Cape Cod Coastal Planner Methodology

A Resource of the Resilient Cape Cod Project

Produced by the Cape Cod Commission
January 2022

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Introduction

This report describes the background and methodology for the Cape Cod Coastal Planner.

The Commission and its partners built the Coastal Planner, a map-based communication and decision-support tool to help residents and decision makers understand the relative environmental and socio-economic effects of implementing adaptation strategies to address sea level rise, storm surge, and erosion. The tool integrates research on potential adaptation strategies for Cape Cod communities and how ecosystem services are impacted by hazards and strategy selection. The Cape Cod Coastal Planner's development was also informed by an extensive stakeholder process, integrating feedback from potential users across the region, and tested through a pilot project with the Town of Barnstable.

A quick start guide for the tool is also available.

Resilient Cape Cod Overview

In early 2016, the National Oceanographic and Atmospheric Administration (NOAA) awarded a three-year, $750,000 grant to the Cape Cod Commission and partners to develop a tool and public outreach program that would investigate the environmental and socio-economic effects of coastal resiliency strategies.

The grant partners were: Cape Cod Commission, Association to Preserve Cape Cod, Waquoit Bay National Estuarine Research Reserve, and the Town of Barnstable.

The supporting agencies were: Woods Hole Sea Grant, the Center for Coastal Studies, and the Massachusetts Office for Coastal Zone management.

The online tool was developed with the Timmons Group, an engineering and technology firm in Virginia. In second half of 2022, Timmons was rehired and completed some significant enhancements.

Project components

- An adaptation strategies database, a collection of information on a broad range of strategies to increase resiliency on Cape Cod;
- A public engagement process, working with stakeholders across the region to improve understanding of the threats under projected sea level rise, erosion, and storm surge scenarios, and exploring options appropriate for Cape Cod communities;
- Socioeconomic analyses, estimating the value of ecosystem services and the impact of projected scenarios and adaptation strategies on those services;
- A communication and decision support tool, communicating the impacts of coastal threats and adaptation strategies, including costs and benefits, and the need for action in a GIS-based tool that allows for user interaction;
- And a pilot project with the Town of Barnstable, applying the information, tools, and resources developed to assist the Town in identifying appropriate strategies to

advance resiliency planning as a follow-up to their Municipal Vulnerability Planning (MVP) process.

Goal of the Cape Cod Coastal Planner

The Cape Cod Coastal Planner is a communication and decision support tool intended to educate users on the climate change hazards impacting Cape Cod's coastline, the adaptation strategies available to address them, and implications for local infrastructure and ecosystems.

Disclaimer

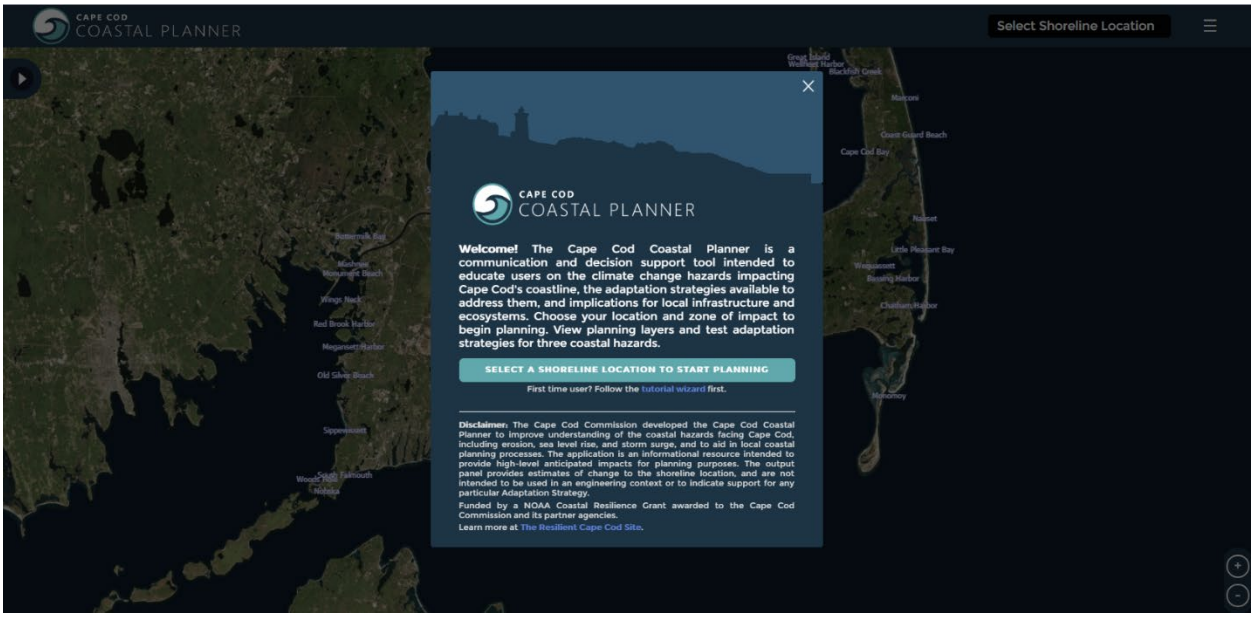
The Cape Cod Commission developed the Cape Cod Coastal Planner to improve understanding of the coastal hazards facing Cape Cod, including erosion, sea level rise, and storm surge, and to aid in local coastal planning processes. The application is an informational resource intended to provide high-level anticipated impacts for planning purposes. The output panel provides estimates of change to the shoreline location and is not intended to be used in an engineering context or to indicate support for any particular adaptation strategy.

Tutorial

The following tutorial outlines the user experience while annotating applicable underlying methodology.

Opening screen orientation

This is the screen you should see upon opening www.capecodcoast.org:



Welcome panel: click to "Select a Shoreline Location to Start Planning" to begin using tool. Click "tutorial wizard" to step through tutorial.

Map: displays names of shoreline locations, which can be clicked to start planning in the map or through the drop down in the top right of the header

- Shoreline locations are based on Cape Cod's littoral cells – complete sediment cycles along the shoreline. Identified by the Cape Cod Cooperative Extension and named by Commission staff based on local water bodies.

