Unit One: What Is The Ocean?

Students are usually fascinated with the ocean making it an ideal theme through which to introduce many aspects of science and other disciplines. The vastness and unknown inhabitants of the ocean excite and stimulate student interest! Before we begin this curriculum, we will start by finding out what the student knows and “warming them up” to the subject. A variety of assessment exercises, as well as a fun investigation of their favorite marine animal are the main ways this is done.

Then as we move into Unit One activities we start from the bottom, literally! Students are introduced to basic geology and plate tectonics so they have an understanding of how oceans form. The ocean floor can vary from smooth sandy bottoms to massive canyons and mountain ranges. In addition, coastlines and beaches form and change. Students will not only gain a basic understanding of these topics, but also learn how to map and present this information.

Once the structure of the ocean is completed we start filling the ocean basin with water and investigate its unique nature. Waves, currents and tides are a major part of understanding how the marine environment works. Students will also investigate the special nature of water, sea water in particular. By participating in a variety of activities which focus on these topics the students will gain an appreciation and understanding of the physical aspects of the ocean. Then they will be prepared for Unit 2, to learn about “What lives in the ocean”!
Lesson 1: Exploring Ocean Features
2 - 3 days

Concepts & Objectives

QUESTIONS

• What does the land under the sea look like?
• How do we show land forms on a map?

UNDERLYING CONCEPT

Underwater topography can vary widely, from smooth slopes to elaborate canyons, valleys, and mountains. This topography is not visible at the ocean surface and is usually too deep to easily explore, therefore scientists have created special measuring methods to map the ocean bottom.

SKILLS

• Using a grid
• Problem solving
• Measuring

METHODOLOGY

Students will create an “ocean bottom” in a shoe box and use measuring skills to decipher what the underlying structures look like when not visible (from the ocean surface). Additionally, students will use this model in an activity in which they will create simple topographic maps.

Vocabulary & Background

VOCABULARY

• bathymetric mapping: the measurement of depths of water in oceans, seas, and lakes
• continental shelf: the under water border of a continent or an island
• sea mount: a high hill under the sea
• island: land surrounded by water and smaller than a continent
• trench: long cut in the ground
• volcano: a hill or mountain composed wholly, or in part, of ejected material from within the earth. This material is often, but not always, in the form of lava.
BACKGROUND INFORMATION

Sea floors have a variety of features including smooth gradual slopes, mountain ranges, volcanoes, trenches, and sea mounts. On the east coast of the United States the continental shelf generally extends in a gentle slope under the ocean, however the West Coast, especially off of Southern California, is quite different. Here the near shore land under the sea contains deep submarine canyons, underwater mountain ranges, deep trenches and valleys. The submarine canyons look like canyons cut by rivers on land....which they once were! Although Catalina Island is only 21 miles across the San Pedro Channel from the Southern California coast, deep trenches and canyons in the Channel might reach 490 fathoms (2940 feet)...or over a half-mile deep! The underwater topography of this area is complex and fascinating. Since most students think of a simple sloping sandy bottom under the ocean, it is helpful for them to understand the variety of land forms possible, in terms of geological and geographical knowledge, as well as potential habitat variations.

Measuring and mapping the land under water is called bathymetric mapping. Prior to the 1920’s oceanographers measured the depth of the ocean using long lines with weights attached that were marked at regular intervals (meters or feet) with knots. The lines were lowered into the ocean until the weight touched the bottom and the depth was noted by the knot mark. Currently, oceanographers use sonar, or sound waves, to measure the ocean bottom. Sound waves are sent from the bottom of a ship toward the ocean floor. By measuring the time it takes the sound to return to the ship (received by a recording device), the ocean depth can be calculated because the speed at which sound travels through water is known (1,454 meters per second). In the following activity the student will do some simplified versions of bathymetric mapping using “depth lines”, as well as some simple topographical mapping.

Activity 1: Shoe Box

Review different types of ocean features or introduce them by direct instruction/discussion.

- What is an island, a trench, a sea mount?
- Where are these features located in the ocean?
- If you were an oceanographer, how would you know where these features were located?

ACTIVITY STEPS

1. Using clay or modeling putty, students will work in small groups to construct an ocean bottom inside a shoe box. They need to include at least three different features.
2. When construction is completed, students should cut a card board lid to fit the top of the shoe box.
3. Students draw lines one inch apart on the card board lid in two dimensions to create a grid pattern.
4. Next, tape the lid on top of the shoe box so that other groups cannot see their features.
5. Students will exchange their shoe box for a shoe box from another group to prepare for Part II of this activity. USC Sea Grant Island Explorers
6. Students will create holes at each 1” intersection along one line of the grid pattern. Insert a pipe cleaner (“depth line”) into the holes to determine what “the ocean floor” in the shoe box looks like by calculating how deep they can extend the probe. They will be able to decipher various heights of the “underwater topography.” They will draw on paper their idea of the shoe box “ocean floor” based on the information on the probes. (Multiple lines of the grid can be probed to get a three-dimensional picture of the ocean bottom.)
7. Remove the lid of shoe box to see if their drawing matches the contour in the shoe box.
8. Return the shoe box to the group which created.
9. Save shoe box ocean floors for topographical mapping activities.

* Note: Students should understand that not every area can be measured and therefore need to create an efficient design for measuring. (This simulates real world scientific research.)

Activity 1: Topo Maps

Create topographical maps from the previous activity.

ACTIVITY STEPS

1. Place clear plastic overlay to top of shoe box
2. Pour colored water to depth of 1” and trace the “contour lines” of the water onto the overlay.
3. Continue to add water 1” at a time until they have drawn a simple contour map at 1” intervals.

Extensions

Have a topographical map of Catalina Island (or any topographical map of an area they know or will be visiting) and a list of features to identify. Have students identify valleys, mountains, hills, etc., on the topographical map. Or they can make their own list of formations that they can identify on the map.

INVESTIGATIVE THOUGHTS & QUESTIONS

How can one tell if a feature on a topographic map is an incline or a decline? (Students should study a topographic map to find the answer)
Lesson 2: Sand and Soil Studies
1 class period

Concepts & Objectives

QUESTIONS

- Where does sand come from?
- How is it the same or different from soil?

UNDERLYING CONCEPT

Sand is created from the break down of larger rocks. The type of sand present, for example at a beach, is determined by the geological make-up of the region.

SKILLS

- Observing
- Problem solving
- Measuring
- Comparing

METHODS

Students will collect different samples of sand and soil. They will perform a variety of tests on these samples to learn more about them, especially, how they are alike and different.

OBJECTIVES

Students will be able to:

- Observe various fragments and particular make-up of sand
- Determine if iron is present in a sand sample
- Compare sand and soil samples

MATERIALS NEEDED

- Samples of coastal sand from a local area
- Samples of topsoil from a school yard
- Black or white construction paper depending on samples
- Hand lenses
- A quart jar and lid
- Water
Create a concept map about the beach, where students can express and organize prior knowledge. This can be done in small groups or as a class. (For further information and examples of concept maps, check out this URL in World Wide Web: www.seagrant.wisc.edu/earthwatch/Teachers/Teacher2. Link to Who We Are click on Education then you will arrive at What is Concept Mapping.) Next, students should create another concept map about the soil.

ACTIVITY STEPS

1. Tell students that they will be exploring an important feature of the beach (sand) and compare and contrast its contents to school soil.
2. Distribute black paper, a hand lens, Activity Sheets 1 and 2, and a small sample of sand to a group of two students.
3. Have the students pour some of the sand onto their hand. Describe what it feels like.
What it smells like.

4. Next, spread the sand sample on the black construction paper. The black paper provides a nice contrast so students can observe the particles more closely. If the sand sample includes many dark particles, you may want to use a different color paper.

5. Observe particles by noting sizes, shapes, and colors and record on Activity Sheet One. They can also do the following exercises and questions:
   a. Heavy minerals with iron in them will be attracted to a magnet. Touch a magnet to the sand. Are the grains of sand attracted to it?
   b. Look at the grains in a magnifying glass. Do they look the same?
   c. Shell fragments are often more rounded and less jagged-looking. Do you see a shell fragment in the sand? Draw the grains of sand.
   d. Gently blow on the sand. When breezes blow on the beach, what do you think happens to the sand?
   e. Put about 1 inch of sand into a jar. Fill the jar with water, put the lid on tightly, and tip the jar. What happens to the sand?
   f. Shake the jar and watch the sand. This shaking is similar to the constant motion of the waves in the ocean. What happens to the sand?

6. Students should obtain a sample of soil from the school yard and observe various soil particles using the same hand lens and recording this under school soil on Activity Sheet 1.

7. After sand and soil has been investigated, students can complete a Venn diagram comparing and contrasting the two samples on Activity Sheet 2.

DISCUSSION

Students should share their observations and Activity Sheets with the class. The teacher may want to engage in a short discussion using a variety of questions that require students to think critically and make important generalizations about the make-up of sand in their area and how it compares with soil on their school campus.

EVALUATION

- Observation skills from Activity Sheet One.
- Venn diagram comparing and contrasting sand and soil samples (Activity Sheet Two)
- Cooperation and participation with partner.

Extensions

Compare different sand samples from diverse beaches in different states. Use sieves to separate particles from sand that contains shells and larger matter in addition to sand grains.
Use a hand lens to observe soil particles. Record observations below; size, color, and shape of particles. Draw pictures when necessary.

<table>
<thead>
<tr>
<th></th>
<th>Beach Sand</th>
<th>School Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors</td>
<td></td>
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<tr>
<td>Shapes</td>
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<tr>
<td>Sizes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Once-living matter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other important features found</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity Sheet Two: Comparing Sand &amp; Topsoil</td>
<td></td>
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<td>---------------------------------------------</td>
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<tr>
<td>What notable differences exist between the soil from the beach and school?</td>
<td></td>
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</tr>
<tr>
<td>Why do you think there soil types are so different given their position on land?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What additional questions do you have about soil?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson 3: Ride The Waves

20 minutes

Concepts & Objectives

QUESTION

How do waves move across the ocean surface?

UNDERLYING CONCEPT

- The water in any given wave moves up and down, but it doesn’t move forward.
- The wave’s energy, not the water’s is transferred along.

SKILLS

- Modeling
- Labeling
- Measuring

OBJECTIVES

Students will be able to;
- Make a human model of ocean waves
- Use the model to demonstrate how waves behave

MATERIALS NEEDED

- Picture or video of waves

Vocabulary & Background

VOCABULARY

- Crest: The highest point of a wave
- Trough (trawf): The lowest point of a wave
- Wavelength: The distance between two wave crests or troughs
- Wave height: The distance from a wave’s trough to its crest

BACKGROUND INFORMATION

Most waves are caused by winds blowing the surface of the water. How long the wind blows,
how hard, and over how big of an area all affect the size of the waves it will produce. Most waves are less than 4 meters (12 feet) high, but much larger waves can form during severe storms.

The highest point on a wave is the crest, and the lowest point is called the trough, as shown here. The distance between two crests is the wavelength. The distance from the trough to the crest is the wave height.

When waves reach shallower regions, the wave troughs drag along the shoreline, but the crests keep going. As a result, the waves jam up, shortening their wavelength and increasing in height. At some point, the wave becomes too tall to hold itself up, and it curls over or “breaks” on the shore.

Underwater earthquakes and volcanoes can result in long, high-speed waves called tsunamis. (These waves are sometimes called tidal waves, although they have nothing to do with tides.)

Such waves can have a wavelength measuring 160 kilometers (100 miles) and speeds up to 800 kilometers per hour (500 miles per hour). Since tsunami’s wavelength is so long, the time between waves hitting the shore can be as long as 15-20 minutes. In the open sea, these waves may be only a half-meter (1.5 feet) tall, but when they build up along a shoreline, they reach heights over 30 meters (100 feet) and have great destructive power. Tsunamis occur most often in Japan, Hawaii, and Alaska, due to earthquakes and volcanic activity in the Pacific Ocean.

Activity

INTRODUCTORY QUESTIONS

- Have you seen waves at the beach or in a lake?
- What do you think causes waves? Wind, earthquakes

ACTIVITY STEPS

1. Line up your students, side by side, in an open space where they are free to move. Ask them if they have seen people at a sporting event move in sequence to make a “wave.” (The first person starts in a crouching position, then stands, reaches high, and crouches down again. Each subsequent person before them in line has partially completed the motions. The result is a rippling wave that runs down the line.) Invite the class to try it. Tell them that they have just become a model of ocean waves.
2. Have the class try different variations, such as fast, slow, high, and low. You might set up scenarios, such as having them imagine a storm is raging at sea, which would suggest that they make fast, high waves.
3. Have them create a wave, and then freeze the motion while you point out different parts of the wave, as described in the Background information (crest, trough, wavelength, wave height). You might have the class line up along the chalkboard, trace the shape of the wave and label it. Have a volunteer make some rough measurements as your wave model tries out different wavelengths and wave heights.

4. Ask: Have you ever noticed that as you make your wave movements, you don’t move along sideways? How is that similar to the way an ocean works? Help students see that the water in any given wave moves up and down, but it doesn’t move forward. The wave’s energy, not the water, is transferred along.

5. Finish the modeling activity by exploring why waves break on the shore and splash up on the beach. You might have students at one end of the line try it by standing on a slightly raised ground (best done outside), crowding the line closer together, reaching the wave crests higher and tipping over (carefully!)

6. Have students make a labeled sketch of a wave. Close by showing the class dramatic pictures or a video of waves in motion, or by demonstrating wave motion in a large shallow pan of water. Float a few small objects remain in position rather than move in the direction of the waves.

Extensions

- Demonstrate how a wave works by having two students hold opposite ends of a long rope and ripple the rope to make waves.
- Invite students to find out more about big waves produced by severe winds.

Adapted from Oceans
Lesson 4: The Moon and Tides
55 minutes

Concepts & Objectives

QUESTION

How does the moon’s path affect the tides?

UNDERLYING CONCEPT

Tides are caused by the gravitational pull among the sun, moon, and earth. The size of the tides depends on where the sun and moon are in relation to the earth.

SKILL

• Observation

OBJECTIVE

Students will:
• experience with movement the relationship between the moon and the high and low tides.

MATERIALS NEEDED

• None

Vocabulary & Background

VOCABULARY

• Tide: The periodic rise and fall of the ocean’s water level due to the pull of the gravity from the sun and the moon.
• Low tide: The two points in the day when the ocean’s level is lowest.
• High tide: The two points of the day when the ocean’s level is highest.

BACKGROUND INFORMATION

Tides are caused by a gravitational tug-of-war between the sun, moon, and earth. All objects
exert gravitational pull on each other. The closer they are, or the larger they are, the greater the pull. All of the planets exert some gravitational pull on the earth. However, the pull of the moon and sun are most noticeable because the moon is so close to us and the sun is so big. It takes the earth 365 days to revolve around the sun. As it revolves around the sun, it spins, or rotates on its axis once every 24 hours. At the same time, the moon revolves around the earth once every 29 days. The gravitational pull of the sun holds the earth in orbit, while the gravitational pull of the earth keeps the moon in orbit.

As a result of this gravitational attraction between the earth and the moon, the side of the earth facing the moon is pulled towards it. Solid objects like the ground and buildings are not distorted as much as liquids like the ocean. A bulge of water occurs on the side of the earth facing the moon. As the earth rotates around the sun, centrifugal force causes an equal bulge of water on the opposite side of the earth. Water is pulled away from these two sides of the earth to form these bulges, or high tides. This leaves a depression, or low spot, in the oceans between. These are the areas of low tides.

Most areas of the earth have two high tides and low tides every day. These high and low tides are slightly more than 6 hours apart. In some areas, the high and the low tides are the same. However, the earth is tilted on its axis, so the bulges are sometimes unequal. Because of this, in the Southern California region, one of the high tides each day is higher and one of the low tides each day is lower than the other. It depends on where you are located in the earth’s surface whether your high and low tides are semidiurnal (the same tide twice a day) or semidiurnal mixed (different tides twice a day).

Activity

INTRODUCTION

- Teacher should begin with a discussion of high and low tides.
- How many of you have been to the beach at high and low tides?
- What did you notice about the seashore? (more rocks, area, and animals can be seen when the tide was ‘out’ or low, waves and water were further up on the beach when the tide was in or high…)
- Ask for students ideas on what high and low tides are, and why they occur.

ACTIVITY STEPS

1. Have the class form a circle in a large area. This could be in the classroom, on a lawn, or if necessary, on the playground.
2. The ideal way for students to sit is crossed-legged with hands holding the next person’s elbows to form a strong circle. If the class is reluctant to touch, have them kneel “knockkneed” next to each other in a circle.
3. One person is the moon and moves around the outside of the circle. The circle is the waters of the earth. As the moon passes behind the students (water), the waters bulge (lean) toward the moon, and then into the center as the moon passes. As the moon moves, have the students that are opposite the moon lean away from the moon (this represents water bulging out on the opposite side of the earth) and then have them lean into the center as the moon passes.

4. Have the moon stop, and let the class see where the high tides are (next to the moon and at the opposite side of the circle). Then the moon continues to circle. Have the moon stop at several points in the circle and let the class see where the high and low tides are in relation to the orbit of the moon. (Low tide will be at the sides halfway between the high tide bulges.)

5. The moon can then circle the earth several times so the rhythm of the passing of the moon and the bulging of the waters is experienced by the class. Before ten minutes are up, even first and second graders have a feel for how the moon affects the tides.

Extensions

- Have the students make suggestions as to other forms this activity can take.
- Check out the daily tides in the newspaper or on the web and graph their heights for a month.

Background information adapted from the Los Marineros Curriculum Guide (1995), published by the Santa Barbara Museum of Natural History (805) 682-4711
Unit Two: What Lives In The Ocean?

Now we are ready to learn about the many different kinds of plants and animals that live in the ocean. The ocean has one of the highest levels of diversity of any environment on earth. Marine organisms range in size from the mighty blue whale (nearly 100 feet in length!) to the microscopic bacteria. The seas are inhabited from the very shallowest to the very deepest parts by creatures sometimes quite strange yet perfectly adapted to their environment.

