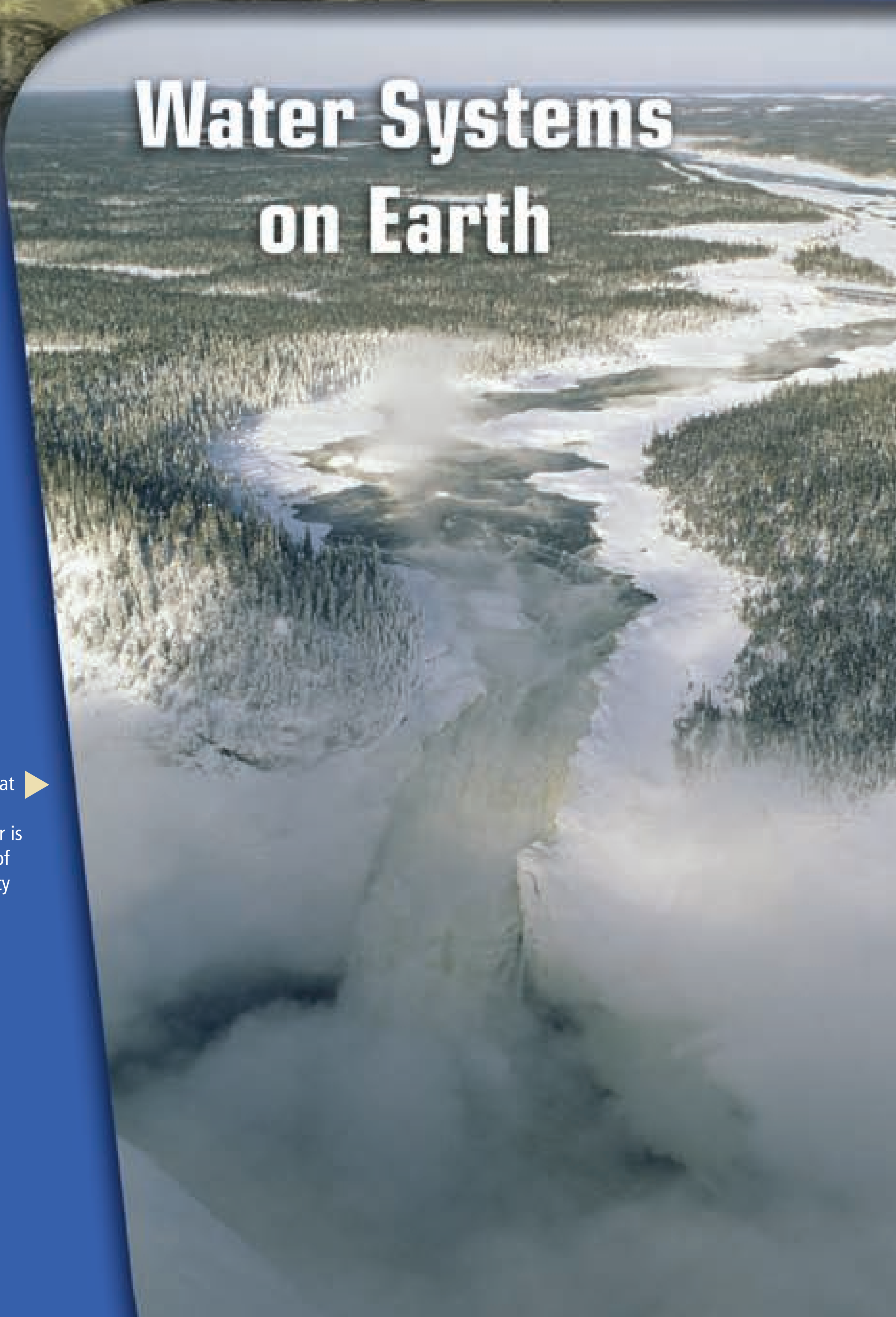
UNIT

1 Water Systems on Earth



The fast moving water that flowed over the mighty Churchill Falls in Labrador is now used to power one of the largest hydroelectricity developments in North America.

Key Ideas

1 The water cycle plays a vital role on Earth

1.1 Distribution of Water
1.2 Comparing Ocean Water and Fresh Water
1.3 Sources of Fresh Water

2 Oceans control the water cycle

2.1 Ocean Basins
2.2 Ocean Currents
2.3 Waves and Tides

3 Bodies of water influence climate and species distribution

3.1 Oceans and Climate
3.2 Living in Water
3.3 Human Impact on Water Systems

Getting Started

Water not only supports life, but also shapes coastlines such as the one here in Freshwater Cove on the Avalon Peninsula.

Earth is covered in water, and because of that, life thrives in almost every location you can think of. From bugs to birds, sunflowers to spruce trees, and halibut to humans, the variety of organisms on the planet seems almost limitless. Water is a part of every living thing, and every living thing—humans included—needs water to stay alive.

Water also has a major effect in shaping the landscapes around us. Rushing rivers and pounding ocean waves, for example, can change the shape of the land overnight. As if that were not enough, water also influences climate and weather around the globe. The world's oceans are not just tubs for holding Earth's water supply: they play an essential role in keeping Earth a suitable place for life.

As you read through this unit, you will learn about how important it is for us to care for this natural resource. Humans have been altering natural water systems for thousands of years. By developing a strong understanding of Earth's water systems and what is needed to keep them healthy, we can learn how best to protect the quality of water all over our planet.

The Many Ways People Use Water

Find Out ACTIVITY

In Newfoundland and Labrador, there is water all around in ponds, lakes, rivers, and the ocean. With so much water available, you might think it could never run out, and rarely pay attention to how much water you use in your daily life. In many parts of Africa, water (especially clean water) is very scarce. On average, in some African countries, a person uses about 5 L of water a day. Compare that with average daily use in Newfoundland and Labrador, which is over 400 L. That is equivalent to about 400 1 L milk cartons! Household use is just one example of how water is an essential part of our lives. The following activity will help you think about what other ways we use water in Newfoundland and Labrador.

What to Do

1. Look at the figure below and create a mind map with "Water" as your starting term. Then, make a list of all the different ways water is being used in the figure. Try to group the items on the list into different categories. For example, you might have categories such as "household use," "personal use," and "recreational activities."

What Did You Find Out?

1. Share your category lists with the rest of the class. Were there any differences?
2. Pick one of your categories and imagine that the water uses listed under it were not available to you anymore. Write a brief paragraph about how your life would be affected.

The water cycle plays a vital role on Earth.

Earth has been called "the blue planet." From space, its surface appears to be mostly oceans of liquid water. There is no doubt that water is everywhere on Earth. Water vapour is found in Earth's atmosphere. Frozen water occurs on moutaintops and at the North and South Poles. The bodies of animals and plants consist mainly of water. In fact, sixty-five percent of your body mass is water.

Water is always on the move. It evaporates into the air and falls from clouds as rain or snow. The best way to understand Earth's water supply is to study it as a system — a system in which water constantly moves around between sea, sky, land, and life. It is one of our most precious resources on Earth.

What You Will Learn

In this chapter, you will
- **describe** how water exists in various states on Earth's surface
- **explain** how water is distributed around the planet
- **describe** how water circulates between land, ocean, and atmosphere
- **identify** why water systems are closely connected

Why It Is Important

By studying Earth's water systems, you will better understand the importance of water in our lives and to all life on the planet.

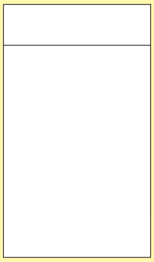
Skills You Will Use

In this chapter, you will
- **study and interpret** maps and tables of water systems
- **communicate** your understanding of the water cycle
- **design** a model of the water cycle
- **investigate** the effect of salinity on water density

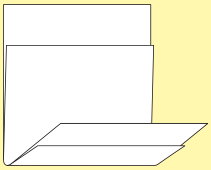
FOLDABLES™
Reading & Study Skills

Make the following Foldable to demonstrate your learning in Chapter 1.

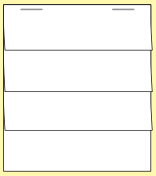
STEP 1 **Collect** 2 sheets of letter sized paper and layer them about 2.5 cm apart vertically. Keep the edges level.



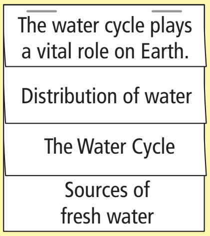
STEP 2 **Fold** up the bottom edges of the paper to form 4 tabs.



STEP 3 **Fold** the papers and crease well to hold the tabs in place. **Staple** along the fold.



STEP 4 **Label** the tabs as shown. (Note: the first tab will be larger than shown here.)



Show You Know As you read the chapter, take notes under the appropriate tab to *describe* the distribution of water on Earth, *illustrate* the water cycle, *compare* ocean water and fresh water, and *identify* sources of fresh water on Earth.

1.1 Distribution of Water

There is hardly a place on Earth where water cannot be found in some form or another. Whether it is frozen in small spaces between tiny particles in rock or floating as invisible droplets in the air, water is everywhere on our planet. With this being the case, you might think that humans could never run out of water to drink. Yet, if you have ever swallowed seawater, you know that not all the water on Earth is drinkable.

Key Terms

atmosphere
hydrosphere
lithosphere
water cycle

Word Connect

The word "aquatic" means watery, and comes from the ancient Latin word aqua, which means water. Some words we use today have the root word "aqua," such as aquarium.

Figure 1.2 Two-thirds of Earth's fresh water is frozen.

In terms of the amount of water on this planet, the water you need to survive is actually in very short supply. The vast majority of water on Earth, about 97 percent, is salt water (see Figure 1.1). You cannot drink salt water. Neither can other land-living organisms.

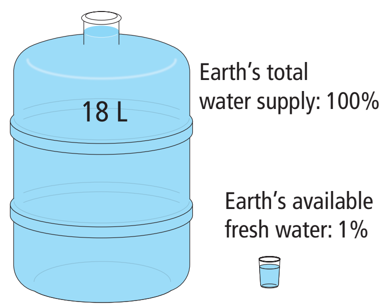


Figure 1.1 Earth's total water supply compared with the distribution of available fresh water.

Only 3 percent of the planet's water is "fresh water," meaning it does not contain salt. That may still seem like a lot of fresh water, but two thirds of that fresh water supply is frozen in large masses of ice. These frozen masses of water form ice sheets at the North and South Poles, and glaciers in the high mountaintops. That leaves less than 1 percent of Earth's water as liquid fresh water. This tiny remainder must supply hundreds of billions of other organisms with the water they need to survive. This includes over six billion humans.

With all of these organisms consuming water, why have we not yet run out of fresh water? To answer this question, we need to examine the water cycle.

The Water Cycle

Have you ever gone for a walk in your neighbourhood just after a heavy rain? What do you notice? Water drips from leaves and runs along gutters or drainage ditches. There are puddles in parking lots, and footpaths across a playing field are muddy. A few hours later, the puddles are gone and the sidewalks are dry. What has happened to the water?

Each drop of rain that falls must go somewhere. Some runs off the land into the streams, rivers, ponds, lakes, and then pours into the oceans. Some soaks, seeps, and flows into Earth's **lithosphere**—the solid rocky ground of Earth's crust. Some appears to just "vanish" into Earth's **atmosphere** – the environment surrounding the planet. All of the water on Earth, be it in the atmosphere, lithosphere, or on Earth's surface, is called the **hydrosphere**.

The ability of water to "disappear" and to reappear somewhere else is not magic. It is the result of two common changes of state: evaporation and condensation. Evaporation is the change of state from a liquid to a gas. Evaporation converts liquid water from Earth's surface into gaseous water vapour. There is always some water vapour in the atmosphere. Condensation is the change of state from a gas to a liquid. Gaseous water vapour remains in the atmosphere until it cools. As it cools, water vapour condenses to form clouds. Liquid and solid water fall from the clouds as precipitation—rain and snow. These two changes of state make the **water cycle** possible. A cycle is a series of events that repeat themselves over a period of time, where the events or steps always lead back to the starting point. In the water cycle, there is no beginning or end. Water is just constantly changing form.

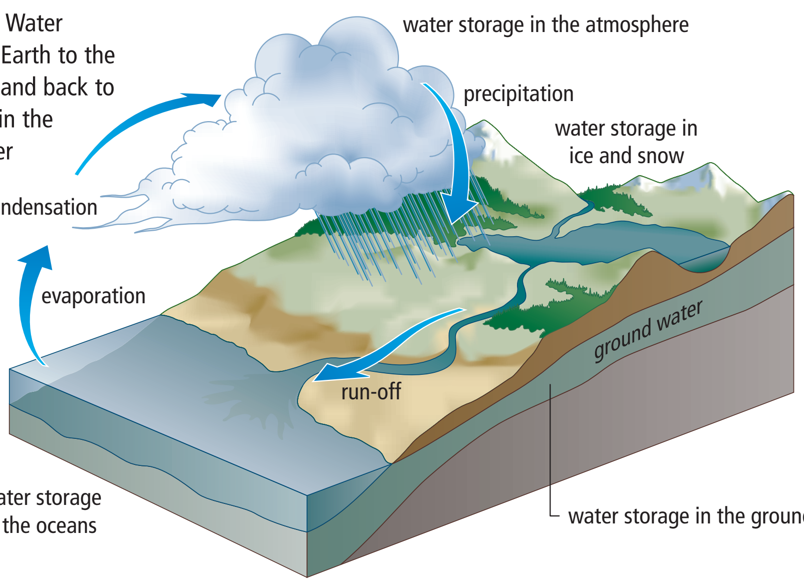


Figure 1.4 Water moves from Earth to the atmosphere and back to Earth again in the endless water cycle.

The Sun's energy drives the water cycle. Each year, about 520 000 km^3 of water from Earth's surface evaporates to form water vapour. That is enough water to fill over 208 000 Olympic-size swimming pools! Water vapour does not remain in the atmosphere for long, though. After being carried by winds to other places on Earth, it eventually condenses and falls to Earth, and the water cycle is repeated.

Word Connect

The root word *hydro* is Greek for "pertaining to water." A *hydrologist* a person who studies Earth's water systems and helps find solutions to problems of water quality and quantity. What other terms can you think of that begin with *hydro*?

Figure 1.3 These water droplets will either fall and soak into the ground, or will evaporate in the air as part of the water cycle.

internet connect

If all the water in the atmosphere rained down at once, it would only cover the ground with a depth of 2.5 cm. Find out more about each part of the water cycle. Go to **www.discoveringscience8.ca** to find out where to go next.

1-1A A Water Cycle Model

Find Out ACTIVITY

Reading about the water cycle can introduce you to the scientific ideas behind this important process. However, actually seeing the changes of state in water can give you a much better understanding of how the water cycle works.

Challenge

Water is the only substance on Earth that can exist naturally in all three states: solid, liquid, and gas. Design a model to show water changing from a liquid to a gas, and then back again. Then, change the water to a solid and back again to a liquid.

Safety

- Be careful—you will be working with hot water and steam.
- Wear your safety glasses, lab jacket, and heat-resistant gloves.
- Only do this investigation under the supervision of your teacher.

Materials

- electric kettle
- bowls of various sizes
- oven mitts or heat-resistant gloves
- ice
- hot plate
- modelling clay
- sand
- soil
- water
- refrigerator
- freezer

Design Specifications

A. Your model must demonstrate how water can exist in all three states.

B. Your model must demonstrate how water can change from a liquid to a gas, from gas to a liquid, from liquid to a solid, and from a solid to a liquid.

