CHAPTER 10

Oceans

The BIG Idea

Oceans are a major feature of Earth.

Heating the Far Shores

Energy from the Sun is absorbed and stored in the oceans. Near Earth's equator, stored thermal energy makes the water warm. Then, ocean currents transfer this thermal energy to distant shores around the world.

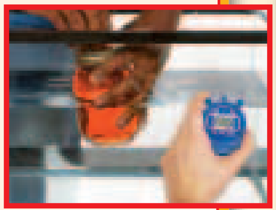
Science Journal Near Earth's poles, where the angle of sunlight is low, the water is cold. Write a hypothesis that explains how warm ocean currents reach higher latitudes and cold ocean currents reach lower latitudes.

Launch Lab

00:20 minutes

Will hot water sink?

What happens when hot water mixes with cold water?



Procedure

1. Complete a lab safety form.
2. Fill a **fish tank** with **cold water.**
3. Get a **jar with a lid** and record how many holes are in the lid of your jar.
4. Fill the jar with **hot water.**
5. Place a few drops of **food coloring** in the jar and screw on the lid.
6. Cover the hole or holes with your fingers and lower the jar to the bottom of the fish tank.
7. Use a **stopwatch** to time how long it takes for all the hot water to escape.

Think About This

- **Observe** What happened to the hot water?
- **Compare** Did other students have faster or slower times? How many holes did their lids have?

4.d

Science Online

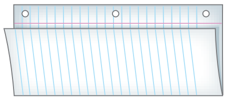
Visit ca6.msscience.com to:

- view Concepts in Motion
- explore Virtual Labs
- access content-related Web links
- take the Standards Check

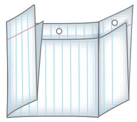
FOLDABLES™ Study Organizer

Ocean Currents Make the following Foldable to compare and contrast ocean currents.

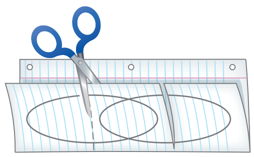
STEP 1 **Fold** a sheet of paper in half lengthwise. Make the back edge about 3 cm longer than the front edge.



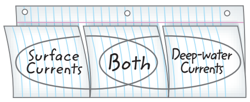
STEP 2 **Fold** into thirds.



STEP 3 **Unfold** and **cut** along the folds of the top flap to make three flaps.



STEP 4 **Label** the flaps as shown.



Reading Skill ELA6: R 2.2

Comparing and Contrasting
As you read Lesson 2, list under the appropriate flap information about surface currents and deep-water currents. Be sure to include causes, direction, and deflection by land.

Get Ready to Read

Summarize

1 Learn It! Summarizing helps you organize information, focus on main ideas, and reduce the amount of information to remember. To summarize, restate the important facts in a short sentence or paragraph. Be brief and do not include too many details.

2 Practice It! Read the text on page 425 labeled *Bathymetric Maps*. Then read the summary below and look at the important facts from that passage.

Summary

Bathymetric maps show the contours of the ocean floor and its geologic features. The ocean floor has the same types of geologic shapes seen on land.

Important Facts

- The ocean floor has mountains, trenches, and flat areas.
- The depth of water is measured from sea level to the ocean floor.
- Sea level is the level of the sea's surface halfway between high and low tides. The ocean floor is Earth's surface underneath ocean water.
- Before modern technology, sailors would make soundings to record water depth and make bathymetric maps.

3 Apply It! Practice summarizing as you read this chapter. Stop after each lesson and write a brief summary.

Target Your Reading

Use this to focus on the main ideas as you read the chapter.

1. **Before you read** the chapter, respond to the statements below on your worksheet or on a numbered sheet of paper.
   - Write an **A** if you **agree** with the statement.
   - Write a **D** if you **disagree** with the statement.
2. **After you read** the chapter, look back to this page to see if you've changed your mind about any of the statements.
   - If any of your answers changed, explain why.
   - Change any false statements into true statements.
   - Use your revised statements as a study guide.

Reading Tip

Reread your summary to make sure you didn't change the author's original meaning or ideas.

Before You Read A or D	Statement	After You Read A or D
	1 The ocean floor is completely flat.	
	2 A map of the ocean floor can be made using sound waves.	
	3 A continuous chain of underwater volcanoes extends through all oceans.	
	4 Surface currents in the ocean are caused by wind.	
	5 Deep currents in the ocean are caused by wind.	
	6 Waves cause erosion along the shoreline.	
	7 Sand is transported by currents along the beach.	
	8 Beaches can be made of different types of sand.	
	9 Hurricanes do not occur in California.	
	10 The rocky shore has a high diversity of organisms.	

Science Online

Print a worksheet of this page at ca6.msscience.com.

LESSON 1

Science Content Standards

7.c Construct appropriate graphs from data and develop qualitative statements about the relationships between variables.

7.f Read a topographic map and a geologic map for evidence provided on the maps and construct and interpret a simple scale map.

Reading Guide

What You'll Learn

- **Identify** the different oceans on Earth.
- **Understand** how bathymetric maps of the oceans are made.
- **Describe** the features of the ocean floor.

Why It's Important

Oceans cover more than 70 percent of Earth's surface.

Vocabulary

sea level
ocean floor
bathymetric map
echo sounding
continental shelf

Review Vocabulary

topographic map: a map that uses lines of equal elevation to show the shape of Earth's surface (p. 54)

Earth's Oceans

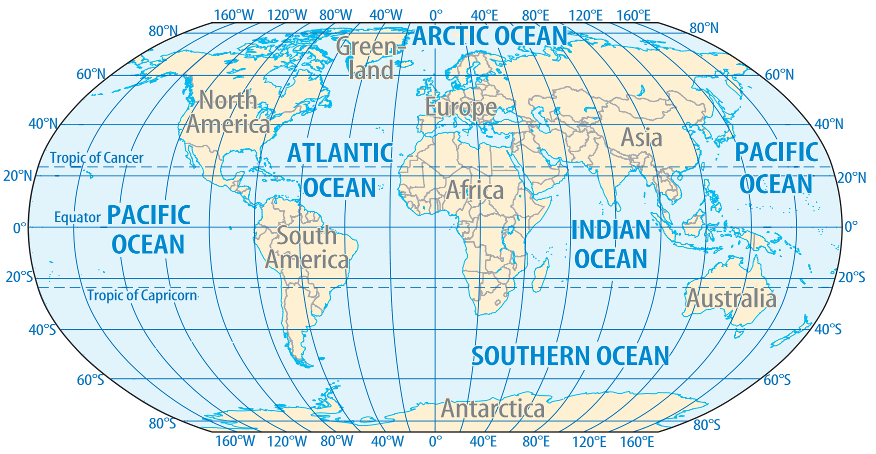
Main Idea Mapping the ocean floor is important to understanding Earth's global features.

Real-World Reading Connection In photographs taken from space, Earth's surface is covered with blue. The blue comes from the oceans, which make up about 71 percent of Earth's surface. This is why Earth is sometimes called the Water Planet.

Mapping Earth's Oceans

As shown in **Figure 1,** Earth contains five major oceans—the Pacific Ocean, the Atlantic Ocean, the Indian Ocean, the Arctic Ocean, and the Southern Ocean. The Pacific Ocean is the largest ocean. However, it is slowly decreasing in size because of the subduction zones that surround it. The Atlantic Ocean is the second largest ocean. The Atlantic Ocean is slowly growing larger because lava continually rises to the surface from deep within Earth. New ocean floor is continually created in the middle of the Atlantic Ocean. The Indian Ocean is the shallowest ocean. The Arctic Ocean is at the most northern part of Earth and much of it is often covered in ice. The Southern Ocean surrounds the continent of Antarctica and extends north to latitude of 60°S. It connects the Pacific, Indian, and Atlantic Oceans.

Figure 1 Modern maps usually include five major oceans.



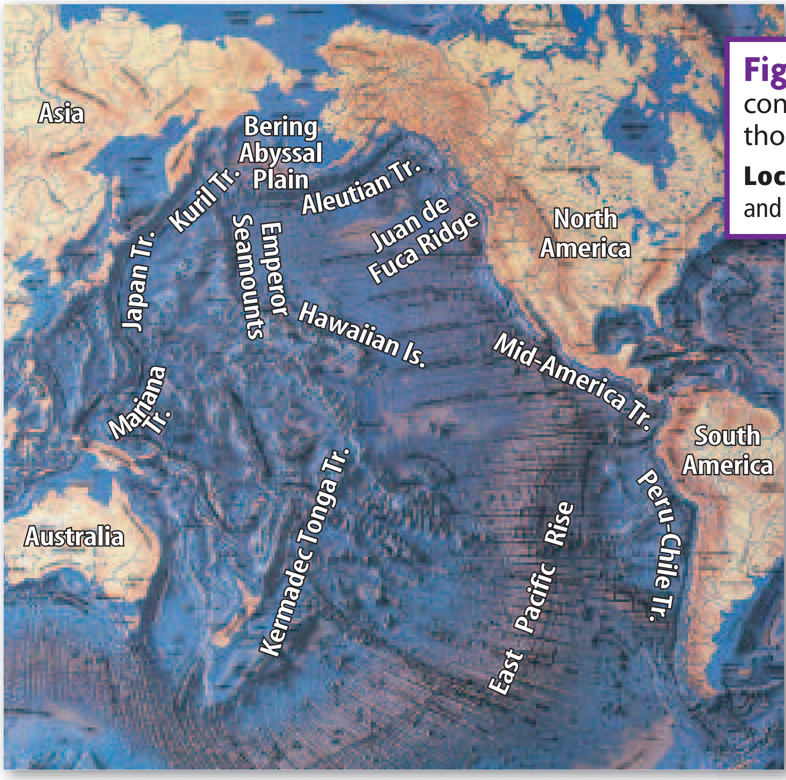


Figure 2 The ocean floor has contours and features similar to those on land.

Locate a trench, a mountain range, and an abyssal plain on the map.

Bathymetric Maps

Figure 2 shows the contours and features of the ocean floor in the Pacific Ocean. On the ocean floor hidden beneath the water, there are the same kinds of geological shapes that we see on land. There are underwater mountain ranges, trenches, and flat areas in each ocean.

One of the most important things you would want to know if you were sailing around the world is the depth of the water and the location of underwater obstacles. The depth of water is measured from sea level to the ocean floor. **Sea level** is the level of the ocean's surface halfway between high and low tides. The **ocean floor** is Earth's surface underneath the ocean water.

Before modern technology, sailors would drop a rope from their ship until it hit the bottom of the ocean. Then they would measure the length of rope they let out and record the water depth. This **method** of measuring water depth is called sounding. By making a large number of soundings and compiling them, a map of the ocean floor, or a bathymetric map, can be created. A **bathymetric** (BATH ih meh trihk) **map,** like the one shown in **Figure 2,** is a map of the bottom of the ocean showing the contours of the ocean floor and its geologic features. Bathymetric maps are like topographic maps except they show land formations that are underwater.

Reading Check What is the purpose of a bathymetric map?

Academic Vocabulary

method (MEH thud)
(noun) a way or process for doing something
Even though John and Sara used different methods to carry out the experiment, they both got the same results.

Word Origin

bathymetric
from Greek *bathys;* means *deep*

Figure 3 Oceanographers use sound waves to create bathymetric maps of the ocean floor.

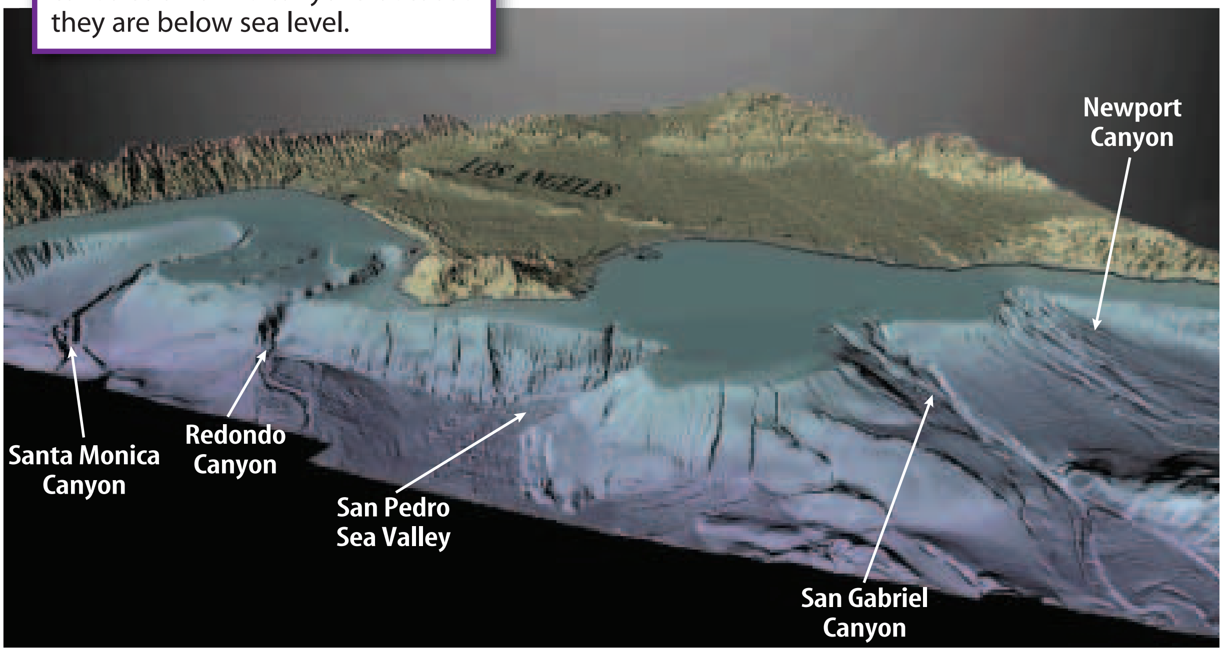
Echo Sounding

Today oceanographers map the ocean floor using sound and radio waves. Sonar **echo sounding** is a determination of the depth of water using sound waves. Scientists attach an instrument to the bottom of a ship that emits a sound wave. They then measure the amount of time that it takes for the sound wave to bounce off the ocean floor and return to the ship, as shown in **Figure 3.** If the sound bounces back quickly, the depth of the ocean is shallow. If it takes a long time, the depth of the ocean is deep.

Sound waves, radio waves, and light waves can be used to map the locations of coastlines, the geological features on the bottom of the oceans, and the location and direction of currents. Satellites use radio waves to detect small bumps and dips in the ocean surface. These bumps and dips reflect the locations of mountains and trenches on the ocean floor. **Figure 4** shows a bathymetric map created by echo sounding of an area of the Pacific Ocean just off the coast of Los Angeles, California.

Reading Check What methods are used to map ocean floors?

Figure 4 These canyons are called submarine canyons because they are below sea level.



