Before this article appeared in March 1979, it was circulated for critical review of content and fairness to the Arctic Environmental Information and Data Center and the Institute of Marine Science (both University of Alaska); the Office of the Mayor, North Slope Borough; Greenpeace Alaska; Sohio Petroleum; and the Alaska Department of Fish and Game.

That is the way things stood in Spring 1979. So now you can do some updating of your own with the class. Find out: What was the bowhead whale quota for this year? How many bowhead were taken last year? What is the role of the Eskimo Whaling Commission today? What have scientific/biological studies revealed for bowhead populations over the past five years? What steps have the oil companies taken to lessen impact on the whales?
**ACROSS**

*1. For many years, only the Native people of Alaska have been allowed to ____ the bowhead for subsistence.*

*5. In 1977, the IWC ordered the (1 across) to ____.*

*9. The only whaling culture left in Alaska today is that of the northern ____ (first 4 letters).*

*10. One of five commercial whaling nations that still has not joined the IWC pact.*

11. As good ____ gold.*

12. Great American poet and scary story writer, Edgar Allan ____.*

14. Short for the middle name of (12 across).*

15. Not wet, but ____.*

*17. Tiny shrimp-like organisms called ____ are the main food source for baleen whales.*

19. Each (abbr.)*

21. Most Wanted (init.)*

*22. The largest creature ever to live on earth.*

25. What the crow says.*

28. Short laugh.*

29. Estimated Time of Arrival (abbr.).* 

31. Fifth letter of the alphabet - twice.*

32. An island in the western Aleutians, occupied by the Japanese during World War II.*

*34. The Eskimos argue that international ____ should not apply to subsistence hunting.*

*36. Shelter at a whaling camp is a ____ pitched on the ice.*

*37. Another word for international agreement, such as that in the IWC treaty (see 10 across for a clue).*
*1. Three whales found in northern polar waters and nowhere else are the narwhal, beluga, and the bow______.
*2. A member of the IWC, but still one of the largest commercial whaling nations.
3. North Korea (init.)
4. The part of the iceberg you see.
*5. When the IWC set a quota of 12 bowheads for Eskimo subsistence hunters, it also allowed commercial whalers to take 6,500 ____ whales.
6. Too easy (init.)
7. Not written, but spoken - as in an ____ test.
*8. It takes a lot of teamwork to ____ a whale up onto the ice.
13. Modern slang for "All right."
16. Biblical word for "All right."
*18. International group formed to conserve the whales and control commercial whaling (init.)
*20. Once a great whaling culture, the ____ people no longer hunt whales for subsistence.
23. Some people ____ spinach.
24. Latin for "and."
*25. Eskimo group formed to regulate their own whale hunt (init.).
*27. No one knows for sure, but the bowheads are believed to spend the winter in the south ____ Bering Sea.
30. High mountain (think of Switzerland).
*33. Bowheads weight over a ____ (abbr.) a foot.
35. Alaska Airlines (init.)
Directions: Cut out and match the numbered pictures with the descriptions. Then make flash cards!
12. JUNIPER - low, spreading evergreen shrub, leaves in groups of three; most widely distributed conifer in the world.

13. TAMARACK - small to medium-sized Interior deciduous tree with clusters of needles on very short branches; also called larch or hackmatack.

ASPen - leaves with slender, flat stems; smooth whitish or greenish gray bark.

ALASKA CEDAR - medium-sized evergreen found in Southeast and southcoastal Alaska; scale-like leaves; short, almost round cones; similar western red cedar found in southern Southeast Alaska.
LODGEPOLE PINE - small to large Southeast evergreen; needles often twisted two to a bundle; egg-shaped cones $\frac{1}{4}$ to 2 inches long.

WILLOW - 33 deciduous species in Alaska ranging from tiny tundra shrubs to small trees; long, narrow leaves; seeds in catkins.

ALDER - 4 deciduous species - 3 of which reach tree size; long male catkins; short female catkins; seeds in small, round cone-like structures; alder roots fix nitrogen from the air and enrich the soil.

POPLAR OR COTTONWOOD - medium to large deciduous tree with large, almost heart-shaped leaves; balsam poplar found in most of state except Southeast; black cottonwood found in Southeast and southcoastal, both species called poplar or cottonwood.

BIRCH - 2 deciduous shrub and 3 tree species in Alaska; the shrubs have round toothed leaves, and the trees have pointed toothed leaves; bark of paper birch used for canoes, baskets, tinder.

BLACK SPRUCE - small, Interior coniferous tree; short sparse branches, short pointed needles; small, short, egg-shaped cones hanging downward, generally found in bogs and moist areas.
WHITE SPRUCE - medium to large-sized Interior conifer; short-stalked needles; cylindrical cones hanging down; skunk-like odor when twigs and needles are crushed; grows on well-drained sites.

WESTERN HEMLOCK - large conifer with soft, flat needles; small 5/8 to 1 inch cones hanging down; the similar mountain hemlock is gnarled and twisted and much smaller.

SITKA SPRUCE - large to very large Southeast and south-coastal conifer; short-pointed needles; 2 to 3½ inch cones hanging down; State Tree.
Wood and Wood Products Inventory

WOOD AND WOOD PRODUCTS INVENTORY

What products of trees are found in and around your house?

<table>
<thead>
<tr>
<th>NAME OF ITEM</th>
<th>USE</th>
<th>ORIGIN (IF KNOWN)</th>
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</thead>
<tbody>
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<td>21.</td>
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<td>22.</td>
<td></td>
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<tr>
<td>23.</td>
<td></td>
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</tbody>
</table>
Log Those Trees

There are three types of logging: clearcutting, seed tree selection, and single tree selection. Read the descriptions and fill in these terms. (Hint: the blanks in the description have the same word roots as the type of cutting.)

1. _____________

A large area is cleared leaving well-spaced _____________ trees. Sometimes fertilizer is added to speed growth. When new growth is established, the _____________ trees are cut. Some of the trees may need to be thinned (cut down) to promote vigorous growth of the trees that are left.

