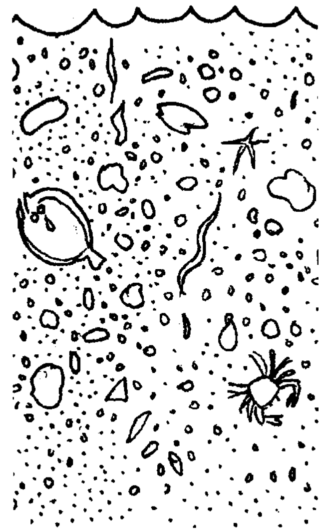
To the Bottom

Key Concepts

1. Sediments from deep ocean mining can affect plant and animal growth in the deep ocean and at the surface.
2. Sediment particle size affects the rate of settling.
3. Experiments which check only a single variable may not provide a good basis for predicting large scale changes in nature.



Background

The size of the particles discharged at the surface by deep-sea miners will play an important role in determining the effect the discharge will have on marine life, and on where the effect will be felt. Larger particles will settle rapidly. Their effect will be to produce a blanket of suffocating silt on the bottom, an effect which will probably be small in comparison with the effect which the collector-dredge of the deep-sea mining system will have on the bottom.

The very fine particles may stay in suspension for quite a period of time. One possible danger is a reduction in light penetration due to the turbidity of the water. Reduced light penetration precipitates a reduction in primary productivity by phytoplankton. This reduction in the base of the food web of the sea may be expected to have at least some local, adverse impact. The fine sediments are also those most likely to clog the breathing and feeding apparatuses of gill breathers and filter feeders. The effect of the fine sediments, then, is more long lived and occurs at or near the lighted, surface zones.

Materials

- fine mud or silt
- sand
- test tubes (4)
- test tube rack
- glass marking pencil or labels
- sea water
- graduated cylinder (50 or 100ml)
- balance
- Erlenmyer flasks (4, 150ml or 250ml)
- photometer
- graph paper
- clock with second hand

Teaching Hints

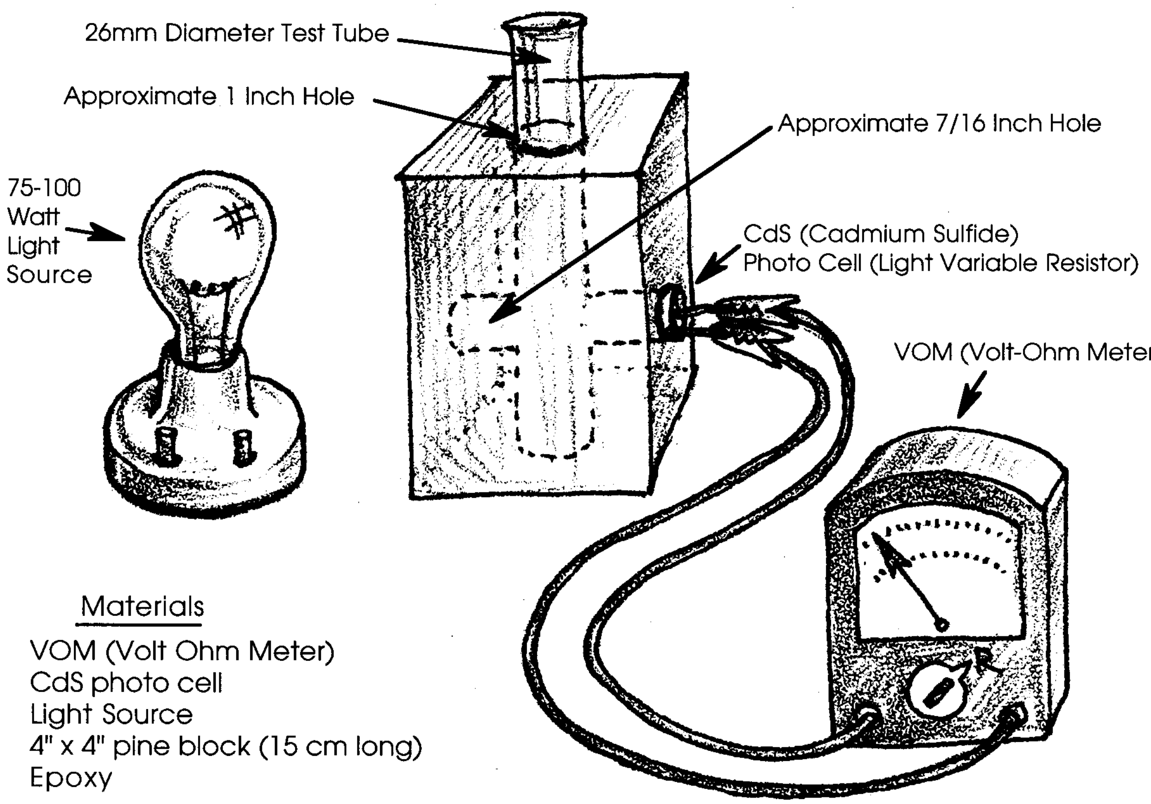
"To the Bottom" provides a "hands-on" sequel to the preceding discussion on deep-sea mining found in "Mining the Ocean Floor". In "To the Bottom" your students will have an opportunity to examine the affect of particle size on the rate of sedimentation.

