Activity: Pelagic Zones - Where To Live in the Ocean

The marine ecosystem is the largest aquatic system of the planet. Its size and complexity make it difficult to deal with as a whole. As a result, oceanographers divide the ocean into zones according to physical characteristics, just as the land environment that we live in is divided into zones (tundras, forests, grasslands, deserts, etc.). The two major zones of the ocean are the sea floor, or bottom region, called the **benthic realm** and the watery region above the sea floor called the **pelagic realm**. Each of these is further divided into correspondent zones according to their living conditions (depth, temperature, and sunlight penetration).

Objectives:

In this activity, the students will demonstrate understanding of the concept of zonation in the ocean environment by:

- explaining why oceanographers divide the ocean environment into zones,
- discussing the causes of pelagic zonation,
- identifying the different pelagic zones in which the marine organisms can live, and
- describing the physical characteristics of each pelagic zone.

Materials:

- student worksheets: **Ocean Zones: Where To Live in the Ocean**

Procedure:

- Introduce the subject of zonation by emphasizing that the marine ecosystem is the largest and most variable aquatic system on the planet. Establish the convenience of dividing it into zones, each of which can then be studied and discussed in terms of the ecological principles that govern life in them.
- Have the students discuss how conditions like light penetration, availability of food, and water temperature change with increasing depth across the pelagic region.

Discussion

- ***Ask the students about examples of pelagic organisms and the types of adaptations that they may have to survive in the zones where they live.***

In general, in the epipelagic zone, there is light, warmer waters, and nutrients. Since plankton need light, they will have adaptations to reduce their sinking rates. Nektonic organisms will exhibit coloration, body shape, and special body features that increase their chances for survival. Silvery, countershading, or warning colorations accompanied by fusiform, rod, depressed or laterally compressed bodies, and the presence of spines are among the adaptations to survive in the epipelagic or photic zone. In deeper waters, there is no light and not much food. Nektonic organisms in these regions will tend to be smaller and darker, with big mouths and long, sharp teeth. They will have bigger eyes, and others will lack eyes or be bioluminescent to attract prey.

Activity: Explore the Benthic Zones of the Ocean Environment

Over 90% of the animal species found in the oceans and most large marine plants live in close association with the sea floor. The living conditions in this region are largely controlled by the physical characteristics of the sea bottom (substrate). Factors like water turbulence, temperature, oxygen content, exchange of substances between the sediments and the water, and the interaction between species make the benthic region a extremely variable one. Plants live primarily in the sunlit shallow areas, whereas animals are found at all ocean depths. Two benthic communities are recognized: the **epifauna**, which refers to the animals that live on the surface and the **infauna**, which refers to the animals that live buried in the substrate.

Objectives:

In this activity, the students will demonstrate understanding of the concept of zonation in the ocean environment by:

- explaining why oceanographers divide the ocean environment into zones,
- discussing the causes of benthic zonation,
- identifying the different benthic zones in which the marine organisms can live, and
- describing the physical characteristics of each benthic zone.

Materials:

- student worksheets: **Explore the Benthic Zones of the Ocean Environment**

Procedure:

- Introduce the subject of zonation by emphasizing that the marine ecosystem is the largest and most variable aquatic system on the planet. Establish the convenience of dividing the marine environment into zones, each of which can then be studied and discussed in terms of the ecological principles that govern life in them.
- Have the students discuss how conditions like light penetration, availability of food, and water temperature change with increasing depth across the benthic region. Determine which of these conditions overlap within the corresponding pelagic zones.

Discussion Questions:

- ***Ask the students about examples of benthic organisms and the types of adaptations that they may have (some crawl along the sea floor, whereas others burrow into it, or live permanently attached to the bottom).***
- ***Compare their adaptations with those of the pelagic organisms.***

Activity: Can You Recognize Me?

An important portion of the zooplankton is comprised by the temporary plankton or **meroplankton**. These include fish eggs and larval forms of both nektonic and benthic invertebrate organisms that usually bear little resemblance to their parents. The time that these temporary forms may spend in the plankton community may vary from two weeks to six months for most benthic species, and several years for the lamprey.

Objectives:
In this activity, the students will demonstrate understanding of the concept of meroplankton by:

- identifying the larval forms of some nektonic and benthic organisms, and

- matching them with the adult form in which they develop into.

Materials:

- student worksheets: **Can You Recognize Me?**
- "on air" demonstrations

Procedure:
- Portrayed on the page are several nektonic and benthic adult organisms that spend part of their lives as plankton (meroplankton). The adults are arranged on the right side of the page, and the larval forms are portrayed on the left.

- Match the organisms by placing the correct letter of the larval form beside the adult organism

- Have the students specify if the adult is a nektonic or benthic organism.

Discussion Questions

What is the contribution of the meroplankton to the planktonic community?

What proportion of the zooplankton community do they expect the meroplankton to comprise, and what possible advantages may arise from being a temporary member of the plankton community?