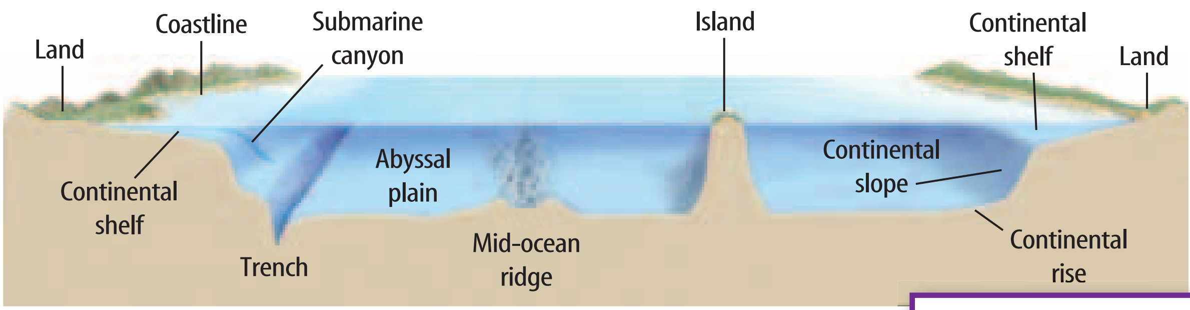


Figure 5 A bathymetric profile of a typical ocean floor shows different geological features.

Describe What are some differences between the continental shelf and the continental slope?

The Ocean Floor

Imagine taking a slice through the ocean floor and looking at it from the side. This is called a bathymetric profile, or a cross-section of the ocean. **Figure 5** shows some typical geologic features you will see in a bathymetric profile of the ocean floor.

Continental Shelf

The **continental shelf** is an underwater portion of continental crust that extends from the continental shoreline and gently slopes toward the deeper parts of the ocean. Along the east coast of the United States, the continental shelf is wide. California has a narrow continental shelf.

Continental Slope

The continental slope is the steep slope between the continent and the deep ocean. Some of these slopes represent locations where the supercontinent, Pangaea, split apart. Many of these slopes contain deep canyons called submarine canyons. Sediments flow down the canyons, sometimes in huge avalanches. The sediments are deposited on the continental rise, between the continental slope and the ocean floor.

Abyssal Plain

Beyond the continental slope and rise, the ocean floor is extremely flat. This region is called the abyssal (uh BIH sul) plain. The abyssal plain is made of blocks of basalt that are thought to have originated along mid-ocean ridges. Later, the blocks were covered with thick layers of sediment.

Ocean Trenches

Deep ocean trenches are extremely deep underwater valleys. The deepest point in the ocean is 11,033 m in the Mariana Trench in the Pacific Ocean. Ocean trenches are subduction zones, places where the tectonic plates are recycled into Earth's interior.

DataLab

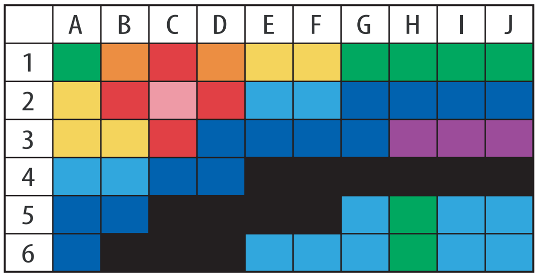
00:20 minutes

How do you read a bathymetric map?

Bathymetric maps have letters and numbers that represent areas of the ocean floor. Depth is represented by different colors. Each color has a matching depth given below.

Data

Examine the bathymetric map and table.



Example of a Simple Bathymetric Map

Ocean Depth (meters)	Color Code
500	pink
1,000	red
1,500	orange
2,000	yellow
2,500	green
3,000	light blue
3,500	dark blue
4,000	purple
4,500	black

US Geological Survey Color Scheme

Data Analysis

1. **Describe** the features of the ocean floor in the map. In which grid is the water the deepest? Where is it the shallowest?
2. **Graph** Choose one row of the map. Draw a profile of what the ocean floor would look like from point A to point J.

7.c, 7.f

Mid-Ocean Ridges

Mid-ocean ridges are a continuous chain of underwater volcanoes more than 65,000 km long that extend through all the ocean basins. The mid-ocean ridges rise 2 km above the ocean floor on average. Mid-ocean ridges are places where tectonic plates are moving away from each other and new sea floor is being created. **Figure 6** shows how the Juan de Fuca Ridge, in the Northeast Pacific, is formed.

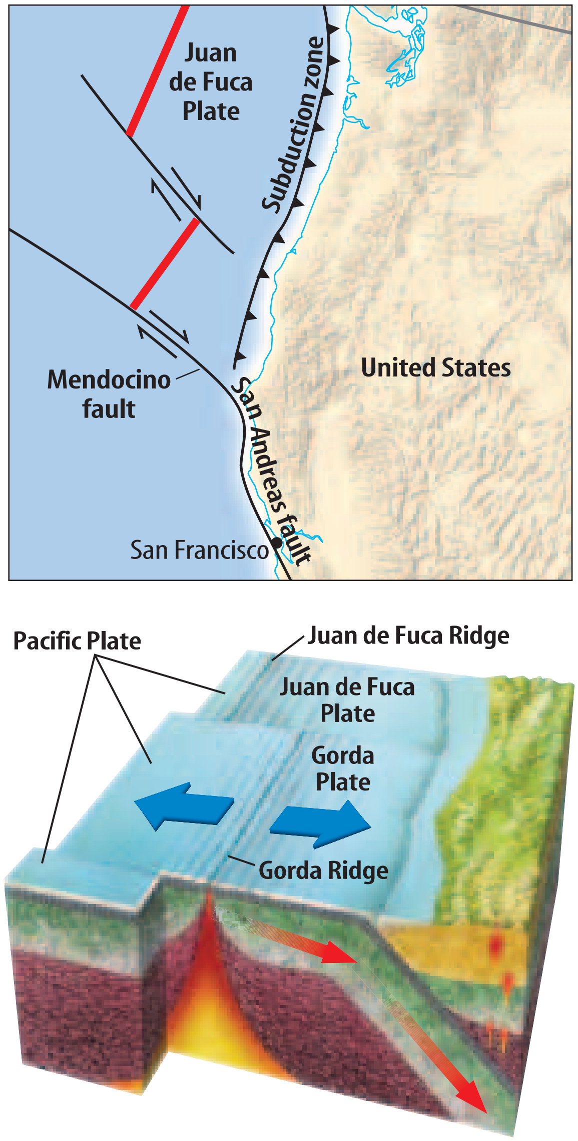


Figure 6 The Juan de Fuca Ridge is formed as the Pacific plate and the Juan de Fuca plate move away from each other.

Features of the Ocean Floor

The five oceans—the Pacific Ocean, the Atlantic Ocean, the Indian Ocean, the Arctic Ocean, and the Southern Ocean—cover more than 70 percent of Earth's surface. The ocean floor has contours and features similar to those found on land, including mid-ocean ridges, trenches, and flat abyssal plains. Bathymetric maps show the contours of the ocean floor and its geologic features. Information about the features of the ocean floor can be collected through echo sounding, using sound waves bounced off the bottom of the ocean; and through satellites, using radio waves bounced off the surface of the ocean. Bathymetric profiles of the ocean floor show the continental shelf, the continental slope and rise, and ocean trenches, ridges, and abyssal plains.

LESSON 1 Review

Summarize

Create your own lesson summary as you design a **visual aid.**

1. **Write** the lesson title, number, and page numbers at the top of your poster.
2. **Scan** the lesson to find the **red** main headings. Organize these headings on your poster, leaving space between each.
3. **Design** an information box beneath each **red** heading. In the box, list 2–3 details, key terms, and definitions from each **blue** subheading.
4. **Illustrate** your poster with diagrams of important structures or processes next to each information box.

ELA6: R 2.4

Standards Check

Using Vocabulary

1. Distinguish between *sea level* and *ocean floor.* 7.f
2. In your own words, write the definition for *echo sounding.* 7.f

Understanding Main Ideas

3. **Identify** the five major oceans and their locations. 7.f
4. Which describes extremely flat regions of the ocean floor?
   A. continental shelf
   B. trench
   C. abyssal plain
   D. mid-ocean ridge 7.f
5. **Explain** how bathymetric maps are made. 7.f
6. **Describe** mid-ocean ridges and how they are formed. 1.a

Applying Science

7. **Draw** a bathymetric profile through an ocean with a narrow continental shelf, a steep continental slope, two mid-ocean ridges, and at least one abyssal plain. **Label** the different features. 7.f
8. **Determine Cause and Effect** Copy and fill in the graphic organizer below to explain how features on the ocean floor are the result of the movements of Earth's plates. 1.a

Causes → Ocean Floor Features → Effects

Science Online
For more practice, visit **Standards Check** at ca6.msscience.com.

LESSON 2

Science Content Standards

4.a Students know the sun is the major source of energy for phenomena on Earth's surface; it powers winds, ocean currents, and the water cycle.

4.d Students know convection currents distribute heat in the atmosphere and oceans.

Reading Guide

What *You'll* Learn

- **Explain** how ocean currents are formed.
- **Explain** how ocean currents distribute thermal energy around Earth.
- **Describe** the major global ocean currents and gyres.

Why *It's* Important

Ocean currents transfer heat and influence weather and climate.

Vocabulary

ocean current
salinity
gyre

Review Vocabulary

latitude: the distance in degrees north or south of the equator (p. 49)

Ocean Currents

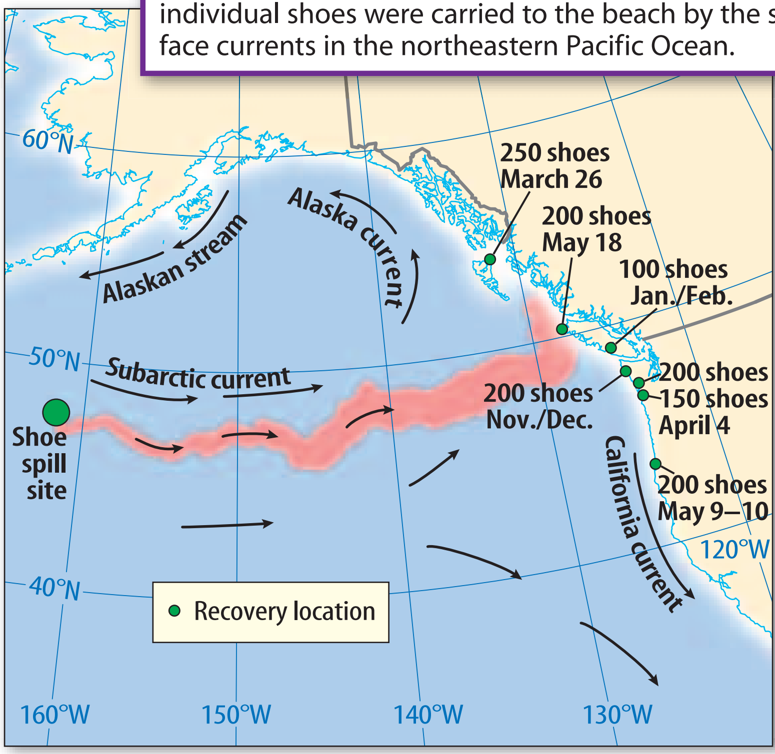
Main Idea Ocean currents help distribute heat around Earth.

Real-World Reading Connection You may have felt a current carrying you downstream when swimming in a river. Similarly, you may have felt an ocean current when swimming at the beach. If you have ever tried to swim against the current, you know it can be strong and fast-moving.

Influences on Ocean Currents

Earth is covered with a network of rivers that are important in many ways. They carry water, redistribute nutrients, and move sediments from place to place. Because it is made up of water, you might not think that the ocean also contains a network of moving water. Ocean water moves from place to place in **ocean currents,** which are like rivers in the ocean. Ocean currents, like the one shown in **Figure 7,** transport water, heat, nutrients, animals and plants, and even ships from place to place in the oceans.

Figure 7 On May 27, 1990, five containers carrying shoes were accidentally spilled over the side of a ship during a storm. When the containers broke open, the individual shoes were carried to the beach by the surface currents in the northeastern Pacific Ocean.



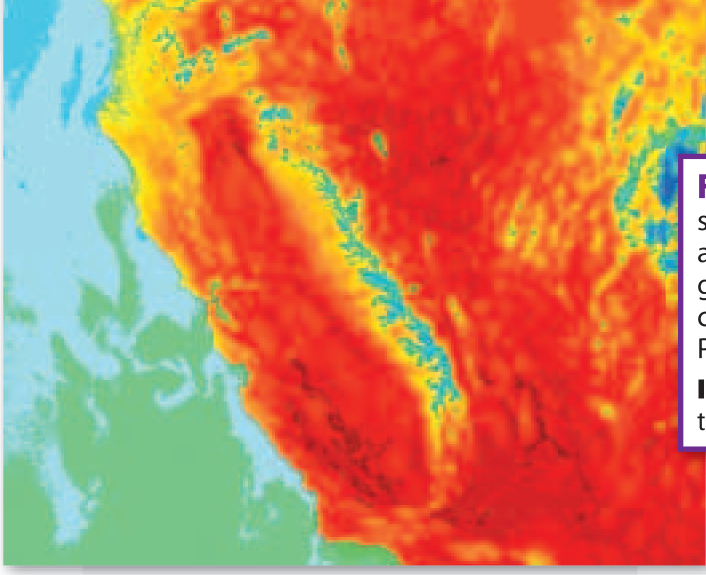


Figure 8 This satellite image shows surface temperatures in California during a heat wave. Blue is coldest, followed by green and yellow. Red is hottest. The cool green-blue area at the left is the Pacific Ocean.

Infer Why do you think the ocean is cooler than the land?

A Huge Reservoir of Energy

Figure 8 shows the difference in temperature between ocean water and land in California on a hot summer day. Have you ever been on the beach on a really hot day? When you step on the sand, it is so hot it feels like it could burn your feet. But when you step in the ocean, the water feels cool and refreshing. The Sun beats down on both the water and the sand with the same energy. What causes the difference?

One of the properties of water is that a large amount of heat can be added to or removed from it before it changes temperature. It takes five times more heat to change the temperature of an area of water than it does to change the same area of sand. As a result, sand changes temperature much more quickly than water does on a hot day. The oceans, because they are a huge reservoir of water, hold an enormous amount of heat.

Heat Transfer by the Oceans

Recall that the amount of energy received from the Sun varies greatly depending on latitude. In general, heat is gained by oceans in areas between 30°N and 30°S latitudes. Heat is lost by oceans at latitudes of above 40°. Even though heat is gained at the equator, the oceans do not boil there. At the same time, the amount of ice in polar regions remains about the same. What keeps heat balanced throughout the planet?

Water's ability to absorb and lose large amounts of heat energy without changing temperature makes it perfect for moving heat around the planet. In general, ocean currents carry heat from the tropics to the poles. This helps equalize the amount of heat throughout the planet.

Reading Check How are oceans involved in balancing heat throughout Earth?

Surface Currents

Have you ever stood on a beach on a calm day? You probably noticed that the waves rolling toward shore are smooth until they break on the sand. But have you watched the ocean on a windy day? The waves not only crash on the beach, but they also form whitecaps out at sea, as shown in **Figure 9.**

As the wind blows over the ocean, it tugs on the surface of the ocean, moving the ocean surface water. On windy days, the wind moves the surface water faster than the wave is moving, causing it to crash in front of the wave. This produces whitecaps. The winds are the most important force driving the movement of surface water in the ocean. They have the strongest effect on the location and movement of the global ocean surface currents.

