The Forces of Waves:
Disappearing Beaches Activity Sheet

Name: Teacher guide ________________ **Date:** ________________

Part A: Make a Beach Simulation Tank

1. Gather your materials to model beach erosion!
    a. Rectangular dish (e.g. tupperware container), Sand, Rocks of varying sizes, Water, Flat spatula, Food Coloring, Toothpicks, Markers (3 colors), Metronome, Ruler

2. Use the ruler to mark at each centimeter along the sides of your rectangular dish. This will help you measure beach erosion throughout the experiment.

3. Add enough sand to your dish that it covers the bottom. Push it all to one side to form a sloping beach.

4. Add water to your ocean model so that it covers the bottom of your dish and some of the sand. *Note: There should be a section of sand above the water line (about 2 inches)*.

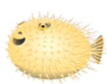
5. Add a few drops of food coloring to your water so that it is easier to see.

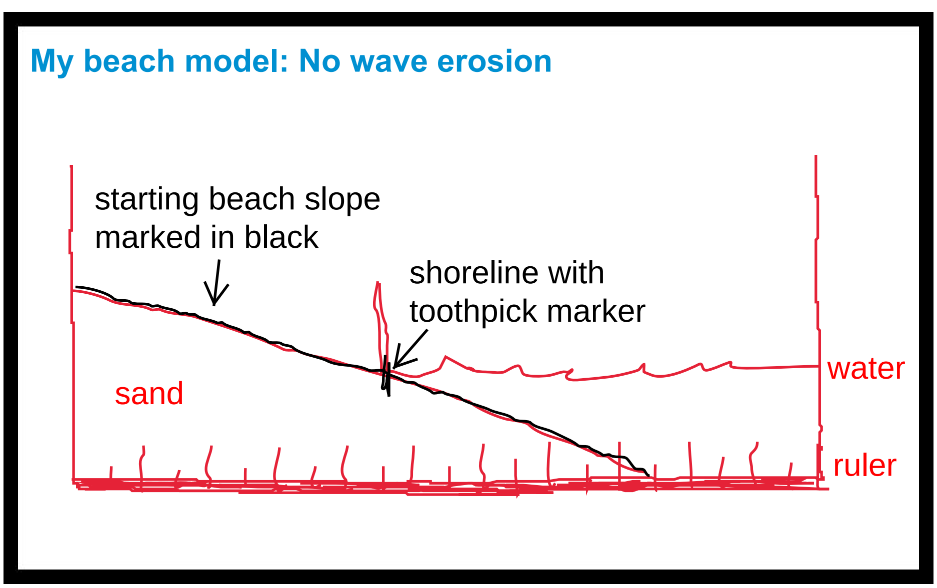
6. Reform your beach to ensure that:
    a. It has a uniform shape from side-to-side
    b. There is at least a 2 inch wide beach above the water

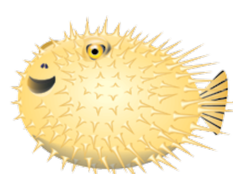
7. Use a permanent marker to trace the slope of your beach on the outside of your container. Draw a small mark where the water and sand meet. This is the **shoreline**. *Note: You will use this line to reform your beach in the same shape for each trial.*

8. Mark the shoreline with toothpicks stuck in the sand.

9. Make a "before" sketch of the side view of the beach. This is the **beach profile**. *Note: you can use your ruler to take measurements of different parts of the beach.*







Part B: Practice Making Waves!

1. Use a metronome or sound recording (search metronome online) set at 60 beats per minute (or similar).

2. Put the large side of your paddle in the water the edge of your container on the opposite side of the beach. Start the metronome, and gently move the paddle towards the beach in time to the beat.

3. What did you see? Write your observations.
   Look for students to describe sand moving from behind the shoreline (toothpick line) toward the water. In general, there should be a flattening of the sand as the force of the waves moves the sand from the beach out to the water.