C. Your model does not need to be all in one location.

Plan and Construct

1. With your group, plan how you will cause water to change state.
2. Draw a labelled sketch of your model, indicating what materials you will use.
3. Obtain your teacher's approval. Then, construct your model.
4. Demonstrate how your model works.
5. Wash your hands after you complete this investigation.

Evaluate

1. (a) Did your model work as you expected?
   (b) What adjustments did you make so it would work, or work better?
2. (a) What scientific knowledge did you use to help you develop your model?
   (b) What scientific knowledge did your model help you develop?
3. How did the models constructed by other groups work? Did other groups have ideas that you would like to use? Did your group have ideas that others wanted to use?
4. What part did heat energy play in this investigation? What part does it play in the water cycle?

Wild, Weird, Wonderful

www Science

The Salty Facts about Penguins

Our bodies rely on sources of fresh water to keep us healthy and alive. Drinking ocean water can make you very sick. But what about for other living creatures who eat and swim in nothing but salt water? Does the ocean water make them sick? One interesting animal has its own way of removing salt from water – the penguin.

Penguins spend half of their lives, swimming and feeding in the ocean on fish, krill, squid, and other small aquatic creatures. Because of this, they digest a large amount of salt water in the process of eating. In order to get rid of the salt, penguins have an organ called the supraorbital gland that collects and excretes the salt, thus keeping it out of the penguin's bloodstream.

The supraorbital gland is located just above the penguin's eye and is connected to capillaries. The gland functions a little like our kidneys, in that it cleans the blood and gets rid of the wastes. To get rid of the salt that the gland collects, the penguin excretes a salty liquid through nasal passages in its bill, which often makes them look like they have a runny nose.

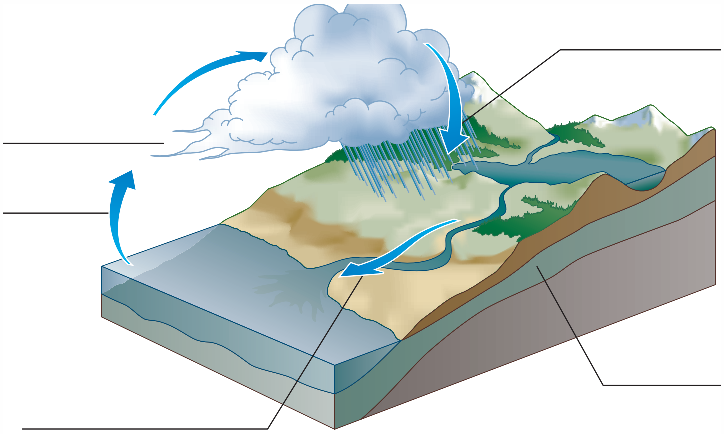
Isn't it amazing that humans have to design systems to take the salt out of water while the penguin naturally has its own built-in removal system!

There are approximately seventeen different species of penguins. All of them have the supraorbital gland that removes salt from their bodies. Supraorbital comes from supra = above, and orbital = orbit of the eye (eye socket).

Check Your Understanding

Checking Concepts

1. What percentage of water on Earth is salt water?
2. Where is most of the world's fresh water found?
3. Why is less than one-third of fresh water available for use by humans?
4. What has to happen in order for water to change from one state to another?
5. Sketch the diagram of the water cycle below into your notebook and label the parts.



Understanding Key Ideas

6. Name the three states in which water occurs and describe where you would find a naturally occurring example of each state.
7. For each of the following descriptions, decide whether they demonstrate evaporation or condensation:
   (a) after wiping a chalkboard with a wet sponge, the board is dry an hour later.
   (b) the dew on the grass early in the morning.
   (c) your breath on a window on a cold day.
   (d) clothes drying on a clothesline
8. If water moves in a cycle, why might activities in one place pollute water in a different place?

Pause and Reflect

Whether you get your drinking water from a tap, from a well, or from bottled spring water, it is all recycled. In your notebook, write a paragraph or poem, or make a drawing that expresses the idea of water moving endlessly through the phases of the water cycle.

1.2 Comparing Ocean Water and Fresh Water

Salt water differs from fresh water in several major ways. The main one is in its salinity. This characteristic gives ocean water a different density, freezing point, and boiling point than fresh water. Even though salt water and fresh water are connected, they play different roles in the water cycle.

Key Terms

density
freezing point
salinity

Although fresh water has tiny amounts of salt, ocean water is more than 200 times saltier. The amount of salt dissolved in a specific amount of water is called **salinity**. The average salinity in all the world's oceans is about 35 parts per thousand. This is the same as if you mixed 35 g of salt in 1 L of water. Salinity in sea water can differ depending on the location. Close to the equator, the salinity is high because of high rates of evaporation. When the water in the ocean transforms into vapour in the air, it leaves the salt behind. Water is very salty near the North and South Poles as well because when water freezes and changes into ice, it also leaves the salt behind. Near continents, the salinity is usually lower than in the middle parts of the ocean. The reason is that the fresh water from the rivers empties into the ocean and dilutes the salt water.

Did You Know?

Ocean water contains valuable minerals such as gold, copper, and uranium. However, before you consider mining the ocean's water, you should know that there is only about 1 part gold for every 250 billion parts of sea water. In other words, if you wanted a gram of gold, you would first have to make 250 thousand tonnes of ocean water evaporate.

Figure 1.5 Intense evaporation in tropical climates is the reason for high salinity in ocean waters near the equator.

1-2A Mini Distillation

Find Out ACTIVITY

Have you ever walked along an oceanside beach on a sunny day and noticed patches of white on the sand where the tide has gone out? The white material is salt crystals that have been left behind after water has been evaporated by the Sun. Separating salt from salt water is a process called desalination. In this activity, you will simulate what happens when salt water evaporates.

Safety

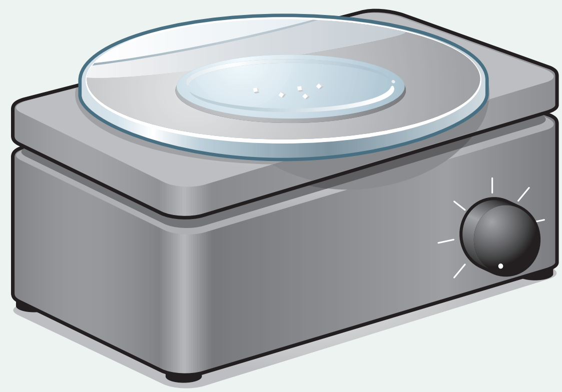
- Be careful when handling glass.
- Be careful when handling hot equipment.

Materials

- 4 g salt
- microscope or magnifying glass
- watch glass
- laboratory balance
- 10 mL distilled water
- stirring rod
- 50 mL beaker
- 5 mL measuring spoon
- tongs
- hot plate or other heat source

What to Do

1. Observe a small sample of the salt under the microscope or magnifying glass. Describe the appearance of the crystals. Sketch one of the crystals in your notebook.
2. Measure and record the mass of the watch glass.
3. Put 1 g of salt into the beaker and add the distilled water. Stir until the salt is completely dissolved.
4. Carefully pour 5 mL of the solution into the watch glass.
5. At medium temperature, heat the watch glass on the heating plate (see below). Continue heating until the water has disappeared. Describe the appearance of the material left on the watch glass. This material is called "residue."



6. Wait until the materials have cooled down, and then measure the mass of the watch glass and the residue combined.
7. Clean up and put away the equipment you have used.

What Did You Find Out?

1. (a) Describe the residue left after the water had evaporated.
   (b) What is the name of the residue?
2. Observe the residue under the microscope or magnifying glass. Is the residue's appearance any different from that of the original salt?
3. (a) To determine the mass of the residue alone, subtract the mass of the watch glass by itself from the mass of the watch glass and the residue. How does this amount compare with the original amount of salt?
   (b) Is this what you would expect? Explain.
4. Describe how this method can be used to purify water.

Where Does the Salt Come From?

Salt arrives in the oceans from several different sources. As you read in Section 1.1, when the rain falls on the land, most of it seeps into the ground, and then eventually into streams and rivers. From there it travels to the ocean. Moving over and through the ground, the water picks up materials from the rocks. These materials are called dissolved solids, and you cannot see them even with the help of a microscope. They get carried by the water from the land and into the ocean (Figure 1.6).

Volcanoes contribute some chemicals as well. Undersea volcanic eruptions from the sea floor release large amounts of sulphur, fluorine, chlorine, and hydrogen into ocean water. Eruptions on land spew similar materials high into the atmosphere. These materials then fall directly into the ocean, or onto Earth's surface from where they get carried to the ocean as run-off.

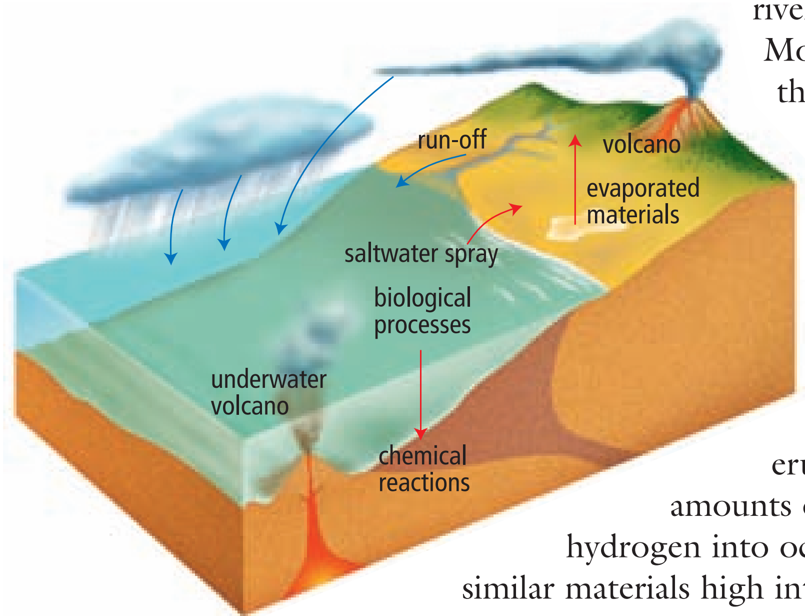


Figure 1.6 Dissolved solids reach the ocean from several different sources on Earth.

By far the most common material that is deposited into the ocean is sodium chloride, which is the chemical name for salt. This the same chemical substance as the table salt you use to season food. Sodium chloride accounts for over 85 percent of all the dissolved solids in the ocean. Because there is so much sodium chloride, the water is salty.

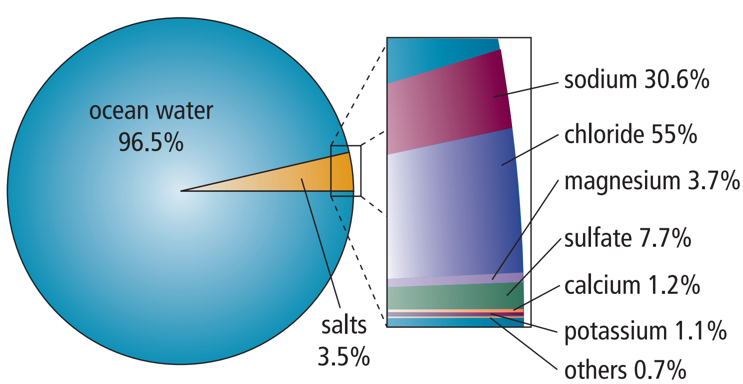


Figure 1.7 Ocean water contains about 3.5 percent salts. Traces of almost every chemical substance on Earth can be found in seawater, including gold and silver. Most of these substances, however, occur in extremely small quantities.

Density of Salt Water and Fresh Water

Density is the amount of mass of a substance in a certain unit volume. Think of density as being a measure of how tightly packed together that material is in the substance. Imagine two objects of equal size, such as a bowling ball and a volleyball. If you put the bowling ball on a pile of fluffy snow, it will sink into the snow because its density is greater than snow's (the bowling ball has a lot of mass in a small volume). The volleyball will likely sit on top of the snow because its density is less than the snow's (the volleyball has a small mass compared with its volume).

Because of the amount of salt in it, ocean water is denser than fresh water. There is more mass in 1 L of ocean water than there is in 1 L of fresh water. Ocean water has a density of 1027 kg/L and fresh water has a density of 1000 kg/L. That is why you may notice that it is much easier to float in salt water than it is in fresh water. The higher density of salt water helps to hold your weight up in the water. In some extremely salty oceans, such as the Dead Sea in southwestern Asia, you can float very easily. Water in the Dead Sea is nearly 9 times saltier than ocean water!

Did You Know?

If all the water could be boiled out of the oceans, the salt left behind would be enough to cover Earth in a layer 154 m thick, which is similar to the height of a 50-storey building.

Freezing Point of Salt Water and Fresh Water

Another difference between salt water and fresh water is their freezing points. The **freezing point** of a liquid is the temperature at which it freezes. As you know, the freezing point of fresh water is 0°C. Because ocean water contains far more dissolved salt than fresh water, its freezing point is different from that of fresh water. Salt water has a freezing point of about –1.9°C.

Figure 1.8 The high density of salt in the Dead Sea makes it easy for a person to float.

Reading Check

1. What is salinity?
2. Why is ocean water saltier near the equator?
3. Name two sources of ocean salt.
4. What is density?
5. Why is ocean water more dense than fresh water?

Suggested Activity

Investigation 1-2B and C on pages 18-21.

1-2B Salinity's Effect on Water Density Core Lab

SkillCheck
- Observing
- Measuring
- Modelling
- Evaluating information

Safety

- Be careful when handling glass

Materials

- 250 mL beaker or large jar
- 5 samples of clear water, prepared by your teacher:
  – tap water (colourless)
  – tap water (blue)
  – slightly salty water (red)
  – very salty water (colourless)
  – very salty water (green)
- medicine dropper or pipette
- plastic spoon

The greater salt content in ocean water makes it much denser than fresh water. Different parts of the ocean also vary in their salinities (the amount of salt in a certain volume of water). In this activity, you will investigate how the two types of water, with their different properties, interact.

Question

How does salinity change the density of water?

Procedure

1. Your teacher will provide you with a table to record your observations for this experiment.

Test 1

2. Fill the beaker about two thirds full with colourless tap water.
3. Fill the medicine dropper with very salty water (green). Place a few drops of this water into the beaker. Record your observations.
4. Empty the contents of the beaker and rinse it and the medicine dropper thoroughly.

Test 2

5. Fill the beaker about two thirds full with very salty water (colourless).
6. Fill the medicine dropper with blue tap water. Place a few drops of this water into the beaker. Record your observations.
7. Again, empty the contents of the beaker and rinse it and the medicine dropper thoroughly.

Test 3

8. Fill the beaker half full with very salty water (green). Holding the plastic spoon just above the very salty water in the beaker, gently and slowly pour colourless tap water over the spoon. The objective is to make a layer of colourless water at least 3 cm thick on top of the very salty green water. Using the spoon will prevent the water from mixing. Record your observations.

Test 4

9. Fill the medicine dropper with slightly salty water (red). Place a few drops of this water into the very salty water (green) layer in the beaker. Record your observations.

