

oceans

Activity Guide for Grades 6-8

BY SHEDD AQUARIUM

Shedd Aquarium Activity Guide Series

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Oceans Activity Guide

for Grades 6-8

OBJECTIVES

This Activity Guide is intended as a resource to assist teachers in incorporating the study of aquatic science, specifically as it relates to the ocean, into their existing curricula. While each activity can be used independently of the others, the activities do build on one another and are most effectively used in the order presented. Each activity will help meet specific learning objectives in science, and if all of the activities in the book are completed the following learning objectives will be met:

- Illinois State Goals in Science: *Goals 11 through 13*
- National Science Standards: *Unifying Concepts and Processes Standard*
- National Science Standards: *5-8 Content Standards A through G*

GOALS

- to provide teachers with an interactive teaching tool and curriculum on oceans for grades 6-8
- to build students' critical thinking skills and scientific literacy
- to approach the study of science in an interdisciplinary way
- to offer students a fun, hands-on learning experience



Where in the World?

Determine your position on Earth using an ancient navigation tool you create yourself.

OBJECTIVES

In this activity students will:

- construct an astrolabe
- use an astrolabe to determine latitude
- discover the navigational problems faced by the mariners of hundreds of years ago

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 11, 12, 13*
- National Science Education Standards: *Unifying Concepts and Processes*
- National Science Education Standards: *5-8 Content Standards D, E, F, G*

TIME

45-50 minutes

MATERIALS

For the class:

- world map or atlas
- cutouts of stars
- dictionary
- reference books

For each student:

- drinking straw
- string (40 cm)
- poster board
- bolt (any size to serve as a weight)
- glue
- one copy of the protractor (page 7)
- Scotch tape
- popsicle stick
- one copy of the student worksheet (page 6)

VOCABULARY

astrolabe: an instrument used to determine latitude by observing the altitude of celestial bodies

latitude: the angular distance north or south of the equator

longitude: the angular distance east or west of an imaginary line running through Greenwich, England

Polaris: the North Star

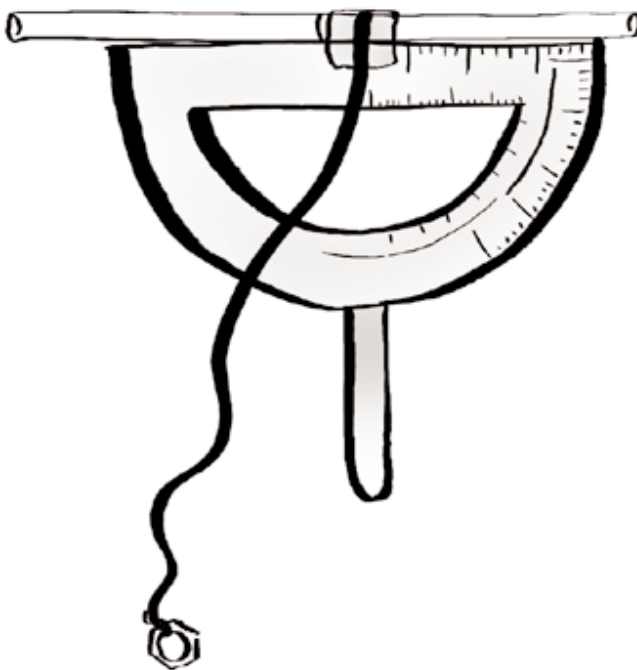
BACKGROUND

Hundreds of years ago, before global satellite positioning data could be obtained, and before the development of high-speed computers to analyze that data, sailors used a device called an astrolabe to determine their position north or south of the equator. This position, or latitude, could be determined by observing the altitude of the sun or a star above the horizon. The earliest known description of the astrolabe is from about 550 BC by a man named Hipparchus. Many of the astrolabes used in ancient times were made from very expensive materials such as gold and silver and could be used to calculate a wide variety of things, from the observer's latitude to the exact time of day and the times of both sunrise and sunset. Although the development of the astrolabe allowed sailors to determine latitude, it was not until hundreds of years later that an accurate means of determining longitude (direction east or west) was developed. Since pinpointing longitude relies on the use of accurate clocks as well as trigonometric tables, this skill had to wait until the late 1700s and the development of the Harrison chronometer.

In using an astrolabe to measure latitude, sailors were dependent on the North Star (Polaris). Polaris is one of the few stars that maintain an almost constant position above the horizon in the Northern Hemisphere. Earth's axis points nearly at Polaris, thus the star remains nearly fixed in the sky. To locate Polaris, sailors used a very familiar constellation, the Big Dipper. Polaris is located on a line drawn through the Big Dipper's two pointer stars, due north from the observer's position. Any measurement of Polaris' altitude, in degrees, gives a fairly accurate estimate of a person's exact latitude north of the equator.

PROCEDURE

1. How did the great explorers who roamed the oceans hundreds of years ago find their way? If your students were stranded in the middle of the ocean, how would they find their way? What could they use to orient themselves? Share the background information with your students.
2. To assume the roles of explorers of long ago, your students need to make astrolabes. First, make a copy of the protractor (page 7) for each student in your class.
3. Using scissors, have them cut out the protractor. Trace and cut out a piece of the poster board matching the size of the protractor. Fix the protractor to the poster board with glue and allow to dry.
4. Center the drinking straw across the straight edge of the protractor and attach with tape. (See below.)
5. Punch a small hole in the center of the X on the protractor. Tie one end of the string to the bolt and pass the other end through the hole in the protractor. Secure the string in the hole by tying a knot in this end.
6. Tape the Popsicle stick to the back of the protractor for use as a handle. (See below.)
7. To use the astrolabe, simply close one eye and peer through the hole in the straw. Locate the North Star (Polaris) through the hole and read the protractor angle where the string hangs. This is the elevation of the North Star above the horizon and, consequently, your latitude.



8. You and your students are now ready to begin your careers as ancient mariners. Ideally, this activity would be done at night using the real North Star. Since that is probably impractical, create a night sky in your classroom. On a classroom wall, tape a series of cutout paper stars. Include the Big Dipper and a star designated as Polaris.
9. Set up four stations around the classroom. Each station should have an observation point at a different height—using chairs, stepstools, asking students to kneel or sit on the floor, etc.—from which to measure their “latitude” using the star designated as Polaris on your night sky wall. Varying the heights from which the measurements are taken will produce varying results using the astrolabe. You should predetermine the heights so that one is between 0° and 20° , one between 20° and 40° , one between 40° and 60° and the final one more than 80° . NOTE: all of the latitudes will be degrees north of the equator as we are in the Northern Hemisphere and using the North Star as our reference point.
10. Provide your students with copies of the student worksheet. You may choose to have your students work individually, in pairs or in small groups. Direct students to move from station to station using their astrolabe to measure the “latitude” at each station. Once they know the latitude, they should be able to use a map, atlas and/or previous knowledge to determine which description goes with which station to complete the worksheet.



ADDITIONAL RESOURCES

Books

- Charton, Barbara. *The Facts on File Dictionary of Marine Science*. New York: Facts on File, 1988.
- Pernetta, John. *Atlas of the Oceans*. Rand McNally, 1994.

Web Sites

www.saundersandcooke.com

This is a commercial site selling reproductions of antique maritime instruments, but has great photographs and interesting historical facts.

www.ruf.rice.edu/~feegi/index.html

This site has a variety of information on early ocean navigation, weather, currents, etc. The site includes a resource page with activities for students of all ages from first grade through college.

www.trimble.com/gps/index.htm

This site contains information on the most modern, state-of-the-art navigational techniques. GPS stands for Global Positioning System.

EXTENSION

Even before human history was chronicled in writing, the ocean has played a vital role in the lives of people. Who were the earliest sailors of the seas? What did they use for transportation and navigation? Have students explore this topic as a research project and share their findings.

Where in the World—Student Worksheet

PART I

Use your astrolabe to determine the latitude of each of the four stations. To use the astrolabe, simply close one eye and peer through the hole in the straw. Locate the North Star through the hole and read the protractor angle where the string hangs. This is the elevation of the North Star above the horizon and, consequently, your latitude. Write the latitude for each station in the chart.

PART II

Read each description below. Using the latitudes you inserted into the chart, a map and any other reference books you need, determine which description matches which station. Write the description number on the chart.

Station No.	Latitude	Description No.
1		
2		
3		
4		

Description 1

At this latitude the skies are almost always clear and it hardly ever rains. The summers are hot, and the winters are mild. The winds at this latitude are light and variable—not very strong at all.

This latitude is in an area that has been nicknamed the horse latitudes.

Description 2

This station is located in a place where it is warm all year long. You might not see the sun, however. At this latitude it is often cloudy, and there is a lot of rain. The winds are fairly weak here—light and variable. This latitude is in an area that has been nicknamed the doldrums.

Description 3

It never gets very warm at this latitude. In fact, the water has sea ice in it for most of the year. In summer, the days are very long with lots of sunshine. In fact, this area is sometimes called the Land of the Midnight Sun. In winter, days are short, and there is very little sun.

Description 4

At this latitude there are four distinct seasons. Winters are cold and summers are hot, with more moderate falls and springs in between. This is an area with strong westerly winds. At this latitude there are often strong storms, especially in the winter.

PART III

Using whatever reference books are necessary, answer the questions below.

1. Which station's latitude most closely represents the latitude at which you live?

2. Why is the area in the first description called the horse latitudes?

3. Why is the area in the second description called the doldrums? How does the dictionary define the word "doldrums"?

WORKSHEET ANSWER KEY

PART I

The actual latitudes will vary according to how you set up the stations. Remember that student answers will vary slightly due to instrument inaccuracy, different heights of students, etc.

PART II

Description 1:

This area falls between 20° and 40° . This is the subtropical zone.

Description 2:

This is the equatorial or tropical zone. This area falls between 0° and 20° .

Description 3:

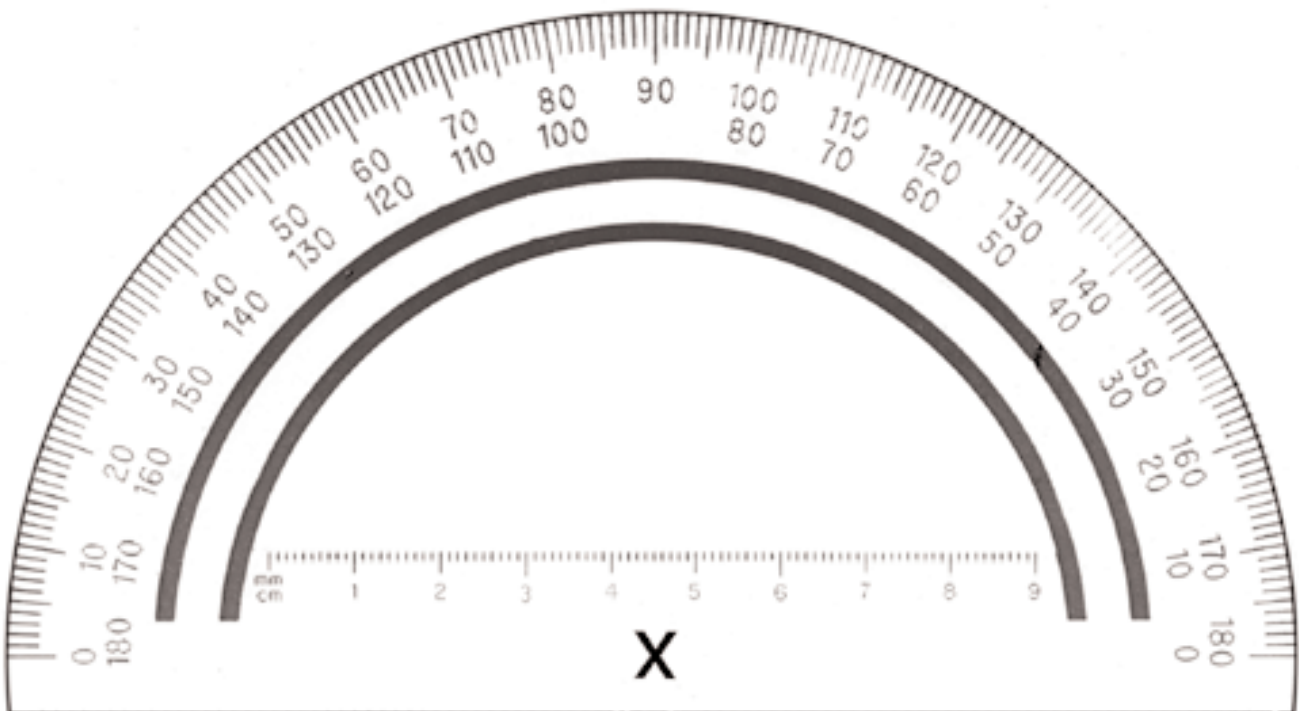
Located above the 80° latitude line, this area is the polar zone.

Description 4:

This area is known as the temperate zone. It is located between 40° and 60° .

PART III

1. Answers will vary depending upon your location.
2. This area was nicknamed the horse latitudes by sailors. Since this is an area of light winds, sailing ships were often becalmed here. It was said that ships carrying horses would have to throw them overboard when long delays caused them to run out of feed. Thus, the name horse latitudes.
3. Sailors named this area the doldrums because of the weak winds. Sailing ships were often becalmed here. As the term doldrums generally refers to a low energy mood, or a period of inactivity, it is easy to see how this area got its name.



We Are the Ocean

Create a visual representation of the makeup of the “water planet.”

OBJECTIVES

In this activity students will:

- gain an understanding of the importance of fresh and salt water in their daily lives.
- develop an understanding of the proportional makeup of water to land on the Earth’s surface.
- construct a visual representation of the Earth’s surface using the human body as a point of reference.

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 11 and 12*
- National Science Education Standards: *Unifying Concepts and Processes*
- National Science Education Standards: *5-8 Content Standards D and F*

TIME

30-40 minutes

MATERIALS

For the class:

- butcher-block paper
- felt-tip marker
- inflatable globe

For each student:

- pen or pencil
- paper

VOCABULARY

neritic zone: area of the ocean shallower than 200 meters (656 feet) occurring over the continental shelves

nonrenewable resource: a resource that is used up faster than it can be replenished

photic zone: the area of the ocean from the surface to the maximum depth at which enough light penetrates to allow photosynthesis

photosynthesis: the process by which organisms containing chlorophyll utilize water, nutrients and sunlight to produce food

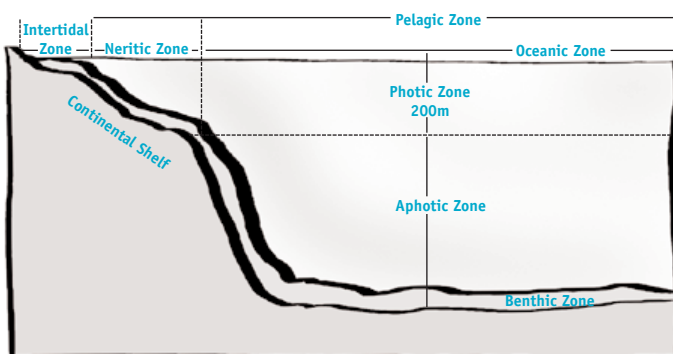
upwelling: areas where dense, cold subsurface waters rise up to replace wind-displaced surface waters. These are usually nutrient-rich areas of high productivity

BACKGROUND

Our planet is often referred to as the “water planet.” This is an apt description, as 70-75% of the Earth is not earth at all, but water! There is water in oceans, lakes, rivers, streams, and even frozen in glaciers and flowing underground. All of the organisms on this planet depend on water for their survival. Your students may believe that because there is so much water, there will always be enough for all the inhabitants of Earth to share. Not true. Fresh, clean water is a limited renewable resource. Of the total amount of water on this planet, only a very small percentage is available for human use. Unfortunately, due to pollution, contamination and overuse of our water supply, that percentage is shrinking daily.

