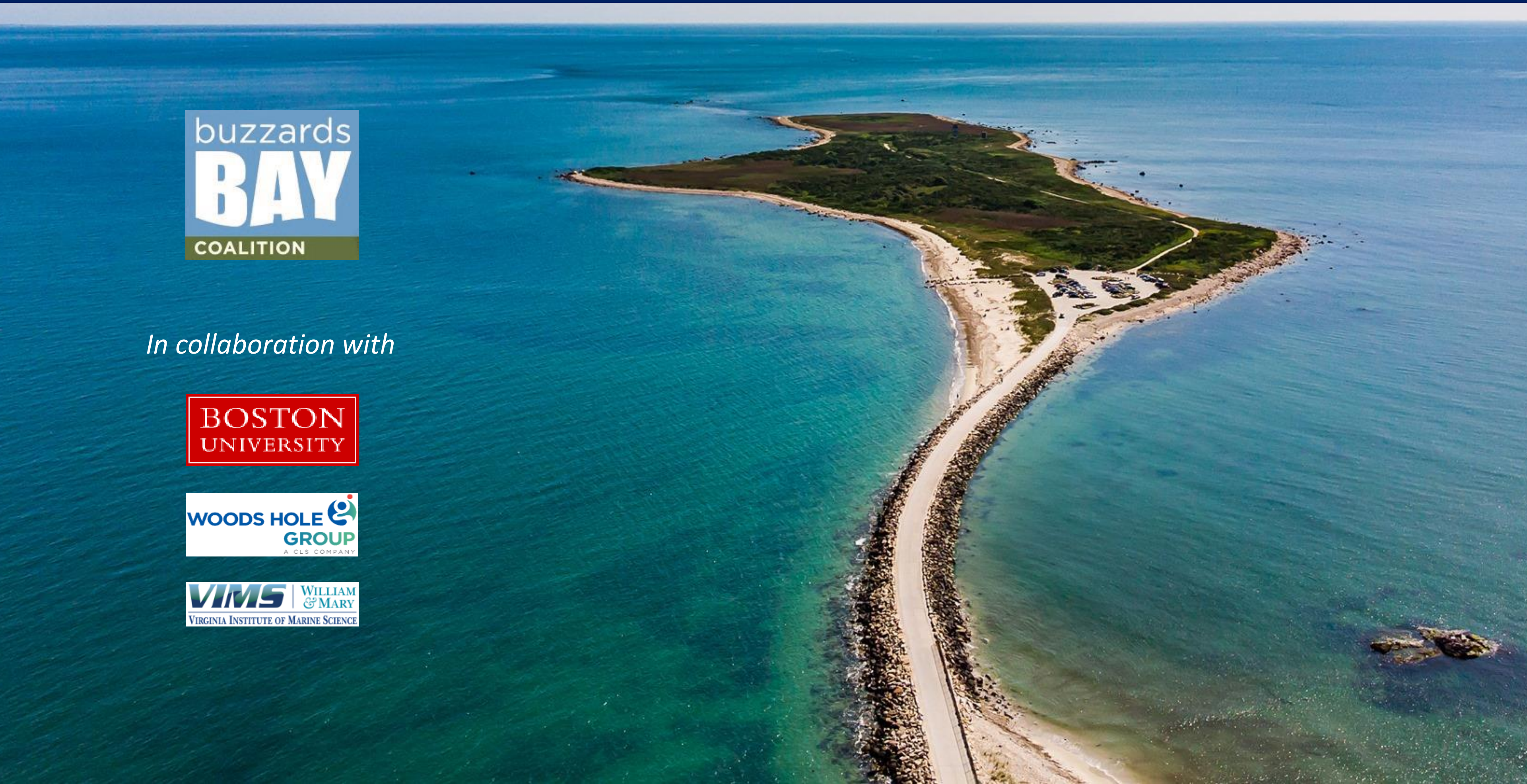
Lower Buzzards Bay Sedimentation & Gooseberry Causeway Impact Study

2022-2024



buzzards BAY COALITION

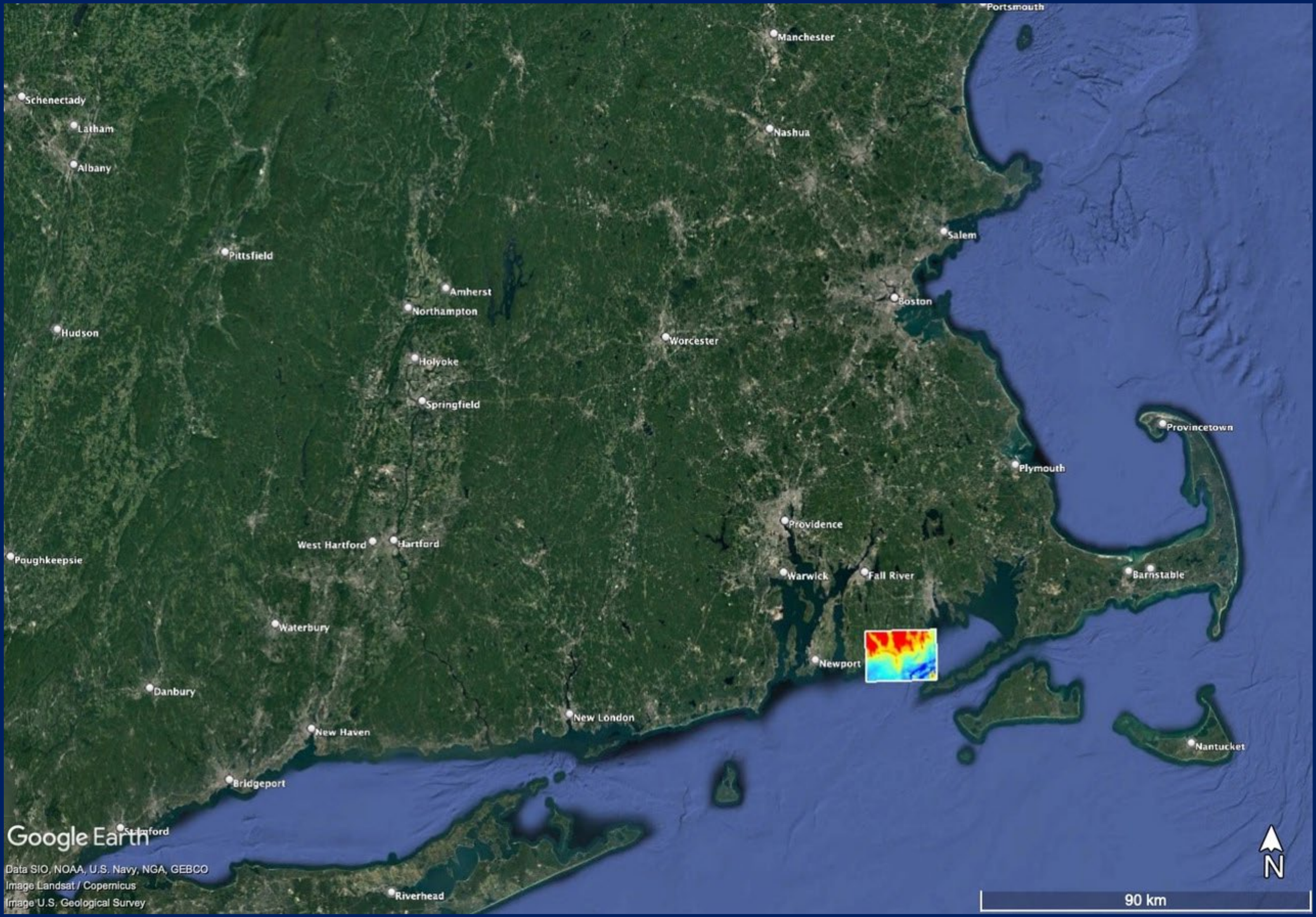
In collaboration with

BOSTON UNIVERSITY

WOODS HOLE GROUP A CLS COMPANY

VIMS WILLIAM & MARY VIRGINIA INSTITUTE OF MARINE SCIENCE

Getting Oriented – Study Area in Southern New England



Getting Oriented – Lower Buzzards Bay Coastline

Getting Oriented – Gooseberry Island, Tombolo, Causeway, Neck

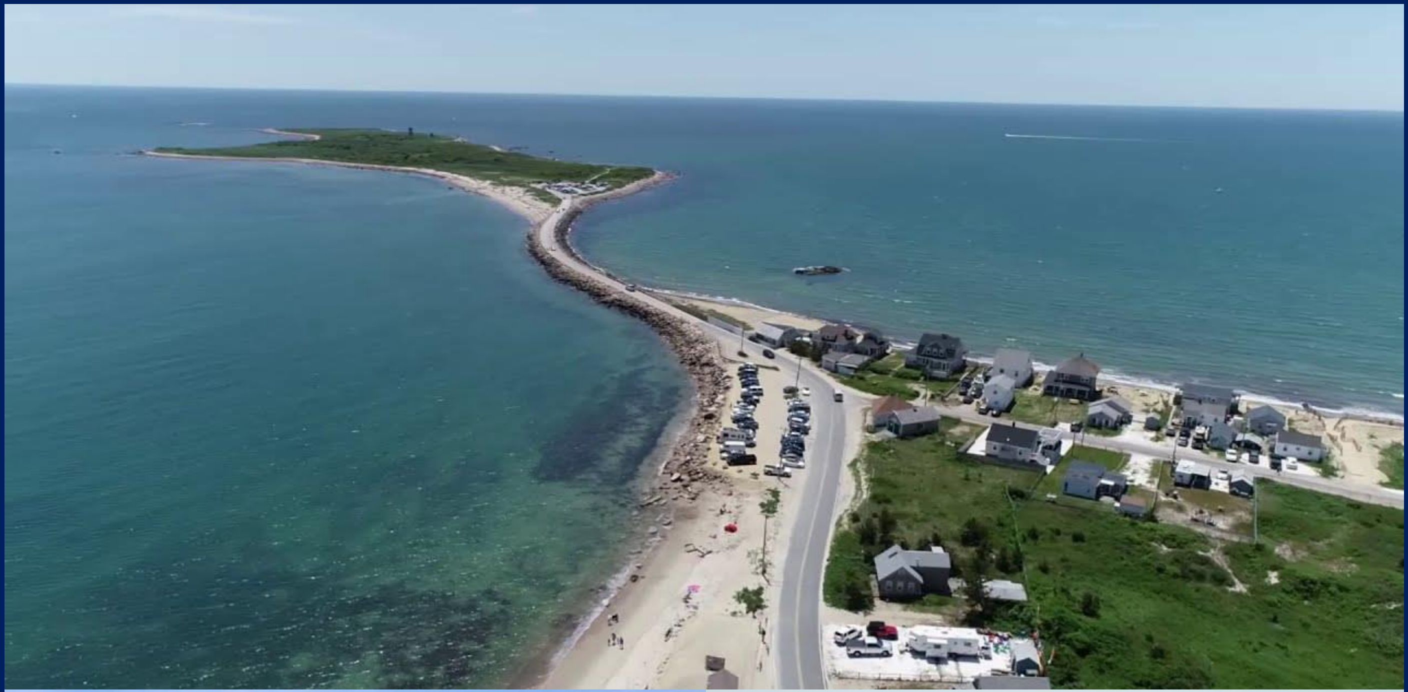
Gooseberry Island originally a tombolo - a bar of sand joining an island to the mainland. Was walkable at low tide.