"To the Bottom" requires the use of a photometer. While it may be possible to borrow photometers from an affiliated high school, a reasonably accurate substitute may be constructed at a low cost. The main component consists of an inexpensive VOM (volt-ohm meter) which can be purchased at any electronics supply store for under $10. The other component which you will need to purchase is a cadmium sulfide photo cell which varies its resistance as a function of the light to which it is exposed. This item ordinarily sells for under $1.50. Both components can be obtained readily at any Radio Shack store.

A few minutes work yields the third piece needed. Use a short (15 cm) length of 4" pine (or any soft available wood). Drill a 1 inch (about 26 mm) hole nearly through from one end. This will hold a large test tube containing the sample.

Next, drill a hole at a right angle to the first, large enough to hold the photocell tightly, completely through from the side. Push the cell slightly into the hole and apply epoxy cement around the edges to hold it in place.

Attach the leads from the VOM to the two leads protruding from the photo cell. Your completed photometer should resemble the drawing on the following page.



To use the photometer:

Set the selector on the VOM to read ohms (R X 1, _, or R). Shine a light from the opposite side of the wooden block, through the block and on to the photo cell. You should notice a deflection on the meter. By moving the position of the light source you should be able to cause the needle to travel “full scale”. If it doesn’t, try a larger bulb (ideally 75-100 watts).

When a test tube containing a turbid sample is inserted, light passage is reduced and a correspondingly smaller meter deflection should be noted. As the sample clears over time the needle will move upward.

NOTE: The VOM has several scales. If your students read the resistance scales (_, or R) they should plot the data on semi-log graph paper. It is also possible to read any of the linear scales since the change is what is being measured. In that case, standard graph paper is used for data plotting. Since you are not strictly measuring per cent transmission with these other scales, have your students relabel their data charts.

Other materials substitutions are also possible. If sea water is not available, a 3.5% salt (NaCl) solution will work well. If your laboratory has no balances, you may substitute volume measures (eg. teaspoon and 1/2 teaspoon measures). While the volumes determined this way are not exactly comparable, they are sufficient for the precision necessary in this experiment. You can increase the comparability by weighing a teaspoon of sand and determining the volume measure of silt necessary to equal the teaspoon weight.

Duplicate the activity pages. One set is recommended per student. This activity is best performed in small groups. It is possible for you to do this activity as a demonstration in which you perform the mechanical manipulations in front of the class while they make the observations and record the data. This approach is only recommended as an alternative to not doing the activity at all. It is much preferred to have your students perform the activity independently. Before your students begin, briefly outline the procedure and demonstrate the use of the photometer. Notice that the uniformity of the time intervals between data collection depends upon the students taking the same amount of time to analyze each of the test tubes. In your discussion of the activity relate the findings on turbidity and the rate of sedimentation to the situation which obtains near a deep-sea mining system where large quantities of silt-laden effluent are discharged into surface waters.

Key Words

control - a standard of comparison for checking or verifying the results of an experiment

particle - a very small piece

photometer - an instrument for measuring light intensity

sediment - material that has been deposited on the bottom of a body of water

silt - a sedimentary material composed of fine mineral particles intermediate in size between sand and clay

transmission - in this case, the passage of light through water

turbidity - a measure of the sediment stirred up or suspended in a liquid

variable - in an experiment, the element that is changed from trial to trial

Answer Key

Text Questions

1. The amount of sediment in the water affects plant life by reducing the light available for plant growth.
2. A photometer is an instrument used to measure the amount of light passing through a substance.