While it is fairly obvious that we must work to preserve our supply of fresh water, what is less obvious is just how important the ocean is to human survival. In fact, without the ocean, there would be no life on Earth. Not only is the ocean presumed to be where all life began, it continues to play a vital role in supporting life even when that life is far from the nearest body of salt water. The ocean controls our climate and is an essential part of the water cycle that replenishes our fresh water. Without the ocean, our supply of fresh water would soon be used up. And without the ocean, we might find it very difficult to breathe! 70% of the world’s oxygen is produced by marine plants—mostly plankton. Besides providing water and oxygen, the ocean is an important source of food and other essentials. It is clear that a clean, healthy ocean is important to all of us.

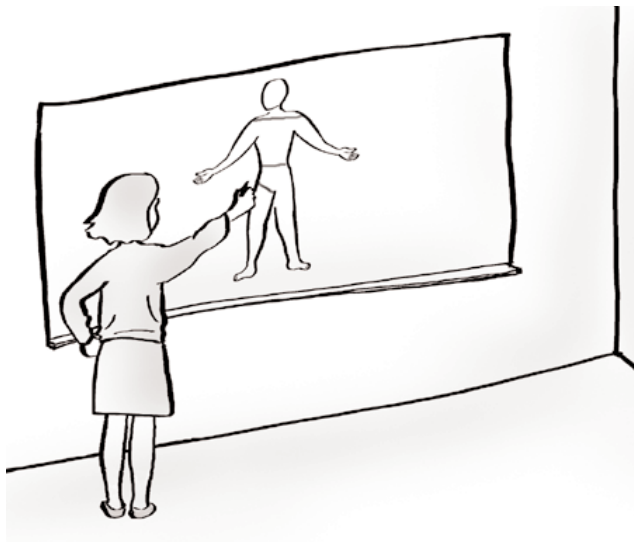
The following activity will illustrate to students, in a manner they can easily visualize, just how important water conservation is if we, along with the other inhabitants of this planet, are to survive.



OCEAN ZONES

PROCEDURE

1. Share the Background information with your students. Begin this activity by asking one of the students to catch an inflatable globe with both hands. Make sure all of the student’s fingertips are on the globe when it is caught. Ask the student where his/her thumbs are. Are they on water or land? Repeat this process five times and tally the results. If the student’s thumb is half on the water, half on the land, count this in favor of the land. The student’s thumbs should land on water about seven out of every ten times. Of course, one trial run might not produce the desired 7:3 ratio. In this case, the teacher must explain that in science experiments are rarely ever run just once. The more trials that are run, the more valid the results will be. Try running a series of 10 trials and averaging the results. Does this produce results closer to expected ratio? How about 20 trials?
2. Ask for four volunteers from the class to help with the next part of the activity. Have each student lie on his/her back on a piece of butcher-block paper and outline their figure with a magic marker. Separate the four outlines and hang them in front of the class. Provide students with paper and instruct them to copy the body outlines for note taking. While you mark the life-sized figures, instruct the students to follow along on their sheets and mark their figures in the same way you are marking the life-size figures.
3. Three of the outlines represent the estimated $\frac{3}{4}$ of the world that is covered by water. The remaining figure represents the $\frac{1}{4}$ of the world covered by land. The figures should be labeled accordingly.
4. With the magic marker, divide the outline representing the land horizontally into two equal pieces. The lower half represents all the uninhabitable land on Earth. Either climate or terrain makes human habitation of this land nearly impossible. The upper half of the figure represents the habitable land.
5. Draw a line isolating the shoulder and head of this figure. This area will represent the habitable land on which we are presently able to grow food. This is just over 3% of the Earth. As you label each area, you may wish to include the percentages as well.



6. Draw the eyes on this figure. In one eye draw a pupil. This dot (which is actually far too large) represents the .03% of the Earth's surface that supplies all of our drinkable water.
7. On one of the three figures representing the water draw a line separating one leg from the rest of the body. The leg, about 6.25% of the entire surface of the Earth, and about 10% of the ocean, represents the neritic zones of the oceans. These are regions of moderate productivity in which over 90% of the world's marine life are found. This area is found over the continental shelves where ocean depths do not exceed 200 meters (656 feet).
8. Next, draw a line isolating this leg's pinky toe. This toe represents .075% of the world's surface (or .1% of the ocean). This tiny piece of the ocean represents the highly productive upwelling areas within the neritic zone. An upwelling is an area where deep water rises to replace surface water that has been displaced by the wind. These are the most nutrient-rich areas of the world's oceans and serve as the feeding and breeding grounds for many marine organisms. Incidentally, about 25% of all the ocean's upwelling areas are found along the Pacific coast of North America. The California coast, especially near San Francisco, is an area of upwelling where the deep water is often colder than the air near the water's surface. This creates the fog for which San Francisco is noted.
9. Now draw the toenail of that pinky toe. This is the photic zone—the top 200 meters of the ocean where enough light can penetrate for

photosynthesis to occur. All plant life, including seaweed and phytoplankton, grow in the photic zone. Since these organisms provide the base for most of the ocean's food web, it is no wonder that almost all ocean life is concentrated in this small area. Animal life below this zone must depend on either detritus falling from above or chemical synthesizing bacteria for nourishment.

10. Of the total water on the Earth's surface, only about 3% is fresh. Represent this by drawing lines to isolate 3 hands on the figures representing the water. About 2% of the total (or about $\frac{2}{3}$ of the fresh water) is frozen in glaciers or icecaps and is unavailable for human use. Highlight one of the hands to represent fresh water available for human use.

EXTENSIONS

1. Add some more mathematical mayhem to this activity! Have your students count the number of classrooms in your school. Let this total be the total surface area of the Earth. How could the classrooms be divided using the percentages listed in the above procedure? For example, if there are 50 classrooms in your school, 36 would be water and the remaining 14 would represent the total land area on Earth.
2. Have students convert the visually represented statistics from this activity into graphic form. A pie graph would be an ideal tool for displaying this information.

ADDITIONAL RESOURCES

Books

Charton, Barbara. *The Facts on File Dictionary of Marine Science*. New York: Facts on File, 1988.

Pernetta, John. *Atlas of the Oceans*. Rand McNally, 1994.

Web Sites

www.cnmoc.navy.mil/educate/neptune/neptune.htm

This web site, called Neptune's Web, is a wonderful resource for students and teachers on general oceanography topics.

Wonderful Water

Discover some
of the properties
of one of the
most distinctive
substances in the
solar system—water!

OBJECTIVES

In this activity students will:

- conduct an experiment to discover how salinity affects the density of water
- conduct an experiment to discover how temperature affects the density of water
- engage in an activity demonstrating the surface tension of water
- conduct an experiment to discover the effects of a common surfactant (soap) on the surface tension of a liquid

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 11, 12 and 13*
- National Science Education Standards: *Unifying Concepts and Processes*
- National Science Education Standards: *5-8 Content Standards A, B, D, G*

TIME

50-60 minutes

MATERIALS

For the class:

- (see materials list for each station)

For each student:

- one copy of the student worksheet
- pen or pencil

VOCABULARY

brackish water: water containing too much salt to be drinkable, but not enough salt to be considered sea water

cohesion: the sticking together of molecules of the same substance

density: the mass of a substance per unit of volume. $D=M/V$

density maximum: the condition at which a substance is most dense. Water has a density maximum of 3.98°C

heat capacity: amount of heat required to raise the temperature of a substance by a given amount

salinity: the amount of dissolved solids present in seawater expressed in parts per thousand

surface tension: force causing molecules at the surface of a liquid to be more cohesive than those in the body of the liquid, thus reducing surface area

surfactant: substance that can change the properties of a liquid's surface

BACKGROUND

Water. It's clear and wet and quenches your thirst on a hot day. We know that it is necessary to support life, but we seldom give it much thought. Yet, this substance has properties that make it unique among all the substances in the solar system! It is the only substance to exist in all three states of matter on one planet—gas, liquid, and solid. Of all liquids, water can dissolve more substances and in greater quantities than any other. It has a higher heat capacity (amount of heat required to raise the temperature of a substance by a given amount) than any liquid or solid except for liquid ammonia. And it has a higher surface tension than any other liquid. Its unique molecular structure makes water the perfect medium for supporting life. The following activities will help your students explore some of these special properties of water.

PROCEDURE

Before the beginning of class, set up the five stations around your classroom as outlined in the following descriptions. Share with your students only the minimum amount of background information to enable them to conduct the experiments. Most of the information should be inferred from the actual results. Provide your students with copies of the data recording sheet. Divide the students into five groups and have them rotate through the stations.

STATIONS 1, 2, AND 3: DENSITY

Background

The first three stations explore water density. Density is defined as the mass of a substance per unit of volume ($D=M/V$). For example, the density of pure water is 1.0 grams per milliliter. The density of seawater, on the other hand, is 1.025 grams per milliliter. Many factors can affect the density of water. The three activities which follow will examine the effect of temperature and salinity on the density of water. Students will then be asked to extrapolate how these changes might affect the living systems within a given body of water.

STATION 1

Materials

- empty two liter bottle with the label removed (cut in half as shown)
- plastic wrap
- rubber band
- table salt
- food coloring
- spoon
- sharpened pencil

Procedure

1. Fill the bottom half of the two liter bottle $\frac{2}{3}$ full of water.
2. Dissolve a spoonful of salt in the water.
3. Add enough food coloring to the salt water to make a dark mixture.
4. Place a piece of plastic wrap over the neck of the remaining half of the bottle and secure with a rubber band.
5. Place the top half of the bottle neck down into the water-filled bottom half (see illustration).
6. Completely fill the top half of the bottle with plain water.
7. Have a student poke a hole in the plastic wrap using a pencil (take care not to dislodge the top half of the bottle or it will leak).
8. Observe what happens and record your results.
9. Answer the questions on the worksheet.



Expected Results

Since water density increases with increasing salinity, the colored salt water will be denser (heavier) than the clear fresh water. Thus there should be little mixing of the two since the more dense salt water is already on the bottom. One would expect the salinity of the ocean to decrease when it rains (and indeed, the variability of salinity is greater at the interface of air and water than at deeper points). Students may note that evaporation will increase salinity and since both occur in fairly equal proportions, salinity is not much affected over time by rainfall. In addition, the sheer volume of the ocean makes dramatic changes in salinity due to rainfall unlikely. Thus the ocean's salinity has remained nearly constant for the last 200 million years. When the tide enters the mouth of a river, there is mixing of the more dense saltwater with the less dense freshwater. Thus the salinity at the mouth of a river may be higher than further upstream, but lower than the ocean. This water is referred to as brackish water. On the other hand, where water flows forcefully into the ocean



from a river, mixing may not occur for some distance. For instance, the Amazon River flows into the ocean with such force that little mixing (by currents, wind, etc.) occurs. In fact, fresh water can be found on the surface of the ocean as far as 200 miles from shore.

STATION 2

Materials

- empty two liter bottle with the label removed (cut in half as shown)
- plastic wrap
- rubber band
- water
- hot plate
- ice
- container for heating water
- container for cooling water
- food coloring
- sharpened pencil

Procedure

1. Chill a container with water in ice until it is just above freezing. There should be enough water to fill half of the two liter bottle.
2. Heat an equal amount of water to a near boil on a hot plate.
3. Fill the bottom half of the two liter bottle $\frac{2}{3}$ full with HOT water (be careful that the water is not too hot or it will melt the plastic).
4. Add enough food coloring to the HOT water to create a dark mixture.
5. Place a piece of plastic wrap over the neck of the remaining half of the bottle and secure with a rubber band.
6. Place the top half of the bottle neck down into the water-filled bottom half (see illustration).
7. Carefully fill the top half of the two liter bottle with COLD water.
8. Have a student poke a hole in the plastic wrap using a pencil (take care not to dislodge the top half of the bottle or it will leak).
9. Observe the results and complete the appropriate section of the worksheet.

Expected Results

Since density increases with decreasing temperature, the colored HOT water will be less dense than the clear COLD water. Since the denser COLD water is on top, it will begin to sink and the less dense HOT water to rise. There will be mixing of the colored and clear water. Since water increases in density the colder it gets, one would expect ice to sink. However, ice floats. Pure water has a slightly anomalous property as it approaches the freezing point. Water decreases in density with an increase in temperature, beginning not at 0°C (the freezing point), but at 3.98°C. It is actually at its most dense at 3.98°C; we refer to this as water's density maximum. Ice, at 0°C, is slightly less dense than the water surrounding it, allowing it to float.

STATION 3

Materials

- 2 identical clear plastic jars
- water
- table salt
- 2 eggs (hard boiled)
- spoon

Procedure

1. Fill both jars with equal amounts of water.
2. Add a heaping teaspoon of salt to one of the jars. Stir.
3. Gently place a hard boiled egg into each jar.
4. Observe the results and complete the appropriate section of the worksheet.

Expected Results

The hard boiled egg in the jar of saltwater should float, because the saltwater is denser than the egg. The hard boiled egg in the jar of freshwater should sink, because the egg is denser than the freshwater. Salt water is denser than freshwater. Humans float better in the ocean than in a freshwater lake for the same reason. As an extension to this activity, you may wish to have students hypothesize what effects water density has on aquatic life. Why are some aquatic animals only able to live in saltwater while others must live in freshwater?

STATIONS 4 AND 5: SURFACE TENSION

Background

Surface tension is caused by the cohesion (sticking together) of water molecules. This forms an elastic-like "skin" on the water that allows for a wide range of phenomena. In fact, water has the greatest surface tension of all liquids. Surface tension allows you to fill a glass of water slightly above its brim, and it also allows an insect known as a water strider to walk on water. Surface tension is also what causes water to bead up on a freshly waxed car. The next two activities will demonstrate surface tension in action. Students will then be asked to extrapolate how these changes might affect the living systems within a given body of water.