Test 5

10. Refill the medicine dropper with slightly salty water (red). Place a few drops of this water into the colourless tap water layer in the beaker. Record your observations.

Test 6

11. Using the plastic spoon, stir the waters in the beaker together. Record your observations.
12. Clean up and put away the equipment you have used.

Analyze

1. When you put the very salty water (green) into the colourless tap water, which one sank? Explain why this happened.
2. When you put the blue tap water into the very salty water, which one floated on the other? Explain why this happened.
3. (a) What happened when you added the slightly salty water (red) to the:
   (i) very salty water (green) layer?
   (ii) colourless tap water layer?
   (b) Why did the red water do this?
4. Why did the different types of water not mix by themselves?

Conclude and Apply

1. How does the amount of salt dissolved in water affect its density?
2. Explain how waters with different densities will act when they meet.
3. Describe what happens when fresh water from a river meets salty ocean water.
4. What causes salt water and fresh water to mix in the ocean?
5. Describe environments on Earth where fresh water would meet salt water.

Career Connect

Oceanographer

Dr. Anna Metaxas is a biological oceanographer at Dalhousie University in Nova Scotia. She studies the larvae of invertebrate creatures (organisms without spines) that live on the ocean floor. Her research takes her all over the world and to the bottom of the ocean.

Q. What is an oceanographer?

A. An oceanographer is a scientist who studies aspects of the oceans. Oceanographers are concerned with the biology, chemistry, geology, physics, and mathematics of the oceans.

Q. Of all the organisms you could study in the ocean, how did you choose invertebrate larvae?

A. The more I learned about the ocean, the more I realized how little is known or understood about the early stages of life of marine invertebrates. Unlike a lot of organisms where the young are geographically near their parents, invertebrate larvae are carried by currents to completely different areas. There are so many questions to be answered. "Where do they go?" "How many survive?" So much is unknown about these tiny but important organisms. That's what fascinates me.

Q. Why is it important to study invertebrate larvae?

A. With any species, it is important to know the rate of survival among the young to ensure that a species exists in healthy numbers. Many invertebrates, such as sea urchins and shrimp, are part of the fishing industry in different countries. We need to understand how the larvae survive and return to replace the adult population. If we don't know the rate of or the factors that affect replacement, we could lose these industries, or even worse, the entire species.

Q. Where does your research take you in the world?

A. Both short and long-term research projects take me from waters right here off the coast of Nova Scotia, to tropical waters in Palau (a tiny island in the Pacific Ocean, 800 km east of the Philippines), to the dark, exciting depths of the ocean floor.

Q. You have been in a submersible and travelled over 2250 m beneath the surface to the ocean floor. What was it like?

A. The first thing you notice is how long it takes to reach the bottom – about two hours. It's dark for the most part, but then you see these flashes of bioluminescent creatures out your window! At that depth of the ocean, the creatures can be pretty bizarre looking, too. It's such an amazing feeling being so far down and remote from people. I've even had the opportunity to see an underwater volcano erupting.

Q. You also study organisms that live around hydrothermal vents in the ocean floor. What is a hydrothermal vent, and what lives there?

A. A hydrothermal vent is a crack in the Earth's surface where super-hot water that is heated from Earth's molten rock comes out. The vents are covered in strange organisms, such as giant clams, tubeworms with no mouths, shrimp, mussels, and crabs. It is a completely different world.

Q. What do you like most about your job?

A. There are two wonderful aspects about my job. The first is that I get the opportunity to travel and do research in places where very few people have ever been, including the ocean floor. The second important aspect is having students. I get to both teach my students and to learn from them and their research. My career is more like being an explorer – it's always a new adventure.

Check Your Understanding

Checking Concepts

1. What is the main difference between ocean water and fresh water?
2. What dissolved chemical occurs in the greatest amount in ocean water?
3. Where does the salt that gives the ocean its salinity originally come from?
4. Fresh rainwater that falls on land eventually makes its way back to the ocean. If that is the case, then why is ocean water salty?
5. (a) Which is more dense: ocean water or fresh water?
   (b) What is the reason for the difference in their densities?
6. What does the addition of salt do to the freezing point of water?

Understanding Key Ideas

7. Ocean water contains many valuable minerals that humans use, including gold and copper. Why don't people try to "mine" these minerals from ocean water?
8. Describe a method you would use to separate dissolved solids from ocean water.
9. Why do oceans in tropical areas have high salinities?
10. Why do oceans around the North and South Poles also have higher salinities?

Pause and Reflect

Are the oceans becoming saltier over time? The answer depends on which ocean you mean. High rates of evaporation in the tropics mean that the remaining ocean water is saltier. At the same time, melting ice in the polar regions causes more fresh water to enter the oceans, making ocean waters less salty in northern and southern parts of the globe. Think about what other factors might increase or decrease the saltiness of ocean water. Write a paragraph describing those factors and how they affect salinity.

1.3 Sources of Fresh Water

Only about 1 percent of all of Earth's fresh water supply is easily accessible. Most of the fresh water is trapped in ice, in Greenland and Antarctica, and not readily available for human use. The fresh water that is available is found wherever water falling as rain and snow runs off the land and is collected in lakes, rivers, streams, and underground.

Key Terms

crevasse
drainage basin
glacier
global warming
gravity
ground water
iceberg
run-off

Lakes, Ponds, and Wetlands

A lake and a pond are basically large holes in the ground, filled with standing water (see Figures 1.9A and B). In general, lakes tend to be larger and deeper than ponds, although sometimes there are cases where a pond is bigger than a lake. There are no strict guidelines that differentiate between a lake and a pond, and often they were named by the early settlers who lived near them.

Figure 1.9A Some lakes, like Quidi Vidi Lake in St. John's, can be right in the middle of communities.

Figure 1.9B Cobb's Pond in Gander, Newfoundland and Labrador

Figure 1.10 Wetlands in Newfoundland and Labrador are an important feeding area for moose, and nesting area for many ducks.

Wherever there is a low area in the land, wetlands can occur. There are many different types of wetlands. However, they have one characteristic in common. They are saturated with water all or much of the time. Marshes, for example, are shallow water wetlands (less than 1 m in depth). They usually remain wet throughout the year. All wetlands provide habitats for an astounding diversity of plants and wildlife.

Streams and Rivers

Streams and rivers are both fast-flowing waterways. However, their individual characteristics vary a great deal. Flowing waters differ greatly in speed, temperature, and clarity. They also differ in the nature of their banks and bottoms. All these factors affect the types of plants and animals that live in them. Fast-flowing waterways are usually rich in oxygen, which fish and other animals need to survive.

Ground Water

While it is easy to see the many sources of fresh water on the surface of Earth, another important source of fresh water lies beneath the surface. Most of the precipitation that falls on land sinks out of sight and is called **ground water**. Below the surface, ground water trickles downward through connected pores and cracks (see Figure 1.11). Eventually, it reaches a layer of bedrock, such as granite. This bedrock forms a barrier, preventing the ground water from flowing down any further. Since it cannot move any deeper, it begins to back up and fill the pores in the material above the bedrock. It is in this layer that people will drill down into to make wells. They then pump the water to the surface for use as drinking water, for factories, or for watering crops and livestock.

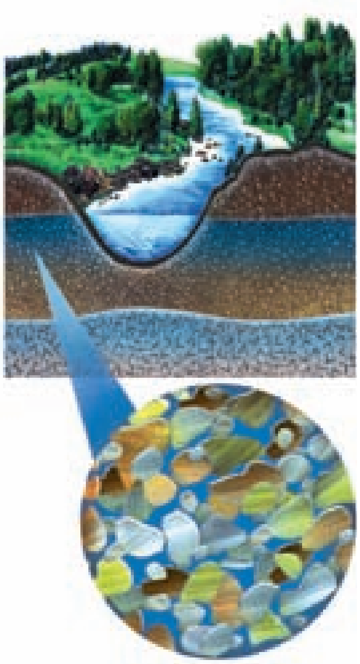


Figure 1.11 Ground water is found under Earth's surface in small spaces between bits of soil and rock.

Glaciers

In some areas of the world, it is so cold that snow remains on the ground year-round. When snow doesn't melt, it begins piling up. As it accumulates, the weight of the snow becomes great enough to compress the bottom layers into ice. Eventually, the snow can pile so high that the pressure on the ice on the bottom causes partial melting. Then, the ice and snow begin to slide downhill. This moving mass of ice and snow is called a **glacier**. Almost two thirds of the world's fresh water today is trapped in glaciers.

Figure 1.12 These Emperor penguins and their chicks live in Antarctica, where massive continental glaciers exist.

Did You Know?

The amount of fresh water underground is about 37 times the amount on the surface in rivers and lakes. About half of this underground water saturates the rock and soil to a depth of nearly 1 km. The remaining half of the water is even deeper—trapped 1–5 km below Earth's surface.

Word Connect

The cryosphere refers to the parts of Earth's surface where water is in its solid form. The term comes from the Greek word *kyro*, meaning "cold."

A glacier will continue to slide down a slope until one of two things happens. If the glacier reaches an ocean, the ice will start to slowly spill over the edge of the land mass toward the water. Deep cracks called **crevasses** will begin to form across the front of the glacier. Under gravity's pull, large pieces of the glacier will eventually break off and crash into the ocean. These big chunks of ice are called **icebergs** (see Figure 1.13).

Figure 1.13 The east coast of Labrador and Newfoundland is known as Iceberg Alley. The icebergs that travel down through Iceberg Alley come from Greenland. To keep shipping lanes and oil rigs safe, sometimes icebergs have to be towed to a different location as shown here.

Glaciers and the Water Cycle

Glaciers and the year round snows in high mountains act as natural reservoirs. These reservoirs collect snow throughout the fall, winter, and spring. They gradually release this reserved water as meltwater in summer.

Glaciers exert a direct influence on the water cycle by slowing the passage of water through the cycle. Glaciers are excellent storehouses of vast quantities of fresh water. They release this water when it is needed the most, during the hot, dry summer months.

Besides their importance as fresh-water storehouses, glaciers provide important clues to the past. Because of the way glacial ice accumulates and endures, glaciers offer an excellent source of information about Earth's past climates.

internet connect

In some areas in the Antarctic, the ice is over 4 200 m thick. Learn more interesting facts about glaciers. Go to **www.discoveringscience8.ca**

Ice Ages

Over the last several million years, Earth has had at least seven major periods of cooling called ice ages. The most recent ice age began about 120 000 years ago, and ended only 11 000 years ago. During this period, the climate was very different from what it is today. Glaciers covered as much as 28 percent of land on Earth.

During the last ice age, much of North America was as cold as Greenland is today. That means the average temperature was near 10°C. Glaciers covered the land from the Arctic to as far south as below the Great Lakes (see Figure 1.14).

Glaciers and Global Warming

You have probably heard a lot about global warming. **Global warming** refers to the increase in the average temperatures of Earth's near-surface air and oceans. In the last 100 years, the average surface temperature on Earth has increased 0.5°C. Although that may not seem like very much, it is enough to have an effect on the glaciers and polar ice caps. Most glaciers in the world today are receding, meaning that they are melting and shrinking. For example, the Athabasca Glacier in Alberta has receded 1.5 km since 1843, and it continues to recede today at a record pace. The importance of this cannot be underestimated as the Athabasca Glacier is a key source of water for Alberta, the Prairies, and many states in the western United States.

Although scientists are still studying glaciers to gather as much information from them as possible, there is a general agreement among them that glaciers around the world are melting at a quicker pace than ever recorded before. Scientists are also trying to predict some of the consequences of the shrinking glaciers. Ocean waters may rise, which can be disastrous for coastal communities. As glaciers melt, the water could flood rivers that are important sources of water for people all over the world. If a glacier completely disappears, these crucial rivers would dry up. Because of their importance, glaciers continue to be closely studied and monitored by scientists.

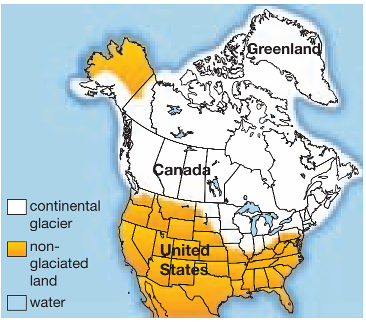


Figure 1.14 During the last ice age, glaciers in North America covered an area three times as large as they do today. Northern sections of the Yukon and Alaska remained free of glaciers because they were too dry.

Figure 1.15 Signposts leading up to the Athabasca Glacier show how much bigger the glacier used to be in certain years.

Suggested Activity

Find Out Activity 1-3B on page 30.

Did You Know?

The Athabasca Glacier is 6 km long and its average width is 1 km. In some places, this glacier is 300 m deep, which is as tall as the Eiffel Tower in Paris.

Reading Check

1. Name four sources of fresh water on Earth.
2. What is groundwater?
3. How is a glacier formed?
4. When did the last ice age end?
5. How is global warming affecting glaciers?

Fresh Water System Links

After learning about the different sources of fresh water, it is important to learn how they are all linked together. As you learned with the glaciers, damage to one system can cause damage to another. By understanding these links, we can take steps to try to minimize damage and maintain healthy water systems—for us as well as for other living things.

Did You Know?

The Churchill River in Newfoundland and Labrador has a drainage basin that is 79 800 km^2. That is 20 percent of the province's size!

Drainage Basins

Water is always on the move in the never-ending water cycle. No matter where a raindrop lands, it will eventually end up somewhere else. The same is true of ice and snow that melts. All fresh water on Earth—whether surface water or ground water —is part of a drainage basin. A **drainage basin**, or watershed, is the area of land that drains into a body of water, such as a river, pond, lake, or ocean. The area of land within a drainage basin can be large or small. Within large drain basins, there are many smaller ones. For example, every stream is part of a large drainage basin. A small stream in your neighbourhood flows until it meets other small streams. The streams join larger rivers. Large rivers merge into major waterways.

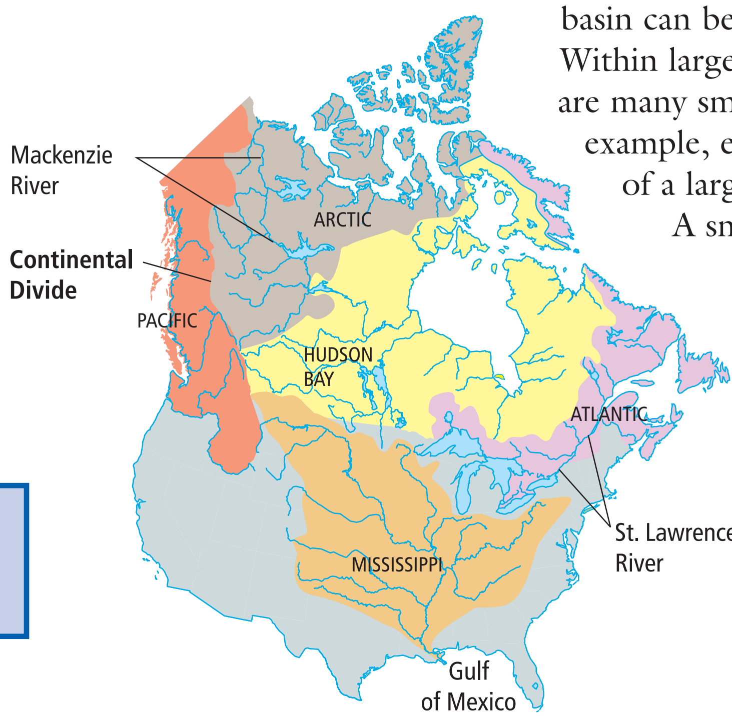


Figure 1.16 Canada has five major drainage basins. Most precipitation falling on Canada drains into the Pacific, Atlantic, and Arctic Oceans, and Hudson Bay. Interestingly, some of Canada's river water also ends up in the Gulf of Mexico.

