Sand-Shakes and Mud Pies

Students collect sediment samples from different wet habitats and measure and compare sediment composition from these locations to find relationships between sediment size and various environmental factors. Elementary students separate and observe layers; older students make calculations based on data.

Background

The composition of the sediments that make up shorelines of the Chesapeake Bay and its tributaries depends on a number of factors such as exposure to wind, waves and currents, established vegetation, source and shoreline slope.

Sediments are often classified by size as follows: clay (less than 0.004 mm), silt (0.004-0.062 mm), sand (0.062-2 mm) and granules or pebbles (larger than 2 mm). Sand is usually classified further as fine, medium or coarse.

There are several kinds of minerals in typical beach sand, including quartz, magnetite, garnet, mica, feldspar and limestone, as well as particles of shell, plastic and sometimes coral. The difference in size, shape and density of these materials determines how they are moved by water and wind along the shoreline.

Shorelines are molded by the energy from moving water (waves and currents) and wind. The amount of energy affecting a site determines, to a large extent, the size of particles present. Denser and larger particles require more energy to be moved than less dense and smaller particles. Smaller particles stay suspended in water until the water movement slows enough to let them settle out. Thus, larger sand particles are moved and deposited by large waves on an open beach but are rarely carried up into tidal creeks by the gentle currents and tides. Silts and clays collect among the roots and stems of plants forming marsh mud.

Storms sometimes move dense sediments onto a beach. Such deposits may be revealed as dark bands if one digs a trench in the sand. The strength of a storm may be inferred by the width of the dark band.

Longshore currents typically move sediments along shorelines. Current direction may change during the year. The movement of coastal sediments is affected by manmade objects such as docks and jetties, which disrupt the flow of sediments along the shore, thereby altering the natural coastline. This can cause accretion (build up) in some places and erosion in others.

Procedure

Before the Trip:

1. Collect enough wide-mouth, straight-sided, plastic jars (such as those used for peanut butter) to have two per sample location.
2. Visit the site to locate at least four areas where the shoreline sand or soil is under the direct influence of wind, water or both. These areas might include:
   - Bay or river beach in the area the waves wash over (swash zone)
   - Bay or river beach above the line of debris left by high tide (wrack line)
   - Bay side of sand dune
   - Top of sand dune (collect from boardwalk)
   - Back side of sand dune
   - Tidal marsh
   - Edge of a tidal creek
   - Bottom of a woodland stream
   - Edge of pond

   List the locations and give each an identifying name. Collect a few small samples of different sediments. Mark

Grade Levels: 4-12

Objectives

Students will investigate natural patterns of sediment organization by:

- *observing* samples;
- *predicting* locations of various types of sediments;
- *identifying* independent variables;
- designing descriptive *data collection* criteria;
- *collecting* samples;
- *graphing* and *quantifying* data;
- *analyzing* data.

Materials

- large-mouth, straight-sided plastic jars with lids (two per group)
- One very large jar, preferably long and narrow
- gardening trowels
- labels for jars
- permanent markers
- rulers
- copies of data sheet
- clipboards, pencils (one per student or group)

When

Any time of year. Daylight hours, low to mid tides best at some locations.

Time Required

At the Site: Allow about one hour in the field, but duration depends on number of locations visited and time required to reach each location the jars with the location names.

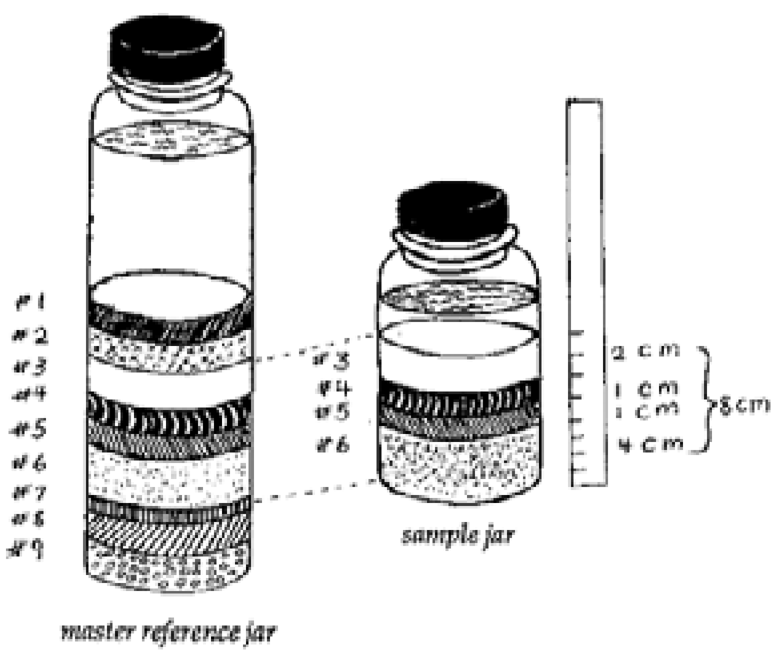
3. Discuss with the class the basic types of sediments. Describe the locations to be visited and have the students describe the types of sediments they would expect to find at each.
4. Students name factors that might affect particle size at a location. List these on the board and then come to a consensus on which factors (two to six) will be investigated on the field trip. Some factors might be: wave action, fetch, current speed or plant density.
5. Explain that each factor listed can be considered an independent variable that might have some effect on the dependent variable, sediment particle size.
6. Share the samples you collected with the class. Make observations on the texture, smell and appearance. *Which samples might be silt? Clay? Sand?*
7. Make small group sampling team assignments. Give each group a copy of the site map with the sampling locations identified. The groups then predict what types(s) of sediment will be found at each location.
8. Assign each group the task of designing an original rating scale for one of the independent variables. Criteria for the scale must be readily observable or quantifiable. For example, for a wave action scale of 1 to 5, 1 could be glassy calm, and 5 could denote white caps.
9. Discuss proposed scales. Correct and improve as necessary. Develop data sheets (see example provided), fill in rating criteria designed by groups and make one copy for each group.