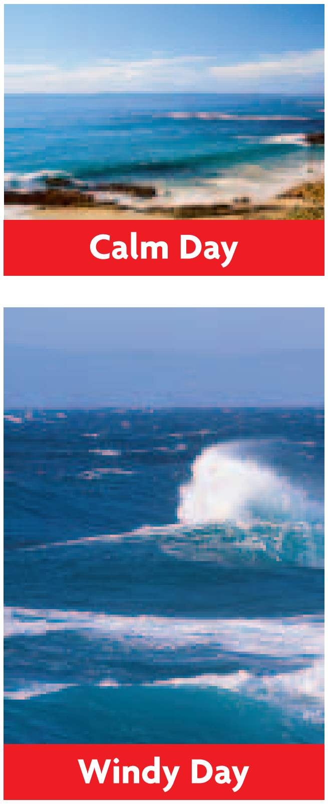


Figure 9 Faster wind produces more whitecaps on waves.

The Coriolis Effect in the Oceans

Recall that the Coriolis (kor ee OH lihs) effect is caused by Earth spinning on its axis. As a result, winds in the northern hemisphere are deflected to the right and winds in the southern hemisphere are deflected to the left. The spinning of Earth affects liquids in the same way it affects the gases that make up air. As shown in **Figure 10,** in the northern hemisphere, ocean currents are deflected to the right and in the southern hemisphere, they are deflected to the left. The overall effect is that currents tend to move in a clockwise pattern in the northern hemisphere and in a counter-clockwise pattern in the southern hemisphere.

Visual Check **Figure 10** How does the Coriolis effect affect surface currents in the ocean?

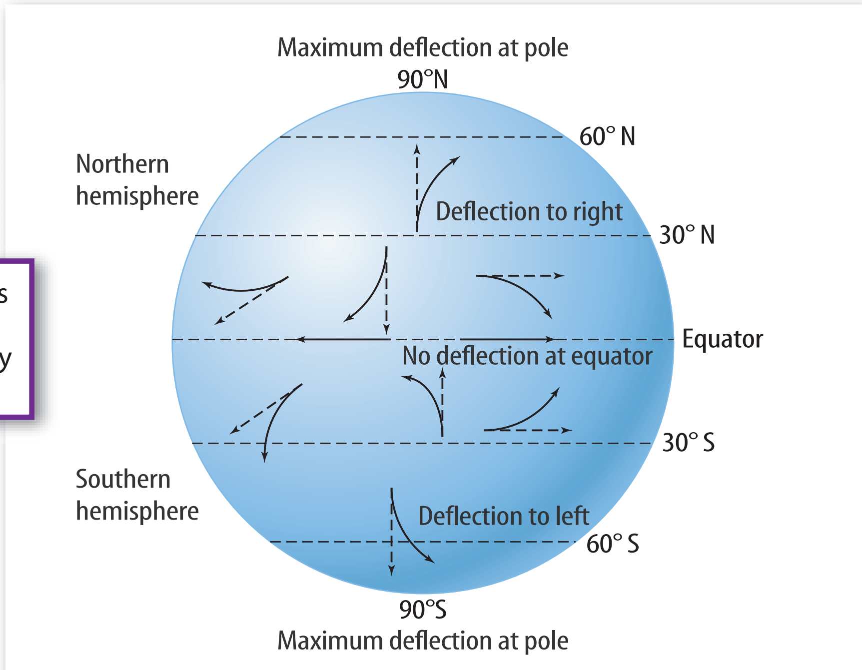


Figure 10 The Coriolis effect deflects ocean currents in the same way that it affects winds.

CONTENTS

Density and Deep Ocean Currents

Not all currents in the ocean are driven by wind across the surface. Some currents are found deep in the ocean where there is no effect of the wind. What drives these currents? The answer has to do with the density of water. The density of water depends on both its temperature and the amount of salt it contains. Recall from the Launch Lab that cooler water has a higher density than warmer water. How does salinity affect the density of water?

The amount of salt that is dissolved in a quantity of water is called **salinity** (say LIH nuh tee). As the salinity of water increases, its density increases. Areas of water in different parts of the ocean have different densities. These differences in density form deep ocean currents.

When surface water becomes denser than the water below it, the surface water sinks. For example, surface water in Antarctica is cooled by air temperatures. It becomes saltier when salt is left behind as ocean water freezes. This makes the surface water dense. As a result, it sinks. This water mass then flows across the ocean floor, producing deep ocean currents, as shown in **Figure 11.**

MiniLab

00:20 minutes

Different Densities?

Recall that the hot water from the Launch Lab rose to the surface of the fish tank. This resulted because the hot water was less dense than the cold water.

Procedure

1. Read and complete a lab safety form.
2. Place a **colored ice cube** in a **container of hot water.** Observe what happens.
3. Use a **stopwatch** to record the amount of time it takes for the two colors to mix.

Analysis

1. **Describe** what happened to the cold water from the ice cube.
2. **Infer** how convection currents are involved in this experiment.

4.d

Try at Home

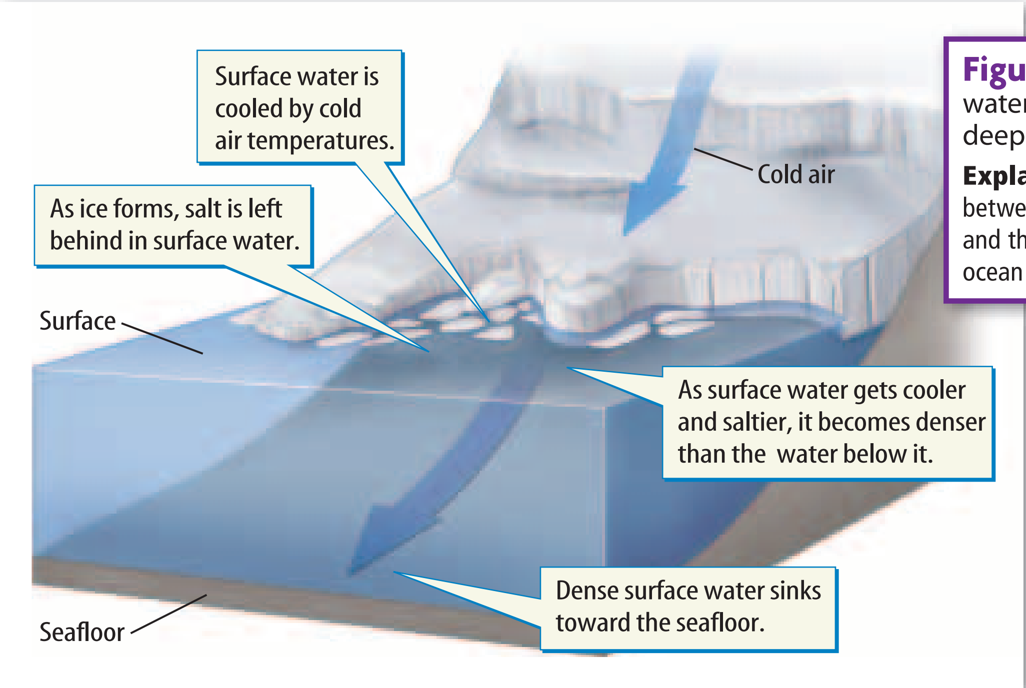


Figure 11 Dense polar water sinks, producing a deep ocean current.
Explain the relationship between the density of water and the formation of deep ocean currents.

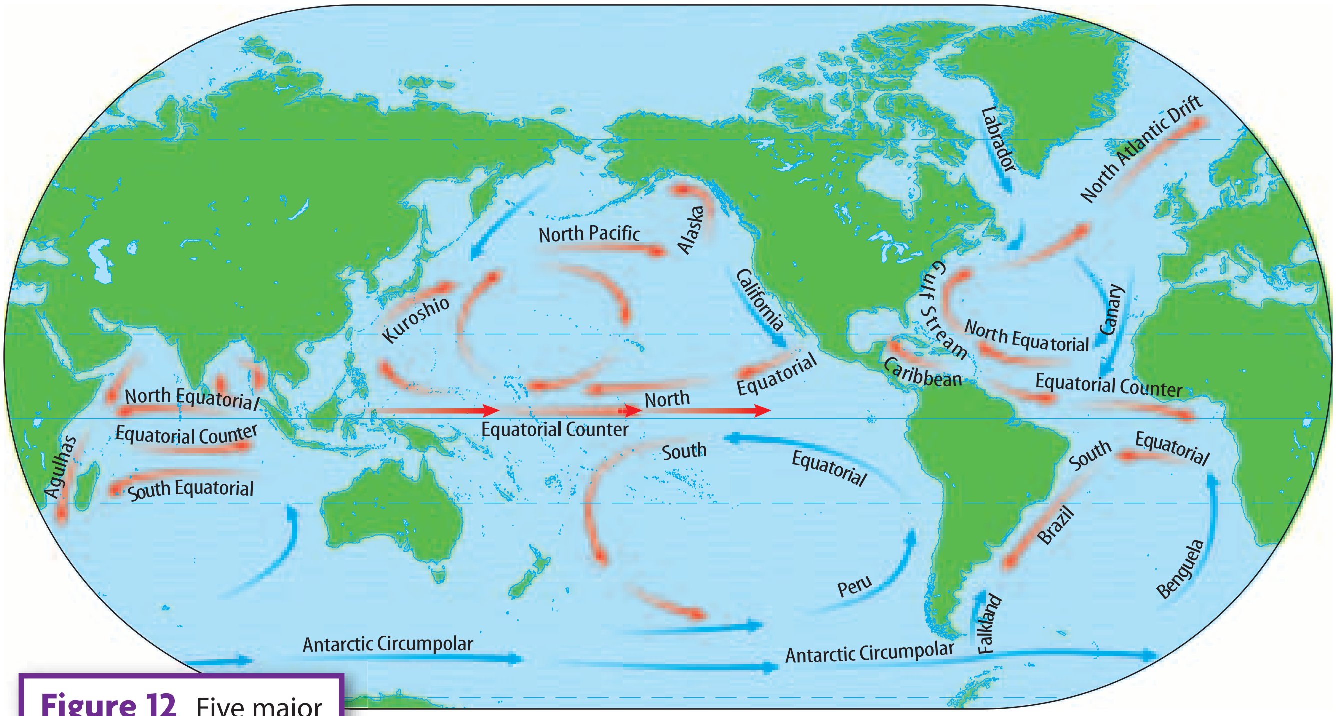


Figure 12 Five major gyres circulate in Earth's oceans.

Identify the currents in the southern Atlantic Ocean and describe how the gyre circulates.

Gyres—Great Ocean Surface Currents

Recall that certain winds, including the trade winds and the westerlies, are concentrated in bands around Earth. Wind is the major factor that influences the movement of surface water in the ocean. The major surface currents are shown in **Figure 12.** Notice the location of the North Pacific Current. It flows along the same path as the westerlies in the northern hemisphere. But what happens when the North Pacific Current reaches the continent of North America? The presence of the land mass, as well as the Coriolis effect, deflects the current to the right, and it becomes the California Current, flowing south along the coast of California.

When the California Current reaches the tropics, the trade winds tug on it, moving it westward. Its name then changes to the North Equatorial Current. When the North Equatorial Current reaches Asia, the land mass and the Coriolis effect again turn it to the right, and it becomes the Kuroshio Current, moving northward past Japan. When the Kuroshio Current reaches the westerlies, it is pushed toward the east into the North Pacific Current again.

A **cycle** of ocean currents, like the ones in **Figure 12,** is called a **gyre** (JI ur). There are five major gyres in Earth's oceans. The North Atlantic and North Pacific Gyres rotate in a clockwise direction. The South Atlantic, South Pacific, and Indian Ocean Gyres rotate in a counterclockwise direction.

Academic Vocabulary

cycle (SI kul)
(noun) a series of events that occur regularly and usually lead back to the starting point; a circular or spiral arrangement
The cycle of four seasons takes one year to complete.

Reading Check Which factors influence the direction in which a major ocean surface current will flow?

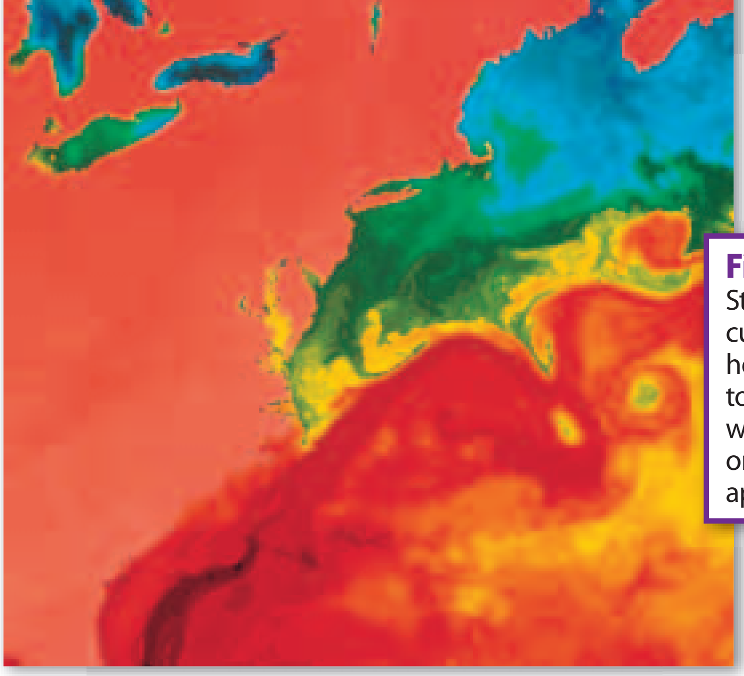


Figure 13 The Gulf Stream is a warm-water current that transports heat from the equator toward the poles. Warm water is shown in red and orange. Cooler water appears in blue and green.

Special Currents and Their Effects

The strongest and deepest currents are found on the western sides of the gyres. These currents are called western boundary currents because they are on the western side of the ocean basins. Eastern boundary currents are on the eastern side of the ocean basins.

The biggest western boundary current is the Gulf Stream, shown in **Figure 13,** which is part of the North Atlantic Gyre. It transports enough water to fill the entire Rose Bowl Stadium about 25 times per second. This water rushes north from the tropics toward the poles. The Gulf Stream and all the other western boundary currents are important to the redistribution of heat throughout the oceans. The Gulf Stream causes the climate in Europe to be milder than you might expect given its high latitude.

Reading Check Why are western boundary currents important to Earth's heat balance?

Surrounding the continent of Antarctica is the Antarctic Circumpolar Current, shown in **Figure 14.** It is a continuous flow of water, but it is not a gyre because it surrounds land rather than water. It is the largest current in the oceans, with twice as much flow as the Gulf Stream. The Antarctic Circumpolar Current is driven in an eastward direction around the southern part of Earth by the strong westerlies.

Figure 14 The Antarctic Circumpolar Current moves around Antarctica in a clockwise direction.