STATION 4

Materials

- 2 pins or needles
- 2 identical clear plastic containers (jars or glasses will work)
- tweezers
- water

Procedure

1. Fill both jars with equal amounts of water.
2. Drop the first pin vertically (point down) into one of the containers of water.
3. Very carefully place the second pin horizontally onto the water in the other jar. (In order to insure the desired results, tweezers might be used to carefully place the pin on the water.)
4. Observe the results and complete the appropriate section of the worksheet.

Expected Results

The pin placed horizontally on the water should float while the pin dropped point-first will sink. Surface tension allows the second pin to float as its weight is spread over a larger area. Students' drawings should show water molecules packed more tightly together at the surface than in the body of the water. Animals that need to float—especially plankton—benefit from water's high surface tension.



STATION 5

Materials

- 1 pie pan
- milk
- food coloring (3 different colors)
- liquid soap

Procedure

1. Fill the pie pan two-thirds full of milk.
2. Keeping each color separate from the others, place a few drops of each color near the center of the pie pan.
3. Pour two drops of the liquid soap in the center of the pan.
4. Observe the results and complete the appropriate section of the worksheet.

Expected Results

When soap, which is a surfactant, is dropped into the milk it will interfere with the surface tension and cause the areas of food coloring to move apart. Surfactants interfere with the molecular forces that cause a liquid to be more cohesive at the surface than in the body of the liquid.

ADDITIONAL RESOURCES

Books

Brower, Kenneth. *Realms of the Sea*. Washington, D.C.: National Geographic Society, 1991.

Charton, Barbara. *The Facts on File Dictionary of Marine Science*. New York: Facts on File, 1988.

Gross, M. Grant. *Oceanography*. New Jersey: Prentice Hall, 1993.

Pernetta, John. *Atlas of the Oceans*. Rand McNally, 1994.

Snyder, Susan Leach. *The Ocean Environment*. Upper Arlington, Ohio: SLS Publishing Company, 1992.

Web Sites

www.odyssey.ycg.org/oceanography4.htm

This is a great general oceanography site for teachers and more advanced students. The graphics would make a useful teaching tool even for younger students.

Wonderful Water—Student Worksheet

(Write your answers on another sheet of paper)

STATION 1

Before you begin: What do you expect your results to be?

After you finish: Record the results of your observation.

1. Based on your observations, which is less dense, fresh or salt water?
2. Based on what you now know, what do you think happens when rain falls in the oceans or when the tide enters the mouth of a river?

STATION 2

Before you begin: What do you expect your results to be?

After you finish: Record the results of your observation.

1. Based on your observations, which is more dense, HOT or COLD water?
2. Given what you have learned from this activity, would you expect ice to sink or float? Does ice sink or float? (If you're not sure, check it out!) Do additional research to find out why ice behaves as it does.

STATION 3

Before you begin: What do you expect your results to be?

After you finish: Record the results of your observation.

1. Why did one egg float and the other sink?
2. Based on the results of your observations, would you float better in one of the Great Lakes or in the Atlantic Ocean? Why?

STATION 4

Before you begin: What do you expect your results to be?

After you finish: Record the results of your observation.

1. What caused one of the pins to float?
2. Sketch what you think the molecules of water look like both at the surface and in the rest of the jar. Label your drawings.
3. What animals might benefit from this phenomenon and how might they benefit?

STATION 5

Before you begin: What do you expect your results to be?

After you finish: Record the results of your observation.

1. Soap is referred to as a wetting agent or a surfactant. This means that it interferes with the surface tension of water (or milk). What do you think the effects on the marine environment would be if large amounts of soap or detergent were dumped into the water?

Interdisciplinary Intermession 1

BACKGROUND

Oceans cover nearly three-quarters of our globe, yet they remain largely unexplored. Indeed, we are more intimately acquainted with the surface of the moon than we are with the depths of our oceans. Since humans first walked along coastal shores, the oceans have been a source of mystery, sustenance, excitement and terror. We have sailed their waters and brought back tales and songs of wonder. We have sailed their waters, and not all of us have returned. We have been lulled to sleep by the sounds of the gentle surf upon the beach. We have been driven from our homes by the fury of an ocean's might crashing on the shore. This is the stuff of which myths are made.

Wherever we live, whatever ocean laps at the shore of our little corner of the world, we have created stories, legends, songs and myths to explain the mysteries of the deep. From terrible sea serpents to beautiful mermaids, from children's nursery rhymes to Hollywood horror films, our fascination with the secrets of the sea stretches from ancient times to the present day. Even children who have never seen an ocean are familiar with at least some of the stories and legends they have inspired. The simple suggestions that follow are intended to capitalize on that familiarity.

PROCEDURE

1. Discuss myths and legends with your students. What are myths and legends? How do they develop? What purpose do they serve?
2. Find out what myths and legends your students are familiar with. Do any of them involve the ocean? Introduce your students to some traditional stories of the sea. You may want to read stories to them or have them find and read stories on their own. You may even choose to use dramatizations on film or video to spark the interest of more reluctant readers.
3. Discuss with your students what components make up a myth, legend or folk tale. For instance, although often fanciful, many legends and myths are based upon a perceived truth. Frequently, myths and legends are designed to offer some explanation—even if a fantastic one—of an unexplained natural occurrence.
4. Have students write their own myth. Ask them to do some planning before they begin. Will their myth tell the story of an imaginary person or animal? Will it be an attempt to explain some natural event? Once the final drafts of the myths are complete, have the students illustrate them. The collection of stories from the entire class can be bound together to form a book. Consider placing this book in the school library for checkout by other students or creating a class web page to share their writing with an even larger audience.

ADDITIONAL RESOURCES

Books

Hoffman, Mary, Ray, and Jane. *Earth, Fire, Water, Air*. New York: Dutton Children's Books, 1995.

Riordan, James. *Stories from the Sea*. New York: Abbeville Publishing Group, 1996.

Yolen, Jane. *Mother Earth, Father Sky: Poems of Our Planet*. Honesdale, PA: Boyds Mills Press, Inc., 1996.



As the Tide Turns

Predicting the future with tide tables and lunar calendars.

OBJECTIVES

In this activity students will:

- create a model of a clock that converts standard time to military time
- read and interpret tide charts and lunar calendars
- make graphic representations of monthly tides for the Atlantic and the Pacific coasts
- use the graphs they have created to make inferences and answer questions about tides and phases of the moon for both coasts
- use the graphs and background information to predict future tide patterns

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 11, 12 and 13*
- National Science Education Standards: *Unifying Concepts and Processes*
- National Science Education Standards: *5-8 Content Standards A, B, D, G*

TIME

Two class periods

MATERIALS

For each group:

- one copy of each of the tide charts
- one copy of the lunar calendar (Student Worksheet 2)
- six pieces of graph paper
- rulers
- pencils
- poster board
- two different colored markers

VOCABULARY

diurnal tides: one high and one low tide per tidal day. Diurnal tides are relatively rare. One place they can be found is the Gulf of Mexico.

ebb tide: another term for low tide

flood tide: another term for high tide

high tide: the highest level of the rising tide

higher high water (HHW): the higher of two unequal high tides in one tidal day

higher low water (HLW): the higher of two unequal low tides in one tidal day

low tide: the lowest level of the falling tide

lower high water (LHW): the lower of two unequal high tides in one tidal day

lower low water (LLW): the lower of two unequal low tides in one tidal day

mixed tides: two significantly unequal high and two significantly unequal low tides per lunar day

neap tides: tides with the smallest range between high and low tide occurring during the first and third lunar quarter

semidiurnal tides: two approximately equal high and two approximately equal low tides per tidal day. The Atlantic Ocean experiences semidiurnal tides

spring tides: tides with the greatest range between high and low tide occurring during new and full moons

tidal day: also called a lunar day, the time between two passes of the moon over a fixed point: 24 hours, 50 minutes

tidal range: the maximum height at high tide minus the minimum height at low tide

tide: periodic rise and fall of the ocean's surface caused by the gravitational pull of the moon and sun

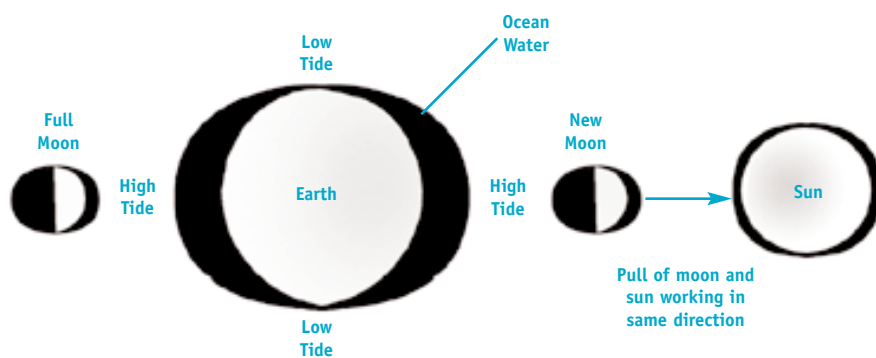
BACKGROUND

Tides affect animals living in or near the coastal ocean, as their environment alternates between being submerged and dry on a daily or twice daily basis. Animals and plants living in this intertidal zone must adapt to a harsh and changing environment. Being able to predict tides is also important for people who depend upon the coastal ocean for livelihood and recreation. Fishers, boaters, divers and swimmers are all affected by the rising and falling of the ocean's surface. Tides also create a great deal of energy which we are just beginning to learn to harness. Power generating stations that rely on tidal energy are already in use in a number of areas such as coastal France and Canada.

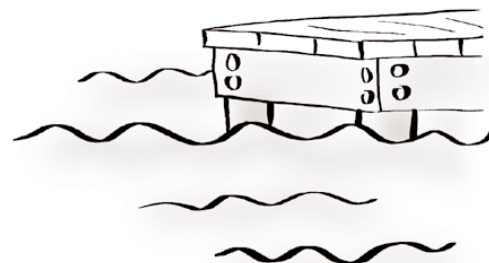
New technology continues to be developed, making the harnessing of tidal energy more efficient and cost-effective.

Tides are the periodic rising and falling of the ocean's surface. Tides are the result of the moon's—and to a lesser extent the sun's—gravitational pull on the Earth. These gravitational forces affect the entire planet, and measurable tides occur not only in the ocean, but also in other enclosed bodies of water such as large lakes. They are most readily measured in the coastal ocean where the water's height relative to the shoreline is easy to observe. Tide cycles can be measured and predicted on a daily basis, a monthly basis, and even over 18 to 19 year cycles. The following activities will explore daily and monthly cycles.

A tidal day is the length of time between two successive passes of the moon over a fixed point on the Earth's surface. Each tidal day measures 24 hours and 50 minutes, somewhat longer than calendar days. On any given coastline, tides exhibit one of three patterns. They may be diurnal, semidiurnal or mixed. When only one high tide and one low tide occur each tidal day, the tide is classified as diurnal. Diurnal tides are the least common of the three types. Semidiurnal tides refer to tidal cycles in which there are two relatively equal high tides and two relatively equal low tides per tidal day. Tides in the Atlantic Ocean are semidiurnal. In the Pacific Ocean tides follow a more mixed pattern. Mixed tides occur when two unequal high tides and two unequal low tides occur each tidal day.



SPRING TIDES



Tides also follow a monthly cycle associated with the position of the moon and the sun. Since both the moon and the sun exert gravitational pull on the Earth, the pattern of tides is influenced by the relative positions of Earth, sun and moon.



When the Earth, sun and moon are aligned, as happens twice each lunar month during the full moon and the new moon, the gravitational pull of the sun and the moon has an additive effect. This additive effect causes high tides to be higher than average and

low tides lower. We call these extreme tides spring tides. Neap tides occur twice per lunar month when the sun and the moon are at right angles to one another. During these times the gravitational effects of the sun and the moon work against one another causing more moderate tides.

PROCEDURE

1. Tide charts are often calculated in military time. This is simply a means of telling time using 24 numerals to mark the hours rather than 12, thus eliminating the need for a.m. and p.m. designations. Instruct the students to draw and cut out a circle from a piece of poster board or other stiff material. Using one colored marker, have them fill in the hours found on a typical clock face. Using a different colored marker, have the students fill in 13-24. 13 should be written under 1, 14 under 2, 15 under 3, etc. Tell students that in the military, the times are read as 100 hours. So 3:00 a.m. becomes "three hundred hours", while 3:00 p.m. becomes "15 hundred hours". Have students practice converting conventional times into military time.
2. Share the background information with the students. Divide the students into pairs or small groups and provide each group with copies of both of the tide tables provided. (Note: Tide tables are easily available over the Internet for many coastal areas. You may wish to provide students with more current charts and/or charts from different areas.) Spend some time with students becoming familiar with reading the tide tables. (Example: Have students find high and low tides for one day.)
3. Give each group of students six sheets of graph paper. Instruct the students to tape three sheets of graph paper together to create one long sheet. Repeat with the second three sheets. Have students mark the horizontal and vertical axis of the graphs as shown in the illustration. At this point, they should not try to fill in the dates. Since tidal days are longer than calendar days, this will create confusion. Both long graphs should be labeled in this way.
4. Students should begin plotting the heights of high and low tides on their graphs. Each group may wish to divide the work so that half of them graphs the Atlantic data while the other half graphs the Pacific data. Instruct students to begin at the left hand side of the first row to graph the first high tide. They should move across the first row, graphing each of the heights listed. When they complete the first row, they should move to the left-most height in the second row to continue graphing. Again, they should ignore the dates at this time. Continuing in this manner, they should plot the high and low tides for the entire month. When finished, they should use a ruler to connect the points on the graph to form one continuous line.
5. Now students can go back and mark off the calendar days and label them. They will notice that while most dates contain data for two high and two low tides, a few dates show only three tides (either two highs and a low or two lows and a high). Ask students why they think this is so. (Because the tidal day is 50 minutes longer than the calendar day, some calendar days have only three tides. There are also fewer tidal days in any calendar month.)
6. After reviewing background material and vocabulary, students should use the graphs they have created to complete Student Worksheet 1.
7. Provide each group of students with a copy of Student Worksheet 2—which includes a lunar calendar—on page 24. (Note: Lunar calendars are available via the Internet. Be sure that the lunar calendar you provide the students is for the same month as the tide tables.) Explain how to read a lunar calendar if necessary.
8. Have students add pictorial symbols to their graphs representing the full moon, the new

moon, the first quarter moon and the third quarter moon. Review any background material and vocabulary needed. Instruct students to use their updated graphs to complete Student Worksheet 2.

