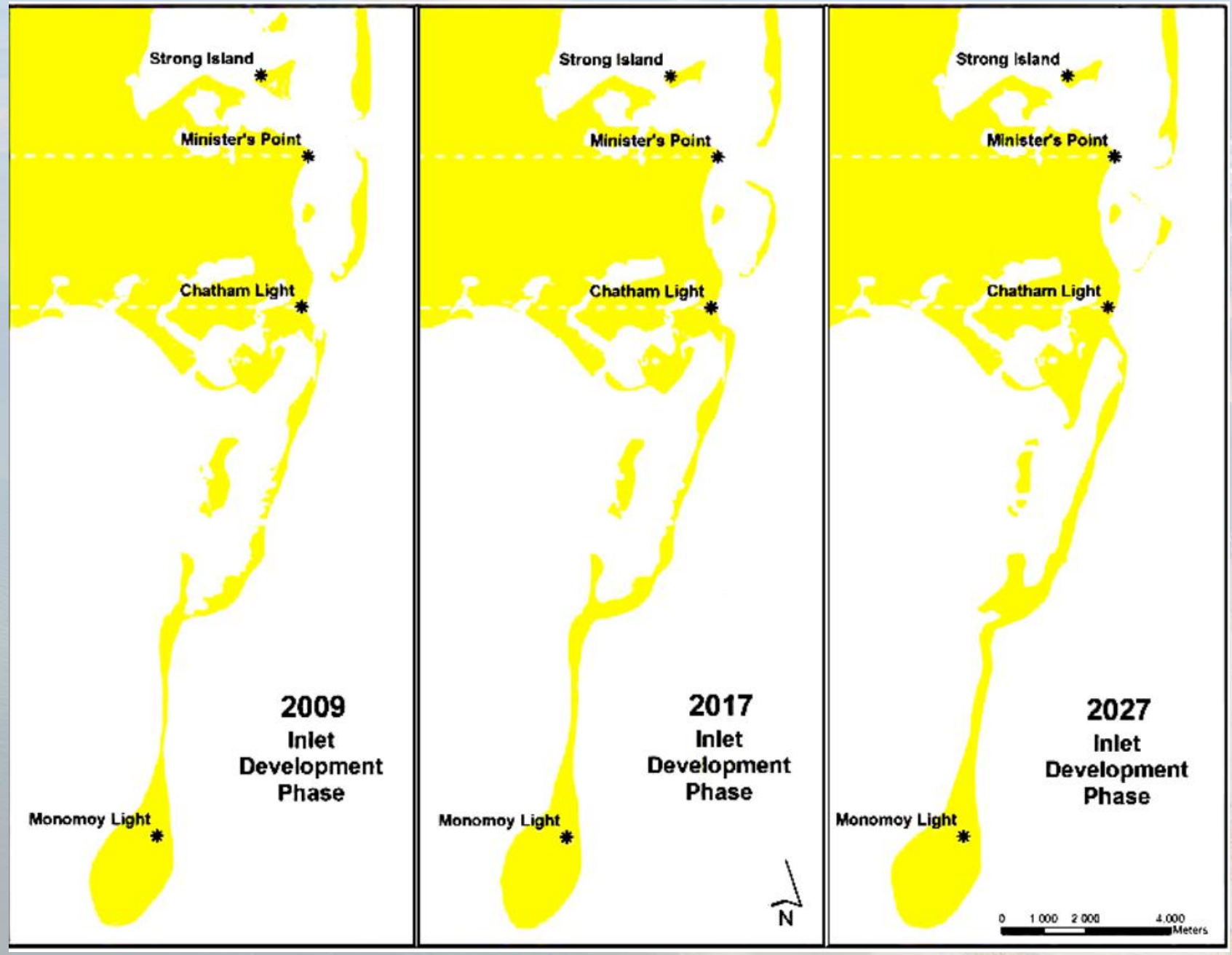
The Estuary in 1910

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

Connection between Stage and Chatham Harbors

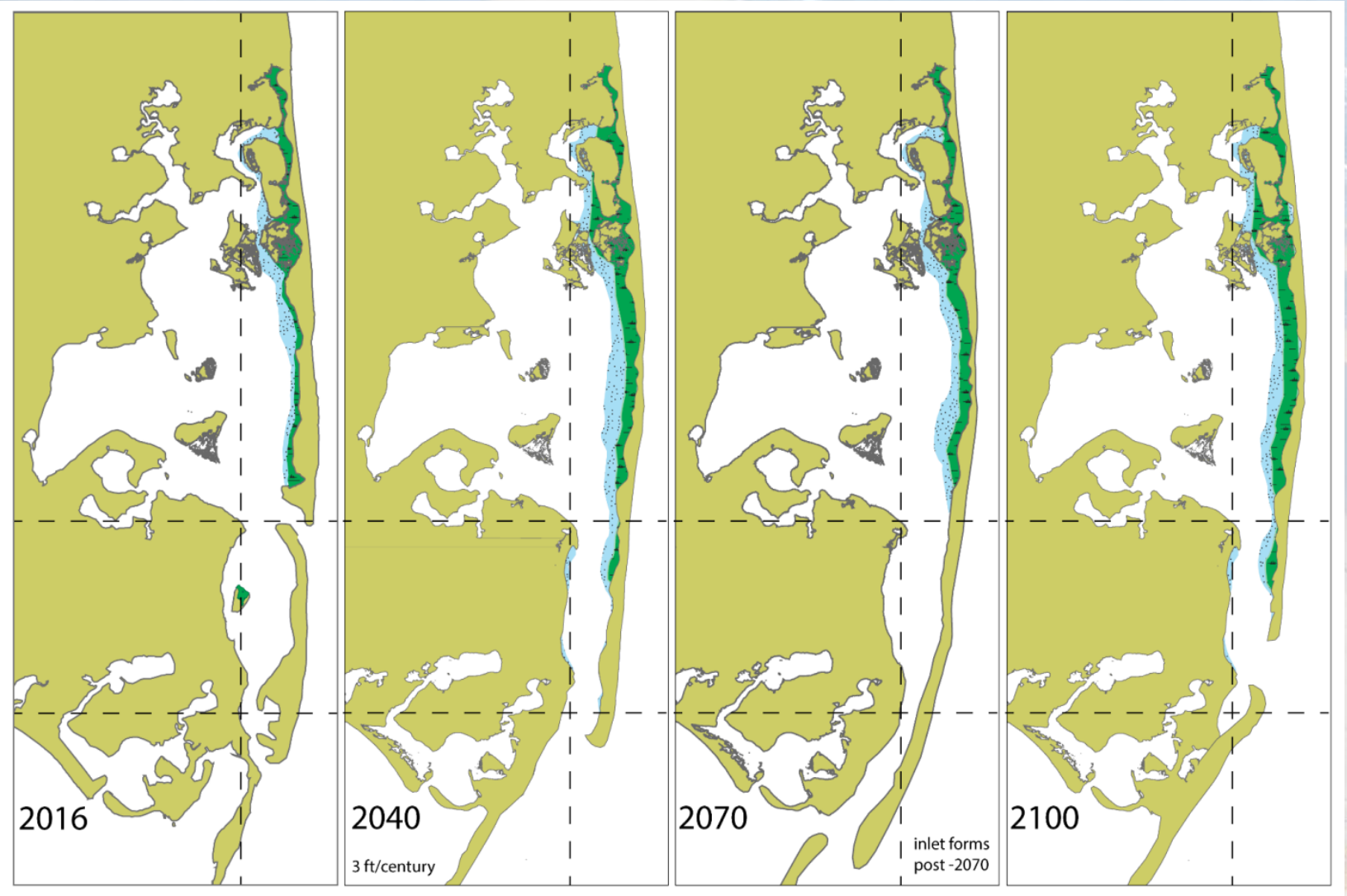


Previous Projections



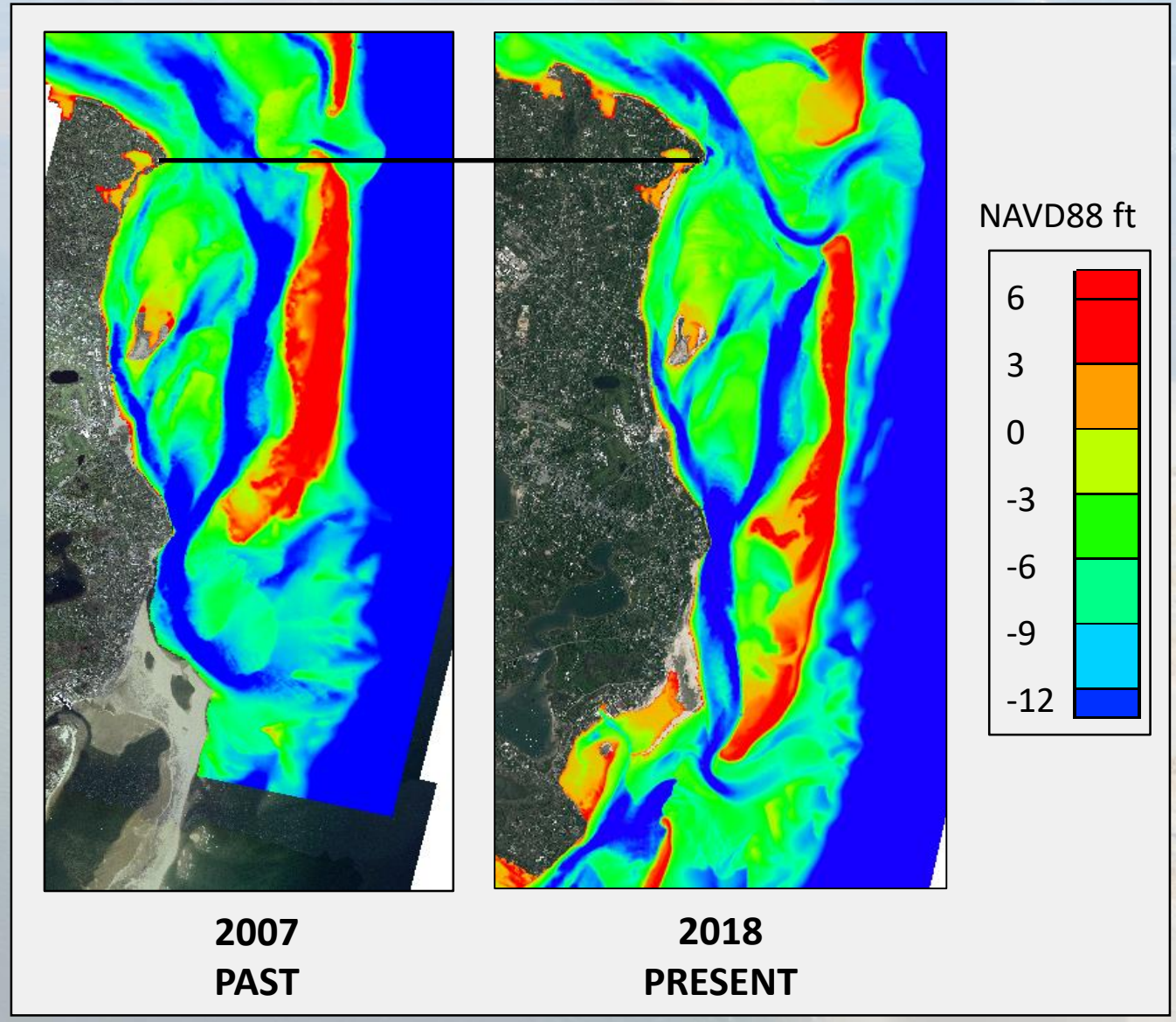
From Giese et al 2009

Previous Projections



courtesy of the Center for Coastal Studies

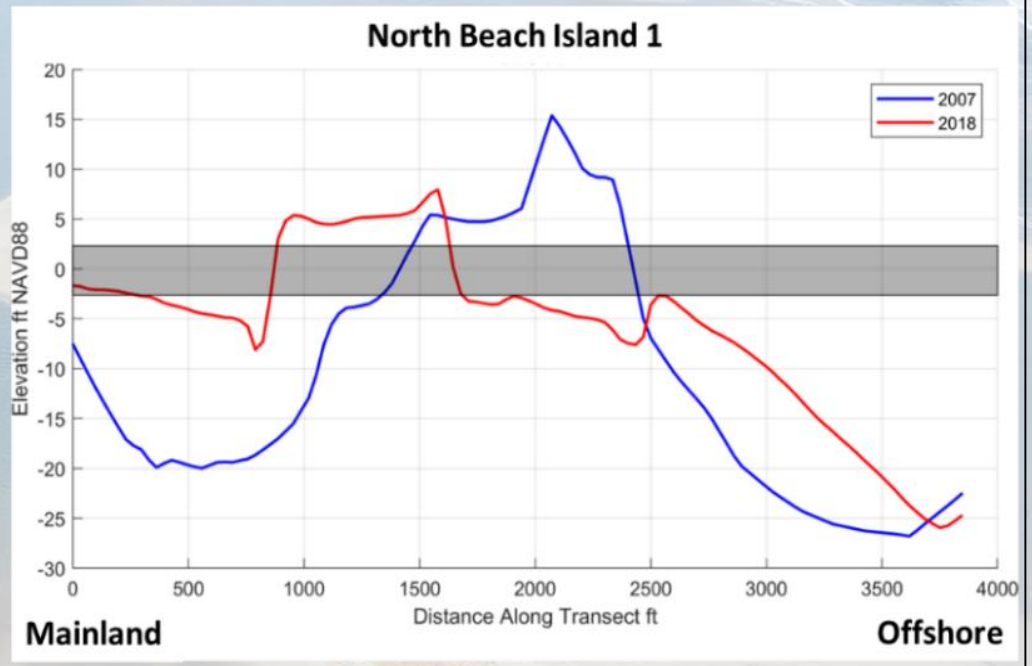
Bathymetry Evolution 2007 to 2018:
Setting Up Cycle Similar to the One Initiated in 1846



East Chatham Harbor Channel shoaled in at northern end

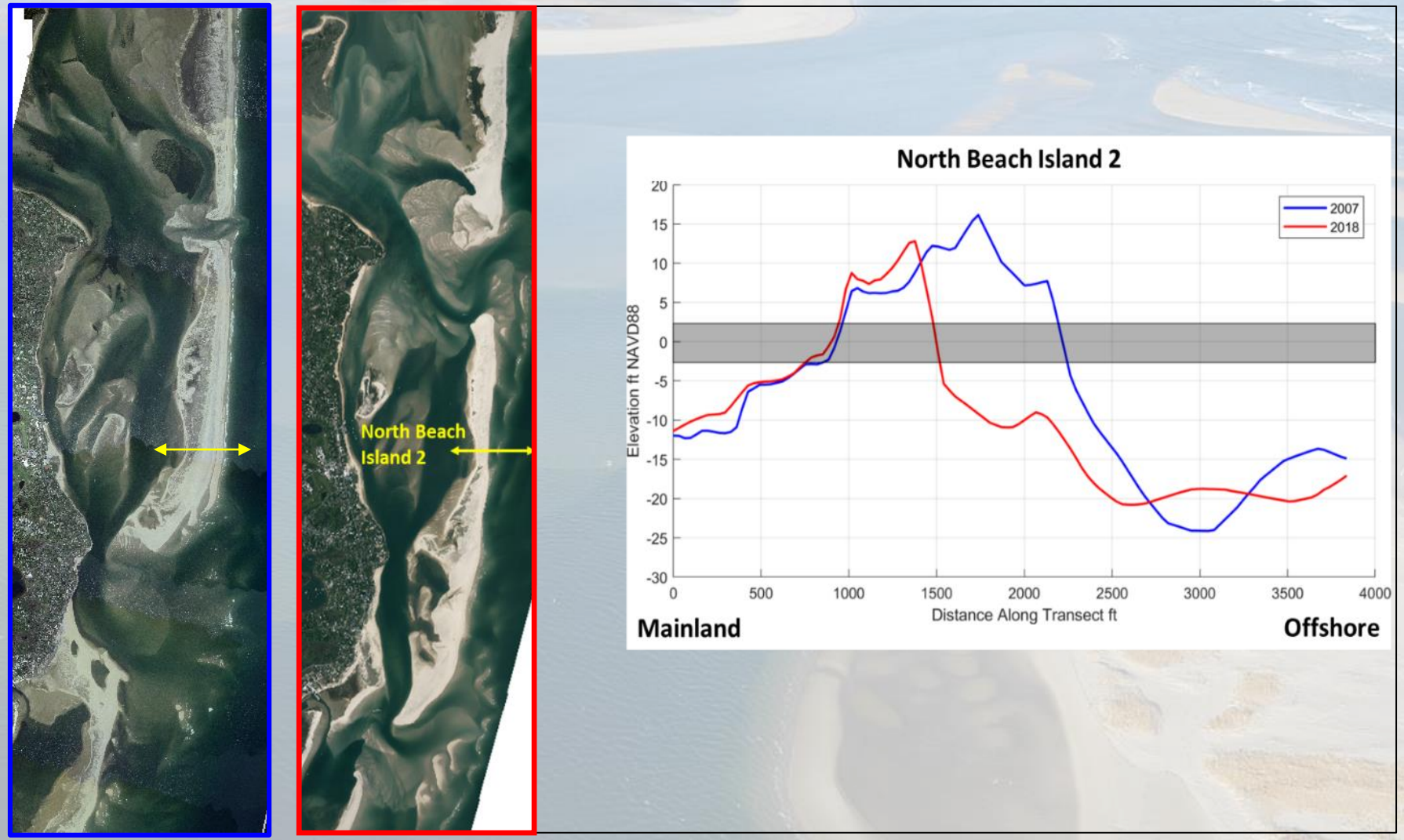
Inlet Evolution: 2007 to 2018 Westward Migration and Southerly Elongation of North Beach Island

