Virginia Eastern Shore Coastal Resilience Mapping & Decision Support Tool

Training Manual Version 3.0 (August 2017)

A project funded by the Department of Interior Hurricane Sandy Coastal Resilience Fund

August 2017

Virginia Eastern Shore *Coastal Resilience Tool*

Training Manual, Version 3.0

With input from the Community Leader Workshop held in November 2014, the customized Virginia Eastern Shore *Coastal Resilience* online mapping and decision support tool for visualizing and assessing regional vulnerability to storm surge, sea-level rise, and changes in coastal habitats can be found at **maps.coastalresilience.org/virginia**. Please visit the project webpage for more information at **coastalresilience.org/virginia**.

Coastal Resilience is a decision support tool that incorporates the best available science and local data to enable communities to visualize the risks imposed by sea-level rise and storm surge on the people, economy, and coastal habitats of the Eastern Shore and identify nature-based solutions for enhancing resilience and reducing risks where possible.

This training manual for the Coastal Resilience tool provides Exercises & Skills to practice real-world problem solving. Hints & Tips for using the tool and a glossary of terms are also included. The tool contains web mapping applications, or "apps." Each one is intended to address a specific coastal issue to inform conservation, mitigation, and/or adaptation planning. Fact Sheets provide additional information about the locally-sourced data and models that were used to generate each app.

Please read the Legal Disclosure carefully for more information about the proper use of the Virginia Eastern Shore Coastal Resilience tool.

Please contact us with your questions and input: vacoastalresilience@tnc.org

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Exercises and Skills

Part One: Basic Navigation

Exercise A. Getting there

- Start by going to the Virginia Eastern Shore Coastal Resilience project website: http://coastalresilience.org/project/virginia-eastern-shore/
  - Scroll down the page to learn more about the Coastal Resilience work going on in the region.
  - In the upper right hand corner of the header banner, click **Mapping Portal** to launch the Coastal Resilience mapping tool *(or enter URL:* http://maps.coastalresilience.org).

- Either click on the **Virginia** pin on the map or scroll down and Click on **United States**, then scroll down and click on **Virginia**. Click on the **Map** button to open the mapping tool.

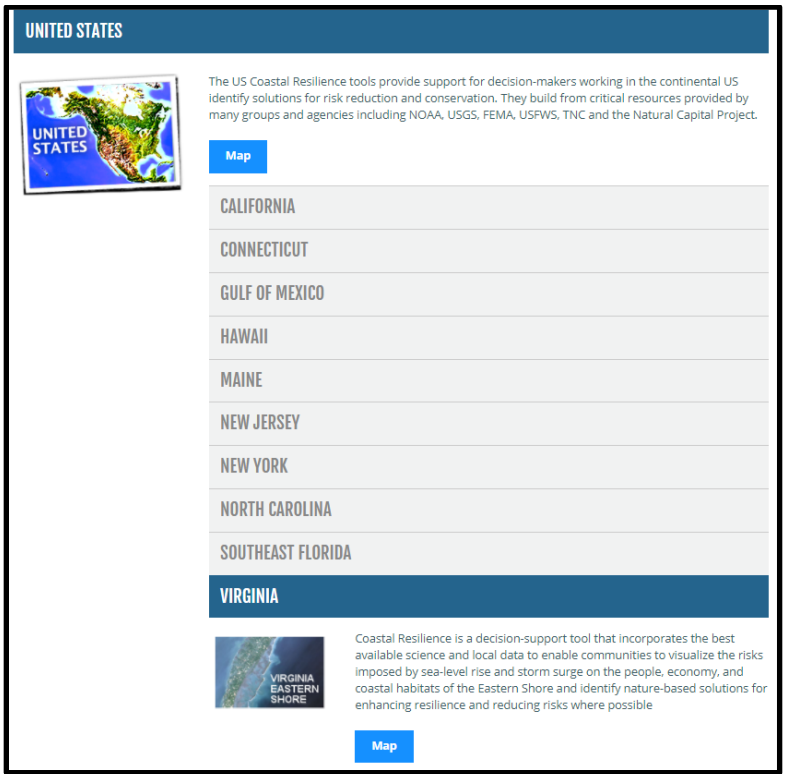

Figure 1. Accessing the Virginia map at maps.coastalresilience.org/virginia

Exercise B. Basic orientation to framework and apps

Figure 2. Orientation to the framework

A. Clicking on **Coastal Resilience** will open a dropdown menu with links to The Nature Conservancy's home site, a legal disclosure, and other Coastal Resilience tool regions.

B. This is a hamburger menu for exploring external links outside of the mapping tool.

C. **Get Started**: This is the start menu that provides an introduction to the mapping application, specific links to apps in the left sidebar, and also partner and collaborator logos. Each item below the heading **Start exploring** contains a web mapping application, or "app."

D. These are the Coastal Resilience tool apps. They are intended to address a specific coastal issue to inform conservation, mitigation, and/or adaptation planning. Click on a symbol to open an app. You can have multiple apps running at the same time when you use the minimize "_" option for an active app. Minimize (the icon will stay blue) and open other apps to view additional data and information. Minimize will leave data on the map, but close the app interface. If you do not minimize, apps and their data remain active until the "x" is clicked either in the app window or next to the app name on the left sidebar (the "x" is only present in the sidebar when the sidebar is expanded and more than one app is open). Use the close "x" to remove data from the map.

E. These are quick links to the Coastal Resilience tool apps. Click on **Go** to open an app.

F. Under **Partners** you can find organizations that partnered with The Nature Conservancy for the development of the Coastal Resilience tool.

G. This arrow collapses and expands the app names to allow for a larger map area.

H. Click **Tour** for an introduction to the map interface. Click on each number for feature information and close this window when finished.

I. Go to the **Find address or place** search window in the top right corner of the map to find and zoom to a particular area on the map:

a. Start typing in your point of interest and you will get a list of available selections from a global address database.

maps.coastalresilience.org/virginia

b. Choose the correct location from the dropdown menu.
c. Close the search window by clicking on the **X** icon.

J. Click **Topographic** in upper right hand corner and select the **Imagery** basemap option. Note that other base maps are available here as well.

K. Click the **plus sign [+]** button to zoom in and the **minus sign [-]** button to zoom out. Note that you can hold down the Shift key and left-click to draw a zoom box.

L. This button opens the **Tools** dropdown menu. It includes the following options:

a. The **Measure** option allows you to measure a distance. Select the tool, then click on a point on the map. You can create several segments; when you are done you need to double-click to display the measurement. You can also measure an area by clicking on the first point again when finished creating a shape. Click the **Clear** button to close this tool.
b. **Zoom to Extent** will zoom to the full extent of the Eastern Shore of Virginia.
c. **Create Map** allows you to print the current extent and selected layers or save the map as an Adobe Portable Document Format (PDF).
d. Click on **Save & Share** to generate a link to the current map, which can be copied and shared with colleagues.

Apps in the Toolbox

Regional Planning

The **Regional Planning** app includes supporting infrastructure, ecological, socioeconomic, and other data important for resilience and adaptation planning. These layers may be used in combination with the other apps to identify and assess vulnerability and potential solutions for specific locations and resources.

Flood and Sea Level Rise

The **Flood and Sea Level Rise** app allows users to view the potential future risk of inundation and flooding due to sea-level rise (SLR) and storm surge on towns, homes, properties, and critical built infrastructure like roads and utilities, as well as coastal habitats. This information helps support planning and decision-making related to hazard mitigation, emergency services, storm water management, land use and conservation.

Future Habitat

The **Future Habitat** app allows users to examine how coastal habitats, like salt marsh or freshwater tidal wetlands, may change and migrate inland over time under different sea-level rise scenarios. This information is useful when developing land acquisition, species management, shoreline management, or restoration plans.

Coastline Change

The **Coastline Change** app's **Historical Data** module and **Future Scenarios** module collectively serve to demonstrate the dynamic nature of barrier islands over time. These modules provide planners and managers with overall trends in shoreline change in response to climate change, auseful context for understanding the barrier islands as they evolve in the future.