1922 - First attempt at building a causeway.
1938 – Hurricane destroys the simple causeway

1943 – US Army establishes WWII installation on island, builds fortified causeway of boulders and concrete that remains to this day.

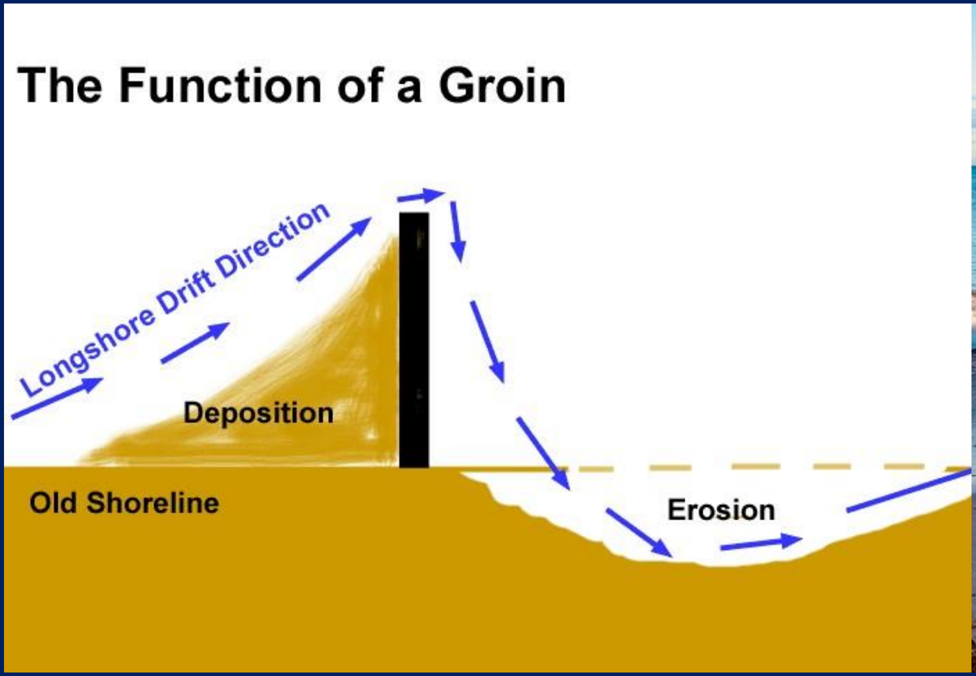
Now referred to as Gooseberry Neck, the combined causeway and island extend ~1 mile into the entrance of Buzzards Bay.

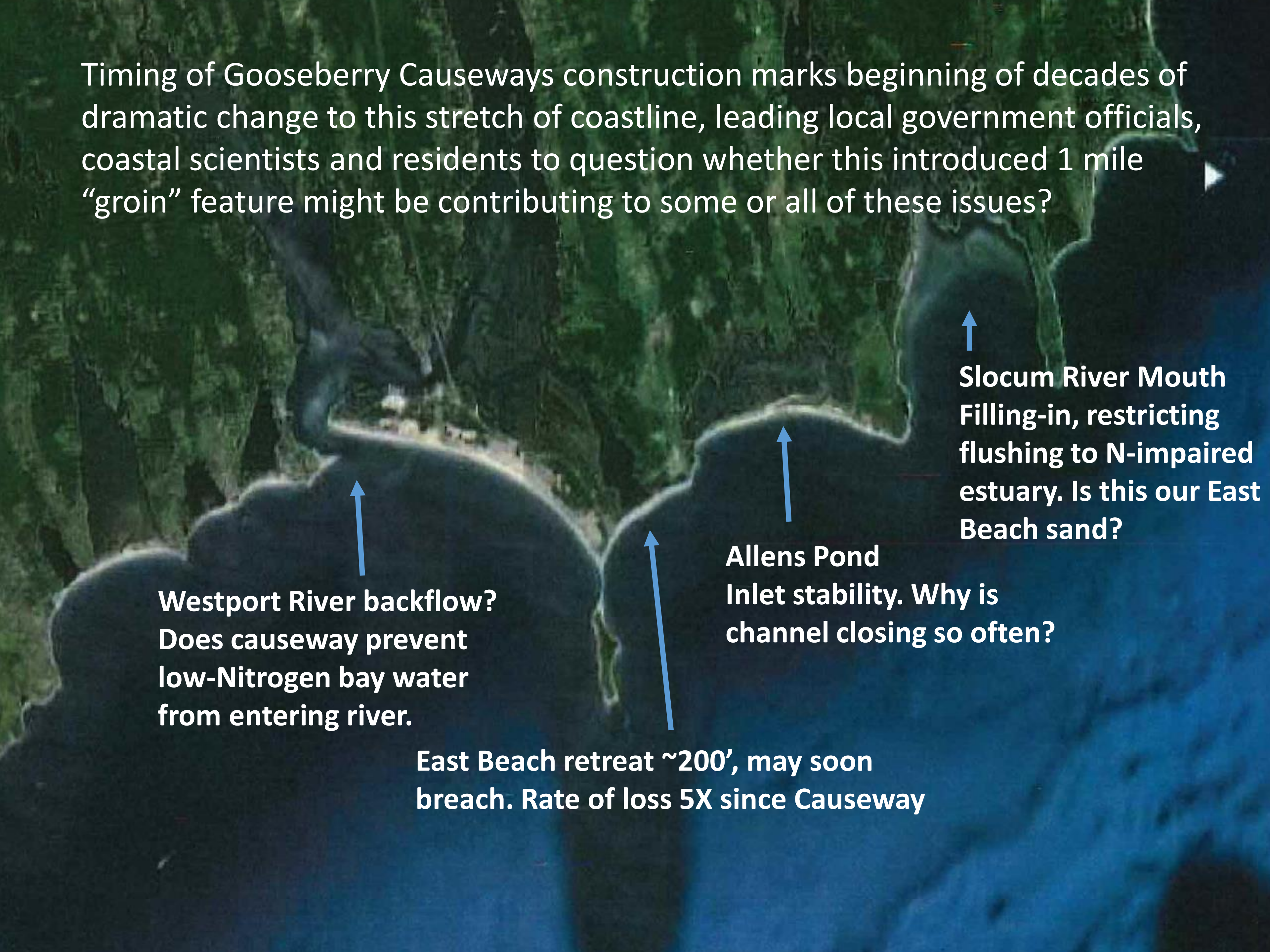
Owned by MA DCR



GROINS 101: The purpose of a groin is either to maintain sand on updrift beaches and to restrict longshore sediment transport.

Widely believed that Gooseberry Neck is functioning in many ways as a one-mile long groin into Buzzards Bay. Sand widens on Horseneck Beach State Reservation to west and downdrift East Beach is starved of sand to the east.




Timing of Gooseberry Causeways construction marks beginning of decades of dramatic change to this stretch of coastline, leading local government officials, coastal scientists and residents to question whether this introduced 1 mile "groin" feature might be contributing to some or all of these issues?
Slocum River Mouth
Filling-in, restricting flushing to N-impaired estuary. Is this our East Beach sand?
Allens Pond
Inlet stability. Why is channel closing so often?
Westport River backflow? Does causeway prevent low-Nitrogen bay water from entering river.
East Beach retreat ~200', may soon breach. Rate of loss 5X since Causeway

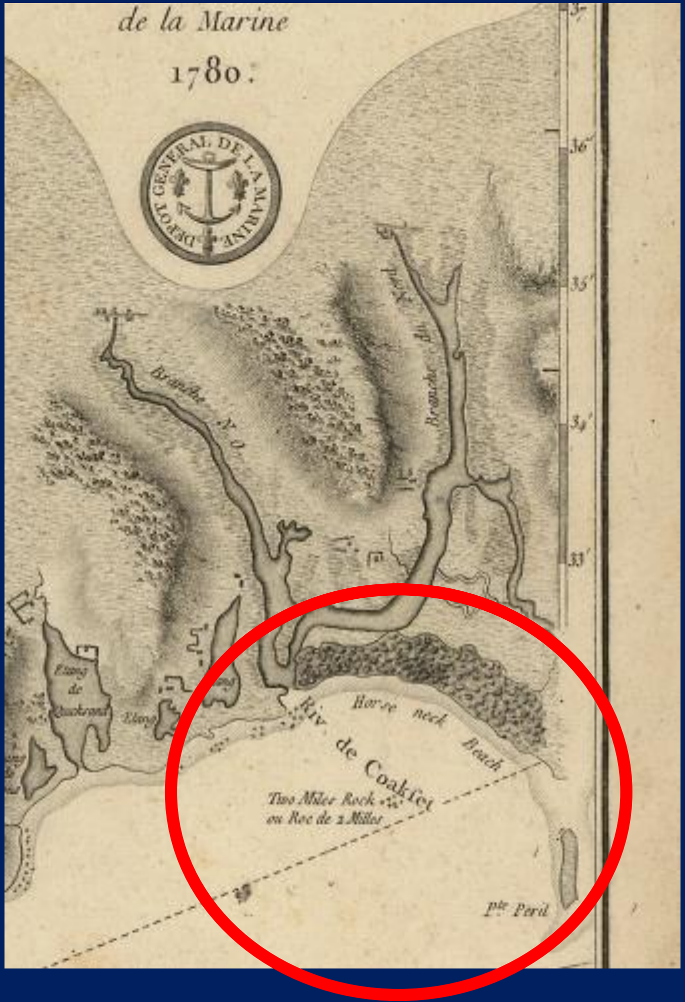
THE MAJOR QUESTIONS:

How Does the Gooseberry Causeway affect…

Tidal exchange, sedimentation and water quality within the Westport River Inlet?

Does the Gooseberry Causeway create ocean backcurrents that limit the ability of the Westport River estuary to exchange clean offshore waters from Buzzards Bay each tidal cycle? The Westport River is severely degraded with excess nitrogen pollution.

Could removal or alteration of the Gooseberry Causeway restore natural flushing to the river and thereby aid water quality recovery?



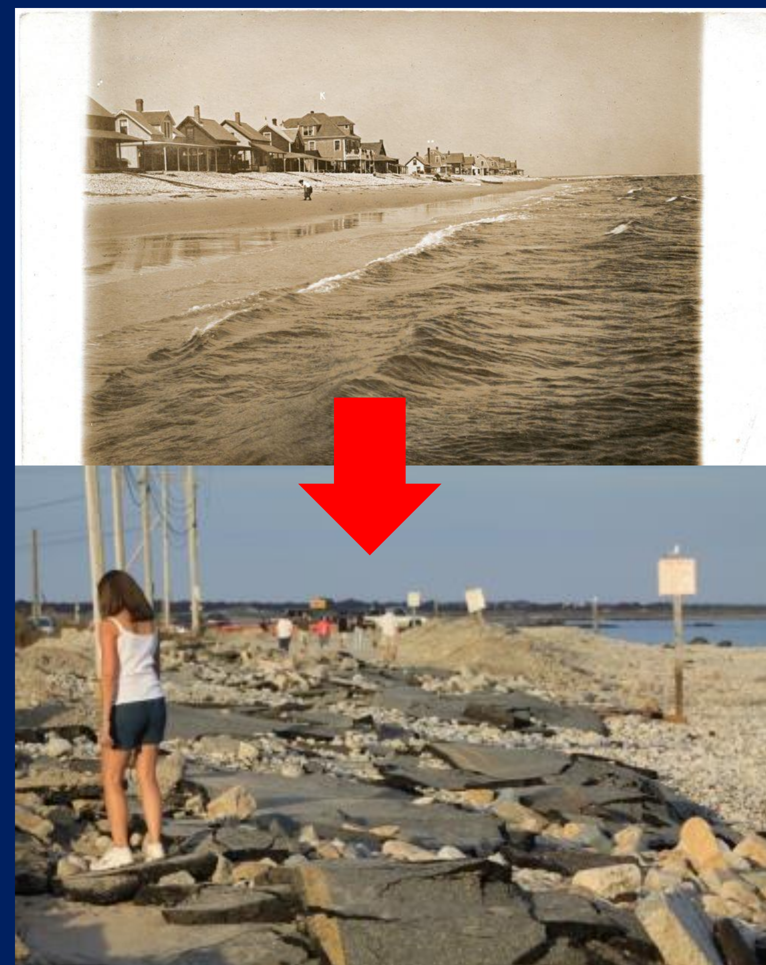
THE MAJOR QUESTIONS:

How Does the Gooseberry Causeway affect…

Accelerated erosion and loss of property along East Beach

The area immediately downdrift of the Gooseberry Causeway known as East Beach has lost nearly 200 feet of land since causeway construction. The area once hosted seaside mansions and hotels and is now a thin cobble barrier close to breaching into the Westport River, threatening a public road and dozens of residential lots.

