Team Project: USGS CVI

Team Members:

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Objective

Compare two coastal sites and examine the physical parameters that affect shoreline stability.

Data Sources

Shoreline Data


http://pubs.usgs.gov/dds/dds68/

Wave Data

National Data Buoy Center (http://www.ndbc.noaa.gov/)

Sea Level Rise:


http://tidesandcurrents.noaa.gov/sltrends/sltrends.html

Bathymetry


Pre Lab

1. Consider the following two coastal locations: Odiorne Point State Park, NH and Fire Island National Seashore, NY. How do you expect these two locations might differ?

2. Create a hypothesis about which area is more vulnerable to shoreline erosion and explain why.

Background: It is often desirable to simplify complex, geologic systems to numerical values that can easily be compared and ranked. While information is inevitably lost in this practice, it is necessary in order to provide usable information to resource managers, home owners, and regulatory agencies. The ability to rank locations with high or low risk factors allows them to be managed effectively. The U.S. Geological Survey has created a rating system to assess the vulnerability of our shorelines based on 6 variables—*geomorphology, slope, relative sea level change, erosion/accretion rates, tide range, and wave height*. Today you will look at each factor, except for tide range. Each factor is briefly described below. The ranking is called the **Coastal Vulnerability Index** or **CVI**. A high score identifies areas at risk for erosion and a low score identifies areas that are stable.
Team Project: Coastal Vulnerability Index

1. **Geomorphology**: Coastlines are made of many different materials and have varying shapes (Figure 1, Figure 2). These differences make some regions more sensitive to erosion by waves and sea level rise. Coastlines with rock, coarse sand, or cobbles are more resistant to erosion than sandy beaches. Large waves can easily wash over low-lying barrier islands during a storm; whereas, a high, rock cliff will stabilize the shoreline.

2. **Coastal Slope**: The slope of the continental shelf affects how quickly the area will be flooded as sea level rises (Figure 3). Beaches with a low slope (nearly flat) will retreat landward quickly as sea level rises. The shoreline will retreat more slowly if the coastal slope is steep (high).

3. **Relative Sea Level**: High rates of relative sea level will flood low-lying areas rapidly. Accelerated rates of sea level rise also put vulnerable habitats, such as marshes, at risk.

4. **Erosion/Accretion Rate**: Historical changes in the shoreline are a good indication of what may happen in the future. If the wave and sediment conditions have resulted in rapid erosion in the past, erosion is likely to continue into the future.

5. **Wave Height**: Larger waves have more energy than smaller waves and have the ability to move more sand offshore.

![Figure 1. Barriers islands are made of unconsolidated sand and have low elevations. This makes them very vulnerable to erosion.](image)

![Figure 2. Some coastlines are made of hard resistant rock. These coastlines are resistant to erosion. The steep slopes and high elevation makes them unresponsive to sea level changes.](image)

![Figure 3. Variations in shoreline retreat due to sea level rise.](image)

**Data Collection and Analysis**

1. For this project you will collect data at 2 sites, Fire Island National Seashore (NY) and Odiorne Point (NH), and then compare the sites. Begin by collecting the data needed for Fire Island. Open the ESRI Explorer app on the iPad. You can continue without signing in. Search for ‘GEOL 211’. Open the map named ‘**Geol 211: CVI Student Map**’ (Figure 4).
Figure 4. Instructions for opening map in Explorer for ArcGIS

2. The first variable in the CVI is geomorphology. You can view Fire Island as a 360° photo or in virtual reality.
   a. Virtual Reality: If you have Google Cardboard glasses and a smart phone, you can virtually visit Fire Island. Open the Street View app on your phone. Select collections. Select the ‘US National Parks and Historic Site’ collection. Then zoom to Fire Island National Seashore. Fire Island is east of New York City. Tap on the red dot. Tap the photo of Fire Island. This should bring up a 360° image of Fire Island National Seashore. Tap the Google Cardboard icon (□) and place your phone into the cardboard viewer.
   b. 360° photo: Open the Street View app on your smart phone. Select collections. Select the ‘US National Parks and Historic Site’ collection. Then zoom to Fire Island National Seashore. Fire Island is east of New York City. Tap on the red dot. Tap the photo of Fire Island. This should bring up a 360° image of Fire Island National Seashore. Pan the image to view the beach in different directions.
3. Determine the morphology of Fire Island. Your choices are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Ranking</th>
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<tbody>
<tr>
<td>a. Rocky, cliffed coast</td>
<td>1</td>
</tr>
<tr>
<td>b. Medium cliffed coast, indented shoreline</td>
<td>2</td>
</tr>
<tr>
<td>c. Low cliffs</td>
<td>3</td>
</tr>
<tr>
<td>d. Cobble beach, estuary, or lagoon</td>
<td>4</td>
</tr>
<tr>
<td>e. Barrier beach, sand beach, salt marsh,</td>
<td>5</td>
</tr>
<tr>
<td>mud flat, delta, mangrove, or coral reef</td>
<td></td>
</tr>
</tbody>
</table>

Choose a geomorphology category described in Table 1. Then record the value and ranking (1-5) in Table 2.