EXTENSIONS

1. Have groups of students graph tides for an entire year, each group graphing one month. Include the phases of the moon. Display the graphs end to end to create a tidal timeline. Students may wish to find or draw pictures illustrating the coastal area represented on the timeline at different seasons of the year.
2. Have students research the plants and animals of the intertidal zone. Concentrate on plants and animals indigenous to the area(s) for which your students created tidal graphs. If you displayed a tidal timeline in your classroom, add text and illustrations from the students' research.

WORKSHEET 1 ANSWER KEY

1. The Atlantic graph shows semidiurnal tides. The high and low tides each tidal day are of fairly equal heights which should be clear on visual inspection of the graphs.
2. The Pacific graph shows mixed tides. The high and low tides are of very unequal heights, which is clear when looking at and comparing the two graphs.
3. July 22 and 23 had tidal ranges of 12.3 feet.
4. July 22 had a tidal range of 7.56 feet.
5. Atlantic: July 31 tidal range: 7.6 feet;
Pacific: July 31 tidal range: 2.57 feet.
6. Spring tides.
7. Neap tides.

WORKSHEET 2 ANSWER KEY

1. During the full and new moons.
2. During the first and third quarter moons.
3. August 8 (approximately).
4. Spring tide.
5. August 22 (approximately).
6. Spring tide.
7. August 14 and August 30 (approximately).
8. Neap tides.

ADDITIONAL RESOURCES

Books

- Charton, Barbara. *The Facts on File Dictionary of Marine Science*. New York: Facts on File, 1988.
- Gross, M. Grant. *Oceanography*. New Jersey: Prentice Hall, 1993.
- Pernetta, John. *Atlas of the Oceans*. Rand McNally, 1994.
- Snyder, Susan Leach. *The Ocean Environment*. Upper Arlington, Ohio: SLS Publishing Company, 1992.

Web Sites

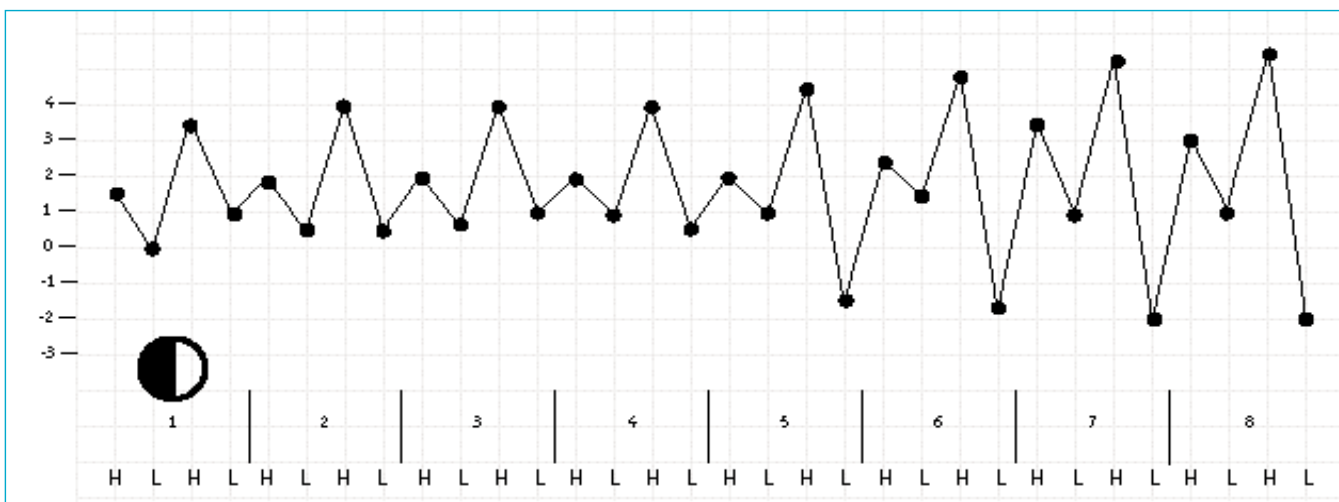
tidalelectric.com

This is a commercial site, but does a good job of describing the technology of harnessing tidal energy for electrical power.

www.surfinfo.com/html/tides.html

This site provides tide charts for the east coast.

NOTE: For tide tables perform a search using a web text search engine such as Alta Vista. Enter the words "tide tables" as well as the name of the port for which you are seeking information as your keywords.



ATLANTIC TIDE CHART

July 1998—Camden Harbor, Maine

Date	Day	High Time/Height(ft.)	Low Time/Height(ft.)	High Time/Height(ft.)	Low Time/Height(ft.)	High Time/Height(ft.)
Jul 1	Wed	0457 / 9.3	1116 / 1.0	1733 / 9.3	2347 / 1.6	
Jul 2	Thu	0551 / 8.9	1206 / 1.4	1824 / 9.2		
Jul 3	Fri		0043 / 1.6	0647 / 8.6	1257 / 1.6	1914 / 9.3
Jul 4	Sat		0139 / 1.6	0743 / 8.5	1347 / 1.7	2004 / 9.4
Jul 5	Sun		0231 / 1.3	0837 / 8.5	1436 / 1.7	2051 / 9.6
Jul 6	Mon		0320 / 1.0	0927 / 8.7	1522 / 1.6	2135 / 9.9
Jul 7	Tue		0404 / 0.7	1012 / 8.9	1605 / 1.4	2217 / 10.2
Jul 8	Wed		0445 / 0.3	1055 / 9.1	1646 / 1.1	2257 / 10.5
Jul 9	Thu		0525 / 0.0	1135 / 9.4	1727 / 0.9	2338 / 10.8
Jul 10	Fri		0624 / -0.3	1216 / 9.6	1809 / 0.6	
Jul 11	Sat	0019 / 11.0	0645 / -0.6	1257 / 9.9	1853 / 0.4	
Jul 12	Sun	0103 / 11.2	0728 / -0.7	1341 / 10.1	1940 / 0.2	
Jul 13	Mon	0150 / 11.2	0813 / -0.8	1427 / 10.4	2031 / 0.1	
Jul 14	Tue	0239 / 11.0	0901 / -0.7	1517 / 10.5	2124 / 0.1	
Jul 15	Wed	0333 / 10.8	0953 / -0.6	1610 / 10.6	2222 / 0.1	
Jul 16	Thu	0431 / 10.4	1047 / -0.3	1706 / 10.7	2325 / 0.1	
Jul 17	Fri	0533 / 10.1	1146 / 0.0	1806 / 10.8		
Jul 18	Sat		0030 / 0.0	0640 / 9.8	1248 / 0.2	1908 / 10.9
Jul 19	Sun		0137 / -0.	0747 / 9.7	1351 / 0.3	2010 / 11.1
Jul 20	Mon		0241 / -0.3	0853 / 9.7	1453 / 0.3	2110 / 11.2
Jul 21	Tue		0341 / -0.6	0953 / 9.9	1551 / 0.2	2207 / 11.4
Jul 22	Wed		0436 / -0.8	1048 / 10.0	1645 / 0.2	2259 / 11.5
Jul 23	Thu		0526 / -0.9	1138 / 10.1	1735 / 0.1	2347 / 11.4
Jul 24	Fri		0613 / -0.9	1225 / 10.2	1822 / 0.2	
Jul 25	Sat	0033 / 11.2	0658 / -0.7	1309 / 10.1	1908 / 0.3	
Jul 26	Sun	0117 / 10.9	0740 / -0.4	1352 / 10.0	1952 / 0.5	
Jul 27	Mon	0200 / 10.5	0821 / -0.1	1433 / 9.8	2036 / 0.8	
Jul 28	Tue	0243 / 10.1	0902 / 0.3	1515 / 9.6	2121 / 1.0	
Jul 29	Wed	0328 / 9.6	0944 / 0.7	1558 / 9.5	2208 / 1.3	
Jul 30	Thu	0414 / 9.2	1027 / 1.1	1642 / 9.3	2058 / 1.5	
Jul 31	Fri	0504 / 8.8	1113 / 1.5	1730 / 9.2	2351 / 1.6	

PACIFIC TIDE CHART

July 1998—Santa Barbara, California

Date	Day	High Time/Height(ft.)	Low Time/Height(ft.)	High Time/Height(ft.)	Low Time/Height(ft.)	High Time/Height(ft.)
Jul 1	Wed	0330 / 3.46	1002 / 1.10	1712 / 4.53	2351 / 1.99	
Jul 2	Thu	0501 / 3.15	1051 / 1.48	1753 / 4.74		
Jul 3	Fri		0053 / 1.49	0628 / 3.06	1138 / 1.77	1829 / 4.99
Jul 4	Sat		0139 / 0.97	0738 / 3.13	1223 / 1.99	1902 / 5.24
Jul 5	Sun		0218 / 0.49	0832 / 3.27	1304 / 2.13	1934 / 5.51
Jul 6	Mon		0253 / 0.06	0915 / 3.42	1343 / 2.19	2007 / 5.77
Jul 7	Tue		0326 / -0.31	0954 / 3.56	1421 / 2.21	2042 / 5.99
Jul 8	Wed		0400 / -0.61	1031 / 3.69	1500 / 2.20	2117 / 6.16
Jul 9	Thu		0435 / -0.82	1107 / 3.82	1541 / 2.19	2155 / 6.22
Jul 10	Fri		0511 / -0.93	1146 / 3.94	1624 / 2.19	2234 / 6.16
Jul 11	Sat		0549 / -0.91	1226 / 4.06	1712 / 2.20	2317 / 5.93
Jul 12	Sun		0629 / -0.75	1310 / 4.19	1806 / 2.23	
Jul 13	Mon	0004 / 5.54	0711 / -0.45	1356 / 4.37	1911 / 2.22	
Jul 14	Tue	0058 / 4.99	0756 / -0.05	1446 / 4.59	2028 / 2.11	
Jul 15	Wed	0203 / 4.35	0844 / 0.43	1539 / 4.87	2156 / 1.80	
Jul 16	Thu	0325 / 3.77	0937 / 0.91	1633 / 5.20	2322 / 1.27	
Jul 17	Fri	0502 / 3.42	1035 / 1.34	1727 / 5.56		
Jul 18	Sat		0035 / 0.61	0634 / 3.37	1136 / 1.65	1819 / 5.91
Jul 19	Sun		0134 / -0.02	0748 / 3.51	1235 / 1.84	1908 / 6.22
Jul 20	Mon		0225 / -0.53	0847 / 3.71	1330 / 1.92	1955 / 6.44
Jul 21	Tue		0310 / -0.88	0936 / 3.90	1420 / 1.92	2039 / 6.54
Jul 22	Wed		0352 / -1.05	1019 / 4.06	1507 / 1.90	2122 / 6.51
Jul 23	Thu		0431 / -1.05	1059 / 4.17	1553 / 1.90	2203 / 6.34
Jul 24	Fri		0509 / -0.92	1138 / 4.24	1637 / 1.93	2242 / 6.04
Jul 25	Sat		0545 / -0.66	1217 / 4.28	1721 / 2.00	2322 / 5.62
Jul 26	Sun		0621 / -0.30	1255 / 4.30	1808 / 2.10	
Jul 27	Mon	0001 / 5.11	0656 / 0.14	1336 / 4.30	1901 / 2.21	
Jul 28	Tue	0044 / 4.54	0732 / 0.62	1418 / 4.30	2004 / 2.27	
Jul 29	Wed	0133 / 3.95	0808 / 1.11	1504 / 4.33	2121 / 2.22	
Jul 30	Thu	0238 / 3.39	0848 / 1.58	1552 / 4.41	2250 / 1.98	
Jul 31	Fri	0413 / 3.01	0935 / 1.99	1642 / 4.56		

As the Tide Turns—Student Worksheet 1

1. Look at the two graphs your group has completed. Which one shows a semidiurnal tide? How do you know?

2. Which graph shows a mixed tide? How do you know?

3. Which date on the Atlantic graph has the greatest tidal range? (HINT: Use your ruler to find the highest and lowest tides.) What was the tidal range on that day? (Go back to your tide table for that day. Subtract the height of the low tide from the height of the high tide. This is the tidal range.)

4. Which date on the Pacific graph has the greatest tidal range? (HINT: Use your ruler to find the highest and lowest tides.) What was the tidal range on that day? (Go back to your tide table for that day. Subtract the height of the low tide from the height of the high tide. This is the tidal range.)

5. Using the same procedure you used to find the answers to questions 3 and 4, find the dates and tidal ranges on each graph that represent the smallest tidal range.

6. Look carefully at each of your graphs. You will notice that there are two periods for each month when the tidal ranges are greater than average. (You found one of them when you answered questions 3 and 4.) Do these represent spring tides or neap tides? Label these time periods with the correct answer.

7. Look at each of your graphs again. You will notice that there are two periods for each month when the tidal ranges are less than average. (You found one of them when you answered question 5.) Do these represent spring tides or neap tides? Label these time periods with the correct answer.

As the Tide Turns—Student Worksheet 2

1. During which phases of the moon are the tidal ranges the greatest?

2. During which phases of the moon are the tidal ranges the smallest?

3. Use your lunar calendar and a standard calendar to predict the next full moon.






4. Would you expect to see a neap tide or a spring tide on the date you listed in question 3?

5. Using your lunar calendar and a standard calendar, predict the next new moon.

6. Would you expect to see a neap tide or a spring tide on the date you listed in question 5?

7. Using your lunar calendar and a standard calendar, predict the next two quarter moons.

8. Would you expect to see neap tides or spring tides on the dates you listed for question 7?

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
JULY 1998				1 <small>First Quarter</small> 	2	3	4
	5	6	7	8	9 <small>Full Moon</small> 	10	11
	12	13	14	15	16 <small>Last Quarter</small> 	17	18
	19	20	21	22	23 <small>New Moon</small> 	24	25
	26	27	28	29	30	31 <small>First Quarter</small> 	

Currents 'Round the World

Trace the flow of water around the world with a map of ocean currents as your guide.

OBJECTIVES

Students will:

- label and interpret a map of ocean currents
- recognize a pattern in the circulation of the ocean's waters
- solve word problems using an ocean currents map

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 11, 12 and 13*
- National Science Education Standards: *Unifying Concepts and Processes*
- National Science Education Standards: *5-8 Content Standards A, B and D*

TIME

45 minutes

MATERIALS

For each student:

- a copy of the Currents 'Round the World map (page 28)
- pencil

VOCABULARY

current: a horizontal movement of water

BACKGROUND

A current is a horizontal movement of water. Surface currents on the ocean are formed because winds push the top layer of water forward, and the rotation of the Earth shifts the direction of the flow. The result is predictable patterns of circulation all around the globe.

Currents in the Northern Hemisphere circulate in a clockwise direction, while currents in the Southern Hemisphere flow counterclockwise. Since this flow moves warm waters from the tropics toward the poles and cold polar waters down to the equator, it helps regulate the Earth's climates. For example, the Gulf Stream brings warmth to Iceland and Great Britain, giving them a much milder climate than other regions so far north.