Where did all of this sand go and is the Causeway responsible?



1938

2011

THE MAJOR QUESTIONS:

How Does the Gooseberry Causeway affect…

Declining stability of Barneys Joy inlet and the vulnerability of Allens Pond saltmarshes

The inlet to sensitive Allens Pond – between the Causeway and Slocum River – has seen increasing instability in recent years. What used to be a 1 per 5-7 year inlet closing is now closer to 1 per 3-4 years making maintenance of high quality salt pond habitats more challenging. Is this instability linked to Gooseberry-altered sediment flows?

THE MAJOR QUESTIONS:

How Does the Gooseberry Causeway affect….
Increasing sedimentation & reduced flushing in Slocum River

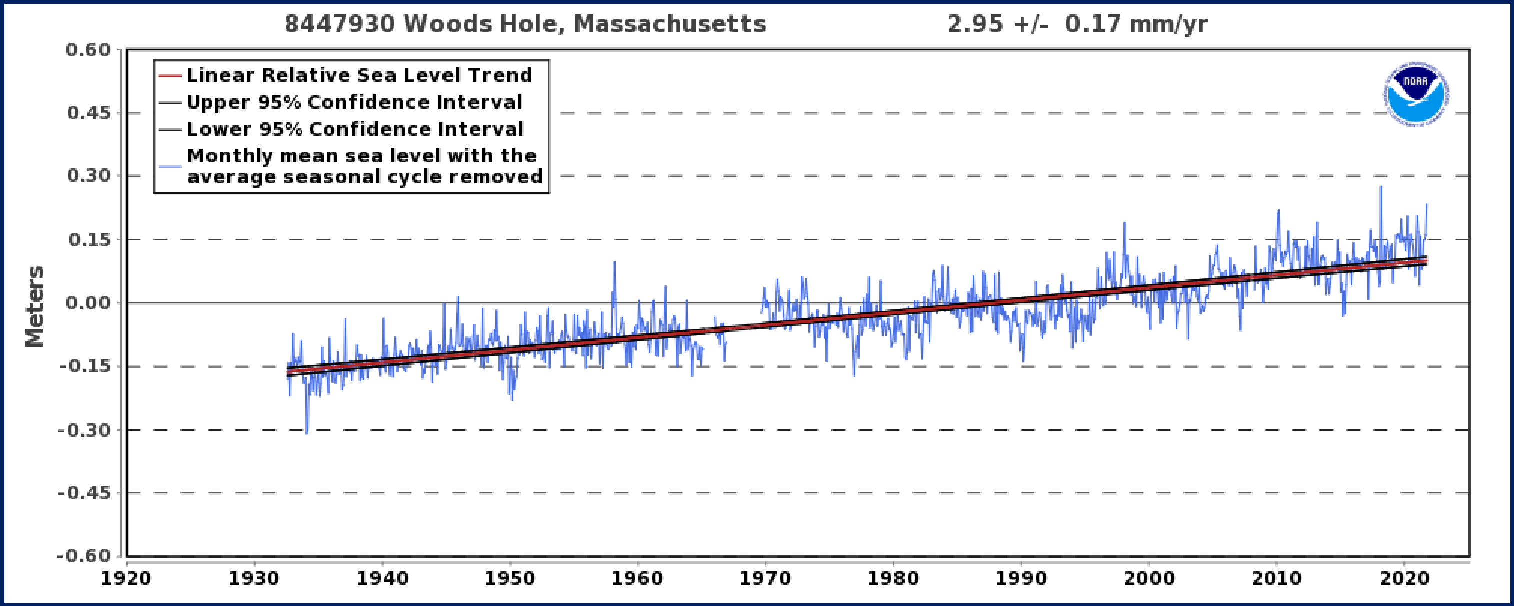
The mouth of the Slocum River has seen dramatic shoaling with new sand filling in around the river outlet and restricting flushing to this Nitrogen-impaired estuary.

Is this the East Beach sand transported more than 5 miles downshore? How much has this new sand contributed to water quality and fisheries declines in the estuary and could removing it improve river health?

THE MAJOR QUESTIONS:

How Does the Gooseberry Causeway affect…

The entire lower Buzzards Bay coastline when coupled with the new pressures of climate change-driven Sea Level Rise and increasing storminess?



Massachusetts Coastal Flood Risk Model projects that sea-level rise will increase by 1.27 feet over 2008 levels by 2030, 2.57 feet by 2050 and nearly 8 feet by 2100.

Project Team:
Boston University, Department of Earth & Environment

<u>Principal Investigator</u>*:*
Zoe Hughes is a coastal oceanographer and geomorphologist specializing in coastal response to climate change, including sea level rise (SLR) and changes in storminess. Her research is cross-disciplinary including feedbacks among hydrodynamics, landscape evolution (such as erosion) and ecosystem science and uses a combination of numerical modeling and field monitoring. She has over fifteen years of experience managing and integrating large, diverse teams of scientists and overseeing project logistics.

Duncan FitzGerald is a sedimentologist and coastal geologist who has been studying nearshore processes, tidal inlets and barrier systems, and impacts of SLR and effects of storms for more than four decades. He has extensive experience in the Westport-South Dartmouth region having directed four Masters and PhD theses dealing with this area and numerous publications concerning this research.

Sergio Fagherazzi is a fluvial and coastal geomorphologist. His research includes the modeling of coastal systems, the study of hydrodynamics and morphology of salt marshes, and the numerical study of coastal processes and hydrology, dynamically linking phenomena occurring at different spatial scales.

Post-doc: TBD. Two Postdoctoral Researchers will work closely with Fagherazzi and Hughes to develop the regional grid and run the scenario sets focusing on the coarser grid

BOSTON UNIVERSITY

Our mission: to understand a changing Earth and its relationships with humankind and to develop strategies for a sustainable future.

Project Team:
Woods Hole Group

Matt Shultz is a Senior Coastal Engineer at the Woods Hole Group and is Team Lead of Coastal Engineering and Modeling. He has over 15 years of experience in coastal studies involving the evaluation of coastal hazards and shoreline restoration.

David Walsh is Team Lead for Coastal Measurements and Sediments at Woods Hole Group and uses field and laboratory data to resolve and evaluate geologic processes within coastal, estuarine, and oceanic environments. His primary specialty is the spatial and temporal quantification of shoreline and bathymetric change using Geographical Information Systems (GIS) and other geospatial software packages to map and define geomorphological processes. In addition, Mr. Walsh has extensive field experience in the acquisition, processing, ground-truthing, and interpretation of bathymetric, side-scan sonar, and sub-bottom sonar surveys in order to investigate subaqueous sedimentary environments on a regional scale.

Katherine Lavallee is a coastal scientist who uses field and laboratory data to evaluate geologic processes within coastal, estuarine and oceanographic environments. Ms. Lavallee specializes in the acquisition, processing, and interpretation of time-series datasets to describe sediment transport patterns in estuaries, in particular ADCP, water quality, and turbidity measurements. She is experienced in geologic and oceanographic field studies and instrumentation, including bathymetric surveys, sediment coring, discrete water quality sampling, and tide gage deployment.

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A CLS COMPANY

Project Team:

Virginia Institute of Marine Science (VIMS)

Christopher Hein is an Associate Professor and coastal geologist at the Virginia Institute of Marine Science. He has specific expertise in beach and barrier-island evolution over periods from decades to millennia, as well as in Radioisotopic Dating (including short-lived radioisotopes) across diverse coastal and wetland settings. He has extensive experience working along the Massachusetts shoreline.

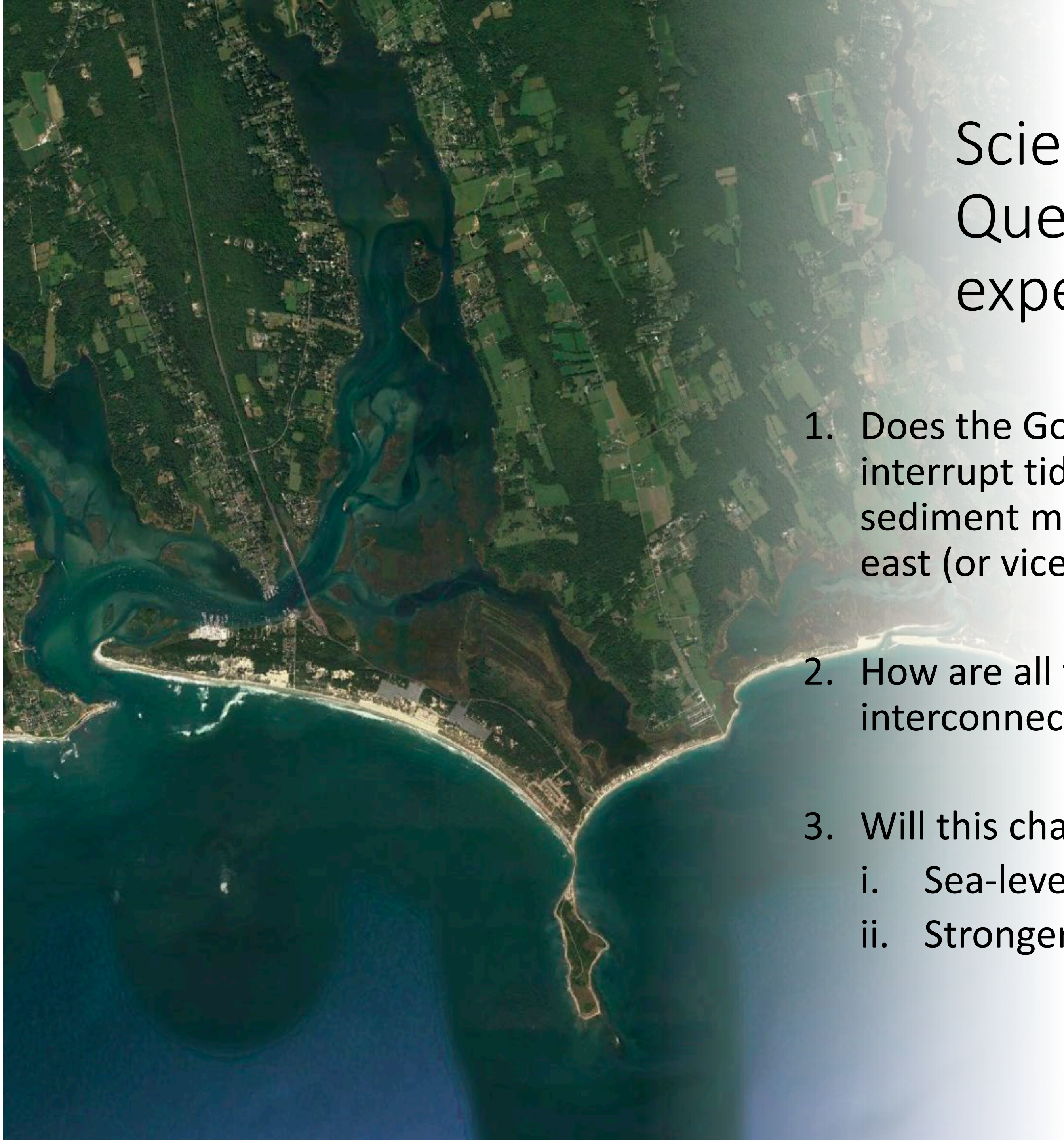
Jennifer Connell is a Laboratory Research Specialist who runs the VIMS Sedimentology and Gamma Lab. She will lead the lab analyses at VIMS. Jen has six years of experience collecting and processing marsh and shallow-water sediment cores for determination of accretion rates using short-lived radioisotopes.

