Marine Science I

Course No. 2002500

Bureau of Instructional Support and Community Services
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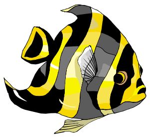

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developed and edited by
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from
Exploring Oceanography
Revised Edition

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Curriculum Improvement Project
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LEON COUNTY SCHOOLS
Exceptional Student Education

http://www.leon.k12.fl.us/public/pass/

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Acknowledgments

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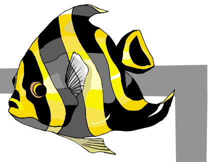
Unit 1: The Hydrosphere

Unit Focus

This unit describes the waters of the Earth and the science of oceanography. Students will learn the importance of the oceans and how oceans are utilized as a resource.

Student Goals

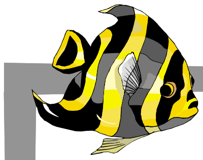
1. Define oceanography.
2. State the four branches of oceanography and describe each branch.
3. State the importance of the world's oceans.
4. Give examples of how humans use the ocean as a resource.



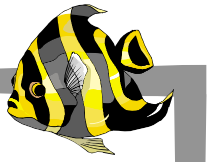
Vocabulary

Study the vocabulary words and definitions below.

biological oceanographers	scientists who study the distribution, natural history, and environment of marine life
chemical oceanographers	scientists who study the chemical composition of seawater and the chemical reactions that occur in seawater
drilling platforms	ships or stationary structures designed to obtain sediment, rock samples, oil, or gas from the deep-ocean floor
geological oceanographers	scientists who study ocean sediments and the topography of the ocean floor
hydrosphere	waters of the Earth
ocean	the vast body of saltwater that covers almost three-fourths of Earth's surface
oceanographers	scientists who study the ocean
oceanography	the study of Earth's oceans
physical oceanographers	scientists who study changes in seawater and the motion of seawater
seas	smaller bodies of saltwater which are frequently enclosed by land



thermal energy	an energy source obtained from the ocean's direct absorption of sunlight and transformed to heat
tidal power	an energy source obtained from the ocean's tides
topography	detailed charting of the features of an area; heights, depth, and shapes of the surface of an area
underwater research vehicle	submersible or submarine specially equipped to explore and study the deep areas of the ocean



Introduction: The Hydrosphere—The Waters of Earth

photograph of Earth

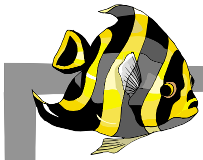
Begin your study of Earth's **hydrosphere**, or its waters, from a point somewhere above Earth. At first glance you notice how blue the surface of Earth looks. The blue you see is Earth's **ocean**, which covers more than 70 percent, or nearly three-fourths, of our planet. As your eyes sharpen their focus, you'll begin to see dark patches that look like islands within the vast expanse of blue. Those *islands* are the continents, or large land masses, upon which we live.

globe of Earth showing the oceans and continents

If you look closely enough, you'll notice that the ocean is not divided. In other words, Earth is covered by a single continuous ocean. However, using the continents as boundaries, we've sectioned this one great ocean into five smaller oceans: the Pacific, Atlantic, Indian, Arctic, and Antarctic oceans. The Antarctic Ocean or Southern Ocean is a smaller ocean that some scientists and geographers dispute as actually being an ocean. There are always difficulties when humans try to determine boundaries on something that has no boundaries. Smaller bodies of saltwater known as **seas** make up another part of this liquid surface of the Earth. Seas are often partially, or even totally, enclosed by land. For example, the Mediterranean, Caribbean, Baltic, Arabian, Red, and Black seas are separated from major oceans by projecting strips of land.

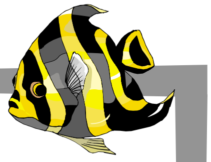
These oceans and seas that surround us have always interested us. We know that as far back as 3,500 years ago, sailors and navigators were exploring and charting the ocean. Today, many scientists continue to study and expand our understanding of the ocean and the organisms that live there.

In addition to our curiosity, other reasons and needs have prompted us to investigate the ocean. We've used the ocean's resources—from fish to water power—to support our existence. We've used the ocean to travel from one landlocked region to another. And we've used the ocean for the pleasure we get from sailing across its waves and swimming amongst its miraculous variety of marine life.



Oceans	
Pacific Ocean	**Description:** The world's largest and deepest ocean, covering one third of the Earth's surface. **Area:** 64,000,000 square miles or 166, 00,000 square kilometers **Average depth:** 14,050 feet or 4,280 meters **Volume:** 173,625,000 cubic mile or 723,700,000 cubic kilometers **Maximum depth:** Marianas Trench - 35,798 feet or 10,911 meters
Atlantic Ocean	**Description:** The second largest ocean and the most heavily traveled. The Atlantic Ocean is about one half the area of the Pacific Ocean. **Area:** 3,166,000 square miles or 82,000,000 square kilometers **Average depth:** 10,930 feet or 3,330 meters **Volume:** 77,235,000 cubic miles or 321,930,000 cubic kilometers **Maximum depth:** South Sandwich Trench - 30,000 feet or 9,144 meters
Indian Ocean	**Description:** The Indian Ocean covers about 20 percent of the total world ocean area and is the world's third largest ocean. **Area:** 28,4000,000 square miles or 73,600,000 square kilometers **Average depth:** 12,760 feet or 3,890 meters **Volume:** 70,086,000 cubic miles or 292,131,000 square kilometers **Maximum depth:** Java Trench - 24,442 feet or 7,450 meters
Arctic Ocean	**Description:** The smallest of the worlds's oceans. The Arctic Ocean is slightly more than one sixth the area of the Indian Ocean and it has a basin that is basically landlocked. **Area:** 4,700,000 square miles or 12,173,000 square kilometers **Average depth:** 3,250 feet or 990 meters **Maximum depth:** Pole Abyssal Plain - 15,091 feet or 4,600 meters
Antarctic Ocean	**Description:** Sometimes referred to as the Southern Ocean. Scientists and geographers dispute the area where three main oceans meet (the Pacific, Atlantic, and the Indian) at Antarctica (the continent) as an actual ocean. The Antarctic Ocean can be taken to include all oceanic areas lying south of the Antarctic Convergence, typically around latitude 55 degrees south. **Area:** 13,513,000 square miles or 35,000,000 square kilometers **Area that is sea ice:** 8,100,000 square miles or 35,000,000 square kilometers **Area that is permanently frozen:** 1,540,000 square miles or 4,000,000 square kilometers

However, understanding the ocean poses many difficulties. Because we're land animals, we've needed to develop special equipment to explore and measure the ocean. Today's scientists use technological equipment such as **drilling platforms** and **underwater research vehicles**. Drilling platforms are ships or stationary structures designed to obtain sediment, rock samples, oil, or gas from the deep-ocean floor. The *Resolution* is a well known drilling ship. The *Alvin* and *Argo* are two examples of underwater research vehicles. The *Alvin* is a tiny submarine designed to withstand pressure changes at more than 4,000 meters. The *Alvin* is equipped with robotic arms to take bottom samples and to collect marine specimens. Television and photography equipment are also on board the *Alvin*. The *Argo* is a sled-like submersible geared with camera, lights, and radar.



Nearly all of the sciences used to study the land are needed to study the oceans. Scientists have drawn on different sciences, from biology to zoology, from chemistry to physics, to probe the mysteries beneath the ocean's surface. **Oceanography** is the study of the Earth's oceans and involves all the other sciences.

The Science of Oceanography

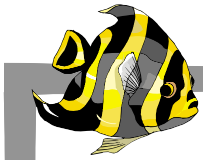
The study of the ocean truly became a science in 1855 when Matthew Fontaine Maury published his research on the physical features of the ocean. In 1872 the British navy launched the *H.M.S. Challenger*, a warship remodeled to house a laboratory, to study the ocean in greater detail. Pioneering scientists on board performed experiments to begin to learn more about the ocean. They collected and recorded information on the ocean's depth, water temperature, water and sediment samples, currents, and plant and animal species.

Scientist who studied the ocean became known as oceanographers.

In the years following, scientists who studied the ocean became known as **oceanographers**. There were so many different features of the ocean to study that oceanographers began grouping themselves according to their interests. Consequently, four different kinds of oceanographers developed.

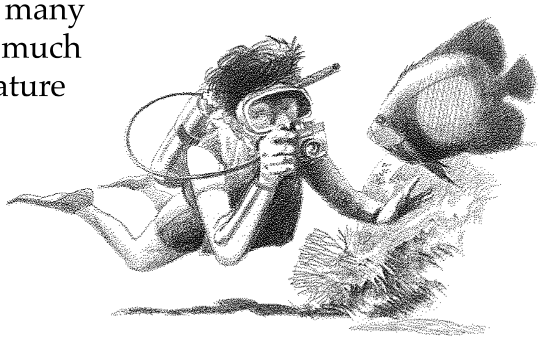
Geological oceanographers study the ocean's sediments and the **topography** of the ocean floor. These scientists analyze the topography and rock movements under the ocean's surface in order to answer the following questions: How were the oceans formed? What is their geological history, and what does movement on and below the ocean's floor suggest about future changes in the ocean?

Chemical oceanographers measure the chemical composition of seawater and the chemical reactions that occur in seawater. Because the ocean covers such a large portion of the Earth's surface, chemical interactions between ocean water and the atmosphere have a big effect on the Earth's climate. For example, carbon dioxide is dissolved in the water. But how



much carbon dioxide dissolves in the water is directly related to the chemical make-up of the water. Thus, the chemical make-up of water determines the amount of carbon dioxide in the air, and the amount of carbon dioxide in the air affects how many clouds form in the atmosphere, how much rain falls, and, consequently, temperature and weather patterns.

Biological oceanographers chart marine life in the ocean. These scientists spend many hours observing, collecting, tagging, and identifying specimens of plant and animal marine life. They work to understand the role of marine life in the ocean and people's impact on marine life.



Biological oceanographers spend many hours observing, collecting, tagging, and identifying specimens of plant and animal marine life.

Physical oceanographers focus on the currents and motions of the ocean. These oceanographers attempt to find answers to the following questions: Where do currents originate? How do liquids that vary in density, temperature, or momentum interact?

Some oceanographers search the seas for potential medicines to cure diseases, while others study ways to predict and even slow the development of hurricanes and other adverse weather conditions. Some oceanographers are working to harness the power of the ocean for use as energy, while others study how to limit our pollution of the seas and create a healthy relationship between human life and marine life.

Some oceanographers study ways to predict and even slow the development of hurricanes and other adverse weather conditions.

What a particular oceanographer wants to understand will determine his or her work site. Oceanographers may work on a research ship, in a laboratory, or on an offshore oil rig, to name just a few of their settings.

An oceanographer may be employed by a university, the government, or in one of the various industries. As people in science, commerce, and industry have begun to understand what an essential role the ocean plays in our lives and how rich it is in resources, more and more career opportunities have opened up in the field of oceanography.

Why Study the Ocean?

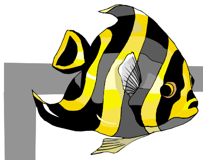

When we study the ocean, we're really increasing our knowledge of how Earth supports life.

Much of our life on land is dependent on the ocean. If the ocean suddenly dried up or its features and composition were radically changed, life on Earth as we know it would not survive. So when we study the ocean, we're really increasing our knowledge of how Earth supports life.

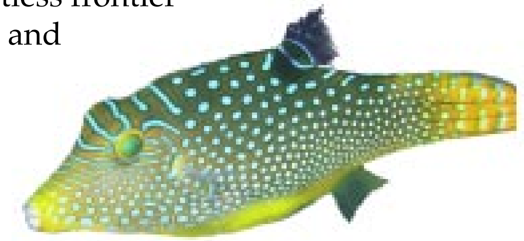
Climate and Weather

When you feel rain, you probably look to the clouds overhead as its source. But the ocean plays an important part in precipitation and other kinds of weather and climate. The rain you feel on your face may have evaporated from the surface of the ocean as it was heated by the sun. The evaporated water rises until it condenses and falls to the Earth as rain, snow, hail, or sleet.

Our weather on land is also affected by the temperature of the nearby ocean. Winds carry warm or cool air from the ocean's surface onto land. This air in turn alters the temperature on land. Sometimes the solar energy radiating over tropical waters is so powerful that it *destabilizes*, or changes the design and condition of, large masses of air, creating huge rotating weather systems of wind and rain known as *hurricanes*. Hurricanes can occur in the North Atlantic Ocean, eastern North Pacific Ocean, Caribbean Sea, and Gulf of Mexico. Such storms in the western Pacific Ocean are called *typhoons*. By studying the Earth's oceans, we will be better equipped to predict water movement, heating, cooling, and evaporative processes that impact weather systems. A better understanding of the oceans will enable oceanographers and meteorologists to forecast dangerous storms such as tornadoes and hurricanes.



The Ocean as a Resource

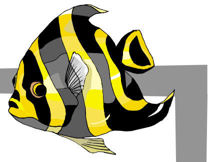


Many of us in Florida are fortunate enough to enjoy a variety of fresh seafood. Looking across the ocean or the gulf as far as the horizon, we may think that these waters are a limitless frontier and that sea creatures are easy to find and eternally plentiful. But such is not the case. *Aquaculturists* help us find seafood, predict its availability, and help insure the continued survival of the delicacies we enjoy from the ocean.

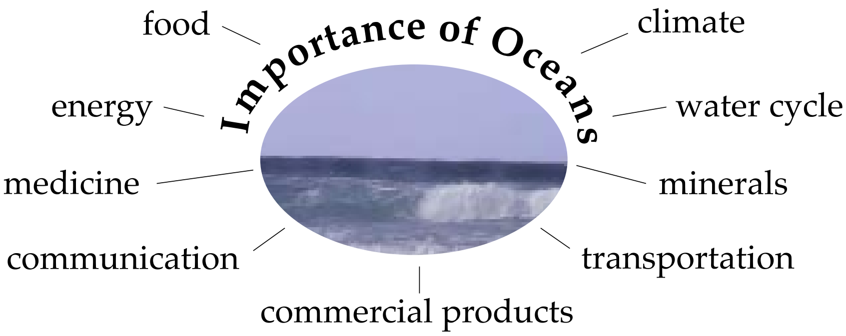
Did you know that the ocean is also a source for many medicines and health products? Fish and marine plants are already used to produce certain drugs, and oceanographers believe many more medicines can be harvested from the ocean. The ocean already supplies us with many chemical resources such as sodium chloride ($NaCl$), or common table salt, magnesium, and bromine. In the future, scientists may even discover a practical way to extract gold and uranium from the ocean.

As we increase our need for energy—forms of power to do work—scientists have looked more and more to the ocean as a source. For example, oceanographers now collect **thermal energy**, or heat, from the ocean's absorption of sunlight. This thermal energy, as well as the force of ocean currents, waves, and tides, can be used to push turbine blades that in turn produce electricity. Tides flowing in and out of channels and bays produce energy collected in power stations. This type of energy is called **tidal power**. Thermal energy, wave energy, current energy, and tidal power are the most abundant forms of energy available from the ocean. Unlike fossil fuel, there is an endless supply of ocean currents, waves, and tides for us to tap in the future.

The oceans are very important to people and all life forms on Earth. Much of our food, water, and other resources are taken directly or indirectly from the oceans. By understanding the chemical and physical aspects of the ocean as well as the organisms that live there, we can learn to properly manage marine resources.

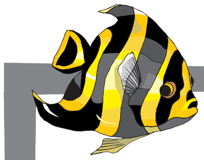


As you continue reading the units in the book, consider the following: Regardless of where you live, whether you can see the ocean or not, the ocean plays an essential role in your survival.



Summary

Nearly three-fourths of our planet is covered by oceans: the Pacific, Atlantic, Indian, Arctic, and Antarctic. Different features of the ocean are studied by four types of oceanographers: geological, chemical, biological, and physical. The ocean is a source for food, water, medicines, energy, recreation, and transportation. Our life on Earth is dependent on the ocean and its well being.

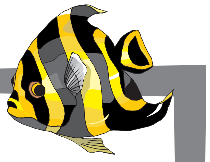


Practice

Use the list below to write the correct term for each definition on the line provided.

animals
drilling platforms
hydrosphere
magnesium
oceans
oceanographers
oceanography
plants
Resolution
sodium chloride
thermal

1. ______________________________ is the study of the Earth's oceans.
2. The ______________________________ is divided by the Earth's continents into five large oceans.
3. The ______________________________ is a well known drilling ship.
4. Medicines already harvested from the ocean come from marine ______________________________ and ______________________________ .
5. ______________________________ and ______________________________ are two of the many chemical resources gathered from the oceans.
6. The energy source obtained from the ocean through the ocean's direct absorption of sunlight is called ______________________________ energy.
7. ______________________________ are ships or stationary structures designed to obtained sediment, rock samples, oil, or gas from the deep-ocean floor.
8. The ______________________________ cover about 70 percent of the Earth's surface.
9. Scientists who study the ocean are known as ________________________ .



Practice

Complete the following.

1. Four types of oceanography have developed over the last hundred or so years. They are ______________________________

   ____

   ____ .

2. We have divided Earth's one great ocean into five smaller oceans, which are called the ______________________________

   ____

   ____ .

3. Three of Earth's many large seas are the __________________

   ____ .

4. The *H.M.S. Challenger* was important to oceanography because

   ____

   ____

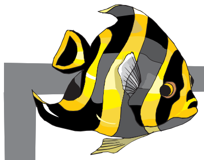
   ____ .

5. The oceans are important to our environment and well being because ____________________________________

   ____

   ____

   ____ .



Practice

Circle the letter of the correct answer.

1. A(n) ____________ studies the oceans of the Earth.
    a. scientist
    b. chemist
    c. oceanographer
    d. astrologer

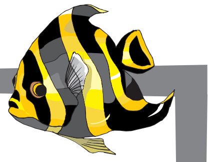
2. ____________ oceanography is the study of the chemical composition of seawater and the reactions that occur in seawater.
    a. Chemical
    b. Biological
    c. Physical
    d. Geological

3. ____________ is the study of the Earth's oceans.
    a. Meteorology
    b. Marine biology
    c. Oceanography
    d. Earth science

4. ____________ , or NaCl, is commonly known as *table salt*.
    a. Sodium pentothal
    b. Sodium chloride
    c. Carbon tetrachloride
    d. Sodium bicarbonate

5. Smaller bodies of saltwater frequently enclosed by land are ____________ .
    a. lakes
    b. ponds
    c. oceans
    d. seas

6. ____________ energy is a form of power which can be obtained from the ocean's absorption of sunlight.
    a. Thermal
    b. Tidal
    c. Current
    d. Wave



7. ____________ oceanography is the study of the Earth below the ocean, including the rocks and rock movements.

   a. Chemical
   b. Biological
   c. Physical
   d. Geological

8. ____________ oceanographers are interested in the ocean's gases and the specific make-up of seawater.

   a. Chemical
   b. Biological
   c. Physical
   d. Geological

9. ____________ oceanographers study and chart marine life.

   a. Chemical
   b. Biological
   c. Physical
   d. Geological

10. The ocean plays an important part in Earth's ____________ .

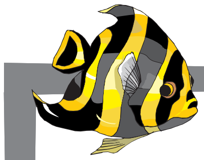
    a. precipitation
    b. weather
    c. climate
    d. all of the above

11. Scientists who focus on the currents and motion of the ocean are ____________ oceanographers.

    a. chemical
    b. biological
    c. physical
    d. geological

12. The ocean is an important resource for ____________ .

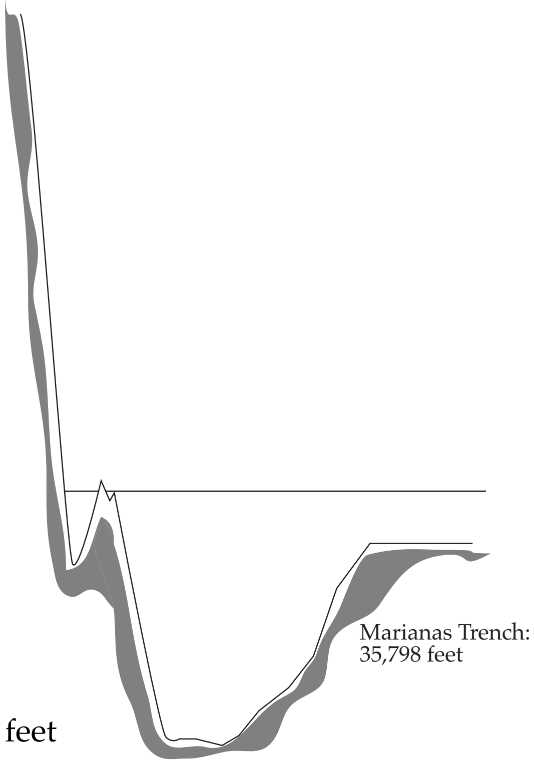
    a. food and medicine
    b. transportation
    c. recreation
    d. all of the above



Practice

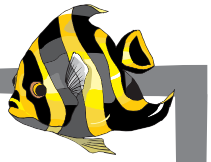
Use the **facts** *below to complete the* **oceanography word problems** *on the following page.* **Round answers to nearest whole number.**

- deepest place in the ocean is the Marianas Trench*: 35,798 feet
- highest place on land is Mount Everest: 29,029 feet
- average height of dry land: 2,854 feet
- average depth of the ocean: 12,237 feet
- biggest animals—
  - blue whale: 90 feet long
  - giant squid: 57 feet long
  - giraffe: 19 feet tall
  - elephant: 10.5 feet tall
- tallest plants—
  - giant Sequoia redwood tree: 360 feet
  - giant kelp: 330 feet
- tallest buildings—
  - Sears Tower in Chicago: 1,559 feet
  - Empire State Building in New York City: 1,473 feet
  - average human: 5.5 feet



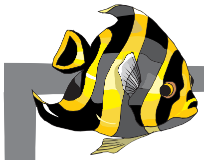
- deepest dive from the surface by a human without SCUBA (self-contained underwater breathing apparatus) gear: 417 feet
- deepest dive from the surface by a marine animal, the sperm whale: 7,381 feet

* trench - long, narrow crack in the ocean floor; the deepest part of the ocean



Remember: Round answers to nearest whole number.

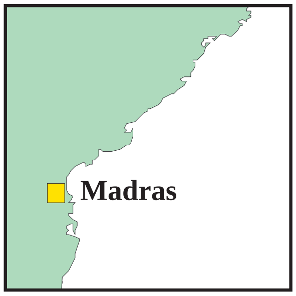
1. How many humans of average height could fit end to end to make a tower going from the surface to the average depth of the ocean? ____________________
2. How many humans of average height would it take to make a tower of the average height of dry land? ____________________
3. How many Empire State Buildings could fit end to end in the Marianas Trench? ____________________
4. How many humans of average height could fit end to end to equal the length of a giant squid? ____________________
5. How many humans of average height could fit end to end to equal the length of a blue whale? ____________________
6. How tall is Mt. Everest in giraffes rather than feet? ____________________
7. How tall is Mt. Everest in blue whales? ____________________
8. Could Mt. Everest fit into the Marianas Trench? ____________________
9. How many elephants would have to stand on top of each other to reach the height of a giant kelp seaweed? ____________________
10. How much further would the deepest human diver without SCUBA gear have to swim to get to the average ocean bottom? ____________________
11. How much further would the deepest diving sperm whale have to go to get to the average ocean bottom? ____________________



Practice

Use a globe or world map to assist you in locating the places shown. Then determine the **ocean which borders the land mass**. *Write the correct name of the* **ocean** *on the line below each map.*

Atlantic Ocean	**Indian Ocean**	**Pacific Ocean**



1. ____________________

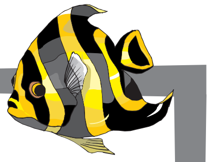
2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________



7. ________________

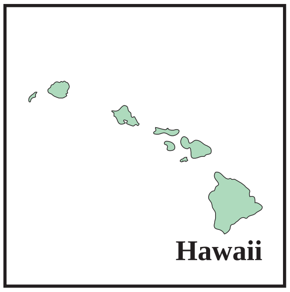
8. ________________

9. ________________

10. ________________

11. ________________

12. ________________



13. ________________

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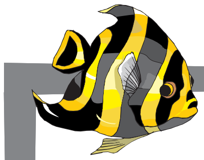


Lab Activity 1: Mapping the World's Oceans

Investigate:

- Use a map to locate oceans and continents.
- Locate points on a map using latitude* and longitude**.
- Relate locations featured on map to their oceanic significance.

Materials:

- colored pencils
- 2 copies of blank world map
- globe, atlas, or map (to be used by several students)

* latitude - measure of a distance north and south from the equator
** longitude - measure of a distance east and west from the prime meridian

Procedure:

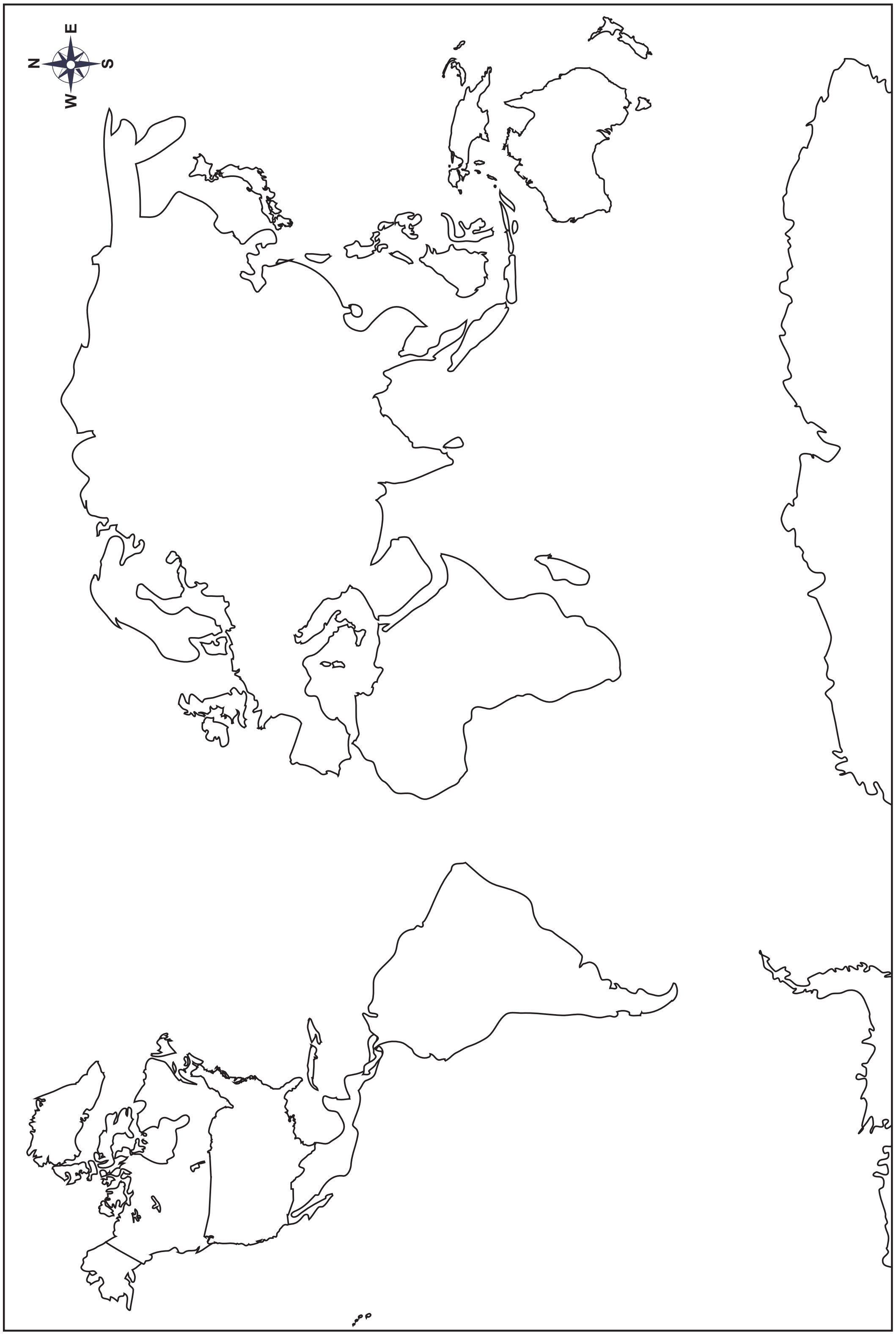
1. Use the map on the next page to label the following bodies of water. Be sure to label each body of water with its correct number and color.

Oceans *Blue*	**Seas** *Green*		**Gulfs** *Red*
1 Atlantic	**6** Mediterranean	**10** Red	**13** Gulf of Mexico
2 Pacific	**7** China	**11** North	**14** Gulf of California
3 Indian	**8** Arabian	**12** Black	
4 Arctic	**9** Japan		
5 Antarctic			

2. Now label the following continents and islands. Be sure to label each continent and island with a black pencil.

Continents		**Islands**	
15 North America	**18** Africa	**21** Greenland	**24** Cuba
16 South America	**19** Eurasia	**22** Philippines	**25** Hawaii
17 Antarctica	**20** Australia	**23** Madagascar	

3. On a separate piece of paper, list the major rivers and tributaries found near your home. Be sure to indicate how they lead to the ocean.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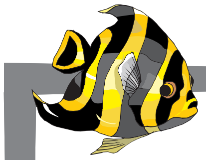
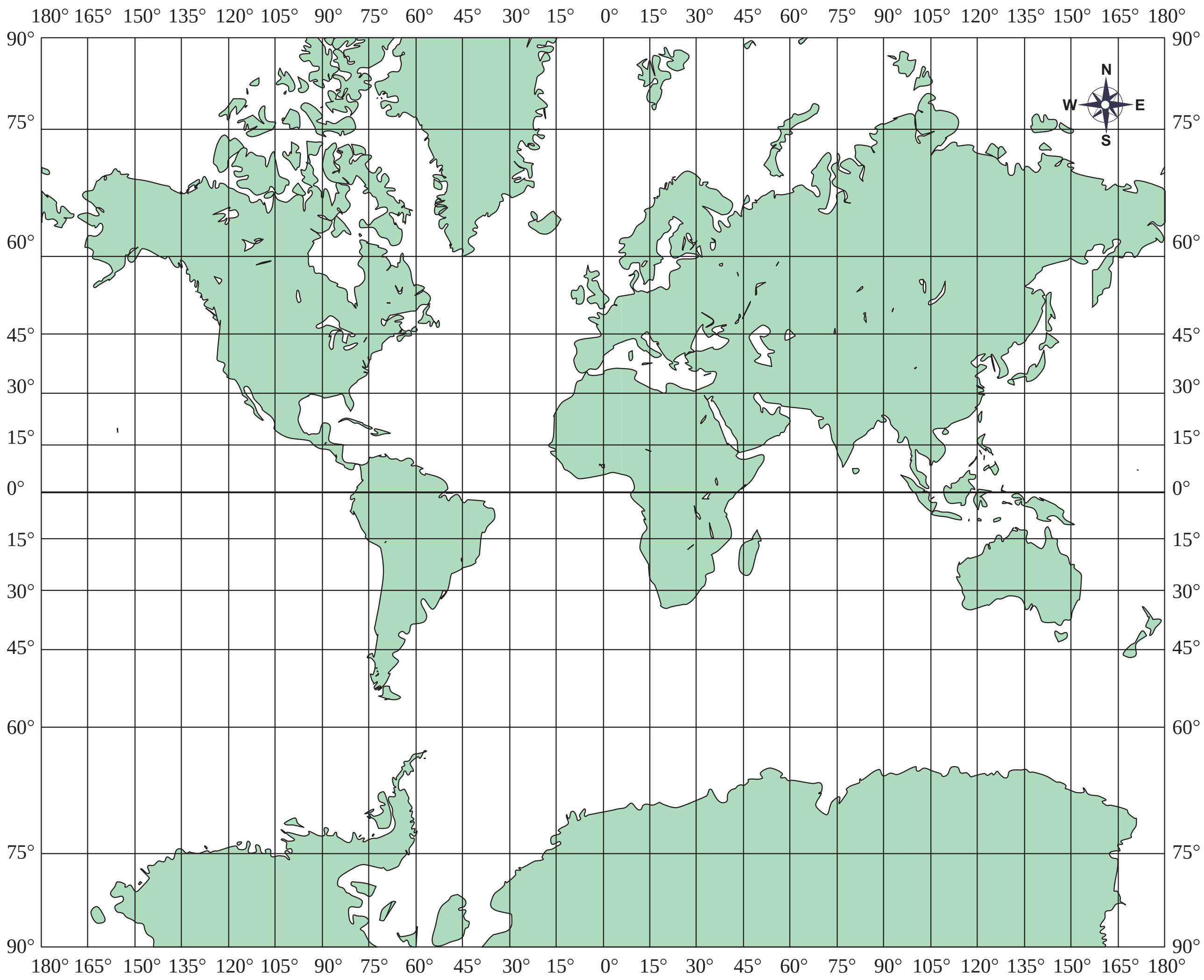


4. Use the second blank map and title it "Latitude and Longitude Coordinates for Ocean Landmarks." Plot and label the following latitude and longitude coordinates. The following locations represent land areas that have a tie to the oceans and others represent actual ocean "seamarks." (degrees = °)

Location	Latitude	Longitude	Ocean Significance
Bering Sea	58°N	160°W	king crab fishing
Chesapeake Bay	38°N	77°W	nursery grounds for the Atlantic
Denmark Strait	68°N	25°W	underwater marine waterfall
Maine	43°N	70°W	lobster fishing
Marianas Trench	11°N	142°W	deepest point in the ocean at 6.8 miles
Mauna Kea	19°N	155°W	highest mountain on Earth rises 33,465 feet from sea
Newfoundland	53°N	56°W	cod declines
New York/ New Jersey beaches	41°N	73°W	medical wastes
Alaskian coast	48°N	161°W	60,000 Nike shoes spilled from a cargo ship May 1990
Peru	12°S	77°W	El Nino
Scandinavia	63°N	14°E	cod liver oil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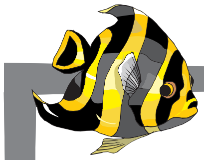


Practice

Use the list below and your completed maps on the previous pages to complete the following statements. **One or more terms will be used more than once.**

Arabian Sea
Arctic Ocean
Atlantic Ocean
Gulf of California
Gulf of Mexico
Indian Ocean
Mediterranean Sea
Pacific Ocean
Philippine Islands

1. The ocean that borders the west coast of North America and South America is the ______________________________ .

2. The ocean that touches the Indian Coast is the ______________________________ .

3. The ocean located at the North Pole is the ______________________________ .

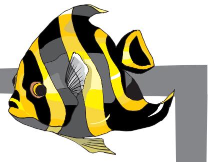
4. The ocean that separates South America from Africa is the ______________________________ .

5. The ocean that separates Asia from North America is the ______________________________ .

6. The ocean that touches the east coast of North America and the west coast of Europe is the ______________________________ .

7. The ocean that touches the east coast of Florida is the ______________________________ .

8. The body of water that touches the west coast of Florida is the ______________________________ .

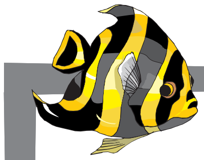


9. The group of islands located in the western Pacific Ocean and east of the China Sea is the ____________________ .

10. The sea located off the coasts of France, Italy, and Spain is the ____________________ .

11. The gulf that touches the west coast of Mexico is the ____________________ .

12. The sea between eastern Africa and western India is the ____________________ .



Lab Activity 2: Postcards from the Oceans

Investigate:

- Create a postcard that illustrates and describes one of the world's oceans, gulfs, or seas that you may study in class.

Materials:

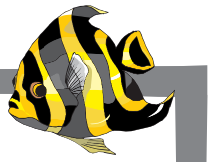
- colored pencils or crayon
- paper or file folder cut to 8″x10″
- reference books or Internet access to research different oceans and seas
- magazine pictures or Internet pictures of oceans and seas

Procedure:

1. Select from the following list of **Bodies of Water** for the location or topic of your postcard. Check with your teacher to see that no other student selected the same body of water.

Bodies of Water

Oceans	Seas		Gulfs
Antarctic Ocean	Adriatic Sea	Kara Sea	Gulf of Aden
Arctic Ocean	Aegean Sea	McKinley Sea	Gulf of Alaska
Indian Ocean	ArabianSea	Mediterranean Sea	Gulf of Finland
North Atlantic Ocean	Baltic Sea	North Sea	Gulf of Mexico
North Pacific Ocean	Barents Sea	Norwegian Sea	Gulf of Oman
South Atlantic Ocean	Beaufort Sea	Red Sea	Gulf of Thailand
South Pacific Ocean	Bering Sea	Sea of Japan	Persian Gulf
	Black Sea	Sea of Okhotsk	
	Caribbean Sea	South China Sea	
	Caspian Sea	Tasman Sea	
	Coral Sea	Tyrrenian Sea	
	East China Sea	Yellow Sea	
	Ionian Sea		



2. Use textbooks, library books, or the Internet to research your body of water. Your postcard summary should include the following six characteristics of your body of water.

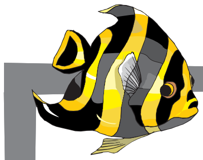
   - climate
   - water temperature
   - marine life
   - nearby countries
   - influence on local countries
   - interesting piece of information about the area

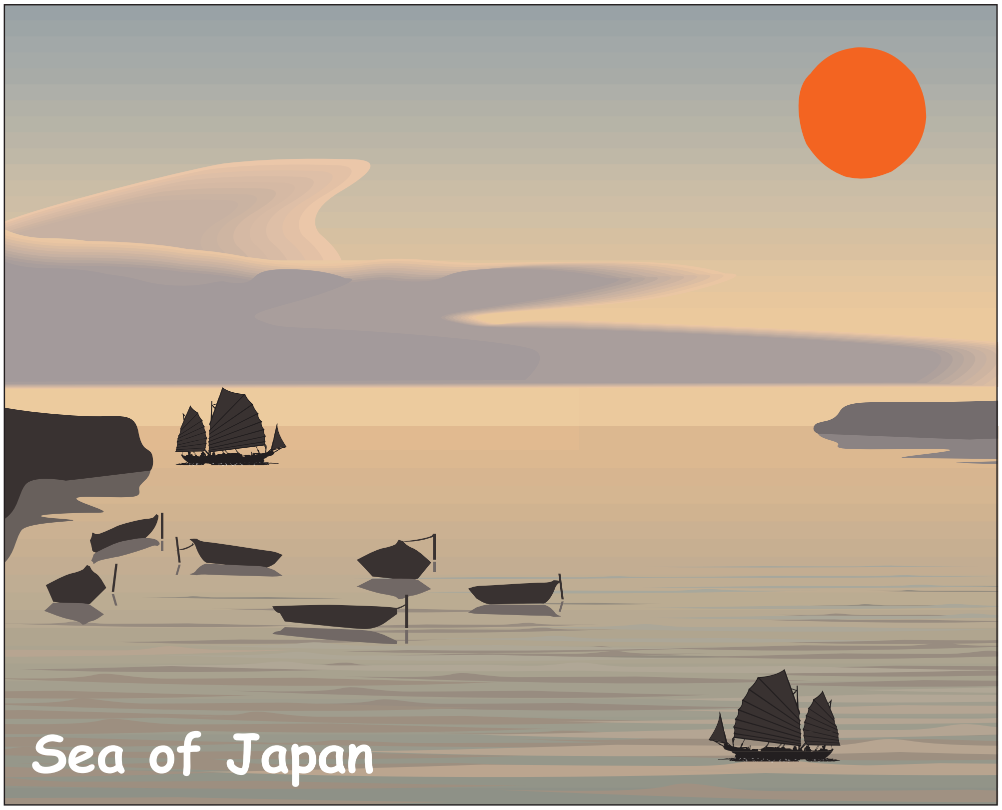
3. The postcard front should have a colored drawing based on your interesting piece of information about the body of water. (Photos from magazines or Internet may also be used).

4. On the back of the postcard in the upper left side, you will write a short description of your picture and a summary, including the characteristics listed above in #2. In the message area of the postcard, describe your imaginary (or real) visit to this location.

5. On the back of the postcard in the upper right side, you will draw a stamp representing something from a country next to your body of water. Address the postcard.

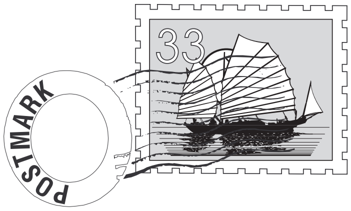
   See example on following page.





Short description of picture:

Summary:



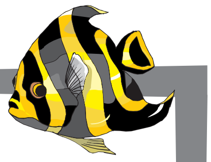
Dear Little Sis,

I just visited the Sea of Japan. Did you know the Sea of Japan is an arm of the Pacific Ocean? If you traveled across the Sea of Japan, you could get to Korea or Russia. Miss you! You will have to come with me next time!

Your big sis,

Suzy

Betty Smith
222 N. Ride Street
Miami, FL 33257



Practice

Use the list below to write the correct term for each definition on the line provided.

biological oceanographers
chemical oceanographers
drilling platforms
geological oceanographers
hydrosphere
ocean
oceanographers
oceanography
physical oceanographers
seas
thermal energy
tidal power
topography
underwater research vehicle

_____________________________ 1. detailed charting of the features of an area; heights, depth, and shapes of the surface of an area

_____________________________ 2. scientists who study ocean sediments and the topography of the ocean floor

_____________________________ 3. an energy source obtained from the ocean's tides

_____________________________ 4. the vast body of saltwater that covers almost three-fourths of Earth's surface

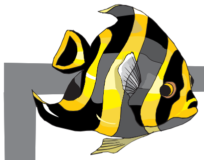
_____________________________ 5. an energy source obtained from the ocean's direct absorption of sunlight and transformed to heat

_____________________________ 6. ships or stationary structures designed to obtain sediment, rock samples, gas, or oil from the deep-ocean floor

_____________________________ 7. scientists who study the distribution, natural history, and environment of marine life

_____________________________ 8. scientists who study the ocean

_____________________________ 9. waters of the Earth



______________________________ 10. scientists who study chemical composition of seawater and the chemical reactions that occur in seawater

______________________________ 11. submersible or submarine specially equipped to explore and study the deep areas of the ocean

______________________________ 12. smaller bodies of saltwater which are frequently enclosed by land

______________________________ 13. the study of Earth's oceans

______________________________ 14. scientists who study the change in seawater and the motion of seawater

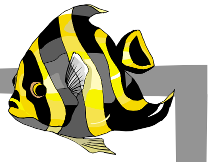
Unit 2: Measuring the Ocean

Unit Focus

This unit describes how oceanographers measure the ocean's chemical and physical characteristics. Students will learn specific chemical and oceanic physical features, such as salinity, density, and temperature, and the instruments used to measure these features.

Student Goals

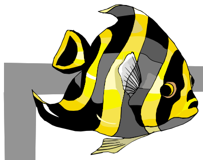
1. Define salinity.
2. Identify methods used to determine salinity.
3. Recognize the relationship between salinity and density of the oceans.
4. Give examples of how humans employ technology to study the ocean floor.



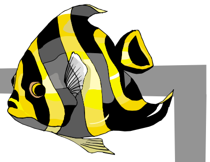
Vocabulary

Study the vocabulary words and definitions below.

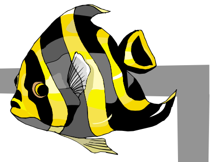
clarity	the state or quality of being clear or transparent to the eye; clearness of water; depth to which light can travel in water
corer	a cylindrical device used to obtain a sample of sediment from the ocean floor
decompression	the gradual return of persons (such as deep-sea divers) or conditions to normal atmospheric pressure
density	in *science*—the mass (amount of matter) of an object per unit volume (space occupied); density = mass / volume $(d) = \frac{m}{v}$
dredge	a scoop-like device used to collect rock samples from the ocean floor
drift bottle	an instrument used to measure the direction and speed of ocean currents
echo sounding	a method that uses sound waves to determine the depth of the ocean floor; also called the *precision depth recorder*
grab sampler	a device that picks up sediment from the ocean floor
hydrometer	an instrument that measures the density of water



ion	an electrically charged atom or molecule formed by gaining or losing one or more electrons
Nansen bottle	an instrument that records the temperature at the ocean's surface and at various depths below the surface
plankton	small, usually microscopic plant or animal organisms that float or drift in the ocean
plankton net	a cone-shaped net of fine mesh that is pulled through water to collect plankton
salinity	the measure of the amount of dissolved salts (solids) in seawater
SCUBA	acronym for **s**elf-**c**ontained **u**nderwater **b**reathing **a**pparatus; portable air tank used by divers
secchi disk	an instrument used to measure the clarity (clearness) of water
seine net	a fishing or sampling net that hangs straight in the water, separating one area from another
seismic profiling	echo sounding using powerful sound waves that reach below the surface of the ocean floor

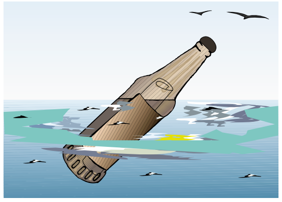


side scan sonar	a method that uses sound waves to view a wide area of the ocean floor; provides pictures of objects on the ocean floor
sodium chloride	NaCl (chemical formula); common table salt; the most common salt in seawater
titration apparatus	an instrument that measures the amount of substances in seawater
trawl	a large net pulled along the bottom of the ocean to gather animals that live on the ocean floor



Introduction: Measuring the Ocean—Collecting Information

Most oceanographers study the ocean with a specific purpose in mind. Some may study the chemical composition of seawater. Others may study its physical properties. For example, a *chemical oceanographer* may measure the amount of dissolved salts in seawater. This would help to detect changes that could affect different organisms. On the other hand, a *physical oceanographer* may want to discover the direction and speed of the ocean's currents. To collect this information, the oceanographer may use something as simple as a bottle with a message sealed inside it, which drifts across the ocean until someone along a coast discovers it. In contrast, a *geological oceanographer* may have to use complex instruments capable of bouncing sound waves off the ocean floor in order to chart the ocean's topography.



Oceanographers may use something as simple as a bottle with a message sealed inside it.

The Ocean's Chemical and Physical Features and How They Are Measured

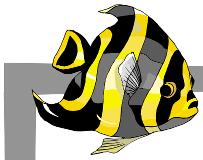
Salinity. **Salinity** is the measure of the amount of dissolved solids, or salts, in seawater. Water dissolves many materials. It's easy to see this when we spoon sugar into a glass of tea, but it's rare—in fact nearly impossible—to observe rainwater percolating through the soil and dissolving weathered rock and minerals. Whether we see it or not, that is what happens. After passing through soil, rainwater carries dissolved minerals (mostly salts) into rivers, and rivers then carry these minerals into the ocean.

Knowing the salinity of specific regions helps scientists determine the location of different organisms. Certain kinds of ocean life thrive in certain salinities. Interestingly, ocean water has a similar salinity to that of our own body fluids—about three percent.

Major Ions Found in Saltwater

Ion	Symbol	Percentage of Ions in Seawater by Weight
Chloride	Cl^-	55.07
Sodium	Na^+	30.62
Sulfate	SO_4^{2-}	7.72
Magnesium	Mg^{2+}	3.68
Calcium	Ca^{2+}	1.17
Potassium	K^+	1.10
trace elements*		.64
		100.00

* Elements in amounts less than on part per million.

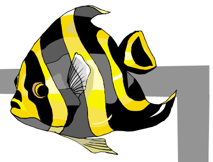


To measure salinity, oceanographers use several methods. One method is measuring the **ions** concentrated in the water sample (see previous page). When salts dissolve in water they form ions.

A total of six major ions are responsible for about 99% of the dissolved salts in the ocean. Some of these ions are sodium (Na) and chloride (Cl), the two ions that make up **sodium chloride** (NaCl), or salt. Other ions that can be measured are sulfate (SO_4), magnesium (Mg), calcium (Ca), and potassium (K). Other elements dissolved in seawater and present in concentrations less than one part per million are called *trace elements*. For example, bicarbonate (HCO_3) is a trace element found in seawater at .40 percent. By measuring these ion concentrations, oceanographers obtain the approximate salinity of seawater. Conductivity testing is another method used to determine salinity. An electrical current is passed through the water. The more NaCl ions there are, or the higher the salinity, the more easily the electrical current flows. Oceanographers also use a *refractometer* to measure the *refraction* (bending) of light through a sample of water. The change in angle of the light changes as the salinity changes.

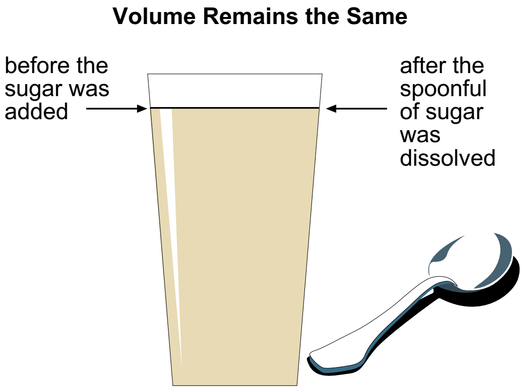
Density. Recall a documentary you've seen on whales, or giant sea turtles. Remember how you watched them glide gracefully through the water, moving their thousands of pounds with seemingly little effort? Why didn't that blue whale weighing 150 tons sink to the bottom? Now remember a documentary or movie that depicted dinosaurs, or rhinoceros, or even elephants using their feet to walk over land. Note how much harder it is for huge land animals to travel. What accounts for the ease with which large animals can move through the water as compared to the large animals traveling on land?

Large land animals have to balance and support their own weight, carrying a thousand or so pounds across the ground. But ocean animals are assisted in carrying their weight by the **density** of ocean water. To understand the concept of density, carry out this simple experiment. First, pass your hand through air. Then pass your hand through water. Which movement took more effort? Which is more dense, air or water? As you've discovered, water is more dense than air. (In fact, water is 800 times more



dense than air.) Now add to pure water all the salt that it collects as it heads towards the ocean, and you can see that seawater is much more dense than air.

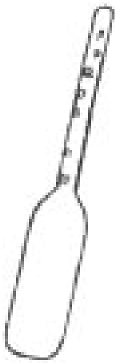
To determine density, we measure the mass in a particular volume of space. Take, for example, a glass of tea. If you dissolve a spoonful of sugar in it, its volume—or the space it filled—does not increase. But its mass—or its amount of matter, does increase. The high mass of salts (or its salinity) in a particular measure of seawater, or its density, helps to support the giant blue whale on its travels through the ocean.



Density—If you dissolve a spoonful of sugar in a glass of tea, its volume—or the space it filled—does not increase. But its mass—or its amount of matter, does increase.

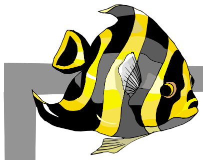
Less dense substances will remain above more dense substances. Air remains above water because it is less dense than water. Fresh water hasn't collected salts and minerals, so it will remain above heavier, salt-filled seawater. Oil, although it may seem more dense than ocean water, is actually less dense. Here's the proof. Remember pictures on the news of an oil freighter spilling its load? Remember seeing the oil floating across the ocean's surface—producing an oil slick? The oil floated and spread, like a poisonous blanket. If that oil had been more dense than seawater, it would have sunk.

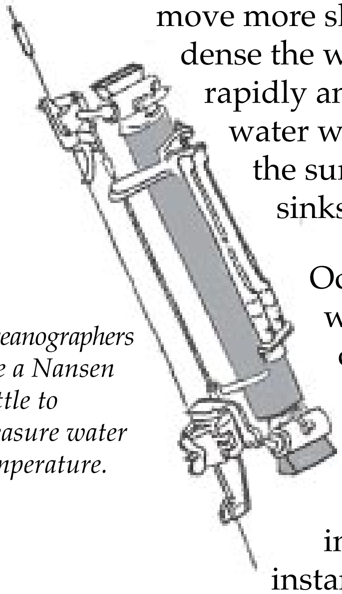
To measure the density of a substance, oceanographers use a **hydrometer**. A *hydrometer* is a weighted glass tube that floats upright in water. It will float high in water that is heavy or more dense, such as seawater, and it will sink in water that is light or less dense, such as fresh water.



A hydrometer is a weighted glass tube that floats upright in water.

Temperature. Temperature also increases or decreases density. Heat is a form of energy. When heat is added to water, molecules move more rapidly and farther apart. When the water is cooled, the molecules move towards one another and consequently there will be more molecules per cubic centimeter. When water molecules





Oceanographers use a Nansen bottle to measure water temperature.

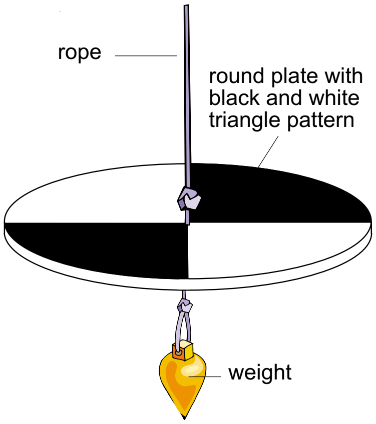
move more slowly and remain closer together, the more dense the water will be. When molecules in water move rapidly and are, therefore, farther apart, the less dense the water will be. So warm water is lighter and remains on the surface, whereas cooler water is more dense and sinks.

Oceanographers use a **Nansen bottle** to measure water temperature. They lower the bottle to different depths, collect some water, and measure its temperature. Then they bring the sample to the surface for further analysis.

Studying water temperature has raised some interesting questions about marine life. For instance, how do organisms keep from freezing to death in frigid water temperatures? The answer? Some organisms have a kind of *antifreeze* in their blood that protects them against freezing—just as the antifreeze in a car's radiator keeps the engine block from freezing in the winter.

How do organisms keep from freezing to death in frigid water temperatures?

Clarity. Marine plants, like nearly all plants on Earth, need light to produce food and survive. By studying how deeply light penetrates different regions of the ocean, oceanographers can determine where plant life could survive and where it could not survive.



secchi disk

Oceanographers use a **secchi disk** to measure **clarity**, or clearness, of water. The secchi disk is a round plate with a black and white triangle pattern painted on its surface. Oceanographers lower the secchi disk on a rope into the ocean until the black and white pattern can no longer be seen. By measuring the length of rope that's been submerged into the water, oceanographers can measure the number of meters light penetrates in a particular area of the ocean.

Composition. Take a look at a periodic table printed in Appendix A. This chart includes every known element scientists have discovered up to now. Then imagine reaching down into the ocean and scooping up a few teaspoonfuls of water in the cup of your hand. In your hand you now hold almost all of the chemical elements that exist in nature.

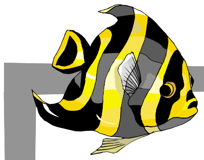
Scientists have also discovered that the proportions of the major elements vary only slightly from one ocean to another. This finding supports the notion that seawater flows from one ocean to another. It may take thousands of years, but eventually a particular cup of water will circulate through all the oceans on Earth.

Three particular gases that chemical oceanographers test for in seawater are oxygen, nitrogen, and carbon dioxide. Each of these gases is used by plants and other organisms for particular processes. For example, oxygen is used by plants and animals during respiration. And carbon dioxide is used by plants during photosynthesis.

To determine the amount of these gases in seawater, oceanographers use a **titration apparatus**. A *titration apparatus* consists of pipettes, or tubes, which slowly drop a chemical indicator into seawater, allowing scientists to see if a chemical reaction will occur and how quickly. The nature of the chemical reaction indicates the amount of oxygen, nitrogen, and carbon dioxide the seawater contains.

Currents. The movement of large masses of ocean water is called a *current*. The study of currents reveals both the direction and speed of ocean waters. Moving water is a powerful force and can carry marine life great distances. For example, some marine organisms begin their life near the shore, and then they are carried out to sea as eggs or larvae by currents. Some marine life that live near shore feed upon plants and organisms carried in by ocean currents.

Moving water is a powerful force and can carry marine life great distances.

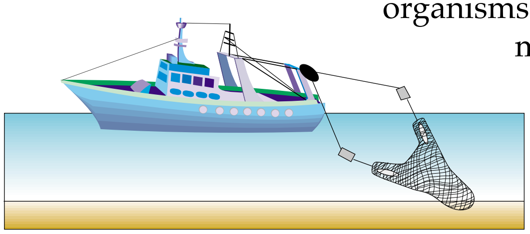


We're all familiar with the cartoon of a man or woman stranded on an island who finds a message in a bottle. In fact, oceanographers use **drift bottles** to collect physical data about ocean currents. They release bottles (in the oceans) containing cards that ask the finder the date, time, and location of the discovery, and request that the finder return the card. Oceanographers use this information to chart ocean currents.

Sampling

The Ocean Floor. When we think of the ocean floor, it's easy to imagine a very dark and cold place with little life. But the ocean floor supports a large community of organisms. Some of these life forms, such as lobsters, crabs, and clams, even make their way to our dinner tables. The group of organisms that live in or on the ocean's bottom are known as *benthic organisms*.

Oceanographers are particularly interested in the life styles of benthic organisms because their food supply is limited. As you know, plants survive by using sunlight for photosynthesis. But light does not penetrate to all parts of the ocean floor, and so there are no plants for benthic organisms to feed on. Consequently, benthic organisms are dependent for food or organic materials from the surface that settle to the bottom. To study the benthos, the organisms that live in or on the ocean's bottom, oceanographers use **trawls**—large nets that are pulled along the bottom to capture animals.



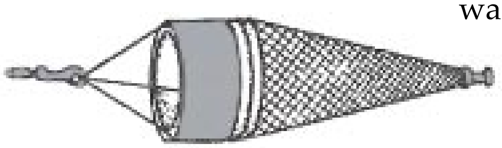
trawl net

Oceanographers also collect *sediments*—actual samples of the seafloor—to determine the *age* and *composition* of the ocean floor. Sediment samples are collected by mechanical devices. A device known as a **grab sampler** looks like a giant set of teeth which bites into the ocean floor. In its "mouth," it collects a sediment known as a *grab sample*. A **dredge**—a kind of giant scoop—collects rock samples as it is dragged along the ocean floor.

A dredge is a kind of giant scoop that is dragged among the ocean floor.

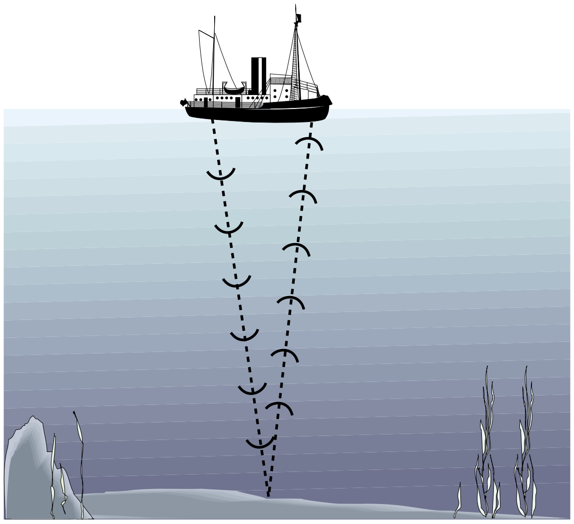
A device known as a **corer** also removes sediment samples from the seafloor. The corer works in the same way as an apple corer and drills a hole in the seafloor to collect a cylindrical or tube-shaped sample. From these core samples, oceanographers can study the changes in marine life populations over thousands of years and the rate at which sediment has accumulated on the ocean floor.

Above the Ocean Floor. All marine life depends in some way on a large group of plants and animals invisible to the human eye. These tiny organisms are called **plankton**. To gather these life forms for study, oceanographers tow a cone-shaped net called a **plankton net** through the water. To capture fish that travel in schools, oceanographers use stationary nets called **seine nets**. By setting these nets at particular depths, oceanographers can capture different kinds of fish.



plankton net

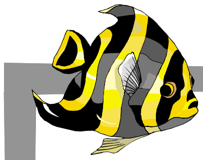
Depth. Just as the land we live on is uneven, ranging from deep valleys to high mountains, the depth of the ocean floor varies greatly from place to place. Until the 1920s, little was known about the *topography*—or rises and dips—of the ocean bottom. Scientists used to tie a weight on a rope and lower it until it reached bottom. This method, as you can imagine, was slow and imprecise.



The echo-sounding method sends sound waves through the water to the ocean floor and measures the time it takes for the sound wave to bounce off the ocean floor and (return) back to the ship.

In the 1920s, *sonar* (sound navigation and ranging) was invented. Sonar uses the **echo-sounding** method, sending sound waves through the water to the ocean floor. By measuring the time it takes for sound waves to bounce off the ocean floor and echo (return) back to the ship, oceanographers can chart the ocean bottom.

Interestingly, the use of submarines in warfare during World War II helped speed the refinement of sonar. Submarine



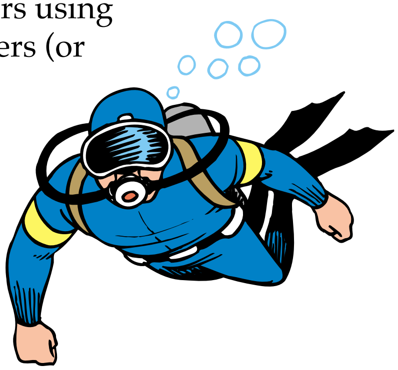
personnel needed to remain aware of their surroundings in order to survive their "blind" travels through the ocean. In order to "see," subs sent out sonar and were able to detect, among other things, enemy ships and subs. Some sea animals, for example dolphins and porpoises, use a system similar to sonar to "see" in their underwater worlds.

Seismic profilers and **side scan sonars** are two powerful types of echo sounding methods. **Seismic profiling** uses powerful sound waves produced by explosions. These waves reach below the surface of the seafloor and bounce off buried rocks. This method gives researchers a deeper geological profile of the ocean floor. Side scan sonars use sound waves to view a wide area of the seafloor. Sound waves are sent out to the sides of the ship and are received by an instrument towed behind the ship. Side scan sonars provide pictures of objects on the seafloor and can be used to locate shipwrecks and large schools of fish.

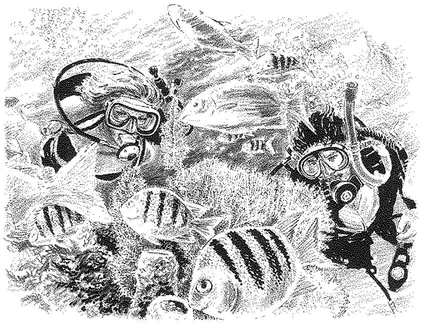
Satellites gather more data faster than ocean vessels with echo sounding can. Signals sent from a satellite are bounced off the ocean surface rather than the ocean floor. Utilizing ocean surface data to map the ocean floor works because the water level of the ocean varies. Water will pile up over undersea mountains and dip over undersea trenches. The dips and hills in the ocean level are revealed by accurate satellite measurements. These measurements are fed into a computer to produce a picture of the ocean floor.

Diving. Most of us have used diving equipment or have seen the air tanks divers strap to their backs to breathe underwater. These tanks are called *aqualungs* or **SCUBA** (**s**elf-**c**ontained **u**nderwater **b**reathing **a**pparatus). Scuba gear enables divers to spend up to an hour underwater exploring up close the marine life and habitats in the upper levels of the ocean.

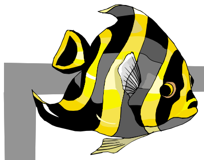
Diving underwater does have its problems. Water pressure—or the force exerted by water—increases with depth. Divers using scuba tanks can withstand pressure to 36 meters (or approximately 118 feet) below the surface. Beyond 36 meters, divers need to wear pressure suits. At depths requiring equipment, divers must go through **decompression** very slowly as they swim to the surface. Most of the ocean floor is too deep for divers to explore without being harmed by extreme water pressure.



Summary



To fully understand Earth's oceans, oceanographers attempt to measure their physical features. Measuring salinity, density, temperature, clarity, composition, and currents, and sampling the ocean floor takes specific and often varied equipment.



Practice

Use the list below to complete the following statements.

benthos
corer
decompression
density
drift bottle
geological
salinity
satellites
SCUBA
sediment samples
side scan sonars
sonar

1. A ______________________________ may be used by oceanographers to study the direction and speed of ocean currents.

2. ______________________________ is the measure of the amount of dissolved solids (salt) in seawater.

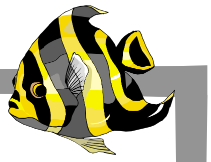
3. To determine ______________________________ , we measure the mass in a particular volume of space.

4. Divers use air tanks known as ______________________________ for exploring and for studying underwater habitats.

5. When divers surface from depths of more than 36 meters, they must go through ______________________________ .

6. Scientists use ______________________________ to bounce sound waves off the ocean floor to measure depth.

7. Organisms that live in or on the ocean's bottom are known as ______________________________ .



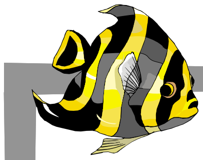
8. Oceanographers collect ______________________________ to study the seafloor.

9. A ______________________________ removes cylindrically shaped sediments from the seafloor.

10. Seismic profilers use powerful sound waves produced by explosions to give researchers a ______________________________ profile of the ocean floor.

11. ______________________________ provide pictures of objects on the seafloor that can be used to locate shipwrecks and large schools of fish.

12. A picture of the seafloor can also be produced from ______________________________ that bounce signals off the ocean surface.



Practice

Match each **feature** *of the ocean with the correct* **instrument** *used to measure or sample it. Write the letter on the line provided.*

______ 1. temperature

______ 2. depth

______ 3. clarity of water

______ 4. gases in seawater

______ 5. density

______ 6. currents

______ 7. sediments on seafloor

______ 8. plankton

______ 9. benthos

A. drift bottle

B. grab sampler, dredge, corer

C. hydrometer

D. Nansen bottle

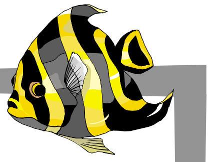
E. secchi disk

F. sonar

G. titration apparatus

H. trawl

I. plankton net



Practice

Answer the following using complete sentences.

1. How do oceanographers use echo sounding to determine the depth of the ocean? ____

____

____

2. What is the difference between seismic profiling and side scan sonar? ____

____

____

____

3. What does SCUBA stand for? ______________________________

____

4. What are two advantages in using SCUBA to explore marine life?

____

____

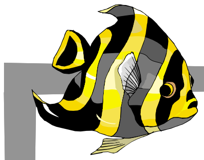
____

5. What are three ways to collect sediments from the ocean floor? ____

____

____

____



Lab Activity: Ocean Depth

Investigate:

- Find the depths of the ocean in given locations.
- Plot the depths of the ocean on a graph to make a topographical map.

Materials:

- data chart
- pencil
- paper

Much of the ocean's topography has been mapped by the use of echo-sounding devices. In echo sounding, sound is sent from a ship's transmitter to the ocean's bottom (see illustration on page 43). The sound bounces off the ocean floor and is picked up by a receiver on the ship. Scientist know that the speed of sound in water is 1,524 meters per second (m/s). By using the speed of sound and applying the formula below, the scientists can measure and map the depth of the ocean.

Formula for Measuring Ocean Depth

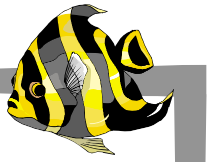
$$D = \frac{1}{2}T \times V$$

D = Depth **T = Time**

V = Speed of Sound in Water (1,524m/s)

Procedure:

1. Find the depths of the ocean in the given locations.
2. Plot the depths on the graph to make a topographical map.



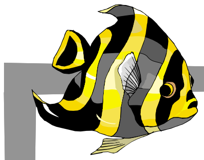
Observation:

A ship traveling in the Gulf of Mexico receives the following sonar signals:

signals	location	time
1st	location A	2 seconds
2nd	location B	4 seconds
3rd	location C	8 seconds
4th	location D	16 seconds
5th	location E	12 seconds
6th	location F	8 seconds
7th	location G	4 seconds
8th	location H	4 seconds
9th	location I	4 seconds
10th	location J	2 seconds

Find the **depth in meters** *at each location. Remember to use the* **formula** *on the previous page to complete the answers.*

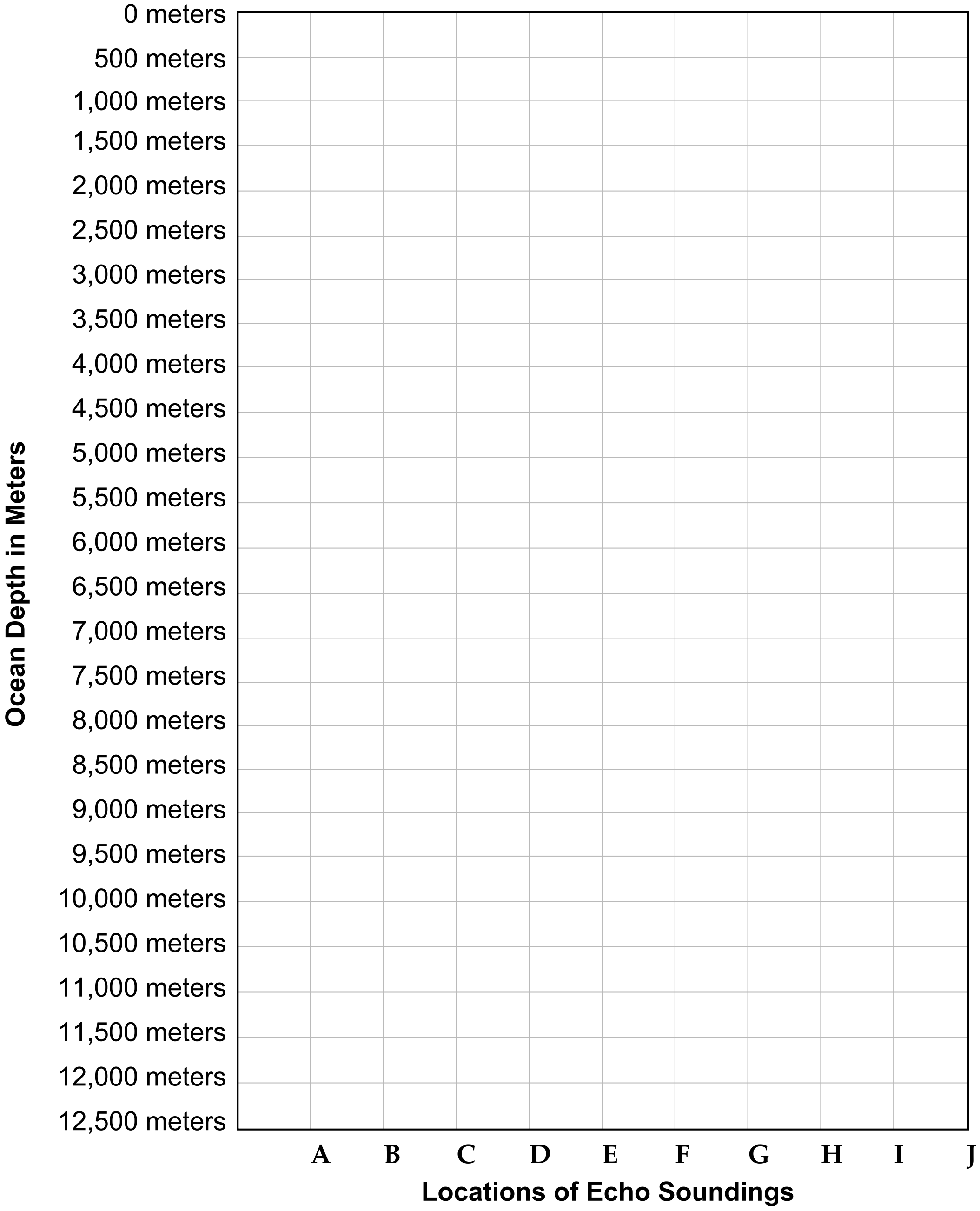
1. Depth at A: ______________________________
2. Depth at B: ______________________________
3. Depth at C: ______________________________
4. Depth at D: ______________________________
5. Depth at E: ______________________________
6. Depth at F: ______________________________
7. Depth at G: ______________________________
8. Depth at H: ______________________________
9. Depth at I: ______________________________
10. Depth at J: ______________________________

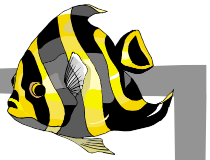


Analysis:

Plot the **depth data** *from the previous page on the graph below. Using your own paper, draw a map of this part of the Gulf of Mexico's ocean floor. Round numbers to the nearest whole number to plot on the graph.*

Ocean Depth Measured by Sounding





Use your **graph** *on the previous page to answer the following.*

11. After examining the profile of the ocean floor that you constructed, what can you conclude about the depth of the ocean?

    ____

    ____

12. What was the slowest signal time received by the sonar? ________

    ____

    Why was this the slowest? _________________________________

    ____

13. What was the fastest signal time received by the sonar? _________

    ____

    Why was this the fastest? _________________________________

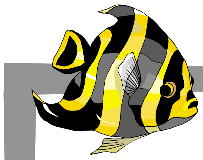
    ____

14. What is the importance of echo sounding to oceanographers? _____

    ____

    ____

    ____



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. the measure of the amount of dissolved salts (solids) in seawater

______ 2. in *science*—the mass (amount of matter) of an object per unit volume (space occupied)

______ 3. an instrument that measures the density of water

______ 4. an instrument that records the temperature at the ocean's surface and at various depths below the surface

______ 5. an instrument used to measure the clarity (clearness) of water

______ 6. the state or quality of being clear or transparent to the eye; clearness of water; depth to which light can travel in water

______ 7. an instrument that measures the amount of substances in seawater

______ 8. an instrument used to measure the direction and speed of ocean currents

______ 9. an electrically charged atom or molecule formed by gaining or losing one or more electrons

______ 10. NaCl (chemical formula); common table salt; the most common salt in seawater

A. clarity

B. density

C. drift bottle

D. hydrometer

E. ion

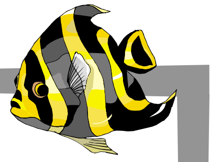
F. Nansen bottle

G. salinity

H. secchi disk

I. sodium chloride

J. titration apparatus



Practice

Use the list below to write the correct term for each definition on the line provided.

corer
decompression
dredge
echo sounding
grab sampler
plankton
plankton net
SCUBA
seine net
seismic profiling
side scan sonar
trawl

______________________________ 1. a cylindrical device used to obtain a sample of sediment from the ocean floor

______________________________ 2. the gradual return of persons (such as deep-sea divers) or conditions to normal atmospheric pressure

______________________________ 3. acronym for **s**elf-**c**ontained **u**nderwater **b**reathing **a**pparatus; portable air tank used by divers

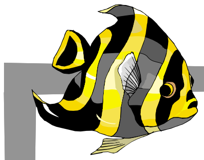
______________________________ 4. a large net pulled along the bottom of the ocean to gather animals that live on the ocean floor

______________________________ 5. a device that picks up sediment from the ocean floor

______________________________ 6. a scoop-like device used to collect rock samples from the ocean floor

______________________________ 7. small, usually microscopic plant or animal organisms that float or drift in the ocean

______________________________ 8. a fishing or sampling net that hangs straight in the water, separating one area from another



_____________________________ 9. a cone-shaped net of fine mesh that is pulled through water to collect plankton

_____________________________ 10. echo sounding using powerful sound waves that reach below the surface of the ocean floor

_____________________________ 11. a method that uses sound waves to view a wide area of the ocean floor; provides pictures of objects on the ocean floor

_____________________________ 12. a method that uses sound waves to determine the depth of the ocean floor; also called the *precision depth recorder*

Unit 3: The Nature of Seawater

Unit Focus

This unit explains the components of seawater and the differences in salinity throughout the world's oceans. Students will gain knowledge about factors such as precipitation, temperature, location, and evaporation, which affect salinity in the oceans.