Students will first learn the conditions necessary for life to exist and how life on earth actually began in the seas many millions of years ago. They will understand the term evolution and will begin to investigate the evolution of living organisms from the most simple organisms to the wide diversity of both simple and complex organisms that we see today. Plants as part of life in the sea and on land will be part of this unit, as well as learning about plankton--a significant foundation to all life in the sea.

In addition, students will learn how scientists classify the myriad of life on Earth using the Linnaean system. They will be introduced to tools that biologists use to identify plants and animals, like the dichotomous key. Finally, the students will progress through a study of all five kingdoms of life in the sea, beginning with the intrepid bacteria and ending with a study of the vertebrates, especially the marine mammals.
Lesson 1: Evolutionary Alphabet Soup

45 minutes

Concepts & Objectives

QUESTION

- What is “natural selection” and how does it work?

UNDERLYING CONCEPT

Organisms that have the best means to deal with their environment are those that will most successfully reproduce.

SKILLS

- Observation
- Deductive reasoning

OBJECTIVES

- Students will be able to define natural selection

MATERIALS NEEDED

- paper lunch bags, one per pair of students
- dried alphabet noodles (or type letters on a computer and cut up)

Vocabulary & Background

VOCABULARY

- Adaptation- Characteristics or traits that allow a species to better survive in its environment.
- Evolution- Process in all plants and animals that transmits traits from one generation to the next; these traits are generally beneficial to the plant or animal’s survival.
- Natural selection- Process through which evolution occurs; those plants/animal’s with traits that are less likely to help that plant/animal survive and reproduce die; process of nature selecting traits that will help a plant/animal to reproduce with healthy offspring
BACKGROUND INFORMATION

Evolution is the gradual change in a species over geologic time, many thousands or millions of years. All organisms go about the business of survival in many different ways. Over time, those that have the best ways of dealing with the environment are those that have the best chance of surviving. For example, a whale with a thicker blubber layer will survive cold northern waters better than another with less blubber. The whale with the thicker blubber layer will survive to pass on this trait to its offspring, which will in turn pass the same trait on to their offspring. Over time, slowly but surely all whales of that species will end up with thicker blubber. Thus, the entire species will end up with thicker blubber. This is called natural selection and was first described by Charles Darwin, an English naturalist who lived in the nineteenth century.

Changes like these can take many thousands or millions of years. These changes are called adaptations.

Activity

INTRODUCTION

- What does the word extinct mean? That a plant/animal is no longer alive and that it cannot reproduce.
- Can you name some animals that have become extinct? Dinosaurs…
- Was there anything that these animals could have done to stay alive? No because their deaths were due to environmental changes.
- Let’s play an activity that will demonstrate how favorable characteristics/traits might help an animal adapt to their environment. Before class: In each bag, put a small handful of alphabet noodles. Make sure that each has at least several of the following letters: E L W H A.

ACTIVITY STEPS
1. Pair the students up into teams.
2. Give each team a bag with the alphabet noodles.
   - The noodles represent all the characteristics in a population of whales. The students play the part of nature, selecting and eliminating certain characteristics because of environmental pressures.
3. Have the students pick five letters at a time out of the bag.
4. The students may throw back into the bag all the letters E, L, W, H and A.
   - Those letters stand for characteristics that help the whale to survive (for example, thicker blubber).
5. All other letters should be set aside; they represent a whale that died off because they had characteristics that were not useful or were harmful to them (for example, thin or no blubber).

Little by little, the students will eliminate the useless or harmful traits and will
concentrate on the good ones in the bag (our “population”). Sooner or later they will draw five letters that happen to spell whale. The students didn’t plan it that way; neither did nature. But this is how whales evolved to have a thick, insulating layer of blubber.

*Note: The game can be continued by using letters typed on the computer/printed out and cut up.

DISCUSSION

Here are some thought questions to ask your students:

• What are some types of environmental pressures that may have caused some species of whales to evolve with thicker blubber than others? Cold water! For example, Northern Right Whales, which live in cold northern waters, can have blubber that is more than 1 foot thick.

• What do we know about whales that tell us that they are related to bears, dogs, cats and humans? They are mammals and so have hair (whales, dolphins and porpoises all have at least a few “whiskers” around the snout area), nurse their young which are born live, breathe air and are warm blooded.

• If whales are mammals, how can they survive living in the ocean? We know that they have thick blubber to keep them warm. What are other ways that they have evolved for a marine lifestyle?
  - Their bodies have become very streamlined and torpedo-like.
  - Their forelimbs have become paddle-like.
  - They can hold their breath for long periods of time while swimming.
  - Their nostrils have migrated over time to the tops of their heads for easy breathing while swimming.
  - They have lost their hind limbs and now have a stiff pair of flat “flukes” which make up their powerful tail used for swimming.
  - They have lost nearly all their hair to become sleek and slippery in the water.
  - They have lost their external ears and other body parts that stick out, again, so that they are more streamlined in the water.

Extensions

Have students investigate other animals that have either successfully or not successfully coped with changes in the environment.
Lesson 2: Convergent Concentration
55 minutes

Concepts & Objectives

QUESTION

Why do some animals which are very different from each other in most ways, share similar characteristics?

UNDERLYING CONCEPT

Ancestrally unrelated animals (species) have independently developed similar characteristics to deal with similar environmental pressures. Examples are wings for flight (such as birds and butterflies) and fins for swimming (such as whales and fish).

SKILLS

- Identification
- Analysis and interpretation

OBJECTIVES

Students will be able to:
- Select examples of convergent evolution
- Explain shared characteristics and how these characteristics helped the animal survive.

MATERIALS NEEDED

- Copies of “Convergent Concentration Game Cards” (enclosed) depicting examples of convergent evolution.
- 2 pages (per group) of 8 1/2 x 11” medium weight construction paper
- Glue, adhesive
- Scissors
Vocabulary & Background

VOCABULARY

- Evolution - a gradual process in which something changes into a different form; life forms changing over time.
- Convergence - to meet; to approach the same point from different directions.
- Adaptation - a feature that allows an animal to survive in its environment.

BACKGROUND

Evolution is the gradual change in a species over geologic time, many thousands or millions of years. Natural selection refers to the fact that an organism which has the most effective way of dealing with the environment is most likely to survive. An example is sea otters; those with warmer thicker fur will survive cold northern waters better than another with less thick fur. The sea otters with thicker fur will survive to pass this trait on to their offspring, so that over time all sea otters end up with thicker fur.

An adaptation is a feature that an animal has that allows it to survive in its environment. Sometimes these adaptations are very similar among different animals. In fact, entirely different species can have the same type of adaptation to survive in similar environments. As mentioned above, wings (to fly and escape) and fins (to swim) are good examples. Other examples include:

- armor (for protection)
- elongated Snouts (for sucking up food)
- horns (for combat and protection)
- large Ears (for both predator and prey to hear better in an environment where hearing is more important than sight)
- large Eyes (for seeing well at night)
- long Necks (for reaching food sources)
- spines (for protection)
- stripes (for predator/prey camouflage)
- tusks (for rooting and digging, protecting or fighting)

To help in your discussion here are some criteria to determine valid examples of convergent evolution. In order to be considered an example of convergent evolution the animals must:

- be ancestrally unrelated
- have structurally similar characteristics
- are using these characteristics for the same function.

In essence they must have similar structures with similar functions. For instance “tails” would
not be a good example of convergent evolution because they are something shared by almost all vertebrates in their life cycle and also because they are not necessarily used for the same function. For example, horses use tails to swish flies and monkeys use tails for balance and certain monkeys use them to hang from trees.

**Convergent Evolution** is what occurs when two different species evolve similar structures from similar lifestyles.

### Activity

#### INTRODUCTION

- To initiate the discussion Teacher shows two examples of two sets of animals using overlays (made up from examples on the cards included in this activity) and a pointer can be very helpful.
  
  Example:
  
  A.) flying insect / small bird, and B.) antelope/steer
  
  - Ask students what they have in common.
  
  - Then give brief description of what convergent evolution is.

- Have students brainstorm other categories/examples of adaptations resulting from convergent evolution.

- Ultimately list on the board the 11 categories described in the background. Ask what these adaptations are for (example: “wings to fly and escape”). You may leave the title of the categories (without explanations) on the board to aid students with the activity, if needed.

#### ACTIVITY STEPS

**Before You Start:**

1. Divide students into groups of four (three or five will also work, but with four you can have the option of working in pairs [against another pair].)

2. Give each group a copy of the two pages of “Convergent Evolution” Animals, two pieces of construction paper, scissors, and glue stick, and one copy of “Convergent Concentration” Score sheet (or groups can make their own).

3. Ask students to paste the sheet of animals to the construction paper and then cut out the squares to make “cards.” In addition each group writes the players name on the score sheet (or creates their own). Choose one player to also be scorekeeper.
How to Play:

- Shuffle the animal “cards” and place face down.
- Students play “Concentration” by taking turns (clockwise around the table). Each student can turn any 2 cards over so the animal is visible. If the cards “match” and the student can say what the shared characteristic is, she/he wins 10 points. If the student can also say how it helped the animal to survive she/he gets another 10 points. The cards are removed from the game and placed face up by the student. Scorekeeper awards 10 (or 20) points by the students name.
- If the cards do not match, they are put back into the original position, face down to be used again. Each time a player is able to match and describe the reason why for a pair, she/he gets another turn; until she/he “misses”.
- The idea is for the students to both remember the position of the cards and more importantly to identify why they are a “match”.

Extensions

- Create a variation of the convergent evolution worksheet using different animals (example; birds and butterflies or fish and whales), and then draw lines connecting animals that share similar characteristics.
- Students (individually or in groups) can research and find other examples of convergent evolution and share their findings with the class.
- Also students can draw and create an example of convergent evolution, as long as the explanation of the shared characteristic and how it helped the animals survive in the similar environment (all can be created) is valid. An environment can be specified for this activity such as “wetlands,” cold Arctic,” “hot desert,” etc. [These animals can be versions of their favorite pair (if appropriate for “their environment”) or entirely new creatures.]
Lesson 3: Sinking Slowly
2 hours, allow time to experiment with the materials they will be using to design plankton

Concepts & Objectives

QUESTION

How do planktonic organisms, which are not strong enough to swim against the current in the water, keep from sinking to the bottom of the ocean?

UNDERLYING CONCEPT

Plankton have a variety of strategies (adaptations) for staying above the bottom of the ocean in the water column.

SKILLS

- Observation
- Prediction
- Inference
- Measurement
- Experimentation

OBJECTIVES

Students will be able to describe strategies used by plankton to keep from sinking and test their predictions about certain strategies in a model building exercise.

MATERIALS NEEDED

- Pictures of different types of plankton
- Movie or video on plankton if available
  - Plankton and the Open Sea, 18 minutes, Encyclopedia Britannica
  - Plankton of the Sea, 12 minutes, Fleetwood Films
  - Plankton: Pastures of the Ocean, 10 minutes. Encyclopedia Britannica
  - Plankton: the Endless Harvest, 18 minutes, Universal Education
- Various art supplies (sticks, string, beads, plastic, clay, styrofoam, wire, aluminum foil, nuts, glue, pipe cleaners, etc.)
- Buckets of water
- Large glass aquarium or trash can full of water
- Stopwatches
- Small prizes
VOCABULARY

- Plankton - Organisms that drift; they cannot swim against a current any stronger than 1 knot (1 nautical mile/hour)
- Phytoplankton - plant plankton
- Zooplankton - animal plankton
- Photosynthesis - process through which plants obtain their energy from the sun
- Adaptation - a feature that allows an animal to survive in its environment.

BACKGROUND

Plankton are organisms that drift; they cannot swim against a current any stronger than 1 knot (1 nautical mile/hour). Usually, plankton are very small, microscopic organisms but some larger animals, like certain jellyfish, are also considered plankton. Plankton are divided into two groups, plants (phytoplankton) or they can be animals (called zooplankton). Phytoplankton make their own food through photosynthesis (using sunlight to combine carbon dioxide and water into sugar), but zooplankton must ingest or eat food from the ocean.

Plankton are usually heavier than water. This is important because if a planktonic organism just floated on the surface of the water, it might not be able to get to food sources below it or it might get too warm or too much light from the sun (even phytoplankton can be “bleached” by the sun!). So plankton will tend to sink in the water column. But phytoplankton do need to stay where sunlight penetrates. Zooplankton feed on phytoplankton so the zooplankton want to stay where the phytoplankton are in the water column. One important note is that zooplankton are usually able to swim upward in the water column very slowly to maintain their position. But if they sink too quickly or are too heavy, they will go straight to the bottom of the ocean and not be able to get back up! Therefore, planktonic organisms will have adaptations that prevent them from sinking too quickly. These adaptations include the following:

- small size (small things sink slower than large things)
- long spines or projections that increase drag
- long, thin or flattened shape - also increases drag
- contain small amounts of oil (which is lighter than water)

Activity

ACTIVITY STEPS

Before Class:

This is a great, messy activity. It is particularly good for a warm day when the class may be
naturally restless and ready for some excitement. The best way to finish this class is with a contest so you may want to think about some possible prizes (coupons for lost homework, small toys) during class.

During Class:

1. Start with observations of zooplankton and phytoplankton. Observe their shapes, projections and behaviors. Most plankton are heavier than water and tend to sink. Ask how they might stay up in the water. Make a list of the students’ observations.

2. Some of the students should notice that many plankton have long projections or antennae or hairs. Have them speculate on how these would affect movement through water. Could the students run through water faster with their own arms spread out or folded up?

3. Now the students are going to see if they can make a model phytoplankton or zooplankton which will sink slowly. Since “thrashing” or swimming is not possible in a non-mechanical model, they must concentrate on designing a plant or animal that is just barely heavier than water and that slows its rate of sinking by increasing its resistance to movement through water with long projections or hairs or that sinks slowly because it swings back and forth as it goes down. Have selections of materials and buckets of water available around the room for design and testing. Use stopwatches to time the speed of sinking. Set a time limit for experimentation and announce a contest for the slowest sinking animal or plant at the end of that time.

4. The best way to have the contest is to gather around a large glass aquarium where everyone can see. A big trash can of water or a large bucket will work, but you cannot give everyone a good view. In that case have several students help you as judges. You can time each separately, but it will be more exciting if pairs of phytoplankton or zooplankton are released to “reverse race” their way down. Put both on a sheet of cardboard so they can be tipped in at the same time for a fair start. The SLOWEST from each pair goes into a second heat and so on until you get down to two.

5. Have the students analyze what they think made each of the last two models winners. Then have them vote on which they think will win the grand prize for slowest overall based on their analysis. Do the final test and distribute prizes. Note: The plankton must SINK not float. They may not sink because they get wet slowly, but rather, because they are heavier than water from the start.

RESULTS

Something just barely heavier than water with lots of projections should win unless a student can produce a flat, pie pan shaped object that makes big swings from side to side as it descends.
DISCUSSION

Have students discuss why certain models floated and others sank.

Extensions

Have the students write a poem or paragraph about what it might feel like to be a phytoplankter or zooplanker, tending to sink. Remember that zooplankton can “swim” their way up.

Adapted from Living in Water. To order, contact Kendall-Hint Publishing 1-800-228-0810
Lesson 4: Sea Water Surprise

40 minutes, depending on age group and depth of investigation

Concepts & Objectives

QUESTION

What life forms can you find in a drop of seawater?

UNDERLYING CONCEPT

Plankton are diverse organisms that cannot swim against a current. Most plankton are microscopic and cannot be seen with the naked eye. In addition, special equipment must be used to collect them because they are so small.

SKILLS

• Observation
• Prediction
• Classification
• Using appropriate scientific tools for investigations

OBJECTIVES

Students will be able to:

• Use a microscope
• Recognize microscopic organisms found in seawater
• Draw one of the planktonic organisms observed
• Identify one or more plankton by comparing with guides

MATERIALS NEEDED

• Microscope Picture and Rules
• Blue butcher paper (cut into shape of large drop of water)
• Markers
• Sea water samples (do not use artificial sea water like, “Instant Ocean”)
• Plankton guides and photographs for students
• Dissecting microscopes and light source
• Petri dishes (or slides or watch glasses to hold samples)
• Paper
• Pens
Vocabulary & Background

**VOCABULARY**

- Plankton – Organisms that drift; they cannot swim against a current stronger than 1 knot (1 nautical mile/hour)
- Microscopic – Living or nonliving particles that are unable to be seen with the naked eye
- Microscope – Scientific instrument used to observe detailed view of living and nonliving objects
- Sampling – The process of taking a small portion of (sample of) a material to study it

**METHOD**

Students will observe plankton under a microscope, record their observations, classify the plankton using guides, photographs and other resources.

**BACKGROUND**

Marine life can be divided into three categories based on lifestyles. Organisms that live in or on the bottom, such as seaweed or crabs, are called benthic. Strongswimming animals that live in the open water, such as squid, whales, and adult fish, are called the nekton. Plankton are small floating or feebly-swimming plants and animals in the water. Plankton may be primitive unicellular organisms or complex multicellular plants and animals. All types of plankton are at the mercy of the waves, tides, and currents for transportation. Most of the organic matter in the sea is plankton, and directly or indirectly, nearly all other marine creatures depend on it as a source of food. Plant plankton (phytoplankton) need to be near the surface, where light is available for photosynthesis. Most animal plankton (zooplankton) need to be near the surface to feed upon the phytoplankton. In order to stay afloat near the surface, plankton have evolved many ways to control their position in the sea. Spikes and other projections on a plankton help to distribute the organisms weight over a large surface area, slowing its sinking. Examples are zoea larva (pre-adult stage of crabs) and brachiolaria larva (preadult stage of sea cucumber). Oil is lighter than water. Many organisms, such as copepods and diatoms, produce oil to help them float. Air-filled floats help many types of marine zooplankton, such as the Portuguese man-o-war, stay afloat. For additional resources and plankton photos, please see Related Sites below.

**Activity**

**INTRODUCTION**

- What can you find in the ocean? *Seawater, fish, whales, rocks, etc.*
- Which of these things are living and which are not? *Fish, whales, squid are alive; seawater and rocks are not.*
• What can you find in a drop of seawater? *Salt...and plankton!*

**ACTIVITY STEPS**

1. Class discusses function of a microscope.
2. Teacher introduces students to the parts of the microscope and explains the basic operation of the microscope.
3. In small groups, students examine samples of ocean water under a microscope.
4. Students try to identify the organisms by comparing them to the plankton pictures/photos from books and websites.