Buzzards Bay Coalition

Rachel Jakuba, BBC's VP of Bay Science, and Mark Rasmussen, BBC President, will manage all grant funding and provide community connections, logistical field support and guidance to the science team.

U.S Geological Survey – Woods Hole Coastal & Marine Science Center

Neil Ganju, Research Oceanographer, at the USGS in Woods Hole will provide an ongoing Peer Review of the Study design and execution, providing a third-party assessment of the outcome.



Scientific Questions drive experiment

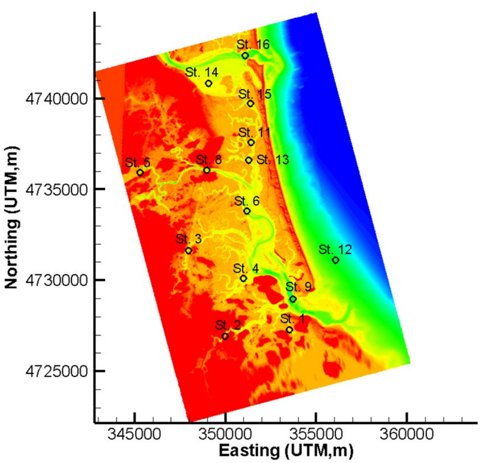
1. Does the Gooseberry Causeway interrupt tidal, wave energy, and sediment movement from west to east (or vice versa)?

2. How are all the “sub-systems” interconnected?

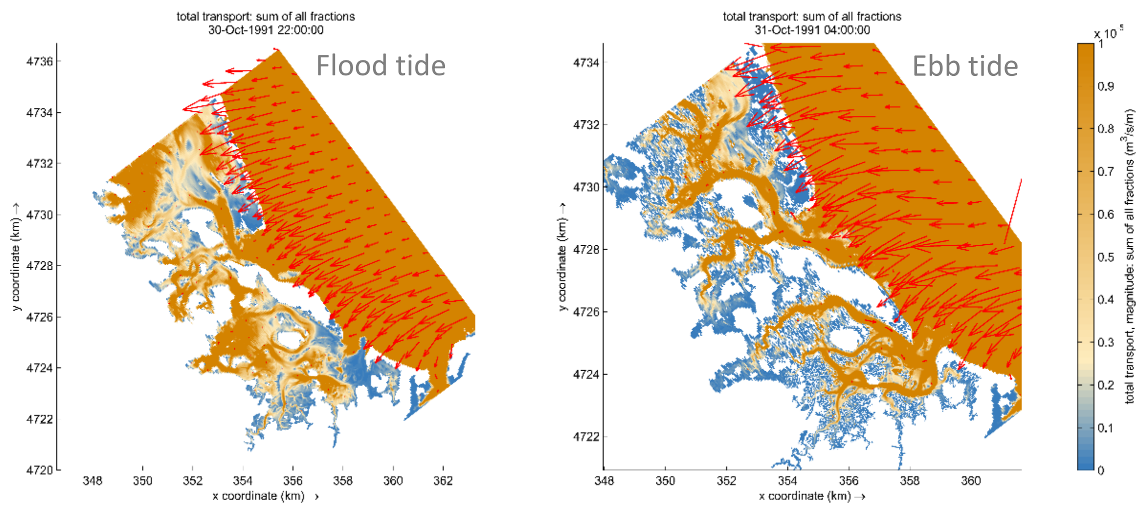
3. Will this change with:
   i. Sea-level rise?
   ii. Stronger/more frequent storms?

Why use a model?

- Covers a large area
- High density of data
- Can model factors that are hard to measure
- Can remove features (causeways) for tests

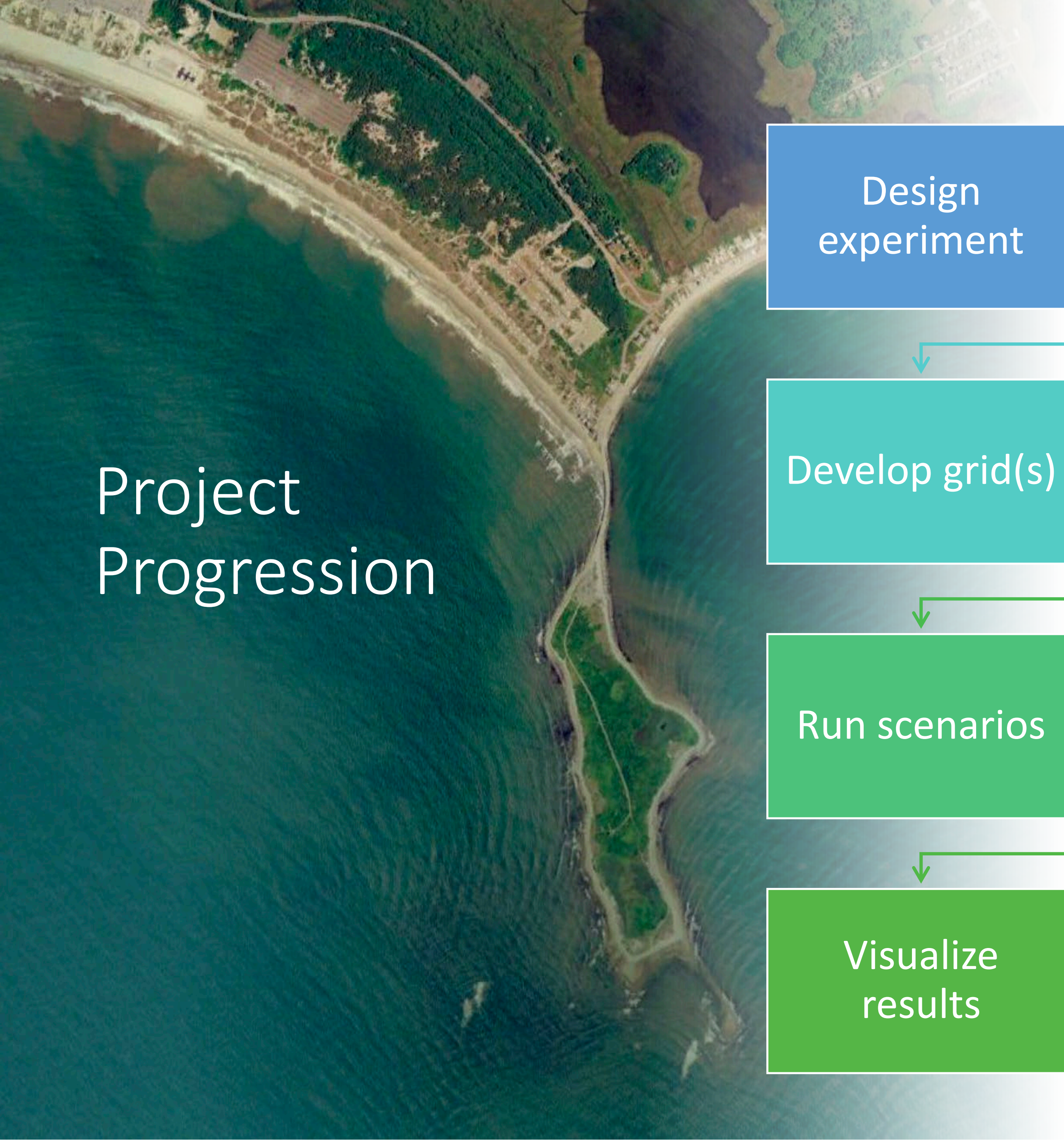


Data everywhere, not just a few points



e.g. instantaneous sediment transport

Project Progression

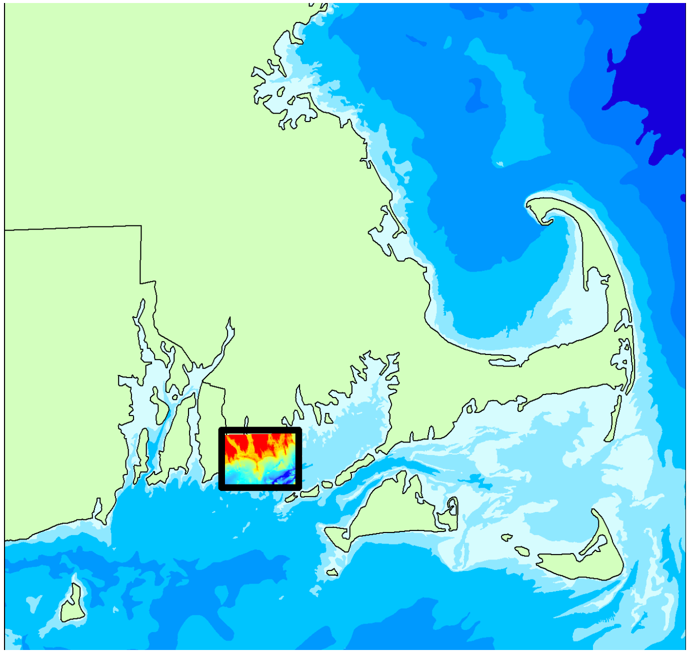


1. Design experiment
2. Collect input data
3. Develop grid(s)
4. Test grid(s)
5. Run scenarios
6. Compile and interpret results
7. Visualize results
8. Report