People make use of their knowledge of the currents when traveling across the ocean. Long ago, sailors learned that sailing the ocean was faster if you traveled with the currents. Benjamin Franklin observed that ships traveling from North America to Europe made better time than they did on the return trip. He published the first chart of the Gulf Stream to help ships' captains plot their routes.

PROCEDURE

1. Give each student a copy of the Currents 'Round the World map. Ask them to label each of the following oceans on their maps: Arctic Ocean, Atlantic Ocean, Indian Ocean, Pacific Ocean and Antarctic Ocean.
2. Tell students that in the world's oceans, massive flows of water called currents help circulate the water. Use the Background information to define currents.
3. Read the descriptions of the currents given below. For each description, have the students find the location for that current on their maps and label the appropriate arrow with the current's name. Note that the names of the currents often give a clue as to their location.

The **North Equatorial Current** flows east to west, just north of the equator. It has three sections—in the Pacific, Atlantic and Indian Oceans.

The **South Equatorial Current**, like the North Equatorial Current, has three sections that flow east to west. It runs just south of the equator.

The **Equatorial Counter Current** squeezes between the North and South Equatorial Currents, right on the equator. It flows in the opposite direction, from west to east.

The **California Current** is in the Northern Hemisphere. It brings cool water down the coast of California.

The **Kuroshio Current**, in the northern Pacific Ocean, travels up the east coast of Asia, past Japan.

The **North Pacific Current** runs from Asia to North America, across the North Pacific Ocean.

The **Gulf Stream Current** flows clockwise up the east coast of the United States and across the North Atlantic Ocean.

The **Labrador Current**, in the North Atlantic Ocean, flows down between Greenland and Canada, bringing cold water to the Gulf Stream.

The **North Atlantic Current** travels from west to east, past Iceland toward Great Britain.

The **Canary Current** is in the Northern Hemisphere. It travels down the west coast of Africa.

The **Benguela Current**, in the Southern Hemisphere, flows up the west coast of Africa.

The **Brazil Current** flows down the east coast of South America.

The **Agulhas Current**, located in the Indian Ocean, runs down the east coast of Africa, between Africa and Madagascar.

The **West Australian Current** brings water north along the west coast of Australia.

The **East Australian Current** moves south along the east coast of Australia.

The **Peru Current** flows north along the coast of South America.

The **Antarctic Circumpolar Current** circles the continent of Antarctica, traveling from west to east.

4. Review maps with students to make sure they are labeled correctly.
5. Ask students if they notice anything about the directions the currents flow. Lead them to see that the currents move clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere. Note that a combination of winds and the rotation of the Earth make these patterns occur.
6. Ask students in which direction the warm waters of the tropics travel, and where the cold polar waters move. Lead them to see that the warm waters move from the equator toward the poles, and the colder waters near the poles move toward the equator. The currents regulate the Earth's temperature by circulating the waters of the oceans.
7. Finally, split the class into small groups. One by one, read the problems listed on pages 26 and 27 and ask the group to use their maps to solve the problems. The first two problems are of about the same difficulty and the third is more challenging. Use a class discussion to review their answers and what they have learned about currents.

PROBLEMS

The Lost Keychain

You're in Newfoundland, off Canada's Atlantic coast, taking a trip on a whale-watch boat. The whales are amazing, and as you point at one, your new souvenir keychain goes flying into the water. Luckily, it's a floating keychain, the kind that fishermen use. You wrote your name and address on it, but, too bad, it's floating away, and there's no hope of retrieving it.

Months and months pass, and one day your keychain arrives in the mail. The note with it says: "Hi. My name is Carmen. I live in Portugal, and I found your keychain on the beach." That's a long way to travel, from Newfoundland to Portugal! Which currents took your keychain on its journey?

Answer

The Labrador Current, the Gulf Stream Current and the Canary Current.

Boogie Board on the Loose

You're boogie boarding off the beaches of San Diego when a monster wave knocks you over. Once you catch your breath, you look around for your board, but it's nowhere to be seen. You think to yourself, "At least it has my phone number on it. Maybe it will turn up." Long after you've given up hope of ever seeing your board again, you get a phone call. Someone in San Francisco found your board. How did it get there?

Answer

Starting in San Diego, it followed the California Current, the North Equatorial Current, the Kuroshio Current, the North Pacific Current and back to the California Current.

Cooler Travels the World

Sitting on a sunny beach in Bali, far off in Indonesia, you're enjoying a picnic. You take a hike, but by the time you get back, the tide has risen and gone out again, taking your cooler with it. The cooler is only a speck in the distance. Oh well, it was the hotel's cooler anyway, but you didn't get to eat your cookies!

Back home in Cape Cod, Massachusetts, you're walking along the shore when you come across a

tattered cooler. On its side is stamped the name of your hotel in Bali! You open the cooler, and a cookie falls out. The cooler traveled from Bali to Cape Cod via the currents. Use your map to find the path it took.

Answer

West from Bali on the South Equatorial Current to the Agulhas Current, around Africa to the Benguela Current, the South Equatorial Current, the North Equatorial Current and the Gulf Stream Current.

EXTENSIONS

1. Encourage students to make up their own stories about lost objects traveling on currents. Then have them trade stories and figure out how the objects reach their final destinations.
2. Have students find news accounts of the accidental dumping of thousand of Nike shoes from a ship in the Pacific Ocean in 1990. Since then, scientists have traced the path the shoes traveled as they flowed with the currents. (An article about the shoes can be found in the magazine *Sea Frontiers*, March-April 1993, on page 14.)

ADDITIONAL RESOURCES

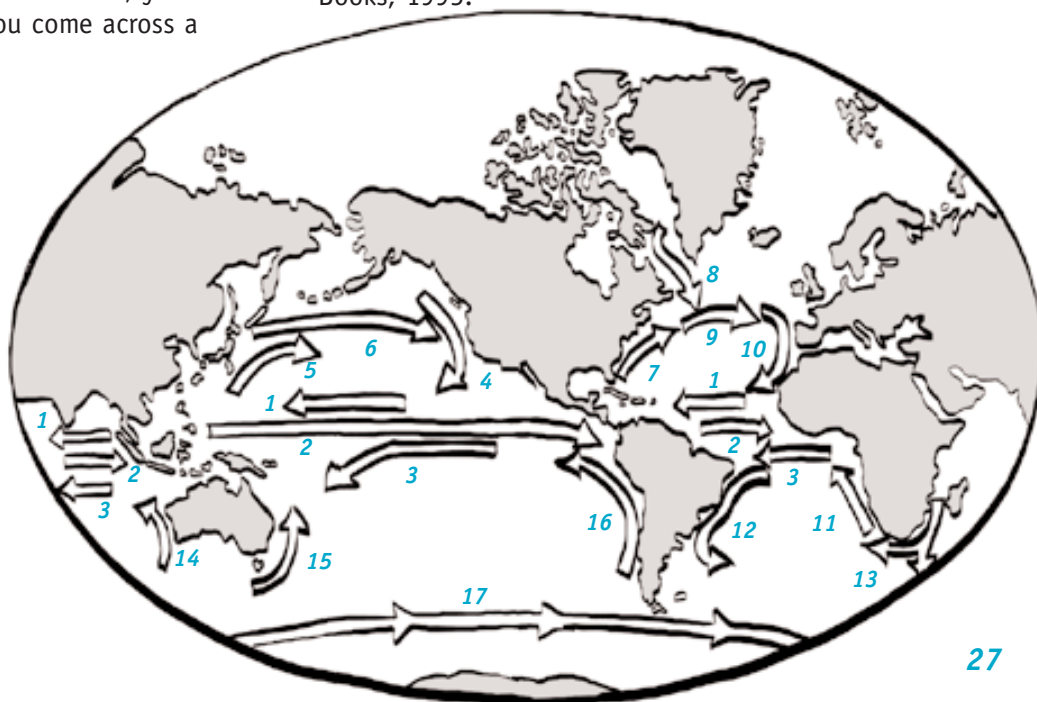
Books

Ganeri, Anita. *The Oceans Atlas*. London: Dorling Kindersley, 1994.

Robinson, W. Wright. *Incredible Facts About the Ocean: The Restless Blue Salt Water*. Minneapolis: Dillon Press, Inc. 1986.

Talbot, Dr. Frank H., ed. *Under the Sea*. Time-Life Books, 1995.

- North Equatorial Current 1
- South Equatorial Current 2
- Equatorial Counter Current 3
- California Current 4
- Kuroshio Current 5
- North Pacific Current 6
- Gulf Stream Current 7
- Labrador Current 8
- North Atlantic Current 9
- Canary Current 10
- Benguela Current 11
- Brazil Current 12
- Agulhas Current 13
- West Australian Current 14
- East Australian Current 15
- Peru Current 16
- Antarctic Circumpolar Current 17



Currents 'Round the World Map



North Equatorial Current
South Equatorial Current
Equatorial Counter Current
California Current
Kuroshio Current
North Pacific Current
Gulf Stream Current
Labrador Current
North Atlantic Current
Canary Current
Benguela Current

Brazil Current
Aguilhas Current
West Australian Current
East Australian Current
Peru Current
Antarctic Circumpolar Current

Food Fights

Explore the interdependency of living organisms in this food web simulation.

OBJECTIVES

In this activity the students will:

- demonstrate how a food web works
- participate in a marine food web simulation
- demonstrate the importance of biodiversity as it relates to survival in marine ecosystems

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 11 and 12*
- National Science Education Standards: *Unifying Concepts and Processes*
- National Science Education Standards: *5-8 Content Standards A, C and F*

TIME

45-50 minutes

MATERIALS

For each group:

- 4 pieces of rope each approximately 10 meters in length
- uncooked macaroni (approximately 250 pieces)

For each pair of students:

- one paper lunch bag
- stopwatch or watch with a second hand
- pencil
- data sheet (see page 33)
- clipboard

VOCABULARY

aphotic zone: the area of the ocean where light penetration is insufficient for photosynthesis to occur

biomass: the amount of living matter, both plant and animal, in a specific area at a specific time. Biomass is measured in milligrams of carbon per unit of volume

chemosynthesis: the conversion of chemical substances into energy

consumer: any organism that eats other organisms

photic zone: the upper layer of the ocean where enough light penetrates for photosynthesis to occur

photosynthesis: the conversion of light into energy

phytoplankton: plant forms of plankton

plankton: organisms that either drift passively or are very weak swimmers

producer: organisms that use either photosynthesis or chemosynthesis to produce energy

trophic level: a strata in the trophic pyramid formed by organisms with a specific feeding style

trophic pyramid: a diagram that shows the energy relationships between organisms in a particular ecosystem

zooplankton: animal forms of plankton

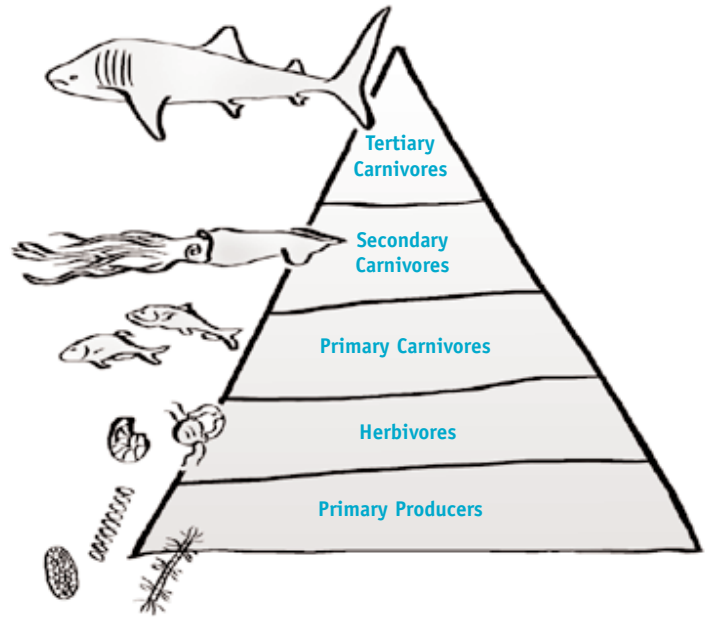
BACKGROUND

All living organisms must have energy to survive. This energy can be acquired from the sun through the process of photosynthesis, from chemicals through chemosynthesis (see extension activities for a discussion of chemosynthesis) or from the consumption of other organisms. Every organism in an ecosystem is dependent upon every other organism. This complex system of relationships between organisms forms an interdependent network known as a food web. Just as breaking one strand of a spider's web weakens the whole, the removal of any organism or link in the food web has wide reaching effects on the remainder of the web.

In the photic zone of the oceans (the top 200 meters where enough light penetrates to allow photosynthesis), plankton forms the basis of the marine food web. Plankton is any plant (phytoplankton) or animal (zooplankton) that floats or drifts freely in the water. Plankton includes microscopic organisms, animal larvae and any larger organisms such as sea jellies that swim too poorly to move effectively under their own power.

Marine phytoplankton, like fresh water phytoplankton and land plants, needs sunlight, inorganic nutrients, carbon dioxide and water to survive. Water and sunlight are available in abundance in the photic zone of the ocean. The cells of phytoplankton contain chlorophyll, which traps the sun's energy for use in photosynthesis. Photosynthesis is the process of converting sunlight, nutrients, carbon dioxide and water into sugars and amino acids. This conversion of sunlight and inorganic substances into food energy is known as primary production. Phytoplankton, as well as other plants and plantlike organisms capable of

photosynthesis are known as primary producers. Animals, from the tiny zooplankton to the massive blue whale feed either on producers or on one another and are known as consumers.



The greatest amount of available energy in a food web is found at the level of primary production. Because a larger amount of energy is available at this level, a greater amount of life—a greater biomass—can be supported here. Using a pyramid as a model, phytoplankton would form the base, or broadest portion of the pyramid in the ocean's photic zone. Sharks, killer whales and other top predators would be found at the apex of the pyramid. This pyramid, modeling the energy relationships among organisms, is known as a trophic pyramid. Organisms in each layer, or trophic level, of the pyramid use about 90% of the energy gained from food to meet their own metabolic needs. This means that only 10% of the original energy is incorporated into the body tissue for consumption by consumers at the next level. Thus there is less available energy at each successive trophic level and each level supports a comparatively smaller biomass than the level below. To illustrate this point, imagine a 5-level trophic pyramid like the one pictured above. A shark at the top of this pyramid will receive only 1/10,000 of the original energy harnessed by the phytoplankton. No wonder a shark has to eat so much!

