Section 4

Currents and Climate

Reading Preview

Key Concepts

- What causes surface currents and how do they affect climate?
- What causes deep currents and what effects do they have?
- How does upwelling affect the distribution of nutrients in the ocean?

Key Terms

- current
- Coriolis effect
- climate
- El Niño
- upwelling

Target Reading Skill

Relating Cause and Effect As *you read, identify the main factors that cause surface and deep currents in the oceans. Write the information in graphic organizers like the one below.*

Cause		Effect
	→	Surface currents

Cause		Effect
	→	Deep currents

Lab zone Discover Activity

Which Is More Dense?

1. Fill a plastic container three-quarters full with warm water. Wait for the water to stop moving.
2. Add several drops of food coloring to a cup of ice water and stir.
3. Gently dribble colored water down the inside of the container. Observe.

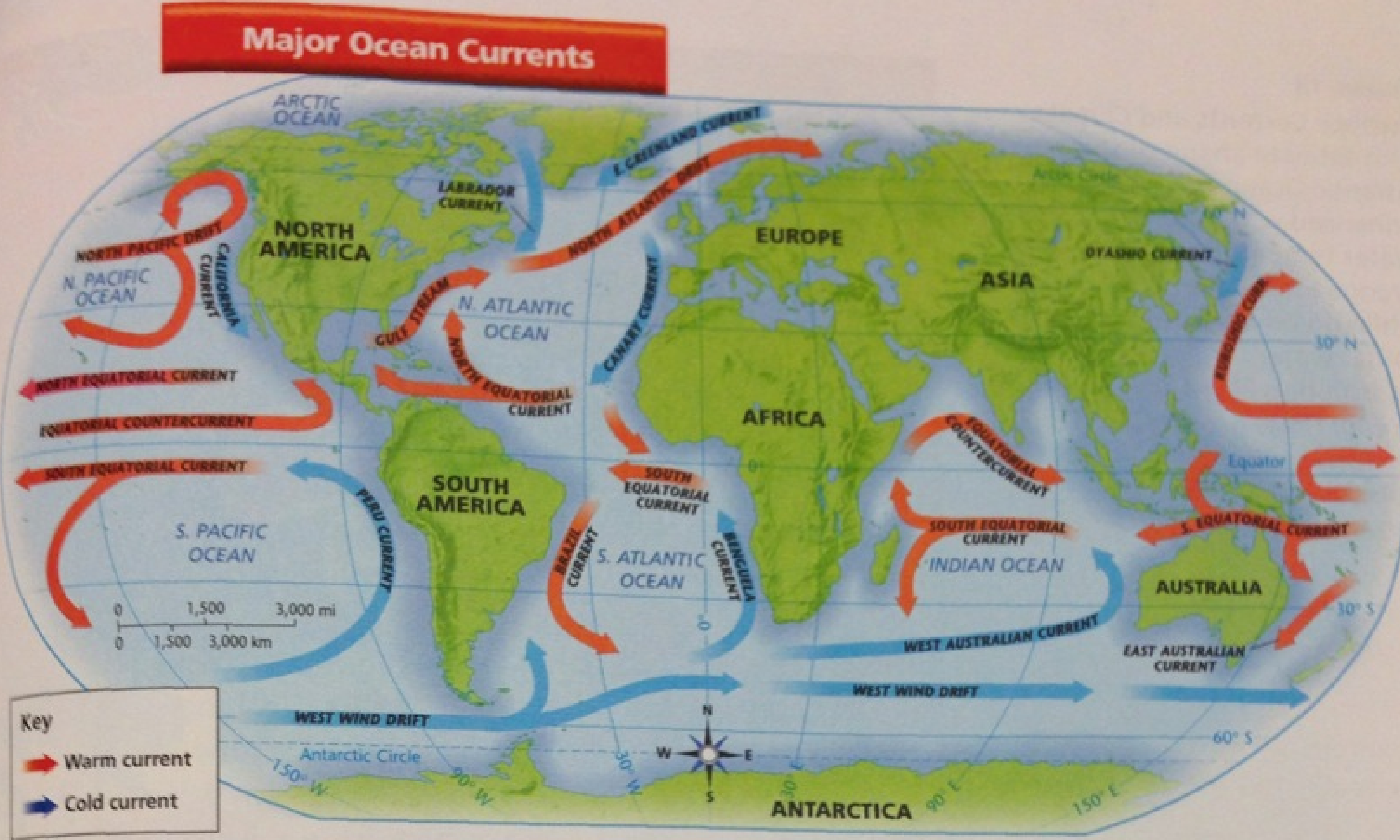
Think It Over

Inferring Describe what happened to the cold water. Which is more dense, warm water or cold water? Explain.

