# Coastline Change App: Future Scenarios Fact Sheet

VIRGINIA EASTERN SHORE *COASTAL RESILIENCE* TOOL

## What is the Future Scenarios module of the Coastline Change App?

The Future Scenarios module of the Coastline Change app in the *Coastal Resilience* tool provides results from a modeling effort that allows users to explore how climate change combined with management actions over a 50-year time frame may affect the rates of shoreline change along a simulated Virginia barrier island system. In exploring the Future Scenarios module of the app, you can compare a variety of possible climate change and management scenarios and learn about potential long-term, large-scale coastline and barrier island evolution resulting from these changes.

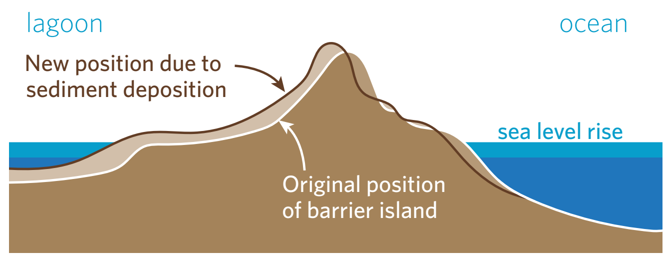
## Who should use it?

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. This information should not be used to identify future shoreline changes for specific locations along the Virginia barrier islands, but rather should be a springboard for additional inquiry and modeling efforts regarding potential local coastline change in the future.

## How does it work?

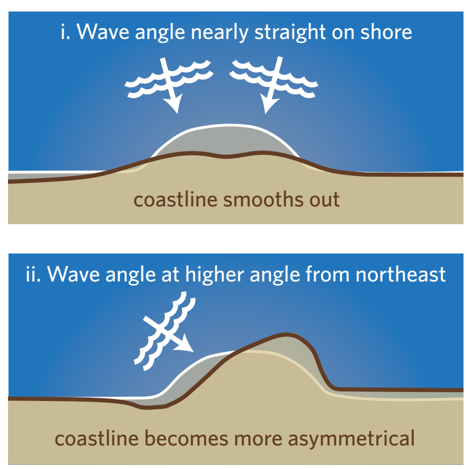
This app enables users to explore 36 different future scenarios of coastline change along a generalized Virginia barrier island system. The scenarios are based on three coastal processes that act alone or in combination to create a shift to the coastline via erosion or accretion of sediment:

- Relative sea-level rise
- Shifts in wave climate
- Beach nourishment



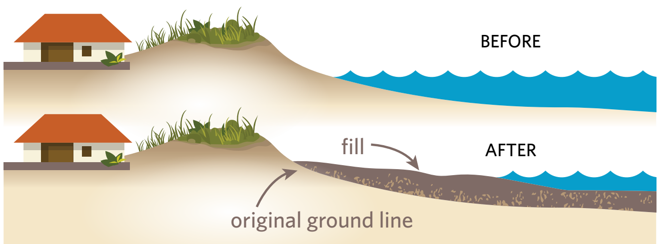

*Landward migration of barrier island as sea level rises*

**Relative sea-level rise** occurs because of the expansion of oceans due to warming temperatures, the melting of land-based ice, and local rates of subsidence. Accelerated rates of sea-level rise can cause barrier islands to migrate toward the mainland, allowing them to maintain elevation as long as they can get enough sediment.




*Shifting wave climate under (i) existing condition and (ii) changing climate scenario*

**Shifts in wave climate**, or the average distribution of wave characteristics over many years, affects patterns of coastline change rates. Wave climate includes a number of factors relevant to sediment transport including the angle waves are approaching from and the height of the waves. If storm frequency or intensity changes because of climate change, the influence of waves approaching from different directions may also change, affecting how sediments shift and therefore how coastlines evolve.