The mortality rate among larval forms, especially during their early stages, is astronomical either because of predation or starvation, or because the larvae may be carried away by the current to non- suitable areas (areas with insufficient oxygen or food, or fluctuating water levels or temperatures). For this reason, the marine animals produce larvae in enormous numbers, the meroplankton constituting an important portion of the zooplankton. The parent animals may produce millions of larvae, but only a small number of larvae needs to survive to adulthood to guarantee the survival of the group. The current may carry the larvae to new distant locations, where they may find better habitats; in this way, re-population of areas in which a species may have died out can occur, and overcrowding in the home area is reduced.

Answer to the match game:

C (benthic), E (nektonic), B (benthic), G (nektonic), F (benthic), D (planktonic/benthic), A (benthic).

Activity: The Nuts and Bolts of How to Name Things

In any plant or animal, there may be hundreds, even thousands, of characteristics which appear to separate it from all other organisms. Experience has shown, however, that most of these are not extremely important in determining the species of the organism. Usually only a few characteristic are valuable in determining the species. But if you were given an organism to classify, you would probably be both amazed and confused by the large number of characteristics that are present. Which characteristic do you use in classifying this organism? The answer is simple. You must center your attention on just a few, critical characteristics and disregard the others. Wouldn't it be nice if only the plants and animals on earth only showed these critical characteristics? Unfortunately, plants and animals do not exist in this manner.

Man-made items sometimes are much simpler than those found in nature. This is true of some of the items in everyday use. Consider all the different types of spoons that help fill the drawers in any kitchen. Or the different kinds of nails, pipe fittings, pins, or bullets.

To make the job of learning to use a **taxonomic key** easier, we have chosen to work with screws. Screws are used for many purposes and come in many shapes and sizes. Each has a specific name, much like a plant or animal. The parts of a screw are extremely simple. There is an extended portion called the head and a long, slender portion called the shaft. Screws can be separated from nails, for example, by the fact that the shaft is threaded, that is, it has a groove spiraling around it from its point toward the head.

Objectives:

Each student shall be able to:
- use a key to separate organisms or items into categories based on known structure.
- define the following terms: taxonomy, taxonomic key.

Materials:
- Five of each of the following for a class of 20-25 students:
- round headed machine screw, hex-headed machine screw, thumb-grip machine screw, eye screw, hex-headed metal screw (without slots and with slots), pan-headed metal screw, flat-headed wood screw, round-headed wood screw, flat-headed metal screw, round-headed metal screw, pan-headed metal screw (Phillips head and/or straight slot)

Procedure:

Using you lab samples, identify one screw at a time. Read each couplet as a unit. If your answer to the first statement is "yes", go to the couplet indicated; if a name appears, you have identified your screw. If your answer to the first statement of the pair is "no", go then to the second statement of that pair. Your answer to this must be "yes". If you can not give a positive answer to the second statement either, you are off track. Return to the beginning of the key and start over, being very careful to read each statement accurately and to examine your screw meticulously.

After you have identified a screw, set it aside with its proper identification indicated. Take another screw and begin with the first couplet again. You must always begin with the first couplet.

Activity: Meet the Marine Plankton Community

Scientists look for ways to classify and group organisms to ease the study of the diversity of life. The taxonomic method of classification categorizes the organisms into natural units. These units also allow scientists to trace the evolutionary relationships among them. In this way, the similarities between organisms are described, and a basis to establish differences and comparisons between the different groups is provided.

Objectives:

In this activity, the students will become familiar with the inhabitants of the marine plankton community. The students should be able to:

- recognize and identify several types of phytoplankton and zooplankton,
- distinguish between holoplankton and meroplankton,
- identify the dominant forms of plankton,
- state comparisons between the major groups, and
- establish the contribution of the main groups to the plankton community.

Materials:

- marine plankton vials and samples
- microscopes, slides, and cover slips
- eye dropper or pipette
- **Marine Plankton Identification Key**
- student worksheets: **Marine Plankton Data Table**

Procedure:

- Gently shake the sample vial to resuspend the organisms that might have settled to the bottom. Take a water sample from the vial using an eye dropper or pipette.
- Mount the slide and study the organisms under the microscope at the lowest power (4x).
- Have the students complete the worksheet while identifying the organisms using the identification key. This activity is not intended to determine exact quantities of organisms; therefore, under the "frequency of organisms" column, the students may use words such as very numerous, numerous, several, few or very few.
- To record the size of the organisms, refer the students to the relative size of the field of view that they are using: 1000 micron = 1 millimeter: Approximate size of organism:
  4x objective = 4200 microns; 10x objective = 1300 microns; 40x objective = 200 microns

Discussion Questions

Discuss the position and importance of the plankton in the marine environment.

How many kinds of organisms were identified and what was the approximate observed proportion of phytoplankton to zooplankton?