Header: click the ☰ button in the top right for About Us, Resources, Methods links; click shoreline location drop down to start planning.

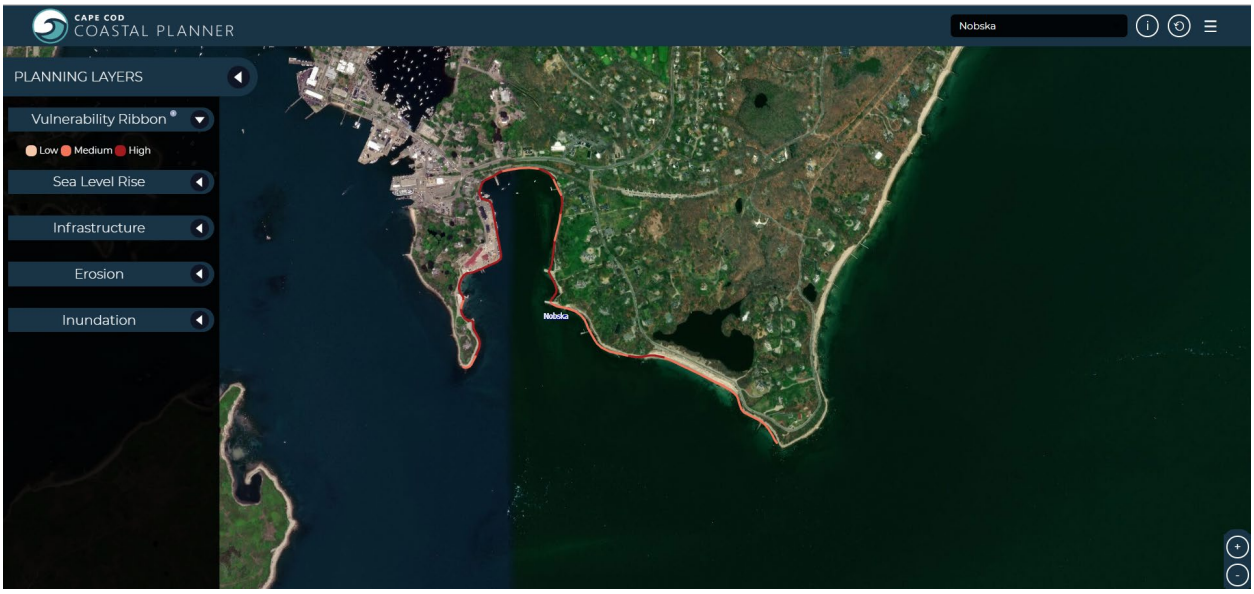
Once you've clicked start:

Hover over Shoreline Location names to highlight that length of shoreline, click to select planning area on the map. You can also select from the list of Shoreline Locations in the header bar, and it will zoom to that location.

The tool doesn't allow for users to click inland, and the name itself must be selected (not just the physical shoreline location).

Once you've clicked shoreline location:

Vulnerability Ribbon appears:



- The Vulnerability Ribbon was based on the South Carolina Beachfront Vulnerability Index: https://coast.noaa.gov/digitalcoast/stories/vulnerability-index.html
- The Ribbon ranks areas of the shoreline by relative vulnerability to major coastal threats. The factors affecting vulnerability include:
    - Distance of structures from the shoreline
    - Presence of coastal beach, coastal dunes, barrier beaches, and/or salt marshes
    - Long-term coastal erosion rates from USGS and MA CZM

    - Presence of coastal engineering structures
    - Beach nourishment projects (1995-2014)
    - Floodplain intersects with roads/structures
    - SLOSH zones intersect with roads/structures
    - SLR scenarios intersect with roads/structures
- Users will place their selected Adaptation Strategies along the Vulnerability Ribbon.

Planning Layers panel appears on the left side of the screen (more information below).

Learn more about your shoreline location: click  button in the header on the top right (more information here)

Moving around the map

Pan around the map by clicking and dragging with your mouse. Zoom in and out of the map by clicking the plus/minus signs on the bottom right corner of the map, or by holding CTRL and using the mouse wheel. The zoom-in stops at a certain extent to avoid household-level planning scenarios.

Reset to beginning: click circled arrow button in the top right

Planning Layers

Planning layers describe what's on the ground at that shoreline location:

- Vulnerability Ribbon. Source: Cape Cod Commission
    - The ribbon categorizes 100-ft shoreline locations by degree of vulnerability (Low, Medium, or High) to the impacts of natural hazards.

- Infrastructure
    - Municipal Properties. Source: Cape Cod Commission
        - All parcels identified as owned by Barnstable County or Municipal Government
    - Public and Private Roads. Source: MassDOT
        - All private and public roads
    - Sewered Parcels. Source: Cape Cod Commission
        - Parcels served by sewer treatment systems
    - Coastal Defense Structures. Source: Cape Cod Commission
        - Includes groins, jetties, and revetments, derived from the planimetrics created in the 2014 Regional Flyover
    - Structures. Source: MassGIS
        - Roofprints of buildings larger than 150 square feet, derived from ortho and LiDAR images collected from 2002-2012

- Historic Districts. Source: The Massachusetts Historical Commission & Cape Cod Commission
  - Local and Regional Historic Districts
- Historic Places. Source: The Massachusetts Historical Commission & Cape Cod Commission
  - All identified buildings and sites of historical significance
- Low-Lying Roads. Source: The Woods Hole Group
  - Point outputs from the Massachusetts Coast Flood Risk Model, a predictive model showing the 50 year probability of road segments being inundated with water under storm surge and sea level rise scenarios

- Sea Level Rise (SLR)
  - 1-6 ft of SLR. Source: Cape Cod Commission
    - SLR was derived from Digital Elevation Model data collected through LiDAR in 2011 and is shown in the tool as a simple representation of a change in elevation - a "bathtub" model. More information is available in the Cape Cod Sea Level Rise Viewer: http://www.capecodcommission.org/sealevelrise/
  - Disconnected Roads. Source: Cape Cod Commission
    - ESRI Network Analyst was used to determine which roads are disconnected from the network at each increment of sea level rise.
    - The user can select the roads disconnected at different sea level rise levels, from one to six feet
    - The data layers for sea level rise data and disconnected roads are connected, so that selecting one level of SLR will also display disconnected roads at that level.
  - Critical Facilities. Source: Cape Cod Commission
    - Critical facilities are identified by towns in their hazard mitigation planning process and indicate locations where any threat of coastal hazard is unacceptable: airports, bridges, child care facilities, churches, military locations, community centers, municipal buildings, fire stations, hospitals, libraries, marinas, police buildings, Red Cross locations, schools, senior centers, wastewater treatment plants, solid waste facilities, veteran's facilities, and water departments.