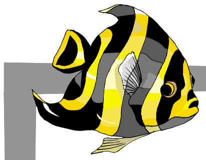
Student Goals

1. Describe how the oceans became salty.
2. Define salinity.
3. Explain how precipitation, temperature, and evaporation affect the salinity of water.

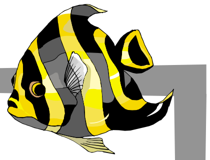
Vocabulary

Study the vocabulary words and definitions below.

acid (acidic)	a compound that joins with a base to form a salt; will cause blue litmus paper to turn red; high concentration of H^+ ions
base (basic)	a compound that joins with an acid to form a salt; will cause red litmus paper to turn blue; high concentration of OH^- ions
brackish	having a lower salinity than normal seawater; a mixture of freshwater and saltwater
buffer	chemical compound that maintains pH level through chemical reactions
condense	to change from a gas or vapor to a liquid
crystallization	a method of desalination involving the freezing of water and then removing the ice crystals to produce freshwater
desalination	a process by which salt is removed from seawater
distillation	a method of desalination involving the evaporation of water with high heat and then condensing it by cooling
evaporate	to change from a liquid into a gas or vapor

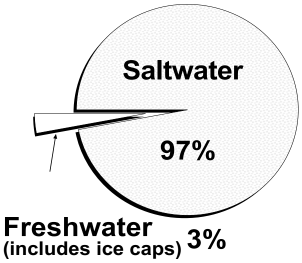


filtration	a method of desalination which involves filtering water through special membranes or materials
hydrologic cycle	the movement of water from the oceans and the land to the atmosphere and then back; also called the *water cycle*, nature's recycling of freshwater *Example*: water evaporates into the air, condenses, and falls back to the ground as precipitation.
hypersaline	water with high levels of salinity
ion	an electrically charged atom or molecule formed by gaining or losing one or more electrons
pH	a measure of the concentration of hydrogen ions (H^+) in a solution expressed as a scale, ranging from less than zero to more than 14, that in turn expresses the concentration of acid or base
sodium chloride	NaCl (chemical formula); common table salt; the most common salt in seawater
thermocline	a layer of water in the ocean where the temperature of the water changes rapidly
water vapor	water in the form of gas

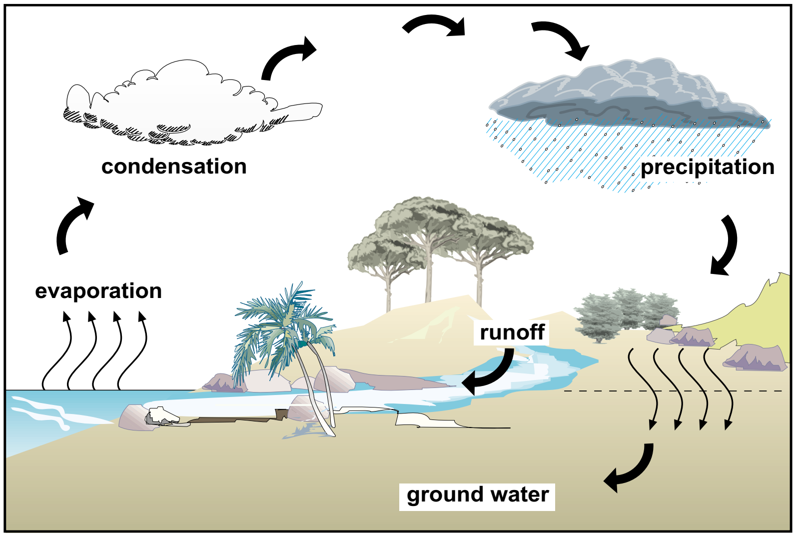


Introduction: The Nature of Seawater

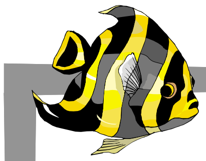
Water appears on Earth in many different places and in many different forms. In oceans, rivers, and lakes, water most often appears as a liquid. Overhead, in banks of clouds drifting by, water has collected as a gaseous vapor. And in glaciers, icebergs, and snow packs, water is in solid form. (Some solid water or ice will melt and become liquid. Some, such as the ice in Antarctica, will never warm above the freezing point.) The *water cycle*, or **hydrologic cycle**, is the movement of water from the ocean and the land to the atmosphere and then back.



Over 97 percent of the water on Earth is too salty to drink! Through evaporation and then precipitation, water becomes purified and free of salt. On the diagram below, follow the pathway of water. One of the paths of the hydrologic cycle, or *water cycle*, is **evaporation**. During evaporation, liquid water turns into a gas. Water molecules at the water's surface move into the air as water vapor. Water vapor is water in a gaseous state. When molecules of water vapor come close enough together, a cloud is formed. The process of cloud formation is called *condensation*. Condensation is the part of the water cycle that typically comes after evaporation. When the clouds become *saturated*, or full, from so many water droplets condensing together, then the droplets fall to the Earth as *precipitation*. Precipitation may be in the form of rain, sleet, or snow.



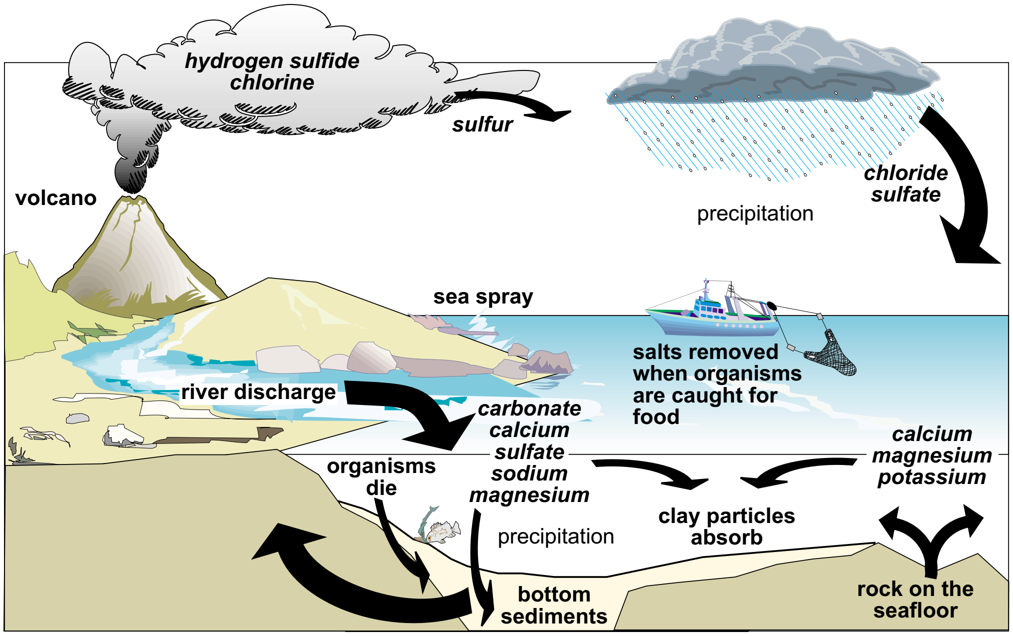
water cycle



Some of the water that returns to Earth will wash into the oceans, lakes, and rivers. This water is called *runoff*. The rest of the water soaks into the ground and becomes *groundwater*. Eventually, the groundwater will return to the ocean through underground channels, where it will continue in the water cycle.

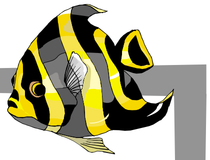
Seawater: So Much to See, So Little to Drink

You may have accidentally swallowed some seawater while swimming in the ocean or gulf. This water, you instantly realized, was far different from *drinking* water. Salts in seawater make it virtually undrinkable. When salts dissolve in water, they form **ions**. Most of the salt in seawater is made up of sodium and chloride ions. Together, these two make up common table salt, or NaCl (**sodium chloride**). These and four other major ions make up a little more than 99 percent of the elements in seawater (see page 37-38). The four other ions are magnesium, sulfate, calcium, and potassium. Although seawater contains almost every element that exists in nature, the others are present only as *trace elements*, such as bicarbonate (HCO_3), and exist in very small quantities.



sea salt cycling - salts are constantly being added and removed from seawater

Where did these elements in the seawater come from? Why are the oceans salty? Well, as the rivers move to the ocean, they dissolve the rocks that they pass over. See the *sea salt cycle* above. The rocks on the riverbeds contain elements that eventually erode and dissolve into the



water. This process takes a very long time! When water evaporates from the ocean and is returned to the land as rain, the dissolved elements are left behind in the ocean. This is why the oceans are salty. Some salts can be removed from the ocean when organisms, such as fish, are taken from the ocean. This percentage of salt loss is very small.

Salinity: Water and Salt

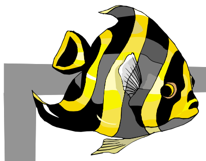
To better understand the composition of seawater, oceanographers measure the amount of dissolved salts in the ocean. Salinity, or the amount of dissolved salts in seawater, is measured in parts of dissolved salts per 1,000 parts of water—or parts per thousand ($\frac{0}{00}$). The average salinity of the ocean is 35 parts of salt per 1,000 parts of water or 35 $\frac{0}{00}$.

Differences in Salinity

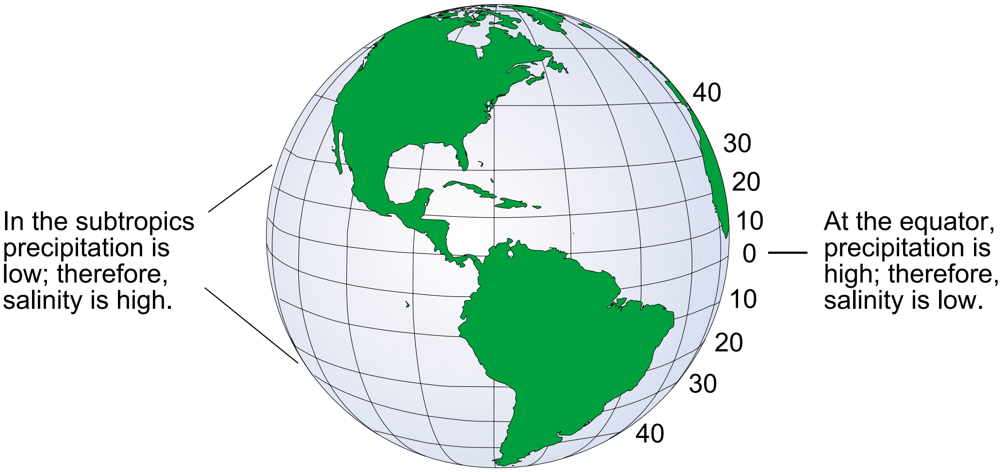
Salinity in the ocean differs from one location to the next. For example, the Red Sea has a salinity reading of 40 and 41 parts per thousand. The Mediterranean Sea has a salinity reading of 38 and 39 parts per thousand. Both these seas have high salinity readings. Bodies of water with high salinities are called **hypersaline**. The Red Sea and Mediterranean Sea are hypersaline because they are in hot, dry areas that have high evaporation and less precipitation than open oceans. Remember, when water evaporates from saltwater, the salt is left behind. Evaporation increases the salinity of saltwater. Other bodies of water which are hypersaline include the Dead Sea, the Persian Gulf, the Great Salt Lake in Utah, and areas around the Gulf of Mexico.

Dead Sea

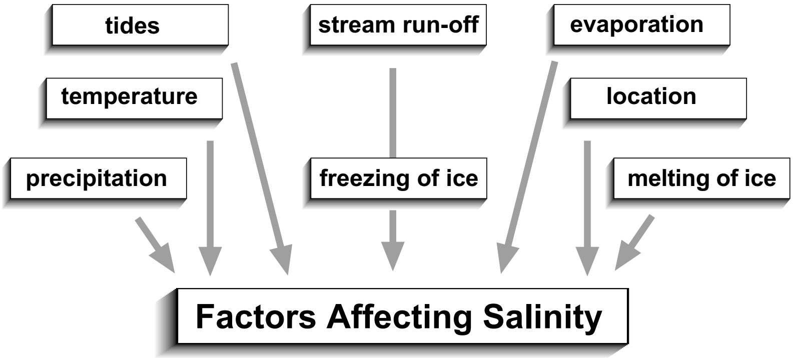
Salinity of saltwater can also change according to latitude. Look at a globe or world map. Locate the area that is 20 degrees north latitude and 20 degrees south latitude. The salinity in this area is about 36 parts per thousand. The salinity at this latitude is higher than at zero degrees



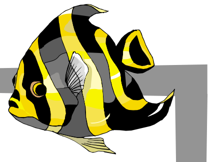
latitude or at the equator. Why do you think that the salinity is lower at the equator? If you answered because it rains more at the equator then you were right! Rain dilutes the water, making it less salty.



Coastal water typically has a lower salinity. Rivers and streams enter the oceans along the coastlines, providing freshwater to the oceans. This freshwater input lowers the salinity of the oceans. Rainwater runoff from the land impacts the salinity of the oceans near the coast as well. Water with a lowered salinity is called **brackish** water. Brackish water is a mixture of freshwater and saltwater.



Salinity can also change as you go deeper in the ocean. The salinity at the bottom of the ocean is greater than at the surface. The change in salinity as you go deeper in the ocean is not uniform. In other words, as you go deeper, salinity does not increase but varies according to factors such as currents and temperature. There is a layer of water in the ocean called the *halocline*. The halocline shows a rapid change in salinity in a depth area between 100 and 200 meters. The change is an increase in salinity. Salinity increases in the halocline because the temperature of the water becomes

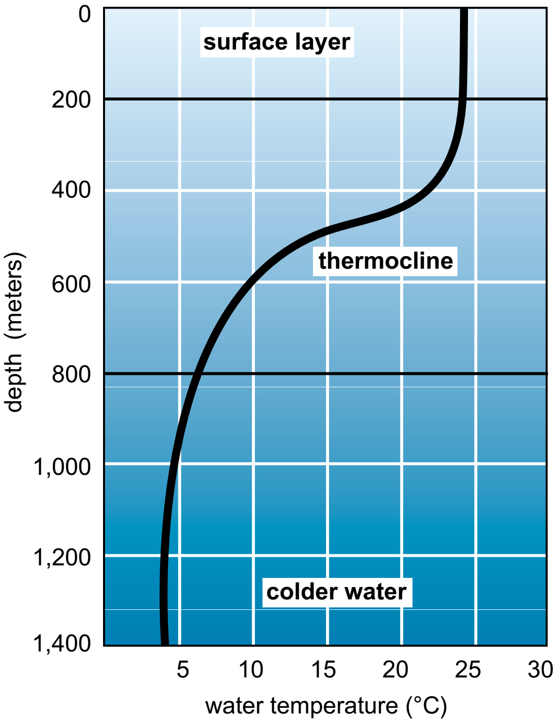


colder at these depths. Cold water contains molecules that are packed closer together. The salt molecules move closer together as well. The molecules moving closer together make salinity higher. In contrast, water at the surface of the ocean is warmer, and the molecules are farther apart, making the water less salty. Other factors besides precipitation, latitude, depth, and temperature affect salinity. These factors are shown in the diagram on page 64.

Temperatures of the Ocean: From Freezing to Warm

The surface temperature of the ocean varies depending on the latitude (its distance from the equator) and the season of the year. Seawater in the Antarctic Ocean during the winter is much colder than the waters in the South Pacific during the summer.

Water at lower depths in the ocean is always colder than water at higher depths and on the surface. On a warm day at the beach, the surface of the ocean, having been warmed by the sun, may feel warm to your skin. As you swim below the water, however, the temperature lowers, and continues to decrease the further down you go. As you'll remember from your reading in Unit 2, warm water is lighter and so remains on the surface, whereas cooler water more dense and sinks.

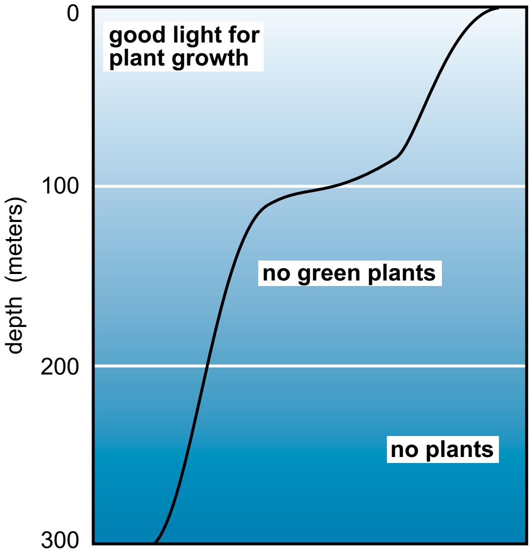


temperature of ocean water decreases with increasing depth

There is a layer of water called the **thermocline** beneath the surface of the ocean where temperature drops radically. If you were swimming through the thermocline, it would be like a sudden burst of cold. Once you passed through it, your body would begin feeling a more gradual drop in temperature as you continued your descent.

Light in Ocean Waters

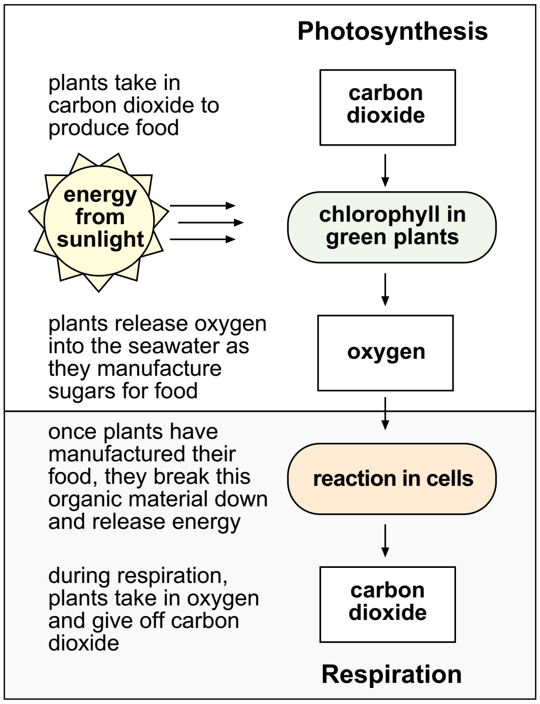
On average, light reaches to about 200 meters below the surface of the ocean, or the distance of two football fields. However, light is not adequate beyond about 100 meters to support photosynthesis (food-making) and plant growth. Beyond about 200 meters complete darkness prevails.



light in ocean waters

Dissolved Gases in Seawater

You've read about dissolved solids, such as salt, in seawater. In addition to solids, seawater also contains dissolved *gases* that come from mixing with air in the atmosphere. Nitrogen, carbon dioxide, and oxygen are the most common dissolved gases found in the ocean.



photosynthesis and respiration cycle

Both plants and animals play roles in removing and replacing gases in seawater. Plants take in and release both oxygen and carbon dioxide. In the process known as *photosynthesis*, plants use carbon dioxide to produce food. During this stage, plants release oxygen into the seawater as they manufacture sugars for food. Once plants have manufactured their food, they break this organic material down and release energy. This is called *respiration*. During respiration, plants take in oxygen and give off carbon dioxide—a reversal of the exchange of gases occurring during photosynthesis. Animals also undergo respiration as they burn oxygen to release energy from food.

CO_2: Buffering Seawater

Extreme shifts in the concentration of either **acids** or **bases** in seawater would threaten or kill many organisms. The measure of the concentration of acids and bases in a solution is done on a scale called **pH**. The scale ranges from less than zero to more than 14. A measure of less than seven on the scale indicates a concentration of acids and a *high* concentration of hydrogen ions (H^+); a measure of greater than seven indicates a *high* concentration of base, a high concentration of OH^- ions, and a low concentration of hydrogen ions (H^+). There is a constant chemical reaction in seawater that maintains a pH range of 7.5 to 8.5—the range that will support marine life.

Essential to this chemical reaction is carbon dioxide (CO_2). Carbon dioxide combines with water to produce carbonic acid, or H_2CO_3. When there are too many hydrogen ions (H^+) released in seawater, chemical reactions occur and the additional hydrogen ions are absorbed by forming more H_2CO_3. If there are not enough hydrogen ions (H^+) to maintain the necessary pH range, carbonic acid in the seawater releases hydrogen ions into the water. Without this **buffering** system, few marine animals could survive changes in the ocean's pH.

Desalination: A New Source of Freshwater

Freshwater—once taken for granted—is now in short supply. Increases in world population and industry have endangered this essential resource. Scientists have begun developing **desalination** methods—or ways to remove salt from seawater and produce freshwater. At the present time, scientists are using three different desalination methods to process saltwater into freshwater; distillation, filtration, and crystallization. Desalination is far more costly than obtaining freshwater from groundwater or surface-water supplies.

Distillation—the most successful method—is a process by which water is heated in a domed structure until it evaporates and becomes **water vapor**. Evaporated water does not contain salt. The evaporated water then **condenses** on the dome to run down its surface into troughs. During **filtration**, water is filtered through special membranes or materials that allow water to pass through but trap salt and other impurities. In the process of **crystallization**, water is frozen. The ice crystals are removed, leaving the salt behind. The ice crystals can then be melted into freshwater.

Summary

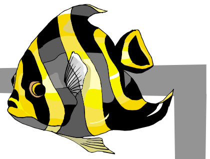
Most of the water on Earth is salty and unfit for drinking. Through evaporation and then precipitation, water becomes purified and free of salt. *Salinity* is the measure of the salt in the ocean. Some seawater is *brackish*, with a lower salinity than normal seawater. Some seawater is *hypersaline* and has such a high salinity that nearly all objects in it will float.

Surface temperature in the ocean varies depending on the latitude and season of the year. Closer to the equator, the water is warmer; nearer the poles, the water is much colder. In addition, water at lower depths is always colder than water directly above it and on the surface. Heat from the sun warms the surface, and the warmer water floats, whereas colder water sinks. The *thermocline* is a layer of water in the ocean where the temperature drops rapidly.

Nitrogen, carbon dioxide, and oxygen are the most common dissolved gases in the ocean. Carbon dioxide (CO_2) plays an especially important function. It helps to *buffer* seawater against sudden changes in its pH.

Overuse and contamination of water has left us with a shrinking supply of freshwater. Scientists are experimenting with different methods of *desalination* to obtain freshwater from saltwater.

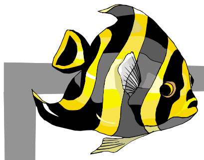
Most of the water on Earth is salty and unfit for drinking.



Practice

Answer the following questions using short answers.

1. How much of the Earth's water is saltwater? ____________________
2. Why doesn't the Earth run out of freshwater? ____________________
3. What six major ions make up more than 99 percent of seawater? ___
4. Where will *hypersaline* waters occur? ____________________
5. Where will *brackish* waters occur? ____________________

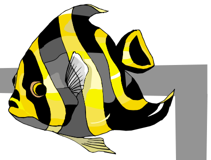


6. What are the factors that affect salinity?

7. Why is carbon dioxide important to marine life?

8. What are the three most common dissolved gases in seawater?

9. What are three methods of desalination?

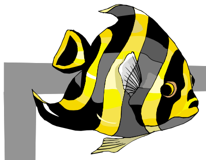


Practice

Use the list below to complete the following statements. **One or more words will be used more than once.**

35
200
brackish
buffering
chloride
Dead Sea
desalination
Great Salt Lake
ground
Gulf of Mexico
hydrologic
latitude
Mediterranean Sea
pH
Red Sea
salts
season
sodium chloride
sodium
thermocline

1. Another name for the water cycle is the ________________________ cycle.
2. ________________________ , or table salt, is the most common salt present in seawater.
3. The average salinity of the oceans is ________________________ parts per thousand.
4. The chemical formula for table salt is NaCl, which is made up of ________________________ and ________________________ .
5. Most of Florida's freshwater supply comes from ________________________ water.
6. The supply of ground water is replenished by the ________________________ cycle.



7. *Salinity* is the amount of dissolved ____________________ in the water.

8. Water with a lowered salinity is called ____________________ .

9. A ____________________ is a layer of water in which the temperature is much colder than the water above it.

10. Examples of a *hypersaline* bodies of water are ____________________, ____________________, ____________________, ____________________, and areas around the ____________________ .

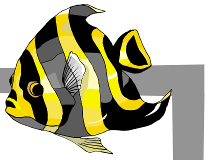
11. The temperatures of the oceans vary, depending on the ____________________ and ____________________ .

12. Light penetrates the ocean waters down to about ____________________ meters.

13. Seawater maintains a constant ____________________ range of 7.5 to 8.5, which supports marine life.

14. Carbon dioxide is essential for the chemical reaction or the ____________________ system that maintains the proper pH in seawater.

15. In a ____________________ process, freshwater is procured by removing salt.



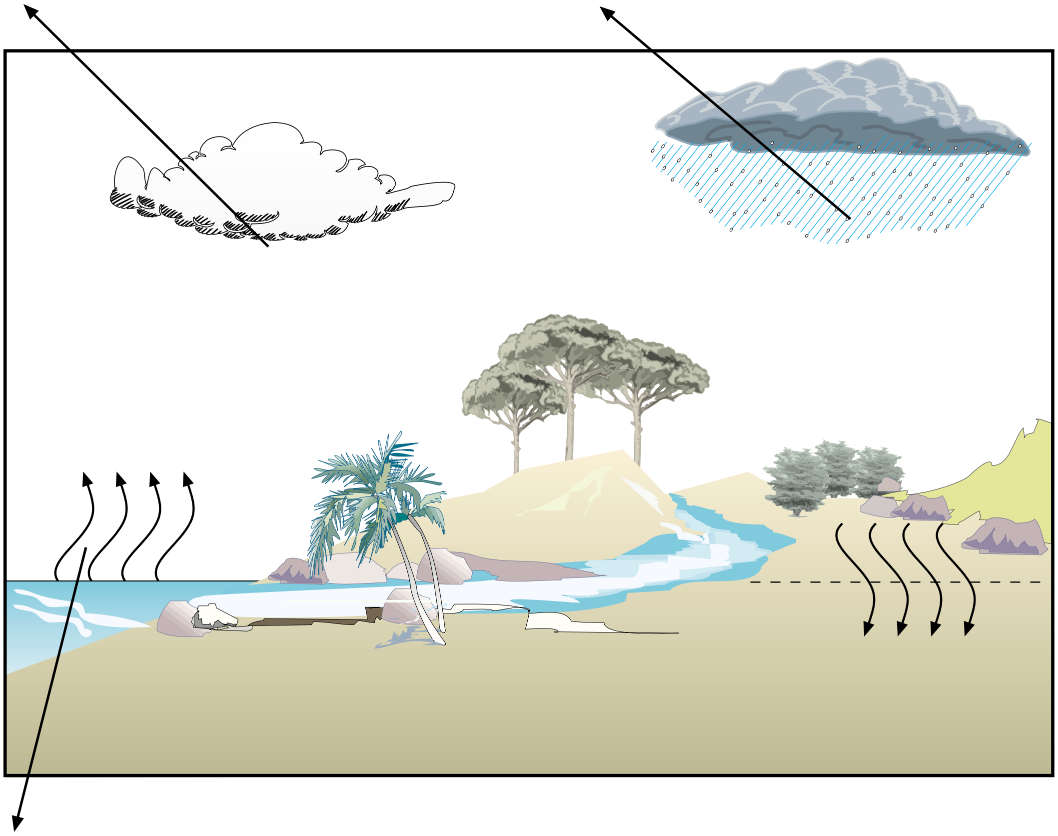
Practice

Use the list below to label the parts of the **water cycle**. *Write the correct answer on the line provided.*

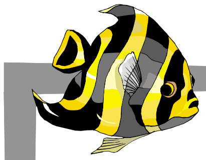
condensation	**evaporation**	**precipitation**

1. ______________________________

2. ______________________________



3. ______________________________



Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

_________ 1. Water appears in many different forms on the Earth's surface.

_________ 2. During respiration, plants produce food and release oxygen.

_________ 3. When water *evaporates,* it turns into a gas.

_________ 4. The hydrologic cycle produces rain.

_________ 5. Salinity in the ocean is the same from place to place.

_________ 6. We can float more easily in saltwater than in freshwater.

_________ 7. Floating in the Great Salt Lake in Utah would be extremely easy.

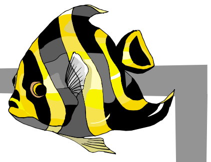
_________ 8. A thermocline is a strip of much warmer water.

_________ 9. Beyond 200 meters ocean plants grow very slowly.

_________ 10. Plants add carbon dioxide and oxygen to seawater.

_________ 11. Scientists use different desalination methods for obtaining freshwater from seawater.

_________ 12. Carbon dioxide is essential to buffer seawater and maintain the pH level.



Lab Activity 1: Properties of Water

Investigate:

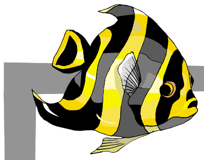
- Determine the mass per volume ratio of saltwater to freshwater.

Materials:

- beaker
- flask
- small jar
- tap and saltwater
- triple-beam balance
- graduated cylinder

Procedure:

1. Obtain a beaker, a flask, and a small jar. Arrange these in order of the volume you think each will hold (from most to least volume).
2. Using a triple-beam balance, weigh each empty container to find the mass of each container. Record the mass in the data table on the next page.
3. Use a graduated cylinder to add tap water to each container. Fill the containers to one centimeter from the top. Record the amount of water added to each container.
4. Weigh each container filled with water to find the mass. Record the mass in the data chart.
5. Find the mass of *water* in each container by subtracting the empty-container mass from the filled-container mass.
6. Calculate the density of the water in each container by using the following formula:
   Density = mass (g) divided by the volume (ml).
7. Place the calculated density of water in the data chart.
8. Repeat steps 1–7 with three volumes of saltwater.
9. Clean up your area.



Density Data Chart

containers	mass empty (g)	volume of water (ml)	mass filled with water (g)	mass of water (g)	density of water (g⁄ml)
flask of tap water	g	ml	g	g	g⁄ml
beaker of tap water	g	ml	g	g	g⁄ml
jar of tap water	g	ml	g	g	g⁄ml
flask of saltwater	g	ml	g	g	g⁄ml
beaker of saltwater	g	ml	g	g	g⁄ml
jar of saltwater	g	ml	g	g	g⁄ml

Average density of freshwater: ____________________

Average density of saltwater: ____________________

Analysis:

1. Explain how to find the density of a liquid. ________________________

   ____

   ____

2. Which has a greater density, freshwater or saltwater? ____________

   Why? ____

   ____

   ____

Lab Activity 2: Comparing Densities

Investigate:

- Compare the densities of warm and cold water and of fresh and saltwater.

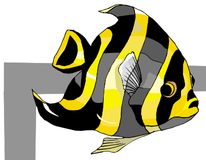
Materials:

- 2 Erlenmeyer flasks
- hot plate
- 3 x 5 index cards
- food coloring
- cool tap water
- granular salt

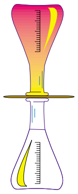
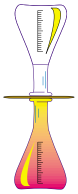
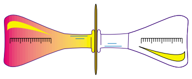
Part 1: Warm Water Versus Cold Water

Procedure:

1. Obtain an Erlenmeyer flask and fill it with cool tap water.
2. Using another Erlenmeyer flask. Fill it one-half full with warm water, and then fill it to the top with cool water.
3. Add a drop of food coloring to the flask containing warm water. Stir.
4. Place a 3 x 5 index card on top of the warm-water flask and invert the flask. Place the warm-water flask on top of the cool-water flask. The upward pressure of the air will help hold the card.
5. Carefully remove the card, and observe what happens. Record your observations in the data chart.
6. Repeat steps 1–4 using new water samples and the following inverting methods:
   A. cool water on top of warm water
   B. flasks held horizontally.



Warm Water vs. Cool Water

test	reaction description
 warm water cool water	
 cool water warm water	
 warm water cool water	

Analysis:

1. Which water sample was more dense? ______________________

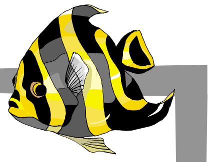
   State evidence which indicated this. ______________________

   ____

   ____

   ____

   ____



2. Where is most ocean water heated? ______________________________

   ____

3. How is ocean water heated? ____________________________________

   ____

4. Would it be easier to float in cool water or warm water? __________

   Explain why it would be easier to float in this water. _____________

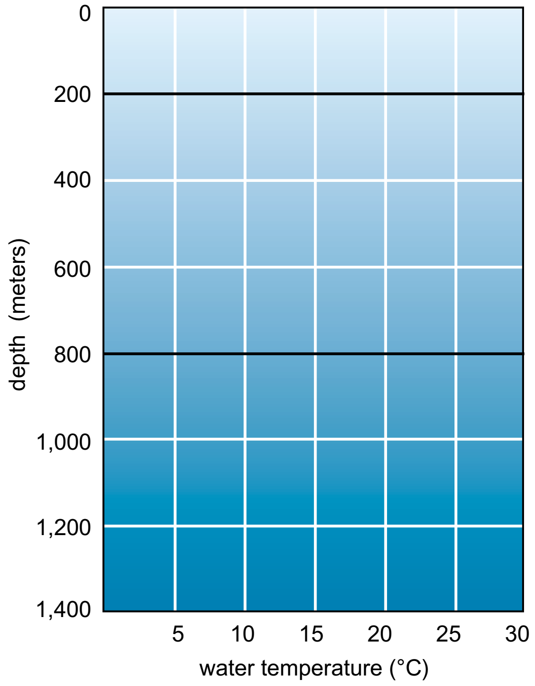
   ____

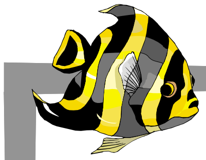
   ____

   ____

5. Label the diagram below with the following terms.

   A. warmer surface water
   B. uniform cold water
   C. area where heating takes place
   D. thermocline
   E. area where water evaporates

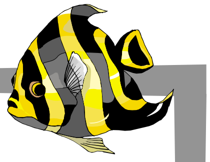




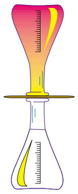
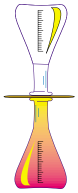
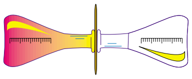
Part 2: Saltwater and Freshwater

Procedure:

1. Obtain two flasks and fill both flasks to the top with water.
2. Dissolve some salt in one flask.
3. Add a drop of food coloring to the salty water. Stir.
4. Place the 3 x 5 index card on top of the saltwater flask. Invert the saltwater flask and place it on top of the freshwater flask.
5. Carefully remove the card. Observe what happens. Record your observations in data chart.
6. Repeat steps 1–5 using the following inverting methods:
   A. saltwater on bottom
   B. flasks horizontal.



Saltwater vs. Freshwater

test	reaction description
 **saltwater** **freshwater**	
 **freshwater** **saltwater**	
 **saltwater** **freshwater**	

Analysis:

1. Which water sample was more dense? ____________________________

   Explain why this sample was more dense?________________________

   ____

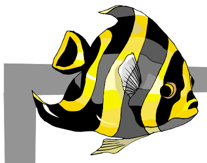
2. Why is it easier to float in saltwater than freshwater?______________

   ____

3. List three ways that the density of seawater can be changed. ______

   ____

   ____



Lab Activity 3: Water Analysis

Investigate:

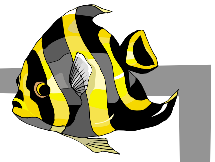
- Observe the dissolved solids present in seawater, distilled water, and tap water.

Materials:

- distilled water and tap water
- sodium carbonate solution
- hydrochloric acid
- seawater
- barium chloride solution
- 3 small test tubes
- nitric acid solution
- silver nitrate solution
- acetic acid solution
- potassium hydroxide solution
- potassium permanganate
- sulfuric acid
- litmus paper
- graduated cylinder
- hot plate

Procedure:

1. Obtain three test tubes.
2. Mark the test tubes **S**, **D**, and **T**, so that you are always using the same tube for ***s**eawater*, ***d**istilled water*, and ***t**ap water*.
3. You will conduct six different water analysis tests. (See observation chart on page 86.)
4. For each test, fill the test tube one-half full of the water to be tested.
5. Rinse test tube after each use.



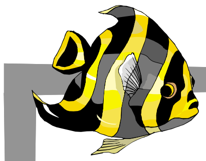
6. Follow the directions which correspond to each water analysis test you will be performing.

   Note: These tests do not have to be done in any special order. In fact, if you do them out of order you will avoid having to wait for a chemical others are using.

Remember: A **positive (+)** reaction means that the substance you are testing for is **present**!

Directions for Water Analysis Tests:

Calcium	To each half-filled test tube, add three drops of acetic acid and three drops of sodium carbonate. Record what you observe in each test tube and put your observations in the chart. (White precipitate means +.)
Sulfates	To each half-filled test tube, add three drops of hydrochloric acid. Slowly heat to boiling (over an alcohol burner or element). Then add three drops of barium chloride solution. Record the results. (White precipitate means +.)
Chlorides	To each half-filled test tube, add three drops of nitric acid and three drops of silver nitrate solution. Record the results. (White precipitate means +.)
Ammonia	To only the water sample add four drops of potassium hydroxide and heat gently. Record the results. (White precipitate means +.)
Organic	To only the water sample, add two drops of potassium permanganate solution and five drops of concentrated sulfuric acid. Heat to boiling and record any change. (Purple changing to clear means +.)
pH	To test the water to find out if is acidic or not, touch a piece of litmus paper to the water sample. Record the color of the wet end of the litmus paper. (Pink means *acid*, blue means *base*.)



Pre-Lab Activity 3: Water Analysis

Use the **lab procedure** *on previous pages to answer the following. Do this* **before** *you perform the lab activities on the next page.*

1. Why should you clearly mark your test tubes *seawater*, *distilled water*, and *tap water*? ____

   ____

2. In each test, how much water sample will you use? ______________

   ____

   ____

3. If you test four samples and get a positive reaction, what does this indicate? ____

   ____

4. What are the six chemical tests you will perform in lab? __________

   ____

   ____

5. What are the three types of water samples to be used in lab? ______

   ____

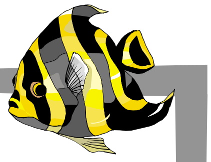
   ____

6. What do you add to test for calcium in a water sample? __________

   ____

7. How will you know if calcium is in your water sample? __________

   ____



8. Describe the test for sulfates.

9. How will you know if sulfates are present?

10. Describe the test for chlorides.

11. What will indicate the presence of chlorides?

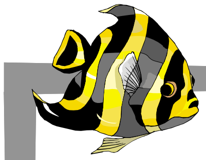
12. What solution and how much will you add to the water samples to test for the presence of ammonia?

13. What will indicate the presence of ammonia?

14. Explain the test for organics.

15. Describe a positive reaction for organics.

16. What type of paper will record the pH of the water samples?



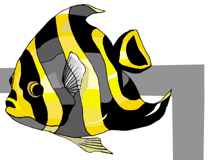
Water Analysis Test Observations			
Description of Test Results			
test	distilled water	tap water	seawater
calcium			
sulfates			
chlorides			
ammonia			
organic matter			
pH			

Analysis:

1. Which type of water had the most positive results? ________________
2. Was any test positive for all three types of water? ________________

   If so, which one? ____
3. Most experiments have a control. The control serves as a standard against which you can compare your results. Which type of water most likely serves as a control in this investigation? ________________

   ____



4. How did the results of the tests on tap water compare with the results from the distilled water? ______________________________

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5. How “pure” is your drinking water? __________________________

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6. Was there a difference in the results of the tests on freshwater and seawater? ____

Explain why there might have been such a difference between the two water samples. ____

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7. The ocean has been called the “washbowl of the Earth.” Why might this be a good description of the ocean? _________________

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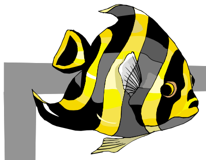


Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. a layer of water in the ocean where the temperature of the water changes rapidly

______ 2. to change from a liquid into a gas or vapor

______ 3. NaCl (chemical formula); common table salt; the most common salt in seawater

______ 4. the movement of water from the oceans and the land to the atmosphere and then back; also called the *water cycle*

______ 5. water with high levels of salinity

______ 6. having a lower salinity than normal seawater; a mixture of freshwater and saltwater

A. brackish

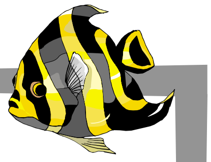
B. evaporate

C. hydrologic cycle

D. hypersaline

E. sodium chloride

F. thermocline



Practice

Use the list below to write the correct term for each definition on the line provided.

acid
base
buffer
condense
crystallization
desalination
distillation
filtration
ion
pH
water vapor

________________________ 1. a method of desalination involving the freezing of water and then removing the ice crystals to produce freshwater

________________________ 2. a method of desalination which involves filtering water through special membranes or materials

________________________ 3. to change from a gas or vapor to a liquid

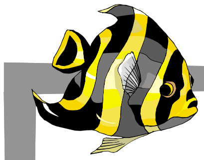
________________________ 4. water in the form of gas

________________________ 5. a method of desalination involving the evaporation of water with high heat and then condensing it by cooling

________________________ 6. a process by which salt is removed from seawater

________________________ 7. chemical compound that maintains pH level through chemical reactions

________________________ 8. a compound that joins with an acid to form a salt; will cause red litmus paper to turn blue; high concentration of OH^- ions



______________________ 9. an electrically charged atom or molecule formed by gaining or losing one or more electrons

______________________ 10. a compound that joins with a base to form a salt; will cause blue litmus paper to turn red; high concentration of H^+ ions

______________________ 11. a measure of the concentration of hydrogen ions (H^+) in a solution expressed as a scale, ranging from less than zero to more than 14, that in turn expresses the concentration of acid or base

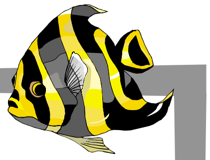
Unit 4: Waves

Unit Focus

This unit emphasizes wave formation and the parts of a wave. Students will also study a variety of wave types and the impact waves have on the coastline.

Student Goals

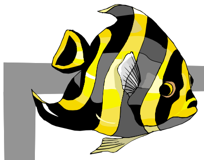
1. Define a wave.
2. Identify the parts of a wave.
3. Describe how deep-water and shallow-water waves form.
4. Explain features of the coastline formed by wave action.



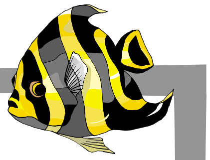
Vocabulary

Study the vocabulary words and definitions below.

beach	shore area of a body of water covered by sand or pebbles; area between high-tide mark and low tide mark
capillary waves	small waves or ripples on the surface of the water
crest	highest point on a wave
elliptical orbit	an oval-shaped path around a center point
orbit	curved path around a center point
plunging breaker	wave that collapses and destroys the wave form as it enters shallow water; produces a crashing sound
rogue wave	a large single wave with very high crests and low troughs
sand bar	underwater deposition of sand
sea cave	a hollowed-out portion of rock that has been eroded by waves
sea cliffs	steep faces of rock that have been eroded by waves
sea stacks	columns of hard rock left behind by the erosion of a sea cliff



spilling breaker	wave that moves as a uniform line as it enters shallow water; a quiet wave
spits	sand bars attached to a mainland or island that extend into open water
terrace	a flat platform of rock and sand at the bottom of a sea cliff
trochoidal	form of a wave having pointed crests, steep slopes, and flat troughs
trough	lowest point on a wave
tsunami (soo-NAM-e)	a large wave with a long wavelength; usually produced by an undersea earthquake or volcanic eruption
wave amplitude	distance from still-water level to a wave's crest
wave height	the vertical distance between crest and trough
wavelength	the distance between two successive or adjacent crests
waves	energy that moves through the ocean; the orbital motion of water
whitecap	a mixture of air and water on the wave

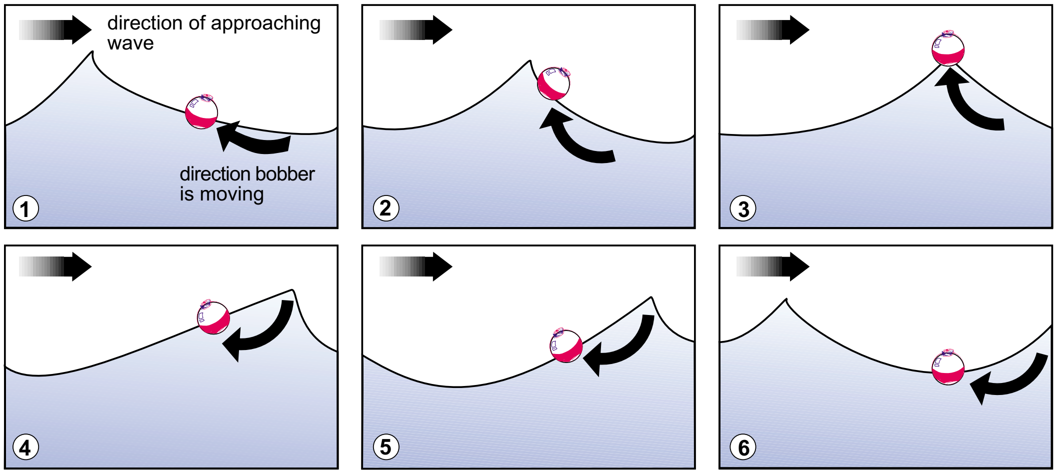


Introduction: Waves—Unpredictable Energy

If you have visited Florida's coast, you've observed the motion of the water we call **waves**. Waves seem to come from nowhere, originating from some mysterious point far out on the horizon. The waves roll toward us and the shoreline endlessly, providing us with constant changes in the surface of the water.

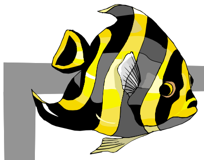
We also know just how destructive the force of the waves can be. Shorelines over a long period of time or even during a few hours of a passing hurricane can be eroded or even nearly wiped away. Coastal towns and cities can be destroyed by the rush of towering waves—and people living in coastal areas may be swept to their death. Like many forces of nature, waves can vary from friendly to menacing. Oceanographers study waves to help us understand their behavior and the way they affect our lives on land.

Making Waves: The Transfer of Energy



The motion or energy of water can be seen with a fishing bobber floating on the surface of a wave. As the wave approaches, the bobber moves up the crest of the wave (diagram 1-3). As the wave moves away (diagram 4-6) the bobber moves down the crest and forward toward its original position.

A *wave* is the orbital motion of water. Although this definition sounds quite simple, the cause of a wave is quite complex. There must be a force, some *form of energy*, that disturbs water and produces a wave's orbital motion. Scientists are unsure how energy is transferred in the form of



waves. Scientists do, however, have some theories to explain this *transfer of energy*. The following experiment describes one of these theories.

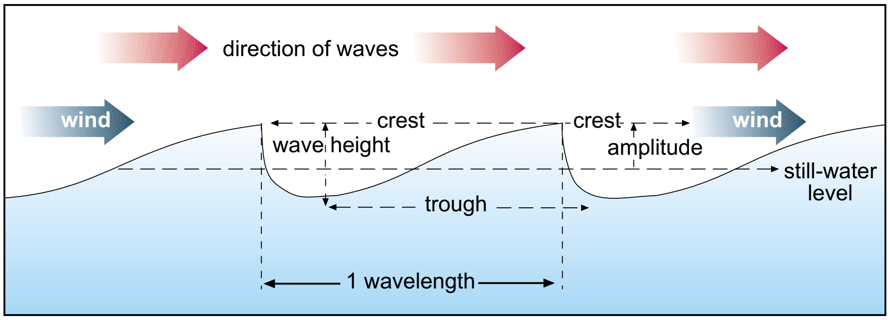
Take a tub or large container of calm water. Now sweep your hand quickly through the container so that you create a wave. You've transferred the energy produced by your body to the water in the form of a wave.

Now repeat this experiment and watch carefully as you pass your hand through the water. Note that as you push aside water along the surface, a space appears just behind—at least momentarily. Water surrounding this space instantly rushes to fill it. But as the water rushes into this space it produces a momentum—a force—that pushes it upward above the surface of the water.

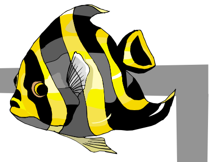
This transfer of energy doesn't stop there. As the water falls back to the surface, it creates another space, which in turn is filled by surrounding water. And, again, the momentum of this rushing water produces another upward force, and so on. The harder you pass your hand through the water, the greater the energy that will be transferred, and the more numerous and powerful will be the waves you will create. Most commonly, energy that is transferred to water originates from wind. Earthquakes and the gravitational pull of the moon also produce waves.

Speaking of Waves

Oceanographers use certain terms when speaking of the features, size, and movement of the ocean's waves. The highest point on a wave is called the **crest**; the lowest point on a wave is called the **trough** (trawf). **Wave height** is the vertical distance between a wave's crest (high point) and its trough (low point). **Wavelength** is the distance between successive or adjacent crests. The term **wave amplitude** refers to the distance from still-water level to a wave's crest.



characteristics of waves

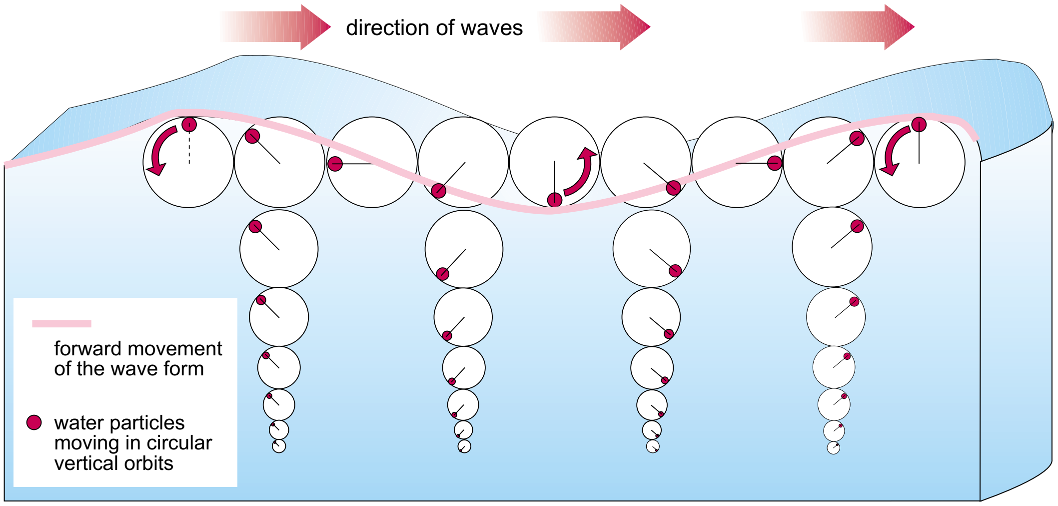


Wave Types: Deep-Water Waves and Shallow-Water Waves

Wave Types. Although *deep-water waves* occur in deep water away from the shore, they have a precise definition. Deep-water waves occur when the water's depth is deeper than one-half the wave's length. This relationship between the water's depth and the wave's length produces a wave that acts in a particular way, as described below.

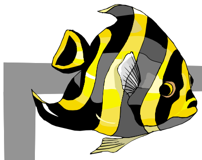
Although the energy of a deep-water wave moves forward, the water it affects stays nearly in its same place in the ocean. Although this may sound hard to believe or imagine, it's true. As a drop of water moves through a wave, it follows an **orbit**, or circular path. The drop of water will rise and move forward on the wave's front slope until it reaches the crest of the wave. This drop of water will then drop down the wave's back slope and continue until it falls under the wave's trough. As you can see from this explanation, waves really refer to *forms of energy* rather than to the water itself.

Orbital Movement of Water Particles



Water particles move in circular vertical orbits at the surface or beneath waves. As a drop of water moves through a wave, it moves forward on the wave's front slope until it reaches the crest of the wave. This drop of water will then drop down the wave's back slope and continue until it falls under the wave's trough.

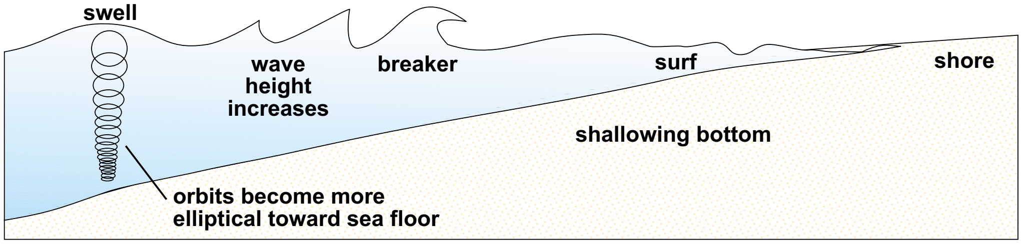
In deep-ocean water, these waves, called *swells*, are usually long and low with rounded crests and troughs and evenly curved surfaces. The swells' wavelength, or distance between crests, stays constant.



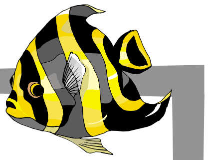
When the depth of the water becomes less than one-half of a wave length, the wave breaks, or splashes onto the shore. When a wave breaks, energy that was stored in the wave is released.

Shallow-Water Waves. As waves near the shore, they change in size, shape, and speed. These *shallow-water waves* slow in speed; their wavelength becomes smaller, and their crests rise higher. In other words, as waves approach the shore, they become slower, higher, and more numerous. The shape of the waves becomes **trochoidal**: Their crests become pointed; their slopes grow steeper, and their troughs flatten. The wave now has begun to make its final roll.

The breaking point of the wave depends on two things: the speed of the water's orbit and the speed of the wave. As the wave climbs higher and moves more slowly, the motion of the water it affects follows an **elliptical orbit**. When the wave's water begins to flow in this oval-shaped path, the wave's crest moves slightly forward. Finally, when the depth of the water becomes less than one-half of a wave's length, the wave *breaks*, or splashes onto the shore. When a wave breaks, the energy stored in the wave is released onto the shore at impact.



Waves do not just break when they are in shallow water. Waves can also break in deeper waters in the open ocean. Steep waves with narrow crests are produced in the open ocean by strong winds. Winds blow the narrow



crests off the wave, creating a **whitecap** on the wave. A *whitecap* is a mixture of air and water on the wave. Whitecaps on the ocean or other large bodies of water are a sign that rough weather is in store.

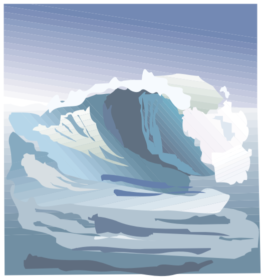
Another wave that is encountered on the open ocean is a **rogue wave**. A *rogue wave* is a large, single wave with very high crests and low troughs. Rogue waves are very tall and are formed when two or more large waves from a storm merge or when waves meet currents that are going in the opposite direction from them. Rogue waves are dangerous and have caused many ships to be lost at sea.

Types of Breaking Waves

Breaking waves, or breakers, are affected by the shape of the ocean floor near **beaches**. The **plunging breaker** forms as a wave rolls over a steep beach slope. The **spilling breaker** develops along flatter beaches. (Spilling breakers are common along Florida's shallow and flat coast.) You can see the differences between each breaker in the lists below.

Plunging Breaker

- falls into itself
- collapses
- destroys the wave form
- produces a crashing sound



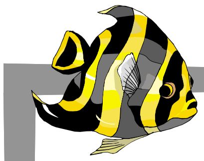
Spilling Breaker

- moves as a line of foam
- moves at the same speed as the wave form
- quiet wave

Capillary Waves

The smallest waves are **capillary waves**, or ripples, sometimes called *cat's paws*. They measure less than one inch in wavelength and affect only the top inch or so of water, whether they appear in deep or shallow waters. These little waves differ from other wind (or *gravity*) waves in several ways.

1. Larger wind waves are primarily acted on by *gravity*, which pulls the crest back to the water surface. Capillary waves, however, are small enough so that *surface tension* pulls their crest back to the water



surface. (Surface tension is the result of water molecules attracting each other.)

2. Capillary waves have crests that are rounded and troughs that are pointed or V-shaped.

capillary wave - small waves or ripples

Gravity waves have crests that are pointed and the troughs that are rounded.

gravity wave - steep waves

3. Capillary waves stop as soon as the wind stops. Capillary waves start gravity waves, and as more wind energy is transferred to the ocean, gravity waves may travel thousands of miles.

Tsunami: The Ocean's Most Powerful Wave

The most destructive wave in the ocean is caused by an undersea earthquake or volcano. Oceanographers call this wave by the Japanese term **tsunami (soo-NAM-e)**. A tsunami is also called a *seismic sea wave*.

An undersea earthquake or volcanic eruption on the seafloor can cause one of two events. If a huge crack, or fault, forms on the seafloor, gravity will force water into it. If the seafloor is raised by a quake or eruption, gravity will pull the water back down off the newly raised surface. In either event, a series of powerful waves will form and travel away from the center of the quake or eruption.

The crest of each wave in the tsunami can be 100 miles apart. These waves rush at speeds of up to 450 miles per hour and can travel as much as 2,000 miles. In the open sea, a tsunami is only a few feet high and may not be noticed; in shallow water, however, these waves become dangerously high. These fast open sea waves are forced to slow down suddenly as they reach shallower waters, pushing the waves to towering heights. The height of a tsunami can range from 30 feet to more than 100 feet. As these tremendous waves break onto shore, they flood and destroy almost anything in their path.

Waves and Erosion: Wearing Away Shorelines


Waves erode and reshape the shoreline they wash over.

Waves erode and reshape the shoreline they wash over. The rate of shoreline erosion depends upon the type of shoreline, the size and force and of waves hitting the shore, and the number and intensity of storms the shore area receives a year. During storms, wave action increases; therefore, erosion generally increases. For example, the powerful waves of Hurricane Andrew in 1992 sliced away parts of Florida's beaches and, in some cases, washed away entire beaches and buildings. Erosion that would have taken years occurred in just a few hours.

Under normal conditions, waves may erode the shore at a rate of one to one-and-a-half meters per year. Along the Florida coast, breaking waves constantly erode the sand and soft soil that compose the beaches. During moderate weather, the effects of erosion along the Florida coast are barely visible to the onlooker. Waves may also deposit sand and soft soil to form new shoreline features.

Along shorelines that are composed of rock, for example on the coast of California, erosion works in a different way. When breaking waves hit the shoreline, they chip fragments off of existing beach rock. These small rocks and sand grains are then swept by waves against other rocks on the shore, causing more beach rock to chip. Waves also cause erosion when breaking storm waves force water into the cracks of rock cliffs. The cracks grow larger and larger and, eventually, the pressure breaks the rocks apart. Erosion is also caused by the chemical action of seawater dissolving minerals from rocks. Over time, the rocks will break apart or dissolve completely.

Sea cliffs are steep faces of rock that have been eroded by waves. Eventually, the sea cliff will be worn away, often breaking off large rocks that fall into the sea. The waves will then erode the large rocks into sand.

Sea cliffs are steep faces of rock that have been eroded by waves.

The buildup of rock and sand at the bottom of the sea cliff form a flat platform called a **terrace**. Terraces help slow down the erosion of sea cliffs. As waves move across the terrace, they slow, striking the cliff with less energy and force. **Sea stacks** are columns of hard rock left behind by the erosion of a sea cliff. Sea cliffs consist of resistant rock and some less resistant rock. In the formation of a **sea cave**, the less resistant rock is eroded away by waves, leaving behind a hollowed-out portion of sea cliff.

Deposits by Waves

Fast-moving waves carry sand, shell fragments, and rock particles across the ocean. As waves slow down and weaken as they approach shorelines, these particles become too heavy for waves to carry. The particles are then deposited offshore or on the shoreline. As a result of waves depositing material in different areas, various shoreline features are formed. These features include beaches, **sand bars**, and **spits**.

Beaches are the shore areas between the high-tide mark and the low tide and usually consist of sand or pebbles.

*Beache*s are the shores areas between the high-tide mark and the low tide mark. They usually consist of sand or pebbles. The type of material that composes a beach will depend upon its source. For example, the white sand on the Atlantic Coast of Florida came from the erosion of the Appalachian Mountains. The black sands on Hawaii's beaches came from the erosion of volcanic rock.

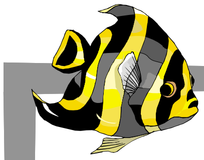
A *sand bar* is an underwater deposition of sand. Sand bars form when longshore currents (currents that move water parallel to the shore) pass across the opening of a bay or cove. The sediments carried within this current are carried inland by waves and deposited. Sand bars that are attached at one end to a mainland or island and extend into open water are called *spits*. You may have walked out on a spit of land that extended into the ocean to fish or look for shells.

Summary

Waves are formed when energy from earthquakes, the gravitational pull of the moon, or, most commonly, the wind, is transferred to the water. Special terminology is used to describe a wave. The highest point on a wave is the *crest*; the lowest point is the *trough*. The vertical distance between these two points is the *wave height*; and the distance between two adjacent waves' crests is the *wavelength*. Wave types include *deep-water* and *shallow-water waves*. Along shallow coastlines *spilling breakers* form, whereas along steeply sloped coastlines *plunging breakers* occur. In open ocean, water *whitecaps* and *rogue waves* can form. Other contrasting waves are *capillary waves* (very small ripples) and *tsunamis*, or seismic waves, which are the largest and most destructive waves.

The wave action on our beaches causes erosion *of the shoreline and changes the shape of the shoreline.*

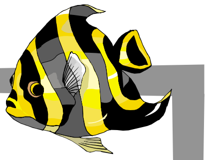
The wave action on our beaches causes *erosion* of the shoreline and changes the shape of the shoreline. The wearing away of the coast can create *sea cliffs*, *terraces*, *sea stacks*, and *sea caves*. Erosion is countered by waves depositing sand and pebbles that form *beaches*, *sand bars*, and *spits*.



Practice

Circle the letter of the correct answer.

1. Waves are created by some form of ____________ that disturbs the water.
   - a. chemical
   - b. energy
   - c. wave
   - d. trough
2. The ____________ is the highest point of a wave.
   - a. wavelength
   - b. amplitude
   - c. crest
   - d. trough
3. The trough is the ____________ part of a wave.
   - a. biggest
   - b. widest
   - c. highest
   - d. lowest
4. The distance from still-water level to a wave's crest is called the wave ____________ .
   - a. amplitude
   - b. crest
   - c. trough
   - d. length
5. The ____________ is the vertical distance between the trough and the crest.
   - a. energy
   - b. wavelength
   - c. wave height
   - d. momentum



6. The distance between two adjacent waves' crests is called the ____________ .

   a. trough
   b. amplitude
   c. wave height
   d. wavelength

7. As waves approach the shore, they become ____________ , bigger, and more numerous.

   a. faster
   b. slower
   c. stronger
   d. deeper

8. Shallow-water waves become ____________ in shape.

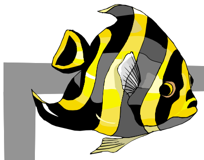
   a. trochoidal
   b. oval
   c. elliptical
   d. shorter

9. Deep-water waves called ____________ are long, low, and evenly spaced apart with rounded curves.

   a. capillary
   b. seismic
   c. cat's paws
   d. swells

10. When a wave breaks, the energy that was stored in the wave is ____________ .

    a. increased
    b. decreased
    c. lost
    d. released



11. The __________ breaker, common in Florida, is a quiet wave.

    a. elliptical
    b. crashing
    c. spilling
    d. plunging

12. The __________ breaker produces a crashing sound.

    a. spilling
    b. plunging
    c. shallow-water
    d. capillary

13. The smallest waves are __________ waves, or ripples.

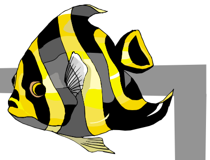
    a. surface
    b. shallow-water
    c. tsunami
    d. capillary

14. The most destructive wave in the ocean is the __________ , or seismic wave.

    a. tsunami
    b. capillary
    c. deep-water
    d. elliptical

15. Water gets its wave energy from the gravitational pull of the moon, earthquakes, and, most commonly, the __________ .

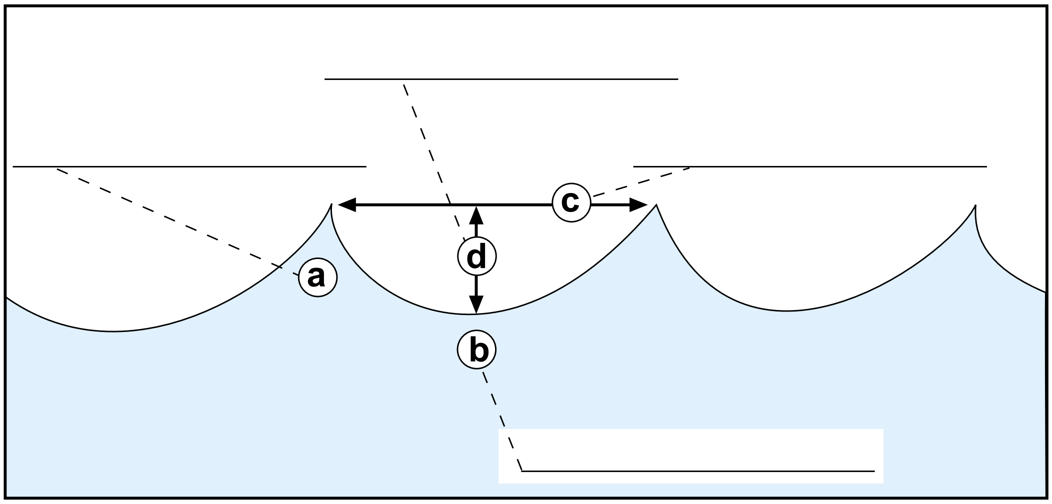
    a. wind
    b. Earth
    c. rotation
    d. erosion



Practice

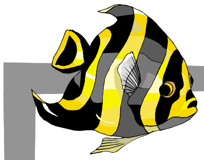
Answer the following.

1. Label the wave diagram below. Write the correct term by each letter in the diagram.



2. Complete the chart below by filling in the description of each wave.

Wave Characteristics	
spilling breaker	
plunging breaker	



Practice

Answer the following questions using short answers.

1. How does a tsunami form? ________________________________

____

____

2. What factors affect the rate of shoreline erosion? ______________

____

____

____

3. What are the three ways that waves erode shorelines composed of rock? ________________________________

____

____

____

4. What features are formed by wave action, or erosion, along a rocky coast? ________________________________

____

____

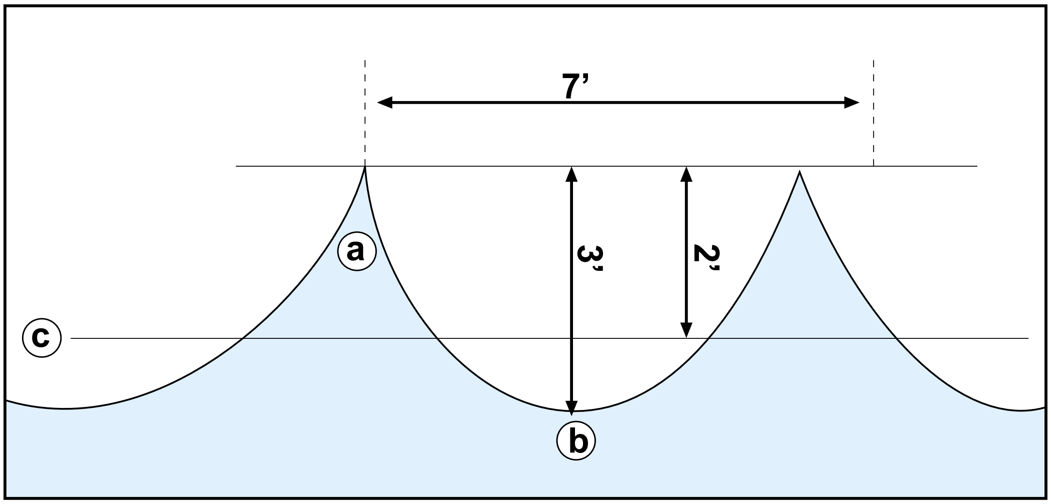
5. What are three shoreline features formed by deposits of waves?

____

____

Practice

Use the diagram below to answer the following.



1. What is the length of the wave (*wavelength*)? ____________________

2. What is the *amplitude* of the wave? ____________________

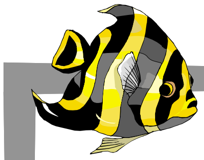
3. What is the *height* of the wave? ____________________

4. From the diagram above, identify the following parts of the wave:

   a: ____________________

   b: ____________________

5. What does line *c* refer to? ____________________



Lab Activity: About Waves

Investigate:

- Use the Savage Seas Web site below to create small, medium, and large waves by selecting how fast, how far, and how long the winds have traveled.

Materials:

- computer with Internet access
- Web site: www.pbs.org/wnet/savageseas
- data table
- pencil or pen

Procedure:

1. Use the Savage Seas Web site to investigate the variables that form waves. First, enter the following address, www.pbs.org/wnet/savageseas. Wait patiently for the Web site to appear on the computer screen.

2. **Click** on the **ship**.

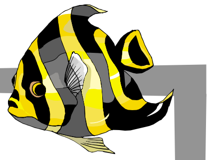
3. **Click** on **The Crow's Nest**.

4. You should now see a list of wave-related items for you to explore. **Click** on **Animations**: **Wave Machine**. The *wave machine* is a simulator that will allow you to create an ocean wave and determine its height. Most ocean waves are formed when the wind blows across the water's surface. The wave height is determined by three factors—wind speed, the **fetch** or distance the wind blows, and the **duration** or length of time the wind blows.

5. As you use the variables to create ocean waves, complete the data table on the following page.

6. **Click** on **Start** to create a wave.

7. **Click** on *speed*, *fetch*, and *duration* variables for creating a small, medium, and large wave. (**Click** on Help as needed.) Note the *height* of the wave created.



8. **Enter** *speed*, *fetch*, *duration*, and *height* data for each wave on the table below. **Click** on **Repeat** to view wave animations again. To create a new wave, **Click** on **Variables** to enter new variables.

9. After completing the data table below, complete the **Analysis** section of the lab.

Complete the following **data table** *for each wave you simulate.*

wind speed	**fetch**	**duration**	**wave height**
small wave _______ knots (use the smallest variables possible)	_______ nautical miles	_______ hours	_______ feet
medium wave_______ knots (use the medium variables)	_______ nautical miles	_______ hours	_______ feet
large wave _______ knots (use the largest possible variables)	_______ nautical miles	_______ hours	_______ feet
create a wave _______ knots (small speed, long fetch, short duration)	_______ nautical miles	_______ hours	_______ feet
create a wave _______ knots (high speed, short fetch, long duration)	_______ nautical miles	_______ hours	_______ feet
create your own wave _______knots	_______ nautical miles	_______ hours	_______ feet

Analysis:

Use the data table to assist you in determining the answers to the following.

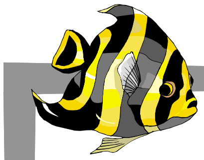
1. State the wind conditions necessary for a *large* wave to exist. (Be sure to include all three wind factors in your response.) __________

   ____

   ____

   ____

   ____



2. State the wind conditions necessary for a *small* wave to exist. (Be sure to include all three wind factors in your response.) __________

   ____

   ____

   ____

   ____

3. Define *wind fetch*. ____

   ____

   ____

4. Define *wind duration*. ____

   ____

   ____

   ____

5. Describe how waves are formed. ______________________________

   ____

   ____

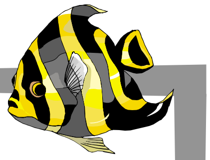
   ____

6. What three factors determine wave height? ____________________

   ____

   ____

   ____



Wave Descriptions:

Small Waves

1. Describe (or draw below) the appearance of the wave. ____________

   ____

   ____

2. Describe what happens to the ship as a wave of this magnitude passes the ship. ____

   ____

3. Is the wave generated under the variables considered dangerous? Why or why not? ____

   ____

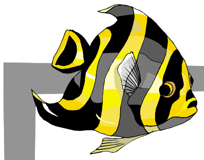
   ____

Medium Waves

4. Describe (or draw below) the appearance of the wave. ____________

   ____

   ____



5. Describe what happens to the ship as a wave of this magnitude passes the ship. ____

____

6. Is the wave generated under the variables considered dangerous? Why or why not? ____

____

Large Waves

7. Describe (or draw below) the appearance of the wave. __________

____

____

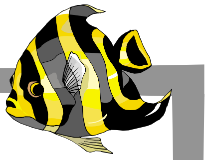
8. Describe what happens to the ship as a wave of this magnitude passes the ship. ____

____

9. Is the wave generated under the variables considered dangerous? Why or why not? ____

____

____



Practice

Use the list below to write the correct term for each definition on the line provided.

crest
elliptical orbit
orbit
plunging breaker
rogue wave
spilling breaker
trochoidal
trough
wave amplitude
wave height
wavelength
waves
whitecap

________________________ 1. a mixture of air and water on the wave

________________________ 2. a large single wave with very high crests and low troughs

________________________ 3. curved path around a center point

________________________ 4. the distance between two successive or adjacent crests

________________________ 5. an oval-shaped path around a center point

________________________ 6. energy that moves through the ocean; the orbital motion of water

________________________ 7. highest point on a wave

________________________ 8. the vertical distance between crest and trough

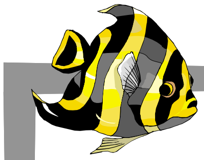
________________________ 9. wave that collapses and destroys the wave form as it enters shallow water

________________________ 10. distance from still-water level to a wave's crest

________________________ 11. lowest point on a wave

________________________ 12. form of a wave having pointed crests, steep slopes, and flat troughs

________________________ 13. wave that moves as a uniform line as it enters shallow water; a quiet wave



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. a large wave with a long wavelength; usually produced by an undersea earthquake or volcanic eruption

______ 2. shore area of a body of water covered by sand or pebbles; area between high-tide mark and low tide mark

______ 3. a flat platform of rock and sand at the bottom of a sea cliff

______ 4. small waves or ripples on the surface of the water

______ 5. sand bars attached to a mainland or island that extend into open water

______ 6. underwater deposition of sand

______ 7. a hollowed-out portion of rock that has been eroded by waves

______ 8. columns of hard rock left behind by the erosion of a sea cliff

______ 9. steep faces of rock that have been eroded by waves

A. beach

B. capillary waves

C. sand bar

D. sea cave

E. sea cliffs

F. sea stacks

G. spits

H. terrace

I. tsunami

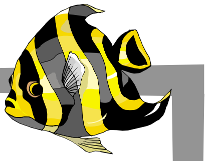
Unit 5: Tides

Unit Focus

This unit illustrates the forces that generate tides. Students will investigate how the tides change daily and the impact of tides on marine organisms.

