Making and Using a Wave Machine

Overview

Students will (1) build a wave tank, (2) create and discover when and how waves break, and (3) record their observations. In this process they will learn about ocean waves, particularly how they act when they approach shore.

Concepts

- Any wave can be described as having height, length and frequency.
- Waves have shape and form.
- As waves interact with matter (sand or rock on beach) waves change in shape, size and form.

Materials (per group)

- 2 Aluminum baking pans (1 long and narrow pan can be substituted)
- Duct tape (optional)
- Tin snips (optional)
- Silicon caulking (optional)
- Water
- Sand
- Stiff piece of plastic or wood big enough to fit across short end of the pans
- Wave chart, included with this activity
- Ruler or meter stick
- Paper and pencil

Preparation

Break class up into groups of 3 or 4.

Using tin snips the teacher or students can cut the ends off of two baking pans so that the two cut ends fit together. Using the duct tape and silicon caulking, connect the two pans together making them water-tight. This will be the wave tank. For simplicity, you could use just one pan, the longer the better, but the greater length of two attached together will make for a much more effective wave tank.

Waves, created in a tank or in nature, have specific *fetch* and force requirements. Fetch is the area over which winds blow to create waves. As waves travel over distances, they change. The same is true in a wave tank. It is important for students to spend the time to develop the wave generator and begin generating waves to get a complete knowledge of frequency, length, height, and form.

Procedure

Engagement

Review *wave height*, *wavelength* and *frequency*, and *period*. Waves are generated in the ocean mainly by wind. Changing the strength, duration and direction of winds creates variations in wave type and size. Also, as waves travel across the ocean they change. Waves break when they reach the shore. The type of wave and shape of the shoreline dictate how and when a wave will break. In this experiment you will create and describe different waves and discover when and how they break.

Activity

1. Add about 5 cm (2 in) of water at the bottom of your wave tank.
2. Add sand to one end and create a relatively flat simulated beach. Make sure some of the sand is above the water line.
3. Begin generating waves by moving the piece of wood or plastic up and down at the non-beach end of the tank. Start slowly. Students creating the wave must experiment with the wave generation process. Try different methods. For example, straight up and down versus a slight underwater fanning motion. What method works best? It is important that waves are about even and rhythmic. When a consistent set of waves is being produced, look at the sides of the tank and use a ruler to estimate the wavelength and height of the waves. Use a watch with a second hand to estimate wave frequency or period [Fig. 1]. Record those values.