Part C: Test the Force of Waves

1. Reshape your beach so it lines up with your original profile line and the shoreline is in the same spot.

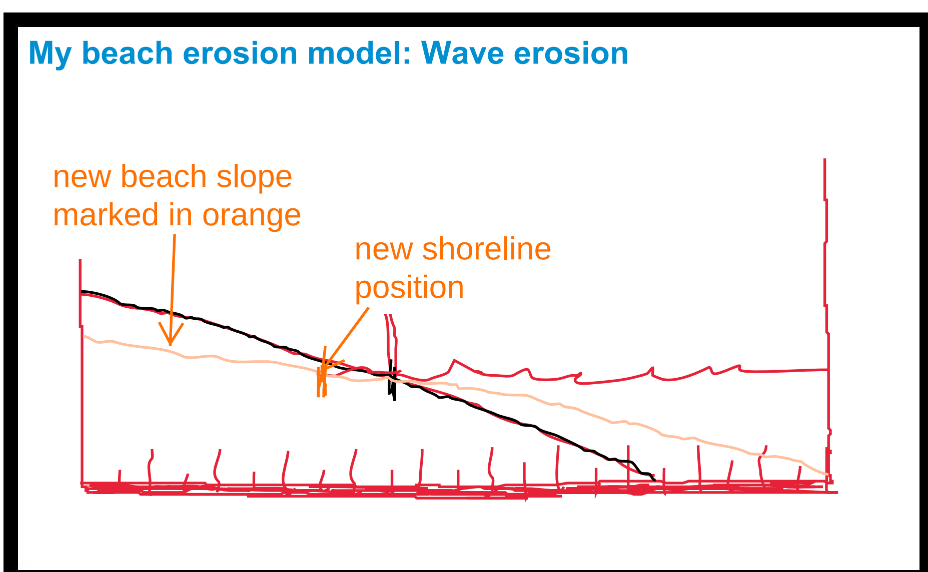
2. Follow the metronome sound and use the paddle to make a wave at each second for 2 minutes. *Note: Try to give each wave the same force with your paddle.*

3. After two minutes of making waves, observe the effect of wave force on sand movement.

4. Use a different color marker to trace the new line of the beach and mark the shoreline on the side of your container

5. Describe how your beach has changed.
   Look for students to describe sand moving as the force of the waves transports the sand from the beach out to the water. Students should be able to describe the change in the beach slope as "flatter" or "less steep."

6. Make an "after sketch" of the beach profile following the wave action.



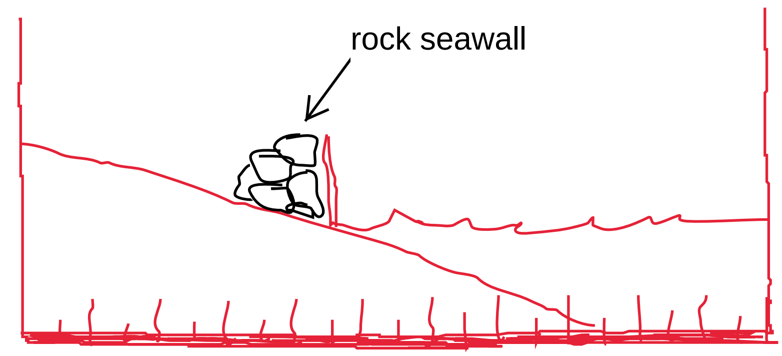
Part D. Test a Sea Wall!

1. Reshape your beach again so that it lines up with your original profile line and shoreline.

2. Create a seawall by placing rocks at the shoreline (above the toothpicks).

3. Draw another "before" sketch of the beach profile.

My beach model: Seawall



4. Repeat part C to test the force of the waves against the seawall.

5. Describe how your beach and seawall has changed.
   Look for students to describe sand moving from behind the rock seawall toward the water and to notice the "undercut" or erosion of sand under the rock wall. The shoreline should also shift inward toward the beach. However, there should be less flattening of the sand as the force of the waves is partially counteracted by the force of gravity holding the seawall rocks in place.
6. Make another "after sketch" of the beach profile following wave action with the presence of a seawall.

My erosion model: Wave erosion with a seawall

Activity Questions

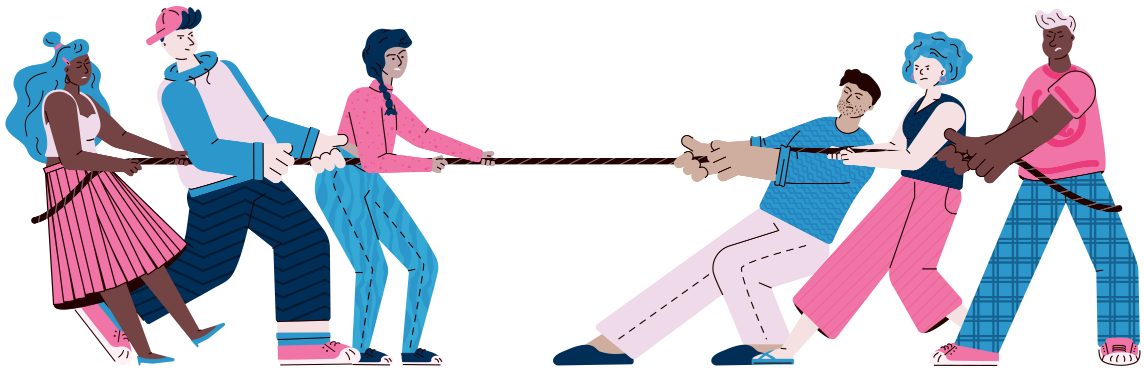
Name: ______________________

You have just experimented with balanced and unbalanced forces!

