**Beach Profiles: Monitoring Sea Level Rise**

Student Activity Sheet

Name _____ Date _____ Class _____

A ***shoreline*** is the area where the water and land meet. This is where we find ***beach:*** areas where sediments (sand or other particles) are in constant motion. Beaches are constantly changing due to wind, tides, storm activity, and the actions of humans. A typical sandy beach is composed of the following areas (see Figure 1): the ***beach face***, the ***berm***, and the ***dunes***. Dunes are actually where the coastal zone begins and are not technically part of the beach. A berm is created by wave action and represents the highest area on the beach that waves can carry and deposit sand. Dunes are formed by the wind carrying sand from the beach face towards land. The dunes are stabilized and built higher by grasses and other plants collecting sand.

When a wave hits a beach, the water in the wave rushes up the beach as far as its energy will carry it. Once there is no more energy to carry the water any further, the water simply falls back down the beach towards the ocean or lake. As the wave moves up the beach towards land, particles of sand or sediment and ***debris*** drop out of the water and are deposited on the beach face. As the water recedes off the beach face, sediment particles are also picked up and carried with the water back to the sea. You can see that a beach is an always changing area. Sediments are constantly moving on the beach, but a balance exists between deposition and removal. Sometimes something happens to upset that balance. In the winter when strong storms are common, beaches generally erode. This is because storms produce waves that are stronger and more destructive. When these storm waves hit the beach, the force of the waves removes more beach sediments than they leave. In the summer, things on the beach are calmer and more sediments are deposited than are removed so that the beach builds up during these months. Again, an overall balance is maintained over time between removal and deposition of sediments on the beach.

Severe storms, such as hurricanes, do the most damage to beaches. They often change the shape and area of the beach entirely. Hurricanes can even level dunes, which stand as the last line of defense to protect the land behind them. Without the dunes to stop the water, waves carry water over roads and into beach houses, sometimes destroying everything in their path. ***Sea level rise***

can also change the appearance and structure of a beach. An increase in sea level may be the result of the ***thermal expansion*** of seawater caused by ***global warming***. Global warming may also raise the sea level by partially melting the continental ice sheets and mountain glaciers. As the sea level rises, waves break higher and higher up the beach, until the beach is constantly covered by water. The waves eventually break down the dunes and the beach 'advances' towards the land into the coastal zone. What was once beach, is now covered with water and the new beach is where the dunes used to be.

A profile is made of the beach to monitor how beaches change over time. By looking at profiles that are made over many years, we can decide if the sea level is rising or falling or if the beach is staying the same. A profile is a diagram made on graph paper that shows how high each part of the beach is above sea level. It shows the beach from the dunes to the water's edge. Your completed ***beach profile*** will look similar to Figure 1.

Beach profiles change constantly over time. Some changes are minor and are almost unnoticed. Others are major and result in a totally new beach profile (example in R.I.- after Hurricane Andrew in 1992, Brigg's Beach, Little Compton was totally changed). In this activity you will be making a beach profile of some beach that may be familiar to you. You will survvey the beach by taking height or elevation measurements (data) in the field. After you come back to class, you will convert and plot your data on graph paper to get your beach profile.

**Objectives:**

- Survey a beach site by taking measurements of the elevations.
- Construct a beach profile from your field data.
- Make predictions about the effect global warming may have on the same beach site in the future.

**Materials:**

| | |
|---|---|
| Clipboard | Line level |
| Premeasured 10 m string | Tape measure |
| Procedure diagrams | Pencil (Student supplied) |
| Data collection table | Graph Paper |

1 Pole (72 in. or 182.9 cm) marked at the 150 cm point (Teacher supplied)

1 Pole (72 in. or 182.9 cm) unmarked (Teacher supplied)

**Procedures:**

This activity will begin after you arrive at a suitable beach site. You will start your beach survey and measurement taking on the side of the dunes closest to the water. Your teacher will tell you whether you are going to do this as one large team or split into smaller groups, each doing their own profile.