Student Goals

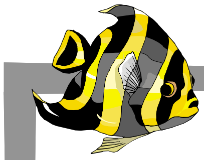
1. Define tides.
2. Explain the forces that cause tides to occur.
3. Describe the differences in tides around the world.
4. Explain how tides influence the survival of marine organisms.



Vocabulary

Study the vocabulary words and definitions below.

diurnal tide	a tide that has one high-water level and one low-water level per day
ebb tide	water level or tide at its lowest point
estuary	mouth of a river or bay where fresh water and saltwater mix; the part of the river where its current meets the ocean's tide
flood tide	tide at its highest point
intertidal zone	the area between high tide and low tide; also called the *littoral zone*
marigram	a graphic record of the rise and fall of the tide in the form of a curve
mixed tide	a tide that has two high-water levels and two low-water levels per day with extreme differences between the heights of the two high and/or the two low-water heights
nadir	the point on Earth's surface farthest from the moon
neap tide	tide occurring at the first and third quarters of the moon when the sun, Earth, and moon form a right angle; this produces tides with a low tidal range
phase	a stage in a process of change or development; may occur in regular cycles



predict	to tell in advance
rhythm	movement with regular recurrence or repetition
semidiurnal tide	a tide that has two high-water levels and two low-water levels per day with little difference between high- and low-water heights
spring tide	tides occurring at the new and full moon when the sun and moon are in a straight line with each other; produces the greatest tidal ranges between high water and low water
tidal bore	a sudden rise in water height caused by tides moving rapidly inland from the mouth of a river; a wall of water
tidal bulge	a concentration of water due to the pull of the moon; occurs on the two sides of the Earth closest to and farthest away from the moon
tidal range	difference between heights of successive high and low waters
tide	the rhythmic rise and fall of ocean water
tide pools	pockets of water formed on uneven shores by outgoing tides
zenith	the point on Earth's surface closest to the moon

Introduction: Tides—The Rise and Fall of Ocean Water

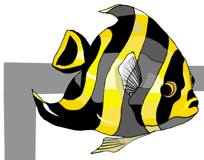
Thousands of years ago sailors and beachgoers began to notice the **tides**, or the rise and fall of the sea around the edge of the land. They put their observations to practical use. The sailor discovered that his beached ship would float when the tide began to rise. When the tide lowered, more of the coastline became exposed and left edible plants and animals easy prey for those who gathered food. Observers of the sea also noticed that changes in the tide followed a regular **rhythm**. They began timing and measuring tidal changes and eventually were able to **predict** their regularity.

When the tide lowers, more of the coastline is exposed.

On most coastlines, observers noticed two high tides and two low tides occurring daily. Early observers must have been puzzled by the fact that the different tides occurred at different times each day. By 350 B.C., the famous Greek scholar Aristotle had discovered the link between the change in tides and the **phases** of the moon. But it was not until a few hundred years ago when Sir Isaac Newton (1642–1727) discovered the relationship between the moon's gravitational pull and the ocean's shifting tides that we began to understand what causes tides.

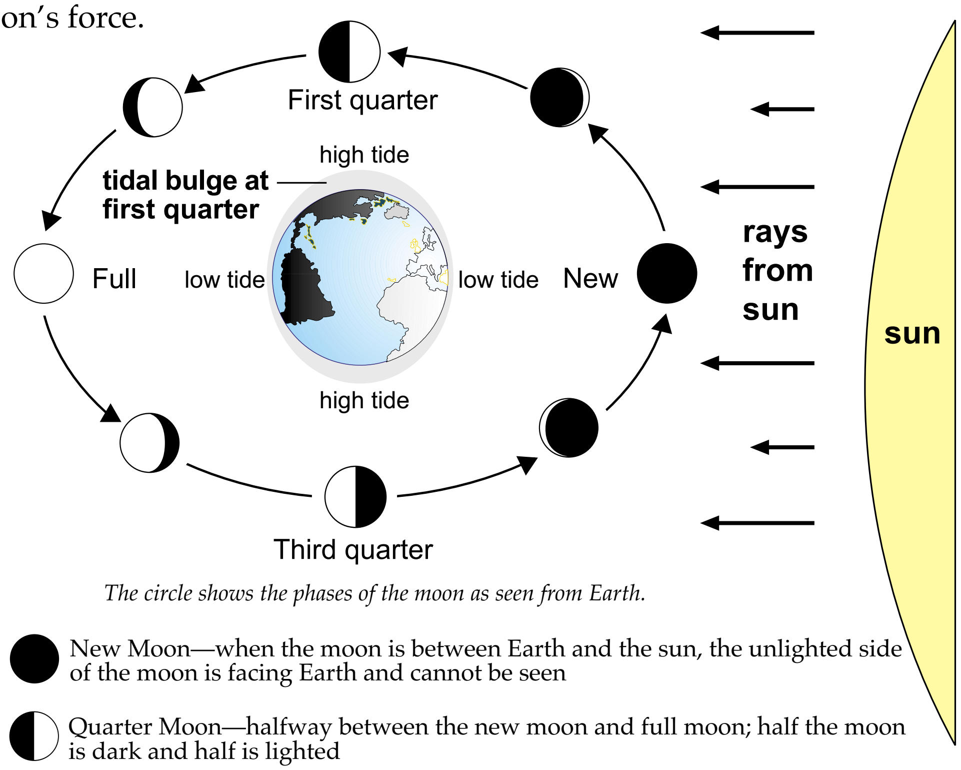
Causes of Tides: The Moon's Gravity

We're all familiar with the tale of Sir Isaac Newton sitting under a tree when a ripe apple fell on the noted scientist's brilliant head. The tale is a simple demonstration of Earth's *gravitational force*. Larger bodies of mass—such as the Earth, sun, and moon—exert a pull on smaller objects. We remain firmly rooted on Earth because of gravity. Earth remains in orbit because of the sun's gravitational pull, and the moon remains in orbit because of Earth's gravitational pull.



Tides are also the result of gravitational pull. Both the sun and the moon are large enough in mass to literally "pull" on the Earth's oceans. Because the sun is so far away from Earth, its pull in the oceans is less than half the pull of the moon.

To understand why tides change, imagine the following illustration. Let a ball or sphere represent Earth, and a slightly smaller sphere represent the moon. Begin to rotate Earth, imagining that our planet makes a complete rotation each 24 hours. You'll notice that Earth is continually presenting a different "face" to the moon. The moon exerts its strongest pull on the center, or nose, of this constantly changing face. The point of Earth closest to the moon is called the **zenith**; the point farthest from the moon on the other side of the Earth, is called the **nadir**. At Earth's zenith, there is an upswelling of water known as a **tidal bulge**. As the Earth rotates, the face changes, and so does the location of the nadir, zenith, and the tidal bulge. Although the ocean or gulf nearest you may never be exactly at the Earth's zenith, it, like all waters on the Earth's face, is raised by the moon's force.



The circle shows the phases of the moon as seen from Earth.

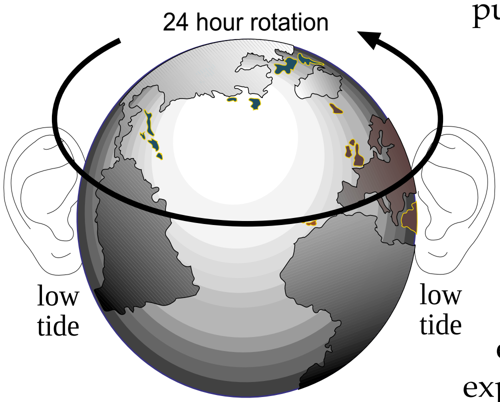
● New Moon—when the moon is between Earth and the sun, the unlighted side of the moon is facing Earth and cannot be seen

◐ Quarter Moon—halfway between the new moon and full moon; half the moon is dark and half is lighted

○ Full Moon—when the moon is on the opposite side of Earth from the sun, the entire lighted side is facing Earth

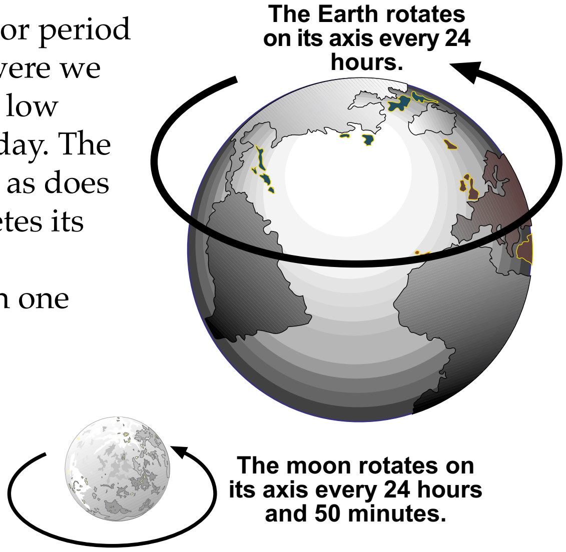
Remember, however, that there are usually two high tides and two low tides daily. Thus far we've explained why the beach nearest you experiences one high tide. What causes the other high tide? Surprisingly, the other high tide occurs when the ocean or gulf nearest you is at its furthest point from the moon or when it is at the back of Earth's face. At that point, a phenomenon called *centrifugal force* pulls water away from the Earth. Just as Earth and the moon exert a pull on one another, each is also pulled equally away from one another by the force of their rotations. Centrifugal force keeps Earth and the moon from colliding and exerts a pull on Earth's water farthest from the moon.

The Earth always shows a "face" to the orbiting moon and always hides a backside of this face. To complete our image, imagine two "ears" on either side of the face. When the ocean or gulf reaches each ear—two times every 24 hours—it experiences a low tide.

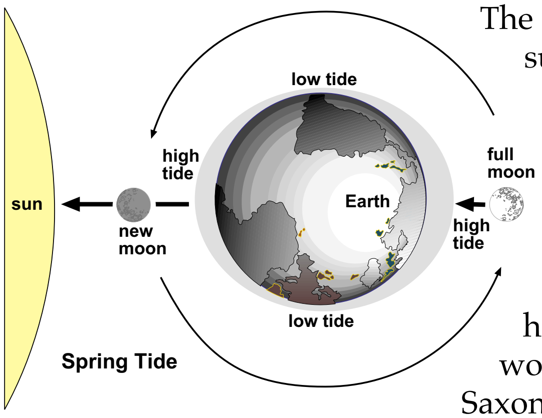


The Tidal Day: 24 Hours and 50 minutes

Not until we understood the cycle or period of the moon's orbit around Earth were we able to explain why high tides and low tides occur at different times each day. The moon rotates in the same direction as does Earth. The moon, however, completes its orbit at a slower speed than Earth. Consequently, it will take the moon one Earth day (24 hours) plus an extra 50 minutes to reach the same position that it occupied yesterday above your nearby coastal waters.

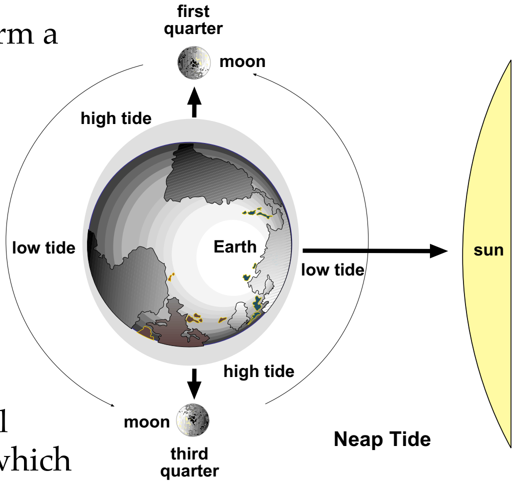


Spring and Neap Tides: Extra High and Low Tides



The orbits of Earth, the moon, and the sun place them in a straight line twice a month—at the full moon and new moon. In this alignment, the moon and sun work together in creating the strongest gravitational pull on Earth's oceans. This super-pull produces a higher tide called a **spring tide**. The word *spring tide* comes from the Anglo-Saxon word *springen*, meaning to *jump up*.

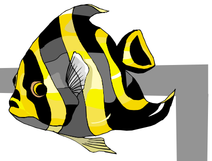
When Earth, the moon, and the sun form a right angle with the Earth at its intersection, the gravitational pull on the ocean is at its weakest. This weaker tide is called a **neap tide** and also occurs twice a month during the first and third quarters of the moon.



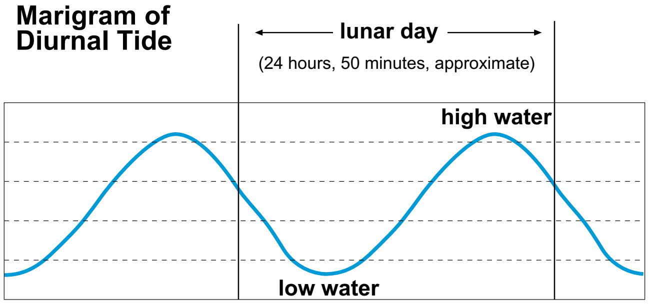
Types of Tides

Along some coastlines there are coastal bays and channels. Unlike the ocean, which is nearly equal in its width and length, bays and channels are long and narrow. This shape alters the incoming tide. It may increase or decrease the height of the ocean's tides. In addition, differences in coastlines and seafloor topography also alter the tides.

Bays, channels, and **estuaries** often have a wide **tidal range**, or the difference between the heights of a consecutive high tide (**flood tide**) and a low tide (**ebb tide**). They have higher ranges than other coastal formations because a lot of water must go in and out of a small area. In estuaries, the tidal range can be extremely high. The largest tidal range known in the world occurs in the Bay of Fundy. Water levels in the Bay of Fundy can range over 50 feet at times. High rock walls and narrow passages force the water higher, creating higher tides. When the wave front is a steep wall of turbulent water, it is called a **tidal bore**. Some adventurous people have been known to surf this wall of water! Some scientists and engineers are studying tidal bores for their potential use in generating electrical power.

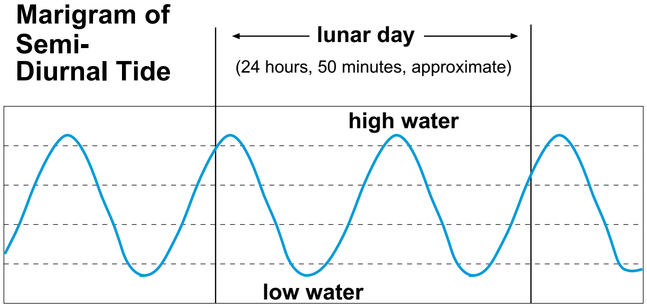


Although most bodies of water have two high and two low tides daily, there are exceptions. Some places in the Gulf of Mexico (off the West Coast of Florida) have only one high tide and one low tide each day. Such tides are called **diurnal tides** and are also common along the coasts of Vietnam and China.



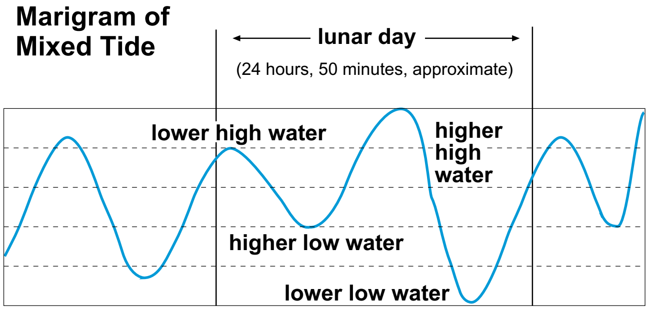
Marigram of Diurnal Tide

Most locations in the world experience little or no difference between their two high- or low-water heights. In a waterway such as the Mediterranean Sea, there is practically no difference between the heights of two high and low tides. This type of tide is called a **semidiurnal tide**. Most tides along the East Coast of the United States and around the Atlantic Ocean are *semidiurnal*.

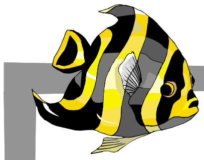


Marigram of Semi-Diurnal Tide

The **mixed tide** has two high-water levels and two low-water levels each day but with extreme differences between the heights of the two high- and/or the two low-water heights. Tides along the Pacific Coast of the United States and many Pacific Islands have *mixed tides*.



Marigram of Mixed Tide

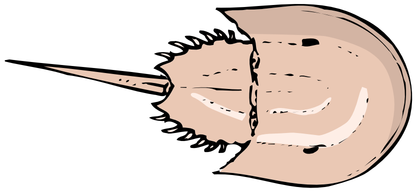


You can determine the type of tide in a particular area by plotting the times and heights of the tides. This type of graphic record is called a **marigram**.

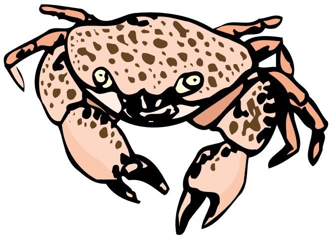
Tidal Influences: The Highs and Lows of Marine Organisms

The ocean's shifting tides present both benefits and hardships for organisms living near the coastlines in the **intertidal zone**. The intertidal zone, also known as the *littoral zone*, is the area between high tide and low tide. At high tide, many areas are covered by water, and at low tide the areas are exposed to the air. This causes changes in temperature, humidity, and the salinity of the seawater these organisms live in. Organisms that cannot adapt cannot survive the changing environment.

Many organisms have evolved to use the changes in tides for their own benefit and depend upon the tides for their survival. For example, the horseshoe crab's life cycle relies on the rhythm of the tides. In May and June, large numbers of horseshoe crabs gather in the shallow estuary areas along the Atlantic and Gulf coasts to mate. The horseshoe crabs wait in the shallow waters for a new or full moon. When the full or new moon arrives, the tide is at its highest, and the horseshoe crabs come ashore in male and female pairs. The smaller male horseshoe crab typically will hitch a ride onshore attached to the larger female crab's back. The female horseshoe crab has a cluster of eggs on her abdomen which is fertilized externally by the male horseshoe crab. The female crab deposits the fertilized eggs in a nest she has hollowed out in the sand. At the time of the next high tide, usually a month later, the eggs hatch and the young move back into the ocean. Horseshoe crabs have developed a natural cycle that matches the phases of the moon and lay their eggs at the time of month when their offspring are most likely to survive. Do you know of any other marine organisms that depend upon the tides for mating or survival?



The horseshoe crab's life cycle relies on the rhythm of the tides.

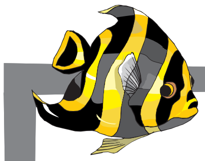


Small creatures such as crabs live in tide pools at low tide.

Outgoing tides do not always carry back all of the water from incoming tides. If the ground near the shore is not smooth, pockets of water can be trapped, forming **tide pools**. Tide pools are often found on rocky coasts, marshy areas, or sandy beaches. Small creatures such as crabs, fish, and sea urchins live in these pools at low tide. These animals must be able to withstand high temperatures and salinities during low tide.

Summary

Gravitational pull by the moon and sun produces tides, or changing levels of water, in Earth's oceans. These tides are really long waves that rise and fall according to their position in relationship to the moon and, to a lesser degree, from the sun. As the Earth and moon rotate, different regions of the ocean rise and fall as they move nearer and farther away from the moon and the sun. This constant shift in water elevation will periodically expose some coastlines and their organisms to air and change the chemistry of coastal waters. Organisms must be adapted to these constant changes in temperature, humidity, and salinity if they are to survive. Tides are important to marine life. The daily change of tides allows for nutrients to flow from an estuary to the open ocean. Tides also transport marine organisms from one location to another and provide many marine organisms with a mechanism for reproduction. Tides create the environmental conditions of marine organisms that live in the harsh *intertidal* zone between the high-water mark and the low-water mark.



Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

50
bulge
diurnal
ebb
flood
marigram
mixed
moon
nadir
neap
range
sea
semidiurnal
spring
tidepools
two

1. Long ago people noticed that there was a regular rhythm to the changes in the level of the ____________________ .

2. In most locations there are ____________________ high tides and ____________________ low tides every day.

3. Tides are caused by the gravitational pull of the ____________________ on the Earth.

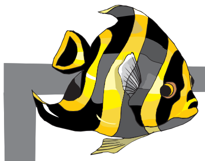
4. Every day the tides occur about ____________________ minutes later than the day before.

5. The tidal ____________________ is responsible for a high tide.

6. The *zenith* is the point on Earth closest to the moon; the ____________________ is the point on Earth farthest from the moon.

7. When the Earth, moon, and sun are in a straight line, ____________________ tides, or extra-high tides, occur.

8. When the Earth, moon, and sun form a right angle, ____________________ tides, or extra-low tides, occur.
9. In the Bay of Fundy the tidal ____________________ is extremely high.
10. The type of tide with very little difference between its two high- and two low-water levels is a ____________________ tide.
11. Certain places, such as Vietnam and China, have only one high tide and one low tide a day, which is called a ____________________ tide.
12. Along the Pacific Coast of the United States, ____________________ tides occur that have extreme differences between the two low-water levels and/or two high-water levels.
13. At low tide, crabs, fish, and sea urchins may be found in ____________________ .
14. High tides are also known as ____________________ tides, while low tides are called ____________________ tides.
15. A ____________________ is a graphic record of rise and fall of tides.



Lab Activity 1: Predicting Time of Tides

Investigate:

- Predict the times of tides at a particular location.

Materials:

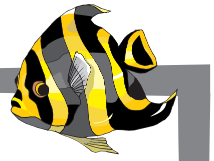
- tide chart from newspaper
- paper
- pencil

Procedure:

1. Use a newspaper to find the times that tides will occur on a particular day.
2. Add 50 minutes to each tide to predict the time of the tides tomorrow. (Remember, there are only 60 minutes in an hour.)
3. Compare your calculated times with those in the next day's newspaper.

Tomorrow's Tides

High	Low	High	Low
St. Marks		**Carrabelle**	
3:41 a.m.	9:46 a.m.	4:06 a.m.	10:11 a.m.
3:58 p.m.	10:05 p.m.	4:24 p.m.	10:38 p.m.
Shell Point		**Alligator Point**	
3:46 a.m.	9:49 a.m.	3:33 a.m.	9:57 a.m.
4:03 p.m.	10:09 p.m.	3:50 p.m.	3:50 p.m.
Apalachicola			
5:31 a.m.	12:25 a.m.		
5:49 p.m.	12:24 p.m.		



Lab Activity 2: Plotting Times and Heights of Tides

Investigate:

- Plot the times and heights of tides on a marigram.

Materials:

- graph
- pencil

Procedure:

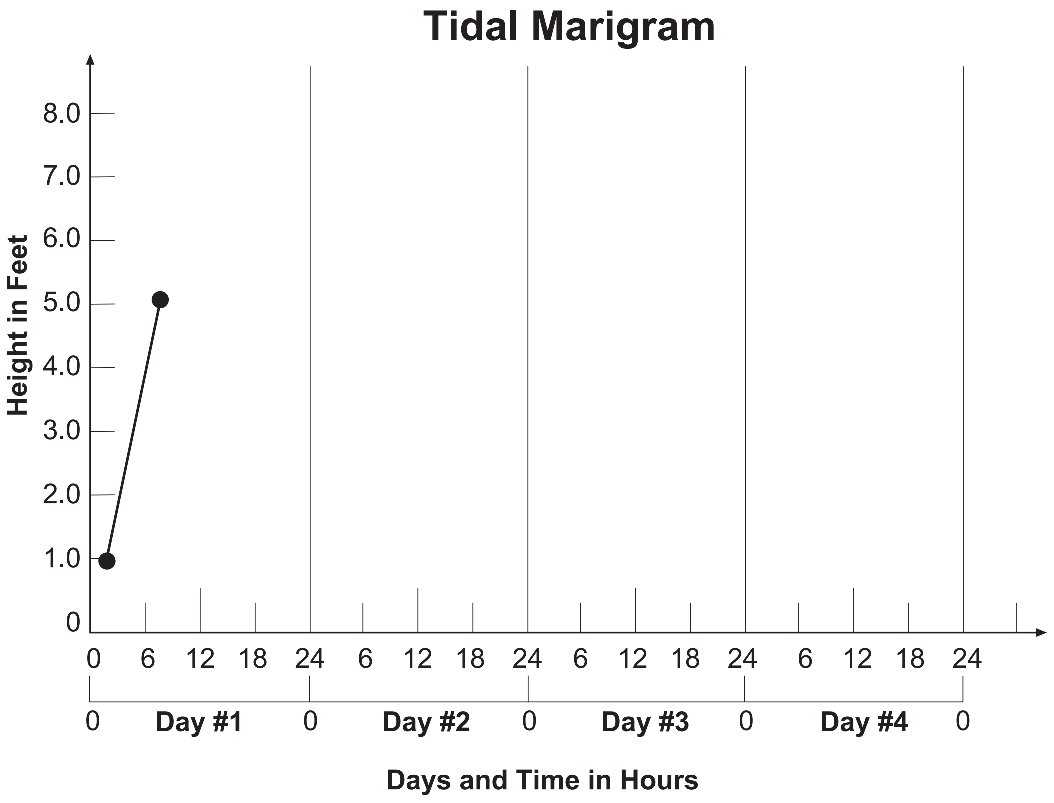
1. The table below shows the times and heights of tides on four successive days. Using the information in the table, complete the marigram on the following page. Be sure to show the times and heights of all the tides listed in the table.
2. Connect all the points with a line.
3. Use your graph to answer the questions.

Tide Predictions

Day	Time		Height
	Hour*	Minutes	Feet
#1	01	30	1.0
	07	45	5.1
	16	00	1.0
	20	30	5.0
#2	02	00	2.0
	08	15	5.5
	14	30	1.0
	21	00	6.0
#3	04	30	1.0
	10	00	3.0
	16	15	1.0
	22	30	3.1
#4	05	00	1.0
	17	30	8.0

* 24-hour day in military time

For help, the first two tides on Day 1 have been plotted for you.

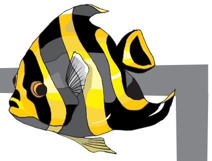


Analysis:

1. On which day is the tide *diurnal*? ______________________________
2. On which day is the tide *mixed*? ______________________________
3. On which days are the tides *semidiurnal*? ______________________
4. What is the largest range in feet? ______________________________

   On which day does this occur? ______________________________
5. What is the smallest range in feet? ______________________________

   On which day does this occur? ______________________________



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. to tell in advance

______ 2. the point on Earth's surface closest to the moon

______ 3. tide occurring at the first and third quarters of the moon when the sun, Earth, and moon form a right angle; this produces tides with a low tidal range

______ 4. tides occurring at the new and full moon when the sun and moon are in a straight line with each other; produces the greatest tidal ranges between high water and low water

______ 5. a concentration of water due to the pull of the moon; occurs on the two sides of the Earth closest to and farthest away from the moon

______ 6. the point on Earth's surface farthest from the moon

______ 7. a stage in a process of change or development; may occur in regular cycles

______ 8. movement with regular recurrence or repetition

______ 9. the rhythmic rise and fall of ocean water

A. nadir

B. neap tide

C. phase

D. predict

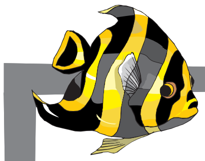
E. rhythm

F. spring tide

G. tidal bulge

H. tide

I. zenith



Practice

Use the list below to write the correct term for each definition on the line provided.

diurnal tide
ebb tide
estuary
flood tide
intertidal zone
marigram
mixed tide
semidiurnal tide
tidal bore
tidal range
tide pools

______________________ 1. pockets of water formed on uneven shores by outgoing tides

______________________ 2. a graphic record of the rise and fall of the tide in the form of a curve

______________________ 3. a tide that has one high-water level and one low-water level per day

______________________ 4. a tide that has two high-water levels and two low-water levels per day with extreme differences between the heights of the two high- and/or the two low-water heights

______________________ 5. a tide that has two high-water levels and two low-water levels per day with little difference between the two high- and low-water heights

______________________ 6. tide at its lowest point

______________________ 7. a sudden rise in water height caused by tides moving rapidly inland from the mouth of a river; a wall of water

______________________ 8. tide at its highest point

______________________ 9. difference between heights of successive high and low waters

______________________ 10. mouth of a river or bay where fresh water and saltwater mix

______________________ 11. the area between high tide and low tide

Unit 6: Ocean Currents

Unit Focus

This unit focuses on forces that produce ocean currents. Students will also examine the impact ocean currents have on coastlines and marine life.

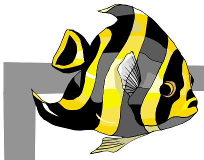
Student Goals

1. Identify currents of the world's oceans.
2. Understand that currents move in circular paths due to the Coriolis effect.
3. Know the role of currents in providing nutrients to marine life.
4. Understand how currents shape coastlines.

Vocabulary

Study the vocabulary words and definitions below.

continental slope	the sloping surface between the outer edge of the continental shelf and the ocean basin
convection current	the movement of a substance caused by differences in its temperature
Coriolis effect	the result of the Earth's rotation, causing a water mass or moving object to flow to the right in the Northern Hemisphere (clockwise) and to the left in the Southern Hemisphere (counterclockwise)
course	path or direction
current	movement of water caused by uneven temperatures or winds
equatorial currents	warm-water currents that flow away from the equator
Gulf Stream	warm-water current that flows from the Gulf of Mexico, around Florida, and up the East Coast of North America
gyres	circular or spiral patterns; refers to circular motion of major ocean currents
hemisphere	half of a sphere (ball or globe)
longshore current	current located in the surf zone, running parallel to the shore as a result of waves breaking at an angle on the shore



polar currents	cold-water currents that flow toward the equator
reversing current	the current as it meets land and moves back into the ocean
rip current	strong, narrow current at or near the surface of the shoreline flowing back toward sea
trade winds	powerful winds produced by the Earth's rotation; movement of air toward the equator, from the northeast in the Northern Hemisphere and southeast in the Southern Hemisphere
turbidity current	strong, underwater current of water, sand, and silt that erodes the ocean bottom
upwelling	process by which deep, cold, nutrient-rich water is brought to the surface, usually by water currents or winds that pull water away from the coast

Introduction: Ocean Currents—Moving Streams of Water

The previous unit discussed how the *gravitational pull* of the moon and sun cause the Earth's oceans to *rise* and *fall*. The sun also influences streams of water in the oceans to flow across the Earth's surface or move *horizontally*. These moving streams of water are called **currents** and follow a regular **course**, or path, as they travel the ocean. *Currents* can move along the surface of the ocean and at any depth below the surface.

The Ocean's Surface Currents: Blown by the Wind, Moved by Temperatures

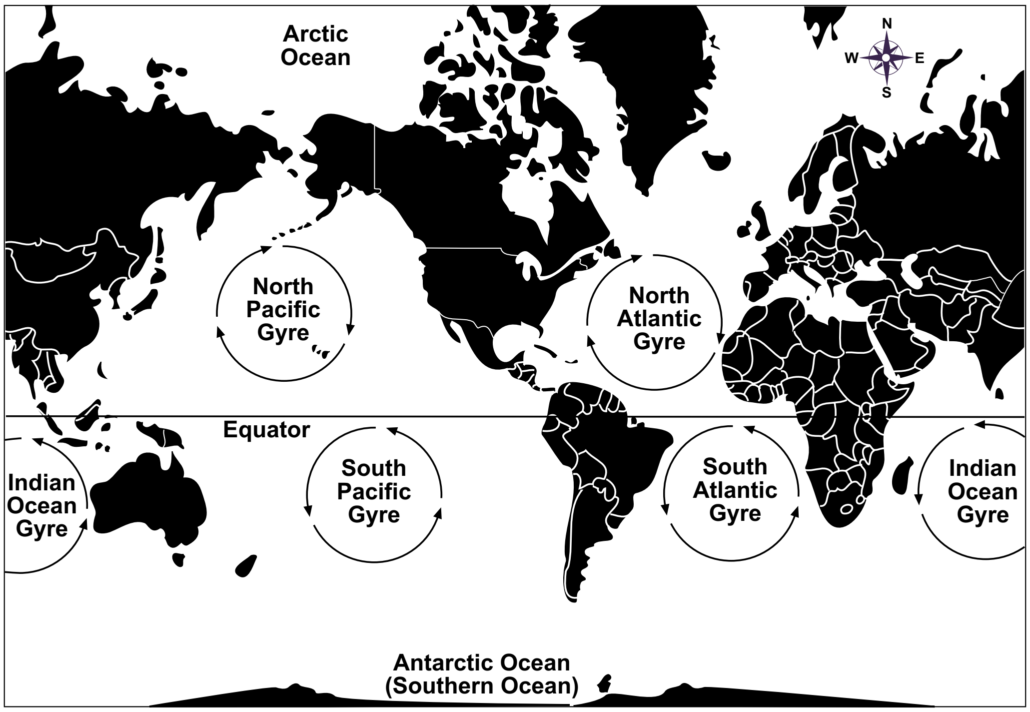
The friction of the wind, or moving air, against the surface of the water set the water in motion.

You've probably noticed the surface of the ocean set in motion by the wind when you've visited the coast. What you're witnessing is the transfer of energy from the wind to the surface of the ocean. The friction of the wind, or moving air, against the surface of the water set the water in motion. The greater the wind, the greater the friction, and, consequently, the stronger the surface currents. In short, on a windy day, the sea will be much choppier than on a calm day. (The next time you see the wind's effect on the ocean's surface, consider this: Wind friction is passed from the surface water to the water levels below. In some places, this transfer of energy continues, level by level, to 200 meters below the surface!)

Our study of the surface currents in the ocean begins with a discussion of wind. You may remember from your previous studies in science that some parts of the Earth receive more direct sunlight than other parts. Heated air expands and rises, while colder, more dense air sinks. If the Earth did not rotate on its axis, the air along the sun-drenched equator would heat and flow towards the north and south poles. At the poles, air would cool, become very heavy, and flow back to the equator where it would be heated again. The winds would move northerly and southerly along the Earth.

The Earth rotates and this feature produces a regular but complex wind pattern in the atmosphere. The result of the Earth's rotation is known as the **Coriolis effect**. In each hemisphere, the Coriolis effect produces three wind systems, or moving bands of air. These moving bands of air, called the *polar easterlies*, the *westerlies*, and the **trade winds** (which are easterlies), move the ocean's currents. The winds are named for the direction from which they come.

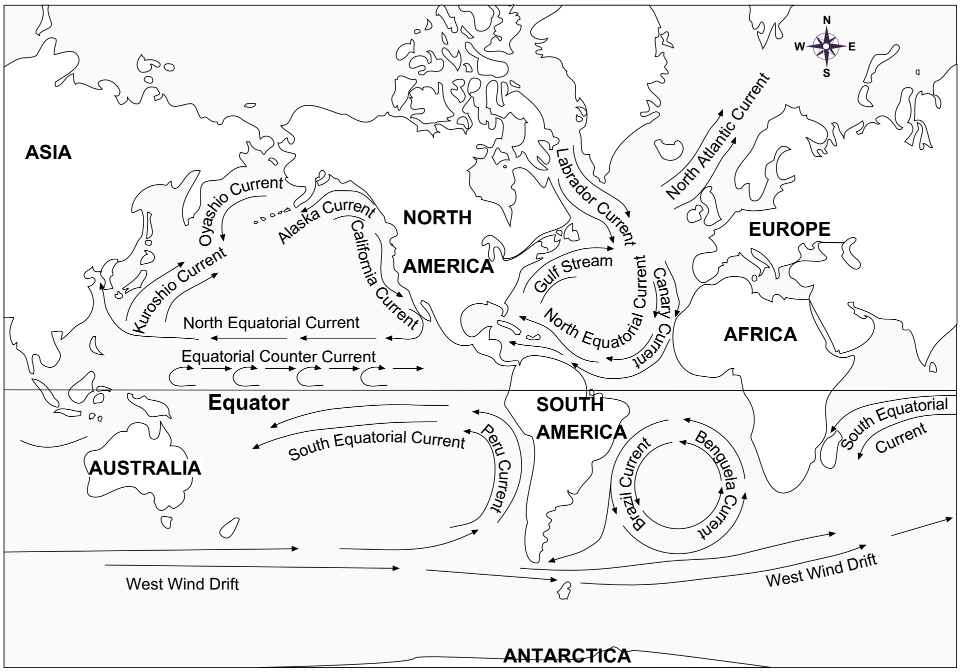
Air along the equator moves north or south. The waters move, consequently, in giant circular patterns called **gyres**. There are five major gyres or circulating patterns in the world's oceans. In the Northern **Hemisphere**, these gyres move in a *clockwise* direction, and in the Southern Hemisphere they move in a *counterclockwise* direction.



gyres of the world

The waters of the Earth have different temperatures. Because the sun is closest to the equator, currents at the equator are warm, whereas currents at the poles are cold. This difference in water temperatures creates **convection currents** in the ocean waters. The colder, more dense water

sinks, and the warmer, less dense water rises above it. **Equatorial currents** carry warm water away from the equator toward the poles. **Polar currents** carry cold water away from the poles toward the equator.



currents of the world

Florida's Currents: The Gulf Stream

One of the most familiar currents to us in Florida is the **Gulf Stream**. The Gulf Stream is a warm-water current that flows from the Gulf of Mexico, around Florida and up the East Coast of North America. Its waters help to warm the water temperature of the eastern North Atlantic Ocean, making the water relatively warm (even in the winter) and moderating our climate.

Turbidity Currents: A Slide in the Ocean

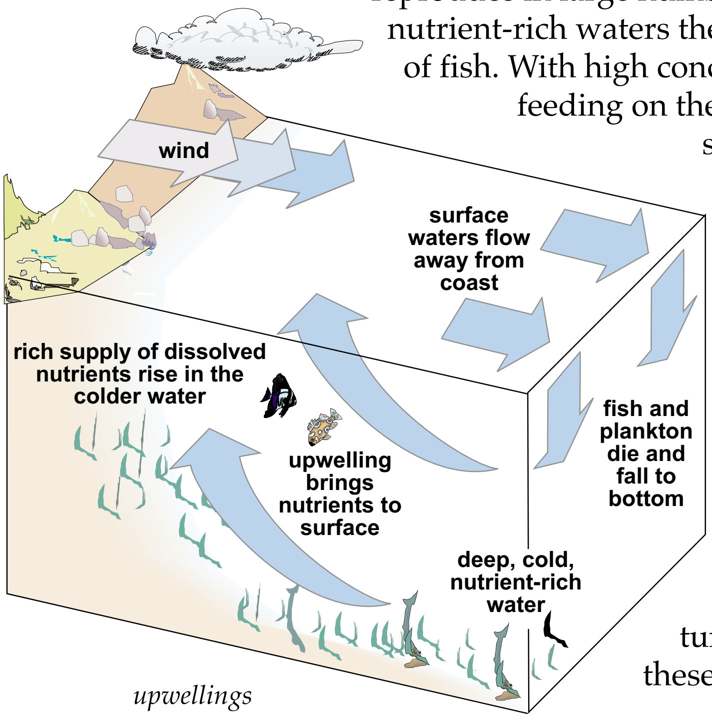
The continental shelf and the slope sometimes have deep cuts that form valleys or canyons. Scientists hypothesize that these valleys and canyons were formed by **turbidity currents**. These are currents that are very thick and carry huge amounts of sediment down the **continental slopes** (see Unit 7). Turbidity currents form when landslides of sediments are pushed down the continental slopes. The landslides are possibly triggered by earthquakes. The speed at which the sediment slides down the continental slope erodes the slope, forming deep canyons.

Making Use of the Currents

For hundreds of years we've observed the currents and used them to our advantage. For example, sailors have long used the currents to decrease their travel time. By moving in the same direction as fast-moving currents, ships save time and reduce fuel use. In some instances, traveling a longer distance along the currents take less time and fuel than traveling a more direct route.

Ships coming to the New World from Europe knew about currents and used them to their advantage. Ponce de Leon noted in 1513 the difficulty of sailing against the Gulf Stream along the coast of Florida. In 1770 Benjamin Franklin used sailors' records to draw simple maps of the currents in the North Atlantic Ocean, including the Gulf Stream.

Fishermen also use the currents to increase their catches. Ocean or wind currents can cause the surface water to flow away from the coast. Then a process called **upwelling** takes place: Deep, cold, nutrient-rich water—an upwelling—is brought to the surface by coastal currents. This upwelling replaces the surface water that has flowed away from the coast because of a water current or the wind. Whenever this occurs, a rich supply of dissolved nutrients rises in the colder water. *Plankton* (small, sometimes microscopic organisms that float or drift) use this nutrient source and reproduce in large numbers (see Unit 10). These nutrient-rich waters then attract large numbers of fish. With high concentrations of fish feeding on these nutrients or other sea life, these areas provide a rich catch for fishermen.



upwellings

Upwellings are common on the west coasts of North America, South America, and Africa. Because of the abundance of fish, many major fisheries, such as anchovy and tuna, are located near these upwelling areas.

Currents and the Availability of Nutrients

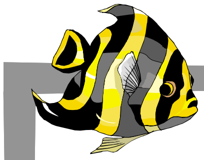
Marine and plant life are typically very abundant along coastal and shallow waters. Do you know why this is so? You may already know that bacterial decay occurs on the ocean floor and *photosynthesis* (the process plants and algae use to make their own food using the energy in sunlight) occurs in the surface waters of the ocean. Bacterial decay provides nutrients for marine plants and algae. Plant life in the surface waters provides food for marine life. But in the open ocean, most of the nutrients sink to the bottom of the ocean. Nutrients located at the ocean bottom are not available to the plant life at the ocean's surface. Therefore, a smaller amount of *phytoplankton*, or plant plankton, are produced in the open oceans (see Unit 9). How do you think limited phytoplankton production affects marine life in the open ocean? Upwelling in deep water brings important nutrients that have sunk to the ocean bottom back to the surface. Once these nutrients are at the ocean's surface, they become available to the phytoplankton. Upwelling and the availability of light play an important role in shaping *ecosystems* (systems formed by the interaction of a community of organisms with their environment) and the productivity of the ecosystem.

Beach Currents: A Possible Danger to the Ocean Swimmer

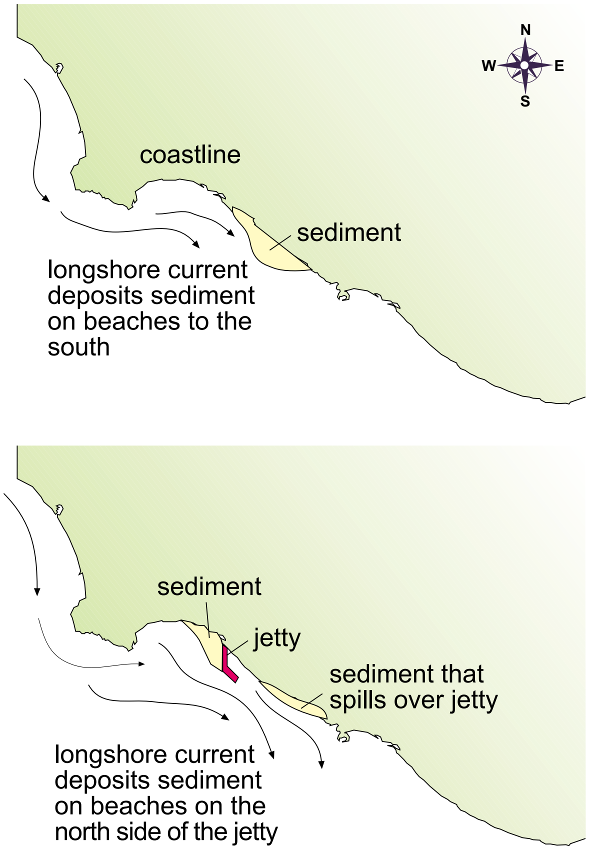
Not all currents are large ocean currents. Smaller currents occur near the shore. A **reversing current** is the movement of the water back toward the ocean. Most reversing currents have the same force as the wave striking the beach. However, when these currents are stronger, they can be dangerous and have caused swimmers to drown.

One of these dangerous reversing currents is the **rip current**. A rip current is a strong, narrow flow of water caused by water returning to the ocean after breaking on a shoreline. The speed and strength of this current depends on the wave and the steepness of the beach.

If you find yourself trapped in a rip current, don't panic and do not fight the current. Let the current carry you out a short distance until the pull has decreased. You can then swim to the beach, but do so diagonally to avoiding swimming into another rip current.



Another beach current is the **longshore current**. This type of current runs parallel to, or along, the beach. Longshore currents are formed when waves hit the beach at an angle. When you are carried away from your towel and beach umbrella while swimming, you have probably been caught in a longshore current. Do not try to swim against strong longshore currents. Simply swim or float directly to shore, then walk back to your starting point.



longshore currents

Longshore currents are responsible for the mass movements of sand and erosion along the beach. Many people try to stop longshore sand movement by building jetties. A *jetty* is a projecting structure made of rocks, concrete, or wood that protects the beach from the current or tide. The longshore current still moves the sand, but with a jetty in place, the sand is trapped. Eventually, however, the sand will spill over to the other side of the jetty. Although jetties can't stop longshore movements or erosion, they can slow it down.

Summary

Ocean currents are movements in the water caused by Earth's rotation (Coriolis effect), wind systems, and differences in water temperature (convection). Currents affect the movement of ships and marine life in the ocean, and carry warm water to the poles and cold water to the equator. You may have experienced currents along the beach, such as rip or longshore currents. These can cause harmful erosion and can be dangerous to a swimmer who gets caught and carried away from land.

Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

convection
counterclockwise
currents
Equatorial
gyres
longshore
Northern
polar
reversing
rip
turbidity
upwellings
winds

1. Moving streams of water are called ____________________ .

2. Ocean currents are caused primarily by ____________________ blowing across the Earth.

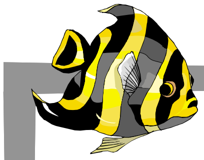
3. ____________________ currents are warm-water currents that flow away from the equator.

4. There are five major ____________________ , or circular patterns of water movement, in the world's oceans.

5. Ocean currents move clockwise in the
____________________ Hemisphere and
____________________ in the Southern Hemisphere.

6. A strong, narrow surface current that can be dangerous is called a ____________________ current.

7. ____________________ are good for fishermen because they bring cold, nutrient-rich water to the surface, which attracts fish.



8. If you are in the water and notice that you have drifted parallel to the beach and away from your towel, you are probably in a ____________________ current.

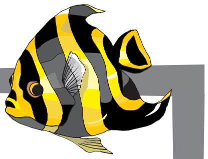
9. A ____________________ current forms when landslides of sediment, possibly triggered by earthquakes, erode the continental slope, forming deep canyons.

10. The movement of the water back toward the sea is called a ____________________ current.

11. The polar easterlies, westerlies, and trade ____________________ move the ocean currents.

12. Differences in water temperature create ____________________ currents that move the ocean water.

13. ____________________ currents carry cold water away from the poles toward the equator.



Practice

Match each **description** *with the correct term. Write the letter on the line provided.*

______ 1. deep, cold, nutrient-rich water brought to the surface by coastal currents

______ 2. a fast-moving avalanche of sand or silt rushing down a slope

______ 3. current that meets land and moves back into the ocean

______ 4. a moving stream of water

______ 5. carry cold water toward the equator

______ 6. giant circular patterns in the ocean

______ 7. carry warm water toward the poles

______ 8. runs parallel to the beach

______ 9. dangerous reversing current at or near the shoreline

______ 10. warm-water current off the East Coast of North America

______ 11. water movement caused by differences in water temperature

A. convection current

B. current

C. equatorial currents

D. Gulf Stream

E. gyres

F. longshore currents

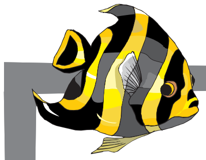
G. polar currents

H. reversing current

I. rip current

J. turbidity currents

K. upwelling



Lab Activity 1: Ocean Currents

Investigate:

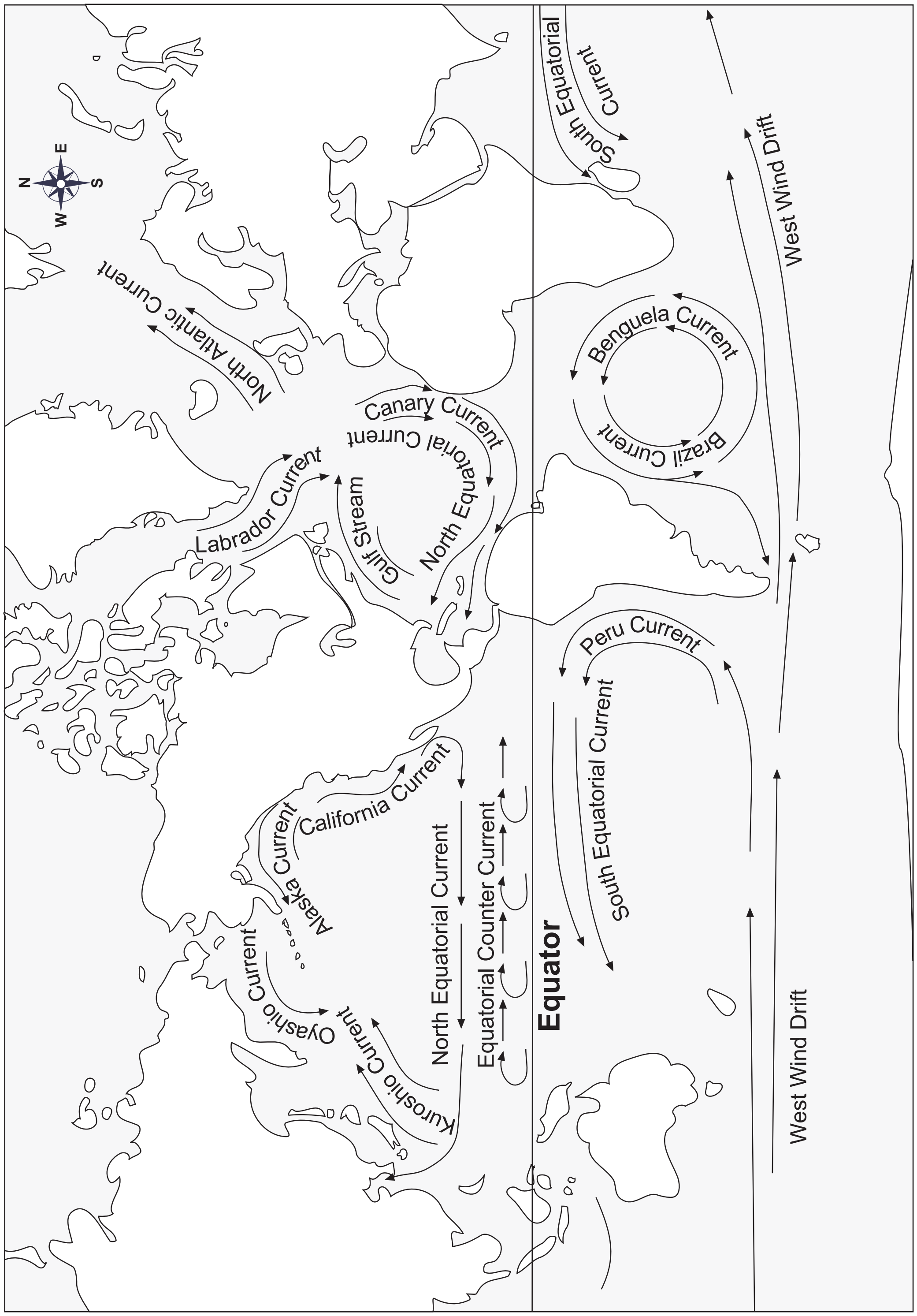
- Study major ocean gyres and the movements of water masses.

Materials:

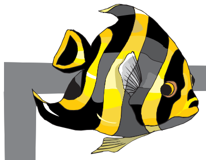
- world map on page 149, globe, or atlas
- colored pencils

Procedure:

1. Assume that all equatorial currents and all currents moving away from the equator to the poles are warm. Color these **red**.
2. Assume that all polar currents and all currents moving away from the poles to the equator are cold. Color these **blue**.
3. Label the *seven continents* on the map on page 149.
4. Label the North Atlantic, South Atlantic, North Pacific, South Pacific, Indian, Arctic, and Antarctic (also known as the *Southern Ocean*) oceans on the map.



Major Ocean Currents of the World



Analysis:

1. In what direction do currents rotate in the Northern Hemisphere?

   ____

2. In what direction do currents rotate in the Southern Hemisphere?

   ____

3. What causes this rotation or the currents? __________________

   ____

4. Why do the waters around Florida remain warm in the winter? ___

   ____

   ____

5. Why does fog often form off the coast of Labrador (East Coast of

   Canada)? ____

   ____

6. What is the general rule regarding the presence of warm or cold currents along the coasts?

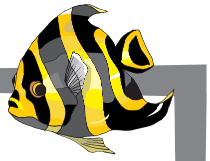
   Along the East Coast, currents are ________________________ .

   Along the West Coast, currents are ________________________ .

7. What is the general rule regarding the temperature of currents moving toward and away from the equator?

   Currents moving away from the equator are ________________ .

   Currents moving toward the equator are ___________________ .



8. Refer to the map of major ocean currents on page 149 and in other reference books to complete the chart below. Under *Coastal Area* fill in the name of the nearest country to each current. Under *Temperature* describe each current as warm or cold.

Ocean Currents

Currents	Coastal Area	Temperature
1. Gulf Stream		
2. California Current		
3. Peru Current		
4. Brazil Current		
5. Benguela Current		
6. Labrador Current		
7. West Wind Drift		
8. Canary Current		
9. North Atlantic Current		

Lab Activity 2: Currents

Investigate:

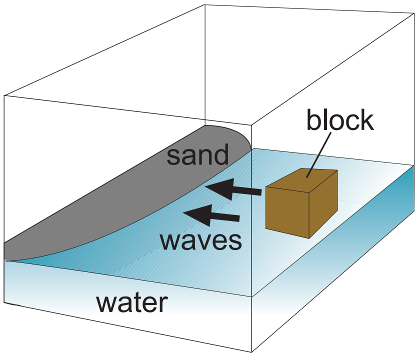
- Study the effects of different types of beach currents.

Materials:

- sand
- water
- wooden blocks
- tray
- small pebbles

Procedure: Beach Currents

1. Construct a small sand beach at one end of the tray.

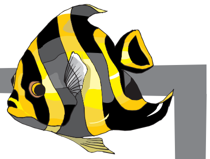


2. Add water to a depth of 1-2 inches. What happened to the beach when the water was added? ____________________

____

____

____



3. Use a small wooden block to generate waves that move toward the beach.

   a. Describe the beach after the first few waves. ________________

   ____

   ____

   ____

   ____

   ____

   b. Describe the beach after a minute of wave action. ____________

   ____

   ____

   ____

   ____

   ____

   c. What would happen to the beach if it had no additional source of sand? ____________________________________

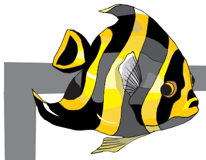
   ____

   ____

   ____

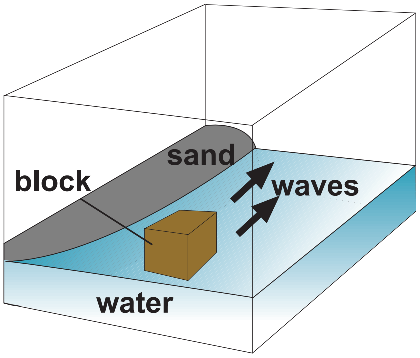
   ____

   ____



Procedure: Longshore Currents

1. Construct a sand beach along one side of the tray.



2. Generate waves with a wooden block along the length of the beach.

   a. What happens to the beach as the waves move across? ________

   ____

   ____

   ____

   ____

   ____

   b. What direction does the beach move? ____________________

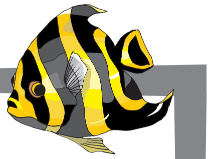
   Why? ____

   ____

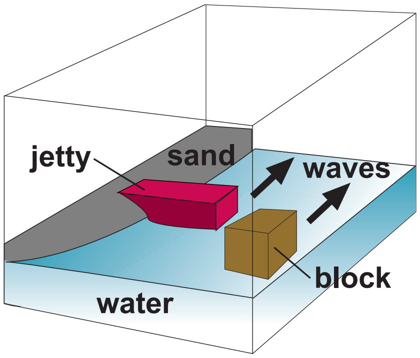
   ____

   ____

   ____



3. Use small rocks or another block to build a jetty sticking out from the beach.



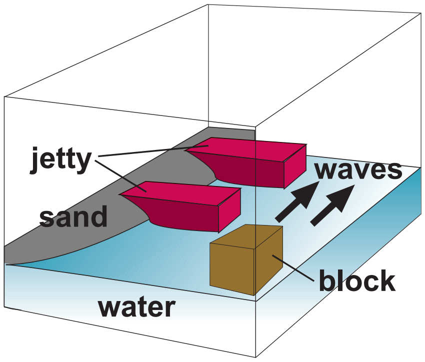
4. Generate waves along the beach with the wooden block.

   a. Describe the shape of the beach after wave action. ____________

   b. Will jetties prevent beaches from being moved? ____________

   Explain. ____________

5. Build a second jetty on your beach.



a. How does the additional jetty affect beach movement? ________

____

____

____

____

____

Analysis:

1. What can be done to prevent beach erosion from the currents? ____

____

2. What types of currents are most destructive to a beach? __________

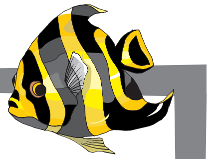
____

Explain. ____

____

____

____



Practice

Use the list below to write the correct term on the line provided.

continental slope
convection current
Coriolis effect
course
current
equatorial currents
gyres
hemisphere
polar currents
trade winds

______________________________ 1. half of a sphere (ball or globe)

______________________________ 2. powerful winds produced by the Earth's rotation

______________________________ 3. cold-water currents that flow toward the equator

______________________________ 4. warm-water currents that flow away from the equator

______________________________ 5. the movement of a substance caused by differences in its temperature

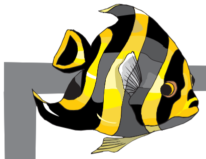
______________________________ 6. the result of the Earth's rotation, causing a water mass or moving object to flow to the right in the Northern Hemisphere and to the left in the Southern Hemisphere

______________________________ 7. circular or spiral patterns; refers to circular motion of major ocean currents

______________________________ 8. path or direction

______________________________ 9. movement of water caused by uneven temperatures or winds

______________________________ 10. the sloping surface between the outer edge of the continental shelf and the ocean basin



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. current located in the surf zone, running parallel to the shore as a result of waves breaking at an angle on the shore

______ 2. strong, narrow current at or near the surface of the shoreline

______ 3. process by which deep, cold, nutrient-rich water is brought to the surface, usually by water currents or winds that pull water away from the coast

______ 4. the current as it meets land and moves back into the ocean

______ 5. strong, underwater current of water, sand, and silt that erodes the ocean bottom

______ 6. warm-water current that flows along the East Coast of North America

A. Gulf Stream

B. longshore current

C. reversing current

D. rip current

E. turbidity current

F. upwelling

Unit 7: The Ocean Floor

Unit Focus

This unit depicts the topography of the ocean floor and describes how the features of the ocean floor are formed.

Student Goals

1. State the features that make up the topography of the ocean floor.
2. Explain how the features of the ocean floor are formed.
3. Examine a profile of the topography of the ocean floor and label its features.

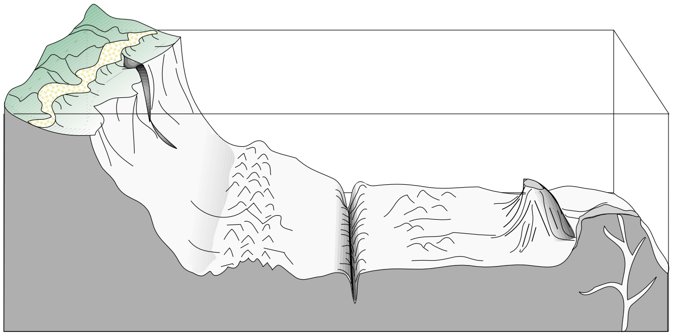
Vocabulary

Study the vocabulary words and definitions below.

abyssal plains	large, flat regions on the ocean floor
basin	the ocean floor at a depth of more than 4,000 meters
continental shelf	a relatively flat part of the continent that is covered by seawater; lies between the coast and the continental slope
continental slope	the sloping surface between the outer edge of the continental shelf and the ocean basin
guyots (GEE-oze or GEE-oots)	underwater volcanic mountains with flat tops
mid-ocean ridge	a mountain chain that rises from the ocean basins; where seafloor spreading takes place
seamounts	underwater, cone-shaped volcanic mountains
submarine canyons	deep, V-shaped valleys found along the continental slope
topography	detailed charting of the features of an area; heights, depths, and shapes of the surface of an area
trenches	long, narrow cracks in the ocean floor; the deepest parts of the ocean

Introduction: The Ocean Floor—Features Underwater

Using sonar, seismic profiling, satellites, and underwater research vehicles, oceanographers have discovered that the **topography**, or shape of the ocean floor is quite similar to many of the dramatic sights we see on the landforms on Earth's continents. The ocean floor has raised masses of land similar to the Rocky Mountains and large areas of smooth and level surfaces similar to the Great Plains. Underneath the ocean's surface, however, we would find canyons that are deeper, mountain ranges that are higher and longer, and plains that are wider and flatter than any landforms on the continents.

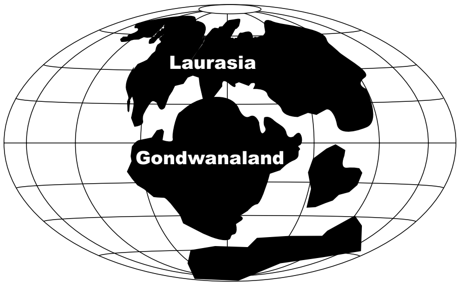


topography of the ocean floor

Crustal Plate Movement: The Pieces of Earth's Giant Puzzle

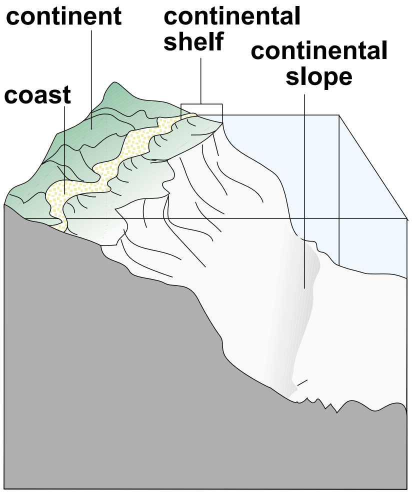
Scientists have collected evidence to show that Earth's continents were once one large landmass known as *Pangaea* (pan-JEE-uh). According to German scientist Alfred Wegener's 1915 hypothesis of continental drift, the continents separated over time and, like pieces of a giant puzzle, *drifted* to their present locations.

A theory known as *plate tectonics* suggests that the Earth's outermost layer, or *crust*, is separated into 12 or more large pieces or plates. These plates include the five-mile thick oceanic crust, which lies beneath the oceans. These plates are still moving, and this movement, or friction, between the plates helps explain why volcanoes and earthquakes occur along the plate boundaries.



German scientist Alfred Wegener suggested that at one time all of the continents were one large landmass called Pangaea. This landmass then split apart and broke into two large landmasses called Laurasia and Gondwanaland. These eventually broke apart and over time drifted across the ocean floor until they reached their present positions.

Continental Shelf: Continents under Water



The part of the continent that is under water is called the continental shelf.

Shorelines do not mark where the continents end; some continents actually extend into the ocean as much as 50 to 65 kilometers. From the shorelines, land begins to slope gently downhill and under water. The edge of the continent that is under water is called the **continental shelf**. Continental shelves were formed as rivers carried tons of particles of sand and soil from the land out to sea. This sand and soil then settled as layers of sediments, or layers of particles of rock and animal remains.

Although continental shelves are usually flat, they differ in their width, or the distance they extend into seawater. The steepness of the land along the coast affects the width of the continental shelf. For example, a mountainous coast will have a continental shelf that is narrow. A low-lying coast will have a long and wide continental shelf.

Layers of sediment and mineral deposits on the continental shelf provide pockets of oil and natural gas—natural resources that are valuable sources of energy. The waters over the continental shelf also provide productive fishing areas.

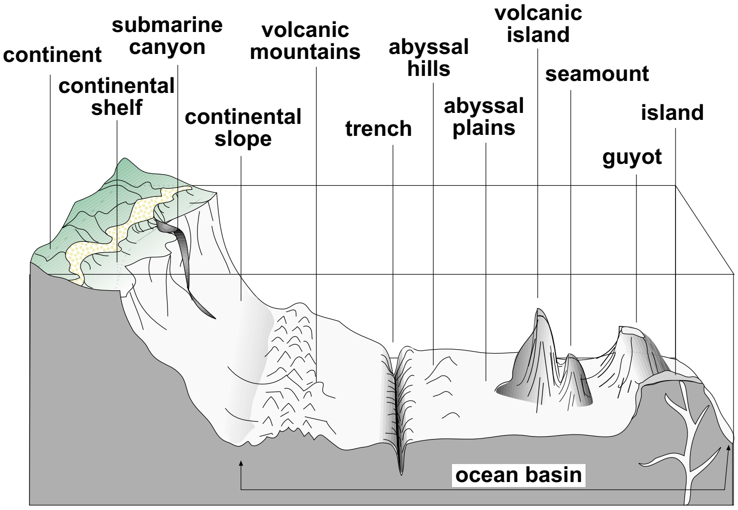
Continental Slope: The Underwater Cliff

At the edge of the continental shelf is a slope that may vary from steep to gradual known as the **continental slope**. The continental slope separates the continental shelf from the ocean floor.

Continental slopes have many gullies and small valleys. **Submarine canyons**, or deep, ditch-like valleys that have been cut in hard rock, also appear along the slopes. The upper part of submarine canyons, scientists believe, were formed by rivers, and the deeper parts by undersea currents of sand and silt such as *turbidity currents* (see Unit 6). The sediment slows at the bottom of the slope and forms a gentle slope known as the *continental rise*. At the end of the rise is the *ocean* **basin**, which is more than 4,000 meters deep.

Abyssal Plains: Earth's Largest Plains

The *ocean basin*, or floor, begins at the bottom of the continental slope. Many plains on the ocean basin are larger and flatter than any found on the Earth's surface. They are called **abyssal plains**. Abyssal plains are formed by sediments deposited by turbidity currents and sediments continually falling from the seawater above. The deepest parts of the ocean floor are long, narrow cracks called **trenches**, which have been caused by shifts in the crustal plates. At some points, these trenches slice into the ocean floor more than 10,000 meters deep, and some run as long as 4,500 kilometers. The Marianas Trench in the Pacific Ocean is the deepest spot in the ocean—over 10,911 meters (6.78 miles) deep.



Like the surface of the continents, the landscape of the ocean floor displays a variety of physical features, including mountains, hills, trenches, and plains.

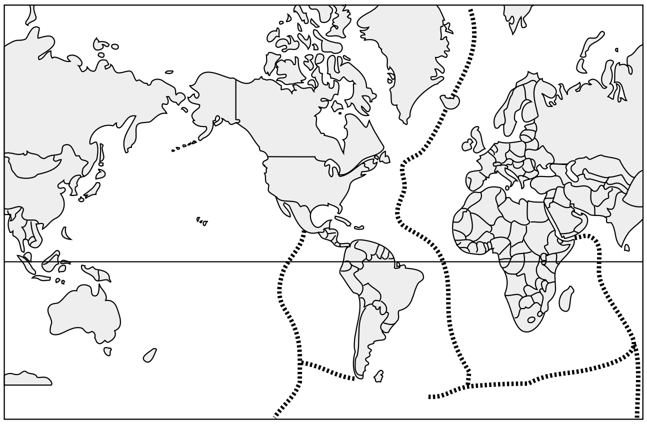
Seamounts and Guyots: Underwater Mountains

Along the ocean floor, often near crustal *plate boundaries*, are underwater mountains called **seamounts**. Seamounts are actually cone-shaped volcanic mountains with steep sides and a narrow summit, or top. Some seamounts rise through the ocean's surface and appear as volcanic islands. Seamounts are most abundant in the Pacific Ocean, possibly because of the activity of plates in the Pacific area.

Many seamounts do not rise to a peak but have a flat top. Flat-topped seamounts are called **guyots (GEE-oze** or **GEE-oots)**. Scientists hypothesize that the seamount tops were above sea level at one time and have been removed by wave action. The flattened seamounts later sunk below the ocean surface. Scientists believe the sinking of the guyots was caused by the movement of crustal plates.

Mid-Ocean Ridges: Underwater Mountain Ranges

The most prominent feature of the ocean basin is the **mid-ocean ridges**. Mid-ocean ridges are underwater mountain ranges. The ridges form a continuous mountain chain from the Arctic Ocean, down through the middle of the Atlantic Ocean, around the tip of Africa and into the Indian Ocean. The chain then continues across to the Pacific Ocean and north to North America. In some areas, the highest peaks of the mid-ocean ranges reach above sea level, forming island chains.

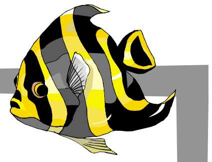


outline of the worlds mid-ocean ridges

Mid-ocean ridges do not form in the same way as mountain ranges on land. Mid-ocean ridges form when molten magma from the mantle flows up to the seafloor. When the lava hits the seafloor, it cools and forms layers, making new crust. This expansion of the Earth's crust is called *seafloor spreading*. The mountain belt located in the Atlantic Ocean is called the *Mid-Atlantic Ridge*. The mountain belt located in the Pacific Ocean is called the *East Pacific Rise* or *East Pacific Ridge*.

Summary

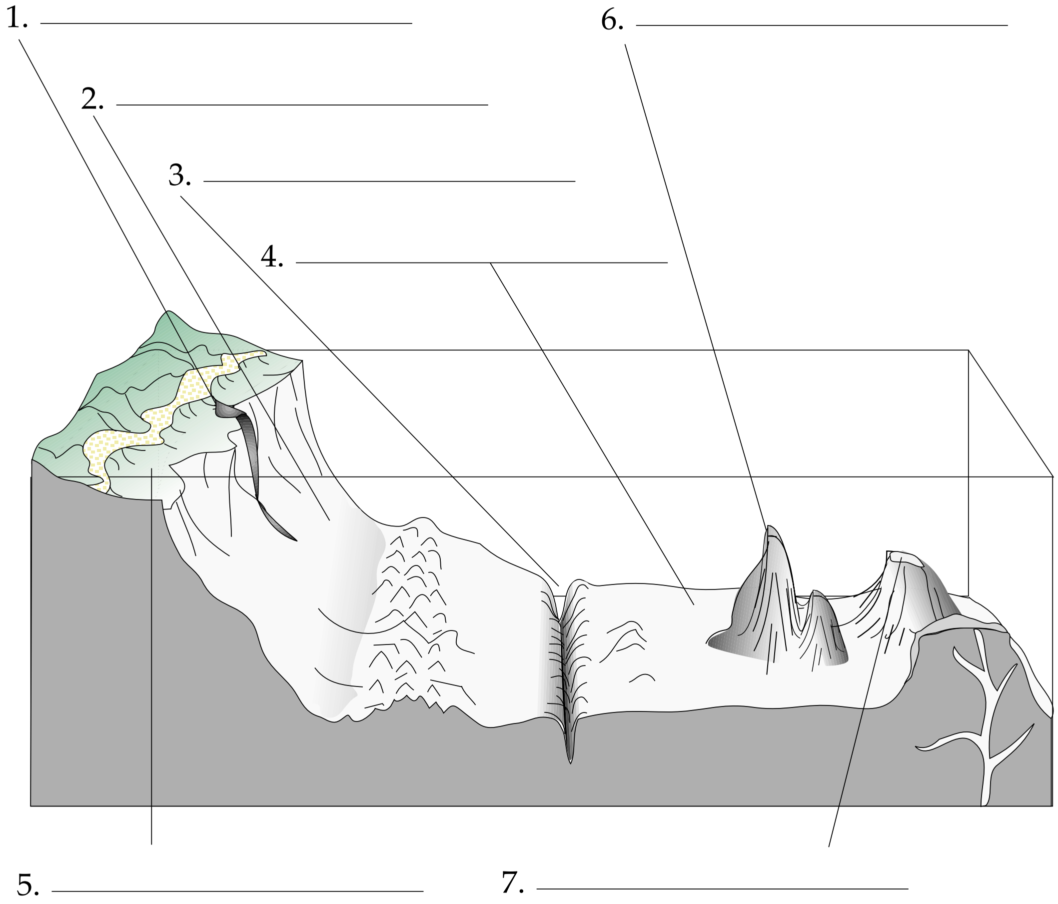
Continents extend into the ocean as much as 30 to 40 miles. These extensions are called *continental shelves* and are usually flat. They were formed by rivers carrying tons of particles from land to the sea. *Continental slopes* separate these shelves from the *ocean floor*, or basin. The ocean basin has a similar *topography* to that of Earth's land. In fact, many plains on the ocean floor are larger and flatter than any found on Earth's surface. And underwater mountains and mountain ranges can be found throughout the ocean.