- Stormtide Pathways
  - Stormtide Pathways. Source: Center for Coastal Studies & Cape Cod Commission
    - This layer shows the location of points where once the total water level, from sea level rise or a storm mixed with the tides, is greater than the elevation of the Storm Tide Pathway water will begin to flow

to inland areas behind. The locations of the storm tide pathways are based on the field surveys conducted during fieldwork and should be seen as an approximation only. The data received from CZM was converted from MLLW to MHHW and aggregated into 1ft increments to generalize the data and provide regional perspective. More information is available: https://coastalstudies.org/marine-geology-2/storm-tide-pathways/

- Stormtide Plane Extent. Source: Center for Coastal Studies & Cape Cod Commission
  - This layer shows the approximate extent of flooding in one foot increments based on the latest lidar dataset available at the time the fieldwork was conducted and should be seen as an approximation only. Again, the original data was converted MLLW to MHHW to be consistent with the other datasets within the Coastal Planner application. Please see this resource for details: https://www.stormtides.org/

- Inundation
  - Flood Zones: Source: FEMA FIRM
    - This layer displays flood zone areas (A, AE, AO, and VE) denoted by 2013 data from FEMA Flood Insurance Rate Maps (FIRMs).
    -

Flood Zone	*Mandatory flood insurance purchase requirements apply to all of these zones.*
A Zone	Corresponds to 100-year flood risk; 1 in 4 chance of flooding over 30-year mortgage
AE Zone	Moderate to high flood risk; depths over 3 feet
AO Zone	Additional hazards from rivers/streams: Areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1-3 feet.
VE Zone	Additional hazards from storm waves; 1 in 4 chance of flooding over 30-year mortgage

More information on FEMA FIRM maps are available here: https://msc.fema.gov/portal/home

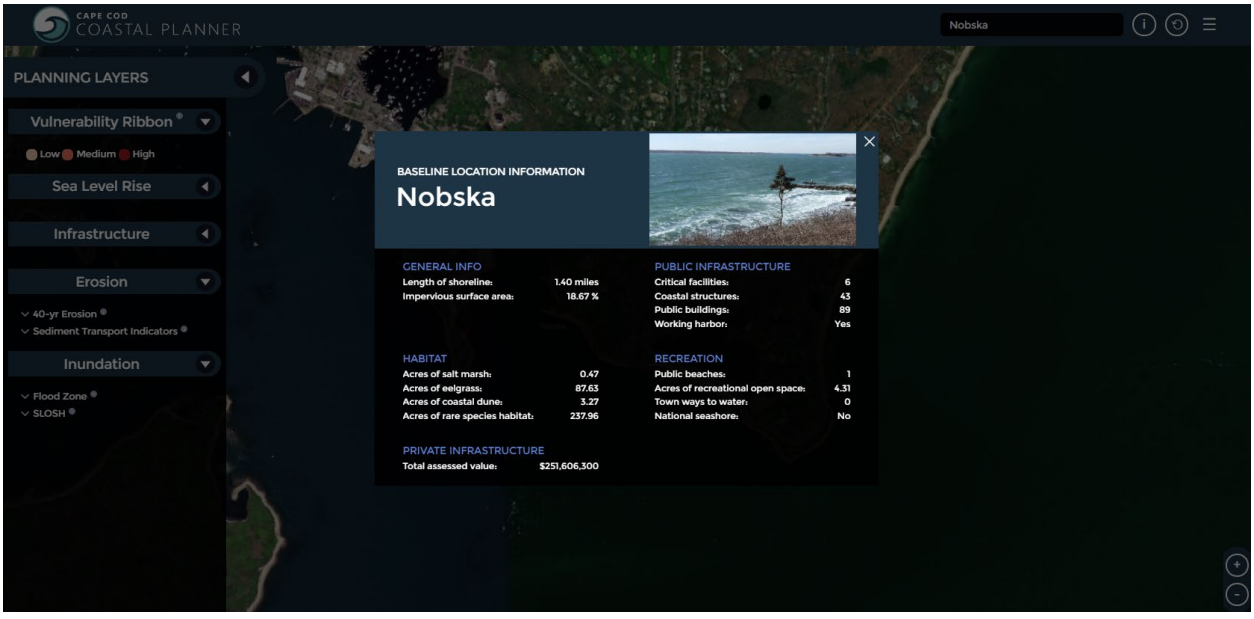
  - SLOSH. Source: NOAA NWS
    - Sea, Lake, and Overland Surge from Hurricanes (SLOSH) mapping represents potential flooding from worst-case combinations of hurricane direction, forward speed, landfall point, and high astronomical tide, developed by NOAA and the National Weather Service (NWS). Categories 1 to 4 reflect "bins" of inundation.

SLOSH Categories	*Flooding levels corresponding to wind speeds sustained for a minute or more:*
Category 1	74-95 mph
Category 2	96-110 mph
Category 3	111-129 mph
Category 4	130-156 mph

- Erosion
  - 40-year erosion. Source: USGS, CZM, CCC
    - This layer displays long-term shoreline accretion and erosion based on a forty-year estimate of sediment transport, generated from the Long-Term Rate of erosion from the MA Shoreline Change Project. More information is available here: https://www.mass.gov/service-details/massachusetts-shoreline-change-project
  - Sediment Transport Indicators: Source: Cape Cod Cooperative Extension
    - This layer displays the flow of sediment along Barnstable County shorelines based on research from Woods Hole Sea Grant and Cape Cod Cooperative Extension. More information is available here: https://www.capecodextension.org/project/longshore-sediment-transport/

Baseline Location Information Panel

The baseline information panel tells the user about the shoreline location selected, and can be accessed by clicking the i-hover next to the shoreline location drop down in the top right of the banner.



