Excerpt from *EDC Earth Science*
Chapter 3 | Patterns in Surface Currents

Teacher Guide to Activities

Purpose

This activity is designed to help students understand that uneven heating of Earth by the Sun provides the energy that drives the ocean currents. Movement of air in the atmosphere and water in the oceans redistribute heat from the equator toward the poles.

Students learn about energy and matter, cause and effect, and patterns. They are asked to analyze and interpret data and construct explanations (NGSS: ESS.C.2, ESS.D.1, ESS.D.2).

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Data Learning Objective

The student will read and make meaning from a variety of data visualizations, and relate the data to real events and physical processes.

Description

The two maps in this activity represent average sea surface temperatures during a period of a month and were created using data from the NASA DICCE Climate Data Portal (**dicce.sri.com**). Students compare the temperature patterns in April and July, 2011, and relate them to the movement of ocean water via warm and cool surface currents. Then they consider the impact of ocean currents on the climate of coastal communities.

READING

Patterns in Surface Ocean Currents

Ocean Gyres

You observed in Activity 2 that few of the currents seem to take a straight path. In fact, there is a circular pattern of movement that repeats itself in each of the major oceans. For example, Figure 3.5 shows the currents in the North Atlantic. The Gulf Stream flows generally northward just off the east coast of North America. Some of this current circles around and flows southward as the Canary Current along the west coast of Spain and Africa. The circle is completed by the North Equatorial Current and the Antilles Current. These large subcircular current systems are called **gyres**. There are five major ocean gyres—two each in the Pacific and Atlantic Oceans and one in the Indian Ocean.

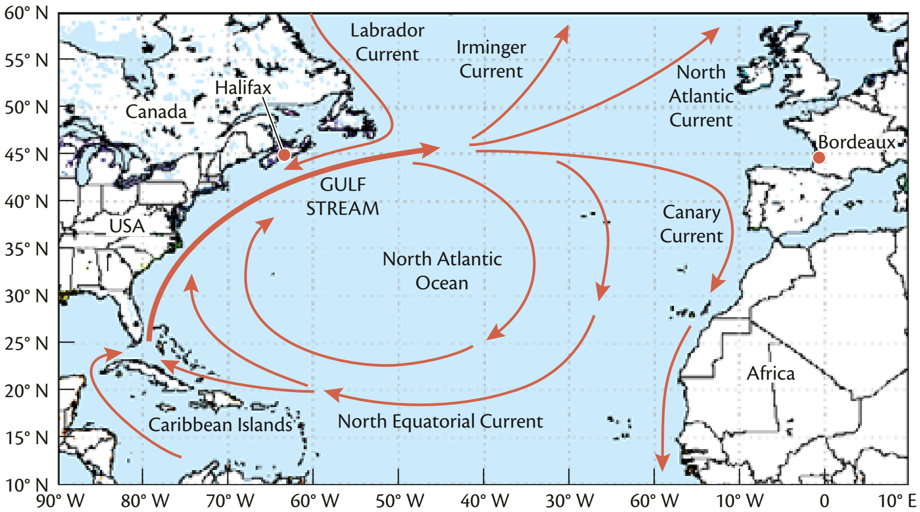

FIGURE 3.5
The North Atlantic Subtropical Gyre.

If you look carefully at the direction of flow within these gyres in Figure 3.4, you'll notice another interesting pattern. The gyres in the Northern Hemisphere flow in a clockwise direction. In the Southern Hemisphere, water moves the opposite way—in a counterclockwise direction.

Not all currents move in gyres. Some seem to take their own path. Some appear to have been channeled through narrow openings between landmasses and even at times deflected into small eddies, like those you might see in a stream. Some, such as those currents that are near the South Pole—where there are few land obstructions—and near the equator, take a more direct path (although keep in mind that you are looking at a flat map of a round Earth, so even these paths are curved).

Warm and Cool Currents

One of the most important patterns can only be observed if you pay attention to the flow of warm and cool currents. Generally, warm currents move water from the equator toward the poles, and cold currents move water from the poles toward the equator. The net effect of all this water movement is to redistribute heat from the warmer to the cooler areas of Earth. These warm and cool water masses have a profound effect on the weather and climate on the continents they flow past. Figure 3.6 shows surface water temperatures in the Northern Atlantic in April and July of 2011. Take some time to study these maps (because they may be different from maps you've looked at before), and answer the Think About It questions.

