Mining the Ocean Floor

Key Concepts

1. The ocean floor contains commercially valuable minerals.
2. Manganese nodules are mined from the ocean floor.
3. Manganese nodules should be considered a "non-renewable" resource.
4. Deep ocean mining can disturb bottom habitats and the organisms in those habitats.

Background

For the last decade, industrial nations have been poised on the edge of the sea awaiting completion of an international treaty to govern deep sea bed mining. During the waiting period, many of the technological problems inherent in deep-sea mining have been resolved. Field testing of deep-sea mining systems has given the National Oceanic and Atmospheric Administration an opportunity to answer some of the environmental concerns. Many serious questions, however, remain to be resolved. As the value of the deep sea minerals increases, the pressure to mine without a treaty and also without knowledge of potential environmental damage increases. The issues are complex, the potential rewards great.

Materials

- "Mining the Ocean Floor", and "Getting the Word Across" activity sheets

Teaching Hints

"Mining the Ocean Floor" provides a glimpse at the expanding field of deep ocean mining.

Duplicate the text and activity pages. One set is recommended per student. These exercises may be completed by individual students as in-class or homework assignments. "Getting the Word Across" is a vocabulary reinforcing activity utilizing some of the unfamiliar vocabulary from "Mining the Ocean Floor". Upon completion plan to allot time for a class discussion of these materials. During your discussion emphasize the complexities of the deep-sea mining issue from both a social and ecological perspective.

Key Words

effluent - something that flows out or forth, often used in conjunction with waste products

environment - the total of living and non-living circumstances surrounding an organism or group of organisms

manganese nodule - ocean floor "rocks" rich in manganese, iron and other minerals

non-renewable resource - a useful item which once used is no longer available to humankind

phytoplankton - plant plankton

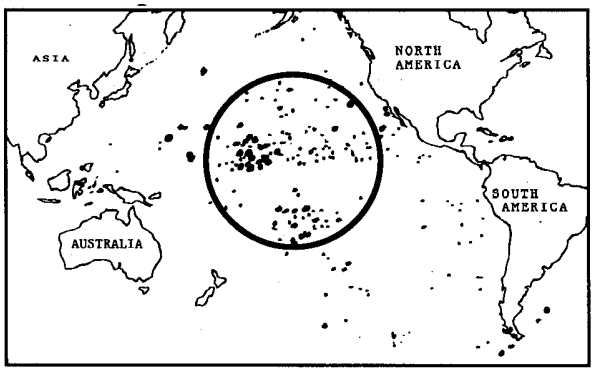
sediment - material that has been deposited on the bottom of a body of water

Extensions

1. An excellent overview of this one thousand billion dollar game of international intrigue was produced for Public Television by the NOVA series. The documentary, entitled "Cashing In On The Ocean" is available from Time-Life Films in 16mm and video-tape formats. The complete transcript of the show is also available from NOVA, WGBH Boston (125 Western Avenue; Boston, Massachusetts 02134) for $2.00.

Answer Key

1. a. The area of greatest interest to prospective miners is that in which the nodule concentration is the greatest. That area is circled on the map below.



b. While the reasons for the choice will vary, most students will base their choice on consideration related to the density of nodules.

2. The approximate value of the manganese nodules in the test area is $50 trillion (50,000,000,000,000).

(i.e.. $\frac{10 \times 10^6 \text{ dollars}}{\text{square mile}} \times \frac{5,000,000 \text{ mi}^2}{}$)

What does this figure mean? You might have your students calculate the number of fancy cars, houses, etc. For example, you could buy 1,000,000,000 cars at $50,000 each. An ultra fancy car for one out of every four people on the face of the earth.

The average cobalt content will likely be less than 1%. We are none-the-less talking about a giant sum of money.

3. A non-renewable resource is a useful item which once used is no longer available to humankind. Non-renewable resources include fossil fuels, metals, and similar finite items. Renewable resources, for example timber, can be regenerated by nature with human help. The definition of non-renewable resource must come from context clues.

4. Your students will be able to suggest a variety of problems that may be caused by deep-ocean mining systems. Perhaps the most obvious problem lies in the fact that any animals or plants living on the bottom are sucked up by the collector. Other problems (reduced light for photosynthesis, increased damage from fine particles, etc.) may be anticipated at the surface as well as on the bottom. This question is designed to start your students thinking about the possible effects of such deep ocean mining systems.