Part Two: Flood & Sea Level Rise App

Assessing Vulnerability of Property and Infrastructure to Sea-Level Rise and Storm Surge

How to use the Tool: Basic Inundation

- ➢ Click on the **Flood & Sea Level Rise** app on the left or the **Go** button for the app in the **Get Started** menu.
- ➢ Click on the **Select a Hazard** dropdown menu and select **Basic Inundation**.
    - Click on the **Report** button ( ) under **Select a Region** for details on the underlying data.
    - Click on the **Data** button ( ) under **Select a Region** to download the geospatial data for this region.
- ➢ Select a **Climate Year** and **Sea Level Rise** scenario from the slider bars to view the predicted impact of sea-level rise in a selected year.
    - Click on the **?** icon for more information on each set of options. Click on the **X** to close the information window for **Climate Year**. Click outside of the pop-up to close the information window for **Sea Level Rise**.
    - Opacity (or transparency) of the layers in this app can be adjusted by using the **Opacity** slider.

Exercise A. Characterizing the risk of sea-level rise in Onancock.

★ **Exercise A Scenario:** *You are the owner of a charter boat company in Onancock. You depend on the town to maintain a functioning marina to support your business. In what **Climate Year** is the Wharf and Marina first inundated under each **Sea Level Rise** scenario? In which **Climate Year** would your livelihood as a charter boat owner be at risk in a business-as-usual scenario? If the town considered protecting the existing marina by raising it in response to predicted SLR, how high should it be raised to remain useful in 2065?*

★ **Exercise A Planning Outcome:** *Identify properties and infrastructure in Onancock that are critical for water access and predicted to become inundated in the future under different scenarios of SLR.*

- ➢ Select the **Flood & Sea Level Rise** app and its **Basic Inundation** option. Go to the **Find address or place** search window on the top right corner of the screen and type **Onancock, VA** and hit **Enter** or click the search result that comes up, then click the **X** to close the search result window.
    - Zoom in or out to adjust extent by clicking on the **plus sign [+]** or the **minus sign [-]** on the upper left or by using the mouse wheel.
    - **Pan**: hold the left mouse button down and move the mouse in the direction you want to pan.
    - Feel free to change the background from **Topographic** to **Imagery** if you find it helps to navigate.
- ➢ Navigate to the Onancock Wharf and Marina.
    - Select various combinations of **Climate Year** and **Sea Level Rise** to view the predicted impact of SLR in a selected year.
    - Adjust **Opacity** as necessary to visualize flooding from SLR.

Question 1-A: In what Climate Year is the Wharf and Marina first inundated under each Sea Level Rise scenario? At which Climate Year would your livelihood as a charter boat owner be at risk in a business-as-usual scenario?

➢ Using the Legend, identify the maximum inundation predicted for each **Climate Year** and **Sea Level Rise** scenario at the Onancock Wharf and Marina.

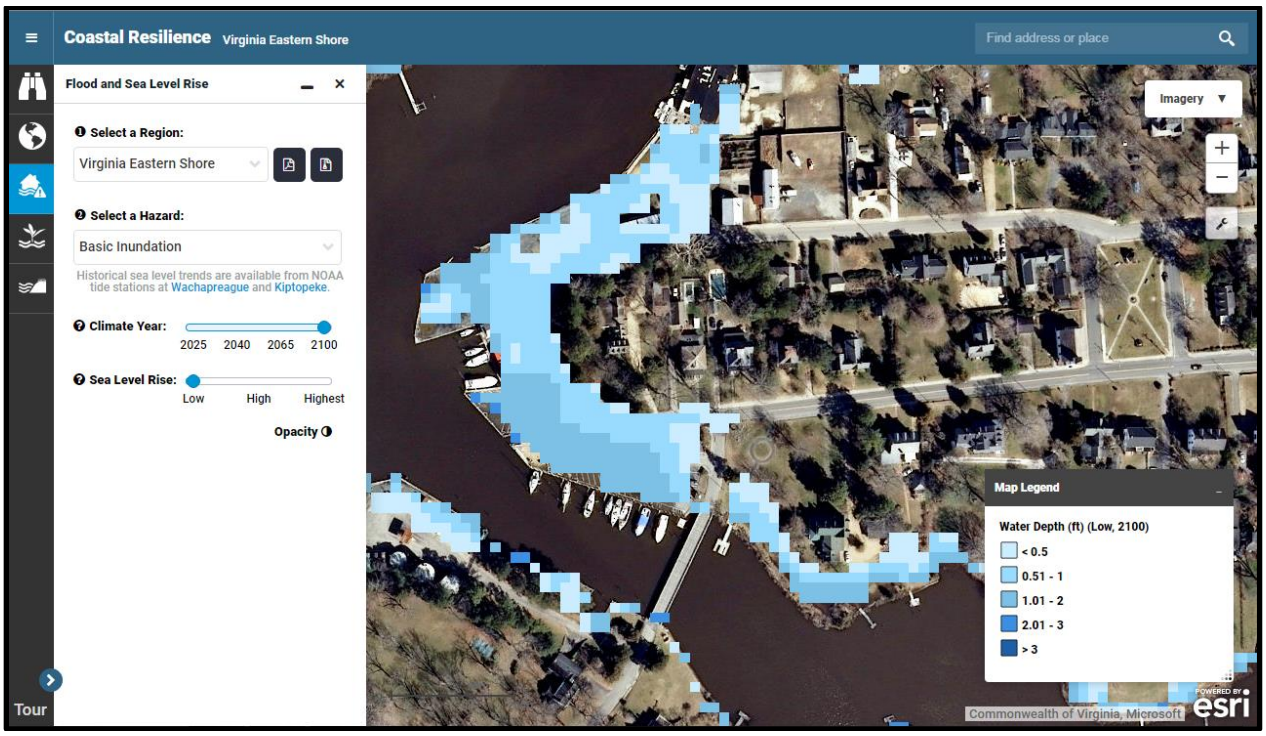

Figure 3. Example of what your screen should look like prior to Question 2-A.

Question 2-A: If the town considered protecting the existing marina by raising it in response to predicted SLR, how high should it be raised to remain useful in 2065 under each SLR scenario?

On Your Own:

Question 3-A: Using the Regional Planning app, note the tidal range for this region. Identify the maximum inundation which could be experienced by the Onancock Wharf and Marina in each Climate Year due to SLR plus a high tide and which should be used as a planning value, rather than just predicted SLR.

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maps.coastalresilience.org/virginia

How to use the Tool: Storm Surge

- ➢ If it is not already active, click on the **Flood & Sea Level Rise** app on the left or the **Go** button for the app in the **Get Started** menu.
- ➢ Click on the **Select a Hazard** dropdown menu and select **Storm Surge**.
    - Click on the **Report** button ( ) under **Select a Region** for details on the underlying data.
    - Click on the **Data** button ( ) under **Select a Region** to download the geospatial data for this region.
- ➢ Choose between Surge Depth and Economic Loss due to storms.
- ➢ Select a **Climate Year** and **Storm Type** scenario from the slider bars to view the predicted impact of storm surge in a selected year.
    - Click on the **?** icon for more information on each set of options. Click on the **X** to close the information window for **Climate Year**. Click outside of the pop-up to close the information window for **Storm Type** or map value display options.
    - The Surge Depth dataset may be displayed as water depth, absolute difference (i.e., depth difference between current and predicted water levels), or percent difference (i.e., percent increase or decrease in water level elevation).
    - Note that the **Storm Type** options include an option to view surge from Nor'Ida, a 2009 nor'easter which was used to validate the data in this app. This is the default selection when loading the app.
    - You can view the Storm track(s) of modeled storms which provided data for this app. You can also view tidal range data to better understand the risks posed by storm surge during different tidal cycles.
    - Opacity (or transparency) of the layers in this app can be adjusted by using the **Opacity** slider.

Exercise B. Characterizing the risks due to flooding and inundation from future storm surge in Cape Charles.