*Barrier island beach profile before and after nourishment*

**Beach nourishment** is a management strategy implemented by people to prevent erosion and beach loss in an effort to stabilize or protect shorelines. Beach nourishment was modeled only for those areas where it has been undertaken in the past (Wallops only) or may be considered in the future (Assateague) based on stakeholder input, **but the selected nourishment scenarios should in no way indicate an endorsement of any management option, either in those areas or elsewhere in the region**.

In this app, you'll be able to explore the modeled effect—alone or combined—of three relative sea-level rise projections, three potential wave climate scenarios, and four beach nourishment scenarios, on the rate of coastline change. The results will show you, along a generalized coastline, whether these scenarios will lead to more erosion and less accretion or less erosion and more accretion along the modeled future shoreline than would be expected to occur in the future under current conditions.

## What are the strengths and limitations?

Because of the uncertainty in the environmental variables affecting coastline change, coastal geomorphologists cannot make detailed predictions of where barrier islands will be or what shape they will have in the future. However, numerical modeling allows scientists to take an important step toward determining how certain physical processes may affect the future evolution of barrier islands and the coastline. Modeled future scenarios in the app of a simulated Virginia barrier island coastline are a leap forward in the field of coastal science. However, at this early stage, the results are not yet intended to support decisions but to serve as a springboard for new and additional research and modeling efforts. Lessons learned from this breakthrough model will provide opportunities for next steps in modeling possible coastline and island evolution and advancing the science of coastal geomorphology.

## Who developed it?

The Coastline Change app was developed through a partnership between a team of coastal geologists and geomorphologists from University of North Carolina at Chapel Hill, University of North Carolina Wilmington, Duke University, and Randolph-Macon College (team that performed the modeling work) and staff from The Nature Conservancy, NASA-Wallops Flight Facility, the U.S. Fish and Wildlife Service Chincoteague National Wildlife Refuge and the Accomack-Northampton Planning District Commission.

For general info about the Virginia Eastern Shore *Coastal Resilience* project: **coastalresilience.org/virginia**

To access the Virginia Eastern Shore *Coastal Resilience* mapping portal: **maps.coastalresilience.org/virginia/**

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# Coastline Change App: Future Scenarios Supplemental Information

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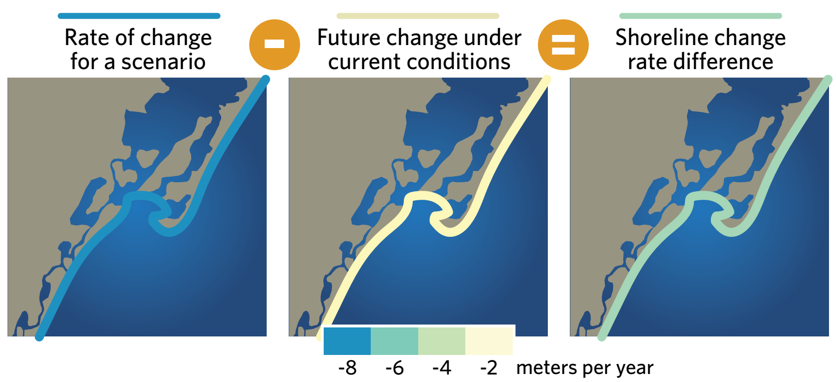
## Overview

A first-of-its-kind model was used to make reasonable estimates of how shorelines might move in the future, along a model coastline that shares some key characteristics with the Virginia coast. To do this, the model extrapolates from the best scientific understanding about processes that contribute to shoreline movement; such as the effect of waves on erosion, transportation and deposition of sand. With more frequent and intense storms expected in the future, waves and currents—in combination with relative sea-level rise (RSLR)—are expected to strongly influence the way that shorelines move. One management strategy employed in response to these changes is the engineered rebuilding of shorelines using a process known as beach nourishment. Wallops Island is one example of a location with a history of using beach nourishment to counter the effects of coastal erosion.