1. Keep the Procedural Diagrams and the Data Collection Table with you on the clipboard. Refer to the diagrams as you do your beach survey.
2. Place the marked (150 cm) pole at the dune edge (Pole 1).
3. Orient the second pole towards the water's edge, 10 meters away from the first pole (Pole 2). Align the poles in as straight a line as possible. The poles should be standing straight. It helps to have a person hold each onto each pole to keep it straight.
4. Attach (tie) the premeasured 10 meter string to pole #1 at the 150 cm mark.
5. Attach the other end of the premeasured string to pole #2. You don't have to measure out 10 meters if you don't want to because the string is measured in 1 meter increments out to 10 meters. Each meter is marked on the string with colored tape. If you attach the string to the second pole at the final tape marking, the second pole will be exactly 10 m away from the first pole. Check Figure 2 to make sure you are setting the poles and line up correctly.
6. You want the line to be as tight as possible. It should be taunt with no sagging.
7. Attach the line level to the string. By looking at the bubble in the line level, you can tell whether your line is level or not. Move the string on pole #2 up or down until the string is level. Once the line is level, the point where the string is attached to the second pole is now 150 cm above the beach surface.
8. You are now ready to begin taking elevation measurements. Move from Pole 1 to the first tape mark at 1 m. At the 1 m mark, measure the distance from the string to the ground with the tape measure. It helps to have two people take the measurements. One person can hold the tape measure and the other pulls the tape out and reads the elevation. A third person will record the measurements.
9. Record this measurement on the data table. As the tape measure is in feet and inches, write your measurement down in inches and convert it to cm when you return to class. You will notice that the data table is divided into three sections. You will write your data in the first section as you are measuring the first 10 meters.

10. Continue to measure the remaining 9 meters in one meter sections and record the height of each section on the data table.
11. When the first 10 meter measurements are recorded, carefully remove Pole 1 from its' present position and move it around Pole 2 towards the water. Pole 2 will stay in the same place and Pole 1 will now be moved to line up in a straight line from Pole 2 towards the water edge. Look at Figure 3 to make sure you understand what to do. Have someone hold onto the string on Pole 2 when you're moving Pole 1. That way the string will stay at the 150 cm position. To be on the safe side, measure up 150 cm or 59.1 in. from the ground and position the string at that place on Pole 2.
12. Make sure the string between the two poles is tight and re-level the line with the line level. Continue to measure and record the height of the string from the ground at one meter intervals until you have completed your entire beach profile (that is, you've reached the water). Make a note on the state of the tide (high or low) on your data table.
13. When you're back in class, you need to convert the measurements you took at the beach that are in inches (in) to centimeters (cm). Remember that there are 100 cm in 1 meter (m) and 1 m is equal to 39.4 in. This means that 2.54 cm = 1 in.

$$\frac{100\text{ cm}}{1\text{ m}} * \frac{1\text{ m}}{39.4\text{ in}} = 2.54\text{ cm/in}$$

To convert your beach data to centimeters, simply multiply your inch measurements by 2.54 cm/in. You can see that your inch units will cancel, leaving you with cm units for your product.

Example: Field measurement = 30 in

$$30\text{ in} * \frac{2.54\text{ cm}}{1\text{ in}} = 76.2\text{ cm.}$$

14. Use graph paper to plot your converted data. The completed graph will actually be the profile of the beach. The X - axis will be distance along the beach in meters and the Y - axis will be height in centimeters from the level line (the line that you kept level at 150 cm). You are going to be doing something different when you make this graph. Instead of having your 0 line for your Y - axis be at the intersection with the X - axis, your 0 line will be at the top of the Y axis. Draw a straight line across your graph at Y = 0 to represent the level line (at

150 cm). Another thing that will be different on this graph is that your 0 for the X axis will be on the right side of the X axis instead of the left where it usually intersects with the Y axis. This is so that your profile will look like the beach, with the highest point at the dunes at the right or away from the water. If it's too confusing to do the X axis this way, do it the way you're used to, with the 0 on the left. Figure 4 is an example of what your graph might look like. This figure ought to clear up any confusion you may have about making this graph. Your teacher will help you if you have problems making your profile. After you plot your data to make your beach profile, see if you can label the parts of the beach on your graph (locate the water, dunes, beach face, and berm).

15. Answer the Discussion Question.

**Discussion Question:**

Based on the information you gathered during this activity, make predictions about the consequences of coastal erosion and sea level rise on your beach profile. Remember that the time of year (winter or summer) plays a part in whether your beach is eroding or building. Consider the month in which you have done your profile as this may help you to make your predictions.

## Vocabulary

**Shoreline:** The line marking the intersection where land or shore and water meet. This 'imaginary' line moves up and down with the tides.

**Beach:** This includes the area from the coast or duneline to below water level. The beach includes the shore and the shoreline.

**Beach Face:** The area of loose sediments from below the water line to the berm on a beach.

**Berm:** The area on a beach that is the highest point owards land that waves deposit or drop sand and other sediments. The berm is usually the highest point in height on a beach and often has a scarp or steep incline leading up to it.

**Dunes:** A hill of windblown sand that is stabilized by grasses and other plants. Dunes are not part of the shoreline but are the first part of the coastal zone. Dunes protect the land behind them from storm waves and strong winds.