5. a. In a one hour period, the Cobalt Blue will mine 208.33 tons.

(i.e.. $\frac{5{,}000 \text{ tons}}{\text{day}} \times \frac{1 \text{ day}}{24 \text{ hours}} = 208.33 \text{ tons/hour}$)

b. In a year of 300 work days, the Cobalt Blue will recover 1,500,000 metric tons of nodules.

(i.e.. $\frac{5{,}000 \text{ tons}}{\text{day}} \times \frac{300 \text{ days}}{\text{year}} = 1{,}500{,}000 \text{ tons/year}$)

6. a. In a 300 day work year, 66,600 acres will be skimmed by the Cobalt Blue.

(i.e.. $\frac{222 \text{ acres}}{\text{day}} \times \frac{300 \text{ days}}{\text{year}} = 66{,}600 \text{ acres/year}$)

b. In a year of 300 work days, 15,000 acres will be compacted by the treads.

(i.e.. $\frac{50 \text{ acres}}{\text{day}} \times \frac{300 \text{ days}}{\text{year}} = 15{,}000 \text{ acres/year}$)

c. The total number of acres skimmed and compacted by the Cobalt Blue each year is 81,600.

(i.e.. 66,600 acres skimmed + 15,000 acres compacted = 81,600 acres)

7. a. In a 300 day work year, 10,800,000 tons of sediment would be sucked up by the mining system.

$$\text{(i.e..} \quad \frac{36{,}000 \text{ tons}}{\text{day}} \times \frac{300 \text{ days}}{\text{year}} = 10{,}800{,}000 \text{ tons/year)}$$

b. In a 300 day work year, 518,100 pounds of living plants and animals would be sucked up by the mining system.

$$\text{(i.e..} \quad \frac{1{,}727 \text{ pounds}}{\text{day}} \times \frac{300 \text{ days}}{\text{year}} = 518{,}100 \text{ pounds/year}$$

8. In a 300 day work year, 300,000 tons of sediments are released at the surface.

$$\text{(i.e..} \quad \frac{1{,}000 \text{ tons}}{\text{day}} \times \frac{300 \text{ days}}{\text{year}} = 300{,}000 \text{ tons/year)}$$

By now the purpose of these mathematical manipulations should be obvious: to impress upon your students the enormity of the project contemplated.

9. Your students may have a variety of thoughts regarding what will happen to the sediment. The majority of the sediment will eventually sink: what happens to it before it sinks and what happens to the organisms and objects upon which it settles are the questions being studied by oceanographers.

10. The increased sediments affect plant growth by reducing the light available for photosynthesis.

11. Your students may have a variety of suggestions regarding how fish respond to the sediment discharge. Evidence seems to indicate that most fish will leave the area. (In this respect, fish have an advantage over many bottom dwellers). If commercially valuable fish species (like tuna, bill fish, etc.) leave the area, mining may have an adverse effect upon the fishing industry.