Barrier Beach Evolution: 2007 to 2018



2007 2018

Barrier Beach Evolution: 2007 to 2018



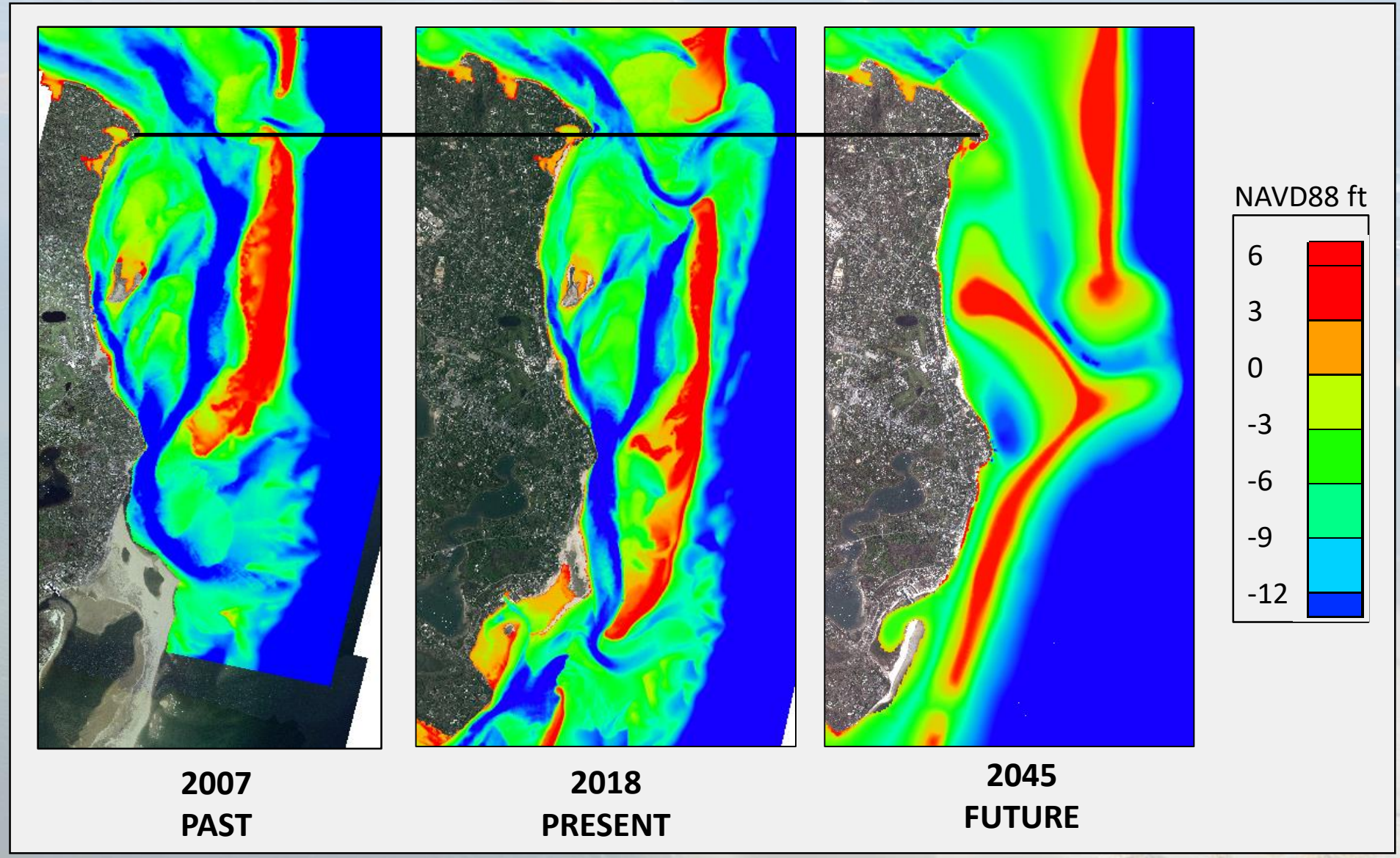
2007 2018

Inlet Evolution: 2007 to 2018

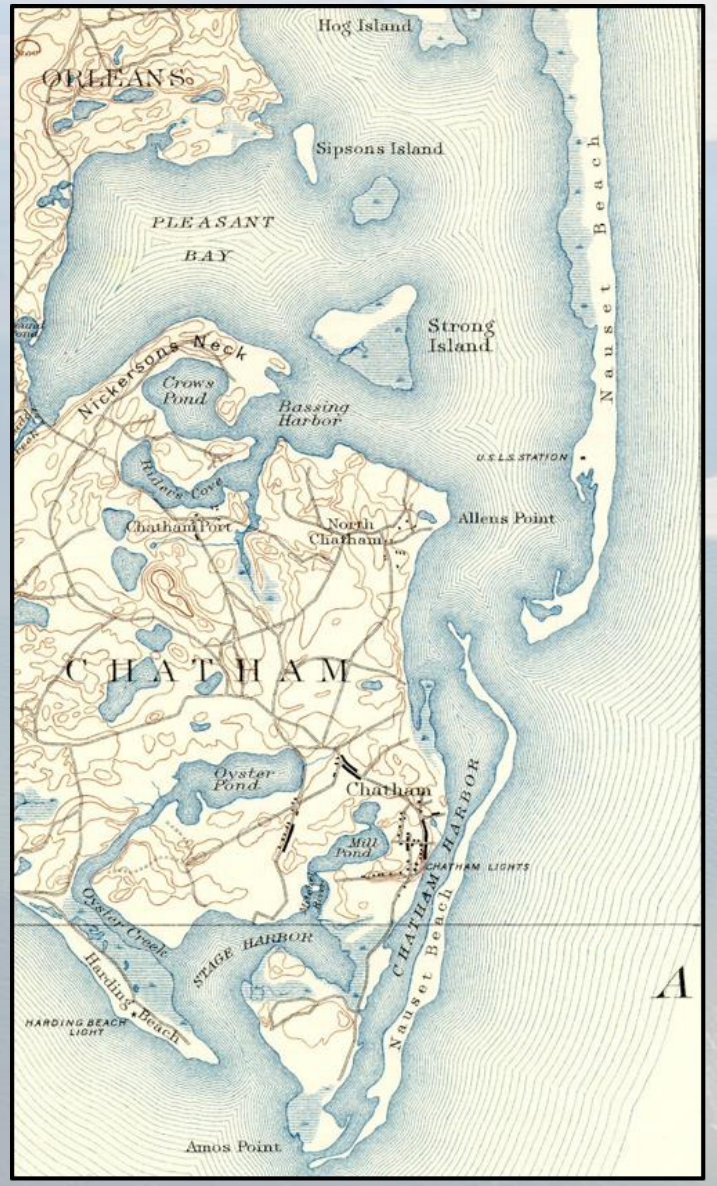
North Inlet 2018

South Inlet 2018

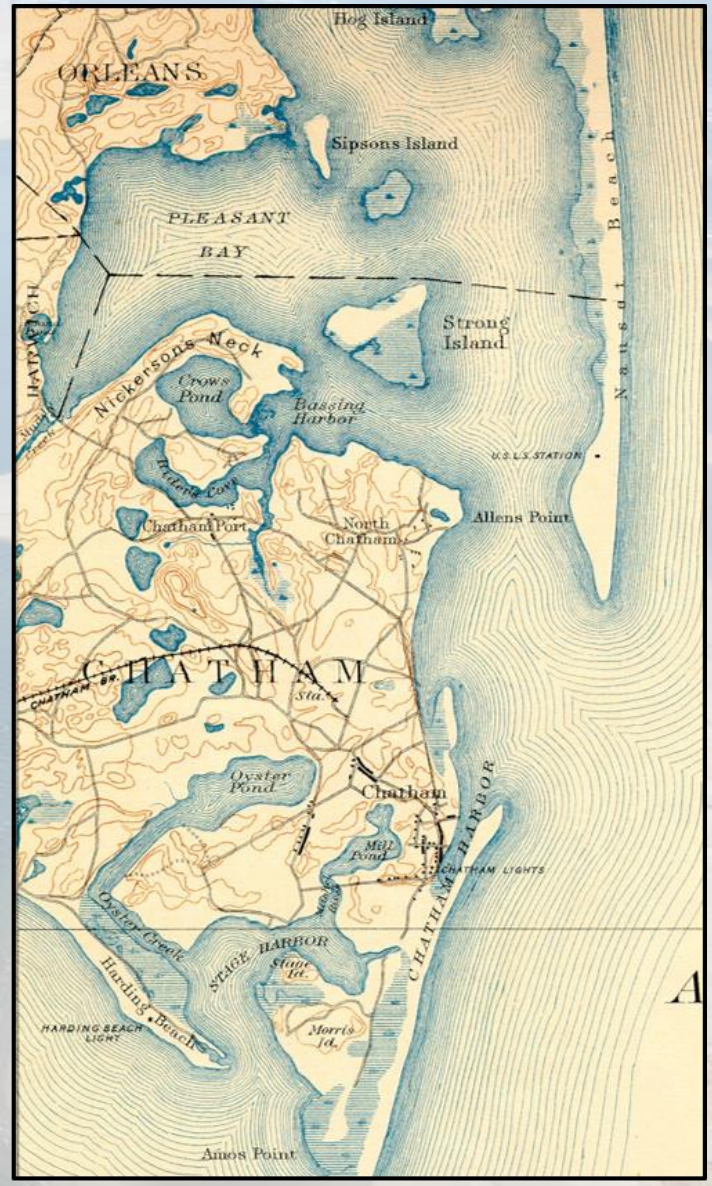
Future Configuration: 2045 Inlets



Future Configuration:
Historic Analysis of Charts

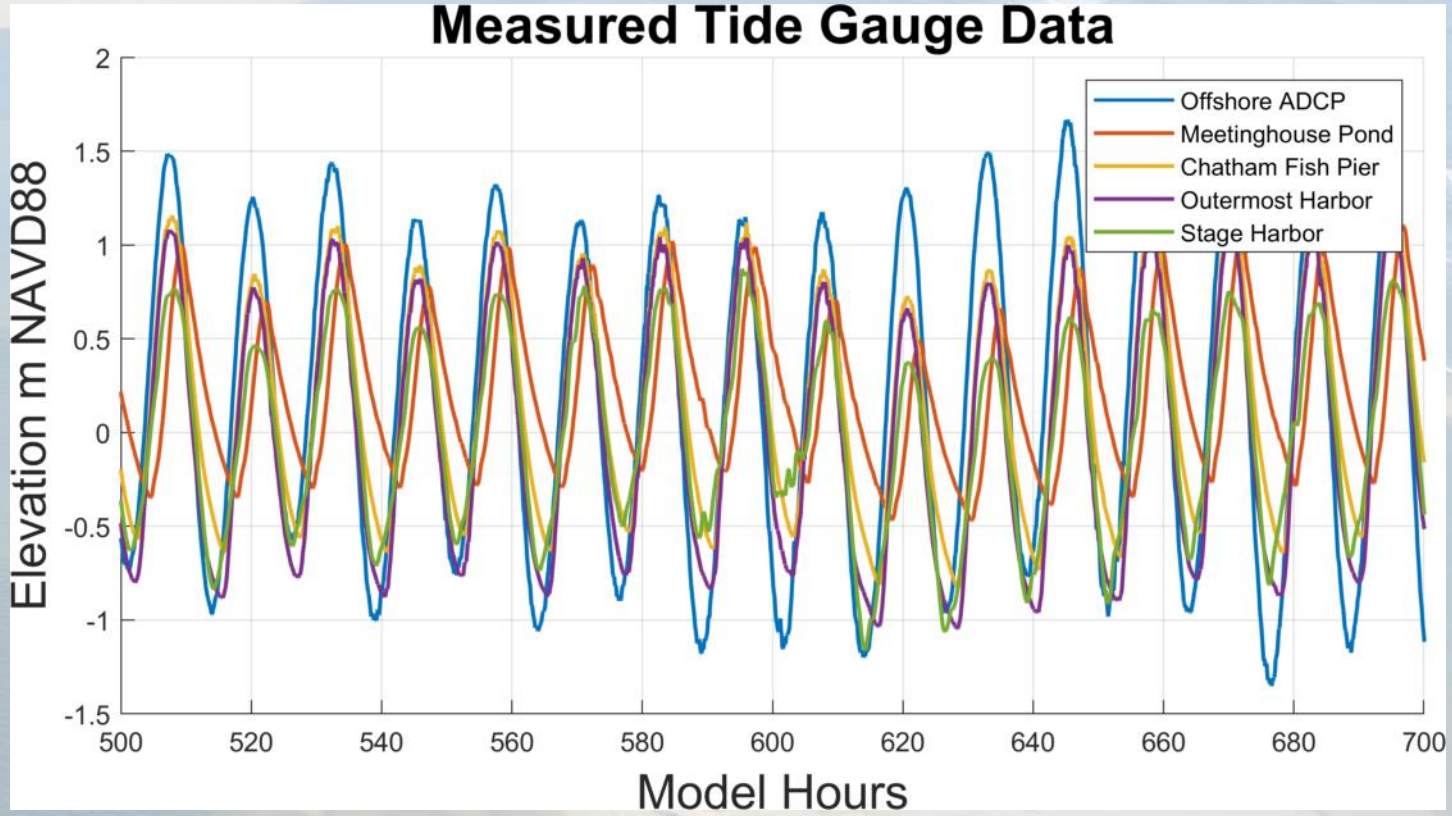


1893



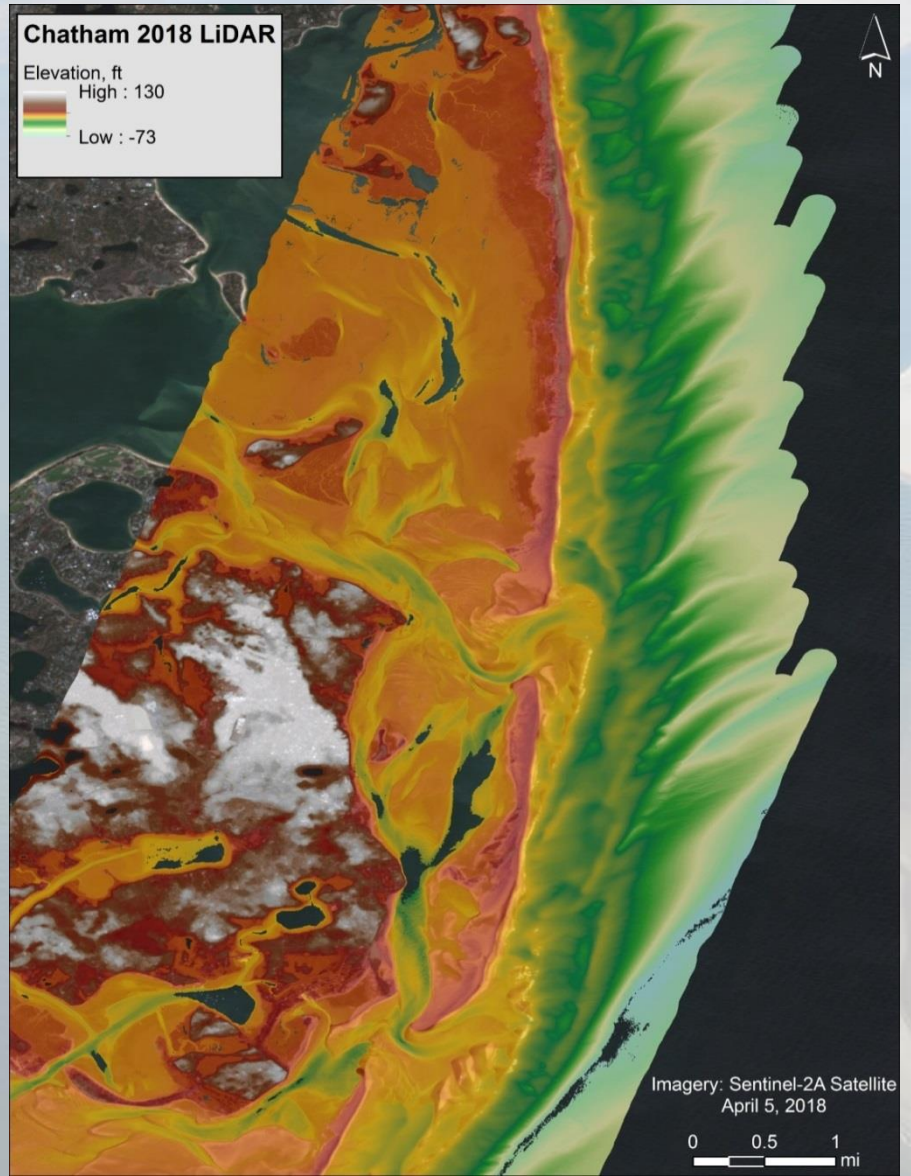
1917

Model Development:
Tidal Data Collection and Adjustment



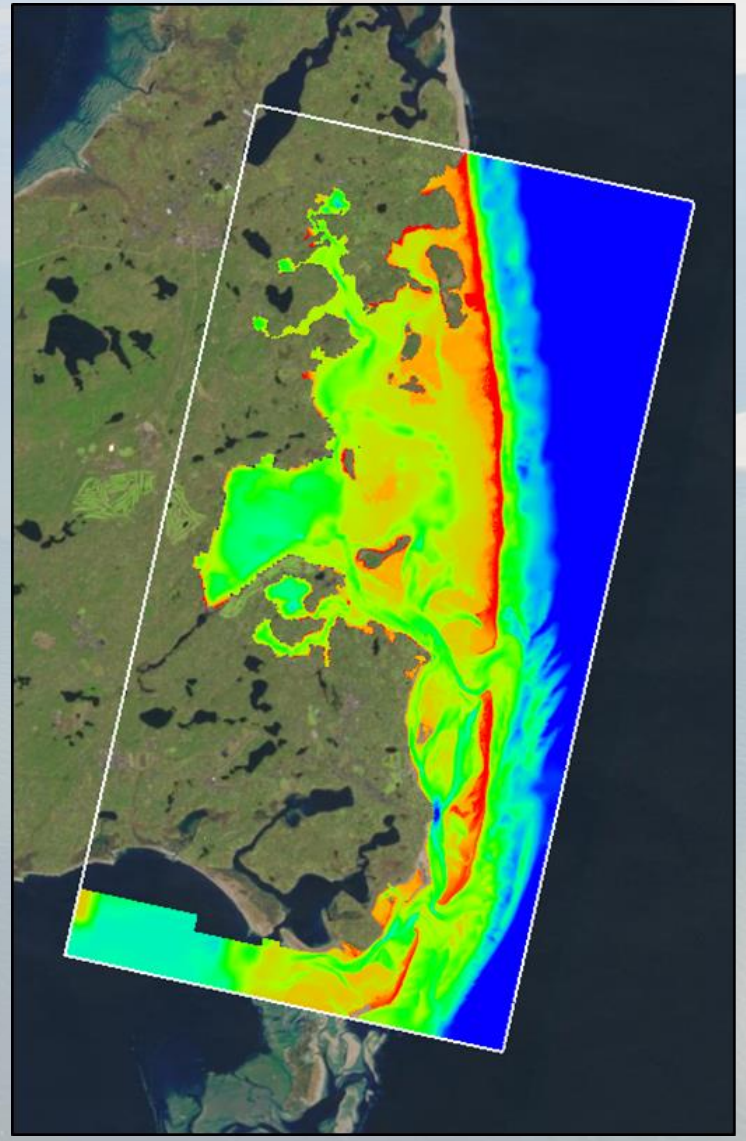
2045 Tides were adjusted for Sea Level Rise of 0.5 feet from present

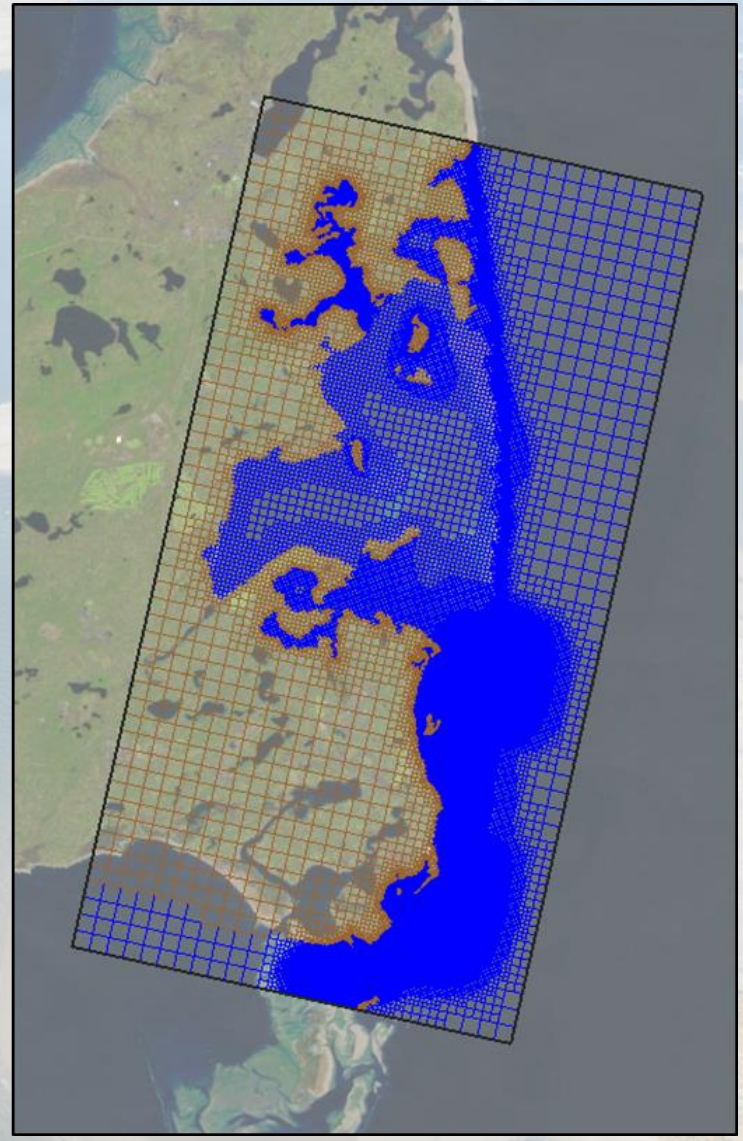
Model Development: Bathymetry Data Collection



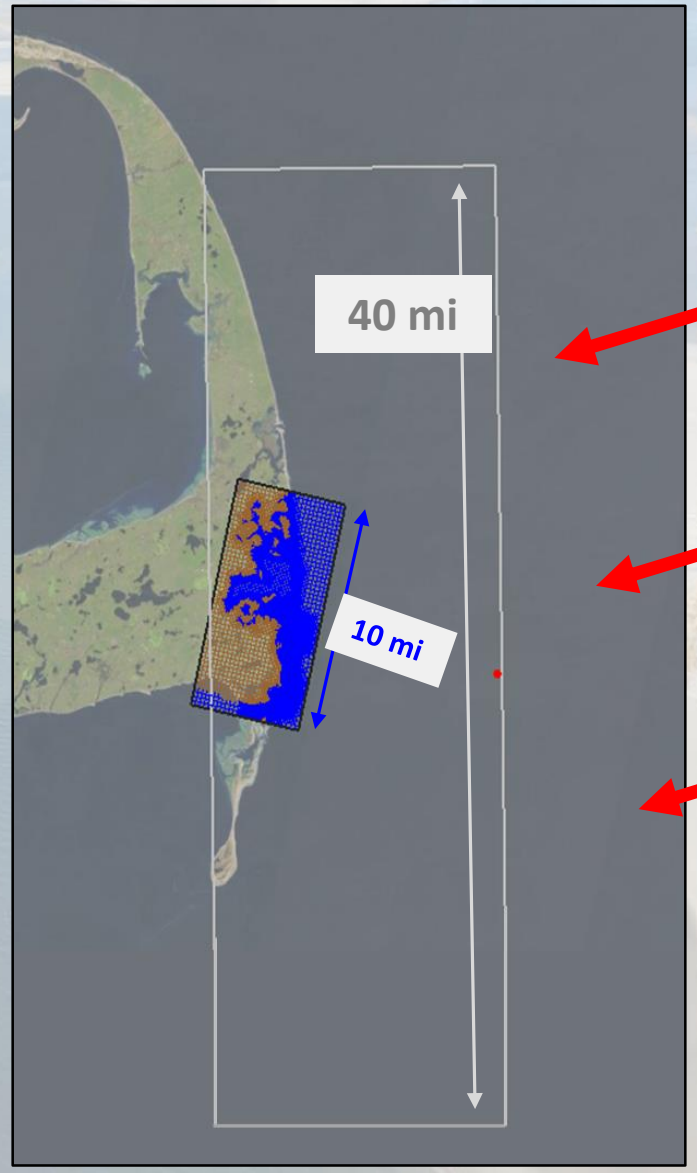
This could then be compared to the 2007 LiDAR data

Model Development:
Hydrodynamic Grid, Daily Conditions





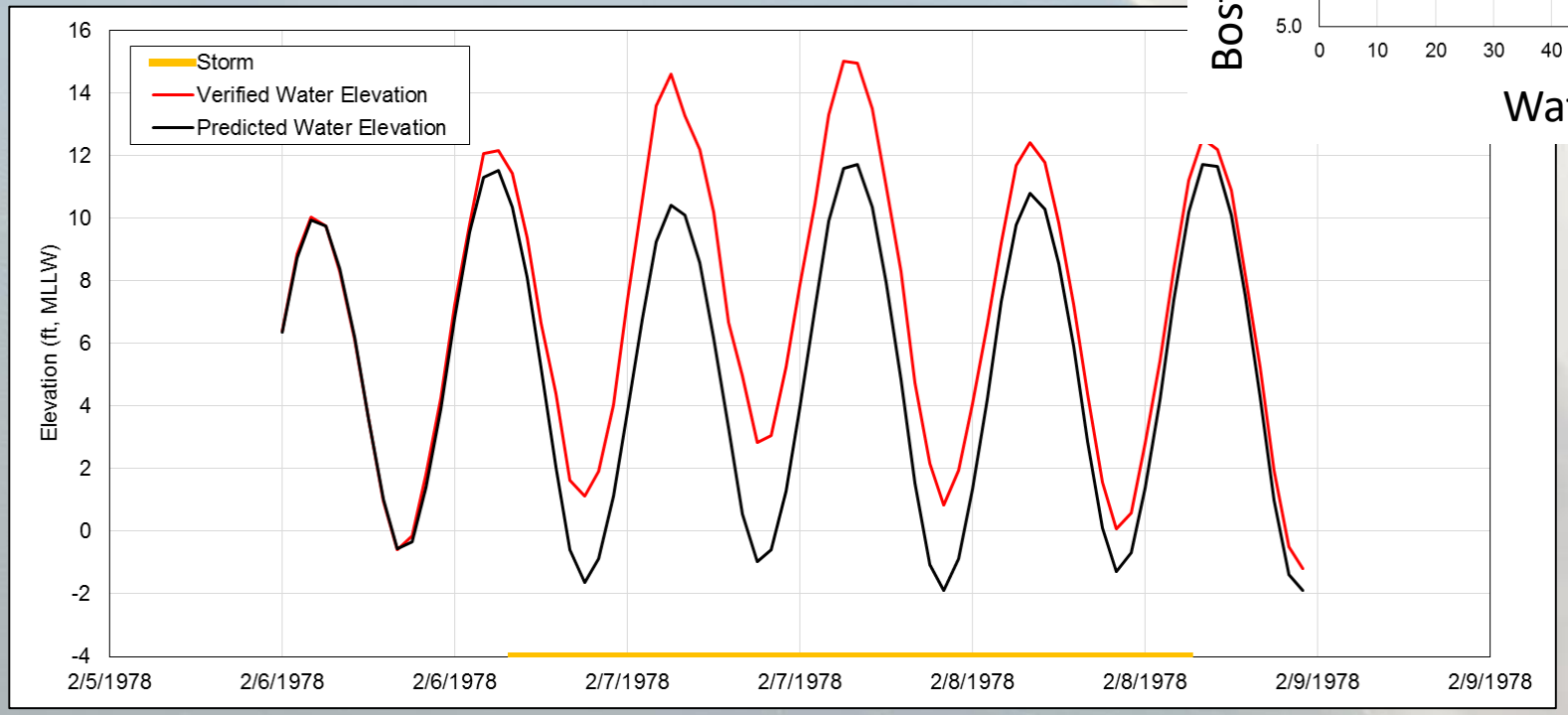
Model Development: Wave Grid, Storm Conditions