★ **Exercise B Scenario:** *Your family has lived in Cape Charles for generations. You have seen hurricanes and nor'easters over the years, but you have heard that the frequency of these storms may increase. You pay for flood insurance even though your property is far from the water, near the town's Central Park. What is the Flood Hazard Area for the neighborhoods near Central Park? In what **Climate Year** is this Flood Hazard Area flooded regularly by low intensity storms? What is the maximum economic loss predicted for properties around Central Park for a medium intensity storm in **Climate Year** 2065?*

★ **Exercise B Planning Outcomes:** (1) *Identify 0.2-pct Flood Hazard Zones in Cape Charles that are at risk for flooding under various scenarios of SLR combined with storm surge and local conditions;* (2) *Identify potential estimated economic losses under different scenarios of SLR combined storm surge.*

- ➢ Select the **Flood & Sea Level Rise** app and its **Storm Surge** option. Go to the **Find address or place** search window and type **Cape Charles, VA** and hit **Enter** or click the search result that comes up, then click the **X** to close the search result window.
- ➢ Navigate to the Cape Charles Central Park.
- ➢ Open the **Regional Planning** app ( ) and select **Virginia** and **Coastal Management**. Select **Flood Hazard Areas (2014)**.

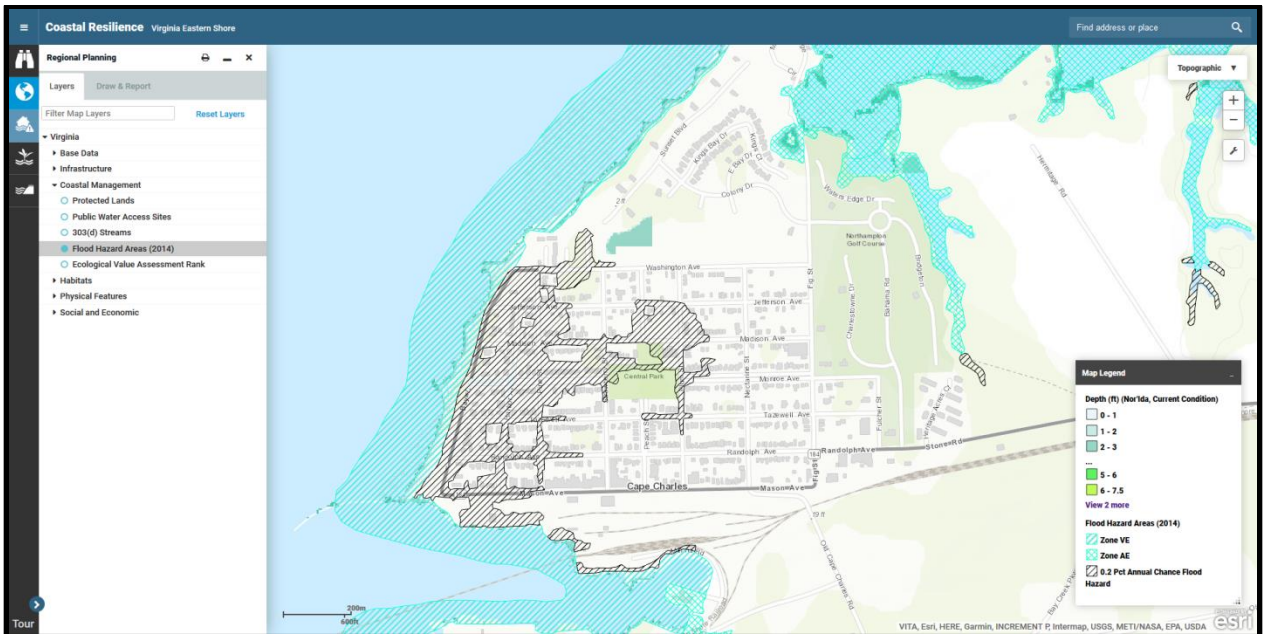

Figure 4. Example of what your screen should look like prior to Question 1-B.

Question 1-B: What is the Flood Hazard Area for the neighborhoods near Central Park?

- Click on the **Flood & Sea Level Rise** app to return to its menu.
- Under **Storm Type**, slide the bar to **Low Intensity** and compare **Climate Year** scenarios for **Current, 2040, and 2065**.

Question 2-B: In what Climate Year is the Flood Hazard Area identified in the previous question flooded regularly by low intensity storms?

- Change the hazard displayed to **Economic Loss**.
- Under **Storm Type**, slide the bar to **Medium Intensity** and the **Climate Year** to **2065**.

Question 3-B: What is the maximum economic loss predicted for properties around Central Park for a medium intensity storm in Climate Year 2065?

On Your Own:

Question 4-B: Compare future Climate Year and Storm Type combinations. How might the current 0.2 Percent Annual Chance Flood Hazard zone change based on predicted flooding by Low and Medium Intensity storms? What do you think will happen to flood insurance rates as a result?

TECHNICAL SKILLS COMPLETED

- ❑ Ability to assess risk and vulnerability to specific places or infrastructure due to a range of flooding scenarios based on SLR inundation only or SLR plus storm surge scenarios.
- ❑ Ability to evaluate the relative impact SLR has on storm surge.
- ❑ Ability to evaluate potential future economic losses due to different scenarios of SLR plus storm surge.
- ❑ Ability to consider hazard mitigation actions that may reduce risk of flooding to specific areas based on planning horizons.

Implementation:

- ❑ You can now use the Flood & Sea Level Rise app to help guide stakeholder workshops or conversations around community socio-economic vulnerability to permanent inundation among a range of projected sea-level rise scenarios along with the potential impacts of sea-level rise on storm surge. For example, the Onancock Wharf and Marina is vulnerable to increased inundation under future SLR scenarios.
- ❑ You can now create a meaningful map that can help clearly communicate to decision-makers and stakeholders that the impacts of sea-level rise on storm surge are not uniform and vary based on place. For example, SLR may have a greater impact on areas which have a larger tidal range.
- ❑ You can use the understanding of flood risk that you have gained to help make the case for adaptation recommendations like infrastructure or evacuation route relocation or future base flood elevation requirements, to help make your community more resilient.

Part Three: Future Habitat App

Identifying and Planning for Areas of Future Marsh Migration

How to use the Tool: Future Habitat

- ➢ Click on the **Future Habitat** app on the left or the **Go** button for the app in the **Get Started** menu.
  - There are three tabs within the **Future Habitat** app: **Choose Parameters**, **Results & Chart**, and **Compare & Chart**. The first tab, **Choose Parameters**, allows you to select various scenarios that affect habitat change. The **Results & Chart** tab shows tabulated data for quantities of habitat types for the chosen SLR scenario. The **Compare & Chart** tab will compare the quantities of habitat types in the chosen future scenario to current quantities. **Compare & Chart** only works if a future **Scenario Year** is selected.
  - Note that this app includes a very large dataset and may take several seconds to load each time its parameters and the zoom level are changed.
  - Click on the **Learn More** link to view a fact sheet regarding this app.
- ➢ Select a **Scenario Year** and **SLR Scenario** from the slider bars to view the predicted impact of sea-level rise on habitat types in a selected year.
  - Note that the **SLR Scenario** slider bar is inactive when the **Scenario Year** is set to **Current**.
  - Click on the **?** icon for more information regarding the **SLR Scenario** data.
  - Use the **Filter Results by Habitat(s) of Interest** checkboxes to show only salt marsh and/or other wetlands.
  - The results presented by this app may be focused on a specific area using the options below **Filter Results by a User Defined Area**. The **Click to Draw an Area** button allows you to click at least three points to choose an area of interest (double-click the last to close the shape). The app will now only show data within this area. Use the **Zoom to Selection** button to zoom to this area. The **Clear Filters** button will remove the area defined by the user and return to the full dataset. Note that this will also reset the **Filter Results by Habitat(s) of Interest** options.
  - Opacity (or transparency) of the layers in this app can be adjusted by using the **Layer Properties** slider.
  - The current geospatial data (either the full dataset or data for an area defined by the user) can be downloaded using the **Download Data** button.
  - The methods used to develop this app can be viewed by clicking the **View Methodology** button.

Exercise A. Future Habitat for Marsh Retreat at a Regional Scale

★ **Exercise A Scenario:** *You are part of a volunteer organization that promotes the preservation of salt marsh. What are the predicted changes in the amount of marsh habitat in 2025?*

★ **Exercise A Planning Outcome:** *Identify general regional trends in marsh habitat distribution and extent under different future SLR scenarios for Virginia's Eastern Shore.*

- ➢ Click on the **Future Habitat** app.