**RELATED WEBSITES**
- Phytoplankton Image Library  
  - www.paulsmiths.edu/aai/phyto.html  
  - Article on “Scientists Map Evolution of Phytoplankton”: http://www.enn.com/arch.html?id=19835

5. Students draw as accurately as possible an organism they have identified.
6. The labeled rendering will be placed on the butcher paper water drop.
7. Students also record their observations in their science journals and identify any characteristics.

**Extensions**

**Science**: Phytoplankton are the primary food source and producers of oxygen in the ocean. This connects to the study of photosynthesis, food chain and life cycles, water, ocean water with fresh water, polluted water with non-polluted water). Compare zooplankton with phytoplankton.

**Math**: Sort and count organisms in a quadrat of the sample. Journal observations and record on a graph.

**Language Arts**: Students create a haiku describing one of their favorite microscopic organisms. Students generate fictional stories about the life of a plankton.

**Social Studies**: Who needs plankton? How do humans use plankton? How do humans adversely affect the plankton population? Can plankton adversely affect humans or other populations?

**Art**: Students paste tissue paper representations of plankton on a circle of white paper representative of the petri dish. The tissue paper is layered to simulate how the plankton overlaps in an actual sample. Students make pipe cleaner mobiles of various microscopic organisms they observed.
1. Make sure to begin with the microscope on the lowest magnification power (for example, 7x instead of 10x).

2. Place the sample on the stage.

3. Turn the light on. The light will most likely be located in the microscope, under the stage. If it is not, then your microscope uses an external light source. In this case, you should point the light at the sample, but keep the light as far away from the sample as possible to avoid overheating it.

4. Adjust the eyepiece so that they are the proper distance apart for you to see through them. This is done by GENTLY pulling them apart or pushing them together.

5. Direct student to look through the eyepiece to see if he/she can see the sample at all. Try moving it around slightly to get a better view. Also make sure to adjust the amount of light coming through your sample. It is best to use as little light as you possibly can to give better contrast of the sample (which will make it easier to see). If the light is too bright or too dark then you might not be able to see the sample very well.

6. Now slowly adjust the coarse adjustment while looking at your sample through the eyepiece. You should do this my starting with the upper part of the microscope (called the objective) as close to the sample as possible without touching it. Use the coarse adjustment knob to move the objective AWAY from the sample until it comes into focus.
How to Adjust a Dissecting Microscope Continued

As you slowly turn the adjustment knob you will notice the image will get clearer and clearer. Stop adjusting when the sample is the clearest.

7. After the sample has been completely focused with the coarse adjustment the microscope can be turned up to a higher magnification power by turning the magnification control knob. Make sure to only go turn the knob up by one magnification at a time and then stop to look through the eyepiece.

SOME RULES TO FOLLOW WHEN USING A MICROSCOPE

Direct students to:

- Be careful and gentle every time they use a microscope. Microscopes are delicate and expensive.

- If any kind of material from your sample (such as water) gets onto any part of the microscope make sure to wipe it off immediately and carefully.

- When carrying a microscope, always hold it underneath the stage with one hand and hold the arm of it with the other hand. Never carry it by the cord or without supporting the stage area.

- Always adjust the coarse adjustment with the microscope on lowest power. This way it will make it easier to focus on the sample and not damage any parts of the microscope.
Lesson 5: What’s on the Outside

2 hours

Concepts & Objectives

QUESTION

How does body shape relate to function (how it swims, where it lives, etc)?

UNDERLYING CONCEPT

How body design relates to function.

SKILLS

- Identification
- Creating Imprints

OBJECTIVES

Students will be able to:

- Create fish prints with paints
- Label the various fish parts
- Identify parts of the organism
- Relate form to function
- Compare the body of a fish to other types of bodies, humans for example

MATERIALS NEEDED

“What’s on the Outside?” activity

- Whole fresh fish (various kinds)
- “Fish: What’s on the Outside?” and “Fish Shapes” activity sheets
- Compound microscope (optional) or magnifying lens
- Newspaper on which to lay fish
- Tweezers
- Fish books for reference
- FISH INFO SHEETS
- FISH PICTURE FOR REFERENCE

“Gyotaku” (fish rubbing/printing)

- Fish
- Paper for fish printing
- Ink for fish printing
- Paper towels for clean up
- 1/2-1 inch brushes (roller) and narrow one
- Push pins
- Tissues
- Plasticene modeling clay
VOCABULARY & BACKGROUND

VOCABULARY

- Vertebrates - animals with backbones
- Lateral line - horizontal “line” on fish that detects physical vibrations in the water

BACKGROUND

All fishes are **vertebrates** (Subphylum Vertebrata), which means that they have a backbone. Fishes are a very diverse group, but the major characteristics of fishes are that they 1) live and grow in water, 2) swim with fins, and 3) use grills for gas exchange (breathing). There are three classes of fishes; the jawless fishes, the cartilaginous fishes, and the bony fishes. As their name suggests, jawless fishes do not have lower jaws, and typically suck onto their prey using hooklike teeth. The cartilaginous fishes are the sharks and rays. They do not have a calcified bony skeleton like ours, but rather a more flexible skeleton made of cartilage, like what our ears and noses are made of. Sharks have a very large oil-filled liver that helps them to remain buoyant in the water column. The bony fishes are the most diverse and abundant class of fishes. They have a calcified bony skeleton like ours and use a special gas-filled organ, the swim bladder, for buoyancy. The more gas the fish pumps into the bladder, the more buoyant it is. This is analogous to a human taking a deep breath of air, the more air in the lungs, the better you float in the water. Of course fishes do not want to float on top of the water, but the principle is the same. Some fast swimming fish, like mackerel, that may move up and down in the water column very quickly, do not use a swim bladder, but rather use oil for buoyancy (if you have ever eaten mackerel you may have noticed that it is a particularly oily fish).

The external anatomy of a fish is very different from our own, because fishes are adapted to move and live in water, and we are adapted to live on land. Therefore, locomotion and sensory structures may look very different, although their general functions are very similar. For example, fishes have “noses” (called nares) that don’t look anything like our own, yet their purpose is to smell chemicals in the water. Likewise, the internal anatomy will look very different from our own, however, most of the major organs are the same (e.g., heart, stomach, liver, spleen) and have the same basic function. A few internal structures, like the swim bladder, are of course unique to fishes. In this lesson we will be examining the external and internal anatomy of a bony fish and comparing this to a human.

Fishes do have a few specialized structures that have no counterpart to humans. The lateral line is one example. The lateral line detects physical vibrations in the water that allows the fish to sense other animals and objects in the water, even if they can’t be seen. Many types of fishes use inner ear stones, called otoliths, to detect changes in body position. Because of their unique characteristics and growth patterns, scientists often use otoliths to classify fish, as well as determine their age. These stones rest on a bed of sensory hairs, that send messages to the brain about the orientation of the fish. Sharks have an organ in their snout, called the ampullae of Lorenzini, that detects weak electric fields. It is thought that they use this structure
to detect prey, perhaps being able to distinguish the weak electrical signals given off by injured animals.

**Activity**

**INTRODUCTION**

- What can you find in the ocean? *Seawater, fish, whales, rocks, etc.*
- Which of these things are living and which are not? *Fish, whales, squid are alive; seawater and rocks are not.*
- What can you find in a drop of seawater? *Salt...and plankton!*

**ACTIVITY STEPS**

1. Class discusses function of a microscope.
2. Teacher introduces students to the parts of the microscope and explains the basic operation of the microscope.
3. In small groups, students examine samples of ocean water under a microscope.
4. Students try to identify the organisms by comparing them to the plankton pictures/photos from books and websites.
5. Students draw as accurately as possible an organism they have identified.
6. The labeled rendering will be placed on the butcher paper water drop.
7. Students also record their observations in their science journals and identify any characteristics.

**RELATED WEBSITES**

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**Extensions**

**Science:** Phytoplankton are the primary food source and producers of oxygen in the ocean. This connects to the study of photosynthesis, food chain and life cycles, water, ocean water with fresh water, polluted water with non-polluted water). Compare zooplankton with phytoplankton.

**Math:** Sort and count organisms in a quadrat of the sample. Journal observations and record on a graph.

**Language Arts:** Students create a haiku describing one of their favorite microscopic organisms. Students generate fictional stories about the life of a plankton.

**Social Studies:** Who needs plankton? How do humans use plankton? How do humans adversely affect the plankton population? Can plankton adversely affect humans or other populations?

**Art:** Students paste tissue paper representations of plankton on a circle of white paper.
representative of the petri dish. The tissue paper is layered to simulate how the plankton overlaps in an actual sample. Students make pipe cleaner mobiles of various microscopic organisms they observed.
You can tell a lot about a fish’s lifestyle by examining its body shape and fins. Does your fish live near the bottom? Is it a fast swimmer? What does the lens from its eye look like? After you have observed your fish, look at another fish that is different from yours.

1. Look carefully at your fish. Draw it on the back of this sheet. Leave room for a written description of your fish under the drawing (Question #6).

2. Look inside your fish’s mouth. Does your fish have:
   a tongue? __________
   teeth? __________ Draw the teeth here:

3. Lift the operculum (gill cover). Describe the gills:. As you slowly turn the adjustment knob you will notice the image will get clearer and clearer. Stop adjusting when the sample is the clearest.
Fish: What’s on the Outside Continued

4. How many fins on your fish? Put the number of each kind in the blank.
   ______ dorsal (on the back) ______ caudal (tail) ______ pectoral (“arms”)
   ______ pelvic (“legs”) ______ Any other fins?
Which fins are spiny? ________________________________

5. Scales: Put a scale on a microscope slide in a drop of water. You can do this by using tweezers to remove the scale. Grasp a scale and pull toward the tail. Look at the scale with a compound microscope or magnifying lens. With a microscope, start at the lowest power (shortest lens). Make a drawing of the scale here:

6. Using the “Fish Shapes” sheet:
   Describe the lifestyle of your fish. Support your statements with information about its body-shape, fins and tail, mouth and eye position. Write your description on the back of this paper under your fish drawing.
Fish Shapes: Bodies

Body shapes can tell us where a fish lives:

**Flat** (flat from top to bottom): good for hiding on bottom

**Flattened** (flat from side to side, or ribbon shaped): good for hiding in tight places

**Torpedo:** usually live in open water and are good swimmers

**Round:** often hide in round, tight spaces

**Long but round in cross section** (hoselike): can fit under and around rocks
Fish Shapes: Fins

The shape of the different fins can tell us many things about a fish’s lifestyle.

**Tail Fin:** A fish’s tail tells us how fast it can swim.

**Pectoral Fins:** Also show how fast the fish can swim:

- **Long, pointed** pectoral fins: fast swimmer
- **Crescent or sickle shaped** tail fin: fast swimmer
- **Round** pectoral fins: moderate swimmer
- **Blade shaped but no “V” notch** tail fin: moderate swimmer
- **Flowing** pectoral fins: slow swimmer
- **Fan-shaped** tail fin: slow swimmer
- **Leg-like or platform-like** pectoral fins: balance or “walking” on bottom

Special use pectoral fins
Fish Shapes: Mouths

The position of a fish’s mouth tells us how it feeds:

Wide, upturned mouth: gulpers which often wait quietly for food to come within gulping distance

Mouth slanted toward top of fish: surface feeder

Long, skinny nose with mouth at the end: prober which searches for food in crevices, cracks, and holes

Mouth on underside: bottom feeder
Fish Shapes: Eyes

The position of a fish’s eyes tells us where it spends most of its time:

- **One eye on each side:** usually swims above the bottom

- **Both eyes on top of head:** stay on or near the bottom

- **Both eyes on one side of the head:** stay on or near the bottom

*Used with permission from OCEAN STUDIES, OCEAN ISSUES FOR SEA: GRADE 8 - Oceanography and Marine Biology, © 1997, James A. Kolb. The FOR SEA series includes 14 guides for grades 1 - 12 available from FOR SEA, Institute of Marine Science, Indianola, WA 98342, www.forsea.org*
Lesson 6: What’s on the Inside

2 hours

Concepts & Objectives

QUESTION

What is the basic internal structure of a fish? How is it similar to a human?

UNDERLYING CONCEPT

There are both similarities and differences between the internal structures of humans and fish. Dissecting a fish will allow the student to see the insides and compare the organs to a human body.

SKILLS

• Dissection
• Identification

OBJECTIVES

Students will be able to:
• Demonstrate dissecting techniques
• Identify parts of the organism and compare the organs to the human body appearance and function

MATERIALS NEEDED

• Fish
• Paper towels for clean up
• Dissecting tools:
  - Scalpel or sharp knife
  - Small sharp scissors
  - Tweezers
• Blunt probes
• Cardboard or thick newspapers (to place fish on)
• Apron
• Soap and water
• INTERNAL FISH ANATOMY DIAGRAM
• CLEANING FISH: INTERNAL ANATOMY
VOCABULARY

Some of the more obvious and important internal structures:

- Gills - for breathing/exchange of oxygen
- Heart - circulation of blood
- Liver - filters and cleans the blood of impurities
- Pyloric caeca - produces digestive juices
- Gonad (ovaries or testes) - produces eggs (orange or yellow) or sperm (white)
- Stomach - digestion of food
- Intestine - digestion of food/movement of wastes
- Anus - exit for solid wastes
- Kidneys - produce urine
- Urogenital opening - exit for urine, eggs and sperm

BACKGROUND

All fishes are vertebrates (Subphylum Vertebrata), which means that they have a backbone. Fishes are a very diverse group, but the major characteristics of fishes are that they 1) live and grow in water, 2) swim with fins, and 3) use grills for gas exchange (breathing). There are three classes of fishes; the jawless fishes, the cartilaginous fishes, and the bony fishes. As their name suggests, jawless fishes do not have lower jaws, and typically suck onto their prey using hooklike teeth. The cartilaginous fishes are the sharks and rays. They do not have a calcified bony skeleton like ours, but rather a more flexible skeleton made of cartilage, like what our ears and noses are made of. Sharks have a very large oil-filled liver that helps them to remain buoyant in the water column. The bony fishes are the most diverse and abundant class of fishes. They have a calcified bony skeleton like ours and use a special gas-filled organ, the swim bladder, for buoyancy. The more gas the fish pumps into the bladder, the more buoyant it is. This is analogous to a human taking a deep breath of air, the more air in the lungs, the better you float in the water. Of course fishes do not want to float on top of the water, but the idea of having greater buoyancy after more air is the same. Some fast swimming fish, like mackerel, that may move up and down in the water column very quickly, do not use a swim bladder, but rather use oil for buoyancy (if you have ever eaten mackerel you may have noticed that it is a particularly oily fish).

The external anatomy of a fish is very different from our own, because fishes are adapted to move and live in water, and we are adapted to live on land. Therefore, locomotion and sensory structures may look very different, although their general functions are very similar. For example, fishes have “noses” (called nares) that don’t look anything like our own, yet their purpose is to smell chemicals in the water. Likewise, the internal anatomy will look very different from our own, however, most of the major organs are the same (e.g., heart, stomach, liver, spleen) and have the same basic function. A few internal structures, like the swim bladder, are of course unique to fishes. In this lesson we will be examining the external and
INTRODUCTION

Explain that you are going to dissect a fish. Have the students discuss the anatomic parts they would expect to find in a fish. Have them:

- List the parts they expect to find.
- Explain why they think each part will be present.
- Tell what they think may be the function of these different parts.

List questions they would like answered when observing fish entrails.

ACTIVITY STEPS

Information for teachers before beginning:

You will probably want to do the opening of the fish for the students, once this is done turn the fish over to the students. Insert a sharp knife in the anus and make a shallow cut along the belly to the area right below the gill opening. Open the body to identify as many organs as possible without removing them. Have them carefully tease the organs away from the body with their fingers.

Where to find parts of the body:

- Heart and Liver- The heart and liver are found right below the gills and cutting should be done carefully so they are not injured.
- Brain- The brain is on the front part of the head. You will need to cut through bone of the head to get at it.
- Eye- The eye can be removed and opened to reveal a round lens.
• Sexing Fish- If fish are about to reproduce, the female ovary will be a sac, usually filled with yellow to orange eggs. The testis of the male will be a gray sac. When fish are not reproducing, the ovaries and testes will normally be difficult to find.

• Things to note:
- The mouth has two exits-one for water through the gills, one for food through the stomach.
- There are several gills on either side of the head.
- The black kidney is right against the backbone.
- The stomach can be opened to see what the fish has eaten.
- The air bladder will look like a cellophane sac.

Do not be concerned if not all body organs are found. (Remember that this is a first exploratory experience.)

1. Clean a fish with the students while pointing out its internal anatomy. You may want do this as a demonstration, or have the students follow along on their own fish. The students should:

- Wear aprons
- Wash their hands
- Watch the opening of the fish (students will observe)
- Find each of the parts identified by the cleaner
- Seek answers to their own questions

2. To open the fish, insert a sharp knife (or scissors) into the anus (see the following fishdiagrams for reference) and make a shallow cut along the belly forward to the area just below the gill opening. You can make another cut from this point, perpendicular to the first, on the upper half of the fish from the belly to a point just behind the eye, and a third cut from the anus toward the dorsal fin. Make sure you are only cutting the muscular top layer of the fish, and not penetrating into the body cavity. The top layer (a fillet of the fish) can then be peeled back to reveal the internal organs.

3. Have the students draw and label the internal parts of the fish. Have them use CLEANING FISH: INTERNAL ANATOMY to record their drawings.

DISCUSSION QUESTIONS

Teacher: I see this fish has a digestive tract similar to a human’s. Food is taken in at the mouth and goes down to the stomach. The digestion starts here and ends at the intestine, where the food is absorbed. The wastes are passed out of the body. This is similar to the human digestive system. What did I find and how is it similar to the human organ?

Student: You found the digestive tract and humans take their food in and get rid of their wastes the same way fish do. The organs are similar.

T: We seem to be very different, but some of our organs function the same way.

T: Does anyone see ovaries in their fish? Do humans have ovaries?