Under the photo and title:

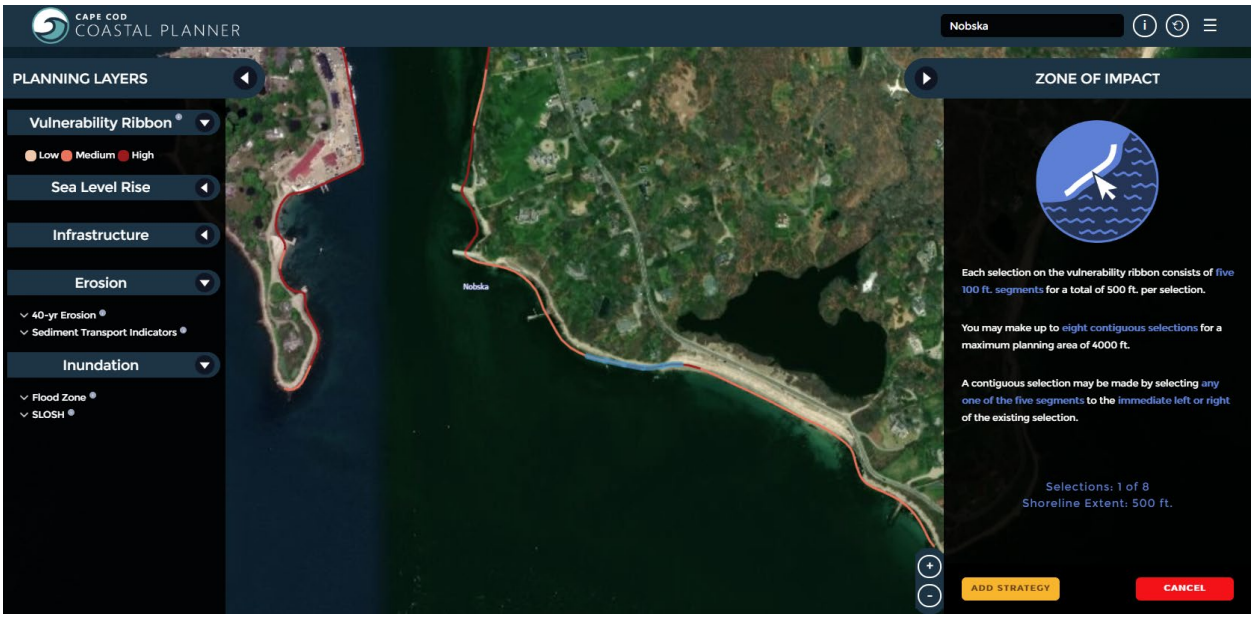
- General Info
  - Length of shoreline:
    - The full length of the shoreline area the user is exploring (not based on the user selecting their zone of impact)
  - Impervious surface area
    - The percent of land area that is impervious (water cannot drain through; acts as a proxy for urbanization); calculated within a third of a mile of the shoreline. The impervious surface was identified in the 2014 regional flyover for planimetrics data for Cape Cod
- Habitat
  - Salt Marsh, Eelgrass, Coastal Dune, Rare Species Habitat
    - The number of acres of habitat occurring within a third of a mile of the shoreline, based on the MassDEP wetlands and eelgrass layers and the Natural Heritage & Endangered Species Program Estimated Habitats of Rare Wildlife[1]
- Private Infrastructure
  - Total Assessed Value:
    - The dollar value of private residences, calculated within a third of a mile of the shoreline, based on town-level assessing data
- Public Infrastructure
  - Critical Facilities
    - Number of critical facilities, identified by Towns in their hazard mitigation planning processes, within a third of a mile of the shoreline
  - Coastal Structures:
    - Number of coastal structures within a third of a mile from the shoreline, identified using the 2014 planimetrics layer
  - Public Buildings:
    - Number of public buildings within a third of a mile of the shoreline, based on the Structures GIS layer intersecting with the Municipally-owned GIS layer
  - Working Harbor:
    - Identified by CZM and MORIS, presence/absence of Working Harbor along the shoreline
- Recreation
  - Public Beaches
    - Number of public beaches within a third of a mile of the shoreline

[1] For more information on the NHESP Program and Estimated Habitat GIS data layer: https://www.mass.gov/service-details/regulatory-maps-priority-estimated-habitats

- Acres of Recreational Open Space:
  - Number of acres within a third of a mile of the shoreline, identified by MassGIS Protected and Recreational Open Space GeoDatabase Data Model; includes privately- or publicly-owned outdoor facilities such as town parks, commons, playing fields, school fields, golf courses, bike paths, scout camps, and fish and game clubs.[2]
- Town Ways to Water
  - Identified by the Office of Fish and Boating Access in the MA Dept. of Fish and Game, this layer indicates the number of municipal coastal access points along the shoreline
- National Seashore:
  - Presence/absence of shoreline within the Cape Cod National Seashore