Regional Grid

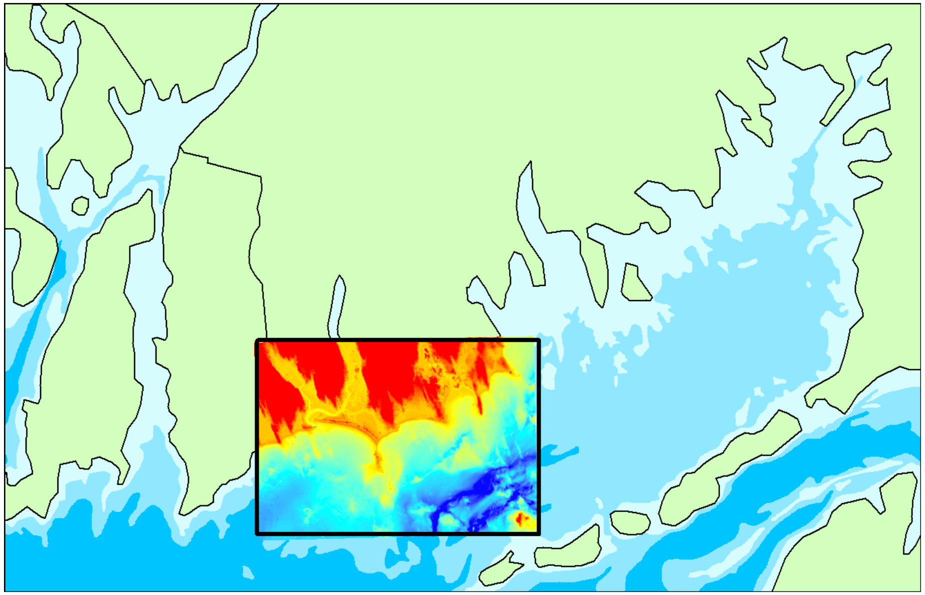
Captures

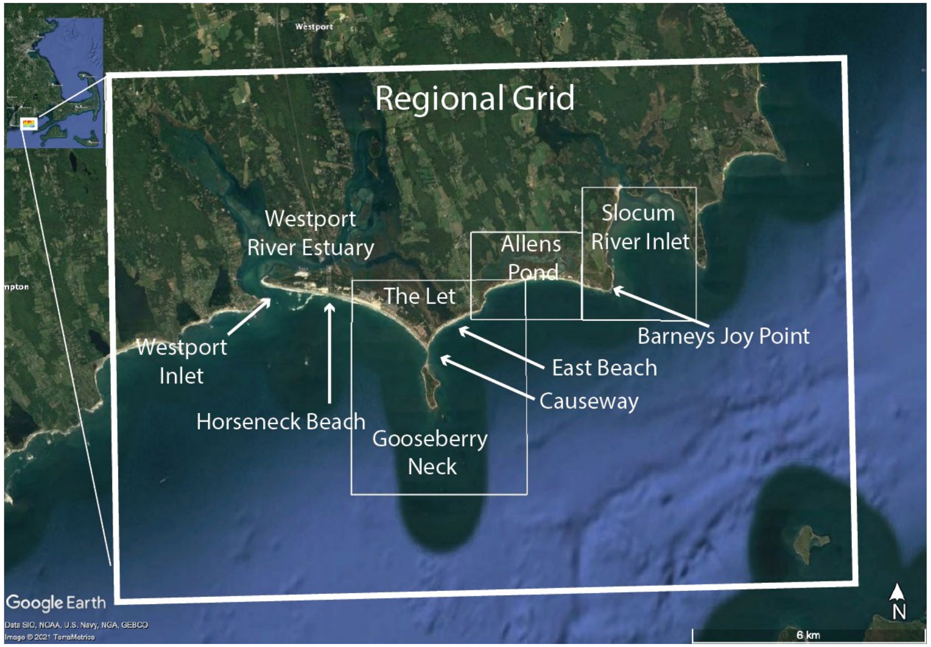
- Large-scale impact
- connectivity
- but not detail



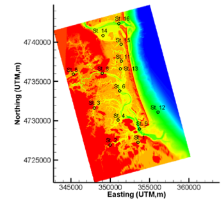
Small high-resolution grids

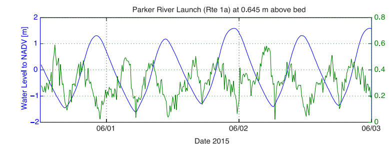
- Given data from the larger model at the edges
- High level of detail