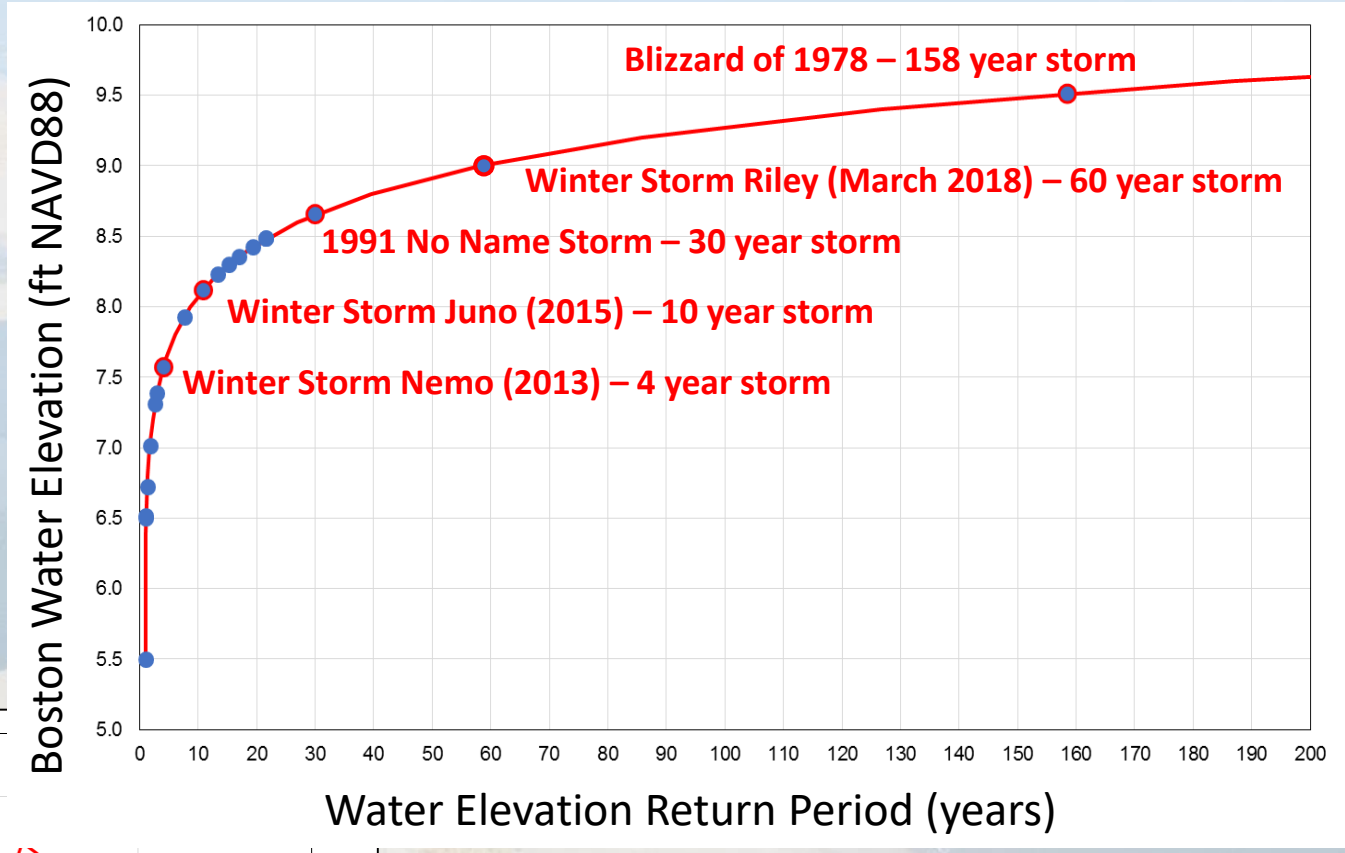


Predominant Offshore Wind and Wave Approach

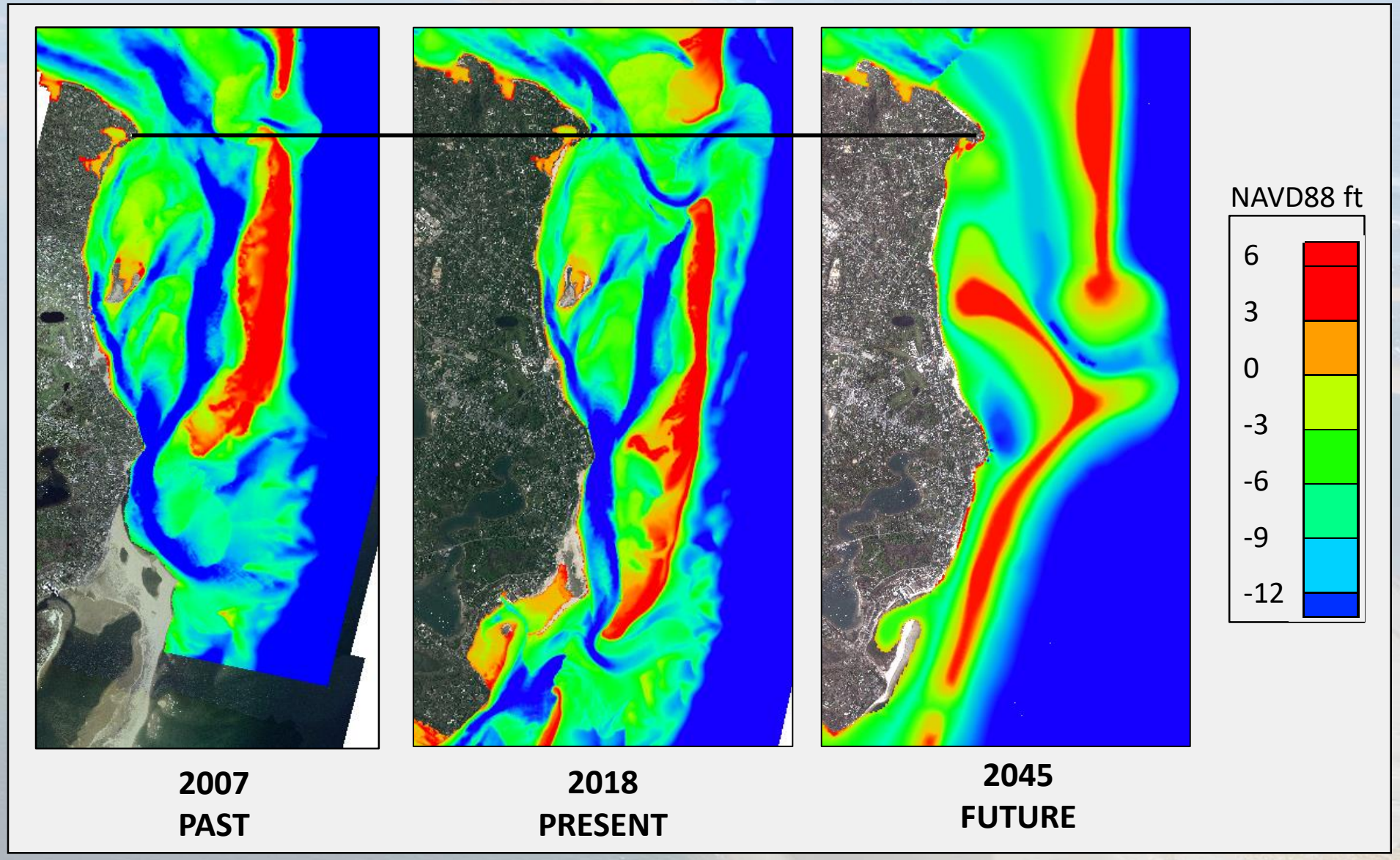
Perspective on Storms

Return Period
Duration
Storm Surge

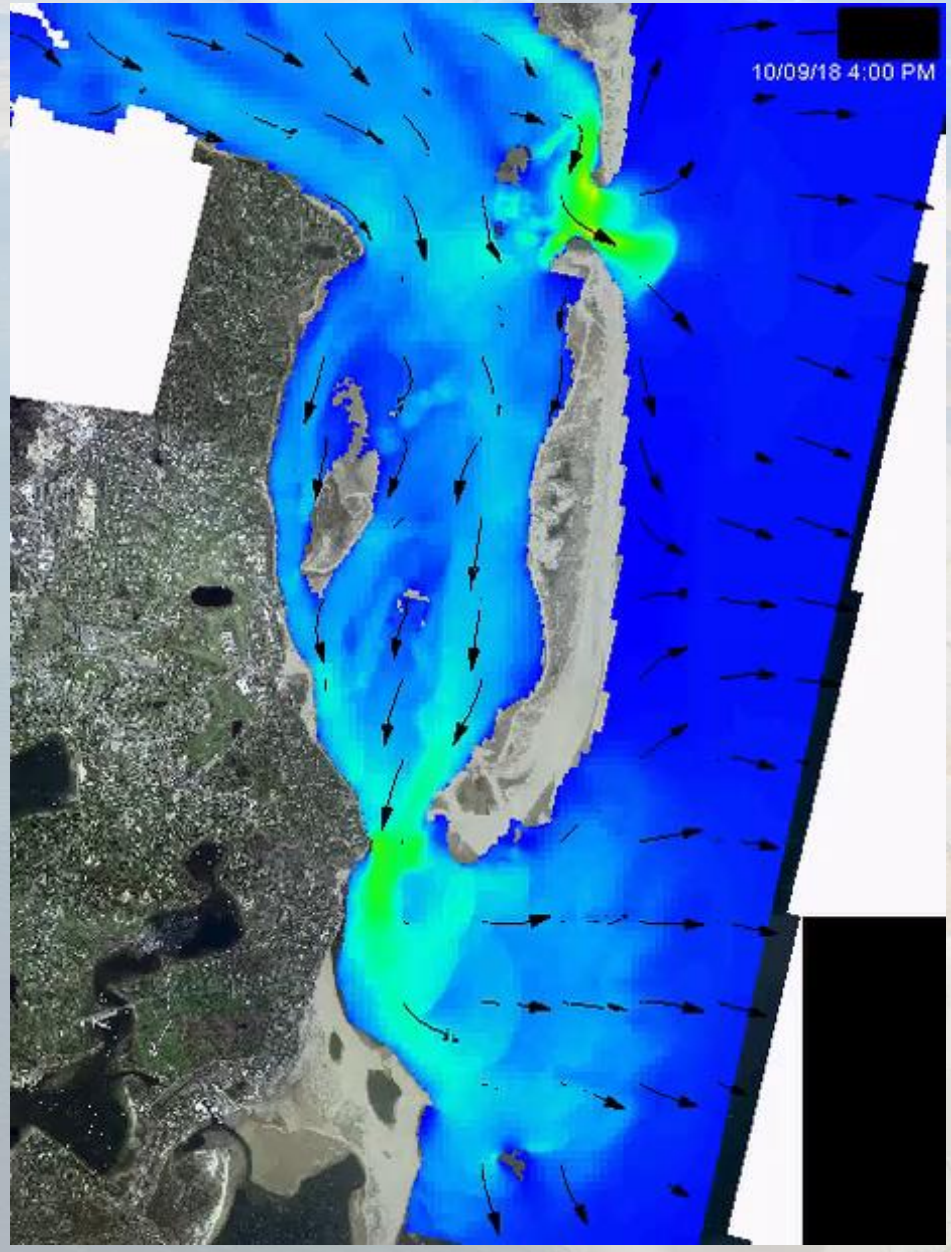




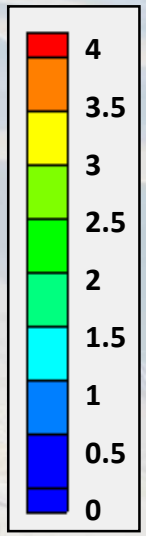
Future Configuration



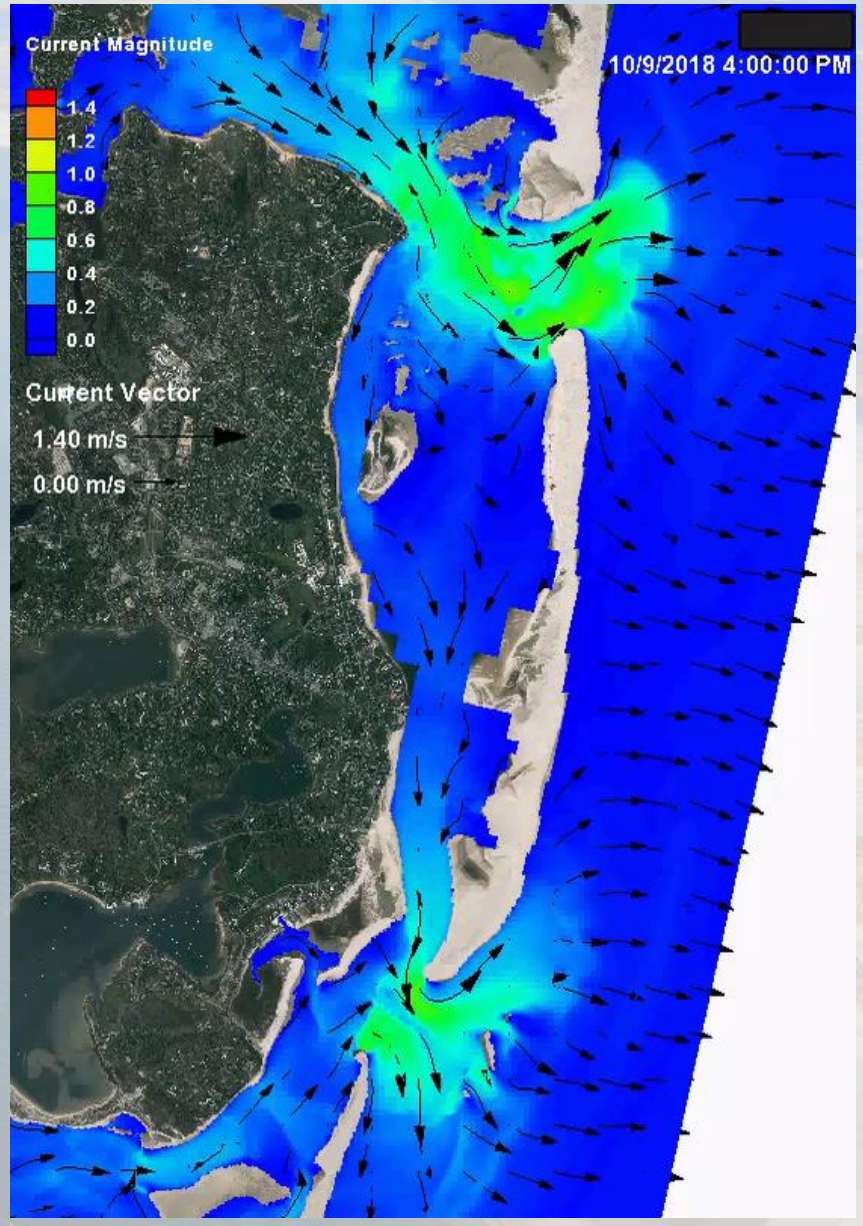
Analysis of Coastal Processes: 2007 Hydrodynamics



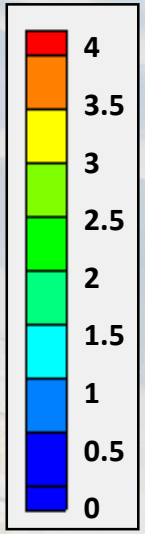
2007 Modeled Velocity



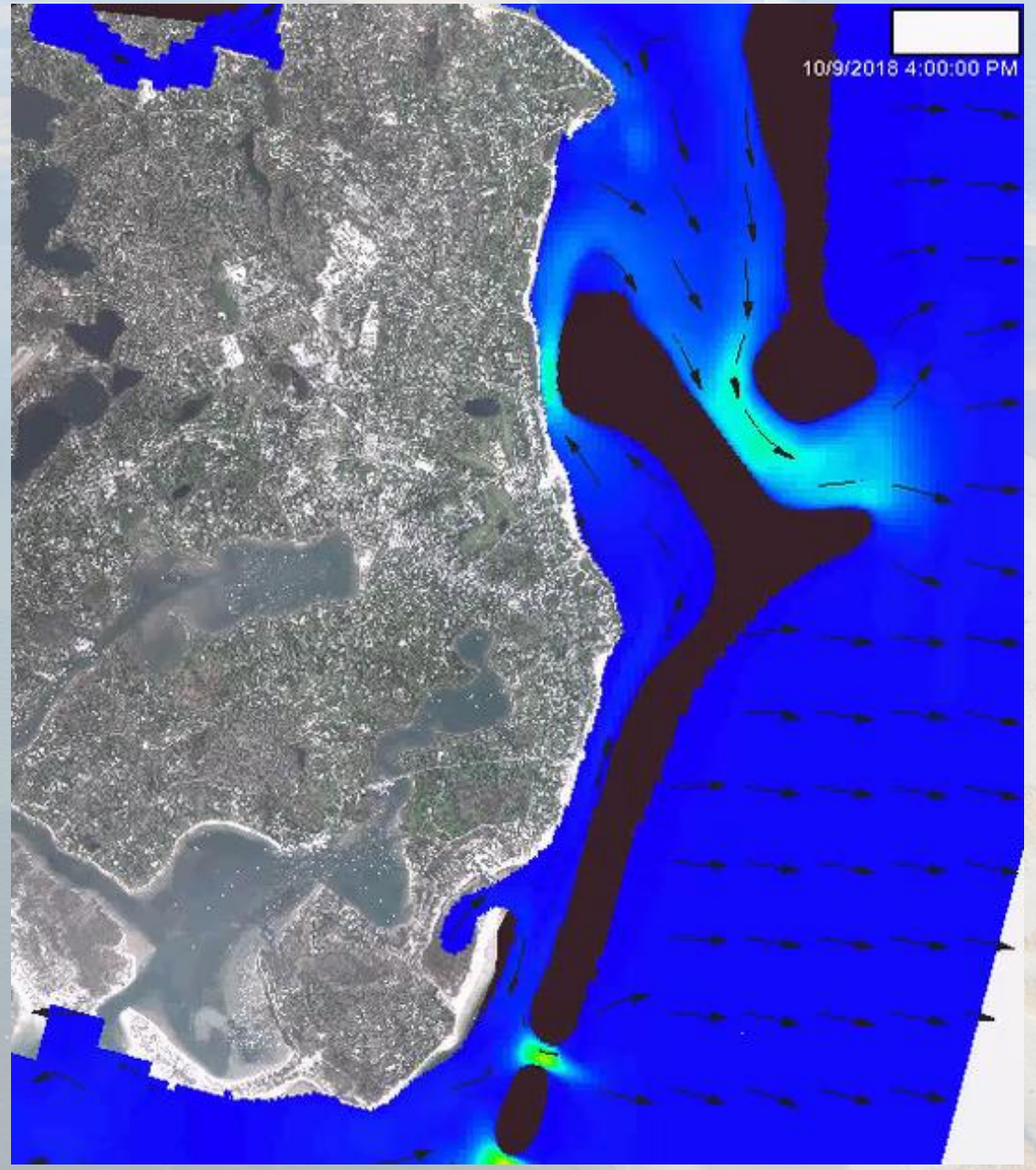
Analysis of Coastal Processes: 2018 Hydrodynamics



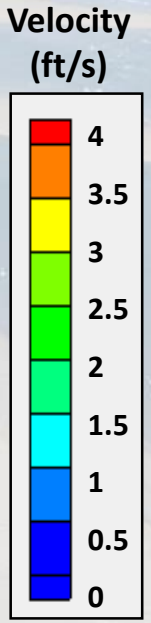
2018 Modeled Velocity



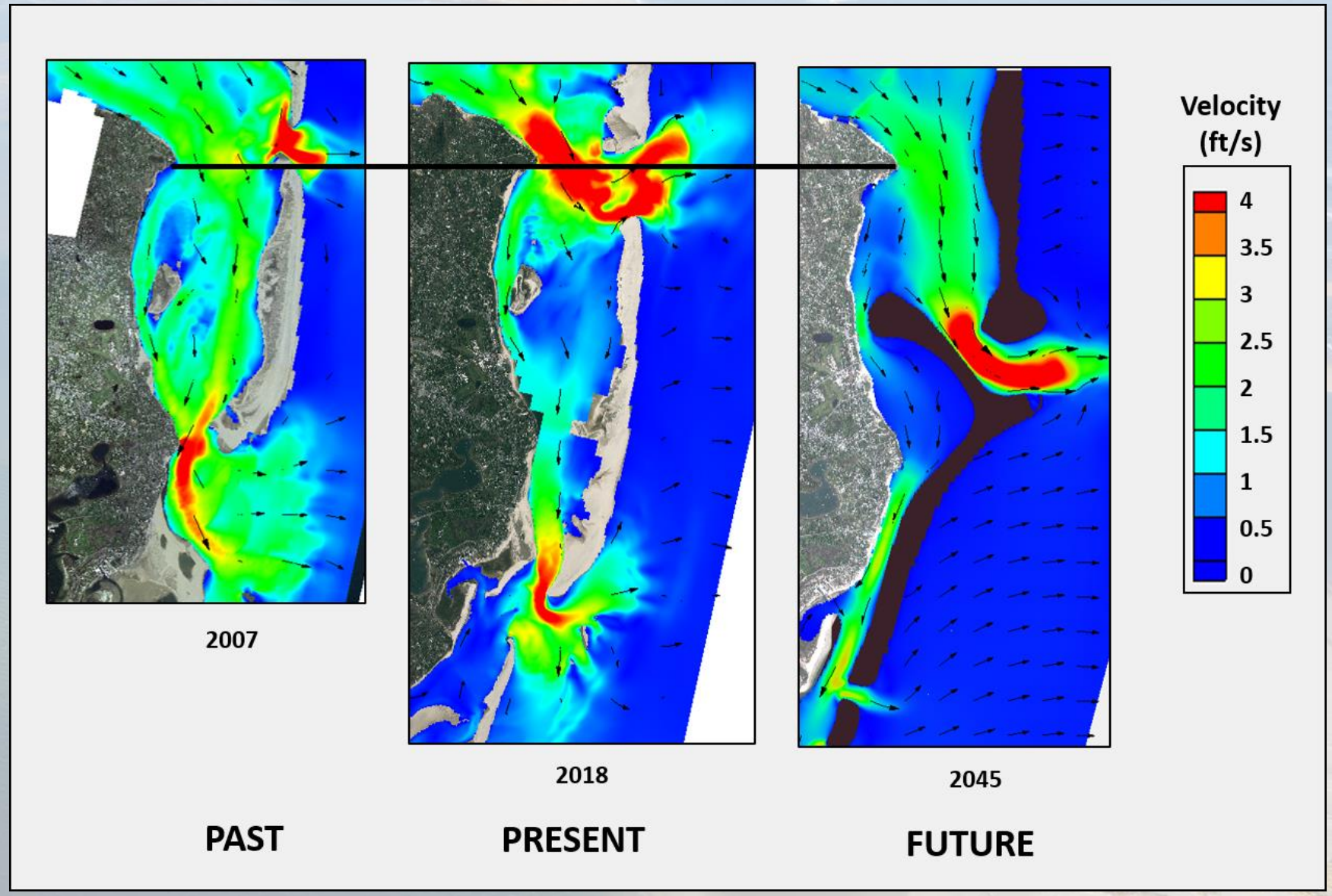
Analysis of Coastal Processes: 2045 Hydrodynamics



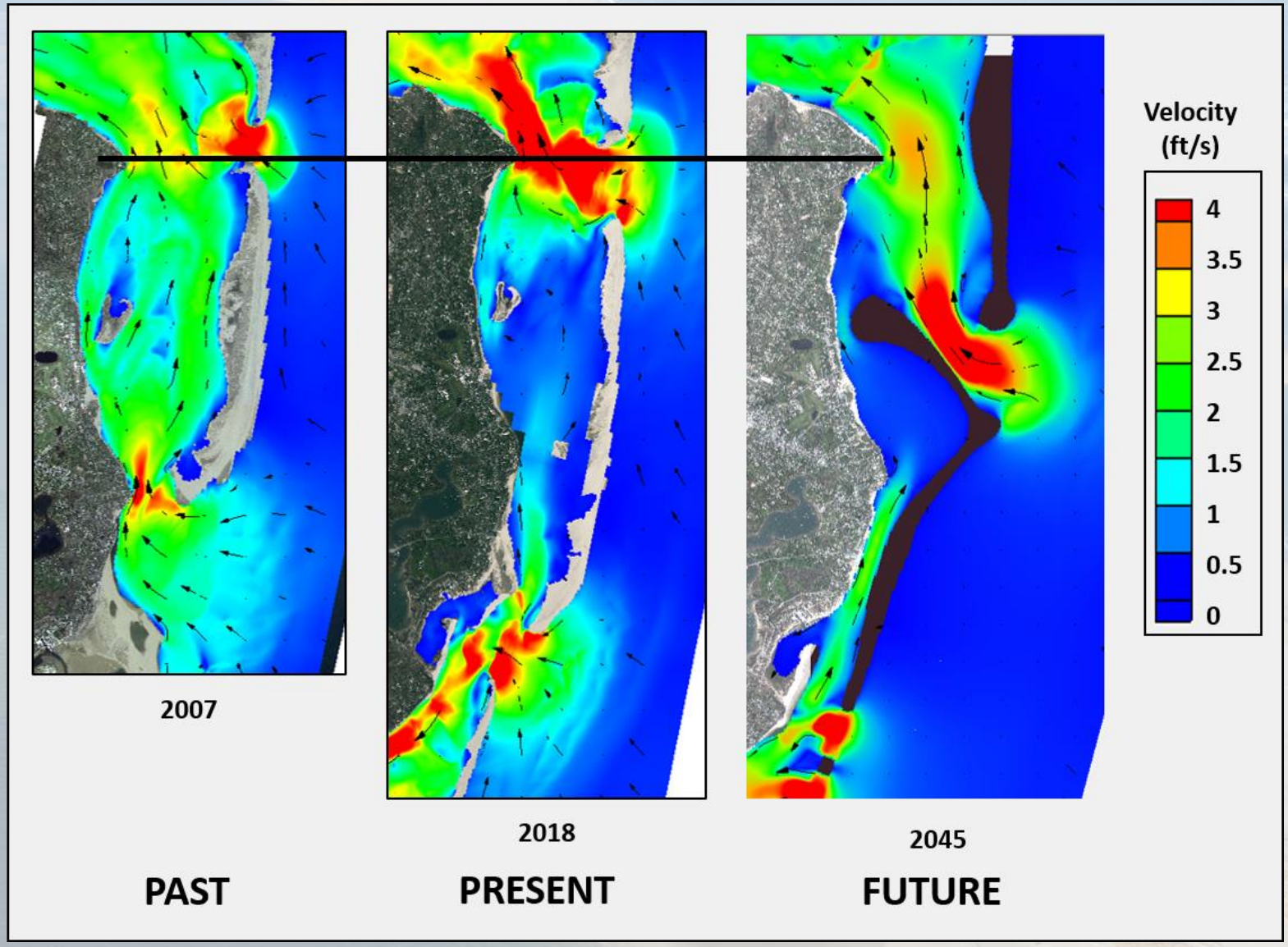
2045 Modeled Velocity



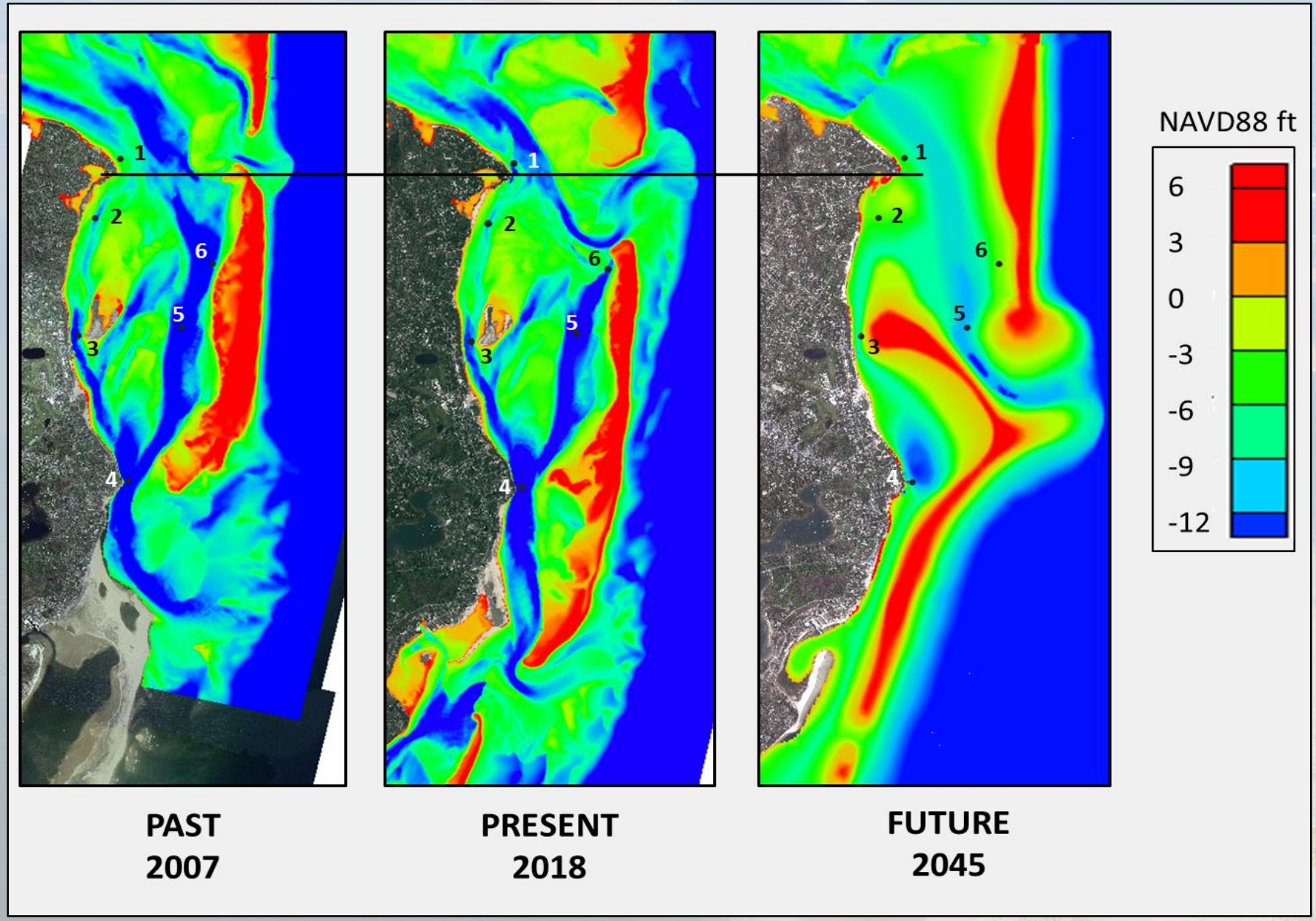
Analysis of Coastal Processes:
Comparing Ebb Flow at Same Model Timestep