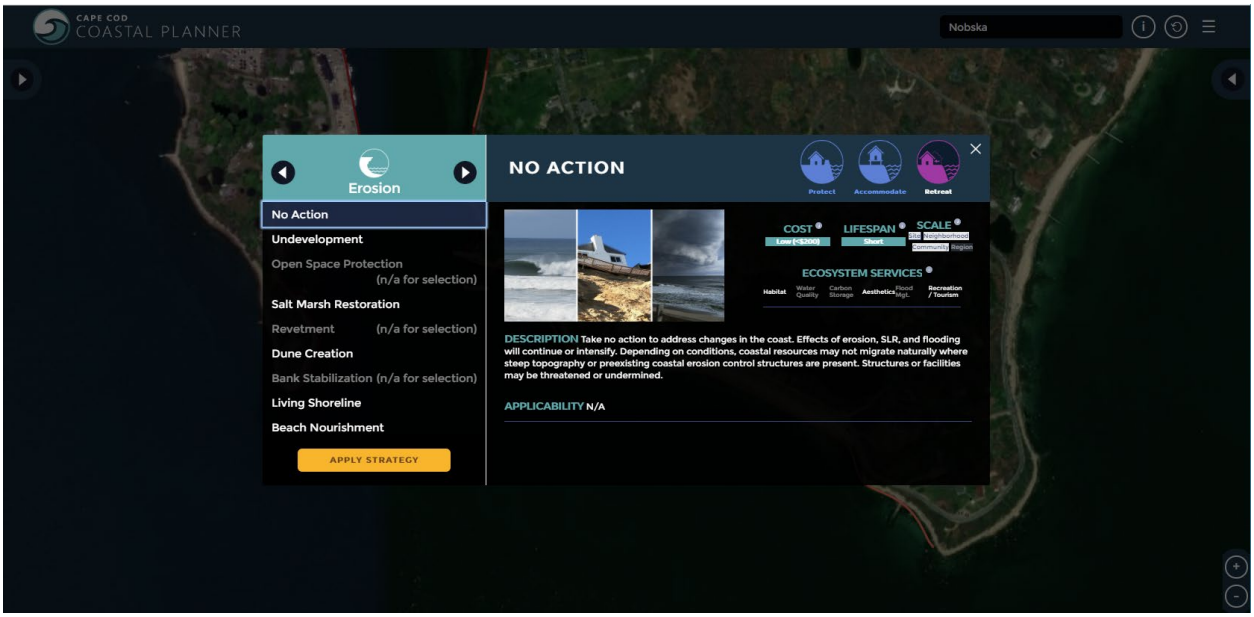
[2] For more information on the MassGIS Protected and Recreational OpenSpace GeoDatabase Data Model: https://docs.digital.mass.gov/dataset/massgis-data-protected-and-recreational-openspace

Selecting your Zone of Impact



1. After selecting and exploring the shoreline location, the user can click any area on the Vulnerability Ribbon in which they want to plan. A Zone of Impact panel pops up on the right side.
2. Each selection on the Vulnerability Ribbon consists of five, 100-feet segments for a total of 500 feet per selection. Users can make up to eight contiguous selections for a maximum planning area of 4,000 feet. A contiguous selection may be made by selecting any one of the five segments to the immediate left or right of the existing selection.
    a. A running total of the number of selections and extent of the shoreline selected displays on the Zone of Impact panel.
    b. The minimum width of the ribbon is intended to prevent users from estimating household-level impacts of various Adaptation Strategies.
3. Select Add Strategy once the entire Zone of Impact that the user wishes to plan for is highlighted in blue.

Selecting your Planning Hazard



- After selecting Add Strategy, the user will need to select which coastal hazard they will plan for: erosion, sea level rise, or storm surge.
    - **Erosion** is based on the long-term (40-year) erosion rates, determined by the MA Shoreline Change Project (More info here: https://www.mass.gov/service-details/massachusetts-shoreline-change-project)
    - **Sea Level Rise** also corresponds to a 40-year time frame, aligned with the planning horizon selected for the MA Municipal Vulnerability Program process. A 2-ft sea level rise is expected in Boston, associated with a 40 year planning horizon, based on Parris (2012):[3]

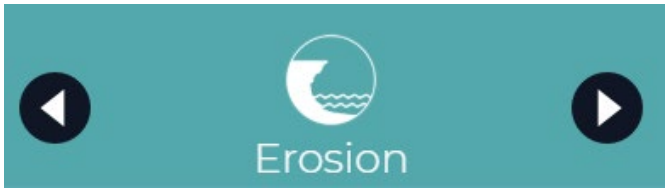
[3] Parris, A.S., Bromirski, P., Burkett, V., Cayan, D.R., Culver, M.E., Hall. J., ...& Sallenger, A.H. (2012). Global sea level rise scenarios for the United States National Climate Assessment.

Table 3. Relative sea level rise estimates for Boston, MA. Global scenarios were adjusted to account for local vertical land movement with 2003 as the beginning year of analysis.

Scenario	2025		2038		2050		2063		2075		2088		2100	
	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
Highest	0.49	0.15	1.08	0.33	1.81	0.55	2.80	0.85	3.92	1.19	5.33	1.63	6.83	2.08
Intermediate High	0.36	0.11	0.73	0.22	1.19	0.36	1.80	0.55	2.47	0.75	3.32	1.01	4.20	1.28
Intermediate Low	0.24	0.07	0.43	0.13	0.65	0.20	0.92	0.28	1.21	0.37	1.55	0.47	1.91	0.58
Lowest (Historic Trend)	0.18	0.06	0.29	0.09	0.39	0.12	0.50	0.15	0.60	0.18	0.71	0.22	0.81	0.25
Range	0.31	0.09	0.79	0.24	1.42	0.43	2.30	0.70	3.32	1.01	4.62	1.41	6.02	1.83

- **Storm surge** is an immediate, one-time event. Storm surge impacts reflect whichever extent is greater of the two, FEMA FIRM or Sea, Lake, and Overland Surges from Hurricanes (SLOSH).

1. The user toggles between these three hazards using the arrows in the top left of the Adaptation Strategies window, selecting which hazard they want to plan for.



Selecting your Adaptation Strategy

- The list of Adaptation Strategies built into the tool is:
  - No Action
  - Undevelopment
  - Managed Relocation
  - Retrofitting Assets
  - Open Space Protection
  - Salt Marsh Restoration
  - Revetment/Sea Wall
  - Dune Creation
  - Bank Stabilization
  - Living Shoreline
  - Beach Nourishment

This list is a subset of the full list of strategies in the Adaptation Strategy Matrix[4]. The subset was selected based on stakeholder feedback from the subregional outreach process conducted as part of the Cape Cod Coastal Planner development. Several adaptation strategies in the tool simplify and blend together features from related strategies (e.g. the Living Shoreline in the Cape Cod Coastal Planner is a combination of varieties: Vegetation only, Combined Vegetation and Structural Measures, and Living Breakwater/Oyster Reefs).

