Lab - Beach in a Pan

(modified from Monterey Bay Aquarium)

Background: A beach is a dynamic system. It is a river of moving sand and a place where sediment is constantly being transported and deposited. Sediment is transported and deposited by wind, waves and currents. Beaches are found in places suited to sediment deposition, like calm areas between rock outcroppings, shores sheltered by offshore islands and regions with moderate surf. A variety of sand grain sizes are usually found on a beach. The finest grains are often found furthest from the water. That's due to wind blowing and transporting fine grains up the beach. When a wave hits the beach, much of the wave energy is lost. The largest sediments drop out first and are deposited higher on the beach. The lighter sediments remain in suspension a bit longer and fall out as the wave recedes. The lightest sediments are carried back out to sea and may eventually settle out beyond the surf line. Therefore the largest particles are often found between the low tide mark and the berm (the berm is the furthest place sand is deposited by waves on a beach), with smaller particles found either offshore or higher up on the beach.

Beach slope is influenced by the size of sand grains and the waves. Coarser sediments tend to produce a beach with a steeper slope. Conversely, a beach with finer sediments tends to be flatter. The force and size of waves influences the beach composition, too. Stronger waves deposit more sediments on the beach and produce a steeper slope. This means that areas with weaker waves tend to be flatter and areas with calm waves tend to be steeper. Since the strength of waves can vary seasonally, the slope of a beach may also vary seasonally. Many beaches share a typical profile, though it will vary seasonally. Dunes, cliffs or seawalls are often the area farthest away from the water. Berms are found closer to the water. The area between the berm and the low tide mark is the intertidal. This is the active zone of the beach where waves crash during the daily rise and fall of the tides.

The dynamic nature of sand can result in challenges to coastal development. With most of the world's population living on the coast, new homes and businesses are built every year in coastal areas. Millions of dollars each year are invested in protecting structures from the natural process of coastal erosion. Breakwaters, groins, jetties and sea walls are all physical structures used to protect structures from strong waves and prevent the erosion of sand. Breakwaters, structures in the water parallel to the shore, prevent the longshore current from moving sand so sand may accumulate and need to be dredged to keep harbors functional. Groins, structures extending from the beach perpendicular to the coast, often result in the erosion of sand on the downdrift side. Jetties are similar to groins but are used to stabilize large inlets. Seawalls are on shore and built parallel to the beach but deflect wave energy into the sand in front of and next to them which cause erosion. Beach sand is sometimes imported to fight erosion. But that sand is often from deeper waters so is fine grained and often erodes faster. Building on solid substrate, like a rocky shore, and a reasonable distance away from the water, is a more sustainable method of coastal construction.

Prelab Questions:

1. In what ways is sand transported on a beach?
2. Why is smaller grained sand found further from the water?
3. Describe the differences between beaches with steep slopes and beaches that are flatter.
4. Describe the difference between a breakwater and a groin.
5. How does coastal development influence beach structure?

Activity:

Create a beach by covering the shallow end of the pan with sand, then slowly pour water into the deep end. Use your "wave maker" to make waves (Marine Ecology is sooo hard…..). Try to make waves of the same height and frequency at a 45^{o} angle to shore. After you have mastered making waves, rebuild your beach and record your observations below. You may need to rebuild your beach between trials. Lastly, experiment with wave angles to determine its effect on sand movement.

(continued on back)

Data:

Wave Strength	Structure	Description of Sand Movement
Low Height and Low Frequency	none	
Low Height and High Frequency	none	
High Height and Low Frequency	none	
High Height and High Frequency	none	
Low Height and Low Frequency	Breakwater	
Low Height and High Frequency	Breakwater	
High Height and Low Frequency	Breakwater	
High Height and High Frequency	Breakwater	
Low Height and Low Frequency	Groin	
Low Height and High Frequency	Groin	
High Height and Low Frequency	Groin	
High Height and High Frequency	Groin	

Analysis:

6. Describe the natural movement of sand on a beach (ie. with 45^{o} angle and no structures present).
7. How does a breakwater alter the natural movement of sand on a beach?
8. How does a groin alter the natural movement of sand on a beach?
9. Identify two benefits of breakwaters and/or groins for a beach community.
10. Identify two negative consequences of breakwaters and/or groins for a beach community.
11. How does changing the angle of the waves affect sand movement on a beach?
12. In North Carolina, waves typically approach the beach at a roughly 45^{o} angle, creating the longshore current. What phenomena would cause that angle to change, even temporarily?