**Debris:** Trash or garbage. Marine debris also includes shells, dead plants and animals, and driftwood. After high tide, a line of debris is left on the beach by the retreating tide.

**Sea Level Rise:** The increase in the height of the ocean due to a volume increase. This volume increase causes the sea surface or the level of the sea to rise. Sea level rise happens because of such natural occurences as land subsiding (sinking) and land rebounding upwards as the weight of glaciers is removed (glacial rebound). Global warming caused by humans adding too much $CO_2$ to the air also may cause the sea level to rise because of thermal expansion of seawater and the melting of land-based ice (glaciers and ice sheets).

**Thermal expansion:** The increased air temperature resulting from global warming will cause the temperature of the oceans and lakes to also increase. When water is heated, the space between its' molecules increases, causing the volume to increase. In the ocean, this increased volume will cause the sea level to rise.

**Global warming**: The increase in the temperature of the atmosphere and the oceans as a result of too much of the greenhouse gas, $CO_2$, being added to the atmosphere. The greenhouse gases act like a blanket over the Earth to keep the sun's heat in. When too many greenhouse gases are added to the atmosphere, the effect is like adding a second blanket. This causes too much heat to be kept in the atmosphere and eventually some of the excess heat will cause the oceans to heat up as well.

**Beach profile:** A survey of the elevations of the surface of a beach to see how it's elevations and features change over time. The end result of the survey is sideways profile from the water's edge to the dunes.

## Teacher Strategy

**Prior Preparation:**

Obtain two 72 inch poles and mark one at150 cm. Tape or a permanent marker will work well to mark the pole. The string is premeasured with tape marks at every meter to ten meters. If you would like to have your class work in teams with each doing their own profile, then you will need to measure 10 meter strings for these teams. It helps to also have a clipboard for each team.

**Instructional Strategies:**

You may want to chose a beach to survey that your class is familiar with. This activity will give them a different perspective on the beach and how it constantly changes. Optimally, it is best to do several surveys of the same beach over time. If possible, do one survey in the beginning of fall to see the summer (building) beach and another in spring to see the winter (eroding) beach. Go over the background material before going into the field and make sure your students understand what they will be doing. When you get to the beach, it helps to assign different duties to your students, i.e., recorder, measurer, pole holder, etc. Show your students how to use the line level and how to take the height measurements. The tape measures are in inches and feet. Remind them to remember to record all the important information while they are in the field because they won't remember it later. Have somone note the tide state (high or low).

When you return to class, the data will have to be converted from inches to centimeters. The conversion formulas are included in the student's procedures but you may want to go over them if your students have not done conversions before. Once they see that it is simply a multiplication and division problem, they shouldn't have any problems. You will probably also want to refresh their graphing skills. Explain if there is any confusion about how the plot is to be set up. This may be the first time they have plotted data in a negative direction from the Y axis and they may be intimidated by this. The first meter should be closest to the dunes and the largest meter distance should be closest to the water's edge. As ever beach's profile will vary, you will want to plot the data and identify the beach areas yourself. Make use of the figures and feel free to add your own to clarify procedures.

**Answers to Discussion Questions:**

Answers will vary, depending upon the time of year the surveys were taken in and the beach's location. If the profile has a gentle gradient, sea level will 'drown' or cover more beach than if

the gradient were steep. Also have your students consider the beach's location and what effects erosion and sea level rise will cause. If the beach is sheltered the erosional state will be far different than if it is at a headland. You may want to discuss many of these issues with your students after they have attempted to answer this question on their own.

**Approximate Time Required:** Two to three class periods.

**Target Audience:** Mathematics and Science.

**Extensions:**

**Grades 4-6**

1. Have a guest speaker come in and tell students about coastal erosion. It would help if this person brought slides or pictures to show the students the effects of coastal erosion on beaches and the coastal environment.
2. Students could write a brief report on coastal erosion explaining the long term effects on the environment.
3. Take a field trip to a location identified by environmental officials as being at risk to coastal erosion. Have your students write a report on ways to stop or slow erosion at this site.

**Grades 9-12**

1. Make two visits to one site, one visit in fall and the other in winter or spring. Separate the surveys by several months. Create a profile for each visit. Answer these additional questions:
    a. Why do the beach profiles show seasonal effects?
    b. Will global warming accentuate these seasonal differences or reduce them? Why?
2. Visit one site before and after a storm. Create a profile of each visit. Answer the following questions:
    a. What are the most significant changes in the profile? What caused them?
    b What has remained the same and why?

**References:**

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