2. _____________

One area is cleared completely. The _____________ area can be planted with young trees or left to reseed from adjacent trees. Once the _____________ block begins to grow, another nearby area can be cut.

3. _____________

Selected trees of various ages are cut, leaving a thinner but even-aged forest. Natural reseeding occurs. But additional planting may be necessary. When the young growth is well-established, the older trees can be cut.
4. Both numbers ___ and ___ above are types of selecting cutting because _________________.

5. Trees need light, water, sun, nutrients and space to grow rapidly. Sometimes foresters will thin a forest to help the best-looking trees grow faster. Thinning means _________________.

6. Trees are a renewable resource because _________________.

7. Foresters have to figure out the sustained yield for the forest, or how much can be harvested year after year so that there will still be trees for future generations. The amount of lumber that can be cut in any one year is called the allowable cut. Use these two underlined terms in a sentence to show that you know what they mean.


8. One of the main problems with logging is that it creates soil erosion. If topsoil is lost, new trees have difficulty finding a good place to grow.

This area is part of a proposed clearcut. Circle the trees you would leave so that there will be only minor soil erosion.
Directions: Tear apart these squares and place them in the proper sequence on another piece of paper—drawing arrows from one to another. (Hint: There are several different routes.)

<table>
<thead>
<tr>
<th>Paper mill</th>
<th>Pulp</th>
<th>Trim branches and top</th>
</tr>
</thead>
<tbody>
<tr>
<td>Book Store</td>
<td>Tree seeds</td>
<td>Logging truck</td>
</tr>
<tr>
<td>Office Supplies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grocery Store</td>
<td>Log boom</td>
<td>Attach choker chain</td>
</tr>
<tr>
<td>Lumber Store</td>
<td>Off to Japan</td>
<td></td>
</tr>
<tr>
<td>Scrap lumber</td>
<td>Your summer job planting trees (draw a picture)</td>
<td></td>
</tr>
<tr>
<td>Full-grown Tree</td>
<td>Lumber and pulp mill</td>
<td></td>
</tr>
<tr>
<td>Tree seedling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Your house (draw a picture)</td>
<td>Skidder hauls to road or tidewater</td>
<td>Timber!</td>
</tr>
</tbody>
</table>
As A Fisheries Biologist

You've just landed a job as a fisheries biologist for the U.S. Forest Service. Your first assignment is to help set up a timber sale. You need to draw up a list of practices that will help protect fish habitat during and after logging.

Here is some information from the Logging and Fish Habitat pamphlet you found on your desk, which may help:

Debris in Streams

Excessive debris in streams can lower the quality of natural stream habitat by forcing streams underground, with resultant loss of rearing and wintering areas. It also blocks adult fish passage and covers suitable spawning beds. Small streams dammed up by logging debris can experience increased water temperatures and reduced oxygen levels. Both may be lethal to fish.

Debris such as bark, needles and small twigs covering the streambed reduces the abundance and variety of insects, thus limiting the capability of streams to support young fish.

Falling and yarding timber away from streams or leaving a fringe of windfirm timber along the streams are ways of avoiding debris in streams.

Stream Cleanup of Logging Debris

If debris and logs do end up in the stream, prompt cleanup is usually necessary to avoid the problems to fish habitat that can result from logs and slash in streams. The best method of protecting a stream is to keep logging debris out of it in the first place. Natural debris in streams that has become a part of the stream environment and is not a block to fish passage should be left in place. For instance, some logs not creating blocks
should be left in place, to afford protection from predators for the young and adult fish in the stream. Although timber sale contracts call for removal of any trees that are dropped into streams, blowdown logs across a stream or those logs that have become partially buried in a stream usually should be left in place by a stream clearing crew—as long as the logs do not create an obvious block to fish passage.

Bank Damage

Stream banks can be damaged by yarding logs from or across the stream, by locating roads too close to the water, or by equipment improperly crossing or working in the stream.

Equipment improperly crossing small streams can often cause the stream to spread out. If this occurs, the stream may be forced underground at low flow, resulting in a blockage to fish as well as a loss of habitat.

Damage to stream banks can be minimized by yarding logs fully suspended above the stream, by using proper stream crossing structures, by orienting road-crossings at right angles to streams, by restricting equipment use in streams, and by leaving a timber screen between the road and the stream if the situation is critical enough to warrant it. In short, stream banks should be left intact if development activity is taking place in the area.

Sedimentation

Many potential sources of sedimentation exist. V-notches and roads are just two examples. Numerous V-notches are encountered in logging areas of southeastern Alaska. These V-notches result from old or current streambeds, and are generally unstable and steep.

If they become clogged with debris or are otherwise disturbed, the potential for soil sliding and erosion increases. Sedimentation from V-notches can be minimized by restricting cutting in critical areas, and by full suspension of the logs while yarding in or near the V-notch.
Roads may expose some bare soil to erosion. This erosion can occur on cut slopes, ditchlines, or from sidecast or wasted material. The type of soil, the steepness of slopes and the steepness of road grades all influence erosion potential. Properly engineered road grades, alignment, cut slopes, waste areas, and culverts or cross drains will minimize the amount of sediment from roads. Maintenance can be just as critical as the initial construction. Revegetated slopes will decrease the area of bare soil subject to erosion. Natural "filter strips" between streams and roads can allow removal of much of the sediment carried by ditch runoff before it can enter the streams. On extremely steep slopes, completely avoid logging and its accompanying roads.

**Blocked Fish Passage**

Poor culvert installation can block fish passage, thereby eliminating upstream rearing areas for young fish as well as upstream spawning areas for migrating adult fish. Blockage occurs when the culvert outlet is inaccessible, or the culvert is too steep or too small. Culverts should be removed from abandoned roads.