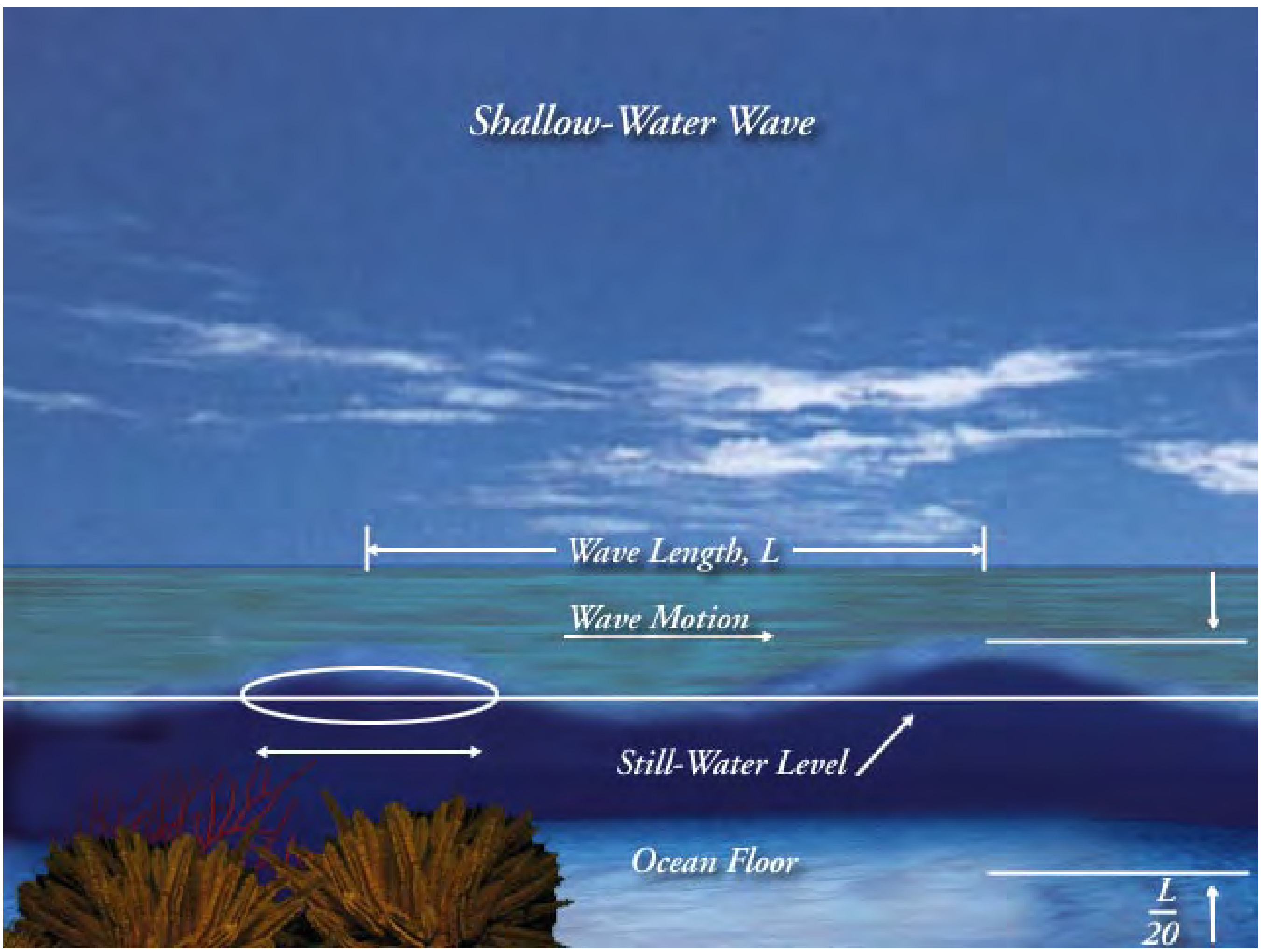

Figure 1. **Characteristics of shallow-water waves**. Particle motion in shallow water waves is a flat, ellipse-shaped orbit. This motion can be almost horizontal in very shallow waters (shown as line with arrows at both ends). Note that shallow water waves occur where the depth is less than 1/20th of their wavelength. Thus, shallow water waves can feel and affect the ocean floor.

4. Describe how the waves are interacting with the beach. You may want to use Fig. 2 as a guide. Do they "slosh up" or break on the beach?
5. Increase the frequency of the waves (speed up "wave generator"). Estimate the wavelength, height and frequency again.
6. Are the waves breaking near the beach yet? At about what height, wavelength and frequency do the waves stop sloshing and start breaking?
7. Move the sand or add more sand to make the beach much steeper (greater than 20° slope). Figure 3 illustrates the difference in shape between spilling, plunging and surging breakers. Does changing the steepness of your beach influence whether you create spilling, plunging, or surging breakers?
8. Repeat steps 3 to 6 with the steeper beach. What differences do you see compared to the flatter beach?

Explanation

All waves can be described using three variables: wavelength, wave height, and frequency. Waves with a long wavelength have a low frequency and a flat face [Fig. 2, deep water swell]. Waves with a short wavelength have a high frequency and a steep face [Fig. 2, breaking waves]. As waves come into shore they begin to feel the bottom and slow down. Slowing down, they bunch up as their wavelengths decrease. They continue to get steeper until the tops of the waves fall over and they break. The steeper the slope on the beach, the faster the waves bunch up and break. This affects the shape of the breakers, as shown in Figure 3.

Extension

If possible, take a trip to the beach (if you do not live near a beach, consider to partner, for example over the Internet, with a school near the beach that can go and report their findings to you). Measure the period of waves with a watch and estimate the wave height. Look on the weather page of the local newspaper and see how close your wave descriptions match those on the weather page. Observe the beach. Is it a mostly horizontal, steep, or very steep profile? Does the beach type match the wave types observed?

If possible, talk to local surfers about their favorite types of breakers. Do they notice a change in the type of breakers from season-to-season? If so, can you guess why?

Vocabulary

fetch *frequency* *period*
wave height *wavelength*

Source

Adapted from Orange County Marine Institute Activity Series.