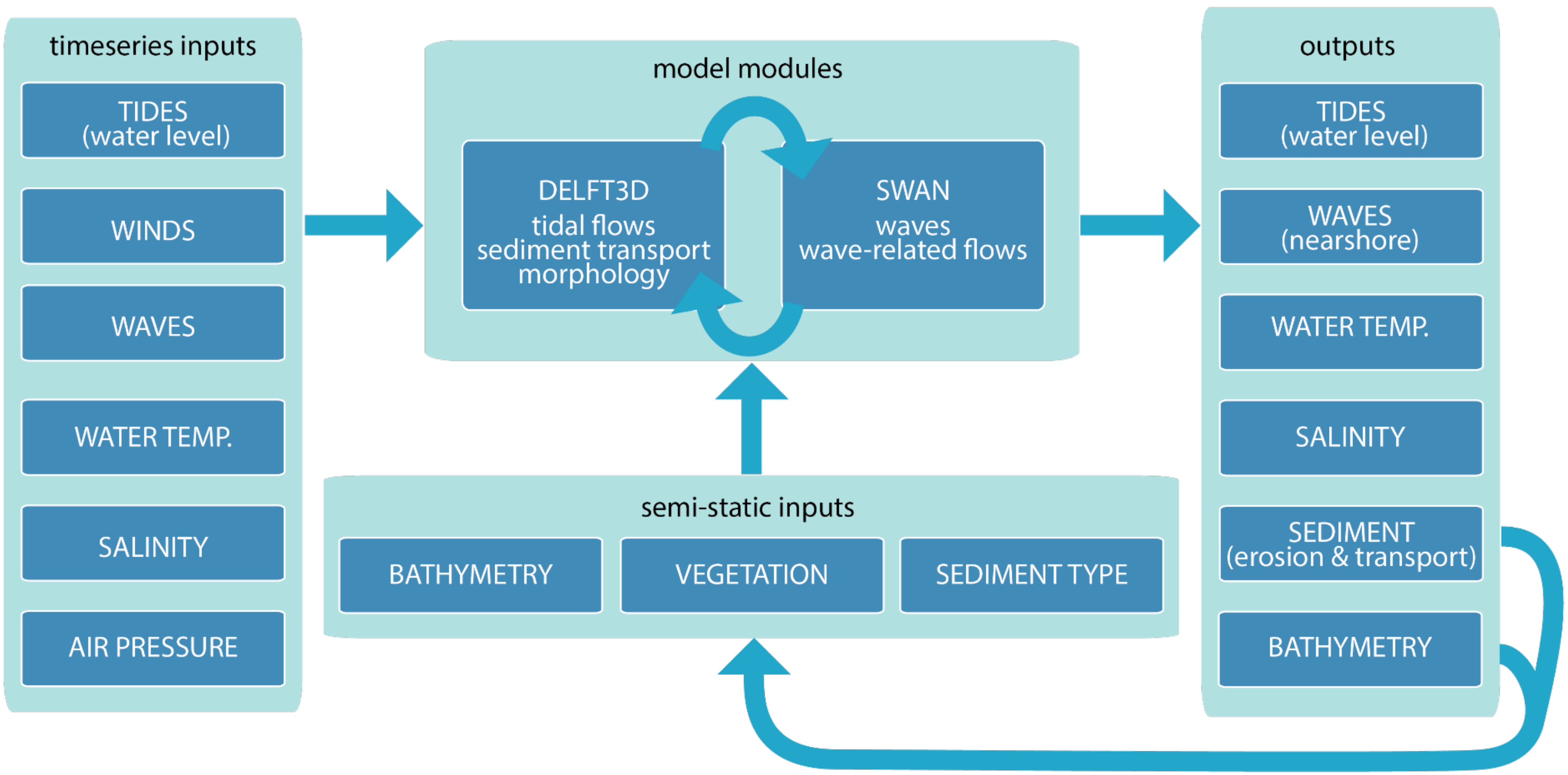




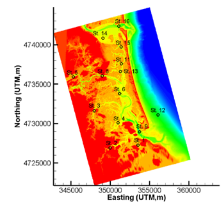
Model development

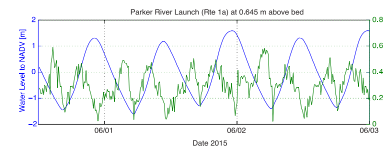


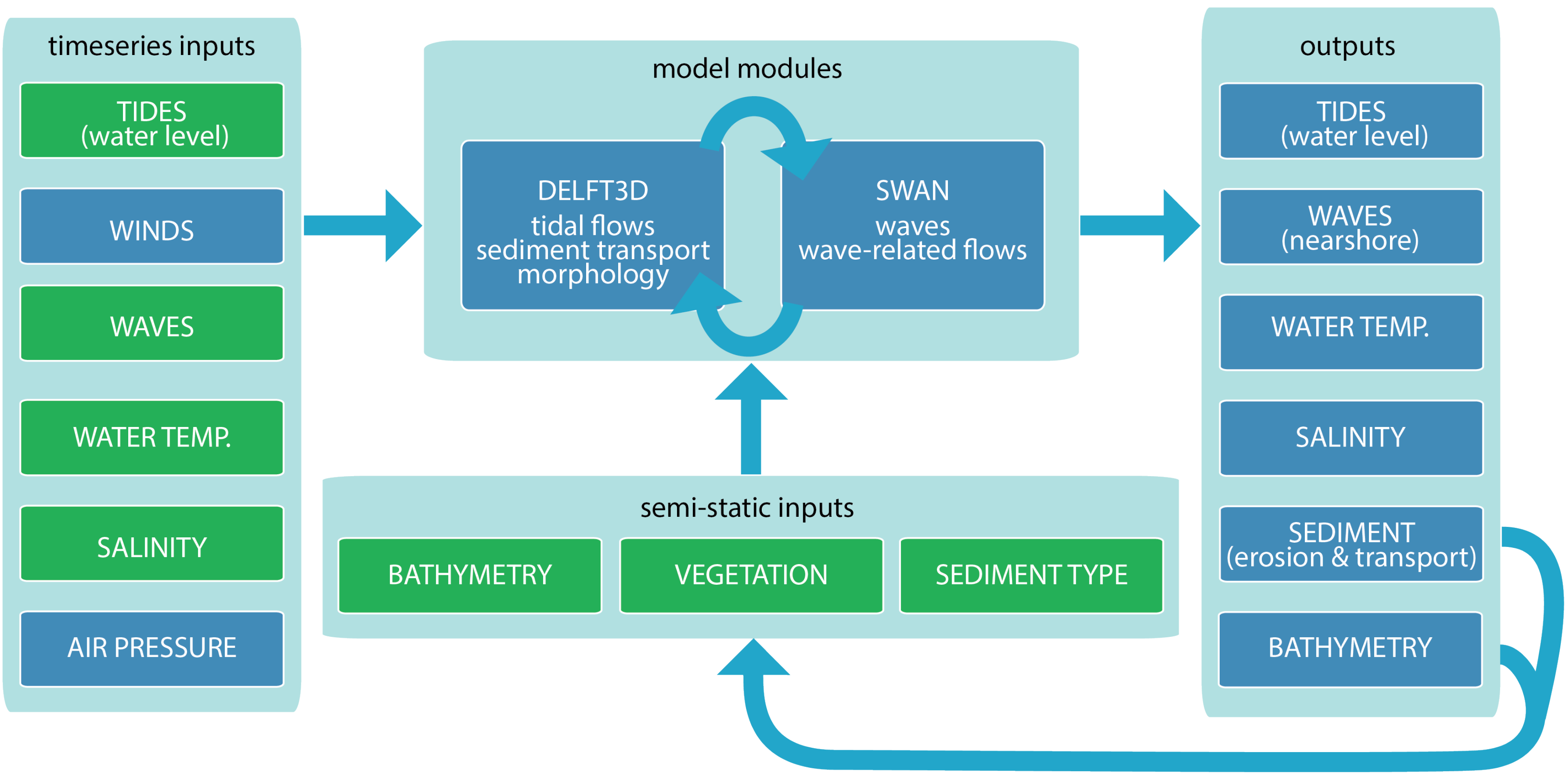




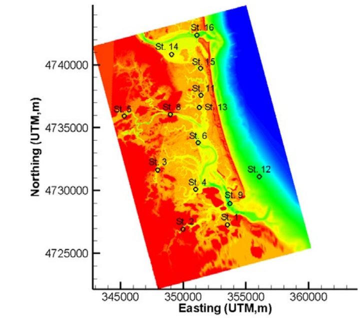
Data for inputs

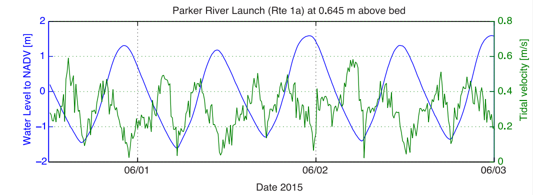


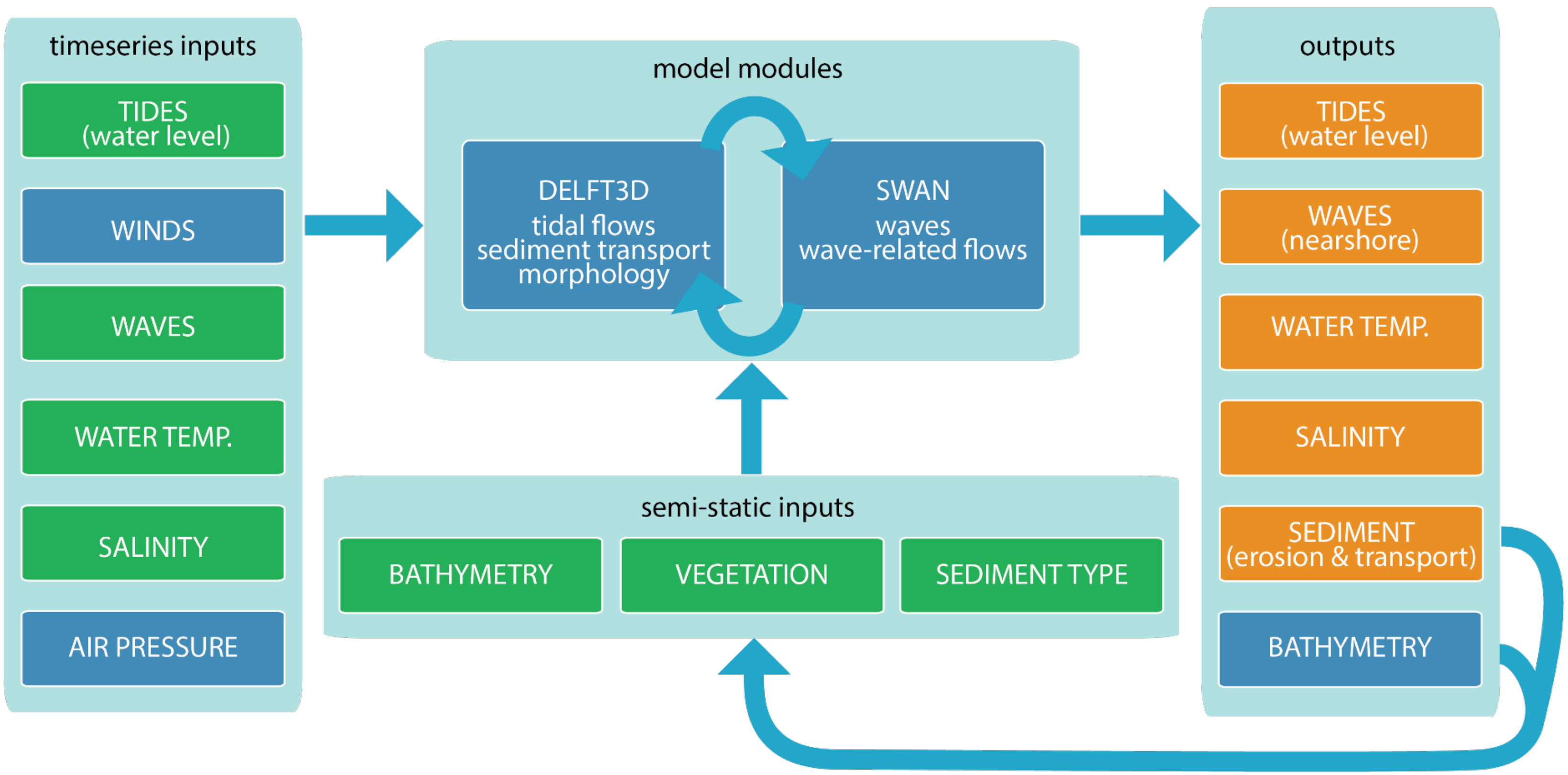




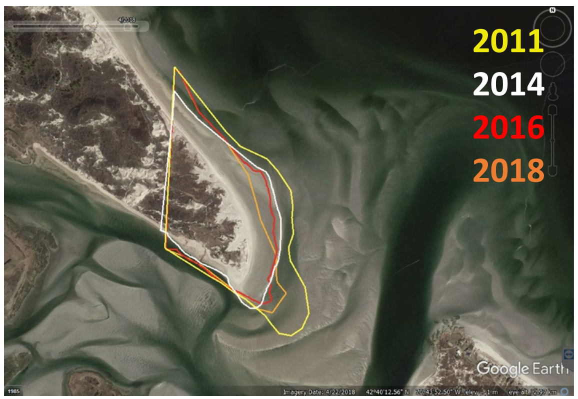
Data for validation



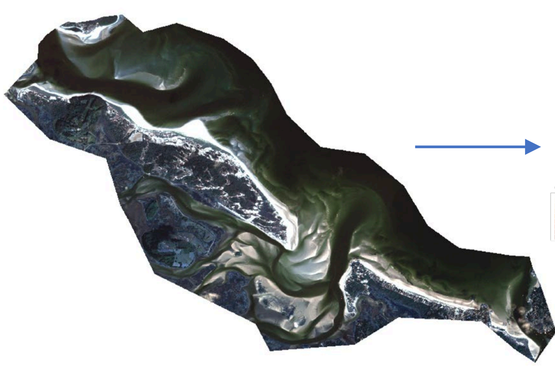




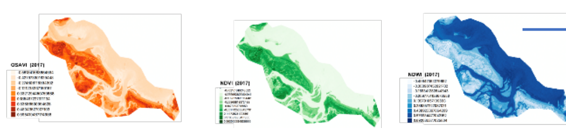
Historical aerial and elevation analyses

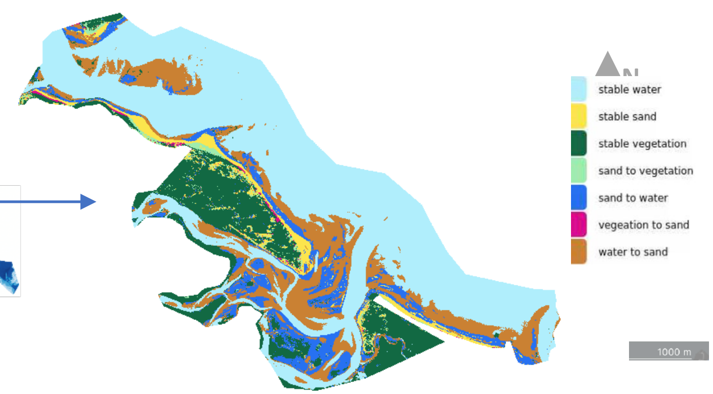


- Obtain images and data
- Georeference
- Digitize
- Or use AI (machine learning)