Fish passage can be maintained by installing properly engineered culverts, and by excavating to the natural streambed when removing culverts. The velocity of water flowing through a culvert, which allows salmonids to move upstream, should be no greater than 1.3 feet per second.
Now, write some guidelines for the timber sale that will protect the fish habitat.

1. 

2. 

3. 

4. 

5. 

6. 

7. 

8. 

9. 

10. 

11. 

And be sure to visit the proposed timber sale site to see if there are any site-specific rules that should be followed.
Graphing Deer Use of Clear Cuts

1. All plant communities are constantly growing and changing until they reach their climax stage of vegetation. Draw this succession in a Southeast Alaska forest after a clearcut.

```
<table>
<thead>
<tr>
<th>Time (years) after clearcutting</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>50'</td>
</tr>
</tbody>
</table>
```

Year
before cut = old-growth forest (height variable to 150')
0 = clearcut (height = 0)
50 = grass, shrubs and seedlings (height 25-50')
100 = trees (height = 75-100')
150 = trees (height = 100-125')
200 = trees (height = 125-150')
250 = trees (height variable to 150')
300 = trees (height variable to 150')

2. Here are two drawings of an even-aged stand of trees and an uneven-aged stand of trees.

```
even-aged forest (70 years old)  uneven-aged forest (300 years old)
```

a. Which stand has the most diversity?

b. Which stand has the most deer food?
3. To discover deer use of clearcuts and old-growth forests, biologists counted pellet groups in 1x10 meter belt transects. Here are some transects that were set up in an old-growth forest. Count the pellet groups in these three belt transects.

How many pellet groups are in belt transect A? _____ (a)

in belt transect B? _____ (b)

in belt transect C? _____ (c)

What is the average number of pellet groups for each one meter square plot? _____ (d)

Biologists list their results in numbers of pellet groups per hectare. A hectare is 100 meters x 100 meters. What is the average number of pellet groups per hectare in this old-growth forest example? _____ (e)

4. Here are the biologists' results in clearcuts and adjacent old-growth forests. They generally sampled 6 transects of 50 plots in each area.
4. Here are the biologists' results in clearcuts and adjacent old-growth forests. They generally sampled 6 transects of 50 plots in each area.

<table>
<thead>
<tr>
<th>Area number</th>
<th>Age of clearcut</th>
<th>Fall Groups/ha</th>
<th></th>
<th>Fall Groups/ha</th>
<th></th>
<th>Spring Groups/ha</th>
<th></th>
<th>Spring Groups/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>new growth</td>
<td>old growth</td>
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<td>new growth</td>
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<td>new growth</td>
<td>old growth</td>
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<tr>
<td>1</td>
<td>0</td>
<td>300</td>
<td>187</td>
<td>643</td>
<td>383</td>
<td>383</td>
<td>383</td>
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<tr>
<td>2</td>
<td>4</td>
<td>91</td>
<td>350</td>
<td>343</td>
<td>1,223</td>
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<td>3</td>
<td>6 - 10</td>
<td>390</td>
<td>1,667</td>
<td>1,667</td>
<td>1,667</td>
<td>1,667</td>
<td>1,667</td>
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<tr>
<td>4</td>
<td>7 - 10</td>
<td>137</td>
<td>1,370</td>
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<td>20</td>
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<tr>
<td>9</td>
<td>30 - 34</td>
<td>168</td>
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<td>10</td>
<td>33 - 37</td>
<td>217</td>
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<td>13</td>
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<td>43</td>
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<td>57</td>
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<tr>
<td>18</td>
<td>85 (burn)</td>
<td>62</td>
<td>577</td>
<td>90</td>
<td>1,570</td>
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<td>1,570</td>
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<td>287</td>
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<td>1,570</td>
<td>1,570</td>
<td>1,570</td>
</tr>
<tr>
<td>20</td>
<td>147 (burn)</td>
<td>50</td>
<td>340</td>
<td>217</td>
<td>1,387</td>
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</table>

What is the average of the fall clearcut pellet densities?  
_______ (a)

...fall old-growth pellet densities?  
_______ (b)

...spring clearcut pellet densities?  
_______ (c)

...spring old-growth pellet densities?  
_______ (d)
5. Read your graphs to figure out at what age forests reach their climax, or old-growth, stage.

6. The present Tongass National Forest policy allows for timber harvesting every 100 years in an area. Go back and mark the 100-year rotation on each of your three graphs. If the forests continue to be cut every hundred years, what will this mean to deer populations in Southeast Alaska?
3G

Birds in the Old-Growth Forest

The best way to find out what happened in a research project is to look at the data and interpret it for yourself. Here is some information from a pamphlet by Dr. Winifred Kessler entitled Bird Population Responses to Clearcutting in the Tongass National Forest of Southeast Alaska, published by the U.S. Forest Service. It studies breeding bird populations in the Tongass, which is the largest national forest in the United States. Forestry practices bring about major, long-lasting habitat changes and this study was done to find out what the effects are on different species of nongame birds.

The study was done on Kosciusco Island. Most of the trees are western hemlock and Sitka spruce. Much of the island has been clearcut so there is great variety in the age of stands there. Dr. Kessler studied bird use in six stands of different successional stages:

Key: 1. Recent clearcut, less than 5 years;
2. Shrub/sapling, 11 years;
3. Sapling/shrub, 17 years;
4. Pole trees, 30 years;
5. Young sawtimber, 80 years; and
6. Old growth, well over 150 years.

Dr. Kessler and her assistant laid out four 300-meter transects in each stand. They walked each transect 12 times over a period of seven weeks from May 30 to July 17, 1978. At every 20 meters, they would stop and listen for five minutes, recording birds seen or heard along the transect.

Here are simplified graphs of some of their results:
The first 14 graphs show population levels of the forest's most common species in six stages of hemlock/spruce forest during summer 1978, Kosciusko Island, Alaska. The last graph shows the total population level of birds in each stand. The population level is defined by Dr. Kessler as the "mean number of bird observations per transect per visit." For example, winter wrens were counted along the four transects in each stand on each of the 12 visits, so there were 48 wren counts to use in figuring the mean for each stand. In the "recent clearcut, less than five years" stand, the mean turned out to the 1.89—that is, there was an average of 1.89 winter wrens observed at each transect on each visit. This shows up on the winter wren graph as a bar very close to the 2.0 mark.