What were the smallest and largest plankton found?

How many different larval forms (meroplankton) were identified?

What was the approximate percentage of holoplankton?

MARINE PLANKTON DATA TABLE

Characteristic shape (sketch)	**Approximate frequency of organisms**	**Common name**	**Unusual characteristic**	**Role in community**	**Size in microns**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

***phytoplankton, permanent zooplankton, or temporal zooplankton (larval forms)**

Activity: How Much Plankton Is There In the Oceans?
Measuring Biomass and Diversity

The biomass or standing stock refers to the weight or number of organisms in a volume or area of water. This number, which represents a balance between reproduction, growth, consumption, and death of the organisms, is very useful to trace the fluxes of energy between trophic levels within an ecosystem. Diversity refers to the amount and relative abundance of different species in any area. This number is used to characterize and monitor changes in the ecosystems caused by natural phenomena or by human intervention. The determination of biomass and diversity in an ecosystem is very complicated and requires specialized knowledge of the species involved. We will perform a simple determination of biomass and diversity of marine plankton using a few easy-to-identify organisms.

Objectives:
In this activity, the students will learn to estimate the populations of phytoplankton and zooplankton from the samples by:

- identifying the organisms in the sample to estimate diversity,
- determining the frequency of the three dominant groups, and
- calculating the biomass of the sample.

Materials:
- marine plankton vials
- microscopes, slides, and cover slips
- sorting trays for the samples
- 1-ml pipette
- **Marine Plankton Identification Key**
- student worksheets: **Plankton Population Data Table**

Procedure:
- Gently shake the sample vial to resuspend the organisms that might have settled to the bottom. Using a pipette, take a 1-ml sub-sample.
- Create several slides of the sample using one small drop of sample per slide. The students can also place the entire 1-ml sample in a clear plastic dish (sorting tray) and count the organisms as a whole sample. Use the reference materials for the identification of the organisms.
- Have the students complete the worksheet. The students will have to count the number of organisms belonging to each group detailed on the worksheet. To estimate the approximate biomass of each group in terms of organisms per liter, multiply the number of observed individuals by 1000. To estimate the total biomass, add the number of all the organisms observed and multiply the result by 1000.

Discussion Questions
What are the three dominant groups? How many different kinds of organisms were represented? This is an indication of the diversity of the sample.

Determine the proportion of phytoplankton to zooplankton in their samples.

PLANKTON POPULATION DATA TABLE

Planktonic Organism	Frequency	Volume of sub-sample	Biomass (organisms per liter)
fish larvae			
arrow worms			
copepods			
other micro-crustaceans			
centric diatoms			
pennate diatoms			
other organisms			
TOTAL NUMBER OF ORGANISMS =		**TOTAL BIOMASS =**	

List the three dominant groups in your sample:

1. ______________________________
2. ______________________________
3. ______________________________

Activity: Plankton Shapes - Maintaining Position in the Water Column

Although many plankton are motile, their ability to move against the water currents is limited. Consequently, they drift with the ocean's currents, which determines their distribution in the water column. Phytoplankton need sunlight to photosynthesize, therefore, they must remain in the photic zone to survive. The zooplankton depend largely on phytoplankton for food, so they too reside in the surface waters. Both exhibit structural and physiological adaptations to increase their buoyancy and effectiveness to acquire the necessary resources for life in the ocean surface waters.

Objectives:

In this activity, the students will investigate how plankton cope with the problem of having to remain in the upper layers of the ocean. The students should be able to:

- describe the structural and physiological adaptations of the plankton,
- discuss the roles of size and shape in relation to sinking rates and absorption of energy, and
- explain the mathematical relationship between surface area and volume

Materials:

- several jars, or aquaria full of water
- pieces of aluminum foil of different sizes and thickness (this could be modified using other materials such as paper, metal, cloth, or cardboard)
- vegetable oil
- timer or stop watch

Procedure:

- Examine several pictures of plankton and become familiar with their body shapes.
- Submerge a flat piece of aluminum foil and record the time it takes to sink to the bottom. This piece of foil should be introduced perpendicular to the water surface to maximize the effect of having a compressed shape.
- Make different shapes by twisting and bending the piece of aluminum foil to simulate the projections of the plankton.
- Test the floating abilities of the different shapes by submerging the pieces gently under the water surface and releasing them. Completely wetting the object will prevent the effect of surface tension.
- Measure the time it takes for different shapes to sink to the bottom. Record your observations. Note: Save the plankton models to be used in the next activity: **Drifting With the Currents**!
- Try folding the material so it will hold a teaspoon of oil. Record the sinking rate.
- Discuss the observations with the students.

Interpretations and Questions

What shapes enabled your material to float the longest?

How did adding oil to your material affect flotation?

Why are waves and surface currents important in keeping plankton afloat?

Why is it important for phytoplankton to stay in the upper layers of the water column?