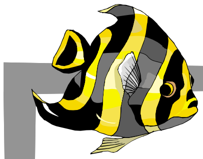


Practice

Use the list below to label the **diagram** *of the* **ocean floor**. *Write the correct term for each part on the line provided.*

abyssal plain
continental shelf
continental slope
guyot
seamount
submarine canyon
trench





Practice

Answer the following using complete sentences.

1. What does the theory of *plate tectonics* suggest? ____________________

   ____

   ____

2. How is the ocean-floor topography different from the topography of exposed land areas? ____

   ____

   ____

3. What is the difference between a *guyot* and a *seamount*? ____________

   ____

   ____

4. How are *mid-ocean ridges* formed? ________________________________

   ____

   ____

5. How did the *continental shelf* form? ______________________________

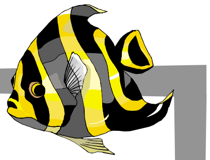
   ____

   ____

6. How did *submarine canyons* form? ________________________________

   ____

   ____



Practice

Use the list below to complete the following statements.

abyssal
basin
continental shelf
continental slope
East Pacific Ridge
guyots
Marianas Trench
Mid-Atlantic Ridge
mid-ocean ridges
Pangaea
plates
seamounts
topography
trenches

1. The ____________________ of the ocean floor is similar to that of the landforms on Earth's continents.

2. Earth's continents were once one large, unbroken landmass called ____________________ .

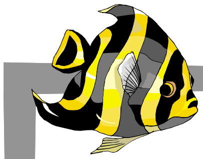
3. The plate tectonics theory suggests that Earth's crust is separated into large pieces known as ____________________ .

4. The ____________________ is the part of the continent that is under the ocean.

5. The ____________________ separates the continental shelf from the ocean floor.

6. The deepest parts of the ocean floor are long, narrow cracks called ____________________ .

7. The largest plains on Earth are the ____________________ plains.



8. The ____________________ in the Pacific Ocean is the deepest spot on the Earth—over 10,911 meters deep.

9. The ocean ____________________ , or floor, begins at the bottom of the continental slope.

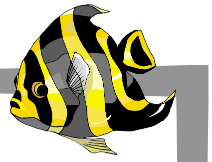
10. Underwater volcanic cone-shaped mountains are called ____________________ .

11. Flat-topped seamounts are called ____________________ .

12. ____________________ are underwater mountain ranges.

13. The mountain belt located in the Atlantic Ocean is called the ____________________ .

14. The mountain belt located in the Pacific Ocean is called the ____________________ .



Lab Activity: Seafloor Contours

Investigate:

- Construct a three-dimensional view of a *bathymetric map* by interpreting data obtained near the mouth of the Columbia River.

Materials:

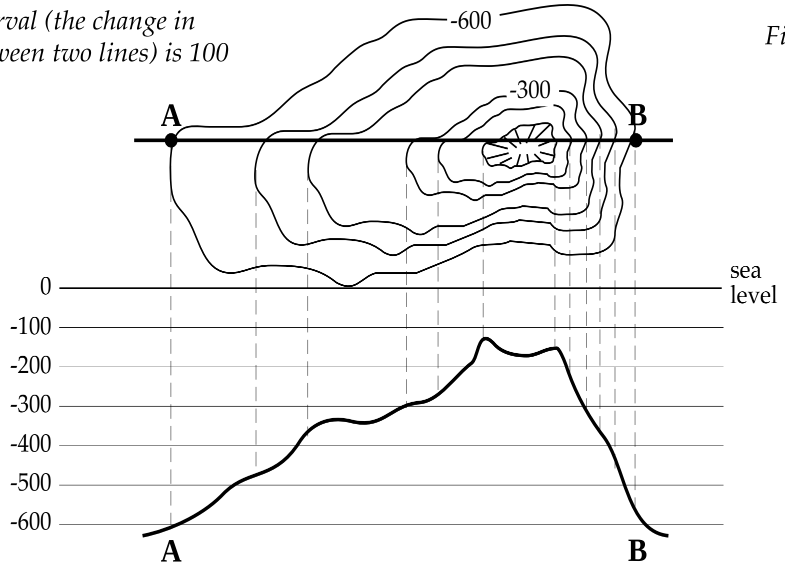
- sounding data
- scissors/utility knife
- colored markers
- carbon paper
- cardboard or tagboard
- pencil
- glue

Contour Model of the Seafloor

With echosounders, oceanographers have gathered large amounts of data about the ocean floor. How can they arrange this data in a form that is useful? One technique—the *side-view bottom profile* technique—is a series of profiles made into a three-dimensional model which gives a good picture of the bottom. However, the models take a long time to make. They also take up lots of storage space. To overcome these problems, oceanographers make a special contour map. Contour maps show a three-dimensional (length, width, height) surface on a two-dimensional (length and width only) sheet of paper. These special contour maps are called *bathymetric maps*. In this lab, you will have a chance to make a bathymetric map. Study the contour map below.

Contour interval (the change in elevation between two lines) is 100 meters.

Figure 1



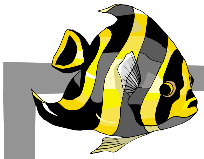


Figure 1 on the previous page shows how an underwater mountain is represented on a contour map. The bottom of *Figure 1* shows a *profile* of the same mountain along a line from *A* to *B*. Several rules must be followed in making a contour or bathymetric map. Study the rules below.

A. All points on a given contour line are the same height or depth.

B. Two contour lines may never cross each other.

C. A contour line never ends. Contour lines usually surround a given parcel of land.

D. If a line does not surround a parcel of land, it must disappear off the edge of the map.

Contour lines should **not** make sharp angles. They generally show smooth, regular changes. For example, if one point shows a depth of one meter and the next point shows a depth of three meters, the contour line for the depth two meters must occur between the two points.

Successive contour lines that are far apart on the map indicate a *gentle slope*. Lines that are close together indicate a *steep slope*. Lines that run together indicate a *cliff*. The illustration below shows how contour lines express *depth* and *form*.

a side-view, or profile of an underwater mountain

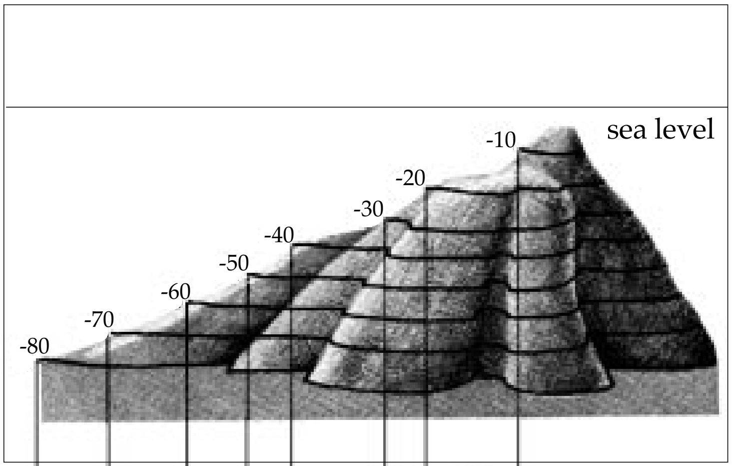


Figure 2

contour map

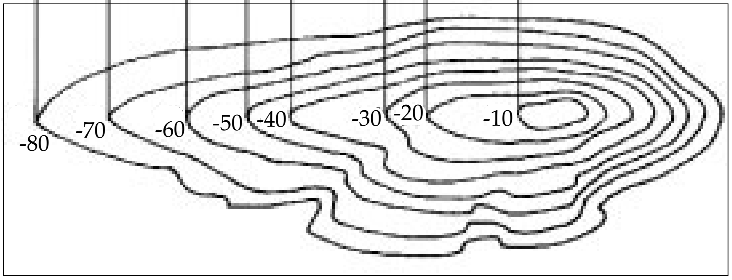


Figure 3

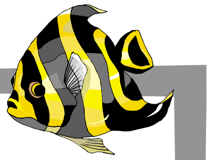


Figure 2 on the previous page also represents an underwater mountain. The contour map in *Figure 3* shows these features as if you are looking down on the area represented from a point directly above it. Labels on contour maps should include the measurements and the units used such as feet, fathoms (6 feet), or meters.

Pre-Lab Study:

Use the **lab activity text** *information on the previous pages to answer the following. Do this before you perform the lab activities on the next pages.*

1. How do contour maps help oceanographers study the ocean floor?

   ____

   ____

   ____

2. What are the underwater contour maps called? __________________

   ____

3. What does the contour map show in *Figure 1*? __________________

4. Do contour lines end? ______________________________

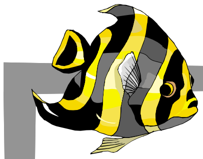
   Explain. ______________________________________

   ____

   ____

5. If the contour lines are far apart, what will this indicate? __________

   ____



6. What is indicated when contour lines are close together? __________

____

7. How will a contour line be drawn if the contour line does not surround a piece of land? ______________________________________

____

____

8. Describe the topography depicted in the contour map in *Figure 3*.

____

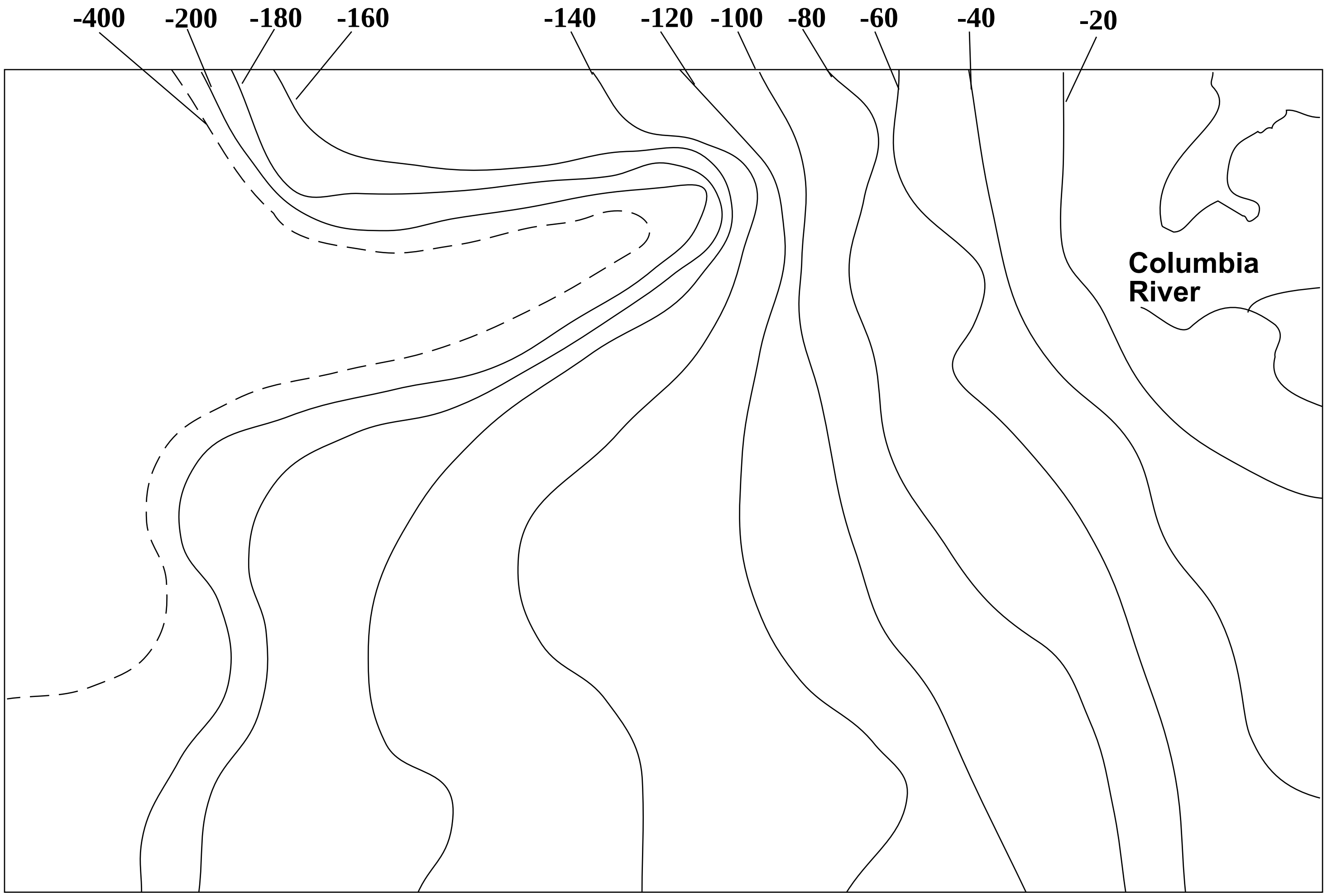
____

Procedure:

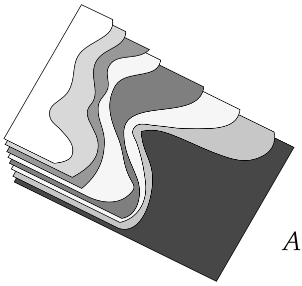
1. Obtain one piece of carbon paper and 4 or 5 pieces of cardboard. (One large-size gift box will be adequate.)
2. Place the carbon paper face **down** on the cardboard.
3. Place the contour map over the carbon paper on the cardboard and trace the -400-meter contour onto the cardboard.
4. Use scissors to cut along the contour line. Keep the larger piece of cardboard. The large piece of cardboard represents the surface of the Earth at a depth of -400 meters. Label the piece you save as *-400 meters* and set aside.
5. Repeat the tracing steps (steps 3 and 4) for each of the other contour lines on the map. Be sure to keep the *shore-side* pieces and discard the *ocean-side* pieces. Ask your teacher for assistance if you need help.
6. Place the cut-out labeled *-400 meters* over the -400-meter contour line. You will layer each cut-out contour in order of decreasing depth on top of the -400-meter cut-out (-400, -200, -180, -160, -140, -120, etc.).
7. Be sure to stagger each cut-out on top of the other so that each contour level can be seen. (See page 177 for an example of a contour cut-out.)
8. Glue each layer in place as you go along.
9. Label the following features on your three-dimensional model: *continental shelf, continental slope, submarine canyon,* and *abyssal plain*.

Study the characteristics below of the contour map on the following page:

- All measurements are in meters.
- The equal-depth points are connected with contour lines
- The contour lines begin with -20 meters, then increase to -40, -60, etc. (intervals of 20).
- The -400-meter contour line is added as a *dashed* line. The dashes show that the interval between the -200-meter line and the -400-meter line is different than the other intervals shown.



Columbia River Contour Map



An example of a contour cut-out.

Analysis:

Use your **three-dimensional model** *from the previous page to answer the following.*

1. What is the most likely cause of the *submarine canyon* on your map?

   ____

2. Compare your model with those of others in your class. Are all of the maps exactly the same? ______________________________

3. How can you account for any differences you may have observed?

   ____

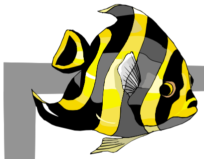
4. At about what depth does the continental shelf become the continental slope? ___________________________________

5. At about what depth does the continental slope become the abyssal plain?____

6. On which representation of the bottom (contour map or model) is it easier for you to see the bottom shape? ____________________

7. Why do most ship captains use contour maps or charts rather than three-dimensional models to show bottom contours? Give two reasons. ____

   ____



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. deep V-shaped valleys found along the continental slope

______ 2. the sloping surface between the outer edge of the continental shelf and the ocean basin

______ 3. the ocean floor at a depth of more than 4,000 meters

______ 4. detailed charting of the features of an area; heights, depths, and shapes of the surface of an area

______ 5. large, flat regions on the ocean floor

______ 6. long, narrow cracks in the ocean floor; the deepest parts of the ocean

______ 7. underwater cone-shaped volcanic mountains

______ 8. a mountain chain that rises from the ocean basin; where seafloor spreading takes place

______ 9. a relatively flat part of the continent covered by seawater

______ 10. underwater volcanic mountains with flat tops

A. abyssal plains

B. basin

C. continental shelf

D. continental slope

E. guyots

F. mid-ocean ridge

G. seamounts

H. submarine canyons

I. topography

J. trenches

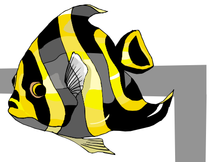
Unit 8: Ocean Sediments

Unit Focus

This unit examines the source of ocean floor sediment and beach sediment. Students will correlate the characteristics of each sediment type to its environment and identify marine organisms that inhabit specific sediment types.

Student Goals

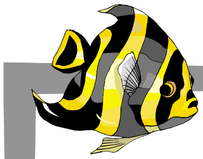
1. Identify the three sediment types that cover the shore and ocean floor.
2. Identify environments that are characteristic of each sediment type.
3. Explain the origin of each sediment type.



Vocabulary

Study the vocabulary words and definitions below.

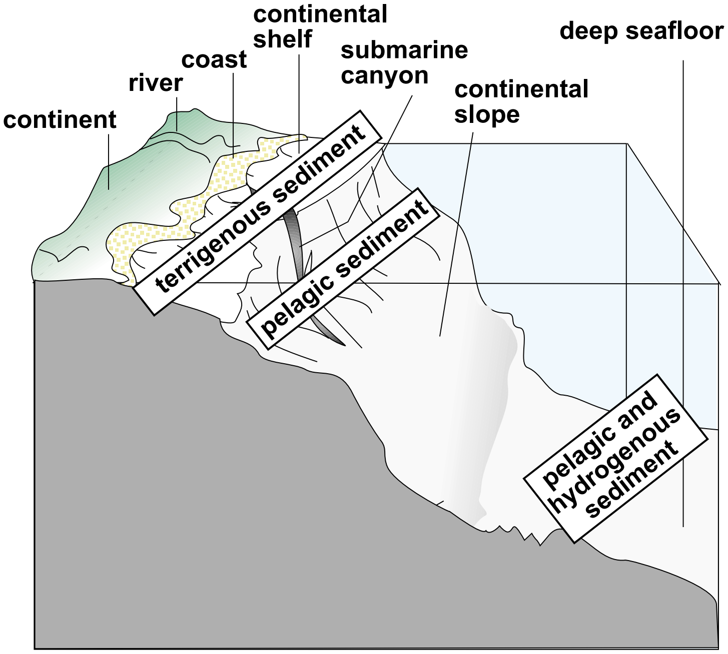
clay	very fine sediment particles
composition	the make-up of something; what is in it
dweller	an organism that lives in a certain place; an inhabitant
feldspar	the most common mineral on Earth; made up of silica, aluminum, and other elements
hydrogenous sediment	particles once suspended in the water that settle to the ocean floor as sediment, such as manganese nodules and phosphorite
lava	molten, or melted, volcanic rock
manganese nodules	rounded lumps of valuable mineral deposits found on the ocean floor containing manganese and other elements; formed from minerals crystallizing from seawater
ooze	mud-like organic remains of animals and plants; common on the deep-ocean floor
organic	made up of parts of once-living organisms; contains carbon atoms



pelagic sediment	sediment from the open ocean
permeability	the speed or rate of flow at which liquid or gas passes through a porous material such as sediment
porosity	the ratio of the volume of all the pores in a material to the volume of the whole
quartz	very hard crystal-like mineral made up of silicon and oxygen; second most common mineral on Earth after feldspar
sediment	particles of sand and silt formed from rock or animal remains
terrigenous sediment	sediment that comes from the land; gravel, sand, mud
tolerate	to endure or resist the action of
transitional zones	zones in a state of change from one condition to another

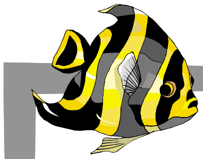
Introduction: Ocean Sediment—Blanketing the Ocean's Floor

If you were to begin walking from your nearby shore and out into the ocean or gulf, your feet would feel a blanket of **sediment** composed of particles from the land, the atmosphere, and the sea. Many of these particles are the remains of once-living organisms. Geological oceanographers have discovered three distinct types of sediment, or deposits, that line the shore and ocean floor: **terrigenous sediment**, **pelagic sediment**, and **hydrogenous sediment**. These three different types of sediment are classified according to their source—where the sediment comes from—and the materials from which they are composed.



Terrigenous Sediment: Building and Covering the Shores and Beaches

Composed of rock or gravel particles, sand, and mud, *terrigenous sediments* build and cover our shores, beaches, and the ocean floor closest to land. Terrigenous sediment comes mostly from the erosion and weathering of land. A lesser amount comes from the activity of land volcanoes. Rivers then carry the sediment to shores, beaches, and the sea. Rivers and the force of waves leave most of these deposits on the continental shelf—near the shore and the mouths of rivers. Beaches form when more sediment is deposited on the shores than is washed away by the action of the waves, tides, and currents.



Terrigenous sediments come in many different sizes, but three sizes are most common and form three different types of beaches. The *rock particles* forming rocky beaches are the largest; *sand particles*, composing sandy beaches, are medium-sized; and *mud*, the smallest particles, form muddy beaches. If you see a rocky beach, you can be reasonably certain that the nearby land also has resistant rocks. Similarly, if you see a sandy beach—quite common in Florida—you can expect the surrounding land to be covered by rocks, such as **quartz**, **feldspar**, and *limestone*, that break down into sand. If you see a muddy beach, the surrounding land will most likely be muddy also.

Rocky Beaches: West Coast Beaches

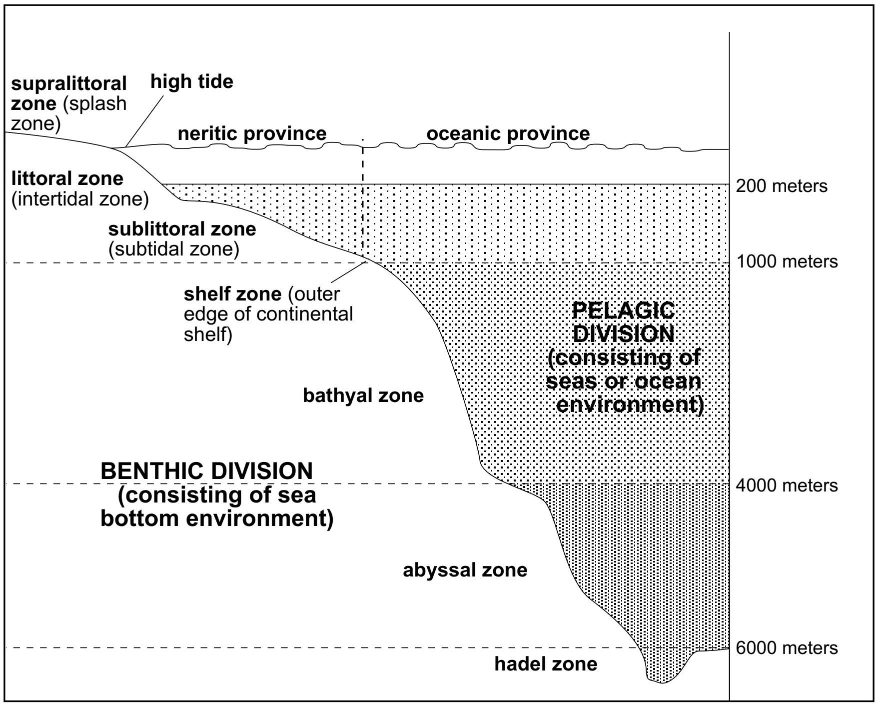
Rocky beaches may be composed of large boulders, medium-sized rocks, or small gravel-sized particles.

Rocky beaches may be composed of large boulders, medium-sized rocks, small gravel-sized particles, or even smaller-sized granules. The beaches on the West Coast of the United States are much rockier than the beaches along the Florida coast. A famous rocky beach is Pebble Beach in California. At Pebble Beach you can see egg-sized smooth rocks that have been carried down from the mountains by fast-moving waters. When you see rocky beaches, you can assume that this *heavier* sediment was carried by forceful waters. Other rocky beaches are common in Alaska and western Canada, as well as in parts of the northeastern United States, such as Maine.

Zones. Zones contain a variety of environments that oceanographers have classified into three major zones: supralittoral, littoral, and sublittoral. (*Littoral* means pertaining to the shore of a lake, sea, or ocean.) Because each zone has its own unique characteristics and environment, certain types of organisms survive and breed in each one.

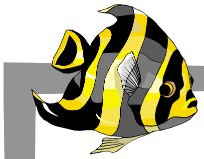
On a rocky shore, rocks, cracks, and crevices provide shelter for organisms, and circulating water carries oxygen and food particles for their survival. Rocky shores have a higher **permeability**—water passes quickly and easily through the spaces between the sediment particles. This higher permeability allows wave action to wash smaller sediments out to sea. These rocky areas between the land and the ocean are considered **transitional zones** because they are a place where land and ocean meet.

The first zone is the *supralittoral zone*, or high-tide zone, which is very dry. Water only reaches this area at very high tides or when strong waves splash it. (Sometimes this area is called the *splash zone.*) Plants and animals must be very sturdy to **tolerate** this zone, which goes from rushing water to extreme, drying sun. Most organisms in this area attach themselves to rocks and can withstand being dry for long periods of time. The most common animal in the splash zone is the periwinkle snail. Algae and other marine plants are also found here. The algae are dark and crusty and form a line at the high-tide level. This black algae line marks the usual high-tide line on rocky shores all over the world.



zones of the marine environment

Below this zone is the *littoral zone*, or normal intertidal zone. This area is constantly being covered and uncovered by the tides. Animals here must also be able to withstand drying out, but for shorter periods of time. Organisms in this zone need a shell or attachment to survive waves pounding the rocky surface. Barnacles, sea urchins, and flexible algae are common inhabitants of the littoral zone.



The *sublittoral zone*, or low-tide zone, remains under water and is a less harsh and demanding environment than the other zones. It is also called the *subtidal zone*. A variety of plants and animals such as sea palms, algae, starfish, and barnacles are common in this zone. Many fish and other animals, such as sea otters and seals or sea lions, feed on the organisms in this low-tide zone.

Characteristics of Rocky Beaches

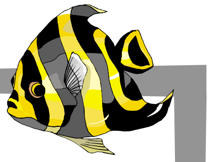
Environmental Conditions	Description	Marine Life	Location Examples
wave action transitional zone good circulation abundant food, shelter, and oxygen	hard surfaces cracks and crevices hiding places exposed areas	most attach to rocks periwinkle snail barnacles starfish sea urchins algae sea palms	beaches in Monterey Bay, California Maine Hawaii most Pacific beaches

Sandy Beaches: Florida Beaches

The **composition** of sandy beaches varies according to the local environment. Hawaii, for example, has black sand beaches composed of **lava** particles that erupted from volcanoes when the islands were formed. Other sandy beaches may be composed of the remains of once-living organisms. Many beaches in the Caribbean, for example, are composed of small particles of coral skeletons. These coral sand beaches may be colored pink or yellow, depending on the type of coral. Other beaches, such as those in southeastern Florida, are composed of sand and small shell fragments.

In most of the United States, the beach sand is made up of *quartz* and *feldspar*—the two most common minerals on Earth. White sand beaches, like those on the northern coasts of Florida along the Gulf of Mexico, contain only these minerals and do not contain any other minerals or impurities that darken the color.

Sand can be very coarse to very fine. Sand has a fairly high degree of **porosity**—or a large amount of pore space—lots of room—between sediment particles. Water, therefore, circulates between the sand particles, providing plenty of oxygen for organisms to survive.



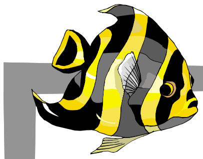
Like rocky shores, sandy beaches experience wave action. The force of the waves determines the size of sand particles found on the beach. In the winter, when the waves are stronger on many shores, many of the smaller grains of sand on the beach are washed away. This sand is then replaced in the spring and summer when the wave action lessens. The waves are constantly moving the sand particles underneath them. You can feel this grinding action if you stand in the surf area as the waves wash particles of sand past your feet. The larger the particle, the less chance the wave action will erode the beach.

Animals that live on sandy beaches must be able to tolerate, or withstand, this force. Many of these animals have shells to protect their soft bodies or are streamlined to move with the waves. All sand **dwellers** must be able to move with the sand or burrow back into it. These actions keep the organisms from being torn up or washed away by the friction of the sand. Clams, worms, crabs, and sand dollars are common animals on sandy beaches. Many other slow-moving or attached animals sometimes wash up on sandy beaches because of the wave action. Shoal grass is also common in offshore sandy areas.

A sandy beach has three zones like those on a rocky shore. The supralittoral zone, or *high-tide zone*, is very dry, and few animals can survive there. The littoral zone, or normal *intertidal zone*, is very harsh with frequent wave action followed by drying. The sublittoral zone, or *low-tide zone*, is less harsh and provides constant protection for young fish and other soft-bodied animals.

Characteristics of Sandy Beaches

Environmental Conditions	Description	Marine Life	Location Examples
oxygen good circulation regular wave action grinding motion	lava sand coral sand feldspar quartz loosely packed	hard-shelled or streamlined must burrow or move with sand clams crabs worms sand dollars shoal grass	beaches in Hilton Head, South Carolina Panama City, Florida most Atlantic beaches



Muddy Shores: Marked by Their Distinct Smell

Mud is formed when tiny particles of sediment settle in areas of resting water with little or no wave action. The lack of wave action makes mud flats quiet and stable environments. Because of its small particle size, mud is tightly packed and very little oxygen circulates through the particles. Bacteria present in mud flats do not require oxygen. These bacteria help break down decaying plants and animals. However, in doing so, they produce hydrogen sulfide gas, which smells like rotten eggs. These bacteria make mud a very nutrient-rich sediment.

Animals that live in this unique environment must be very well adapted. They usually live on or very near the surface so that they can get oxygen. Most of these animals have special gill systems to prevent the small, tightly packed mud particles from clogging respiratory systems. Some mud dwellers must create currents that bring oxygen and water into their burrows.

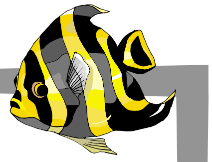
Eel grass, turtle grass, and other grasses are common in muddy areas. The roots of these plants trap particles of mud that build up in these environments. As the area fills in, it is exposed to the sunlight and begins to dry up. Over time, these changes may turn a mud environment into a dry-land environment.

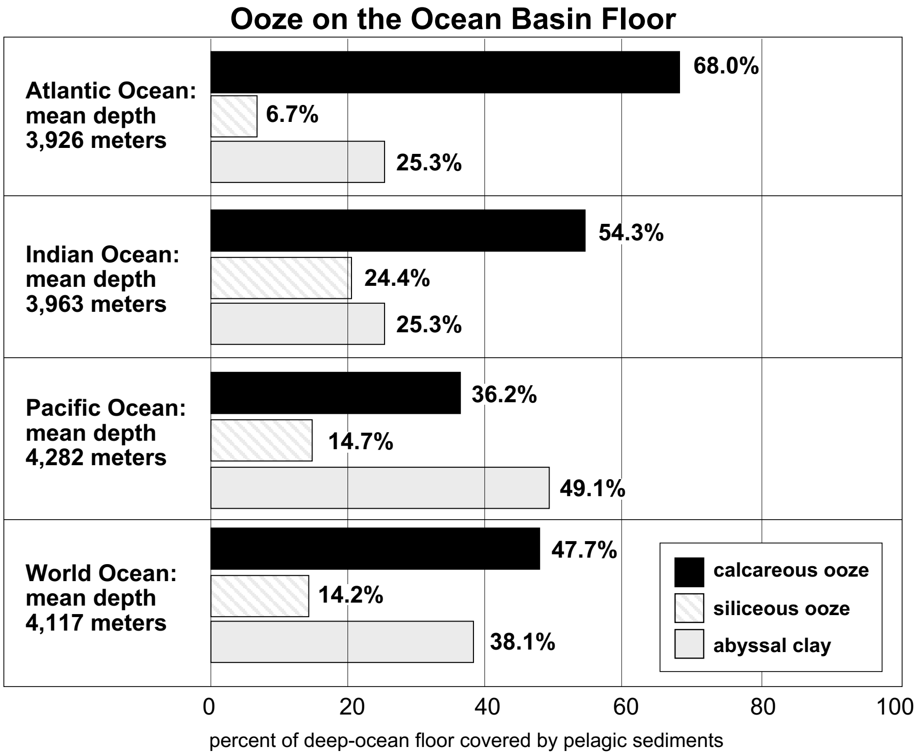
Characteristics of Muddy Shores

Environmental Conditions	Description	Marine Life	Location Examples
little oxygen no circulation no wave action quiet area stable soft	fine particles soft tightly packed	special gill systems worms clams bacteria eel grass turtle grass	coastal areas with large estuaries Chesapeake Bay Apalachicola, Florida

Pelagic Sediments: The Ocean-Floor Blanket

Pelagic sediment covers most of the deep-ocean floor where terrigenous sediments cannot reach. The two main types of pelagic sediment are **clay** and **ooze**. Pelagic deposits range in thickness from 60 meters to 3,330 meters. They are thickest in zones of upwelling.





Clay is composed of very tiny particles. Some of these particles are blown from land and fall from the atmosphere out at sea. Other pelagic clay includes dust from volcanic eruptions. These inorganic red clay deposits cover 38 percent of the ocean bottom. In some parts of the ocean floor, the clay is hundreds of feet thick. Scientists study these clay deposits to learn about ancient weather and the effects of past volcanoes and meteorites.

Pelagic *ooze* comes from the **organic** remains of tiny plants and animals that once floated near the surface of the ocean. This material was once living and may contain small microscopic fossils. There are two types of ooze. The most abundant type comes from animals that had shells made of calcium. This *calcareous* ooze covers 48 percent of the ocean floor and is mostly associated with warmer, shallow waters. *Siliceous* ooze comes from the remains of animals and plants that had glass-like shells composed of silica. The remains of these silicon-shelled organisms cover 14 percent of the ocean floor and are mostly associated with colder, deep waters.

Hydrogenous Sediments: The Bed of Minerals

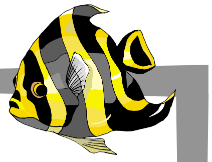
Scientists are just discovering a variety of different types of hydrogenous sediments on the deep-ocean floor on places where pelagic sediments typically do not accumulate. *Hydrogenous* means "derived from sea water.” These deposits are formed from a chemical action within seawater. Some of these deposits are too difficult and, therefore, expensive to gather, and so their use by industry has been limited. Other deposits have too low a concentration of minerals and so are not yet valuable to industry. *Phosphorite* is one example of a valuable hydrogenous sediment found in high concentration on the ocean floor. Phosphorous is used to produce phosphates—a key ingredient used in fertilizer and the production of other chemicals. As our mineral supplies on land decrease, industry will direct more effort towards extracting these deposits from sediments.

Manganese nodules, lumps of the mineral manganese, are the best known of the hydrogenous deposits. They contain manganese and iron with smaller amounts of nickel, copper, cobalt, and aluminum. Researchers estimate that over one billion tons of these nodules are sitting on the seafloor, mostly in the Pacific Ocean. Because this mineral lies over 3,200 meters down, extracting it is not yet practical. One machine being developed to collect these nodules functions like a giant vacuum cleaner that sucks them up from the sea bed.

Summary

The ocean’s floor is blanketed by *sediment*—particles from the land, atmosphere, and the sea, and often from the remains of once-living organisms. Scientists classify sediment according to its source and where it is deposited. Different kinds of sediment support different organisms. Wave action continually moves sediment onto and off of coastal areas, often sweeping smaller particles away and leaving larger ones. Where there is no or little wave action, mud accumulates.

The composition of sandy beaches varies according to the local environment.



Practice

Match each **characteristic** *with the correct* **habitat**. *Write the letter on the line provided.* **One or more habitats will be used more than once.**

______ 1. very little oxygen

______ 2. may be made of quartz and feldspar

______ 3. quiet, stable, and soft

______ 4. abundant food, shelter, and oxygen

______ 5. grinding motion

______ 6. barnacles, starfish, algae

______ 7. hiding places, hard surfaces

______ 8. animals bury themselves or have hard shells

______ 9. animals may be attached

______ 10. eel grass

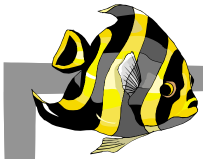
______ 11. no waves or circulation

______ 12. loosely packed

M. Mud

R. Rock

S. Sand



Practice

Match each **description** *with the correct* **zone**. *Write the correct letter on the line provided.* **One or more zones will be used more than once.**

______ 1. high-tide zone

______ 2. between tides

______ 3. low-tide zone

______ 4. remains under water

______ 5. constantly covered and uncovered by water

______ 6. very dry zone

______ 7. sea urchins, flexible algae

______ 8. periwinkle snails

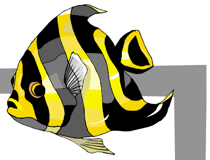
______ 9. fish, sea palms

______ 10. black algae line, splash zone

A. littoral

B. sublittoral

C. supralittoral



Practice

Use the list below to write the correct term for each description on the line provided.

hydrogenous sediment
terrigenous sediment
pelagic sediment

________________________ 1. eroded land material

________________________ 2. comes from the open ocean

________________________ 3. manganese nodules

________________________ 4. clay and ooze

________________________ 5. rock, sand, and mud

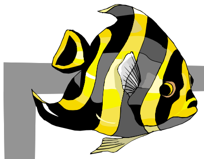
________________________ 6. comes from minerals in seawater

________________________ 7. remains of once-living organisms

________________________ 8. found close to land

________________________ 9. formed from chemical action within seawater

________________________ 10. sinks to the deep ocean



Lab Activity: Sand Observations

Investigate:

- Observe the different components of sand.

Materials:

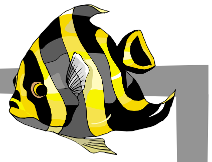
- sand samples from different areas
- white paper
- double-sided tape or clear glue diluted 3 to 1 with water
- magnifying glass or microscope
- metric ruler

Procedure:

1. Take a sample of sand.
2. Place one drop of glue diluted 3 to 1 with water on the microscope slide or a piece of double-sided tape.
3. Sprinkle a small amount of sand on the glue or tape and allow to dry.
4. Look at your prepared slide under the magnifying glass or microscope.
5. Record your observations below.
6. Repeat for the number of samples provided.

Observations:

1. **Color:** Describe any color in your sand sample.
2. **Shape:** Draw the shape of the sand grains seen under magnification.
3. **Size:** Measure the average length of the grains in millimeters (mm).



4. **Luster:** Describe the surface appearance of the sand grains (such as shiny, glassy, dull).

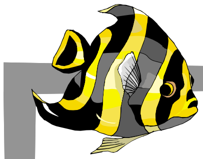
5. **Origin:** Describe the type of sediment (such as terrigenous—from land).

6. **Roundness:** Describe whether or not the sand grains are rounded or have sharp edges.

7. **Other:** List any other observations of the sand grains. Draw any shells or parts present.

Sand Observations

	Sample #1	Sample #2	Sample #3
Color			
Shape			
Size			
Luster			
Origin			
Roundness			
Other			



Analysis:

1. Compare the different types of sand grains you observed. ________

   ____

   ____

   ____

   ____

   ____

2. Where did each of our samples probably come from? ____________

   ____

   ____

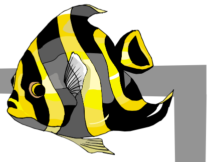
   How can you tell? ____

   ____

   ____

   ____

   ____



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. to endure or resist the action of

______ 2. zones in a state of change from one condition to another

______ 3. the speed or rate of flow at which liquid or gas passes through a porous material such as sediment

______ 4. particles once suspended in the water that settle to the ocean floor as sediment, such as manganese nodules and phosphorite

______ 5. sediment from the open ocean

______ 6. sediment that comes from the land; gravel, sand, mud

______ 7. particles of sand and silt formed from rock or animal remains

A. hydrogenous sediment

B. pelagic sediment

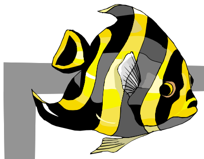
C. permeability

D. sediment

E. terrigenous sediment

F. tolerate

G. transitional zones



Practice

Use the list below to write the correct term for each definition on the line provided.

clay
composition
dweller
feldspar
lava
manganese
nodules
ooze
organic
porosity
quartz

____________________ 1. rounded lumps of valuable mineral deposits found on the ocean floor containing manganese and other elements; formed from minerals crystallizing from seawater

____________________ 2. made up of parts of once-living organisms; contains carbon atoms

____________________ 3. mud-like organic remains of animals and plants; common on the deep-ocean floor

____________________ 4. very fine sediment particles

____________________ 5. an organism that lives in a certain place; an inhabitant

____________________ 6. the ratio of the volume of all the pores in a material to the volume of the whole

____________________ 7. the most common mineral on Earth; made up of silica, aluminum, and other elements

____________________ 8. very hard crystal-like mineral made up of silicon and oxygen; second most common mineral on Earth after feldspar

____________________ 9. molten, or melted, volcanic rock

____________________ 10. the make-up of something; what is in it

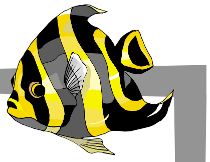
Unit 9: Food Chains and Food Webs

Unit Focus

This unit reviews energy production in plants and animals, feeding relationships, and symbiosis in the ocean. Students will become familiar with the hierarchy in food chains and will become better acquainted with food webs and symbiosis between marine organisms.

Student Goals

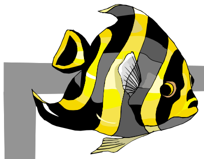
1. Define food chain.
2. Identify producers, primary consumers, secondary consumers, tertiary consumers, and decomposers within a food chain.
3. Define food web.
4. Understand that simple food chains are vulnerable to extreme changes and that food webs are more complex and stable.
5. Know that species within a food web may interact with each other through commensalism, mutualism, or parasitism.



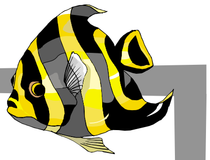
Vocabulary

Study the vocabulary words and definitions below.

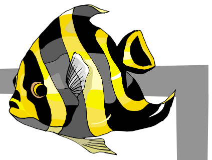
biomass	total amount of organisms per unit volume
carbohydrates	compounds containing the elements carbon, hydrogen, and oxygen
carnivore	an organism that eats animals *Example*: lion, shark
commensalism	a symbiotic relationship in which one organism benefits and the other is unaffected
consumers	organisms that eat other organisms
decomposers	organisms that eat dead plants and animals, as well as animal wastes
food chain	the transfer of energy from the sun to producers to consumers; describes groups of organisms, each of which is dependent on another for food
food web	interrelated food chains in an ecosystem; the feeding relationships between various plants and animals
herbivore	organism that eats only plants *Example*: sheep, manatee
hydrolysis	a chemical reaction where water is used to break down compounds; typically occurs when food is digested



krill	shrimp-like zooplankton
lipids	high energy nutrients such as fats and oils
metabolism	a chemical process in which animals break down and utilize nutrients
minerals	naturally occurring, inorganic elements and compounds found in water and soil that do not contain the element carbon
mutualism	a symbiotic relationship in which both organisms benefit
nutrients	any organic or inorganic material that an organism needs to metabolize, grow, and reproduce
omnivore	organism that eats both plants and animals *Example*: humans, killifish
parasitism	a symbiotic relationship in which one organism (the parasite) benefits and the other (the host) is harmed
photosynthesis	the process plants use to make the sugar glucose from water, carbon dioxide, and the energy in sunlight
phytoplankton	small, usually microscopic plant plankton that float or drift in the ocean
primary consumers	organisms that eat plants (producers)

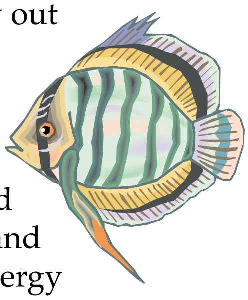


producers	organisms that make their own food through photosynthesis
protein	complex organic compound made up of amino acids
scavengers	animals that eat the remains of already dead animals and plants
secondary consumers	organisms that eat primary consumers but may also eat producers
symbiosis	a permanent, close relationship between two organisms that benefits at least one of them
tertiary consumers	organisms that eat secondary consumers but may also eat primary consumers and producers
zooplankton	small, usually microscopic animal plankton that float or drift in the ocean



Introduction: Food Chains and Food Webs—Energy Production and Transfer

Marine animals perform a variety of activities in their daily struggle for survival. Squid use jet propulsion; scallops clap their shells; fish dart in and out of seagrasses and coral banks. In order for these animals to carry out these tasks, they must use energy. Animals get energy from food.



Plants obtain energy for survival from the sun. Plants convert the sun's energy into a food source. Animals cannot make their own food and therefore must consume food to satisfy their energy needs. Food provides useful chemical compounds or **nutrients** for plants and animals. Proteins, sugars, starches, fats, vitamins, **minerals**, and water are the basic nutrients needed by plants and animals to maintain their energy levels. Plants and animals break down and utilize these nutrients through a process called **metabolism**.

Cells of living organisms are composed of **proteins**, **carbohydrate**s, and **lipids** (also known as *fats*). Living organisms obtain these compounds from the foods they consume. Proteins are made up of tiny building blocks called *amino acids*. There are 20 different amino acids. Growth in animals occurs when amino acids join together inside the cell to make proteins.

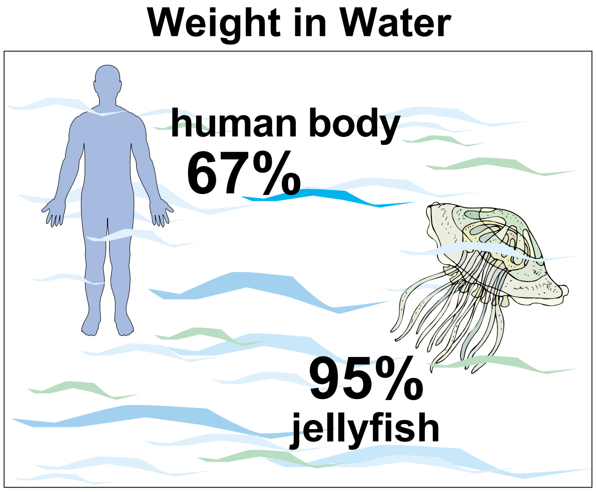
There are two nutrients that organisms can obtain energy from quickly. These two nutrients are sugars and starches. Together, sugars and starches make up carbohydrates. Carbohydrates are compounds that contain the elements carbon, hydrogen, and oxygen in specific proportions. An example of a simple sugar compound is glucose. Glucose has the molecular formula $C_6H_{12}O_6$. The molecular formula represents how many atoms of each element are present. In a molecule of glucose, $C_6H_{12}O_6$, there are 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms. When glucose is not being used in the body, it is changed into and stored as starch. Starches can be changed back into molecules of glucose when a plant or animal needs energy. The process of changing starch back into glucose is a chemical reaction called **hydrolysis**. Hydrolysis is a breaking down process and occurs when food is digested. During the breaking down process, energy is released when the chemical bonds of the molecules are broken. Living cells perform these important chemical reactions to fulfill their energy needs.

Fats and oils are high energy nutrients called *lipids*. Because a lipid molecule has a greater number of carbon-hydrogen bonds, it contains more energy than that of a carbohydrate molecule. During hydrolysis, the breaking down process, the carbon-hydrogen bonds in fats are broken and energy is released.

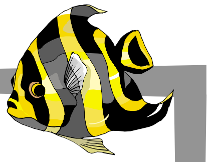
Vitamins are organic compounds that are needed, in trace amounts, to sustain good health. Vitamin D is an example. Vitamin D is necessary for healthy bone growth and is produced in small amounts in marine mammals when ultraviolet light reacts with the fat located just under the marine mammals' skin. Many animals and humans consume marine plants. Marine plants are a rich source of vitamins A, E, K, and B.

Living things need to take in proteins, carbohydrates, lipids, and vitamins, but living things also need minerals and water for their survival. Elements and compounds found in water and soil that do not contain the element carbon are minerals. An example of a mineral found in seawater is sodium chloride, NaCl, or salt. Marine plants obtain the minerals they need by absorbing the minerals from the water. Marine animals that eat marine plants absorb the plants' minerals into their body tissues. Sodium and chloride ions found in seawater are utilized in the muscles and nerves of many marine animals. Other minerals found in seawater include silica, the main ingredient in the manufacture of glass, found in the cell wall of microscopic diatoms.

Water is the most abundant nutrient in most living organisms. About 80 percent of an organism's weight is water. The exact amount of water varies from one species of organism to another. To illustrate, the human body is about 67 percent water while the jellyfish is about 95 percent water. Water contains and transports many dissolved substances within the bodies of living organisms. Water is also necessary for chemical reactions such as **photosynthesis** to occur.



Water is the most abundant nutrient in most living organisms.

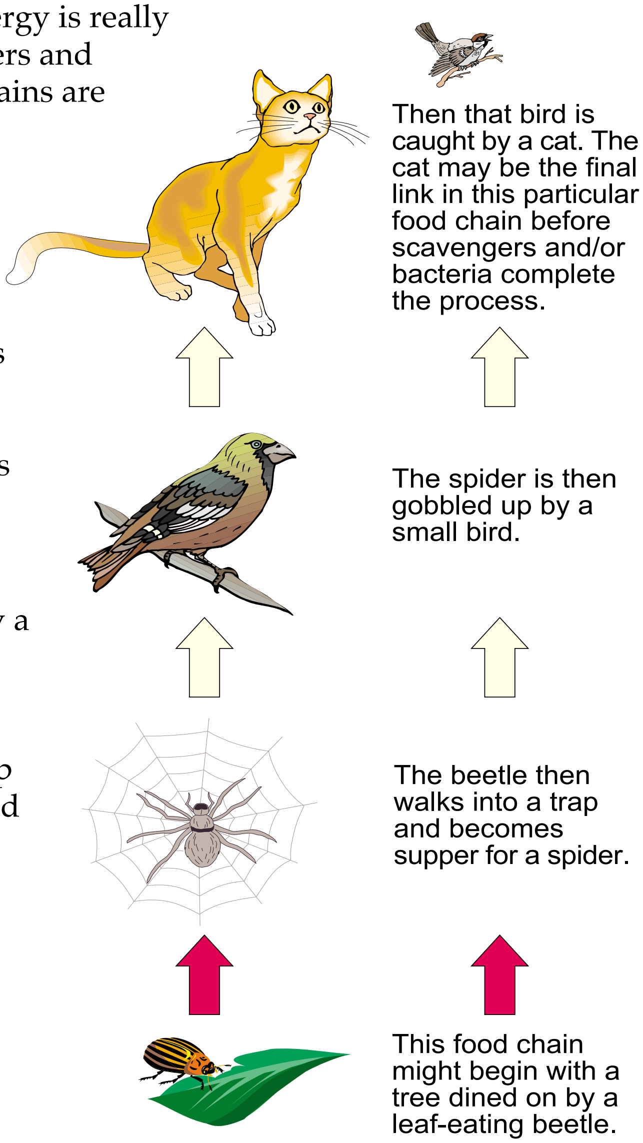


The Food Chain

All organisms on Earth—including human beings—survive by participating in a **food chain** and a **food web**. Food chains and food webs show the *transfer of energy* from the sun to **producers**, such as plants, which transfer their own food to **consumers**, such as people. For example, the first-order consumer may be a plant eater, or **herbivore**, such as a sheep or manatee. The second-order consumer may then be a meat-eater or **carnivore**, such as a dog or shark, or an animal that eats both plants and animals, an **omnivore**, such as a person or a killifish. The transfer of energy is really complete when both producers and consumers die and their remains are consumed by **scavengers**. Scavengers eat what is left of producers and consumers. Examples of marine scavengers include some snails and crabs. The end of a food chain or web occurs when **decomposers**, such as bacteria, break down dead plants and animals, as well as wastes.

A different food chain might begin with a tree dined on by a leaf-eating beetle. The beetle then walks into a trap and becomes supper for a spider. The spider is then gobbled up by a small bird. Then that bird is caught by a cat. The cat, if lucky, may be the final link in that particular food chain.

Some food chains are complex and may move through many steps before they reach their endpoint. Other food chains, particularly those in extreme or harsh



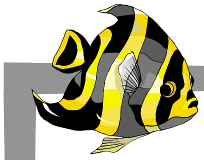
Then that bird is caught by a cat. The cat may be the final link in this particular food chain before scavengers and/or bacteria complete the process.

The spider is then gobbled up by a small bird.

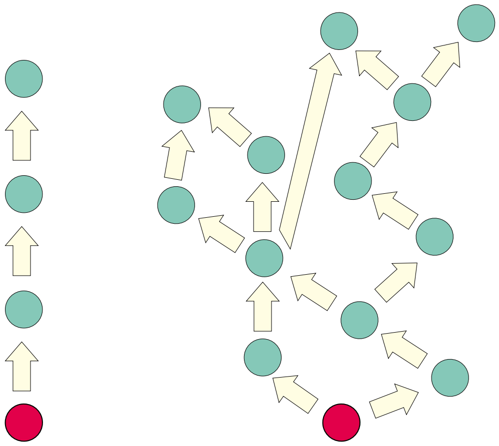
The beetle then walks into a trap and becomes supper for a spider.

This food chain might begin with a tree dined on by a leaf-eating beetle.

food chain



environments, may be quite simple and have only a few links. Food webs, as shown in the diagram below, contain many interrelated food chains and allow consumers to have choices in their diet.



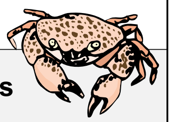
food chain
single-line system

food web
many small food chains

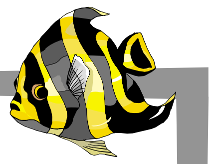
Hierarchy in Food Chains: Who Eats Whom

In food chains and food webs, there is a hierarchy, or order, of "who eats whom." At the first level are plants, which are called *producers* because they produce the food necessary for themselves and all consumers and decomposers on the food chain. Although plants are at the bottom of the food chain or web, they are the most important part of the chain. Without plants, the chain would collapse, and all animals above would starve and perish.

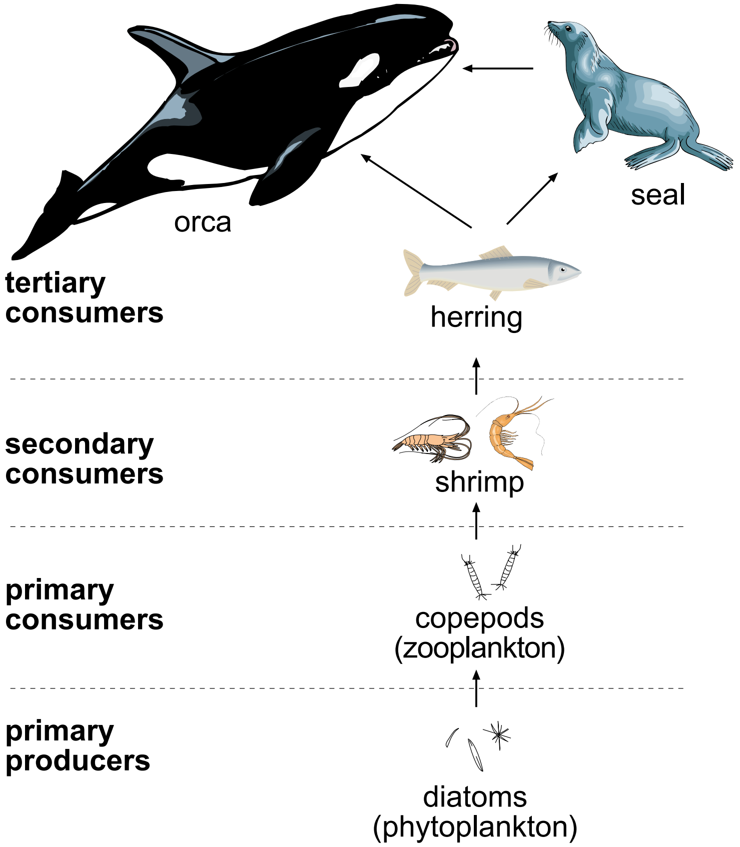
What Eats What in a Marine Ecosystem?



		Organism Type	**Method of Obtaining Food**	**Examples**
decomposers	feed on dead organisms on all levels	producer	makes its own food	phytoplankton, sea grass, zooxanthellae
		consumer	obtains food by eating other organisms	sea star (starfish), sponge, shark
		herbivore	eats only producers	manatee, limpet
		carnivore	eats only consumers	shark, octopus, sea otter
		omnivore	eats both consumers and producers	basking shark, killifish sponge, coral, crab



The animals that eat the plants are called **primary consumers**. Those animals that consume primary consumers are called **secondary consumers**. **Tertiary consumers** are those animals that feed on secondary consumers. Some secondary and tertiary consumers may also eat producers or plants. For example, crabs feed on plants as well as fish. Typically, the highest level upon which a consumer feeds determines what it is called, even though it may feed on more than one level.



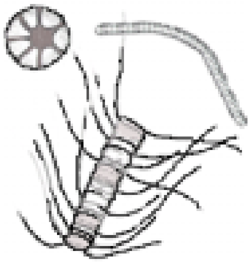
feeding levels in a marine food chain

The Ocean's Plants: Providing for the Sea's Carnivores and Herbivores

Biomass, the total amount of organisms per unit volume, of carnivores (meat-eaters) is much less than that of the herbivores (plant-eaters) they consume. Similarly, the biomass of herbivores will be much less than the total weight of the plants they consume. For example, a hundred tons of plants would produce only about 10 tons of herbivores, which would, in turn, feed and sustain only one ton of carnivores. As you move up levels on the food chain, biomass decreases.

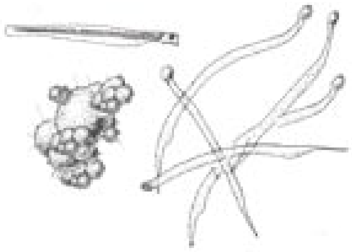
Phytoplankton: The First Level of the Ocean's Food Chain

On land and in the ocean, plants are the basis of all life and are the first level of food chains. **Phytoplankton**, the most plentiful plants in the ocean, are the most important plants in the ocean's food chain. Phytoplankton float in the ocean's currents and become food for the ocean's most numerous and greatest biomass of herbivores, the plant-eating **zooplankton**. Zooplankton also float in the ocean and depend on phytoplankton for survival.



phytoplankton

Zooplankton: Converting Plant Tissue to Animal Tissue



zooplankton

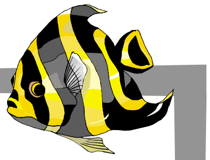
Zooplankton are the majority of the ocean's *primary consumers*: They convert plants (phytoplankton) into animal tissue (the zooplankton themselves). Zooplankton then become food for the next organisms higher up in the food chain: the zooplankton-eating animals. If we keep moving up the ocean's food chain, we finally reach organisms that are not food, or prey, for any other marine organisms; for example, sharks and killer whales.

Some zooplankton do not eat individuals one at a time but swallow large amounts of water and then trap phytoplankton while filtering out the water. By spending most of their feeding time in the photic zone—where plants grow—zooplankton can find and eat enough phytoplankton to sustain themselves.

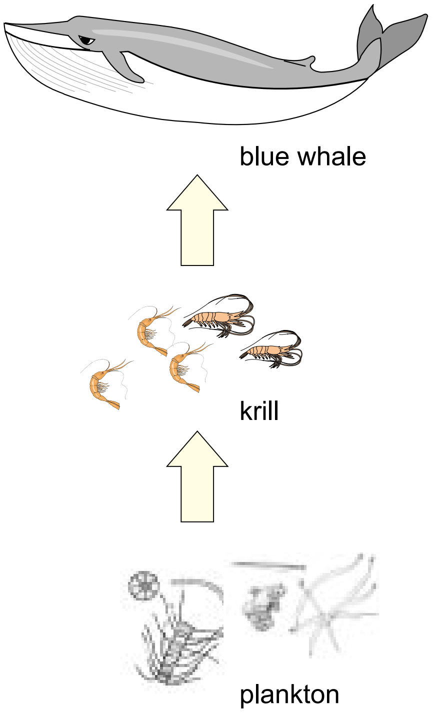
Zooplankton are not as abundant as phytoplankton. When zooplankton eat phytoplankton, only some of the phytoplankton become part of the zooplankton. Most of the food energy consumed by the zooplankton is given off as either energy for survival or as waste.

A Simple Food Chain: From Phytoplankton to Krill to Baleen Whales

One of the simplest food chains in the ocean involves the whale. In the ocean off Antarctica, the sun remains in the sky for up to 24 hours during the summer. Because of this, many phytoplankton grow there at that time



of the year. The phytoplankton are eaten by **krill**. *Krill* are shrimp-like zooplankton and form the second level in this food chain. Krill, then, are trapped and eaten by the carnivorous baleen whales. Baleen whales, the third level in this food chain, filter large amounts of krill out of the water with rows of whalebone plates in their mouths that act as sieves (see Unit 16).



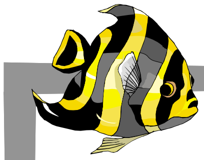
food chain of the baleen whale

The picture to the left shows the basic food chain of a baleen whale. The food chain becomes complicated when other animals get into the picture and create a food web. A *food web* is a network of food chains that are linked together. For example, krill are not only eaten by whales but are also eaten by other fish, penguins, and seals. The baleen whale may also be eaten by the killer whale. In that case, the killer whale would be at the top of this food web.

A food web, even one as simple as the web described above, follows a *natural* order. Plants or animals at the lower levels are consumed by animals higher up in the chain. If a plant or animal at lower levels begins to die out or disappear, then animals higher up would also begin to die from lack of nourishment. There are a number of causes for a break in a food web.

Disease or sudden weather changes can alter the biomass of particular plants, such as phytoplankton, or animals, such as zooplankton. Disease and harsh weather are natural phenomena. Over time, a food web will usually recover from such occurrences.

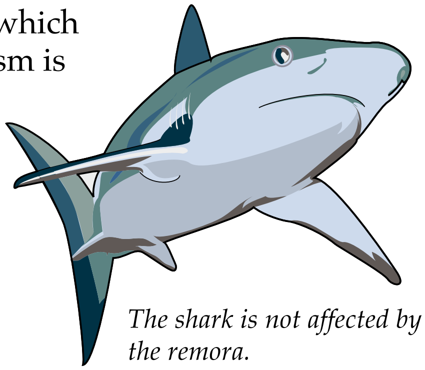
The world's fishing industry, however, is something that could destroy the ocean's food chain. If the fishing industry began wiping out lower levels of the food chain, they would upset the balance of marine life. Eventually, marine life at all levels would begin to disappear because of this break at a lower level of the food chain. To preserve ocean life, as well as make sure that there will be fish to be caught in the future, the fishing industry must monitor itself and not catch too many fish at any level in the ocean's food web.



Food Relationships in the Ocean

In the marine environment, there is a steady struggle for survival. Marine organisms must always be on the look out for hungry predators as well as hunt for food, search for mates, and stake out territories. To aid or benefit in their survival, many organisms have established relationships with organisms not within their species. A relationship that benefits an organism is called **symbiosis**. **Commensalism**, **mutualism**, and **parasitism** are examples of *symbiotic* relationships.

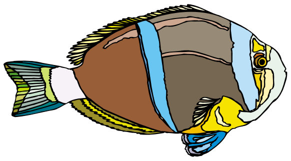
Commensalism is a symbiotic relationship in which one organism *benefits* while the other organism is *unaffected* by the relationship. Examples of marine organisms in commensalistic relationships with each other are several species of sharks and a small group of pilotfish, or a *remora*. The shark and the remora have a symbiotic relationship called *commensalism*.



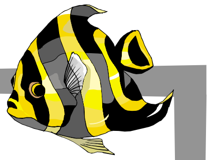
The shark is not affected by the remora.

The remora is a small scavenger fish that attaches to the underside of many sharks. The remora feeds on the leftover particles of food that the shark does not eat. The shark is not affected by the remora, and the remora gains food by tagging along with the sharks. Another commensalistic relationship is found between some species of whales and barnacles. The barnacles live on the backs and around the mouths of some whales. Can you explain which of these organisms is benefiting and how?

Mutualism is a symbiotic relationship in which *both* organisms *benefit* from the relationship. Examples of marine organisms that are in a mutualistic relationship with each other are *coral polyps*, the basic structure of the coral animal, and algae known as *zooxanthellae*. The zooxanthellae live inside the coral polyps. The zooxanthellae benefit from the coral polyps in that they receive a place to live and food in the form of carbon dioxide, nitrates, and phosphate. The coral polyps receive food in the form of glucose and oxygen from the zooxanthellae. In this relationship both organisms receive something from the other. Another mutualistic relationship is found between the sea anemone and the clownfish. The clownfish lives



clownfish

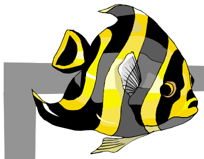


among the stinging tentacles of the sea anemone. Can you explain how the relationship between the clownfish and sea anemone is mutualistic?

Parasitism is a symbiotic relationship in which one organism *benefits* and the other organism is *harmed*. An example of marine organisms that have a parasitic relationship with each other is isopods and fish. Isopods are very small crustaceans similar in appearance to a rolly polly insect. The isopods attach to the fish's skin and gills. They obtain nutrients from the fish's blood much as a tick obtains nutrients from a dog. Can you think of any other parasitic relationships that occur between marine organisms?

Summary

Food chains show the "transfer of energy" from the sun to *producers* (such as plants) and on to *consumers* (such as people) and finally to *decomposers*. Each consumer in a food chain has a smaller *biomass* than the links below it. *Simple food chains* are those with fewer links. Simple food chains usually exist where the environment is vulnerable to extreme change or where plants have a short growth season. A *food web* describes interrelated food chains within an ecosystem. Species within a food web may interact with each other through *predation*, *commensalism*, *mutualism*, and *parasitism*. We must protect natural food webs to preserve the food supply for all marine life.



Practice

Match each **description** *with the correct term in each* **section**. *Write the letter on the line provided.*

food chains

______ 1. plant- and animal-eaters

______ 2. animal-eaters

______ 3. plant-eaters

A. carnivores

B. herbivores

C. omnivores

---

consumers

______ 4. eat primary consumers and sometimes producers

______ 5. eat only producers

______ 6. eat secondary consumers, and sometimes primary consumers and producers

A. primary

B. secondary

C. tertiary

---

symbiotic relationships

______ 7. one organism benefits while the other is unaffected

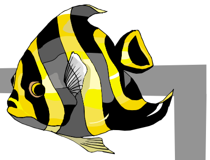
______ 8. one organism benefits while the other is harmed

______ 9. both organisms benefit

A. commensalism

B. mutualism

C. parasitism



Practice

Answer the following using complete sentences.

1. What are some causes for a break in the ocean's food chain? ______

   ____

   ____

   ____

   ____

   ____

   ____

2. How might a break in the ocean's food chain affect us? __________

   ____

   ____

   ____

   ____

   ____

3. How is a *food web* different from a *food chain*? ________________

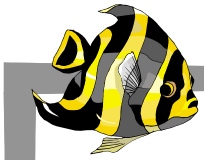
   ____

   ____

   ____

   ____

   ____



Practice

Use the diagram below to answer the following question.

List four possible food chains in the food web pictured below. (Example: humans, sheepshead, sea star (starfish), bristleworm.)

____

____

____

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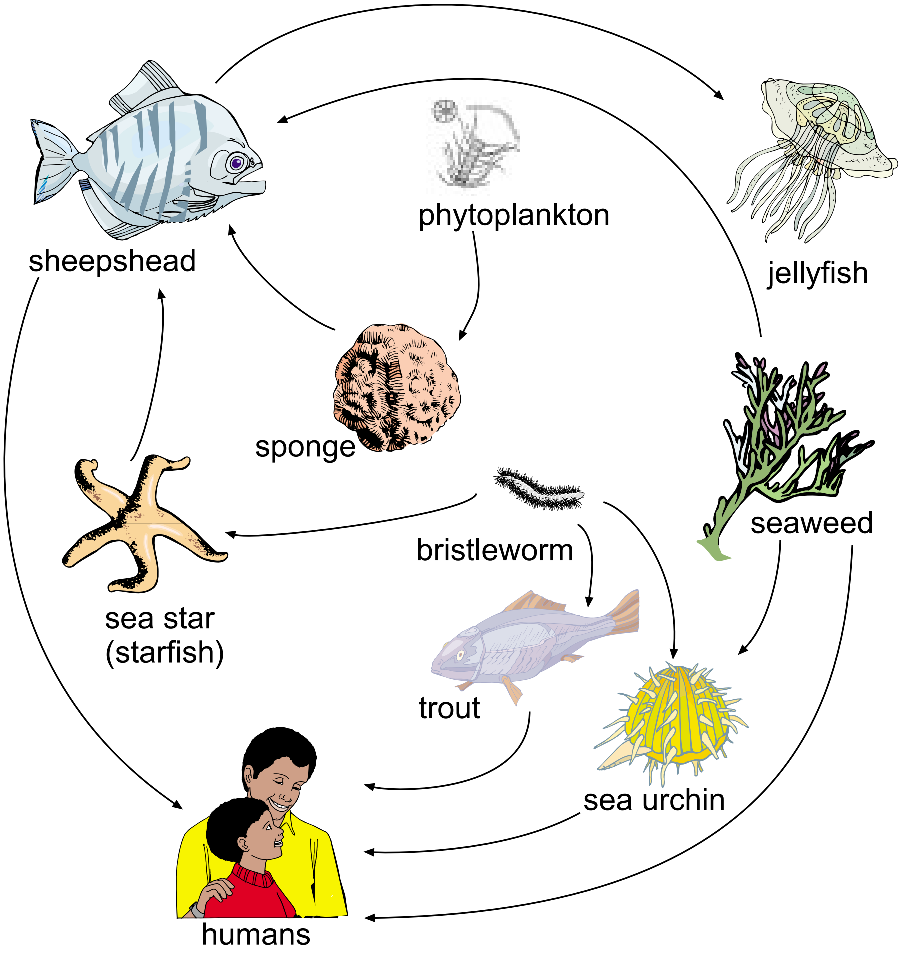
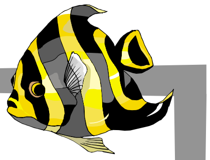
Intertidal Food Web





Lab Activity: Ocean Food Webs

Investigate:

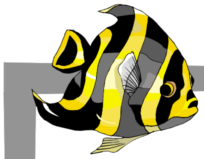
- Create an ocean food web mural to study individual food chains and their place in a food web.

Materials:

- mural page
- page of organisms
- colored pencils
- Inside Scoop chart
- glue or tape

Procedure:

1. Use a **copy** of the mural on page 220 of an estuarine environment.
2. Use a **copy** of the page of organisms. **Cut** out each of the marine organisms (and their names) from the page of organisms on 221.
3. **Color** each marine organism (optional).
4. **Preview** the **Inside Scoop** chart on the following page for each plant and animal in the estuary community. The **Inside Scoop** chart will help you find what each animal and plant depends upon for survival, and where each is found in the water column of the estuary mural. **Place** each organism in the correct area of the mural.
5. Consider the organization and layout of the food web before you actually paste or tape each organism in place. Be sure to use all the space represented on the page of the estuary mural. **Hint**: Important animals that are eaten by many others (zooplankton and phytoplankton) should be placed in the center of the estuary mural.
6. For each animal or plant used from the page of organisms, show what each animal or plant depends upon. To do this, **draw** an arrow from the animal or plant *to what it depends upon*. To make the food web neater, cross as few lines as possible. **Color** or **code** web lines for each organism.



7. Each animal or plant should be placed in its correct **position** in the water column. Positions are stated in the **Inside Scoop** chart.