- ➢ Compare various **Scenario Year** and **Sea-Level Rise Scenario** combinations by sliding the bars to visualize where habitat types may change due to SLR.
- ➢ Click on the **Compare & Chart** tab to compare the modeled changes in habitat type quantities to current values.

Question 1-A: What are the predicted changes in the amount of salt marsh acreage in 2025 for each Sea Level Rise Scenario?

Exercise B: Future Habitat Changes in Wachapreague

★ **Exercise B Scenario:** *You are a town planner for Wachapreague. The town is proud of its scenic waterfront. However, you know that this area is vulnerable to SLR and associated habitat change. What habitat changes can be expected for Wachapreague between now and 2100 in a business-as-usual scenario? What areas of the town are most susceptible to habitat change as a result of SLR and what kinds of nature-based solutions could be implemented to reduce risks? Are there scenarios in which the surrounding area may change substantially, including loss of access routes, despite adaptation by the town?*

★ **Exercise B Planning Outcome:** *Identify areas of potential future marsh retreat within currently developed areas that should be the focus of adaptation actions.*

- ➢ Click on the **Future Habitat** app. Go to the **Find address or place** search window and type **Wachapreague, VA** and hit **Enter** or click the search result that comes up, then click the **X** to close the search result window.
- ➢ Compare various **Scenario Year** and **Sea-Level Rise Scenario** combinations by sliding the bars to visualize where habitat types may change due to SLR.

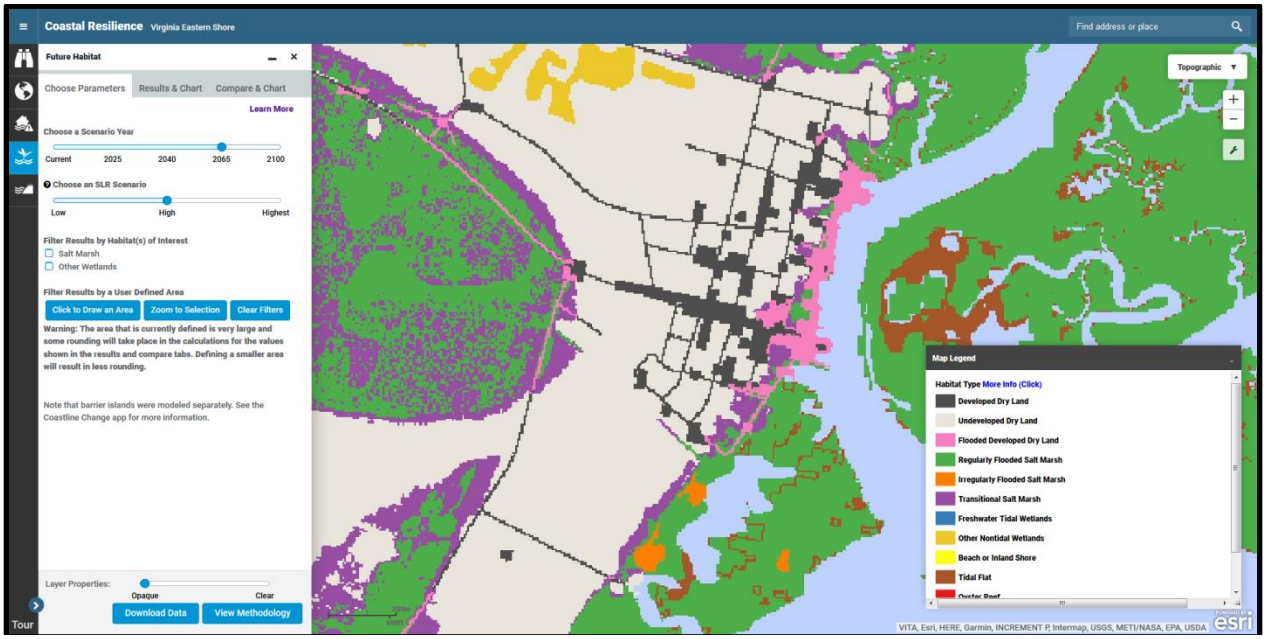

Figure 6. Example of what your screen should look like prior to Question 1-B.

Question 1-B: What habitat changes can be expected for Wachapreague between now and 2100 in a business-as-usual scenario?

- Using the slider bars and the Legend, identify the areas of Wachapreague that may experience habitat change first and the types of habitat predicted to replace **Undeveloped Dry Land**.

Question 2-B: What areas of the town are most susceptible to habitat change as a result of SLR? What kinds of nature-based solutions (e.g., marsh enhancement, seagrass beds, oyster reefs) could be implemented to reduce risks?

- Click on the **Regional Planning** app and select **Virginia** and **Base Data**. Select **Town Boundaries**. This will appear as a dark gray line around the town (you may choose to adjust the opacity of the Habitat Change app to better see it).
- Using the slider bars and the Legend, identify areas around Wachapreague which may experience significant habitat change, affecting access and infrastructure in the town.

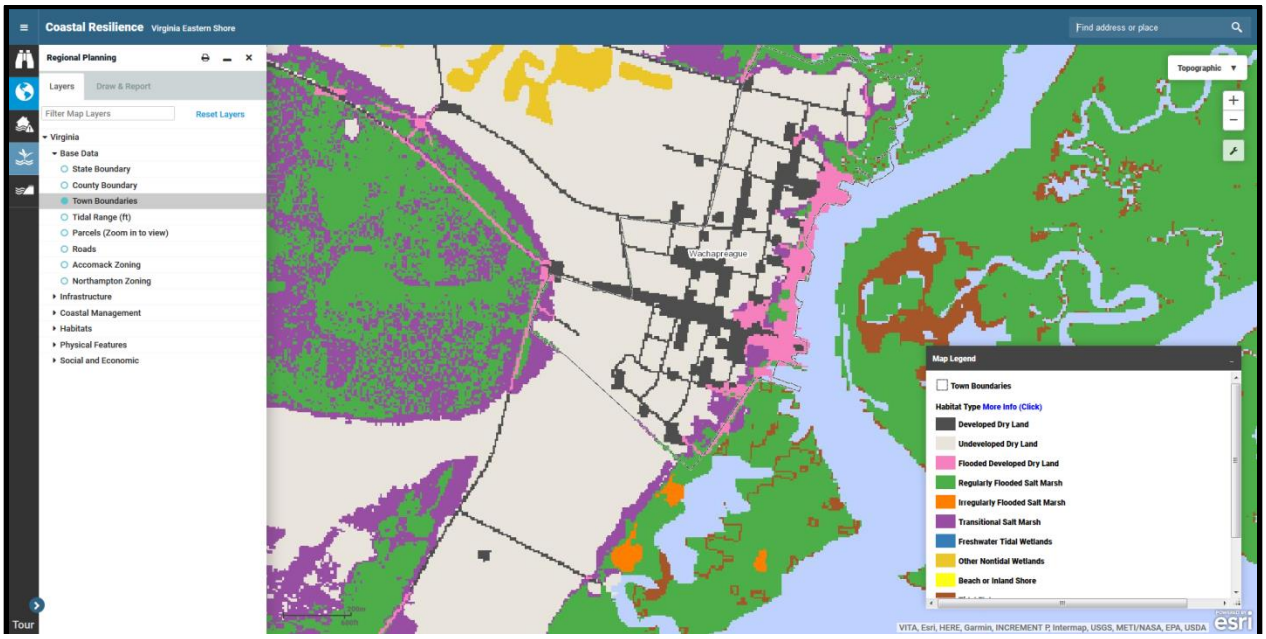

Figure 7. Example of what your screen should look like prior to Question 3-B.

Question 3-B: Are there scenarios in which the surrounding area may change substantially, including loss of access routes, despite adaptation by the town?

On Your Own:

Question 4-B: Using the Click to Draw an Area button, trace a general outline of the Wachapreague town boundaries. How does the acreage of Undeveloped Dry Land change between Scenario Years under the High SLR Scenario? How many acres of Developed Dry Land are at risk by Scenario Year 2100 under various SLR Scenario options?

TECHNICAL SKILLS COMPLETED

- ❑ Ability to identify places where habitats, particularly salt marsh, may change in the future due to sea-level rise.
- ❑ Ability to identify areas that are currently undeveloped dry land but that could become salt marsh under future sea-level rise scenarios.
- ❑ Ability to consider a range of planning options that would allow marshes to migrate naturally.