3. The more/<u>less</u> light measured by a photometer, the more cloudy (turbid) is the water. (The correct answer is underlined).

Analysis and Interpretation:

1., 2. Data will depend upon the experimental results.

3. a. Test tube D serves as a control against which the other tubes are compared. This is a good point at which to reacquaint your students with the classic components of an experiment.

   b. The variable that differs from test tube to test tube is the particle size.

4. While the answer depends upon the experimental results, test tube A would be expected to clear the fastest.

5. Again, while the answer depends upon the experimental results, test tube C would be expected to clear the slowest.

6. While the answer depends upon the data collected, the expected relationship would show that the larger the particle size, the faster the rate of clearing. Conversely, the smaller the particle size, the slower the rate of clearing.

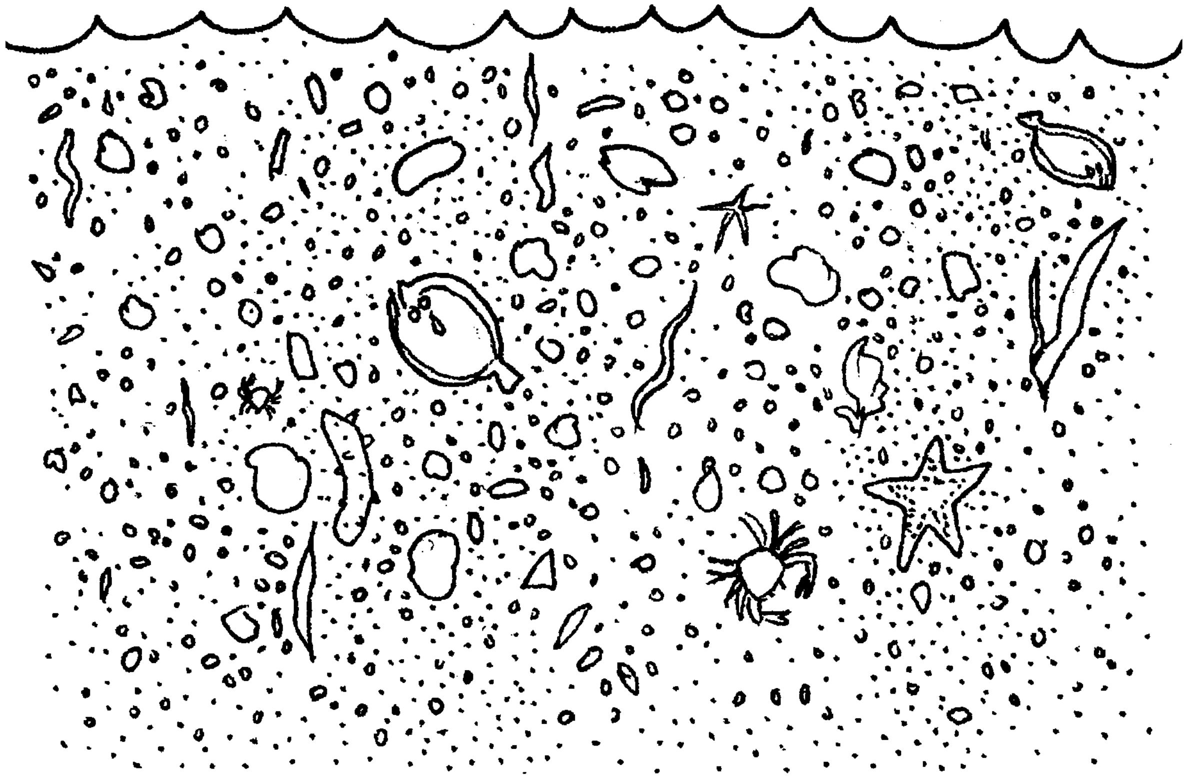
7. In the area of a deep-sea miner, the smallest particles will have the longest effect on light transmission. The smallest particles are the last to settle out.