Explanation to the experiment:

The sinking rate (SR) of an organism is related to:

- the density of the organism (W_o),
- the density of the water (W_w),
- the amount of body weight by which the organism exceeds the weight of a similar volume of water (W_o - W_w); displacement
- the resistance of the surface to the water (R), and
- the viscosity of the water (V_w) by:

$$\text{SR} = \frac{(W_o - W_w)}{(R)(V_w)}.$$

The organisms can not change the viscosity of the water; therefore, the mechanisms to reduce their sinking rate must involve either reductions in the body weight, increases in their surface area, or surface resistance to the fluid. To increase the surface of resistance, the plankton have evolved appendages (appendages increase the frictional resistance of the plankton body when they are moving through the water, but add little to their weight). Small size also increases the surface area of an organism. Surface area increases with the square of the length, whereas the volume increases as the cube, smaller organisms have greater surface area relative to their volume.

The reduction of weight may be accomplished by altering the composition of the body fluids and replacing them with less-dense fluids. The diatom *Ditylum* , for example, is capable of excluding high-density ions from its cell fluid and replacing them with less-dense ions. Another mechanism is to produce and store oils. Oils have lower density than water, so they increase the buoyancy of the organism and reduce its sinking rate.

Activity: Drifting With the Currents!

Currents are large masses of water moving throughout the ocean. Although some currents may affect only a small area (in response to local, seasonal conditions like rainfall or storms), most are permanent and involve large parts of the ocean. The currents play an important role in the world climate by moving large masses of warm water to the cold latitudes and cold water to the warm latitudes. They also affect the productivity of the oceans by bringing up nutrients used by phytoplankton from deeper waters (upwelling). In fact, the best fishing areas are those where two currents merge together. The currents are also helpful in the navigation of sailboats and ships. For this activity our interest in currents is to see how they passively disperse the larval forms of nektonic and benthic invertebrate organisms to new locations.

Two main types of currents are recognized: the **surface currents** and **the deep-ocean currents**. Surface currents are what move plankton from place to place, while deep water currents move nutrient-rich waters to the surface. This activity will deal with the surface currents, which occur in regions where the winds blow over the ocean with a reasonable constancy of direction and velocity. The water movement in this type of current is generally horizontal. There are other factors affecting the direction of the currents (friction with other water masses and the Coriolis effect). The Coriolis effect is a force of the earth's rotational movement that causes the water masses in the Northern Hemisphere to deflect to the right and to the left in the Southern Hemisphere. We are going to devote this exercise to studying the effects of the wind, which is the main cause of the surface currents.

Objectives:
In this activity, the students will become familiar with the concept of surface currents. The students should be able to:

- describe the relationship between the wind and the ocean currents,
- discuss the effect of wind direction and speed upon the ocean current patterns,
- describe the effect of land formations upon the surface currents, and
- explain the ecological importance of the surface currents to plankton and humans.

Materials:
- baking pans
- flat black, enamel, rust-proof paint
- white chalk
- modeling clay
- coloring pencils
- plastic drinking straws with flexible elbow (one per student)
- black permanent markers
- 400 ml. of rheoscopic fluid[1]
- towels or rags for cleanup
- student worksheets: **Maps and Data Sheet**

Procedure:
Although this activity can be carried out as demonstrations, it is recommended that the class be divided into small groups (3 to 4 students per group),and that each group perform the investigations.

[1] To obtain the rheoscopic fluid, you can contact Novostar Designs, Inc. at 1-800-659-3197. The rheoscopic fluid is ideal for demonstrating a variety of currents, including convection currents and aerodynamic flow. It can be reused for years.

- Paint the interior of the baking pans. Allow, at least, one hour for the paint to dry. Other types of paint may be used, but make sure the paint dries with a flat or matte finish, not glossy.

- Bend the straw at the elbow. Write your name on the shorter end of the straw using the black permanent marker. This will allow you to identify your straw. Do not put the marked end of the straw into your mouth when blowing through it.

- The maps on the worksheet show the position of the continents in black and the oceans in white color. Using Map 1 and the white chalk, draw an outline of the eastern coasts of North and South America, and the western coasts of Africa and Europe inside the baking pan. Then, draw an arrow in any area other than the Atlantic Ocean to indicate the northward direction.

- Following the chalk pattern, place ridges of modeling clay along the bottom of the baking pan to create a boundary system to contain the "ocean". Press the clay firmly to the baking pan. Also smooth the gaps between the clay and the baking pan. It is important to create a water-tight seal to prevent "oceanic" leaks.

- Fill the center (oceanic area) of the model with rheoscopic fluid. Wait for the swirling patterns in the solution to settle. (Although the rheoscopic fluid is non-toxic, you may wish to require the students to wear safety goggles. As with any foreign substance, flush with plenty of water if eye contact occurs).