Suggested Activity

Investigation 1-3C on page 31.

What usually separates one drainage basin from another is called a divide, an area of very high ground. The Rocky Mountains are part of a long chain of mountains that extends down the length of North America. These mountains form the Continental Divide that separates the Pacific drainage basin from drainage basins to the east of the Rocky Mountains (Figure 1.16)

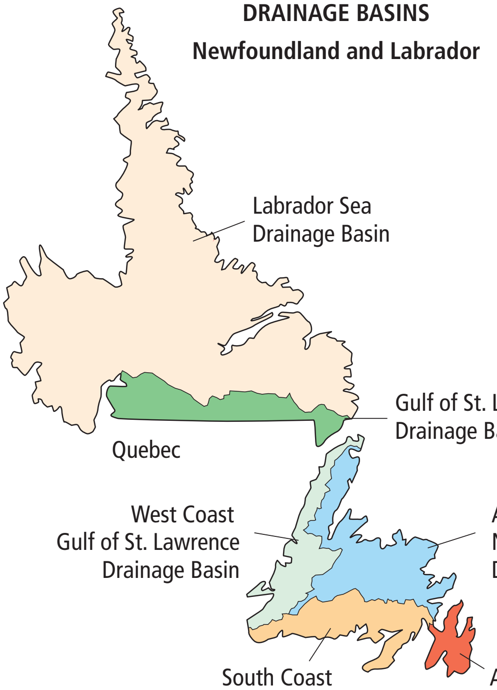


Figure 1.17 Newfoundland and Labrador has 6 major drainage basins. In which drainage basin is your community located?

Run-off

You may have noticed that after heavy rainshowers, mini-rivers of water wash over sidewalks, driveways, and roads. Where does this vast amount of water go? Some of it evaporates or soaks into the ground, but a lot of it simply flows over the surface of the ground and "runs off" into streams, rivers, other water bodies, and even city sewer systems. Water that does not soak into the ground or evaporate but instead flows across Earth's surface is called **run-off**.

If you overfill a glass of water, the extra water will behave like run-off. It will flow down over the side of the glass and will not stop until it reaches the lowest point that is possible. The force pulling it down to the lowest point is **gravity**, the same force that keeps us on the ground. Under gravity's influence, run-off will flow along the ground until it hits a low point on the surface or finds its way into a stream.

Factors Affecting Run-off

Run-off is essential for filling the lakes, streams, and rivers that in turn help to keep the oceans filling with water. In this way, run-off plays a vital role in the water cycle. The amount of run-off is higher in some areas than in others. It can also vary in the same area, depending on different conditions. Run-off is affected by the following factors:

- **The nature of the ground material:** If the ground is covered in rock, it will not absorb the surface water easily. This results in an increase in run-off. If the ground is mostly soil, it will be able to absorb water and the amount of run-off will decrease.

Figure 1.18 The Humber River rises and flows more quickly in springtime as run-off from the melting winter snow reaches its banks. This water will soon reach the Atlantic Ocean.

- **The amount of rain:** If it rains heavily, the ground may quickly become saturated (it cannot absorb anymore water). This means that the unabsorbed water will become run-off.
- **The length of time it rains:** If it rains for long periods of time, the ground may become saturated, as described above. This results in an increase in run-off.
- **The slope of the land:** The steeper the land is, the faster the water will flow downhill. When water moves too fast, it cannot be easily absorbed into ground. This results in an increase in run-off. Slow-moving water on gently rolling land has more time to be absorbed. This results in a decrease in run-off.
- **The amount of vegetation:** Grass, trees, and shrubs absorb water along with the soil, so areas with little vegetation will have a greater amount of run-off than an area with a lot of vegetation (see Figure 1.19).

Figure 1.19 When there is little vegetation on a hillside, such as in a clearcut like this, precipitation is not absorbed as quickly and so run-off increases.

- **The amount of development in the area:** Wherever there is a lot of pavement or concrete on the ground, water is usually channelled immediately into storm sewers (see Figure 1.20). This results in an increase in run-off. Areas with little development, and therefore more bare ground to absorb water, will have less run-off.

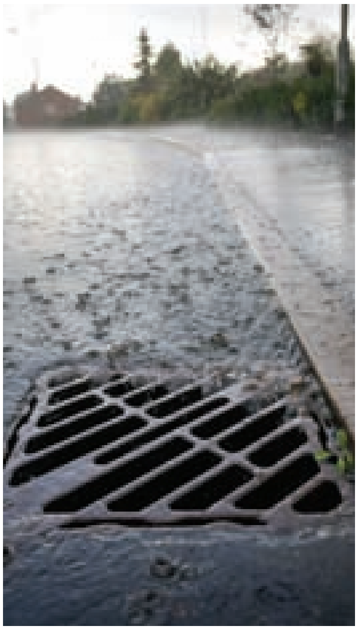


Figure 1.20 Water pooling in areas of development means that less water will be absorbed into the ground and more will end up in sewers as run-off.

Reading Check

1. What is a drainage basin?
2. What is the Continental Divide?
3. Explain what run-off is.
4. What force pulls run-off to the lowest possible point?
5. Name four factors that affect run-off.

1-3A Tracking Run-off

Find Out ACTIVITY

Whenever people change Earth's surface, they change a natural balance. Therefore, if they are planning a development and want to clear land for it, they must first consider the long-term effects their actions may cause. Imagine you have been hired by a community that has several plans for development in the area shown below. Your job is to review what the community plans to do and help it identify any run-off–related consequences that could result from their development. Here is the list of community plans:

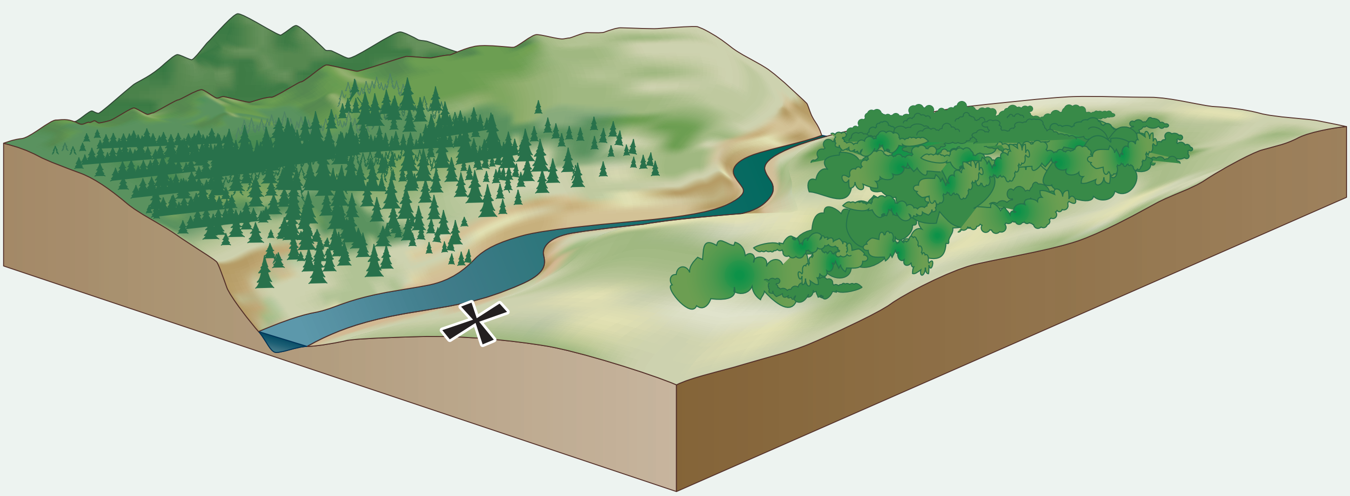
- A small group of houses will be built on the bank of the river, near the area marked with an X.
- The forest on the far slope of the river will be clearcut (entirely logged) and then replanted.
- The bushes to the right of the forest will be removed.
- The area to the bottom right will become a shopping mall with a parking lot.

What to Do

1. Make a simple three-column table by drawing two lines down a page in your notebook. Print "Proposed action by the community" at the top of the left column, "Possible consequences related to run-off" at the top of the middle column, and "Possible solutions" at the top of the right column.
2. Study the sketch. Fill in your table with any concerns you have about the community plans and how the proposed actions might affect run-off.

What Did You Find Out?

1. What consequences do you predict if the community goes ahead and carries out all of its plans for development?
2. Should anything in the plan be changed? If so, what, and why would you recommend that it be changed?



1-3B How Can Global Warming Be Slowed?

Find Out ACTIVITY

Human activities affect the air in our atmosphere. Burning fossil fuels and removing vegetation are examples of two such activities. Both activities add carbon dioxide to the atmosphere and may contribute to global warming. How can we help reduce the amount of carbon dioxide in the atmosphere?

Procedure

1. In a group, brainstorm ways in which we rely on energy from burning fossil fuels in our community. You might need to do some research in the library or on the Internet.
2. Now brainstorm some ways in which we can change our daily activities to reduce our reliance on energy from burning fossil fuels. (Hint: Think about transportation and how we heat and cool our homes, for example.)
3. Design a brochure or a website informing people about steps we can take in our daily lives to slow down global warming.

Extension

1. Research what actions people and the government in Newfoundland and Labrador have undertaken to reduce the amount of carbon dioxide in the atmosphere. Prepare a report and share your findings with your class.

What kind of changes in transportation could we make to avoid traffic jams like this and to reduce the amount of fossil fuels that we burn?

1-3C How Much Water?

Think About It

Grey River, Newfoundland and Labrador

Study the table below. It lists the sizes of Canada's five major drainage basins and the volumes of water that flow from each river into the oceans. The volume of water flowing from a river into an ocean is called the **mean discharge**.

Canada's Major Drainage Basins

Drainage	Area (km^2)	Mean Discharge (L/s)
Pacific	1 009 064	24 100 000
Arctic	3 583 265	16 400 000
Hudson Bay	3 860 136	30 900 000
Gulf of Mexico	26 677	25 000
Atlantic	1 570 071	33 400 000

What to Do

Rank the drainage basins in order of

(a) size (area in km^2), from 1 (largest area) to 5 (smallest area)

(b) mean discharge, from 1 (largest volume) to 5 (smallest volume)

Analyze

1. Explain the difference in rankings.
2. To which coastline does most of Canada's water flow—north, east, or west?
3. What percentage of the total flow goes in this direction?

Science Watch

Turning on the Fog Faucet

Humans have adapted to living in many difficult environments around the world, from scorching deserts to frigid mountains. In many such places, a serious problem is the lack of a safe water supply. This problem may have developed because people are using existing water sources faster than the supply can be replaced naturally. Other reasons might be that the water has become polluted and unsafe to use, or that the local climate is too dry to produce enough water in the form of precipitation.

Think how convenient it would be if water could be collected from the air as easily as it can be collected when it falls from rain clouds.

At the beginning of this chapter, you learned that the atmosphere contains small amounts of water. A group of clever Canadians has developed ways to "harvest" that water so that it provides a useful supply of fresh water for people living in otherwise dry areas. Working with scientists in Chile (a country that lies along the southwest coast of South America), the non-profit organization FogQuest has designed a system for collecting the small droplets of water that form in the air when water vapour comes in contact with objects. The mist and fog we often see in Newfoundland and Labrador, for example, are really just low clouds of water droplets that have condensed on particles in the air. This may seem like a small amount of water, but it can be collected in reasonably large amounts in areas that often have fog and heavy morning dew.

The fog collectors shown here are large rectangular panels made of nylon netting. The nets are set up so that the moisture-carrying wind hits them directly. Each collector panel measures 2 m by 24 m. As the water condenses on the nets, it drips down along the panel and is collected in a series of pipes and storage tanks. The collectors can be adjusted to suit weather conditions and water needs. The system is simple and easy to set up and maintain, and it does not cost a lot of money to operate. This makes it an ideal way to help people obtain a safe supply of water where it would be too expensive to do so by other methods.

Questions

1. How do fog catchers work?
2. What climatic conditions would be necessary in order for a fog catcher to be useful?
3. Would producing water from fog catchers be useful in your area? Explain why or why not.

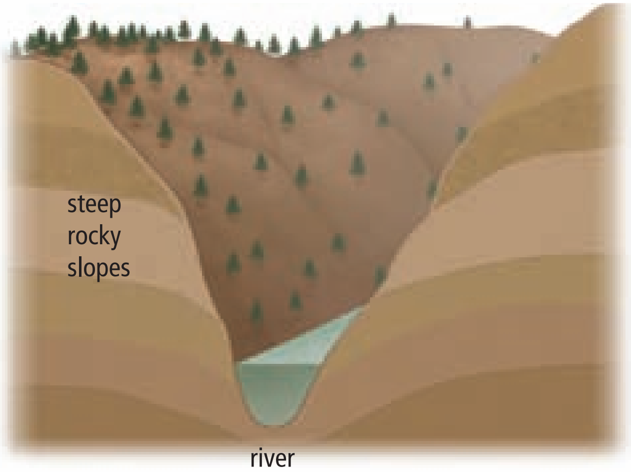
Check Your Understanding

Checking Concepts

1. Explain how a glacier is formed.
2. After a heavy rain, you notice a large amount of water flowing down a hillside. What could be a possible explanation for why it has not soaked into the ground?
3. How is run-off an important part of the water cycle?
4. "No matter where a raindrop lands, it will eventually end up somewhere else." What is meant by this sentence?

Understanding Key Ideas

5. For each of the following activities, state whether the activity would lead to an increase or decrease in the amount of run-off entering the river in the diagram below. Explain your answer.
   (a) planting trees along the slopes
   (b) removing material to make the slopes less steep
   (c) developing the area on one side of the river (for example, building roads and parking lots)



6. Using your knowledge of drainage basins, explain how water pollution in one part of the province could affect water supplies in another part.
7. List three reasons why glaciers are important to all living things.

Pause and Reflect

Canada has about 1300 glaciers. Since 1850, these glaciers have lost between 25 percent and 75 percent of their mass. The total amount of ground covered by glaciers in Canada is the lowest it has been since the last ice age, 10 000 years ago. How do you think this might be affecting the water cycle? Write a paragraph summarizing your ideas.