At the Site:

1. Divide the class into small groups for on-site collecting.
2. At each collection location, students half-fill appropriately labeled jars (two per location) with sediment samples.
3. Students rate the independent variables for each location on their data sheets.

Follow-up:

1. Prepare a large master reference sediment jar by half-filling one jar with equal amounts of sediment collected at each location. (Groups collected two jars at each site. Use one of those jars from each group of this step.)
2. Fill the master reference and all of the remaining sample jars with water to within 1 cm of the top and screw on the tops. Shake them vigorously until all of the particles are well-separated and suspended. Set them side-by-side in a well-lit place in the classroom where they can be studied by the class without being moved again.
3. The next day, study the sediment layers in the master reference jar with the class. The top layer has the lightest and finest particles and the bottom layer the coarsest and heaviest particles. Create a particle size category scale by numbering the layers, starting the numbering with the top layer. (#1 represents the finest sediments and the highest number—the total number of layers—represents the heaviest sediments.)
4. Each team carefully compares the layers in their sample jar with the layers in the master reference jar and assigns the corresponding particle size category scale value (layer number) to each layer in the sample jar. They should write these values on their sample jar.
5. The teams next measure and record the depth of each sediment layer and the total sediment depth in their sample jars.



Resources

Gross, M.G. 1972. *Oceanography - A View of the Earth* (Chapter Five). Prentice Hall, Inc., NJ. (new editions also available)

Ogburn, C. Jr. 1966. *The Winter Beach*. Simon & Schuster, Inc., NY.

Ranwell, D.S. 1972. *Ecology of Salt Marshes and Sand Dunes.* John Wiley & Sons, Inc., NY.

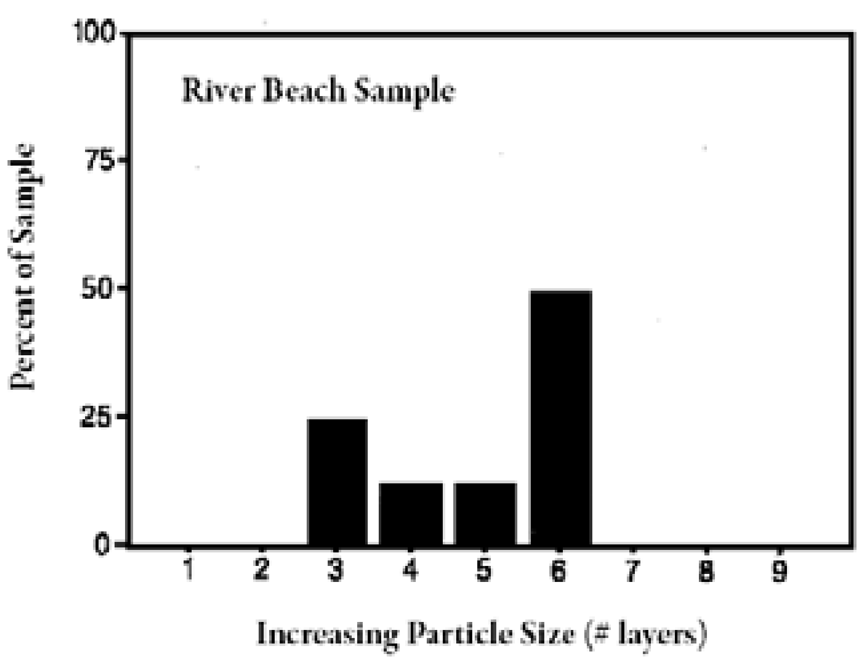
Ricciuti, E. 1982. *The Beachwalker's Guide.* Doubleday & Co., NY.