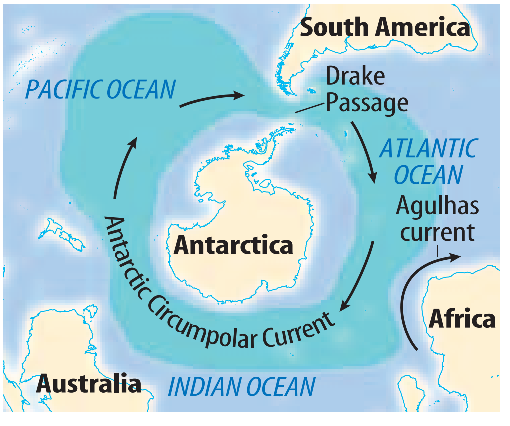
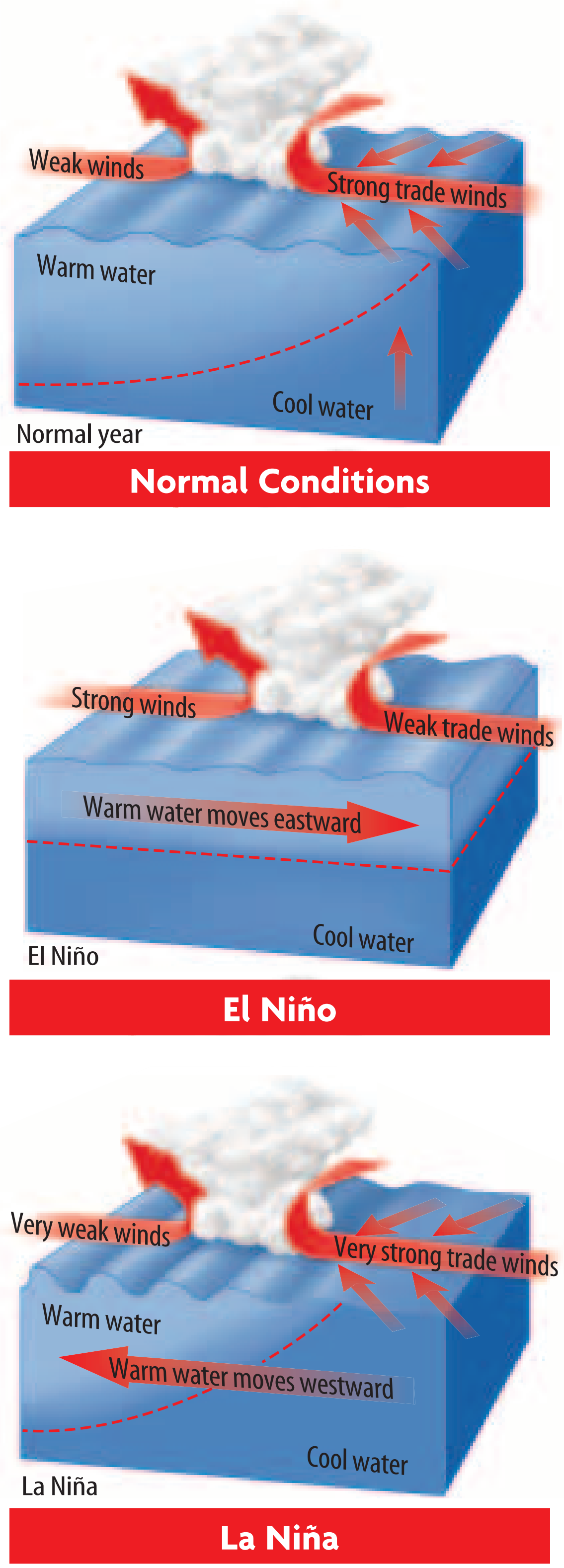


Figure 15 These drawings illustrate the differences in the trade winds and the currents during normal years and during El Niño and La Niña events. Green represents warm water and blue represents cold water.



Effects of El Niño and La Niña on Currents

In the Southern Pacific Ocean, the trade winds push tropical water westward from Central and South America toward Australia. As shown in **Figure 15,** cool, deep water normally rises to the surface near South America. However, sometimes the trade winds weaken or even reverse direction.

When the trade winds stop driving the flow of water across the Pacific, the South Equatorial Current slows down. Warm water from the western side of the Pacific sloshes back across the ocean, as shown in **Figure 15.** This phenomenon is known as an El Niño event. Because ocean currents and winds are connected throughout the planet, El Niño conditions have effects all over Earth. Effects of El Niño include droughts in the western Pacific areas of Australia and Indonesia and increased rain and flooding in the eastern Pacific including Peru and California. During an extremely strong El Niño in 1997 and 1998, the rainfall in California was twice the normal amount. Landslides and avalanches occurred more frequently than usual.

Reading Check What changes occur in winds and the ocean during an El Niño event?

When the trade winds begin to blow again, they usually do with great strength, as shown in **Figure 15.** Warm tropical water is pulled across the Pacific toward Australia. The coast of South America becomes unusually cold and chilly. These conditions are called La Niña. El Niño and La Niña events occur about every three to eight years. Researchers are still trying to determine what drives these global-scale changes to the world's weather and ocean currents.

Visual Check **Figure 15** How do wind and ocean conditions change during a La Niña event?

Water Movement in the Ocean

Surface currents are driven by wind and their direction is influenced by the Coriolis effect and land formations. Large gyres circulate in each major ocean basin. Deep ocean currents are driven by differences in water density. Ocean currents transfer and distribute heat throughout Earth and help keep Earth's heat balanced. Ocean currents also affect weather and climate. Western boundary currents, such as the Gulf Stream, are warm-water currents that can influence regional climates by making them milder. Weather all over the world can be strongly influenced by El Niño and La Niña events, which act on winds and ocean currents.

LESSON 2 Review

Summarize

Create your own lesson summary as you design a **study web.**

1. **Write** the lesson title, number, and page numbers at the top of a sheet of paper.
2. **Scan** the lesson to find the **red** main headings.
3. **Organize** these headings clockwise on branches around the lesson title.
4. **Review** the information under each **red** heading to design a branch for each **blue** subheading.
5. **List** 2–3 details, key terms, and definitions from each **blue** subheading on branches extending from the main heading branches.

ELA6: R 2.4

Standards Check

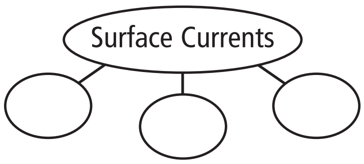
Using Vocabulary

Complete the sentences using the correct vocabulary term.

1. _________ transfer thermal energy from the Sun around the globe. 4.a
2. A cycle of currents is called a(n) _________. 4.d

Understanding Main Ideas

3. Which can cause an increase in the density of water?
   A. a decrease in temperature
   B. a decrease in salinity
   C. an increase in volume
   D. an increase in wind 4.d
4. **Identify** Copy and fill in the graphic organizer below to identify the three influences on ocean surface currents.



5. **Describe** the major global ocean currents and how they form gyres. 4.d
6. **Examine Figure 12. Determine** which current is the western boundary current in the South Atlantic Gyre. **Explain** how this current transfers heat. 4.d

Applying Science

7. **Design an Experiment** You are given two samples of ocean water. One is from the North Pacific Gyre and the other is from the Mediterranean Sea. Design an experiment to determine which is denser. 4.d
8. **Hypothesize** What would happen to the North Pacific Current if the westerlies stopped blowing? 4.d

Science Online
For more practice, visit **Standards Check** at ca6.msscience.com .

Brain POP **Ocean Current** ca6.msscience.com

LESSON 3

Science Content Standards

2.c Students know beaches are dynamic systems in which the sand is supplied by rivers and moved along the coast by the action of waves.

Reading Guide

What *You'll* Learn

- **Understand** how waves shape the shore.
- **Distinguish** between different types of sand.

Why *It's* Important

Beaches are always changing shape.

Vocabulary

shore
shoreline
longshore current
longshore drift
rip current
sand

Review Vocabulary

sediment: rock that is broken down into smaller pieces or that is dissolved in water (p. 99)

The Ocean Shore

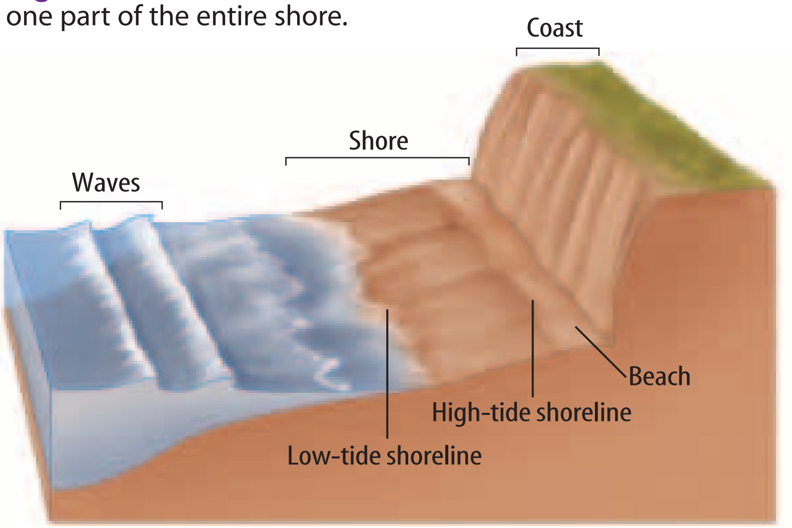
Main Idea The shore is shaped by the movement of water and sand.

Real-World Reading Connection Have you ever watched a stream of water as it runs through dirt? You might have noticed that the water carries pieces of the dirt from one place to another, redistributing them. In the same way, the movement of water shapes the ocean's shore.

Shoreline Processes

As shown in **Figure 16,** the **shore** is the area of land found between the lowest water level at low tide and highest area of land that is affected by storm waves. The **shoreline** is the place where the ocean meets the land. The location of the shoreline constantly changes as the tide moves in and out. Tides are the alternate rising and falling of the surface level of the ocean. A beach is the area in which sediment is deposited along the shore. Beaches can be made of fine sand, tiny pebbles, or larger stones. The size and composition of the sediment that makes up a beach depends on where the sediment comes from. Sometimes the shore is rocky and there is little sand. Waves and currents close to shore influence the shape of a shore as they erode or deposit sediment.

Figure 16 The beach is only one part of the entire shore.



Effects of Wind and Waves

Wind and waves constantly beat the shoreline, causing erosion. Wind picks up tiny pieces of sediment, called grit, and then smashes it against rocks. The grit acts like sandpaper, rubbing large rocks into smaller ones. Crashing waves force air and water into cracks in rocks, breaking them into pieces. Waves also hurl sand and gravel at the shoreline, wearing larger rocks down into smaller pieces. Finally, water itself can dissolve many minerals in rocks, causing them to break apart.

Erosion Shoreline erosion by wind and waves depends on two factors—the type of rock found in the area and the intensity of the wind and waves. Hard rocks, like granite and basalt, erode very slowly. Soft rocks, like limestone and sandstone, may wear away quickly. As waves erode the rocks, shoreline features such as the sea arch and the sea stack shown in **Figure 17** are created. A sea arch is a tunnel that has been carved out of rock by erosion due to wind and waves. A sea stack is formed when a sea arch collapses and one side becomes separated from the main land formation.

Reading Check What type of shoreline features can be created from erosion?

Deposition Sediment that is eroded from one area of the shoreline eventually is deposited in another area. The deposition occurs where the energy of waves is low. The sediment falls out of the water and settles on the seafloor. Shoreline features such as baymouth bars and tombolos (TOHM boh loh), shown in **Figure 17,** are formed by the deposition of sediment. A baymouth bar is an accumulation of sediment that completely crosses the opening of a bay, sealing it off from the open ocean. A tombolo is a ridge of sediment that connects an island to the mainland or another island.

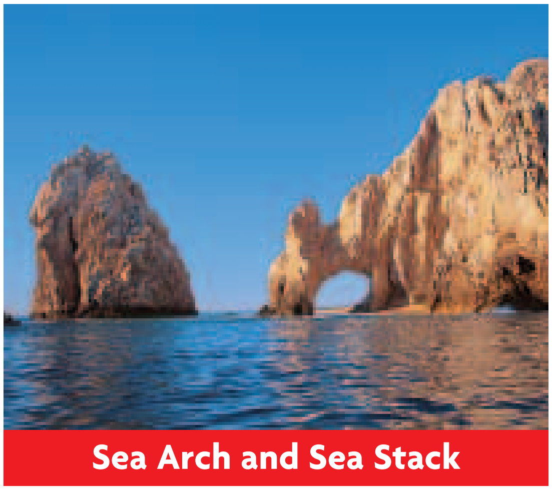
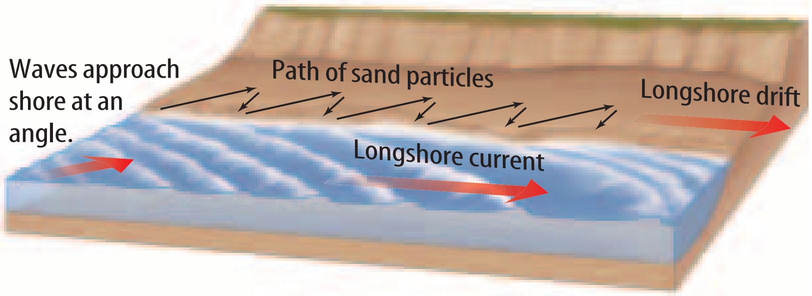


Figure 17 The effect of wind and waves shapes the shoreline. Sea arches and sea stacks are the result of erosion. Baymouth bars and tombolos are the result of deposition.

Contrast What is the difference between a baymouth bar and a tombolo?

Figure 18 Because waves hit the shoreline at an angle, sediments are moved down the shore.

Describe How does the longshore current transport sand?



Longshore Drift

Once sediments are eroded from rocks, they usually do not stay in one place very long. The water from a breaking wave pushes sand up the beach at an angle. However, when the water from the wave runs back toward the ocean, it goes straight downhill because of gravity. As shown in **Figure 18,** this process moves sand along the beach. Part of the energy from the waves coming into the beach at an angle moves parallel to the shoreline. This energy drives a narrow current parallel to the shore called the **longshore current.** Sometimes the longshore current can move up to 4 km/h. Longshore currents transport sand that is **suspended** in the surf along the shoreline. The combination of the movement of sand on the beach by breaking waves and the movement of sand in the longshore current is called **longshore drift.**

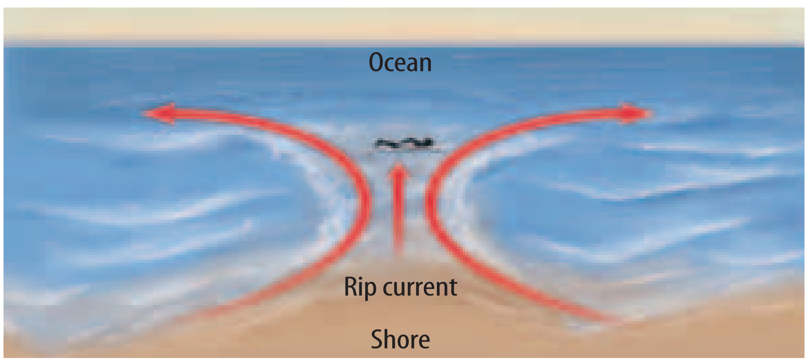
Academic Vocabulary

suspend (suh SPEND)
(verb) to keep from falling or sinking by some invisible support, e.g., dust in the air
The silt that was stirred up from John walking in the river remained suspended in the water for several minutes.

Rip Currents

Sometimes a lot of waves hit the shore at once and pile up a lot of water. Usually the longshore current moves excess water along the beach. But when too much water piles up, the current cannot move it fast enough. The water breaks through the surf in a few places and rushes back out to the ocean. These swift currents that flow away from the beach are called **rip currents,** and are shown in **Figure 19.**

Figure 19 Rip currents are narrow currents of water moving offshore.



Human Activity and Beaches

Have you ever tried to build a sand castle near the ocean? If one wave comes farther up the beach, it can cause the whole thing to collapse. Since beaches are always changing, building on the beach is a difficult task, both for sand-castle builders and people who build real buildings.