The Inside Scoop		
Organism	**What the Organism Eats**	**Where the Organism Lives**
zooplankton	phytoplankton	mid-water to surface
phytoplankton	energy from the sun	surface waters
oyster	phytoplankton/zooplankton	benthic
snail	seaweed	benthic
seagrass	energy from the sun	shallow water/benthic
fish	shrimp	mid-water to surface
blue crab	shrimp, snails, oysters, and whelks	benthic
shrimp	zooplankton	mid-water to grass beds
whelk	snails and oysters	benthic
seagull	shrimp, fish, oysters, crabs, snails, whelks	above surface of water
lobster	crabs, whelks, oysters	benthic/sea grasses

Analysis:

1. Which organisms are *producers*? ______________________________

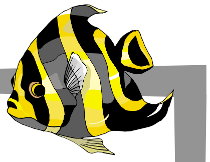
____

2. Which organisms are the top *carnivores*? ______________________

____

3. Which animals are only *herbivores*? ___________________________

____



4. Which animals are both *herbivores* and *carnivores*? ________________

____

5. Which animals are only *carnivores*? ________________________

____

____

____

6. What would happen if *all* the *producers* were wiped out? __________

____

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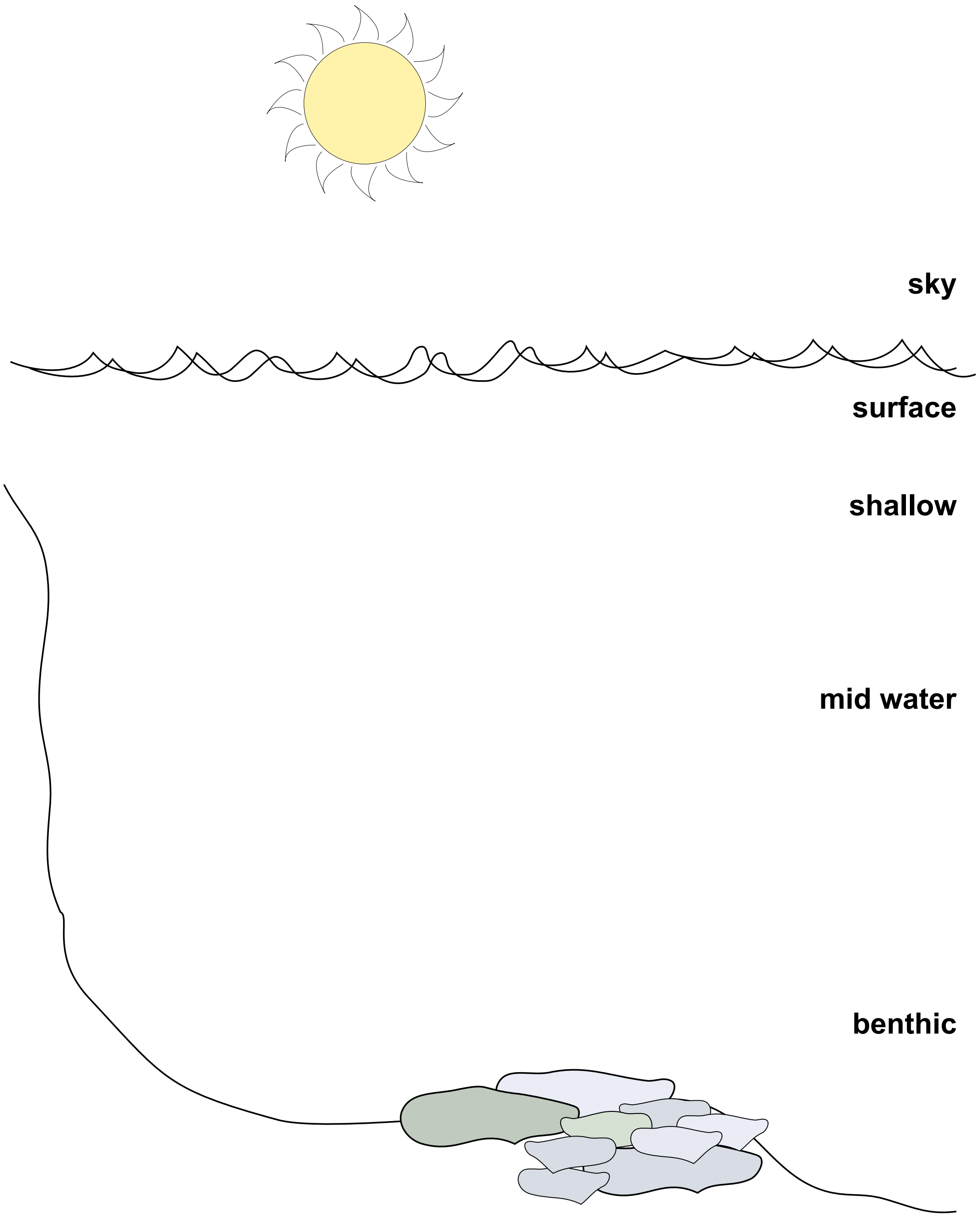
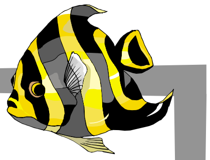
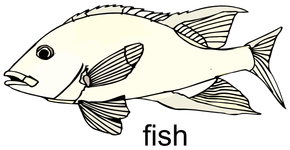
Mural



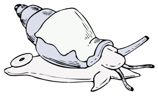


Organisms

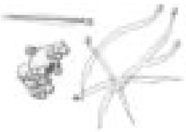
seagull



fish

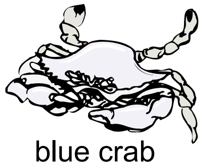


snail

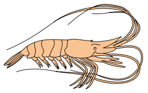


zooplankton

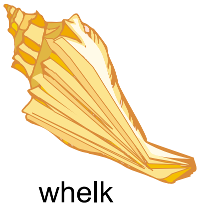
phytoplankton



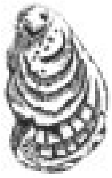
blue crab



shrimp



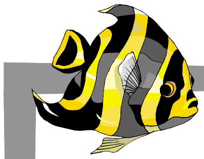
whelk



oyster

seagrass

lobster



Practice

Use the list below to write the correct term for each definition on the line provided.

carbohydrates
carnivore
consumers
decomposers
food chain
food web
herbivore
hydrolysis
lipids
metabolism
minerals
nutrients
omnivore
photosynthesis
producers
protein
scavengers

______________________________ 1. animals that eat the remains of already dead animals and plants

______________________________ 2. the process plants use to make the sugar glucose from water, carbon dioxide, and the energy in sunlight

______________________________ 3. organism that eats both plants and animals
Example: humans, killifish

______________________________ 4. an organism that eats animals
Example: lion, shark

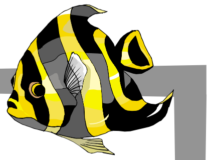
______________________________ 5. organism that eats only plants
Example: sheep, manatee

______________________________ 6. organisms that eat other organisms

______________________________ 7. organisms that make their own food through photosynthesis

______________________________ 8. interrelated food chains in an ecosystem; the feeding relationships between various plants and animals

______________________________ 9. the transfer of energy from the sun to producers to consumers; describes groups of organisms, each of which is dependent on another for food



______________________________ 10. naturally occurring, inorganic elements and compounds found in water and soil that do not contain the element carbon

______________________________ 11. high energy nutrients such as fats and oils

______________________________ 12. a chemical reaction where water is used to break down compounds; typically occurs when food is digested

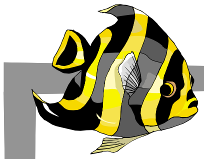
______________________________ 13. compounds containing the elements carbon, hydrogen, and oxygen

______________________________ 14. a chemical process in which animals break down and utilize nutrients

______________________________ 15. any organic or inorganic material that an organism needs to metabolize, grow, and reproduce

______________________________ 16. organisms that eat dead plants and animals, as well as animal wastes

______________________________ 17. complex organic compound made up of amino acids



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. a permanent, close relationship between two organisms that benefits at least one of them

______ 2. a symbiotic relationship in which one organism benefits and the other is harmed

______ 3. a symbiotic relationship in which both organisms benefit

______ 4. a symbiotic relationship in which one organism benefits and the other is unaffected

______ 5. shrimp-like zooplankton

______ 6. small, usually microscopic animal plankton that float or drift in the ocean

______ 7. small, usually microscopic plant plankton that float or drift in the ocean

______ 8. total amount of organisms per unit volume

______ 9. organisms that eat secondary consumers but may also eat primary consumers and producers

______ 10. organisms that eat primary consumers and may also eat producers

______ 11. organisms that eat plants (producers)

A. biomass

B. commensalism

C. krill

D. mutualism

E. parasitism

F. phytoplankton

G. primary consumers

H. secondary consumers

I. symbiosis

J. tertiary consumers

K. zooplankton

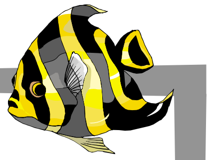
Unit 10: Ocean Zones

Unit Focus

This unit describes the marine biome's two major regions: pelagic (water) and benthic (bottom) environments. Students will learn the characteristics of each of these marine environments and how marine organisms adapt to pelagic and benthic environments.

Student Goals

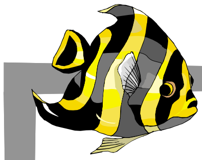
1. Identify the pelagic and benthic environments within the marine biome and the zones into which each is further divided.
2. Recognize organisms that live within each marine zone or environment.
3. Give examples of adaptations marine organisms use to live in pelagic or benthic communities.



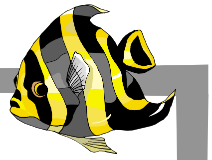
Vocabulary

Study the vocabulary words and definitions below.

abyssopelagic zone	the depths of the ocean between 4,000 and 6,000 meters; in the aphotic or midnight zone
aphotic zone	area of ocean where light does not penetrate; also called the *midnight zone*
bathypelagic zone	the depths of the ocean between 1,000 and 4,000 meters; in the aphotic or midnight zone
benthic	bottom environment; refers to animals living on or in the seabed
biome	large-area ecosystem sharing similar characteristics; an environmental unit
disphotic zone	dimly lit region of the ocean where there is not enough light to carry on photosynthesis; also called the *twilight zone*
epifauna	animals that live *on* the surface of the seabed
epipelagic zone	upper layer of water extending to depth of 200 meters; in the photic or sunlit zone



habitat	specific area or type of environment in which an organism is found
hadalpelagic zone	the depths of the ocean below 6,000 meters in the deep-ocean trenches; in the aphotic or midnight zone
infauna	animals that live *within* the sediments of the seafloor
littoral zone	area between the tides; also called the *intertidal zone*
mesopelagic zone	middle layer of ocean water between 200 and 1,000 meters; in the disphotic or twilight zone
nekton	free-swimming organisms
neritic province	waters over the continental shelf; near-shore zone
oceanic province	waters beyond the continental shelf; open-ocean zone
pelagic	of or pertaining to the seas or oceans
photic zone	lighted region of the ocean; area where photosynthesis can occur; also called the *sunlit zone*

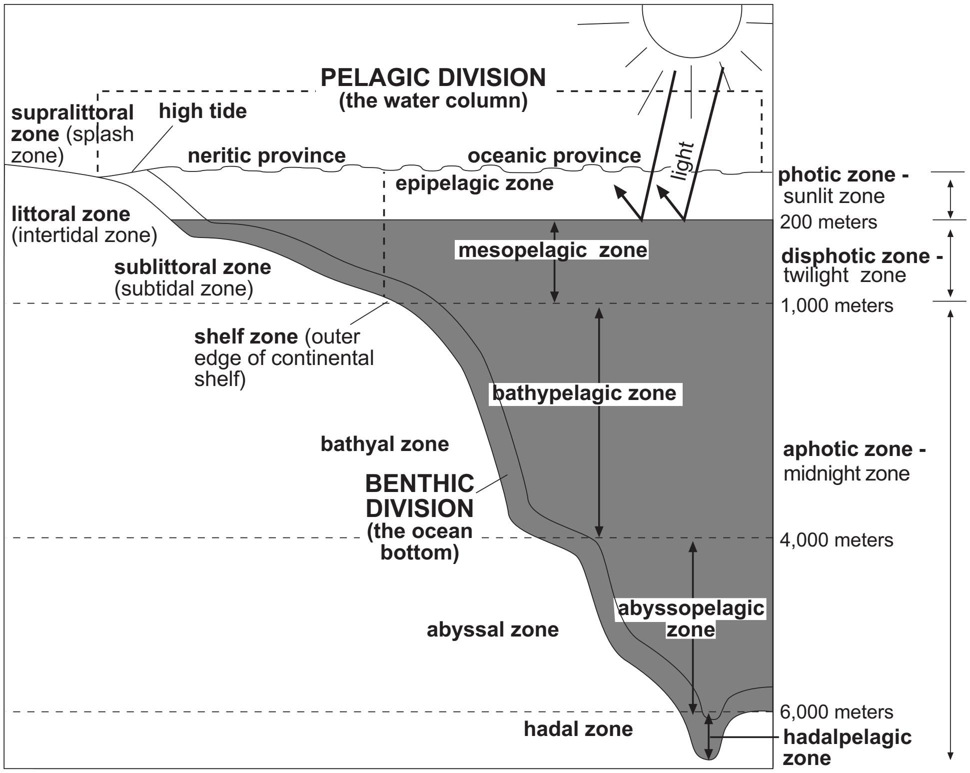


plankton	small, usually microscopic plant or animal organisms that float or drift in the ocean
province	a particular area or region
rocky coasts	shores made up of solid rock and usually steeper than sandy beaches
sessile	organisms that are attached to a surface and cannot move around
sublittoral zone	benthic area of the continental shelf below the low-tide area; also called *subtidal*
supralittoral zone	dry area above the high-tide line; sometimes called the *spray* or *splash zone*
surf zone	the area of crashing waves along a sandy beach
tide pools	small habitats formed when spaces between rocks retain water at low tide

Introduction: Ocean Zones—A Range of Environments

Oceanographers and ecologists have divided up different parts of the marine world according to their location and characteristics. Because each region is a unique environment, or **habitat**, it is better suited for certain types of organisms rather than others. Each of these habitats make up an *ecosystem*: a community of organisms and the nonliving environment with which they interact.

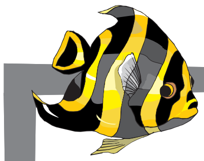
A large-area ecosystem, or environmental unit, with similar characteristics is called a **biome**. There are two biomes in the aquatic, or water, environment. One is the *freshwater* biome of rivers, lakes, ponds, and streams. In this unit we will study the other large-area ecosystem—the *marine* biome—which includes the oceans, bays, and seas, as well as the shores at the edges of the oceans and the ocean floor itself.



marine biome

The Marine Biome

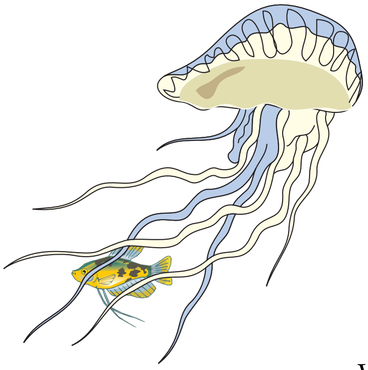
The marine biome can be divided into two major *divisions* or regions: the **pelagic**, or water environment, and the **benthic**, or bottom environment. These two divisions are separated by distinct differences in their water



and sediments. Within each division there are several zones. Each of these zones has local organisms that have adapted to its range of environmental changes. For example, organisms living in a particular zone in the pelagic division can withstand its range of temperature, light, salinity, and pressure.

Pelagic Environment: The Largest Region of the Marine World

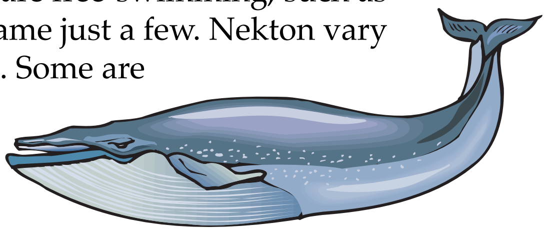
The pelagic environment begins at the shore and includes all the waters of the oceans. The effect of the pelagic environment on the Earth's land is immeasurable: It provides needed oxygen and food, and it influences both climate and weather. Its rich and varied community includes some of the largest—and the most frightening of marine animals. But its food chain is dependent on its smallest organisms, called **plankton**.



Portuguese man-of-war is a large plankton that floats or drifts with the current.

Pelagic Organisms. Pelagic (ocean) organisms are classified in two groups: those that swim (nekton) and those that do not swim (plankton). Most plankton—with the exception of the jellyfish and the Portuguese man-of-war—are very small organisms that float or drift with the currents. There are both plant and animal plankton. Plant plankton (*phytoplankton*) grow only in shallow or surface waters where there is enough sunlight for photosynthesis. Animal plankton (*zooplankton*) are also found in these waters where they can feed on the plant plankton.

The **nekton** are those organisms that are free-swimming, such as fish, squids, sharks, and whales, to name just a few. Nekton vary greatly in the way they move and eat. Some are *herbivores* (plant-eating), some are *carnivores* (meat-eating), and some eat whatever they can find. Nekton populate all the regions of the pelagic environment.



whale

Scientists have divided the pelagic environment into two major **provinces**: the neritic and oceanic. The **neritic province** includes the water and life over the continental shelf, which accounts for about 10 percent of ocean water. The rest of the waters—nearly 90 percent of the ocean's surface—are in the **oceanic province**, or the deep waters away from land.

The Neritic Province Characteristics

- the area above the continental shelf
- 10% of the ocean's surface
- more productive than adjacent ocean waters
- 90+% of the world's commercial fishing
- subject to tidal forces that help to mix the water column
- higher mixing insures continual supply of nutrients from deeper waters
- higher supply of nutrients and sunlight results in greater growth of phytoplankton

Neritic Province. The neritic province is greatly influenced by being near land. Rivers run off into this region's bays and estuaries. This runoff adds large amounts of fresh water, thereby reducing the salinity in areas near the river mouths. In shallow areas, however, heating by the sun may increase evaporation, thus raising the salinity. Waters in the neritic province are shallow enough to be penetrated by light. Light enables plants to carry out photosynthesis and thrive. Consequently, these sun-filled, shallow waters support large areas of plant growth that smaller organisms feed on. Here the temperature of the water changes with the seasons.

The neritic province is also the only area of the ocean where submerged plants such as seagrasses and seaweeds are found.

Most of the neritic province is in the **photic zone**, or *sunlit zone*. The photic zone is the lighted region of the ocean. Because this zone gets light, plants can carry out *photosynthesis* (food-making), and large numbers of phytoplankton and other marine algae can grow and reproduce. The neritic province is also the only area of the ocean where submerged plants such as seagrasses and seaweeds are found. With so many nutrients and plankton present, these waters may also appear murky or cloudy. Over 90 percent of all organisms sold commercially, such as shrimp, crabs, lobsters, oysters, and fish, are harvested, or caught, in this province.

Oceanic Province. The conditions in the open ocean, or oceanic province, are much more stable, or constant, than the conditions over the continental shelf. The temperature and the salinity in these waters do not change very much. Because the water is clearer due to lack of nutrients, light penetrates farther into this region. Although the photic zone is only a small part of the oceanic province, it contains most of the ocean's life.

Oceanic Province			
zone	**depth** (in meters)	**light**	**organisms**
Epipelagic	0-200	yes—photic zone or sunlit zone	fish, sharks, plankton, jellyfish
Mesopelagic	200-1000	very little—disphotic or twilight zone	octopus, fish, squid, krill
Bathypelagic	1000-4000	none—aphotic zone or midnight zone	fanfin, anglerfish, gulper
Abyssopelagic	4000-6000	none—aphotic or midnight zone	blackdevil, anglerfish, snipe eel
Hadalpelagic	6000+	none—aphotic or midnight zone	rattail fish, isopods, worms

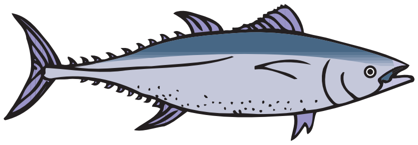
Beneath the photic zone, the water quickly becomes very cold. The temperature decreases with depth—the deeper you go, the colder the water. Beyond 300 meters deep, however, the temperature remains fairly constant—about 4°C, or just a few degrees above freezing. Pressure also increases with depth.

Animals that live in the deep ocean must adapt to low temperatures, high pressures, and very little or no light. Many animals move up to the photic zone to feed. Others live on the dead plants and animals that sink from shallower waters or prey on living animals. Some animals produce their own light and "glow in the dark" to either attract prey and mates or to help them find food.

The oceanic province can be divided into five stacked layers, or zones, based on depth. Each zone supports different types of life.

The **epipelagic zone** ranges from the surface to about 200 meters (about 600 feet) deep. This area is in the *photic zone* or sunlit zone. Consequently, phytoplankton thrive and support large numbers of zooplankton

Some animals produce their own light.



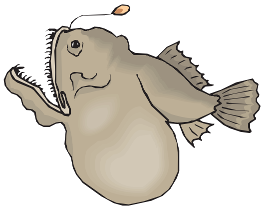
tuna

and fish higher up in the food chain, like tuna. Most fish in this region are *countershaded*—that is, darker on top than on the bottom—which helps them blend in with the lighted waters.

Below this lighted region is the **disphotic zone**, also known as the *twilight zone*. The disphotic or twilight zone corresponds with the **mesopelagic zone**. The mesopelagic zone ranges from 200 meters to 1,000 meters in depth. Life here is less plentiful and varied than in the epipelagic zone because food is scarce and difficult to locate. Most fish in this region have light spots on their bodies or are silvery in order to reflect what little light is present. Many weird-looking fish are also found here with features such as snake-like bodies, needle-sharp teeth, or huge eyes.

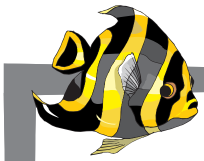
Below the twilight zone is the **aphotic zone** or *midnight zone*. The *aphotic zone* is an area where light does not penetrate. Ninety percent of the ocean is in this zone. In the aphotic zone there are deep-ocean regions of total darkness, cold temperatures, high pressure, and limited food. These regions include the **bathypelagic zone** (depths between 1,000 and 4,000 meters), the **abyssopelagic zone** (depths between 4,000 and 6,000 meters), and the **hadalpelagic zone** (waters in the deep-ocean trenches more than 6,000 meters).

In these zones, conditions remain constant throughout the year, and food is always scarce. Organisms in these zones have to take advantage of every possible meal. Deep sea fish have adapted to the harsh conditions of the deep. Some deep sea fish have huge mouths and long, sharp teeth to assist them in catching prey in their dark environment. Other deep sea fish have mouths that are pointed upward possibly to assist them in catching scraps of food that fall from the waters above. Some common organisms in these regions that have adapted to the harsh conditions are the anglerfish and the gulper. The anglerfish attracts its prey with a lure that hangs over its mouth, while the gulper fish has a huge mouth and elastic stomach which enables it to eat prey much larger than itself.



The anglerfish attracts prey with a lure that hangs over its mouth.

The gulper can eat prey much larger than itself.



Benthic Environment

Regardless of the depth of the water, the benthic environment includes all of the area at the bottom of the ocean. It includes the sediments along the shore, continental shelf, and the ocean basin. It also includes all organisms living along the ocean floor. The makeup of the benthic division will vary depending on the types of sediments present. Scientists have divided the benthic environment into six regions, or locations. See the chart below.

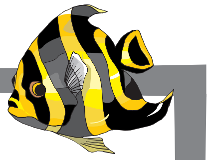
Benthic Environment	
supralittoral	above the high-tide line; splash zone
littoral	between the tides; intertidal zone
sublittoral	below low-tide line on the continental shelf; subtidal zone
bathyal	between 200 and 4,000 meters on continental slope
abyssal	between 4,000 and 6,000 meters on abyssal plains
hadal	below 6,000 meters in deep-ocean trenches

Benthic Environment along the Shoreline. Three of the major zones or regions within the benthic environment are found along the shoreline (see Unit 8). Above the high-tide line is the **supralittoral zone**, also called the *splash zone*, a dry region that only gets wet when splashed by waves. Very few organisms can survive in this zone. Some algae, crabs, and barnacles, however, have adapted to life here.

Closer toward the ocean, there is an area continually covered and uncovered by cycles of the tide—the **littoral zone**. This area, also called the *intertidal zone*, is one of the harshest places for plants and animals to live. To survive here, organisms have to deal with exposure to saltwater and to air, the risk of drying out, and the constant pounding of the waves and tides.

Below the littoral zone lies the **sublittoral zone**. This area is also called the *subtidal zone*. It extends from the low-tide line to the edge of the continental shelf. This area is always under water and provides a stable environment for the largest number of benthic organisms.

Some organisms in the sublittoral zone have structures that help them cling to hard surfaces. These clinging structures prevent the organisms from being swept away by the waves and currents. A "boring" sponge is



an example of a sublittoral organism that has adapted to this environment. This sponge secretes an acid that allows it to drill into rocks and shells. The sponge is protected by the rock's or shell's hard outer covering. You may have found shells on the beach which are pockmarked with holes from the boring sponge.

Another animal that lives in the sublittoral zone is the sea star (starfish). Sea stars cling to rocks and other hard surfaces by means of suction cups located on their tubefeet. The pounding waves cannot dislodge the sea stars from their locations on the rocks. Barnacles also live in the sublittoral zone. (Many also live in upper zones.) These organisms have the strongest method for clinging to hard surfaces. They cement themselves with a type of glue to rocks and other hard surfaces.

Some organisms in the sublittoral zone have flattened bodies. Having a flat body minimizes the animals' exposure to wave impact. The flounder is a flat fish that buries itself in the sand to avoid wave turbulence and to hide from predators.

Plants have also adapted to live in the sublittoral zone. Kelp and rockweed are types of marine algae which anchor themselves to rocky surfaces by a tissue called a *holdfast*. A holdfast is similar to a large root.

Benthic Environment beyond the Continental Shelf. Beyond the edge of the continental shelf, the benthic environment is relatively uniform. The *bathyal zone* covers the area of the continental slope or the region between 200 meters and 4,000 meters in depth. The *abyssal zone* is the region of the ocean floor, including the abyssal plains, that is between 4,000 meters and 6,000 meters in depth. In the sediments of the trenches is the *hadal zone*—the deepest of all.

Benthic Organisms

Because plants need light for photosynthesis, they inhabit only those benthic environments in the neritic zone or along shallow coastal areas and the intertidal zones. Animals, however, inhabit all depths of the benthic environment. Crabs, worms, sea stars (starfish), and bacteria are some common ones. Benthic organisms can be classified by either their movement or their location. Organisms that attach themselves to the seafloor are called **sessile**. Some common sessile benthic animals include oysters, sponges, coral, and barnacles. Sessile organisms feed by using parts of their body to filter out food particles suspended in the water. Most of these sessile organisms depend on waves and currents to bring them food. Organisms capable of movement are considered to be *mobile*. Mobile scavengers can freely move about in search of prey or to scavenge for a meal of remains from the ocean bottom.

Benthic organisms are also classified according to where they live in the benthic environment. They can either live on the top of the ocean floor or within the sediments. **Epifauna** are those animals that live *on* the surface of the seabed. Some examples include crabs, sea stars, sea urchins, and sea cucumbers. Most epifauna either hunt prey or scavenge for remains. Animals that live *within* the soft sediments are called **infauna**. Common infauna include worms and clams. These animals may feed on other infauna, filter their food from the water, or directly take in sediments from which they filter their food.

Sandy Beach Environment

upper beach

Thinking of a vacation at the beach brings up images of sandy white beaches. Sandy beaches are the most familiar environments along the coast and are composed of sand or loose sediment. Sandy beaches come in a variety of sand types: black lava sand, white quartz sand, or even crushed coral sand. The loose sediment along the coastline is easily shifted and transported by wind and water. Because the sandy beach area is constantly changing, this environment is a harsh place to live for marine plants and animals.

intertidal zone

The upper beach area contains beach plants consisting of trees, bushes, and grass. The roots of these plants play an important role in building beach and dune areas. The plants' roots hold onto the sand and prevent sand erosion from wind and wave action.

The environment on the beach changes as you near the water. The area of wet sand on the beach is the *intertidal zone* or the *littoral zone*. This area of the beach is sometimes covered with water and at other times not. When the intertidal area is covered with water, it houses a variety of marine animals. When the tide goes out and the intertidal area is exposed, its marine life retreats to deeper waters or burrows in the wet sand.

surf zone

The region of crashing waves along a sandy beach is called the **surf zone**. The surf zone moves with the tide as the tides alternate between high and low. Water in the surf zone is in constant motion. This constant motion moves sand about with each passing wave. Marine life in the surf zone is constantly swept up and down the beach.

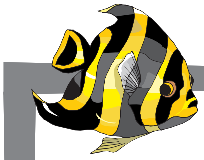
The mole crab is an example of a marine organism that has adapted to life in the turbulent surf zone. The mole crab has paddle-like appendages that it uses to dig into the sand as waves approach it. Once buried in the sand, the mole crab then sticks its feather-like appendages above the sand to filter out microscopic food from the water. The body of the mole crab is shaped like a jelly bean and has a smooth exterior. The shape of the mole crab allows it to swim with minimal resistance through the swirling surf.

The Rocky Coast

Shores that are composed of solid rock are called **rocky coasts**. The western coastline of the United States is predominately rocky. Rocks of rocky coasts provide a surface for marine organisms to attach themselves. Just as with sandy beaches, the rocky coast has definite habitat zones. There are four zones of habitats: upper intertidal, mid-intertidal, lower intertidal, and subtidal.

Shores composed of solid rock are called rocky coasts.

The *upper intertidal zone* is also known as the *splash zone*. This area is above the high tide mark and receives moisture from the ocean spray. The damp rocks provide a perfect environment for the growth of *blue-green bacteria* or *algae*. The periwinkle snail grazes on algae in the upper intertidal zone.



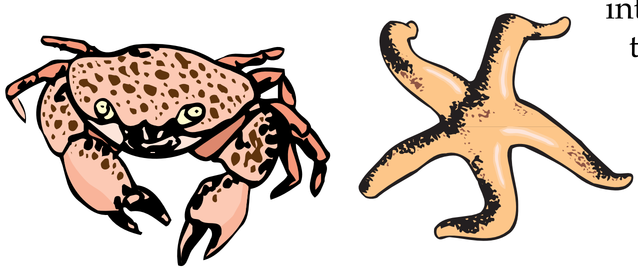
The *mid-intertidal zone* is located below the upper intertidal zone. The mid-intertidal zone is characterized by barnacles, mussels, and seaweeds. Barnacles are attached to the rocks so strongly that even the most powerful wave cannot dislodge them. During high tide, barnacles are covered by water. Barnacles feed on plankton during high tide. Barnacles are filter feeders and whip their feathery appendages called *cirri* to capture food. During low tide when the tide is out, barnacles shut their shells tight to keep from drying out. Barnacles have sharp, overlapping shells that protect them from predators. The dog whelk, a marine snail, is the only predator that can penetrate the tough exterior shell of the barnacle. The dog whelk secretes an acid from its foot. This acid softens the barnacle shell and allows the whelk to drill into the barnacle.

Beneath the mid-intertidal zone is the *lower intertidal zone*. This area of the rocky coast is dominated by seaweeds. During low tide, pockets between the rocks retain water forming small pools called **tide pools**. Tide pools create habitats for a variety of organisms such as algae, small fish, and invertebrates.

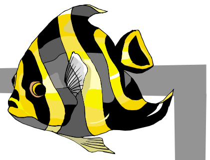
The *subtidal zone* is completely underwater and has an abundance of marine life. Sea urchins feed on giant kelp. Sea stars suction themselves to rocks. Sea anemones, crabs, and lobsters hide in the rock crevices in the subtidal zone.

Summary

The marine biome contains two major divisions or regions: *pelagic* (water) and *benthic* (bottom) environments. The pelagic environment begins at the water's edge and includes two major provinces—the neritic province (the water over the continental shelf) and the oceanic province (the open-water zone). The oceanic province is divided into five stacked layers. The benthic environment is divided into six regions, according to their location in or on the sediment on the ocean floor. Organisms in each layer or region differ because they are adapted for the conditions in that specific region.



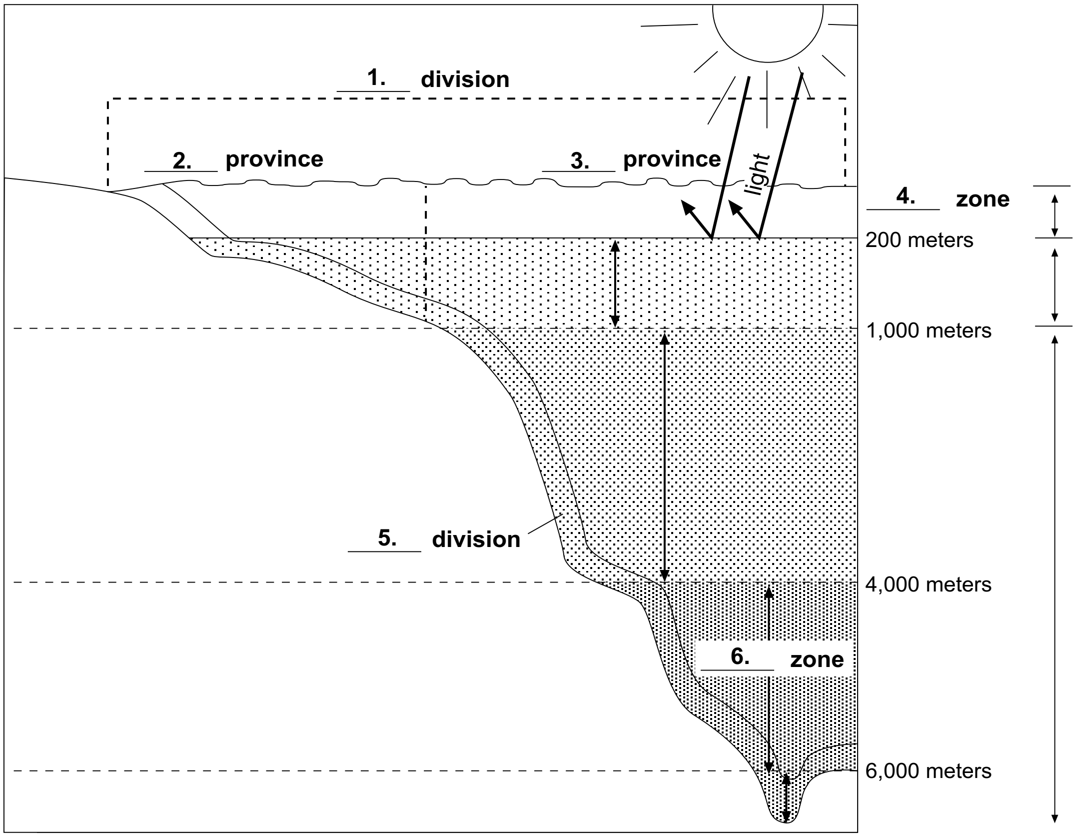
Crabs and sea star (starfish) are example of epifauna that live on the surface of the seabed.



Practice

Use the list below and the chart on page 231 to complete the following diagram. Write the correct name of each **zone** *or* **division** *on the line provided.*

abyssopelagic
benthic
neritic
oceanic
pelagic
photic



1. ______________________

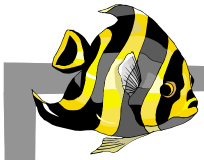
2. ______________________

3. ______________________

4. ______________________

5. ______________________

6. ______________________



Practice

Use the information in this unit and the charts on pages 233 and 234 to answer the following using short answers.

1. What is the name of the pelagic province over the continental shelf?

   ____

2. Which oceanic zone includes the photic zone?

   ____

3. Which zone in the benthic division includes the abyssal plains on the deep-ocean floor between 4,000 meters and 6,000 meters?

   ____

4. Which benthic zone includes the deep-ocean trenches? ________

5. How many meters deep does the epipelagic zone extend? ______

6. Which benthic division is seldom wet? ___________________

7. What is another name for the mesopelagic zone? ____________

   ____

8. In which zone are the most plant plankton found? ___________

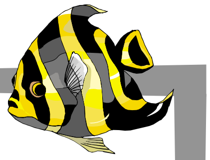
   ____

9. Why is the neritic zone high in nutrients and marine life?

   ____

   ____

   ____



10. Which pelagic zones are aphotic? ______________________________

____

____

____

____

11. Which pelagic zone is the deepest? ____________________________

12. Which pelagic zone is located at a depth between 4,000 and 6,000 meters? ____

13. State three adaptations for marine organisms that live in the benthic sublittoral zone. ______________________________________

____

____

14. Sandy beaches come in a variety of sand types. List three sand types.

____

____

____

15. Why is the sandy beach a harsh area for marine animals to live? ___

____

____

____

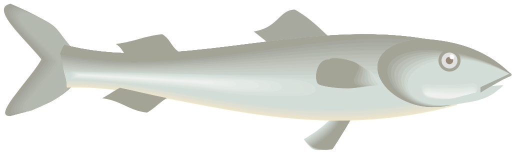
____

____

Practice

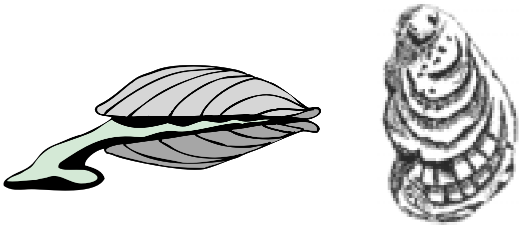
Use each diagram and description below to answer the questions that follow. Circle the term that best **completes the sentence** *or* **describes the organism***.*

This fish below lives in the waters over the continental shelf.



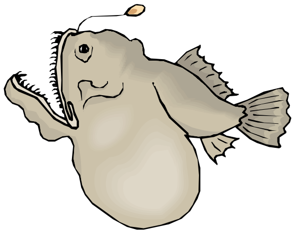
1. This fish is (**pelagic** / **benthic**).
2. It is found in the (**neritic** / **oceanic**) provinces.
3. The fish is an example of a (**plankton** / **nekton**) because it is a good swimmer.

Clams and oysters live in the area of sediments between the high-tide line and the low-tide line. Clams live within the sand, while oysters attach themselves to the surface.



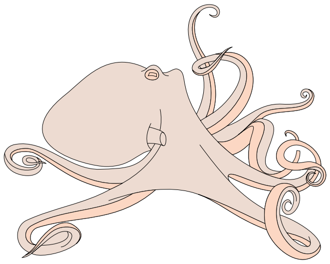
4. Clams and oysters live in the (**supralittoral** / **littoral** / **sublittoral**).
5. Both clams and oysters are (**benthic** / **nekton** / **plankton**).
6. Because oysters are attached and do not move, they are (**mobile** / **sessile**).
7. Clams would be classified as (**epifauna** / **infauna**) because they live in the sand.

The anglerfish below lives in total darkness at about 2,000 meters in depth. It uses a lighted lure to attract other fish as prey.



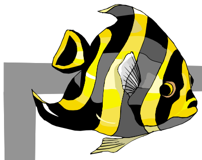
8. The anglerfish above lives in the (**mesopelagic** / **bathypelagic** / **abyssopelagic**) zone.

The octopus below lives in the open ocean in the twilight where there is only a little light.

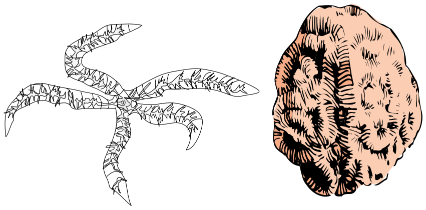


9. This octopus lives in the (**neritic** / **oceanic**) province.

10. If the octopus is in the twilight area, it would be in the (**epipelagic** / **mesopelagic**) zone.



Brittle stars and sponges below are common on the sediments of the continental shelf.

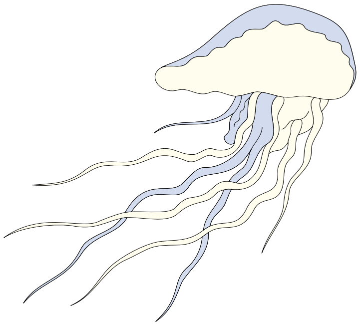


11. Both of these organisms would be considered (**benthic** / **nekton** / **plankton**).

12. They would be found in the (**sublittoral** / **bathyal** / **abyssal**) zone.

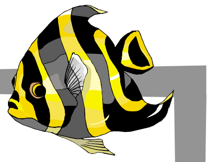
13. The sponge would be classified as (**epifauna** / **infauna**) because they live on the surface.

Jellyfish are very common in near-shore waters over the continental shelf. As they float along with the currents, they are often washed into beaches by waves.



14. Jellyfish are found in the (**pelagic** / **benthic**) zone.

15. They would be considered (**infauna** / **nekton** / **plankton**).



Practice

Use the list above each section to complete the statements in that section. **One or more terms will be used more than once in the first section.**

benthic
biome
epifauna
freshwater
infauna
marine
nekton
neritic
oceanic
pelagic
photic
plankton
sessile

1. A large-area ecosystem with similar characteristics is called a ________________________.

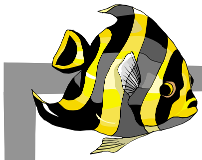
2. The aquatic environment has two biomes: ________________________ (lake) and ________________________ (sea).

3. Two major divisions or regions in the marine biome are the ________________________ (water) and ________________________ (bottom).

4. The largest region of the marine world is the ________________________ environment.

5. The pelagic environment is divided into major provinces: the ________________________ and ________________________ .

6. The ________________________ province includes the water and life over the continental shelf.



7. The ____________________ province includes nearly 90 percent of the ocean waters.

8. Most of the fish sold commercially are caught in the ____________________ province and in the ____________________ zone.

9. Photosynthesis takes place in the lighted region of the ocean, which is known as the ____________________ .

10. Beneath the ____________________ zone, the water quickly becomes very cold and the pressure increases.

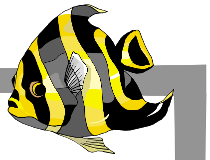
11. Oysters, coral, and sponges are ____________________ benthic animals, meaning they attach themselves to the seafloor.

12. The jellyfish and the Portuguese man-of-war are large ____________________ that float or drift with the currents.

13. Fish, squid, and whales are free-swimming organisms called ____________________ .

14. Benthic animals living on the surface of the ocean floor are classified as ____________________ .

15. Benthic animals living within the sediments are classified as ____________________ .



algae
barnacles
intertidal
invertebrates
littoral
rocky
small fish
splash
surf
tide

16. ____________________ are organisms that cement themselves with a type of glue to rocks or other hard surfaces and live in the sublittoral zone.

17. The area of wet sand on the beach is the ____________________ zone or the ____________________ zone .

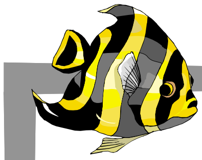
18. Water in the ____________________ zone is in constant motion.

19. The western coastline of the United States is made up mostly of ____________________ coasts.

20. The upper intertidal zone of the rocky coast is called the ____________________ zone.

21. Some marine organisms that can be found in a tide pool are ____________________, ____________________ and ____________________ .

22. Pockets between rocks retain water during low tide forming small pools called ____________________ pools.



Lab Activity: Something's Environmentally Fishy!

Investigate:

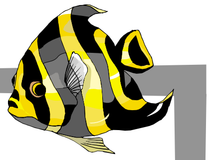
- Identify adaptations that marine organisms utilize to survive in specific marine environments.
- Identify a marine organism's environment from observations of its external features.
- Demonstrate knowledge of marine environments.

Materials:

- butcher paper or poster board
- newspaper
- glue
- variety of arts and crafts supplies
- cornstarch
- markers and paint
- paint brushes or sponges

Procedure:

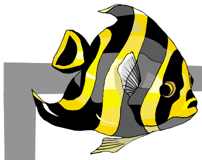
1. Select a marine environment or zone of your choice. Choose from oceanic environments (epipelagic, mesopelagic, bathypelagic, abyssopelagic, hadalpelagic zones) or from benthic environments (rocky beaches, sandy beaches, supralittoral, littoral, sublittoral, bathyal, abyssal, or hadal).
2. Once you have determined a marine environment, choose a marine organism (or design one of your own) that illustrates unique characteristics for survival reflecting the marine environment you have selected. (You may scan a marine science textbook for marine organisms or conduct a search on the Internet by doing a keyword search for your particular marine environment.)
3. Make a model of the marine organism. The model of your organism should be true to life size, slightly larger, or made to scale depending upon the organism you



choose. The organism model should display the adaptations that the organism needs for survival in the environment you have selected. Be sure to include correct coloration, appendages, etc.

4. Include with your model a name tag and description card. The name tag should state the organism's common name, and the description card should summarize where the organism lives and adaptations to its environment.

5. After completing your model, display your model in a mural setting or arrange your models to simulate a marine environment with other student models. Be sure that all the benthic organisms are displayed in their correct environment, and all the pelagic organisms are displayed in their correct environment.



Practice

Use the list below to write the correct term for each definition on the line provided.

biome
benthic
habitat
nekton
neritic province
oceanic province
pelagic
plankton
province

______________________________ 1. waters beyond the continental shelf; open-ocean zone

______________________________ 2. waters over the continental shelf; near-shore zone

______________________________ 3. a particular area or region

______________________________ 4. free-swimming organisms

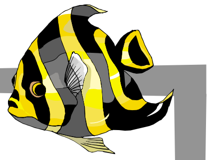
______________________________ 5. small, usually microscopic plant or animal organisms that float or drift in the ocean

______________________________ 6. of or pertaining to the seas or oceans

______________________________ 7. bottom environment; refers to animals living on or in the seabed

______________________________ 8. large-area ecosystem sharing similar characteristics; an environmental unit

______________________________ 9. specific area or type of environment in which an organism is found



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. area of ocean where light does not penetrate; also called the *midnight zone*

______ 2. lighted region of the ocean; area where photosynthesis can occur; also called the *sunlit zone*

______ 3. dimly lit region of the ocean where there is not enough light to carry on photosynthesis; also called the *twilight zone*

A. aphotic zone

B. disphotic zone

C. photic zone

______ 4. the depths of the ocean below 6,000 meters in the deep-ocean trenches; in the aphotic or midnight zone

______ 5. the depths of the ocean between 4,000 and 6,000 meters; in the aphotic or midnight zone

______ 6. the depths of the ocean between 1,000 and 4,000 meters; in the aphotic or midnight zone

______ 7. middle layer of ocean water between 200 and 1,000 meters; in the disphotic or twilight zone

______ 8. upper layer of water extending to depth of 200 meters; in the photic or sunlit zone

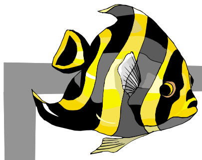
A. abyssopelagic zones

B. bathypelagic zone

C. epipelagic zone

D. hadalpelagic zone

E. mesopelagic zone



Practice

Use the list below to write the correct term for each definition on the line provided.

epifauna
infauna
littoral zone
rocky coasts
sessile
sublittoral zone
supralittoral zone
surf zone
tide pools

________________________ 1. small habitats formed when spaces between rocks retain water at low tide

________________________ 2. the area of crashing waves along a sandy beach

________________________ 3. shores made up of solid rock and usually steeper than sandy beaches

________________________ 4. animals that live *within* the sediments of the seafloor

________________________ 5. animals that live *on* the surface of the seabed

________________________ 6. organisms that are attached to a surface and cannot move around

________________________ 7. benthic area of the continental shelf below the low-tide area; also called the *subtidal zone*

________________________ 8. area between the tides; also called *intertidal zone*

________________________ 9. dry area above the high-tide line; sometimes called the *spray* or *splash zone*

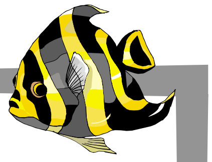
Unit 11: Near-Shore Ecosystems

Unit Focus

This unit previews two coastal environments, wetlands and coral reefs. These environments are important in maintaining the balance of life both in the sea and on land. Students will study wetlands such as estuaries, mudflats, saltmarshes, swamps, and mangroves. Students will also investigate the formation of coral reefs and the diversity of life in the reef environment.

Student Goals

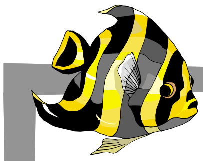
1. Define wetland.
2. Explain the importance of wetlands.
3. State several examples of wetland environments.
4. Describe the formation of a coral reef.
5. Explain the importance of coral reefs.
6. Describe the negative impact humans have on wetlands and coral reefs.



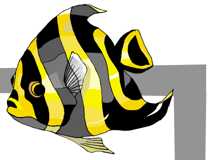
Vocabulary

Study the vocabulary words and definitions below.

atoll	ring-shaped coral island usually located in deep water; developed from fringing reef formed around a volcanic island or landmass
barrier reef	coral formation that is separated from land by water (a *lagoon*)
coral reef	underwater community of living and dead corals; supports life in warm tropical waters
detritus	decaying plant and animal material
dredge	to remove underwater land or sediments by suction or digging
estuary	the mouth of a river or bay where freshwater and saltwater mix; the part of the river where its current meets the ocean's tide
Everglades	large, mixed wetland area located in southern Florida
fringing reef	coral reef that grows around the edge of a volcanic island or landmass
hammock	wooded area surrounded by marsh



lagoon	water separating land from a coral reef or sand bar
mangrove	tree found in muddy tropical wetlands whose twisted roots grow partly above ground
mudflat	slightly sloping beach with dark, muddy sand, no marsh grasses, and very little wave action
salt marsh	low, coastal wetland covered by salt-tolerant grasses
swamp	wooded wetland located further inland than marshes
temperate	describes moderate climate zone between the tropics and the poles
wetlands	an area that is a combination of water and land; may be exposed, partially submerged, or covered with water



Introduction: Near-Shore Ecosystems—Wetlands and Coral Reefs

Two habitats that thrive along the ocean's coasts are **wetlands** and **coral reefs**. These two near-shore habitats have become familiar topics and issues in Florida news. More scientists are becoming aware of just how important wetlands and coral reefs are to maintaining the balance of life both in the sea and on land.

The term *wetlands* describes any area that is a combination of land and water. A *wetland* at different times may be totally covered with water, partially submerged, or, on occasion, dry and exposed to the sun and wind. Its state often depends on tides, the season, the weather, and many other factors. Because wetlands are near shorelines, some wetlands have been destroyed by developers who have filled them in and built ocean-front residences and recreational areas in their place.

Coral reefs offer us one of the more colorful environments in nature. The panorama of lively tropical colors in coral reefs comes from the living coral animals that compose the reef, the many animals that attach themselves to the layers of limestone, and the large number of diverse swimming animals competing for food in this community. The commercial value of coral has prompted some people to destroy these living monuments in an attempt to turn a profit.

Coral reefs offer us one of the more colorful environments in nature.

Wetlands: A Zone Between Land and Sea

Purifying Water

Wetlands serve as a transitional zone for water as it makes its way to the sea. Water runoff from land contains wastes, or pollutants, as it flows into wetlands. Bacteria on the roots of plants and trees in wetlands break down pollutants into compounds that are less harmful to the chemical balance of the water in rivers, lakes, and the ocean. However, polluted stormwater runoff is becoming a greater problem in Florida as wetlands are destroyed.

A Nursery for Aquatic Animals

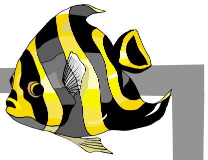
Wetlands provide an ideal breeding ground for many aquatic animals. Most wetlands have a muddy substrate—or a floor—that provides food and shelter for organisms. On this floor, protected by water, animals breed and lay their eggs. When the eggs hatch, the young thrive on the plankton and tiny pieces of decaying plants and animals in the waters of the wetlands. Shallow water protects them from ocean predators, or larger animals that would feed on them. Some animals, such as the snapper, only spend the first part of their life in the wetlands and then return to the open ocean as adults. Other animals, such as the oyster and mullet, spend most of their lives in wetland areas.

Nutrient-Rich Wetlands Feed Plants and Animals

Wetlands provide rich sources of nutrients for both plant and animal growth. They may be so rich in organic material that their waters may be murky. **Detritus**, or decaying plant and animal material, is the first link in the wetland food chain. Bacteria and wave action help to break down organic materials into usable forms for zooplankton and many juvenile, or young, organisms. Many of these particles are trapped in the wetlands, providing food, cover, and protection for many animals.

Wetlands provide an ideal breeding ground for many aquatic animals.

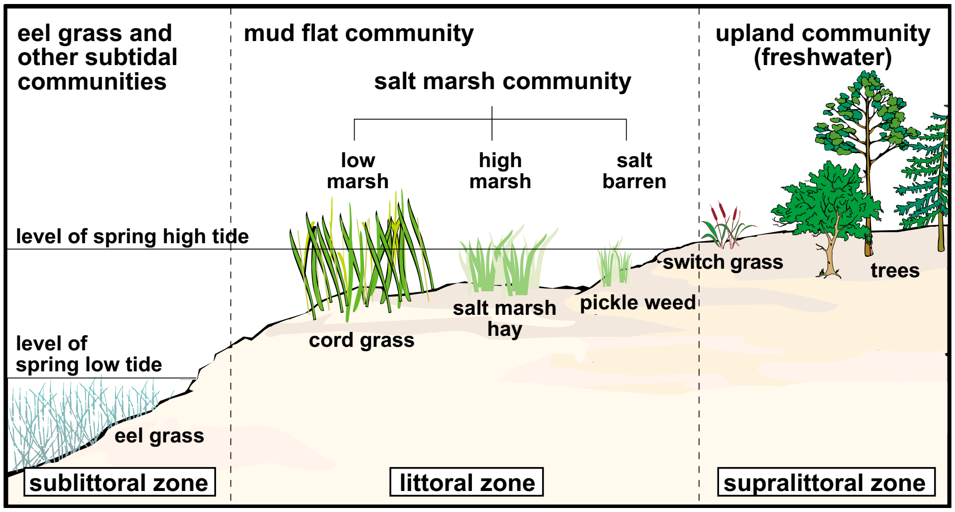
The abundance of food and shelter in wetlands provide a perfect near-shore habitat for many organisms throughout their adult life. Animals such as the blue crab, shrimp, and some fish feed on juvenile organisms and only leave wetlands to release their eggs into the open ocean. After hatching, their young drift in the ocean currents before returning to the wetlands to mature and live out their adult life.



Estuaries: Where Saltwater and Freshwater Meet

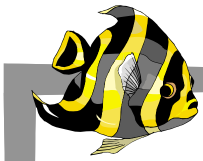
One type of wetland is an **estuary**—an area where freshwater from the land and saltwater from the sea flow together. Estuaries are generally located where a river empties into the ocean or where freshwater from land drains into the ocean. The resulting water is brackish, or salty to some degree. Because saltwater is denser than freshwater, the deeper depths in an estuary's water column will be saltier; whereas the shallow depths will be less salty. Salinity of the water increases near the open sea and decreases closer to land.

The water level and salinity of estuaries change according to the tides and seasons. At high tide, saltwater flows farther up into the estuary than it does at low tide. At low tides, many areas are exposed to heat and air. An estuary's salinity will be highest during the summer when evaporation is the greatest. During winter and spring, increased storm runoff and decreased evaporation rates lower salinity.



zonation of an estuarine community

The mixing of freshwater and saltwater creates a unique environment for organisms. Many marine animals cannot tolerate the changing salinity in estuaries. Consequently, the number of species inhabiting estuaries is smaller than those living in nearby marine and freshwater habitats. Among the animals that have adapted to the extremes of estuaries are oysters. At high tide they open up their shells to take in water and filter through the rich supply of nutrients. At low tide they trap water inside their shells and close up to prevent the air from overheating them and drying them out. Other permanent residents in estuaries include blue crabs, worms, mussels, and barnacles.



Because the changeable conditions in an estuary keep out many would-be predators, organisms that can live there thrive. But even these organisms are restricted to certain zones according to the level of salinity they can withstand. This separation of marine life in a habitat into definite zones or bands is called *zonation*. Freshwater organisms are restricted to the upper end of the estuary, and saltwater organisms are usually found only near the ocean. The snapper, for example, only moves in and out with the tides, and only along areas of constant salinity, to feed or reproduce. Some organisms, however, have adapted and regulate their salt content and move freely about the entire estuary. The mussel and the marsh periwinkle, a type of snail, are well suited to survive this constantly

The Zonation of Marsh Life

Zone	Dominant Organisms	Environmental Characteristics
low marsh zone (inundated for many hours each day)	*Spartina alterniflora* cord grass ribbed mussel annelid worms marsh periwinkle	slowly traps sediments, increasing the height of the marsh anaerobic mud (mud without oxygen)
high marsh zone (flooded a few hours each day)	*Spartina patens* salt marsh hay salt-resistant herbaceous plants and succulents pickle weed seaside lavender seablight seaside golden rod fiddler crabs	accumulation of detritus gradual formation of thin layer of top soil continued increase of elevation
salt barren zone (flooded only at extreme high tide, usually once each month)	stunted forms *Spartina patens* reed grass pickle weed mounds of partially decayed plant or animal material remaining from last high tide mice and rats amphipods insects	decay of stranded vegetation begins the process of humus (partially decomposed organic material) formation elevation continues to increase
transition zone (above the level of the highest tide)	bayberry *Myrica pensylvanica* groundsel tree poison ivy wildflowers sweet everlasting soapwort British soldier lichens (resistant to salt spray) permanent populations of small mammals	humus forms fresh water accumulates in the soil temperature of soil increases from direct rays of sun reaching the surface

changing environment. These organisms spend their entire life in this habitat.


seagrass beds

Seagrass beds are common in sublittoral estuarine environments. They provide food and protection for many smaller animals. Common seagrasses in Florida include widgeon grass, shoal grass, turtle grass, and manatee grass.

Estuaries are small in area compared to the oceans of the world, but they produce much life. The rivers that flow into them carry minerals and nutrients from the land. The waves and tides help to mix these waters, ensuring a rich food supply. Because so many juvenile organisms depend on this environment for their survival, estuaries are often called the *nurseries of the sea*.

Salt Marshes: Part of the Ocean Nursery

Salt marshes are low, flat coastal wetlands bordering estuaries and well-protected bays in **temperate** areas. Salt marshes develop in littoral zones: When the tide is high, the water completely covers the flat land; during low tide, the muddy land is exposed to air. Any organism or species living in these *littoral zones*, also called the *intertidal zones*, must be able to adapt to the extremes created by tides.

Salt marshes are dominated by salt-tolerant grasses such as *Spartina* and *Juncus*. These grasses survive being partially covered with saltwater by excreting excess salt through special pores. The roots of these grasses trap particles of dirt and detritus thus preventing erosion and building up salt marshes.

Many animals use salt marshes as resting places during migration. Ducks, geese, and shorebirds are very common in marshes, feeding on the wide variety of organisms present. Other animals such as raccoons and turtles enter the marsh at low tide to feed. Common permanent residents of the salt marsh include the periwinkle snail, the fiddler crab, and the killifish. These animals adapt to the changing conditions by shifting their positions with the flow of the tides. The periwinkle snail crawls up and down the grass to stay above the water line. Armies of fiddler crabs emerge at low tide to feed on the nutrient-rich detritus. At high tide, the crabs quickly retreat into their burrows.

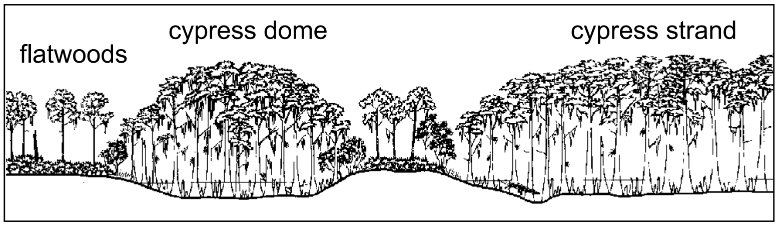
Mudflats: Provide an Environment for Bacteria

Mudflats are environments that have slightly sloping beaches and are characterized by dark, muddy sand. The mudflat area is unvegetated. It lacks seagrasses and marsh grass. Mudflats have very little wave action. The lack of wave action causes sediments to contain little or no oxygen. However, the lack of wave action does allow organic debris, such as *detritus* (decaying plants and animals), to accumulate on the mudflats. Mudflats are jokingly referred to as the "graveyards" of the wetlands because wastes decompose in the mud. Bacteria live in the mud and decompose wastes from marine organisms.

Mudflats usually have a characteristic odor similar to rotting eggs. This smell is a result of the production of a gas called *hydrogen sulfide* from decay. Hydrogen sulfide accumulates in the oxygen-deficient mud. Too many people consider the mudflats an environment devoid of life and importance, but marine scientists have found that mudflats are very important in the structure of the food web. Mudflats provide an environment for bacteria, which play an important role in converting wastes into useful nutrients. Nutrients produced in mudflats are transported by tidal flow to other parts of the estuary and to the open ocean. These nutrients are a major food source for oceanic plankton. Mudflats also provide homes and shelter for mud snails, clams, and worms.

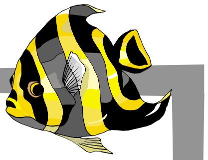
Swamps: Marked by Their Trees

Swamps usually develop further inland from the ocean than do estuaries and salt marshes. Because of their location, swamps are not influenced much by tides. Like all wetlands, however, swamps are cleansing areas for the water that flows through them. The ground of a swamp is covered with detritus-rich mud filled with bacteria that help to break down water pollutants. One by-product of the bacterial action is the gas hydrogen sulfide, which smells like rotten eggs (see *mudflats*, above). This gas production can sometimes be seen as bubbles rise from the mud.



freshwater swamp

The most visible feature of a swamp is its trees. In Florida, the most common tree in a swamp is the



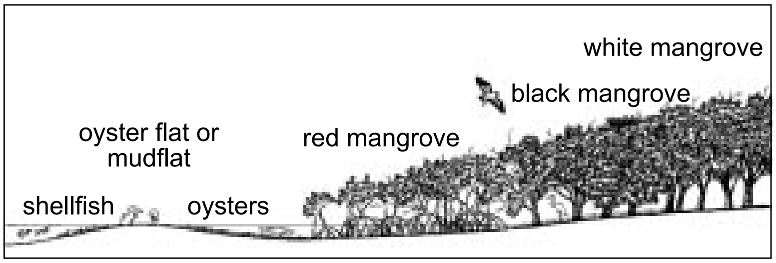
cypress. The cypress tree has large roots or *knees* that stick up out of the water. Tannic acid given off by cypress tree bark makes the water in a swamp slightly acidic. This acid makes the water appear dark. It also leaves rings or stains, showing the water level on trees or other objects in the swamp. Some swamps have scattered mounds of land. These wooded areas or swamp islands are known as **hammocks**. Common organisms found in a swamp include alligators, bass, trout, frogs, birds, and numerous insects.

Mangrove Swamps: Habitats for a Unique Tree

Mangrove swamps are wetlands that cover a large part of the coast in tropical and semi-tropical areas. In Florida, mangrove trees are found in southern Florida and the Keys. The **mangrove** tree is particularly adapted to tolerate the salty mud that covers coastal areas. Like *Spartina* and *Juncus* grasses, the mangrove can excrete excess salt to regulate its biochemistry.

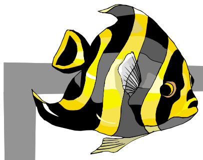
Many small animals find shelter and protection in the mangrove roots. Muddy detritus, which is produced from tides bringing in organic debris and dead leaves from the mangrove trees, provides the basis for most of the mangrove food chains. Like the mudflats, the products of decay from the mangroves enrich the mangrove environment with nutrients. These nutrients are carried out to sea by the tides and are consumed by plankton in the open ocean. Mangrove swamps provide shelter for organisms that live in the water as well as for organisms that are land and air dwellers. Raccoons, osprey, and brown pelicans are just a few of the animals that make their home among the leaves and branches of the mangroves.

Mangroves also protect the shore from erosion. Mangrove tree roots hold sand in place. The entire mangrove community protects the shoreline from storms by absorbing rising storm waters and the impact of the storm waves.



Florida mangrove swamp

There are four types of mangrove trees: the red mangrove, the black mangrove, the white mangrove, and the buttonwood. Red mangrove trees are most noticeable for their many *prop roots*. Prop roots are above-ground roots that give extra support to the red mangroves. The roots grow from the trunk and



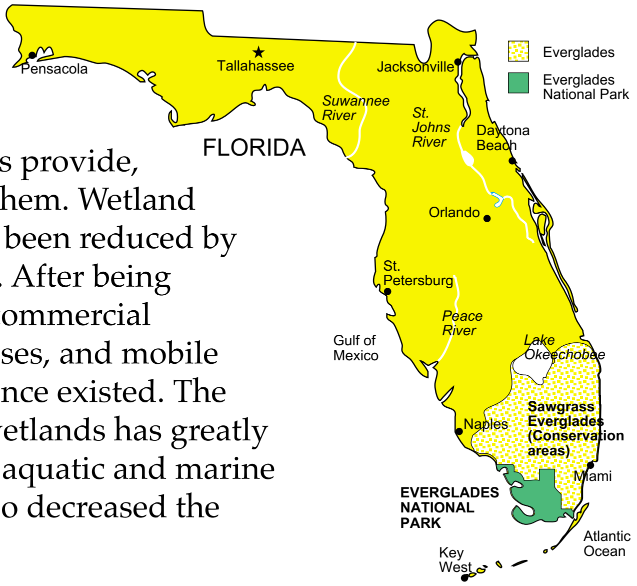
branches and arch above the water before submerging. Many small animals find shelter and protection in these roots. Muddy detritus, which is produced from falling leaves, provides the basis for most of the mangrove food chains. Crabs, oysters, clams, worms, and sponges take refuge on and in the roots of mangroves.

Everglades: Grassy Water

The Florida Everglades provide habitat and food for many birds.

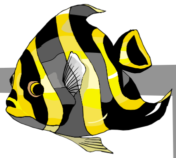
The Florida **Everglades** is a very large wetland area in southern Florida. It is a mixed wetland dominated by grasses. Native Americans knew the Everglades as Pa-Hay-Okee, or *Grassy Water*. Spanish explorers called it *El Laguno del Espiritu Sanctu*, or Lake of the Holy Spirit.

The main source of water in the Everglades is rainwater and overflow from Lake Okeechobee and nearby rivers. In the past, this overflow moved through the Everglades as a huge river of water that began north of Lake Okeechobee. Since the early 1900s, however, the area draining through the Everglades has been ditched and cultivated, and many south Florida rivers have been deepened and straightened. Despite the drastic changes affecting the Everglades, this huge wetland still provides habitat and food for both marine and land animals. This unique habitat has been changed due to pollution and the diverting of the water flow.



Destruction of Wetlands

In spite of the benefits wetlands provide, we have continued to destroy them. Wetland areas in the United States have been reduced by over 40 percent since the 1950s. After being **dredged**, they are filled in for commercial development. Hotels, golf courses, and mobile home lots sit where wetlands once existed. The clearing and development of wetlands has greatly decreased the area available to aquatic and marine animals. This shrinkage has also decreased the



wetlands' ability to filter and clean stormwater runoff before it reaches our lakes, rivers, and oceans. The destruction of wetlands is disturbing the balance of life both in the sea and on land.

Millions of acres of the Florida Everglades have already been destroyed, and the water flow that fed this wetland has been completely changed. The space available for plants and animals that depend on wetlands is constantly being decreased. Almost two-thirds of the total fish catch in the United States is dependent on the survival of healthy wetlands. Yet the water necessary to replenish the wetlands is increasingly being used for agricultural and human uses, causing wetland areas to dry up. Wetlands also serve as natural buffers against storms. As we build on and destroy these buffer zones, we leave ourselves more vulnerable to the destructive forces in nature.

Coral Reefs: The Exotic Community

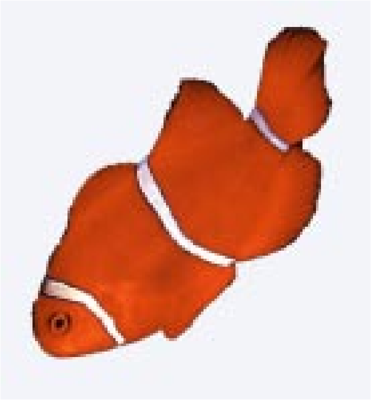
Coral reefs are named for the main organism that creates them. Reefs are made of *corals*—tiny sea animals that have a hard skeleton made of calcium carbonate. Certain types of algae that also produce calcium carbonate contribute to the formation of coral reefs. Corals build layer upon layer up toward the ocean's surface. Algae help cement the coral shells, other types of shells, and sand together to help produce the reef formation. The base of the reef is formed from the skeletons of *dead* coral; only the top of the reef is *living* coral and algae.

Coral reefs provide habitats for many of the more unusual and colorful marine animals.

Coral and algae have a two-way, or symbiotic, relationship called *mutualism*—each depends on the other to survive (see Unit 9). Microscopic algae called *zooxanthellae* are captured by the *coral polyps*, which are the basic structure of a coral animal. The algae then grow within the coral animal. The algae benefit by living safely within the coral polyp's cells and use the waste products of the coral. In return, the algae supply oxygen and nutrients for the coral animals. Corals are *sessile* filter feeders. Therefore, in addition to the algae, corals must depend on water currents to bring them food and help remove wastes because they are attached to a surface and cannot move around (see Unit 10).


lionfish

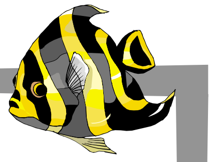
Reef-building corals require warm, tropical waters where the temperature does not drop below 20°C (68°F). The water also must be clear and shallow—less than 100 feet deep—because some species of coral have algae that live in their tissues, and need lots of sunlight so the algae can produce their food. Therefore, reefs are most common in the Pacific, but a few are found in Florida. One of the most well known in our state is in John Pennecamp Coral Reef State Park in the Florida Keys.


clownfish

Coral reefs provide habitats for many of the more unusual and colorful marine animals. Can you guess why? Coral reefs are composed of many types of coral growing together. The different coral types have varying shapes, sizes, and patterns which provide holes and crevices for marine organisms to seek shelter. Corals are classified into two types, hard corals and soft or flexible corals. Examples of hard corals are brain coral and staghorn coral. Soft corals include the gently waving sea fans and the sea pens. Both the soft coral and hard coral provide environments for over 3,000 animal species. Among the colorful marine species are the parrot fish, lionfish, moray eel, sea urchin, cleaner fish, and more.

Coral reefs are productive but fragile environments. Pieces of coral can be broken easily by extreme wave action or from someone touching the coral. Coral is covered by a protective membrane. If the membrane is damaged, then the coral is at risk for infection or disease. Corals around the world are in danger from coastal development, decline in water quality, and too much fishing and diving.

Scientists distinguish among three different types of coral reefs: the **fringing reef**, the **barrier reef**, and the **atoll**.

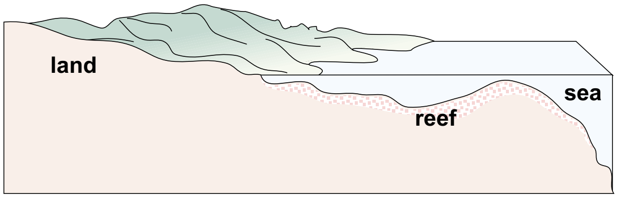


Fringing Reef

Fringing reefs develop in shallow water along the edge of a volcanic island or land mass. These reefs create a fringe of living coral on the border of a land form. The coral on the side farthest from land has more oxygen and food than the land-side coral and so grows more rapidly. Fringe reefs are commonly found in the Hawaiian Islands in the South Pacific and parts of the Caribbean.

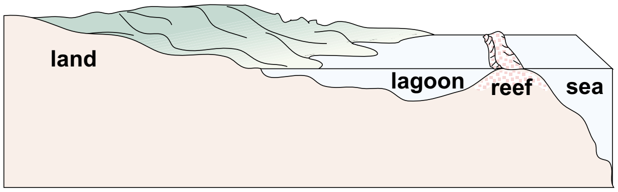
Barrier Reef

Unlike the fringing reef, the *barrier reef* is separated from the land by a body of water called a **lagoon**. The lagoon may be a few miles wide or very narrow.



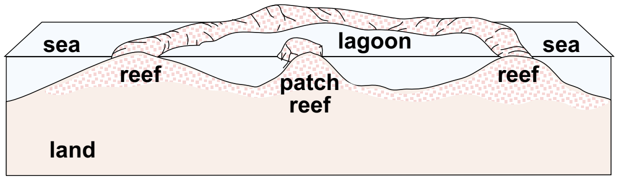
fringing reef - connected directly to shore

The Great Barrier Reef of northern Australia in the Coral Sea is an example of this type. This reef stretches 1,250 miles along Australia's coast and varies in width from 12 to 100 miles. The Great Barrier Reef is the largest barrier reef in the world.



barrier reef - separated from the shore by a lagoon

Atoll Reef



atoll - surrounded a central lagoon

Atolls are ring-shaped reefs that develop from fringing reefs. As the volcanic island or land mass begins to sink, the coral continue to build new layers on top of the old layers. Eventually, the volcanic mountain is completely submerged beneath the water, leaving behind an atoll with a large lagoon in the center.

Atolls are common in the Pacific and Indian oceans and can exist in deep water. The largest atoll, named Kwajalein, surrounds a lagoon over 60 miles long. Kwajalein is in the Marshall Islands, southwest of Hawaii and east of Guam.

Coral Reef Formation

For a long time scientists did not understand how atolls could have been formed in deep water when they knew that living coral required shallow, sunlit waters. Charles Darwin, the famous biologist, studied atolls and developed a theory of reef formation in 1831. He suggested that volcanic islands provided the shallow-water base that coral needed to grow on. As the islands slowly sank or the sea level rose, the coral grew upward, creating lagoons between the coral and the land, forming a barrier reef. By maintaining growth upward, the coral remained in shallow waters, and the top portions of the coral stayed alive. As the islands continued to sink or as sea level rose, eventually only the coral portion remained near the surface, forming an atoll surrounding a shallow lagoon.

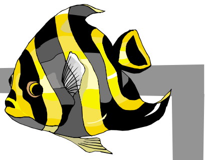
Reef-building corals require warm, tropical waters.

Summary

Two coastal habitats important to maintaining the balance of life both in the sea and on land are *wetlands* and *coral reefs*. Wetlands contain bacteria that help to break down pollutants in water before they reach the sea. Wetlands also provide a nutrient-rich, protected breeding ground for many aquatic animals. Different types of wetlands include *estuaries, salt marshes, swamps, mudflats, mangrove swamps*, and the *Everglades*. Commercial development has destroyed many wetlands and endangered these essential buffer zones.

Seagrasses provide food and protection for many smaller animals.

Coral reefs are made of layer upon layer of calcium carbonate. They develop only in sunlit, tropical waters and provide habitat for many of the oceans' more colorful and unusual animals. Different types of coral reefs include the *fringing reefs*, the *barrier reef*, and the *atoll*. Like wetlands, coral reefs are threatened by commercial interests.



Practice

Answer the following using short answers.

1. What is a *wetland*? ____

____

2. What are the three types of coral reefs? ______________________

____

3. What conditions must coral have to grow? ___________________

____

____

4. Why are estuaries called *nurseries of the sea*? ________________

____

____

5. Where is the Everglades located? _____________________________

6. Why are wetlands valuable to us? ____________________________

____

____

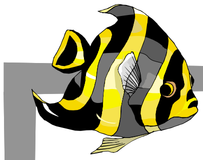
____

7. What are ways that mankind is destroying wetlands? ___________

____

____

____



Practice

Use pages 261-266 to correctly complete the chart below.

Classifying Near-shore Ecosystems				
Habitat	**Common Plants**	**Water**	**Effect of Tides**	**Animals**
Estuaries				
Salt Marshes				
Swamps				
Mangrove Swamps				

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. decaying plant and animal material

______ 2. large mixed wetland area in South Florida dominated by grasses

______ 3. fringing, barrier, and atoll

______ 4. combination of water and land

______ 5. tiny sea animals with a limestone skeleton

______ 6. common Florida seagrass

______ 7. an area where freshwater and saltwater meet

______ 8. low, flat coastal wetlands bordering estuaries or bays

______ 9. wooded wetland located further inland than marshes

______ 10. slightly sloping beach with dark, muddy sand

A. coral reefs

B. corals

C. detritus

D. widgeon grass

E. estuary

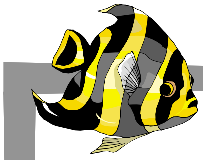
F. Everglades

G. mudflats

H. salt marshes

I. swamps

J. wetland



Lab Activity: Near-Shore Ecosystems

Investigate:

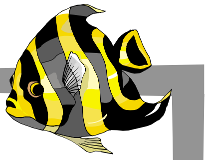
- Investigate some adaptations necessary for life in a salt marsh by building your own bird.