S: I see them, this must be a female fish because female humans have ovaries.
T: What is the function of the ovaries in the human?
S: They carry the eggs that can become babies.
T: Ovaries have the same function in the fish. (Draw and list function on chart)
T: With a partner, decide which organs are similar to human organs (find them in the fish). After ten minutes, I will call on volunteers to share what they have found. Tell me the organ, where it is found, and how the function is similar to the human organ.
S: We found a kidney and humans have kidneys. Kidneys are used to remove wastes from the body. It is near the intestine.

ADDITIONAL DISCUSSION QUESTIONS

• What parts of the fish’s anatomy seem to be involved in processing food? Agree on the mouth, tongue, teeth, stomach, intestine, anus.
• How were these parts arranged in the fish?
• Where were the sex organs of the fish?
• How do eggs or milt (sperm) leave the body of the fish? Locate a second opening behind the anus. This is the urogenital opening.
• Where was the heart of the fish?
• How was the heart connected to the rest of the body? Only large blood vessels will be observable.
• Where were the kidneys of the fish?
• Where were the gills of the fish?
• How were they connected to the rest of the body? The blood vessels leading to the heart may be found.
• What questions of your own did you investigate? What answers did you find?

Extensions

Continue looking for organs and labeling them. If they are similar to human organ write how their function is the same or different. If the fish has an organ a human does not have, label the part in your drawing and write its function on your chart.

EVALUATION

• Review the detail and accuracy if the students worksheet on internal anatomy.
• Have the students make a wall chart of the external anatomy of a fish.
Cleaning Fish: Internal Anatomy

Draw the internal anatomy of a fish and label the organs listed in the table #2
## Cleaning Fish: Internal Anatomy

Suggest what the following organs might do:

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<tr>
<th>Organ</th>
<th>Function</th>
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<tr>
<td>Tongue</td>
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<td>Stomach</td>
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<td>Intestine</td>
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<td>Pyloric Caeca</td>
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<td>Anus</td>
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<td>Kidneys</td>
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<td>Gonads (testes, ovaries)</td>
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<td>Air Bladder</td>
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<td>Heart</td>
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<tr>
<td>Brain</td>
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<td>Urogenital Opening</td>
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</table>
Lesson 7: Critters Classified
About 1 hour

Concepts & Objectives

QUESTION

What are the major groups of invertebrates and what do they look like?

UNDERLYING CONCEPT

Scientists divide organisms into different groups (phyla) according to their shared characteristics. Most marine invertebrates fall into one of the six major phyla.

SKILLS

• Observation
• Comparison
• Critical analysis

OBJECTIVES

Students will be able to:

• Recognize the major phylogenetic groups of invertebrate animals.
• Work through a dichotomous key to identify the phylum of specific invertebrates.

MATERIALS NEEDED

• Several pictures of various invertebrates within each phylum.
• Dichotomous key.

Vocabulary & Background

VOCABULARY

• Body plan: the overall organization of an animal's body.
• Invertebrate: an animal that does not have a backbone.
• Phylum: animals grouped together by their similar body plans.
• Segmented: animal whose body is divided into distinct sections so that it looks jointed, such as a centipede.
- Tentacle: slender, finger-like extension usually found near an animal’s mouth or head
- used to catch and handle food.

BACKGROUND

Invertebrates are animals that do not have backbones. Over 90% of all the animals on the earth are invertebrates! There are thousands of types of invertebrates to be seen along the shores and in the ocean off Southern California.

Scientists group all animals according to the similarities in their body plan. A body plan is the overall organization of an animal’s body: what it looks like; what kind of internal and external parts it has and where they are located; how it moves and feeds. A group of animals with a similar body plan is called a phylum. Organisms within a phylum have a shared evolutionary history as well, meaning they are “related” to one another through a distant common ancestor. Invertebrates are so diverse that they include dozens of phyla (plural). In contrast, vertebrates, animals with backbones, are only a small subgroup within one phylum.

Most commonly seen invertebrates belong to one of these six phyla. If an animal belongs to one phylum, it does not belong to any other phyla.

6 Major Invertebrate Phyla:

Porifera - sponges (por IF er ah)
Cnidaria - sea anemones and jellyfish (ny DARE ee ah)
Mollusca - snails, slugs, squids and octopuses (mall US kah)
Annelida - segmented worms (repeated body segments) (a NELL i dah)
Arthropoda - insects, shrimps, lobsters and crabs (are thro POE dah)
Echinodermata - sea stars, urchins, brittle stars (ee ky no der MAH tah)

We can learn to recognize all these different groups by the similarities in their body plans.

Activity

1. Before discussing the major phyla: Have 3 pictures of different invertebrates from each of the major phyla. Tell students that you would like them to group the animals into 6 (and only 6) groups and that there should be 3 animals in each group. Have the students work in small teams to decide on their groups.

2. As a class, discuss the groups that the student teams have come up with. Ask them to describe why they put certain animals together. Next, show the students the “correct” groupings of the animals (a key with the proper groups will be provided). These are the groups that scientists have come up with. Ask the students to describe the main “traits” or similarities within each group (i.e., those things that all the animals in a group have in common). The students will not be able to come up with all of the characteristic traits of
each phylum just by looking at photographs. But it is important to stress to them that they will be able to experience the same process that scientists go through when they group organisms.

3. Dichotomous Key (also contained in PDF file CrittersClassified.pdf) Hand out pictures of 3 different animals, from 3 different phyla, to the teams again. The students will work through the dichotomous key to discover the name of the phylum that each animal belongs to.

Adapted from “Marine Life of Southern California (2nd Ed.) by Donald J. Reish (1995)
Dichotomous Key

1. Body shape is regular........................................................................................................ Go to 2
   Body shape is not regular (like a lumpy blob).......................................................... Porifera

2. Has a head or eyes......................................................................................................... Go to 3
   Does not have a head or eyes.................................................................................. Go to 4

3. Body is segmented (it has distinct body sections)......................................................... Go to 5
   Body is not segmented.............................................................................................. Mollusca

4. Has tentacles .................................................................................................................. Cnidaria
   Does not have tentacles............................................................................................. Go to 6

5. All body segments look the same.................................................................................. Go to 7
   Body segments do not all look the same (some are different).................................... Arthropoda

6. Has spines ...................................................................................................................... Echinodermata
   Does not have spines.................................................................................................. Go to 8

7. Animal has legs (even tiny ones).................................................................................. Go to 10
   Does not have legs..................................................................................................... Mollusca

8. Animal attached to bottom.......................................................................................... Porifera
   Not attached to bottom............................................................................................. Go to 9

9. Body very soft and jelly-like ....................................................................................... Cnidaria
   Body more firm......................................................................................................... Echinodermata

10. Animal has hard covering all over body (including legs)........................................... Arthropoda
    Does not have hard covering .................................................................................. Annelida
Porifera
Cnidaria (Cnidarians)
Mollusca (Mollusks)
Annelida (Annelids)
Echinodermata (Echinoderms)
Arthropoda (Arthropods)
Organisms are not isolated in their environment. Organisms must interact with other individuals of their own species, with other species, and with their physical environment. The study of the interactions between organisms and their environment is called ecology (Greek: oikos- house; logia- study). The study of ecology can encompass all aspects of biology; from physiology to behavior, because any change within an organism has the potential to affect its relationship with the environment. Likewise, ecological interactions can be studied at many different levels; between an organism and its environment, between an organism and a group of organisms, or between two groups. In this unit we will cover many of the important concepts within ecology.
QUESTION

How can a scientist find out how many organisms live in an area?

UNDERLYING CONCEPT

Scientists can learn a lot about an area by having a clear idea of how many and what kind of organisms live there. It’s very difficult to literally count all of the organisms in a large area or zone so scientists use tools (such as quadrats), identification, and estimation as important keys in determining this answer.

SKILLS

- Using a grid
- Problem solving
- Categorizing
- Estimating

METHODS

Spread out a 12-bean soup and macaroni mixture on the table. Students will use home-made quadrats to mark out a section. By categorizing and counting what is in the quadrat area they will estimate the number and variety of “organisms” on the table.

OBJECTIVES

Students will be able to:

- Categorize objects
- Estimate a number in an area
- Apply the grid principle to multiplication skills

MATERIALS NEEDED

- 1 package of 12-Bean dry soup mix
- 1 package each of 2 or 3 varieties (and colors) of pasta (macaroni)
- small plastic bags (to hold one mixture for each group or team)
• wire coat hangars, each one shaped into a square (‘quadrat’)  
• Quadrat Craze Data Sheet (included in lesson plan--choose appropriate sheet for your grade )  
• stiff paper or ruler to scoop mixture together for clean up

Vocabulary & Background

Vocabulary

• Identification- finding out what something is  
• Categories- groups of similar things  
• Community- group of living things that live in a certain area  
• Organisms- any individual living thing  
• Estimation- a rough idea of the size of something

Background Information

How can a scientist determine the quantity and type of organisms living in an area, and why is it important? Identification and estimation are important keys in determining these answers. Having a clear idea of how many and what kind of organisms live in a specific area can tell scientists a lot. For example, they can record data on several occasions and learn about how populations and communities may change over time. With such information they can find answers to many other questions and also create new questions to explore.

Scientists use a variety of methods and tools to find answers to questions. Some tools and methods are very sophisticated while others are simple and uncomplicated. In the above example, it is obviously very difficult to count every organism in an entire area (or community); in this case quadrats and simple mathematical computations are often the tools and methods of choice. A quadrat is a square of a determined size (usually 1 meter or 1/2 meter square) which is placed on a portion of the area/community to be studied, in a tidepool zone, for instance. By counting how many organisms are in the quadrat and multiplying that by the number of quadrats that would fit into a certain area, estimates can be made about population sizes for each kind of organism that lives in an area. Another way to gather information about the organisms in the quadrat is to measure them and determine their actual size (length) and ranges of sizes. This will give an idea of the likely range of sizes for individuals within a given category. In the following activity students get an opportunity to use similar skills in their classroom.

Introduction

T: How many trees ( or bushes or ..... ) are around our school (your neighborhood, park, etc.)?  
T: If there are too many to count easily, how else could we find the answer?  
T: Would we need to use some math?
Today we are going to talk about some of the tools that scientists use to study organisms. One of the most important tools that a scientist uses is Math. So today’s activity will involve some addition and multiplication. Another tool that scientists use a lot is identification, finding out what something is, and categorization or putting things into similar groups. A third tool that a scientist might have to use is estimation. Let’s say that you have a very large community area and you want to find out how many of a certain kind of organism live within the community. You could count all of the organisms in that area, but that would probably take a very long time (say the trees in our school area, park, or neighborhood). Or you could count the organisms in a smaller area within the community and then estimate (roughly figure) the total number in the whole community from that.

(Teacher can do a simple diagram on board, draw large square with lots of ‘x’s for the trees. Then outline a smaller square within the big one. Have the students count the ‘trees’ in the small square and decide how many of those small squares it would take to fill up the big square and multiply by that number. Early elementary grades could use smaller quantities and practice addition.)

Next introduce the quadrat (a real one if available, or the coat hangar shaped into a square). This is one more tool that a scientist would use for this kind of study. It is a square of a known size or area (the area is the amount of space that is covered by the quadrat). This area can be calculated by multiplying the length of the quadrat by the width. A scientist would put this over an area of the community and count the organisms in it. Then she would estimate the number of these quadrats that would fit in the total community. Then, using multiplication (or larger groups of numbers and addition for pre-multiplication grades), we multiply the number of each organism by the number of quadrats.

So today we are going to study a make-believe community that has many different kinds of organisms:

- What is a community? (Answers will vary: a neighborhood, ....Real answer: a group of living things that live in a certain area)
- What is an organism? (Answers: a body with organs, .... Real answer: a term for any living thing)
- If grade appropriate: What is a population? (Answers: a group of people, many animals...... Real answer: the group of a single species in a community)

We are going to identify some of the organisms in this community and then estimate their total number within the community.

ACTIVITY
1. Divide into pairs or groups of 3.

2. T: Pass out a plastic bag which contain a mixture of 12 bean soup and macaroni (be sure to have at least 8 different things in each bag) to each group. Also hand out Quadrat Craze Data Sheet. [Choose Data Sheet I (students not yet introduced to fractions) or II (students understand fractions).]

3. Students spread the “community” of beans and pasta on a table or desk top. Two teams can work independently on the same ‘community’.

4. Students are to identify 8 categories of “organisms.” It is up to the teams how they want to categorize the organisms; it can be done by: color, shape, pasta, beans or a combination of those. They can decide on real or made up names.

5. Write this on the Quadrat Craze sheet. It has 4 columns: one for the name of the category, one for a description of what it is, the third column is for the number within the quadrat. (Ex: BB, black beans, 12)

6. Estimate the total number within the community. Do this by counting how many quadrats would fit into the whole community (table top) and multiply that number by the number of ‘organisms’ in the category. Place this number in the last column of the sheet. This can be simplified for younger students by using a smaller number of categories, and a smaller area (desk top) for the total community (so it takes only 2 or 3 quadrats to cover the whole ‘community’) and then use addition.

7. Have each team report on their ‘findings’.

DISCUSSION

• Why are there differences between estimates of teams at same table? (Different objects may have clustered together due to weight, texture, etc.)
• How is this similar to differences in the natural world/wild? (Animals and plants may group together because of better food sources, temperature, and other conditions.)
• What are the problems of estimation? (It is a rough ‘guess’ and not completely accurate.)
• What are some of the problems using quadrats? (You are only covering a certain area and the next area might be very different.)
• Would scientists use just one quadrat count? (No, With older students discuss how scientists would normally count several quadrats in an area and then calculate an average (appropriate to grade level: discuss averages)

Extensions

• Add rulers (with metric and standard measurements) to your “materials.” Pick a
“category” or grouping and put them into “size classes” (grouping by size). For example: How many organisms in the quadrat (or category) are greater or smaller than a particular size chosen by the teacher (example 2cm). Also, students can count how many of the objects in the chosen category are: less than 1 centimeter, how many are between 1 and 2 centimeters and how many are over 2 centimeters in length (teacher can choose relevant sizes). Which are the smallest and largest in each size class? Write down the results.

Ask these additional discussion questions:

- Are individuals in the same group or category more similar in size to each other or to individuals of other groups? (This will depend on the original groupings that the students have made; if “green” was a group category, then there may be as much variation in size within the group as between groups.)
- Why are there different sizes in the same group? (Some beans may have had more ‘food’ as they grew, the pasta may have been cut differently. In the natural world some organisms are more successful at competing for food or are surrounded by more favorable conditions (environmental factors))

- If the “rulers”/’size’ Extension is chosen, then additionally one can have students: Make a size distribution graph: On graph paper plot the number of individuals that are in each size class. On graph paper, write the size classes on the x-axis (horizontal axis) and the number of individuals on the y-axis (vertical axis). For each size class, plot the number of individuals that you observed in that class. The resulting graph is known as a size distribution for that category of organism.

- For older elementary students use the multiplication grid provided and practice multiplication tables. Explain that it is essentially a quadrat on paper, broken into smaller parts.

- Use the quadrat to introduce fractions: Divide a quadrat into 4 quarters. (The quadrat can be made out of PVC, rope, string, etc.) Ask students to count how many organisms are in one quarter, 2 quarters, 3 quarters and 4 quarters (to demonstrate how 4 quarters make a whole).

- Introduce the concept of density: the number of organisms per unit area. For example: “There are 24 snails per square meter in the community.”

- After doing the “Quadrat Craze” activity in class, repeat it in the school yard, at a tidepool, at a touch tank, at an aquarium, etc.
# Quadrat Craze Data Sheet

Name: ________________________________________________

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<th>Category</th>
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## Quadrat Craze Data Sheet II

Name: __________________________________________

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<th>Category</th>
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# Quadrat Craze: Multiplication Tables

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Lesson 2: Kelp Forest Reading Area
3 - 5 class periods

Concepts & Objectives

QUESTION
What makes up a kelp forest environment?

UNDERLYING CONCEPT
The kelp forest is a unique habitat supporting many organisms.

SKILLS
- Designing
- Planning
- Conceptualizing
- Measuring

METHODS
Students will create a “kelp forest reading center” in order to learn about the ecosystem of a kelp forest.

OBJECTIVES
Students will be able to create a walk-through kelp forest in the classroom.

MATERIALS NEEDED
- Rope
- Green trash bags
- Thin wire
- Glue
- Small Styrofoam balls (optional)
- Thin rope or green yarn
- 2 or 3 rocks (as many rocks as kelp plants)
VOCABULARY

- canopy - The masses of blades and stipes at the top of the kelp that are seen on the surface of the ocean.
- holdfast - The anchoring system of the kelp.
- blade - The "leaves" of a kelp plant.
- stipe - The "stem" of a kelp plant.
- air bladder - A small balloon at the base of each blade that helps to keep the stipe and the blades of the kelp to float near the surface of the water, where the sun is.

Categories:
- groups of similar things

- Community - group of living things that live in a certain area
- Organisms - any individual living thing
- Estimation - a rough idea of the size of something

BACKGROUND INFORMATION

Kelp Forest

Kelp is a type of marine algae, or seaweed. Seaweeds come in three color variations, red, green and brown. Kelp is a kind of brown seaweed that grows to be very large. Although kelp resembles a kind of weed or tree, it is quite different from plants that grow on land. First of all, kelp has no roots. Kelp does have a way to anchor itself to the bottom of the ocean floor, but this anchoring system, called the holdfast, does not take in nutrients like plant roots do. The "leaves" of a kelp plant are called blades and the "stem" is called the stipe. Another structure unique to kelp is the air bladder, which looks like a small balloon at the base of each blade. The stipe of the kelp is very flexible and cannot stand up on its own - the air bladders help the stipe and blades of the kelp float in the water, which allows the kelp plant to grow up toward the surface of the water, where the sunshine is brightest.