- For centuries, the sailors have used the trade winds to cross the Atlantic from Europe and Africa to Central and South America. To simulate these winds, hold your straw so that the shorter end (with your name on it) is parallel to the ocean surface. Point your straw from the bulge of Africa westward toward the coast of South America. Gently blow through the straw and observe the pattern of ocean currents that the wind produces. (To see how plankton are dispersed with the currents, the students may deploy the miniature plankton models used in the plankton shapes activity).

- Using the coloring pencils, sketch the swirling pattern produced by the trade winds on Map 1 of the worksheet. With a different color pencil, draw a single arrow to indicate the direction your straw was pointing when you blew (wind direction).

- Alter the direction of the straw by pointing it more northerly or southerly, and gently blow through it. Observe the change in the current pattern. Sketch your observations on Map 2, not forgetting to draw the arrow to indicate the wind direction. Pay particular attention to what happens when the water flows around land masses, like Florida.

- Repeat the previous step, at least, three times, and record your observations on the remaining maps. This will help you to visualize the relationship between wind direction, land masses, and current patterns. You may create small islands and place them into your ocean to observe their effect upon the current patterns**.**

Discussion Questions

What is the relationship between wind and ocean surface currents?

What variables (like wind direction, wind speed, and land formations) seem to be related to the ocean current patterns?

What is the ecological importance of the surface currents?

Explanations

Although there are other factors affecting the direction of the surface currents, the wind flow definitively imparts momentum to the water in open areas of the ocean, driving regular patterns of surface currents. The surface water is moved basically horizontally, although not parallel to the wind direction because of the deflection effect of the rotational movement of the earth (Coriolis effect). Since wind flow is instrumental in maintaining the surface currents, increasing wind speeds will increase the surface current speed. Continental masses and islands can alter the direction of the surface currents and obstruct their continuous flow. When obstruction occurs, the water transported by these currents is moved from one side of the ocean and accumulates on the other side. The surface of the equatorial Pacific Ocean, for example, is higher on the west side. The opposite is true in the middle latitudes of both hemispheres, where the east side is higher than it is on the west side. Although surface currents are relatively shallow ocean currents, some (Gulf Stream) may carry water at depths of 1500 m or more, and transport hundreds of times the volume of water carried by all of the earth's rivers combined. Such currents greatly affect the distribution of marine organisms and the rate of heat transport from tropical to polar regions.

Activity: When Two Currents Meet

The deep-ocean currents are large masses of water that move both horizontally and vertically, extending into the deepest parts of the oceans. They are mainly caused by differences in the density between adjacent masses of water. Denser water masses sink, carrying dissolved oxygen to the deep areas of the ocean, which allows marine life to exist at all depths. The upwelling processes eventually bring nutrient-rich, deep waters (marine bacteria decompose the organic matter into nutrients) back to the surface. Both patterns of water transport are slow, time spans of thousands of years being required for waters that sink in the North Atlantic to reach the surface again in the Southern Hemisphere. If it were not for the **deep-ocean currents**, the oceans would be stagnant and without oxygen in the deep zones, and the surface productivity of plankton would be less significant.

Objectives:
In this activity, the students will explore how density currents occur. The students should be able to:

- describe the effect of salt content upon the density of water,
- discuss how temperature affects the density of the water, and
- explain the ecological importance of the density currents.

Materials:
- two 1-pint milk bottles or two 250-ml Erlenmeyer flasks with flat lips
- 3x5 cards
- table salt
- food coloring
- paper towels or rags to cleanup
- plastic dishpan or any other container suitable to catch water

Procedure:
Although this activity can be carried out as demonstrations, it is recommended that the class be divided into small groups (3 to 4 students per group),and that each group perform the investigations.

Experiment 1: Salinity currents
- Fill both bottles with water. In one bottle, dissolve 1/2 teaspoon of salt and add one drop of food coloring.
- Place a 3x5 card on top of the salt-water bottle and carefully invert it. In most cases, the upward pressure of air will hold the card in place.
- Place the salt-water bottle on top of the freshwater bottle and have someone remove the card. (Before removing the card, place the dishpan below the bottles to catch the water that will spill). Observe what happens and record the results.
- Clean the bottles and repeat the first two steps . Place the freshwater bottle on top of the salt-water bottle, remove the card, observe, and record your results.
- Again, clean the bottles and repeat the first two steps. This time, place both bottles horizontally, remove the card, observe, and record your results.

Experiment 2: Temperature currents

- To test the effect of temperature upon the density of water, fill one bottle with warm water and the other with cool water. Add one drop of food coloring to the warm-water bottle. Place a 3x5 card on top of the warm-water bottle and carefully invert it.

- Place the warm-water bottle on top of the cool-water bottle, remove the card, observe, and record your results.

- Repeat the procedure of filling the bottles; add the food coloring to the warm-water bottle, place the card on top, and invert it. This time, place the cool-water bottle on top of the warm water bottle, remove the card, observe, and record your results.