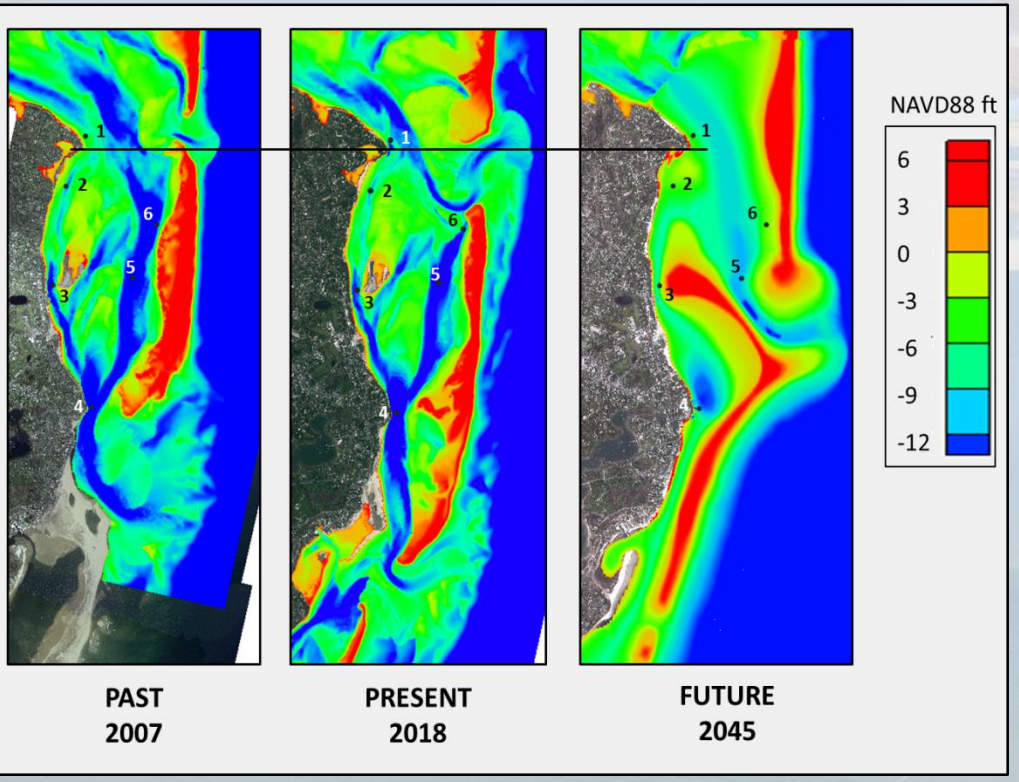


Analysis of Coastal Processes:
Comparing Flood Flow at Same Model Timestep



Hydrodynamic Conditions: Compare by Location

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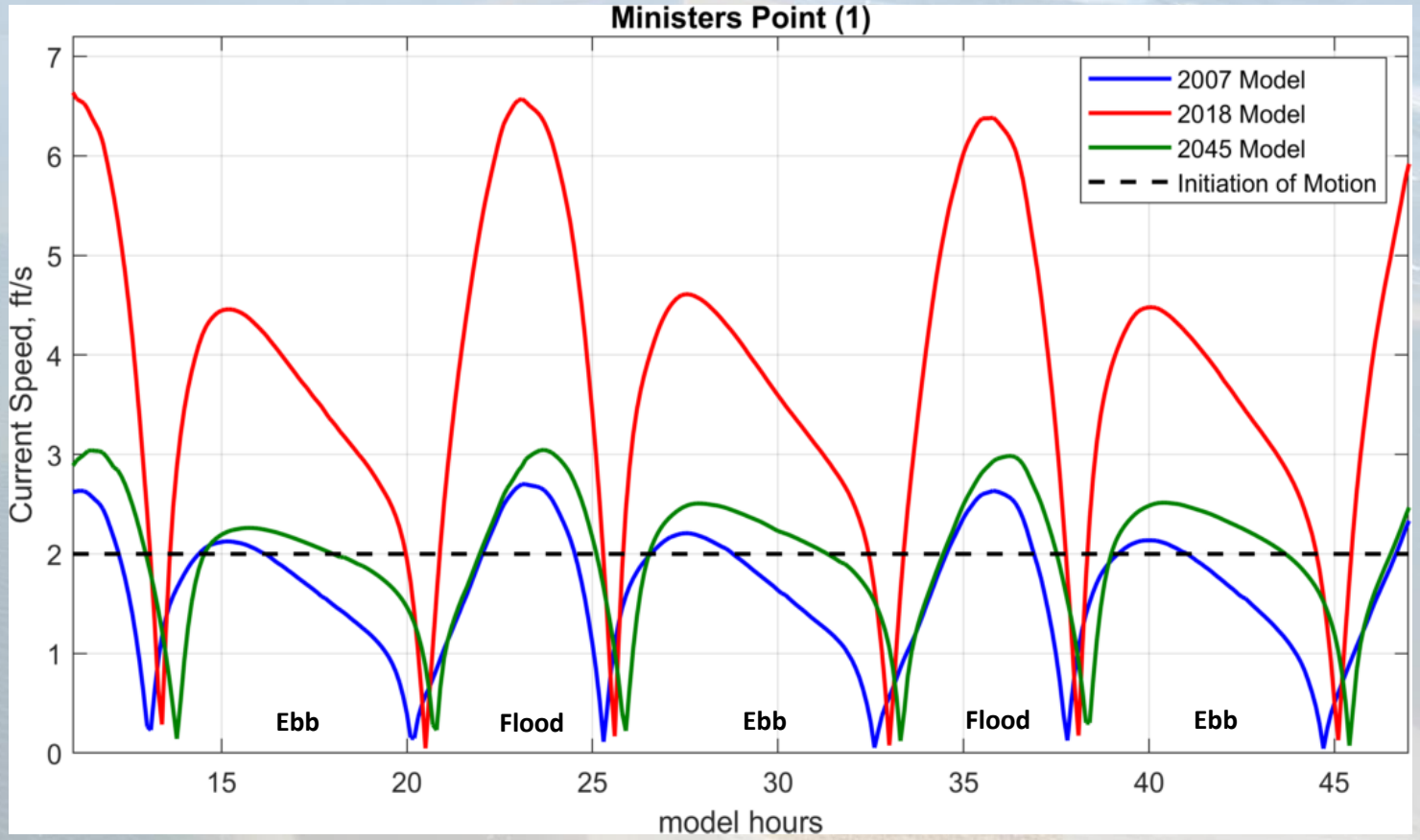
PAST
2007
PRESENT
2018
FUTURE
2045


Ministers Point (1)
2007 Model
2018 Model
2045 Model
Initiation of Motion
Current Speed, ft/s
model hours
Ebb
Flood
Ebb
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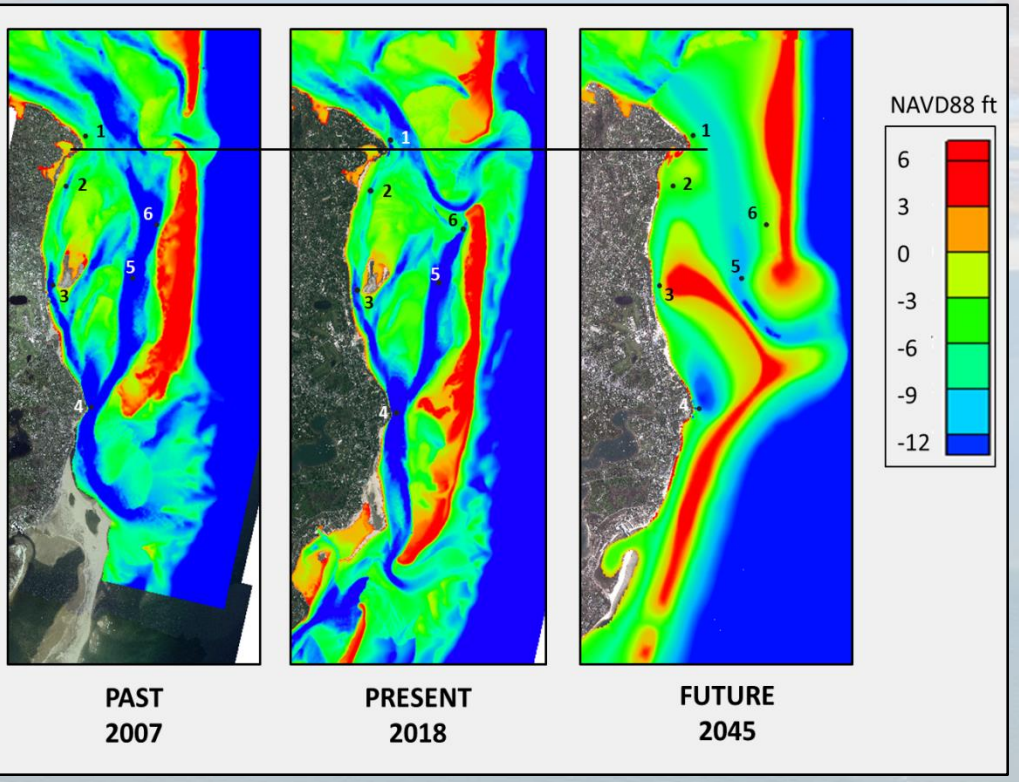
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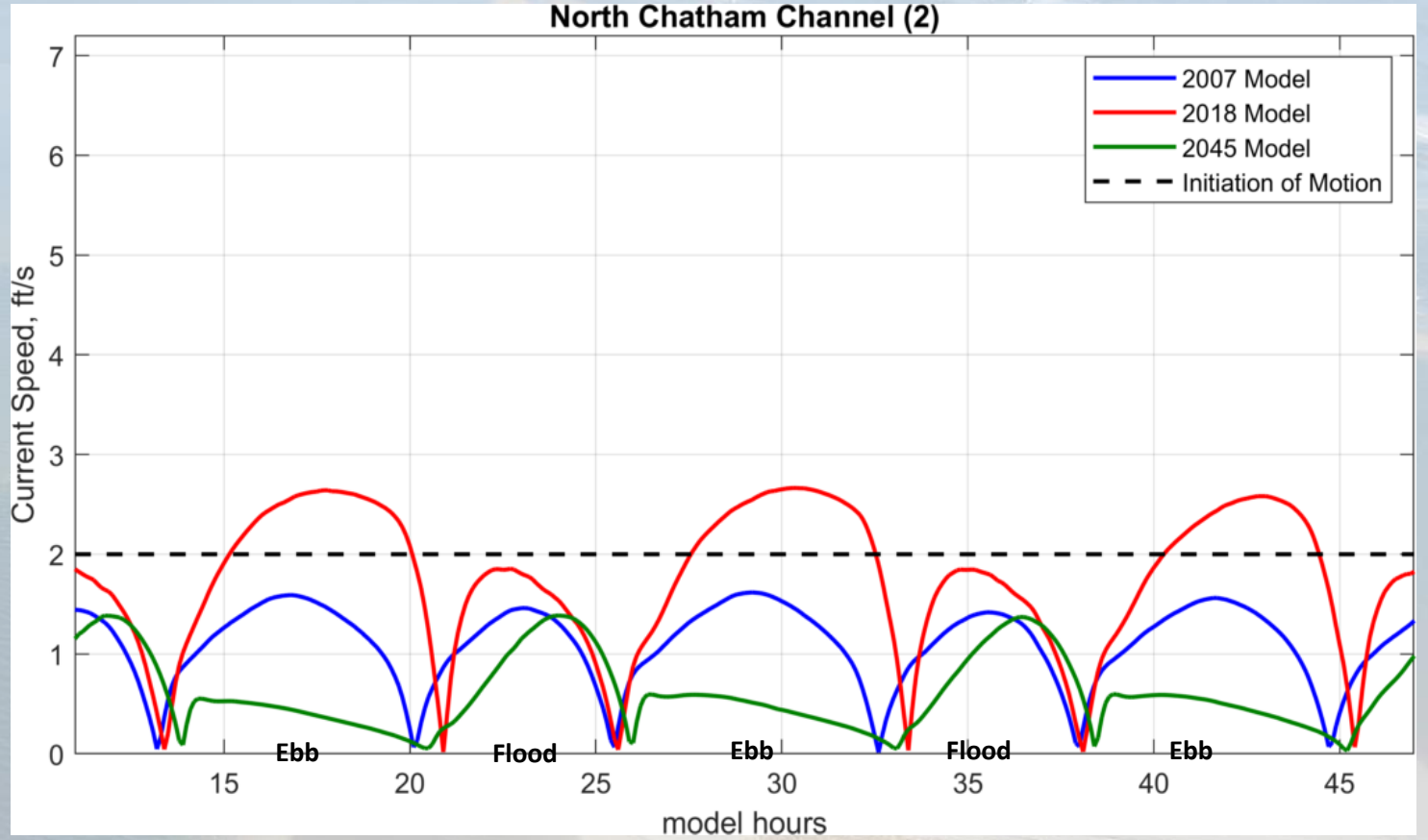
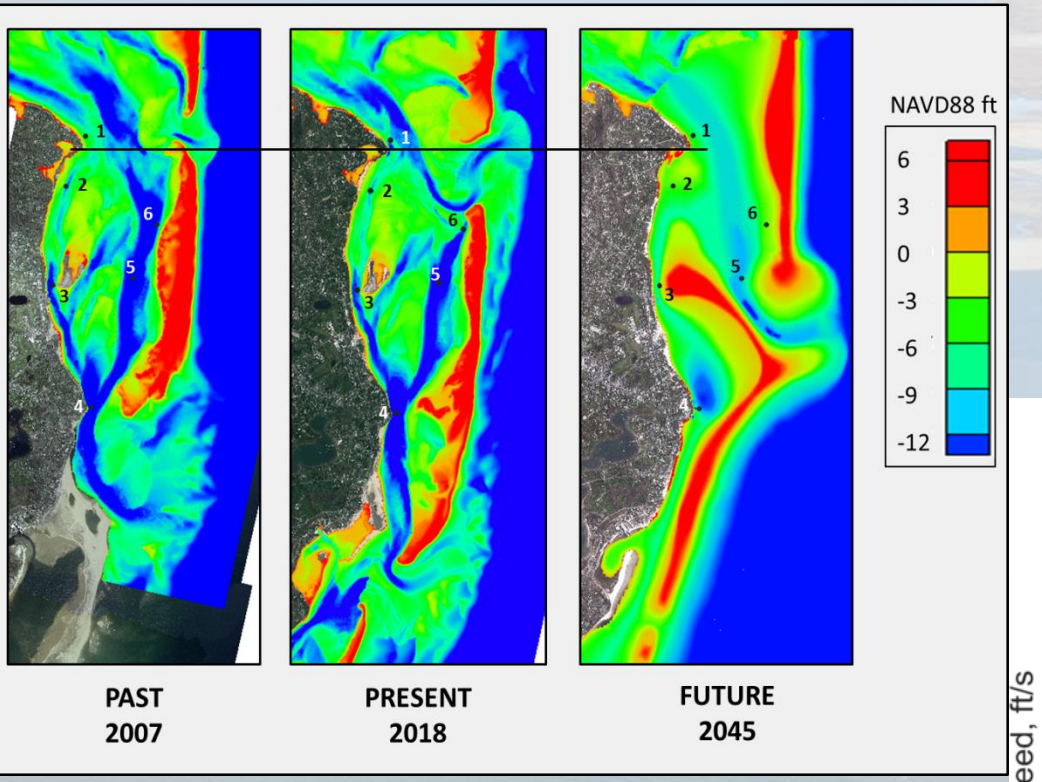
2018
FUTURE
2045


North Chatham Channel (2)
2007 Model
2018 Model
2045 Model
Initiation of Motion
Current Speed, ft/s
model hours
Ebb
Flood
Ebb
Flood
Ebb


NAVD88 ft
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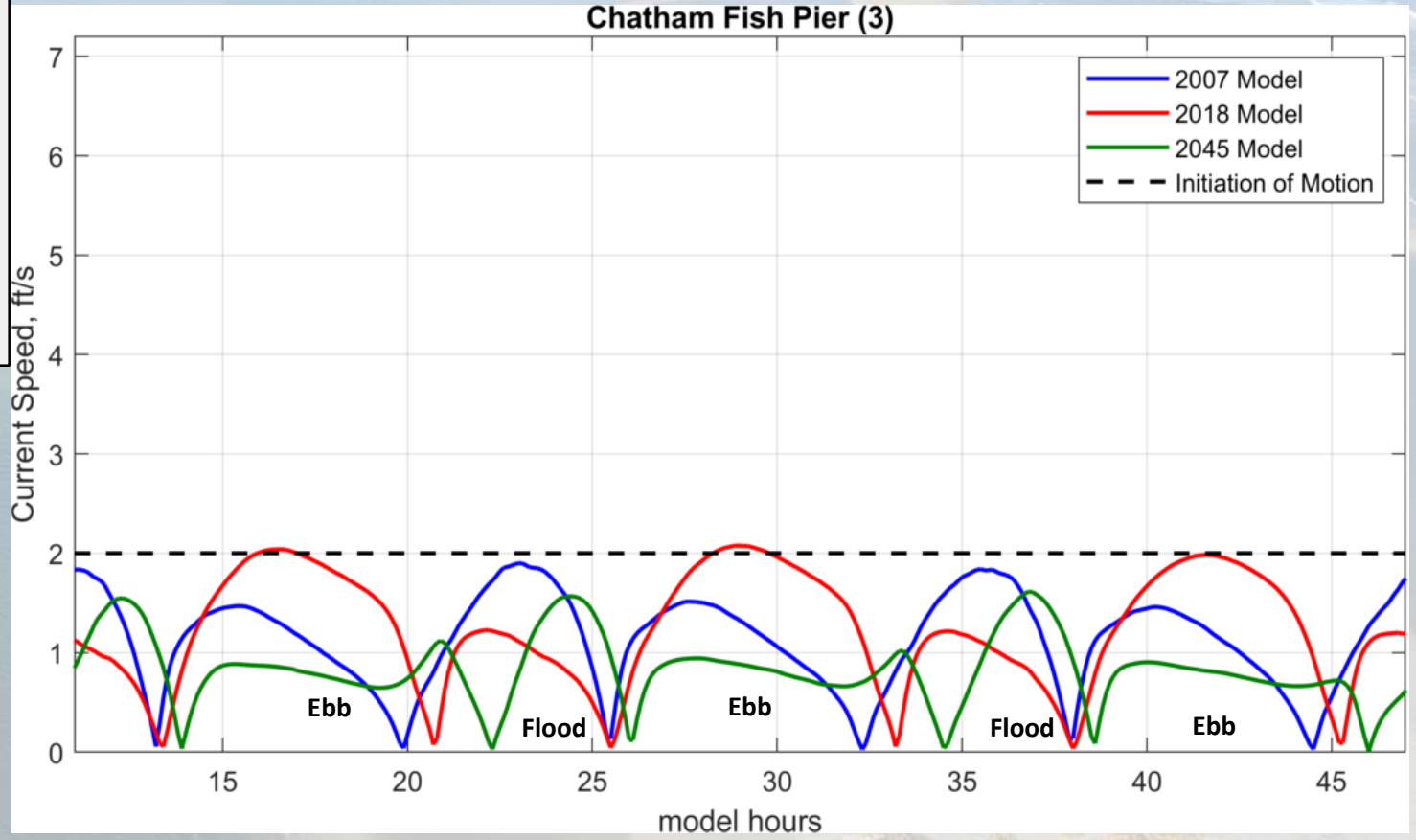
2007
PRESENT
2018
FUTURE
2045


Chatham Fish Pier (3)
2007 Model
2018 Model
2045 Model
Initiation of Motion
Current Speed, ft/s
model hours
Ebb
Flood
Ebb
Flood
Ebb
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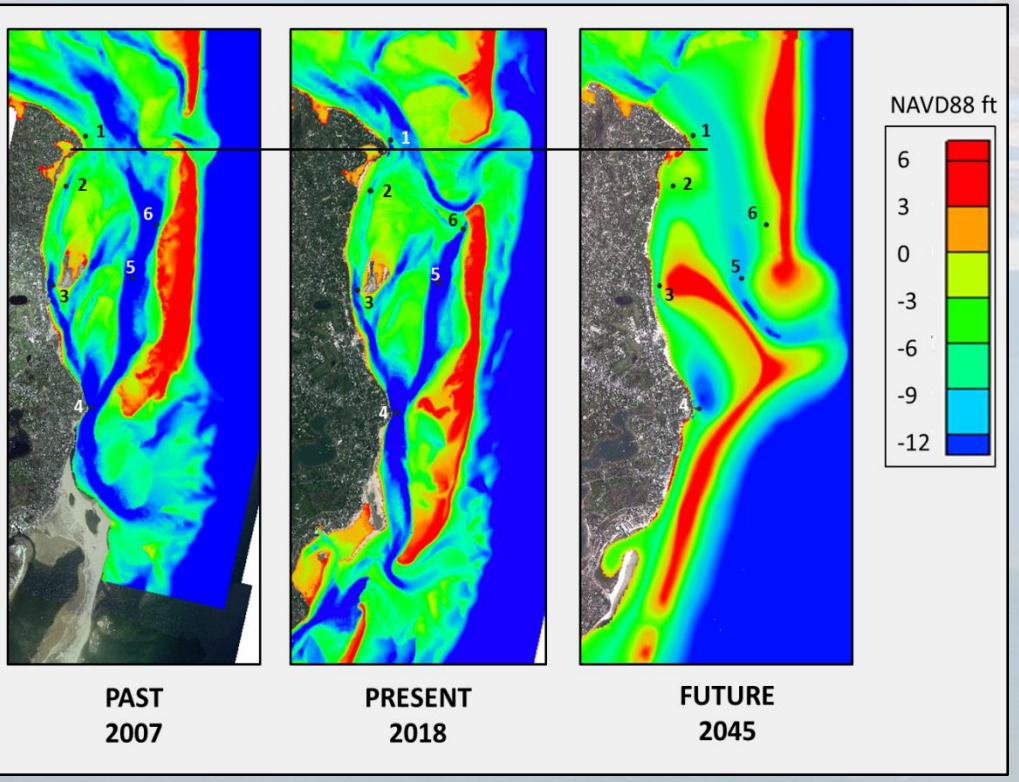
NAVD88 ft
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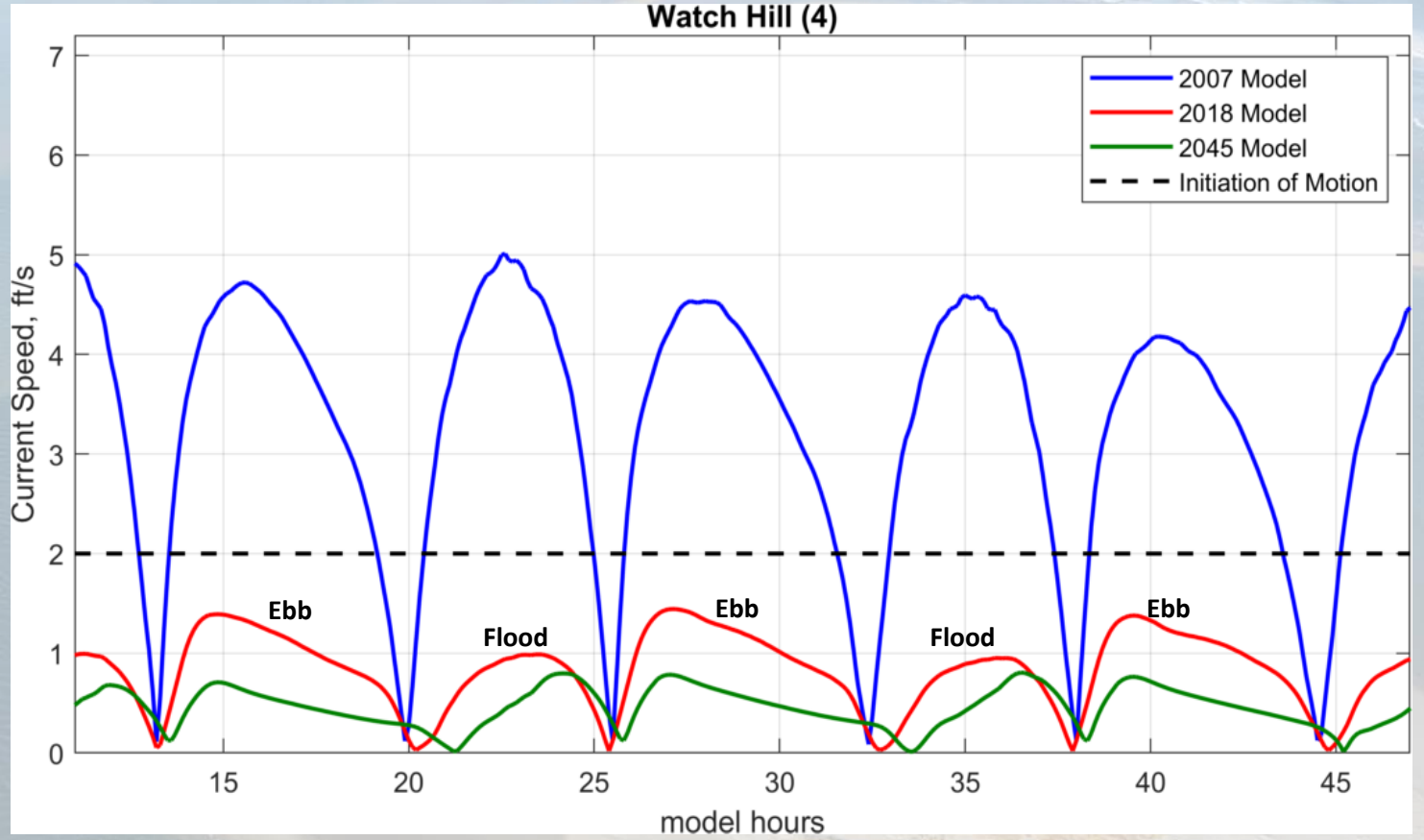
FUTURE
2045