8. Your students may suggest a variety of ways in which deep-sea miners might reduce the negative effects of surface discharge including: filtering out of the fine sediments for disposal onshore or at depth; no discharge at all; adding chemicals to precipitate the sediments (this may simply move the problem to a different depth); discharge at depth.

9. While your students may suggest a variety of possible dangers from adding alum, the “hint” included in the student text provides the direction the discussion should pursue. The possible danger lies in a chemically induced disruption of the bottom ecosystem. Use this question to point out the dangers of an “out-of-sight, out-of-mind” philosophy.

10. Scientists would be interested in lots of information including: baseline background data, quantities of sediment released, the depth of release, the currents in the area, the types of materials released, the kinds of plants and animals in the area, and a multitude of other parameters. Use this question to emphasize the need for sound ecological information before large-scale mining is begun.

To the Bottom



Deep-sea mining systems discharge large amounts of material into the surface waters. Every working day, each miner releases 1,000 metric tons of sediment, 50 tons of crushed nodules, and 51 pounds of plants and animals into surface waters. How long does it take for these materials to settle to the bottom?

The speed with which the waste water from the miner settles will have an effect on plant life in nearby waters. Microscopic ocean plants (plankton) need light to grow. All of the animals in the area depend directly or indirectly on the plants for food. The growth of these marine plants, then, is very important to the life of the sea. In this activity you will see how the size of the particles affects the speed of settling.

1. How does the amount of sediment in the water affect plant life?

With a piece of equipment called a **photometer** we can determine how fast particles settle. As the name implies a “photo-meter” measures “photos”. What are “photos”? “Photo” is the Greek word for light. A photometer measures light. How is light related to the speed with which particles settle?

Particles in the water make the water cloudy. This cloudiness is called **turbidity**. The more cloudy the water is, the less light that can pass through the sample. By watching the change in the light that passes through a water sample over time, we can determine how fast particles settle. Samples in which the sediments settle quickly will let light shine through quickly. Samples which remain turbid will not let very much light shine through.

2. What is a photometer?

3. The <u>more/less</u> light measured by a photometer the more cloudy (turbid) is the water. (Circle the correct answer.)

Materials:

- fine mud or silt
- sand
- test tubes (4)
- test tube rack
- glass marking pencil or labels
- sea water
- graduated cylinder (50 or 100ml)
- balance
- Erlenmyer flasks (4, 150ml or 250ml)
- graph paper
- clock with second hand

Procedure:

1. Obtain four Erlenmyer flasks and label them A through D.

2. Using a graduated cylinder, add 50ml of sea water to each of the four flasks.

3. Weigh out a 10 gram sample of sand. Add the sand to Flask A.

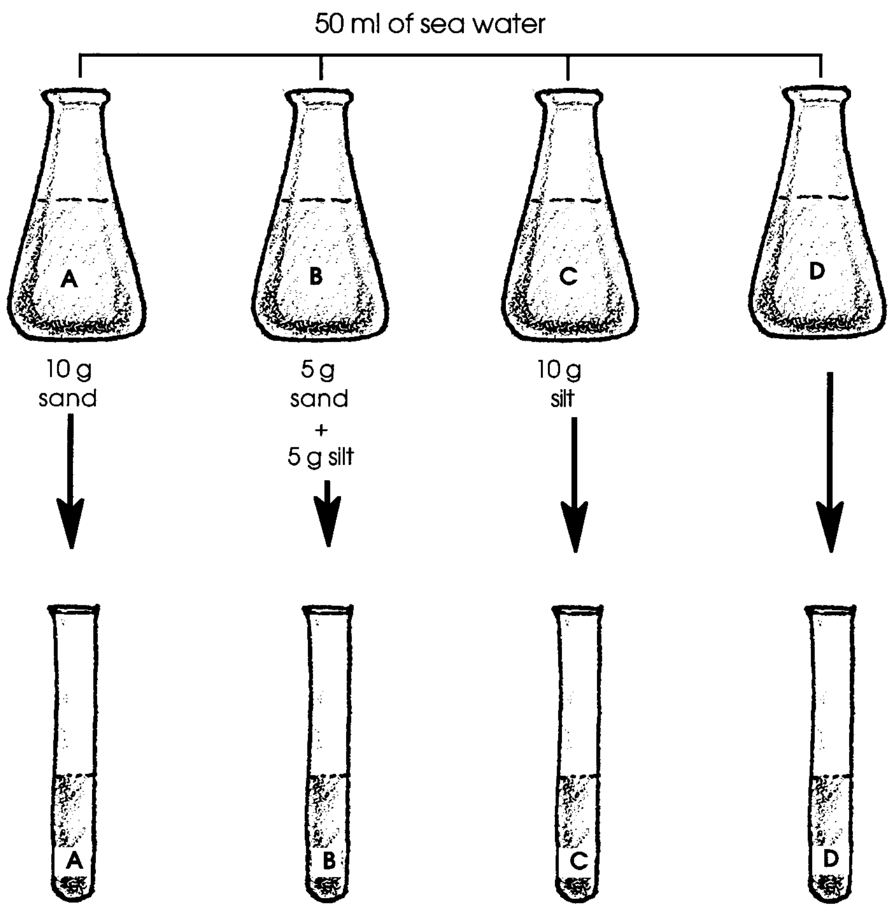
4. Weigh a 5 gram sample of sand. Add the sand to Flask B.