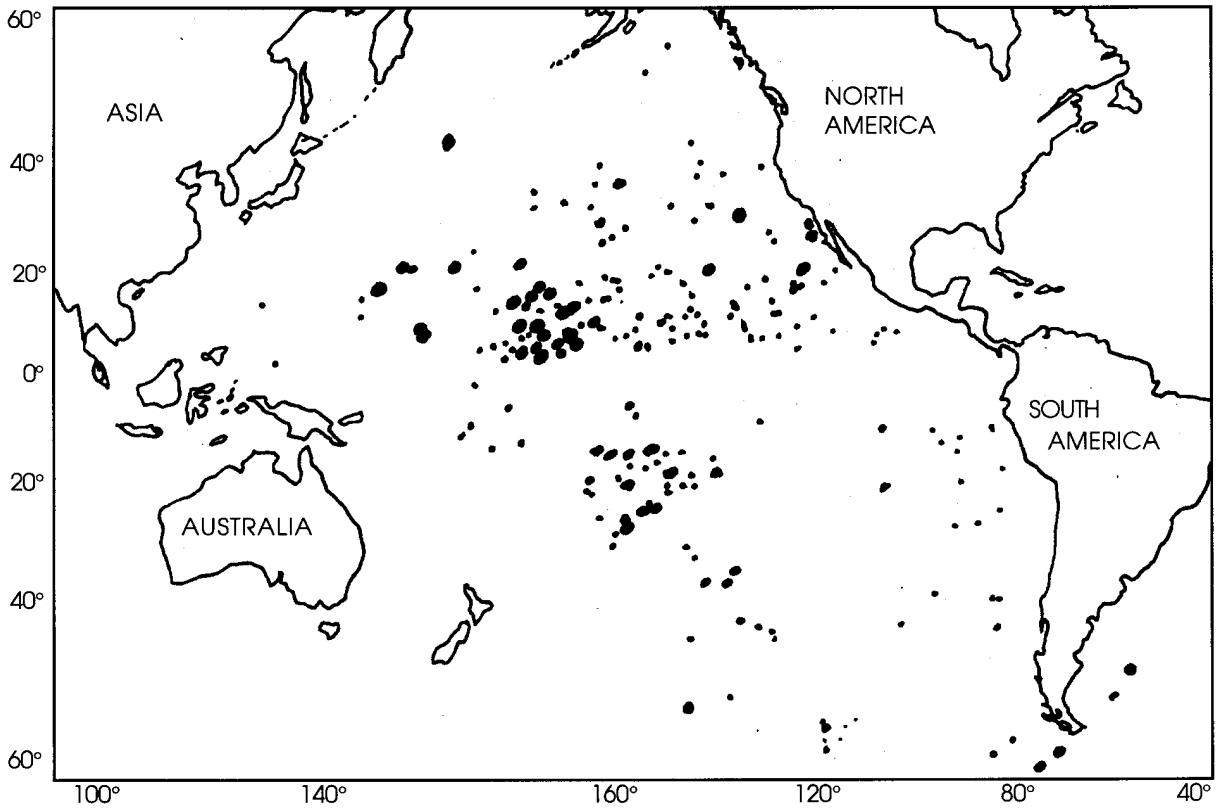
12. If microscopic animals do indeed cause manganese nodules, the most obvious effect of mining which destroys the animals living on the bottom may be that no new nodules will be formed.

13. The statement that disturbances on the bottom will have little effect on the surface fails to view the ocean as an integrated whole. The fact that a one month study shows no effect on the surface cannot be construed to indicate that a multi-year mining program will similarly have no effect. In short, the statement appears, to this author, to be an unreasonable conclusion. Your students may have a variety of opinions. You should note that this question does, in fact, ask for an opinion. As such, there are no right or wrong answers. In your discussion of this question review the dangers in making a long term prediction from highly limited data.

Answer Key - Getting the Word Across

1. NO**D**ULES
2. COLL**E**CTOR
3. EFFLU**E**NT
4. **P**LUME
5. EGG**S**IZE
6. S**E**DIMENT
7. **M**ANG**A**NESE
8. L**I**GHT
9. PLA**N**KTON
10. FILT**E**RING
11. NON**R**ENEWABLE

Mining the Ocean Floor



For thousands of years, the sea-bottom was a mystery to humans. People wondered what lay on the bottom. Occasionally, storms would produce strange and interesting mysteries from the depths. Slowly, humans began to develop tools for exploring the deep ocean. One hundred years ago, the British research vessel HMS *Challenger* brought up strange "rocks" from the ocean floor.

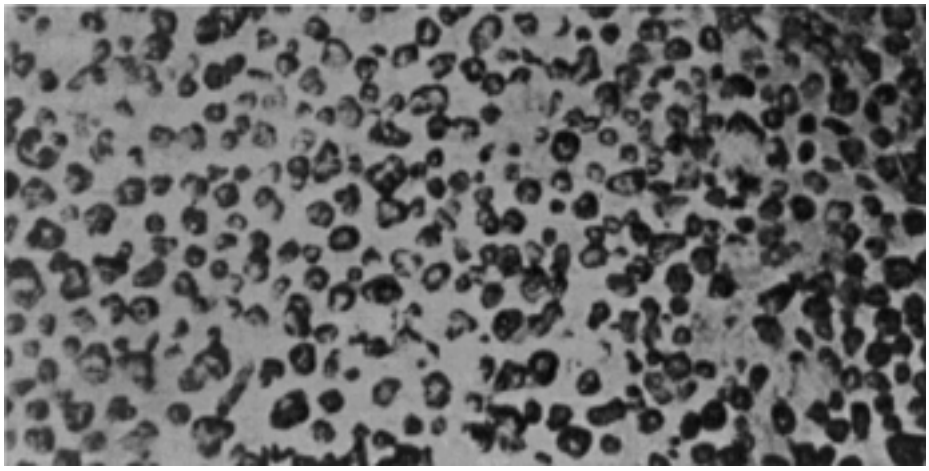
What were these potato-shaped "rocks"? They were not pretty. Study showed that the special "rocks" were rich in iron and manganese.