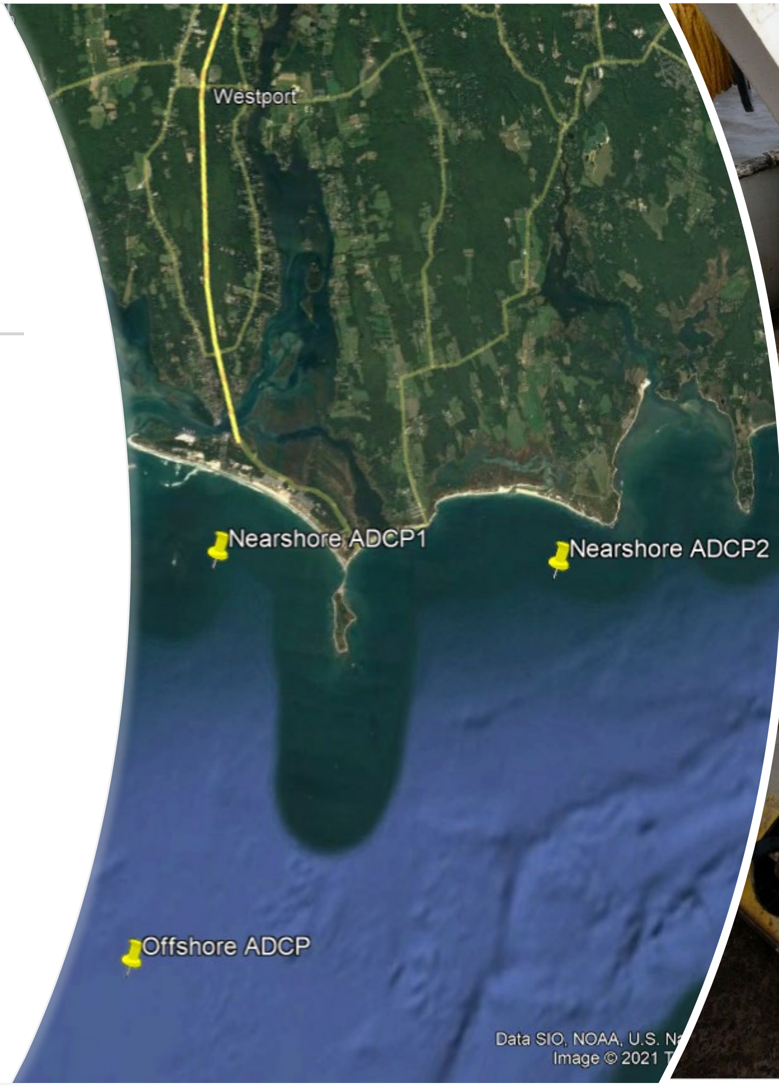
Spectral analyses and classification



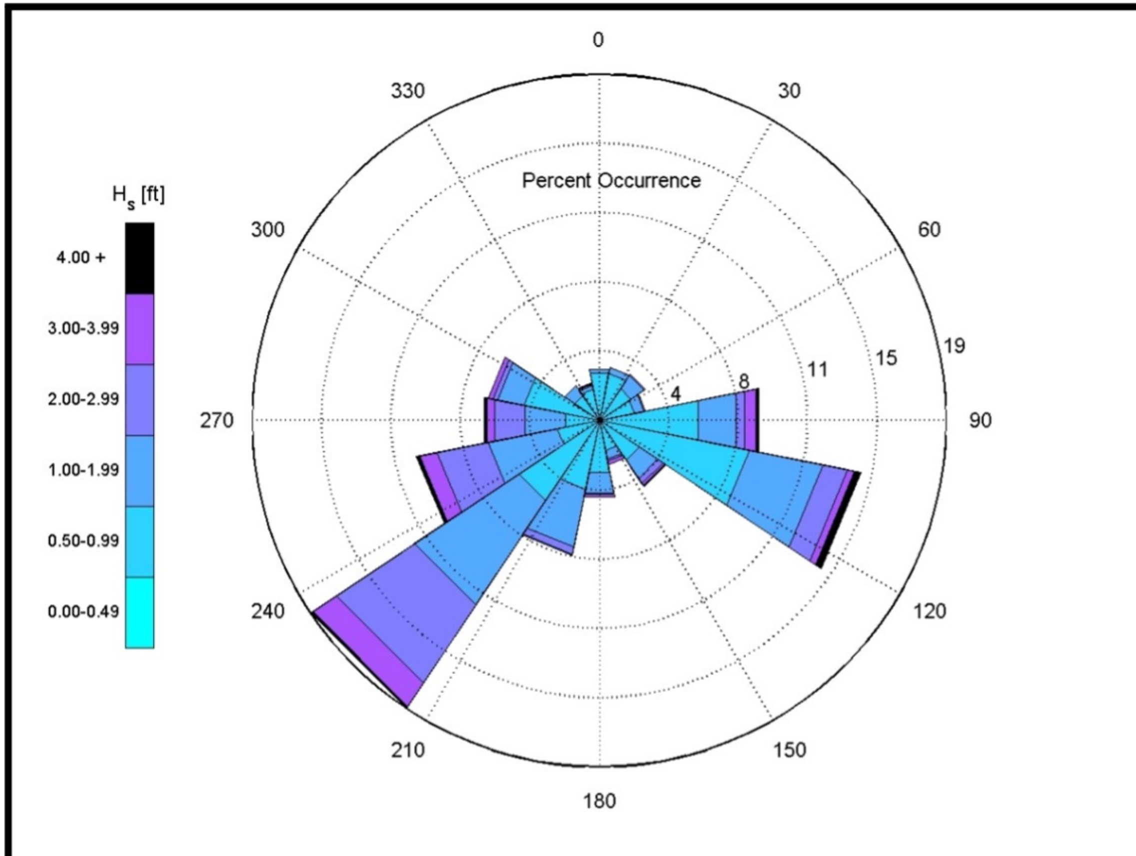


Field Data: ADCP moorings

- Wave moorings for Regional and Causeway Grids
- Suggested locations
  - either side of causeway
  - offshore



Example of directional wave data



Shallow water deployments

- Velocity profile
- Water level (tide)
- Salinity
- Temperature
- Sediment

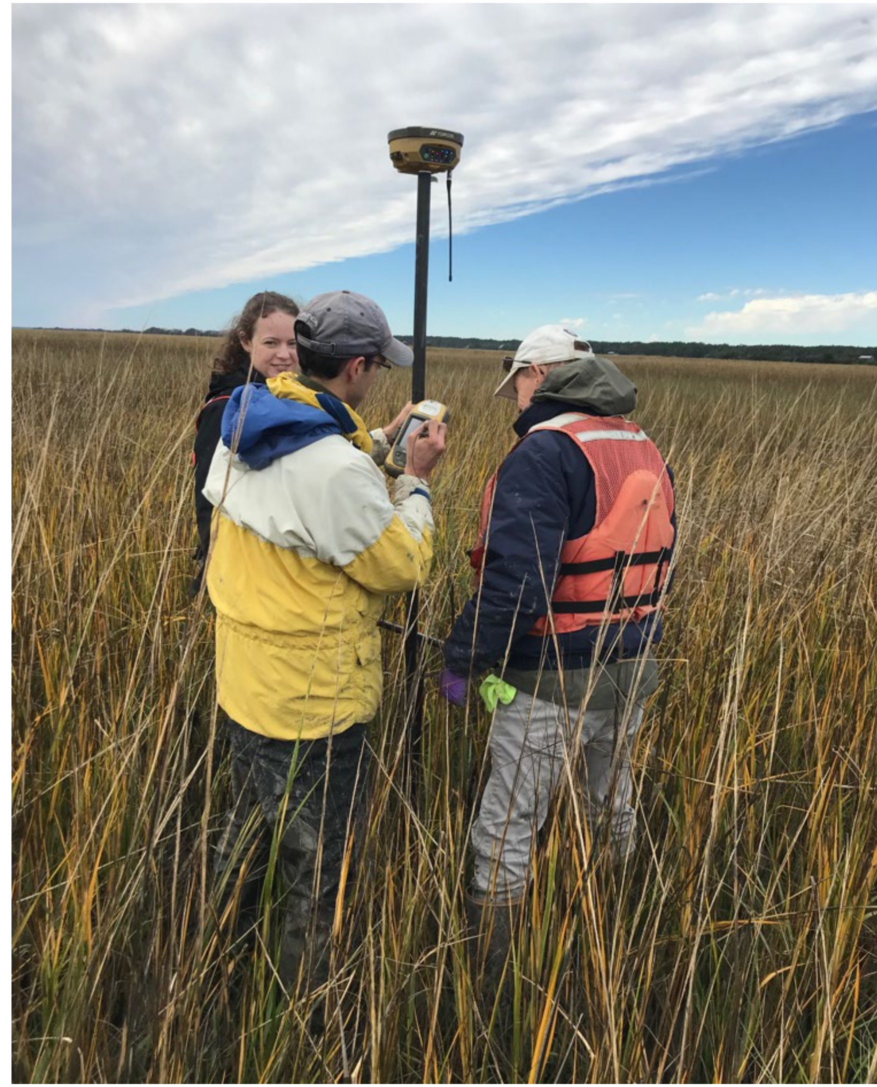
Shallow water deployments

Suggested locations:

- 5 sites Westport River.
- 5 sites Allens Pond.
- 5 sites Slocum River Inlet.

RTK-GPS Surveys

- Real Time Kinematic Global Positioning System
- cm accuracy
- Water levels and bathymetry





Small boat surveys

- Bathymetry
- Currents (if needed)

Sediment sampling

- Grab samples offshore
- Samples along shore
- Returned to lab for analysis

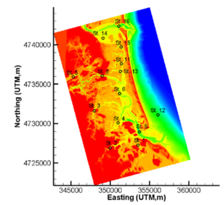
Accretion cores

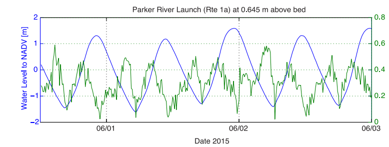
- Taken with open barrel (to prevent compaction)
- Surveyed in to cm accuracy
- To lab for ^{210}Pb analyses
- Backbarrier evolution over time

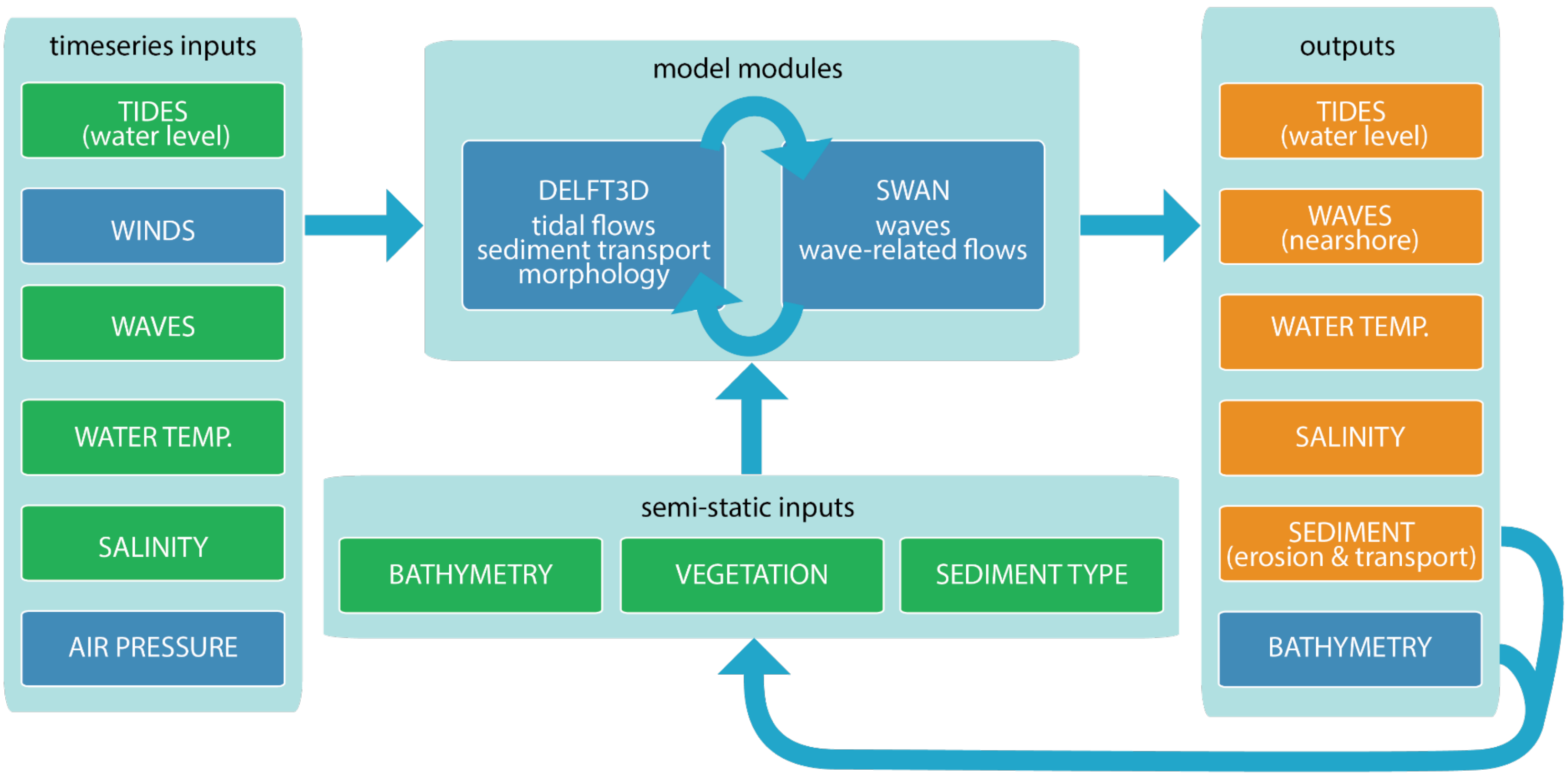
Shoreline Dating

- Short core samples taken
- To lab for Optically stimulated luminescence analyses
- Provides shoreline evolution

Model development







The Simulations

Running the Models to identify Possible Management Actions

1. BASELINE – How does the entire coastal system function currently?

Assess the general flow and sediment transport patterns in each zone by running a set of specified significant wave height and wave direction conditions (5 wave heights and 5 wave directions, i.e., 25 conditions). For each simulation, we will determine sediment transport fluxes along the shoreline and the related long-term morphological changes. This will allow us to examine water circulation and sediment transport at Westport Inlet (Q1), transport patterns along Horseneck and East Beach (Q2) and within Slocum River Inlet (Q3).