Chapter Review

Prepare Your Own Summary

In this chapter, you investigated the water cycle and the essential role it plays on Earth. Create your own summary of key ideas from this chapter. You may include graphic organizers or illustrations with your notes. Use the following headings to organize your notes:

1. Water Cycle
2. Differences Between Ocean and Fresh Water
3. Sources of Fresh Water

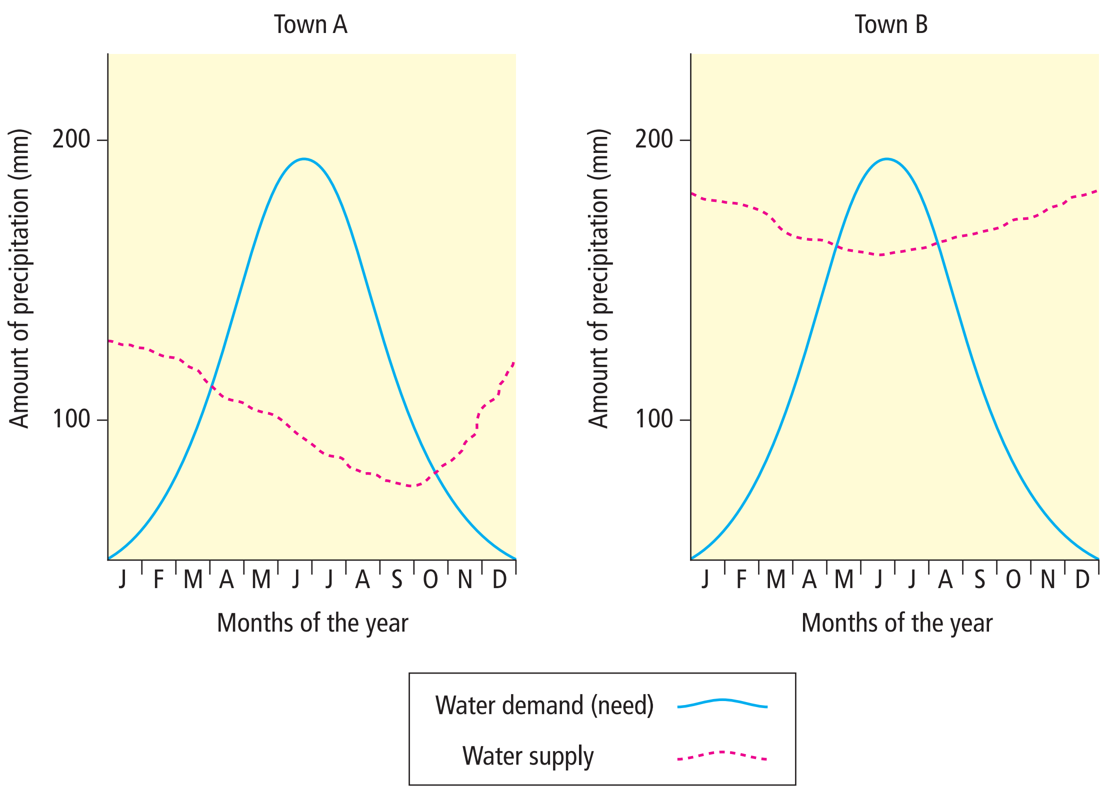
Checking Concepts

1. (a) What percentage of Earth's surface is covered in water?
   (b) How much of that water is fresh?
2. What supplies the energy for the water cycle?
3. What is the name given to a person who studies water systems and helps solve problems related to controlling the quality and quantity of water?
4. Why is it so easy to float in the Dead Sea?
5. What separates one drainage basin from another?
6. Most of the world's glaciers are receding.
   (a) What does receding mean?
   (b) What effect could this start having on sea level?

Understanding Key Ideas

7. Make a flow chart to illustrate the events in the water cycle in sequence, beginning with precipitation falling to Earth.
8. Describe how each of the following would affect the local water cycle.
   (a) construction of a large shopping mall
   (b) building a subdivision for 200 houses with families
   (c) logging a large forest in a hilly area
9. When constructing roads in hilly areas, trees and bushes are stripped from steep banks exposing soil underneath. Should these banks be covered with rocks or should plants be used to replace the trees and bushes that were removed? Explain your answer.
10. Why would you want to control the amount of run-off in an area?

11. The graphs below show how much water residents in two different mythical towns take from their water supply (demand) and how quickly each water supply refills from precipitation (recharge).



Analyze the data shown on the graphs and answer the following questions:

(a) Which town will most likely have a shortage of water in the summer? Explain.

(b) When is water demand lowest in both towns? Explain.

(c) (i) At what times does the water supply drop for both towns?
(ii) Why do you think this occurs?

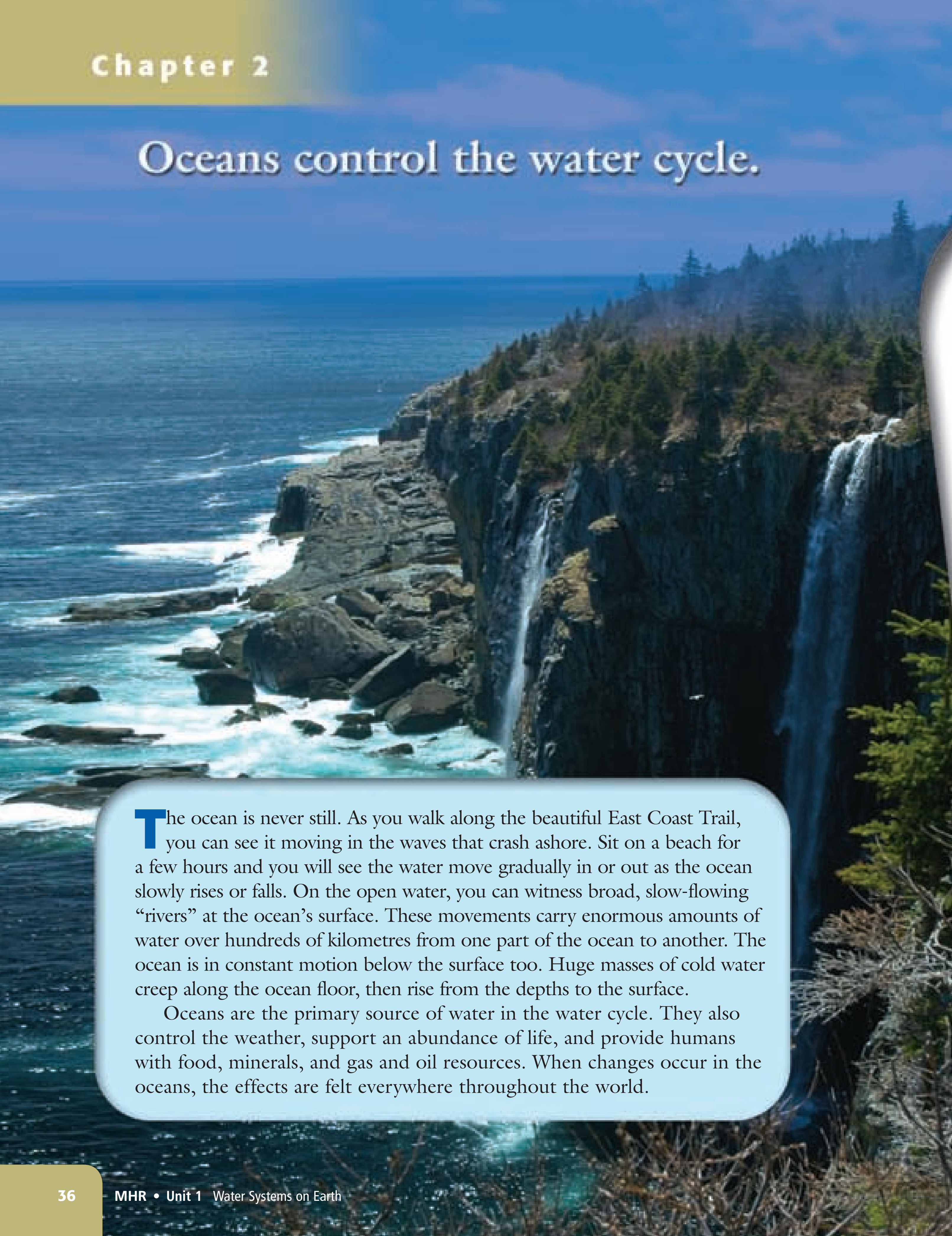
12. Approximately 29 percent of Newfoundland and Labrador's population relies on groundwater as a source of drinking water. With your knowledge of the water cycle, what possible dangers must the government watch out for to keep this water safe?

Pause and Reflect

Recent climate change around the world is causing areas that are covered in ice to melt at an increasing rate. Large pieces of Antarctic ice are breaking off and floating away from the continent. How could an event like that, so far away, affect Newfoundland and Labrador? Think about all you learned in this chapter and describe as many effects as you can.

Chapter 2

Oceans control the water cycle.



The ocean is never still. As you walk along the beautiful East Coast Trail, you can see it moving in the waves that crash ashore. Sit on a beach for a few hours and you will see the water move gradually in or out as the ocean slowly rises or falls. On the open water, you can witness broad, slow-flowing "rivers" at the ocean's surface. These movements carry enormous amounts of water over hundreds of kilometres from one part of the ocean to another. The ocean is in constant motion below the surface too. Huge masses of cold water creep along the ocean floor, then rise from the depths to the surface.

Oceans are the primary source of water in the water cycle. They also control the weather, support an abundance of life, and provide humans with food, minerals, and gas and oil resources. When changes occur in the oceans, the effects are felt everywhere throughout the world.

What You Will Learn

In this chapter, you will
- **describe** the features of Earth's ocean basins and the processes that created them
- **define** ocean currents and identify factors that influence their formation
- **describe** waves and tides and their interactions with shorelines

Why It Is Important

No matter where you live, you cannot escape the influence of the ocean. Learning about oceans and their connection to Earth's water cycle helps us to better understand the relationship between human activities and the balance of nature.

Skills You Will Use

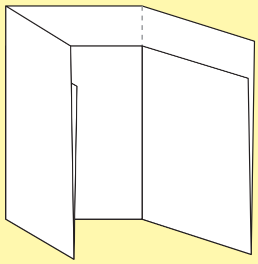
In this chapter, you will
- **investigate** mapping of the sea floor
- **graph** the temperature of ocean water at different depths
- **research** historical disasters and new technologies to prevent erosion

FOLDABLES™
Reading & Study Skills

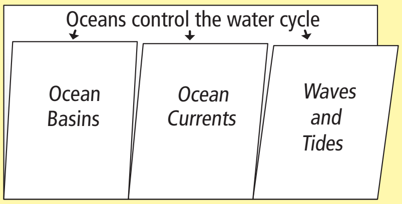
Make the following Foldable to guide your notetaking on Chapter 2.

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

STEP 2 **Turn** the paper so the fold is on the bottom. Then, **fold** it into thirds.



STEP 3 **Unfold** and cut only the top layer along both folds to make three tabs. **Label** the Foldable as shown.



Show You Know As you read the chapter, take notes under the appropriate tab to *describe* the features of Earth's ocean basins, *define* ocean currents and sediment movement, and *describe* how waves erode coastlines and how tides are linked to the Moon.

2.1 Ocean Basins

A basin is a low spot in Earth's surface that is completely or partially surrounded by higher land. Oceans are basins into which water has flowed and accumulated over millions of years. The same tectonic processes that gave continents their valleys, mountains, and plains also shaped the ocean floor. Long ridges of mountains, deep trenches, and flat plains are part of the underwater world that is still slowly changing. Through advances in underwater technology, scientists are able to explore the ocean depths and learn more about the ocean environment.

Key Terms

abyssal plain
continental drift
continental shelf
continental slope
ocean ridges
trench

As you learned in Chapter 1, a little over two thirds of Earth's surface is covered by oceans. The five major oceans, in order from largest to smallest, are the Pacific, Atlantic, Indian, Southern, and Arctic (see Figure 2.1). The Southern Ocean includes all the southern portions of the Pacific, Indian, and Atlantic Oceans. It completely surrounds the continent of Antarctica.

Figure 2.1 Earth's oceans

Did You Know?

In 2000, the International Hydrographic Organization created the fifth world ocean – the Southern Ocean – from the southern portions of the Atlantic Ocean, Indian Ocean, and Pacific Ocean. The Southern Ocean completely surrounds Antarctica.

2-1A How Ocean Basins Become Bigger

Find Out ACTIVITY

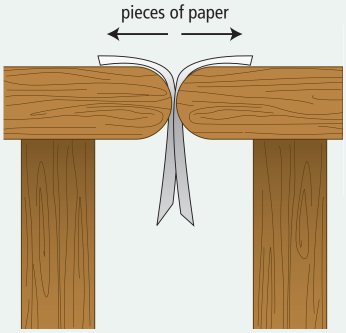
Earth's surface is always in motion because the crust is made up of large, separate plates that float over molten (partially melted) rock. The ocean floor is both moving and getting wider. When molten rock rises to the surface between the plates, it cools and turns to solid rock, creating an ocean ridge. As more molten material comes up, it pushes the new rock away to both sides. This constant process gradually widens the ocean floor. Near the ridge is the young rock, and farther from the ridge is the old rock. In this activity, you will simulate the motion of the plates beneath ocean basins, and calculate how fast the floor is spreading.

Materials

- 2 flat-topped desks (or tables)
- 2 pieces of legal-size paper
- pencil
- calculator
- ruler

What to Do

1. Working with a partner, slide the desks together, leaving only a small gap between. The gap represents a spreading ridge on the bottom of the ocean.
2. Place the pieces of paper together, one on top of the other. Slide them down into the gap between the desks, leaving the top 2 cm of paper sticking up above the desks.



3. Place an X on your piece of paper. Now your partner should place an X opposite of yours on their sheet of paper. The two X's indicate the position where new rock forms at a spreading ridge.
4. Slowly start sliding each piece of paper along the desk tops away from each other.
5. Just before the end of the pieces of paper leaves the gap, place a "Y" near the gap on both pieces of paper.
6. Pull both papers out and measure the distance (to the nearest centimetre) between X and Y on each piece.

What Did You Find Out?

1. (a) What do the two pieces of paper moving in opposite directions represent?
   (b) At the end of the activity, which letter represents the oldest rock? Explain why.
2. How fast plates move away from the spreading ridge is called their rate of motion. It is usually expressed as the distance moved (in centimetres) in a specific time period (a year). To calculate the rate of plate motion in your example, take the distance between X and Y on one piece of paper and divide it by the age (in years) of the oldest rock. Assume that the rock at "X" is 10 years old.
3. Your calculation shows the rate of motion for one plate. Would the plate on the other side of the ridge show the same rate or a different one? Explain your answer.
4. How old would you expect the rock to be at half the distance to X? Explain.
5. Imagine that a plate near a spreading ridge in the Atlantic Ocean was found to have moved 25 000 000 cm in 10 000 000 years. Calculate the rate of plate movement for this plate. How does this rate compare to the rate you calculated above? Can you think of a reason why plates might move at different rates?

Origin of the Oceans

Over 200 million years ago, the surface of Earth looked very different from the one you know today. All of the continents were together in one land mass called Pangea.

Figure 2.2 Over 200 million years ago, all the continents formed one large land mass called Pangea.

Slowly, Pangea began to split up. In a process called plate tectonics, pieces of the land mass began to move over Earth's surface. The entire surface of Earth is made up of large, slow-moving sections of rock called tectonic plates. These sections of rock are solid, but float over a layer of molten rock called magma. As the magma heats up from the heat energy in Earth's core, the molten rock rises. This pressure can force two plates apart. Over millions of years these plates moved the land into the map that we are familiar with today. As they moved into their current position, they formed the oceans that now exist on Earth. Today, the continents are still slowly moving. The Pacific Ocean is actually shrinking while the Atlantic Ocean is getting wider.

Figure 2.3 The process of plate tectonics slowly moved continents into their current position.