Today we call the "rocks" manganese nodules. Some are small enough to fit under a fingernail. Most of those seen with underwater cameras are eggsize and larger. They lie in a single layer on the ocean floor. In some places they are widely scattered. All together manganese nodules are estimated to cover 25% of the sea floor.

1. a. As President of SEA-MINE Inc., you wish to mine manganese nodules. On the map above circle the area in which you would begin mining.

b. Why did you choose the area you circled?

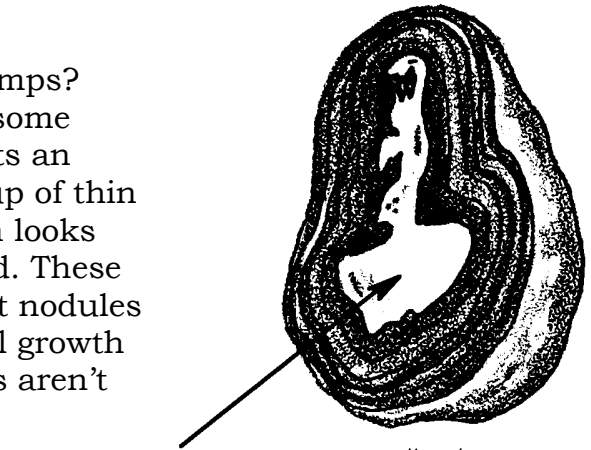
In some areas, the ocean floor is covered with manganese nodules.



The nodules differ in their make-up from area to area. They are largely iron and manganese with small amounts of copper, nickel, and cobalt. The small amounts of copper, nickel and cobalt are what interest mining companies. These metals are important to industry. They are also valuable. For example, if the nodules contain only one percent cobalt their value runs to over $10 million per square mile.

2. The three deep mining test sites currently being explored cover about 5 million square miles of ocean floor. If the average cobalt content is 1%, what is the approximate value of the manganese nodules in the test area?

What is the origin of these valuable lumps? Scientists are not sure but they do have some ideas. A cross-section of a nodule presents an interesting pattern. The nodule is made up of thin layers of varying colors. The cross section looks something like an onion sliced end-to-end. These rings have helped convince scientists that nodules grow. (The growth is more like salt crystal growth than plant or animal growth. The nodules aren't thought to be alive).