Kelp is very good at growing - the giant kelp off the coast of California can grow up to 2 feet per day! Like land plants, kelp uses energy from sunlight to make its own food. This process is called photosynthesis. Sunlight is captured by the plant and the energy particles in sunlight (photons) are used to drive a chemical reaction that produces sugar. This sugar is the food for the plant. In a land plant, usually only the leaves are capable of photosynthesis, but all parts of the kelp plant can photosynthesize. A kelp plant starts out as a single flat blade attached to the bottom and then grows into a mature plant. Giant kelp can get to be over 150 feet long! Kelp sometimes grows in dense patches of many individual kelp plants - these dense patches are called kelp forests, because they resemble a forest of trees.

Sea urchins (red, white and purple ones), certain types of snails, (sea hares, Norris snails and abalone), and a few fish species (like the halfmoon and the opaleye), regularly feed on kelp. There is another animal that eats kelp, humans! Have you ever eaten ice cream, chocolate
milk, apple pie or salad dressing? If so, then you have eaten kelp! Unlike other kinds of seaweed, like red algae, which are used directly as food, kelp is not usually eaten directly by humans. Instead, certain compounds are extracted from the kelp and then used in other foods. Algin is one of these compounds and is used to help make different ingredients stick together and form gooey gels. Algin and other compounds from kelp are also used in other products used by humans, like paint, cosmetics and some drugs.

Kelp Forest Habitat
In addition to providing food for some organisms, kelp is an important habitat for many organisms. The structure of giant kelp (Macrocystis) affects which organisms live where. Let’s start from the top to the bottom:

Canopy
Did you know there are nurseries in the kelp forest? The canopy of the kelp (the mass of blades and stipes at the top of the kelp that are seen on the surface of the ocean) can go down a meter or more below the surface. The canopy slows the water currents, making this the perfect spot for tiny organisms like floating (planktonic) eggs, larvae and very small organisms to gather. The organisms grow easily here due to the warmth and light and are protected from hungry predators by the thick kelp growth. The canopy is often called the nursery or brood area for nearshore fishes and invertebrates. Small senorita fish and the tiny topsmelt like to dine in this area.

Below the canopy
Below the canopy the waters are filled with fish life. Surfperches may feed in a variety of places in the canopy, in the water between the plants or around the holdfasts (on the bottom). Most fish prefer the area of the kelp forest where their prey lives. Kelp bass find the middle of the kelp forest to be a good hunting area, while Sheephead, a boldly colored fish, like to feed on the algae invertebrates that live among the kelp stipes and tend to hang out towards the bottom of the kelp forest. A variety of species of rockfishes feed on other fishes and invertebrates near the bottom.

Holdfast and rocky bottom dwellers
More little creatures live down here! It’s the spot where a variety of attached (nonmoving) invertebrates live: sponges, sea anemones, sea squirts, and barnacles. Among these attached animals, motile or moving animals can be found...by the millions! Brittle stars, snails, and small crustaceans are abundant. The large amount of plant material attracts plant-eaters (herbivores) like sea urchins, sea hares and abalones. Sea stars, such as sea bats and sunflower stars, also are found in the kelp bed, often eating sea urchins, other sea stars and many other invertebrates.

Some animals like sea otters and sea lions hunt through all areas of the kelp. Sea lions consume vast quantities of fish, and find all areas of the kelp forest to be an abundant “fish market.” Also, many small animals, and certain types of algae actually live inside the kelp plant, making the kelp holdfast their home. The inside of the holdfast provides protection from predators and from strong ocean currents. Animals that you might find in a holdfast include...
worms, baby sea urchins, snails, brittle stars, tiny crustaceans, and maybe even mussels or barnacles.

Activity

INTRODUCTION

View pictures, videos or online sites that illustrate a kelp forest. (The Sea Grant online site for kelp is given in the Extensions section of this activity.) Engage in a teacher directed discussion of what kelp is like, how it differs from land plants, and what it would be like for an animal to live in that habitat. Students can also do more in-depth research projects on kelp and kelp forest inhabitants as part of this overall activity.

ACTIVITY

1. Choose a spot in your classroom to designate as the “kelp forest” area. The space that you choose does not need to be a large one, a 6’x 6’ space is fine.

2. Suspend rope from the ceiling (this will be the stipe) and attach kelp blades that the students cut from heavy green trash bags. A piece of thin wire glued up the middle of the “blade” will allow the students to bend the blades, this will make the kelp more life-like, and can also be used to attach the blade to the “stipe.”

3. For additional realism, small Styrofoam balls painted green can be strung onto the wire at the base of the blade before it is attached to the stipe.

4. Holdfasts can be made from many strands of thinner rope or green yarn, attached to the base of the stipe and then glued in a tangled mass to a rock or two.

RESEARCH

After the students create their classroom kelp forest, they can research the animals that live in the kelp forest, and then make them from various materials to inhabit the kelp forest. Don’t forget the tiny crabs, shrimp, worms, and sea stars that hide in the holdfasts.

LITERACY

The reading room can be the center for all types of reading. Of course, any marine science books and/or stories and books relating to the ocean would fit perfectly into this reading area!
Extensions

- Students can have reading and research projects that make use of the resources in the reading room.
- Throughout the year or semester as new information is gained, continue to make additions to the kelp forest.
- Use the reading room kelp forest as a comparison to other marine environments; interesting comparisons can also be made to terrestrial forests.
- Refer to the zonation activities and create an extended zonation map to use as a wall decoration for the kelp forest.
- For an interactive kelp activity, see, www.usc.edu/go/seagrant; click on Education, next click on Online Activities, then click on “Help With Kelp”
WHAT IS KELP?

What’s that waving back and forth in the ocean? It looks like a tree - a tree in the ocean?! No, it’s kelp! Kelp is a type of marine algae, or seaweed. Seaweeds come in three different color varieties, red, green and brown. Kelp is a kind of brown seaweed that grows to be very large. Although kelp resembles a kind of weed or tree, it is quite different from plants that grow on land. First of all, kelp has no roots. Kelp does have a way to anchor itself to the bottom of the ocean floor, but this anchoring system, called the holdfast, does not take in nutrients like plant roots do. The other parts of the kelp also have different names. The “leaves” of a kelp plant are called blades and the “stem” is called the stipe. Another structure unique to kelp is the air bladder, which looks like a small balloon at the base of each blade. The stipe of the kelp is very flexible and cannot stand up on its own - the air bladders help the stipe and blades of the kelp float in the water, which allows the kelp plant to grow up toward the surface of the water, where the sunshine is brightest.

HOW DOES IT GROW?

Kelp is very good at growing - the giant kelp off the coast of California can grow up to 1 or 2 feet per day!! Like land plants, kelp uses energy from sunlight to make its own food. This process is called photosynthesis. Sunlight is captured by the plant and the energy particles in sunlight (photons) are used to drive a chemical reaction that produces sugar. This sugar is the food for the plant. In a land plant, usually only the leaves are capable of photosynthesis, but all parts of the kelp plant can photosynthesize. A kelp plant starts out as a single flat blade attached to the bottom and then grows into a mature plant. Giant kelp can get to be over 150 feet long! Kelp sometimes grows in dense patches of many individual kelp plants - these dense patches are called kelp forests, because they resemble a forest of trees.
Who Eats Kelp?

- worms
- snails
- clams
- crabs
- lobsters
- sea urchins
- sea stars
- fish
- sharks
- seals
- sea lions
- otters
- humans

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</table>

If so, then you have eaten kelp!
In addition to providing food for some organisms, kelp is an important habitat for many organisms. Can you guess which organisms might live in a kelp forest? Let’s start from the top to the bottom.

The structure of giant kelp (Macrocystis) affects which organisms live where. The blades and stipes of the kelp are handy homes or ‘hanging out’ places for other small species. A variety of fish live in the whole water column from the top to the bottom and are attracted to sections of the kelp where their favorite meal lives or spends time hanging out.

CANOPY
Did you know there are nurseries in the kelp forest? There certainly are. The canopy of the kelp, the mass of blades and stipes at the top of the kelp that are seen on the surface of the ocean, can go down a meter or more below the surface. Since the canopy slows the water currents, this is the perfect spot for tiny organisms like floating (planktonic) eggs, larvae and very small organisms to gather. The organisms grow easily here due to the warmth and light and are protected from hungry predators by the thick kelp growth. The canopy is often called the nursery or brood area for ‘nearshore’ fishes and invertebrates. Small senorita fish the tiny topsmelt like to dine in this area!

BELOW THE CANOPY
Below the canopy the waters are filled with fish life! Surfperches may feed in a variety of places in the canopy, in the water between the plants or around the holdfasts (on the bottom). However, most fish prefer certain sections of the forest and are usually found in the area of the kelp forest that harbors their prey. Kelp bass find the middle of the kelp forest to be a good hunting area, while Sheephead, a boldly colored fish, like to feed on the larger invertebrates that live among the kelp stipes and tend to hang out towards the bottom of the kelp forest. A variety of species of rockfishes feed on other fishes near the bottom, as well as on invertebrates.
HOLDFAST AND ROCKY BOTTOM DWELLERS
More little creatures live down here! It's the spot where a variety of attached (non-moving) invertebrates (animals without a backbone) live: Sponges, sea anemones, sea squirts, and barnacles. Among these attached animals, motile or moving animals can be found...by the millions! Brittle stars, snails, and small crustaceans are abundant. The large amount of plant material attracts plant-eaters (herbivores) like sea urchins, sea hares and abalones. Sea stars, such as sea bats and sunflower stars, also are found in the kelp bed, often eating sea urchins, other sea stars and many other invertebrates. Many organisms actually live inside the kelp plant! Many small animals, and certain types of algae, make the kelp holdfast their home. The inside of the holdfast provides protection from predators and from strong ocean currents. Animals that you might find in a holdfast include worms, baby sea urchins, snails, brittle stars, tiny crustaceans, and maybe even mussels or barnacles. During storms, kelp plants may be ripped up from the bottom and be washed ashore onto the beach. The tiny organisms that live in the holdfast will also be transported onto the beach, or they may fall off and land in a another habitat.

AND...
Some animals like sea otters and sea lions hunt through all areas of the kelp. Sea lions consume vast quantities of fish, and find all areas of the kelp forest to be an abundant "fish market." They find good shopping there! The sea otter, however, may spend almost its entire life in the kelp bed. While they also eat fish, their favorite meals are two invertebrates: abalone and sea urchins. If the population of sea otters gets too low, the number of sea urchins can easily increase; sea urchins eat kelp. Scientists have found that in Southern California kelp beds that were once inhabited by sea otters have gradually disappeared. Without their natural predators, sea urchins increased in number and moved through the kelp in an "urchin front," eating all the plants in their path. Even when the kelp beds were gone, young kelp plants could not get started due to the hungry urchins. So, the sea otter plays an important role in the health of the kelp forest habitat.
Did you know that you probably eat a bit of the ocean every time you eat some of your favorite foods? A substance called algin is found in the cell walls of the kelp plant. Algin makes the kelp plant flexible enough to withstand the pressure of the ocean’s movement. When it is processed, algin can be used to thicken, gel, and stabilize. For this reason, alginates are used in making pudding, ice cream, salad dressing and non-food items like shampoo, paint, toothpaste, and fertilizer. Make a batch of these delicious kelp cookies* to share with a friend.

SEAWEED SWEETS

You will need:
- 1 c. margarine (2 sticks)
- 1 t. vanilla
- 1 t. almond flavoring
- 3 c. flour
- 1 c white sugar
- 2 large mixing bowls & spoons
- 1 t baking soda
- 3 c. flour
- 1 c brown sugar
- measuring spoons
- 1 t salt
- baking sheets
- 2 eggs
- stove
- 1 t brown sugar
- hot pads
- 2 eggs
- wire cooling racks

Follow these steps:
- In a large mixing bowl, combine the margarine, sugar, eggs, vanilla, and almond flavoring. Blend well.
- Combine the flour, kelp, salt, and baking soda in another bowl. Combine the ingredients in the two bowls and mix well.
- Drop the dough by teaspoonfuls onto greased baking sheets. Bake at 400 for 8 minutes. Lift the cookies off the baking sheets onto wire cooling racks. When cool, store in an airtight container. The cookies will be chewy, and will sat fresh for several days.

* Recipe by Erniew Mae Campodonico of Nipomo, California.
** Available at natural food stores.

HAND ROLLED SUSHI

You will need:
- Sheets of nori cut in half lengthwise
- 1 medium carrot, peeled and cut into 3 to 4-in pieces
- 2 c. cooked rice, cooled to room temperature
- 1 medium cucumber, peeled and cut into 3- to 4-in pieces
- 1 T. rice vinegar
- 1/2 c. soy sauce

- Slice the carrot and cucumber pieces into narrow strips.
Fun With Kelp: Recipes Continued

- Add rice vinegar to cooked rice, stirring thoroughly.
- Take a sheet of nori in the palm of your hand and spoon a heaping teaspoon of rice onto its center and add carrots and cucumbers.
- Wrap nori around rice and vegetables to make a roll.
- Dip sushi roll in soy sauce.

LAVER SOUP

You will need:

- 1 c. dehydrated nori
- one 10 1/2-oz can beef consommé
- 2 c. water
- juice of 1/2 lemon (or less, to taste)

- Tear dried nori into pieces.
- Simmer in water until soft.
- Bring the water to a boil, then add the consommé and lemon juice. Heat just to boiling.
- Add a twist of lemon peel in each serving bowl.
- Serve with crackers of toast.
Fun With Kelp: Pressing

The study of marine plants, or seaweeds, attracts students and professional biologists alike. The larger plants of the sea are almost exclusively members of a diversified assemblage known as algae, and their study is known as algology. Some scientists are interested in their physiology (life processes), others work on ecology, distribution reproductive activities. Basic to much of this is the field of taxonomy, or identification and categorization of the many species. All of the other study areas rely on taxonomists to identify the plants upon which they do their observations or experiments.

In order to prepare the plants for examination and identification, there are several standard processes and procedures which must be followed. These methods are similar to those used by professional collectors. The plants are collected, preserved, mounted on special paper and dried. Then they are catalogued for future reference and identification. By using these methods, you may wish to begin a small personal collection, or merely to press some plants for framing or for greeting cards.

COLLECTION AND PRESERVATION

The greatest abundance of marine algae is found in the relatively shallow, sunlit nearshore waters (40 feet or less). They can be observed and collected using scuba or by snorkeling. A number of the more resistant species are in the large piles of seaweed found on the beach after a storm.

Once collected, the plant material may either be mounted and pressed while fresh (almost immediately), or preserved and kept in a suitable container, away from the light, for longer periods of time. The fresh material may retain slightly more color than the preserved, but drying will take longer. It is best to collect specimens in a plastic bag, then transfer them to a container of seawater and formaldehyde mixed in a 19:1 ratio. Small amounts of formaldehyde may be obtained at a drugstore, while large quantities can be ordered from a biological or chemical supply house. If specimens are to be kept some time before mounting, storage is best in a tightly closed metal can or in a glass jar, in the liquid, away from light.

MOUNTING AND DRYING

Mounting is easy, but also requires some special materials. The specimens are floated onto a special high quality, acid-free rag paper (herbarium paper) then pressed and dried in a plant press or by using weighted plywood. The addresses of suppliers are listed at the end of this activity.

- several specimens of fresh marine algae
- thin piece of masonite cut to fit the pan
- clean fabric to cover masonite
- shallow baking pan or plastic painter’s drip tray or broad enamel pan
- newspapers
- corrugated cardboard
DIRECTIONS:

1. A small amount of tap water is placed in a painter’s drip tray and a piece of herbarium paper is laid in the bottom. (If using a baking pan, also place the masonite in the pan and the herbarium paper.)

2. A fresh or pickled plant is floated in the water and allowed to settle down on the paper.

3. Place some sheets of newspaper on top of a piece of corrugated cardboard.

4. After it has been spread out and suitably arranged, the paper and plant are carefully slid out of the tray (and off the masonite, if it has been used), drained momentarily, and laid on the corrugated cardboard that has newspaper on top.

5. Wax paper or clean fabric is placed over it, then another newspaper and top with cardboard, and then another paper with its specimen.

6. Place a piece of newspaper over the cloth and top with another piece of corrugated cardboard. You can stack several different specimens for mounting using this same layering procedure: cardboard, newspaper, mounting paper with specimen, newspaper, cardboard.

7. Place the finished stack between the two pieces of plywood. Tie together securely with rope and weight down with bricks or rocks. Place near a heater or a warm, open window.

8. After 24 hours, change the cloth, newspapers, and cardboard. After 48 hours remove the cloth. Change the newspapers and cardboard daily until the specimens are dry to the touch. Delicate plants will take about 48 hours to dry completely; coarse plants may take up to 5 days.

9. When the pressing is complete, the algae is usually stuck to the paper. If not, use white glue to fasten it permanently to the paper. Do some research about the specimens of algae. Label your specimens with the species name, place and date of collection, collector’s name.

10. Stored flat in albums or in herbarium cabinets.

SUPPLIERS

Herbarium Dept.
927 Thomas Ave., SW
Renton, WA 98055-2931

Herbarium Supply
705 Bridger Dr, Unit D
Bozeman, MT 59715-2292
Tel: 800.348.2338
Tel: 406.994.0006
Fax: 406.994.9211
Email info@herbariumsupply.com
Website http://www.herbariumsupply.com
Lesson 3: Zonation & Distribution
1 - 2 class periods

Concepts & Objectives

QUESTION

Are organisms distributed evenly throughout all parts of the ocean? Can each organism live in any area of the ocean?

UNDERLYING CONCEPTS

Organisms are not distributed evenly throughout all parts of the ocean. Life in the ocean is most heavily concentrated in the coastal (nearshore) zones. Furthermore, every organism is limited in the area that it can inhabit. This results in a zonation of organisms, with certain species occupying certain zones. This is due to both physical and biological factors.

SKILLS

• Research
• Interpretation

METHODS

Students will be able to:
• determine/describe the habitat of a variety of common marine organisms.
• describe the major distribution pattern of marine life.

OBJECTIVES

Students will be able to:
• determine/describe the habitat of a variety of common marine organisms.
• describe the major distribution pattern of marine life.