- Data for the adaptation strategies, in addition to the tool and matrix, are also available as Fact Sheets.[5] The Matrix is the most high-level detail available on the strategy; the Fact Sheets are condensed for use in an educational context; and the tool contains the most abridged information on each strategy, easy to understand for non-practitioners but enough to inform their adaptation strategy selection.

1. Once the user selects a hazard, the applicable adaptation strategies for the Zone of Impact they selected are highlighted to indicate they can be applied. Strategies that cannot be applied – typically due to what's currently on the ground in that area – remain grayed out. The table below is based on research conducted as part of the adaptation strategies Matrix development.

	H A Z A R D		
Adaptation Strategy	**Erosion**	**Storm Surge**	**Sea Level Rise**
No Action	✓	✓	✓
Undevelopment	✓	✓	✓
Managed Relocation	✓	✓	✓
Retrofitting Assets	✓	✓	✓
Open Space Protection	✓	✓	✓
Salt Marsh Restoration	✓	✓	✓
Revetment/ Sea Wall	✓		✓
Dune Creation	✓	✓	✓
Bank Stabilization	✓	✓	
Living Shoreline	✓	✓	
Beach Nourishment	✓	✓	

[4] Adaptation Strategies Matrix: https://barnstablecounty-my.sharepoint.com/:x:/g/personal/danielle_donahue_capecodcommission_org/EYLsbys2w6lNpEOflmYzSXwBTm5VZ6Y4N-QE9xOrySW40Q?e=E0aC4Q

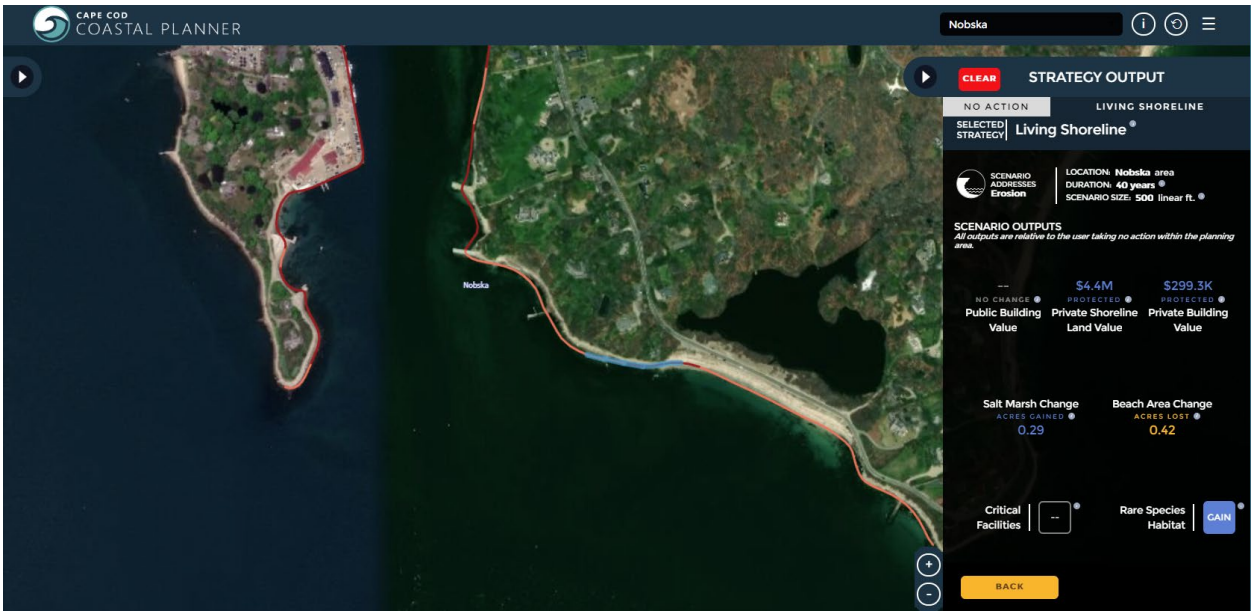
[5] Link to Adaptation Strategies Fact Sheets: https://spark.adobe.com/page/UmFTo4lYXSUVb/

2. Users can read information about the Adaptation Strategies, distilled from the Matrix, in the selection window, including:
    - A brief description
    - Applicability: how the strategy is expected to impact the output of the tool
        - E.g., "Expect this strategy to protect buildings and land and increase salt marsh acreage, sometimes at the expense of beach area."
    - An evaluation of its construction costs (low, medium, or high, compared to the full suite of Strategies)
    - Lifespan (short, medium, long, or permanent, compared to the full suite of Strategies)
        - While lifespans are often project-specific, based on local research, short lifespans are generally less than five years; medium is five to seven years; long represents seven to ten years; and permanent is longer than ten years.
    - Scale (at what scale is implementation most appropriate: Site, Neighborhood, Community, Region)
    - Ecosystem Services: whether the implementation of the Strategy will impact habitat, water quality, carbon storage, landscape aesthetics, flood management, and recreation/tourism
        - For the purposes of this tool, we defined Ecosystem Services as the direct and indirect benefits that nature provides that influence human well-being.
        - For more information on the tool's socio-economic research component, a fact sheet was developed for Stakeholder Outreach meetings.[6]
    - Whether the Strategy will Protect, Accommodate, or Retreat from the hazard

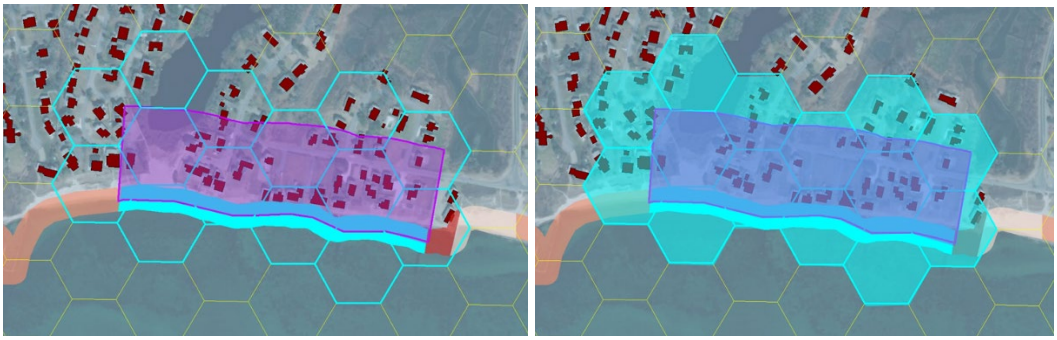
3. Select using the Apply Strategy button, and an output panel pops up.