Implementation:

- ❑ You can use the Future Habitat app to more effectively communicate to decision-makers and stakeholders that coastal habitats will respond dynamically to sea-level rise.
- ❑ You have a better understanding that, although existing tidal marshes could be lost due to sea-level rise in the future, the landscape has high capacity for marsh migration on the mainland at the regional scale. The ability for marsh migration to occur unimpeded on the mainland will ultimately depend on shoreline management and land use decisions. With this information, you can begin to work with private landowners, resource management entities, and localities to identify open spaces or parcels where accommodating inland marsh migration is a viable management approach.
- ❑ You can use the “Save and Share” feature to work collaboratively with colleagues to get input on an analysis or create a map to help make the case for a project proposal.

Part Four: Coastline Change App

Understanding Past and Future Changes to the Seaside Barrier Islands

How to use the Tool: Coastline Change

- ➢ Click on the **Coastline Change** app on the left or the **Go** button for the app in the **Get Started** menu.
- ➢ There are two datasets within the **Future Habitat** app: **View Historical Data** and **View Future Scenarios**. Click on **Explain Each Choice** for each dataset to see a description of the options listed below. Click **Learn More** to view a fact sheet for each dataset.
    - **View Historical Data** allows you to view historical shorelines of Virginia Eastern Shore islands. Available data ranges from the 1850s to 2014. Under **Select Data Type**, **Historical shorelines** may be displayed using the **Slider** or by selecting **Multiple** shorelines at once. Under **Select Data Type**, the **Change Rate** option shows **Long Term** or **Short Term** change rates for Virginia Eastern Shore shorelines, indicating either seaward movement (accretion) or landward movement (erosion). Individual transects may be selected to view location-specific change rates.
    - **View Future Scenarios** allows you to view the effects of various combinations of **Sea Level Rise Scenario**, **Wave Climate Change Scenario**, and **Nourishment Scenario** on the **Rate of Change Difference** for Virginia Eastern Shore shorelines. In the graph, the **Rate of Change Difference** represents the 50-year average difference in the rate of shoreline change (in meters per year) between the current conditions and a modeled scenario. Note that zooming is disabled for this dataset.

Exercise A: Historical Shoreline Change Data for Virginia's Barrier Islands

★ **Exercise A Scenario:** *You and a group of friends regularly visit Virginia's barrier islands for kayaking and fishing. Over the years, you have noticed that the islands change constantly, some growing, some receding. What do historical shoreline data tell us about the overall **Long Term** and **Short Term** change rates for the Virginia barrier island chain? What percentage of barrier island transects are experiencing **Seaward Movement** and **Landward Movement** in each of the **Change Rate Types**?*

★ **Exercise A Planning Outcome:** *Gain understanding of historic long- and short-term rates of shoreline change at the scale of individual barrier islands and for the regional Virginia barrier island chain.*

- ➢ Click on the **Coastline Change** app.
- ➢ Select **View Historical Data**.
- ➢ Under **Select Shoreline Year,** click **Play** to watch the change in historical shorelines from the 1850s to 2014. Click **Stop** to stop on a particular year and end the animation.
- ➢ Under **Select Data Type,** click on **Change Rate** to view the shoreline change rate calculated from historical shorelines. Under **Show Change Rate Type,** select **Long Term** and then **Short Term** change rates and look at the differences in the graph.

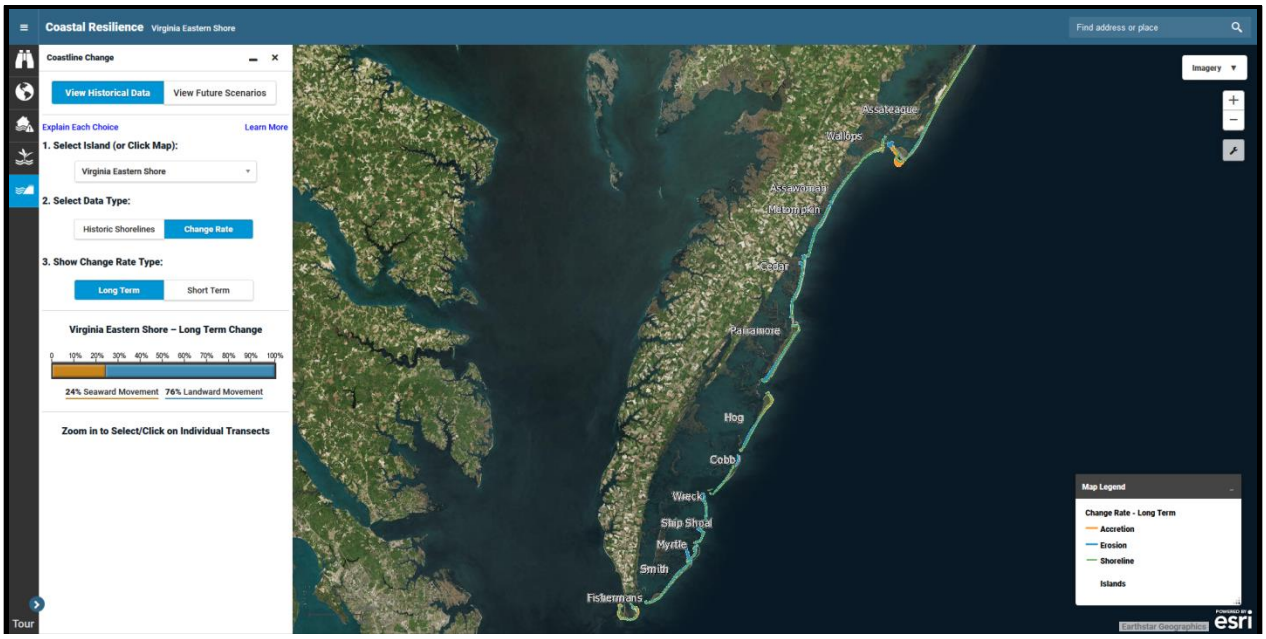

Figure 8. Example of what your screen should look like prior to Question 1-A.

Question 1-A: What do historical shoreline data tell us about the overall Long Term and Short Term change rates for the Virginia barrier island chain?

- Select one of the Virginia barrier islands in the **Select Island** dropdown. The map will zoom in to your selection.
- Click on a few transects on the map to view change rate information about each transect. Note that the length of each transect is proportional to the change rate.
- Compare the **Long Term** and **Short Term** change rates for various transects on the island.
- Compare the **Long Term Change** and **Short Term Change** values shown as a percentage of island transects. For example, the **Long Term Change Rate** for Hog Island is 41% **Seaward Movement**.

Question 2-A: What percent of this barrier island is experiencing Seaward Movement and Landward Movement in each of the Change Rate Types?

On Your Own:

Question 3-A: Where is the Short Term rate of change the greatest for both erosion and accretion on the island you selected? Hint: Look for very long transect lines.

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maps.coastalresilience.org/virginia

Exercise B: Future Scenarios of Barrier Island Evolution

★ **Exercise B Scenario:** *You and your family visit Chincoteague Island every year on vacation for birding, surfing, and hiking. One of your favorite locations for these activities is Assateague Island. You have heard that there are plans to relocate current beach access routes farther to the north. What is the predicted* ***Rate of Change Difference*** *estimate for the south end of Assateague Island under various SLR and wave climate change scenarios? What effect does beach nourishment on Wallops Island have on the same Assateague Island* ***Rate of Change Difference*** *estimates?*

★ **Exercise B Planning Outcome:** *Understand the extent to which relative sea-level rise, changes in wave climate, and beach nourishment activities may change and influence the evolution of the Virginia barrier island chain.*

- ➢ Click on the **Coastline Change** app and the **View Future Scenarios** option.
- ➢ Note that the data presented in this app represent a modeled, hypothetical shoreline and do not represent the actual individual islands illustrated on the base map.
- ➢ Find the general location of Assateague Island on the map.
- ➢ Select and compare the various combinations of **Sea Level Rise Scenario** and **Wave Climate Change Scenario** options. Note that the bar graph changes with the various combinations of data. These values and those in the legend refer to the difference in rate of change from a baseline. The baseline is future change under current climate conditions where relative sea level rises at the rate of 3 mm per year, the wave climate is consistent with the best-known present wave climate, and no nourishment occurs at any location.