Watch Hill (4)
2007 Model
2018 Model
2045 Model
Initiation of Motion
Current Speed, ft/s
model hours
Ebb
Flood
Ebb
Flood
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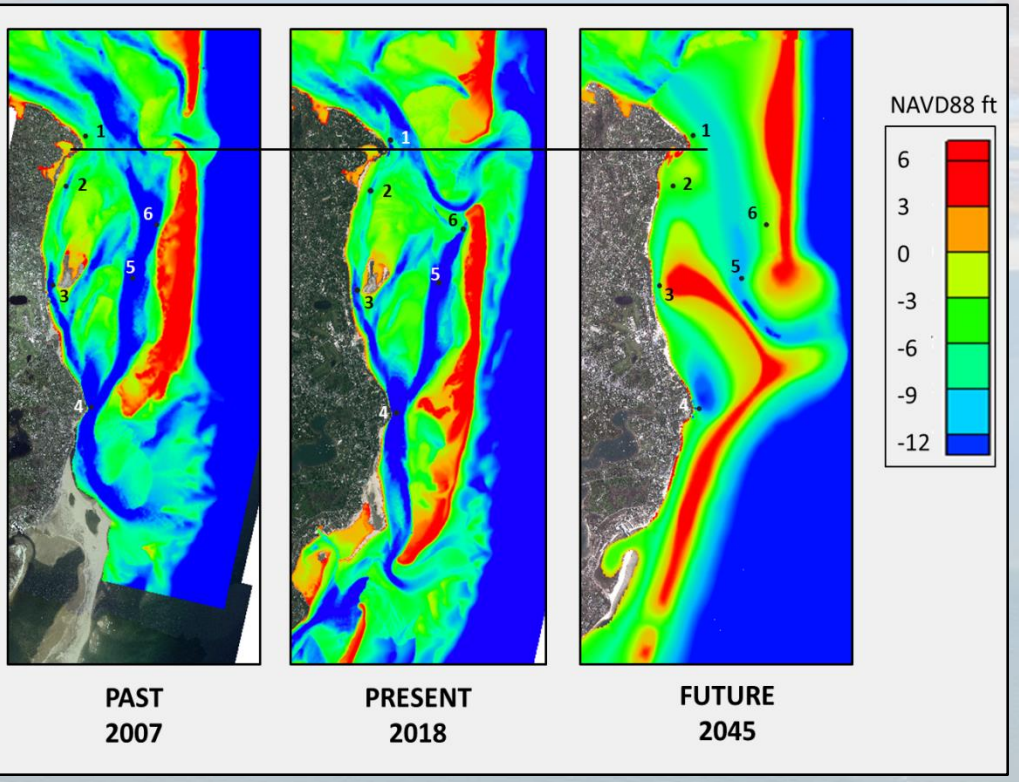
NAVD88 ft
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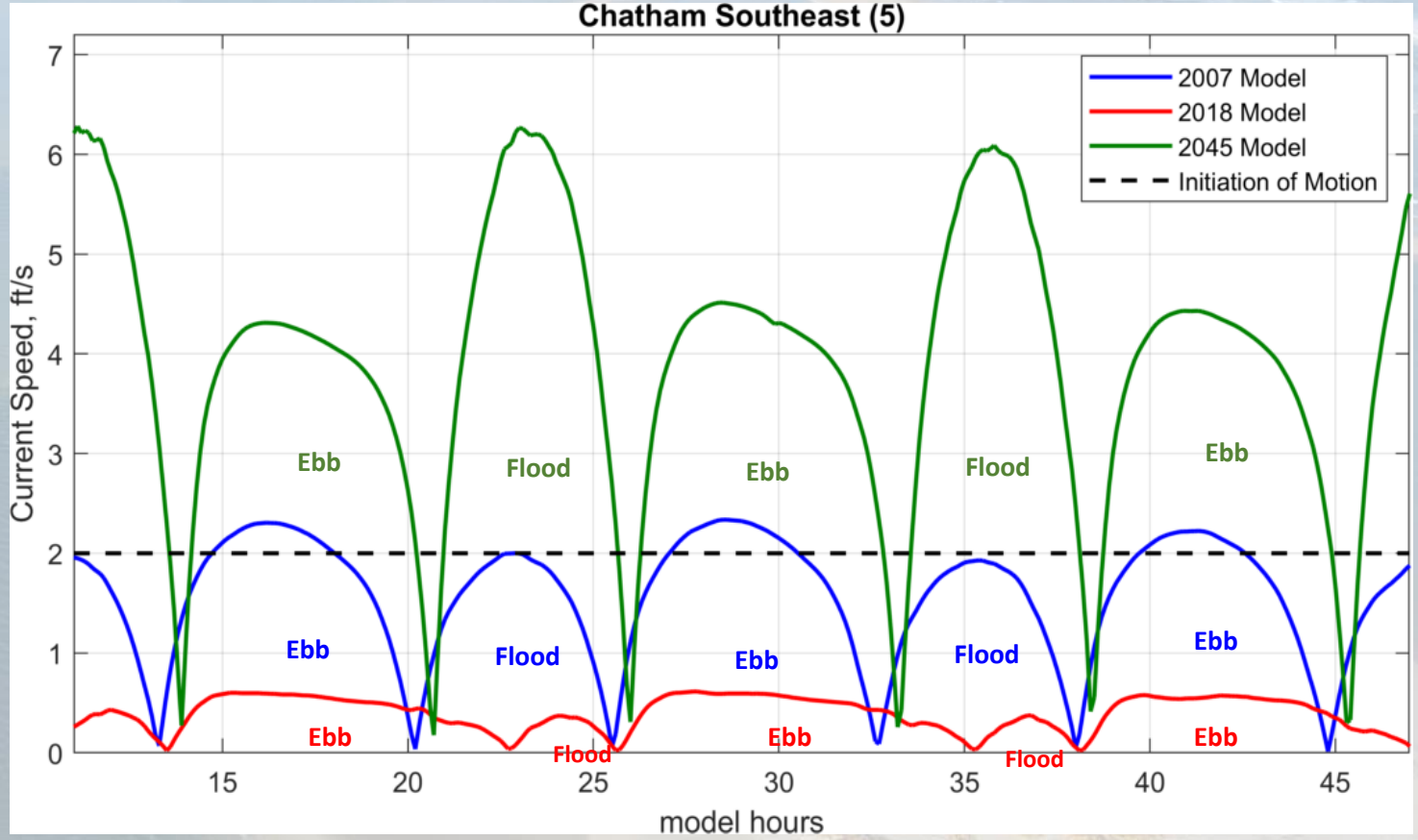
2018
FUTURE
2045


Chatham Southeast (5)
2007 Model
2018 Model
2045 Model
Initiation of Motion
Current Speed, ft/s
model hours
Ebb
Flood
Ebb
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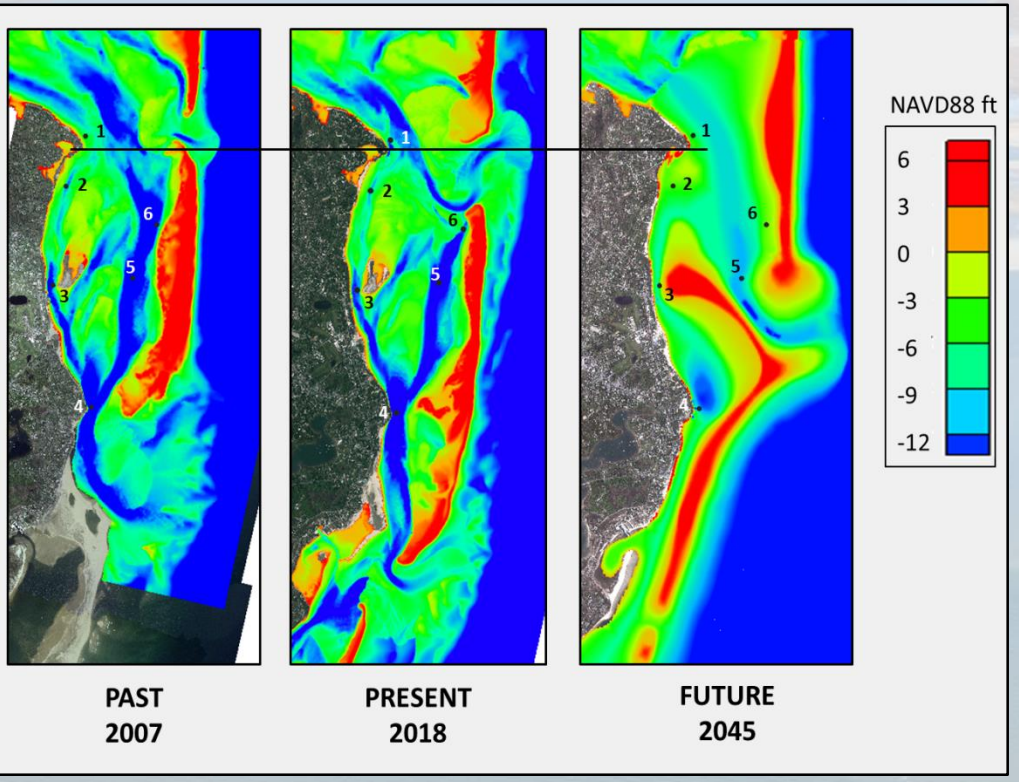
NAVD88 ft
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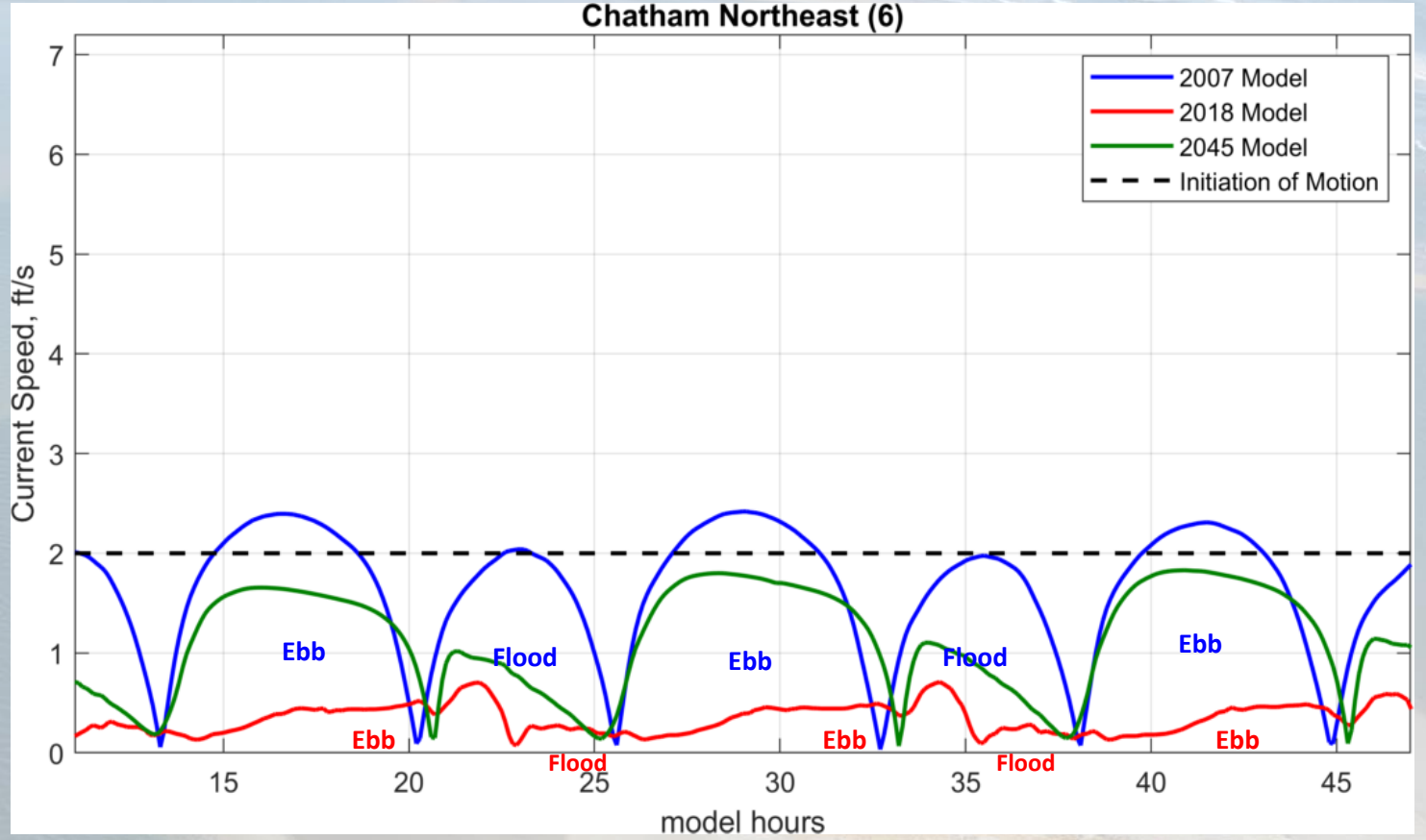
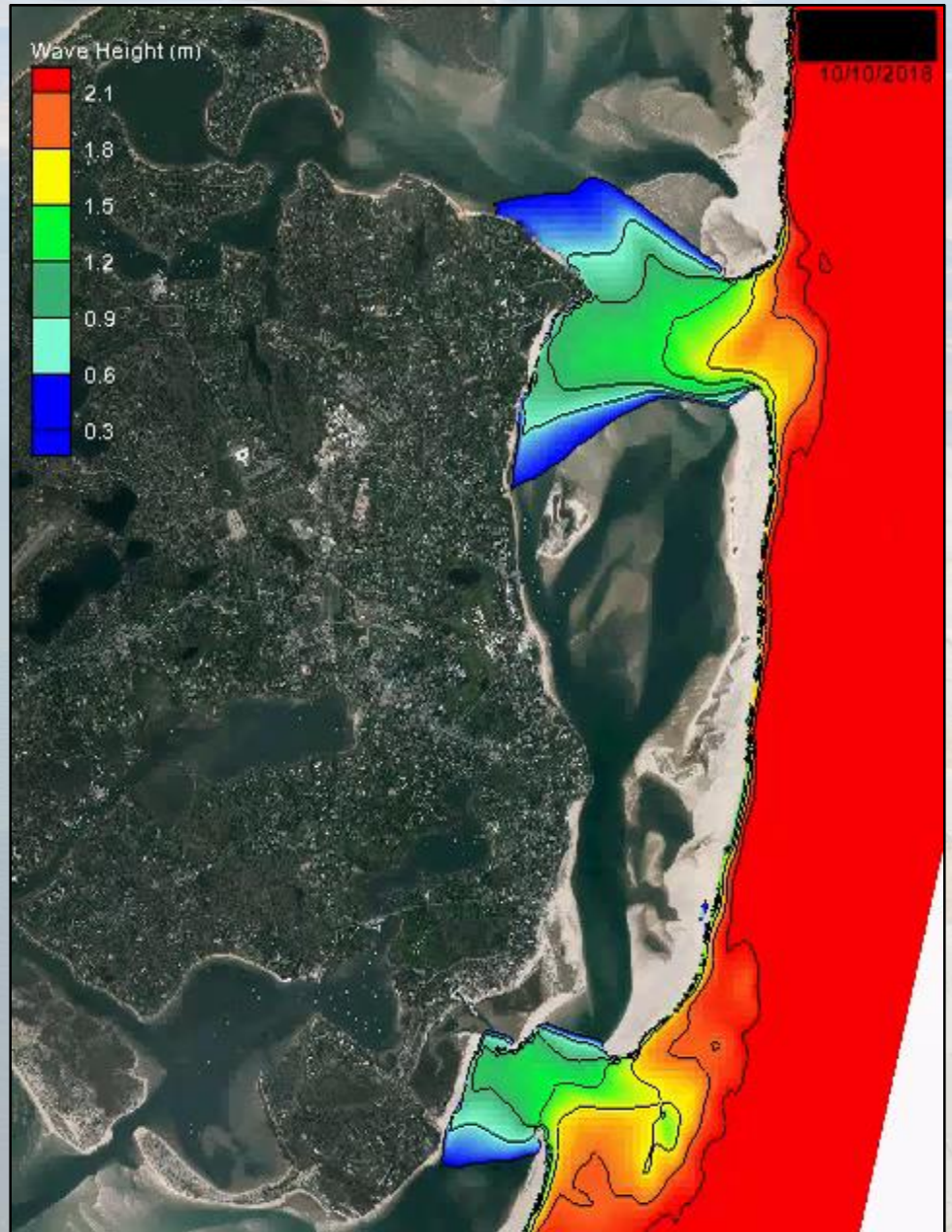
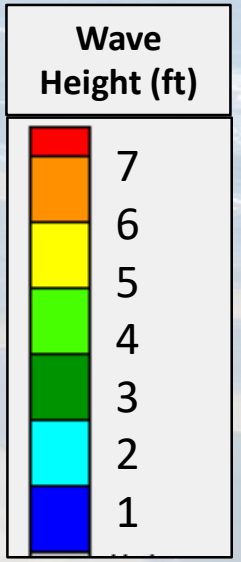
PRESENT
2018
FUTURE
2045

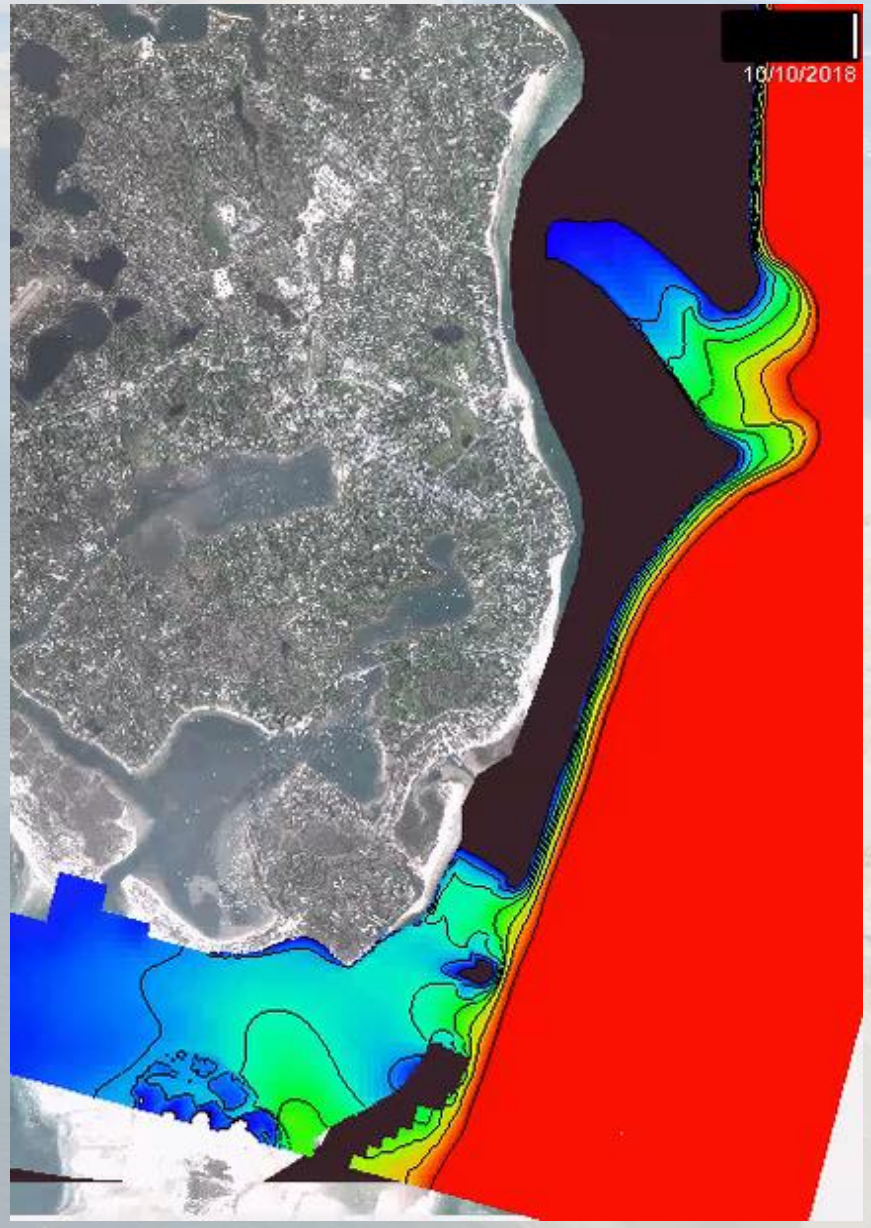

Chatham Northeast (6)
2007 Model
2018 Model
2045 Model
Initiation of Motion
Current Speed, ft/s
model hours
Ebb
Flood
Ebb
Flood
Ebb
Flood
Ebb
Ebb
Flood
Ebb

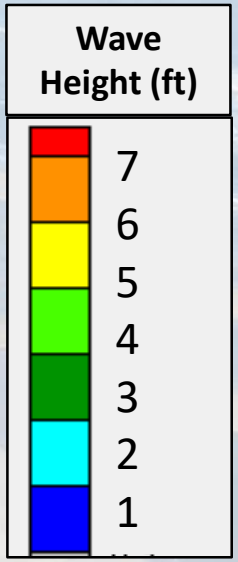
Analysis of Coastal Processes: 2018 Storm Wave Patterns Video



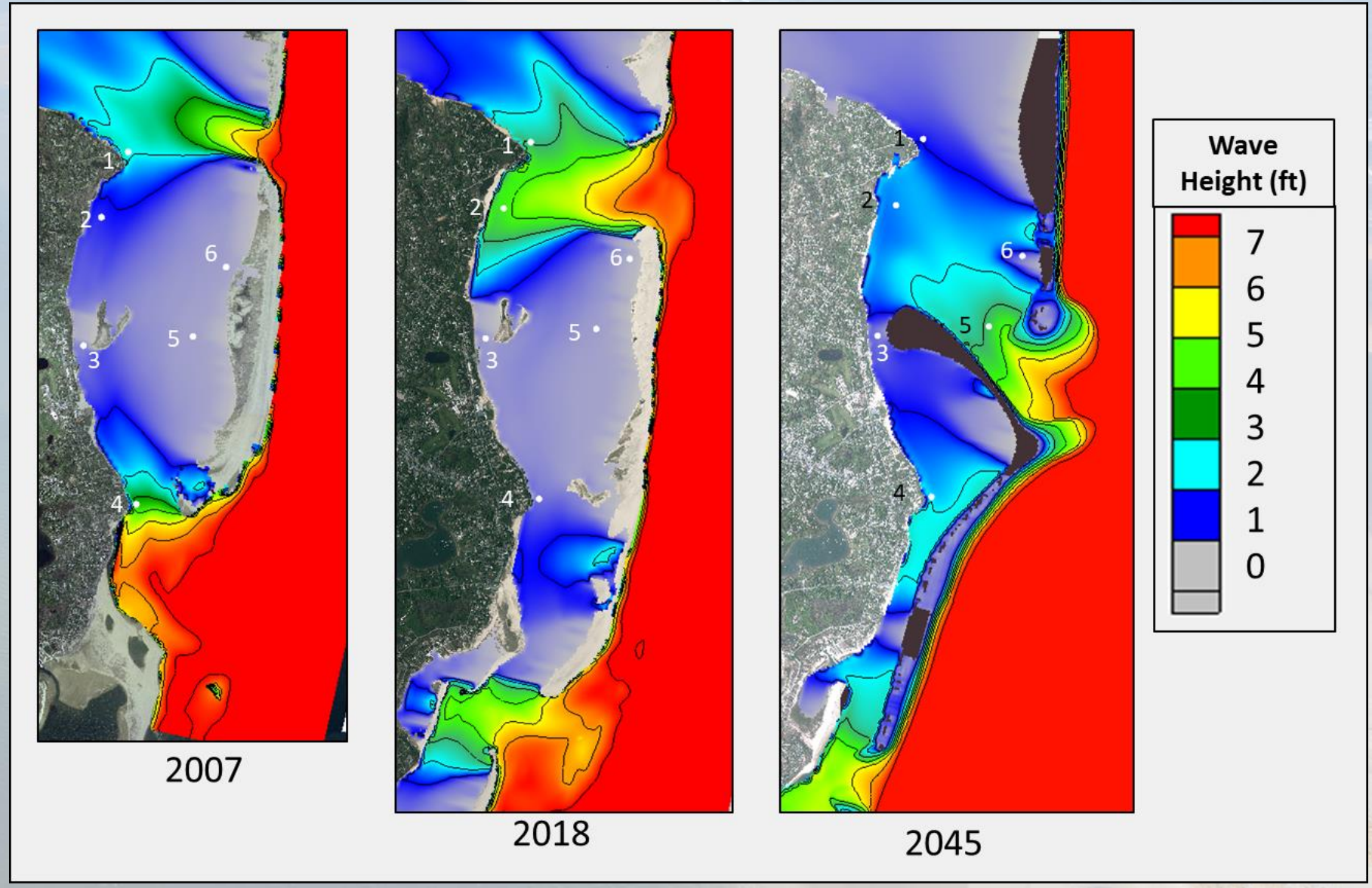


Analysis of Coastal Processes: 2045 Storm Wave Patterns Video





Wave Heights during Storm Conditions during Incoming Tide



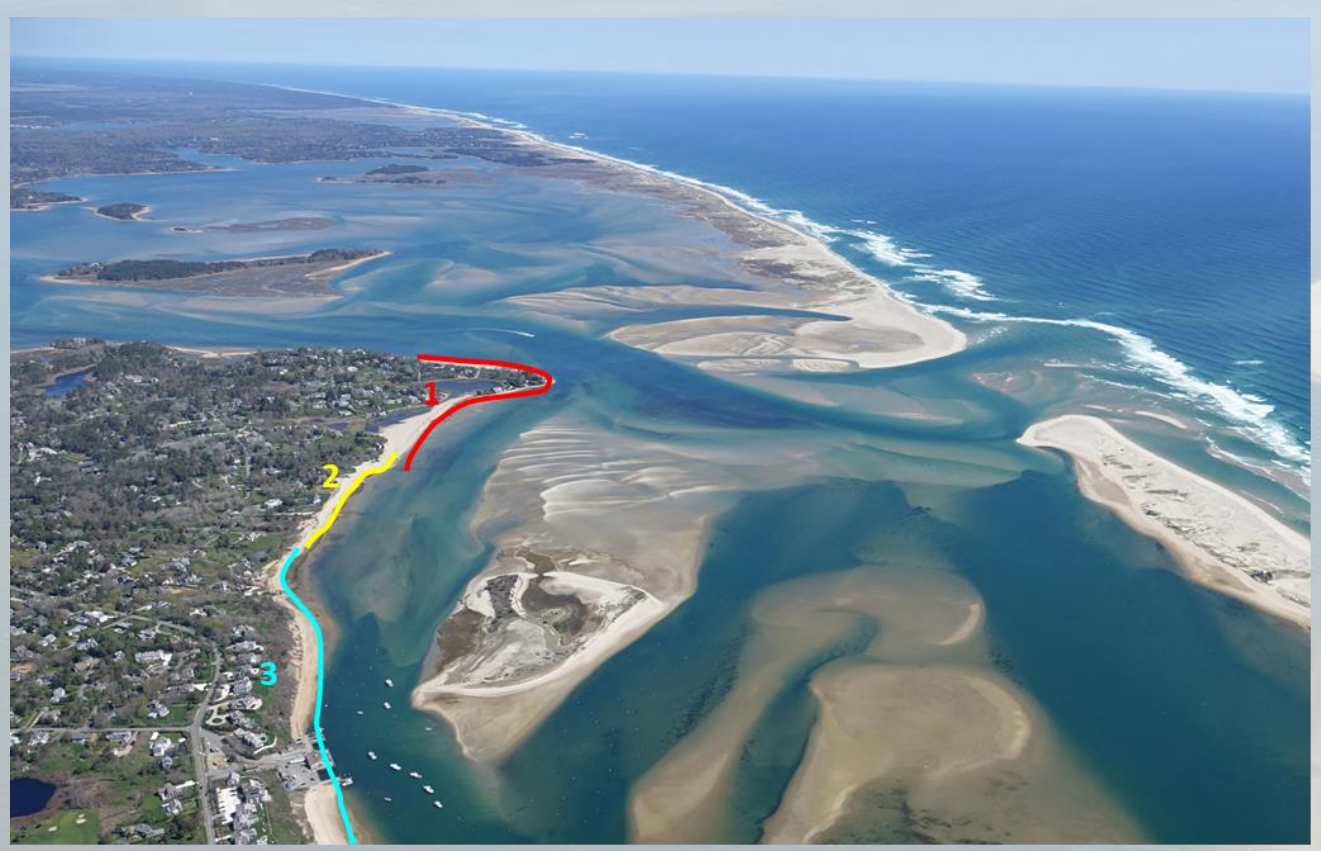
Current and Future Shoreline Management Concerns			
Assessment Area	**Location**	**Current**	**Future to 2045**
1	Minister's Point to Linnell Ln Beach	Severe	Moderate
2	Linnell Ln Beach to Thayer Ln	Moderate	Moderate to Severe
3	Thayer Ln to Chatham Lighthouse	Minimal	Minimal
4	Little Beach/Outermost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