[6] Socio-economic brief: https://barnstablecounty-my.sharepoint.com/:b:/g/personal/danielle_donahue_capecodcommission_org/EQG_lIZF7jRIpP4PZVrgx18BfhEY-lAasg7lMGiPvCipSg?e=Ed1cY8

Calculating Output



- There is a layer of 2-acre hexagons built into the map that aggregates data within each shape. For example, each hexagon will have a total public and private building value associated with it. This also helps prevent the household-level layer of planning this tool was not intended for and speeds up the output calculation process.
- The selection of a line segment on the vulnerability ribbon reaches 500 feet inland, generating the "zone of impact" for the strategy. Output calculations are based on this localized area around the strategy. The selection collects data from those hexagons that this 'reach' touches. Each individual 100-foot line segment reaches straight back inland, creating a rectangular grab area where the coastline is straight, a fan shape where the coastline is concave, and a roughly triangular shape where it's convex:



- While all the strategies have the same 500-ft zone of impact, each adaptation strategy has a different on-the-ground footprint. The impacts of an adaptation strategy differ in its zone of impact compared to its footprint. For example, if we are considering Rare Species Habitat, the creation of a dune will increase Rare Species Habitat; however, it would only create it within the strategy footprint, and not 500-ft inland.

Adaptation Strategy	**Width**
No Action	N/A
Undevelopment	100 ft
Managed Relocation	N/A
Retrofitting Assets	N/A
Open Space Protection	N/A
Salt Marsh Restoration	30 ft
Revetment/ Sea Wall	10 ft
Dune Creation	30 ft
Bank Stabilization	10 ft
Living Shoreline	30 ft
Beach Nourishment	30 ft

- Strategies can only be placed on the Vulnerability Ribbon where they would actually be built. For example, bank stabilization can only be placed on existing coastal bank.

	P L A C E M E N T
Adaptation Strategy	**(on vulnerability ribbon)**
No Action	N/A
Undevelopment	anywhere
Managed Relocation	anywhere
Retrofitting Assets	anywhere
Open Space Protection	only on undeveloped parcels
Salt Marsh Restoration	anywhere
Revetment/ Sea Wall	only on coastal bank
Dune Creation	anywhere but salt marsh
Bank Stabilization	only on coastal bank
Living Shoreline	anywhere but salt marsh
Beach Nourishment	anywhere but salt marsh

No Action Scenarios

- For every scenario run in the tool, a No Action scenario is run in the background. All the outputs in the output panel are meant to compare to what happens if the user had opted to take no action at that location. The No Action scenario becomes the basis for calculating "loss avoided."

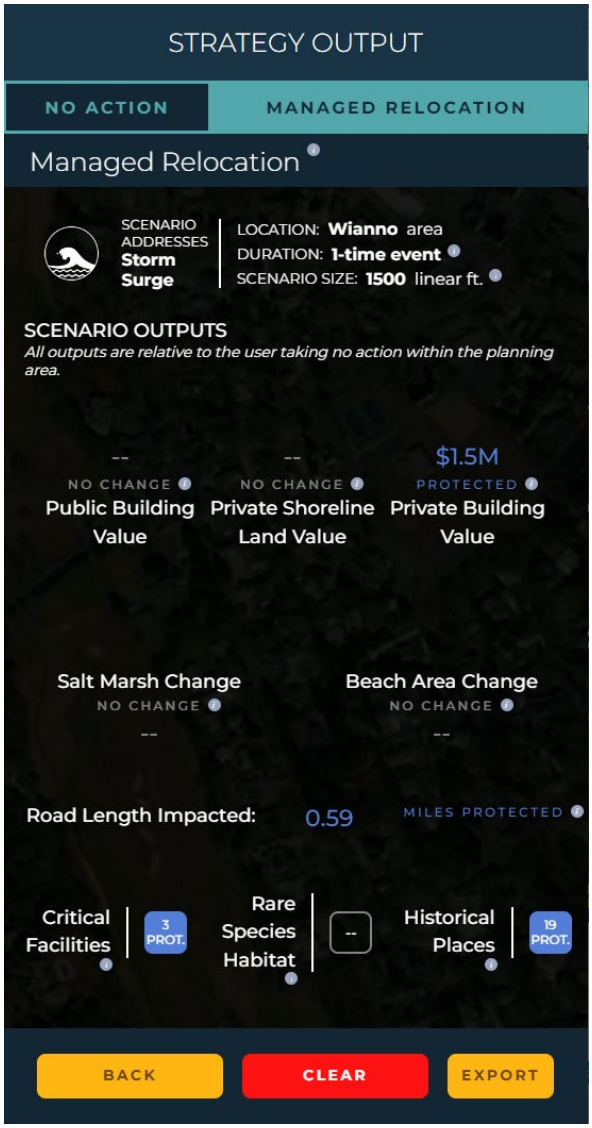
Output Panel

- There are four categories of output: public infrastructure, private infrastructure, recreation, and habitat. The output panel also includes some general scenario info, including what scenario the user planned for, the shoreline location, the length of the planning period (based on the selected hazard), and the scenario size – how long an area did the user select.

- Scenario outputs are blue if they represent a protection, loss avoided, or gain. Outputs are yellow if they represent a loss.

- Outputs may be grayed out – this most often occurs when that output value (in this example, public building values) are not present in the selected area.