One spring day, people strolling along a beach in Washington State saw an amazing sight. Hundreds of sneakers of all colors and sizes were washing ashore from the Pacific Ocean! This "sneaker spill" was eventually traced to a cargo ship accident. Containers of sneakers had fallen overboard and now the sneakers were washing ashore.

But the most amazing part of the story is this—scientists could predict where the sneakers would wash up next. And just as the scientists had predicted, sneakers washed up in Oregon, and then thousands of kilometers away in Hawaii!

How did the scientists know that the sneakers would float all the way to Hawaii? The answer lies in a type of ocean movement known as a current. A **current** is a large stream of moving water that flows through the oceans. Unlike waves, currents carry water from one place to another. Some currents move water at the surface of the ocean, while other currents move water deep in the ocean.



Surface Currents

Figure 17 shows the major surface currents in Earth's oceans. **Surface currents, which affect water to a depth of several hundred meters, are driven mainly by winds.** Following Earth's major wind patterns, surface currents move in circular patterns in the five major oceans. Most of the currents flow east or west, and then double back to complete the circle.

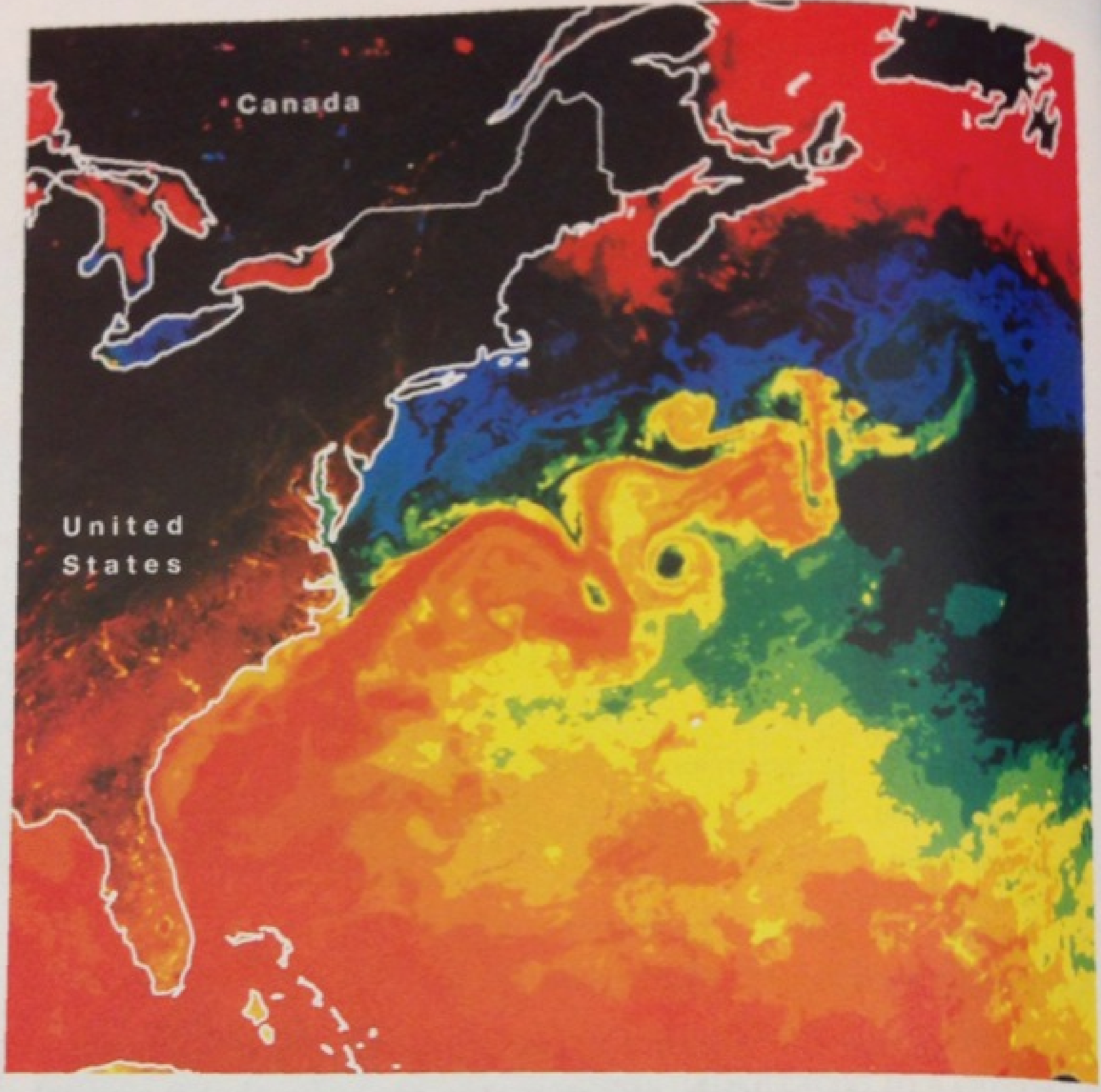
Coriolis Effect Why do the currents move in these circular patterns? If Earth were standing still, winds and currents would flow in straight lines between the poles and the equator. But as Earth rotates, the paths of the winds and currents curve. This effect of Earth's rotation on the direction of winds and currents is called the **Coriolis effect** (kawr ee OH lis). In the Northern Hemisphere, the Coriolis effect causes the currents to curve to the right. In the Southern Hemisphere, the Coriolis effect causes the currents to curve to the left.