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

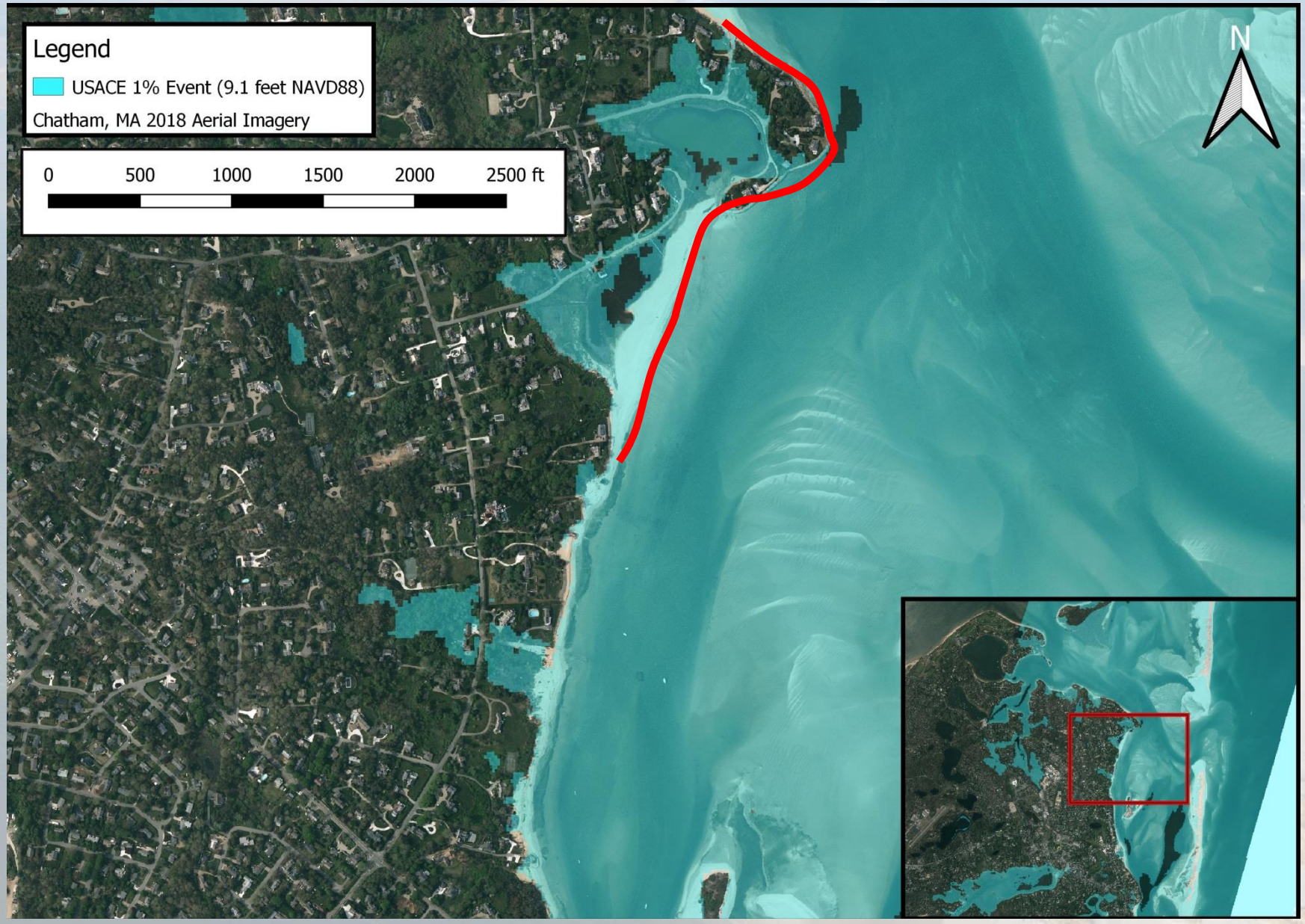
Linnell Lane Beach facing north, showing the low-lying overwash area, continuous revetment at Minister's Point, and eroded beach face and exposed marsh peat layer

Existing Engineered Structures
Assessment Area 1

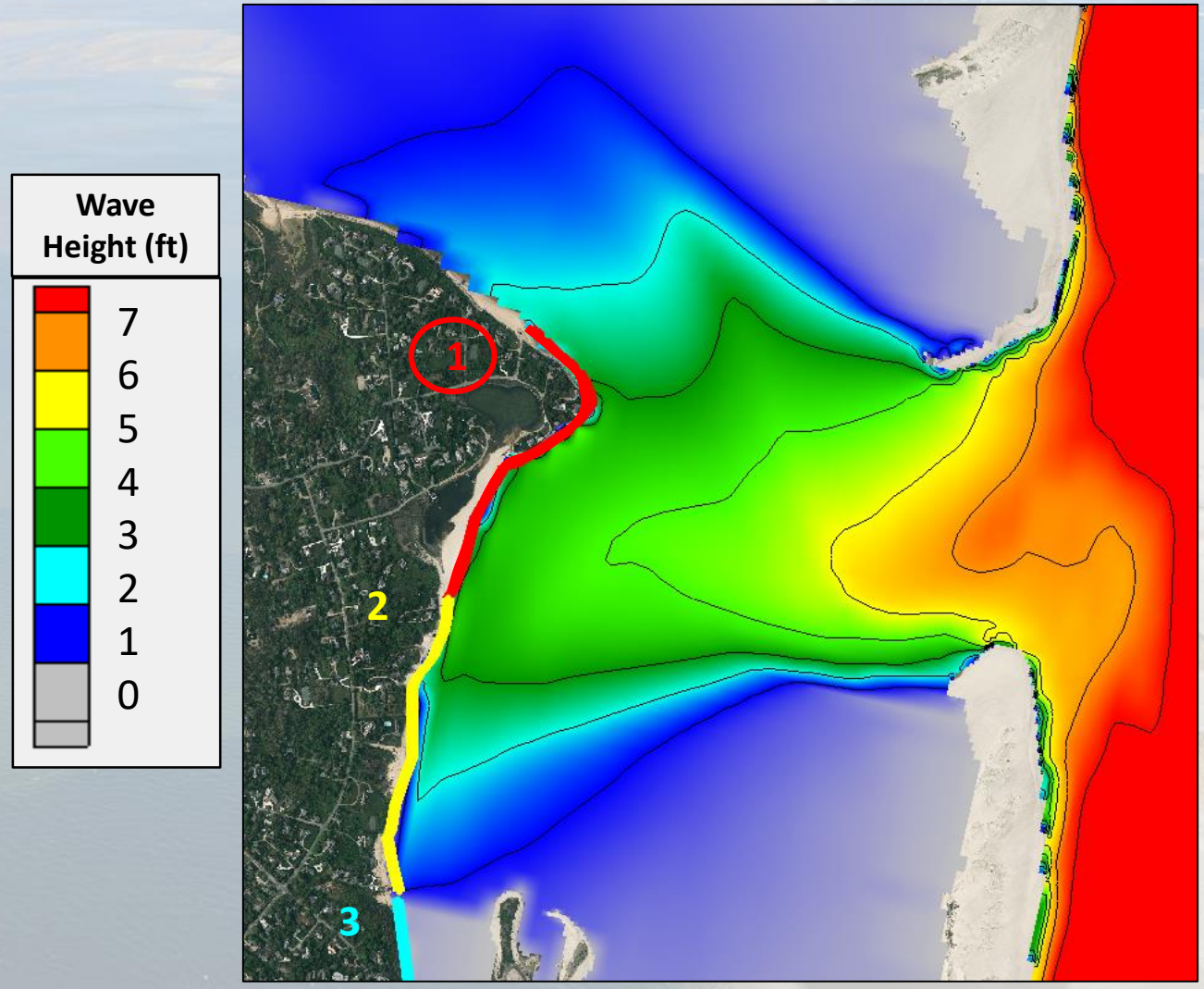
Active Tidal Channel to Pleasant Bay
Assessment Area 1



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

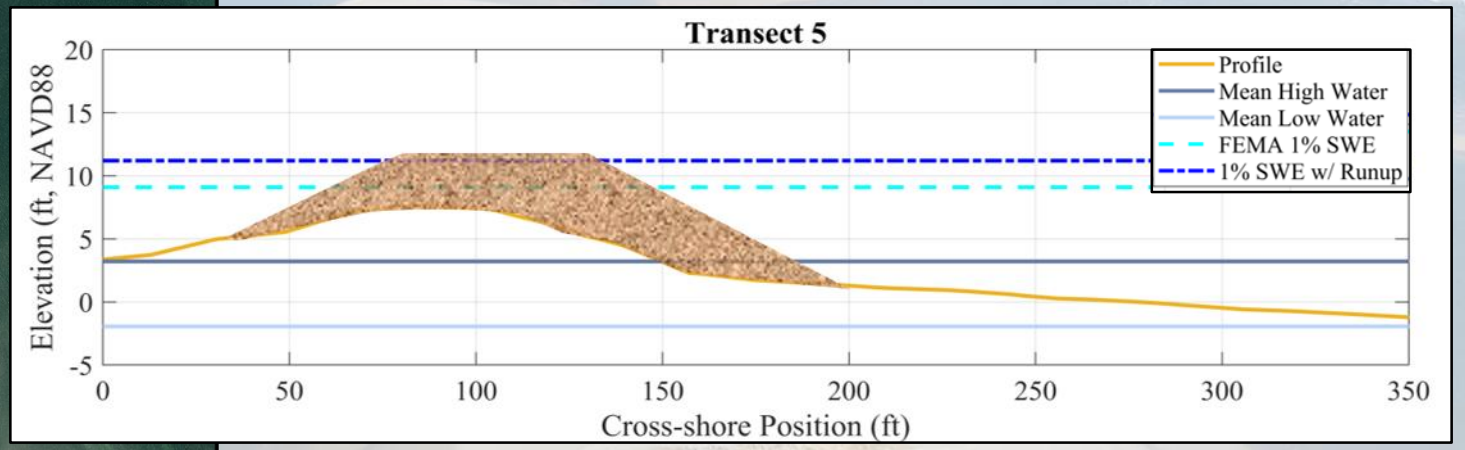
Assessment Area 1: Stabilize Revetment Toe

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

Assessment Area 1: Offshore Structures to Re-Direct Currents

Pros	Cons
• Reduce/eliminate scour along Minister's Point	• Potential increased scour at other locations • Cost
Challenges • Likely significant regulatory concerns regarding encroachment on resource areas, potential impacts on other resources by re-directing currents, etc.	

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



Beach Nourishment

~32,000 cubic yards

Assessment Area 1: Linnell Lane Beach Nourishment

Pros	Cons
• Prevent storm-induced overwash into salt marsh and Linnell Lane area • Provide sediment supply to downdrift beaches	• Increased sediment supply will make maintaining inlet to the salt marsh difficult (may require a culvert) • Maintenance costs until North Inlet migrates further south
Challenges • Need to maintain and/or improve salt marsh.	

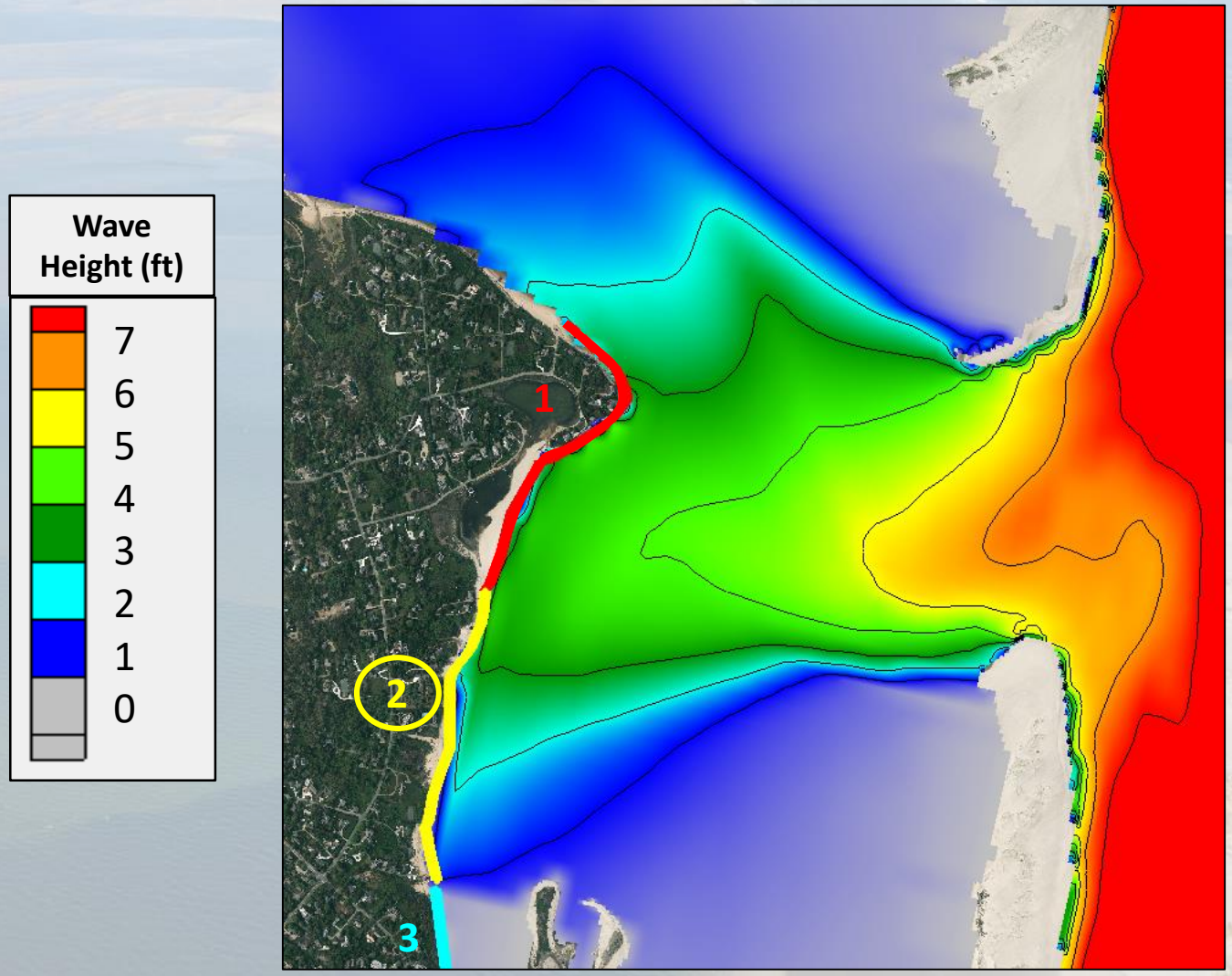
Linnell Ln Beach to Thayer Ln, Assessment Area 2

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.

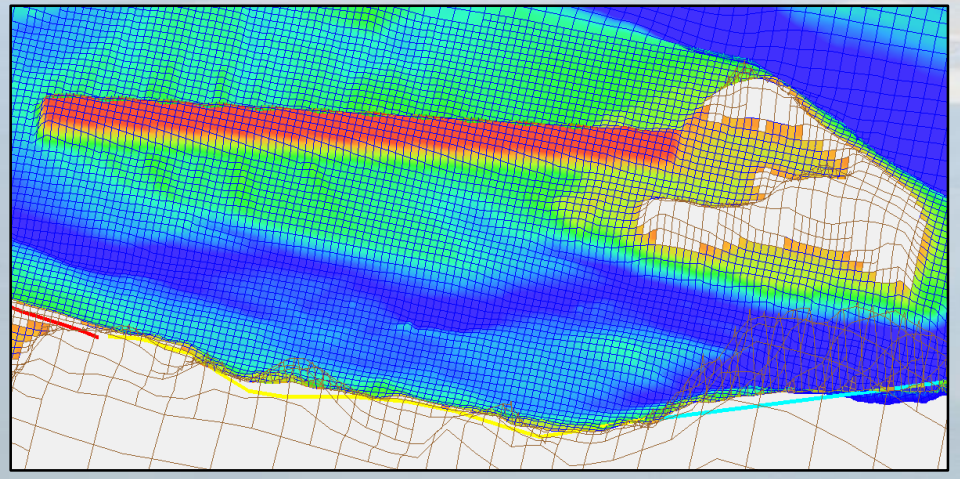
Existing Engineered Structures
Assessment Area 2

Storm Wave Heights: Assessment Area 2



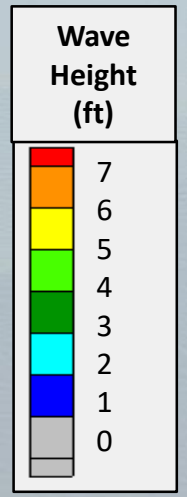
Present: Moderate 2040: Moderate to Severe

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



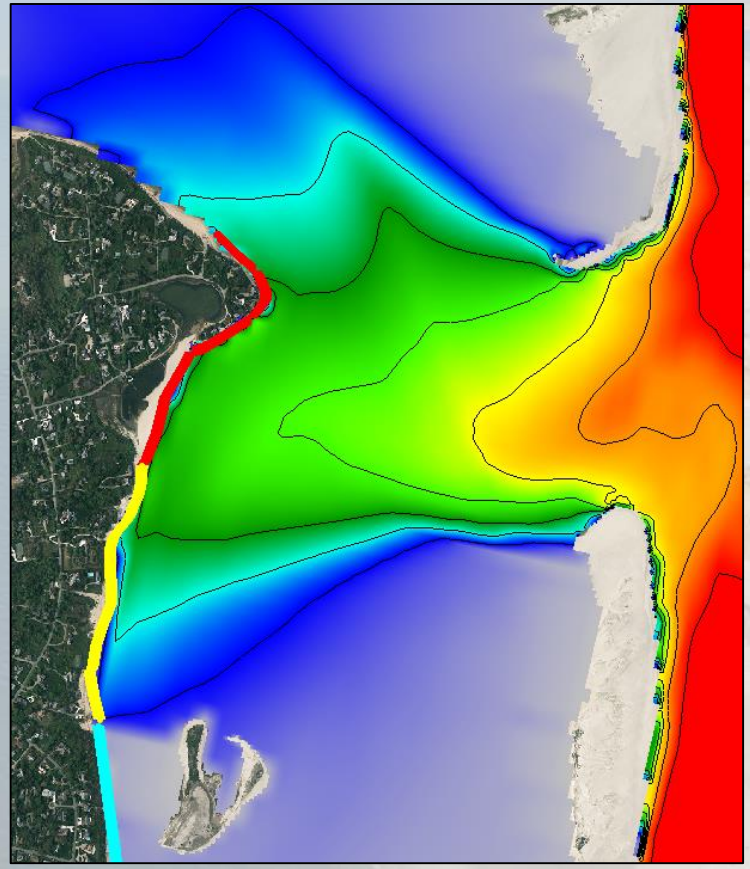
6’ NAVD88 top
150’ Wide Crest
2,700’ long

~150,000 cubic yards

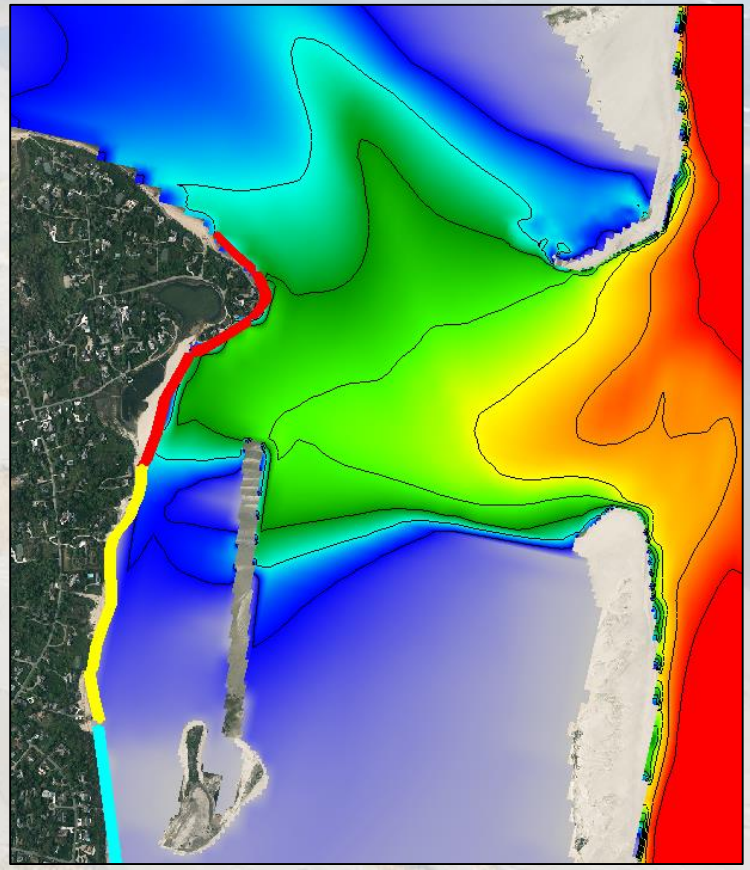


Tern Island Flats Nourishment

Status Quo



With Nourishment



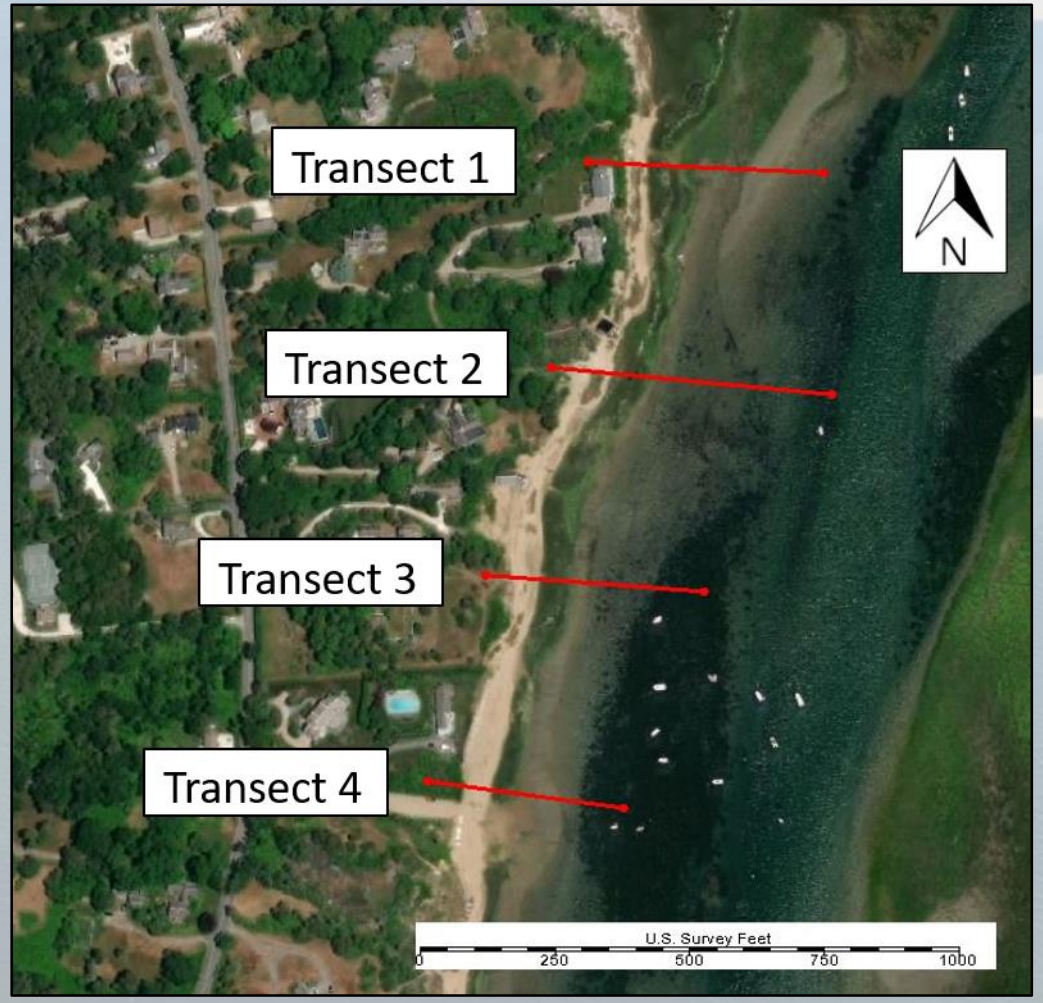
Assessment Area 2: Tern Island Flats Nourishment

Pros	Cons
• Reduce storm wave energy along shoreline until North Inlet migrates further south • Provide sediment supply to nearshore area	• Cost (including maintenance) • Will not provide complete protection of the shoreline 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)	