By comparing the difference between the base case of shoreline movement and experimental future scenarios, this app helps identify climate and nourishment scenarios that are likely to cause shifts in the rates of shoreline change. The base case is defined as 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. The results are presented as the *shoreline change rate difference* (SCRD). The shoreline change rate difference is the 50-year average difference in the rate of shoreline change between the base case and the experimental scenario (which includes a higher rate of RSLR and may include a shift in wave climate or beach nourishment).




*Shoreline change rate difference calculation used in model*

A negative SCRD indicates that the experimental scenario causes more erosion or less accretion relative to the base case, whereas a positive SCRD indicates that the scenario causes more accretion or less erosion relative to the base case. Although this information cannot be used to identify specific shoreline positions at future points in time, it does support the exploration of different regional climate and nourishment scenarios in order to better estimate and plan for the management of future shoreline changes.

## The Selection of Scenarios

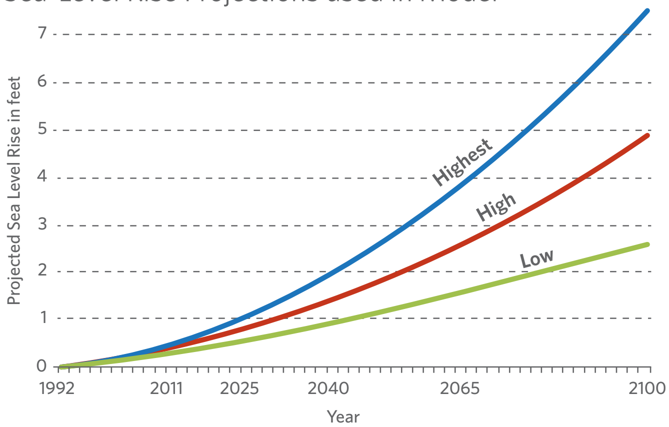
A scenario is a specific combination of potential climate and/or human management changes that might affect shoreline change rates. A total of 36 future scenarios were modeled for the app. These include different combinations of three sea-level rise scenarios, four wave climate scenarios, and three beach nourishment scenarios. The specifics of each scenario are described below.

| Description | No. of Scenarios |
|---|---|
| Sea-Level Rise Only | 3 |
| Sea-Level Rise + Wave Climate Change | 6 |
| Nourishment + Sea-Level Rise | 9 |
| Nourishment + Sea-Level Rise + Wave Climate Change | 18 |
| **Total** | **36** |

**A. Relative sea-level rise:** Relative sea-level rise scenarios are based on the customization for Virginia, developed by the Virginia Institute of Marine Science, of the 2012 National Climate Assessment. The three sea-level rise scenarios that were modeled were selected by stakeholders and are as follows:

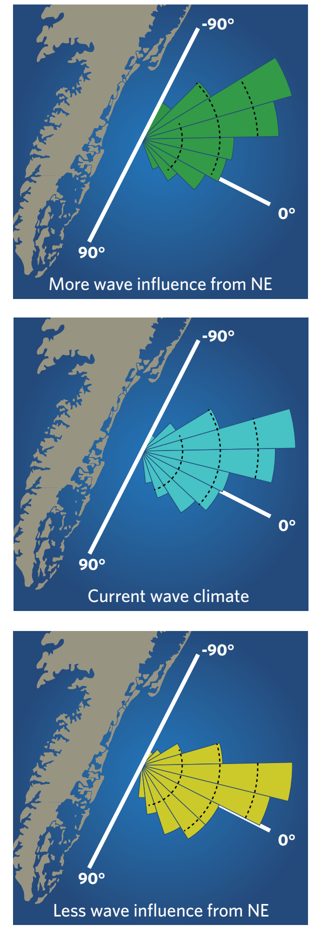
1. The "low" scenario is based on the Intergovernmental Panel on Climate Change 4th Assessment model using conservative assumptions about future greenhouse gas emission (the B1 scenario).
2. The "high" scenario is based on the upper end of projections from semi-empirical models using statistical relationships in global observations of sea level and air temperature. Generally, scientists currently see this as the most likely scenario.