1. Which populations of birds are greater in the 11-year stand than in the old-growth forest? Which are smaller? (Tiny changes in the bars don't count in this kind of study.)

2. What is the most common bird in the recent clearcut stand? In the sapling/shrub 17-year stand? In the 80-year saw-timber stand?

3. Which two species would have the most trouble if there were no forests 80 years or older?

4. Is the total population of birds highest in a newly cut stand, a mid-successional stand, or in the old-growth forest?

5. Would the total population be highest in the same successional stage if the study were done elsewhere?

6. In the 80-year stand, there is not much shrubbery because the treetops form a thick canopy that blocks out light from the forest floor. There is a much greater variety of plants both in the younger stands and in the old-growth stand. How might this effect bird populations in the 80-year stand?

7. Here is another table from Dr. Kessler's report. It includes the birds on the graphs and several less common species. For this table, birds listed as increased by clearcutting are those that are considerably more numerous in one or more stages of forest succession than in the old-growth forest. Species listed as decreased by clearcutting are those that are absent or rare in some of the stages after logging. Those for which this study did not provide sufficient data are listed as inconclusive.
It is important to note that some species dependent on old-growth may not be listed at all either because of nocturnal habits or because they are so rare and have such broad ranges that they may be present in the forest but never have been in the study area while counts were taken. These species include the goshawk, great gray owl, pygmy owl, northern three-toed woodpecker and several others. Most of them are cavity nesters, dependent on snags which are present—unless there is a policy of saving them during logging—only in old-growth forests.

Cut the pictures from the following page and place them under the proper columns. Use a field guide to help you. As you identify each bird, write down what type of habitat it nests in. Circle the 14 most common species, those listed in the previous chart.

Table 14. Effects of clearcutting on populations of bird species observed in logged and unlogged hemlock/spruce forest, Kosciusko Island, Alaska.

**BIRD SPECIES POPULATIONS**

<table>
<thead>
<tr>
<th>Increased by clearcutting</th>
<th>Decreased by clearcutting</th>
<th>Inconclusive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter wren</td>
<td>Chestnut-backed chickadee</td>
<td>Tree swallow</td>
</tr>
<tr>
<td>Orange-crowned warbler</td>
<td>Golden-crowned kinglet</td>
<td>Wilson's warbler</td>
</tr>
<tr>
<td>Dark-eyed junco</td>
<td>Townsend's warbler</td>
<td>Common raven</td>
</tr>
<tr>
<td>Fox sparrow</td>
<td>Varied thrush</td>
<td>Sharp-shinned</td>
</tr>
<tr>
<td>Steller's jay</td>
<td>Western flycatcher</td>
<td>hawk</td>
</tr>
<tr>
<td>Swainson's thrush</td>
<td>Yellow-bellied sapsucker</td>
<td></td>
</tr>
<tr>
<td>Ruby-crowned kinglet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>American robin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Song sparrow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hermit thrush</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8. Where do most of the birds found in the old-growth forest nest?

9. The following year, Dr. Kessler ran transects along streams and forest edges in both clearcuts and old-growth forests. Do you think she found more or fewer birds during the second study?

An important ecological fact is that wildlife tends to be most dense and diverse around bodies of water such as streams and along habitat edges between, for example, a forest and a meadow. So if you guessed that Dr. Kessler found more birds the second year you were correct. Dr. Kessler went on to say that stream habitats in Southeast Alaska seem especially important for cavity-nesting species. I found much greater abundance of these birds (such as woodpeckers, tree swallows, chickadees) along riparian areas. I also found species that show strong preference for riparian zones (song sparrows, western flycatchers, Lincoln's sparrows).

a. Just from your reading, what would you guess that "riparian" means?

b. Design a clearcutting plan for the drawing below that affects relatively few birds and animals. Circle the trees you would cut.
c. This time Dr. Kessler had enough observations to show that tree swallows increased with clearcutting, and that Wilson's warblers, the common ravens, and sharp-shinned hawks all decreased. Make the corrections by drawing arrows on your question no. 6.

d. Write down some questions of your own on the effects of clearcutting on birds, and then design a study to answer those questions.
Save that Snag!

One way that loggers can help preserve bird use of an area is by leaving snags. Figure out some of the reasons by matching these descriptions with the following pictures and placing them in the proper sequence.

1. At full maturity, a 300-year-old conifer provides nesting habitat for some bird species.

2. In and under the mushy remains of the old log, insects, snails and other small creatures find food and a good place to hide until woodpeckers and other birds begin to pick at them among the tree's rubble.

3. After the tree dies, bare branches provide perches for predators. A red-tailed hawk replaces the eagle atop the increasingly fragile crown.

4. After lightning and wind further break up the snag, other cavity nesters, such as downy woodpeckers, move in. Researchers have found that even snags that appear to be falling down are valuable for nesting.

5. As the bark loosens, foraging becomes easier for woodland species such as the brown creeper. Using its tail as a prop, the bird moves up and around a tree, searching for insects. Both brown creepers and winter wrens nest behind pieces of bark that curl out from the tree. Bats are also common around the dead tree at this stage.

6. Stripped clean, the bleached snag becomes an attractive nesting site for strong-billed woodpeckers. Their holes later provide homesites for other animals. Such creatures as flying squirrels, chickadees, and flickers often choose to live in these abandoned holes.

7. A century or more after the mature tree began to deteriorate, its insect-ridden stump remains a good food source for some wildlife. As it continues to break down into the soil, new trees sprout and the entire cycle begins anew.
8. Decomposed, soft and now heavily riddled with holes, the snag becomes a shelter for songbirds that lack the woodpecker's strong beak. With more passageways available for non-boring insects, invertebrate life becomes more diversified.