PROCEDURE

1. Begin by asking your students to name a fish, a marine bird, a marine mammal and two invertebrates. Write their responses in a random fashion on the board. Along with these, add phytoplankton. Discuss with your students the ways in which all of these organisms are related. Guide the discussion with questions about the feeding habits of each organism until all seven of the original organisms are connected in some way. *For example:* Suppose your students named squid, zooplankton, fish, penguin and the killer whale as their invertebrates, fish, bird and mammal. You can talk about the fact that zooplankton eat phytoplankton. Squid and penguins both eat zooplankton. Penguins also eat squid and fish. A killer whale may dine on a penguin, and so on. Ask the students what would happen if certain organisms were taken out of this system. They will quickly observe that even one small change can have far reaching effects on the entire system. Using the Background information, explain how food webs function and why biodiversity is important to any ecosystem.
2. Explain to the students that they will be taking part in a simulation to demonstrate the ideas they have just been discussing. In this simulation consumers (represented by students) will search for food to meet their daily energy requirement. Macaroni will represent the primary producers, the first link in the food web.
3. The simulation is best conducted out-of-doors. It can, however, be adapted to a gymnasium or other large indoor space. Begin by locating a patch of grass at least 10 meters square. Using four pieces of rope, lay out a 7m x 7m square to serve as the feeding site. Mark off one square for each team of 10 students. Scatter the macaroni throughout the feeding site, taking care not to leave large clumps in any one location.
4. Divide students into teams of 10. Within each team, create 5 pairs of students. One student in each pair will participate in the simulation while the other student acts as a timer/recorder. At the end of the simulation, the pairs may change roles. Designate four of the participants to be primary consumers (baitfish) and one to represent a secondary consumer (shark).
5. Tell the participants that their job is to find enough food each day to survive. Provide each of the baitfish, as well as the shark, with a paper lunch bag in which to collect their food. The daily requirement of the baitfish is five food items per day. The shark must collect 10 food items each day in order to meet its daily requirement.
6. The baitfish should all choose one side of the square as their communal hiding place. The shark will have the opposite side as its hide-away. Designate one of the timers to call "Start." Once start has been called, each consumer has 60 seconds in which to collect their daily requirement of food and return to their hiding spot. Baitfish may "eat" only the items at the base of the food web (pieces of macaroni). Each piece of macaroni represents one food item. Sharks, however, may "eat" both the macaroni and the baitfish. Again, each piece of macaroni is worth one food item, while a baitfish is worth five.
7. Macaroni is considered eaten when it is placed in the lunch bag each consumer carries. The shark is able to prey on the baitfish by tagging them if they are in the feeding site. When not preparing to tag a baitfish or picking up a piece of macaroni, the shark must keep its hands behind its back. Once tagged, the baitfish who was caught must leave the square and is excluded from the remainder of the game. If a baitfish has collected its food items and returned to its hideaway, it may not be tagged.



8. Baitfish may fall prey to the shark any time they are within the feeding site. Baitfish are not totally without recourse, however. If a baitfish is about to fall prey to a shark in the feeding site, any baitfish may call out a warning by yelling “shark.” Any time the shark’s hands are not behind its back, a baitfish may yell “shark.” Once the alarm has been given, the shark must return its hands behind its back and freeze in position for three seconds. The baitfish may use this time to flee to a safer area of the feeding site and continue gathering food. The timers also serve as judges to keep both the baitfish and the shark honest.
9. Each timer should record on the data sheet the time, in seconds that his or her partner needed to find the daily requirement of food and return to safety. This time will be used to determine a relative food collecting efficiency for each of the consumers. If the consumer fails to return safely home with the required food items in the time allotted, that consumer starves to death. In this case, the timer should record a time of 60 seconds on the day of starvation and for all subsequent days.
10. Repeat steps 6-9 above 11 more times to complete a 12 day run. The simulation ends when the 12 days are completed or when all of the consumers fail to find their daily requirement of food, whichever comes first. You may choose to have the simulation last more or less time than this by adjusting the number of trials.
11. At the end of the simulation, student pairs may change roles and the simulation can be repeated.
12. Students should graph, either individually or as a group, the feeding times of each consumer in their site to compare their relative feeding efficiency. The graphs should illustrate that as the days progressed and prey became harder to find, feeding times increased.
13. Discuss the results with the students. Talk about the effect of the population at each trophic level when the food at the lowest level (the macaroni) became harder to find. Talk about the amount of energy the shark had to expend to gather the macaroni versus the amount of energy needed to capture the baitfish. How would the baitfish starving to death affect the shark?

EXTENSIONS

1. Try varying the population size of each trophic level in the simulation. You may also wish to try running the simulation with additional trophic levels added. This will be a bit more cumbersome, but may be a good challenge for more advanced groups.
2. The above simulation represented a food web in the photic zone. Photic zone food webs are based on photosynthesis. In the deepest part of the aphotic zone there exists a completely different sort of food web. Hydrothermal vents that spew superheated water filled with toxic sulfur compounds can be found on the ocean floor. In this world without sunlight, plants cannot survive. Long thought to be a barren, lifeless place, scientists have only recently discovered an entirely new sort of food web. Around the vents, the base of the trophic pyramid is formed by bacteria that are able to synthesize sulfur compounds that would prove toxic to most other organisms. These bacteria are the primary producers of the deep. Consumers, such as the giant tube worm, either feed directly on the bacteria or live in symbiosis with them. Have your students research the food web of the deep. Perform the above simulation adding symbiosis into the mix.

ADDITIONAL RESOURCES

Books

Hale, W.G. and Margham, J.P. *The Harper-Collins Dictionary of Biology*. New York: HarperCollins Publishers, 1991.

Sumich, James L. *An Introduction to the Biology of Marine Life*. Dubuque, IA: Wm. C. Brown Publishers, 1996.

Web Sites

encarta.msn.com/schoolhouse/oceans/ocmarine.asp

A good resource for general information on marine food webs, plankton and hydrothermal vents.

mcnet.marietta.edu/~biol/102/ecosystem.html#FoodChainsandWebs4

This is a more technical site of use to teachers and advanced students.

Food Fights—Data Sheet

Recorder's name _____

Partner's name _____

Baitfish or Shark? (Circle one.)

Day	1	2	3	4	5	6	7	8	9	10	11	12
Time												

Day on which starvation occurred _____

Notes:

Recorder's name _____

Partner's name _____

Baitfish or Shark? (Circle one.)

Day	1	2	3	4	5	6	7	8	9	10	11	12
Time												

Day on which starvation occurred _____

Notes:

Creature Keys

Learn how to
classify everything
from pennies to
sharks using a
dichotomous key.

OBJECTIVES

In this activity students will:

- Develop an understanding of the use of a dichotomous key in classification
- Use a simple dichotomous key to classify several cartilaginous fish (fish with cartilage rather than bone) to the level of family
- Create a dichotomous key to classify common objects found in a classroom

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goal 12*
- National Science Education Standards: *Unifying Concepts and Processes*
- National Science Education Standards: *5-8 Content Standards A and C*

TIME

45 minutes

MATERIALS

For each student:

- pencil
- paper
- one each of the following objects:
 - die
 - half dollar
 - quarter
 - dime
 - nickel
 - penny

For each group:

- 3 or 4 picture cards (page 39)
- copy of the Elasmobranchii Dichotomous Key (page 38)
- one set of 6-8 items commonly found in a classroom
- paper

VOCABULARY

dichotomous: divided into two parts

dichotomous key: a tool for identifying living organisms to some specific taxon (phylum, family, species, etc.) using a series of pairs of choices

key out: use a dichotomous key to identify a specific organism

taxa: the plural of taxon

taxon: any specific taxonomic level such as phylum, family, species, etc.

taxonomy: the science of classification, especially of living things

BACKGROUND

Taxonomy is the science of classification, usually of living organisms. Scientists use taxonomy to systematically organize information about the relationship between organisms as well as to identify new organisms. Taxonomy creates hierarchical levels of similarity among living things. Each of these levels is called a taxon. Using the great white shark as an example, and starting from the top, a taxonomic hierarchy might look like this:

Kingdom: Animalia (animal)

Phylum: Chordata (having a central nerve cord)

Subphylum: Vertebrata (having vertebrae)

Class: Chondrichthyes (having a cartilaginous skeleton)

Subclass: Elasmobranchii (having plate-like gills)

Order: Selachii (sharks)

Suborder: Galeiforme (referring to the typical shark-like shape)

Family: Lamnidae (family of fierce pelagic sharks)

Genus: Carcharodon (having sharp, triangular teeth with serrated edges)

Species: Carcharias (the great white shark)

There are a number of different tools that scientists can use to place an organism into the taxonomic

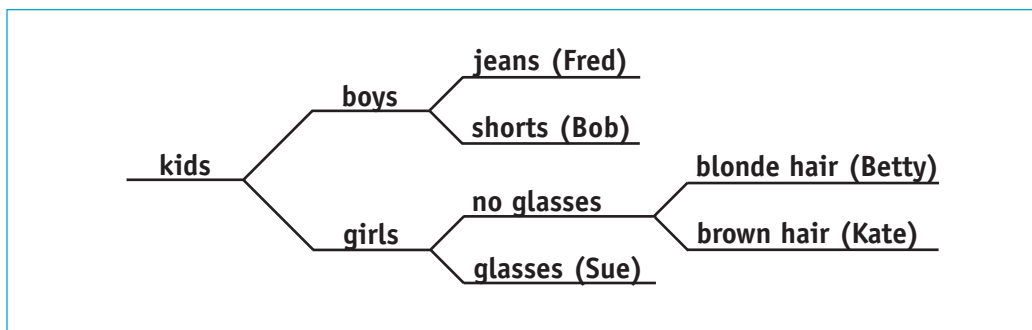
hierarchy. One frequently used and especially helpful tool is the dichotomous key. A dichotomous key is a series of descriptive choices regarding the characteristics of an organism arranged in pairs or couplets. Each pair asks the user to make the choice which most closely fits the organism to be identified. The pairs usually begin with fairly general characteristics and become more detailed as more choices are needed to separate organisms.

An example of a very simple dichotomous key to classify a group of 5 children might be as follows:

- | | |
|------------------------|----------------|
| 1. Sex is male | go to 2 |
| 1. Sex is female | go to 3 |
| 2. Wearing jeans | child is Fred |
| 2. Wearing shorts | child is Bob |
| 3. Glasses are absent | go to 4 |
| 3. Glasses are present | child is Sue |
| 4. Hair is blonde | child is Betty |
| 4. Hair is brown | child is Kate |

This dichotomous key follows several important rules of construction that are designed to make it easier to read. Every other pair of choices should be indented. The characteristics should be easy to observe and the part described should be listed before any descriptive term. This is especially important as the keys increase in complexity, as it quickly draws the user's attention to the characteristic being observed. Finally, each statement in a pair should begin with the same word if possible.

When developing a dichotomous key, a branching diagram like the one below makes a good sorting tool. The group of objects (we'll use the same group as in the above example) is divided into two groups using some distinguishing characteristic. Each group is noted in the diagram. Each of the two groups is divided into two smaller groups and so on until no more divisions can be made. This diagram can then be used for writing the key itself. During this stage of creating the key it is not necessary to observe the syntax rules that will be used in the final key.



BRANCHING DIAGRAM

Dichotomous keys may be as simple as the above example or very complex. Their complexity is determined by the specificity of the identification required as well as by the number of organisms included. For the purpose of these activities we will be using a simplified dichotomous key with a limited number of organisms represented. We will “key out” organisms to the level (or taxon) of family.

PROCEDURE ACTIVITY 1



1. Give each student a set of the following objects: a die, a half dollar, a quarter, a dime, a nickel and a penny.
2. Create a branching diagram on the chalkboard as you proceed. Provide students with paper and instruct them to create their own diagram for note taking.
3. Direct the students to examine their objects. On the first line of the diagram write the word “objects”.
4. Explain to students that they must first separate their objects into two groups. What characteristic will they use? The most obvious division is “round” and “cube”. This division creates the first two branches on the diagram. On the top line of the branched pair, write the word “cube”. On the bottom line, write the word “round.”
5. Ask students whether the cube group can be sorted any further. Since there is only one object in that group it cannot. Write the word “die” in parentheses next to the word “cube.”
6. Have the students examine the group labeled “round”. How can they divide that group into two distinct groups? There may be several suggestions. You may want to get a consensus from the class or you may wish to direct their choices. For this example, we will use the characteristic of color. Some of the objects are silver colored while some are copper colored.
7. Draw a pair of lines branching from the line labeled “round”. Write “silver colored” and “copper colored”—one word for each line in the pair. Next to the words “copper colored”, write the word “penny” as this is the only copper colored coin.



8. Continue in this way until each coin has its own line.
9. Explain to students the rules for constructing a dichotomous key (see Background). Working on the chalkboard, have students help you convert their graphic representation into a dichotomous key similar to the examples provided.

ACTIVITY 2

1. Divide the students into groups of three or four students.
2. Provide each group with a copy of the Dichotomous Key for Elasmobranchii found on page 38.
3. Provide each group with 3 or 4 picture cards copied and cut from page 39.
4. Instruct students to key out each of the animals pictured on their cards. They may write their answers on the back of the picture. The answers should say whether the animal is a Selachian or a Batoid and list the family name and the common name.
5. Discuss the results with the class. Do you think this key listed every family of Elasmobranchs? *No. There are more than 30 families, this key lists only a dozen.* To what taxon did this dichotomous key identify the animals? *To the taxon of family.* Could you use this key to distinguish between animals in the same family? *No, the key would need to be far more detailed.* (A list of common names for Elasmobranchii Families is on page 37.)

ACTIVITY 3

1. Keep students in their groups from Activity 2.
2. Provide each group with at least six items (of your choice, or students may select their own items) commonly found in a classroom.
3. Provide each group with paper to create a branching diagram.
4. Instruct students to use the sorting method from Activity 1 to sort their objects.
5. Have students rename the objects using nonsense words, letter substitution codes or any other method to disguise the true name of the object. (This will prevent students keying out items from simply looking for the name of the

object.) The group should keep a copy of the new names and their meanings.

6. Once the objects are sorted and renamed, have students create a dichotomous key like the one they used for the animals in Activity 2. They should use only the “coded” name of the objects on their dichotomous keys.
7. Have the groups exchange objects and keys. Each group should see if they can key out the new objects using the student-created dichotomous keys. The group who created the original key can provide the answers to the “coded” names after the groups are finished.
8. Discuss the results with the class. Would one group’s key work with another group’s set of objects? *Only if that group had an identical set of objects.* Could two groups with identical sets of objects come up with different dichotomous keys? *There could certainly be differences in the keys depending on what characteristics each group used to sort their objects.* Scientists can also use different characteristics to create their classification systems. While some might rely on external characteristics, others may use internal biology to make their decisions. Scientists don’t always agree on the final classification of an animal. You may find an animal classified several different ways in different pieces of literature.