The largest and most powerful surface current in the North Atlantic Ocean, the Gulf Stream, is caused by strong winds from the west. It is more than 30 kilometers wide and 300 meters deep, and carries a volume of water 100 times greater than the Mississippi River. The Gulf Stream carries warm water from the Gulf of Mexico to the Caribbean Sea, then northward along the coast of the United States. Near Cape Hatteras, North Carolina, it curves eastward across the Atlantic, as a result of the Coriolis effect.

FIGURE 17
Large surface currents generally move in circular patterns in Earth's oceans. **Interpreting Maps** *Name four currents that flow along the coasts of North America. State whether each current is warm or cold.*

Go Online
SCILINKS NSTA
For: Links on ocean currents
Visit: www.SciLinks.org
Web Code: scn-0834

FIGURE 18
Surface Currents and Climate
This satellite image of the Atlantic Ocean has been enhanced with colors that show water temperature. Red and orange indicate warmer water, while green and blue indicate colder water.
Interpreting Maps *The Gulf Stream flows around Florida in the lower left of the map. Is the Gulf Stream a warm or cold current?*



Effects on Climate The Gulf Stream and another warm current, the North Atlantic Drift, are very important to people in the city of Trondheim, Norway. Trondheim is located along Norway's western coast. Although it is very close to the Arctic Circle, winters there are fairly mild. Snow melts soon after it falls. And fortunately for the fishing boats, the local harbors are free of ice most of the winter. The two warm currents bring this area of Norway a mild climate. **Climate** is the pattern of temperature and precipitation typical of an area over a long period of time.

Currents affect climate by moving cold and warm water around the globe. In general, currents carry warm water from the tropics toward the poles and bring cold water back toward the equator. **A surface current warms or cools the air above it, influencing the climate of the land near the coast.**

Winds pick up moisture as they blow across warm-water currents. For example, the warm Kuroshio Current brings mild, rainy weather to the southern islands of Japan. In contrast, cold-water currents cool the air above them. Since cold air holds less moisture than warm air, these currents tend to bring cool, dry weather to the land areas in their path.

Lab zone **Skills Activity**

Drawing Conclusions

Locate the Benguela Current in Figure 17 on the previous page. Near the southern tip of Africa, the winds blow from west to east. Using what you have learned about surface currents and climate, what can you conclude about the impact of this current on the climate of the south-western coast of Africa?