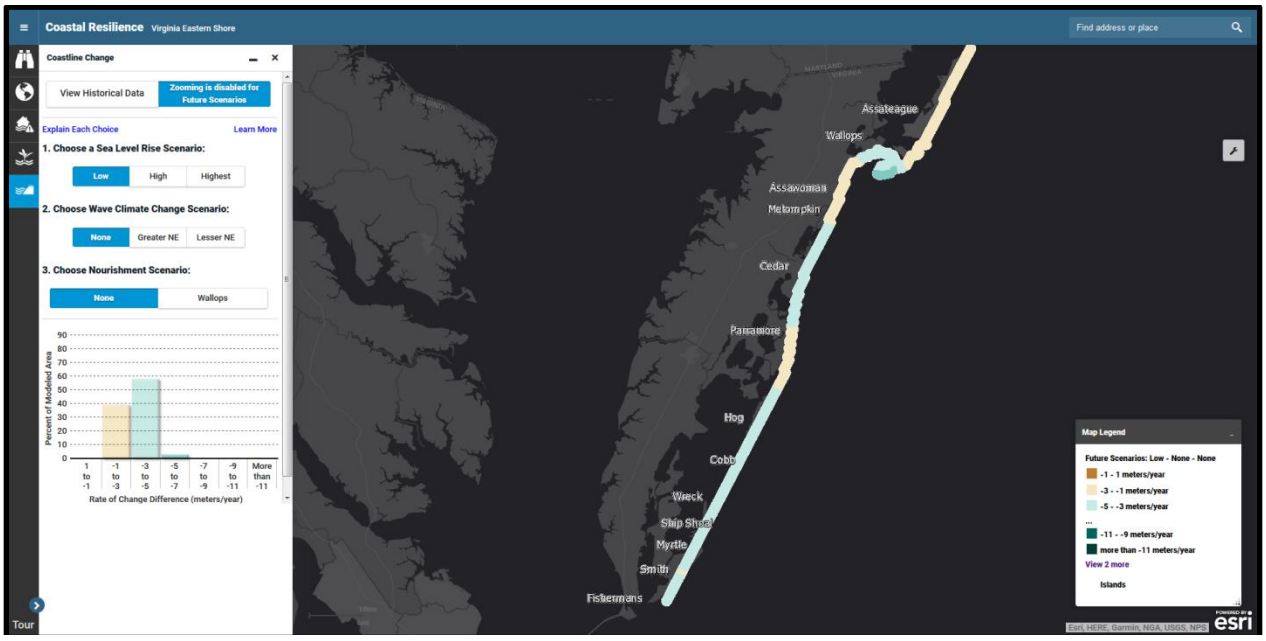


Figure 9. Example of what your screen should look like prior to Question 1-B.

Question 1-B: What is the predicted Rate of Change Difference estimate for the south end of Assateague Island under various SLR and wave climate change scenarios?

- Select and compare the various combinations of **Sea Level Rise Scenario**, **Wave Climate Change Scenario**, and **Nourishment Scenario** options.
    - **NOTE:** *Wallops Island was modeled as a zone where beach nourishment may occur in the future since it has been implemented in the recent past. The modeled projections should in no way indicate an endorsement of beach nourishment as a management option, on Wallops or elsewhere in the region.*

Question 2-B: What effect would beach nourishment on Wallops Island have on Assateague Island Rate of Change Difference estimates?

On Your Own:

Question 3-B: Based on the data presented in the View Future Scenarios dataset, would moving the current Assateague Island beach access routes farther north be an appropriate adaptation strategy?

TECHNICAL SKILLS COMPLETED

- ❑ Ability to view various historic shoreline positions along with rates and direction of barrier island movement for all of the Eastern Shore barrier islands.
- ❑ Understanding of how sea-level rise, potential wave climate shifts, and nourishment scenarios may affect future changes to barrier island shorelines.

Implementation:

- ❑ Organizations and agencies who manage barrier islands, research scientists, and local governments may use the Future Scenarios module in the Coastline Change app to explore different regional climate and nourishment scenarios in order to better anticipate and manage shoreline changes in the future.
- ❑ Suggested conclusions of the Future Scenarios modules outputs:
    - ❑ The Coastline Change app demonstrates that the Virginia Barrier Island chain is highly dynamic and dependent on the interaction of local and regional processes.
    - ❑ On a regional scale, the results suggest that relative sea-level rise is the dominant factor in causing more erosion or less accretion along the barrier island chain.
    - ❑ Nourishment activities are suggested to have a more limited and local effect on the barrier island chain than expected.
- ❑ The information from Future Scenarios is a springboard for additional inquiry and modeling efforts regarding potential local coastline change in the future.

Answer Key

Flood & Sea Level Rise

Question 1-A: In what Climate Year is the Wharf and Marina first inundated under each Sea Level Rise scenario? At what point in time would your livelihood as a charter boat owner be at risk in a business-as-usual scenario?

Answer: Low = 2065; High = 2040; Highest = 2040. Depending on the experienced SLR and the severity of inundation that can be tolerated, your livelihood might be at risk as early as **Climate Year** 2040.

Question 2-A: If the town considered protecting the existing marina by raising it in response to predicted SLR, how high should it be raised to remain useful in 2065 under each SLR scenario?

Answer: Low: at least 0.5 ft in most locations; High: up to 2 ft in many areas; Highest: 2-3 ft.

Question 3-A: Using the Regional Planning app, note the tidal range for this region. Identify the maximum inundation which could be experienced by the Onancock Wharf and Marina in each Climate Year due to SLR plus a high tide and which should be used as a planning value, rather than just predicted SLR.

Answers: 2025/Low = 1.5 ft; 2025/High = 1.5 ft; 2025/Highest = 1.5 ft
2040/Low = 1.5 ft; 2040/High = 2 ft; 2040/Highest = 3 ft
2065/Low = 3 ft; 2065/High = >3 ft; 2065/Highest = >5 ft
2100/Low = 4 ft; 2100/High = 6 ft; 2100/Highest = >7 ft

Question 1-B: What is the Flood Hazard Area for the neighborhoods near Central Park?

Answer: 0.2 Pct Annual Chance Flood Hazard

Question 2-B: In what Climate Year is the Flood Hazard Area identified in the previous question flooded regularly by low intensity storms?

Answer: 2065

Question 3-B: What is the maximum economic loss predicted for properties around Central Park for a medium intensity storm in Climate Year 2065?

Answer: $5,000,000

Question 4-B: Compare future Climate Year and Storm Type combinations. How might the current 0.2 Percent Annual Chance Flood Hazard zone change based on predicted flooding by Low and Medium Intensity storms? What do you think will happen to flood insurance rates as a result?

Answer: If Low Intensity storms are predicted to regularly flood the current 0.2 Percent Annual Chance Flood Hazard zone in Cape Charles in 2065, this area could be reclassified as a different Flood Hazard Zone in the future. Flood insurance rates would likely be adjusted accordingly.

Future Habitat

Question 1-A: What are the predicted changes in the amount of salt marsh acreage in 2025 for each Sea Level Rise Scenario?

Answer: Regularly Flooded Salt Marsh
2025/Low = -38 acres; 2025/High = +171 acres; 2025/Highest = +1,234
Irregularly Flooded Salt Marsh
2025/Low = -616 acres; 2025/High = -1,155 acres; 2025/Highest = -2,230
Transitional Salt Marsh
2025/Low = --588 acres; 2025/High = -148 acres; 2025/Highest = +271

Note: clicking on **Salt Marsh** under **Filter Results by Habitat(s) of Interest** will narrow results to only salt marsh.

Question 1-B: What habitat changes can be expected for Wachapreague between now and 2100 in a business-as-usual scenario?

Answer: Salt marsh encroachment and conversion of **Developed Dry Land** to **Flooded Developed Dry Land**.

Question 2-B: What areas of the town are most susceptible to habitat change as a result of SLR? What kinds of nature-based solutions (e.g., marsh enhancement, seagrass beds, oyster reefs) could be implemented to reduce risks?