2. NO CAUSEWAY – What if the Gooseberry Causeway was never built?

Identical scenarios to BASELINE will be run using a version of the model in which we artificially remove the Gooseberry Causeway from the model. This will allow us to evaluate the influence of the causeway on sediment fluxes and bathymetric and morphologic changes examined in the first set of model runs (Q1-3).

3. DETAILED CAUSEWAY ALTERNATIVES – Would a ‘different’ causeway improve conditions?

We will examine the system-wide impact of the Causeway using the Regional Model grid, however, we will also use a fine scale model to examine nearshore wave dynamics and sediment fluxes around the Causeway. This allows us to look at in detail at how the Causeway impacts waves and longshore sediment fluxes and also to test several options for Causeway mediation: 1) Causeway present; 2) complete removal 3) replacement with a bridge). This will help us to determine if and when sediment can pass around Gooseberry Neck, and the extent to which the Causeway impacts that.

The Simulations

Running the Models to identify Possible Management Actions

4. SLOCUM RIVER INLET SEDIMENTATION – From where and how is the sand getting here?

In order to assess the infrequent pulsing of sediment around Barney's Joy Point into Slocum River Inlet (Q3), we will use the regional grid examine the effects of high-energy (storm) events on sediment transport and erosional-depositional processes. We will run the model for a set of 3 high intensity storms (of increasing intensity). These will be identified based on a frequency and magnitude analysis of local storms. We will look for initiation of sediment bypassing around the point and the type of storm needed to force it in order to determine the frequency of this pulsing and how this may change in the future. We will also use a function in the model to track the sediment within the model to confirm the source of sediment into Slocum River Inlet.

5. SLOCUM RIVER WATER QUALITY – Can river health be improved by managing this sand?

In addition to identifying the source of sediment and rate of infilling at Slocum River Inlet, we will examine how changes in infilling over time or dredging of the sediment would impact water quality in the estuary. In order to do this we will use the water quality module available in Delft3D, invoking salinity as a proxy for flushing and exchange in the system. We would undertake this sub-study using separate, local, fine scale grid. Scenarios would include three initial conditions 1) present day; 2) dredged; 3) increased infilling.

The Simulations

Running the Models to identify Possible Management Actions

6. Allens Pond Inlet and Marshes – Why is the inlet closing so often; can it be managed?

The position of the Allens Pond inlet is a function of tidal currents keeping the inlet open and the wave-driven longshore transport, which acts to close or migrate the inlet. Allens Pond Inlet stability cannot easily be assessed using the coarse regional grid, although patterns and gross changes in the longshore transport rate will be determined. For finer scale, we will run present and future conditions at this site using a higher resolution grid. This finer grid will better resolve the complex wetlands and the associated tidal prism flowing through the inlet. This analysis will provide a better assessment of how changes in the inlet position occur, and what is causing the increased westerly spit accretion and inlet migration (and the need to artificially reopen the inlet updrift on the beach).

7. Sea Level Rise – How will climate change affect all scenarios?

The impacts of rising sea level will be evaluated by modeling conditions under two SLR scenarios (present-day and 2070, high emissions). SLR at 2070 will be estimated based on recent projections provided in the Climate Ready Boston report (UMass Boston, 2016). Sediment transport fluxes will be determined and compared to present conditions, with and without the Causeway. This will provide answers to questions raised by various Causeway mediation alternatives.

Project Timeline 2022-2024

	Tasks	Group	2022				2023				2024			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Field Data Collection & Analysis	Task 1.1 Identify/obtain existing data (historic aerial images/bathy.)	BU	■											
	Task 1.2 Shoreline change analysis of Westport and East Beach	BU	■	■										
	Task 1.3 Slocum River infilling assessment	BU	■	■										
	Task 1.4 Allen's Pond Inlet migration/change	BU	■	■										
	Task 2.1 Collect new nearshore & offshore bathymetric data	WHG		■	■									
	Task 2.2 Collect new river & inlet bathymetric data	BU		■	■									
	Task 2.3 Deployments: inlet/backbarrier water levels and currents	BU		■	■									
	Task 2.4 Deployments: offshore/nearshore waves and water levels	WHG		■	■									
	Task 2.5 Marsh vegetation mapping (Allen Pond and West Port)	BU		■	■	■								
	Task 2.6 Collect sediment samples (beach and nearshore)	BU		■	■									
	Task 2.7 Collect marsh accretion cores	VIMS		■	■									
	Task 2.8 Collect samples for OSL dating	BU/VIMS		■	■									
	Task 3.1 Post-processing of deployment data	BU/WHG			■	■	■							
	Task 3.2 Grain size analyses of sediment samples	BU			■	■	■							
	Task 3.3 Laboratory analysis of marsh accretion cores	VIMS			■	■	■	■	■					
	Task 3.4 OSL analysis (external lab)	BU				■	■	■	■					
Create Regional Model	Task 3.5 Model input development (pres./future bathy, veg map)	BU/WHG	■	■	■	■	■							
	Task 4.1 Development of regional grid	BU		■	■	■	■							
	Task 4.2 Determine wave/wind conditions for runs from BUZM3	BU				■	■	■						
	Task 4.3 Calibrate and validate regional model	BU					■	■						
	Task 4.4 Development of high-res Causeway grid.	BU					■	■	■					
	Task 4.5 Development of high-res Slocum River grid.	BU							■	■	■			
	Task 4.6 Development of high-res Allen's Pond grid.	BU								■	■	■		
	Task 4.7 Generate and extract boundary conditions	WHG/BU				■	■	■	■	■				
	Task 4.8 Calibrate and validate nested model	BU							■	■	■	■		
Evaluate Scenarios	Task 5.1 Scenario set 1: regional model Baseline Scenarios	BU						■	■	■				
	Task 5.2 Scenario set 2: regional model No Causeway Scenario	BU						■	■	■	■	■		
	Task 5.3 Scenario set 3: regional model SLR Scenario	BU								■	■	■		
	Task 5.4 Scenario set 4: Slocum River Scenarios	BU									■	■	■	
	Task 5.6 Scenario set 5: Detailed Causeway Scenarios	BU									■	■	■	
	Task 5.7 Scenario set 6: Allens Pond Scenarios	BU									■	■	■	
	Task 6.1 Create output maps	ALL							■	■		■	■	■
	Task 6.2 Create geodatabase of results for sharing with BBC	BU											■	■
Project Mgmt.	Task 7.1 Contracting	ALL	■											
	Task 7.2 Quarterly team meetings	ALL	■	■	■	■	■	■	■	■	■	■	■	■
	Task 7.3 Update meetings with Donors	ALL				■				■				■
	Task 7.4 Presentations at conferences/to stakeholders	ALL				■				■			■	■
	Task 7.5 Report preparation	ALL				■				■		■	■	
	Task 7.6 Final Report submission	ALL												■

Gooseberry Project Budget

Gooseberry Project Expense Summary	
Boston University	$ 925,000
Woods Hole Group	$ 200,000
Virginia Institute of Marine Sciences	$ 120,500
Buzzards Bay Coalition	$ 79,500
	$ 1,325,000

Gooseberry Project Funding Plan

Income Sources	2022	2023	2024	Totals
Rathmann Foundation request	$ 500,000	$ 500,000	$ -	$ 1,000,000
BBC Private Fundraising Match	$ 125,000	$ 100,000	$ 100,000	$ 325,000
Annual Income Totals	$ 625,000	$ 600,000	$ 100,000	$ 1,325,000

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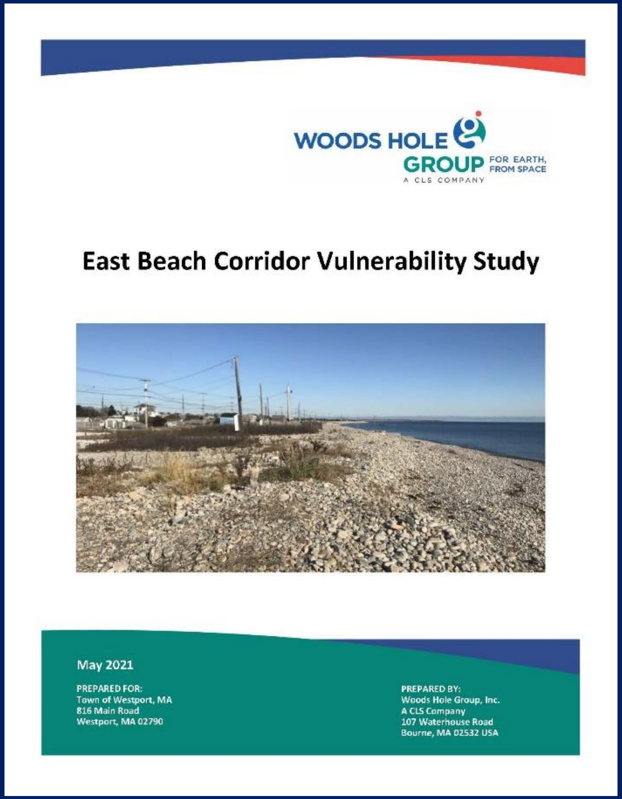
Study fulfills key recommendation of Westport's MVP Program-funded 'East Beach Corridor Vulnerability Study'



3.6 MODEL COASTAL PROCESSES TO EVALUATE THE IMPACT OF THE CAUSEWAY AND IN-WATER ADAPTATION STRATEGIES

Except: "There are several questions, some longstanding (65-100 years) and some new, that could not be answered within the scope of the present study. Answers to these questions are needed to facilitate consensus building on what type(s) of medium- to long-term strategies the Town should invest in…

2. How would removal or modification of the Gooseberry Island Causeway, to reestablish historic alongshore sediment transport, affect the frequency with which beach renourishment would be needed?

…. To answer the questions identified above, a more detailed understanding of coastal processes along East Beach and Horseneck Beach would need to be developed through data collection, research, and numerical modeling.

Coastal processes govern the dynamic nature of these beaches, interact with barrier beach processes, affect the Westport River and Let side hydrodynamics, and ultimately shape Westport's coastline**. Developing a detailed understanding of these governing physical processes, and how coastal infrastructure such as the Gooseberry Causeway may impact sediment supply and transport, or how features like East Beach may affect upstream coastal flood risks and ecology is critical to refining the alternatives identified in this study and identifying community-supported, feasible, sustainable, and cost-effective solutions to the present and future stressors that the East Beach Corridor faces. Additionally, an updated evaluation of existing conditions will not only provide necessary information and data to the coastal processes study, but also serve as a touchpoint for evaluating the feasibility of any proposed solutions. …**

This proposed study would provide the scientific and technical basis for developing a comprehensive resiliency plan for this critical part of Westport's shoreline that balances the protection of property and infrastructure with habitat restoration and natural processes. "

THE TIME IS NOW

Could one wartime decision be contributing to a cascade of negative impacts that are still affecting the health of more than a quarter of the Buzzards Bay watershed today? The Buzzards Bay Coalition, local government officials, and leading oceanographic scientists believe it is beyond time that these questions be answered.

Fortunately, the science of modeling the complex fluid dynamics and sediment transport processes behind the Gooseberry question have developed to a point where it can be answered. Without a major investment in the science, however, local communities and the Commonwealth of Massachusetts will never have the evidence to make the case for change.

New state and federal funding directed at Climate Change Adaptation makes this the moment for action. 2021 Infrastructure Bill includes $47 Billion for communities to prepare for climate change impacts from sea level rise, storms and flooding. The projects with the science and the plans ready will be the ones that move.

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