To try to stabilize the beach, artificial structures often are put in place, as shown in **Figure 20.** Jetties, groins, and breakwaters all are structures that extend from the beach out into the water. Seawalls are built on land and usually are parallel to the shore. Sometimes building structures to protect beaches has unintended results. Breakwaters, jetties, and groins trap sand, which stops the normal flow of sand along the shoreline. Farther down the shoreline, the beaches may become smaller. The sand that would usually be deposited by longshore drift is trapped by the structures. Seawalls also can cause erosion. The wave energy that is deflected by the seawall can be redirected on either side of it and below it. This can erode sand from around the seawall, causing it to collapse.

Reading Check How do jetties and groins affect the longshore current?

Science Use v. Common Use

deposit

Science Use to let fall, as in sediment. *The sediment was deposited as the speed of the current slowed down.*

Common Use to place something, such as money, for safekeeping. *Laura deposited her paycheck into her bank account.*

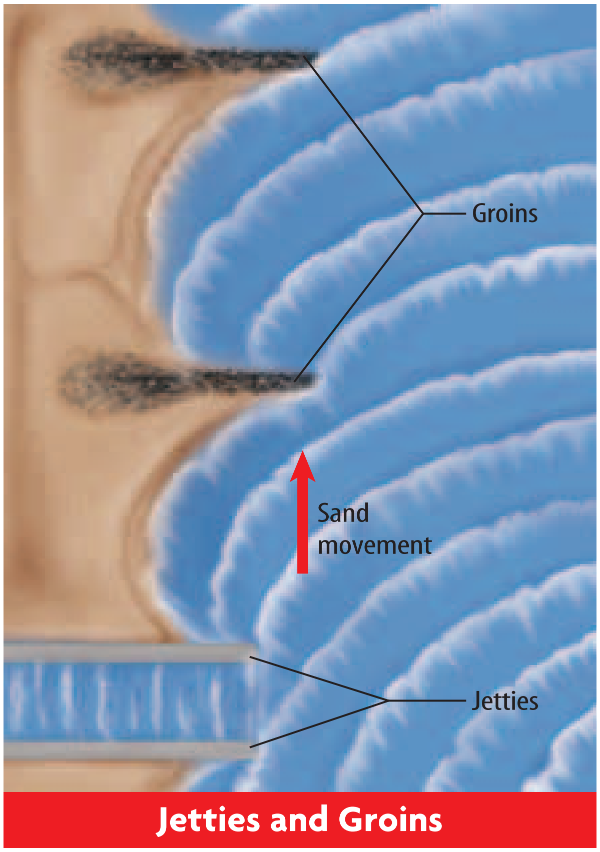


Figure 20 Jetties and groins stop erosion because they slow longshore drift. Seawalls deflect the energy of the waves on the beach.

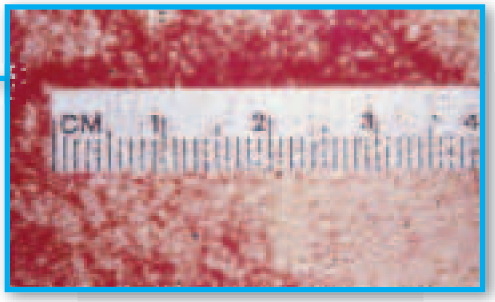
Sexto Sol/Getty Images

Table 1 Range of Sediment Sizes

Name	Size
Boulder	> 256 mm
Cobble	64–256 mm
Very coarse gravel	32–64 mm
Coarse gravel	16–32 mm
Medium gravel	8–16 mm
Fine gravel	4–8 mm
Very fine gravel	2–4 mm
Very coarse sand	1–2 mm
Coarse sand	$\frac{1}{2}$–1 mm
Medium sand	$\frac{1}{4}-\frac{1}{2}$ mm
Fine sand	125–250 µm
Very fine sand	62.5–125 µm
Silt	3.90625–62.5 µm
Clay	< 3.90625 µm

Boulder

Medium Gravel



Fine Sand

Concepts In Motion
Interactive Table To explore more about sediment size, visit ca6.msscience.com.

Sand and Weathered Material

Sand is a term that is used to describe rocks that are between 0.0625 mm and 2.0 mm in diameter. Within this range, sand is categorized as very coarse, coarse, medium, fine, and very fine, as shown in **Table 1.** Rocks that are larger and smaller than sand are also shown in **Table 1.**

Sand Origins

Weathering breaks large boulders into smaller rocks. Rain then washes small rocks into rivers. Rivers transport these rocks to the ocean. Along the way, the rocks continually break into smaller pieces. These small pieces of rock then are transported in currents along the shoreline. The broken up rocks are eventually deposited as sand on sandy beaches. The sand that ends up on a beach in San Francisco Bay may have originated hundreds of kilometers away in the Sierra Nevada. Sand also may be from local rocks that have been weathered away just meters from the beach.

(t)Darrell Gulin/CORBIS, (c)ADAM HART-DAVIS/SPL/Photo Researchers, (b)B. Runk/S. Schoenburger/Grant Heilman Photography

Sand Composition

Sand is made up of different minerals and rocks, depending on where the sand originated. White sand might be quartz or calcium carbonate from ground-up shells and coral skeletons. Black sand can be basalt, mica, or magnetite. Magnetite is a mineral that is attracted to magnets. Green sand can be a mineral called olivine that originates in lava, or from a rock called feldspar. Sand that is pink or white also can be feldspar. Red sand can come from coral and from iron in volcanic cinders.

Reading Check What types of minerals can be found in sand?

Sand Deposition

Even after sand reaches the ocean and then rests on a sandy beach, it does not stay there for long. Sand is continuously eroded, transported, and deposited along the shoreline. In the process, sand is sorted according to its size. The smaller grains of sand end up on low-energy beaches, and the larger grains remain on high-energy beaches. Most sand usually ends up on the ocean floor. As shown in **Figure 21,** the ocean floor near California contains several deposition beds, where sand and sediments accumulate.

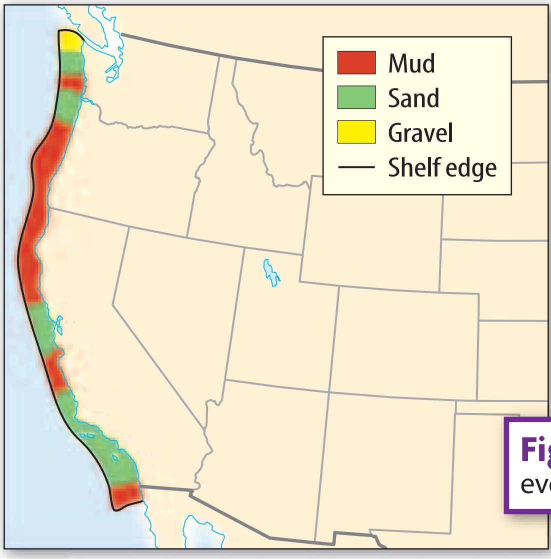


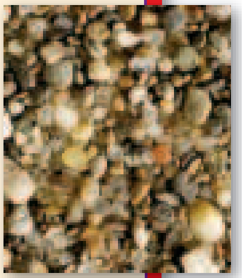
Figure 21 Sand and other sediments eventually are deposited in the ocean.

MiniLab

00:20 minutes

Isn't all sand the same?

Different beaches have different types of rocks and minerals in their sand. An examination of a sample of beach sand can reveal what types of rocks and minerals are in the area.



Procedure

1. Read and complete a lab safety form.
2. Examine the **sand** your teacher has given you. Make a note of the various sizes, shapes, and colors of the grains.
3. Study the grains with a **magnifying lens.** Try to identify the types of minerals and rocks that are present in your sample—quartz, feldspar, shell fragments, or volcanic rock.
4. Wrap a large **magnet** in a **plastic bag** and pass it through your sample. Are any sand grains attracted to the magnet?

Analysis

1. **Summarize** the composition of your sand sample. What rocks or minerals could you identify? What colors and shapes were the different grains? Where do you think the sand came from?
2. **Compare** your summary to other students' summaries. Did everyone have the same type of sand?
3. **Infer** What type of mineral would you find using a magnet?

2.c

Shaping the Shoreline

Beaches are areas of constant change. Wind and waves erode the rocks along the shoreline, creating features such as sea arches and sea stacks. Deposition of sediment occurs in areas of low energy, where sediment falls out of the water and settles on the seafloor. Baymouth bars and tombolos are shoreline features created by sediment deposition. Human activities can affect the shape of beaches as well. Artificial structures such as breakwaters, jetties, and groins can interfere with the longshore current, resulting in abnormal erosion and deposition of sediment.

LESSON 3 Review

Summarize

Create your own lesson summary as you write a script for a **television news report.**

1. **Review** the text after the **red** main headings and write one sentence about each. These are the headlines of your broadcast.
2. **Review** the text and write 2–3 sentences about each **blue** subheading. These sentences should tell *who, what, when, where,* and *why* information about each **red** heading.
3. **Include** descriptive details in your report, such as names of reporters and local places and events.
4. **Present** your news report to other classmates alone or with a team.

ELA6: LS 1.4

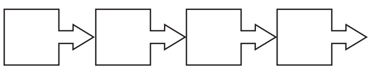
Standards Check

Using Vocabulary

1. Distinguish between *longshore current* and *longshore drift.* 2.c
2. Use each term in a separate sentence: *shoreline* and *shore.* 2.c

Understanding Main Ideas

3. Which is a swift current that flows away from the beach? 2.c
   - **A.** longshore current
   - **B.** rip current
   - **C.** Bengula Current
   - **D.** California Current
4. **Explain** the major processes that affect the shape of shorelines. 2.c
5. **Sequence** Draw a graphic organizer like the one below and arrange the following in order from largest to smallest: coarse gravel, coarse sand, cobble, and silt. 2.c



6. **Explain** how sand gets to sandy beaches. 2.c

Applying Science

7. **Design** You are given a bag of sand from a beach. Design a method to separate it into fine sand, medium sand, and coarse sand. 2.c
8. **Interpret** The first year a beach is measured, it is 13.1 m from the average low-tide mark to the cliffs behind the beach. The next year, the beach is 11.7 m from the cliffs to the average low-tide mark. What do these measurements mean in terms of erosion and sediment deposition? 2.c

Science Online
For more practice, visit **Standards Check** at ca6.msscience.com.

Applying Math

Sediment Deposition Rates

2.b

MA6: SP 1.1, SP 1.2

Sediment deposition rates were measured in the areas below lake level for Searsville Lake in Santa Clara and San Mateo counties.

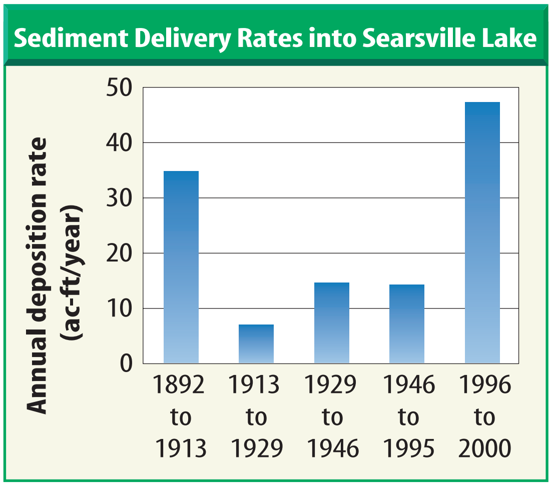
Example

Find the mean annual deposition rate of the data from 1913 to 1946.

What you know: From the graph, the datum from 1913 to 1929 is 3 ac-ft/yr. From the graph, the datum from 1929 to 1946 is 7 ac-ft/yr.

What you need to find: The mean of the data

The mean of the data is the sum of all the numbers in the data set divided by the number of values. Rather than list all the data and then add, you can find how many years have a value of 3 ac-ft/yr and how many years have a value of 7 ac-ft/yr.



Source: Balance Hydrologics, Inc, Searsville Lake Sediment Impact Study

1. Find how many years are included in the data beginning with 1913 to the beginning of 1929, but not including 1929, to find how many years have a value of 3 ac-ft/yr. — 16 years $\times$ 3 ac-ft/yr $=$ 48 ac-ft

2. Now find how many years are included in the data beginning with 1929 to the beginning of 1946, but not including 1946, to find how many years have a value of 7 ac-ft/yr. — 17 years $\times$ 7 ac-ft/yr $=$ 119 ac-ft

3. Now find the mean. — $\frac{48 + 119}{33}$ or about 5.06 ac-ft/yr

Answer: For the 33-year time span, there is an annual deposition rate of about 5.06 ac-ft/yr.

Practice Problems

1. Find the mean annual deposition rate from 1892 to 1929.
2. Find the median annual deposition rate from 1913 to 1995.

Science Online
For more math practice, visit **Math Practice** at ca6.msscience.com.

LESSON 4

Living on the California Coast

Main Idea Geology and ocean currents influence life in California.

Real-World Reading Connection How far away from the coast do you live? Have you ever been to the beach in California? Was the water cold or warm?

Science Content Standards

1.e Students know major geologic events, such as earthquakes, volcanic eruptions, and mountain building, result from plate motions.
4.d Students know convection currents distribute heat in the atmosphere and oceans.
7.c Construct appropriate graphs from data and develop qualitative statements about the relationships between variables.
7.f Read a topographic map and a geologic map for evidence provided on the maps and construct and interpret a simple scale map.

Reading Guide

What *You'll* Learn

- **Understand** the geology of the California coastline.
- **Explain** how ocean currents affect California.

Why *It's* Important

The entire western border of California meets the Pacific Ocean.

Vocabulary

California Current
Davidson Current
habitat
marine

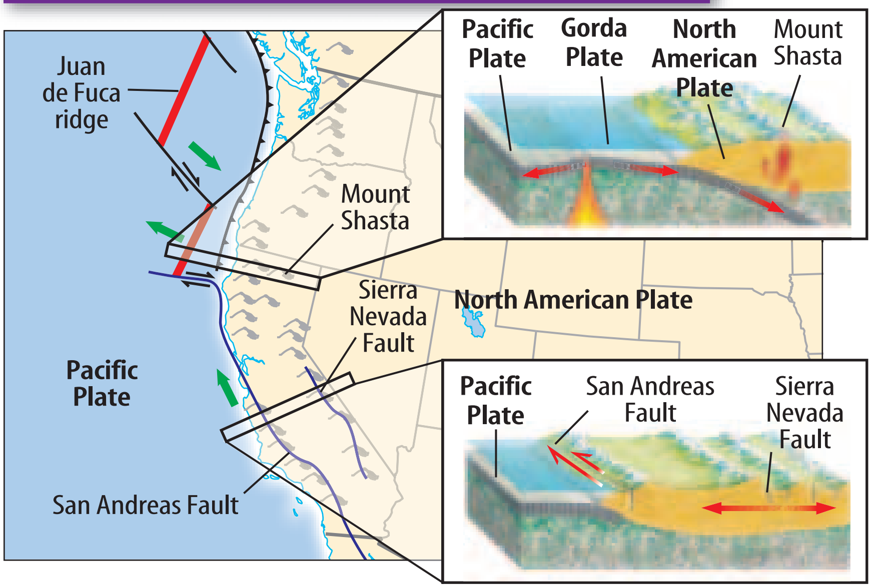
Review Vocabulary

transform plate boundary: boundary formed where two lithospheric plates move sideways past one another (p. 220)

Geology of the California Coast

The geology of California is based on the movement of tectonic plates. Most of California lies on the North American plate, while the Pacific Ocean rests on the Pacific plate. Until about 30 million years ago, these two plates smashed directly into each other. The force of this collision created the coastal mountains in Northern and Southern California. About 30 million years ago, the plates changed direction and started slipping past each other. This created a transform boundary. This slipping lifted up and crushed the sea floor into mountains in central California. As a result of this tectonic activity, coastal mountain ranges stretch along the entire state of California, as shown in **Figure 22.**

Figure 22 Mountain ranges dominate the geology of the California coastline.
Describe how the mountains in central California were formed.