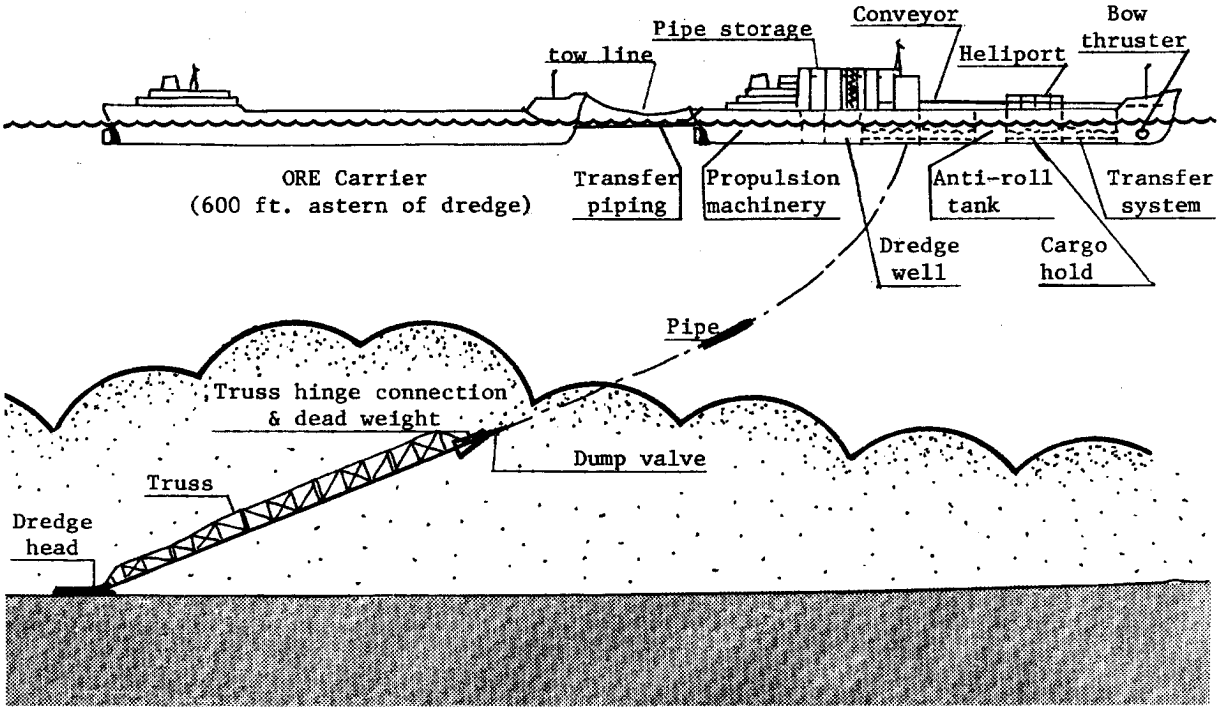


Manganese Nodule

There are more questions about nodules than there are answers. Nodules are older than the sediments on which they sit. How do they remain on top? What keeps them from being buried under new sediments? What determines the chemical composition of nodules? What is the role of animals in nodule formation? Some nodules are formed around prehistoric shark teeth. Microscopic organisms add to the growth by building homes on the nodule surface. What is the rate of growth? If the growth rate is as slow as it appears, we must consider the nodules as a "non-renewable" resource, at least for many generations.

3. What is meant by a "non-renewable" resource?

What does the future hold? The first deep ocean mining system has been tested. The system reaches down through miles of water to scoop up manganese nodules from atop the sediments. Most deep-sea mining systems are similar. A collector, or dredgehead, travels along the sea floor. The collector sucks in nodules, surface sediments, and whatever else lies in its path. The materials are pumped to a ship at the surface. The waste products, or effluent, are discharged at the bottom and at the surface. The bottom discharge is called a benthic plume. The drawing below shows a typical deep ocean mining system.

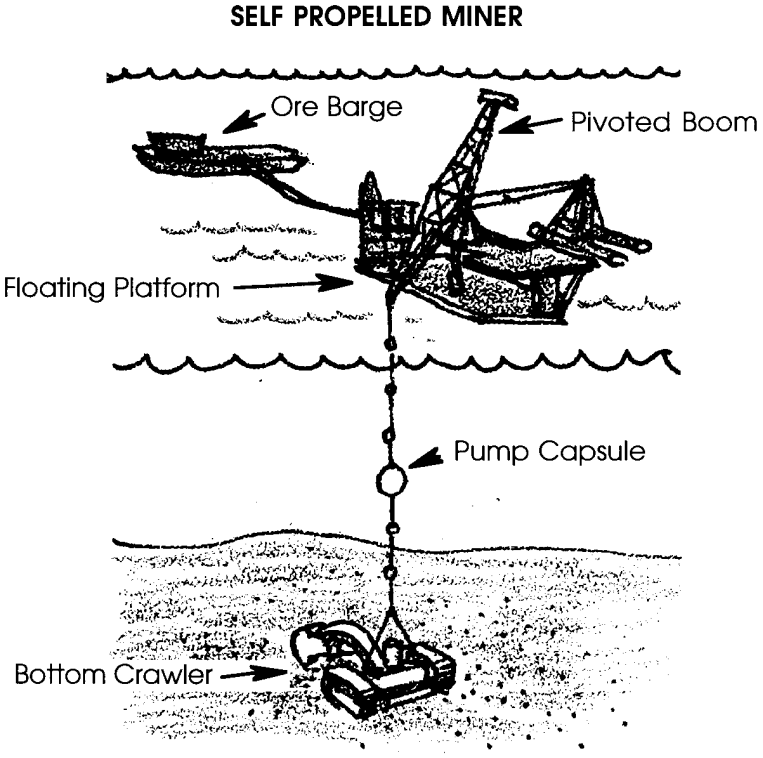


4. What is one possible problem the deep ocean mining system may cause?

Such mining ships will each recover 5,000 to 10,000 metric tons of nodules a day. They will be operating 24 hours a day, about 300 days per year.

5. a. The *Cobalt Blue* deep ocean mining system can recover 5,000 metric tons of nodules a day. How many tons will it mine in one hour?

b. How many tons will the *Cobalt Blue* recover in a year of 300 work days?