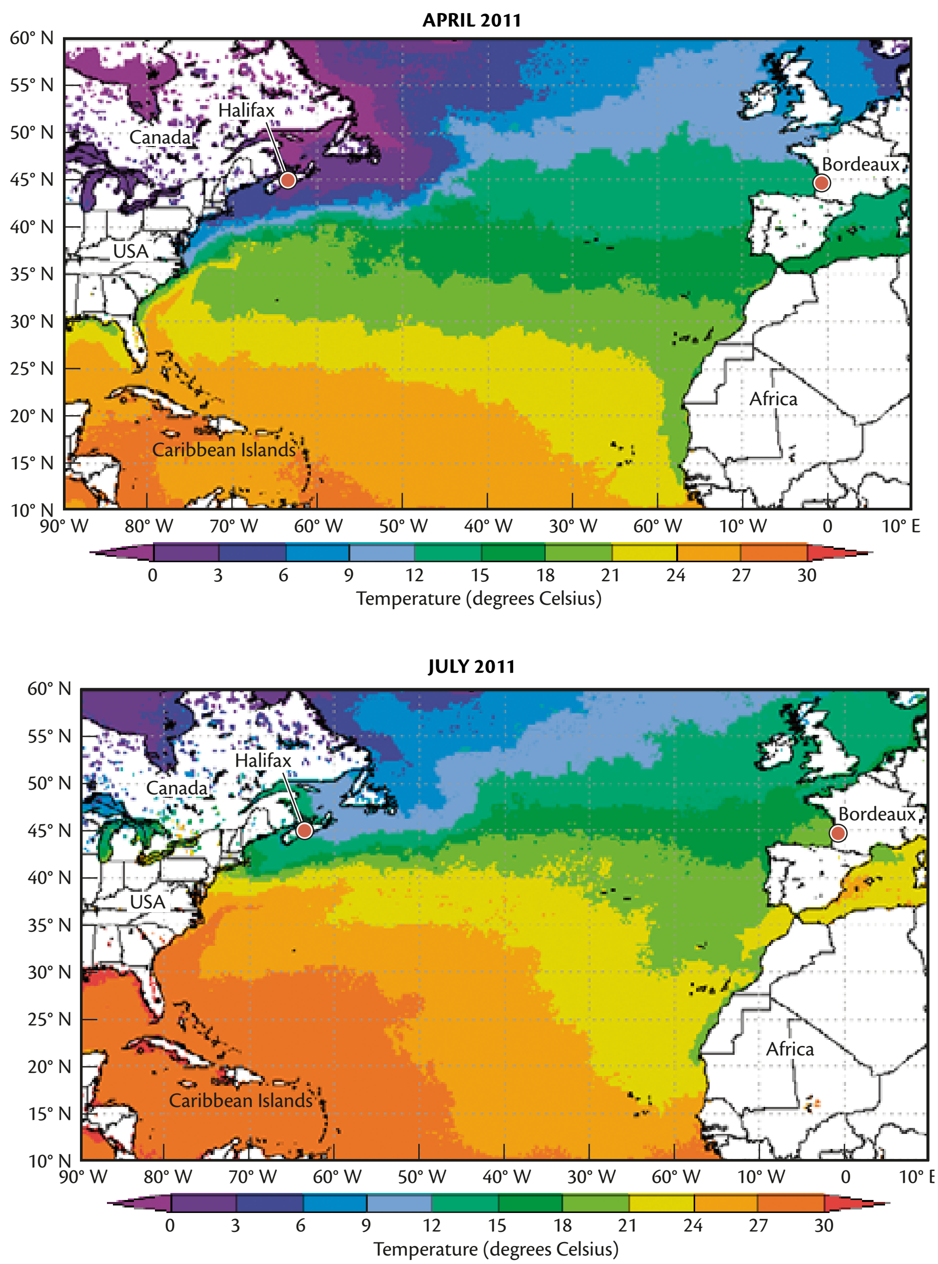

FIGURE 3.6
The average temperature of the ocean surface water during April and July of 2011. Yellow and orange indicate the warmest water, whereas blue and purple are the coolest. Note the ocean temperatures near Halifax, Nova Scotia, and Bordeaux, France, which are close to the same latitude.[2]

Think About It 1 The two maps in Figure 3.6 show the northern Atlantic Ocean, and the colors represent average sea-surface temperatures for the months of April and July 2011.

1. In general, what regions of the ocean had the coolest temperatures during April?
2. What regions of the ocean had the warmest temperatures during April?
3. Write a few sentences that describe how sea-surface temperatures changed between April and July.

Think About It 2 Now, think about why the temperature patterns in the Atlantic Ocean look the way they do.