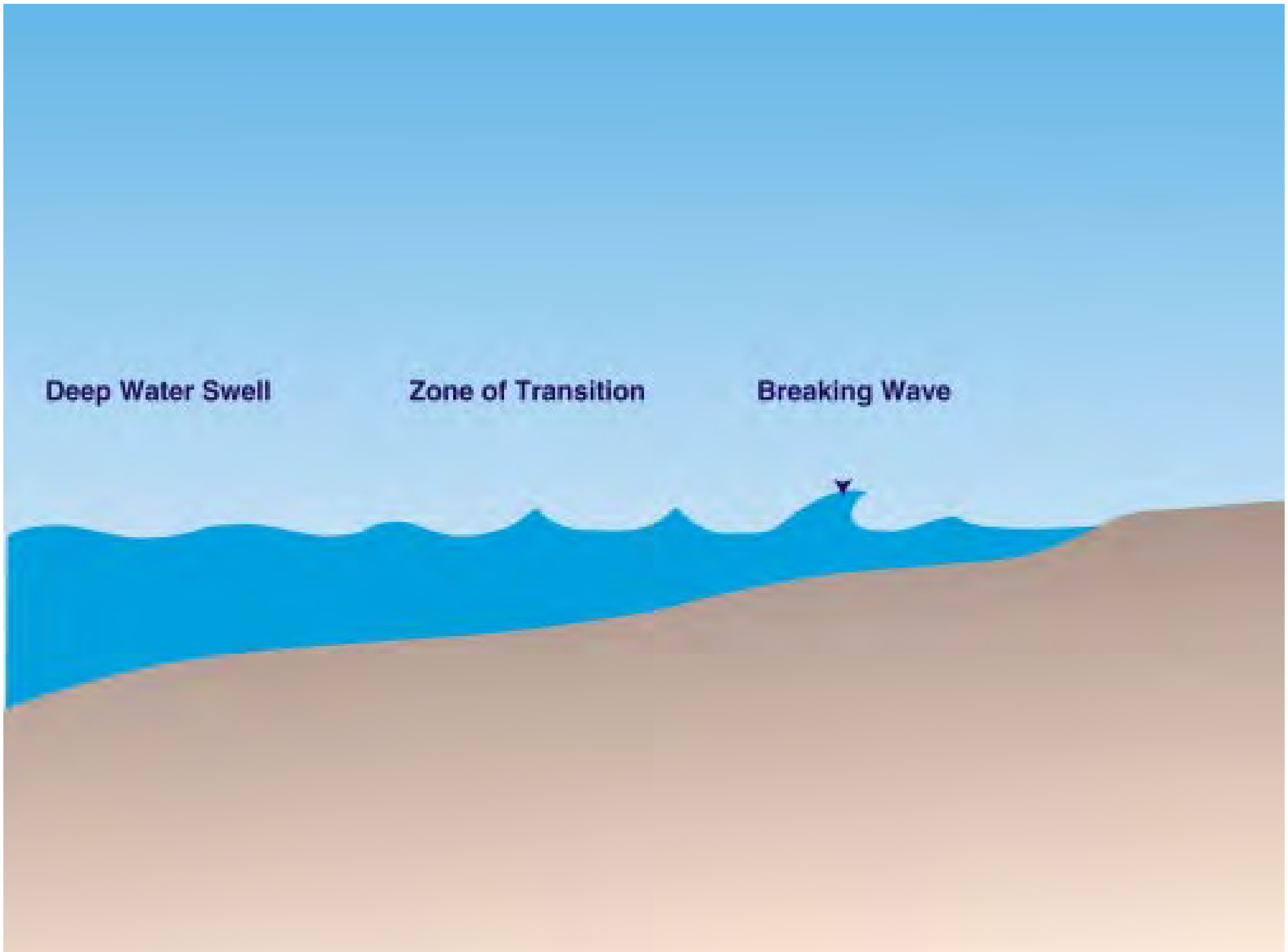

Figure 2. **Transition from deep water swell to nearshore breaking wave.** As deep water swells approach the shore they encounter shallower depths. In the zone of transition, the ocean bottom begins to interfere with the motion of water particles. This causes the swells to slow, the wave heights to increase, and the wavelength to decrease. As the bottom continues to shallow, the wave steepness increases until breaking waves form.