- When two equal forces act in opposite directions, the forces are **balanced** and there is no motion.
- When one force is stronger than the other, the forces are **unbalanced** and lead to the motion of an object.

Use this information and your observations from your experiment to answer the following questions:

1. Imagine that two teams are playing tug-of-war on a rope.



   a. If their strength is equal and neither team is winning, are the forces balanced or unbalanced?
      The pulling strength of both teams is balanced if both teams are pulling equally. The rope is not moving, and neither team will win.

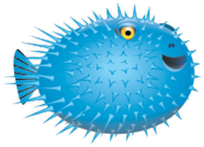
   b. If one team lets go, and the other team wins the rope, are the forces balanced or unbalanced?
      If one team lets go, the forces become unbalanced.

2. Think back to when you first set up your beach:

   a. What would the beach profile look like the next day if you did nothing to it? (Hint: would the sand move by itself?)
      The profile should stay the same and no sand would move.

   b. If you return the next day, and the **sand has not moved**, were the forces acting on the sand balanced or unbalanced?
      Students may respond that the forces are balanced. This is correct for this level of understanding and the NGSS performance expectation. Students might also say that the force of gravity is keeping the sand in place; this is also a good response.

   c. If you return the next day, and the **sand has moved**, were the forces acting on the sand balanced or unbalanced?
      If the sand moves, then forces acting on it were unbalanced, which caused the movement.



3. What happened to your beach profile when there was wave action? Explain.

   The force of waves caused the sand to move. We could see sand moving and sliding down the beach out into the water, flattening the beach slope.

4. When waves interact with the shoreline to move sand, are the forces:

   a. **Balanced** or **Unbalanced** (Circle one)

   b. What evidence do you have to support your answer?

   We know that if forces are balanced, the sand will stay put. The waves acted as an unbalanced force that moves the sand. Also, we could see that the sand only moved when we made waves.

5. Why do you think that people build rock walls (or other hard structures) at the beach?

People generally build rock walls and other hard structures to keep sand and property from being carried to the water by the force of waves (wind and storm waves as well as tide waves).

6. After you added your rock wall, did waves affect the beach profile differently than before? Describe.

The sand moved less (or more slowly) away from the top of the beach. The beach slope changed less too. Generally, the rock seawall was able to hold more of the sand on the beach than before the wall was there. However, there was erosion under the wall.

7. Based on your observations, can you think of a reason why beach scientists often recommend **against** building sea walls in line (or parallel) with the beach? (hint: look at the entire beach profile, from under the wall and into the water).

Seawalls that are built in line (or parallel) to shore (like this model), tend to help save the beach and property—but only for a while. The force of waves, especially large waves over extended time, will erode the wall and then the beach. Also, the sand in front of the wall tends to go away. Groins, or t-groins, which are perpendicular to the beach, tend to help keep sand on the beach longer. The best way to maintain a healthy beach, however, is to build far enough back that the beach can grow and shrink with the force of waves and wind.

8. What other ways can people protect homes and property besides building seawalls parallel to the beach? (hint: think about how far property is built from the water, the amount of sand needed to protect property, the role of native plants in holding sand on a beach, and the various shapes and positions of seawalls compared to groins or piers.)

Over the long term (think geologic time), beaches are temporary. Beach sand originally comes from erosion of the land or by the breakdown of calcified organisms like corals, shells, and algae. Sand piles up at beaches because of the forces of wind and waves. Small waves tend to help build a beach up, and large waves tend to scour and remove sand from beaches. Healthy beaches have sufficient sand banks above the shoreline to be able to grow and shrink seasonally. Native plants, like naupaka, pōhuehue (beach morning glory), and ʻakiʻaki grass, help to hold sand on the beach and keep the beach healthy. Building far up from the shoreline, planting native plants, and not driving on the beach are all helpful in keeping the beach healthy and protecting property. If walls are necessary, it is good to use designs like textile groins that are perpendicular to the beach and also decompose over time.

For more information on beach structures, check out the Exploring Our Fluid Earth unit on Beaches and Sand and scroll down to read "Sand Transport, Coastal Erosion, and Human Impact on Beaches" (http://manoa.hawaii.edu/exploringourfluidearth/physical/coastal-interactions/beaches-and-sand)