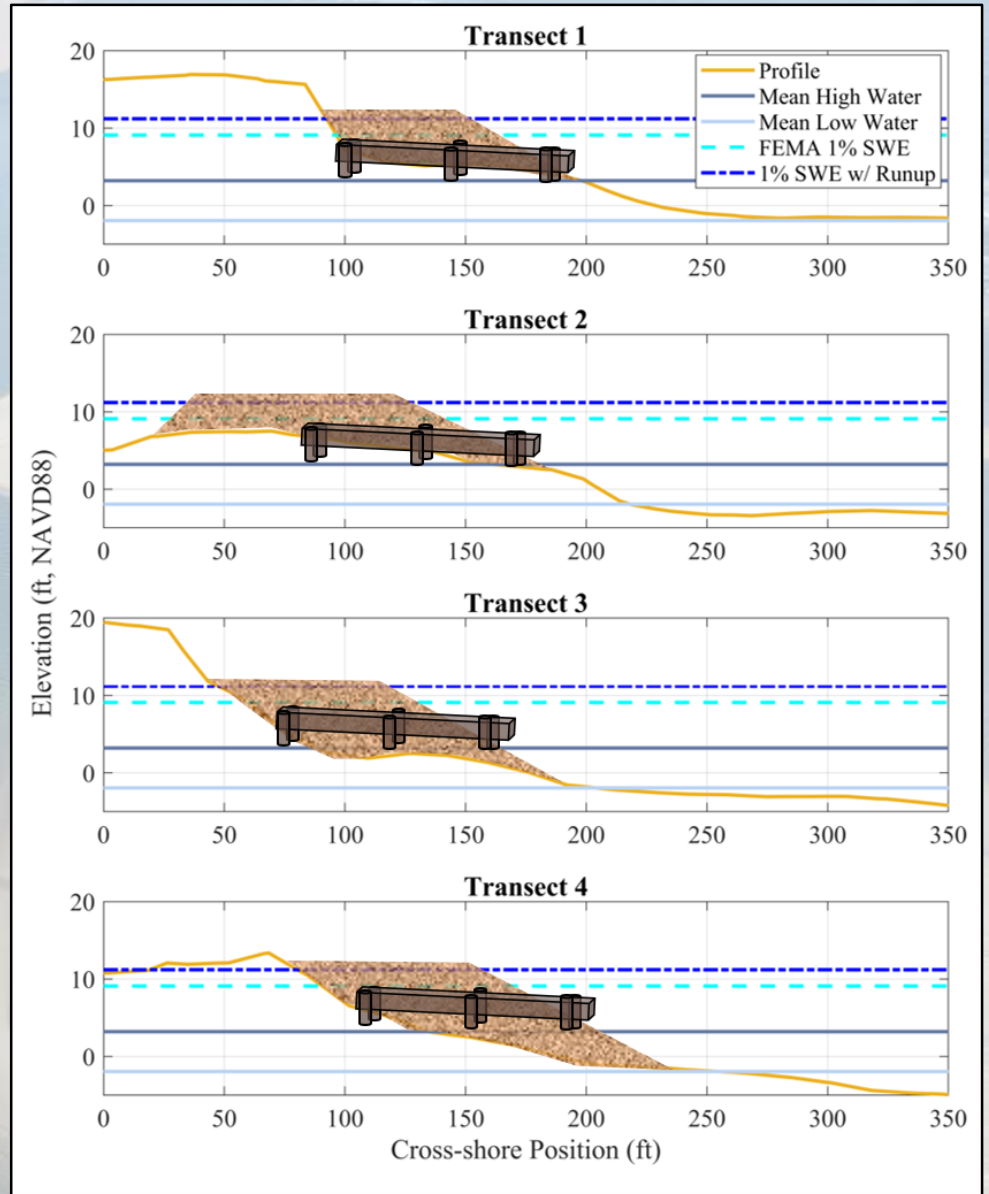
Management Strategy:
Linnell Lane Beach to Thayer Lane,
Assessment Area 2

- 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



Wooden Groins



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

Example Wood Groin

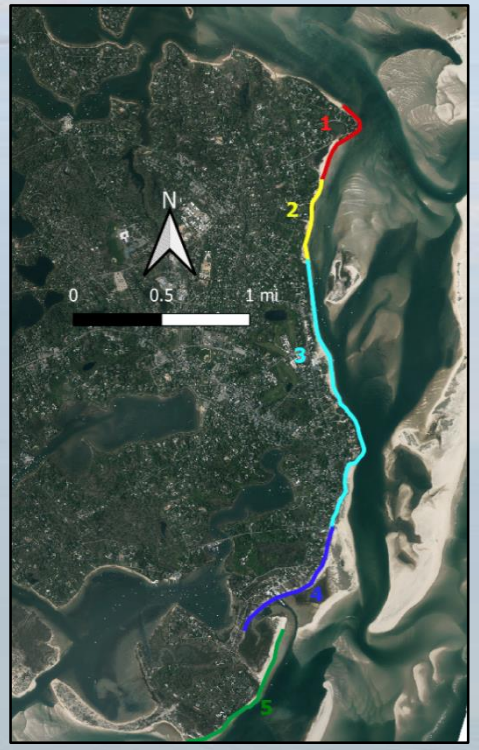
Assessment Area 2: Temporary Groins and Nourishment

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

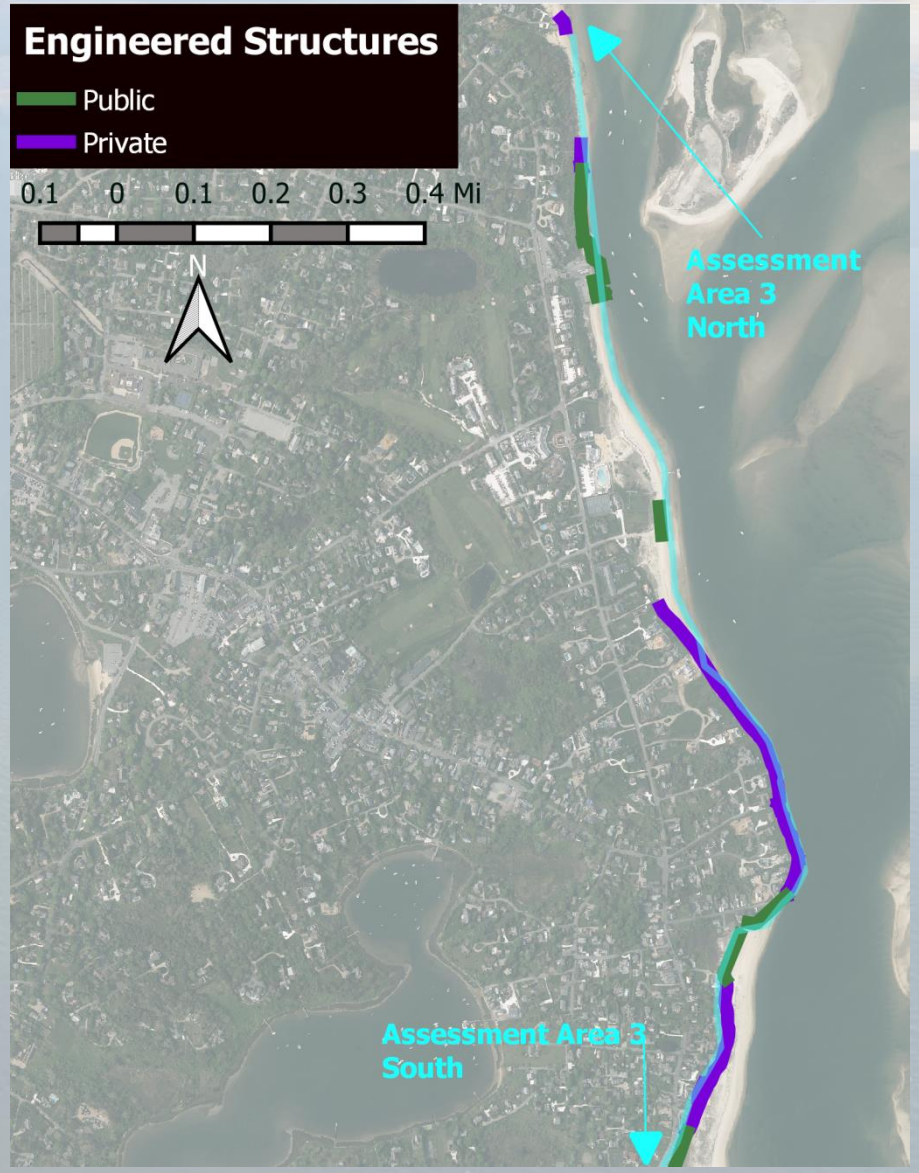
Thayer Lane to Chatham Lighthouse, Assessment Area 3



Looking north from Chatham Lighthouse towards Watch Hill

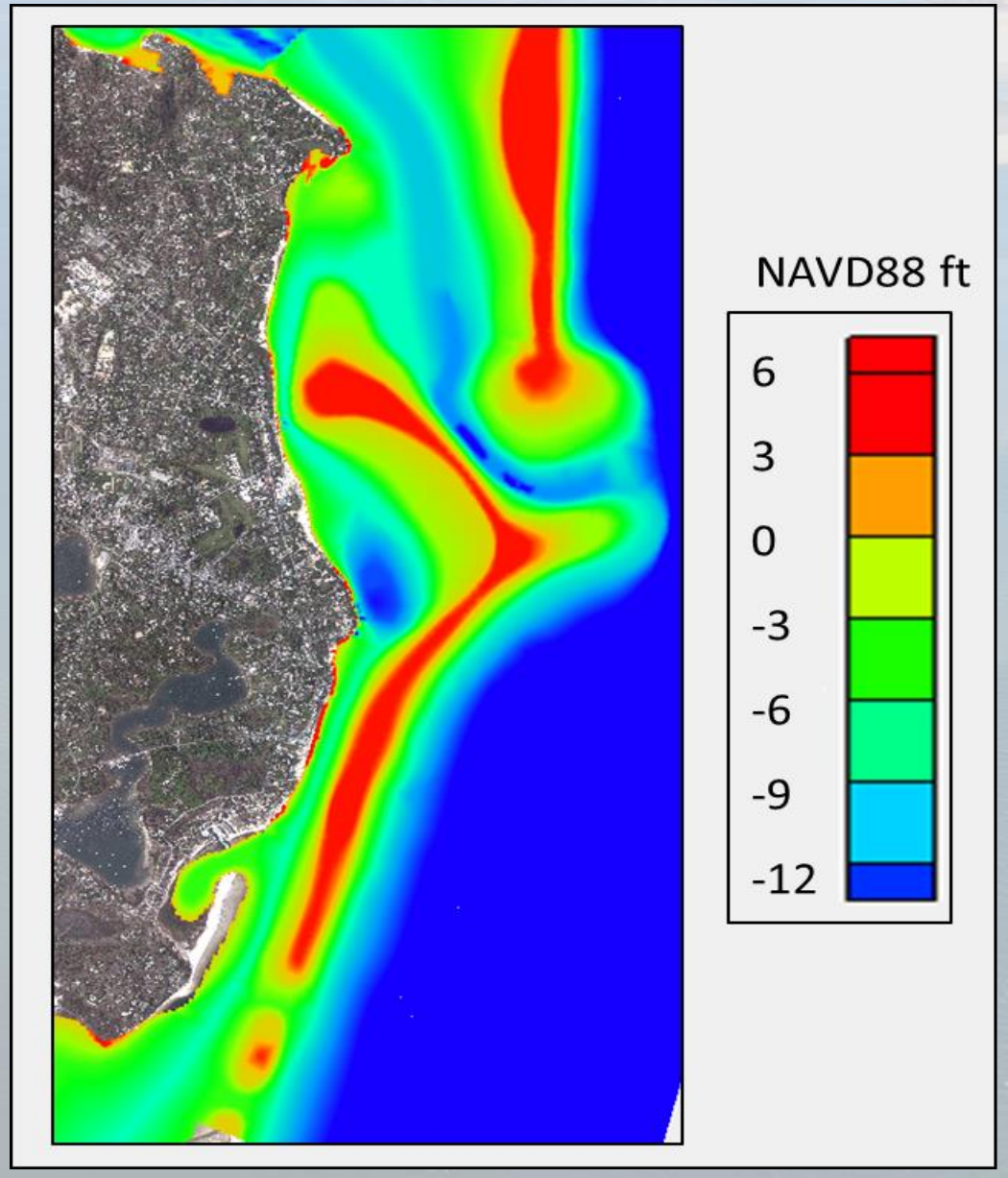
Chatham Fish Pier, facing east

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



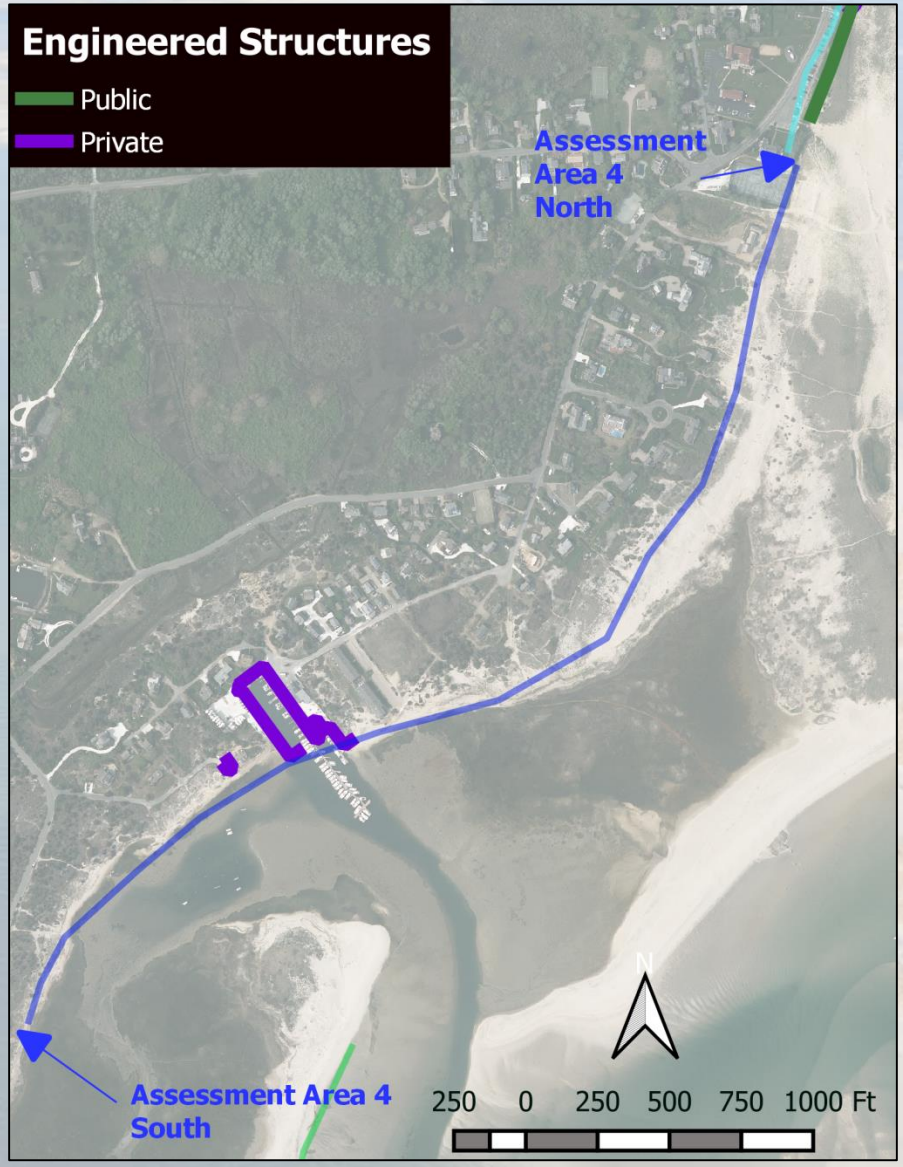
- Remnants of North Beach Island will continue to protect the shoreline
- Hydraulic separation of system will reduce tidal currents along much of the shoreline
- Based on existing and anticipated future conditions through 2040, no significant shore protection efforts likely will be needed

Little Beach/Outermost Harbor, Assessment Area 4

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

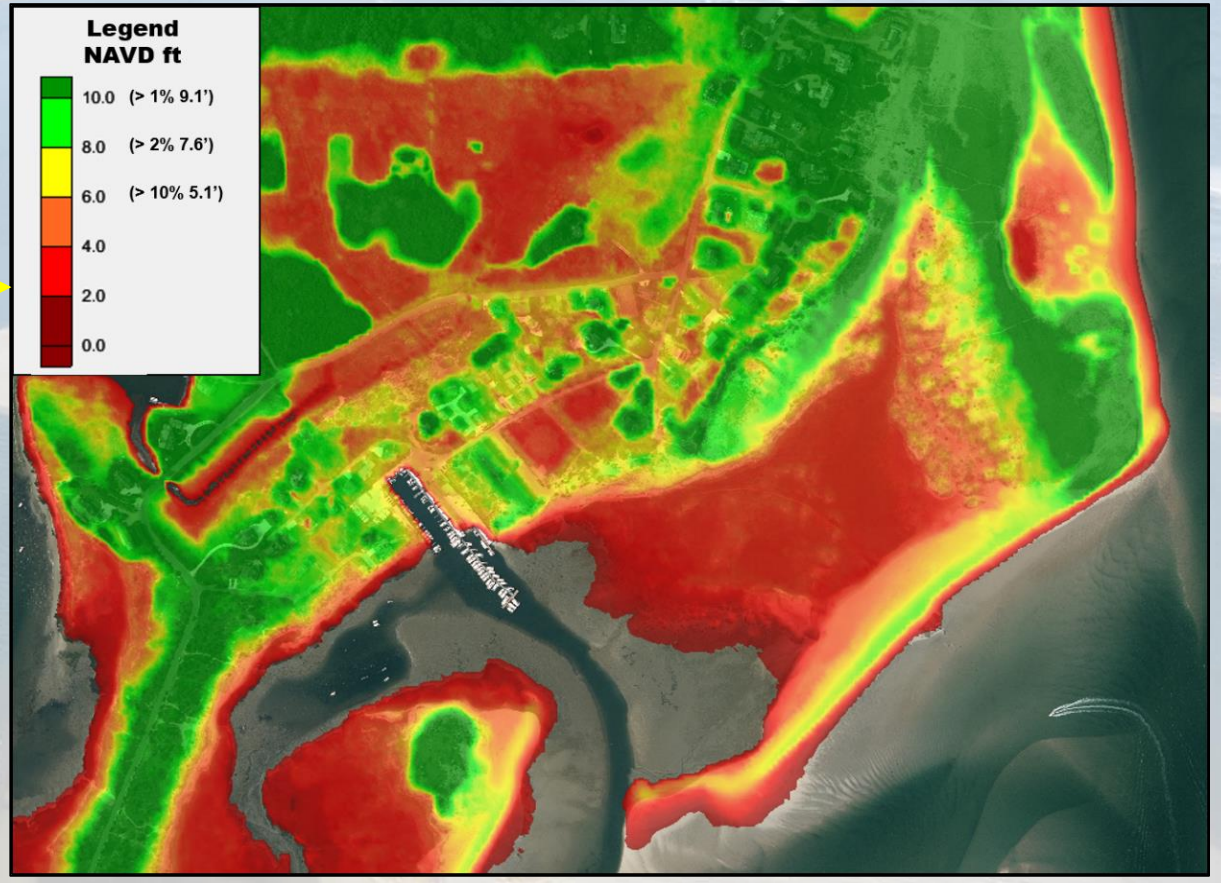
Little Beach, low elevation marsh seaward of sandbag levee temporary fix, view facing east.

Existing Engineered Structures
Assessment Area 4



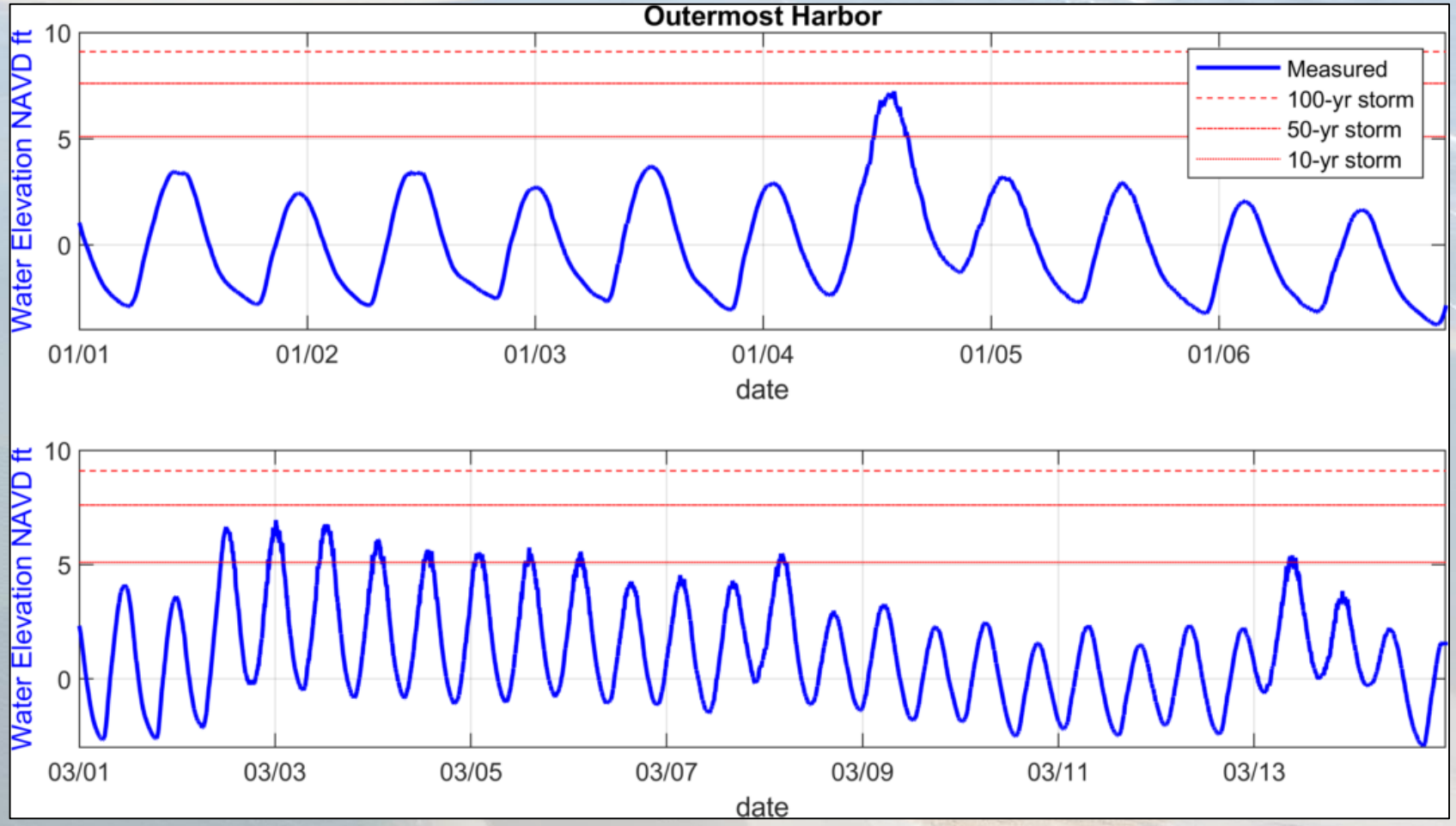
Severe Flooding
Little Beach/Outermost Harbor,
Assessment Area 4