9. Eventually, the aging tree is attacked by diseases, fungi and boring insects. The insects attract small birds and the tree's crown is still strong enough to support an eagle's heavy nest.
What differences did you notice?

<table>
<thead>
<tr>
<th></th>
<th>CLEARCUT</th>
<th>OLD GROWTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stream conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish signs or sightings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal signs or sightings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bird signs or sightings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperatures</td>
<td>soil</td>
<td>water</td>
</tr>
<tr>
<td>Insects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trees and other plant species and heights</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
From Pterodactyls to Petroleum

How well can you predict the connections between pterodactyls and petroleum? Read the statements and write true or false in this handy prediction guide, then read the information and correct your guesses.

<table>
<thead>
<tr>
<th>Your Prediction</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

1. Some pterodactyls were as big as small planes.
2. At one time all of Alaska was under water.
3. Tremendous pressures changed the silt, sand and clay sediments into oil.
4. Petroleum means "rock oil."
5. Petroleum lies in great underground lakes.
6. To find oil, scientists look for sedimentary rocks.
7. Only one out of 20 wells drilled have produced enough oil to be profitable.
8. Special mud is used in the drilling operation.
9. Once oil is struck, it always has to be pumped out of the ground.

All pterodactyl art by Tim McKittrick, Dimond High School, 10th grade, Anchorage. From Alaska Tidelines Volume IV, No. 4. See credit on next page.
WHERE DID OIL COME FROM?

Start with this far-out flying reptile, which glided around in prehistoric times on wings made of skin attached to long-fingered arms in the best TV Batman fashion. It had a pointy head and a nose like a beak. And fossils show that it ranged from the size of a small sparrow to that of a giant with a wing-span like a Piper Cub. Its scientific name is pterodactyl (tair-oh-DACK-til), from the Greek petron meaning "wing" and dactylos meaning "finger."

In pterodactyl's day—say, 150 million to 65 million years ago—a warm, shallow sea stretched from what is now the Arctic coast of Alaska almost to the Gulf of Mexico (see Map #1). As billions of generations of pterodactyls, along with countless other forms of plant and animal life, lived and died over that enormous time span, their remains settled to the bottom of the ancient sea. There they were broken down by bacteria and covered over by silt, sand and clay.

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MAP #1: This is the way the North American continent is believed to have looked around 100 million years ago when much of the land was flooded by shallow inland seas.

MAP #2: Beneath the ancient seafloors, deep basins were formed by layers of sediment and decaying plant and animal life. This map shows 14 such sedimentary basins in Alaska that are of special interest to oil geologists.
Over the ages, layer upon layer of decaying material and debris crushed down upon each other, forming what are called sedimentary basins, thousands of feet deep (see Map #2). And in some mysterious way (which we still don't really understand and have never been able to copy), the great pressure, heat and dampness changed the once-living remains of pterodactyl and his like into oil and natural gas, while the silt, sand and clay were molded into rock. So the right name for the kind of oil we're talking about is petroleum (puh-TROH-lee-um), which comes from the Latin petra, meaning "rock," and oleum, meaning "oil."

HOW DO YOU FIND IT?

When you hear about oil "pools" and "reservoirs" (or oil "wells" for that matter), you might get the idea that petroleum lies in great underground lakes. But instead, as its name suggests, it is squeezed into tiny holes in the porous rock with which it was formed, very much like water soaked into a sponge. When this oil-bearing rock—usually sandstone or limestone—is surrounded by layers of hard rock, the oil is trapped and collects in large quantities (see sketch).

So to find the oil, scientists must first find the right kinds of rocks. They start by making surveys of surface formations, giving special attention to sedimentary basins left behind long ago by inland seas. They also look for earthquake faults or fractures that may have sealed in the oil. Complicated instruments give clues as to what kinds of rocks lie below. The seismograph (SIZE-mo-graf), for example, maps underground rock formations by measuring the time it takes for sound waves to bounce back.

But the only way you can tell for sure whether there is oil down there is to drill. And only one out of every fifty wells drilled produces enough oil to make it worth the effort.
Drilling is done from a tall rig or platform with a heavy-duty system of pulleys and blocks to handle long lengths of pipe that must be added as the hole gets deeper. That wicked-looking rotary drill bit (see sketch) works much like a dentist's drill.

A special kind of drilling mud flows down the hollow pipe to flush away rock cuttings as the drill grinds through the earth. This mud then rises through the outer shell casing to carry the rock chips to the surface, where they are screened out and checked for traces of oil. The mud also serves as the first line of defense against possible blowouts.

When oil is struck, the drill pipe and bit are pulled up and holes are punched in the casing for the oil to flow through. And it is pushed up the pipe by the incredible underground pressures that have been building up since the pterodactyl's time.
Where Does the Oil Go?

Directions: Read the following story and answer the questions at the end.

Once the oil comes in, the well is capped and equipment is installed to control the flow, and to separate the crude oil from the natural gas. What happens after that depends on where the well is located.

At Prudhoe Bay, for example, the largest known oil and gas field in North America lies beneath the lonely Arctic coast, which is ice-bound most of the year. So the oil must run a long route to market.

From the wells, the crude oil moves through small pipelines to the big trans-Alaska pipeline. There it begins the 800-mile journey to Valdez, where it is loaded on tankers for shipment Outside. The natural gas that comes up with the oil is run through a gas compressor plant at Prudhoe and then pumped back into the earth for storage, where it awaits construction of the proposed natural gas pipeline, which would carry it either across Canada to the Lower 48, or across Alaska to some ice-free port, from which it would then be shipped Outside via tankers.

On the other hand, the Kenai-Cook Inlet Basin, Alaska's only other producing field, lies close to population centers. Much of its natural gas is piped directly to Anchorage and other nearby communities for use as fuel. And at Nikiski on the Kenai Peninsula, modern plants and refineries process the oil and natural gas into gasoline, jet fuel, heating oil, diesel, liquified gas and fertilizer.