EXTENSIONS

1. Have students extend the Dichotomous Key for Elasmobranchii to the level of genus for one or more of the animals they keyed out.
2. Have students practice keying out other marine animals using more complete dichotomous keys.
3. Provide students with specimens or pictures of a variety of marine invertebrates. Ask students to create their own dichotomous keys to identify these animals.

ADDITIONAL REFERENCES

Books

Allen, Thomas B. *Shadows in the Sea: The Sharks, Skates, and Rays*. New York: Lyons and Burford, 1996.

Charton, Barbara. *The Facts on File Dictionary of Marine Science*. New York: Facts on File, 1988.

Green, Thomas F. *Marine Science*. New York: Amsco School Publications, Inc., 1998.

Gross, M. Grant. *Oceanography*. New Jersey: Prentice Hall, 1993.

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Sumich, James L. and Dudley, Gordon H. *Laboratory and Field Investigations in Marine Biology*. Dubuque, IA: Wm. C. Brown Publishers, 1992.

Web sites

www.zoo.utoronto.ca/~able/volumes/vol-12/7-timme/7-timme.htm

This site is a good resource for both teachers and students. It includes a good discussion of the rules for constructing a dichotomous key as well as some examples.

www.iit.edu/~smile/bi8611.html

This site has some interesting additional activities for teaching students to use dichotomous keys.

pc65.frontier.osrhe.edu/hs/science/hbotkey.htm

This site includes some links to other dichotomous keys that students can use for the extension activities.

COMMON NAMES OF ELASMOBRANCHII FAMILIES

Alopiidae: Thresher sharks

Carcharhinidae: Requiem or gray sharks

Dasyatidae: Stingrays

Hexanchidae: Six- and seven-gilled sharks

Lamnidae: Mackerel, mako, and great white sharks

Mobulidae: Devil rays

Pristiophoridae: Saw sharks

Pseudotriakidae: False cat sharks

Rajidae: Skates

Rhincodontidae: Whale sharks

Scapanorhynchidae: Goblin sharks

Sphyrnidae: Hammerhead sharks

Squalidae: Dogfish sharks

Dichotomous Key for Elasmobranchii

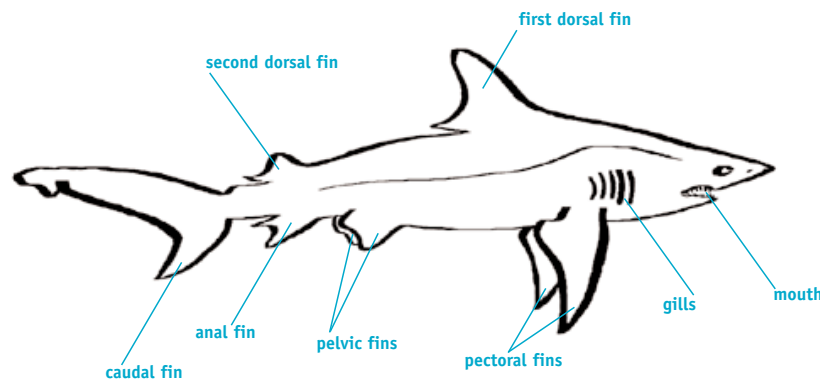
- 1. Body is shaped like a kite go to 11
- 1. Body is not shaped like a kite go to 2

Selachians

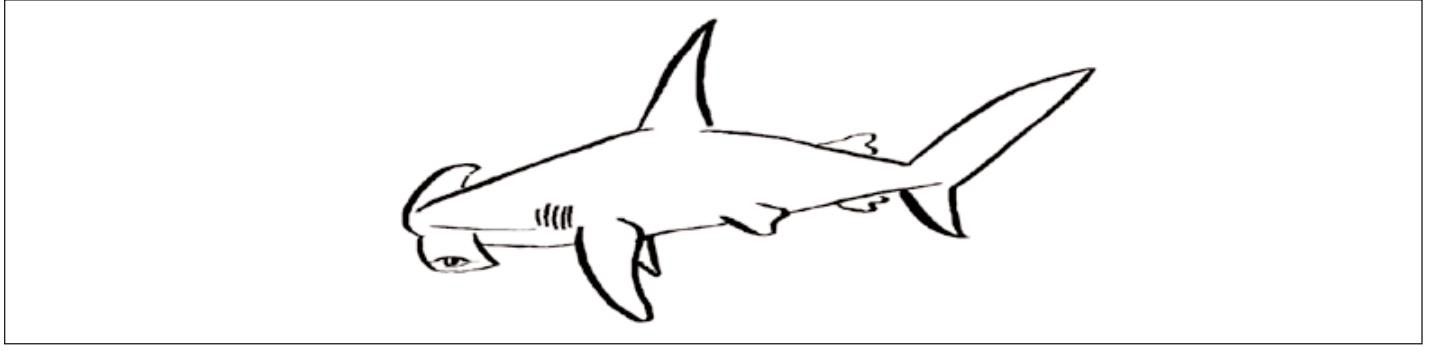
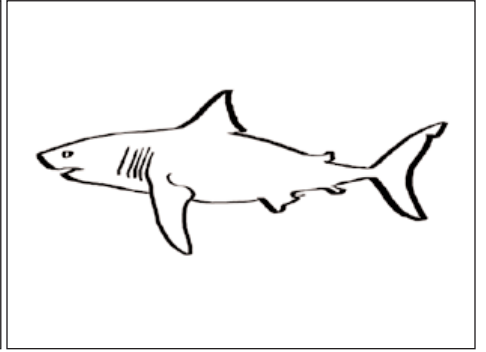
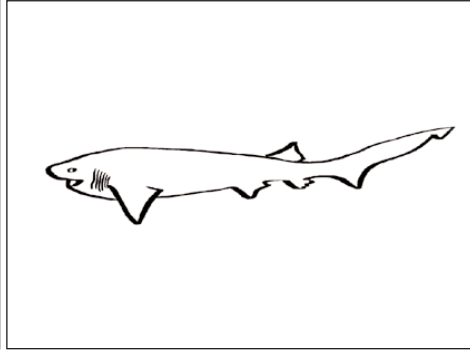
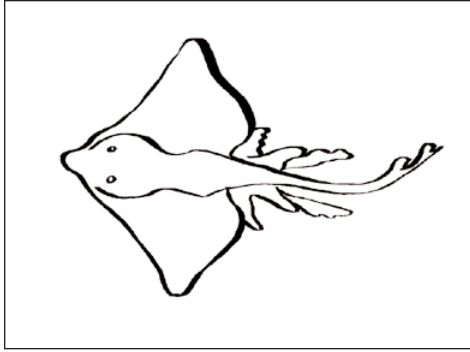
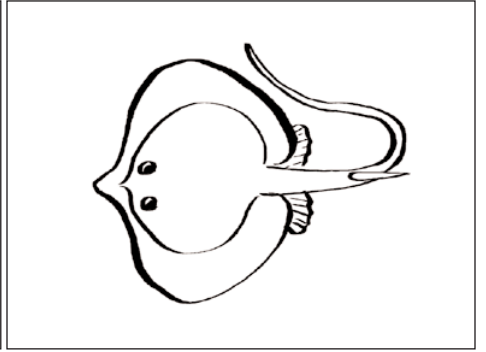
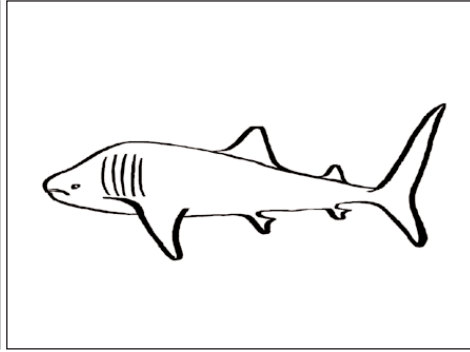
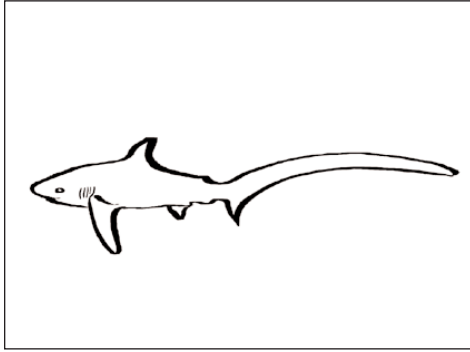
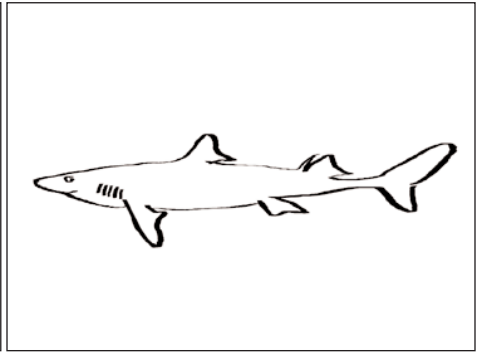
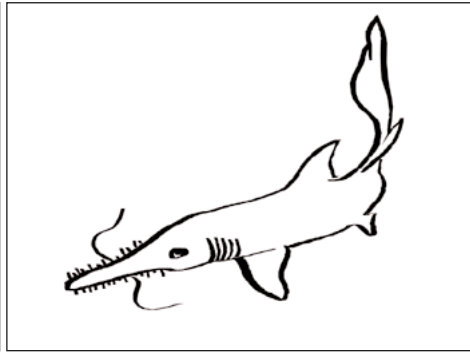
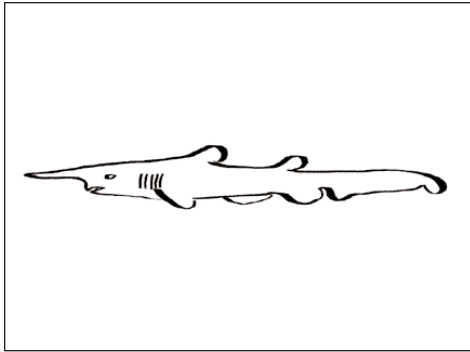
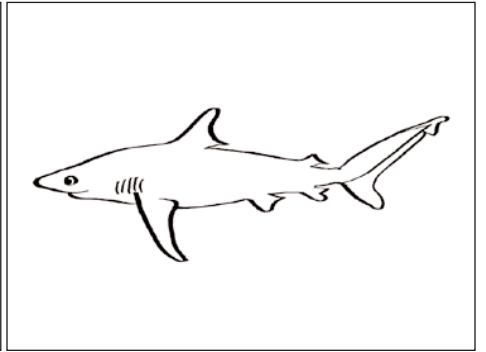
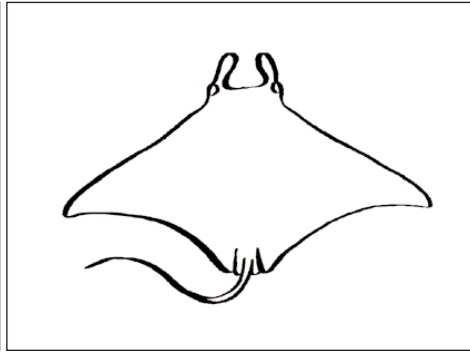
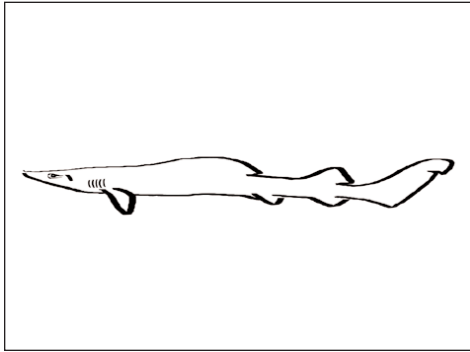
- 2. Pelvic fin absent Family Pristiophoridae
- 2. Pelvic fin present go to 3
- 3. Gill slits number six Family Hexanchidae
- 3. Gill slits number five go to 4
- 4. Mouth at front of snout Family Rhincodontidae
- 4. Mouth on underside of head go to 5
- 5. Head flattened and elongated, eyes on tips of lobes Family Sphyrnidae
- 5. Head not flattened and elongated go to 6
- 6. Caudal fin equal size and shape top and bottom Family Lamnidae
- 6. Caudal fin unequal size or shape top and bottom go to 7
- 7. First dorsal fin elongated, almost half total length of body Family Pseudotriakidae
- 7. First dorsal fin regular length go to 8
- 8. Caudal fin elongated, almost as long as entire body Family Alopiidae
- 8. Caudal fin regular length go to 9
- 9. Snout ends in long point Family Scapanorhynchidae
- 9. Snout without long point go to 10
- 10. Anal fin absent Family Squalidae
- 10. Anal fin present Family Carcharhinidae

Batooids

- 11. Dorsal fin present near tip of tail Family Rajidae
- 11. Dorsal fin absent go to 12
- 12. Horn-like appendages present Family Mobulidae
- 12. Horn-like appendages absent Family Dasyatidae



Creature Keys—Picture Cards



Interdisciplinary Intermission 2

BACKGROUND

Archaeological evidence shows that humans have been sailing the seas for as long as 40,000 years. European maritime trade has been well-established for the last 5,000 years, and one of the oldest surviving ships is an Egyptian Cheops ship dating from 3000 BC. Much of this early ocean-going activity took place relatively close to shore. It is only since the 1400s that navigational instruments sophisticated enough to allow voyages of exploration have been developed. During the next 300 years those voyages resulted in a fairly comprehensive knowledge of the geography of the ocean. It was not until the mid-1700s, however, that significant scientific exploration began and it would be yet another 100 years before the science of oceanography was born.

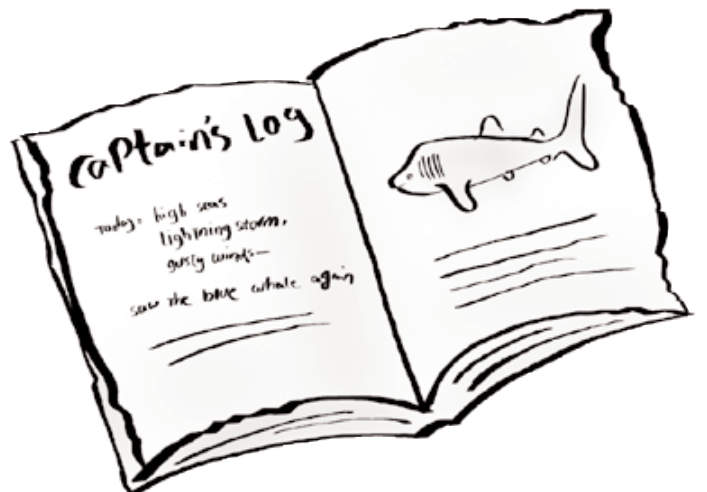
PROCEDURE

1. This activity builds upon the information explored in Activity 1 (Where in the World) and Activity 4 (As the Tide Turns). For further background information you may wish to refer to Activity 6 in *Oceans: Activity Guide for Grades 3-5*.
2. Invite your students to use their imaginations and travel back in time to the early days of ocean exploration. Ask them to choose both a starting point and a destination using a world map or globe. There are no right or wrong choices.
3. Have students plot a route from their starting point to their destination using what they have learned about tides, currents and ancient navigational techniques. Students should decide what century this journey is taking place and what types of navigational tools were in use at the chosen time as well as the kinds of vessels most often employed in ocean exploration.
4. Students should write a short paper describing their proposed route, the kind of ship they will be using, the navigational instruments they will have on hand and how long they estimate the journey will take. They may also include any additional information such as the size of the crew, etc. that they think is pertinent to the story of their voyage.
5. Have each student write an imaginary "Captain's Log" chronicling their journey. The log might begin with the information prepared in number 4 above. In addition, it might include a description of their point of departure. Research could be assigned to make the description more accurate. Each day of the journey should then be chronicled. They should include information about weather, navigational information, marine life they encounter, etc. The last section of the log should describe their destination. Again, research may be assigned to add authenticity to the account.
6. The activity is culminated by having the students share their logbooks with one another. This may be done by passing them back and forth to be read silently or by reading them aloud. Consider making the sharing a bit more exciting by using simple costumes and props and have the students gather to share their seafaring tales.