Answer: The waterfront and areas near creeks or streams (to the north and south). Enhancement of existing marshes or use of oyster castles may prevent marsh loss and migration into **Undeveloped Dry Land** and **Developed Dry Land** within the town.

Question 3-B: Are there scenarios in which the surrounding area may change substantially, including loss of access routes, despite adaptation by the town?

Answer: Yes. Beginning in 2065 under the **Low** or **High SLR Scenarios**, or as early as 2040 under the **Highest SLR Scenario**, low areas to the west, south, and north of the town begin to change from **Undeveloped Dry Land** to marsh habitats which may affect access or other aspects of the town's prosperity.

Question 4-B: Using the Click to Draw an Area button, trace a general outline of the Wachapreague town boundaries. How does the acreage of Undeveloped Dry Land change between Scenario Years under the High SLR Scenario? How many acres of Developed Dry Land are at risk by Scenario Year 2100 under various SLR Scenario options?

Answers:
Undeveloped Dry Land: 2025 = -2 acres; 2040 = -7 acres; 2065 = -24 acres; 2100 = -125 acres
Developed Dry Land: 2100/Low = 21 acres; 2100/High = 59 acres; 2100/Highest = 67 acres

Coastline Change

Question 1-A: What do historical shoreline data tell us about the overall Long Term and Short Term change rates for the Virginia barrier island chain?

Answer: The historical shoreline data indicate that the **Long Term** and **Short Term** change rates vary by island and may depend on a number of factors. Overall, the trend is landward movement (erosion) in both **Change Rate Types**.

Question 2-A: What percent of this barrier island is experiencing Seaward Movement and Landward Movement in each of the Change Rate Types?

Answers:
Assateague Island
Long Term = 54% Seaward/46% Landward; Short Term = 18% Seaward/82% Landward
Wallops Island
Long Term = 30% Seaward/70% Landward; Short Term = 30% Seaward/70% Landward
Assawoman Island
Long Term = 0% Seaward/100% Landward; Short Term = 0% Seaward/100% Landward
Metompkin Island
Long Term = 0% Seaward/100% Landward; Short Term = 34% Seaward/66% Landward
Cedar Island
Long Term = 1% Seaward/99% Landward; Short Term = 0% Seaward/100% Landward
Parramore Island
Long Term = 7% Seaward/93% Landward; Short Term = 0% Seaward/100% Landward
Hog Island
Long Term = 41% Seaward/59% Landward; Short Term = 19% Seaward/81% Landward
Cobb Island
Long Term = 0% Seaward/100% Landward; Short Term = 2% Seaward/98% Landward
Wreck Island
Long Term = 0% Seaward/100% Landward; Short Term = 46% Seaward/54% Landward
Ship Shoal Island
Long Term = 0% Seaward/100% Landward; Short Term = 20% Seaward/80% Landward
Myrtle Island
Long Term = 0% Seaward/100% Landward; Short Term = 0% Seaward/100% Landward
Smith Island
Long Term = 0% Seaward/100% Landward; Short Term = 0% Seaward/100% Landward
Fishermans Island
Long Term = 73% Seaward/27% Landward; Short Term = 61% Seaward/39% Landward

Question 3-A: Where is the Short Term rate of change the greatest for both erosion and accretion on the island you selected? Hint: Look for very long transect lines.

Answer: This will vary depending on the island selected. For example, Wreck Island is eroding most at its north end and accreting most at its south end.

Question 1-B: What is the predicted Rate of Change Difference estimate for the south end of Assateague Island under various SLR and wave climate change scenarios?

Answer: Low/(all **Wave Climate Change Scenarios**)= -7 to -5 meters/year
High/(all **Wave Climate Change Scenarios**) = -11 to -9 meters/year
Highest/(all **Wave Climate Change Scenarios**) = more than -11 meters/year

Question 2-B: What effect would beach nourishment on Wallops Island have on Assateague Island Rate of Change Difference estimates?

Answer: The **Rate of Change Difference** estimates of Assateague Island change very little in response to the Wallops Island **Nourishment Scenario**.

Question 3-B: Based on the data presented in the View Future Scenarios dataset, would moving the current Assateague Island beach access routes farther north be an appropriate adaptation strategy?

Answer: Based on the results presented in the **Coastline Change** app, the south end of Assateague Island will be subject to relatively high **Rates of Change Difference** when compared with areas to the north. Therefore, relocating current beach access routes further north would be an appropriate adaptation strategy.

Virginia Eastern Shore Coastal Resilience Tool
Training Manual, Version 3.0 (August 2017)

Glossary of Terms (alphabetical)

Locations where these terms occur are noted in [brackets]:
Flood & Sea Level Rise = [F&SLR] Future Habitat = [FH] Regional Planning = [RP] Coastline Change = [CC]
Map Viewer = [Map Viewer]

Absolute Difference: A measure in feet of the difference between current water levels and those during modeled storm events. [F&SLR]

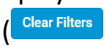
Base Data: A map layer which shows boundaries, parcels, and roads. [RP]

Basic Dark Gray: A gray background map layer. [Map Viewer]

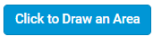
Basic Inundation: A data source, which displays predicted sea-level rise for several sea-level rise scenarios and scenario years. [F&SLR]

Change Rate Type: Includes both long- and short-term change rates for historical shorelines. Long-term change rates are calculated using all historic shoreline data from the earliest to the most recent dates for the selected area. Short-term change rates are calculated using historical shoreline data from the most recent change in the long-term rate to the most recent dates for the selected area. [CC]

Choose Parameters: A tab, which allows you to select the Scenario Year and SLR Scenario, affecting the data displayed in the map viewer. [F&SLR]

Clear Filters: Clicking this button (

) resets the visible data to its original state, removing drawn areas and other filters that narrow results. [FH]

Click to Draw an Area: Clicking this button (

) allows you to draw an area of interest, which will exclude all other data. [FH]

Coastal Management: A grouping of map layers that include public access sites, boat ramps, streams, flood hazard areas, protected lands, and Virginia Ecological Value Assessment. [RP]

Coastline Change App: An app (
), which shows historic and future changes in coastlines in response to predicted sea-level rise. [Map Viewer]

Compare & Chart: A tab, which allows you to view changes between the current habitat area and the predicted condition. Note that data is only displayed if a future Scenario Year (e.g., 2025) is selected. [FH]

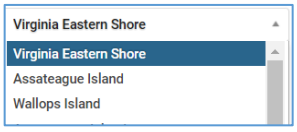
Create Map: Accessible through the wrench icon in the upper right of the screen (
). Create Map allows you to export the current view as a pdf. [Map Viewer] [RP]

Download data: Clicking this button (

) or (

) within an app allows you to download a GIS file geodatabase. [FH]

Dropdown menu: A vertical menu of options, like that shown to the right, which is opened by clicking on it.



maps.coastalresilience.org/Virginia

Economic Loss: Estimated potential monetary impacts resulting from the selected storm surge scenario. [F&SLR]

Ecosystem: A system of biological components (species) and physical components (geography and resources). [FH]

Erosion: Degradation of features such as shorelines or structures, usually by the action of water or wind. [FH]

Explain Each Choice: Clicking this text (Explain Each Choice) shows additional information regarding Coastline Change App options. Additional information may be hidden by clicking on the "Hide Explanations" text (Hide Explanations). [CC]

Filter Results by Habitat(s) of Interest: A section, which allows you to reduce the data being displayed to only salt marsh or only "other wetlands". [FH]

Flood & Sea Level Rise App: An app (), which shows the predicted effects of sea-level rise and storm surge on the Eastern Shore of Virginia. Includes two datasets: Basic Inundation (focuses on the effects of sea-level rise) and Storm Surge (displays predictions for storm surge from hurricanes and tropical storms). [Map Viewer]

Future Habitat App: An app (), which shows changes in habitat type in response to predicted sea-level rise. [Map Viewer]

Get Started: Get started () provides a splash screen that allows you to access apps by clicking on the "Go" button. [Map Viewer]

Habitat: The biological and physical settings in which species exist. Also, a map layer, which shows commercial shellfish aquaculture, public oyster grounds, and tidal marshes. [RP] [FH]

Hide Explanations: Clicking this text (Hide Explanations) hides additional information. [CC]

Imagery: Aerial imagery base map of the Virginia Eastern Shore. [Map Viewer]