4. The next variable is the coastal slope. Calculate the slope between the shoreline and 50 km offshore. Use Figure 5 to calculate the slope offshore of Fire Island. The distance and elevation units must be the same. The slope is calculated as:

\[
\text{slope(\%)} = \frac{\text{change in elevation}}{\text{distance}} \times 100
\]

Record the percent slope in Table 2 under ‘value’. Use Table 1 to determine the coastal slope ranking (1-5). Record this number (1-5) in Table 2 under ‘ranking’.

Table 1. CVI Ranking System

![Table 1. CVI Ranking System]

Figure 5. Offshore profile for Fire Island National Seashore. Elevation data is from U.S. Coastal Relief Model. This data should be used to calculate the offshore slope. Source: National Geophysical Data Center, 1999. U.S. Coastal Relief Model - Northeast Atlantic. National Geophysical Data Center, NOAA. doi:10.7289/V5MS3QNZ [May 18, 2018].
5. On the iPad, use the bookmark to zoom to Fire Island. Locate the NOAA tide station at Sandy Hook, just west of Fire Island near the mouth of the Hudson River. Click on the station and then the i for more information. Follow the data link. This page will give you the rate of sea level rise. Record this value in Table 2. Find the ranking in Table 1 and record this also.

6. Return to the map. Locate the NBDC wave buoy south of Fire Island. Click on the buoy and follow the link to the data. This link will take you to the National Data Buoy Center. Estimate the average significant wave height from the chart. Use table 1 to determine the ranking. Record the mean annual wave height and ranking in Table 2.

7. The next step is to calculate the erosion/accretion rate. The rate of shoreline change is the change in shoreline location (m) divided by the time (years).

\[
\frac{\text{Change in Location (m)}}{\text{Time (yrs)}} = \text{rate of change (m/yr)}
\]

Used the bookmark to zoom to ‘Fire Island.’ Zoom in close enough to see the individual shorelines. Each colored line is a historic shoreline location. You can tap on the line or check the legend to find the date. Be sure you are looking at the legend for Fire Island, not Odiorne Point. Measure the distance between the location of the shoreline in 1999 (red) and 2007 (black) using the ruler tool. Measure the distance in meters. If you need to change the units, tap on the units and choose the unit you would like. Calculate the rate of change and record the value in Table 2. The shoreline can accrete (grow seaward) or erode (get smaller). **If the beach is eroding record the rate of change as a negative but if the beach is accreting record a positive number.**

8. Repeat the data collection process for Odiorne Point. Use the bookmark to zoom to Odiorne Point.
   a. Search for Odiorne Point State Park in Google Street View. Change the search option at the top to ‘explore,’ rather than ‘collections.’ This beach is on the border of New Hampshire and Maine. The park is on the south side of the Piscataqua River. Choose one of the red dots close to the shoreline, not along the road.
   b. Calculate the offshore slope (Figure 6).
   c. Use the Portland tide station to determine the rate of sea level rise. Portland is north of Odiorne Point. You will need to zoom out to find it.
   d. Use the Station 44007 for the wave data. You may need to zoom out to see the buoy.
   e. Use the bookmark to zoom to ‘Odiorne Point.’ Find the rate of shoreline change along Odiorne Point between 1901 (red) and 1953 (black).

9. Once Table 2 is complete, calculate the CVI for each site using the formula below:

\[
\text{CVI} = \sqrt{\frac{a \cdot b \cdot c \cdot d \cdot e}{5}}
\]

where,

- \(a\) = geomorphology
- \(b\) = coastal slope
- \(c\) = relative sea-level rise rate
- \(d\) = shoreline erosion/accretion rate
- \(e\) = mean wave height

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**Figure 6. Offshore profile Odiorne Point.** Elevation data is from U.S. Coastal Relief Model. This data should be used to calculate the offshore slope. **Source:** National Geophysical Data Center, 1999. U.S. Coastal Relief Model - Northeast Atlantic. National Geophysical Data Center, NOAA. doi:10.7289/V5MS3QNZ [May 18, 2018].
Team Project: Coastal Vulnerability Index

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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Fire Island</th>
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<th>Odiorne Point</th>
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<tbody>
<tr>
<td></td>
<td>Value or Description</td>
<td>Ranking (1-5)</td>
<td>Value or Description</td>
<td>Ranking (1-5)</td>
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<tr>
<td>Geomorphology</td>
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<tr>
<td>Coastal Slope</td>
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<tr>
<td>Relative Sea Level Rise</td>
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<td></td>
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<tr>
<td>Erosion/Accretion</td>
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<tr>
<td>Mean Wave Height</td>
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<tr>
<td></td>
<td>Overall CVI</td>
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<td>Overall CVI</td>
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Summary Questions

1. Which location, Fire Island or Odiorne Point, is more stable?

2. Explain why this site is more stable?

3. Review your initial hypothesis. Was it correctly? If not, explain the flaw in your reasoning.

4. The wave height is similar at both locations but Fire Island is less stable. Why?

5. Explain why coastal slope can affect shoreline stability to sea level rise. You can draw a picture if it helps.

6. Explain why it is useful to provide a numerical ranking for coastal vulnerability to shoreline erosion.

7. Suppose you were to include a location from the Gulf Coast of Louisiana in this analysis.
   a. List one parameter that you would expect to change.

   b. How would this parameter change? (hint: Would it increase or decrease?)

   c. Would this change increase or decrease the stability of the shoreline?