The Origin of Ocean Water

Scientists believe that the oceans have been on Earth for more than 3 billion years. When the planet first formed about 4.5 billion years ago, it started as a hot ball of molten (melted) rock. The outside of Earth gradually cooled down, but heat continued to be released from deep within the planet through volcanoes (Figure 2.4). Water trapped inside the volcanic materials was also released into the atmosphere in the form of water vapour—much like steam escaping from a kettle. As the water vapour cooled and condensed, it fell to Earth's surface as precipitation. Because gravity causes water to flow downhill, the vast amounts of water that fell began collecting in the lowest parts of Earth's surface, the ocean basins.

Some scientists speculate that much of the original water on the planet came from ice in comets that hit the young Earth.

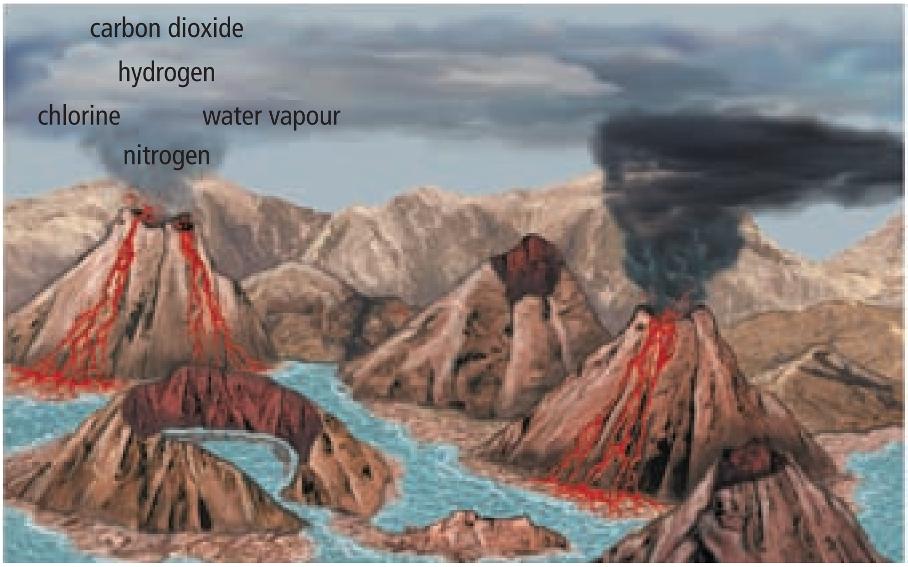


Figure 2.4 Vapour from volcanic eruptions helped to create the oceans.

A Journey on the Ocean Floor

Imagine you could empty the oceans of water and take a journey along the sea floor. What would you see? For one thing, you might be surprised to find many of the features that you see on land. There are mountain ranges, steep valleys, and vast plains (see Figure 2.5). Not only that, but all of these features under the ocean tend to be much larger than the similar features on land. But how did these formations get here?

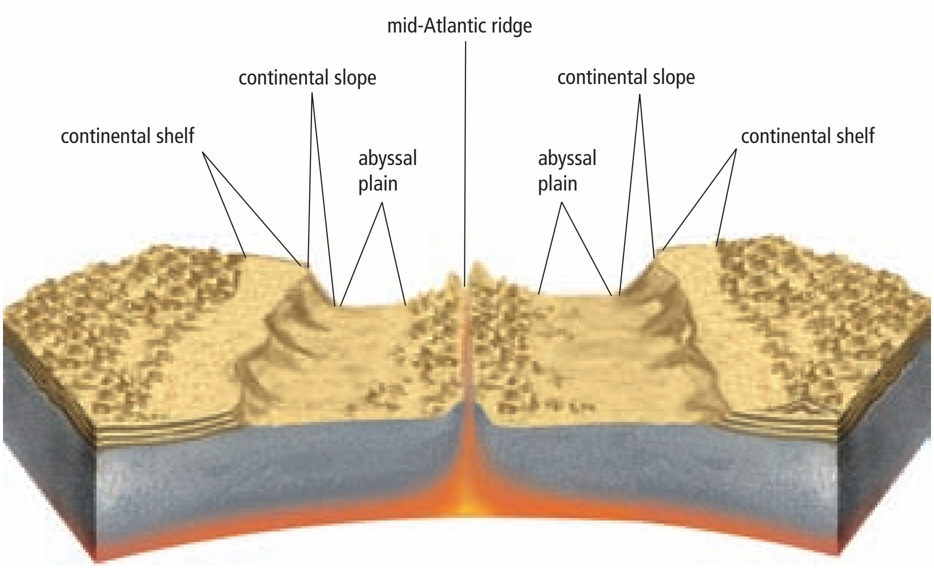


Figure 2.5 The ocean basins contain mountain ranges, deep valleys, and wide plains.

The greatest influence in shaping the ocean floor is the movement of Earth's crust through the tectonic processes you just read about. When two plates are pushed apart, the underlying magma oozes up and quickly hardens, and forms long, undersea mountain chains called **ocean ridges**. These ridges are the youngest areas of the sea floor and are still being formed by volcanic eruptions underneath the ocean. With each new eruption, the new material pushes the tectonic plates further apart. Ocean ridges may be more than 1000 km wide and rise 1000-3000 m above the sea floor. The largest oceanic ridge is the Mid-Atlantic Ridge in the Atlantic Ocean.

Did You Know?

Did you know that North America and Europe are moving further apart by about 3 cm each year? This means that the Atlantic Ocean is getting larger and the Pacific Ocean is getting smaller!

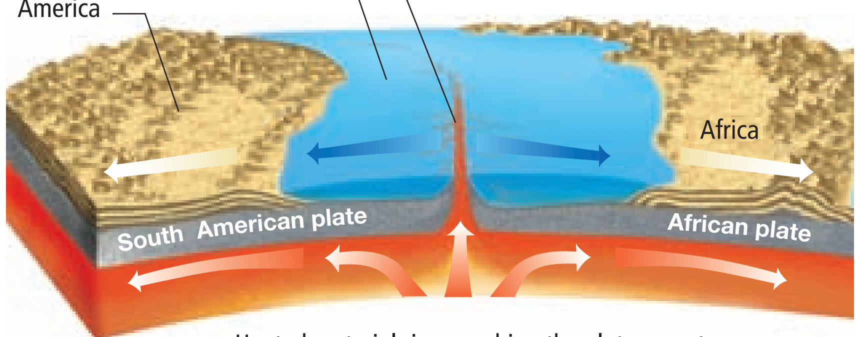


Figure 2.6 As the tectonic plates are pushed apart, a ridge is formed. In the Atlantic, it is known as the mid-Atlantic ridge and stretches from the North Atlantic to the South.

internet connect

Scientists estimate there are over 10 000 underwater volcanoes. Find out how Canadian technology is helping to investigate some of them. Go to **www.discoveringscience8.ca** to find out where to go next.

As you can imagine, however, plates cannot simply be pushed away from each other forever. At some point, plates moving apart from a mid-ocean ridge must come in contact with other plates. When an oceanic plate collides with a continental plate, the denser ocean plate is forced to bend steeply down beneath the less dense continental plate. When this happens, an ocean **trench** is formed. Most trenches occur around the margin of the Pacific Ocean. The deepest trench, called the Marianas Trench, extends 11 km below sea level. This distance is deep enough to submerge an object as tall as Mount Everest.

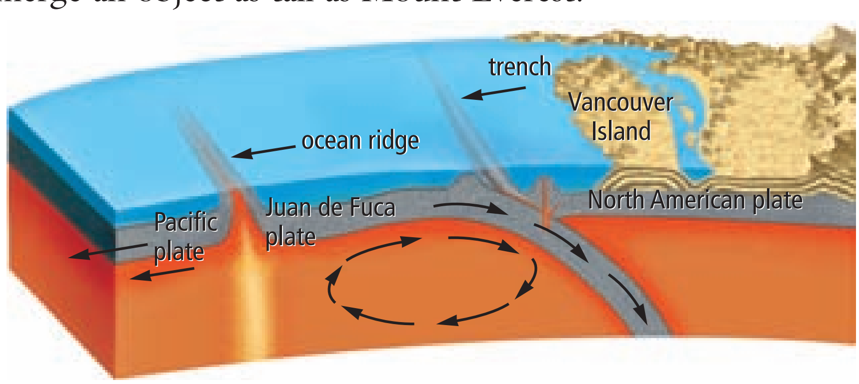


Figure 2.7 When tectonic plates collide, an ocean trench forms as the oceanic plate is forced beneath the continental plate.

Between the high mountain ranges at the centre of the basin and the deep trenches at their edges, the ocean floors are very flat. These wide, open features of the deep sea are called **abyssal plains**. They are formed of thick deposits of sediment, up to 1 km deep in places. The sediments come from the continents, brought to the ocean edge by rivers. They reach the sea floor by great underwater landslides. These landslides, also called turbidity currents, are started by earthquakes, or simply by the force of gravity. From time to time, massive volumes of mud and sand slide down the slopes at the edge of the continents, and are spread over the abyssal plains by ocean currents.

Reading Check

1. What is a basin?
2. Where do scientists believe that water originated?
3. Describe what is meant by plate tectonics.
4. Define ocean ridge, trench, and abyssal plains. Explain how these features are created.

Continental Margins

Ocean basins do not begin at the coastline. Instead they begin many kilometres out at sea. The area between the basin and the coastline is called the continental margin. The continental margins are the regions of the ocean floor that lie underwater along the edge of the continents (see Figure 2.8). These margins are made up of the **continental shelf**, and the **continental slope**. The continental shelf is the submerged part of the continent between the coast and the edge of the basin. Continental shelves slope gradually away from the land before dropping steeply downward at the shelf edge. The average width of a continental shelf is about 80 km. However, the Grand Banks, the continental shelf off of the island portion of Newfoundland and Labrador's east coast, is 480 km wide, one of the widest in the world. The depth of the water on the continental shelves ranges from 30 m to 600 m.

Did You Know?

In 1929, an earthquake triggered an underwater landslide off the coast of the island of Newfoundland. The ocean landslide carried material almost 1000 km eastward and cut 12 telegraph cables on the ocean floor. Knowing the exact time the earthquake occurred and the time each cable was broken, scientists calculated the speed of the landslide at 60–100 km/h.

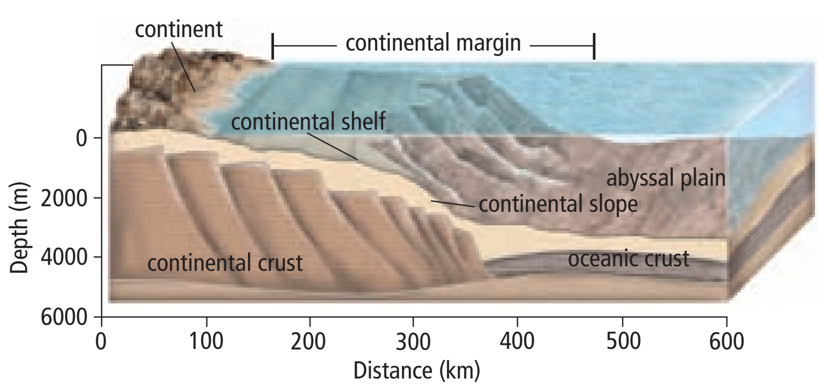


Figure 2.8 Continental margin

From the edge of the shelf, the continental slope plunges at a steep angle to the sea floor. Continental slopes are usually less than 200 km wide and descend to about 3 km. Beyond the base of the continental slope lies the floor of the ocean basin (the abyssal plain).

Suggested Activity

Investigation 2-1B on page 48.

Exploring the Oceans

The first map of the sea floor was produced in the 1870s. Scientists on board the expedition ship HMS *Challenger* lowered weighted wire lines at intervals to the ocean floor. When the weight hit the bottom, they would measure the length of line that was released into the water. By using this method, they discovered the Mid-Atlantic Ridge.

Did You Know?

The HMS *Challenger* expedition discovered over 4500 previously unknown species of marine life. The space shuttle Challenger was named after the HMS *Challenger.* Can you think of a reason why they would name a space shuttle after this ship?

Sonar Mapping

Since the *Challenger* expedition, many new technologies have been developed to help scientists explore the ocean basins. Sonar mapping uses sound waves to probe the seabed. The depth of water is found by sending sound waves directly down from a ship and measuring the time it takes for the signals to hit the sea floor and bounce back to the surface.

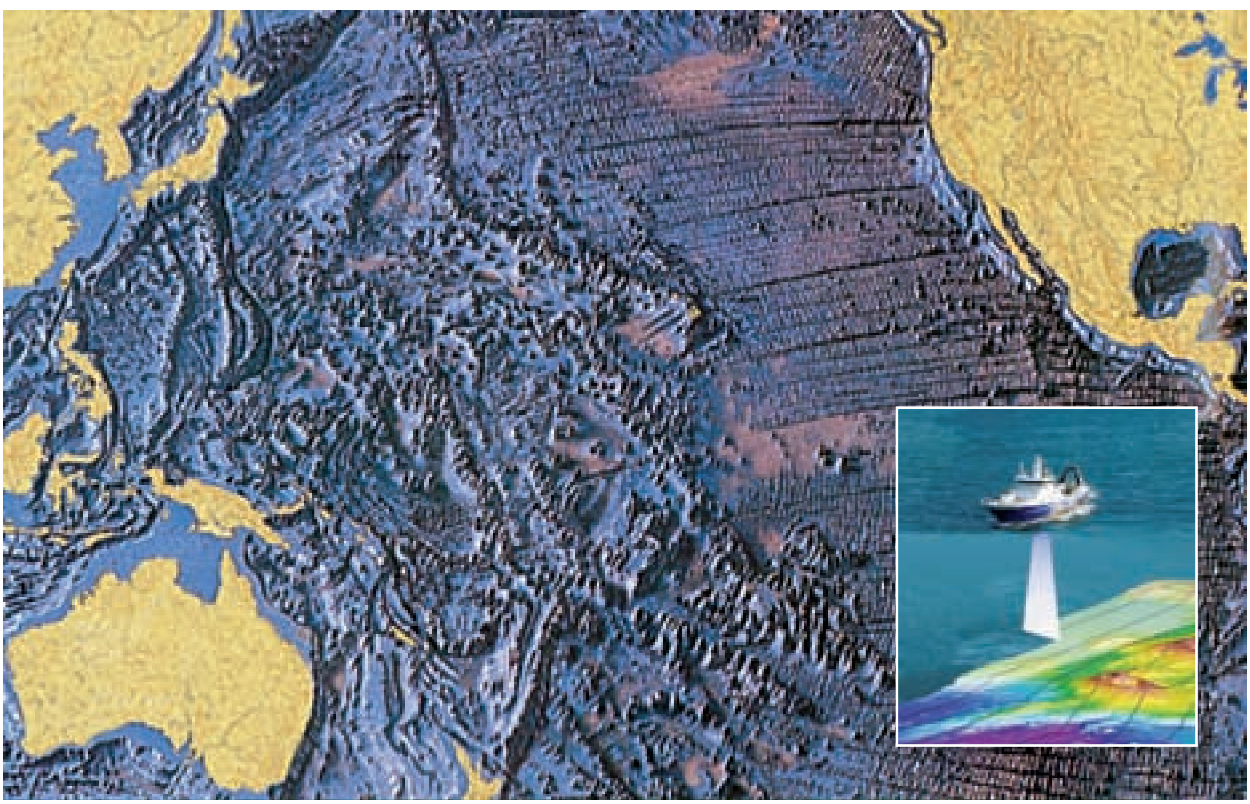


Figure 2.9 By measuring the reflection of sound waves bouncing back from the ocean bottom, scientists have been able to map mountains, valleys, and canyons on the ocean floor.