And those are just a few of the products that can be made from petroleum. Petrochemicals (chemicals made from oil and gas) are used as a base for a wide assortment of things, from plastics to vitamins to records, detergents, movie films, fabrics and anti-freeze.

This strange stuff we call petroleum is made up almost entirely of only two elements—hydrogen, a gas-like element that will burn; and carbon, a chemical element that is found in all living matter. If you really want to sound like a pro, you can use the scientific word for petroleum, which is "hydrocarbons." These hydrocarbons are present in thousands of different combinations that can be separated and purified in the process called "refining."

The first step in refining is to sort out the major "fractions" or parts of the hydrocarbons that make up crude oil. These fractions boil and vaporize (like steam) at different temperatures. So the simplest form of refining works like this:
a. The crude oil is heated in a furnace and the vapor is piped into a tall refinery tower.

b. Hot steam is pumped in below to speed up the process.

c. The vapors from the different fractions rise, cool off and condense (turn back into liquid) at different levels.

d. There they are drawn off and collected for further processing if necessary—except for the ghost of Pterodactyl, who has finally taken wing again.

The preceding worksheets are excerpted and adapted from Alaska Tidelines (see credit at beginning).

REVIEW:

1. Where does the gas from Prudhoe Bay go? ________________________________

2. Where does the gas from the Kenai-Cook Inlet Basin go? ____________________________

3. Where does the oil from Prudhoe Bay go? ____________________________

4. Where does the oil from the Kenai-Cook Inlet Basin go? ____________________________

5. Define petrochemicals. ____________________________

6. What are the major elements that make up petroleum? ____________________________
7. Here is a drawing of a refinery tower that shows at which points the different products are drawn off and collected. Fill in the blanks. (Hint: Lubricating oil is drawn off first; then heating oil; then jet fuel; then gasoline; then fuel gas.)

---

8. Circle the most highly refined fuel in each case:
   a. jet fuel or gasoline
   b. lubricating oil or asphalt
   c. heating oil or jet fuel
DIRECTIONS: Make a timeline: draw a straight line on a large sheet of paper. Mark off in equal segments to represent the first 100 years of Alaska's oil development, leaving room at the right end of the line to write in recent events. Then cut out the following paragraphs and place them in the proper order on your timeline.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long before the white man came,</td>
<td>September 1969 - The first North Slope oil lease auction sale brings the State of Alaska $900 million in oil company bonus money.</td>
</tr>
<tr>
<td>Alaska's Native people had known about the oil. They found it oozing out of the ground in smelly seeps at widely scattered spots along the North Gulf coast, or gathered in dark, gooey ponds on the frozen Arctic slope. Sometimes they burned it in their stone lamps or used it to coat their skinboats. But for the most part they ignored it.</td>
<td>1957 - Commercial production comes of age with a major oil strike at Swanson River on the Kenai Peninsula. Operations quickly spread to offshore waters of Upper Cook Inlet as other large oil and natural gas fields are tapped.</td>
</tr>
<tr>
<td>The oil age in Alaska as we know it now began slightly more than 100 years ago. And the story opens with a prospector known only as Edelman.</td>
<td>November 1981 - The two billionth barrel of Prudhoe Bay oil arrives at Valdez.</td>
</tr>
<tr>
<td>April 1974 - Construction begins on the North Slope Haul Road--the first road to the Arctic Coast--built to carry supplies to Prudhoe Bay.</td>
<td>1882 - The first oil and gas claim recorded in Alaska is staked at Iniskin Bay on the west side of Cook Inlet by a prospector who signs his name simply &quot;Edelman.&quot;</td>
</tr>
<tr>
<td>1911 - Katalla begins to look like a boom town as the population swells to nearly 200. More shallow wells are dug and Alaska's first refinery goes into operation. (The refinery burned down in 1933 and the wells were capped, after producing a total of 154,000 barrels of oil--about one day's present production from Cook Inlet.)</td>
<td>1900 - The first Alaska exploratory well is drilled on the Iniskin Peninsula--not by Edelman (who has taken off for parts unknown), but by a firm called the Alaska Petroleum Company. Oil is struck at 700 feet. But unfortunately the drillers choose to continue, hit water, and have to abandon the effort.</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1925-1941</td>
<td>Action picks up as major oil companies enter the Alaska scene, sinking test wells at a variety of locations in southern Alaska from Killisnoo on Admiralty Island in the Panhandle to Kanatak on the Alaska Peninsula. Exploration ceases with the outbreak of World War II.</td>
</tr>
<tr>
<td>1902</td>
<td>Alaska's first production well is brought in on prospector Thomas White's claim at Katalla, about 50 miles southeast of Cordova. Oil is struck after drilling to only 366 feet, but it is tough going--&quot;drilling&quot; at that time involving pounding away at the ground with a heavy drilling bit suspended from a wooden derrick, and stopping from time to time to let workers bail out the rock chips from the hole.</td>
</tr>
<tr>
<td>1923</td>
<td>President Warren G. Harding signs an executive order creating National Petroleum Reserve No. 4, a 37,000-square-mile area of the North Slope (including Mr. Van Valin's lake) set aside to &quot;insure a future supply of oil for the Navy.&quot;</td>
</tr>
<tr>
<td>July 1977</td>
<td>First Prudhoe Bay oil arrives at Valdez for tanker shipment Outside.</td>
</tr>
<tr>
<td>July 1968</td>
<td>News of the discovery at Prudhoe Bay of the largest oil and gas field in North America marks a major turning point in Alaska's history. The field is estimated to hold nearly 9.5 billion barrels of recoverable oil and 26.5 trillion cubic feet of natural gas.</td>
</tr>
<tr>
<td>1914</td>
<td>After hearing reports of an &quot;oil lake&quot; near Smith Bay southeast of Barrow, Wainwright school teacher William Van Valin hitches up his reindeer and drives 550 miles to investigate. He finds a lake of what looks like engine oil, 200 by 400 feet in size, and puts up a sign reading &quot;Arctic Rim Mineral Oil Claim.&quot; It is the first petroleum claim to be staked on the North Slope.</td>
</tr>
<tr>
<td>March 1975</td>
<td>After many delays, construction begins on the 800-mile-long Trans-Alaska Pipeline from Prudhoe Bay to the ice-free port of Valdez. When finished, it will have cost $7.7 billion.</td>
</tr>
</tbody>
</table>
Ready for a little high finance?