Materials:

- page of bird bodies
- page of bird beaks
- page of bird feet
- scissors
- glue or tape
- colored pencils

Procedure:

1. Use the information discussed in class or from your text about salt marsh habitats to design the perfect marsh bird.
2. Ask yourself the following questions about the marsh bird you wish to create.
    - What kind of food will my salt marsh bird eat?
    - What type of beak will the bird need?
    - Will the marsh bird need a short or long neck? Why?
    - How mobile is my marsh bird?
    - What type of feet will my bird need? Why?
3. Decide upon the body, beak, and feet of your "perfect" marsh bird. Use a **copy** of pages 276-278 and **cut** out the selected body parts. **Color** each section appropriately. **Glue or tape** the parts together.
4. After creating your marsh bird, complete the **Analysis** section of the lab.



Analysis:

1. Describe the shape of the body of your marsh bird. ______________

____

____

2. Describe the beak of the your marsh bird. ________________________

____

____

3. Why do you think a marsh bird would need the type of beak you selected for its environment? ________________________________

____

____

4. Describe the structure of the feet you selected for your marsh bird.

____

____

5. Why do you think a marsh bird would need the type of feet you selected for its environment? ________________________________

____

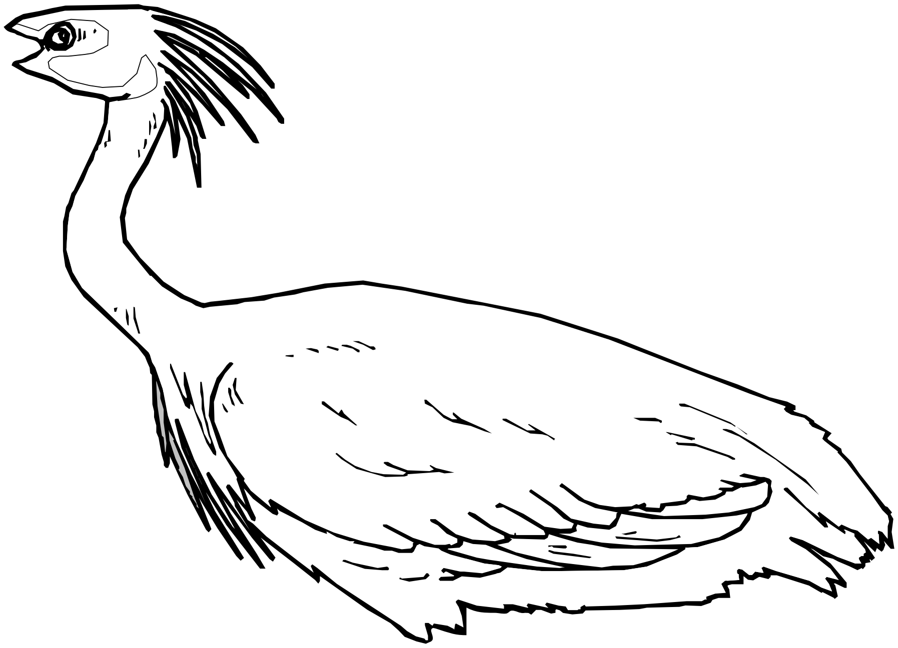
____

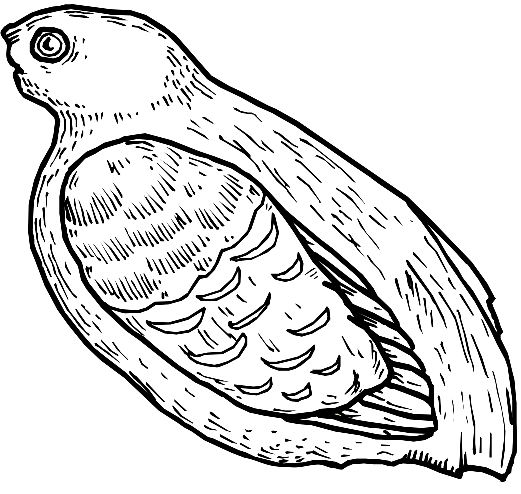
6. Explain how salt marsh organisms are adapted to their habitat. ____

____

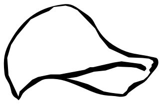
____

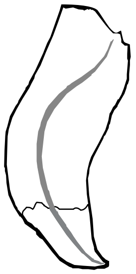
Bird bodies

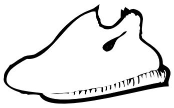


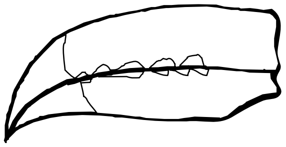


Bird beaks

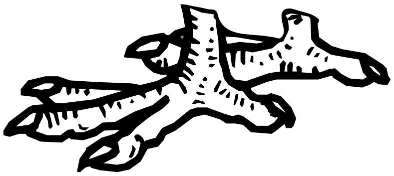


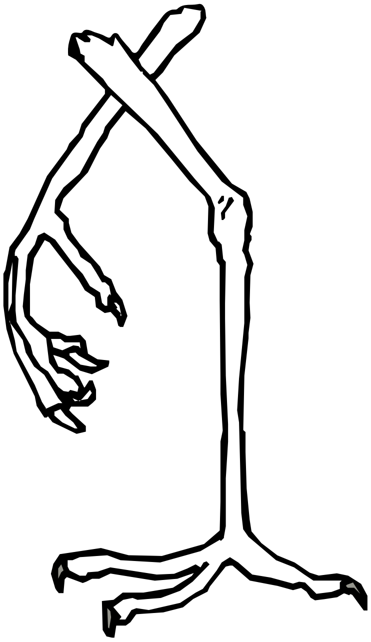


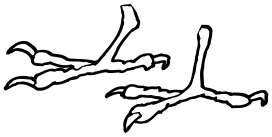


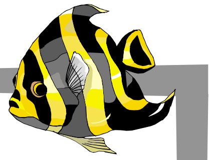


Bird feet









Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. slightly sloping beach with dark, muddy sand, no marsh grasses, and very little wave action

______ 2. describes moderate climate zone between the tropics and the poles

______ 3. low, coastal wetland covered by salt-tolerant grasses

______ 4. the mouth of a river or bay where freshwater and saltwater mix; the part of the river where its current meets the ocean's tide

______ 5. decaying plant and animal material

______ 6. underwater community of living and dead corals; supports life in warm tropical waters

______ 7. an area that is a combination of water and land; may be exposed, partially submerged, or covered with water

A. coral reef

B. detritus

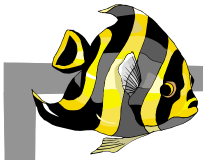
C. estuary

D. mudflat

E. salt marsh

F. temperate

G. wetlands



Practice

Use the list below to write the correct term for each definition on the line provided.

atoll
barrier reef
dredge
Everglades
fringing reef
hammock
lagoon
mangrove
swamp

____________________________ 1. ring-shaped coral island usually located in deep water; developed from fringing reef formed around a volcanic island or landmass

____________________________ 2. water separating land from a coral reef or sand bar

____________________________ 3. coral formation that is separated from land by water (a *lagoon*)

____________________________ 4. coral reef that grows around the edge of a volcanic island or landmass

____________________________ 5. to remove underwater land or sediments by suction or digging

____________________________ 6. large, mixed wetland area located in southern Florida

____________________________ 7. tree found in muddy tropical wetlands whose twisted roots grow partly above ground

____________________________ 8. wooded area surrounded by marsh

____________________________ 9. wooded wetland located further inland than marshes

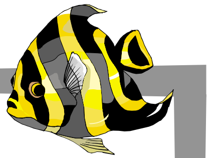
Unit 12: Plankton

Unit Focus

This unit describes the two predominant plankton types: phytoplankton (plant) and zooplankton (animal). Students will investigate the important role of plankton in the food chain and learn that some plankton are larval stages of larger marine organisms such as lobster, fish, and crab.

Student Goals

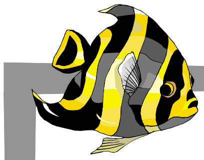
1. Define plankton.
2. Identify the two main types of plankton.
3. Discuss the importance of phytoplankton in the ocean environment.
4. Name and describe the two types of zooplankton.



Vocabulary

Study the vocabulary words and definitions below.

copepods	small crustaceans that have two long antennae for movement and gathering food; most common zooplankton
diatom	composed of two identical halves encased in a shell made of silica or "glass"; most common phytoplankton
dinoflagellates (dy-noh-FLAJ-eh-laytz)	small plankton with characteristics of both plants and animals; causes red tide
flagella (FLA-gel-la)	tiny whiplike hairs used for movement or catching food
foraminiferan (fo-RAM-i-nif-e-ran)	a single-celled holoplankton with a calcium carbonate shell
holoplankton (hol-o-PLANK-ton)	organisms that spend their entire lives as plankton
larva	form of an organism that is immature and very different looking from the adult organism; plural is *larvae*
megalops (meg-A-lops)	planktonic larval stage of the crab; follows the zoeal stage
meroplankton (mer-o-PLANK-ton)	organisms that spend only part of their lives as plankton
mesh	open spaces in a net or screen



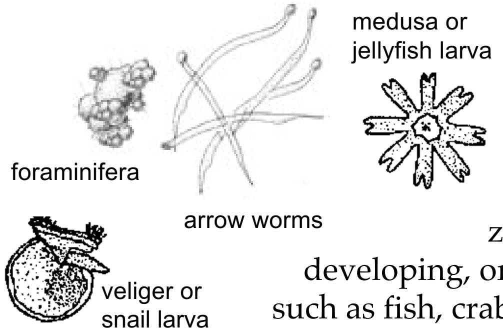
mysis	planktonic shrimp larva
photic zone	the lighted region of the ocean; area where photosynthesis can occur; phytoplankton live in this region
phytoplankton	small, usually microscopic plant plankton that float or drift in the ocean
plankton	small, usually microscopic plant or animal organisms that float or drift in the ocean
plankton net	a cone-shaped net of fine mesh that is pulled through the water to collect plankton
pseudopod (SOO-duh-pod)	footlike projection
radiolarian **(ray-dee-oh-LAYR-ee-uhn)**	a single-celled holoplankton with a transparent body or shell
tentacles	long, threadlike structures that hang from some organisms; may contain dangerous stinging cells
zoea (zo-E-a)	young planktonic larval state of the crab
zooplankton	small, usually microscopic animal plankton that float or drift in the ocean

Introduction: Plankton—Small but Vital

Plankton are either plants or animals that float or drift in the water. In fact, the word *plankton* comes from the Greek word meaning *to drift*. Plankton may live near the surface of the water or near the ocean floor. Plankton are primarily carried along by ocean waves, tides, and currents. In spite of their size and their appearance as simple organisms, they are essential in sustaining life as we know it both in the sea and on land.

There are two main types of plankton—plant and animal. **Phytoplankton** (*phyto* means *plant*) are the floating or drifting plant plankton. As plants, phytoplankton need light to produce their own food through the process of photosynthesis; they must, therefore, live in the **photic zone**, where light can penetrate.

Zooplankton (*zoo* means *animal*) are the animal plankton, and they are the most abundant animals in the ocean. They do not need light and can live below the photic zone. Some zooplankton migrate up and down the water column to feed on phytoplankton or other zooplankton. Zooplankton include the developing, or *larval* stages, of larger adult animals such as fish, crabs, and other small organisms. The **larva** is the form of an organism that is immature in development and can be very different looking from the adult organism.

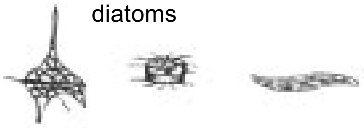


zooplankton

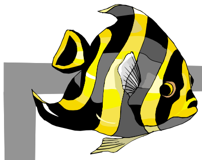
Phytoplankton

These small, usually microscopic sea plants are the dominant plant form in the ocean. Phytoplankton produce their own food through the process of *photosynthesis*. Phytoplankton are essential for life both in the ocean and on land. They are the primary food producers for all marine food chains. They also produce over 80 percent of the oxygen supply, which we need to survive.

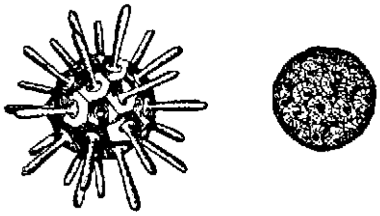
The most common type of phytoplankton in cold waters is the **diatom**. These organisms are very small, but they exist in large numbers. Each diatom has a shell made of silica, a glassy compound, with two equal halves.



phytoplankton

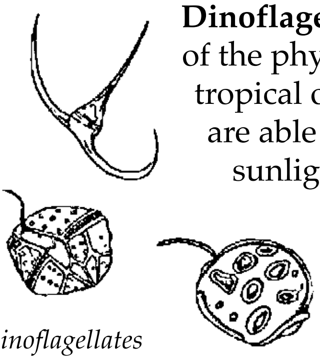


Diatoms reproduce by splitting in two. Each new diatom gets half its shell from the parent and grows another half to form a new organism. This is how it got the name *diatom*, which means *two atoms*. Diatoms are particularly abundant in cold Arctic waters.



coccolithophores

Another type of phytoplankton is the *coccolithophore*. These small plants have chalky shells made of calcium carbonate and can swim by moving tiny, whiplike hairs called a **flagella (FLA-gel-la)**. Coccolithophores are usually found in warmer waters. Even though they are too tiny to be seen individually, a dense population in an area will give the water a milky appearance.



dinoflagellates

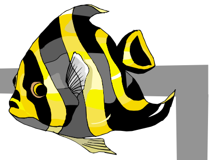
Dinoflagellates (dy-noh-FLAJ-eh-laytz), another member of the phytoplankton, are often the most common plant in tropical oceans. Like other phytoplankton, these plankton are able to produce their own food with the aid of sunlight. Unlike most plants, they are able to move around with the aid of a flagellum. When there is not enough light to produce their own food, many dinoflagellates will eat other plankton. Many scientists classify dinoflagellates somewhere between plants and animals because they have characteristics of both.

In tropical or semi-tropical waters, dinoflagellate algae produce *red tide* by secreting toxins, or poisons, that can kill fish and other marine life. Such red tide *blooms* are common in the Tampa Bay area in Florida. Sea birds and even people are sometimes poisoned by eating shellfish or fish contaminated with these toxins.

Dinoflagellates, like fireflies, produce light without heat, a phenomenon called *bioluminescence*, the biological production of light. You can see this occurrence as twinkling lights in the water just above where waves break.

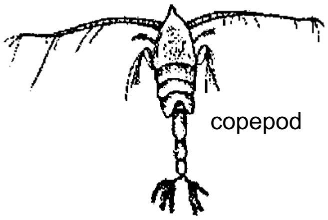
Zooplankton

Zooplankton, or animal plankton, are usually larger than the phytoplankton and cannot make their own food. To survive, they consume phytoplankton or smaller zooplankton. Zooplankton are divided



into major groups: **holoplankton (hol-o-PLANK-ton)**, plankton that spend their entire lives as part of the plankton community. **Meroplankton (mer-o-PLANK-ton)**, on the other hand, spend only part of their larval stages as plankton. They then *metamorphize* or change into their adult non-plankton stage.

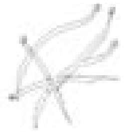
Holoplankton: Permanent Members of the Plankton Community



holoplankton

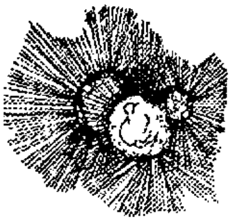
Copepods, the most important and numerous members of the holoplankton, look like tiny shrimp. They have two long antennae which are used to help the copepod float and move around in the water. They also have six pairs of jointed legs and a tail. These antennae and bristly legs help the copepod trap its food—phytoplankton or small plant material. Copepods are the food source for many fish in the ocean. They help form the food chains that feed larger animals and humans.

The arrow worm, another member of the holoplankton, has a transparent head, body, fins, and a tail. They are predators that use grasping spines or *fangs* to grab their prey. Arrow worms are very common in areas occupied by copepods.



holoplankton

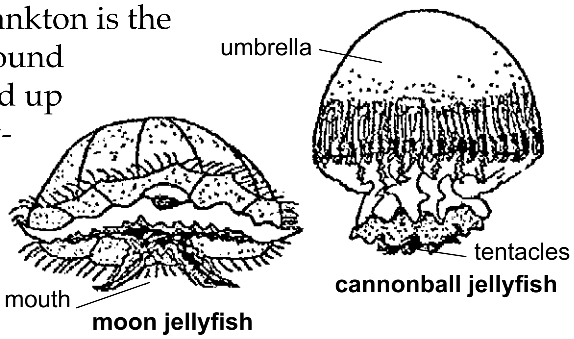
Some holoplankton are single-celled. The most common of these are the microscopic **radiolarian** and **foraminiferan (fo-RAM-i-nif-e-ran)**. Radiolarians are transparent and have long spines that branch out from their body, like the spokes of a wheel. The branching spines of the radiolarian provide buoyancy and protection.



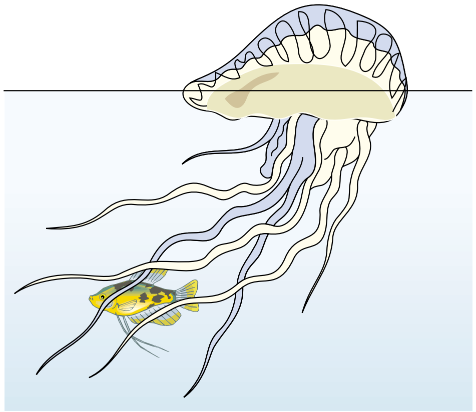
holoplankton

Foraminiferans are enclosed in a shell made up of calcium carbonate. Forams have holes in their shells that allow the organism's **pseudopods (SOO-duh-pods)**, or *footlike projections*, to flow out and catch food. When a foraminiferan dies, the shell of the animal falls to the ocean floor. Over a period of time, the shells accumulate on the ocean floor and form chalk deposits.

A larger type of permanent zooplankton is the jellyfish. Jellyfish are commonly found floating near the surface or washed up on the beach. A jellyfish has a jelly-like body called the *umbrella*, with a mouth on the underside surrounded by **tentacles**. The tentacles contain stinging cells that are used in defense and feeding. Some jellyfish may be harmful to humans, whereas others are harmless because we are not affected by the stinging cells. Above are two common jellyfish found in Florida waters.



common jellyfish found in Florida waters



Portuguese man-of-war

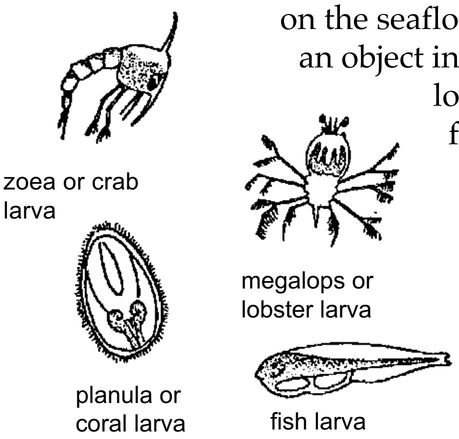
In tropical waters, you might see the Portuguese man-of-war. It is a large jellyfish-like colonial organism with a blue or pink float that resembles a floating plastic bag. Beneath the float are tentacles that may be up to 30 feet long. Portuguese men-of-war can be very toxic to humans—so it is best to stay clear of them.

The stings of the jellyfish and the Portuguese man-of-war can be very painful. The following chart shows the symptoms and treatment of a jellyfish or man-of-war sting.

Jellyfish and Portuguese Man-of-War Stings	
symptoms	**treatments**
• burning or itching pain • rash • swelling • possible breathing difficulty • cramps • nausea • fainting or dizziness	• don't rub the affected area • rinse the affected area thoroughly with hot water • clean the area with alcohol; then carefully apply a paste of meat tenderizer and water • avoid the sun or water and rest • get medical treatment if necessary

Meroplankton: Temporary Member of the Plankton Community

Meroplankton spend only part of their lives as plankton. Many invertebrates and vertebrates spend the early or young larval stages as meroplankton. As they mature, they metamorphize or move out of the planktonic stage. They spend their adult life either crawling on the seafloor, swimming, or permanently attached to an object in the ocean. Often, their planktonic stage looks completely different from their adult form.

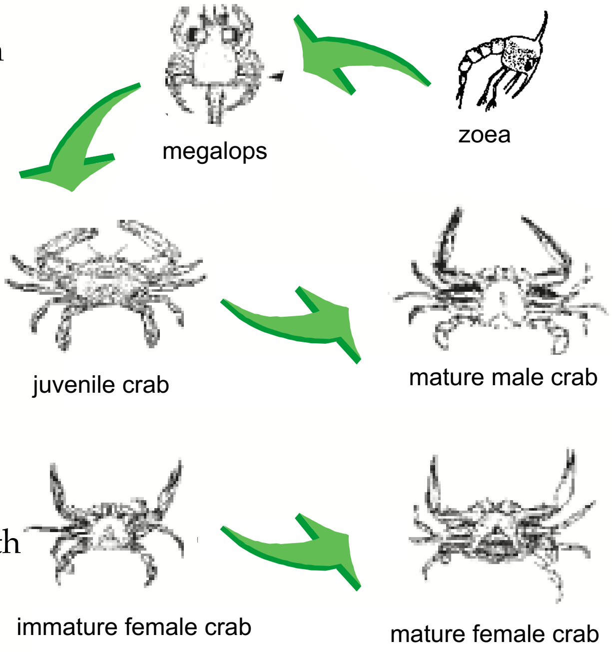


meroplankton

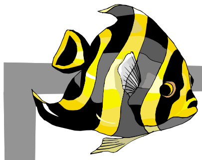
Crabs, for example, are planktonic for a short time after they hatch. A crab's first larval stage is called the **zoea (zo-E-a)** stage. Its second larval stage is the **megalops (meg-A-lops)** stage, which is also planktonic but with some of the features of an adult crab. The megalops will then develop into the adult benthic crab and can no longer be classified as a plankton. See the illustration below.

Shrimp are also planktonic when they first hatch from eggs. The shrimp larva is called a **mysis** and closely resembles an adult shrimp.

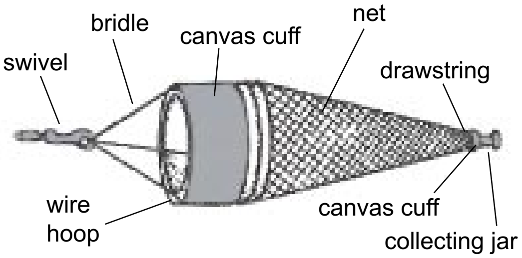
Many other organisms also have meroplankton stages, including the oyster, barnacle, sea star (starfish), sea urchin, and many types of fish. During the meroplankton stages the young are distributed to new areas in the ocean by drifting with the tides and currents.



Life Stages of a Crab



Collecting Plankton

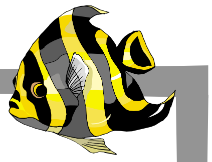


plankton net

Because they are so numerous and have no defenses, plankton are easy to collect and observe. A **plankton net** is pulled through the water with the mouth or large end of the net leading. Water passes through the net's mouth and out the small **mesh** of the net as the plankton are trapped on the inside of the net.

Summary

Plankton are organisms—both plant and animal—that float or drift in the ocean waves, tides, or currents. Plant plankton, or *phytoplankton*, live in the *photic* (lighted) *zone* for photosynthesis. As the primary food producers, they are essential to all marine food chains. Animal plankton, or *zooplankton*, can live in deeper parts of the ocean and migrate up and down the column to feed on phytoplankton and smaller zooplankton. Organisms, such as the copepods and jellyfish, that spend their entire lives as zooplankton are called *holoplankton*. Two of the larger zooplankton, the jellyfish and Portuguese man-of-war, have tentacles that can cause a painful sting. *Meroplankton*, such as the crab, shrimp, oyster, and sea star in their larval stages, are temporary members of the zooplankton, changing as they mature. Plankton are easy to collect in a plankton net for study in the lab.



Practice

Answer the following using short answer.

1. What does the term *plankton* mean? ______________________________
2. What are the two main types of plankton? ________________________

   ____

3. Why must phytoplankton remain in the photic zone? _____________

   ____

   ____

   ____

4. Why are phytoplankton important for sustaining life? _____________

   ____

   ____

   ____

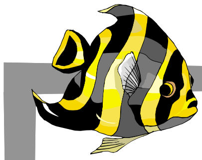
5. What are the shells of diatoms made of? __________________________

   ____

6. Why are dinoflagellates considered to be between plants and animals? ____

   ____

   ____



7. What is *red tide*?

8. What do zooplankton feed on?

9. What are animals that spend their entire lives as plankton called?

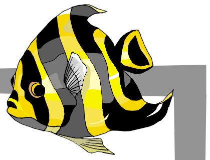
10. What are animals that spend only part of their lives as plankton (usually as larvae) called?

11. What are two members of the holoplankton?

12. What should you do if stung by a jellyfish or Portuguese man-of-war?

13. What are two animals besides the crab that experience the meroplankton stages?

14. What equipment is used to catch plankton?

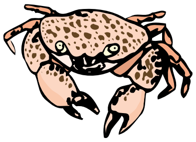


Practice

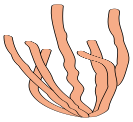
Below are examples of **meroplankton**. *Use examples provided in the unit to match each* **adult meroplankton** *with the correct* **planktonic larvae**. *Write the letter on the line provided.*

adult meroplankton

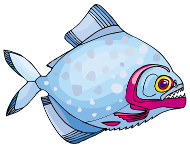
______ 1. crab



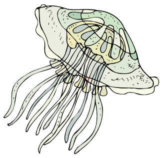
______ 2. coral



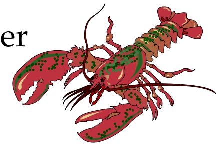
______ 3. fish



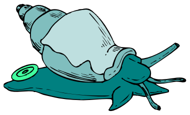
______ 4. jellyfish



______ 5. lobster



______ 6. snail



planktonic larvae

A.

B.

C.

D.

E.

F.

Lab Activity 1: Plankton Net

Investigate:

- Perform virtual or "computer" plankton trawls to examine the differences in the number and variety of phytoplankton, copepods, and invertebrate larvae in the open bay in comparison to the number and variety in the grass beds.

Materials:

- EcoVentures CD-ROM
- computer with CD-ROM drive
- Plankton Identification Data Sheet
- Plankton Data Sheet
- pencil or pen

Procedure:

1. Your teacher will provide you with an EcoVentures CD or will have the activity installed on a computer desktop for you. **Click** on the Ecoventures logo.

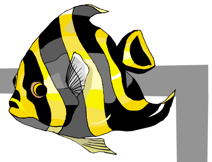
2. You should be viewing a map of **R. U. Green State Park**. **Click** on the **marine site** located on the lower right corner of the computer screen.

3. On the marine site screen, **click** on the **EcoVentures** box of the site map.

4. You should be viewing the Marine Ecoventures map. **Click** on the **pontoon boat** icon located in Snapper Bay.

5. You are now viewing the **trawl screen**. **Click** on the **red arrow**.

6. You are now viewing two pontoon boats. Each boat is ready to trawl for plankton. **Click** on **either boat**. Please note that one boat will trawl in the **seagrass area**, and the other boat will trawl in the **open ocean area**. You will have to operate both boats, but for now, **select one**.



7. After the boat has completed the trawl, **click** on **plankton**. A short video clip of how plankton are collected will appear on the screen. Please view the video clip.

8. After the video clip, a microscope screen containing a slide of plankton will appear.

9. You are now ready to begin counting the variety of plankton you collected in your plankton net. Count the kinds and number of plankton for **five different locations** on the microscope slide.

10. Use the **Plankton Data Sheet** on page 297 to keep track of the plankton you identify and count.

11. Using the **Plankton Identification Data Sheet** on page 298, sketch one example of each plankton type in the two areas and summarize your observations.

Identifying and Counting Plankton Tips:

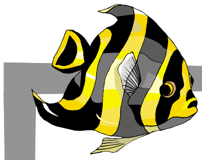
1. **Click** on the word **count** and **select** the **organism** you wish to count.

2. Using the **mouse**, move the circle to **five different locations** on the microscope slide. At each location, record the type and number of plankton. (**Hint**: **Click** on each plankton as you count it. This will ensure that you do not count it twice.)

3. If you are **not sure** of the type of plankton you are observing, use the **reference** selection located in the tool bar at the top of the computer screen.

4. Select **Field Guides** and **Plankton Book**.

5. Browse the list of plankton and click on the plankton names to view images for identification.



Analysis:

1. Which tow area contained the greatest number of plankton? ______

   ____

2. Explain why the tow area in question 1 had the greatest number of plankton. ______________________________________

   ____

   ____

   ____

   ____

   ____

   ____

   ____

3. Explain why you think certain plankton types were found in smaller numbers in the open ocean than in the seagrass area. __________

   ____

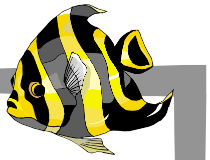
   ____

   ____

   ____

   ____

   ____



Plankton Data Sheet

Tow Area: Seagrass

Organisms **Total**

Copepods ______

Larvae ______

Phytoplankton ______

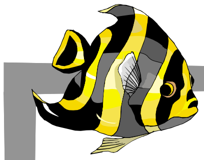
Tow Area: Open Bay

Organisms **Total**

Copepods ______

Larvae ______

Phytoplankton ______



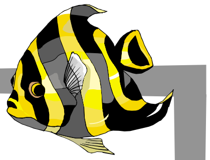
Plankton Identification Data

Seagrass Area

Plankton Type	Sketch	Summary
copepods		
larvae		
phytoplankton		

Open Bay Area

Plankton Type	Sketch	Summary
copepods		
larvae		
phytoplankton		



Lab Activity 2: Plankton Shape and Movement

Investigate:

- Determine how plankton remain floating in the upper levels and mid levels of the water column.

Materials:

- Marine Plankton Sheet
- Plankton Floating Data Sheet
- baby food jars
- tissue paper
- plastic baggies
- toothpicks
- clay
- cardboard
- vegetable oil
- stop watch
- pipe cleaners
- variety of odds and ends

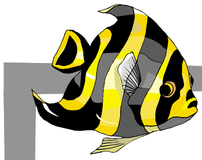
Procedure:

1. Study pictures of plankton on the **Marine Plankton Sheet** on page 301. Discuss with your teacher and classmates how the shape of plankton and the surface area of plankton affect their ability to float.

2. Create your own plankton. Select the best material type from the assortment of odds and ends provided by your teacher.

3. After constructing your plankton, test its ability to float. Place your plankton in a sink full of water. (Wet your plankton model first to eliminate surface tension.) Time how long the plankton is able to float on top of the water. Once the plankton begins to sink, **stop** timing and retest the plankton's ability to float. Repeat the floating test three more times for a total of five trials. Record your times on the **Plankton Floating Data Sheet** on page 302.

4. Some plankton produce oil within their bodies. Create a new plankton (or keep the same design) but add about a teaspoon of oil to its body design.



5. Test the *oil-producing* plankton's ability to float. Remember to wet the plankton first. Time how long the *oil-producing* plankton is able to float on top of the water. Once the plankton begins to sink, **stop** timing and retest the plankton's ability to float. Repeat the floating test three more times for a total of five trials. Record your times on the data sheet.

Analysis:

1. From observing classmates' plankton models and recorded times, which design or shape of plankton floated the longest? __________

2. Do you think waves and currents affect plankton movement? _____ How? __________

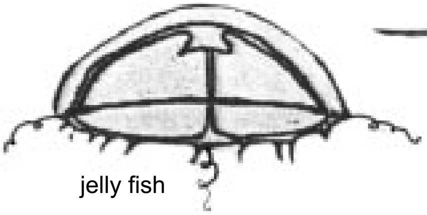
3. Why do phytoplankton need to stay near the surface? __________

4. What type of design or shape would best be suited for phytoplankton? __________

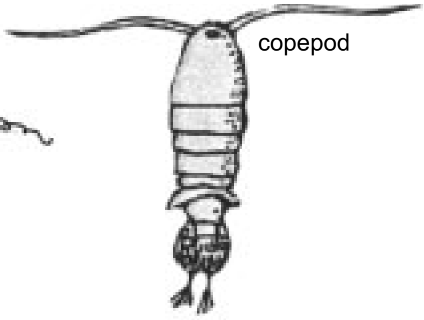
Marine Plankton Sheet

Holoplankton—spend their lives as plankton

zooplankton

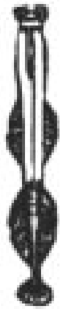


jelly fish



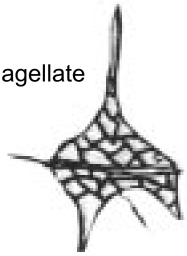
copepod

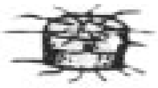
arrow worm



phytoplankton

dinoflagellate



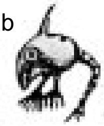


centric diatom

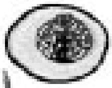
pennate diatom

Meroplankton—spend only part of their lives as plankton

crab



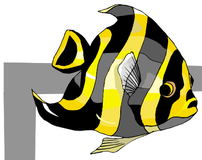
fish egg



fish

urchin

snail



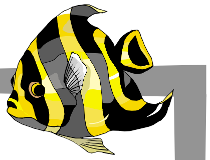
Plankton Floating Data Sheet

Regular Plankton

Trial	Floating Time
______________	______________
______________	______________
______________	______________
______________	______________
______________	______________

Oil-Producing Plankton

Trial	Floating Time
______________	______________
______________	______________
______________	______________
______________	______________
______________	______________



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. small, usually microscopic plant and animal organisms that float or drift in the ocean

______ 2. plant plankton

______ 3. the lighted region of the ocean; area where photosynthesis can occur

______ 4. animal plankton

______ 5. tiny whiplike hairs used for movement or catching food

______ 6. small plankton with characteristics of both plants and animals; causes red tide

______ 7. organisms that spend their entire lives as plankton

______ 8. organisms that spend only part of their lives as plankton

______ 9. composed of two identical halves encased in a shell made of silica or "glass"; most common phytoplankton

A. diatom

B. dinoflagellates

C. flagella

D. holoplankton

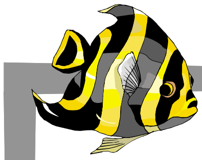
E. meroplankton

F. photic zone

G. phytoplankton

H. plankton

I. zooplankton



Practice

Use the list below to write the correct term for each definition on the line provided.

copepods
foraminiferan
larva
megalops
mesh
mysis
plankton net
pseudopod
radiolarian
tentacles
zoea

____________________ 1. a single-celled holoplankton with a transparent body or shell

____________________ 2. a single-celled holoplankton with a calcium carbonate shell

____________________ 3. long, threadlike structures that hang from some organisms; may contain dangerous stinging cells

____________________ 4. young planktonic larval state of the crab

____________________ 5. small crustaceans that have two long antennae for movement and gathering food; most common zooplankton

____________________ 6. planktonic larval stage of the crab; follows the zoeal stage

____________________ 7. open spaces in a net or screen

____________________ 8. a cone-shaped net of fine mesh that is pulled through the water to collect plankton

____________________ 9. planktonic shrimp larva

____________________ 10. footlike projection

____________________ 11. form of an organism that is immature and very different looking from the adult organism

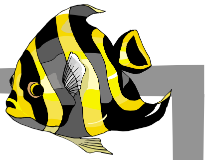
Unit 13: Marine Plants

Unit Focus

This unit focuses on the variety and importance of marine plants. Students will study emergent and submergent marine plants, as well as investigate the single-celled phytoplankton and multicellular marine algae.

Student Goals

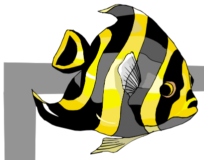
1. Describe the process of photosynthesis.
2. Differentiate between submergent and emergent marine plants.
3. State examples of submergent marine plants.
4. State examples of emergent marine plants.
5. Explain why seaweeds are classified as marine algae.
6. State products manufactured from marine algae.



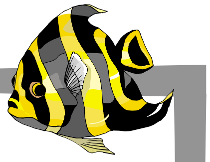
Vocabulary

Study the vocabulary words and definitions below.

agar	gelatinlike substance covering some seaweeds; used as a medium to grow bacteria and in canning meats
algae	primitive plants without roots, stems, and leaves; usually found in aquatic environments (alga, *singular*)
algin	seaweed extract that helps in absorbing large quantities of water; used in ice cream, frostings, and paints
blade	leaflike area of a seaweed
carrageenan	seaweed extract used to keep substances suspended in solution; used in chocolate milk, toothpaste, and other products
chlorophyll	green pigment found in plants that helps in photosynthesis
Chlorophyta	group of green algae
emergent	rising up out of the water
holdfast	thickened, rootlike structure that attaches some seaweeds to the bottom
mariculture	farming of the sea or ocean (also called *aquaculture*)

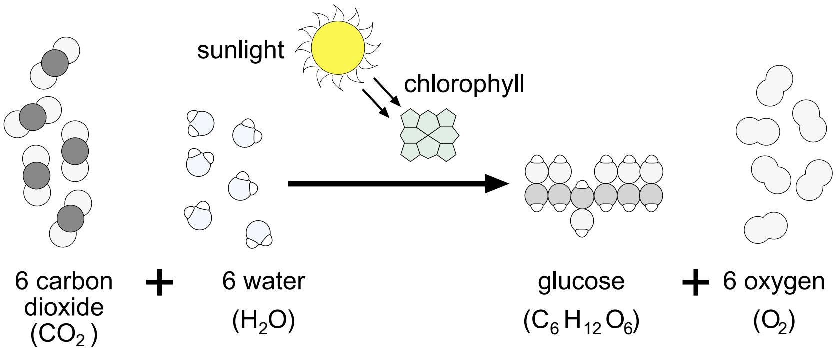


Phaeophyta	group of brown algae
protists	simple organisms whose cells are not specialized for different functions
Rhodophyta	group of red algae
seaweeds	the group of marine algae large enough to be harvested for use as food and in industrial products
stipe	stemlike part of a seaweed that holds its blades near the surface of the water
submergent	growing while covered with water



Introduction: Marine Plants—The Producers

The ocean contains many plants and plantlike organisms. Some are similar to plants we see on land. Others are very different. But all of these plants and plantlike organisms have one thing in common. They are producers. Producers produce their own food through a process called *photosynthesis*. Through photosynthesis, producers capture sunlight with special pigments, such as **chlorophyll**. Producers combine light energy with water and carbon dioxide to form a sugar called *glucose*. Oxygen is a by-product of this reaction. Energy for the process is supplied by sunlight to create sugars that fuel the producers' life functions.



Through photosynthesis, carbon dioxide and water combine with sunlight, supplying the energy to form a sugar called glucose. Oxygen is a by-product of the reaction.

Most of the producers we are familiar with on land are classified as plants. Plants also grow in the ocean. Grasses are the most widespread example. However, most of the producers in the ocean, such as phytoplankton and seaweed, are very different from plants. Because of these differences, many biologists classify them with a totally different group of organisms—the **protists**.

Protists are organisms whose cells are very simple. A protist may have just one cell, as do the millions of tiny producers that float in the phytoplankton. Or protists may live together with thousands of other cells—all alike—to make a large, plantlike structure. This is the case with many species of green, brown, and red **seaweeds**. These seaweeds are also known as marine **algae**.

Plants: Complex Producers Rooted to Land

Plants differ from protists in that their cells are not all the same. The structure of a plant cell is usually customized, or specialized, for a particular job. This job depends on where the cell is located in the plant. For example, plant cells in leaves are specialized to carry out photosynthesis. Plant cells in stems are specialized to transport nutrients up and down the stem.

Plants that live in the ocean or along the shoreline are members of the most complex and specialized group of plants. This group is known as the *flowering plants*. Some flowering plants in the marine environment live totally beneath the water. They are **submergent**. Others are rooted in the ocean floor but rise up above the water level. They are **emergent**.

Coastal plants stabilize and prevent erosion. Many organisms depend on grass beds and beach plants for food and shelter. Because housing and recreational developments have destroyed many of these plants and their habitats, they have become endangered and are protected by state and federal laws. Treat plant life at the beach and in the ocean with care. Do not pick or pull plants growing on the beach or under water.

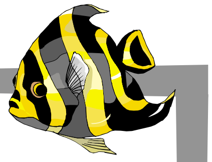
Submergent Plants: Plants That Live Underwater

Seagrasses are submergent plants that have adapted to life under water.

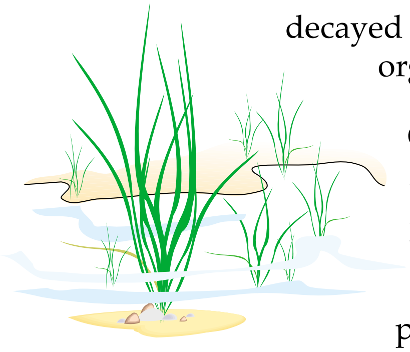
Seagrasses are submergent plants that have adapted to life under water. They help maintain water clarity by trapping sediments with their leaves and roots. Just as trees and plants on dry land help to hold soil and lessen erosion, seagrasses are important in stabilizing soft bottoms. They also provide food and shelter for many species of invertebrates, fish, and algae, which may grow on the leaves of seagrass. There are seven types of seagrasses found in Florida: manatee grass, shoal grass, turtle grass, paddle grass, star grass, widgeon grass, and Johnson’s seagrass.

Emergent Plants: Plants That Are Salt-tolerant and Adaptable

Plants that grow near the shore or out of the water are classified as *emergent* plants. These plants are salt-tolerant and have specific adaptations to this harsh habitat. Many salt-tolerant plants have thick,



waxy coverings that prevent water loss. Others have a wooly coat of hair. Emergent plants, such as mangroves, help stabilize shoreline sediments and prevent erosion so that other plants can also grow in this habitat. *Pioneer plants* are the first to colonize, or start growing on, exposed land. They are the first step in stabilizing sediments. Grasses, vines, and sprawling shrubs are common pioneer plants. Examples include sea oats, railroad vine, and sand bur. As plants die, they are broken down into nutrients and contribute to the *detritus*, or rich layers of decayed organic matter, that provides food for many organisms.



Plants that grow near the shore or out of the water are classified as emergent plants.

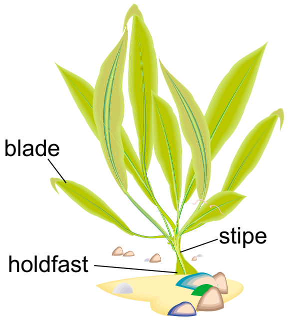
Grasses such as salt grass (*Distichlis*), needle rush (*Spartina*), and cord grass (*Juncus*) can be found growing in marshes and swamps. These plants adapt to saltwater by excreting salt from the edges of their leaves through pores. Other emergent plants include trees, such as several types of mangrove, all of which protect themselves from salt in different ways.

Marine Algae: Different and Colorful

Marine algae—green, brown, and red seaweeds, for example—often resemble the plants we see on land. Actually, as we discussed before, seaweeds are not plants but are simple-celled producers called *protists*. Some seaweeds float in the water like their smaller relatives, phytoplankton. Other seaweeds, like kelp, anchor themselves and grow quite large.

Although all seaweeds contain photosynthetic pigments, they are not all green. Other pigments such as carotene (orange) and xanthophyll (brown) mask the green color of chlorophyll, help in photosynthesis, and give seaweeds their color.

On our Florida beaches we often find colorful stringlike material draped over rocks and lining the beaches. This widespread marine algae is seaweed. Seaweed can be either attached or free floating. Seaweed attached to the ocean floor or stable objects have a thickened, rootlike extension called a **holdfast**, which helps the seaweed anchor itself in soft

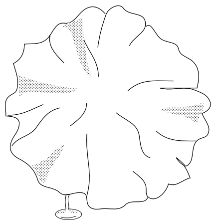


The Structure of Marine Algae

mud or grip onto rocks, barnacles, or mussels. The holdfast, however, does not provide any nourishment for the algae and, unlike plants with roots, the algae will not die if the holdfast is broken off. Some seaweeds have a stemlike structure called a **stipe** that holds the blades near the water surface. The **blade** is the leaflike section of a seaweed. Floating seaweeds may have air sacs that keep the blades afloat at the water surface to get sunlight.

Types of Seaweeds: Green, Brown, or Red

Scientists classify seaweeds partly on the basis of their color: green seaweeds, brown seaweeds, and red seaweeds.



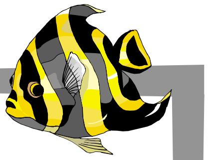
The sea lettuce, Ulva, is the best known of the green seaweeds.

Chlorophyta, or the green seaweeds, are more common in fresh water than in the ocean. The sea lettuce, *Ulva*, is the best known of the green seaweeds. It resembles thin, flat, clear sheets of lettuce and is sometimes collected by humans for food.

The brown seaweeds, or **Phaeophyta**, are common along the coastal areas, especially in colder waters. The Phaeophyta are the largest of the seaweeds, some growing to over 100 feet long. Some common brown seaweeds are kelps, *Macrocystis* and *Nereocystis*, and the floating seaweed *Sargassum*. *Sargassum* can be found washed up all over Florida beaches. It is leafy with small air sacs that help it float. This seaweed provides shelter and food for juvenile crabs, shrimp, and fish. Because brown seaweeds are so plentiful and easily harvested, some industries use them as a source of iodine, trace minerals, fats, and even vitamins.

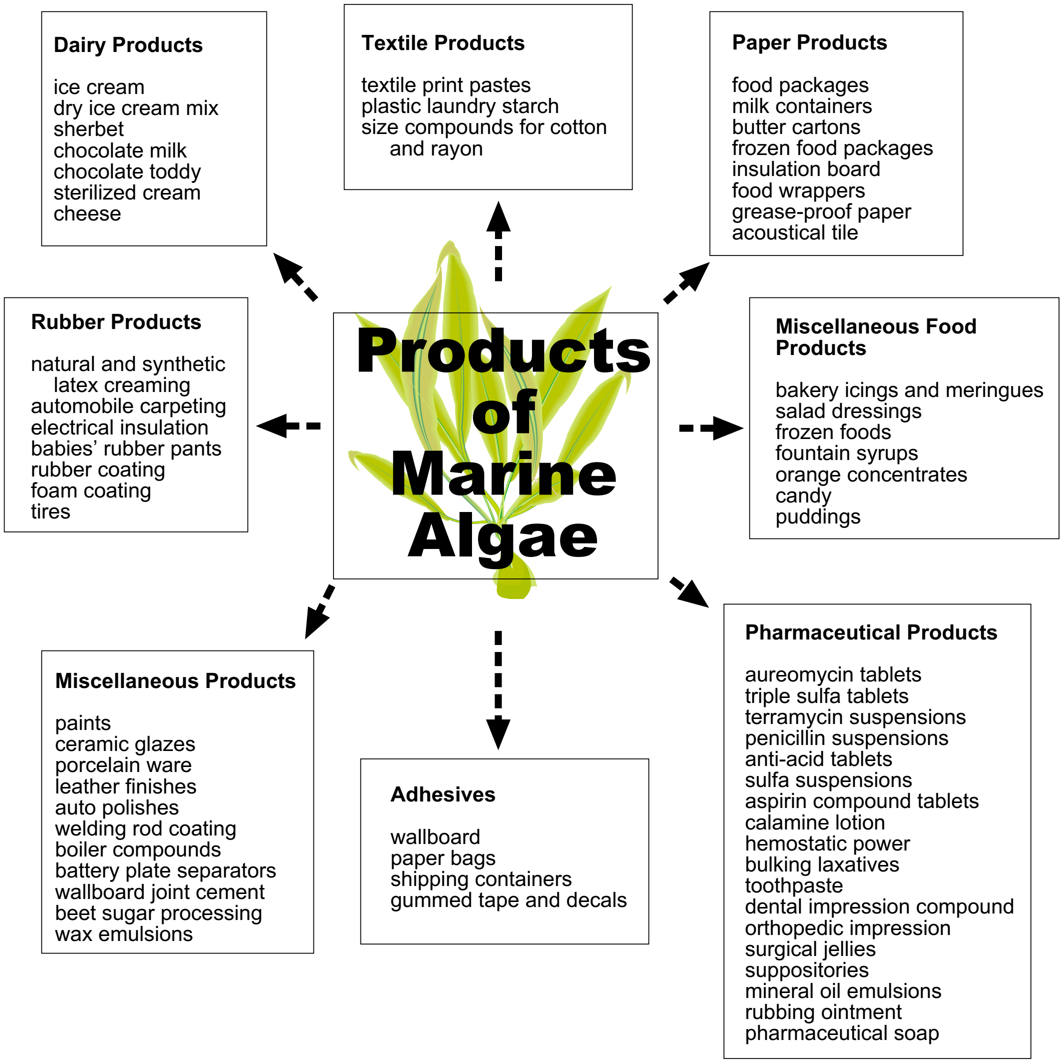
Red seaweeds, or **Rhodophyta**, are almost entirely marine. Most red seaweeds grow attached to rocks or on the seabed where light barely penetrates. Many red seaweeds are reddish-purple or reddish-brown in color. Most of them are found growing on coral reefs or oyster beds. Red seaweeds are used to make soups and seasonings.

Seaweeds are usually found in zones or bands along the edge of the shore. Red seaweeds live at the deepest levels, whereas brown and green seaweeds survive closer to the surface. The depth at which different seaweeds live depends upon the amount of light they need to carry out photosynthesis.



Uses of Seaweeds: From Foods to Fertilizer

For centuries, people of the Far East have nurtured and harvested seaweeds in their **mariculture**, or farming of the sea or ocean. As early as the 17th century, people processed brown seaweed into soda ash for use by glass and pottery makers. Potash, a fertilizer, is derived from burned or dried seaweed. Iodine can also be derived from seaweeds. Today many types of seaweeds are prized as specialty foods because they are rich in minerals and vitamins.



Dairy Products

- ice cream
- dry ice cream mix
- sherbet
- chocolate milk
- chocolate toddy
- sterilized cream
- cheese

Textile Products

- textile print pastes
- plastic laundry starch
- size compounds for cotton and rayon

Paper Products

- food packages
- milk containers
- butter cartons
- frozen food packages
- insulation board
- food wrappers
- grease-proof paper
- acoustical tile

Rubber Products

- natural and synthetic latex creaming
- automobile carpeting
- electrical insulation
- babies' rubber pants
- rubber coating
- foam coating
- tires

Miscellaneous Food Products

- bakery icings and meringues
- salad dressings
- frozen foods
- fountain syrups
- orange concentrates
- candy
- puddings

Miscellaneous Products

- paints
- ceramic glazes
- porcelain ware
- leather finishes
- auto polishes
- welding rod coating
- boiler compounds
- battery plate separators
- wallboard joint cement
- beet sugar processing
- wax emulsions

Adhesives

- wallboard
- paper bags
- shipping containers
- gummed tape and decals

Pharmaceutical Products

- aureomycin tablets
- triple sulfa tablets
- terramycin suspensions
- penicillin suspensions
- anti-acid tablets
- sulfa suspensions
- aspirin compound tablets
- calamine lotion
- hemostatic power
- bulking laxatives
- toothpaste
- dental impression compound
- orthopedic impression
- surgical jellies
- suppositories
- mineral oil emulsions
- rubbing ointment
- pharmaceutical soap

Currently, brown seaweeds or kelps are harvested by the use of a *mower*. The mower cuts off the top four or five feet and pulls it up onto a barge. The kelp is then dried and used to produce **algin**, **agar**, and **carrageenan**. The kelp left in the sea grows back in several weeks to be harvested again.

Algin is a powdery extract that absorbs large quantities of water. Algin is added to ice cream to prevent ice crystals from forming. It keeps frostings and gels from sticking to packaging. Algin is also used to suspend antibiotics in solution and pigment in paints. *Agar*, the gel that is extracted from seaweeds by boiling, is used as a medium for growing bacteria in microbiological studies. The agar gel is nontoxic and is widely used in canning meat and fish and in the glue of postage stamps. Many products use another seaweed extract called *carrageenan*. Carrageenan helps to keep substances suspended in solution. It is commonly used in chocolate milk, toothpaste, and cosmetics. Most people have eaten or used seaweed and never known it.

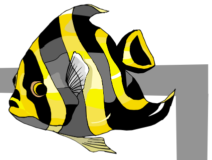
Summary

The ocean contains many plants and plantlike organisms. These are producers that make their own food through the process of *photosynthesis*. The producers in the ocean are divided into two major groups: plants and *protists*. Plants are complex organisms whose cells are specialized for different jobs. Protists are simpler organisms. They may have one cell or many cells, but protist cells are all alike, with the same structure.

Marine plants may be either *emergent* or *submergent*. Emergent plants raise their stems and leaves out of the water. Submergent plants are totally covered with water. Plants do many important jobs. They stabilize shoreline sediments and help to prevent erosion. They also provide food and shelter to marine animals.

Emergent plants raise their stems and leaves out of the water.

Marine protists include single-celled *phytoplankton* and multicelled marine *algae*. Marine algae is also known as *seaweed*. Seaweed often has plantlike parts and air sacs that help it float. By floating, seaweed can stay close to sunlight. There are green seaweeds, *Chlorophyta*, brown seaweeds, *Phaeophyta*, and red seaweeds, *Rhodophyta*. Seaweeds have been used both as food and fertilizer. Substances removed from seaweed are also used in many products, including glue and cosmetics.



Practice

Use the list above each section to complete the statements in that section.

blade
brown
holdfast
mariculture
producers
protists
Rhodophyta
submergent

1. Plants and plantlike organisms are all ________________________ — they make their own food.

2. The red seaweeds, or ________________________ , are used to make soups and seasonings.

3. The Phaeophyta, the largest seaweeds, are ________________________ in color.

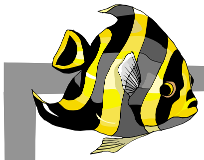
4. Seaweeds are grown through ________________________ , or aquaculture, for food and industry.

5. The ________________________ is the leaflike part of an algae that is responsible for photosynthesis.

6. The rootlike part of seaweed that is used for attachment is the ________________________ .

7. Seagrasses are examples of ________________________ plants that have adapted to life under water.

8. Marine algae such as seaweeds are ________________________ with very simple, unspecialized cells.



algin
chlorophyll
erosion
flowering
kelp
photosynthesis
pioneer
salt-tolerant
sargassum
stipe

9. The green pigment ________________________ is found in plants and marine algae to help in photosynthesis.

10. The most complex group of ocean plants is known as ________________________ plants.

11. The stemlike part of a seaweed where the blade attaches is the ________________________ .

12. ________________________ , a powdery seaweed extract, is added to ice cream and frostings to absorb large amounts of water.

13. The process by which plants and algae produce their own food with the help of pigments is called ________________________ .

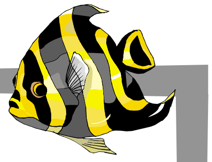
14. The common brown seaweed that is found washed up on Florida beaches is ________________________ .

15. ________________________ , a brown seaweed, is dried and used to produce the extracts algin, agar, and carrageenan.

16. Emergent plants such as mangroves help prevent ________________________ on the beaches.

17. Emergent plants are ________________________ , and many have adaptations to prevent water loss.

18. ______________________ plants such as sea oats are the first to colonize.



Lab Activity: Identify Products with Seaweed

Investigate:

- Identify products that have seaweed-based ingredients.

Materials:

- products such as canned food with labels indicating ingredients from the sea

Procedure:

Locate and collect packaged food or other products that have algin, agar, carrageenan, xanthan, gum, alginates, etc., listed as ingredients. (See chart on page 313 of the student book.)

Analysis:

1. What types of products contain agar? ____________________

   ____

   ____

2. What types of products contain algin?____________________

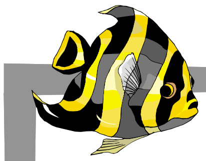
   ____

   ____

3. What types of products contain carrageenan? ______________

   ____

   ____



4. Do you think that advertisers would be wise to promote seaweed as an ingredient in their products? ______________________________

   Why or why not? ____

   ____

5. What other names could these seaweed extracts be listed under?

   ____

   ____

6. In what way are seaweeds important economically? ____________

   ____

   ____

7. Use the Internet and find three places where seaweeds are harvested and processed. ____

   ____

   ____

   ____

   ____

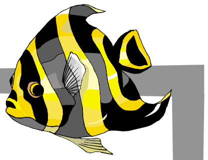
   ____

   ____

   ____

   ____

   ____



Practice

Use the list below to write the correct term for each definition on the line provided.

algae
blade
chlorophyll
emergent
holdfast
protists
seaweeds
stipe
submergent

________________________ 1. stemlike part of a seaweed that holds its blades near the surface of the water

________________________ 2. leaflike area of a seaweed

________________________ 3. thickened, rootlike structure that attaches some seaweeds to the bottom

________________________ 4. rising up out of the water

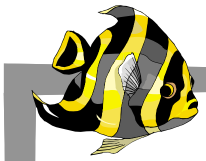
________________________ 5. growing while covered with water

________________________ 6. primitive plants without roots, stems, and leaves; usually found in aquatic environments

________________________ 7. simple organisms whose cells are not specialized for different functions

________________________ 8. the group of marine algae large enough to be harvested for use as food and in industrial products

________________________ 9. green pigment found in plants that helps in photosynthesis



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. gelatinlike substance covering some seaweeds; used as a medium to grow bacteria and in canning meats

______ 2. farming of the sea or ocean (also called *aquaculture*)

______ 3. group of red algae

______ 4. group of brown algae

______ 5. seaweed extract used to keep substances suspended in solution; used in chocolate milk, toothpaste, and other products

______ 6. seaweed extract that helps in absorbing large quantities of water; used in ice cream, frostings, and paints

______ 7. group of green algae

A. agar

B. algin

C. carrageenan

D. Chlorophyta

E. mariculture

F. Phaeophyta

G. Rhodophyta

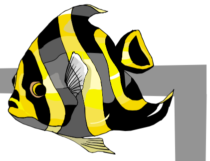
Unit 14: Classifying Marine Animals

Unit Focus

This unit covers the hierarchy of marine organism classification. Students will discover that marine organisms are categorized according to their level of organization or complexity. Students will also preview each phylum, beginning with the most primitive (phylum Porifera) to the most advanced marine organisms, the marine mammals.

Student Goals

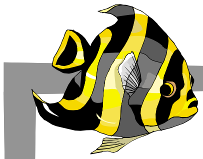
1. Define phylum.
2. Distinguish between invertebrates and vertebrates.
3. Identify marine organisms by their phylum characteristics.
4. Classify which organisms are primitive and which organisms are advanced.



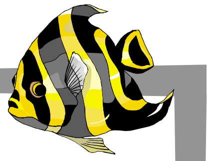
Vocabulary

Study the vocabulary words and definitions below.

amphibians	cold-blooded vertebrates that spend part of their lives in water
annelids	segmented worms
arthropods	animals with jointed legs and hard exoskeletons
birds	warm-blooded vertebrates with feathers
chordates	animals with a nerve cord, gill slits, and notochord (rod that supports their body)
Cnidaria (NI-da-ri-a)	phylum of animals with stinging cells
crustaceans	group of marine arthropods with segmented bodies, paired limbs, and antennae
echinoderms (eh-KY-noh-derms)	animals with spiny skin and tube feet
endoskeleton	internal support structure or skeleton
exoskeleton	external support structure or skeleton
fish	cold-blooded aquatic vertebrates with scales and gills
gills	respiratory organ of some marine, freshwater, and land animals

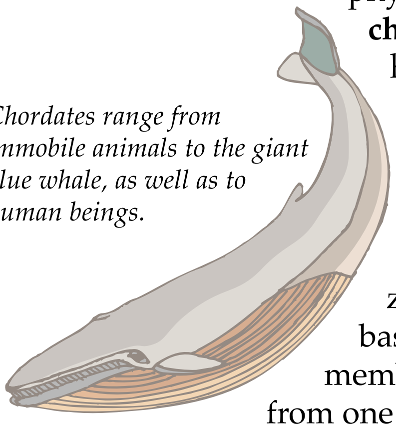


hydrostatic skeleton	a body cavity filled with water that is surrounded by muscles
invertebrates	animals without backbones
mammals	vertebrates that are warm blooded, have hair, provide milk for young, have lungs and breathe air
mollusks	invertebrates with soft bodies and a muscular foot
phylum	a major group of organisms (phyla, *plural*)
Porifera (PO-rif-er-a)	phylum of sponges; simple animals with pores; means “pore bearing”
reptiles	cold-blooded vertebrates that live on land and have dry, scaly skin
vertebrates	group of chordates that have backbones
zoologist	scientist who studies animals



Introduction: Classifying Marine Animals—Primitive to Complex

Zoologists classify animals into major groups. One of the largest classification groups is called a **phylum**. See the chart called *Phyla of Marine Organism* on the following page. Animals belonging to a specific phylum will share similar traits. For example, **chordates**, animals in the phylum *Chordata*, all have notochords (rods that support their bodies), nerve cords, and gill slits at some point in their lives. Chordates range from immobile animals to the giant and complex blue whale, as well as to us—human beings. This broad range of chordates illustrates that zoologists group animals according to some basic traits they share. It also shows that members of a phylum may look very different from one another.



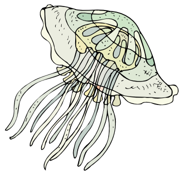
Chordates range from immobile animals to the giant blue whale, as well as to human beings.

The phylum Chordata includes **vertebrates**, a highly developed group of animals with backbones. Most animals, however, are in the other *phyla*. They do *not* have backbones and are classified as **invertebrates**. This unit will survey some of the invertebrates and vertebrates that are common in the marine environment.

Invertebrates: Well Adapted to Their Habitats

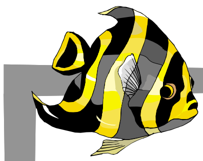
Invertebrates are often thought of as being more primitive—less complex—than vertebrates. Animals in some invertebrate phyla do have very simple body structures. But animals in other invertebrate phyla have nervous systems and skeletons as intricate as those of vertebrates.

For example, marine invertebrates have a variety of different kinds of skeletons. The type of skeleton an animal has is specially suited to its environment. There are three types of skeletons: the **hydrostatic skeleton**, the **exoskeleton**, and the **endoskeleton**.

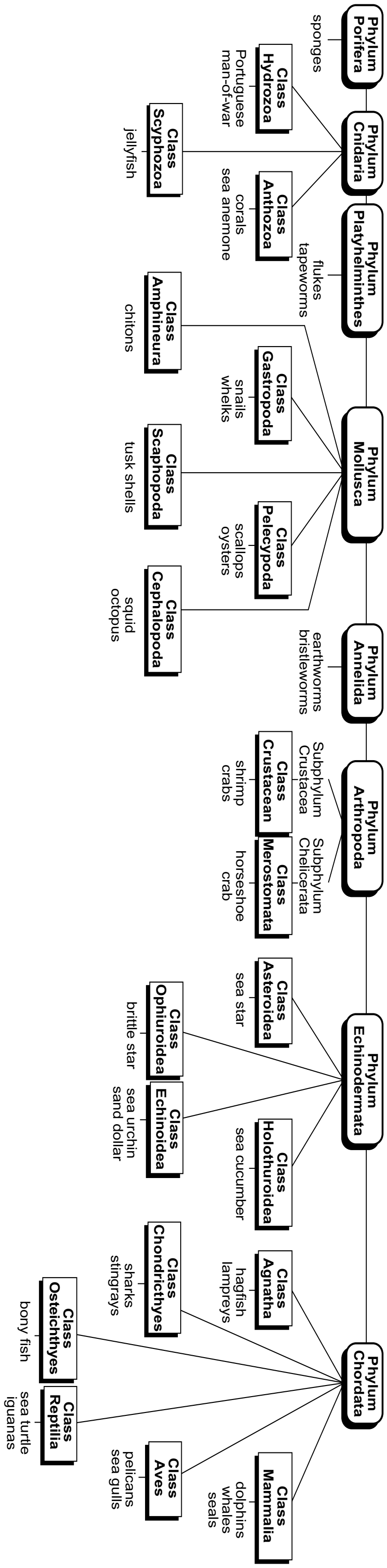


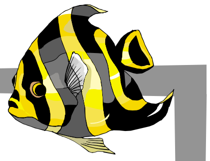
Jellyfish have a hydrostatic skeleton.

An animal with a *hydrostatic* skeleton is built like a bag made of muscles. When the muscles contract, or shorten, they push against the water inside the muscle bag, or cavity. This is very easy to see in a jellyfish, which has a



Phyla of Marine Organisms



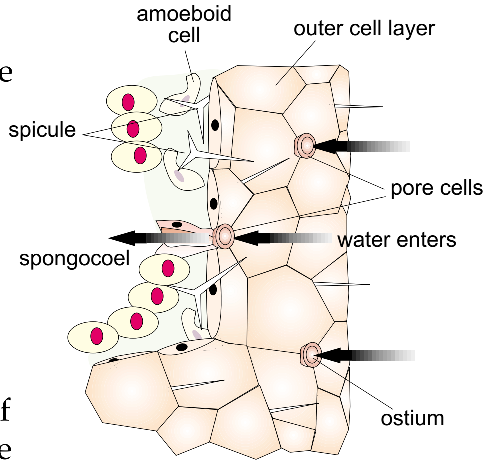


hydrostatic skeleton. An *exoskeleton* is a hard coating that covers an animal's internal organs and muscles. Insects are examples of animals that have exoskeletons. An *endoskeleton* is a framework that is located inside the body of an animal. One of the simplest animals in the world has an endoskeleton—the sponge. One of the most complex animals in the world also has an endoskeleton—the human!

Porifera: Phylum of the Ancient and Primitive

The phylum **Porifera (PO-rif-er-a)** contains the most primitive *multi*celled animals found on Earth. Sponges have been on our planet for at least 500 million years. They probably evolved from one-celled animals that lived together in colonies. The cells then became dependent on each other and lived together for mutual benefit. The sponge is a result of the close association of these cells. The sponges now found in the ocean have different cell types. Each type specializes in specific functions but relies on other types of cells for survival. A sponge can be ground up into individual cells that will reassociate to form a new animal.

Porifera means "pore bearer" and describes the sponge's structure. Its body is made up of two layers of cells that have pores or holes. Some cells have the task of drawing a current of water in through the pores and flushing it out through the top of the animal. As the water passes through the sponge, other cells filter out tiny particles of food, usually plankton. Other cell types then transport this food to all the cells in the sponge; and other groups of cells dispose of waste and reproduce. Inside their many pores, sponges sometimes provide shelter and habitat for numerous other organisms. The inside of a sponge may even serve as home for the entire life of some small or microscopic marine organisms.



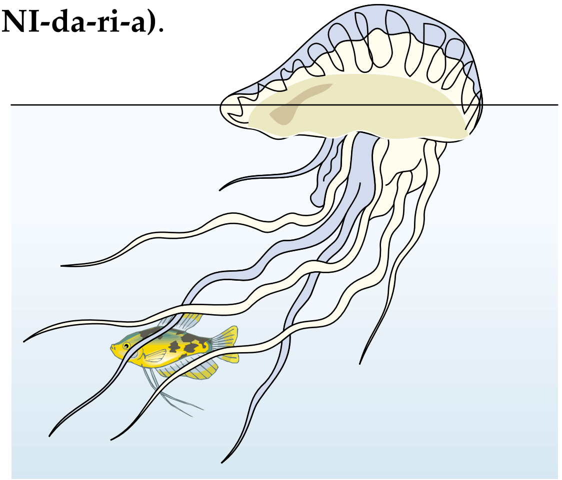
anatomy of a sponge

Between the layers of cells in sponges are tiny support structures called *spicules*. These spicules interconnect to form an endoskeleton. When a sponge dies, it is this spicule skeleton that is left behind. Some sponges do not have spicules; instead they have a skeleton made of a protein called *spongin*.

Most of the over 10,000 different kinds of sponges live in the ocean; however, some are found in freshwater habitats. Most are found in shallow waters and all are *sessile*: They are immobile and attach themselves to permanent objects such as rocks, shells, coral, piers, and even boats. Until recently, these marine animals were used as the common "sponge" to "sponge" up water in our kitchens and bathrooms. Most sponges used today are made of synthetic materials.

Cnidaria: Stingers in the Ocean

Most beach-goers in Florida are quite familiar with members of the phylum **Cnidaria (NI-da-ri-a)**. Cnidaria means "stinging celled," and it aptly describes its members, which include the stinging jellyfish and Portuguese man-of-war. Most members of this phylum have tentacles armed with tiny, stinging cells that they use for gathering food and protecting their soft bodies. Some of these animals can cause severe stings and even death, whereas others are harmless to humans.

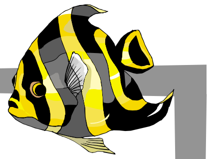


The Portuguese man-of-war is a member of the Cnidaria phylum and have tentacles armed with tiny, stinging cells that use for gathering food and protecting their soft bodies.

Animals in this phylum have bag-like bodies made up of two-cell layers. Their stomach cavity or "gut" has only one opening—the mouth. The jellyfish and Portuguese man-of-war are part of the *plankton* (drifting or floating organisms); other members such as the coral, sea whip, and sea anemone are *benthic*. They attach themselves to the seafloor or other surfaces.

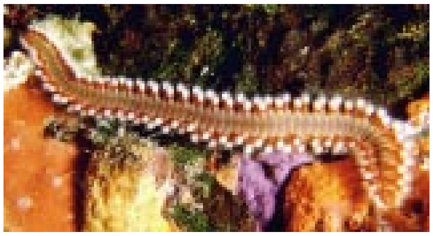
Phyla of Worms

Many different phyla of worms swim and inch through the ocean. Most of them are benthic—crawling or burrowing in the sediments of the seafloor. A few types of worms, however, actually swim or float. Some worms build tubes out of cemented sand grains or small shells. Others are *parasitic* and survive by living on the **gills** or bodies of other marine animals. Three noteworthy and numerous worm groups are the *flatworms* (in the phylum *Platyhelminthes*), the *roundworms* (in the phylum *Nematodes*), and the *segmented worms* (in the phylum *Annelida*).



Flatworms are flat, ribbonlike worms that have a solid body wall with no body cavity and one body opening. Many survive as parasites on vertebrates and are commonly found on the gills of the horseshoe crab. Other flatworms, however, are "free living" and must search for food.

The most numerous group of worms is the roundworms, or nematodes. They are found in almost every type of habitat. Most roundworms are small—less than one centimeter long. Their bodies are round and *unsegmented*, containing a body cavity and a tube-like digestive track. They have well-developed muscles, and many roundworms survive as parasites.



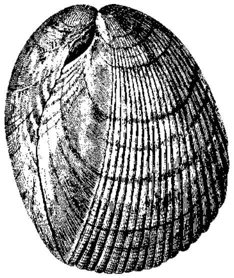
Many different phyla of worms swim and inch through the ocean.

Segmented worms, or **annelids**, are the most advanced of the worms. Their round bodies are elongated and divided internally and externally into repeating segments. They have a body cavity, circulatory system with blood vessels, a nerve cord, and an entrance and exit to their digestive system. Annelids can be fairly large. Some clamworms, for example, grow to over 18 inches long. Bloodworms and bristleworms are other common annelids found near shore.

Mollusks: Soft Bodies Protected by Shells

One of the largest groups of invertebrates is the phylum *Mollusca*. **Mollusks**, which means "soft bodied," are sometimes referred to as *shellfish*. Many mollusks have a special fold of skin called a *mantle,* which secretes some type of shell to protect their soft bodies. Another distinctive characteristic for all mollusks is the muscular "foot" they use to move from place to place. Mollusks include snails, nudibranchs, clams, oysters, mussels, octopus, and squid.

univalve



bivalve

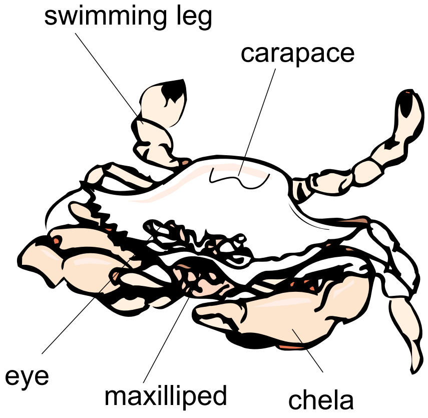
The shelled mollusks are divided into those with one shell (the *univalves*), such as the snail, and those with two shells (the *bivalves*), such as the clam and oyster. The squid and octopus belong to a different group because they lack an external shell and have a well developed head. Most mollusks are valued as a food source, and their shells are sometimes used for jewelry.

Arthropods: From Lobsters to Spiders

Members of the phylum *Arthropoda* are called **arthropods** (meaning "joint-footed") and range from lobsters to spiders to ants and other insects. They are the most numerous in the animal kingdom and share some very distinct traits. In addition to having jointed feet or legs, they have segmented bodies and a hard outer shell called an *exoskeleton*. Periodically, arthropods shed their shells, a process called *molting*, and secrete a new shell to accommodate growth.

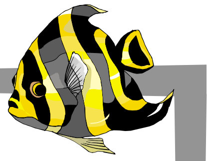
Arthropods (meaning "joint-footed) range from lobsters to spiders to ants and other insects.

Most marine arthropods belong to a subgroup or class called **crustaceans**, which are found in all benthic environments. Barnacles, lobsters, shrimp, and crabs belong to this family. Most crustaceans use gills to breathe and have two pairs of sensory appendages on their heads called *antennae*. They also have paired limbs, or appendages, that are adapted to their specific habitat. The lobster and crab, for example, have large pincers which they use to grab their food and to protect themselves. Shrimp have legs modified for walking, feeding, and swimming. Barnacles, sessile animals, use their modified legs for filtering food from the water.



external anatomy

The phylum Arthropoda contains the widest variety of organisms in the ocean, from planktonic forms such as the copepod to the ancient horseshoe crab.



Echinoderms

Echinoderms are spiny-skinned marine animals such as the sea star (starfish). Adult echinoderms have radial symmetry, or a circular design, with five body parts.