1. Do the water temperatures seem to be similar at the same latitudes? Describe parts of the ocean in the two maps where the temperature trends are not what you would predict simply based on latitude.
2. Do you see any evidence that ocean currents might be redistributing heat in the Atlantic Ocean? Describe where you think this might be happening.
3. Look back at Figure 3.5, which shows the ocean currents in the North Atlantic. Do any of the following ocean currents seem to be affecting the pattern of sea-surface temperature? Explain how.
   a. Gulf Stream
   b. Canary Current
   c. Labrador Current

Think About It 3 Halifax, Nova Scotia, and Bordeaux, France, are both located near the Atlantic coast at a latitude of approximately 44°50′ N. If you go to weather websites, you can get statistics about average temperatures calculated based on 30 years of data. The average temperature in Halifax in April is 4.2°C or 39.6°F. The average temperature in Bordeaux in April is 11°C or 51.8°F. Hypothesize about why the average temperature in Bordeaux is higher than in Halifax, even though they are at the same latitude.

How Much Water Do Currents Carry? How Fast Do They Go?

Maps such as the ones in Figures 3.4 and 3.5 can only convey certain information about ocean currents. The slim arrows don't provide much of a sense of the volume of water that is moving or its speed. Although currents vary in speed and strength, the major currents carry massive quantities of water. For example, the Gulf Stream transports 90 million cubic meters per second, moving 100 times as much water as all the rivers on Earth. If the Gulf Stream was moved like a hose and used to fill the basin of Lake Superior, the lake would be full to the brim in just one and a half days!

Responses to *Think About It* for "Patterns in Surface Ocean Currents"

Think About It 1 The two maps in Figure 3.6 show the northern Atlantic Ocean, and the colors represent average sea-surface temperatures for the months of April and July 2011.

1. In general, what regions of the ocean had the coolest temperatures during April? *In April, the coolest sea-surface temperatures were in the northwestern part of the map, around New England and Atlantic Canada.*
2. What regions of the ocean had the warmest temperatures during April? *The warmest temperatures in April are in the southwestern part of the map area, around the Caribbean Islands.*
3. Write a few sentences that describe how sea-surface temperatures changed between April and July. *Students should notice that the general pattern is similar, but the warmer-water areas expanded to the north. For example, in July the warmest a reas of ocean water (>24°C) extend much closer to the northeastern United States, and into the Mediterranean Sea.*

Think About It 2 Now, think about why the temperature patterns in the Atlantic Ocean look the way they do.

1. Do the water temperatures seem to be similar at the same latitudes? Describe parts of the ocean in the two maps where the temperature trends are *not* what you would predict simply based on latitude. *Students should notice that up to latitudes of about 35°N, the water is warmer in the western part of the map than it is at similar latitudes in the eastern part of the map, near Africa. In the northern part of the map area, the opposite is true—the sea-surface temperature is generally cooler in the western part of the map, near New England and Atlantic Canada, than at similar latitudes in the eastern part of the map, near Europe.*
2. Do you see any evidence that ocean currents might be redistributing heat in the Atlantic Ocean? Describe where you think this might be happening. *Students might hypothesize that ocean currents are moving warmer water north along the U.S. east coast until the latitude of 35°–40° N, and then moving it across the Atlantic in a northeasterly direction toward Europe. Currents may be moving cool water from the arctic southward along the east coast of Canada and New England.*
3. Look back at Figure 3.5, which shows the ocean currents in the North Atlantic. Do any of the following ocean currents seem to be affecting the pattern of sea-surface temperature? Explain how. *Students should be able to recognize the effects of all three of these currents on the pattern of sea-surface temperature in the North Atlantic. You may want to project these maps on the board or print copies of them and have students draw the locations of the currents.*
   a. Gulf Stream: *The Gulf Stream is carrying relatively warm water up the east coast of the United States, and then across the Atlantic to Europe and Northern Africa.*
   b. Canary Current: *The Canary Current is carrying cooler water southward along the Atlantic coast of northern Africa.*
   c. Labrador Current: *The Labrador Current is carrying cooler water from higher latitudes southward, along the coasts of Atlantic Canada and New England.*

3. **Think About It 3** Halifax, Nova Scotia, and Bordeaux, France, are both located near the Atlantic coast at a latitude of approximately 44°50´ N. If you go to weather websites, you can get statistics about average temperatures calculated based on 30 years of data. The average temperature in Halifax in April is 4.2°C or 39.6°F. The average temperature in Bordeaux in April is 11°C or 51.8°F. Hypothesize about why the average temperature in Bordeaux is higher than in Halifax, even though they are at the same latitude. Students should recognize that the air temperatures in these two coastal cities are likely to be affected by the temperature of the ocean water. In Figure 3.6, it is apparent that the ocean temperature near Halifax is cooler than the ocean temperature near Bordeaux. The Atlantic near Nova Scotia is cooled by the Labrador Current, which flows south from the Arctic, whereas relatively warm water from the Gulf Stream flows across the Atlantic toward France.