MATERIALS NEEDED

• Butcher paper
• Crayons and markers
• Tape
• Organism cutouts
• 3” x 5” index cards (optional)
• Marine biology books or references (optional)
**VOCABULARY**

- **zonation**—describes the different zones or areas of the marine environment
- **distribution**—describes where animals live within these zones
- **pelagic**—all waters of the ocean
- **benthic**—extends from the intertidal, to the continental shelf, to the continental slope, to the deep ocean floor
- **coastal (or neritic)**—the nearshore ocean environment, that which occurs above the continental shelf
- **oceanic**—all of the ocean beyond the continental shelf, it is by far the most extensive
- **littoral**—includes the supratidal zone (or spray zone), intertidal zone, which occurs between the highest and lowest tides in an area, and the subtidal zone, which is always covered by seawater, and extends into the neritic zone

**BACKGROUND INFORMATION**

**Distribution**

To describe relationships in the marine environment, we must be able to define where different groups of organisms live in the ocean. Marine ecologists have divided the ocean into two major zones: the pelagic zone includes all the waters of the ocean, and the benthic zone includes the ocean bottom. The pelagic zone is further divided into the littoral, neritic, and oceanic zones (Figure 1). The littoral zone includes the supratidal zone (or spray zone). The littoral zone also includes the intertidal zone, which occurs between the highest and lowest tides in an area. The final area of the littoral zone is the subtidal zone, which is always covered by seawater, and extends into the neritic zone. The neritic zone is the nearshore ocean environment, that which occurs above the continental shelf and is often called the coastal waters. The oceanic zone, by far the most extensive, is all the rest of the ocean beyond the continental shelf. The benthic zone extends from the intertidal, to the continental shelf, to the continental slope, to the deep ocean floor. The material that covers the ocean floor can range from mud or silt to large rocks.

Life in the ocean is not evenly distributed. Organisms are much more abundant in nearshore waters than in oceanic waters. Scientists often use the term biomass to indicate the total mass of all organisms in an area. Biomass is usually given as grams/m² or grams/m³. Although the oceanic zone comprises 90% of the ocean’s area, the neritic zone has ~ 40 times more biomass than the oceanic zone. The greater abundance of biomass in coastal areas is due primarily to the abundance of phytoplankton in this zone. Phytoplankton are the basis of most food chains in the ocean; they are at the “bottom” of the food chain. Phytoplankton are more abundant closer to shore because there are more nutrients (inorganic molecules needed to survive) here. Most organisms live closer to shore because this is where most of the food is.
Organisms in Groups
Ecologists may study the interaction of one individual organism with its environment, but more often, they study the interactions within groups of organisms. Groups of organisms are organized into distinct levels:

- **A population** is a group of individuals of the same species living in a particular place.
- **A community** consists of all the populations (plants and animals) inhabiting a given area.
- **An ecosystem** includes all of the communities and their physical environment within a large geographical area. Ecosystems are very important in ecology because they convey the concept that all organisms are a part of a system of interacting biotic (living) and abiotic (not living) factors. A change in one species in an ecosystem will effect all other species in that system in one way or another. Ecosystems have specific characteristics:
  - they have a source of energy, most often the sun
  - they cycle nutrients between the abiotic and biotic environments
  - they convert inorganic energy into organic molecules
  - they regulate the flow of energy from organism to organism

**Activity**

Using the butcher paper and large markers, make a map of the ocean floor like the one shown in Figure 2. Make sure that the map is large enough to paste many 3”x5” pictures of marine organisms about onto it. Discuss the major zones of the ocean and label them on your map. Hang your giant map at the front of the classroom.

Hand out the organism cards to the students (2 per student for a class of 25). On the back of each card is a brief description of the animal and its habitat. Have each student come up to the front of the class and tape their organism onto the appropriate area of the map.

**Extensions**

- Students can research their organisms to find out the correct coloration, then color in the drawings with crayons or markers.
- You may paste the organism cutouts onto index cards to cover up the description on the back. Then have the students research each organism to find out where it lives. This will require an extra class period and marine biology reference books. You may want to try one of the following:
  - From the Sea to Shining Sea by; Amy L. Cahn
  - Life Starts in the Sea by; Andrea Lamas
  - One Small Square-Seashore by; Donald M. Silver
  - The Complete Aquarium by; Peter W. Scott
- Discuss the organization of organisms within groups and the concept of an ecosystem.
HARBOR SEAL

Coastal
 Mostly Pelagic

PLANKTON

Pelagic
 Coastal and Oceanic
 Mostly Near Surface

(zooplankton, phytoplankton)

OWL LIMPET

Coastal
 Mid to Upper Intertidal
 Rocky Shore
ACORN BARNACLE

Coastal
Rocky Shore
High to Low Intertidal
Benthic

FLYING FISH

Oceanic
Pelagic
Shallow Water

SHEEPHEAD FISH

Coastal
Pelagic
30-60 Ft Deep
(in kelp beds)
BRITTLE STAR
Coastal
Rocky Shore
Subtidal to 100 Ft Deep
Benthic

BRITTLE STAR

MUSSEL
Coastal
Rocky Shore
Mid Intertidal
Benthic

MUSSEL

SEÑORITA FISH
Coastal
Pelagic
10-60 Ft Deep
(Often in Kelp Beds)

SEÑORITA FISH
MORAY EEL
Coastal
Subtidal
Shallow Water

MIDSHIPMEN
Oceanic
Deep Water
(>3000 Meters)

KEYHOLE LIMPET
Coastal
Low Intertidal to Subtidal
Rocky Shore
Benthic
CANCER CRAB
Coastal
Rocky Shore
Intertidal to 130 Ft Deep
Benthic

HATCHET FISH
Oceanic
Pelagic
Deep Water
(>3000 Meters)

SARGO
Coastal & Oceanic
Pelagic
ANCHOVIES
Mostly Coastal
(Oceanic Sometimes)
Pelagic

MOON JELLY FISH
Coastal
Pelagic

SEA STAR
Coastal
Rocky Shore
Mid Intertidal to Subtidal
Benthic
ABALONE
Coastal
Subtidal to 500 Ft Deep
Benthic

SCULPIN
Benthic
Subtidal 20-30 Ft Deep

SEA HARE
Coastal
Low Intertidal to 60 Ft Deep
Rocky Shore (Sheltered)
Benthic
**RED STRIPED SHRIMP**
Mid to Low Tidal (tide pools)
Rocky Shores

**AGGREGATING ANEMONE**
Coastal
Rocky Shore
Mid Intertidal to Shallow Subtidal
Benthic

**GIANT KELP**
Coastal
Rocky Bottom
Subtidal 20-1000 Ft Deep
Benthic
GREY WHALE
Coastal and Oceanic
Pelagic
Shallow to Very Deep

GRAY WHALE

SEA LION
Coastal
Pelagic and Benthich
Rocky Shores

SEA LION

GREAT WHITE SHARK
Coastal and Oceanic
Pelagic
Shallow to Very Deep

GREAT WHITE SHARK
FEATHER BOA KELP
Coastal
Rocky Shore
Mid-Intertidal
Benthic

LEOPARD SHARK
Coastal
Subtidal
Sandy Bottoms
Mostly Benthic

SQUID
Coastal and Oceanic
Pelagic
Shallow to Very Deep
CORALLINE RED ALGAE
Coastal
Rocky Shore
Mid Intertidal to > 50 Ft Deep
Benthic

SEA URCHIN
Coastal
Rocky Shores
Low Intertidal to 500 Ft Deep
Benthic

Copy Organism pages and cut along gray outline. When each Organism is cut out, fold in half to create a “flash card” with picture on one side and information on reverse.
Lesson 4: Zonation & Distribution II
1 class period

Concepts & Objectives

QUESTIONS

What is the underlying cause for the uneven distribution of life in the ocean? Why are organisms concentrated closer to shore?

UNDERLYING CONCEPTS

Life is concentrated in coastal areas because phytoplankton, which are at the bottom of the food chain, are concentrated here. This is due to the high amounts of nutrients available in coastal waters.

SKILLS

- Research
- Interpretation

METHODS

Use the internet to view and compare maps of phytoplankton found in different geographic areas.

OBJECTIVES

Students will be able to describe the distribution of phytoplankton in the ocean.

MATERIALS NEEDED

- Internet access

Vocabulary & Background

VOCABULARY

- nutrients- organic molecules that help organisms grow
- herbivores- animals that only eat plants or algae
• carnivores - animals that eat other animals
• pigments - molecules that a plant uses to gather sunlight for photosynthesis
• chlorophyll - the most abundant type of pigment in plants and algae
• satellites - a device that orbits the earth and has cameras and sensors to detect certain features.

BACKGROUND INFORMATION

Once your map is complete, it will become apparent that most of the marine life is concentrated nearshore. Although some very large animals live in the oceanic zone, their numbers are small in comparison to the size of it. Ask the students to describe the trend they see.

This trend is due mainly to the abundance of light and nutrients in the coastal zone. It is much shallower than the oceanic zone, sunlight penetrates all the way to the ocean floor. This is important because phytoplankton, which are at the bottom of almost all food chains, require this light for photosynthesis. In photosynthesis, sunlight is captured by the plant and the energy particles in sunlight (photons) are used to drive a chemical reaction that produces sugar. This sugar is the food for the plant. Why don’t we see an abundance of life in the upper layers of the oceanic zone also? Because light is not the only important factor. Phytoplankton also require inorganic and organic nutrients like iron and nitrogen. These compounds are most abundant nearshore, because of runoff from the land. Without these nutrients, phytoplankton do not grow as well.

As we said above, phytoplankton are at the bottom of the food chain. This means that herbivores eat them, other animals eat the herbivores, and so on. The more phytoplankton that are available, the more herbivores there will be to eat them, and the more herbivores there are, the more carnivores to eat them. Ultimately, if there are lots of phytoplankton, there will be lots of organisms else too.

Because phytoplankton are so important, scientists have lots of ways of measuring their abundance. One fairly new method uses images of the ocean taken from satellites in space. Satellites take a picture of the ocean and send it back to earth electronically, like a television signal. These satellites have sensors in them that can detect the specific pigments that phytoplankton use for photosynthesis (the most common pigment is chlorophyll). They then convert the concentration of these pigments into a color. When a scientist looks at a satellite image of the ocean, he or she can tell how much phytoplankton is in the water by the color. Red usually means a lot of phytoplankton and blue/purple means very few phytoplankton. These colors are of course not the actual color of the phytoplankton, but instead are a “false color” used to relay information.
Activity

For this exercise, you will be visiting a site on the internet that posts “false color” image maps of phytoplankton in the ocean. By viewing these maps, students can observe that phytoplankton are most heavily concentrated nearest to shore. The directions for accessing one of these sites is given on the next page.

DISCUSSION

Have the students compare the maps for different areas of the world or different times of the year and relate their findings in a group discussion. Generally, the more sunshine and nutrients that are available, the more phytoplankton there will be. Point out to the students that there is almost always more phytoplankton closer to shore than there is in the open ocean.
Lesson 5: Food Web
2 class periods

Concepts & Objectives

QUESTION

What is a food web?

UNDERLYING CONCEPTS

Animals obtain the energy they need to live from food. Organisms are connected to other organisms through food webs. A food web is a diagram of “who eats whom” for the organisms in a given area.

SKILLS

- Interconnecting ideas and information
- Investigating.

OBJECTIVES

Students will be able to:
- Describe what certain organisms eat.
- Demonstrate the flow of energy through a food web.

MATERIALS NEEDED

- Marine biology books and resources
- Examples of Marine Food Webs
- Predator/prey lists
- Crayons

Vocabulary & Background

VOCABULARY

- food web- the interconnected food chains between organisms in a community
- predator- an animal that captures and eats another animal
- prey: an animal that is hunted and eaten by another animal
- parasitism: A relationship between two organisms in which one (the parasite) infects or attaches to another (the host), and the host organism is harmed in the process.
- herbivores: organisms that eat plants, algae or phytoplankton

**BACKGROUND INFORMATION**

Almost all animals must eat other organisms to obtain energy. Animals do not generally eat just one thing, nor are they eaten by only one thing. This means that each organism, through feeding, is interconnected to many different organisms. This interconnection is called a food web.

When an animal captures and eats another animal, it is a predator. The animal which is hunted is called the prey. Notice that an animal can be both a predator and a prey. For example, a small fish may eat certain types of snails, but he may also be eaten by an octopus. So the fish is both predator and prey. The key to survival is to be a successful predator without becoming a prey. (Some biologists consider herbivores to also be predators, and parasitism, in which one organism infects another and does it harm, is also considered to be a form of predation.)

**Activities**

**INTRODUCTION**

Let’s talk about why we think organisms are distributed the way they are. First, we noticed from our zonation map that many more organisms live in coastal waters than in oceanic waters, even though the oceanic zone is a much larger part of the ocean. Let’s list the things that might be important for an organism to be able to live in a certain area:

- Shelter
- Right temperature
- Food
- Etc.

The availability of food is the most important reason for why organisms are located mostly in the nearshore coastal area.

How many of you have heard of a **food chain**? Let’s draw a simple food chain that is familiar to us:

Grass ➔ Cows ➔ Humans

Grass is a kind of plant, and plants make their own food. But animals can’t make their own food, they have to either eat plants, like the cow, or they eat other animals, like a wolf, or a human. Some animals, like humans, eat both plants and animals.

In the ocean, it’s the same thing, but the organisms are different. I am going to introduce a new word to you – **phytoplankton** (sound it out: fi-to-plankton.) Like the grass or the plants on land,
phytoplankton is the base, or bottom, of the food chain in the ocean. These are very tiny, microscopic organisms that make their own food just like land plants. To do this they need two things:

**Sunlight** – energy from the sun  
**Nutrients** – things that help them grow

We find the most sunlight near the surface of the water (less than 200 meters deep), and many of the nutrients actually come from the land and are washed into it during rains. So the area with the most nutrients will be closest to the shore.

Let’s go back to the food chain. Notice that the arrows are pointing toward the animal that is doing the eating. Scientists do this to demonstrate the flow of energy from the thing that is being eaten to the one that is doing the eating. We eat food because we need energy from that food. There are two words that you have already heard but let’s discuss their meaning:

**Predator** – an animal that eats other animals/organisms  
**Prey** – an organism that is eaten

Using our example of a simple food chain, we could add many more organisms to this food chain:

- What else eats grass? (*Teacher should provide 2-3 more examples of animals that eat food.*)  
- What else might eat a cow? (*Teacher should provide 2-3 examples of animals that may eat a cow.*)

We call this a **food web** because it is a connection of many different food chains.

**ACTIVITY 1**

1. Place students into groups of 4-6 students. Each table will have their own marine food web to study (they will be passed out after instructions are given).

2. Teacher now passes out examples of marine food webs emphasizing the direction of the arrows and predator/prey roles. They must carefully study the pictures and the arrows will be explained.

3. Students will now create a simple chain from the web they are given, like the food chain with only one animal at each stage. Each student will explain their food chain.

4. The teacher will ask each of the students the following questions:
ACTIVITY 1 DISCUSSION

• What is the start of the food chain and why?
• Explain your food chain (one type of animal at each stage).

ACTIVITY 2

1. Divide students into pairs so that they may make their own food webs.

2. Pass out the predator/prey list.

3. Give each pair a picture of an organism (ideally one from the food chain activity in activity one).

4. Students should paste the picture onto a blank sheet and color it.

5. Using the predator/prey list, create a food web.

ACTIVITY 2 DISCUSSION

• Do the larger animals eat all of the animals smaller than them? (Not necessarily, some eat only certain organisms.)
• Do some animals have more than one type of prey? If so, what are they?
• Do small animals only eat what is smaller than them or can they eat animals larger than them?
• If they can, what type of features on their body allow them to eat larger animals? (Special size of mouth, claws, beaks, etc.)

ACTIVITY 3

1. Using the distribution map that you constructed in the previous exercise (Link to Zonation) you are going to draw in the food webs that interconnect the organisms on your map.

2. Assign each student two organisms from the map to research. Using books, magazines, the internet or any other source you like, have them find out what those organisms eat and what eats them. This will probably take 1 to 1 1/2 class periods. It is best to leave the organisms cards on the map because you will want them in place for the next part of the activity. Have the students write down the information on a separate piece of paper.

3. Next, have the students present their findings to the class. Using a large marker, draw a line on the map between an organism and the animal that eats it. If a particular prey or predator of an animal is not on the map, write it in, place a box around it, and draw a line between it and the other organism. Draw the lines with an arrow pointing toward the predator. This indicates the direction of the flow of energy from the prey to the predator. When you are done, your map will have many lines with arrows connecting all the organisms together and you will have created a food web.
ACTIVITY 3 DISCUSSION

Food webs are not the only way in which organisms interact with each other. When organisms exist in groups with others of their own species and of different species, many types of interactions can occur. Ecologists have categorized these interactions according to their purpose, they are competition, communication, and symbiosis:

- **COMPETITION**: What do we mean by competition (for a resource)? When two organisms are each using the same limited resource, they are competing with each other. Organisms may compete for food, space, mates or territory. There are two kinds of competition:
  - **interspecific competition**, in which the two organisms are of different species.
  - **intraspecific competition**, in which the two organisms are of the same species. Because individuals of the same species use resources in very similar ways, this type of competition can be much more intense than interspecific competition.

- **COMMUNICATION**: Can you name some reasons they might communicate? Animals may communicate with one another for a variety of reasons. We know that animals of the same species, such as dolphins, communicate with each other for mating, play, distress and hunting, but animals of different species may also communicate. This may be as simple as a color display to warn another animal to “back off” (like an octopus) or a posture to indicate that an animal is going to attack (sharks do this).

- **SYMBIOSIS**: Who can tell me what a symbiotic relationship is? Symbiosis is a broad term that generally means “living together.” Usually, this applies only to organisms that live in very close proximity (often one inside the other) to each other for a substantial portion of their life histories. Symbiotic interactions can be beneficial, harmful, or nonconsequential to the organisms involved:
  - **mutualism**: A relationship both parties benefit. Most often, symbiosis refers to this type of interaction (examples: clownfish and anemone or coral reefs, which contain symbiotic algae).
  - **commensalism**: one party benefits and the other is unaffected (it is very difficult to prove such a case and many biologists doubt whether this type of interaction exists).
  - **parasitism**: one party benefits and the other is harmed.
    - When speaking of symbioses, the organism that lives inside the other organism is called the **symbiont** and the larger organism is called the host.
Extensions

- Write up ideas of how humans fit in the web of life.
- Have students explore how a shortage or excess of resources may alter food webs.
- Challenge students to design a demonstration of a food web.
- As students learn about new organisms, have them place these organisms on the zonation map.