To recover 5,000 tons of nodules, a mining system will have to skim the top from 222 acres of ocean floor. During the process 50 acres of ocean floor will be compacted by the treads of the collector.

6. In a 300 day work year:

   a. How many acres will be skimmed by the *Cobalt Blue* ?

   b. How many acres will be compacted by the treads?

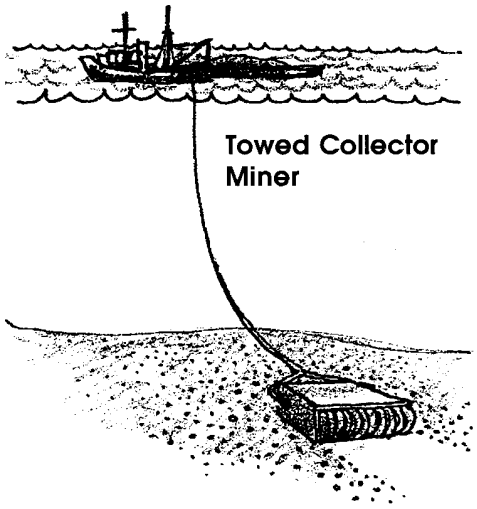
   c. How many acres total will be skimmed and compacted by the *Cobalt Blue* each year?

Along with the nodules, the mining system would also suck up 36,000 tons of sediment, 1,727 pounds of living plants and 3,530,000 cubic feet of water. Most of this would be spurted back into the lower layer of the sea.

7. In a 300 day work year:

   a. How many tons of sediment would be sucked up by the mining system?

   b. How many pounds of living plants and animals would be sucked up by the mining system?



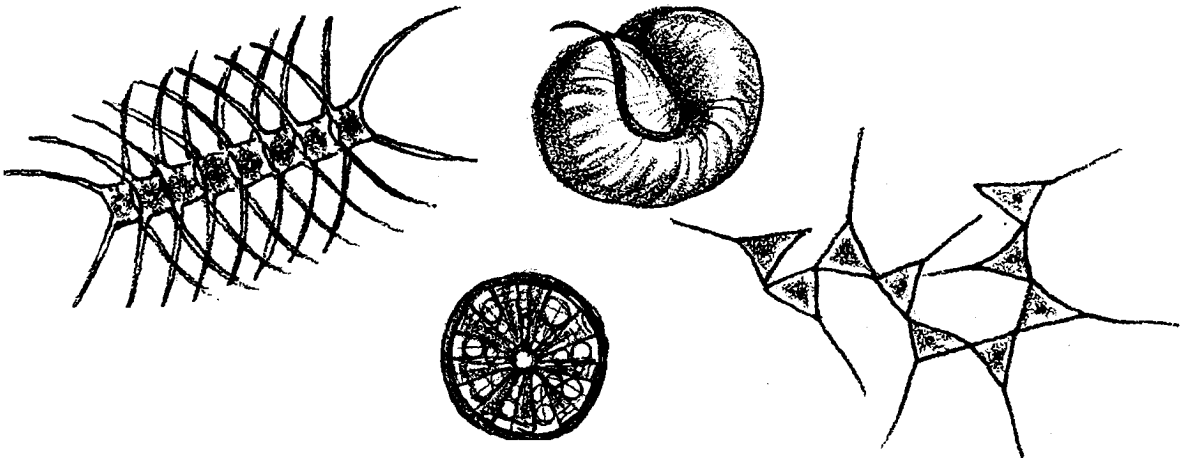
Not all of the effluent is spurted back into the lower layer of the sea. At the surface, 1,000 metric tons of sediment, 50 tons of crushed nodules, 51 pounds of plants and animals, and 706,200 cubic feet of water are released.

8. In a 300 day work year, how many metric tons of sediment are released at the surface?

9. What do you think will happen to the sediment?

It is clear from the amount of materials moved that deep-sea mining will have some important effects on life in the sea. Let's first look at some of the concerns scientists have about the surface effluent.

Sediments brought to the surface by mining would greatly reduce light penetration into the upper waters. The microscopic plants, called phytoplankton, which form the basis for all life in the sea need light. Without light the plants can't grow. Without plants, the animals can't live.



Light penetration will increase as soon as the mining system passes. Within 24 hours, the water will clear enough to allow about 50% of the normal growth. The effect of the sediments will be felt within about 100 kilometers (60 miles) of the miner.