Satellites

Today we have detailed pictures of the oceans produced by satellites in orbit far above Earth. Spacecraft can automatically record data using radar, infrared light, or other technologies to measure features on Earth. A great advantage of satellites over ships is that satellites can survey very large areas of ocean in a relatively short time. Satellites are also able to record and transmit data in all kinds of weather, and in both day and night.

Satellites can also receive information from buoys that are anchored to the ocean floor at fixed points. Instruments on these buoys collect information about water and air temperature, and transmit the information to satellites. These satellites then transmit this data to stations all over the world. This data can help scientists predict weather changes and monitor water movements.

Word Connect

The word "sonar" comes from term <u>so</u>und <u>na</u>vigation <u>r</u>anging.

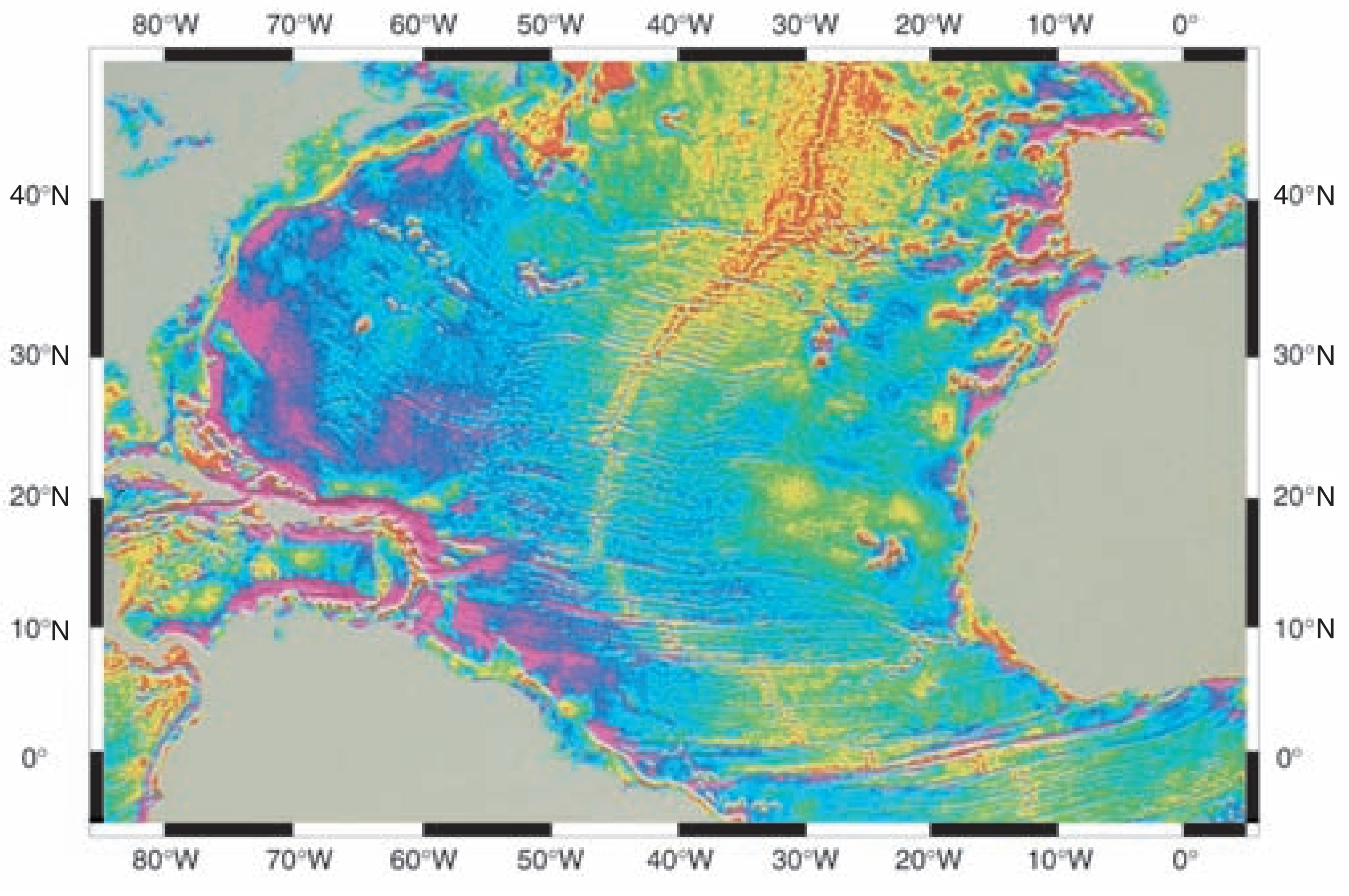


Figure 2.10 This image of the Atlantic sea floor was produced by instruments on a satellite.

Submersibles

The most detailed information we have about the deepest parts of the ocean comes from submersibles. Much of the ocean is permanently dark and extremely cold. At the deepest sections, there is more than 2000 kPa of pressure. All of these factors together make it impossible for people to explore the deep sea without the help of technology.

Submersibles are small but extremely strong vehicles that are capable of travelling to great depths. There are two types of submersibles: manned submersibles and remotely-operated vehicles. Manned submersibles carry people inside and allow them to make their own observations of the deep sea. Remotely-operated vehicles (ROVs) allow people to control the vehicle from a ship that is safely on the surface. They can control the arms, lights, and cameras of the vehicle with a device that is similar to the joystick you use for playing video games. ROVs can stay down much longer than manned submersibles and continuously send data to the ship.

Figure 2.11 Remotely-operated vehicles are controlled by people from the surface. They can collect data, pictures, and objects.

Scientists are also working on a third type of submersible called an automated underwater vehicle. These submersibles will run on artificial intelligence, need little control from people, and will be able to stay underwater for months at a time.

Deep Sea Cameras and Video

Deep sea photography and videography are providing a chance for people to see the undersea world as never before. Cameras towed from ships can take thousands of high-resolution photographs a day. New deep sea cameras and video allow pictures and video to be taken 6000 m beneath the surface. Scientists are still discovering new species at deep sea levels that were never known to have existed before.

internet connect

Right now, there are scientists living under the sea and studying the oceans. To find out more about *Aquarius*, the only undersea laboratory, go to **www.discoveringscience8.ca** to find out where to go next.

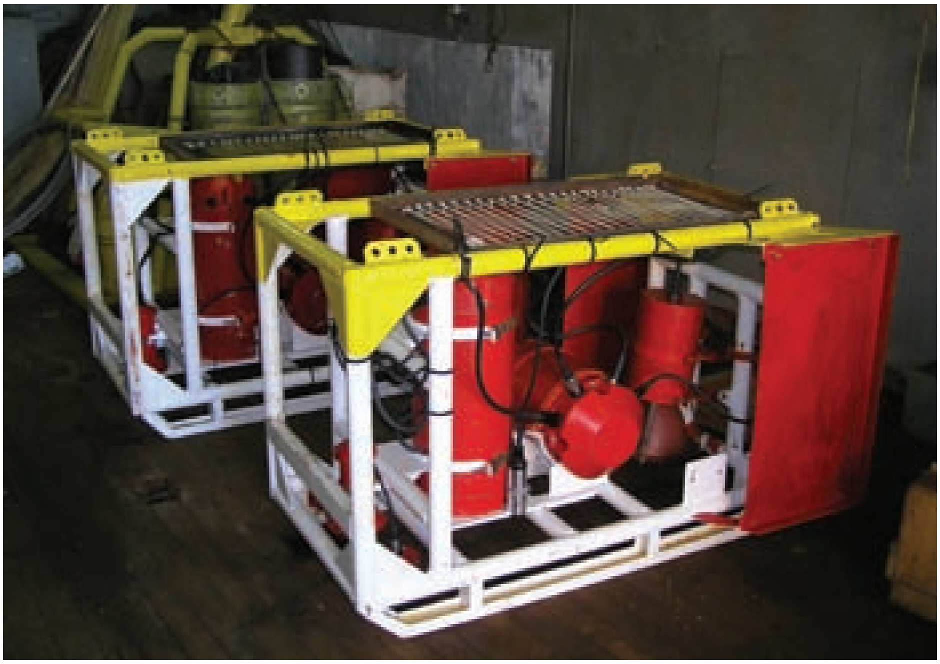


Figure 2.12 Deep sea cameras such as the NEPTUNE can reach ocean depths of 6 km.

Reading Check

1. What two features make up the continental margin?
2. Describe the process of sonar mapping.
3. What is an advantage of satellite mapping?
4. Describe two types of submersibles.

2-1B Getting to Know the Ocean Floor

SkillCheck

- Measuring
- Graphing
- Modelling
- Evaluating systems

Materials

- shoebox with lid
- a variety of small objects (such as little blocks of wood, erasers, rolled up paper, and modelling clay)
- tape
- felt pen
- ruler
- scissors
- drinking straw
- graph paper
- pencil

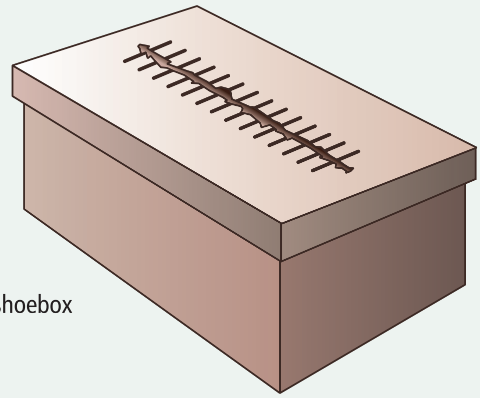
Scientists make both direct and indirect measurements. Direct measurement can be done when an object can be physically touched or the quantity to be measured can be seen. An example is measuring the length of a table with a metre stick or weighing a bag of apples. When the object to be measured cannot be physically reached or seen, indirect measurement must be used. For example, scientists wanting to measure the size of a rock on Mars have to do it by using a remote-sensing device. In this investigation, you will use indirect measurement to map a model of an ocean floor.

Question

How can you determine what the bottom of the ocean looks like if you cannot see it?

Procedure

1. You are going to make a model of a section of the ocean floor, which you will then exchange with a classmate. Tape the different objects you have gathered down the middle of the shoebox, lengthwise. Make sure the objects vary in how high they sit from the bottom of the shoebox. Do not let your partner see how you have set up your model.
2. Draw a line with the felt pen down the centre of the shoebox lid lengthwise. Along the full length of the line, mark off spaces about 2 cm apart.
3. Use the scissors to make a slot down the long line drawn on the shoebox lid. Make the slot wide enough to allow the straw to slide through. Put the lid on the shoebox.



Set-up of shoebox model

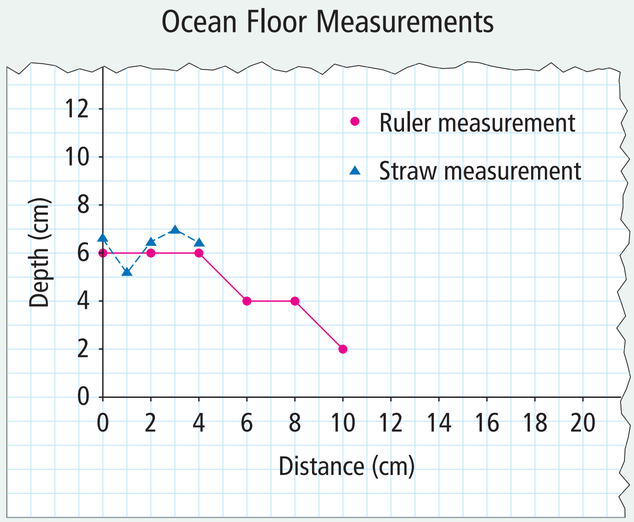
4. Using the felt pen and the ruler, mark the straw with 1 cm intervals.
5. Exchange shoeboxes with a classmate.
6. Copy a data table like the one on the next page into your notebook. Give your table a title.

Distance	Depth 1 (cm) Ruler	Depth 2 (cm) Straw
0		
1		
2		
3		
4		

7. To begin your task of mapping this ocean floor you cannot see, make your first measurement by sliding the ruler through the slot in the first interval marked. Gently push the ruler far enough down so that you can feel it just touching the first object on the ocean floor. The reading on the ruler at the level of the shoebox lid will be the depth. Record this measurement, as well as the distance along the line from where the slot begins.
8. Raise the ruler and insert it at the next 2 cm interval and repeat Procedure step 7. Continue to take measurements at every interval until you have reached the opposite end of the shoebox.
9. Using the straw as your measuring device, repeat Procedure step 7. This time, however, take measurements every 1 cm (half-way between the interval lines marked on the shoebox lid). When a reading on the straw lies between two marked lines, estimate the depth (for example, 2.5 cm). Record the depth to the ocean floor, as well as the distance along the line from where the slot begins.
10. On the piece of graph paper, plot a line graph of your depth and distance data. This will give you a cross section of the ocean floor model. Use a different symbol (such as ● and ▲) for each measuring device you used.

Analyze

1. Once you have completed your cross section, open the lid and see how closely your drawing matches the actual model.



Guidance for graphing your data.

2. Which measuring device provided the best match to the actual model? Explain the difference.
3. What were the strengths and weaknesses of the ruler and the straw as measuring devices?

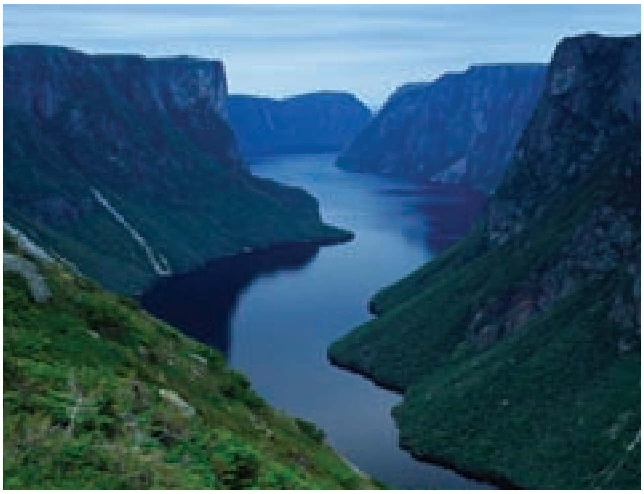
Conclude and Apply

1. Why is this method not the most accurate way to make a cross section?
2. Suggest ways of making this method more accurate.
3. Does this method of measurement give a clear picture of the model ocean floor? Explain why or why not.
4. What could you do to improve the accuracy of your measuring method?
5. When oceanographers are mapping sections of the ocean floor, they do not map the entire floor all at once. Instead, they map many small portions, or samples, and put the pieces together to construct an overall "picture" that represents the ocean floor. In this activity, how does the size of your ocean floor sample (that is, the shoebox) relate to the amount of detail shown in the picture you constructed?

