Deep Current and Landforms

Strand Earth and Space Systems

Topic Oceanography

Primary SOL ES.10 The students will investigate and understand oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include

a) physical and chemical changes related to tides, waves, currents, sea level and ice caps, upwelling, and salinity variations;

d) systems interactions.

Related SOL ES.1 The student will plan and conduct investigations in which

c) scales, diagrams, charts, graphs, tables, imagery, models, and profiles are constructed and interpreted.

Background Information

Surface currents are generated largely by wind. Their patterns are determined by wind direction, Coriolis forces from the Earth's rotation, and the position of landforms that interact with the currents. Surface wind-driven currents generate upwelling currents in conjunction with landforms, creating deepwater currents.

Currents may also be generated by density differences in water masses caused by temperature and salinity variations. These currents move water masses through the deep ocean—taking nutrients, oxygen and thermal energy with them. Occasionally, natural events may also trigger currents. Huge storms move water masses. Underwater earthquakes and landslides may trigger devastating tsunamis. Both move masses of water inland when they reach shallow water and coastlines. Earthquakes may also trigger rapid downslope movement of water-saturated sediments, creating turbidity currents strong enough to snap submarine communication cables. Bottom currents scour and sort sediments, thus affecting what kind of bottom develops in an area—hard or soft, fine grained or coarse. Bottom substrate determines what kinds of communities may develop there.

Finally, when a current that is moving over a broad area is forced into a confined space, it may become very strong. On the ocean floor, water masses forced through narrow openings in a ridge system or flowing around a seamount may create currents that are far greater than in the surrounding water—affecting both the distribution and abundance of organisms as well as the scientists and their equipment seeking to study them.

Materials

- Plastic flower window box (light-colored or spray painted white inside) about 30cm wide by 1m long by 20cm deep
- Sink with small diameter hose attached to faucet or 5-gallon capacity container with a siphon and flow-control clamp
- Rubber or plastic tubing about 1/2-in in diameter
- Cork or rubber stopper same size as hole in box

- Drill bit and drill with diameter that matches the tubing diameter
- Silicone aquarium cement
- Large plastic eye dropper or pipette
- Two adjustable hose clamps
- Dye solution: 20 drops food coloring or India ink in 250 ml water
- Two or three blocks of modeling clay per student group
- Mixed sand (collected from several locations on a beach or builders' sand from builders supply store, about 150 ml per group)

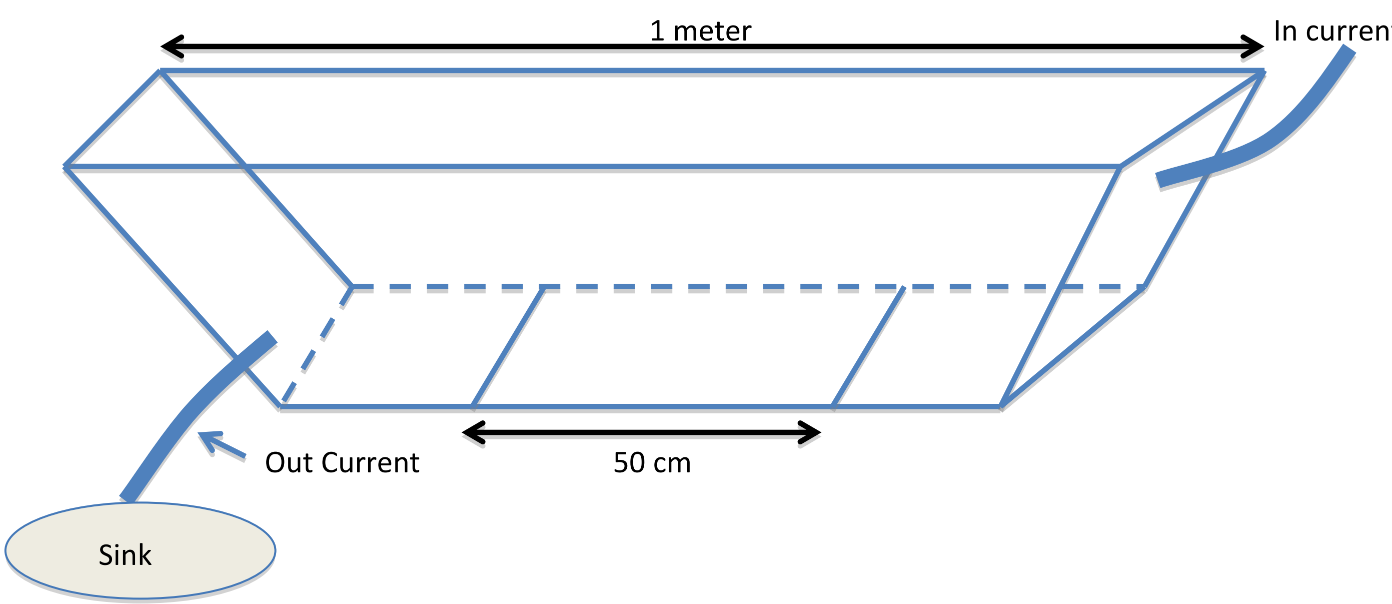
Vocabulary

seamount, Mid-Atlantic ridge, submarine canyon, reef, bank, currents

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

Introduction – Building the Current Chute

1. Build the current chute by filling the bottom holes in the window box if there are any.
2. Drill holes on the vertical ends as shown below. They should be the same diameter as the tubing on the sink faucet or siphon. Insert the faucet tubing in the high end and seal using the silicon aquarium cement.
3. Add tubing to the low end and set it over the sink to catch the overflow.
4. Attach hose clamps to each tube. Use a waterproof marker to make a 50 cm current racecourse in the center of the box, marking the front and back ends. See illustration for design. Modeling clay does not perform well when repeatedly soaked, but can be used more than once if handled carefully and not left in water very long.