Why does California have so many rocky beaches?

Very few offshore islands protect the coast of California. The waves that hit the shore carry a lot of energy with them. Because California rests on a transform boundary where plates are compressed, the shoreline is elevated. The high-energy of the waves erodes the cliffs along the shoreline, leaving large boulders and cobbles.

What about tsunamis?

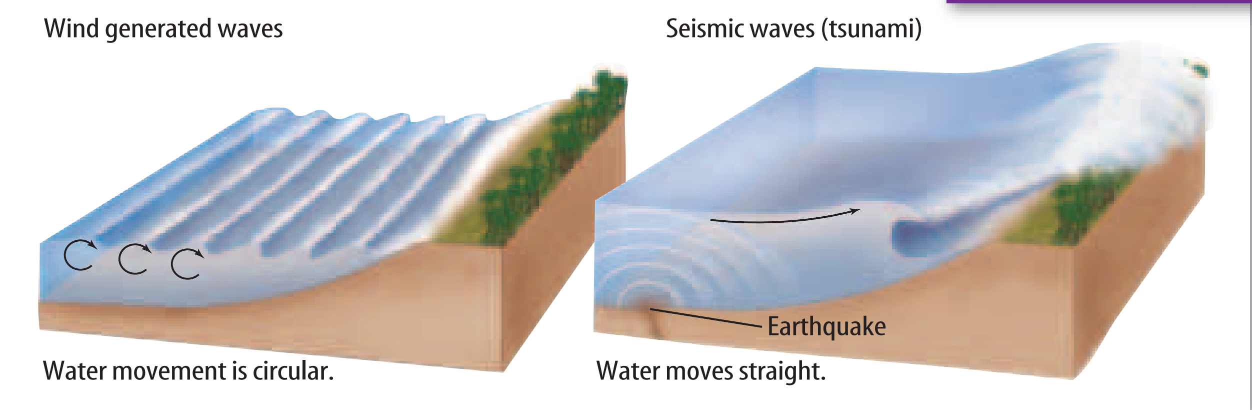
Tsunamis are large sea waves. They are caused by anything that displaces a large amount of water, such as landslides, icebergs falling off glaciers, volcanic explosions, and undersea earthquakes. Undersea earthquakes create the largest tsunamis.

When an earthquake occurs under the ocean, the movement of Earth displaces a large amount of water. This creates waves. The waves then move away from the location of the earthquake in all directions. When a tsunami reaches the shore, the bottom of the wave drags on the seafloor. This causes the enormous amount of water carried by the wave to pile up on itself. The excess water runs up on shore, similar to a fast and strong high tide. **Figure 23** shows the difference between a tsunami and waves caused by wind.

Reading Check What causes a tsunami?

Because there is tectonic activity throughout the Pacific Ocean, the California coast is at risk from tsunamis. Since 1812, 14 tsunamis have hit California, and 12 have caused damage. A sudden rise or drop in sea level is a warning sign of an approaching tsunami. To stay safe, people should to move to higher ground immediately. When tsunamis are generated far from California, the Tsunami Warning Center alerts local officials who will make decisions about evacuations.

Figure 23 Tsunamis are created when underwater earthquakes displace ocean water.



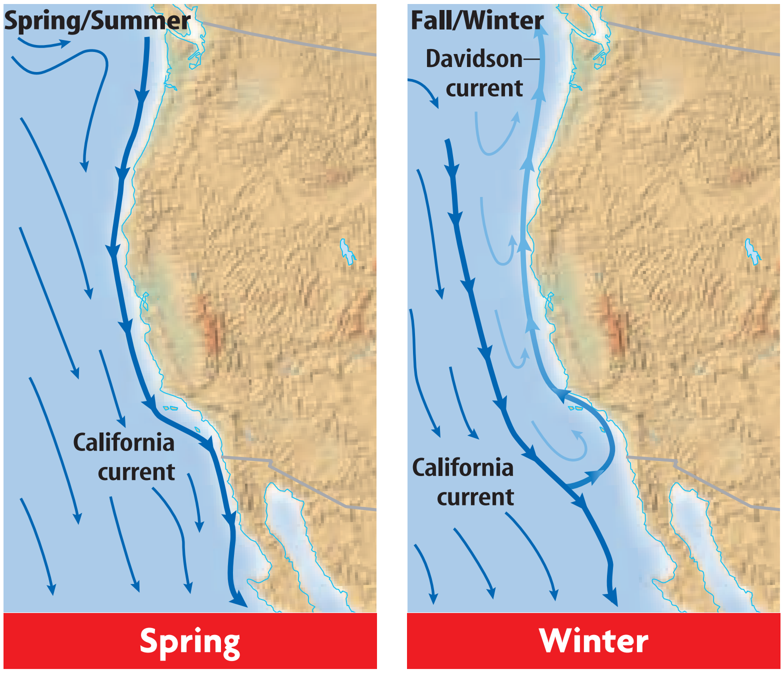


Figure 24 The cold California Current and the warmer Davidson Current are the major ocean currents along the California coast.

Compare and contrast the Davidson Current in the spring and in the winter.

Currents Along the Coast

Figure 24 shows the major ocean currents near California. The **California Current** is a wide, slow-moving, cold-water current along the California coast. It flows southward, bringing cool water from northern latitudes. The **Davidson Current** is a narrow, warm water current that flows northward, close to the California coast, from lower latitudes to higher latitudes. The Davidson Current is a seasonal current. It is stronger in the winter than the summer. California is cooled in the summer by the California Current, and warmed in the winter by the Davidson Current. The two currents often collide near Point Conception, just north of Los Angeles. At this point the California Current moves offshore.

The California Current

If you have ever jumped in the ocean in northern or central California, you might have been shocked by how cold the water was. The chill in the ocean off California is caused by the California Current.

The California Current is an eastern boundary current up to 1,000 km wide. It comes from the Gulf of Alaska, where most of the easterly flowing North Pacific Current is deflected to the south by the Coriolis effect and by hitting North America. Also, offshore winds and deflection by the Coriolis effect draw nutrient-rich deep waters to the surface.

Why are there no hurricanes in California?

Hurricanes are large storms that form in warm, tropical **regions.** As shown in **Figure 25,** they usually move from the east to the west, pushed by the trade winds. Every year, about 18 tropical storms form near Central America in the Pacific Ocean. About half become hurricanes. These storms curve northward and either hit land or lose energy at higher latitudes.

But no hurricanes have been recorded hitting California. The largest storm to hit California was September 25, 1939, in Long Beach, just south of Los Angeles. It had winds of 80 km/h, about two-thirds as strong as the winds of a hurricane. Why are there no hurricanes in California?

The power of a hurricane comes from the warm water in tropical areas. Hurricanes need approximately 27°C water temperature to survive. When the storm system moves into cold water, it loses energy. Recall that the California Current brings cold water along the California coast from northern latitudes. The California Current's surface temperature can be 15°C or even lower. The cold water around California acts as a hurricane shield.

Reading Check Explain why there are no hurricanes in California.

Figure 25 The cold water of the California Current takes the energy away from hurricanes.

ACADEMIC VOCABULARY
region (REE juhn)
(noun) a broad geographical area with similar characteristics *Tropical regions are warm and near the equator.*

DataLab

00:20 minutes

How many whales are in the ocean?

The Channel Islands are at a latitude of about 34°N with an average water temperature of about 55–60°F. The Hawaiian Islands lie further south in the Pacific at latitudes between 19–22° N. The average water temperature in Hawaii is 73–78°F.

Data Collection

These data show the number of species recorded in the Channel Islands and the Hawaiian Islands.

Species Counts

Species	Channel Islands	Hawaiian Islands
Whales and dolphins	30	4
Seals and Sea lions	7	1
Fishes	at least 40	at least 59
Birds	60	11
Invertebrates	at least 35	at least 33
Marine plants	10	10
Reptiles	0	4

Data Analysis

1. **Graph** the data in the table above.
2. **Analyze** Which groups differ the most between the two locations? Which location has the highest total possible number of species?
3. **Draw Conclusions** How would you explain the differences between the two locations?

4.d, 7.c

Try at Home

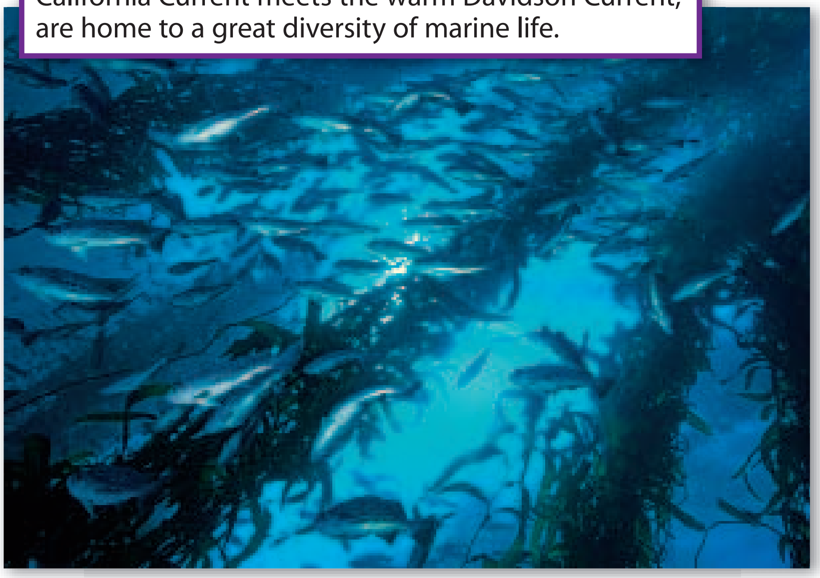
Sea Life

The place in which an organism lives is called its **habitat.** Critical elements that affect habitat include the types of food available, the shelter, the moisture, and the temperature ranges needed for survival. In places where warm and cold water come together, the ocean usually is full of life. This is exactly what happens in the Channel Islands where the warm Davidson Current meets the cold California Current. The Channel Islands, along the coast of southern California, are home to a wide variety of different marine animals and plants, as shown in **Figure 26.** **Marine** refers to anything that is related to the ocean.

Reading Check Why is the diversity of organisms high in the Channel Islands?

The rocky shore also provides a variety of habitats for the organisms that live there. The intertidal zone is the area of shore that is between the lowest low-tide line and the highest high-tide line. On rocky shores, the intertidal zone provides many different habitats for marine creatures. The amount of water and exposure to air and the Sun varies in the intertidal zone. **Figure 27** shows some organisms that live in the intertidal zone.

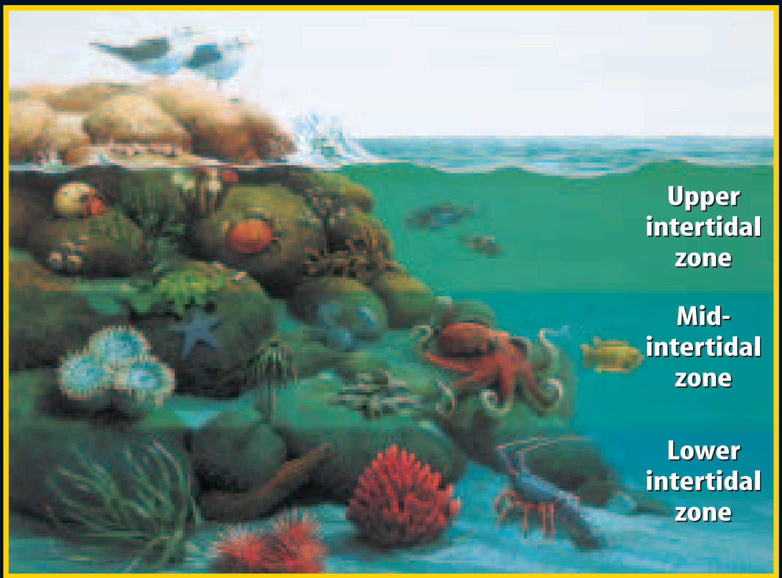
Figure 26 The Channel Islands, where the cold California Current meets the warm Davidson Current, are home to a great diversity of marine life.



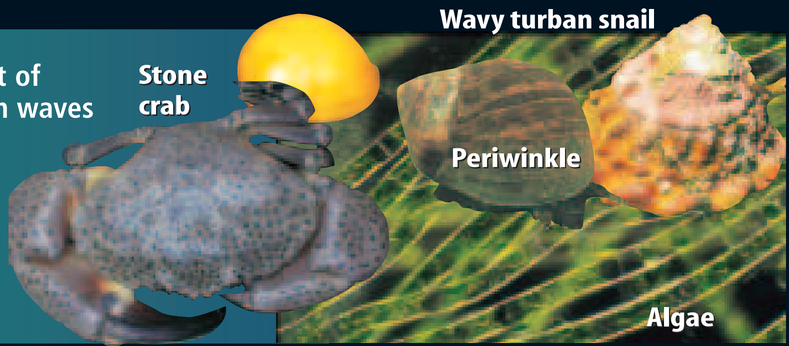
Visualizing the Rocky Shore Habitat

Figure 27

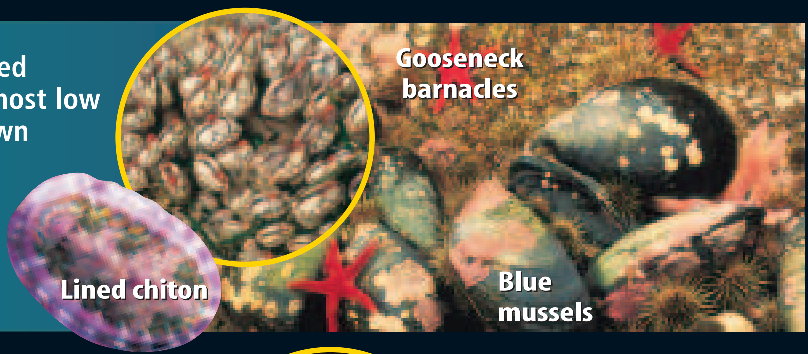
Life is tough in the intertidal zone—the coastal area between the highest high tide and the lowest low tide. Organisms here are pounded by waves and alternately covered and uncovered by water as tides rise and fall. These organisms tend to cluster into three general zones along the shore. Where they live depends on how well they tolerate being washed by waves, submerged at high tide, or exposed to air and sunlight when the tide is low.



UPPER INTERTIDAL ZONE This part of the intertidal zone is splashed by high waves and is usually covered by water only during the highest tides each month. It is home to crabs that scuttle among periwinkle snails, limpets, and a few kinds of algae that can withstand long periods of dryness.