EVALUATION

- Journaling – Have students write down what they have learned
- Teacher will evaluate final food webs for accuracy and thoughtfulness.
### Predators & Prey

<table>
<thead>
<tr>
<th>Predator</th>
<th>Prey</th>
</tr>
</thead>
<tbody>
<tr>
<td>sea urchin</td>
<td>kelp</td>
</tr>
<tr>
<td>mussel</td>
<td>plankton</td>
</tr>
<tr>
<td>acorn barnacle</td>
<td>plankton</td>
</tr>
<tr>
<td>red striped shrimp</td>
<td>plankton</td>
</tr>
<tr>
<td>sea star</td>
<td>mussels, barnacles</td>
</tr>
<tr>
<td>brittle star</td>
<td>plankton</td>
</tr>
<tr>
<td>cancer crab</td>
<td>barnacles, worms</td>
</tr>
<tr>
<td>abalone</td>
<td>red algae</td>
</tr>
<tr>
<td>aggregating anemone</td>
<td>plankton</td>
</tr>
<tr>
<td>moon jelly fish</td>
<td>plankton</td>
</tr>
<tr>
<td>squid</td>
<td>shrimp, worms</td>
</tr>
<tr>
<td>anchovy</td>
<td>plankton</td>
</tr>
<tr>
<td>sargo fish</td>
<td>barnacles, shrimp, crabs</td>
</tr>
<tr>
<td>senorita fish</td>
<td>worms, kelp, shrimp, crabs</td>
</tr>
<tr>
<td>leopard shark</td>
<td>crab</td>
</tr>
<tr>
<td>great white shark</td>
<td>sea lion, seal, squid, leopard shark</td>
</tr>
<tr>
<td>seal</td>
<td>senorita fish, anchovy</td>
</tr>
<tr>
<td>sea lion</td>
<td>senorita fish, anchovy</td>
</tr>
<tr>
<td>owl limpet</td>
<td>barnacles, mussels</td>
</tr>
<tr>
<td>sea hare</td>
<td>kelp</td>
</tr>
<tr>
<td>flying fish</td>
<td>crabs, shrimp</td>
</tr>
<tr>
<td>bat star</td>
<td>algae, sea stars</td>
</tr>
</tbody>
</table>
Unit Four: Human Impact on the Sea

Throughout this curriculum students have been learning about the structure and make-up of the ocean environment and its inhabitants. Now it is time to look at how we as humans affect the marine environment.

Through a variety of activities students will be introduced to the problems and effects of pollution, habitat destruction and the idea of limited resources. They will start out by observing what is in their own homes and how those items and everyday living actions can impact the marine environment. Learning about storm drains provides the student with an idea of how actions in the urban environment directly affect the marine ecosystem. Where we build houses, anchor ships, throw our trash and how much of the seas resources we consume all have an effect on the ocean environment.

Not only will they be involved with learning about our impacts, but more importantly, with exploring solutions to these problems. Direct individual action and community involvement are both ways to make a difference in our environment and students will get a chance to do just that as they proceed through this unit!
Lesson 1: A Shortage in the Sea
55 minutes

Concepts & Objectives

QUESTION

Are the things that we use from the ocean unlimited? Can we run out?

UNDERLYING CONCEPT

Resources are limited and we must take care in how we use them. Our actions now can affect the amount of the resource we have in the future.

SKILLS

• Brainstorming
• Analyzing
• Problem Solving

OBJECTIVES

Students will be able to:
• List ways that we use resources from the ocean environment
• Demonstrate the idea of a limited resource
• Conceptualize solutions to these problems

MATERIALS NEEDED

Various candies/crackers or items representing different marine resources. (Based on time and availability, any item can be used (paper clips, pencils, candy, crackers, etc.) There should be an uneven number of these “resources” for each group of 4 students, for example, 17, 9, 3, etc.; some number not evenly divisible by 4.

Suggestions:
• Fisheries - gummi fish or goldfish crackers
• Oil - black licorice
• Natural gas - blue “flame” gummies
• Pharmaceuticals - chocolate hearts (red wrapped)
• Minerals - gold chocolate coins
• Kelp/seaweed - green sour rings
• Corals, shells, pearls- white, orange, red or black candies
Vocabulary & Background

Vocabulary

- Resource: a supply of something that we can draw from when necessary (usually it is something that we need, such as food/fish, or that we can make other things from, like kelp or oil or use for energy)
- Renewable: can grow or start over again (capable of being replaced by natural cycles or sound management practices, example: trees)
- Nonrenewable: resource cannot be replaced (there is no more once it is gone, example: oil takes millions of years to form and cannot be replaced in any realistic human time)
- Biosphere: living things together with their environment (surroundings)

Background Information

Humans are part of the biosphere and rely on it for food (fish, marine life) and energy (mineral and oil/natural gas). Resources such as fish (or trees) are renewable, as long as too many are not taken/destroyed. They can continuously replenish themselves if not interfered with and inhibited from doing so. Other resources such as oil and minerals are non-renewable (at least in our lifetime). They are formed over millions of years and once depleted will take millions of years to replenish. We need to be aware of this in our patterns of consumption.

There are also human impacts not only from the consumption and depletion of the resource, but also from the exploration and production to market the resource. Pollution is one of the main effects of these activities.

Resources are limited and we need to take care in how we use them. If we take too many fish from the sea, or too much kelp to make ice cream, or too much oil for our cars, we will no longer have these resources. In addition, when we remove them from the environment it affects other species in the environment as well—for example: other organisms depend on the “scarce” fish for food and kelp has a whole community of organisms which depend on it. Coral is a good example of this problem. In many parts of the world coral (as well as decorative shells and pearls) is used for jewelry. Coral reefs are extremely fragile and are harmed by any impact: a diver chipping pieces off the reef and snorkelers and swimmers stepping on the reefs are two ways this can happen. There is also evidence that pollution and changes in climate (affecting ocean temperatures) are also harming coral. As a result coral reefs are beginning to die around the world. As they die not only are the organisms lost (coral reefs are alive—made up of millions of coral polyps, small soft-bodied animals that build calcium carbonate exoskeletons for protection) but the fish and other organisms that live on and around the coral reef die, too. Therefore in the case of coral reefs there are more reasons to protect them rather than to use or harm them.
Here is some further information about the uses of specific marine resources:
- Fish: food, fish meal (inexpensive protein for poultry, livestock), fish oil (margarine, cosmetics, paint, fertilizers, pet food)
- Oil: to use as fuel and to make plastics and other petroleum products
- Natural Gas: fuel for heat and for powering some cars and industries
- Pharmaceuticals (drugs from the sea): antibiotics and anti-inflammatory agents from corals and sponges, anesthetic and painkillers from poisons found in puffers and porcupine fish, heart attack prevention from oils found in fish
- Minerals: commercial value; can be from ocean mining (seabed sand and gravel, offshore coal mines, tin, iron, and even diamonds and gold. Also minerals, especially table salt, are taken from sea water (virtually every element on earth is in sea water)
- Kelp/seaweeds: ice cream, chemicals used in food processing, cosmetics, plastics. Corals, pearls, shells: used in jewelry.

Since resources can be limited we need to take good care of them and not take too much. We need to use them in a way that will allow them to continue to exist in the future.

### Activity

**INTRODUCTION**

Ask for ideas of what a “resource” is and ask for examples (trees, minerals, oil, water, etc.) What do the words “renewable” and “non-renewable” mean? Place those definitions on the board. Using students’ resource examples, decide which are renewable (like trees) and which are nonrenewable (like minerals). Next make two columns on the board: “renewable” and “nonrenewable” and leave them blank, they will be filled in during the activity. Then divide the class into groups of 4.

**ACTIVITY STEPS**

1. Working in groups brainstorm things we use from the sea (ex: fish, kelp, krill, minerals, oil, pharmaceuticals) --and what we use these things for. List these on your Marine Resources Worksheet List (or a blank piece of notebook paper).

2. Make a list on the board of some of the student’s ideas and talk about what they are and how we get them. As you list the resources, ask the students if they are either “renewable” or nonrenewable,” and place in the appropriate column.

3. Pass out one set (of 4) “country cards” to each group, and a “resource” (candies/items). From the list on the board you will most likely have the resources listed in the “materials” section of this lesson plan, if not then make suggestions in order to end up with 6 or 7 different resources (depending on class size).
4. Each student in the group gets a “country” card. Read to class: “The card contains a description of some basic conditions of your imaginary country. (All groups should have the same set of 4 cards.) You will pretend that you are representing your country at a world conference on how to handle the world’s marine resources. You have to make decisions about how to use /share that particular global resource (oil, fisheries, kelp, etc.) with the other countries in your group. As a group you will determine how to handle the shortage of resources (not enough to be divided up evenly). Consider your countries needs, the amount of resources available, if it is renewable or non renewable. List your ideas and the reasons for your decisions on your “Marine Resources Worksheet” (or a piece of paper). Come up with a group decision.”

5. Have a representative from each “Resource Conference” group describe how their group of countries decided to deal with dealing with their resource. (Do we cut them up into smaller pieces so each country has a little less? Should some of the countries simply go without? Do we take turns for who goes without? Should none of the countries have use of the resource? Are there other ways to get more or similar resources?)

DISCUSSION

- What kinds of problems can we have when we take resources from the sea? Shortages: from over consumption; overfishing. Impact on the ocean environment: pollution from harvesting methods for oil/minerals; altering habitat (for example, if we take too much kelp).
- As we use these resources up how can that affect other animals in the sea? (Examples: Who eats krill (small shrimp-like animals)? (Some whales) The Japanese harvest krill, what do you think might happen to the whales if too much of this resource is used? (Remind students of the food web) What about kelp? We use kelp to make ice cream. Who eats or lives in kelp? (fish, sea otters, sea urchins, etc. They would be affected if too much kelp was lost.)
- How does this work in the real world/how do we conserve our resources? (Suggestions: Fish: catch limits (#s and size), licensing, regulated ‘seasons’. Have regulated kelp cultivation.
- There is very little regulation of marine pharmaceuticals, we could do more in that area. Pollution issues can be addressed by reducing or stopping off -shore oil drilling and improving and enforcing laws about how it can be safely done if it is done at all.)
- What are possible solutions? (New alternative resources (ex: whale oil is no longer needed), new technologies, conservation and better management practices.)
- Should we not take any resources? (This would create other types of problems such as hunger, transportation and economic problems. Also, some cultures rely on certain resources. Without these resources that culture might not exist the in the same way.)
Extensions

This activity can vary widely depending on grade level and age groups.

Social Science: Instead of country cards, each student (or team of students) can pick a country and research it to determine its current population, economy, what are it’s most important needs, what about future needs for marine resources?

Additional thought questions:
- Should people/countries pay for the right to take resources?
- Who should get the money?
- What should be done with the money?
- Do you think technology can solve all of these problems of shortages or must we use stronger measures of conservation; why?
- How can we use/divide the resources better among all groups of people and between people and marine life? (Use alternative things---students can come up with ideas for what those things might be----use less of each item.)
- Have a discussion of how we are part of the biosphere and depend on the sea.
### Activity Cards

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>COUNTRY</th>
</tr>
</thead>
<tbody>
<tr>
<td>This country has a very large population.</td>
<td>This country has a small population.</td>
</tr>
<tr>
<td>This country does not have much industry or a high level of technology.</td>
<td>This country has much industry and a high level of technology.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>COUNTRY</td>
<td>COUNTRY</td>
</tr>
<tr>
<td>This country has a small population.</td>
<td>This country has a very large population.</td>
</tr>
<tr>
<td>This country does not have much industry or a high level of technology.</td>
<td>This country has much industry and a high level of technology.</td>
</tr>
</tbody>
</table>
Lesson 2: Toxins in the Marine Environment

55 minutes

Concepts & Objectives

QUESTION

How do toxins enter the marine ecosystem, what are the effects of toxic pollutants on marine life, and how do toxins become concentrated in the food web?

UNDERLYING CONCEPT

Pollution comes from many sources, sewage outfalls and storm drain run-off are just a few. The effect of simple human actions, such as throwing motor oil down a drain, extends farther into the environment than the original action.

SKILLS

• Calculating
• Assessing
• Analysis
• Interpretation

OBJECTIVES

Students will be able to:
• Demonstrate the build up and concentration of toxins in an organism
• Interpret how that buildup can affect animals in an ecosystem

MATERIALS NEEDED

• Red or brightly colored candies such as sweet tarts, etc.
• Clear plastic bags
• Score sheets (optional) students create them

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VOCABULARY

- toxin: poisonous
- pollution: contamination of air, soil or water by the discharge of harmful substances
- industrial wastes: waste products produced by factories and other industries that often contain harmful chemicals
- DDT (Dichloro Diphenyl Trichloroethane): a colorless insecticide, toxic to humans and animals when swallowed or absorbed through the skin
- bioaccumulation: toxins building up in each organism as they eat animals in the food web who have already eaten a toxin.

BACKGROUND INFORMATION

Pollution comes from many sources. It is more difficult to control when it is in water because water itself is a common solvent for many things and transfers pollutants throughout the ecosystem. Southern California has many problems with pollution in the marine environment.

There are many types of pollution, some of the worst are DDT and PCBs (polychlorinated biphenyls—used as insulation in the 1970’s). Industrial wastes pollute wetlands, bays, estuaries, and the ocean itself.

Pollutants enter the marine ecosystem in a variety of ways. Until the 1960’s some chemicals were allowed to be disposed of off-shore; we did not know then about their long term toxic effects. Today urban street runoff, farm fields and industrial sites contribute to the toxins in the ocean. Some, such as mercury, which is spewed out by coal burning power plants, fall from the air.

Another important way pollutants enter the marine ecosystem is through sewage plants (outfall sites). They impact the environment through the effects at the outflow site (where the final treatment is deposited into the ocean). Soft, muddy sediments are like sponges that slowly soak up all of the chemicals and toxins. Small animals that live in the sediment pick up tiny particles of it and are then eaten by larger animals. Poisons are then spread throughout the food web. Southern California’s Hyperian Sewage Plant is unfortunately a very good example. DDT has been found in the sludge from the Hyperian outfall site. It was thought that by depositing the sludge far out in the bay that the ocean would dilute and cleanse the outfall, but this did not happen.

Benthic (bottom dwelling) animals that live in the soft muddy sediment take the toxins and chemicals into their system, by eating the particles or through taking in the water with the dissolved contaminants. For example, on Catalina Island mussels have been found to contain arsenic. Small fish eat small animals and crustaceans in the sediment. Bigger fish such as the
white croaker and California Halibut, eat these smaller fish as well as crustaceans who have already been contaminated. Essentially, fish that eat bottom-dwelling organisms become contaminated over time, as do the bigger fish who eat those fish.

Fish-eating birds and mammals also then become contaminated. Brown pelicans were nearly wiped out along the West Coast because they ate anchovies and other fish contaminated by DDT that flowed into waters off Palos Verdes from a pesticide plant. Scientist say that the DDT that destroyed the egg shells of the bald eagles and led to their extinction on Catalina Island, is related to the DDT in the San Pedro Channel. Years later after DDT had been outlawed, bald eagles were reintroduced to Catalina Island but once again they began to die out. It was discovered that the eagles were eating the seagulls’ chicks and eggs who eat the fish which have levels of DDT in them. So although DDT was no longer being put into the San Pedro channel it was still present in the food causing the new group of eagles to have problems in hatching their young.

Dolphins in the San Pedro Channel have higher levels of toxins in them than dolphins found elsewhere. In general dolphins and seals off of Los Angeles County remain highly contaminated. They may grow tumors or lose their ability to fight off disease.

DDT (and other toxins that bioaccumulate) never leaves the system of an organism. Every time an animal is eaten by another animal the DDT or other toxin goes into the new animal and becomes even more concentrated, because the bigger the animal, the more contaminated food they will eat. It is important to note that people are not immune to this problem. People can get very sick from eating tainted fish or shellfish. These toxins can cause cancer or birth defects.

Activity

INTRODUCTION

- What are ways that poisons could get into the ocean and wetlands? (storm drain run off/ urban streets, farm lands, industry , air pollution, sewage plants)
- How do the poisons get into an animal? (gets into the food that it eats; direct instruction about sediments under the water absorbing chemicals)
- Who can tell me how the food web works? (brief review; be sure predator/prey is understood)
- Do you think that the poisons stay in the body of the animal or do you think that they leave? (stay there)
- What do you think happens to the poisons when the small animal is eaten by a bigger animal? (they go into that animal too)

Lets play a game to see how this works!
Before you start:
- Divide students into predator and prey groups.
- For example: In a group of 35 students have at least 5 levels within the food web.
- Example:
  - 12 zooplankton/crustaceans/clams/worms, etc
  - 9 small fish
  - 7 medium/large fish
  - 5 birds (sea gulls)
  - 2 bald eagles

Explain:
- Animals can only “eat” the level below them. Students wear crepe paper ties—colored according to predator/prey level.
- Be very clear who can “eat” whom.

To Play:
Students wear a color tie according to their animal group and play a simple walking tag game. Everyone starts off with 2 candies each in their bags. Teacher explains that this is a “safe” amount of DDT or toxins in the animal’s system.

ACTIVITY STEPS

1. Assign (or let students choose) their “roles” and wear the appropriate name tag name tag sheet included).

2. The lowest level: plankton, tiny shrimp, crustaceans, etc. have 2 candies in their bags and these students are the “prey”. The next higher up predator group (example, “small fish”) are “its predators”. (NOTE trying not to use the word “taggers”). Playing walking tag game, predators must capture the crepe tie of the prey below their “trophic” level. When they “get” someone the predator “consumes” the prey’s candies by adding those candies to the predator’s bag. The prey then moves out of the group and sits down.

3. Tagging continues until all the prey is caught.

4. When the game is over the eagles have all of the candies.

Option:
Everyone except the sea gulls and eagles begin playing. Then the seagulls and eagles enter game as group gets smaller.