El Niño When changes in wind patterns and currents occur, they can have a major impact on the oceans and neighboring land. One example of such changes is **El Niño,** an abnormal climate event that occurs every two to seven years in the Pacific Ocean. El Niño begins when an unusual pattern of winds forms over the western Pacific. This causes a vast sheet of warm water to move eastward toward the South American coast. El Niño conditions can last for one to two years before the usual winds and currents return.

El Niño can have disastrous consequences. It causes shifts in weather patterns around the world, bringing unusual and often severe conditions to different areas. For example, a major El Niño occurred between 1997 and 1998 and caused an especially warm winter in the northeastern United States. However, it was also responsible for heavy rains, flooding, and mudslides in California, as well as a string of deadly tornadoes in Florida.

Although scientists do not fully understand the conditions that cause El Niño, they have been able to predict its occurrence using computer models of world climate. Knowing when El Niño will occur can reduce its impact. Scientists and public officials can plan emergency procedures and make changes to protect people and wildlife.

Reading Checkpoint **Why is it helpful to be able to predict when El Niño will occur?**

FIGURE 19
El Niño's Impact
El Niño can cause severe weather all around the world.

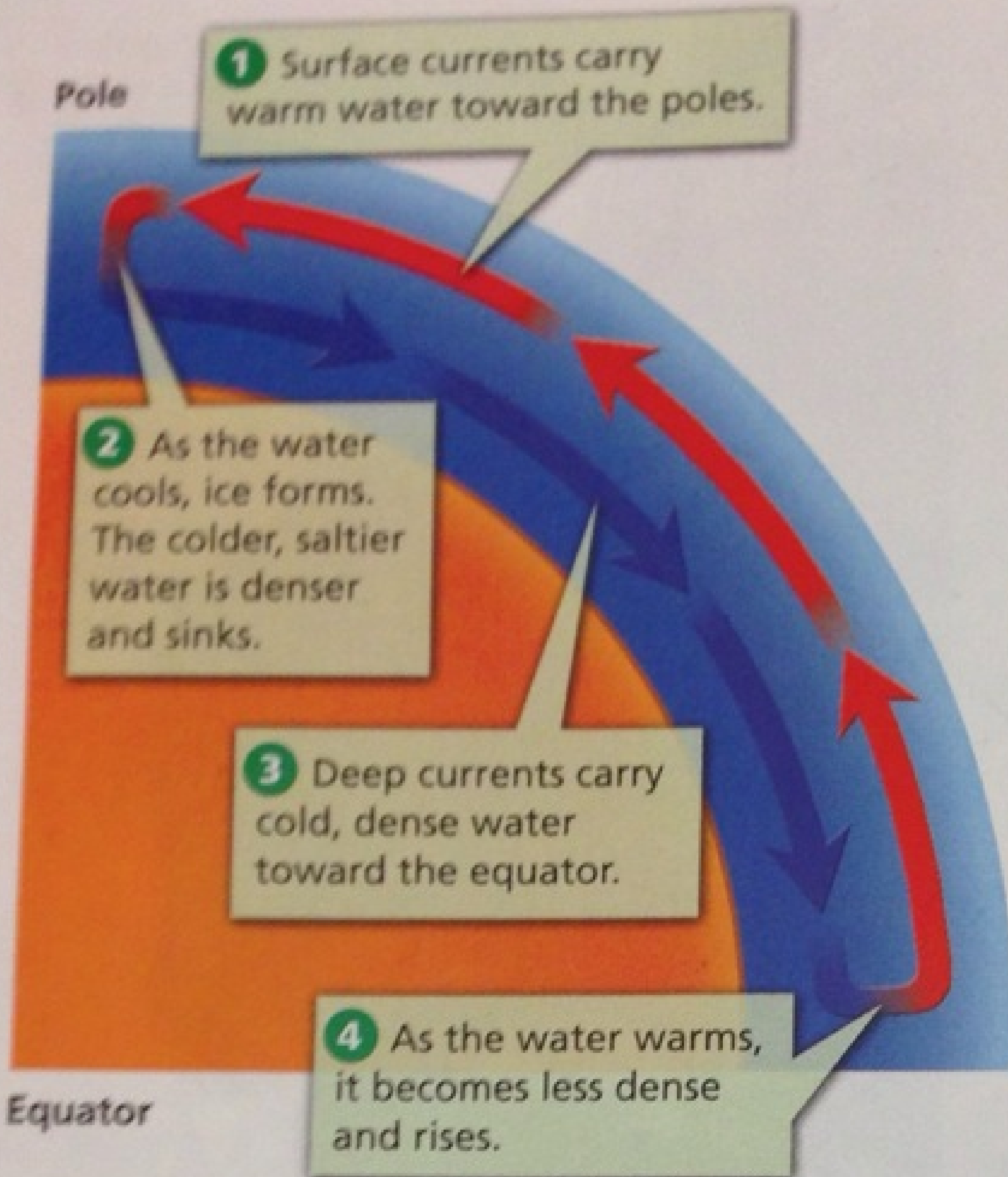


Figure 20
Deep Currents
Deep currents are caused by differences in the density of ocean water.

Deep Currents

Deep below the ocean surface, another type of current causes chilly waters to creep slowly across the ocean floor. **These deep currents are caused by differences in the density of ocean water.**

As you read earlier, the density of water depends on its temperature and its salinity. When a warm surface current moves from the equator toward one of the poles, it gradually cools. As ice forms near the poles, the salinity of the water increases from the salt left behind during freezing. As its temperature decreases and its salinity increases, the water becomes denser and sinks. Then, the cold water flows back along the ocean floor as a deep current. Deep currents are affected by the Coriolis effect, which causes them to curve.

Deep currents move and mix water around the world. They carry cold water from the poles toward the equator. Deep currents flow slowly. They may take as long as 1,000 years to flow from the pole to the equator and back again!