MID-INTERTIDAL ZONE Submerged at most high tides and exposed at most low tides, this zone is populated by brown algae, sponges, barnacles, mussels, chitons, snails, and sea stars. These creatures are resistant to drying out and good at clinging to slippery surfaces.



LOWER INTERTIDAL ZONE This section of the intertidal zone is exposed only during the lowest tides each month. It contains the most diverse collection of living things. Here you find sea urchins, large sea stars, brittle stars, nudibranchs, sea cucumbers, anemones, and many kinds of fish.

Contributed by National Geographic

Human Impact on the Coast

Humans use California's coastal waters for a variety of activities including swimming, boating, fishing, and even generating energy from the changing water level of the tides.

Fisheries

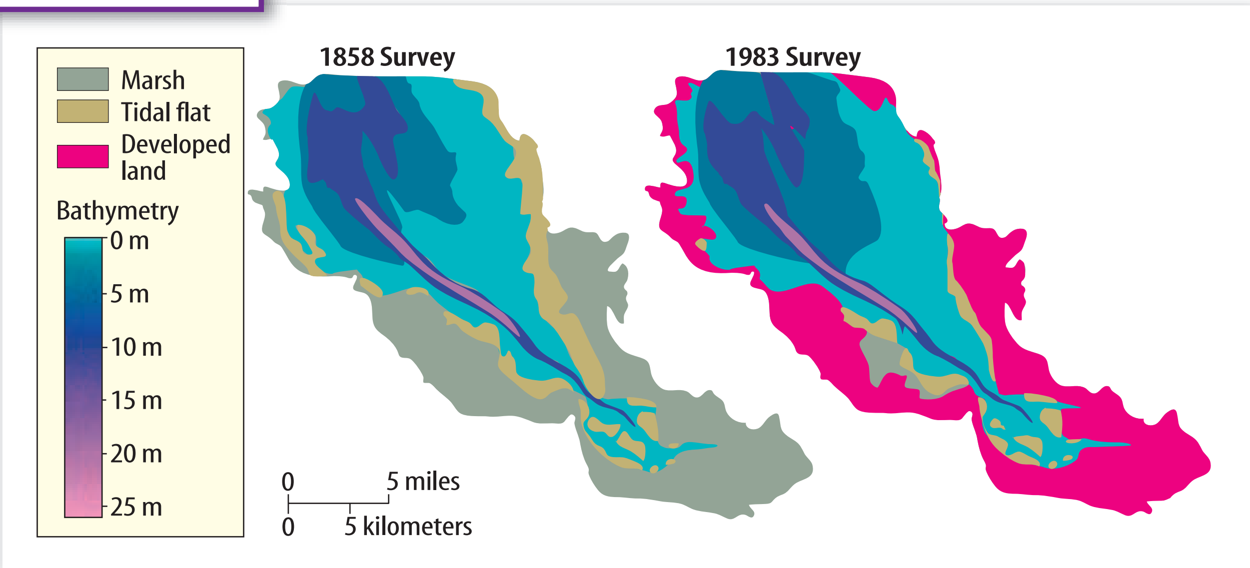
Many people fish in the ocean for business. They remove large amounts of herring, sea bass, sea urchins, and squid to sell to stores or restaurants. If too many organisms are removed, the organism may become threatened or endangered. Laws regulate the amount of organisms that can be removed, the time they can be removed, and the sizes of organisms that are removed. Fisheries are regulated by government agencies such as the California Department of Fish and Game.

Each fishery has a specific management plan. For example, the squid fishery is California's largest fishery with more than 160 million pounds of squid caught in 2002. The Market Squid Fishery Management Plan has policies to keep the fishery healthy and the population of squid out of danger.

Habitat Changes

Some human activities can alter the habitats of organisms. Wetlands and other coastal marsh areas are habitats for birds, fish, insects, plants, and marine invertebrates. **Figure 28** shows the difference in the amount of marsh area in the San Francisco Bay area between 1858 and 1983. Between these dates, more than 80 percent of the marsh area was developed for agriculture and buildings. This habitat loss has led to the decline in numbers of some species. Some native organisms, including the California clapper rail and the salt marsh harvest mouse, are endangered partly due to loss of habitat.

Figure 28 Marshes and wetlands often provide food, shelter, and nursery areas for many land and marine species.



Coastal California

The coast of California has been shaped by the tectonic activity of the North American Plate and the Pacific Plate, resulting in coastal mountains and rocky shorelines, as well as the threat of tsunamis. The California Current and the seasonal Davidson Current affect water temperatures, sea life, and weather along the coast of California. Due to the cold temperature of the water carried by the California Current, hurricanes do not occur in California. Marine life in the waters off of California is diverse. Organisms living on beaches, rocky shores, and in coastal waters can be affected by habitat change.

LESSON 4 Review

Summarize

Create your own lesson summary as you organize an **outline.**

1. **Scan** the lesson. Find and list the first **red** main heading.
2. **Review** the text after the heading and list 2–3 details about the heading.
3. **Find** and list each **blue** subheading that follows the **red** main heading.
4. **List** 2–3 details, key terms, and definitions under each **blue** subheading.
5. **Review** additional **red** main headings and their supporting **blue** subheadings. List 2–3 details about each.

ELA6: R 2.4

Standards Check

Using Vocabulary

1. Distinguish between *California Current* and *Davidson Current.* 4.d
2. Use each term in a separate sentence: *marine* and *habitat.* 5.e

Understanding Main Ideas

3. Which describes a sea wave caused by an earthquake? 1.e
   - **A.** current
   - **B.** transform wave
   - **C.** tsunami
   - **D.** wind wave
4. **Organize Information** Copy and fill in the graphic organizer below to describe the two major currents that affect California. 4.d

Current	Description
California Current	
Davidson Current	

5. **Explain** the connection between the geology of California and how many rocky beaches California has. 1.e
6. **Explain** why you can find both fish that live in warm water and fish that live in cold water on San Clemente Island, one of the Channel Islands. 5.e

Applying Science

7. **Construct** a set of guidelines that could be handed out to people who go to the beach that provides information about tsunamis. 1.e
8. **Infer** The east coast of the United States is hit by hurricanes every year. What can you infer about the current that flows by this part of the country? 4.d

Science Online
For more practice, visit **Standards Check** at ca6.msscience.com.

Lab

Matt Meadows

Mapping the Ocean Floor

Materials

shoe box with lid
dowel rod marked in centimeters
modeling clay
colored markers

Safety Precautions

Science Content Standards

7.f Read a topographic map and a geologic map for evidence provided on the maps and construct and interpret a simple scale map.

Problem

Mapping the ocean floor is a challenging activity involving data collection and analysis. In this lab, you will make a model of the ocean floor and then collect data to make a map.

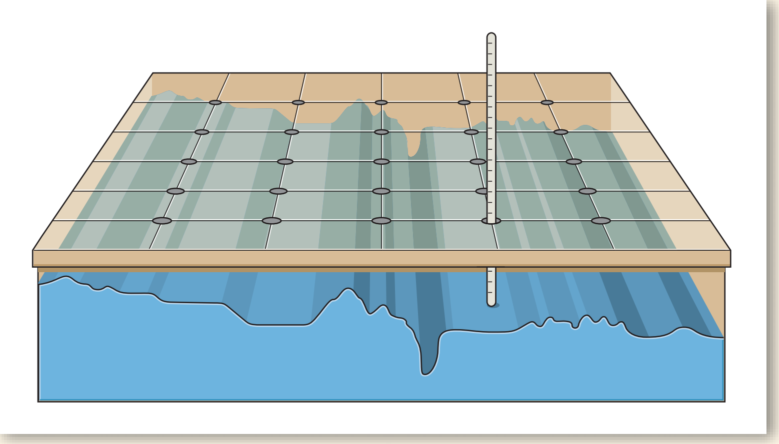
Form a Hypothesis

How can you make a bathymetric map?

Collect Data and Make Observations

Build the Ocean Floor

1. Read and complete a lab safety form.
2. Obtain a shoe box. Use the modeling clay to make a model of the ocean floor at the bottom of the shoe box.
3. Your model should include some of the features of the ocean floor such as ridges, abyssal plains, trenches, the continental shelf, and the continental slope. Do not allow other groups to see your ocean floor.
4. Place the lid on the box and exchange your box with another group.



Collect Data

5. Examine the grid on top of the lid.
6. Design a data grid like the one shown to the right that has the same number of squares as the grid on the box.
7. Starting at square A1, put the dowel rod into the hole in each square of the grid.
8. Find the square on your data grid that matches the square on the box lid. Record the depth to the nearest centimeter. Continue until you have recorded a depth for each square.

	A	B	C	D	E	F
1						
2						
3						
4						
5						
6						

Analyze and Conclude

1. **Interpret** the data you have collected. Use the Depth and Color table to color code your data grid. Color each square of your data grid the color that corresponds most closely to a measurement found in the table below.
2. **Classify** the different areas of the bottom of the box. Are there any ridges, trenches, or abyssal plains?
3. **Describe** what the bottom of the box looks like. Did you find anything unexpected?
4. **Think critically** about the method you used to make your map. How does it differ from how scientists make their maps? Is it similar to any other method you have learned about?
5. **Analyze** the bottom of the box once your teacher opens the lid. How closely did your map mirror the bottom of the box?

Depth and Color

Ocean Depth (cm)	Color Code
12	Black
10	Purple
8	Dark blue
7	Light blue
5	Green
4	Yellow
3	Orange
2	Red
1	Pink

Communicate

WRITING in **Science** ELA6: W 2.5

Write an Advertisement Suppose you make bathymetric maps of near-shore areas based on data collected by scientists. You want to sell the maps to boat captains and other navigators. Write an ad to be placed in a boating magazine to sell your maps.

Real World Science

Science & Career

Shipboard Instructor

Would you like to sail on a research vessel, teaching students about the physics, chemistry, biology, and geology of the ocean? You can spend 3–12 months on voyages as an instructor. Many colleges and universities around the world offer such programs. To qualify for such a position, you will need to take science classes in high school and college. Most instructors have master's degrees or significant outside experience.

Visit Careers at ca6.msscience.com to learn more about becoming a shipboard instructor. Visit at least three Web sites of oceangoing instructional ships and **make a chart** to compare what qualifications you would need to work at each. **Decide** upon which ship you would prefer to work and give three reasons why.

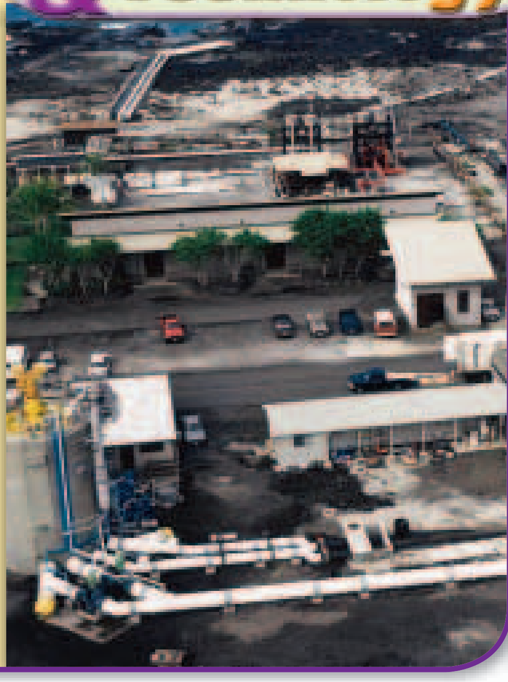
Science & Technology

OTEC

Ocean Thermal Energy Conversion (OTEC) relies upon a difference in the temperature of the ocean at the surface and at depth. Offshore OTEC power plants use this temperature difference to produce electricity, freshwater, and air conditioning. Such a plant is expensive at this time, but may be an excellent choice in the future for island communities with no fossil fuel resources and insufficient fresh water.

Visit Technology at ca6.msscience.com to learn more about OTEC technology. Pretend you are living in American Samoa, an island in the South Pacific. **Write** a letter to the editor of the local newspaper in support of using this technology to provide power and drinking water for the island. Give at least five reasons to support your position.

ELA6: W 1.2



(t)NOAA/Channel Islands NMS, (b)Dr. Luis Vega/U.S. Department of Energy

Science & History

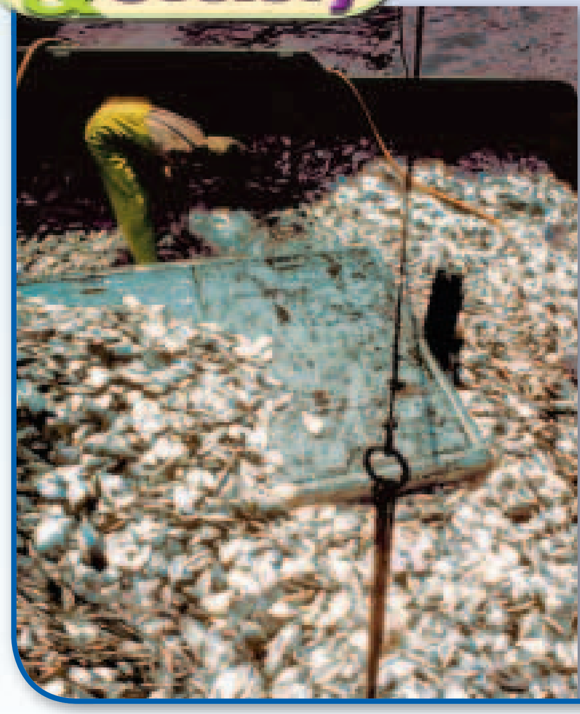
Marie Tharp

During the Cold War, there was a great demand for precise knowledge of the seafloor. Having studied geology at the University of Michigan while the men were away at war, Marie Tharp joined a research group at Columbia University in New York in 1948. She spent several decades with Dr. Bruce Heezen analyzing and piecing together the data that the team had compiled of the Atlantic seafloor. She patiently hand-inked version after version of contour maps that showed the mid-oceanic ridge that solidified the theory of plate tectonics.

How did Marie Tharp make her contour maps? Visit **History** at ca6.msscience.com to learn more about where she got her data. Work through the tutorial to create your own contour maps in the same way that Marie Tharp did.

Science & Society

Overfishing the Oceans



One in five people of the world rely upon fish as their primary source of protein. However, since the early 1800s, certain cultures have been capable of depleting and sometimes have depleted the local population of certain fish. According to the Food and Agriculture Organization of the United Nations, over 70 percent of fish species are fully exploited or depleted. Although a greater tonnage of fish is caught with each passing year, the fishing industry is catching smaller and smaller fish each year.

Visit **Society** at ca6.msscience.com to learn more about overfishing. Pretend that you are a subsistence fisher working to support and feed your family. How do you feel about new restrictions on the size of your catch to keep the fish population from collapsing? How effective do you feel these measures will be?

Standards Study Guide

The BIG Idea Oceans are a major feature of Earth.

Lesson 1 Earth's Oceans

7.c, 7.f

Main Idea **Mapping the ocean floor is important to understanding Earth's global features.**

- Bathymetric maps of the oceans are made by using soundings, and they show geologic features under water.
- The ocean floor typically includes the continental shelf, the continental slope and rise, mid-ocean ridges, trenches, and abyssal plains.

- **bathymetric map** (p. 425)
- **continental shelf** (p. 427)
- **echo sounding** (p. 426)
- **ocean floor** (p. 425)
- **sea level** (p. 425)

Lesson 2 Ocean Currents

4.a, 4.d

Main Idea **Ocean currents help distribute heat around Earth.**

- Wind is the major driver of currents in the oceans.
- Deep ocean currents are driven by differences in the density of ocean water.
- Gyres are cycles of currents that move water and distribute heat around ocean basins.