Sea-Level Rise Projections used in Model




3. The "highest" scenario is based on estimated consequences from global warming combined with the maximum possible contribution from ice-sheet loss and glacial melting (a practical worst-case scenario based on current understanding).

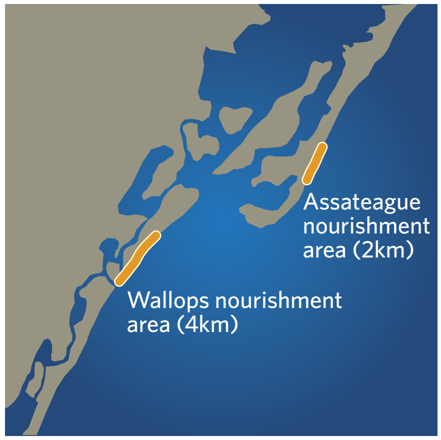
**B. Wave Climate:** Climate change is likely to lead to increases in the frequency of the most intense hurricanes. In addition, the frequency and magnitude of winter storms is likely to shift in a changing climate. This will affect future patterns of coastal erosion and accretion by altering the prevailing wave climate (specifically wave heights and angles of approach). Although it is not clear how wave climate may change in the future, two potential future wave climates were considered to provide an understanding of how changes in storm intensity may alter patterns of shoreline change along the Virginia Eastern Shore. The modeled wave climates represent changes to the present wave climate that involve either a greater or lesser proportion of wave influence approaching from the northeast. The three wave climate scenarios modeled in the app are:




*Wave climate angles of approach for three scenarios used in model*

1. No change; present wave climate stays the same in future.
2. Shift to northeast by 15 degrees from present wave climate.
3. Shift to southeast by 15 degrees from present wave climate.

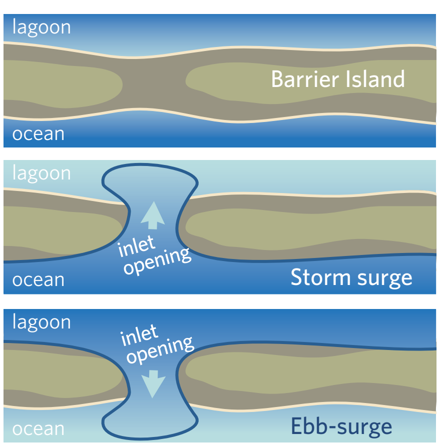
**C. Beach Nourishment**: Based on stakeholder input, two zones corresponding roughly to sites on Assateague Island and Wallops Island were identified as areas where beach nourishment may take place in the future. To estimate the effects of nourishment, the model considered a 2 km stretch of beach as the nourishment zone for Assateague Island and a 4 km stretch for Wallops Island. The model assumes that (1) nourishment is done at just the right long-term rate to maintain the shoreline position, (2) the sand used for nourishment comes from far enough away that removing it doesn't affect the coastal response, and (3) nourishment will continue for the entire model run regardless of cost. These projections represent hypothetical future scenarios which are intended to enhance the stakeholders' understanding of the potential evolution of the coastline in response to climate change and management interventions. Beach nourishment was modeled only for those areas where it has been undertaken in the past (Wallops only) or may be considered in the future (Assateague). ***However, the modeled projections should in no way indicate an endorsement of any management option, either in those areas or elsewhere in the region.***




*Suggested zones of existing or potential future beach nourishment used in model*

### Potential Inlet Openings

Tidal inlets are openings in the shoreline connecting the ocean to bays, lagoons, or marshes. On low-lying barrier islands, inlets may form during storms when storm surge overtops island dunes and erodes sediment from the top of the barrier island, effectively cutting a channel, or when water levels on the bay side of barrier islands become higher than water levels on the ocean-side causing a channel to be cut in the seaward direction. Whether an inlet remains open depends on the volume of water flowing into and out of the inlet during the tidal flood and ebb cycles. This process is represented in the model, yet the temporal and spatial resolution of the model experiments do not allow for explicit predictions of where and when inlet openings could occur. At the beginning of each model experiment, the model starts with enough inlets so that the processes that keep inlets open are working at about the same magnitude as they currently do on the Virginia coast (note: the specific locations of initial inlets are generalized and don't correspond to the present-day inlet locations). At the end of each 50-year experiment, island height is measured at each shoreline location. Areas with critically low elevations at the end of the 50-year experiment, and which are in excess of the number of original open inlets, are deemed as coastal areas with enhanced potential for inlet opening.