Members of the phylum *Echinodermata*—called **echinoderms (eh-KY-noh-derms)** —are spiny-skinned marine animals quite familiar to beach-goers. You would know them as sea stars (starfish), sea urchins, sand dollars, brittle stars, and sea cucumbers. In addition to their spiny, bumpy external covering, adult echinoderms have *radial symmetry*, or a circular design, with five body parts. They also have an endoskeleton called a *test* made up of plates or bumps of calcium carbonate. Echinoderms move about by forcing water along a system of tubes and canals in their bodies connected to tubed feet. By alternately contracting and expanding these tube feet, most echinoderms can slowly crawl across the ocean floor. Their tube feet also function in sensing their surroundings and in feeding.

Chordates

Chordates—animals in the phylum *Chordata*—all have these traits at some point in their development:

(1) a notochord, a thin flexible rod to support their body;

(2) a nerve cord running down their back; and

(3) gill slits, which develop for respiration in **fish** and into pharyngeal arches, which aid in circulation, in **reptiles**, **birds**, and **mammals**.

These traits are *not* all apparent in all adult chordates. However, they do occur at some life stage in all chordates. For example, we do not see gill slits in humans because they are visible only in the embryo stage, before birth.

All of the *lower* chordates are marine animals. These include tunicates, which do not resemble animals at all. Tunicates are sessile-filter feeders that resemble a sponge or blob. Examples include sea porks and sea squirts.

The more advanced chordates belong to the subphyla *Vertebrata*. These animals with a backbone are commonly called *vertebrates* and are divided into five groups: fish, **amphibians**, reptiles, birds, and mammals.

Fish: Jawless, Cartilaginous, and Bony

Fish are *cold-blooded* animals that live in water and breathe through gills. Cold-blooded animals have a body temperature that changes with the temperature of their surroundings. There are three classes of fish: *the jawless fish* (lampreys), the *cartilaginous* fish (sharks and rays), and the *bony fish*. Each class of fish has distinguishing characteristics. (See Unit 15.)

Lampreys are slimy, scaleless, jawless fish. They resemble a muscular tube with a mouth full of razor-sharp teeth and a strong tongue. A lamprey is parasitic and feeds on the body fluids of other living fish.

Familiar cartilaginous fish include sharks and stingrays.

Cartilaginous fish have flexible skeletons made of cartilage: a softer version of bone. They have fine, sharp, toothlike spines covering their bodies. Familiar cartilaginous fish include sharks and stingrays.

Bony fish—all 30,000 species—include most other fish, including the goldfish.

Bony fish—all 30,000 species—include most other fish: the goldfish, mullet, flounder, and seahorse, to name just a few. Bony fish are distinguished by skeletons made of bone, and broad, flat scales covering their bodies.

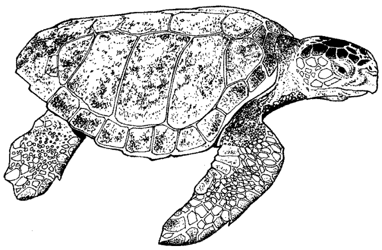
Amphibians: Living in Water and on Land

After hatching from eggs, most *amphibians* live in water and breathe through gills. After developing into adults, they live most of their lives on land, although near water, and breathe through lungs. Nearly all amphibians return to water to reproduce. Among the most familiar amphibians are frogs, toads, and salamanders. Most amphibians are not able to live in saltwater because their skin is too thin to protect them from the drying effect of salt.

Reptiles: Adapted to Life on Land

A group of cold-blooded, air-breathing vertebrates known as *reptiles* includes turtles, lizards, alligators, crocodiles, and snakes. Reptiles do not have to live in water because they have dry, scaly skin that protects against water loss. In addition, their eggs have a coating or shell that keeps them from drying out. Several types of reptiles, however, do live in water. Poisonous sea snakes are found in tropical waters; alligators and crocodiles are common in near-shore habitats such as swamps and marshes; and marine iguanas can be found on rocky shores, mangrove swamps, and beaches in the Galapagos Islands.

Many huge turtles also make the sea their home. Two species of sea turtles, the green and the loggerhead, grow to weigh over 400 pounds. The Atlantic Ridley and the hawksbill turtles are found in Florida waters and nest on our beaches. Female sea turtles crawl above the high-tide line on the beach to lay their eggs in nests under the sand. Then they leave their nests and return to the sea to feed. When the young turtles hatch, they must find their way to the sea on their own. Many are eaten by dogs or raccoons; some head towards lighted roads instead of the water, and only a very few survive to adulthood. Marine turtles are classified as *endangered*. It is illegal in the United States to kill or possess sea turtles or their eggs, harass nesting turtles, or disturb turtle nests.



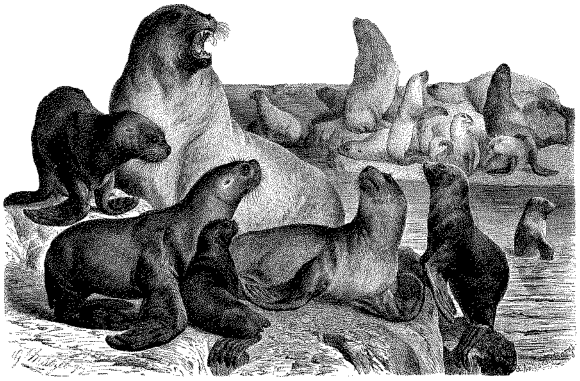
Many huge turtles make the sea their home.

Birds: Low Weight and High Power

Birds are *warm-blooded* vertebrates with feathers. Warm-blooded animals have a body temperature that stays about the same temperature no matter what the temperature of the surroundings is. All birds also have wings, although some use them for purposes other than flying. Penguins, for example, use them to swim. Most birds have two traits that make them well adapted for flying. Birds have a lightweight skeleton of hollow bone that is easy to carry in flight. They also have a high metabolic rate that generates energy and power necessary for flight.

Sea birds are common in coastal habitats. Many birds rely on the ocean for food during long migrations. Common marine birds include the gulls, terns, skuas, albatross, and penguins.

Mammals: Earth's Largest Creatures

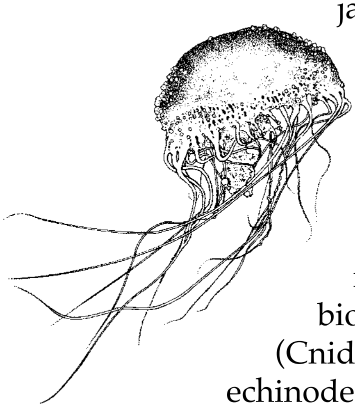


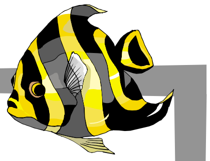
Marine mammals include the whale, porpoise, seal, sea lion, sea otter, and manatee.

Mammals are another group of vertebrates. They have lungs, breathe air, provide milk for their young, and have hair. Mammals also maintain a regular body temperature, making them warm-blooded. The largest creature to have ever lived is a mammal—the blue whale—which may weigh in at over 150 tons and can measure 100 feet in length—about the length of two and one-half school buses. Marine mammals include the whale, porpoise, seal, sea lion, sea otter, and manatee. A separate unit is devoted to marine mammals (see Unit 16).

Summary

Animals are classified in major groups called *phyla*. One phylum of animals—the chordates—has notochords, nerve cords, and gill slits at some point in their development. *Vertebrates*, a more developed subphylum of chordates, are animals with backbones such as fish, amphibians, reptiles, birds, and mammals. Three classes of fish, the jawless fish (lampreys), cartilaginous fish (sharks and rays), and bony fish (30,000 species), make their home in the marine environment. With the exception of amphibians, other types of vertebrates live in saltwater habitats, too. Most animals do *not* have backbones and are classified as *invertebrates*. Groups of invertebrates commonly found in the marine biome include sponges (Porifera), jellyfish (Cnidaria), worms, mollusks, arthropods, and echinoderms.

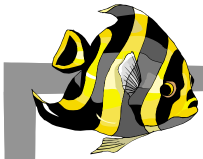




Practice

Use pages 323-333 to write the correct **animal phylum** *on the line provided.*

1. sponge ________________________
2. jellyfish ________________________
3. crab ________________________
4. squid ________________________
5. shark ________________________
6. sea anemone ________________________
7. shrimp ________________________
8. bird ________________________
9. sea star ________________________
10. oyster ________________________
11. round segmented worm ________________________



Practice

Use the list above each section to complete the statement in that section.

chordates
Cnidaria
crustaceans
echinoderms
invertebrates
mammals
phyla
zoologist

1. A scientist who studies animals is called a
   ________________________ .

2. Scientists classify animals that share major traits into major groups called ________________________ .

3. Animals that have a nerve cord at some time in their development are called ________________________ .

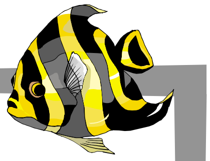
4. Most animals do *not* have backbones and are classified as
   ________________________ .

5. ________________________ such as the whale and manatee have hair, nurse their young, and are warm-blooded.

6. Most marine arthropods belong to a subgroup called
   ________________________ .

7. The phylum of animals with stinging cells is called
   ________________________ .

8. ________________________ include sea star (starfish), sea urchins, and sand dollars.



amphibians
birds
bony
cartilaginous
exoskeleton
hydrostatic
jawless
reptiles
turtles

9. ____________________ are cold-blooded vertebrates with dry, scaly skin that lay eggs.

10. The three classes of fish are the ____________________ fish , the ____________________ fish, and the ____________________ fish.

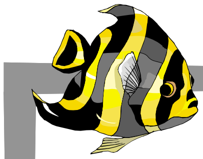
11. Frogs and toads are classified as ____________________ .

12. The Atlantic Ridley and the hawksbill ____________________ are found in Florida waters.

13. Common sea ____________________ include gulls, terns, and penguins.

14. Arthropods have a hard outer shell called a ____________________ .

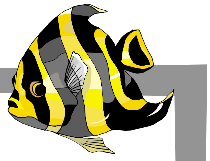
15. An animal with a ____________________ skeleton is built like a bag of muscles.



Practice

Use pages 323-333 and other resources as needed to complete the chart below.

Classifying Marine Animal					
Phyla	Examples	Symmetry	Skeleton	Segmentation	Features/Characteristics
Porifera					
Cnidaria					
Annelida					
Mollusca					
Arthropoda					
Echinodermata					



Lab Activity 1: Phyla Identification

Investigate:

- Compare different phyla of invertebrates.

Materials:

- charts below
- preserved specimen or pictures of different invertebrates
- reference books (textbooks, encyclopedias, field guides, etc.)

Procedure:

1. For each specimen, complete one of the charts below.
2. Draw a picture of your specimen in the space provided.
3. Use reference materials to identify the scientific name and phylum.

Analysis:

Lab Specimen

phylum: ______________________________

scientific name: ______________________

common name: _______________________

skeleton: ____________________________

body shape: ________________________

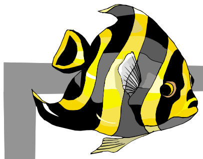
segmentation: _______________________

other characteristics: _________________

____

____

specimen drawing



Lab Specimen

phylum: ____________________

scientific name: ______________

common name: ______________

skeleton: ____________________

body shape: __________________

segmentation: ________________

other characteristics: _________

____

____

specimen drawing

Lab Specimen

phylum: ____________________

scientific name: ______________

common name: ______________

skeleton: ____________________

body shape: __________________

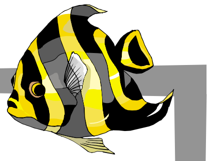
segmentation: ________________

other characteristics: _________

____

____

specimen drawing



Lab Activity 2: Crab Observation

Investigate:

- Observe the behaviors and adaptations of a living arthropod.

Materials:

- living blue crab (may substitute live crayfish, shrimp, or lobster)
- tray or small aquarium
- saltwater (fresh or prepared from mix)

Procedure:

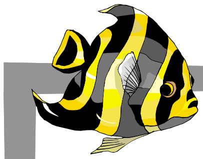
Obtain a blue crab, and place it in a small tray or aquarium of saltwater to cover its gill cavity. **Be careful of the pincers.**

Analysis:

1. What phylum does the blue crab belong to? ____________________
2. Draw the shape of the exoskeleton, the body of the crab, and describe the color.

____

____



3. Carefully turn the crab over; diagram the shape of its abdomen, and describe the color.

   ____

   ____

4. How does this coloration help the crab? ____________________

   ____

   ____

5. Describe how the crab moves. __________________________

   ____

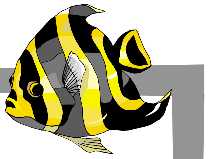
   ____

6. How many pairs of legs does the crab have attached to its

   exoskeleton? ______________________________________

7. Are all legs the same? _______________________________

   Are any legs missing? _______________________________



8. Draw an example of each type of leg in the space below and describe its function.

____

____

9. What does the crab use the pair of legs near its head for? (List two purposes.) ____

____

10. What does the crab use the next three pairs of legs for? __________

____

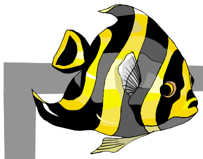
11. What does the crab use the last pair of legs for? ________________

____

12. Gently touch the eye of the crab with a pencil eraser. Describe the crab's reaction. ____

____

____



13. How does this behavior help the crab? ____________________

    ____

14. Give the crab a small piece of chicken or shrimp. Describe the crab's

    reaction. ____________________________________

    ____

    ____

15. How does the crab feed? ______________________________

    ____

16. What appendage does the crab use to feed? ________________

    ____

17. Do you think the crab is a predator or a scavenger? __________

    Why? ______________________________________

    ____

18. Look at the shape of your crab's abdomen. If it is rounded like a "U"

    or a "V," then it is a female. If it is shaped like a "T," then it is a

    male. What is the sex of your crab? ____________________

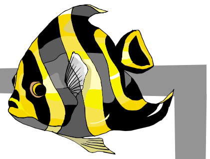
19. How wide is your crab in centimeters from point to point on the top

    of its exoskeleton? ______________________________

20. Write the size and sex of your crab on the board. Compare it with
    those of your classmates.

    The largest crab in the class: sex: ________ width: __________

    The smallest crab in the class: sex: ________ width: __________



21. Which sex is more numerous? ____________________________________

22. Does size seem related to sex? ____________________________________

23. Knowing that female crabs with eggs are not allowed to be taken by fishermen, would this explain your answer to question 21 and 22?

    ____

    How would your answer change? ______________________________

24. Based on your observations, describe two behaviors the crab has for protection. ____

    ____

    ____

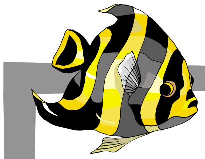
    ____

25. Based on your observations, describe two physical adaptations the crab has for protection. ____

    ____

    ____

    ____



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. scientist who studies animals

______ 2. a major grouping of organisms

______ 3. animals with a nerve cord, gill slits, and notochord

______ 4. group of chordates that have backbones

______ 5. animals without backbones

______ 6. a body cavity filled with water that is surrounded by muscles

______ 7. external support structure or skeleton

______ 8. internal support structure or skeleton

______ 9. phylum of sponges; simple animals with pores; means “pore bearing”

______ 10. phylum of animals with stinging cells

A. chordates

B. Cnidaria

C. endoskeleton

D. exoskeleton

E. hydrostatic skeleton

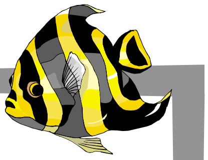
F. invertebrates

G. phylum

H. Porifera

I. vertebrates

J. zoologists



Practice

Use the list below to write the correct term for each definition on the line provided.

amphibians
annelids
arthropods
birds
crustaceans
echinoderms
fish
gills
mammals
mollusks
reptiles

______________________________ 1. vertebrates that are warm blooded, have hair, provide milk for young, have lungs, and breathe air

______________________________ 2. warm-blooded vertebrates with feathers

______________________________ 3. cold-blooded vertebrates that live on land and have dry, scaly skin

______________________________ 4. cold-blooded vertebrates that spend part of their lives in water

______________________________ 5. cold-blooded aquatic vertebrates with scales and gills

______________________________ 6. animals with spiny skin and tube feet

______________________________ 7. group of marine arthropods with segmented bodies, paired limbs, and antennae

______________________________ 8. animals with jointed legs and hard exoskeletons

______________________________ 9. invertebrates with soft bodies and a muscular foot

______________________________ 10. segmented worms

______________________________ 11. respiratory organ of some marine, freshwater, and land animals

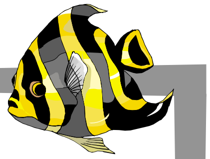
Unit 15: Fish—Cold-Blooded Swimmers

Unit Focus

This unit provides students with an overview of the distinguishing features of the three classes of fish: the Agnatha, the Chondrichthyes, and the Osteichthyes. Students will learn the differences between the three classes of fish and adaptations of fish to the oceans.

Student Goals

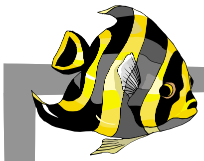
1. Name the three classes of fish.
2. State characteristics of cartilaginous fish.
3. State characteristics of bony fishes.
4. Describe some unusual adaptations in fish.



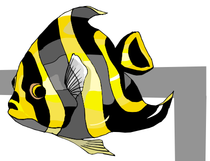
Vocabulary

Study the vocabulary words and definitions below.

Agnatha	group of jawless fish with cartilage skeletons; includes lampreys and hagfish
ampullae of Lorenzini	nerve receptors in tiny pores in the shark's snout that can detect electric fields of other animals
buoyancy	tendency to remain afloat in a liquid or gas
cartilage	firm but flexible material that makes up the skeletons of sharks, rays, lampreys, and hagfish
cartilaginous	class of fish with skeletons of cartilage; includes sharks and rays
caudal	at or near the tail
countershading	coloration in many fish where the dorsal side is dark and the ventral side of the fish is light
denticles	small toothlike structures that cover the body of sharks and rays
disruptive coloration	coloration in fish where the colored body pattern contains many lines which hide the fish's outline and helps camouflage the fish



dorsal	located on the back
fusiform	a streamlined body shape exhibited by many pelagic fish
gill slits	visible opening for breathing found in cartilaginous fish only
lamprey	a jawless parasitic fish with a tubelike body and large teeth
lateral line	line of sensitive sound receptors along each side of a fish's body
operculum	flap of tissue that covers the fish's gills
pectoral	at or near the chest
scales	thin, flat plates that make up the covering of bony fish
school	large group of fish of the same type, size, and age that travel and feed together
spawning	depositing or releasing a mass of eggs and sperm directly into the water
swim bladder	gas- or air-filled organ that regulates the buoyancy of bony fish
ventral	located on the stomach or belly

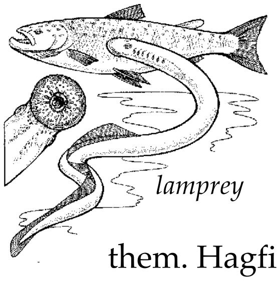


Introduction: Fish—Cold-Blooded Swimmers

In earlier units you read about small and microscopic marine animals called *zooplankton*. These organisms, you'll remember, were carried by the oceans' currents. Fish, on the other hand, are nekton, or marine animals that swim independently of the ocean waters' force.

Fish can be defined as cold-blooded vertebrates that live in water, use fins to swim, and breathe through gills. There are three classes of fish. Two of these classes—the **Agnatha**, or jawless fish, and the **cartilaginous** *fish*—have skeletons of **cartilage**. The third class of fish—the *bony fish*—has a skeleton of bone. These three classes of fish differ in their body covering, the types of fins they possess, and their methods of maintaining **buoyancy**, or remaining afloat. As you can imagine, as life forms inhabiting water, fish need a mechanism to remain buoyant and free to move around in search of food and habitat.

Agnatha: The Jawless Lamprey and Hagfish



Agnathans existed as far back as 550 million years ago. And, when compared to other fish, there is something quite *ancient* about them. They do not have a lower jaw. Instead they have a sucker-like mouth with large teeth and a rasp-like tongue. The **lamprey** scrapes a hole in its prey and then sucks the body juices from them. Hagfish also scrape a hole in the side of fish but then enter their prey and feed from the inside. Both fish have a flexible cartilage skeleton and small fins on an elongated snake-like body. They travel by attaching themselves to other more mobile fish. Many lampreys and hagfish make the Great Lakes their home.

Cartilaginous Fish: Sharks and Rays

Sharks and rays are examples of fish that have skeletons of cartilage rather than of bone. And, like all members of *Chondrichthyes*, a class of vertebrate fish made up of cartilaginous fish, they have small toothlike **scales** called **denticles** which cover their skin. All the points on the denticles face towards the tail. If you stroked a shark from head to tail, the skin would feel smooth. However, if you stroked the shark in the opposite direction—from tail to head—the skin would feel rough. (Shark skin was once used as sandpaper!) Some cartilaginous fish bear live young; others lay eggs. Unlike bony fish that have an air-filled **swim bladder** to keep them afloat, the shark and ray must keep swimming to avoid sinking. Many possess large oily livers to help maintain their buoyancy.

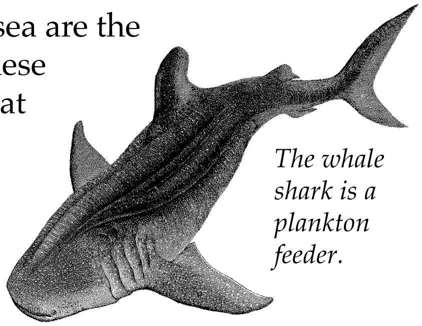
Sharks: *Mostly* Peaceful, Longtime Inhabitants of the Sea

Sharks have been swimming the seas for over 450 million years! During the last 300 million years they have changed very little. Most of us think of danger and sharp teeth chomping off body limbs when we think of sharks. But shark attacks are not as common as the media might lead us to believe. Fewer than 100 people a year are attacked by sharks, and very few of those attacks result in death. Consider that more people are hit by lightning in the United States than are attacked by sharks. Still, the media continues to mark them as a constant and overwhelming threat to beach-goers.

In fact, of the 350 known species of sharks, only 35 have shown themselves to be dangerous to humans. Of these, the hammerhead, mako, and tiger are among the best known. The most feared shark, however, is the great white shark, partly because of its representation as a creature of terror in the movie *Jaws*. The great white shark does deserve respect: It can grow to 25 feet in length and is one of the fastest swimming of all sharks. It tends to live in colder waters near large prey such as seals.

Many shark attacks on humans may be cases of mistaken identity. A swimmer on the surface of the water may look to a shark like a wounded marine animal. Other shark attacks may be the result of humans invading or disturbing sharks' territories.

Except for whales, the largest animals in the sea are the docile whale shark and the basking shark. These giant creatures are gentle plankton feeders that can grow to 40 feet and longer. Divers have been known to touch them and even on rare occasions to hitch a ride on them. Sharks range in size from these massive creatures to the six-inch cigar shark.

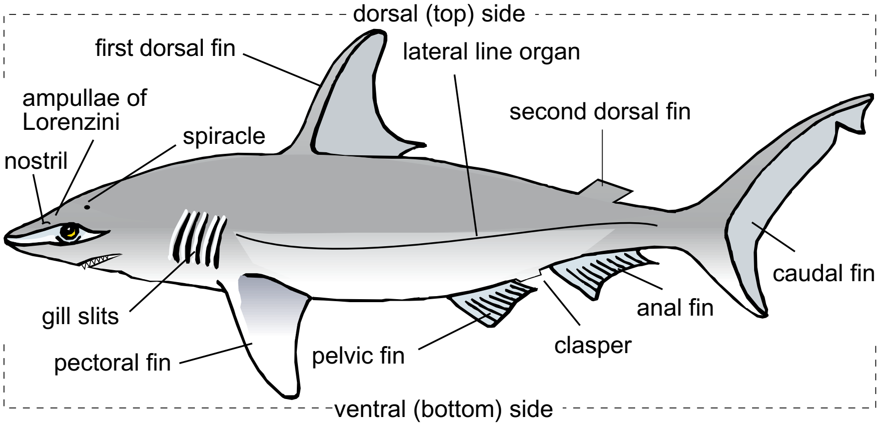


The whale shark is a plankton feeder.

The Structure of Sharks: Fins and Gills

Most sharks share a basic body structure that is characterized by their fins, which they use to push or propel themselves through water. On the top side, or *dorsum*, sharks may have several fins. Looking from head to tail, we first see a **dorsal** fin. (It is this fin that moviemakers show above water to indicate dangerous sharks swimming about.) Next, on some sharks we see a second dorsal fin, smaller than the first and nearer the shark's tail. Their tail fin is called the **caudal** fin.

Sharks may also have fins on their **ventral**, or stomach, side. The large front fins on the side of sharks are the **pectoral** fins. The pectoral fins provide the lift which glides the shark through the water and also prevents the shark from sinking. Next are a pair of pelvic fins, located under sharks and near their tail. On the edge of their pelvic fins, males have a long extension, called a *clasper,* which they use in mating. The last pair of fins—present in only some sharks—are the anal fins, located near the tail.



structure of a shark

Sharks, like other fish, breathe through gills located on the sides of their body. The gills of bony fish are concealed or covered by a fleshy flap. Unlike bony fish, sharks and rays have visible or exposed **gill slits**. Because most sharks cannot force water over their gills to breathe, they must keep swimming or rely on currents to move water over the gills.

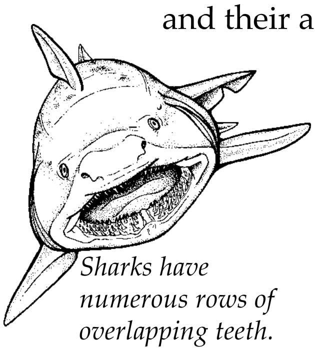
Cartilaginous fish, like sharks, also have a pair of breathing holes called *spiracles*. The spiracles are located on their dorsal side behind each eye.

Sharks: Built for the Hunt

Sharks' bodies have many features that make them ideal for hunting and killing prey. Their many sense organs aid them in locating potential prey. Sharks *feel* vibrations in the surrounding water through special receptor cells located along both sides of their bodies. The receptor cells make up the **lateral line** organ. The lateral line organ picks up vibration (weak and strong) as the energy from the vibration travels through the water. When the vibration hits the lateral line of the shark, the shark feels a change in pressure along its body. The feeling the shark experiences from the vibration is similar to when someone pokes you in the back and continues to poke you. This feeling is irritating to the shark so the shark goes to investigate the source of the vibration.

Sharks also have a pair of nostrils they use for detecting smells in the water. A shark's sense of smell is so sharp that a shark can detect a small amount of blood nearly a half a kilometer away. Marine biologists studying shark behavior have determined that the size of the shark's brain is responsible for its keen sense of smell. Nearly two-thirds of the shark's brain is utilized in detecting smells in the water. Other sensory cells that a shark uses to assist in locating prey are the **ampullae of Lorenzini**. These tiny cells are located in the snout of the shark. The ampullae of Lorenzini detect electric fields generated by the muscles of fish and other animals in the water. The presence of these cells explains the bizarre behavior of sharks attacking metal boat propellers and of consuming discarded metal cans and automobile license plates.

As sharks near their prey, they cover their eyes with a protective eyelid. Without vision, sharks then rely on their ability to detect the electrical fields produced by fish, other marine life, and objects. This lack of vision and their attraction to electrical fields may explain why sharks have attacked metal objects or boat motors when closing in on their prey. Once sharks begin their attack, their jaws and teeth do not permit many prey to escape. Their jaws are hinged, allowing them to disjoint during feeding. This feature permits sharks to chew large animal parts and whole animals. Sharks have numerous rows of overlapping razor-sharp teeth that are quickly regrown when they are broken off or worn down.

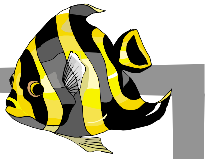


Sharks have numerous rows of overlapping teeth.

This description of the ocean's ultimate hunter should encourage us to be prepared for sharks when we swim in the sea. So what should swimmers do if they see a shark while in the water?

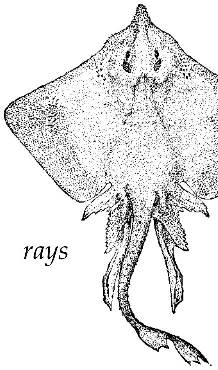
- Do not panic or try to drive the shark away by splashing or yelling.

- Remain calm and move slowly towards the surface or the shore.



Rays: Bottom Dwellers in the Ocean

Rays are close relatives of the shark: They also have skeletons of cartilage and denticles. Unlike sharks, however, rays have enlarged pectoral fins that resemble broad wings. Some rays may grow to 20 feet or more from one fin tip to the other. Rays flap these fins to propel themselves through the water or to bury themselves in the seafloor's sediments. Many rays, such as the southern stingray and the skate, live close to shore. They are hard to see because they bury themselves in the sand, and their coloring blends in with the sediments. Other rays such as the eagle ray or the manta ray live in deeper waters and feed on plankton schools. A ray's mouth is on its underside, and their *teeth* are broad, flat plates of cartilage used to grind up shellfish. They can even be fed by hand without danger of getting bit. Rays feed mainly on benthic animals including worms and clams.



rays

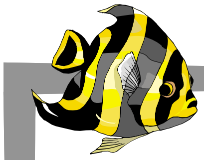
A few rays can be dangerous. The stingray has a sharp, poisonous barb near the bottom of its tail, which it can drive into its enemy. This barb may stick in the skin and cause an infection. To avoid being stung, drag your feet as you walk along the bottom—this action scares them away. If you are stung by a stingray, do not try and remove the spine yourself. Remain calm, apply a cold compress to the site, and seek medical attention quickly.

Bony Fish: The Ocean's Most Numerous Fish

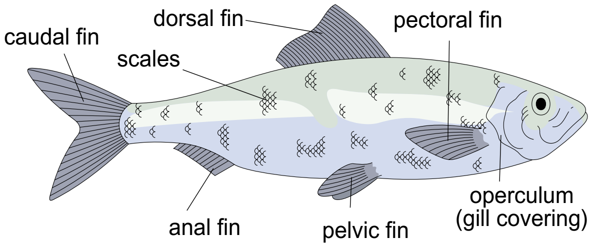
Osteichthyes, the class of bony fish in the ocean, far outnumber sharks, rays, lampreys, and hagfish combined. They are found in every habitat of the ocean. And although they may swim long distances, they tend to remain and swim in a small range of depths. Fish are very well suited to their specific environments. For example, fish living near plants or narrow channels may be compressed from side to side so they can move safely around dangerous limbs or narrow passages. Fish that live on or near the sea bottom may be compressed from top to bottom, enabling them to rest on the marine floor. Most fish produce a large number of eggs during **spawning**, though only a small percentage survive to reach maturity.

Structure and Features of the Bony Fish

Unlike land animals, the bony fish's skeleton does not have to support much weight. Instead, the body of bony fish is entirely suited for moving



through water and staying afloat. Attached to their skeleton of bone are muscles, which fish contract and expand to move their fins and propel themselves through water. Their fins can be folded back against their body or fully extended to help them move and steer through water. Their ability to swim smoothly and with little effort is enhanced by their streamlined shape.



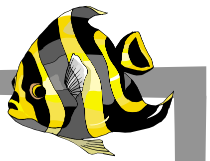
structure of bony fish

Overlapping plates called *scales* cover and protect fish's bodies. Fish feel slimy to the touch because their scales are covered with a coating of mucus. This coating serves as a defensive barrier that keeps bacteria and diseases from entering the fish's body through its scales. The coating also helps the fish move easily through the water. The slimy coating reduces the drag and friction, allowing the fish to glide through the water. You can determine the age of some fish by the number of rings on their scales. A single band on a scale may represent one year's growth.

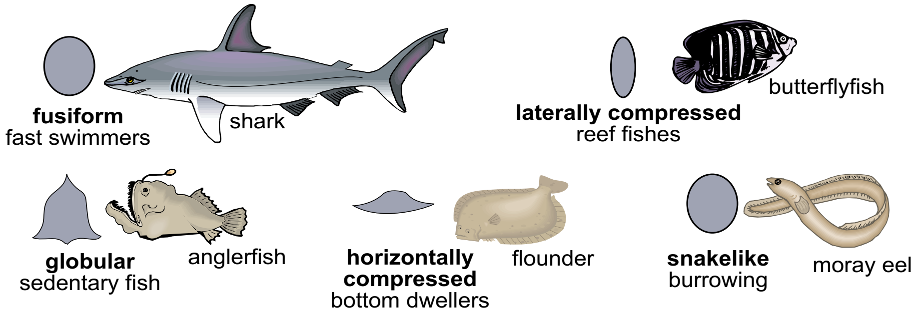
Fish obtain oxygen from the water through their gills. The gills are covered by a flap of tissue called the **operculum**. If you have observed fish in an aquarium, you may have noticed the movement of the operculum as the fish breathed.

Fish are always on the move. Bony fish have an organ called a *swim bladder* that allows them to periodically float in the water. The swim bladder assists the fish in maintaining its buoyancy. *Buoyancy* is the ability to float or rise in a liquid medium such as water. The swim bladder is a gas filled organ (similar to a balloon) that fish use to rise, sink, or maintain their position in the water.

Although bony fish have the general structure and features described above, they come in all shapes and sizes. Open water, or *pelagic*, fish are much faster swimmers and cover a wider area than the bottom dwelling species such as the flounder. Pelagic fish have a body shape that is **fusiform**, or *streamlined*. A fusiform body shape produces little resistance to movement through the water. The fastest swimming speeds are reached when a fish uses its *caudal fin*. The shape and the height of the caudal fin affect speed. Tuna and sharks are examples of fish which are fast pelagic swimmers. These fish have a greater fin height than do slower fish.



Fish that live in seagrass or on coral reefs have a *laterally compressed* body that helps them to swim more efficiently through the seagrass or coral heads. The butterflyfish and angelfish are fish that have laterally compressed bodies. Bottom dwelling fish, like the flounder, have a *horizontally compressed* or flattened body. These fish swim horizontally instead of vertically and are poor swimmers. The toadfish and anglerfish are also bottom dwelling fish but have *globular* or rounded bodies and pectoral fins that are enlarged to help support their body on the seafloor. These fish are commonly called "ambush hunters" because they wait patiently on the seafloor and ambush their prey. *Burrowing* fish and fish that live in between rocks have long, snake-like bodies and usually have reduced (or lack) pelvic and pectoral fins. A moray eel is a fish that exhibits a snake-like body.



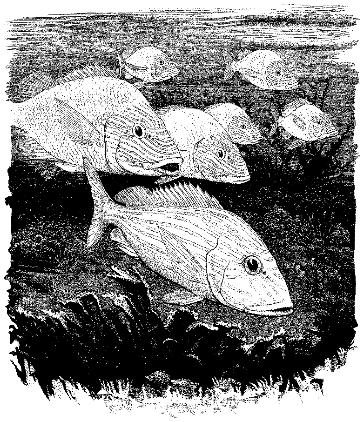
fish shapes

Fish use color for species recognition and concealment. Fish that live in the open ocean have body coloration known as **countershading**. In countershading, the fish's dorsal side (top) is dark and the ventral side (bottom) of the fish is light. How does this type of coloration help camouflage oceanic fish?

Coral reef fish exhibit a different coloration from oceanic fish. Reef fish have markings on their bodies that typically exhibit a banded pattern. The coloration pattern is called **disruptive coloration**. The banded patterns usually run vertically along the fish's body. This helps to break up the pattern of the fish's body. Predators have a harder time locating reef fish that display disruptive coloration.

Fish Schools: Survival in Numbers

About half of the species of fish live in **schools**. *Schools* describe large numbers of the same kinds of fish traveling and feeding together. Fish live in schools in freshwater streams and lakes, as well as oceans. Types of fish that form schools can be as small as minnows or as large as tuna. The numbers of fish in a school range from about a dozen to thousands. Regardless of the size of the schools, they are made up of fish of nearly the same size and age.



Fish live in schools to increase their chances for survival.

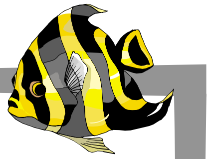
Fish live in schools to increase their chances for survival. Fish in a school become quickly aware of an attack from a predator and, consequently, increase their chance that at least some will survive. In addition, swimming in schools may be easier for fish than swimming alone (as flying together is easier for birds than flying alone). Fish release a slippery film that make them glide through the water more easily; swimming in a school permits fish to use the film released from surrounding fish. Fish also create little currents for each other, thereby reducing drag (similar to a *draft* created by a big truck on the highway). By properly spacing themselves, fish swim more efficiently. Gathering into schools also provides fish with suitable mates to help insure reproduction.

Summary

Fish are cold-blooded vertebrates that live in the water and breathe with gills. Two classes of fish—*Agnatha* (lampreys and hagfish) and *cartilaginous* (sharks and rays)—have backbones made of *cartilage*. The third class of fish—the bony fish—is the most numerous by far, and has a skeleton made of bone. Most fish have scales and fins and well developed body systems. Special *buoyancy* systems and *swim bladders* equip them for locomotion in the water.

Sharks are some of the largest marine animals, growing up to 40 feet in length. They are particularly well built for hunting and killing. Their sense organs are designed to detect potential prey, and their overlapping razor-sharp teeth penetrate and kill prey easily. Although feared, sharks do not often kill humans. Rays are bottom dwellers that feed on benthic animals. Some rays are equipped with poisonous barbs.

Bony fish are well adapted to their specific environment. They may be shaped quite differently to swim easily and safely through their own particular surroundings. Many bony fish swim in *schools* for protection and reproduction benefits.



Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

age
Agnatha
bony
bottom
buoyancy
cartilage
denticles
great white shark
hagfish
schools
sense
sharks
size
spawning
swim bladders

1. Two classes of fish have skeletons of __________________ and the third has a __________________ skeleton.

2. __________________ is the ability to float.

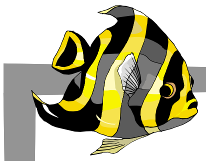
3. The __________________, or jawless fish, such as the lampreys and __________________ travel by attaching themselves to other fish.

4. __________________ are the largest animals in the sea besides the whale.

5. Sharks' __________________ organs make them ideal for hunting prey.

6. Fish swim in __________________ to increase their chances of survival.

7. The most feared shark is the __________________ .



8. Sharks have toothlike scales called ______________________ covering their bodies.

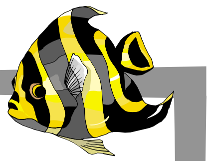
9. Rays dwell on the ______________________ of the ocean.

10. The most numerous class of fish is the ______________________ fish.

11. Most fish produce a large number of eggs during ______________________ .

12. Fish have ______________________ that allow them to maintain their position in the water column.

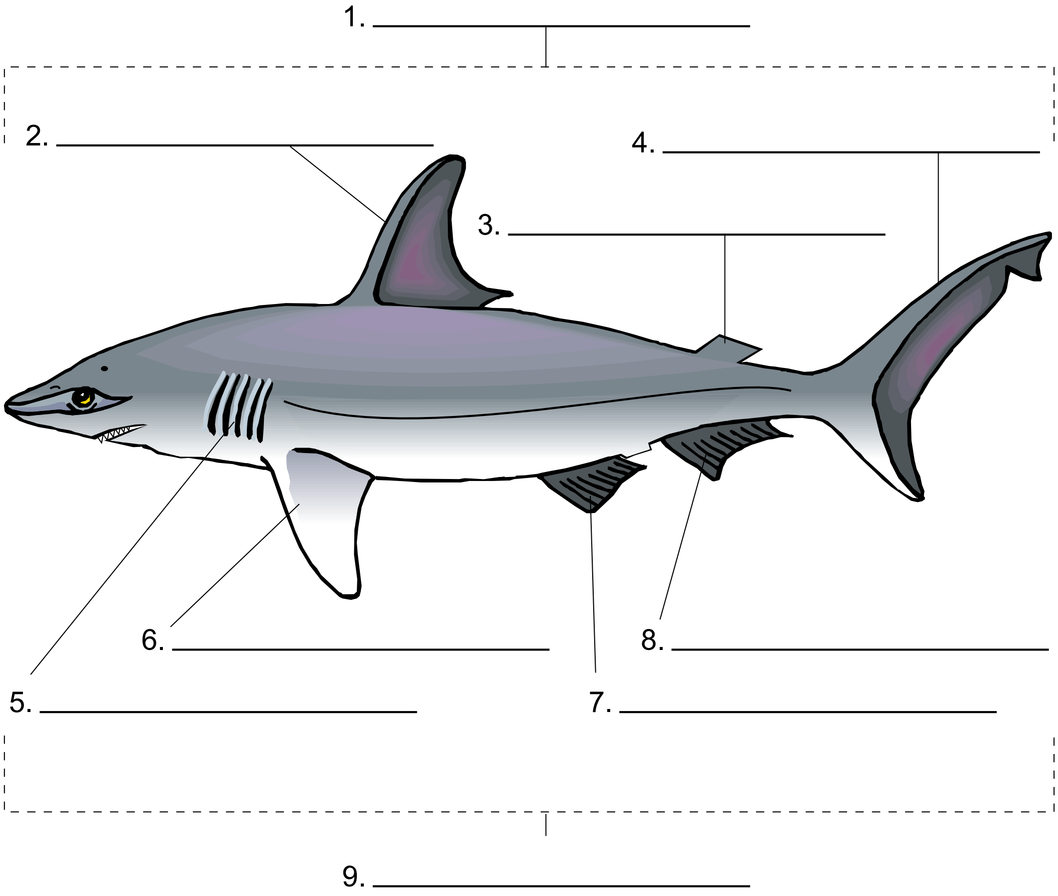
13. All fish in a school are about the same ______________________ and ______________________ .

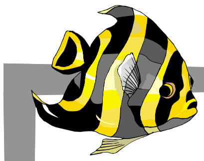


Practice

Use the list below to correctly label each **part of the shark** *on the diagram below. Write the correct term on the line provided.*

anal fin
caudal fin
dorsal side
first dorsal fin
gill slits
pectoral fin
pelvic fin
second dorsal fin
ventral side





Practice

Answer the following using complete sentences.

1. State the purpose of a fish's scales and the mucus coating. ________

   ____

2. Describe how the lateral line organ of the shark detects vibration.

   ____

   ____

3. What does the swim bladder of bony fish do? ___________________

   ____

4. What do the ampullae of Lorenzini do for the shark? _____________

   ____

5. Describe what a fish will look like that has countershading as its

   body color. ____

   ____

6. Where will a fish with countershading body color live? ___________

   ____

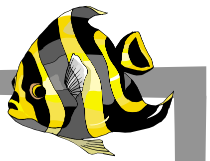
7. State examples of fish that exhibit the following body types:

   a. fusiform: ____

   b. depressed or flattened: _________________________________

   c. laterally compressed: __________________________________

   d. snake-like bodies: _____________________________________



Lab Activity 1: Identify Species of Sharks and Rays

Investigate:

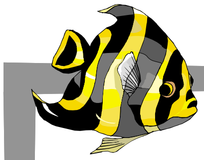
- Identify species of sharks, using a key.

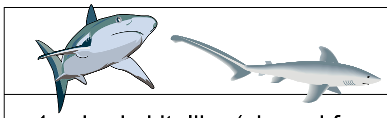
Materials:

- shark pictures and key

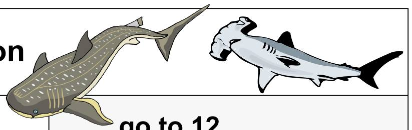
Procedure:

1. Use the following statements to identify the sharks and rays pictured.
2. Begin at choice number 1 with each shark or ray. Decide whether the *first* or *second* sentence best describes the shark or ray. Use that choice to either identify the shark or ray and continue down the key.
3. Once the shark or ray is identified, write the name in the blank.
4. Then go to the next picture. Begin again at number 1. Each name is used only once.

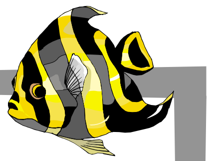




Shark Identification



1.	body kitelike (viewed from top) body not kitelike	**go to 12** **go to 2**
2.	pelvic fin absent and nose sawlike pelvic fin present	**sawsharks** **go to 3**
3.	seven gill slits present five gill slits present	**sevengill sharks** **go to 4**
4.	only one dorsal fin two dorsal fins	**cat sharks** **go to 5**
5.	mouth at front of snout not underside mouth on underside of head	**whale sharks** **go to 6**
6.	head expanded on side with eyes at end head not expanded	**hammerhead sharks** **go to 7**
7.	top of caudal fin same size and shape as lower top of caudal fin different from lower	**mako sharks** **go to 8**
8.	first dorsal fin very long, half of body first dorsal fin regular in length	**false catsharks** **go to 9**
9.	top of caudal fin very long, half of body top of caudal fin different from lower	**thresher sharks** **go to 10**
10.	long needle-like point on end of nose nose without long point	**goblin sharks** **go to 11**
11.	anal fin absent anal fin present	**dogfish sharks** **requiem sharks**
12.	small dorsal fin present near tip of tail no dorsal present near tip of tail	**skates** **go to 13**
13.	two horn-like appendages on front no horn-like appendages	**manta rays** **stingrays**



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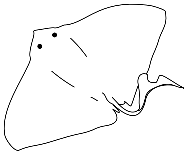

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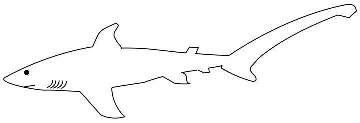

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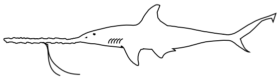

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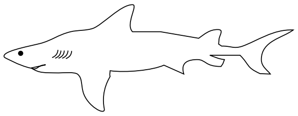

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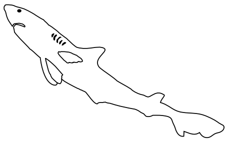

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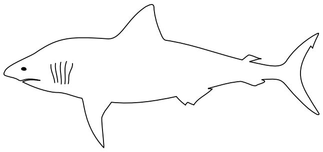

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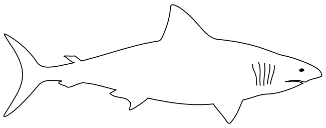

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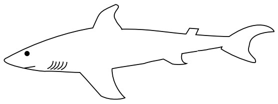

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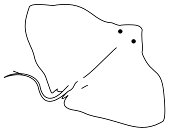

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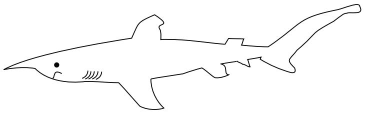

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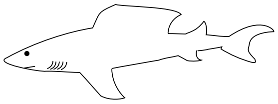

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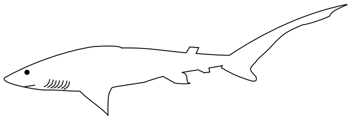

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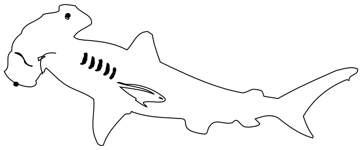

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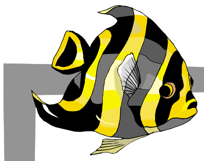


Lab Activity 2: Fish Printing

Investigate:

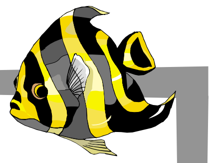
- Observe the body form and fins of a fish.

Materials:

- whole, intact, fresh fish from market
- water-soluble ink or paint
- newsprint or other grainy paper
- small pieces of modeling clay or toothpicks
- newspapers
- piece of sponge

Procedure:

1. Cover work area with newspaper.
2. Rinse fish and pat dry to remove oils and slime.
3. Place fish on newspaper and spread fins and mouth. Use clay or toothpicks to hold in place (on underside only).
4. Use a small sponge to dab, not spread, paint on surface of fish. This is much like sponge painting. Do not slide sponge on surface. A little paint goes a long way.
5. Make sure area around fish is not covered with paint, and carefully place a piece of paper on top of your fish. Use your hands to press the paper all over the fish, covering all parts without sliding it or picking it up.
6. Gently peel the paper from the fish—you've created art!
7. Let dry; then label the fins, gill cover, and any other features you can see.
8. Write a paragraph describing the adaptations and habitat of the fish used.



Lab Activity 3: New Millennium Fish

Investigate:

- Review what you have learned regarding the anatomy of fish, the ocean environment, and the organism's methods of adapting to survive.

Materials:

- butcher paper
- notebook paper
- colored pencils or markers
- scoring rubric
- textbook or other marine resources

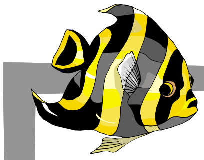
Procedure:

1. Imagine it is the year 2055. Since the turn of the century, overfishing and global warming have dramatically altered characteristics of oceans. Make a list of 10 characteristics that would describe the Pacific Ocean in 2055. List these on a sheet of paper titled *New Millennium Ocean*.

2. Given the hypothetically evolved condition of the Pacific Ocean, *create* a fish of the *future*. Make a list of the different ways this *New Millennium Fish* would adapt to survive. Write this list on the same sheet of paper of the *New Millennium Ocean* characteristics. Title this list *New Millennium Fish*.

3. Draw and color a picture of the *New Millennium Fish* on a sheet of paper. Use the entire sheet of paper. Include labels for the fish anatomy or descriptors for any new or unusual adaptations the fish may have evolved. Be sure to use the correct coloration, appendages, fins, etc. Using the fish's adaptations, create a name for the *New Millennium Fish*.

4. After completing your New Millennium Fish drawing, display your drawing and list of characteristics on the wall. Enjoy viewing your classmates' fish creations.

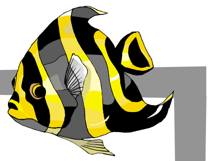


Analysis:

Your drawing will be graded using the following rubric or scoring guide. Your teacher will tell you what points are possible to earn for each category. Write in the possible points in the first column, then use the second column to compare your scored rubric with your teacher's.

New Millennium Fish Rubric

	points possible	self-rating	points earned
1. The drawing has illustrated the correct and total number of adaptations listed.			
2. Color, labels, and other descriptors clarify what the model intended to show.			
3. Name is suitable and correlates to the characteristics listed.			
4. The drawing is neat and presentable.			
		total points	



Practice

Use the list below to write the correct term for each definition on the line provided.

Agnatha
buoyancy
cartilage
cartilaginous
caudal
denticles
dorsal
lamprey
pectoral
scales
ventral

________________________ 1. at or near the chest

________________________ 2. located on the stomach or belly

________________________ 3. at or near the tail

________________________ 4. located on the back

________________________ 5. small toothlike structures that cover the body of sharks and rays

________________________ 6. thin, flat plates that make up the covering of bony fish

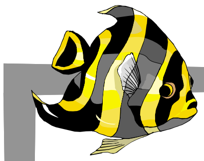
________________________ 7. a jawless parasitic fish with a tubelike body and large teeth

________________________ 8. firm but flexible material that makes up the skeletons of sharks, rays, lampreys, and hagfish

________________________ 9. tendency to remain afloat in a liquid or gas

________________________ 10. class of fish with skeletons of cartilage; includes sharks and rays

________________________ 11. group of jawless fish with cartilage skeletons; includes lampreys and hagfish



Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. large group of fish of the same type, size, and age that travel and feed together

______ 2. coloration in fish where the colored body pattern contains many lines which hide the fish's outline and helps camouflage the fish

______ 3. coloration in many fish where the dorsal side is dark and the ventral side of the fish is light

______ 4. a streamlined body shape exhibited by many pelagic fish

______ 5. flap of tissue that covers the fish's gills

______ 6. depositing or releasing a mass of eggs and sperm directly into the water

______ 7. nerve receptors in tiny pores in the shark's snout that can detect electric fields of other animals

______ 8. line of sensitive sound receptors along each side of a fish's body

______ 9. visible opening for breathing found in cartilaginous fish only

______ 10. gas- or air-filled organ that regulates the buoyancy of bony fish

A. ampullae of Lorenzini

B. countershading

C. disruptive coloration

D. fusiform

E. gill slits

F. lateral line

G. operculum

H. school

I. spawning

J. swim bladder

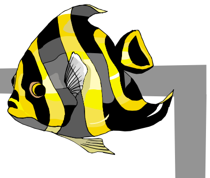
Unit 16: Marine Mammals

Unit Focus

This unit provides students with an overview of the basic characteristics of cetaceans, pinnipeds, sirenians, and other marine mammals. Students will learn about the adaptations these mammals have acquired for life in the ocean and about the unique diving responses of marine mammals.

Student Goals

1. Classify marine mammals as cetaceans, pinnipeds, or sirenians and note other marine mammals.
2. Explain the importance of bradycardia for diving marine mammals.
3. Describe the feeding methods of cetaceans, pinnipeds, sirenians, and other marine mammals.
4. Describe the difference in feeding methods between toothed and baleen whales.



Vocabulary

Study the vocabulary words and definitions below.

baleen whales	whales without teeth but with rows of whalebone plates that act as a sieve for feeding *Example*: blue whale
blowhole	opening located on the top of the head of whales and dolphins, used for obtaining oxygen
blubber	the fat of marine animals, which is used to keep the animal warm
echolocation	use of sounds to locate objects
endangered	in danger of extinction due to natural or manmade factors
flippers	front limbs of dolphins, other whales, and seals; used for balancing and steering
fluke	tail fin of whales, including dolphins
melon	fatty area on the forehead of whales, including dolphins, that controls the reception of pulses and echolocation
moratorium	a legal ban; a legally authorized period of delay
toothed whales	whales which have teeth *Examples*: sperm whale, dolphin

Introduction: Marine Mammals—Back to the Sea

All mammals share certain traits. They breathe air, nurse their young, have backbones, body hair, and are warm-blooded. Marine mammals, however, evolved from being land-based animals to living totally or partially in aquatic (water) environments. The legs of land-based mammals have been replaced by **flippers** in most marine mammals. Marine mammals have developed streamlined bodies for swimming, spongy bones for buoyancy, and layers of body fat (**blubber**) to provide insulation against low temperatures. They have also developed adaptations to help them see, breathe, and navigate in aquatic environments. One important difference distinguishes marine mammals from fish and other fully-developed aquatic organisms: Marine mammals are dependent on the oxygen in the atmosphere to breathe. To breathe, these mammals must surface for air. Other marine mammals such as polar bears, walruses, sea otters, and seals go ashore to breed and raise their young, returning to the ocean only to feed.

Marine mammals have developed streamlined bodies for swimming, and layers of body fat to provide insulation.

Many marine mammals such as whales, dolphins, and manatees never leave the water during their lifetime. They bear and nurse their young in the water. When the young mature, they breed, rest, and feed in the water.

All marine mammals share many similarities including their physical structures and aquatic habitat. Each, however, is adapted to its own special lifestyle and environment. For example, marine mammals that live in cold areas or deep water have developed layers of blubber for insulation, whereas marine mammals that live in warmer waters, such as the manatee, have not.

Classification of Marine Mammals

Cetaceans	Pinnipeds	Sirenians	Other Marine Mammals
toothed whales baleen whales roqual whales right whales gray whales dolphins porpoises	fur seals sea lions walruses true seals	manatees dugongs Steller's sea cow	sea otters (member of weasel family) polar bears (member of bear family)

Marine mammals that are predators or carnivores, such as the polar bear and killer whale, have developed speed, strength, and sharp teeth or claws to catch and kill prey. Marine mammals that are herbivores do not have the physical structures of their carnivorous relatives; instead they have grinding molars to break down plants.

Polar Bears: Living on the Ice

polar bear

The marine mammal that is most adapted to land is the polar bear, a member of the bear family (*Ursidae*). The polar bear lives on *ice floes* (pieces of floating ice) and on the shore in the north polar region. It has thick fur and a thick layer of blubber to keep out the arctic cold. The thick fur and blubber also help the polar bear to retain body heat.

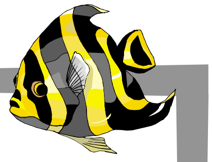
The polar bear is mainly a solitary animal and is adapted for living on the land. However, the polar bear occasionally will swim in the arctic waters to catch a seal. Seals are the favorite food of the polar bears. Polar bears are not fast swimmers. They usually catch their prey by stalking seals relaxing in the sun or when seals pop up through holes in the ice.

Sea Otters: Tool Users

Sea otters are the smallest marine mammals. They are closely related to the smaller river otters found in freshwater streams and are members of the weasel family (*Mustelidae*). Sea otters are commonly found in the giant kelp beds along the rocky California coast. They are carnivorous and can eat many different types of ocean creatures including sea urchins, shellfish, and other marine invertebrates.

sea otters

Sea otters spend much of their time in the oceans diving for food. They must eat constantly to survive. Sea otters are one of the few marine mammals to use “tools” to get their food. For example, when a sea otter eats an abalone, a type of shellfish with a hard exterior shell, its shell must be cracked open. Many sea otters do this while floating on their backs. They place the abalone shell on their stomachs and use a rock to whack the abalone shell until it opens.



Bradycardia: Surviving Long Periods without Oxygen

In order to live, all mammals must breathe and our hearts must pump blood throughout our bodies. These processes carry oxygen to our tissues and remove the waste, carbon dioxide. Any interruption of breathing or circulation threatens our life. Not *all* of the tissues of an animal need to be continuously supplied with fresh oxygen. Most parts of the human body can, and often do, survive *asphyxia* (too little oxygen). The kidney can survive without circulation for a similar period. And a transplanted cornea can survive for many hours. The heart and brain, however, are extremely sensitive to asphyxia. Suffocation and heart failure kill a human within a few minutes, and the brain may suffer irreversible damage if its circulation ceases for more than five minutes.

Time of Breath Hold and Depth of Dive

Marine Mammal	**Maximum Breath Hold** (minutes)	**Depth** (meters)
sea otter	4-5	55
porpoise	6	305
dolphin	8	650
killer whale	10	30-60
manatee	20	10-16
sea lion	30	168
true seal	73	575
sperm whale	90	2,200

Marine mammals often dive and remain underwater for periods far longer than five minutes. So how do marine mammals avoid these problems during their very long dives? The simplest explanation would be that diving animals have a large capacity for storing oxygen. But examinations of marine mammals have found that their lungs are not unusually large. Scientists have found, however, that every animal studied exhibits *bradycardia*: a slowing of the heartbeat when the animal is submerged. In addition to slowing down their heartbeat when they dive, marine mammals also close down circulation to many of their body parts while maintaining circulation to the heart and brain. Typically, during a dive, their bodies greatly reduce the blood supply to their muscles, intestines, and parts of their lower bodies.

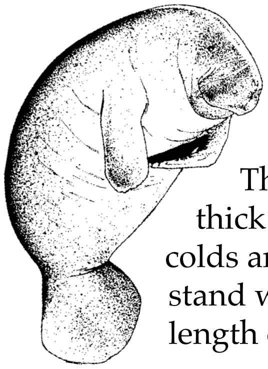
Manatees: The Gentle Giant


Courtesy of Pat Rose and Save the Manatee Club

The West Indian manatee, a large, gray-brown aquatic mammal, is known for its gentle nature. The manatee population in the United States is concentrated primarily in Florida. During the winter months in Florida the manatees come to the springfed coastal areas to feed and keep warm. In Florida, manatees can be found in the St. Johns, Suwannee, Crystal, Homasassa, Manatee, Indian, and Wakulla rivers, as well as Blue Springs and other waters and bays along the coast. Little is known about the manatee's ocean migration during the summer.

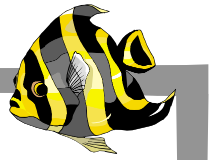
Anatomy

Manatees look like a gray blimp with a small head and a square snout (nose) with upper lip. The manatee's split lip lets it move each lip separately while tearing off bits of plants to eat. They have an endless supply of molars known as *marching molars*. The molars form in the rear, with six to seven on each side of the jaw and move forward. As older molars in front become worn, they fall out and are replaced by new teeth in the back. The molars are worn down by what the manatee eats—abrasive plants that are often mixed with sand.



The average manatee is about 10 feet long and weighs about 800-1,200 pounds. Large manatees have been known to exceed lengths of 13 feet and weigh over 3,500 pounds. Females are generally larger than males. The manatee's skin is about two inches thick—not quite thick enough to keep out cold. Consequently, manatees catch colds and pneumonia very easily. Manatees seem unable to stand water temperatures below 65 degrees Fahrenheit for any length of time and often die when severe cold spells occur.

The front limbs of manatees are paddle-shaped flippers. Manatees do not have hind limbs but have a fan-shaped tail. They nave no external ears and have very small eyes.



Feeding Habits

Manatees are herbivores, feeding on submerged, emergent, and floating plants. They feed mainly at night but will sometimes graze during the day. On average, manatees return to the surface every three to four minutes. However, manatees can stay underwater for up to 20 minutes. Some of their favorite foods include turtle grass, widgeon grass, and shoal grass—all of which are marine vegetation. Manatees also have favorite freshwater plants such as water hyacinths and water lettuce. Manatees eat about 10 to 15 percent of their body weight daily. Therefore, a 1,000 pound manatee would eat between 100 to 150 pounds a day.

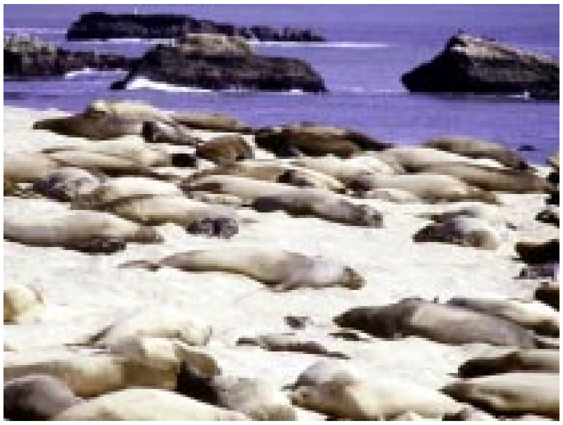
Terminology, Longevity, and the Law

Manatees live a maximum of 50 to 60 years. They belong to the class Mammalia and the order *Sirenia*. Manatees have become **endangered** because poachers once killed them for their meat and skin. Manatees are also killed by motorboats, cold water, and red tides. Many of the manatee's coastal feeding areas are in danger of destruction by dredging, runoff, and herbicide spraying. This coastal destruction is reducing the manatee populations and threatening its survival. It has been estimated that the manatee population in Florida today is about 3,280.

Federal and State Protection Laws	
Marine Mammal Protection Act of 1972	Provides protection for manatee and other marine mammals; includes restrictions on products derived from these animals. Penalty - one year in prison and/or fine up to $50,000
Endangered Species Act of 1973	States that it is illegal to kill, hunt, collect, harass, harm, pursue, shoot, trap, wound, or capture a member of an endangered species. Penalty - one year in prison and/or fine up to $50,000
Florida Manatee Sanctuary Act of 1978	Established all of Florida as a sanctuary for manatees. Slow and idle speed zones may be established in Florida waterways to protect these animals from boat injuries. Penalty - 60 days in prison and/or fine of $500

State and federal laws have been passed to protect manatees. The Endangered Species Act of 1973 and the Marine Mammal Protection Act of 1972 are federal laws which protect manatees. The Florida Manatee Sanctuary Act of 1978 is a state law in Florida.

Seals and Sea Lions: Escaping Extinction



Seals spend much of their time on rocky beaches.

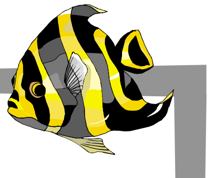
Seals and sea lions inhabit a broad range of climates from the tropics to the polar seas. Seals and sea lions are not common to the Florida coasts and waters but are common along the California coasts and in polar areas. They spend much of their time out of water on rocky beaches, ice floes, and caves. They migrate long distances and then band together in large groups to breed. Human hunters, in search of the valuable fur and oil of the seal and sea lion, nearly hunted them to extinction. Under protection of some national governments, the seal and sea lion have survived. Seals and sea lion pups engage in mock battles, jousting chest to chest, weaving their necks, and nipping and barking. This playful behavior helps males prepare for battles they will engage in as adults. Victorious bulls will mate with females to produce strong offspring.

Anatomy

All four limbs of the seal and sea lion have developed into *flippers*. Sea lions rotate their hind flippers under their bodies so they can "gallop" along on all four flippers. Seals "hump" along, undulating their bodies like caterpillars and pushing with their front flippers. Seals have a more streamlined body than sea lions and are able to swim like fish. Both sea lion and seals have a thick layer of *blubber* between their skin and muscles. This layer of blubber helps them to withstand the cold polar waters. The blubber can also be used for a source of reserve energy, buoyancy, and padding.

Seals and sea lions have large eyes with thick, curved lenses, making them nearsighted on land but able to see well underwater. These mammals also have good hearing.

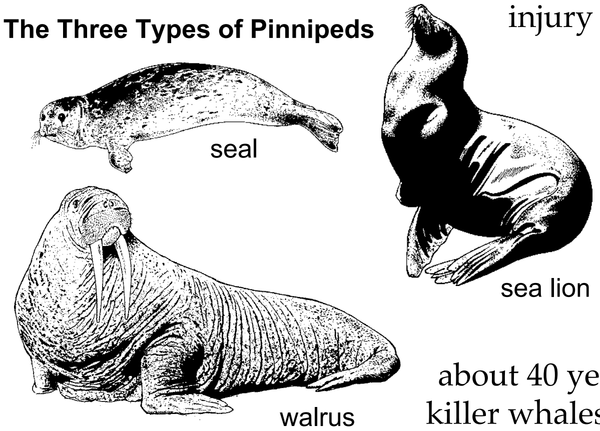
Seals have no ear flaps but only ear holes, which adds to their streamlined bodies. Sea lions have small ear flaps, similar to those of land mammals. The nose of seals and sea lions is on the front of their snout and not on the top of the head.



Feeding Habits

The diet of seals and sea lions consists of fish and squid. Their teeth are adapted for grasping and tearing, not chewing. Sea lions practice tossing and catching pebbles in their mouths. This skill helps them to catch fish and swallow them head first, avoiding injury from spines and scales.

The Three Types of Pinnipeds



Longevity and Terminology

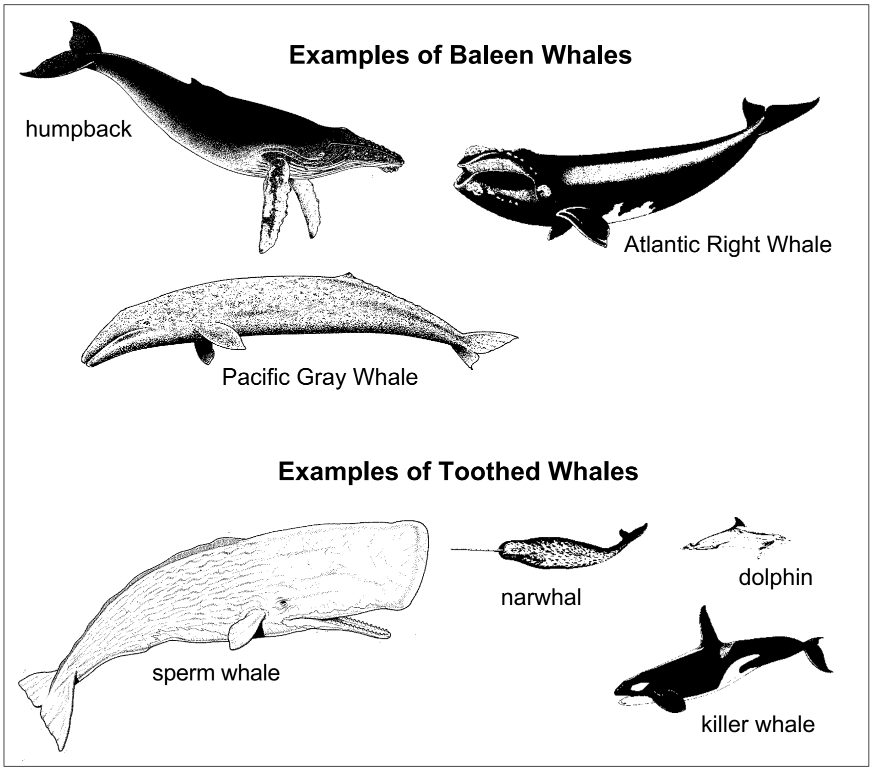
Seals and sea lions belong in the class Mammalia and the suborder *Pinnipedia*. Pinnipedia means "flipper footed." Pinnipeds live for about 40 years. Their enemies include man, killer whales, and polar bears.

Whales: Baleen and Toothed

Whales belong to the class Mammalia and the order *Cetacea*. Whales are divided into two groups—whales that have teeth and whales that do not have teeth. Whales that do not have teeth are called **baleen whales**. Instead of teeth, they have a row of whalebone plates attached to their mouths that function like a sieve. During the summer, baleen whales travel to polar regions to feed on the abundant, small shrimp-like organisms called krill. During the other seasons, baleen whales roam the oceans feeding on krill and plankton. The largest baleen whale, the blue whale, may gather three tons of krill a day! The blue whale is the largest animal to have ever lived and may be longer than any dinosaur. Baleen whales are very gentle, slow-moving animals. They do not chase their food but cruise through the open ocean waters water with their mouths open, allowing the baleen plates to collect the krill and plankton like a sieve.

Toothed whales are whales that have small teeth to help them catch fish and other small marine animals for food. The sperm whale is the largest toothed whale, growing to 60 feet in length. The head of the sperm whale is squarish in shape and contains an abundance of oil. Hunters once hunted the sperm whale to near extinction for the oil supply in its head. The well-known fictional sperm whale Moby Dick was hunted by the peg-legged Captain Ahab in Herman Melville's novel *Moby Dick*.

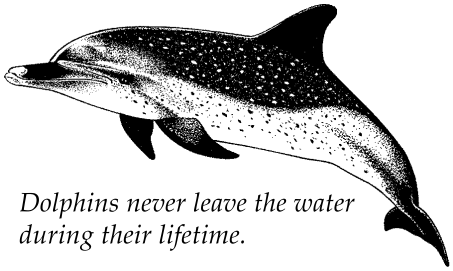
Toothed whales have very good hearing and produce high frequency clicking noises to communicate with other members of their group or pod. Toothed whales also use clicking noises to find prey and to judge distances and speed. Killer whales, another toothed whale, are black and white in color and feed mainly on fish, seals, sea lions, sharks, squid, and penguins. Killer whales are not known to feed on humans.



Dolphins: The Gentle and Social Creatures of the Sea

Dolphins are toothed whales found in all oceans and in some rivers and lakes around the world. They are also common to Florida waters. They exhibit highly intelligent behavior.

Dolphin Anatomy

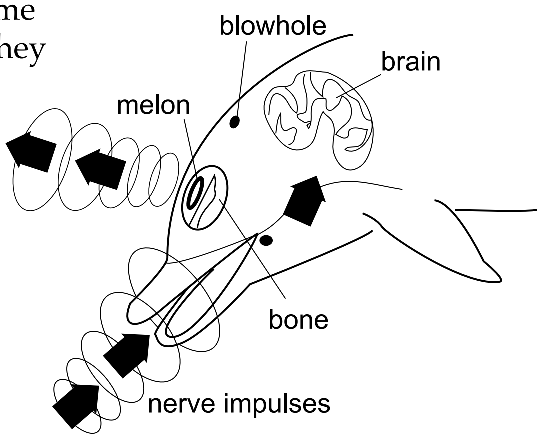


Dolphins never leave the water during their lifetime.

Because dolphins do not have sweat glands, they must rely on the water to act as a cooling system for their bodies. Consequently, when dolphins are stranded or beached out of water, their body heat will cause them to die. Although dolphins have no ears, they have a very keen sense of hearing. They depend mostly on **echolocation** to detect objects or prey. They have no sense of smell, even though they have a single opening called a **blowhole** located on the top of the head. The blowhole is connected to the dolphin's lungs. The dolphin's mouth does not connect to the lungs but leads directly to the stomach.

Dolphins have a **fluke**, or tail fin, which propels them through the water. They use their front limbs, or flippers, for balancing and steering. Dolphins also have a small fin on the back—the dorsal fin.

Echolocation: Using Sound to See



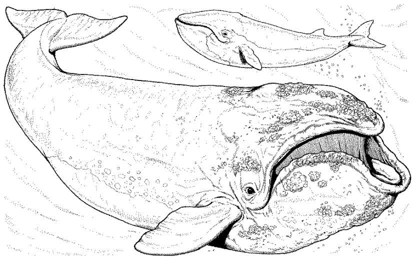
Dolphins use echolocation to become familar with their surroundings. They produce sounds such as whistles, squawks, and clicks through the **melon**, a fatty area on their forehead. The melon contains fat tissue which can change in shape, allowing the dolphin to control the sound emitted. They emit these echolocation sounds in pulses to focus on surrounding objects. They emit lower frequencies to get a general picture of their surroundings. To focus in on a specific object they've found, they use higher frequencies. These sound pulses bounce off objects, and dolphins then "feel" the rebounding sound through their lower jaw. The vibration is then transmitted from the lower jaw to the brain. Echolocation enables dolphins to find food such as fish, octopus, and squid—which they swallow whole, usually head first. A dolphin's echolocation is so exact that dolphins can find half a vitamin pill on the bottom of a pool while blindfolded.

Terminology, Longevity, and the Law

Dolphins belong to the class Mammalia and the order *Cetacea*. The longevity or life span of the dolphin varies between species. The Atlantic bottle-nosed dolphin can reach an age of 25 years or more. Dolphins are protected by the Marine Mammal Protection Act of 1972 (see page 380). The act protects dolphins from being molested by anyone in the United States and provides a **moratorium**, or ban, on capturing and importing marine mammals and marine mammal products.

Summary

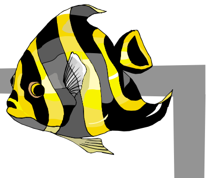
Marine mammals share certain traits with land-based mammals. Both breathe air, nurse young, have backbones, grow body hair, and are warm-blooded. Marine mammals, however, have adapted to their aquatic environments. They have developed flippers and buoyancy to swim, and *blubber* for warmth.



To survive lengthy dives, marine mammals are capable of *bradycardia*: a slowing of the heart action when the animal is submerged. This trait enables them to remain underwater far longer than a land-based mammal could on the same volume of air.

Notable marine mammals include manatees, dolphins, seals and sea lions, and whales. Manatees are gentle giants that look like gray blimps. In the United States, they are concentrated primarily in Florida. Poachers and motorboats have endangered the manatee and created the need for its protection under law. Seals and sea lions have also been hunted to near extinction. Their valuable fur and oil have made them attractive prey for hunters.