DISCUSSION
- Students discuss who has the most candies/DDT. Is it too much to live, or to have healthy baby eagles?
• What happens if there are no longer any healthy baby eagles being born? (the eagle population will die out)
• How did the animal get so much DDT? (by eating the other animals)
• Teacher explains the situation on Catalina Island.

Note to teachers: This is where background information should be presented.

Extensions

• Students brainstorm ways to keep the toxins out of the system. (laws, better testing procedures)
• Is there a way to help the eagles? (maybe monitoring and studying them, testing the sea gulls)
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Activity Cards
Lesson 3: Extinction is Forever
55 minutes

SEQUENCE: Students should have an understanding of the concept of toxins. For lesson that deals with this subject, please see the activity “Toxins in the Marine Environment.”

Concepts & Objectives

QUESTION

What are some of the reasons that animals become extinct and what are some of the results of extinction? How would it feel to be the last of your kind?

UNDERLYING CONCEPT

Human actions affect the ecosystem in many ways, some have permanent affects on other species. It is important to understand the finality of extinction, and our impact on other species.

SKILLS

- Interpretation
- Predicting

OBJECTIVES

Students will be able to:
- Postulate what it would be like to be the last animal of its kind
- Describe their interpretation of extinction

MATERIALS NEEDED

- writing paper, pens, pencils

Vocabulary & Background

VOCABULARY

- Extinction: When a certain type of animal or plant no longer exists.
- Exotic species: A species that is not native to the region; it has been introduced by humans.
BACKGROUND INFORMATION

Animals become extinct for several reasons: sometimes animals are hunted, killed, or pollution kills them, their home is destroyed or their food is taken away, and occasionally environmental changes take place so that they no longer can survive. When there are too few of animals of a species left, the species can no longer successfully reproduce itself, no more individuals are born and the species becomes extinct.

Brown Pelicans are a good example of an animal which almost became extinct. In the 1960's they were on the brink of extinction and no one understood why. A scientist at the Los Angeles County Natural History Museum, Ralph Schrieber, discovered that DDT was the source of the near extinction. The egg shells were breaking and no young brown pelicans were being born. This was one of the first discoveries of how DDT affected wildlife.

Even the largest species are not immune to these problems of extinction!

The Gray Whale which travels through the San Pedro Channel on its long migration from Alaska to Mexico, had previously become an endangered species. Historically it was killed in vast numbers for its blubber and meat. They were in danger of extinction and therefore became protected. Now their numbers are increasing and they have been moved off the endangered species list but are still protected against whaling.

Currently other fish that often end up on our dinner plate are being overfished and could possibly one day be threatened: tuna, shark, swordfish and halibut fall in this area. An important thing to remember about overfishing is that it is not just the number of the fish that are taken that affects a population, but also the age. If you take the younger fish then they cannot grow up to have baby fish and the population is decreased quite rapidly.

Catalina Island once was home to the California Sea Otter, but they were killed off for their fur pelts. Now only a sub-species exists at Monterey Bay and because their numbers are so limited they could be wiped out. Efforts to re-introduce sea otters to Southern California have met with objections from the fishing industry (due to competition for abalone). Also a reintroduction attempt at another Channel Island (San Nicholas Island) was a failure. The reintroduced sea otters all disappeared and it is unknown if they simply swam away or were killed by fisherman (who had threatened to shoot them).

It is important to note that with the sea otters gone it has changed the local ecosystem. Sea otters ate sea urchins and the sea urchins ate kelp. By upsetting the predator/prey balance it interferes with the web of sea otter/sea urchin/kelp forest. The sea urchin population increased due to the removal of sea otters and also lobster and sheephead which eat sea urchins are also being overfished. The lobster and sheephead fish ate also ate sea urchins. The increase in the sea urchin population (plus the effects of “El Nino” --which is a change in a major ocean current which affects upwelling and food sources) contributed to decrease in kelp.

On land in Southern California other extinctions have almost occurred. One of these is
Activities

INTRODUCTION

- How many of you remember our activity with DDT?
- What did DDT do? (It concentrated in the animals and made the animals higher up in the food web more toxic/full of DDT; in birds it made the eggshells thin and easy to break, then the chicks could not hatch.)
- If enough animals are killed or if the animals can’t have babies, what do you think happens to the species? (The species cannot continue and eventually there are no more of that kind of animal left.) Teacher can use direct instruction to describe the Brown Pelican’s near extinction due to DDT.
- Ask students to brainstorm about any animals (or anything) that they know of that has gone extinct (ex: dinosaurs)
- Why did these animals/plants etc. go extinct?

[You can ask the following question of groups who can brainstorm amongst themselves to get answers.]: What kinds of human action cause another species to go extinct? (over hunting harvesting, not enough food, not enough land to live on, poisons/pollutants----[Teacher can refer to the above background]).

ACTIVITY

Story Writing:
Individually or in pairs have students write a story about what it feels like to be the last one “of your kind”. Students can choose either an animal that they like or they can choose to create one.

They can also draw a picture of their animal if they want.

After 15-20 minutes of writing ask students to share their stories with the class.
BEYOND

- How would the world be different if your favorite animal was no longer around (was extinct) or your favorite kind of tree, bird, etc.
- Could an oil spill cause a local extinction? (Possibly if an animal was only located in that area such as a rare “endemic” {native} species that does not occur anywhere else).

Extensions

- Students can draw a picture of their animal.
- Students can do a small research project on a particular endangered or extinct species.
- Or create an informative poster about their animal.
Lesson 4: Eco Challenge
Two 55 minute class periods, two ten minute follow-ups a week apart

Concepts & Objectives

QUESTION

What do you have in your home that can harm the environment and what steps can we take to minimize that impact?

UNDERLYING CONCEPT

Common items in our home can pollute the environment. How we live and what products we choose to use, and how we dispose of those products makes a difference in the harmful impact that we have on the environment.

SKILLS

• Analyzing
• Observing

OBJECTIVES

Students will be able to:
• List toxic and non-toxic products that they have in their home environment
• List alternative products that are not as harmful to the environment.
• Demonstrate how something as simple as a 6-pack ring can harm wildlife
• Determine personal actions they can take to improve the environment

MATERIALS NEEDED

• Eco Challenge Sheets
• Several six-pack rings
• A broom handle
• Two 12-foot pieces of rope
• Measuring tape
Vocabulary & Background

VOCABULARY

- urban: of or relating to a city
- toxic: poisonous
- “green”: green in this sense means something, a product or a behavior that is not harmful to the environment

BACKGROUND INFORMATION

There are many common products that we use that get into the ecosystem and can cause harm. Products such as paint thinners, oil, and phosphate detergents may harm the environment by directly poisoning it. Plastic products are also harmful to our environment, they hurt and even kill marine and other wildlife. Our behavior which includes how much water we use, how much electricity, and how much gas we use also make a difference. For example, to produce the electricity to light your home requires burning barrels of oil. The resulting waste products pollute both our air and the water.

Activity, Day 1: What’s Around the House?

INTRODUCTION

- Who knows what a toxin is? *Something that is poisonous*
- Do you think you have any toxins in your home? *yes/no*
- What do you use to clean the sink? To clean up a paint brush after you paint a wall?

ACTIVITY

1. Teacher passes out Eco-Challenge game cards. (Can be done in pairs).
2. Play Eco-Challenge.
3. Have each pair chooses 4 or 5 items and decide what they could use instead. After they have attempted to find alternative products pass out the “Household Alternatives” sheet and let them see how correct or close they were (or have them turn over the card if you are using the original printed game cards).

   Next: Let’s talk about how other types of waste products you have around your home can harm wildlife.

   *Has anyone ever seen one of these before? (Teacher holds up plastic six-pack ring)*
   Proceed with “Drastic Plastic” activity which is found directly after this activity description. *Please be sure to pass out one sheet to each student.*
HOMEWORK

Have students make a list of:
- electric appliances they have in their home.
- other ways that they use electricity in their home.
- how often and in what ways do they use water?

Activity, Day 2: What’s Around the House?

ACTIVITY

1. Students discuss and compare their homework lists.

2. Using their personal lists of their own home electricity and water use, students will write down what environmentally friendly changes they will attempt to make in their home.

3. Add to the list other changes they will make regarding recycling, chemical use, six-pack rings, etc.

4. Teacher asks students to make as many changes as possible over the next two weeks. Students will discover what actual changes they can make in their own home environment.

FOLLOW-UP

At the end of the week and again at the end of the following week, have students repeat the list and see what changes and improvements they have actually made. What specific things did they do this week to improve how they impact the environment?

Possible examples:
- Reduced amount of garbage, because we are recycling more things.
- Change at least one thing to do with the chemicals around your house
- Cut the six-pack rings.
- Have turned off unused lights. How many times have you done this?
- Turn off the water while you brush your teeth
- Get their parents to take their own bags to the grocery store so they don’t have to use more plastic bags.
Extensions

- Teacher passes out “Our Urban Environment” question sheet.
- Students research the answers, using the internet, by contacting the local city or county offices, asking experts, and/or doing library research. They may do this in groups or as individuals, over a series of days and present their information.
Our Urban Environment Question Sheet

1. What is the most important thing to know about chemicals in your house?
   - That they can go into the environment and harm it, we must be careful how we dispose of them, we should use alternative products that do not harm the environment....

2. What should we look for on the labels of products in the store to know if they are safe for the environment?
   - What are the ingredients---are they harmful to the environment; consider the packaging lots of extra packaging adds to the landfill problems, we can buy products in bigger boxes to reduce waste....

3. What are 3 ways that we can save electricity and energy?
   - Turn off lights and appliances that are not being used, buy appliances that use less electricity, insulate your house, put insulation around doors and windows.....

4. What are 3 things we can do to reduce our water use?
   - Fix leaky faucets, water lawns and shrubs in the evening or early morning so you can water less often, install low-flow toilets--or put a plastic carton of water in the tank, take shorter showers---use the shower just to rinse on and rinse off, do not leave the hose running when you wash the car.....

5. How much trash does a typical person produce each year (or month or day)?
   - Students will get information directly off of the exhibit---9 pounds per day, 270 pounds per month, over 1.5 tons per year

6. Why do we have smog in the city?
   Exhaust from cars, smoke and fumes from industry, ---all put chemicals in the air--as well as dust and particle matters, the geography of the Los Angeles Basin and the air layer above the basin (inversion layer) traps these chemicals in the air above the city. Sunlight hits the chemicals and causes more reactions that all combine to form smog.
Drastic Plastic

How would you like to spend you life with a choke collar around your neck? Discarded plastic six pack rings pose this threat to the ocean wildlife. The consequences of this type of entanglement can be quite serious and, in some cases, fatal. An animal that has gotten entangled in a six-pack ring or an abandoned fishing line has trouble catching food and avoiding predators. The material can cause chafing and even deep wounds. When a marine mammal is entangled in a net underwater, it may not be able to come to the surface to breathe, and consequently, it dies. Because these materials are made to be strong and durable, animals are usually unable to free themselves. Try this demonstration to learn how strong these materials really are.

MATERIALS NEEDED

- Several six-pack rings
- A broom handle
- Two 12 foot pieces of rope
- Measuring tape

STEPS

1. Using both hands, try to break a double or tripled six-pack ring. Were you able to break it? __________
2. String 4 six-pack rings onto the broom handle. Have two strong adults hold the broomhandle horizontally. Grab two rings with each hand and hang your feet off the ground.
   - Did the rings break? _________ Did they stretch? __________
   - Do you think an entangled seabird or sea lion could break free? __________
   - Why or why not? __________________________________________________

3. Fold 3 six-pack rings in half lengthwise to make 6 three-packs. Tie a piece of rope to each end of the three-packs. Hold one end of the ropes and have a friend hold the other. Play tug-of-war.
   - Did the rings break? _________
   - If not, have another friend join each team and play again. Keep increasing the number of kids on each team until the rings break.
   - How many kids did it take to break the rings? __________

CONCLUSION

Now that you know how hard that it is to break the six-pack rings, be sure to cut each of the things before you put them in the trash.

ON YOUR OWN

Next time that you go to the supermarket, take a look at the soda cans on the shelves. Try to count all of the rings. Now imagine the number of animals that may be caught in these plastic rings.
A Winner!

Everyone That Makes a Game

The "Eco-Challenge"

Island Explorers: Unit 4, Lesson 4

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Draw an X on "toxic" stuff you have at home.

Check the household alternative list to learn more about using "green" products.

### Number of X's Drawn

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<td>Book</td>
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<tr>
<td>Food</td>
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</tr>
<tr>
<td>Latex gloves</td>
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<tr>
<td>Old toothbrush</td>
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</tr>
<tr>
<td>Wax</td>
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</tr>
<tr>
<td>Telephone</td>
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<tr>
<td>Paper towels</td>
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### Number of O's Drawn

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### Island Explorers: Unit 4, Lesson 4

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Lesson 5: Down the Drain

Two 55 minute class periods

SEQUENCE: For a better understanding of concepts, students should first have done “Eco Challenge”

Concepts & Objectives

QUESTION
How do wastes from your neighborhood end up on the beach?

UNDERLYING CONCEPT

We are all part of the biosphere. The wastes that we produce directly enter the ocean ecosystem through the storm drain system or indirectly via the sewage system. We need to be aware and responsible for what goes down the drain.

SKILLS

• Deciphering
• Plotting
• Mapping

OBJECTIVES

Students will be able to:
• Mark storm drains to help raise awareness of the debris problem
• Conceptualize a system whereby pollutants enter the environment

MATERIALS NEEDED

• Paint
• Stencils
• Copy of map of the immediate area surrounding the school (preferably enlarged)
• Colored pens or markers
• Information door hangers
• 8 minute video “Make the Connection: An Educational Tour of Los Angeles” to order, please contact City of Los Angeles, Storm Water Management Division 231-847-6350
Vocabulary & Background

VOCABULARY

• Catch basins: red curb areas with openings under them for water to flow into
• Storm drains: system of catch basins and tunnels which are underneath the city and allow the water to flow off of the streets and into the drains and down into the ocean
• Source: where something comes from
• Non-point source pollution: pollution that enters the ocean from many sources (cars, farmlands, trash, etc.) and not from a single source such as a sewage outfall.

BACKGROUND INFORMATION

Many coastal cites have a drainage system built into their infrastructure to handle excess run-off from rain and storms.

Everything that enters a storm drain ultimately ends up at the beach. Trash, leaf litter, oil from cars, and many other types of debris flow through the storm drains.

One of the biggest problems occurs when it rains, especially the first rain of the season. All of the trash, oil, etc. that has built up on the roads and in the catch basins (red curbed areas with openings) where the storm drains are visible on the street) is “flushed” down the storm drains to the beach. Marine wildlife can become entangled in the debris, they can also harm themselves by eating it. In addition, oils and other pollutants literally pollute the ocean environment. This includes bacteria and viruses that cause health problems for humans.

We need to be aware that what goes down the drain comes out in the sea.

Activity, Day 1: Mapping the Storm Drains

PRIOR TO THE ACTIVITIES:

Two to three weeks prior to the activity, contact the agency in your area that is in charge of marking storm drains. In the Los Angeles area contact “Heal the Bay.” Contact your local city officials to find the agency in your area (they will handle all of the paperwork involved in being able to mark on the storm drains).

INTRODUCTION

• What happens to the animals at the beach and in the ocean when there is trash? (issues of 6-pack rings, plastic that is eaten, pollution from chemicals)
• How does trash get from the neighborhood to the ocean? (*through the underground storm drain system*)
• What is the hole under the sidewalk with the red paint on the curb called? (*catch basins*)
• What can we do to the catch basins to let people know that what goes into them ends up in the ocean? (*By putting special signs/marks on them*)

Let’s take a walk around the school block and find the catch basins and storm drains so we can paint them and put signs on them.

**ACTIVITY**

1. Students and teacher (and assistants) walk around the block or two surrounding their school. Using either local street maps or student generated maps note where the storm drains are--- either write down the location such as: “in the middle of the 1100 block of Harvard Ave” and then mark it on the map when they return to the classroom---Or find the exact location and mark it on the street map guide while they are on the walk.

2. Write down and note which storm drains are unmarked and which need to be re-painted.

3. These maps will be used during the next day’s activity.

**Day 1 Extensions**

• In Los Angles the water in storm drains could flow into the LA River or could flow to Biona Creek. Contact Heal the Bay or your local water resource agency to determine exactly which path is taken by your local storm drains.

• How is the impact different if it goes through the LA River or to the Biona Creek? (In Los Angeles, the LA River goes directly into the ocean, while the Biona Creek passes through a large wetland area and can have other impacts besides the direct beach environment. There are other animals and plants that live in the wetlands that are a little different from those that live just on the beach.)

**Activity, Day 2: Down the Drain**

**ACTIVITY**

1. This activity works best by dividing the class into groups of 2 or 3. You will need an assistant for the other group(s). If that is not realistic, one group can remain in the classroom/library doing internet research on the impact of trash and pollution on marine life. During this time, the other students stencil one or two of the storm drains.

2. Using the maps, take students out to the storm drains that are in easy walking distance of your school.
3. Note and record any trash seen around the catch basin.

4. Following the instructions on the stencil kit, stencil the storm drains.

5. Under Teacher’s supervision (or an adult) students may hang the information provided by your local agency (or students can create information signs as part of their activity) signs on the door knobs of the nearby residents.

6. Graph any data or record in a science journal.

DISCUSSION

- How should people clean their sidewalks? *(sweep away from the catch basin and throw the waste into the trash)*
- What should people do with the oil from their cars when they change their own oil? *(take it to a recycling station or garage that is equipped to handle it for them)*
- What should people do about their dog’s waste? *(put it in the trash or it will eventually washout into the ocean)*
- What can we do to be sure that people know about the storm drain problem? *(put up more signs, talk to our friends, families, and neighbors, place posters at local stores)*

**Day 2 Extensions**

- Students can make flyers to educate the neighborhood and pass out to neighbors and post at local stores.
- Students can keep track of the storm drains they marked and periodically check for debris build up--and keep them clean.
- Contact your local agency that maintains the sewers. Often someone will come to your school and discuss the difference between sewers and storm drains; possibly including opening a manhole cover on the street to illustrate the difference in routes between storm drains and sewers.