- **gyre** (p. 434)
- **ocean current** (p. 430)
- **salinity** (p. 433)

Lesson 3 The Ocean Shore

2.c

Main Idea **The shore is shaped by the movement of water and sand.**

- Wind and waves continually erode beaches.
- Longshore drift is the movement of sand along the shoreline.
- Sand is composed of different rocks and minerals.

- **longshore current** (p. 440)
- **longshore drift** (p. 440)
- **rip current** (p. 440)
- **sand** (p. 442)
- **shore** (p. 438)
- **shoreline** (p. 438)

Lesson 4 Living on the California Coast

1.e, 4.d, 7.c, 7.f

Main Idea **Geology and ocean currents influence life in California.**

- The major currents along the California Coast are the California Current and the Davidson Current.
- Where the California Current and the Davidson Current meet, marine life is abundant and diverse.
- Hurricanes do not reach the shore in California.

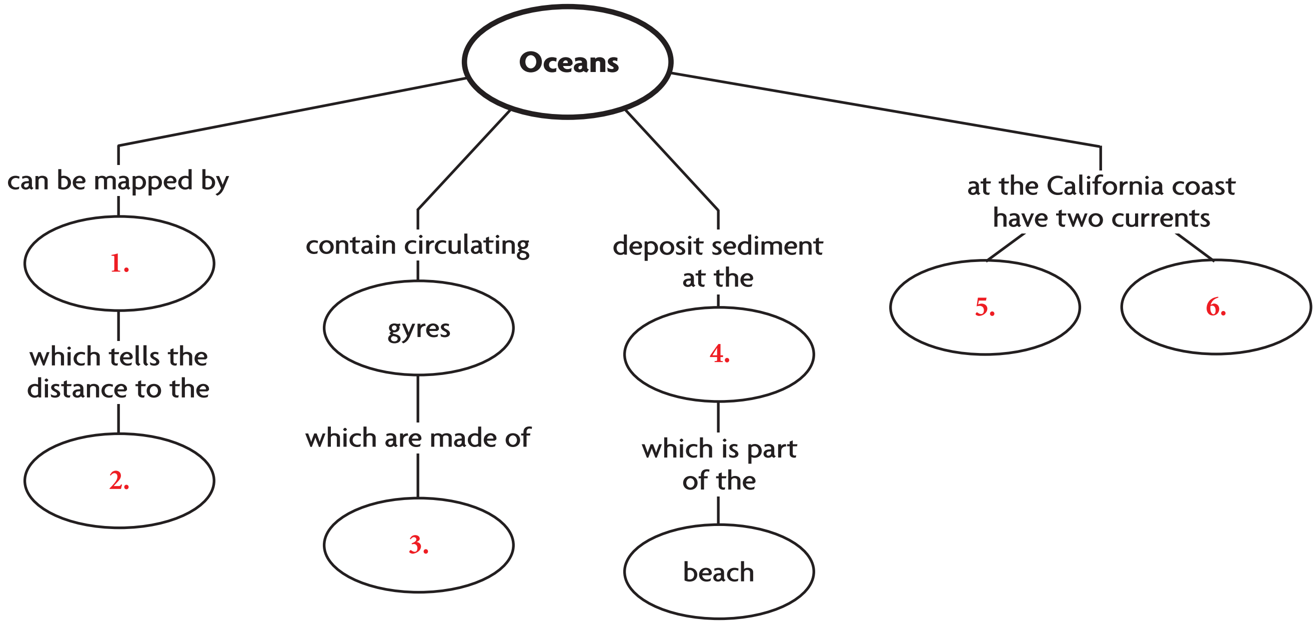
- **California Current** (p. 448)
- **Davidson Current** (p. 448)
- **habitat** (p. 450)
- **marine** (p. 450)

STUDY TO GO Download quizzes, key terms, and flash cards from ca6.msscience.com.

Science Online Interactive Tutor ca6.msscience.com

Linking Vocabulary and Main Ideas

Use the vocabulary terms from page 458 to complete this concept map.



Science Online

Visit ca6.msscience.com for:

- Vocabulary PuzzleMaker
- Vocabulary eFlashcards
- Multilingual Glossary

Using Vocabulary

Fill in the blanks with the correct vocabulary terms.

7. ________ is the amount of salt dissolved in water.

8. A(n) ________ is like a river in the ocean.

9. ________ is quicker and less costly than dropping a rope to the bottom of the ocean to determine the depth of the ocean floor.

10. When sand moves along the shoreline as a result of waves hitting the shore at an angle it is ________.

11. ________ is any rock between 2 mm and 62.5 µm.

12. The ________ brings cool water along the California coast.

13. A(n) ________ is a fast-moving current that moves water offshore.

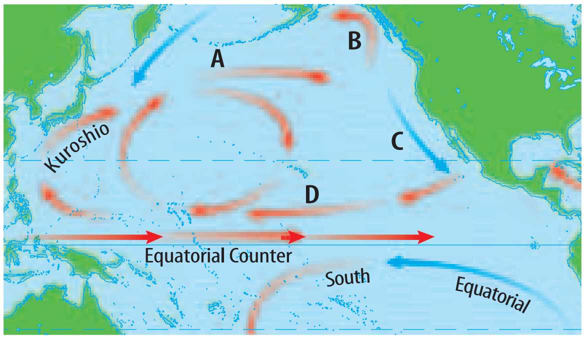
14. Animals that are found in the ocean are called ________.

Standards Review

Understanding Main Ideas

1. Where is new ocean floor formed?
   A. mid-ocean ridge
   B. abyssal plain
   C. deep ocean trench
   D. continental rise 1.a

2. The map below shows currents in the northern Pacific Ocean.



Which current is labeled A?
   A. Alaska Current
   B. California Current
   C. North Equatorial Current
   D. North Pacific Current 4.d

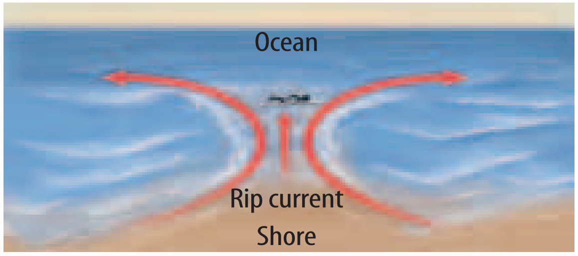
3. Which is most important to the flow of deep ocean currents?
   A. the density of water
   B. the wind
   C. the specific heat capacity of water
   D. the convection in the atmosphere 4.d

4. During El Niño, which occurs?
   A. The westerlies blow with increased force.
   B. The trade winds intensify.
   C. The California Current reverses directions.
   D. The North Equatorial Current weakens. 4.d

5. Which is true in the northern hemisphere?
   A. The Coriolis effect deflects the winds to the left.
   B. There are four major gyres.
   C. The strongest currents are on the eastern side of the oceans.
   D. The gyres rotate clockwise. 4.d

6. Which statement is correct?
   A. The sand on beaches originates from rocks within a 5-km radius.
   B. The sand on beaches usually is made up of a single type of rock or mineral.
   C. The sand on beaches may have originated as boulders hundreds of miles from the beach.
   D. The sand on beaches always remains in the same location. 2.c

7. Examine the figure below.



Which best describes what is happening in this figure?
   A. The water from a tsunami is piling up on itself and surging up the shore.
   B. A rip current is collecting on the beach.
   C. A hurricane is making landfall on the central California coast.
   D. The longshore drift is pulling water above the high-tide mark. 2.c

8. Why is California relatively protected from hurricanes?
   A. Hurricanes are only found at tropical latitudes.
   B. Hurricanes only move from east to west.
   C. Hurricanes require warm water for power.
   D. Hurricanes develop when underwater earth-quakes occur. 4.d

Applying Science

9. **Compare and contrast** a mid-ocean ridge and a deep ocean trench. 1.a

10. **Describe** how you might construct a bathymetric profile across San Francisco Bay. 7.f

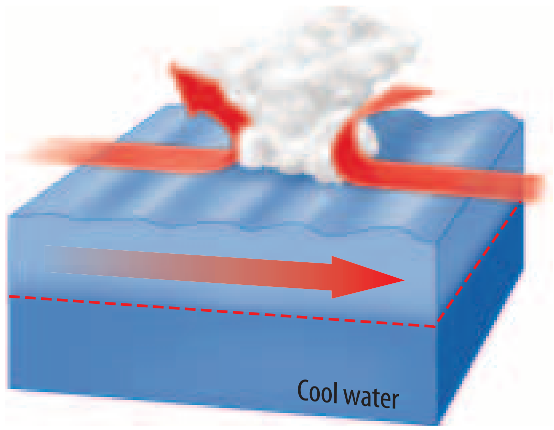
11. **Hypothesize** What would happen to the North Pacific Gyre if Earth spun the opposite direction on its axis? 4.d

12. **Explain** what influences the flow of the major currents in the North Atlantic Gyre. Include the North Equatorial Current, the Gulf Stream, the North Atlantic Current, and the Canary Current in your answer. 4.d

13. **Hypothesize** what the effects of longshore drift on a beach would be where the waves always hit exactly parallel to the shoreline. 2.c

14. **Interpret** You examine two samples of white sand under the microscope and decide they must be from different beaches. Explain what you might have seen that led you to this. 2.c

15. **Analyze** What event is shown in the diagram below? What happens to the winds during this event? How is water affected during this event? 4.d



WRITING in Science

16. **Suppose** there is a massive earthquake in the seafloor near Puerto Rico. Write a 500-word story from the point of view of someone in Miami, Florida. ELA6: W 2.1

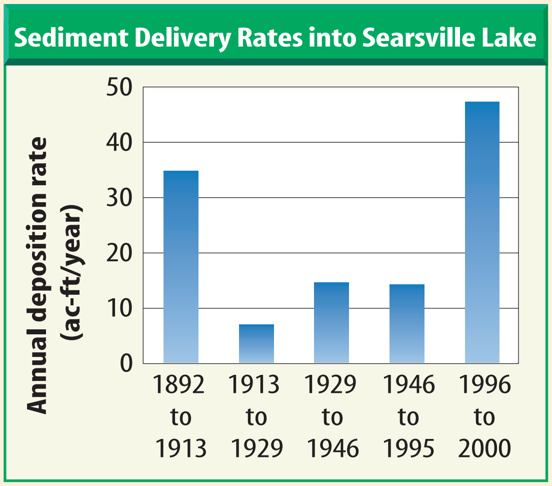
Cumulative Review

17. **Explain** how the Sun and Earth's atmosphere make conditions on Earth suitable for life. 4.a

18. **Identify** and describe the three types of radiation that make up solar radiation. 4.b

Applying Math

Use the graph below to answer questions 19–23.



19. Find the mean annual deposition rate from 1946 to 2000. MA6: SP 1.1, SP 1.2

20. Find the median annual deposition rate from 1946 to 2000. MA6: SP 1.1, SP 1.2

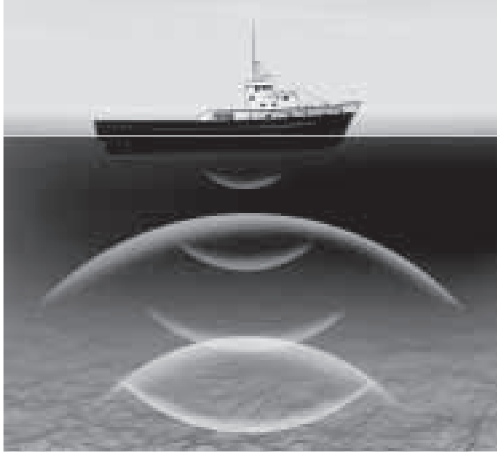
21. Find the mean annual deposition rate from 1892 to 1946. MA6: SP 1.1, SP 1.2

22. Find the median annual deposition rate from 1892 to 1946. MA6: SP 1.1, SP 1.2

23. Find the mean annual deposition rate from 1929 to 1995. MA6: SP 1.1, SP 1.2

Standards Assessment

Use the illustration below to answer questions 1–2.



1 **Which process is shown in the illustration above?**

A conduction

B convection

C echo sounding

D longshore drift

7.f

2 **The process above is used to create which type of map?**

A bathymetric map

B geologic map

C geologic cross section

D satellite map

7.f

3 **Why aren't all ocean surface currents the same temperature?**

A Different currents move at different speeds.

B The surface water is deeper in some areas than others.

C Different latitudes receive different amounts of solar energy.

D Surface currents start out warm but transfer all of their thermal energy.

4.d

4 **Which drives ocean surface currents?**

A conduction

B evaporation

C salinity

D wind

4.d

Use the table below to answer questions 5–6.

Partial Sediment Size Range	
Name	**Size**
Boulder	>256 mm
Coarse gravel	16–32 mm
Fine gravel	4–8 mm
Coarse sand	0.5–1 mm
Fine sand	125–250 µm
Silt	3.90625–62.5 µm
Clay	<3.90625 µm

5 **What size sediment would you expect medium sand to have?**

A 250 µm—0.5 mm

B 300 µm—1 mm

C 8 mm—9mm

D 8mm—15mm

2.c

6 **Which type of sediment is more likely to be found on a low-energy beach?**

A boulder

B gravel

C coarse sand

D fine sand

2.c

7 **Which geological feature is the result of plate movements?**

A abyssal plain

B continental shelf

C continental slope

D deep ocean trench 1.e

8 **The photo shows a tombolo behind Morro Rock, California.**

Which formed the tombolo shown in the photo?

A convection

B deposition

C erosion

D rip currents 2.c

9 **Which is an effect of La Niña?**

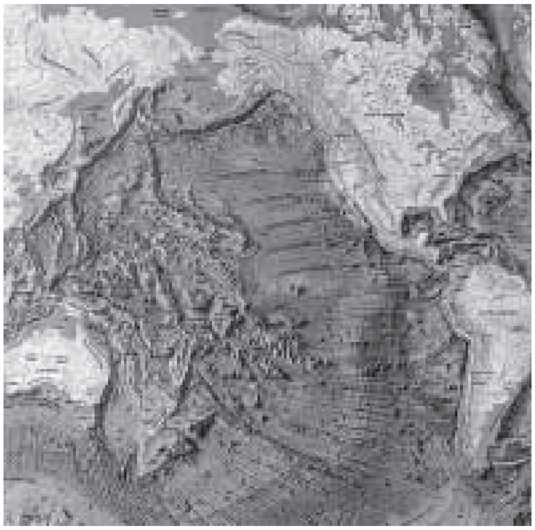
A cold and chilly South American coast 4.d

B droughts in the western Pacific region

C global increase in temperature

D increased flooding in California and Peru

Use the illustration below to answer questions 10–11.



10 **The figure above is an example of**

A bathymetric map.

B geologic map.

C geologic cross section.

D satellite map. 7.f

11 **Which feature is not visible on the map above?**

A abyssal plain

B asthenosphere

C mountain range

D ocean trench 7.f

12 **How are the North Pacific Current and the westerlies related?**

A They both flow along the coast of California.

B They flow along the same path in the northern hemisphere.

C They flow in opposite paths in the northern hemisphere.

D They both flow in concentrated bands around the Earth. 4.d