Upwelling

In most parts of the ocean, surface waters do not usually mix with deep ocean waters. However, mixing sometimes occurs when winds cause upwelling. **Upwelling** is the movement of cold water upward from the deep ocean. As winds blow away the warm surface water, cold water rises to replace it.

Upwelling brings up tiny ocean organisms, minerals, and other nutrients from the deeper layers of the water. Without this motion, the surface waters of the open ocean would be very scarce in nutrients. Because nutrients are plentiful, zones of upwelling are usually home to huge schools of fish.

One major area of upwelling lies in the Pacific Ocean off the west coast of South America. Many people depend on this rich fishing area for food and jobs. The arrival of El Niño prevents upwelling from occurring. Without the nutrients brought by upwelling, fish die or go elsewhere to find food, reducing the fishing catch that season and hurting people's livelihoods.

Reading Checkpoint **What is upwelling?**

FIGURE 21
Upwelling
As cold water rises from the deep ocean, it brings a new supply of nutrients to the surface. The nutrients feed enormous schools of fish such as these anchovies.
Relating Cause and Effect *What causes cold water to rise during upwelling?*

Section 4 Assessment

Target Reading Skill **Relating Cause and Effect** Refer to your graphic organizer about the causes of ocean currents to answer Questions 1 and 2 below.

Reviewing Key Concepts

1. a. **Defining** What is a current?
   b. **Describing** What causes surface currents to occur? How do surface currents affect the climate of coastal areas?
   c. **Predicting** What type of climate might a coastal area have if nearby currents are cold?
2. a. **Explaining** Explain how deep currents form and move in the ocean.
   b. **Comparing and Contrasting** Compare the causes and effects of deep currents and surface currents.
3. a. **Reviewing** What causes upwelling?
   b. **Explaining** Why are huge schools of fish usually found in zones of upwelling?
   c. **Applying Concepts** Why would the ability to predict the occurrence of El Niño be important for the fishing industry on the western coast of South America?

Lab zone At-Home **Activity**

Modeling the Coriolis Effect With the help of a family member, use chalk and a globe to model the Coriolis effect. Have your family member slowly rotate the globe in an easterly direction. As the globe rotates, draw a line from the North Pole to the equator. Use your knowledge of the Coriolis effect to explain why the line is curved.