Procedure

1. Begin by reviewing the major forces that drive ocean currents. Be sure students distinguish between currents that are largely wind-driven (less than 100 m deep) and those that result from pressure gradients due to differential density and/or depth.

2. Ask the students how scientists study currents in the lab. (Scientists build test tanks that simulate conditions in the ocean and study waves and currents in models of the real world.) Display your test tank.
3. Review the undersea features such as seamounts, mid-Atlantic ridges, banks, and submarine canyons. Challenge your students to make models of these features to test in your underwater current testing box. Assign each group one of the five geologic features listed. Explain that they will be making observations on the effects of these features on current flow. These should be designed as follows, using modeling clay:
    a. **Bank #1**: a flat round surface, like a pancake, about 10 cm diameter and 2 cm high.
    b. **Bank #2 or Reef**: a low rounded form like half of a hardboiled egg about 10 cm long, 5 cm at its highest point and 5 cm at its widest point; rocky outcrops are referred to as reefs by mariners.
    c. **Seamount**: a cone-shaped mountain that is 6-8 cm high and 10 cm across at the base.
    d. **Mid-Atlantic Ridge**: a ridge of clay that spans the entire width of the test tank that is 6 cm high, 6 cm wide and as long as the tank is wide; cut two notches in the ridge—one 5 cm deep and the other 2 cm deep.
    e. **Submarine Canyon**: collect spare clay from other groups and make a platform that fills the box from side to side in the middle and is about 5-6 cm high; carve a canyon in it with the shallow end on the side with the incoming current and the deepest end all the way to the bottom of the test tank on the outflow end; there may be twists in the canyon if desired.
4. To study the effects of the models on current flows:
    a. Set up the tank at the sink and test its function before class; empty it.
    b. Place a model in the test tank nearer the inflow end with the object just touching the upstream start of the 50-cm range markings.
    c. Fill the window box about ¾ full of water. Adjust the clamp on the siphon tubing so that water is flowing into one end at about 500 ml per minute.
    d. Adjust the outflow to match input when the box is ¾ full.
    e. Fill a pipette or long eyedropper about half full with dye solution. Being careful not to squeeze the rubber bulb, place the tip of the pipette just above the model surface at the end of the 50-cm mark. Gently squeeze a small amount of dye solution out of the pipette, and measure the time required for the dye plume to reach the other end of the 50-cm interval mark. Repeat this procedure by placing the tip of the pipette at the end of the model nearest the inflow from the siphon. Repeat these steps twice more, and calculate the average flow rate in cm per second.
    f. Repeat for each model.
5. Then test the model for current effect on sediment before switching to the next model. Pour about 50 ml of mixed sand into the top end of the test tank and record observations.
6. Increase the flow rate to about 1,000 ml per minute and repeat sediment test. Record students' observations.
7. Clean test tank and repeat with the next model.
8. Have groups present their results to the class. Lead a discussion to analyze these results. Students should have observed that current flow is increased around steep objects or objects that confine the water flow to a narrow passage. This flow acceleration can cause large, slow flowing water masses to become extremely strong and rapid currents. Students

should also have observed that smaller particles of sand tend to be carried farther by currents than larger particles and that when speed of the current increases, the particle-carrying capacity of the current also increases.

9. Ask the students what happened to sediment landing on the models? What characteristics would be required of organisms growing on these sites? How might current influence on the distribution and sorting of sediments by particle size affect species composition of a soft bottom area?

Assessment

- **Questions**
  - What happened to sediment landing on the models?
  - What characteristics would be required of organisms growing on these sites?
  - How might current influence on the distribution and sorting of sediments by particle size affect species composition of a soft bottom area?
- **Journal/Writing Prompts**
  - Tell students to imagine that they are visitors to one of the uninhabited Northwestern Hawaiian Islands. Have them write a short essay on what signs they might look for in potential swimming areas that could indicate the presence of dangerously-strong currents.

Extensions and Connections (for all students)

- Students may read the Pisces IV log entries of September 22, 2002, (http://oceanexplorer.noaa.gov/explorations/02hawaii/logs/sep22/sep22.html) to get a sense of the force of deep-sea currents.
- Relate rock types and sequences found in the geologic record to modern-day turbidity current deposition. Ask students to determine the types of rocks that correspond to the sediments deposited by such currents.

Strategies for Differentiation

- Have students create a graphic organizer to relate the ocean feature to the associated current behavior.
- Have students create drawings of their observations in a sequence of events.