Once again repeat the procedure described above. Place both bottles horizontally, remove the cards, observe, and record your results.

- Discuss all the observations with the students.

Explanations

Density is normally controlled by changes in salinity and temperature. Because salt water (colored) is heavier (denser) than freshwater due to the addition of salts, it will displace the lighter water and occupy the bottom of the bottles in all three cases. Owing to the difference in color between the two water types, the students should be able to see the motion of the two water masses, as well as the turbulence mixing in the interface. In the temperature part, the warm water (colored) will remain in the upper portion of the bottles in all three cases because it is lighter (less dense) than the cool water.

In the open ocean, the seasonal changes in temperature are more important than the salinity changes in determining the density of the water. The major changes in temperature occur at the surface of the ocean. In the North Atlantic, for example, the surface waters lose heat to the atmosphere, which produces an increase in its density. As a result, this water mass sinks to the bottom of the ocean. Close to the shore, the salinity becomes more important in controlling the density of the water. In the western basin of the Mediterranean Sea, for example, excessive evaporation increases the salinity of the water and, consequently, its density. This water mass also sinks to intermediate depths and flows out of the Mediterranean Sea through the Gibraltar Strait. This water mass can be detected as far as the mid Atlantic Ocean.

Discussion Questions

- ***Is salt water heavier or lighter (higher or lower density) than fresh water? Explain your answer in terms of the results you obtained from the experiment.***

- ***What happens to river water when it flows into the ocean?***

- ***Where does most heating of ocean water take place?***

- ***Where does most dilution of sea water occur?***

- ***Is it easier for a human to swim in salty or fresh water? Explain.***

- ***Is it easier for a human to swim in cool or warm water?***

(Note: This activity was adapted from the Marine Science Center, Poulsbo, WA.)

Activity: Create Your Own Marine Food Web

Food chains and **food webs** are both ecological models that represent the pathways followed by nutrients and food energy as they move through the succession of plants, grazing herbivores, carnivorous predators, and decomposers. However, a food web results from the interlocking of food chains and, consequently, the organisms or group of organisms involved are rarely consumed by just one kind of animal. A food web is, therefore, a more detailed ecological model than the food chain since it shows the interdependence among plants, animals, and the environment.

Objectives:

In this activity, the students will demonstrate understanding of the marine food web by:

- identifying the producers, the primary, secondary, tertiary, fourth order consumers, and the decomposers,
- describing the general flow of energy among marine organisms and the ways in which energy can be lost to the environment in each trophic level,
- describing the interdependence among marine organisms, and
- discussing the effects of removing the phytoplankton from the marine environment.

Materials:

- **two** student worksheets: **Create Your Own Marine Food Web**
- scissors
- scotch tape or glue

Procedure:

- Make reference to the food chain, which is a simple ecological model that describes the sunlight-energy transfer from producers to consumers as organisms feed on each other. Understanding this concept is essential in learning more complicated ecological models, like the food web.
- Introduce the subject of food web by using the analogy of a spider web, in which all threads are interconnected. In the same way, a food web shows interconnections or interdependence between organisms living in a ecosystem. A food web results from the interlocking of food chains and, consequently, organisms or group of organisms are rarely consumed by just one kind of animal. A food web is, therefore, a more detailed ecological model than the food chain.
- Have the students cut out the organisms shown in Handout 3A. Using the descriptions of the organisms provided in Handout 3B, construct a marine food web in the worksheet. Special attention should be given to the position of the organisms in the water column.
- Have the students show the survival relationships between organism by asking them to draw arrows from the organism that serves as the food source to the organism that consumes it (direction of energy and nutrient flow). It is important to show that the organisms rarely rely upon a single source of food, hence, the interdependence.

Discussion Questions

In what ways can energy be lost to the environment in each trophic level?

What will happen to this marine ecosystem if the phytoplankton (producers) are removed?

How it is possible that animals like the blue whale (largest living animal on the planet) and the whale shark (largest fish) survive by feeding mainly on plankton?

Explanations

As energy is passed from one trophic level to another, some of it is lost as heat. Energy loss also occurs because of the foraging activity of searching for food, metabolic and digestive processes of the organisms.

If the plankton dies, the food web will collapse, and all animals would be directly affected.

Large size represents an advantage because it is often more difficult to catch and eat a large animal than a small one. However, large animals require large amounts of food (energy) to support their size. The zooplankton feed on phytoplankton, which are the producers or base of the food chain in the ocean. The zooplankton are, therefore, the first link between the primary production of plants and the rest of the consumers. It is advantageous to feed on plankton because these organisms occupy the most energetic trophic levels. Baleen whales (blue whale, fin whale, right whale, humpback whale, and others) and the whale shark can afford to be large because they obtain the largest possible amount of energy for a consumer by feeding directly on the zooplankton.