- All outputs are relative to the user taking no action within the planning area. In this example, the gain in salt marsh acreage is a 'gain' over what would occur in the No Action Scenario. Users can click back and forth between the No Action results and the selected strategy to see the tradeoffs between the two choices.



The outputs are broken down as follows:

- Public Infrastructure:
    - Building Value: Total assessed value of publicly-owned buildings impacted by the strategy and/or hazard
    - Critical Facilities: Number of critical facilities impacted by the strategy and/or hazard

- Road Length Impacted: Total road length impacted by the strategy and/or hazard

- Private Property
  - Land Value ($830.44/sq. m)
    - This dollar value is based on research conducted by Dr. James Opaluch at the University of Rhode Island, who evaluated the average value per square meter of land located within 100 feet of the shoreline based on towns' assessed values. [7]
  - Building value: Total assessed value of privately-owned buildings impacted by the strategy and/or hazard
    - Storm surge damage to residences is not a total; it's calculated based on the Army Corps of Engineers Flood Damage Curve. CCC averaged the percent of damage across all single-family residence types for the heights of water included in the curve for a one-time loss of 20.9% of assessed value.

Type of Single Family Residence	Height of Water			
	0 ft	1 ft	2 ft	
One Story, No Basement	13.4%	23.5%	32.1%	
Two or More Stories, No Basement	9.3%	15.2%	20.9%	
Split-Level, No Basement	7.2%	9.4%	12.9%	
One Story, With Basement	25.5%	32.0%	38.7%	
Two or More Stories, With Basement	17.9%	22.3%	27.0%	
Split-Level, With Basement	18.5%	23.2%	28.2%	**Average Percent Loss for All Types of Residences**
Average Percent Loss by Water Height	*15.3%*	*20.9%*	*26.6%*	**20.9%**

  - Historical Places: Number of historical buildings or sites impacted by the strategy and/or hazard

- Habitat
  - Salt Marsh: Number of acres gained or lost due to the strategy and/or hazard
    - Salt Marshes provide key ecosystem services to people, including protection from flooding and storm damage, habitat, and recreational areas. This value is included because the impacts of coastal hazards and adaptation strategies on the number of acres of salt marsh along the shoreline will influence the ecosystem services provided to the community.
    - Rare Species Habitat: Gain or loss due to the selected strategy and/or hazard. The Priority Habitats of Rare Species provide ecosystem services, as they are the habitat of state-listed Rare Species in

[7] Opaluch, James J. and Jasmine Hwang. Memo to Cape Cod Commission. 13 April 2018.

Massachusetts (such as piping plover). The data is based on observations documented in the last 25 years in the Natural Heritage and Endangered Species Program database.[8] This value is included because the impacts of coastal hazards and adaptation strategies on the amount of Rare species Habitat along the shoreline serves as a proxy for the health of the environment and the ecosystem services provided to the community.

- Recreation
    - Beach Area Change: Number of acres gained or lost due to the strategy and/or hazard
        - Beaches provide key ecosystem services to people, including protection from recreation, habitat, and erosion protection. This value is included because the impacts of coastal hazards and adaptation strategies on the number of acres of beach will influence the ecosystem services provided to the community.

The Strategy Output and associated map can be exported to pdf and downloads to your computer by clicking the EXPORT button in the lower right corner. The export function takes a "screen shot" of the application at the moment and inserts it into a custom template.

[8] MassGIS Priority Habitats for Rare Species: https://docs.digital.mass.gov/dataset/massgis-data-nhesp-priority-habitats-rare-species

Note that the user can open the planning layers for a legend of layers turned on and can frame their map to best represent their scenario before export.

Conclusion

The Cape Cod Coastal Planner is an online decision support tool meant to communicate tradeoffs in coastal management to a broad audience. It's not meant to make decisions – it's intended to inform them. The outputs are not exhaustive and intentionally exclude key considerations in coastal management that would be project specific, as it's not expected to be used in an engineering context. However, the tool can communicate the differences between different shoreline locations, explain why decision makers may select a particular adaptation strategy over others – or may choose not to act. The tool consolidates geographic information about Cape Cod's coastline in one location and should be used to communicate potential impacts to both traditional and non-traditional audiences.

For more information about the Resilient Cape Cod project, please visit www.capecodcommission.org/resiliency

Glossary

Adaptation Strategies: Actions that can be taken to address coastal hazards, whether they protect an area, accommodate the changes, or facilitate retreat from the hazards.

Critical Facilities: Critical facilities are those for which any damage due to extreme weather or flooding are unacceptable. Each Town designates their own critical facilities, typically while creating their Hazard Mitigation Plans. At the state level, critical facility types include military facilities, police facilities, fire facilities, hospitals, emergency operation centers, and colleges/universities. (Massachusetts State Hazard Mitigation and Climate Adaptation Plan)

Ecosystem Services: Benefits from nature provided to people (e.g. buffering homes and roads from flooding; reducing wave energy from storms; providing nursery and feeding resources for fish)

Rare Species Habitat: Habitat that is protected under Massachusetts law, and provides habitat to plant or animal species listed as Endangered, Threatened, or Special Concern. (https://www.mass.gov/service-details/ma-endangered-species-act-mesa-overview)

Additional Resources

1. NOAA Coastal Resilience Grant Page: https://coast.noaa.gov/resilience-grant/
2. Cape Cod Commission Open Data Hub: http://gis-cccommission.opendata.arcgis.com/
3. MassGIS Bureau of Geographic Information: https://docs.digital.mass.gov/massgis
4. Spark page: https://spark.adobe.com/page/H3TgtzULGkbjH/
5. Adaptation Strategies Matrix: https://barnstablecounty-my.sharepoint.com/:x:/g/personal/danielle_donahue_capecodcommission_org/EYLsbys2w6lNpEOflmYzSXwBTm5VZ6Y4N-QE9xOrySW40Q?e=E0aC4Q
6. Adaptation Strategies Fact Sheets: https://spark.adobe.com/page/UmFTo4lYXSUVb/