*Barrier island inlet formation process*

## Major conclusions for each group of scenarios

*The specific locations mentioned in the summaries below are referenced only for the purpose of discussion. The scenarios presented in the module were considered for the model coastline that shares some key characteristics with the Virginia coast, not for the actual Virginia coastline. Additional research will be necessary to confirm the summary statements for the specific locations mentioned below.*

### Relative Sea-level Rise only

- In all scenarios, accelerated sea-level rise results in more erosion or less accretion compared to the base case scenario (which includes only 3 mm/yr relative sea-level rise). Some areas respond to sea-level rise more dramatically than other areas. For example, in the model, the south end of Assateague Island is more responsive to increased sea-level rise compared to its surroundings, while the Wallops Island area is less responsive to increased sea-level rise. These results indicate that future rates of shoreline change are likely to be sensitive to the rate of relative sea-level rise.
- The model does not indicate enhanced potential for inlets to open along the simulated coastline under the sea-level rise only scenarios.

### Relative Sea-Level Rise + Wave Climate Change

- During both wave climate change scenarios, the southern end of Assateague Island is still affected more strongly by accelerated rates of sea-level rise compared to its surroundings.
- In contrast, the southern end of Assateague just north of Fishing Point may be affected less strongly by accelerated rates of sea-level rise compared to its surroundings. This effect is diminished when a lesser proportion of wave influence is from the northeast.
- The Wallops Island area is also affected less strongly affected by accelerated rates of sea-level rise compared to its surroundings. This effect is diminished when a greater proportion of wave influence is from the northeast.
- The model indicates the enhanced potential for inlets to open in the vicinity of southern Wallops Island when a greater proportion of wave influence is from the northeast at the highest sea-level rise rates.

### Nourishment + Relative Sea-Level Rise

- Differences in shoreline change rates resulting from nourishment appear to be limited to within only a couple of kilometers of the nourishment area. This finding is surprising given that previous work suggests that effects of nourishment are often non-local.
- At higher sea-level rise rates, nourishment affects shoreline change rates more dramatically and farther away from the nourishment site than in low sea-level rise scenarios.
- The model does not indicate the enhanced potential for inlets to open along the simulated coastline under the nourishment plus sea-level rise scenarios.

### Nourishment + Relative Sea-Level Rise + Wave Climate Change Conclusions

- **Relative sea-level rise is the dominant factor in causing more erosion or less accretion along the coastline**. Although sea-level rise may affect some parts of the coast more strongly than others, these results suggest that, with accelerated rates of sea-level rise, the whole coast will experience more erosion or less accretion, regardless of wave climate shifts.
- **Wave climate shifts affect patterns of erosion and accretion.** Generally speaking, a greater proportion of waves approaching from the northeast is predicted to result in lower rates of erosion near the southern part of Assateague Island and higher rates of erosion in the Wallops Island area. The converse is true for lesser proportions of waves approaching from the northeast. These findings have implications for rates of nourishment needed at each site to maintain a constant shoreline position.
- **Nourishment has a more limited alongshore effect than previously anticipated.** For this area, the nature of the wave climate relative to the shoreline limits alongshore effects of nourishment.
- **The model suggests that there is enhanced potential for inlets to open in the vicinity of southern Wallops and Assateague Islands** under various combinations of wave climate and beach nourishment scenarios at the high and highest sea-level rise rates.

## Further Information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