ADDITIONAL RESOURCES

Books

- Green, Thomas F. *Marine Science*. New York: Amsco School Publications, Inc., 1998.
- Pernetta, John. *Atlas of the Oceans*. Rand McNally, 1994.
- Shedd Aquarium. *Oceans: Activity Guide for Grades 3-5*. Chicago: Shedd Aquarium Society, 1996.



Making Headlines

Assume the role of investigative reporter to learn about the damage humans cause to the ocean and explore solutions in this interdisciplinary activity.

OBJECTIVES

In this activity students will:

- investigate descriptions of ocean destruction by analyzing written scenarios
- predict the possible effects of human-caused ocean destruction on marine life
- determine specific human actions that can lead to damage in the oceans
- effectively communicate information about the impact of human negligence as it pertains to the marine environment by writing a persuasive news article
- collaboratively create possible solutions to avoid further damage

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 11, 12 and 13*
- National Science Education Standards: *Unifying Concepts and Processes*
- National Science Education Standards: *5-8 Content Standards A, C, E, F and G*

TIME

One or two class periods

MATERIALS

For each group

- copy of one of the scenarios (page 45)
- poster board
- notebook paper
- pens/pencils/markers
- crayons
- Scotch tape or glue
- books and articles on conservation OR Internet access OR access to a library

BACKGROUND

When exploring the problem of ocean destruction it is sometimes easiest to recall fairly recent, widely publicized examples such as those addressed in newspapers and on the evening news (large scale ocean dumping, massive oil spills, etc.). As a result, we may overlook the less obvious day-to-day damage that occurs in the ocean. These less dramatic scenarios are, however, no less threatening to the future of aquatic life than the more highly publicized ones. These smaller scale abuses also offer an opportunity for students to become more directly involved in the protection of our ocean resources.

One example of such a problem is the discarding of seemingly innocent litter in or near bodies of water. The plastic rings that hold together six packs of soda pop cans can be deadly to a variety of marine and terrestrial animals. Animals become entangled in these rings and are unable to escape. There have even been instances where a young animal such as a seal may get a plastic ring around its neck. As the animal grows, the ring tightens and the animal eventually strangles. Another common item tossed on beaches and in the water is the plastic sandwich bag. These float in the water and are easily mistaken for jelly fish by hungry sea turtles. Not only are the bags a choking hazard, but turtles have been known to ingest such quantities of this indigestible material that their digestive system becomes blocked. Unable to receive nourishment from their food, the turtles slowly starve to death.

Litter is not the only danger to marine life. The fragile coral reef, composed of the skeletons of tiny animals and home to a host of marine plants and animals, can be damaged easily by careless divers, boaters or swimmers. Coral is sometimes deliberately collected by souvenir seekers, but more often is killed or damaged by accident. Just touching the beautiful coral can damage its protective covering and introduce deadly bacteria into the colony. A colony that may have taken hundreds of years to form can be destroyed by a single careless footstep.

Boaters also pose an increasing hazard to aquatic animals, especially marine mammals that may swim just inches away from deadly engines and propellers. In fact, at least 50 manatee deaths each year in Florida are blamed on boat accidents. With the total population of manatees in that state being only 1,400 it is not difficult to see that this rate of destruction could soon spell extinction for this quiet vegetarian mammal. Although humans usually do not intend to damage the oceans or ocean life, they often do—without even knowing it.

PROCEDURE

1. Lead the class in a discussion about the destruction of the oceans. What do they know about damage being done to the oceans? How did they hear about it? Have they seen any such damage personally? Who is to blame for the destruction? Can it be prevented? Can students, even those who live far inland, have any impact on preventing ocean destruction? Why should we even care about the cleanliness and safety of our oceans? Encourage students to generate their own discussion about how the media portray such events. Draw on any recently publicized events that students may have read about or seen on television. Keep a record of words, phrases and general ideas on the board for future reference.
2. Share any necessary background information with the class.
3. Continue with a brief class discussion on journalism. What do journalists do? Why do we have newspapers? When a reporter covers a story, what important facts are necessary to include? Are newspaper stories fact or fiction? What's the difference? Where do opinions fit into a news story? Review with the students the essential



story ingredients of who, what, where, when, why and how. Why would it be important for journalists to write stories about environmental or ocean-related topics? Is it important that such writers be well-versed in scientific writing? Why? What potential impact could such writing have on the future of our oceans?

4. Explain to students that they will be assuming the role of investigative, environmental reporters. Divide the class into groups of three or four students. Set the stage by telling them that they have been called to the scene of a particular event that was damaging to the ocean. Each group of reporters should be given enough copies of one of the three scenarios provided on page 45 for each group member. (Different groups may be given different scenarios, but each member of a group should have the same scenario as the other members.)
5. Students should read the scenarios and imagine that the report they are reading is actually what they see when arriving at the imaginary scene. As a team of journalists, the local paper is depending on the group to uncover clues that led to the ocean damage.
6. Students should read through the scenarios again and highlight or underline details that could be potentially harmful to the surrounding aquatic environment. Remind them to focus on the 5 w's and 1 h of journalism: who, what, where, when, why, and how. What went wrong? Who was involved? How could the humans involved have behaved differently? Someone in the group should take brief notes on clues or facts that seem to stand out in the scenario. Underlined ideas should be compared and a particular angle for the story should be agreed upon. How will the story end? Will the situation be resolved? Are there ways the situation could have been prevented? Could future occurrences be prevented? If so, how?
7. To answer some of the questions generated in the group discussion, students may need to do further research. Investigative reporters often have to research their topic before completing their stories. If students are to do independent research, library or Internet time and access should be made available. The research should concentrate on the specific questions raised by their investigation.

8. After analyzing the scenarios and conducting any necessary research, the reporting team is ready to write the story. The story should effectively communicate the facts about what happened as well as suggest what potentially harmful effects may have resulted. The students have the task of re-creating the scene in an interesting and realistic manner. They are free to expand the end of the story as they see fit. Did marine life die? What were the consequences for the humans involved?
9. The most attention-grabbing news stories have captivating photographs. Have students draw their photograph and give it a caption. How can they best represent what the story says without words? What are the images that will capture a reader's attention?
10. Students can now design the layout for their front page story by creating an enlarged version on poster board. The news story, photograph and caption should be arranged attractively on the poster board. The team



should come up with a headline that will capture the attention of their readers. Students may also want to include a "Helpful Hints" box detailing further suggestions for actions that readers can take to improve the conditions of the oceans.

EXTENSIONS

1. Have students use a desktop publishing tool or word processor to create the final layout of their

newspaper story. If students have access to the World Wide Web, they may wish to enhance their story by downloading actual photographs.

2. Expand the activity by adding more scenarios created by the teacher or the students. Not all ocean conservation problems have simple solutions. Often livelihood, culture and the economy of entire communities are involved. You may wish to choose some of these more complex issues to explore.
3. Have students debate one of the more controversial conservation issues such as the collecting of tropical fish for the aquarium trade. Have some students take the viewpoint of conservationists, while others argue from the stance of people whose ability to feed their family is dependent on the aquarium trade, etc. Is there a right or wrong answer? Is compromise a possibility?

ADDITIONAL RESOURCES

Books

Kaufman, Donald G. and Cecilia, Franz M. *Biosphere 2000: Protecting Our Global Environment*. New York: HarperCollins College Publishers, 1993.

Sheehan, Kathryn and Waidner, Mary, Ph.D. *Earth Child: Games, Stories, Activities, Experiments and Ideas About Living Lightly on Planet Earth*. Tulsa: Council Oak Books, 1994.

All About Endangered Species: 4-8 Teacher's Guide. This is published by Sea World, Inc., Tampa Bay (1993).

Marine Ecology and Conservation: 4-8 Teacher's Guide. All information as above.

Furnweger, Karen, editor. *Aquaticus. Journal of the Shedd Aquarium*. Vol. 24. No. 1. 1993. An Alliance for Conservation: Understanding the Marine Mammal Protection Act.

Web sites

www.yoto98.noaa.gov/index.html

A good general site with information about various ocean conservation issues.

www.savethemanatee.org

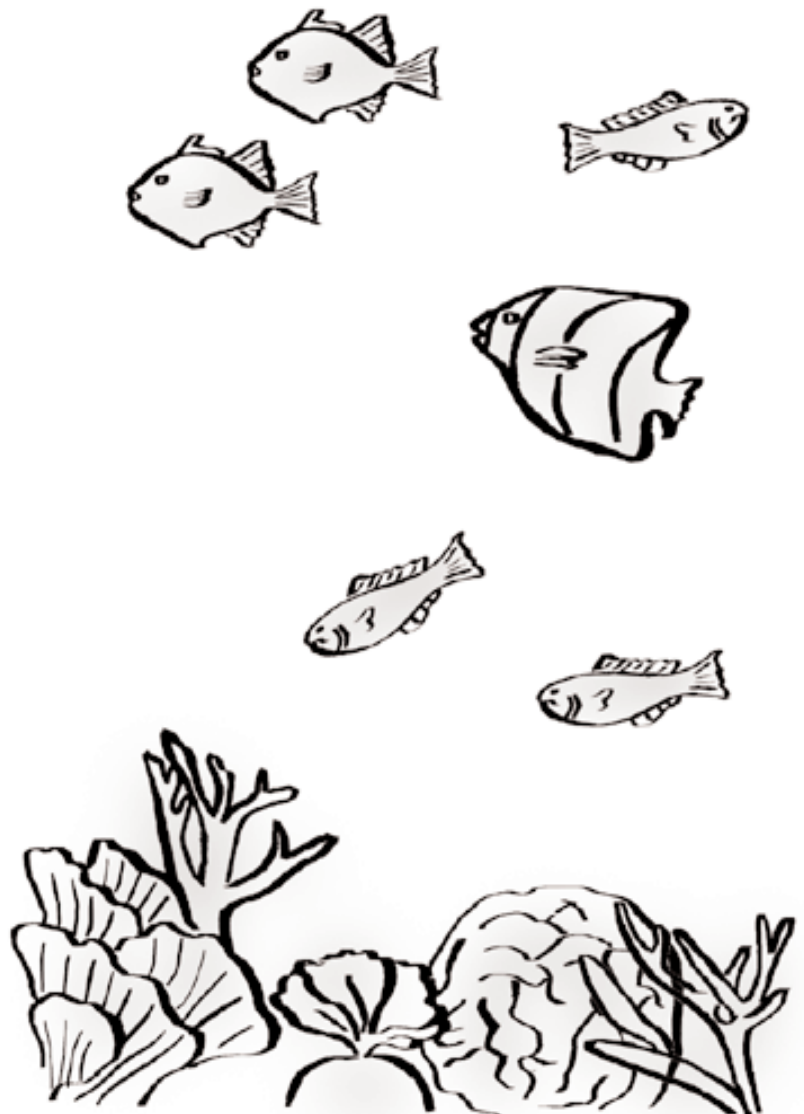
This is the address for the Save the Manatee Club. This site contains a great deal of information about manatees and their conservation.

www.turtles.org

A fun site with all kinds of information about sea turtles in general as well as conservation issues.

coral.aoml.noaa.gov

This is NOAA's Coral Health and Monitoring Program site. It is updated frequently and has current research and information on coral conservation.



Making Headlines—Student Worksheet

Scenario 1: “Dangerous Divers”

A group of newly certified scuba divers is vacationing in the Florida Keys and has decided to try underwater photography for the first time. Camille, one of the divers, has offered to help her friend Dan. She picks up various shells for the camera, holds a pufferfish, traces the markings of several corals with her fingers, attempts to chase a couple of sea turtles and continues to follow a disinterested nurse shark into semi-secluded areas. Dan has found that he gets a better view of all the action by positioning himself on a huge, brightly colored coral with one foot and resting the other foot on a small grouping of plants. Two other divers, Wendy and Karen, are nearby collecting all of the shells and other interesting objects they can carry. They were sure to bring plenty of plastic bags underwater with them for holding their treasures; they know how excited their friends at school would be to see all the cool stuff they found.

Scenario 2: “Family Follies”

A family has decided to spend a holiday weekend together at the beach. They have rented a speed boat and enough water skis for everyone to test their skills. The family has been saving their pennies for a long time to afford this vacation and are very excited about their adventure. The area in which they have chosen to try out their skiing prowess is known for its manatee population and boaters are warned to keep their speed to a safe idle. The fine for disobeying the posted signs is well over \$1,000. The family looked the area over closely for any signs of manatees but spotted none. Not wanting to disappoint the family, the parents assured them that had manatees actually been in the area, they would have been swimming quite fast beside the boat—just like dolphins. (Research hint: How fast do manatees swim?) Everyone agreed that it would be safe to ski in the area despite the warning signs.

Scenario 3: “Nets or Nests?”

A small gathering of friends are enjoying a day at the beach playing volleyball in the sand. While setting up their volleyball net, Mary—one of the girls in the group—noticed several marked off areas designated as “Sea Turtle Nests.” She shared this information with the rest of the group. Everyone stopped and looked around the beach for turtle nests, but found none. James suggested that they move the net farther down the beach. Because the net was more than half set up, everyone groaned and began to argue. Finally, the group decided to play volleyball right where they were because they hadn’t seen any nests. Of course, they had to move the pesky nesting signs out of their way. James still wasn’t sure they were doing the right thing and asked the group what they should do if they should happen to come across any sea turtle eggs. After giving the matter some thought, the group decided that should this happen, they would carefully transport the eggs to the water’s edge. That way, they decided, they would be saving the baby turtles a long walk once they hatched.

For more information about Shedd Aquarium and its education programs, please write, call, fax or visit our home page:

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