1. This pie chart shows where the State of Alaska's money came from during fiscal year 1981. What percentage of the state's income was paid by the oil and gas companies? _______ percent

2. Total revenue (taxes and other income) received by the state that year was about $4 billion. What did the 10 percent from non-petroleum sources amount to in dollars? $________

What was the dollar amount paid by oil and gas industry sources? $________

Oil & gas property taxes (4%) 
Oil & gas income taxes (20%) 
Oil & gas royalties & bonuses (37%)* 
Oil & gas production taxes (29%) 
All other state income (10%) 
State income (FY 1981) Total: $4,073,000,000.

*"Royalty" is money paid to a landowner for oil taken from his property. A "bonus" is the cash bid paid by oil companies for the exclusive right to lease or rent potential oil lands. About 95 percent of the oil produced in Alaska today comes from state-owned lands.
This pie chart shows what the members of the 1981 state legislature decided to do with the money. (Although it looks as if they spent more money than the state took in, this figure includes funds from the federal government not shown on the chart above, plus $918 million left over from the year before.)

As you can see, the money went in almost equal amounts to three general areas:

1. PERMANENT FUND. This fund was set up in 1977 to save some of those billions for that rainy day when the oil income tapers off. The fund totaled about $2 billion in 1982 and was earning about 16 percent of that a year in interest and investments. (If you want to find out how much it made in 1982, multiply $2,000,000,000 x .16 = $___________.)

2. CAPITAL BUDGET. "Capital" projects are major things that are built or bought, such as highways, docks, schools, airport improvements, ferries, educational TV equipment and such. The capital budget also provides money for low-cost loans, mostly in housing construction. About 74 percent of this budget (or $1.4 billion) was earmarked in 1982 for capital projects. That left about ____ percent for loans.

3. OPERATING BUDGET. This budget takes care of the ongoing expenses of state government and the operating costs for schools, social services, the court system, etc. It pays the salaries of the Alaska's 15,000-plus full-time state employees.

State spending (FY 1982)
Total: $6,172,300,000.
Operating budget (FY 1982)
Total: $1,964,300,000.

- Development (economic, community) (11%)
- Transportation (road, air, marine) (11%)
- General government (16%)
- Public safety and courts (9%)
- Natural resource management (7%)
- Health and social services (12%)
- Education (including Univ. of Alaska) (34%)

a. The operating budget pie chart shows that the state is spending about half of all its operating funds in just two areas. What are they?

b. What general area gets the least amount of money?

c. If you were a state legislator, how would you carve up this pie?

Where would you spend more money?

Where would you spend less?
Petro Puzzler

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Starred (*) words are based on information in this activity.

**ACROSS**

1. The word "petroleum" in Latin means ____ oil.
5. Alaska is believed to have about ____ of the nation's remaining undiscovered oil reserves.
9. Turning pterodactyls (and such) ____ oil took millions and millions of years.
10. Oil companies paid about $3.6 billion in state taxes during the 1982 fiscal ____ ending July 1.
11. Southcentral (abbr.).
14. Northeast (abbr.).
15. Kenneth's friends call him ____.
17. Unprocessed oil is called ____ oil.
19. Letters of the alphabet between D and G.
21. Oil soop (int.)
22. The first oil and gas ____ in Alaska was staked by a prospector named Edelman.
25. The kind of 2-year technological degree offered by a number of Alaska community colleges is called ____ (init.).

**DOWN**

1. One of the prices we pay for oil development in Alaska is the ____ of damage to our wildlife and environment.
2. The process of making oil has never been duplicated, so ____ it's gone, it's gone forever.
3. Cent (abbr.).
4. Republic of Korea (init.) (backwards).
5. The chemical word for petroleum is ____ carbons.
6. Atomic energy (init.)
7. About 95 percent of the oil produced in Alaska today comes from state-owned ____
8. The Trans-Alaska pipeline runs from Prudhoe Bay to the ice-____ Port of Valdez.
9. East Chugach (init.)
10. National Education Association (init.)
11. Alaska supplies the ____ (init.) with about 18 percent of the oil it uses each day.
ACROSS

28. Alaska Airlines (init.)
*29. You need a very tall drilling _____ to sink an oil well.
31. Equal Employment (init.)
32. A good Christmas present is cross-country _____.
*34. National Petroleum Reserve No. 4 (PET-4) was created in 1923 when President Harding set aside a 37,000-square-mile _____ of the North Slope.
*36. Oil is formed in mysterious ways under great pressure, _____ and dampness from the decaying remains of plant and animal life...
*37. ...squeezed down between layers of silt, _____ and clay.

DOWN

*20. Alaska's _____ refinery was built at Katalla in 1911.
*22. A "bonus" is a _____ payment by oil companies for the right to lease potential oil tracts.
*23. You may find an "oil _____" on the surface (like Mr. Van Vain did), but underground it is sealed in porous (1 across).
24. Third note of the musical scale.
26. See, saw, _____.
*27. Bacteria helps in the formation of oil by breaking down _____ material.
*30. Along with the oil, Prudhoe Bay fields are believed to contain 26.5 trillion cubic feet of natural _____.
33. Iowa (abbr.).
35. Regular Army (init.).
Ocean Oil Pollution

Adapted from OIL SPILL! by Rosanne Fortner and Stephanie Ihle, Ohio Sea Grant Program, Ohio State University, 1980. Used by Permission.