Descriptions of Who's Who To Create Your Own Marine Food Web

Albatross: long, thin-winged bird that feeds on fishes. Albatross may expend most of their lives wandering the oceans, and not come to shore for several years. Albatross use wind-velocity gradients existing near the ocean surface to glide; in this way, they can cover long distances without using much energy while looking for food. The wingspan of the wandering albatross (*Diomedea*) is over 10 ft.

Arrow worm: highly predatory animal that has a pair of jaws at the anterior end of the body and a pair of tail flukes at the opposite end. It is a voracious predator to copepods, capable also to swallow other planktonic organisms that are several times its own bulk. Arrow worms rise to the surface at dusk and night, and occupy deeper zones at noon and midnight. They are consumed by fishes, jellyfishes, and pelagic worms.

Baleen whale: "baleen" are the thin plates that hang from the upper ridge of the mouth of some whales. The baleen plates are used for straining water and capturing the food while the animal feeds on plankton (mostly krill), shrimp, and fishes (baitfish). Blue whales are the largest of the baleen whales. Whales are marine mammals.

Brittle star: most conspicuous benthic invertebrate (echinoderm) on the deep sea floor, although it is also found on the continental shelf. Some feed on plankton and small nekton, whereas others consume worms and crustaceans, or are detritus-feeders.

Bonito: fast-swimming fish related to tunas and mackerel. It feeds primarily on other fishes.

Copepod: microscopic crustacean related to shrimps and crabs. Copepods are the most abundant planktonic animals, occurring in all seas in a wide range of depths. They feed on diatoms in the upper waters; in lower waters, some feed on smaller copepods and other small animals. They are consumed by other zooplankton (euphausiids and arrow worms), fish larvae, and some small fishes.

Crab: one of the most numerous benthic crustaceans (arthropod). Most crabs are scavengers, although some species eat algae and others feed on animals. Some species emerge on to land at night to forage; others become fully terrestrial in the adult stage, even ascending trees (mangrove crab). Crabs are consumed by other crabs, birds, turtles, and some fishes.

Crab larva: free-swimming, young stage of crabs (crustaceans). Crab larvae are a popular food choice for other larger plankton (amphipods, euphausiids, and arrow worms), and fishes.

Diatom: single-celled plant that forms the base of the marine food pyramid. Diatoms may occur singly (centric or pennate), or form long chains.

Dinoflagellate: motile, single-celled organism (one or two flagella) that is smaller than diatoms. Dinoflagellates represent the second major group of producers in the ocean. They are solitary, rarely forming chains. Dinoflagellates are capable of producing toxins that are released into the water; when dinoflagellates are extremely abundant, mass deaths of fishes and invertebrates may occur (red tide). Some are bioluminescent.

Fish larva: young stage of fishes that lacks the effective motility of the adult stage. Fish larvae are a favorite food item of larger zooplankton, tunicates, jellyfishes, and fishes.

Herring: small schooling, silvery fish that feeds primarily on plankton (copepods, amphipods, and pelagic worms).

Jellyfish: saucer-shaped animal that possesses stinging tentacles around its margin. It feeds on other planktonic animals and fishes, which are engulfed through a mouth opening on the lower side of the umbrella. It is consumed by some turtles, the sunfish (*Mola mola*), and other fishes.

Krill: shrimp-like animal (crustacean) about 5 cm (2 in) in size that feeds primarily on diatoms, although it can feed also on some smaller zooplankton. It is mostly found in waters near the Arctic and Antarctica. Marine mammals, fishes, and birds consume krill.

Mackerel: fast-swimming fish that often travels in small schools. It feeds primarily on other fishes (mostly herrings, flying fish, jacks, and snappers), and occasionally on squids. Highly prized as food and game fish.

Sea-squirt: benthic, sessile organism (tunicate) that lives attached to rocks, shells, mangrove roots, and other hard surfaces. It may be solitary or colonial, or may live with many individuals grouped under a common covering. It feeds on plankton.

Shark: cartilaginous fish that feeds on many species of fishes (including tunas and marlins), crabs, sea turtles, squids, and marine birds and mammals. The whale shark is the largest fish in the ocean and feeds exclusively on plankton.

Snail: benthic, soft-bodied invertebrate (mollusk: gastropod) that usually secretes an external calcareous shell. Sea snails vary from herbivores to detritus feeders, although the majority feed on other animals, including other mollusks and fishes. Sea snails are consumed by fishes and other mollusks.

Tuna: fast-swimming fish that feeds on a variety of fishes, squids, and crustaceans. Tunas often travel in small schools and undertake great migrations. Large tunas are one of the few fishes whose body temperature is higher than the water temperature because of their high metabolic rate. Tunas constitute a popular and valuable commercial fisheries.

Activity: Be An Aquatic Engineer By Constructing Your Own Plankton Net

Objectives:

In this activity, the students will demonstrate understanding of the plankton ecology by:

- constructing a net for the collection of plankton samples,
- identifying the organisms and the dominant groups, and
- discussing the adaptations that seem to be necessary for their survival.