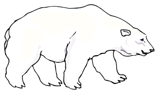
Whales, the largest of the marine mammals, are divided into two groups: those with teeth and those without teeth. *Toothed whales* use their teeth to catch fish and other small marine animals for food. Dolphins—also toothed whales—use *echolocation* to map their surroundings. They emit whistles, squawks, and clicks, and then *read* these sounds as they bounce off surrounding objects. The largest toothed whale—the sperm whale can grow to 60 feet in length. Those whales without teeth, *baleen whales*, swim the ocean with their mouths open, as they collect krill and plankton with their rows of whalebone plates acting like a sieve.



Practice

Use this unit and other references to find the **favorite food(s)** *and* **habitat(s)** *of these* **marine mammals***. Write* **all** *letters that apply on the line provided.*

__________ 1.

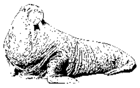


polar bear

__________ 2.

manatee

__________ 3.

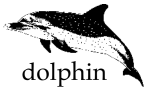


walrus

__________ 4.

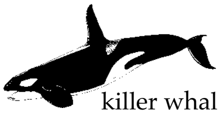
sea otter

__________ 5.



dolphin

__________ 6.

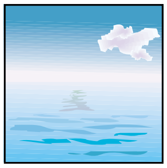


killer whale

A.

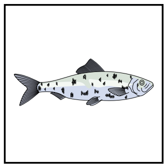
coastal cliffs

B.



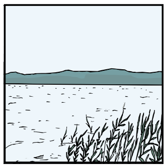
deep sea water

C.



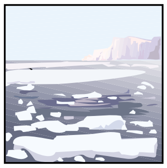
fish

D.



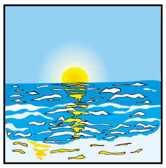
grassbeds

E.



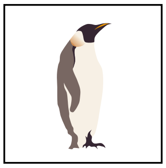
ice packs, icebergs

F.



open water

G.

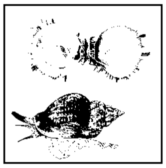


penguins

H.

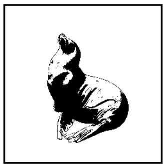
shallow, warm

I.

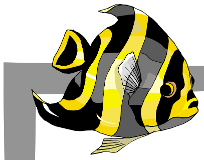


shellfish, oysters

J.



seals



Practice

Use this unit and reference books to answer the following using short answers.

1. What is *echolocation*? ____

   ____

2. What is *bradycardia*?____

   ____

3. Why were seals and sea lions nearly hunted to extinction? ________

   ____

4. Into what two groups are whales divided? _____________________

   ____

5. Why and how are manatees protected? ________________________

   ____

   ____

   ____

6. How does the layer of blubber under the skin of seals help them?

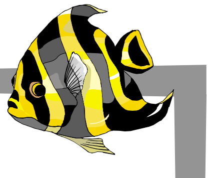
   ____

   ____

7. How will the playful behavior of sea lion and seal pups be used as adults?____

   ____

   ____



Practice

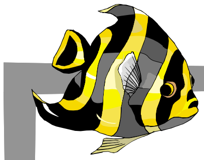
In this activity, you will use your math skills to **calculate feeding rates of whales** *and* **compare** *this to the* **feeding rates of humans**. *Show all work. Place a* **box** *around your final answer.*

Conversion Information:

- A typical human weighs 150 pounds and takes in 3,000 calories a day.
- A typical whale weighs 50 tons and needs 395,000 calories a day.
- A whale may spend 15 hours a day feeding during the summer season.
- A whale can swim at speeds of 1.5 meters per second while feeding.
- A whale can open its mouth 1.5 square meters wide.
- Right whales feed where plankton densities (thickness) are 4,000 to 15,000 per cubic meters.

Problems:

1. How many **cubic meters** of water enter the **open** mouth of the whale each **minute** as it moves through the water at 1.5 meters per second? ____
2. How many plankton can a whale ingest **per second** if the density is 4,000 per cubic meter? ________________________________
3. How many plankton can a whale ingest **per second** if the density is 15,000 per cubic meter? ________________________________



4. How many plankton can a whale ingest **per minute** if the density is 4,000 per cubic meter? ____________________________________

5. If a whale ingests 500,000 calories **per day**, how many calories is it ingesting **per hour**? ______________________________________

6. If a whale ingest 500,000 calories **per day**, how many calories is it ingesting **per minute**? ____________________________________

7. Complete the following investigation. Tomorrow, keep track of your own food consumption. Complete the chart below with your results.

number of minutes you spent feeding	**number of calories ingested**	**number of calories ingested per minute**
______________	______________	______________

8. Compare your caloric intake per minute with that of a whale. Who has the higher caloric rate? ________________________________

9. What factors account for the difference in caloric intake? ________

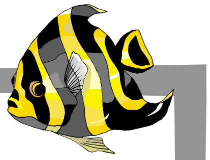
____

____

____

____

____

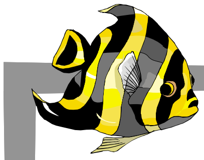


Practice

Use this unit and other reference books to complete the chart below. List the **characteristics** *of each of the* **marine mammals** *in a few words or phrases.*

Comparison of Marine Mammals

Mammal	Mammal Characteristics					
	nostrils	special features	appendages	diet	enemies	habitat
baleen whales						
sperm whales						
dolphins						
seals						
sea lions						
manatees						
walruses						
polar bears						
sea otters						



Lab Activity 1: Observing Dolphins

Investigate:

- Observe dolphins and record data on eating, swimming, and breathing habits.

Materials:

- pencil
- paper
- video or laser disc

Procedure:

Observe a dolphin in an aquarium, in the wild, or on a video or laser disc.

Analysis:

1. Where did you observe the dolphin? ____________________________

   ____

2. What kind of dolphin was it? __________________________________

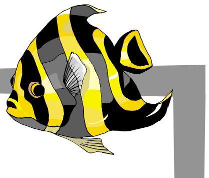
3. Describe its shape and color. __________________________________

   ____

4. When is the blowhole open? ___________________________________

5. When is the blowhole closed? __________________________________

6. Count the number of times the blowhole opens and closes. How many times does the dolphin breathe per minute? _______________



7. Watch the dolphin swim. How does its streamlined shape affect its speed? ______________________________

____

____

____

8. Is the movement of the dolphin's fluke vertical or horizontal? How does this direction of movement help the dolphin? __________

____

____

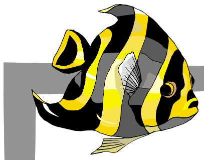
____

9. Watch the front flipper's movement as the dolphin swims. What is the function of the front flippers? ____________________

____

____

____



Lab Activity 2: Marine Mammal Population

Investigate:

- Investigate how hunting has affected the populations of marine mammals and study specific laws that protect marine mammals.

Materials:

- reference books
- pencil
- paper
- video programs

Procedure:

1. Research a marine mammal of your choice.
2. Present your research in a poster presentation or a video presentation.

Analysis:

1. How has hunting affected the species' population? ________________

   ____

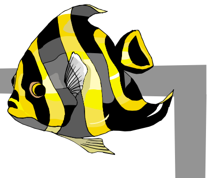
2. Is the selected species considered endangered? ____________________

3. Which laws protect this species? ________________________________

   ____

   ____

   ____



Lab Activity 3: Bradycardia

Investigate:

- See if humans show the same diving responses as marine animals.

Materials:

- dish pan
- towels
- cold tap water
- stopwatch or watch with a second hand

Procedure:

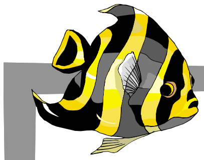
1. Work in pairs. Record all data as you collect it on the data chart. Sit quietly for two minutes. During this time, your partner can practice taking your pulse. After the two-minute rest, have your partner count the pulse for 15 seconds. Multiply this number by four to find the number of heart beats per minute and record this figure on your chart. Repeat the above twice more, and determine the average for the three trials.

2. Rest for two minutes.

3. After the rest, practice holding your breath for 35-second periods without activity. Rest for one minute between trials.

4. While holding your breath for 35 seconds, have your partner count your pulse the *last 15 seconds of the 35-second period*. Rest and repeat twice more, and determine the average of the three trials.

5. *Practice* holding your breath with your face in the pan of cold water for 35 seconds. Submerge your face up to your ears. Have towels ready. When you have your self-confidence established and can do it without excitement, you are ready for the next test.



6. With your face in the water up to your ears, have your pulse measured the *last 15 seconds of the 35-second period*. Repeat twice more and determine an average for the three trials, as before. Rest briefly and catch your breath before proceeding to the next procedure.

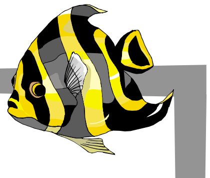
7. Exercise strenuously for two minutes (run in place, do push-ups, sit-ups, jumping jacks). Have your partner determine your pulse *immediately*. Record the beats per minute on the data chart. Repeat step 2 twice more and determine the average rate for the three trials.

8. Empty and rinse the pan when finished. Assist your partner; repeat the experiment and collect the data.

9. Clean up the counters, floor, sinks, and spread the towels out to dry.

Bradycardia Experiment

Activity	**Pulse Measurements in Beats per Minute**				
	resting	**1st trial**	**2nd trial**	**3rd trial**	**average**
1. Hold breath for 35 seconds; check the last 15 seconds.					
2. Hold face in cold water for 35 seconds; check pulse the last 15 seconds.					
3. Immediately after two minutes of strenuous exercise, check the pulse again.					



Lab Activity 4: Whale Migrations

Investigate:

- Use mapping skills to plot the migration patterns of four unknown whales. After studying the plotted migrations, determine the sex and age of the whales.

Materials:

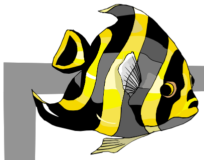
- map with coordinates of the east coast of the United States
- whale migration data
- colored pencils

Procedure:

1. Read the background information to obtain working knowledge about whale migration.
2. Using the *latitude* and *longitude* coordinates from the data chart, plot the migrations of each of the four whales. Plot each whale's migration in a different color. Be sure to include a map legend explaining the color key for each whale.
3. Mark each coordinate on the map with a solid triangle pointed downward for the trip south. Use an open triangle pointed upward for the trip back north.

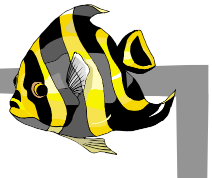
Background information:

Some whales spend the spring off the coast of New England, where they eat plenty of plankton. In the early summer, they head north to breeding and nursery area in the Bay of Fundy and in areas south of Nova Scotia. In the winter, some of the adult females migrate to the coastal waters off the southeastern United States. They particularly like the shallow waters from Savannah, Georgia southward to Cape Canaveral, Florida. Very few juveniles or males migrate to this region. Often, females are alone early in the season. They give birth to their calves and then move back north. Scientist believe that most births occur between December and March. This is the only known calving area for some whales, and it is unknown where the nonpregnant females go.

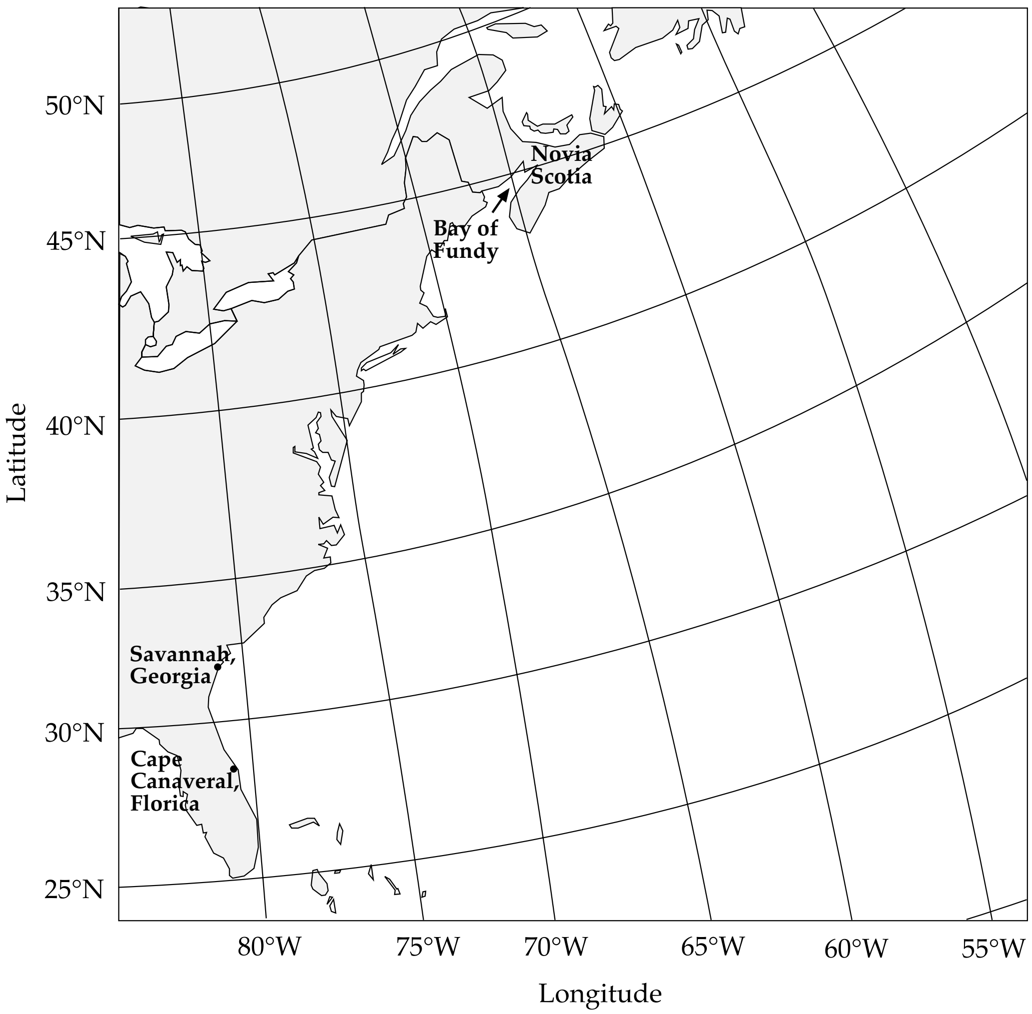


Data

Whale #1			Whale #2			Whale #3			Whale #4	
Date	Lat/Long		Date	Lat/Long		Date	Lat/Long		Date	Lat/Long
6 - 01	45/66		6 - 02	45/66		6 - 03	45/66		12 - 02	31/80
6 - 21	44/66		6 - 21	44/66		6 - 21	44/66		12 - 24	30/80
7 - 04	43/69		7 - 03	45/67		7 - 25	43/69		1 - 05	30/81
7 - 25	40/72		7 - 27	44/67		8 - 28	42/70		2 - 28	32/80
8 - 19	39/73		8 - 06	43/67		9 - 07	40/72		3 - 07	34/77
9 - 25	38/74		8 - 31	42/67		9 - 12	37/43		3 - 17	36/75
10 - 25	34/76		9 - 05	42/64		9 - 14	37/47		4 - 01	39/74
11 - 03	33/79		5 - 02	43/67		10 - 05	34/76		4 - 04	41/70
11 - 07	32/80		5 - 18	44/66		1 - 31	31/80		5 - 01	42/69
11 - 19	31/80		5 - 20	45/67		2 - 12	32/78		5 - 20	44/68
12 - 23	1/81		2 - 19	34/75		5 - 25	45/67			
12 - 24	30/80		3 - 17	36/73						
1 - 05	30/81		4 - 02	40/72						
2 - 28	32/80		5 - 15	43/69						
3 - 07	34/77		5 - 18	42/68						
3 - 17	36/75		5 - 21	44/69						
4 - 01	39/74		5 - 25	45/66						
4 - 04	41/70									
5 - 01	42/69									
5 - 20	44/68									
5 - 25	45/67									



Sighting Map



Analysis:

1. State if each whale was male or female.

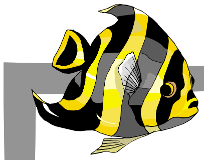
   whale 1: ________________ ; whale 2: ________________ ;

   whale 3: ________________ ; whale 4: ________________

2. State a logical reason as to how you determined the sex of each whale.

   whale 1: ____

   ____



whale 2: ____

____

whale 3: ____

____

whale 4: ____

____

3. State if each whale is less than one year old, a juvenile,

   or an adult. whale 1: ______________ ; whale 2: ______________ ;

   whale 3: ______________ ; whale 4: ______________

4. State a logical reason as to how you determined the age of

   each whale.

   whale 1: ____

   ____

   whale 2: ____

   ____

   whale 3: ____

   ____

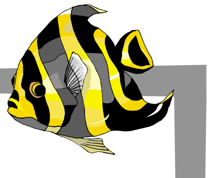
   whale 4: ____

   ____

5. What benefit does this journey provide for each whale?

   whale 1: ____

   whale 2: ____



whale 3: ____

whale 4: ____

6. What are some of the hazards the whales may encounter during their migrations? ______________________________________

____

7. List the areas within the routes that cause greater risks to the whales. ____

____

8. Determine the average distance traveled between sightings for each whale. Round to nearest hundredth.

whale 1: ____

____

whale 2: ____

____

whale 3: ____

____

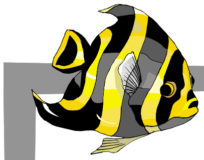
whale 4: ____

____

9. Determine the average traveling speed for each whale. Round to nearest hundredth.

whale 1: _______________ ; whale 2: _______________ ;

whale 3: _______________ ; whale 4: _______________



Practice

Use the list below to write the correct term for each definition on the line provided.

baleen whales
blowhole
blubber
echolocation
endangered
flippers
fluke
melon
moratorium
toothed whales

________________________ 1. whales which have teeth
Examples: sperm whale, dolphin

________________________ 2. opening located on the top of the head of whales and dolphins, used for obtaining oxygen

________________________ 3. whales without teeth but with rows of whalebone plates that act as a sieve for feeding
Example: blue whale

________________________ 4. a legal ban; a legally authorized period of delay

________________________ 5. front limbs of dolphins, other whales, and seals; used for balancing and steering

________________________ 6. fatty areas on the forehead of whales, including dolphins, that controls the reception of pulses and echolocation

________________________ 7. the fat of marine animals, which is used to keep the animal warm

________________________ 8. tail fin of whales, including dolphins

________________________ 9. use of sounds to locate objects

________________________ 10. in danger of extinction due to natural or manmade factors

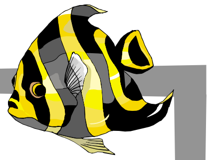
Unit 17: Marine Pollution

Unit Focus

This unit provides students with an overview of the impact of sewage pollution, toxic chemicals, and solid wastes on the marine environment. Students will also have a better understanding of the importance of clean waters to marine organisms.

Student Goals

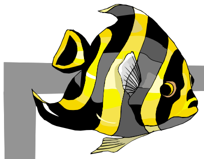
1. Identify types of marine pollution.
2. Explain the difference between point-source and nonpoint-source pollutants.
3. Describe the effects of pollution on the marine environment and how this impacts humans.
4. Describe efforts to cut down on marine pollution.



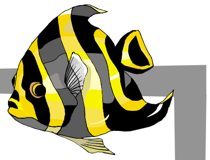
Vocabulary

Study the vocabulary words and definitions below.

acid rain	rain containing substances harmful to the environment
biodegradable	capable of being decomposed by biological agents, especially bacteria
contamination	corruption, pollution, infection; making impure by contact or mixture
dispersant	a substance used to drive off or scatter another substance
mechanical containment	a method used to control oil spills by placing booms around the spill to prevent the movement or spreading of the oil
nonpoint-source pollutant	pollution that does *not* come directly from one source *Example*: surface-water runoff, acid rain
oxidation	the combination of a substance with oxygen or other compounds, involving the loss of electrons
PCBs	stands for *polychlorinated biphenyls*, a group of persistent and toxic chemicals used in transformers and capacitors; banned in the United States since 1979
pesticides	chemicals used to destroy insects



point-source pollutant	pollution that comes directly from a source *Example*: raw sewage from a sewage pipe
pollutant	something that causes contamination, especially a waste material that contaminates air, soil, or water
raw sewage	untreated liquid and solid waste usually carried off in sewers or drains
thermal pollution	an artificial increase or decrease in water temperature that disturbs marine life



Introduction: Marine Pollution—The Hazards of Producing Waste

Our oceans are so deep and broad that they may seem to go on forever. Perhaps this sense that beyond the horizon the ocean goes on and on endlessly has permitted us to be less aware and concerned about the waste we dump into it. But now we have reached a critical point: The sewage and other **pollutants** we have dumped in the ocean—intentionally and unintentionally—have threatened the balance of life in many marine environments. The question of what to do with our pollutants and how to safeguard against oil-tanker or chemical spills will not go away. But becoming aware of the pollutants and their effects is a good first step toward keeping cities and industries from further damaging our marine environments.

Our rivers, lakes, and other bodies of water do have certain natural properties that help in eliminating pollutants. In one process, bacteria that live in water break down organic wastes. In another process, *nonacidic* (basic) substances in water neutralize destructive acids that fall to Earth in rain and snow. Sunlight penetrating the water also helps to break down certain compounds. And some wastes are destroyed by the simple process of **oxidation**, or being exposed to the oxygen present in water (H_20) and the atmosphere.

Typical Water Pollutants

Pesticides	Chemicals	Radioactive Waste
DDT 2–4 D	acids ammonia arsenic chlorides phosphates dyes hydrogen sulfide lead mercury nitrates tars urea zinc	radium 226 strontium 90

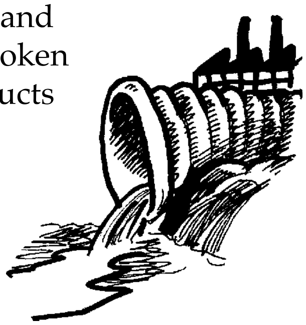
There are, however, limits to the waters' natural purifying properties. If too much waste is dumped into or enters the water, the natural purifying systems become overloaded and cannot break down the pollutants fast enough. This occurs, for example, when too much **raw sewage** enters the marine system. From feeding on the increasing amount of raw sewage, or organic waste, bacteria multiply and begin consuming more and more oxygen. The oxygen level drops and leaves fish and other marine organism starving for air. When the oxygen level in water can no longer support life, we call the water *dead.*

Marine Pollution Generated by Our Homes, Industry, and Agriculture

People create sewage during their day-to-day living. They create *raw sewage* when they drain water down sinks, bathtubs, and washing machines, and when they flush waste down toilets. The waste from these daily activities includes soaps, detergents, and human excrement. Other examples of *raw* sewage include rainwater and even melted snow runoff from streets. These forms of raw sewage carry soil particles, leaves, and other litter to marine environments. As you can see from this brief list, marine environments have to purify millions upon millions of gallons of water to keep pace with our waste production.

In addition to these pollutants, consider those produced by our industrial and agriculture practices. Many modern industries dump pollutants that are not **biodegradable** into oceans and estuaries. *Nonbiodegradable* pollutants cannot be broken down by the waters' natural systems. Plastic products are a common example of a nonbiodegradable pollutant people dump into marine systems. The plastics will remain unchanged for hundreds of years.

Another example of nonbiodegradable pollutants are some **pesticides**, which can become concentrated in bodies or organisms and cause a threat to organisms and to those who eat them.



Industry dumps thousands of different chemicals directly into the marine environment.

Agriculture and industrial production also create *chemical* pollutants. These pollutants often end up fouling our marine environments. For example, fertilizers and pesticides from agriculture production get washed into our water system. And industry dumps thousands of different chemicals directly into the marine environment. Other wastes from industry enter the marine environment through the air in the form of **acid rain**, which falls on and pollutes the water environments.

Industry also releases heated or cooled water into the waterways, a type of pollution known as **thermal pollution**. Other sources of marine pollution include surface and underground mining operations that produce heavy metals. Uranium mines and nuclear power plants create dangerous radioactive pollutants that take hundreds of years to break down. In addition, ships often pollute the ocean. They spill oil into waterways, either accidentally or by flushing their holds. The oil then clogs the gills of fish and damages the feathers of marine birds and the fur of mammals.


The oil spilled damages the feathers of marine birds.

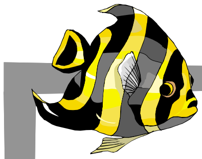
A major source of marine pollution comes from dredged material from rivers, harbors, and channels. These areas must be dredged periodically to keep them clear of sand buildup so ships can navigate these waterways. The dredged material that is hauled out to sea for disposal contains sediment that has absorbed heavy metals, grease, pesticides, and polychlorinated biphenyls (**PCBs**).

Point- and Nonpoint-Source Pollutants: Tracing Pollution

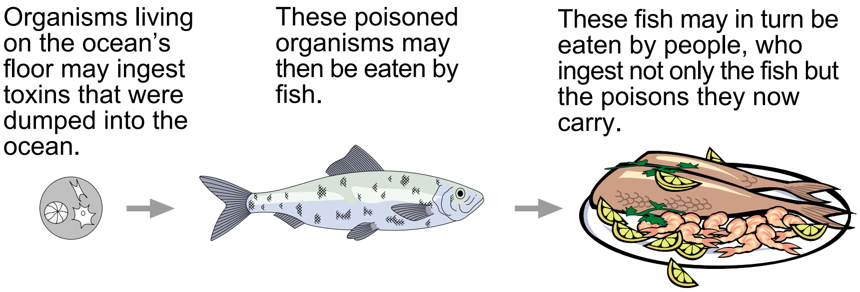
Pollutants that come directly from a single source are called **point-source pollutants**. Examples of point-source pollutants are wastes carried from a factory or sewage plant into a waterway. Pollutants that have been washed into waterways or that seep into groundwater are **nonpoint-source pollutants**. Surface-water runoff is an example of a nonpoint-source pollutant. Since nonpoint-source pollutants have no single source, it is nearly impossible to trace them back to the persons or organizations responsible for them.

Effects of Marine Pollution

Different pollutants create different effects on the marine environment. Some pollutants will choke the ocean of necessary oxygen and starve many marine organisms over a long period of time. Other pollutants have more immediate consequences. The *chemical* pollutant *dioxin* is a very toxic substance that kills mosquito minnows at concentrations of one drop per 1,000,000,000,000 drops of water! And other chemicals released into the marine environment become even more dangerous *after* they break down into toxic and cancer-causing substances.



Some poisons in the marine environment can travel through food chains and webs. So, for example, organisms living on the ocean's floor may ingest toxins; these poisoned organisms may then be eaten by fish. These fish may in turn be eaten by people, who ingest not only the fish but the poisons they now carry. As you can see, no matter how inconsequential or far away the marine environment may seem, what happens in the ocean and other waterways creates ripple effects that travel quite far.



Human Health: Polluting Ourselves

People become sick by drinking contaminated water, inhaling disease-causing organisms, or by being exposed to contaminants at beaches or pools. Waterborne illnesses are most common where living conditions are poor and water purification is not available. The most serious illnesses from poor water quality are cholera and typhoid fever. These diseases are spread through water or food that has been contaminated with the feces or urine of people with diseases. Cholera is caused by bacteria called *Vibiro*. When Vibiro bacteria is ingested, the victim suffers from diarrhea, vomiting, dehydration, and cramps. Typhoid fever is caused by the bacterium *Salmonella typhi*. Symptoms of this disease include fever, headache, and loss of appetite. If this disease is untreated, the victim may develop internal bleeding. Another disease transmitted by water **contamination** is hepatitis A, a viral disease causing inflammation of the liver.

People often ingest dangerous chemicals when they eat contaminated fish or shellfish. In the 1970s, large amounts of PCBs used in the making of electrical appliances were released in the marine environment in the Hudson River area. The PCBs accumulated in the tissues of fish, some of which were eaten by humans. The PCBs caused liver damage and cancer in many who ate the contaminated fish.

The Health of Marine Life: Damaged by Human Hands

Sewage and fertilizers cause tremendous algae blooms in the marine environment. If algae blooms deplete too much oxygen from the water, much of the marine life will die and beaches will become polluted. Some communities used to dump millions of gallons of sewage into the oceans each day. Today, this practice has been outlawed in the United States.

Pollution by people can harm marine organisms in other ways, too. The pH of water is very important to the health of organisms in marine communities. Acid rain lowers the pH of seawater, often to a level that weakens or deforms fish and other organisms. Suspended sediment from dredging harbor floors can limit light penetration, thereby interfering with plant photosynthesis. Other pollutants in the marine environment, such as plastics, cause animals to starve and strangle. Turtles and seabirds often eat plastic bags and other plastic trash, mistaking them for prey. The animals then starve because the plastic prevents them from digesting real food. In addition, birds become trapped or tangled in plastic six-pack rings and can strangle to death.

Thermal Pollution: Changing Temperatures

Power plants release large amounts of heated water into the marine environment. This water is not changed chemically but is used as a cooling agent to absorb the heat created during the power plant process. When the heated water is released into bays or estuaries, the natural water temperature rises, causing *thermal pollution*. Raising the water temperature of the natural environment reduces the water's ability to absorb oxygen. Lower oxygen levels make it hard for the fish and other organisms to breathe. It also reduces the ability of bacteria to decompose wastes in the water. Higher water temperatures can interfere with the animals' ability to reproduce as well. It may also increase populations of plants and animals that are not native to the area. In Florida, manatees may remain in colder regions due to the warmth generated by power plant waste. When they move out to feed, they may catch cold in the surrounding waters.

When the heated water is released into bays or estuaries, the natural water temperature rises, causing thermal pollution.

Thermal pollution can be reduced by constructing high cooling towers to cool the water before releasing it into the environment. Pumping thermal water into ponds and allowing it to cool before being released into the ocean is also effective.

Oil Pollution: Catastrophes in the Ocean

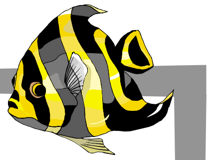
There has been pollution of the marine environments due to oil-tanker spills and offshore drilling accidents. One of the most familiar and tragic oil spills occurred on March 24, 1989, in Prince William Sound in the Gulf of Alaska. The oil tanker *Exxon Valdez* struck a reef in the sound and spilled about 11 million gallons of oil into the sound. The oil spill had a serious effect on the ecosystem, the inhabitants of the ecosystem, and the fishermen who depend on the area's waters for their livelihood. The remains of about 1,000 sea otters and 34,000 sea birds have been recovered. The less visible creatures affected by the oil spill were intertidal organisms such as starfish, sea urchins, and young embryonic fish. The exact number of animals who died as a result of the spill will never be determined.

Effect of Oil Spills

Oil spills cause catastrophic damage to marine organisms. An oil spill will affect every type of marine organism—bacteria, algae, zooplankton, fish, shellfish, birds, and mammals. Some of these marine organisms die immediately from exposure to oily water. Others die slowly or suffer from long-term problems. Clams, sea urchins, lobsters, starfish, and other benthic animals are destroyed by the oil that sinks and covers the ocean bottom. Sea birds landing on top of the oil slicks are soon covered with oil themselves.

With their feathers coated in oil, birds cannot fly and soon starve to death or die from exposure. Some birds, such as the bald eagle, die from the oil they ingest when they feed off of other animals covered in the oily mess.

With their feathers coated in oil, birds cannot fly and soon starve to death or die from exposure.



The oil digested by the eagles coats their intestines preventing the birds from absorbing water and nutrients. The eagles soon die of starvation and dehydration.

When a sea otter is exposed to oily waters, its fur soaks up the oil and loses its ability to keep the otter warm.

Sea otters do not have a thick layer of blubber; instead, they rely on their thick coat of fur for warmth. When a sea otter is exposed to oily waters, its fur soaks up the oil and loses its ability to keep the otter warm. Otters are also poisoned from oil they swallow as they groom their fur to rid it of the oil.

Cleanup Efforts

Cleaning up an oil spill is not as simple as mopping up spilt milk. Many factors such weather conditions, wave height and speed, the spill's distance from the shore, and the readiness of cleanup crews, determine the success or failure in containing an oil spill. Three of the most commonly used methods to clean up oil spills are **mechanical containment**, chemical dispersion, and burning.

Mechanical Containment

Oil can be contained or trapped in an area by placing floating booms in a ring around the oil. The oil, once it is contained, can then be pumped into storage tanks. Booms usually work best in calm waters and when they are put in position soon after the spill happens.

Chemical Dispersion

Dispersants are chemicals which break up the oil. The chemical dispersants, sprayed on the oil spill by planes and helicopters, separate the oil into tiny droplets, allowing the natural chemicals in the water to more easily break up the oil. Chemical dispersants can be used on large spills but must be applied quickly before the oil spreads.

Burning

If the oil in a spill is particularly thick, then burning may be the best method to rid the area of the spill. Burning, however, is only effective in the early stages of a spill. It also causes problems by introducing noxious chemical by-products into the atmosphere which may return as acid rain.

A Future Method

The use of oil-eating bacteria is the newest method of controlling oil spills, but this is still in the experimental stage.

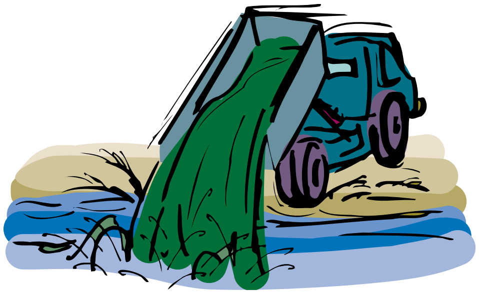
Prevention: Our Only Cure

Since the *Exxon Valdez* tragedy, many regulations have been proposed to prevent future oil spills. Environmentalists strongly promote requiring double-hulled tankers and barges that transport oil. Other suggestions designed to curb oil-spill disasters include better traffic control systems to guide tankers, drug and alcohol screening of ships' pilots, and requiring oil tankers to carry more oil-spill equipment on board.

Summary

The immensity of the oceans may have helped to create a careless attitude about dumping raw sewage and other pollutants in the Earth's waters. We have learned, however, that nonbiodegradable pollutants, both point-source and nonpoint-source, affect not only the health of marine life but also our own. Water has certain natural purifying properties that can reduce some pollutants, but these properties cannot purify all contaminated water.

Dumping hazardous wastes generated by our homes, industry, and agriculture into the marine environment must be regulated. Chemicals (fertilizers, pesticides), thermal pollution, dredging, PCBs, acid rain, and oil spills are some of the pollutants and sources that must be controlled by government regulations and education.



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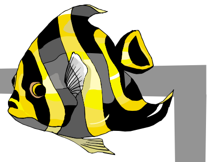


Practice

Use the list above each section to complete the statements in that section. **One or more terms will be used more than once *only* in the *second* section.**

Alaska
cholera
dispersants
Exxon Valdez
hepatitis A
nonbiodegradable
plastic
point-source
raw sewage
thermal
typhoid

1. ____________________ is untreated liquid and solid waste that is carried off in sewers or drains.

2. Pollution that comes straight from a single source is called ____________________ pollution.

3. ____________________ pollutants are those that cannot be broken down by the waters' natural biological systems.

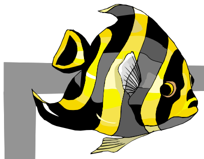
4. A common example of a nonbiodegradable pollutant is ____________________ .

5. One of the most familiar and tragic oil spills was that caused by the ____________________ and occurred in Prince William Sound in the Gulf of ____________________ in 1989.

6. Power plants release large amounts of heated water into the marine environment and cause ____________________ pollution.

7. ____________________ are chemicals which break up oil.

8. Ingesting contaminated water or food may cause diseases, including ____________________ , ____________________ , and ____________________ .



acid rain
bacteria
nonpoint-source
oxidation
PCBs
prevention
sunlight

9. Water cleanses itself naturally with ____________________ ,
____________________ , and ____________________ .

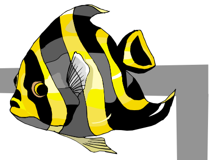
10. Dredged material hauled out to sea for disposal may contain sediment contaminated with ____________________ .

11. Acid rain is an example of a ____________________ pollutant.

12. ____________________ is the only way to cure marine pollution.

13. Eating fish contaminated with ____________________ may cause liver damage and cancer.

14. Industrial wastes in the air that fall as ____________________ pollute the water environment.



Practice

Answer the following using short answers.

1. What are four causes of marine pollution? ______________________

   ____

   ____

   ____

   ____

   ____

2. What are three animals affected by oil spills? ____________________

   ____

   How? ____

   ____

   ____

   ____

   ____

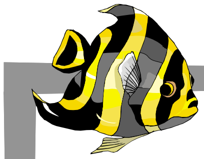
   ____

3. What are two ways environmentalists are working to prevent oil spills? ____

   ____

   ____

   ____



4. What are two ways water can cleanse itself naturally? ____________

____

____

____

____

5. What happens if too much raw sewage enters a marine environment? ______________________________________

____

____

6. What effect does *plastic* have on marine animals? ________________

____

____

7. How does *thermal pollution* affect the marine environment? _______

____

____

____

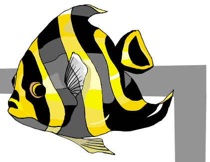
8. What is your role in preventing marine pollution? _______________

____

____

9. What is the newest method of controlling oil spills? ______________

____



Practice

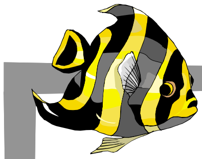
Read "How Laws are Made" below. On the following page, you will find four environmental problems to match with the law that was passed to solve it.

How Laws are Made

A member of Congress, in either the Senate or the House of Representatives, may introduce a bill. A bill is an idea for a law. First, a committee gathers information about the bill and debates whether it should become a law.

If the bill passes the committee, it is sent to either the Rules Committee in the Senate or the Rules Committee in the House of Representatives. Where the bill is sent is determined by which legislative branch originally introduced the bill, the Senate or the House. Next, the bill is debated by all the members of the House and the Senate. If the House and Senate pass different versions of the same bill, members of Congress will meet to work out the differences. Then, Congress votes on the new bill.

If the bill passes, it is sent to the President. The President can either sign it into law or veto the bill. The process of establishing new laws is sometimes long and difficult, *but* Congress has passed many laws to protect our environment.



Match each **problem** *with the correct* **law *and* description of the law** *that was passed to solve it. Write the letters on the line provided.*

	The Problem	The Law	What It Does
1.	Trash thrown off ships by people can litter beaches and harm sea animals.		
2.	Sea turtles population are so low that they could become extinct.		
3.	Polluted runoff can make drinking water and beaches unsafe.		
4.	Some dolphins and whales were being killed in fishing nets.		

Environmental Laws and Their Descriptions

A. Creates new programs to control runoff and other water pollution in their cities.

B. People can be fined $500,000 for throwing plastic and other trash into the ocean.

C. CWA: Clean Water Act. An important law to restore the good quality of our county's waters.

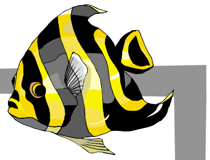
D. MPPRCA: Marine Plastic Pollution Research and Control Act. A law to keep plastic out of the ocean.

E. Shrimpers must use special gear in their nets to protect sea turtles from getting trapped.

F. MMPA: Marine Mammal Protection Act. This law works to protect whales and seals from harm.

G. Creates new programs to stop the accidental entanglement of whales and seals in fishing nets.

H. ESA: Endangered Species Act. This law works to protect animals and plants whose populations are low.



Lab Activity 1: An Oily Mess

Investigate:

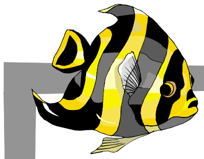
- Investigate how hard it is to clean up an oil spill.

Materials:

- 2 aluminum foil pie pans
- water
- used motor oil
- dropper
- cotton balls
- nylon string
- paper towels
- dishwashing liquid
- feather
- salt (optional)

Procedure:

1. Fill a pie pan half full with water.
2. Create an "oil spill" in the water by putting in five to 10 drops of oil. Observe the reaction of the water to the oil.
3. Create waves on the "ocean" in the pie pan by blowing on the water or moving the pie pan. Observe the water's movement.
4. Dip a feather into the "oil spill." Observe the effect of the oil on the feather.
5. Which material—cotton ball, nylon string, or paper towel—cleans up the spill best? Test each material on the spill. Be sure to make a new "spill" if necessary.
6. Create an "oil spill" with five to 10 drops of oil in the second pie pan with water. Add five drops of dishwashing liquid to this oil spill. Observe the effect the dishwashing liquid has on the spill.



Analysis:

1. Does the oil mix with the water? ______________________________

2. What happens to the oil when the water moves? ________________

   ____

3. Why would it be so important to clean up the oil spill immediately?

   ____

4. What happened to the appearance of the feather when dipped into the oil? ____

   ____

   ____

5. How would oily feathers affect a bird? ________________________

   ____

   ____

6. How much oil is cleaned up by each of the materials used to test on the spill? ____

   ____

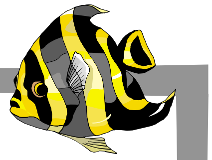
7. How quickly can these materials clean up the spill? _____________

   ____

8. What problems did you encounter in cleaning up your spill? ______

   ____

   ____



9. What happened to the oil as time passed? ____________________

____

____

10. How difficult would it be to clean up the spill if there was a terrible storm? ____

____

____

11. What happened to the second oil spill when you added the dishwashing detergent? ____

____

____

12. Where would the oil go in a real ocean? ____________________

____

____

____

13. How “clean” is the water now that it has dishwashing liquid in it?

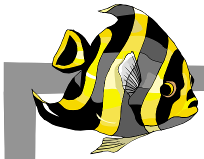
____

____

____

14. What’s worse—oil or the dishwashing cleaner—in the ocean? _____

____



Lab Activity 2: Deadly Waters

Investigate:

- Investigate the problem of pollution through a simulated study.

Materials:

- pollution information
- sheet brown paper bag filled with “tokens”
- M&Ms
- Fruit Loops

Procedure:

1. Read the pollution information sheet (page 428); then classify each of the following pollutants as naturally occurring or manmade.

sediments ________________

petroleum ________________

animal waste ______________

organic materials __________

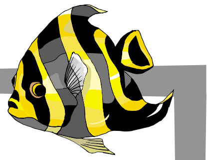
detergents ________________

heated rain _______________

pesticides ________________

fertilizer __________________

2. You and a partner will analyze the pollution content of a hypothetical river.
3. Obtain a brown paper bag filled with “tokens” from your teacher. This bag filled with tokens represents your hypothetical river.
4. Each “token” in the bag represents a type of pollution represented on the pollutant information sheet.



5. Take each token out one by one, and place each one in the category established by your teacher. For example, if you pull a dark brown M&M from your bag, that M&M represents a sediment. Continue pulling all tokens from the bag until none are left. Be sure to place each token in its specific category.

6. After selecting all tokens from the bag, construct a bar graph to represent the pollution content for your river. For your graph, use the same order for the pollutants as listed on your pollution information sheet.

7. Some things to remember about your river are the following: a) each token represents one unit of pollution and b) any pollutant over six units (the base level) can cause problems.

Analysis:

(Place your bar graph here.)

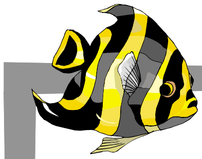
1. What does the *base level* represent? ______________________________

   ____

2. Do all the pollutants cause problems at seven units? _____________

   Explain. ____

   ____



3. Which types of pollutants cause problems at the lowest levels? ____

    ____

    Why? ____

    ____

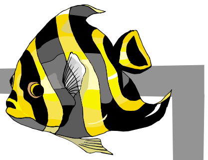
4. Rank your top five pollutants in order. State whether they will have long-term or short-term effects and what major problems they will cause.

Top Five Pollutants

Pollutants	Long-Term or Short-Term Effects	Major Problems
1.		
2.		
3.		
4.		
5.		

5. Which pollutant in "your river" will cause the most significant problems? ____

    ____



6. Which pollutant will cause the least significant effect? ____________

   Why? ____

   ____

7. Describe the probable location of your river (*example*s: urban, agriculture). ____

   ____

   What clues helped you in determining its location? ______________

   ____

   ____

8. What is the most likely source of your biggest pollutant? _________

   Why? ____

   ____

   ____

9. Would you eat fish caught in your river? _______________________

   Why or why not? ____

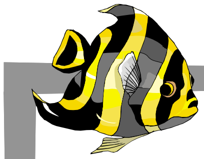
   ____

   ____

   ____

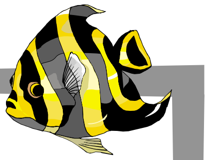
   ____

   ____



Pollutant Information Sheet

Pollutant	**Pollutant Token**
Sediments Particles of soils, sand, silt, clay, and minerals wash from land and paved areas into creeks and tributaries. In unnaturally large quantities, these natural materials can be considered a pollutant. Construction projects often contribute large amounts of sediment. Certain lumbering practices affect sediment in runoff. Sediments may fill stream channels and harbors that later require dredging. Sediments suffocate fish and shellfish populations by covering fish nests and clogging the gills of bottom fish and shellfish.	Dark Brown
Petroleum Products Oil and other petroleum products like gasoline and kerosene can find their way into water from ships, oil-drilling rigs, oil refineries, automobile service stations, and streets. Oil spills kill aquatic life (fish birds, shellfish, and vegetation). Birds are unable to fly when oil loads their feathers. Shellfish and small fish are poisoned. If it is washed on the beach, oil requires much labor to clean up. Fuel oil, gasoline, and kerosene may leak into ground water through damaged underground storage tanks.	Red
Animal Waste Human wastes that are not properly treated at a waste treatment plant and then released into water may contain harmful bacteria and viruses. Typhoid fever, polio, cholera, dysentery (diarrhea), hepatitis, flu, and common cold germs are examples of diseases caused by bacteria and viruses in contaminated water. The main source of this problem is sewage getting into the water. People can come into contact with these microorganisms by drinking the polluted water or through swimming, fishing, or eating shellfish in polluted waters. Often unexpected flooding of barnyards or stock pens can suddenly increase the toxic effects of animal waste in water. Animal waste can also act as a fertilizer and create damage by increasing nutrients. (see Fertilizers below)	Light Brown
Organic Wastes Domestic sewage treatment plants, food processing plants, paper mill plants, and leather tanning factories release organic wastes that bacteria consume. If too much waste is released, the bacterial populations increase and use up the oxygen in the water. Fish die if too much oxygen is consumed by decomposing organic matter.	Orange
Inorganic Compounds Detergents, pesticides, and many synthetic industrial chemicals are released to waterways. Many of these substances are toxic to fish and harmful to humans. They cause taste and odor problems and often cannot be treated effectively. Some are very poisonous at low concentrations.	Yellow Loops
Inorganic Chemicals Inorganic chemicals and mineral substances, solid matter, and metal salts commonly dissolve into water They often come from mining and manufacturing industries, oil-field operations, agriculture, and natural resources. These chemicals interfere with natural stream purification; they destroy fish and other aquatic life. They also corrode expensive water treatment equipment and increase the cost of boat maintenance.	Red Loops
Fertilizers The major source of pollution from agriculture comes from surplus fertilizers in runoff. Fertilizers contain nitrogen and phosphorous that can cause large amounts of algae to grow. The large algae blooms cover the water's surface. The algae die after they have used all of the nutrients. Once dead, they sink to the bottom where bacteria feed on them. The bacterial populations increase and use up most of the oxygen in the water Once the free oxygen is gone, many aquatic animals die. This process is called *eutrophication*.	Green
Heated or Cooled Water Heat reduces the ability of water to dissolve oxygen. Electric power plants use large quantities of water in their steam turbines. The heated water is often returned to streams, lagoons, or reservoirs. With less oxygen in the water, fish and other aquatic life can be harmed. Water temperatures that are much lower than normal can also cause habitat damage. Deep dams often let extra water flow downstream. When the water comes from the bottom of the dam, it is much colder than normal.	Orange Loops
Acid Precipitation Aquatic animals and plants are adjusted to a rather narrow range of pH level. pH is a measure of the acidity of a solution. When water becomes too acidic, due to inorganic chemical pollution or from acid rain, fish and other organisms die.	Green Loops
Pesticides, Herbicides, Fungicides Agricultural chemicals designed to kill or limit the growth of life forms are a common form of pollution. This pollution results from attempts to limit the negative effects of undesirable species on agricultural crop production. Irrigation, groundwater flow, and natural runoff bring these toxic substances to rivers, streams, lakes, and oceans.	Yellow



Practice

Use the list below to write the correct term for each definition on the line provided.

acid rain
biodegradable
contamination
dispersant
mechanical containment
nonpoint-source pollutant
oxidation
pesticides
PCBs
point-source pollutant
pollutant
raw sewage
thermal pollution

________________________ 1. a method used to control oil spills by placing booms around the spill to prevent the movement or spreading of the oil

________________________ 2. stands for *polychlorinated biphenyls*, a group of persistent and toxic chemicals used in transformers and capacitors; banned in the United States since 1979

________________________ 3. rain containing substances harmful to the environment

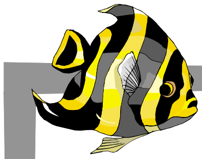
________________________ 4. capable of being decomposed by biological agents, especially bacteria

________________________ 5. chemicals used to destroy insects

________________________ 6. corruption, pollution, infection; making impure by contact or mixture

________________________ 7. an artificial increase or decrease in water temperature that disturbs marine life

________________________ 8. pollution that comes directly from a source
Example: raw sewage



______________________________ 9. pollution that does *not* come directly from one source
Example: surface-water runoff; acid rain

_____________________________ 10. something that causes contamination, especially a waste material that contaminates air, soil, or water

_____________________________ 11. the combination of a substance with oxygen or other compounds, involving the loss of electrons

_____________________________ 12. a substance used to drive off or scatter another substance

_____________________________ 13. untreated liquid and solid waste usually carried off in sewers or drains

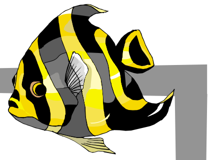
Unit 18: Marine Resources

Unit Focus

This unit introduces the student to the delicate balance between humans' use of the ocean and the amount of use that the ocean can tolerate. Students will investigate the importance of the ocean as a natural resource.

Student Goals

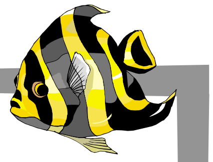
1. Define marine resources.
2. List important living and nonliving marine resources.
3. Distinguish between nonrenewable resources and renewable resources.



Vocabulary

Study the vocabulary words and definitions below.

aquaculture	sea farming; also called *mariculture*
biological resources	living organisms (plants and animals) from the ocean harvested for commercial use
manganese nodules	rounded lumps of valuable mineral deposits found on the ocean floor containing manganese and other elements; formed from minerals crystallizing from seawater
nonrenewable resources	sources available in limited amounts; cannot be replenished
physical resources	nonliving resources from the ocean such as minerals, energy, and the water used for recreational purposes
renewable resources	sources that can be replenished
reservoir rock	thick layer of animal and plant remains that accumulate on the continental shelf; often contains productive oil deposits
resource	a source or supply
spat	a juvenile oyster
upwelling	process by which deep, cold, nutrient-rich water is brought to the surface usually by water currents or winds that pull water away from the coast



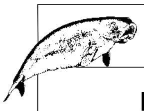
Introduction: Marine Resources—Balancing Use and Overuse

From the earliest moments of civilization, the ocean has provided us with many essential and nonessential **resources**. Marine animals and plants, of course, have provided us with nourishment to survive. Other types of resources including oil and gas have enabled us to develop into industrial societies. Without resources from the ocean, we would not be able to live at the level that many of us enjoy today.

Until recently, many people believed that the ocean would provide *unlimited* resources. As you can well imagine, it is difficult to see any real impact in the ocean even after gathering tons of fish each year or drilling offshore oil wells. However, the ocean's resources have become threatened in a number of different ways.

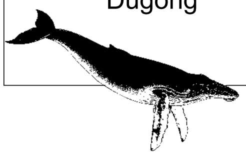
Some of the ocean's resources such as oil and gas are **nonrenewable resources**. There is no natural process that will produce new reserves of these resources. Once we drain our sources of available oil or gas (or many other nonrenewable resources), we will have to learn to live without them. Some resources such as fish and plants are **renewable resources**. These living resources continue to reproduce and provide us with new stores to replenish our stock.

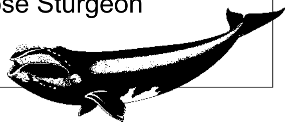
But even renewable resources are not completely safe from destruction by human activities. As we continue to dump our sewage and toxic chemicals in the ocean, we are continuing to kill some or most—perhaps even all—of the food and other resources that we depend on. We also threaten some renewable resources by harvesting too much of them. If, for example, we catch all of a particular kind of fish, there will be none of this type of fish left to reproduce. If a species of fish or other marine organism became extinct, the food web of the ocean and Earth would be damaged. As resources from the ocean have begun to diminish, we have become aware of just how fragile is the balance of life in the ocean.

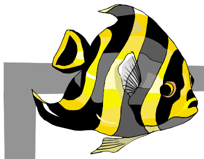


Endangered or Threatened Marine Life

Right Whale
Blue Whale
Humpback Whale
Sperm Whale
Dugong
West African Manatee
West Indian Manatee
Steller Sea Lion
Mediterrerranean Monk Seal
Shortnose Sturgeon







Nonrenewable Resources: The Ocean's Natural Resources

In addition to the obvious natural resources—such as oil and gas—industries also mine some other valuable deposits from the ocean. Sulfur is a nonmetallic element used in the production of rubber, insecticides, and pharmaceutical products. Some of the more important metals discovered on oceanic ridges and the ocean floor include zinc, iron, and copper, as well as silver, lead, gold, and platinum. These metals are used in a variety of ways. Zinc and copper, for example, are used in electrical wiring. Gold is also used as an electrical conductor, as well as in jewelry, and as an international monetary standard.

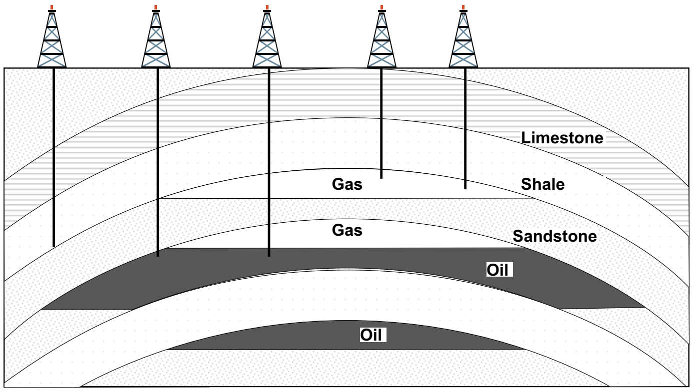
oil rig tower

Some resources mined from the ocean provide the construction industry with building materials. Sand, gravel, and shells are collected from the *continental shelf*. The continental shelf is the relatively flat part of the continent covered by seawater, between the coast and the continental slope (see Unit 7). And red clay and *oozes*, or soft mud, have also been mined from the *abyssal plain*, the large, flat regions on the ocean floor, and used in construction. The agriculture industry mines phosphates from the continental shelf for producing fertilizers.

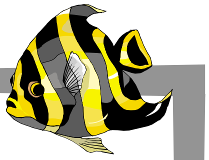
Natural resources from the ocean are *nonrenewable*. Not only does overuse of these resources threaten our limited supply, but our methods of harvesting these resources often damage the marine environment.

Oil and Gas Deposits: Fueling Our Civilization

In our high-energy society, it is easy to see why oil and gas are the most valuable of marine resources. Oil and gas come from the remains of plants and animals that once lived in the rivers or seas. Long ago their remains settled to the ocean



oil and gas deposits in reservoir rock



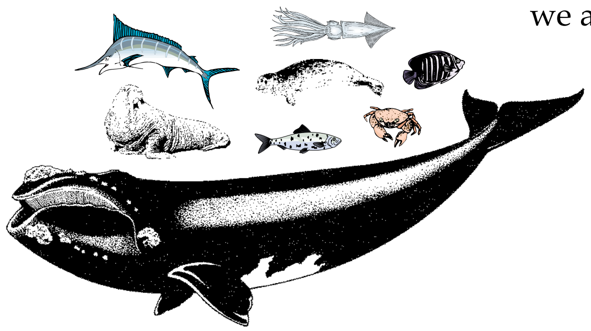
floor. How these remains changed into oil and gas was a long and complex process. Heat, pressure, and time combined to transform these remains into deposits of oil and gas. Oil and gas deposits are usually found in rocks that are no less than two to three million years old. To locate deposits, researchers usually look for areas on the continental shelf that have a thick layer of plant and animal remains. This thick layer is called a **reservoir rock**. Areas of reservoir rock have a high chance of containing productive oil deposits.

Manganese Nodules: A Potential Resource with an Expensive Price Tag

The deep ocean provides an interesting mineral resource called **manganese nodules**. These mineral deposits are round, black and about one inch in diameter. The elements found within manganese nodules have economic value, including copper, nickel, cobalt, and manganese. Recovery of these nodules, however, is quite expensive. Mining of these nodules requires special ships and vacuum-like equipment to sweep them off the ocean's floor. Consequently, mining of manganese is not done on a large scale.

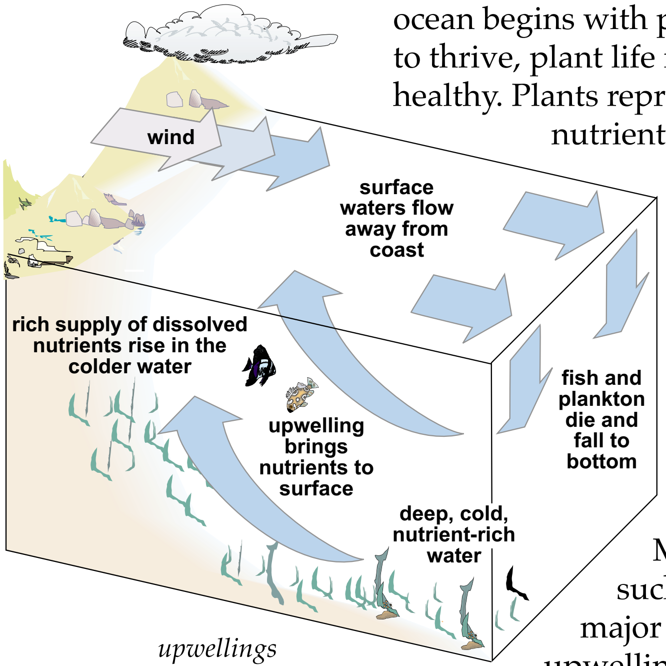
Renewable Resources: Biological (Living) Resources

The **biological resources**, or *living* resources, from the ocean are probably the most important in sustaining our lives. Without marine life to feed on, the world's population would suffer even more greatly from famine and hunger. Most of the food we harvest from the ocean is in the form of fish (tuna, salmon, flounder, and others), crustaceans (shrimp, crab, lobster, and krill), mollusks (squid, clams, mussels, and abalone), and marine mammals (whales and seals). From fish, we also harvest oil to be used in producing paints, drugs, and other commercial products. Marine plants are also an important food source (see Unit 13). Red and brown seaweed, for example, are common food sources in many Asian nations.



Most of the food we harvest from the ocean is in the form of fish, crustaceans, mollusks, and marine mammals.

As you know from your earlier reading, the food chain in the



upwellings

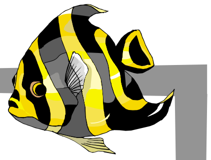
ocean begins with plants. For marine animals to thrive, plant life must be plentiful and healthy. Plants reproduce plentifully in nutrient-rich waters. Nutrient-rich waters, however, are often found at lower levels where many plants cannot survive. **Upwelling**, or the *upward* movement of water, carries nutrient-rich waters to the ocean's sunlit layers (see Unit 6).

Many regions in the ocean, such as the coast of Peru, are major fishing areas because of upwelling. Marine animals live and migrate to these areas to feed on thriving marine plants and animals.

Fishing is not the only method of harvesting biological resources from the ocean. As long ago as 2000 B.C., "farmers" in Japan and China were "growing" different kinds of fish, crustaceans, and mollusks. **Aquaculture**, or *sea* farming, provides many nations with plentiful supplies of food, including oysters, clams, and shrimp, to name just a few.

Oyster farming is an industry in Florida and along the eastern coast of the United States. Baby oysters, called **spats**, float in the currents of the ocean until they come across a shell on the bottom of the ocean floor to which they can attach themselves. To provide the spats with an ideal location to attach and grow, oyster harvesters place shells on the shallow-ocean floor or in an *estuary*. An estuary is an area where a river empties into the ocean or where water from the land drains into the ocean. The spat will stay attached to the shell and grow until large enough to be harvested by the oyster farmers.

Another method used in harvesting oysters is to suspend shells on a wire in the water column. The spats then attach themselves to these shells. The wire-growing method allows sea farmers to grow more spats in a single area and also removes the growing oysters from natural enemies on the ocean's floor, such as starfish. The wire method of growing oysters is primarily used by the Japanese.

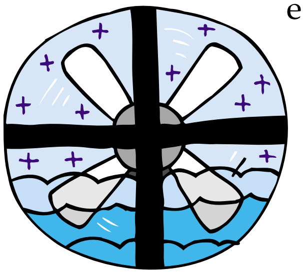


Lobsters and shrimp also do very well in aquaculture systems. These organisms are usually grown in an enclosed system supplied with heated water. The heated water increases the speed at which organisms grow in their natural environment.

Renewable Resources: Physical (Nonliving) Resources

As you learned in earlier units, the ocean has many regions of strong moving water. Scientists and engineers have developed ways to capture this force and convert it into usable energy. Perhaps the most obvious of the ocean's **physical resources**, or *nonliving* resources, is simply its water.

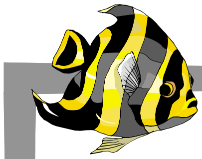
It is estimated that the energy available in ocean waves is about 3,000 times the generating capacity of the Hoover Dam. Energy is collected from the tides, waves, and currents by paddle-like wheel mills called *turbines*. When high tides come in, their water is trapped in an estuary; when the tide water flows out during the low tide, the water is channeled to turbine blades, which in turn generate electricity. The stronger the tide or current, the faster the blades will turn and the more electricity will be produced. Because the energy that produces tides, waves, and currents is fairly constant, we can depend on tidal power and wave power as *renewable resources*.



Turbine blades generate electricity.

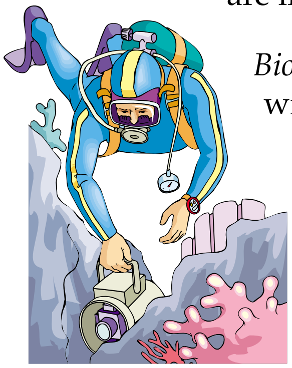
The ocean is one of the most popular areas in which to recreate. It seems that we naturally enjoy the ocean, and so the ocean has always been a recreational resource for us. Many of us use the oceans for sailing, fishing, scuba diving, surfing, and swimming. Tourists flock to Florida, in particular, to take advantage of the state's beautiful coasts and beaches. In fact, much of the state's revenue comes from tourists who visit our state to enjoy the recreational activities provided by the ocean.

As is true of all resources, overuse and overdependence cause and lead to problems. In Florida, scientists are working on plans that will permit all of us to continue enjoying our water wonderlands without destroying the fragile balance necessary for marine environments to survive.

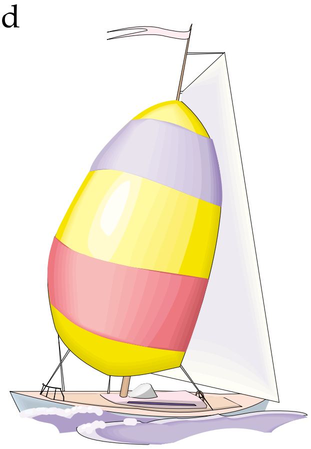


Summary

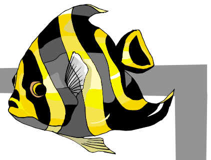
The ocean provides us with both *renewable* and *nonrenewable* resources. Minerals are harvested from the ocean for use in construction, drugs, and other commercial products. Oil and gas are essential in sustaining our high-energy society. Like all natural resources, oil and gas are limited in supply.



Biological resources provide the world with food in the form of fish, crustaceans, and other types of marine life. *Aquaculture*, or sea farming, has been used for thousands of years and continues to help supply the world's population with food.



The ocean also provides renewable energy resources. Tides, waves, and currents turn turbines, which in turn produce energy. The ocean has always been, and will continue to be, one of the most popular sources for recreation. In part because of its warm waters and beautiful coasts and beaches, Florida has become a leader in tourism in the United States. Great care must be taken to protect both nonrenewable *and* renewable resources for future generations to come.



Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

aquaculture
biological
gas
nonrenewable
oil
physical
renewable
upwelling

1. The most valuable natural resources from the ocean are ______________________ and ______________________ .

2. Areas having reservoir rock have a high rate of containing a(n) ______________________ deposit.

3. Oil and gas are ______________________ resources.

4. A(n) ______________________ is a current from the deep waters bringing nutrient-rich water to the surface of the ocean.

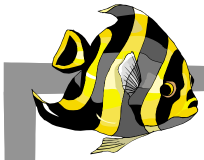
5. The main advantage of using tidal power is that this type of energy is ______________________ .

6. ______________________ resources are *living* resources.

7. Marine resources which cannot be replenished are known as ______________________ resources.

8. *Nonliving* resources, such as minerals and tidal power, are known as ______________________ resources.

9. *Sea* farming is called ______________________ .



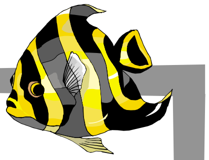
Practice

Use the text and other references to complete the chart below. First choose 10 resources from the list below and write them on the chart. Then check whether the resource is renewable **(R)** *or* nonrenewable **(N)** *and* biological **(B)** *or* physical **(P)**. *Write the uses for each resource and the location where each resource may be found.*

crustaceans
fish
gold
iron
lead
mollusks
nickel
oil
phosphates
platinum
salt
seaweed
shells
sulfur
zinc

Resources from the Ocean

Resources	R	N	B	P	Uses	Location
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						



Practice

Answer the following using complete sentences

1. How is *oil* formed? ____

   ____

   ____

   ____

   ____

2. What are *manganese nodules*? ______________________________

   ____

   ____

3. How do oyster farmers *grow* oysters? _______________________

   ____

   ____

   ____

   ____

   ____

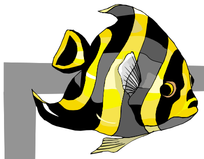
4. In what ways is the ocean valuable to us? ____________________

   ____

   ____

   ____

   ____



Practice

Use the list below to write the correct term for each definition on the line provided.

aquaculture
biological resources
manganese nodules
nonrenewable resources
physical resources
renewable resources
reservoir rock
resource
spat
upwelling

________________________ 1. a source or supply

________________________ 2. rounded lumps of valuable mineral deposits found on the ocean floor containing manganese and other elements; formed from minerals crystallizing from seawater

________________________ 3. process by which deep, cold, nutrient-rich water is brought to the surface usually by water currents or winds that pull water away from the coast

________________________ 4. a juvenile oyster

________________________ 5. sources that can be replenished

________________________ 6. thick layer of animal and plant remains that accumulate on the continental shelf; often contains productive oil deposits

________________________ 7. sea farming; also called *mariculture*

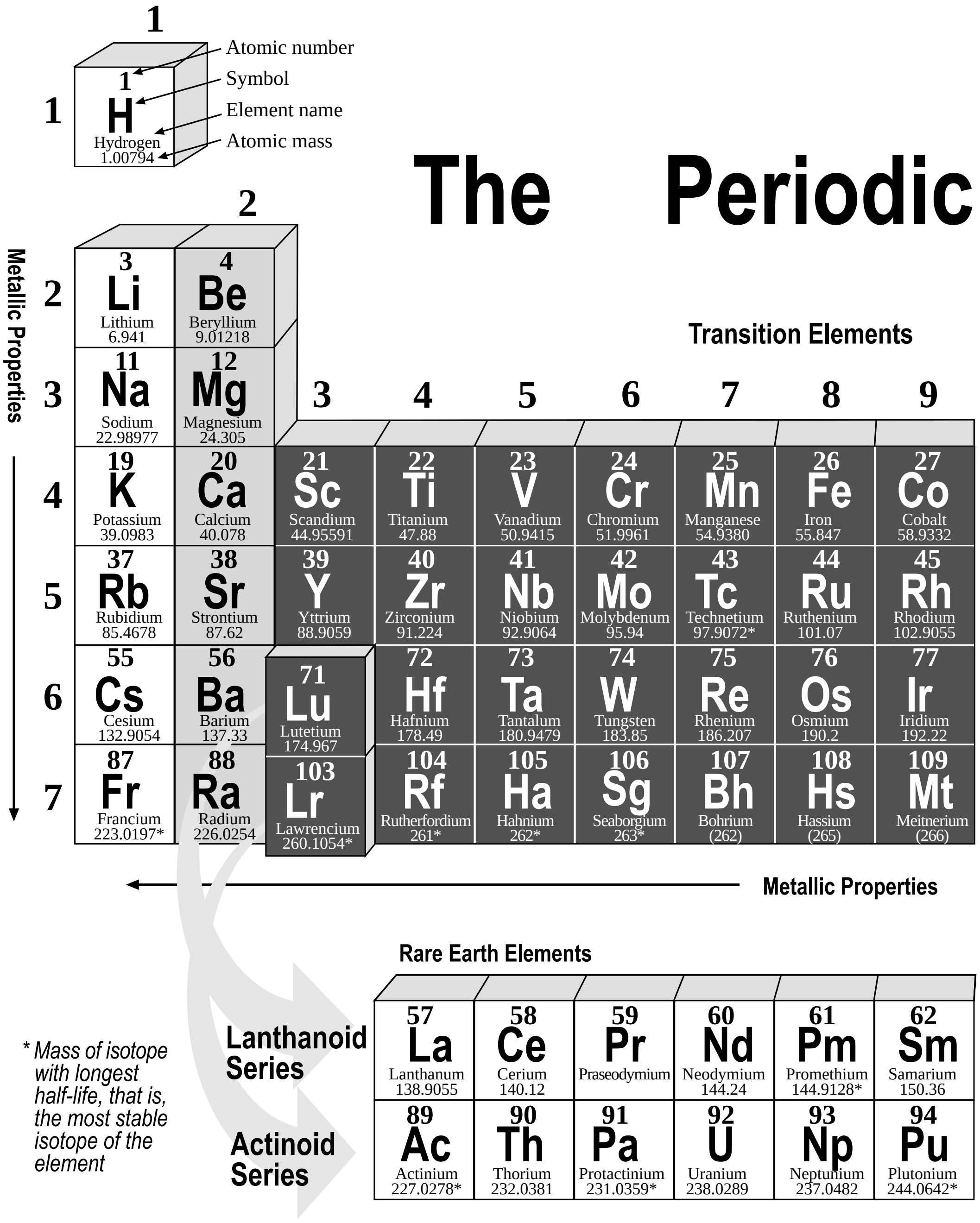
________________________ 8. sources available in limited amounts; cannot be replenished

________________________ 9. living organisms (plants and animals) from the ocean harvested for commercial use

________________________ 10. nonliving resources from the ocean such as minerals, energy, and the water used for recreational purposes

Appendices

Periodic Table



	1	2	3	4	5	6	7	8	9
1	1 H Hydrogen 1.00794								
2	3 Li Lithium 6.941	4 Be Beryllium 9.01218							
3	11 Na Sodium 22.98977	12 Mg Magnesium 24.305							
4	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.95591	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.9380	26 Fe Iron 55.847	27 Co Cobalt 58.9332
5	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.9059	40 Zr Zirconium 91.224	41 Nb Niobium 92.9064	42 Mo Molybdenum 95.94	43 Tc Technetium 97.9072*	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055
6	55 Cs Cesium 132.9054	56 Ba Barium 137.33	71 Lu Lutetium 174.967	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.2	77 Ir Iridium 192.22
7	87 Fr Francium 223.0197*	88 Ra Radium 226.0254	103 Lr Lawrencium 260.1054*	104 Rf Rutherfordium 261*	105 Ha Hahnium 262*	106 Sg Seaborgium 263*	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)

Lanthanoid Series	57 La Lanthanum 138.9055	58 Ce Cerium 140.12	59 Pr Praseodymium	60 Nd Neodymium 144.24	61 Pm Promethium 144.9128*	62 Sm Samarium 150.36
Actinoid Series	89 Ac Actinium 227.0278*	90 Th Thorium 232.0381	91 Pa Protactinium 231.0359*	92 U Uranium 238.0289	93 Np Neptunium 237.0482	94 Pu Plutonium 244.0642*

** Mass of isotope with longest half-life, that is, the most stable isotope of the element*

Table

10	11	12	13	14	15	16	17	Noble Gases 18
								2 He Helium 4.002602
			5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.998403	10 Ne Neon 20.179
			13 Al Aluminum 26.98154	14 Si Silicon 28.0855	15 P Phosphorus 30.97376	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
28 Ni Nickel 58.69	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.59	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.710	51 Sb Antimony 121.75	52 Te Tellurium 127.60	53 I Iodine 126.9045	54 Xe Xenon 131.29
89 Pt Platinum 195.08	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium 208.9824*	85 At Astatine 209.98712*	86 Rn Radon 222.017*
110 § Uun Ununilium 269*	111§ Uuu Unununium 272*	112§ Uub Ununbium 277*	113§	114§	115 §	116 §	117 §	118 §

Nonmetallic Properties

Metallic Properties

63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.9254	66 Dy Dysprosium 162.50	67 Ho Holmium 164.9304	68 Er Erbium 167.26	69 Tm Thulium 168.9342	70 Yb Ytterbium 173.04
95 Am Americium 243.0614*	96 Cm Curium 247.0703*	97 Bk Berkelium 247.0703*	98 Cf Californium 251.0796*	99 Es Einsteinium 252.0828*	100 Fm Fermium 257.0951*	101 Md Mendelevium 258.986*	102 No Nobelium 259.1009*

§ *Synthesized elements that are highly unstable. Research on these is continuing and may change what we know about them.*

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