What are the sources of ocean oil pollution? Here's a chart that tells what the sources were in 1975. They haven't changed much since then.

<table>
<thead>
<tr>
<th>Source of Petroleum</th>
<th>Column 1 (metric tons)</th>
<th>Column 2 % of total</th>
<th>Column 3 Size of Wedge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural seepage*</td>
<td>0.60</td>
<td>10</td>
<td>36°</td>
</tr>
<tr>
<td>Tanker operations</td>
<td>1.33</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Tanker accidents</td>
<td>0.20</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Other transportation activities</td>
<td>0.60</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Runoff from rivers and cities</td>
<td>1.90</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Coastal facilities</td>
<td>0.80</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Offshore drilling</td>
<td>0.80</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Atmospheric fallout</td>
<td>0.60</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6.11</td>
<td>100%</td>
<td>Degrees 360°</td>
</tr>
</tbody>
</table>

*Leaks from oil deposits.

(Data from U.S. National Academy of Sciences, Petroleum in the Marine Environment. Washington, D.C., 1975.)

Now, fill in column 3 above and use your protractor to complete the pie graph below. Find wedge sizes for column 3 by multiplying the percentage (column 2) by 360 (the number of degrees in a circle). For example: 0.10 (the same as 10%) x 360° = 36°. After you've filled in the column, add the numbers to see whether they total 360°. If so, measure the angles with your protractor, then mark wedges and label your "pie."
1. a. Most of the oil spills we hear about involve which one of the sources on the chart?

b. What percentage of ocean oil pollution is caused by that source? ____________

2. a. Which source describes oil spills in harbors?

b. What percentage is caused by that source? ____________

3. When an oil tanker (ship) is carrying no oil, it fills up its cargo space with water so that the ship will be stable. A ship getting ready to load new cargo will dump the water it has been using as ballast. This ballast will have picked up oil from the hold, and the oily wastes are flushed out into the harbor.

a. Which source describes this type of pollution?

b. What percentage is caused by that source? ____________

4. How could oil get into the water from offshore drilling operations?

5. a. List some ways that petroleum could get into rivers.

b. The next time you are riding on a highway, look at the road ahead of you. A well-traveled highway usually has a dark streak running down the center of each lane. The streak is caused by petroleum products, such as crankcase oil, that drip out of vehicles. How could this serve as a source of oil pollution for water?

6. a. Which of these ocean oil pollution percentages do you think will increase in the future? ____________

b. Which do you think will decrease? ____________
Oil Spills and Clean-ups

Oil on beaches damages shoreline life. Oil seeps downward into sand and remains there for years. Rocky shorelines can clean themselves naturally through wave action, but bays, estuaries and marshes have few waves. Oil spills in such areas are very damaging.

Oil causes serious harm to birds by coating their feathers. An oily bird does not float, and it has no insulation against temperature changes. Also, birds poison themselves by eating the oil that coats them.

Oil is sometimes responsible for smothering communities of animals that live on the sea floor. This is especially important to the shellfish industry. Most of these areas will eventually become settled again, but some organisms, like mussels, cannot survive in an oiled area.

Adult fish are not affected by oil pollution as much as other organisms. A massive spill can kill large numbers of fish, but, ordinarily, adult fish are able to escape injury from minor accidents. Smolt and eggs are extremely vulnerable to oil spills, however.

Different petroleum products have different effects on organisms. Diesel or heating oils are the most poisonous, while heavy crude and fuel oils are the worst for smothering animals.

Now, answer these questions:

1. Describe a kind of oil spill that could kill large numbers of adult fish, smolt, or eggs.

2. What kinds of petroleum products have the most undesirable effects?

3. How do these affect the organisms?

4. Are all areas of the coastline affected in the same way by oil pollution? ________ If not, explain these differences.
Success in cleaning up an oil spill depends upon preparedness and rapid action by the spiller and by federal, state and local agencies. When a spill occurs, it is reported to the nearest U.S. Coast Guard station. If the spiller does not clean up the pollution, the Coast Guard takes over and the spiller pays the clean-up costs.

If an oil spill is contained in one area, cleanup is easier and less environmental damage is likely to occur. Containment must be done as soon as a spill is detected if it is to be effective.

5. Now get out your container of water. Assume that an oil tanker springs a leak in the middle of your "ocean." Drop a few drops of oil in your pan or bowl of water.

Try to contain the oil. Tie the ends of a piece of string together and gently place the circle of string on top of the water with the oil inside. Slowly add two more drops of oil inside the circle as your "tanker" continues to leak. Does the string keep the oil from spreading over the entire ocean? ________ This is how a "boom" operates to contain a spill.

6. Some contained oil can be reclaimed (collected for further use). Use a dropper to try to reclaim some of your oil. About how much oil were you able to reclaim?

7. Ordinarily, oil floats on water because it is not as dense as water. Increasing the oil's density will make it sink to the bottom. Sprinkle enough sand on the oil spill to cause it to sink.

a. Does this method removal all (or most) of the oil from the surface?

b. When this method is used, what effects will it have on the ocean environment?
c. Is sinking a good way to clean up an oil spill?

Explain.

8. Now try to mop up the spill with a paper towel. How well does that work?

9. Household detergents are used to remove oil from laundry or grease from dishes. Add detergent to your "ocean." How do detergents help to clean up an oil spill?

Unfortunately, many detergents cause more damage than the oil spill itself!

10. Now try some commercial oil-absorbent material. How well does that work?

Unfortunately, it is very expensive when you consider the size of most oil spills.

11. Add another drop of oil to your "ocean." Then put some seaweed or pondweed in the oil spill.

a. What happens?

b. How would this affect the ability of plants to produce food?

12. Add a bird feather to the oil spill.

a. What happens?
b. What would happen to a bird that swam into an oil spill?

Simulate some of these conditions and record your results.

14. Now clean up your "ocean" and decide on a proper place to dispose of your oil messes!