Infographic: A simple graphic meant to quickly illustrate the purpose or main concepts of an app, accessible by clicking () in the upper left corner of the app window. [FH]

Infrastructure: A grouping of map layers that include schools, fire stations, roads vulnerable to sea level rise, and evacuations routes. [RP]

Inundation: Flooding of upland areas. [FH]

Land Accretion: Increase in elevation or area of land due to sediment deposition. [FH]

Legend: A window, which shows the list of active layers and their symbology. [Map Viewer]

Regional Planning App: An app (), which includes information appropriate for regional-scale planning, such as schools, roads, tidal range, protected lands, and wetlands. [Map Viewer]

Measure: Accessible through the wrench icon in the upper right of the screen (). Used to measure distance and area in various units. [Map Viewer]

Methodology: A description of the methods used to develop data layers. [FH]

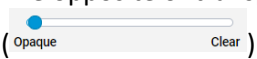
National Geographic: A background map layer developed by National Geographic. [Map Viewer]

Nor'Ida: A nor'easter that impacted the mid-Atlantic in November 2009. [F&SLR]

Nourishment: The action of replenishing or restoring a beach with sand. [CC]

Ocean: A background map layer developed by the National Oceanic and Atmospheric Administration. [Map Viewer]

Opacity: The extent to which an image is not transparent. [RP]

Opaque: The opposite of transparent. Appears in transparency slider bars (

). [F&SLR] [FH]

Pan: Moving the map by clicking, holding, and dragging the mouse. [Map Viewer]

Percent Difference: A measure in percentage of the difference between current water levels and those during modeled storm events. [F&SLR]

Permalink: A bookmark hyperlink to a map showing selected features. [Map Viewer]

Physical Features: A map layer, which shows physical geography. [RP]

Reset Layers: Clicking this text (Reset Layers) clears all selected layers in the Regional Planning App. [RP]

Rate of Change: Difference: The 50-year average difference in the rate of shoreline change (in meters per year) between the current conditions and a modeled scenario. Also known as the shoreline rate of change difference. [CC]

Results & Chart: A tab, which allows you to view a pie chart and table explaining acreage of habitat types in the total dataset or a user-defined area for the selected Scenario Year and SLR Scenario. [FH]

Save & Share: Accessible through the wrench icon in the upper right of the screen (). Save and Share allows you to copy a link that saves the current state of the map and all active apps in order to share it with others. [Map Viewer]

Scenario Year: The year for which predictions (sea level rise, storm surge, or habitat change) were calculated. [F&SLR] [FH]

Sea Level Rise (SLR): The predicted increase in the elevation of sea water over time. [F&SLR] [FH] [RP] [CC]

Shaded Relief: A background layer, which shows elevation of uplands. [Map Viewer]

Social and Economic: A map layer, which shows persons by age, area, and certain types of employment, as well as percent of mobile home housing units and 1% annual chance flood economic losses. [RP]

Storm Surge: Increased water height due to storm dynamics. Also a data source. [F&SLR]

Storm Tracks: Paths taken by hurricanes and tropical storms which were used as the basis for modeling storm surge. [F&SLR]

Storm Type: A dataset. Impacts from low Intensity storms were based on three theoretical Category 1 hurricanes with max winds of 80 miles per hour

	(mph). Impacts from Moderate Intensity storms were based on six theoretical Category 1 and 2 hurricanes with max winds of 85-110 mph. Impacts from High Intensity storms were based on seven Category 2 and 3 hurricanes with max winds of 95-115 mph. Impacts from Nor'Ida were based on the storm surge generated by that particular storm. Impacts from each of these Storm Types are shown for current conditions and two future Scenario Years. [F&SLR]
Streets:	A background map layer, which shows roadways. [Map Viewer]
Terrain:	A background map layer, which shows differences in terrain. [Map Viewer]
Tidal Range (ft):	Data regarding the typical variability in water level due to tides. [F&SLR] [RP]
Topographic:	A background map layer, which shows roads, waterways, elevation, forested land, and wetlands. [Map Viewer]
Tour:	Clicking this text () at the bottom left corner of the screen opens a quick reference for the parts of the *Coastal Resilience* tool map viewer. [Map Viewer]
Transect:	A line along which data is collected. [CC]
Water Depth (ft):	A measure of the predicted depth of water in feet due to storm surge. [F&SLR]
Wave Climate:	A term, which includes the predominant direction of wave influence on a system. [CC]
View Methodology:	Clicking () within an app will load a document which explains the methods used to develop data for that app. [FH]
Zoom:	To change the scale of the map viewer. Click on the zoom in button () for a narrower view or the zoom out button () for a wider view. [Map Viewer]
Zoom to Extent:	Accessible through the wrench icon in the upper right of the screen (). Zoom to Extent returns the view to the entire Virginia Eastern Shore. [Map Viewer]
Zoom to Selection:	Clicking this button () will zoom to the area you draw using the Click to Draw an Area option. [FH]

Hints and Tips

1. The *Coastal Resilience* tool is web-based. Make sure your internet connection is working before use.

2. The *Coastal Resilience* tool can be used in most internet browsers, including Chrome, Internet Explorer, Firefox, and Safari. However, be sure your browser is up-to-date to avoid issues.

3. It is a good practice to reboot your device before using the tool to ensure that you have sufficient memory available to use it.

4. It may be helpful to periodically refresh the browser window (refresh button or F5 key) in which you are viewing the *Coastal Resilience* tool in order to prevent errors from occurring. Keep in mind that refreshing will return the *Coastal Resilience* tool to its starting condition.

5. If the *Coastal Resilience* tool really seems to be stuck, try clearing the local cache in your browser by pressing Control + F5 (you may want to press this several times to fully clear the system). On an Apple machine press Command + R. You can also close the browsing window or tab and open it again to fully refresh the site.

6. Another option to avoid issues caused by web browser history is to open the *Coastal Resilience* tool in a window which does not retain cookies or other browsing data. This is known by different names in different web browsers. For example:
    - Chrome: incognito window
    - Internet Explorer: InPrivate Browsing
    - Firefox and Safari: private browsing window

7. The *Coastal Resilience* tool is optimized to work on desktops and laptops, and may experience issues when open in a tablet or hand-held devices. Additionally, the *Coastal Resilience* tool map viewer may seem crowded when viewed on a laptop.

8. If a background map layer does not load (grey screen displayed), try choosing another layer or changing the zoom level. Some layers do not appear when zoomed in extensively.

9. For a quick run-down on the functions of the tool click on "Tour" at the bottom left corner of the screen – this will point to the different elements of the tool and give a short explanation of them.

10. When you open an app the icon changes color and appears like an app on your phone. When done using the app you can either use the close ('x') button in the upper right hand corner to remove it from being active, and remove its data from the map, or the minimize ('_') button to have it remain active and, therefore, keep data on the map. You can have multiple apps open – minimizing the apps helps maximize how much of the map is shown.

11. Likewise, the Map Legend can be minimized ('_'). To show the legend again, click on the plus button ('+') on the right side of the Map Legend header. The legend can also be dragged to a different location.

12. App data displays in the order in which you access it. For example, if you open the Flood & Sea Level Rise app first, then the Future Habitat app, future habitat data will be layered on top. For this reason, we recommend opening the Regional Planning app last if you wish to use it.

13. Clicking on data that appears on the map will open an Identify window showing the attributes of the data layer at that point. If the Identify box is too big and goes off the map then pan the map (click and hold mouse down, then drag) until you see the entire window. Note that the Identify window does not move.

14. You can also hold the Shift key down and click and hold the mouse to draw a box for zooming into a particular area. This may allow you to zoom to a level that is between those used by the zoom in and zoom out buttons.

15. Remember that the *Coastal Resilience* tool is a work in progress! If you find obvious errors, feel free to report them to vacoastalresilience@tnc.org.

Thank you very much for using the *Coastal Resilience* tool!

If you have any feedback, please submit it to vacoastalresilience@tnc.org

Cover Photo:
Aerial view the seaside, near Red Bank, Virginia.
Photograph ©2017 Gordon Campbell/At Altitude Photography
Following Page Photo:
Fowling Point, Hog Island Bay
Photograph ©2015 Gordon Campbell/At Altitude Photography