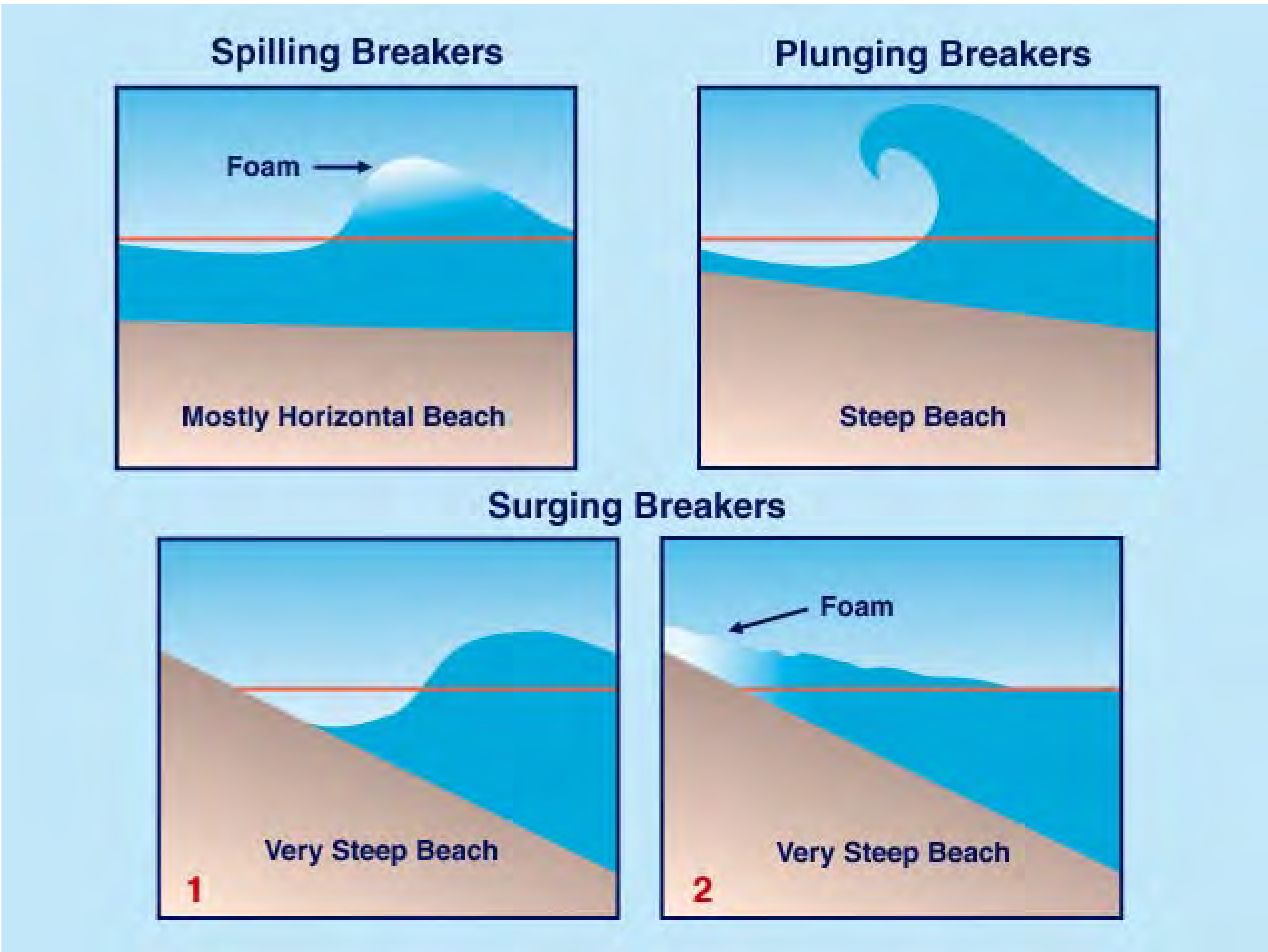

Figure 3. **Breakers.** The types of breakers in any surf zone are related to the profile--or steepness-- of the beach. A common type is the spilling breaker that results from a relatively gentle bottom slope. These have a relatively long life span but give surfers a less exciting ride than plunging breakers. Plunging breakers have a curling crest that moves over an air pocket. They form on moderately steep beach slopes. Surging breakers form on very steep beaches.