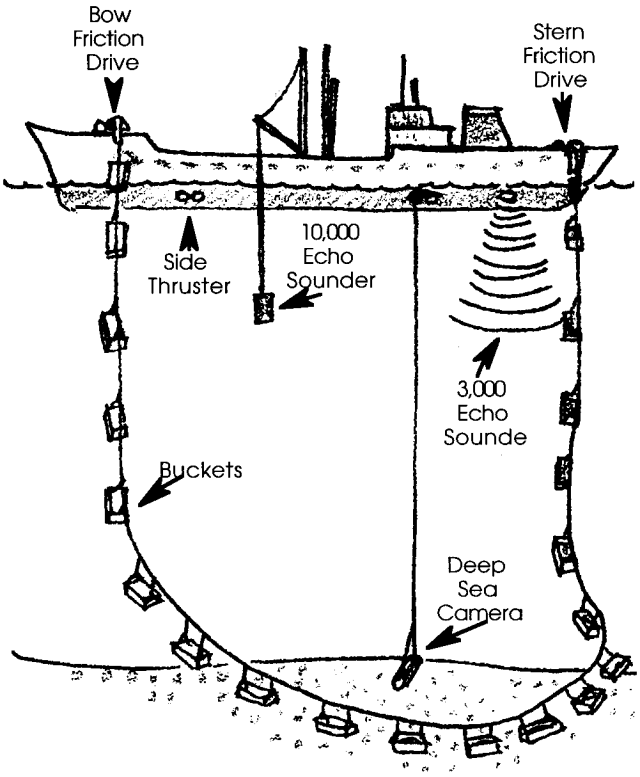
10. How do the increased sediments affect plant plankton growth?

The sediment particles may clog the breathing and feeding parts of marine animals. Microscopic animals which feed by filtering may help the sediment to settle faster.

11. What is one way in which fish may respond to the sediment discharge?

The long term effects of surface sediments on the food chain of the ocean are unknown. What do we know about the bottom sediments? The ocean bottom is a stable environment Things on the bottom change very slowly. As a result, plants and animals on the bottom probably cannot stand sudden changes. The plume of bottom sediments might choke bottom life. The 1,727 pounds of plants and animals sucked up each day will definitely be affected. The homes of other animals will be destroyed by the blanket of sediment. Other effects remain to be seen.

12. Some scientists believe that microscopic animals may cause manganese nodules. If this is true, what might be one long term effect of mining which destroys the animals living on the bottom?



Continuous Line Bucket System

Scientists working with deep-sea mining feel it is important to know what ecological upset will be caused by the destruction of bottom animals and plants **before** large scale mining begins. As one scientist said, "There will be damage to bottom animals and plants; there's no way around that". To reduce the damage, we had better go forth into the sea armed with the knowledge of just what it is that we are doing.

13. One early study of deep-sea mining stated "it appears from study so far that disturbances at the ocean bottom will have little, if any, effect on the surface." In view of the interrelationships that exist within the sea, do you think this is a reasonable conclusion? Please explain your answer.

GETTING THE WORD ACROSS

Directions: Using the clues at the bottom of the page, complete the spelling of each word.

1. _ _ D _ _ _ _ _
2. _ _ _ _ E _ _ _ _
3. _ _ _ _ _ E _ _
4. P _ _ _ _
5. _ _ _ S _ _ ___
6. _ E _ _ _ _ _ _ _
7. M _ _ _ A _ _ _ _
8. _ I _ _ _
9. _ _ _ N _ _ _ _
10. _ _ _ _ E _ _ _ _
11. _ _ _ R _ _ _ _ _ _ _ _ _

1. These special “rocks” are rich in iron and manganese.
2. On the miner, the_____sucks in the nodules.
3. The waste products discharged from a deep-sea miner.
4. The bottom discharge of wastes is called a benthic_____.
5. On the underwater camera, most of the manganese nodules appear to be_____.
6. Solid matter which settles out of a liquid.
7. The nodules which deep-sea miners are searching for are made mostly of iron and_____.
8. Without _____, which sediments reduce, ocean plants can’t grow.
9. Microscopic plants living in the ocean are called phyto_____.
10. Microscopic animals that feed by _____ may help the sediment settle faster.
11. If the growth rate is as slow as it appears, nodules are a _____resource, at least for many generations.