2007 2018

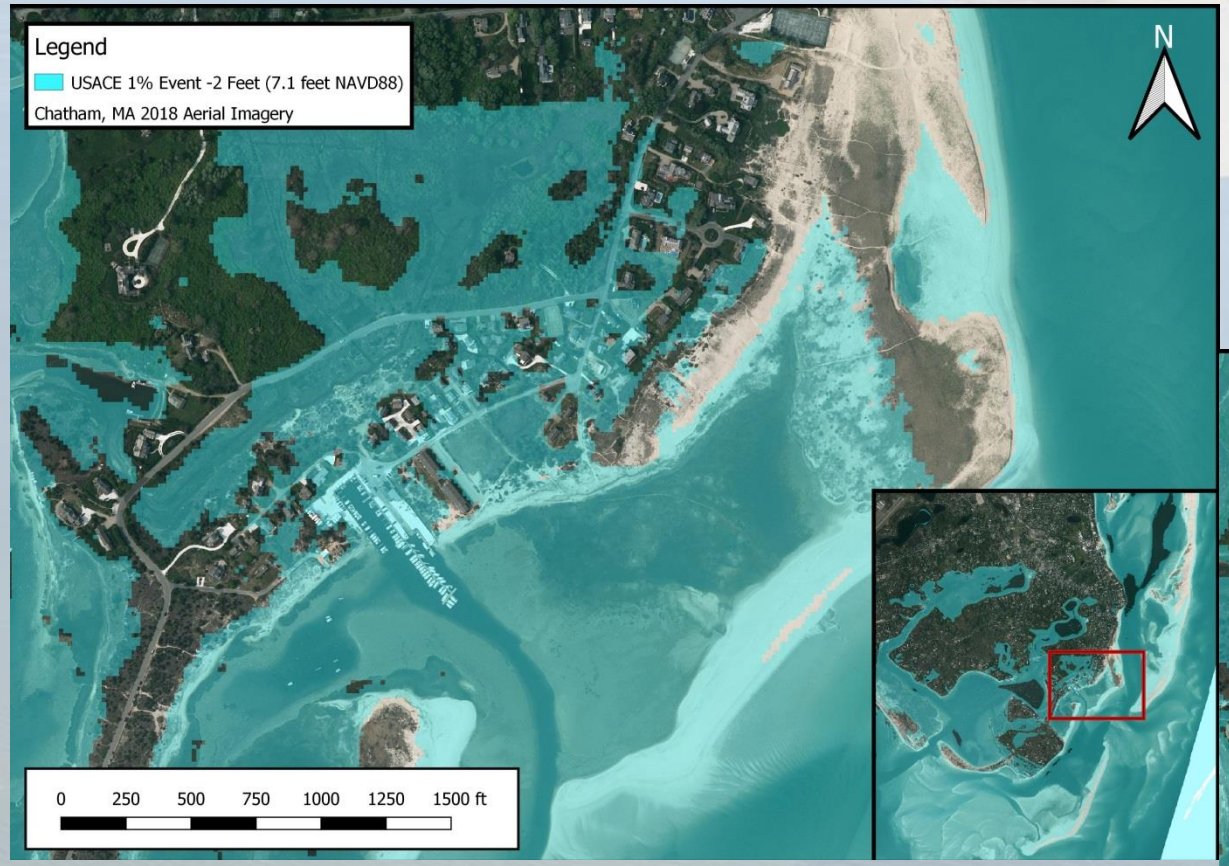


Recent Storms

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

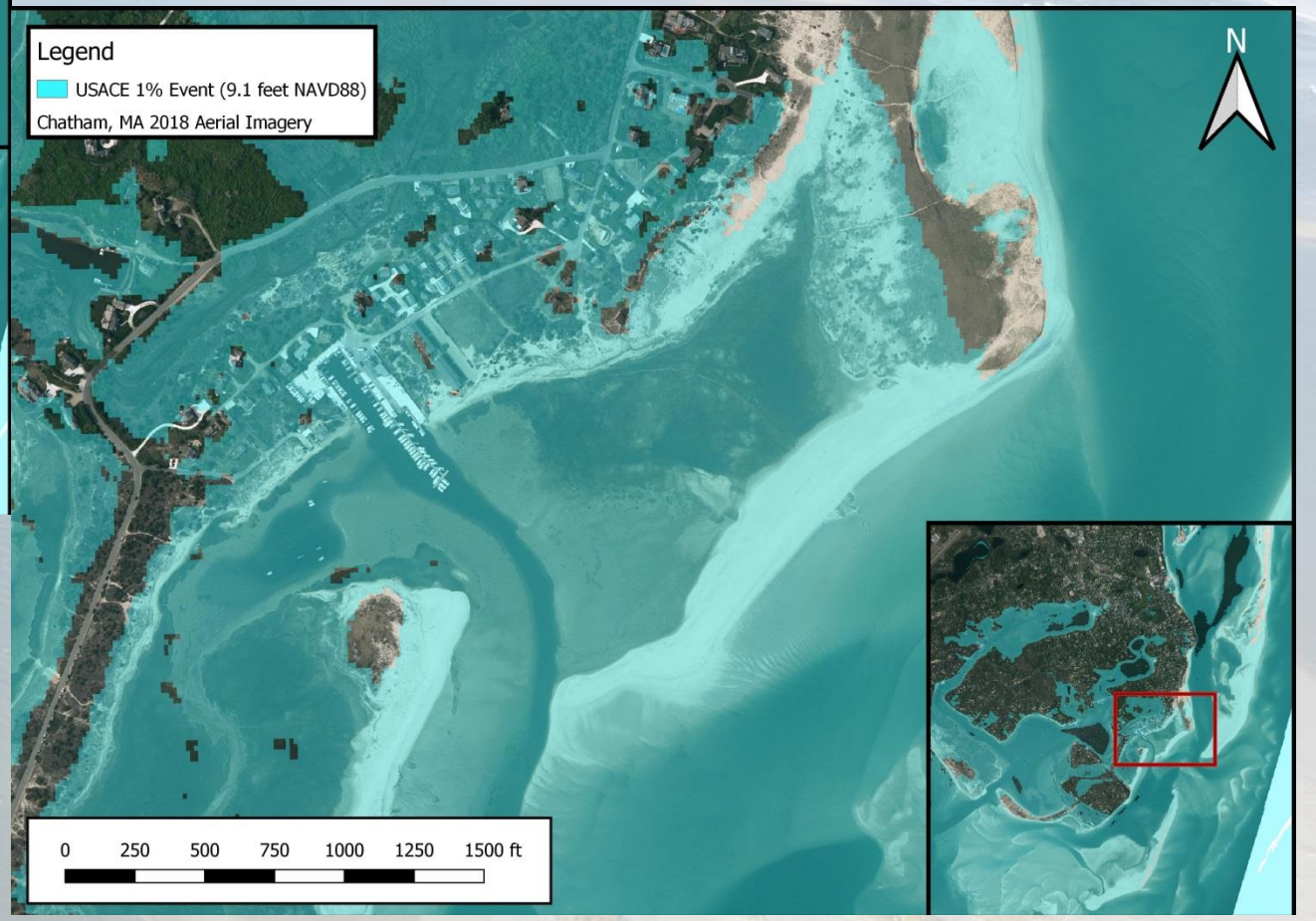


Severe Flooding:
Assessment Area 4



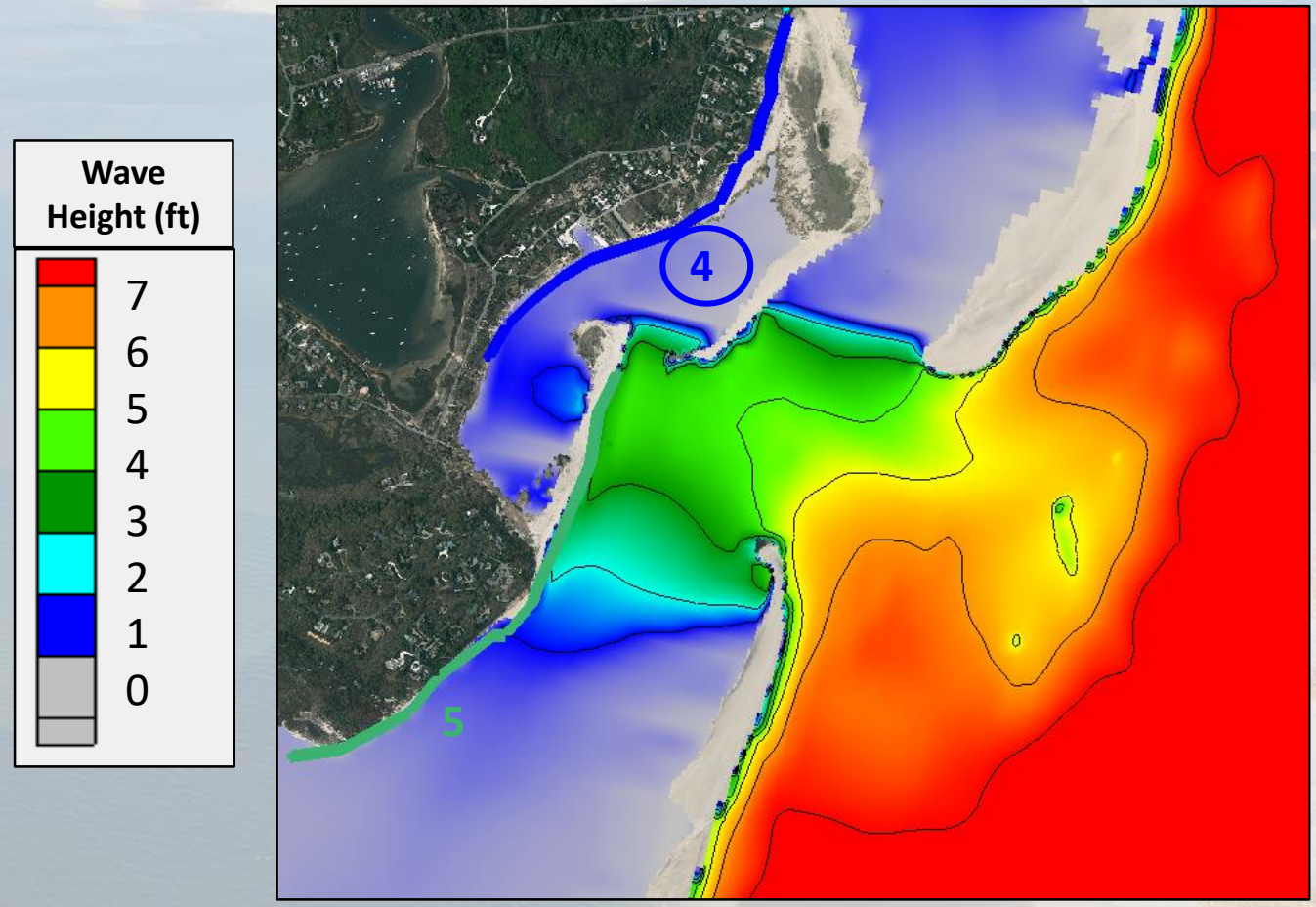
Significant Storm

Severe Storm



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

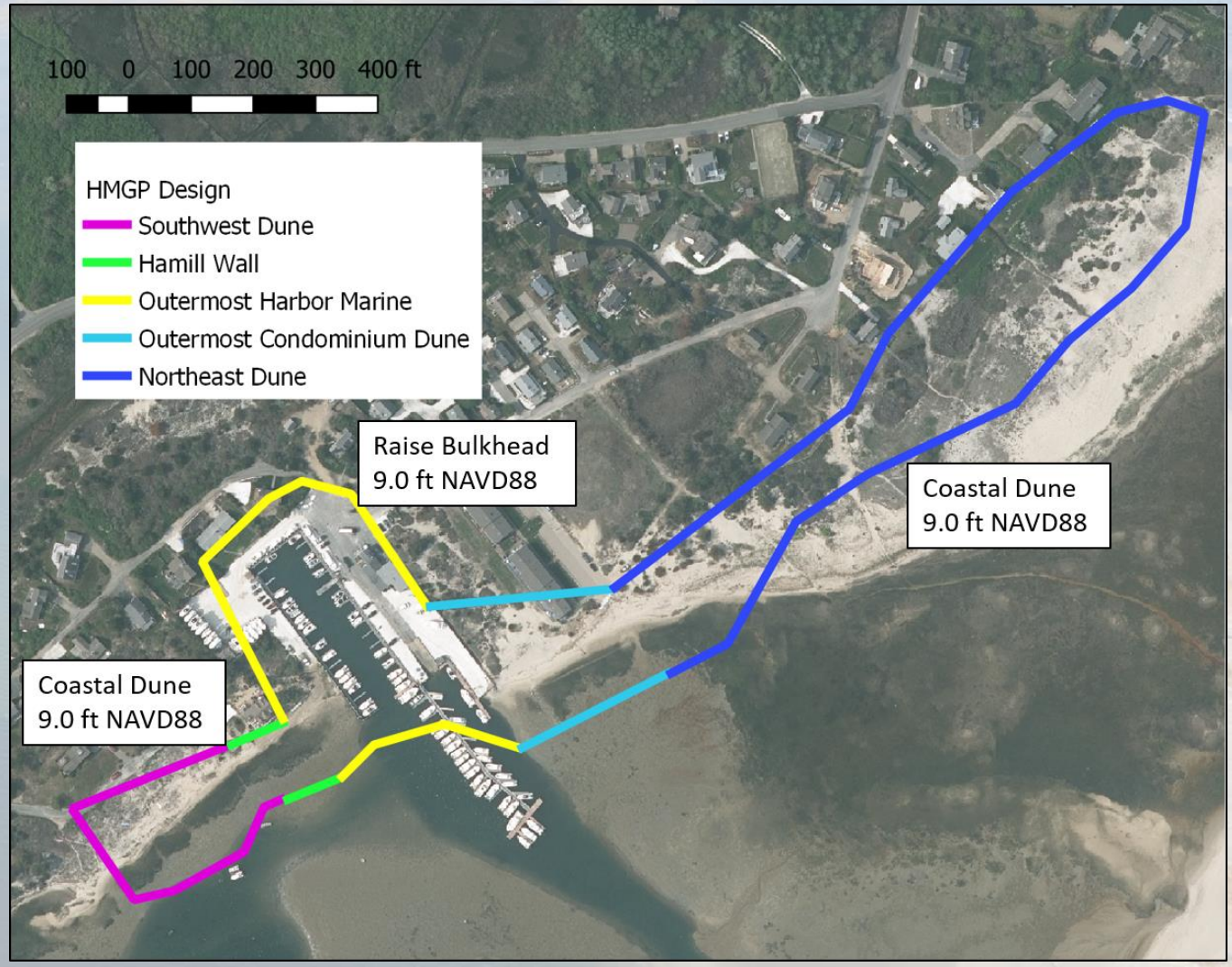
Storm Wave Heights and Wave Setup
Assessment Area 4



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

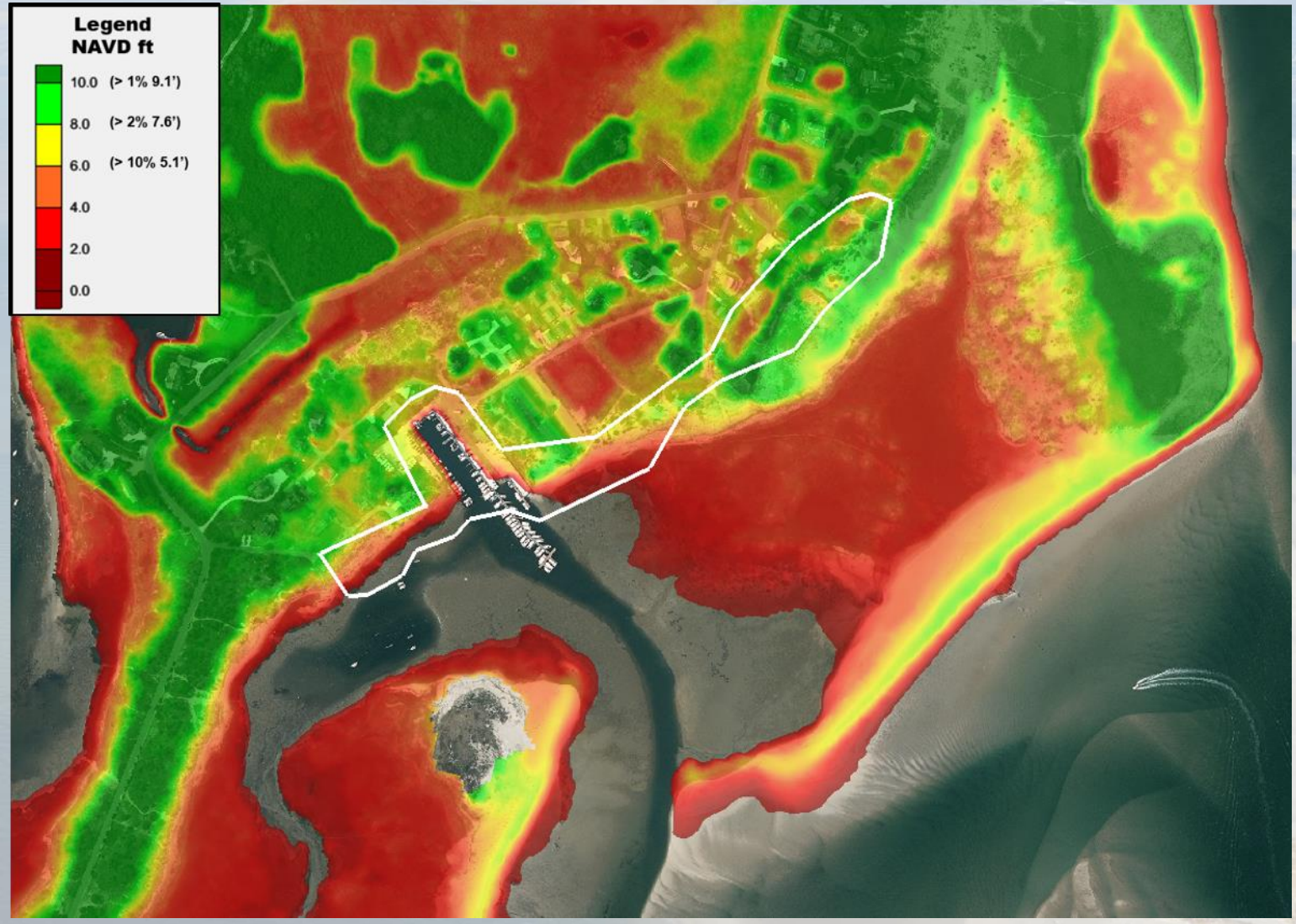
1938 Aerial:
Contiguous wide beach in area of Outermost Harbor Marina

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



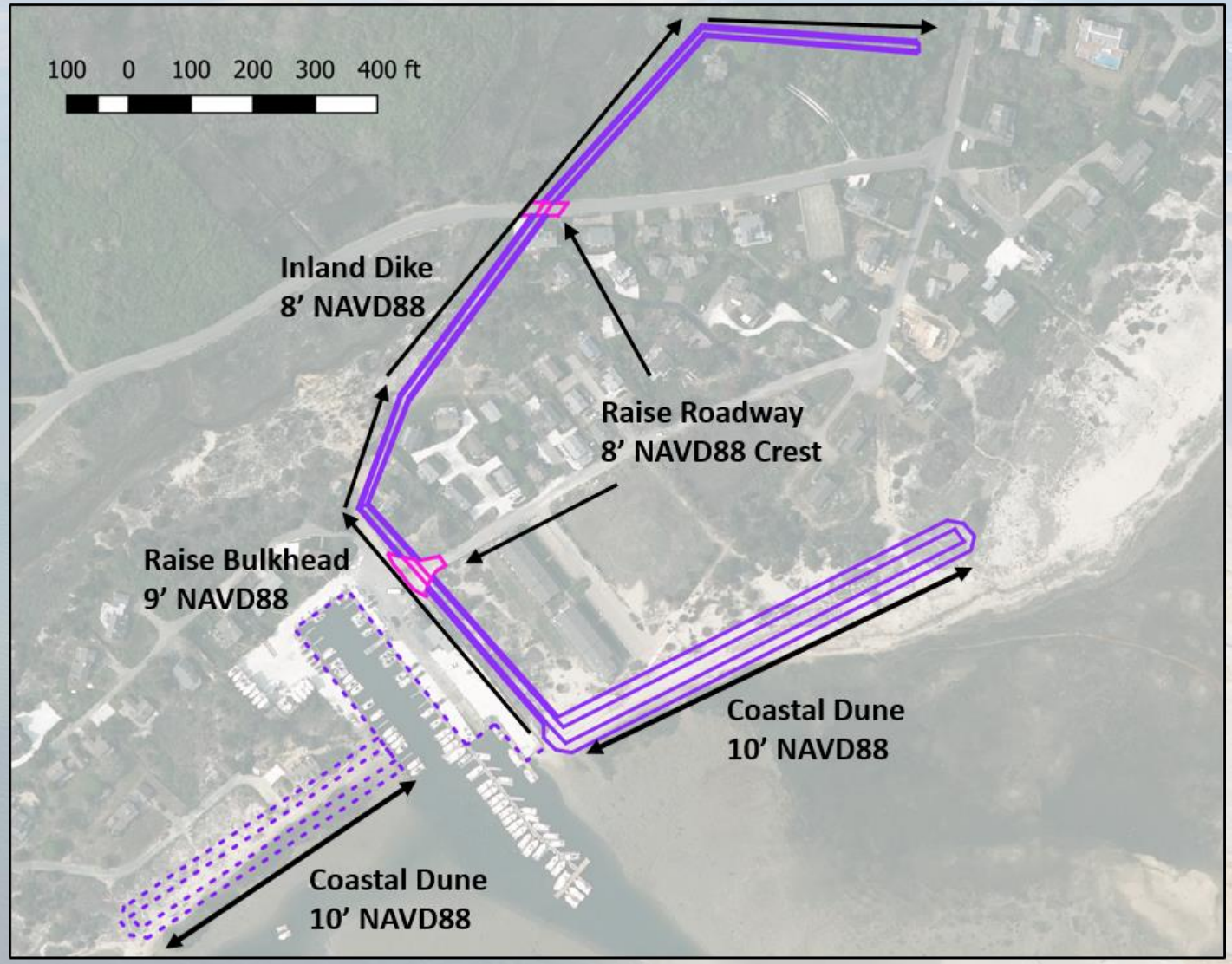
HMGP Design

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



HMGP Design

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



Alternative Design

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

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

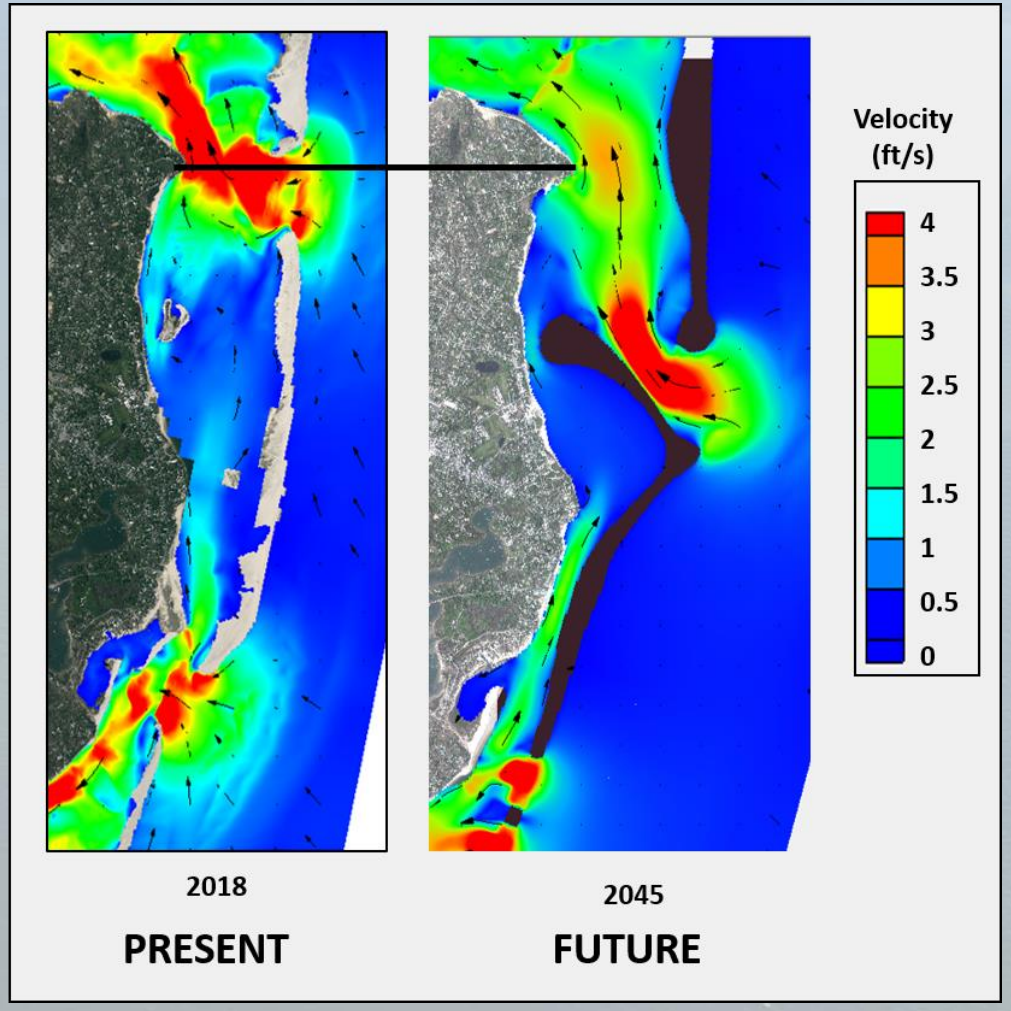
Quitnesset Barrier Beach to Morris Island, Study Area 5

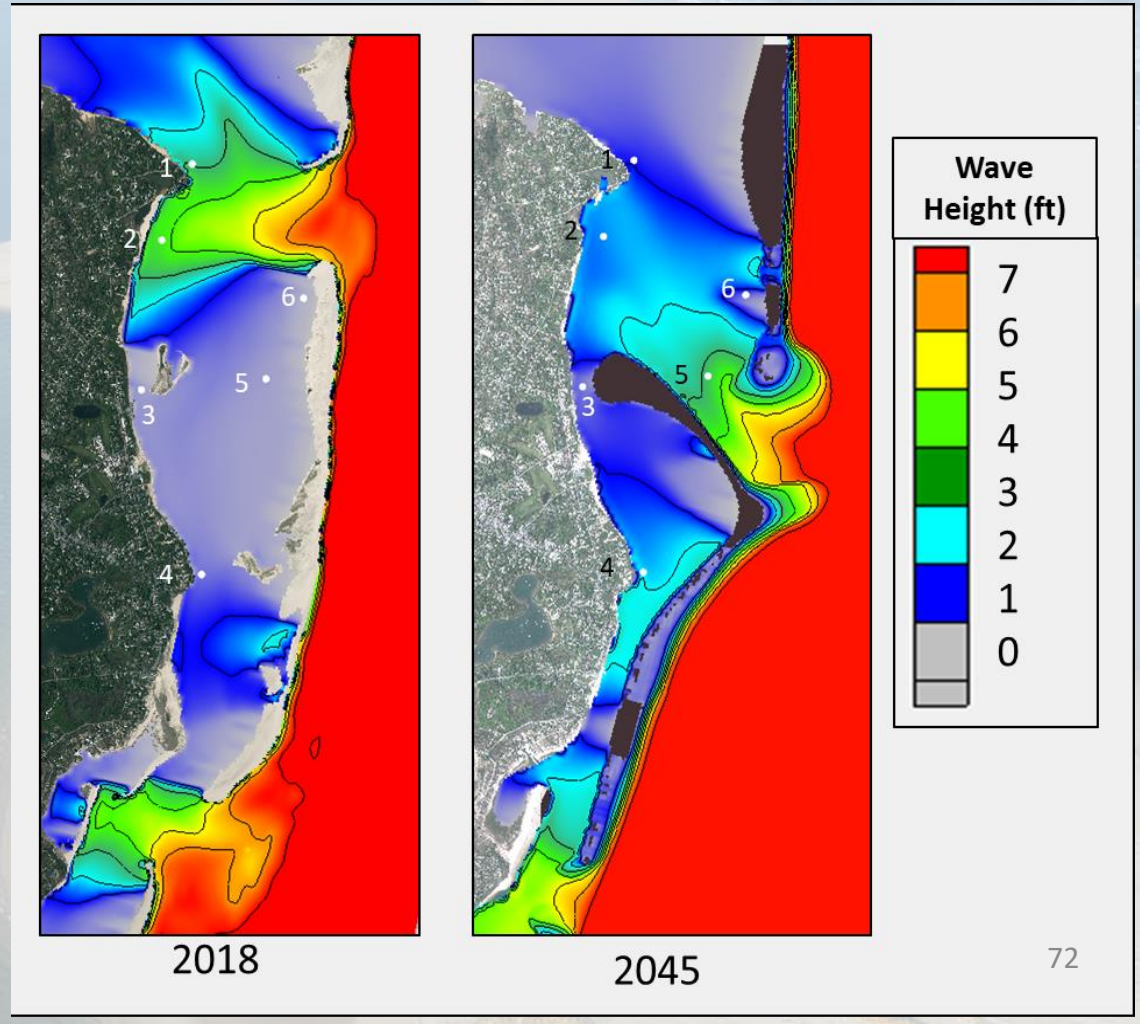
Monomoy Refuge facing
south towards Morris Island

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

Pros	Cons
• Direct protection to upland properties already fronted by revetments	• May cause end effects if exposed to increased wave energy • Does not protect Monomoy National Wildlife Refuge property • Cost, if tidal currents cause significant scour
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	• Stabilize existing structures or re-direct tidal currents (Minister's Point) • Enhanced nourishment (Linnell Lane Beach)
2	Linnell Lane Beach to Thayer Lane	Increased erosion and wave exposure as inlet migrates	• Temporary groins with nourishment • Tern Island Flats nourishment
3	Thayer Lane to Chatham Lighthouse	None	• None; however, maintaining navigation channel could serve as a source for nourishment material
4	Little Beach/Outermost Harbor	Storm flooding and increased wave activity, emergency egress	• Coastal dune/berm/bulkhead to improve protection against flooding
5	Quitnesset Barrier Beach to Morris Island	Increased wave activity and tidal currents as inlet migrates, emergency egress	• Maintain and/or improve existing shore protection structures

Questions