NOTE: This activity can be carried out in either freshwater or seawater.

Materials:

- one leg of a nylon pantyhose or a nylon stocking
- one wire coat-hanger or a plastic milk jug
- needle and thread
- duct tape
- one vial or small, plastic or glass bottle (with a lip)
- strong cord or rope
- one small fishing sinker or lead weight
- drag net along shoreline by hand
- microscopes, slides, and cover slips
- eye dropper or pipette
- **Marine Plankton Identification Key** or the **Freshwater Algae & Protozoan Picture Idendification Key (4 pages),** if the activity is carried out in a lagoon, lake or pond
- student worksheets: **Marine** and/or **Freshwater Plankton Data Table**

Procedure:

- Twist the coat hanger into a ring. Attach the wide end of the pantyhose leg to the coat hanger using the needle and thread. Reinforce the stitching with the duct tape. (Alternatively, the stocking or pantyhose can be stitched to the milk jug after its bottom and part of the top have been cut out).
- Attach the strong cord to three places on the ring, knotting the string together a foot or so in front of the net, or tie the string to the handle of the milk jug.
- Add cord for a towing line.
- Cut-open the toe of the stocking. Tie-on the small catch bottle, making certain that the string is tight around the lip of the bottle.

The plankton net should be towed through the water for approximately 5 to 10 minutes by hand. The net should be pulled fairly fast to keep it off the bottom, or you will collect more than plankton. Smaller nets can be attached to a large fishing rod and reel, cast-out over the water and reel-in. (As you pull the net through the water, tiny drifting organisms will be trapped by the net and washed down the side into the catch bottle).

- Bring the vial or catch bottle to the classroom. Gently shake the sample vial to resuspend the organisms that might have settled to the bottom. Take water samples using an eye dropper. Mount the slides and study the organisms under the microscope using reference materials for their identification. Begin to observe the organisms with the lowest power (4x).

- Have the students complete the worksheet.

- To record the size of the organisms, refer the students to the relative size of the field of view that they are using: 1000 micron = 1 millimeter

  Approximate size of organism:
  4x objective = 4200 microns
  10x objective = 1300 microns
  40x objective = 200 microns

<u>Discussion</u>

- ***How many of the collected organisms were identified?***

- ***What was the approximate observed proportion of phytoplankton to zooplankton?***

- ***What were the smallest and largest plankton found?***

- ***How many different larval forms were identified?***

- ***Discuss the position and importance of the plankton in the food web.***

MARINE PLANKTON DATA TABLE

Characteristic shape (sketch)	Approximate frequency of organisms	Common name	Unusual characteristic	Role in community	Size in microns
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

***phytoplankton, permanent zooplankton, or temporal zooplankton (larval forms)**

FRESHWATER PLANKTON DATA TABLE

Characteristic shape (sketch)	Approximate frequency of organisms	Common name	Unusual characteristic	Role in community	Size in microns
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

***phytoplankton, permanent zooplankton, or temporal zooplankton (larval forms)**

Plankton Series Quiz: Who Am I and Where Do I Live?

Match the description of the organisms and their habitat to the group to which they belong by writing the correct letter in the space provided.

A. unicellular organisms that may occur in chains and have a cell wall impregnated with silica; abundant in both freshwater and marine habitats

B. oval shaped crustaceans that are the most common planktonic animals in the ocean; extremely abundant also in freshwater habitats

C. highly predatory, worm-like animals that constitute a significant portion of the marine zooplankton; voracious on copepods and other zooplankton

D. translucent embryos of nektonic adult organisms; lack the swimming speed of the adult

E. comprise an important part of the marine phytoplankton; possess a cell wall made mostly of cellulose and usually gave two flagella

F. embryos of invertebrate benthic organisms; developmental stage in marine waters is the zoea

G. common freshwater protozoans; include *Euglena* and *Chilomonas*

H. most characteristic group of freshwater animals; possess a corona of cilia that beat in a rotatory way, from which their name, meaning “wheel bearer”, is derived

I. very common animal group (crustaceans) in freshwater habitats; include the water fleas (*Daphnia*) and their relatives

J. marine and freshwater crustaceans possessing a body wholly enclosed within a carapace except the antennae; appendages are reduced in number more than any other crustacean group

K. usually laterally compressed crustaceans possessing no carapace; may live in a variety of habitats, but most are benthic

L. these organisms are protozoans and contribute to the marine sediments when their silica skeletons sink to the ocean floor to form a siliceous ooze

1_____ ostracods
2_____ diatoms
3_____ dinoflagellates
4_____ green flagellates
5_____ copepods
6_____ cladocerans
7_____ rotifer
8_____ arrow worms
9_____ amphipods
10_____ fish larvae
11_____ crab larvae
12_____ radiolarians

Answers to the match: J, A, E, G, B, I, H, C, K, D, F, L