Tucker, M.E. 1982. *The Field Description of Sedimentary Rocks.* Geological Society of London Handbook Series. John Wiley & Sons, Inc., NY.

Zim, H. And P. Shaffer. 1957. *Rocks and Minerals.* Simon & Schuster, Inc., NY.

Zim, H., P. Shaffer, R. Perlman, 2001 *Rocks, gems and minerals: A guide to familiar minerals, gems, ores and rocks.*

6. From these measurements, they determine the percentage of each sediment component by dividing each layer depth by the total sediment depth in the jar, then converting that fraction to a percentage. Using the sample given:
   #3: 2 cm/8 cm = .25
   #4: 1 cm/8 cm = .125
   #5: 1 cm/8 cm = .125
   #6: 4 cm/8 cm = .50
7. Teams next prepare bar graphs for their samples showing the percentage of each sediment component. (In the example shown, the numbers of the X-axis correspond to the particle size scale determined for the master reference jar.)
8. Discuss the results to determine which location(s) had the smallest particles (silt and clay), which had the largest particles and which had the greatest range of sizes. Consider the independent variables. *What inferences might be drawn?*
9. Determine which factors affected particle size at the locations using the following procedures:
   - Determine the average particle size category for each sample by multiplying the numerical rating of each particle size layer by its percentage within the sample.
   - Add these values for all particle size categories in the sample (using the sample given):
     3 x .25 = .75
     4 x .125 = .50
     5 x .125 = .625
     6 x .50 = 3.00
     4.875
     (rounded off = 4.9)
     4.9 = average particle size category at the location.
   - Complete the data sheets by recording the average particle size category for each location.
   - Make a graph for each variable by plotting the numerical rating for that variable for each location on the X-axis against the average particle size category for the same location on the Y-axis. (See example.)
10. Discuss the students' results:
    - *Is there a clear relationship between particle size category and one or more of the independent variables?* (Graphs with points that can be connected with a fairly straight line show the most direct correlation between the two variables.) *If so, what seems to be the relationship?*
    - *Do some independent variables show little or no relationship to particle size category? If so, why might that be?* (Some chosen variables may actually have no influence on particle size categories. In other cases, an independent variable may have an overriding influence on particle size category. For instance, the plot in the example shows the stream as a waveless location with medium-sized particles. Here, a strong stream current might have more effect than no waves.



Extensions

Students write letters to schools, tourist bureaus or marine labs in different locations, asking them to send a small sample of sand or sediment. Send return envelopes and small sturdy plastic bags.

- Compare sand samples from around the U.S., world or both for particle size, shape, color and composition.
- Look for tiny pieces of plastic with the samples. Plastic sand (called beach confetti) is a growing environmental problem worldwide.
- Use maps to plot the locations of samples received and discuss the possible origin of the sand in each of these places.

Variations

Younger students:
Omit the calculations but concentrate on having students make detailed observations of the sediments collected and suggesting possible causes for variations in particle size at different locations.

Data Sheet

	Independent Variables					Dependent Variable
Site Name	Wave Action	Fetch	Current Speed	Plant Density	Other Factor	Average Particle Size Category* at Each Location

Explanation:

Location Name: Use name assigned by instructor. Be sure it corresponds with name of sample jar.

Wave Action: 1 = smooth as glass
5= white caps

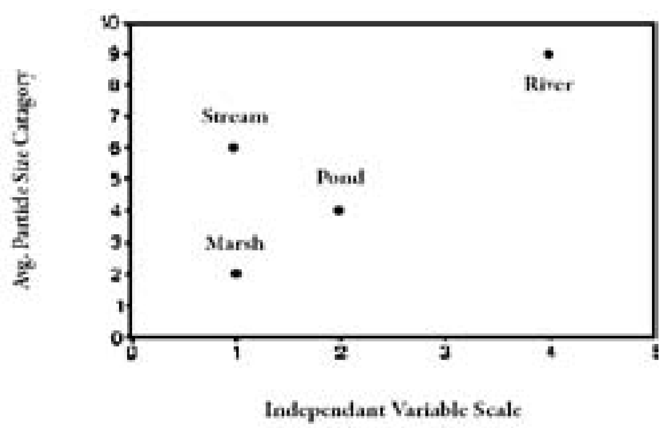
Fetch (means distance across open water wind can blow):
1 = can toss pebble to opposite bank
5 = cannot see opposite shore

Current Speed: 1 = no perceptible current (floating object does not move)
5 = strong current (floating object moves quickly)

Plant Density: 1 = no plants growing on site
5 = plants so thick you can hardly dig up a soil sample

*Average Particle Size Category: To be determined with sample back at school and calculated separately for each location sample.

Example. Wave action rating for each location versus average particle size category.



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SOL – Science 4.1,4.9,5.1,5.7,6.1,6.7,6.9,ES.1,ES.2,ES.6,ES.10
Math 4.14,5.5,5.15,6.1,6.2,6.6,7.11,7.12