5. Weigh a 5 gram sample of fine mud or silt. Add the silt to the sand in Flask B.

6. Weigh a 10 gram sample of fine mud or silt. Add the silt to Flask C.

7. Obtain 4 clear test tubes and label them A through D. Only handle the neck of the test tube. Mix the sediments in Flask A vigorously and add the contents of Flask A to test tube A. Repeat this procedure for Flasks B through D. Take care that all of the sediments from each flask get transferred to each test tube.

You have now completed the following procedures:



8. Place test tube D in the photometer. Adjust the photometer so that 100% of the light is transmitted (passes) through the water sample. Remove test tube D from the photometer.

9. Every two minutes you will record the turbidity of each test tube.

Shake test tube A vigorously. Place it in the photometer and immediately read the scale. This is the percentage of light that passes through test tube A at time interval 1. Record this number on your data chart. Enter the clock time in the **first** available space:

_______,_______,_______,_______,_______,_______,

_______,_______,_______,_______.

Add two minutes to this time and enter the time in the **first** available space:

_______,_______,_______,_______,_______,_______,

_______,_______,_______,_______.

10. Shake test tube B vigorously. Place it in the photometer and immediately read the scale. Record this number in the correct place on your data chart.

11. Shake test tube C vigorously. Place it in the photometer and immediately read the scale. Record this number in the correct place on your data chart.

12. Shake test tube D vigorously. Place it in the photometer and immediately read the scale. Record this number in the correct place on your data chart.

13. When the clock reaches the time you recorded in the first space on the second set of blanks in step 9, repeat steps 9 to 13 with one important change. DO NOT SHAKE THE TEST TUBES AGAIN. All together you will make ten readings on each test tube.

14. After you have gathered your data, clean up your lab station.

Analysis and Interpretation:

1. Data Table: % Light Transmissions

Test Tube	Sampling Interval Number 1	2	3	4	5	6	7	8	9	10
A										
B										
C										
D										

2. Using the data collected, graph the results for each of the test tubes on a single graph. Take care to complete each line or curve before proceeding to the next. Your teacher will provide the proper graph paper and exact graphing instructions. Plot time on the horizontal axis and percent light transmitted on the vertical.

3. An experimental control is a sample which is treated exactly like the other samples except for one difference. The difference is called the **variable**. The variable changes in the experimental situations.

   a. Which test tube serves as a control against which the other tubes are compared?

   b. What is the **variable** that differs from test tube to test tube?

4. Which test tube cleared the fastest?

5. Which test tube cleared the slowest?

6. From your graph, what is the relationship between particle size and rate of clearing?

7. In the area of a deep-sea miner, particles of what size will have the longest affect on light transmission?

8. Suggest one way in which deep-sea miners might reduce the negative effects of surface discharge.

9. Alum is a material added to swimming pools to cause very fine particles to settle. What is one possible danger of using alum to cause mining wastes to settle more rapidly? (Hint: Where do the particles go when they settle?)

10. Because this experiment only checked a single variable, particle size, it may not be a good basis for predicting large scale changes in nature. What is one piece of information, aside from the rate of settling, which would help scientists make reasonable predictions about the effect of surface discharge from deep-sea miners?