Science Watch

Gros Morne National Park: Tablelands Provide Evidence of Plate Tectonics

There are few landscapes that compare to the beauty of Gros Morne National Park on the west coast of the province. Visitors from all over the world travel to hike its trails, canoe or kayak its waters, and enjoy its breathtaking scenery. However, did you know that Gros Morne National Park is also famous for providing scientists with the first evidence of the process of plate tectonics?



The idea that Earth's crust is made of sections that move around was first introduced in the 1500s. But it was not until the 1970s that scientists found evidence for the theory of tectonic plate movement —and they found it in Gros Morne!

Several hundred million years ago, tectonic plates collided and part of Earth's mantle (its rocky shell) was pushed upwards. The rocky material that was pushed up is called peridotite. Scientists knew that if they could find evidence of this material, they would have proof for plate tectonics. Peridotite is lacking in minerals that are needed to sustain plant life, so they knew they would be looking for barren landscape.

In the 1960s, Dr. Harold Williams discovered that the Tablelands in Gros Morne National Park were made of peridotite. Along with other geological evidence in the area, Williams was able to advance the theory of plate tectonics.

The Tablelands in Gros Morne National Park are composed of peridotite, which is from deep in the Earth's mantle.

Because of its importance to our geological understanding of Earth's history, Gros Morne National Park was designated a UNESCO World Heritage Site in 1987. This means that it is protected and will be conserved for future generations.

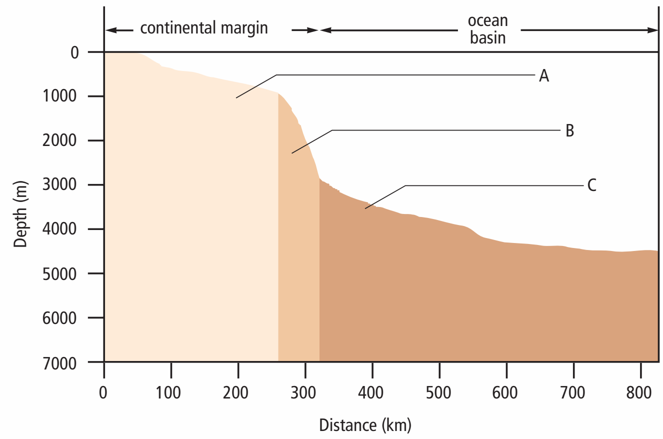
Check Your Understanding

Checking Concepts

1. (a) Name the five major oceans on Earth.
   (b) Which is the largest and which is the smallest?
2. Scientists speculate that most of the water that originally formed the oceans several billion years ago came from two different sources. What are these sources?
3. What are the wide, flat areas of ocean basins called?
4. What is the name of the ocean floor where two tectonic plates are moving apart?
5. What feature marks the location where one tectonic plate is pushed underneath another plate?
6. What is the steep side of the edge of a continent called?

Understanding Key Ideas

7. How did the continents move into their current location?
8. Explain how erupting volcanoes contributed to the formation of oceans.
9. Briefly describe each of the following features of the ocean floor and explain how they formed:
   (a) ridge
   (b) trench
10. The diagram below shows the cross section of an edge of a continent. Draw the diagram in your notebook and label each part.



11. Name three modern technologies that have helped scientists explore the deep ocean.

Pause and Reflect

As tectonic plates slide around, they occasionally bump into one another. Colliding plates are responsible for everything from building mountains to triggering earthquakes and volcanoes. In some places on Earth, tectonic plates move as fast as 17 cm a year. However, the average rate of movement is about 2.5 cm a year. With that information, calculate how far the average plate (a) has moved in your lifetime, and (b) how far it will move if you live to be 100 years old.

2.2 Ocean Currents

Ocean currents are large masses of moving ocean water, almost like a river within an ocean. Like a river, a current flows in one direction and connects one place with another. Knowing how and why the ocean's water moves is important to understanding how oceans can affect the whole planet. Ocean currents exist both on the surface of the water, and deep within the ocean.

Key Terms

Coriolis effect
density current
ocean current
thermocline
upwelling

An **ocean current** is a large amount of ocean water that moves in a particular and unchanging direction. There are more than 20 major ocean currents in the world (see Figure 2.13). The largest current in the ocean is the Antarctic Circumpolar Current (also called the West Wind Drift) in the Southern Ocean. It is 24 000 km long and circles the entire continent of Antarctica. Each year, the current carries 100 times more water than all the rivers on Earth combined—3 million cubic kilometres.

Figure 2.13 There are many different currents on the ocean surface.

Beginning in the Caribbean and ending in the North Atlantic, the Gulf Stream Current is important to Newfoundland and Labrador. Carrying warm water from the tropics, the Gulf Stream helps make the Grand Banks one of the world's largest and richest resource areas. The warm water mixes with the cold water from the Labrador Current, making the area an ideal location for nutrients that provide food for fish and other marine life. The mixing of the two currents is also what generates the heavy fog along much of the province's coastline, especially in the spring.

Ocean currents can be divided into two types: surface currents (that extend to an average depth of 200 m) and deep water currents (that occur deeper than 200 m). Depending on their origin, currents can also be either a warm or a cold current. All types have major effects on ocean ecosystems and on human activities. The movement of surface currents are caused by wind action, Earth's spin, and the shape of the continents. (The effects that are the result of Earth's spin are called Coriolis Effects.) The movement of deep currents is caused by the temperature and salinity of the water.

2-2A Winds and Currents

Find Out ACTIVITY

How do winds affect surface currents? If you turn a skateboard upside down and run your hand across a wheel, friction between your hand and the wheel starts the wheel moving. The direction in which you move your hand determines the direction in which the wheel spins. Similary, winds blowing over the surface of the ocean cause the surface waters to move. The surface currents flow in the same direction as the wind. What happens when a moving ocean current reaches land?

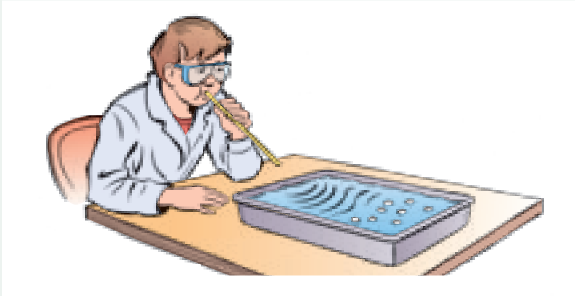
Safety

Materials

- rectangular pan
- water
- 2 drinking straws
- stone
- 12 small circles of paper from a hole punch

What to Do

1. Fill the pan with water. Place six of the pieces of paper on the water at one end.
2. Hold a straw just above the water over the floating papers and gently blow. Repeat several times until the papers have reached the far side of the pan. Watch what happens and sketch your observations in your notebook.



3. Place the other six pieces of paper in the opposite end of the pan. With a partner, gently blow through the straws from opposite ends of the pan toward the middle. Watch what happens when the floating papers meet, and sketch your observations.
4. Place an object in the centre of the pan (but not on the top of the papers). Repeat step 3.
5. Clean up and put away the equipment you have used.

What Did You Find Out?

1. How did the wind you created affect the movement of water on the surface of the pan?
2. What was the effect of two winds coming from opposite directions?
3. How did the object affect the path of the paper?
4. Based on the results of this activity, what do you think happens when surface currents in the ocean meet an object such as a large island?

Surface Currents

Currents of water at the ocean surface are driven by winds. Most surface currents flow in the top 100–200 m of water. The steady flow of currents results from major wind patterns. These wind patterns blow in fairly constant directions around the world (see Figure 2.14).

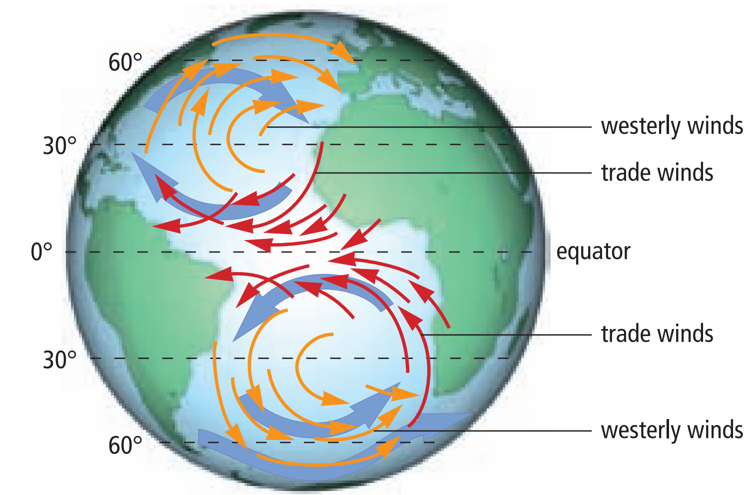


Figure 2.14 Winds (red and orange arrows) travel in a clockwise direction north of the equator, and counter-clockwise south of the equator. Ocean currents (blue arrows) move in the same directions as the winds.

Three factors influence ocean surface currents: wind, rotation of Earth, and the shape of Earth's continents.

The Effect of Wind

Winds are the result of masses of air moving rapidly from one area to another because of uneven heating of Earth's surface. Air near a warm surface is heated and its particles move farther

Figure 2.15A Wind energy can set the ocean's surface in motion.

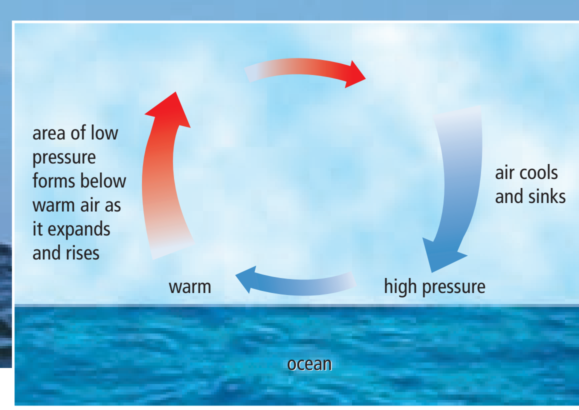


Figure 2.15B Air movement caused by uneven heating creates winds.

apart. As a result, the warm air is less dense and rises. This produces an area of low air pressure beneath the rising warm air. Cool air, with a higher pressure, moves into the area of low pressure. These moving masses of air create wind. As this moving air crosses over the ocean's surface, its energy is transferred by friction to the water molecules, causing the ocean water to move (Figure 2.15A). The direction and speed of surface currents are directly connected to the direction and speed of the wind blowing over the water.

Did You Know?

The volume of water in ocean currents makes even the mightiest rivers appear tiny by comparison. For example, the Gulf Stream moves about 26 000 000 m^3 of water per second, or about 1000 times more than the Mississippi River!

The Effect of Earth's Rotation

The spinning of Earth on its axis affects both winds and ocean currents all over the planet. Earth spins from west to east (counter-clockwise). As winds and currents move over this spinning body, their path gets redirected (deflected) depending on what side of the equator they are on. This alteration of direction is called the **Coriolis effect**. In the northern hemisphere, no matter which direction the winds begin to blow, they will be deflected to the right, or in a clockwise direction. In the southern hemisphere, winds will be deflected to the left, or in a counter-clockwise direction.

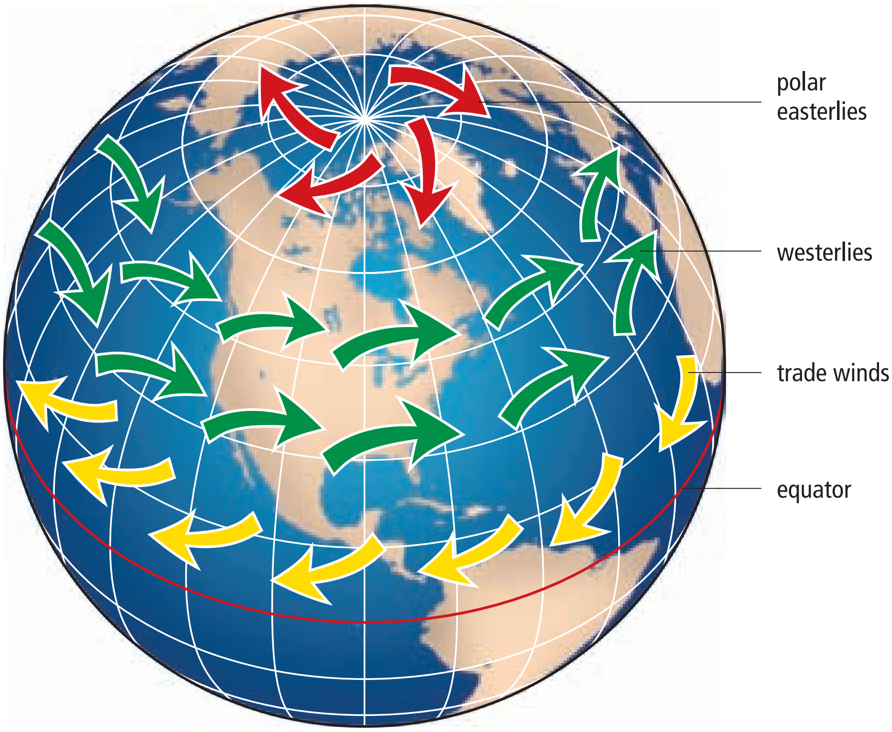


Figure 2.16 The Coriolis effect, caused by Earth's rotation, results in the path of air being directed clockwise in the northern hemisphere and counter-clockwise in the southern hemisphere.

The Effect of Continent Shape

The third factor that affects ocean currents is the shape of continents. As you observed in the Find Out Activity on page 53, moving currents are forced to turn when they meet a solid surface. Continents deflect east-west currents either to the north or to the south.

The combined influence of winds, the Earth's rotation and the shape of continents keep ocean surface currents circulating clockwise in the northern hemisphere, and counter-clockwise in the southern hemisphere.

internet connect

Water travelling in some currents can take decades to make it back to where it started! Find out more about ocean currents at **www.discoveringscience8.ca**

Reading Check

1. What is an ocean current?
2. What three factors produce ocean surface currents?
3. Explain how wind influences ocean currents.
4. How does the spin of Earth affect ocean currents?
5. Explain how the shape of continents affects ocean currents.

Deep Currents

You have seen how wind, the spin of Earth, and the shape of continents can affect the movement of surface currents in the ocean. For currents deep in the ocean, the most important influences on movement are water temperature and salinity.

Water Temperature and Deep Currents

Water in the ocean does not have the same temperature at every depth, nor does it decrease steadily with depth. Figure 2.17 shows that water temperature changes sharply to form three distinct layers: the surface (or mixed layer), the thermocline, and deep water. The warmest layer is the surface, where the Sun's energy heats the water. Surface currents keep the surface water mixing and the temperature fairly consistent, thus it is sometimes referred to as the mixed layer. Lower down where the effects of the Sun cannot be felt, the water temperature drops rapidly. This layer is called the **thermocline** and it exists approximately 200 m to 1000 m beneath the surface. The temperature in the thermocline may fall from 20°C to a chilly 5°C. Below the thermocline lies the deep water layer. Temperatures at this level approach the freezing point of water.

Word Connect

The root word of thermocline is "thermo," which comes from the Greek word *thermos*, meaning "hot." What other words can you think of that start with the root word "thermo"?

Thermoclines also occur in lakes. If you have gone swimming in a lake early in the summer, you might have noticed that the surface water is much warmer than the water even just a few centimetres down. Later in the summer, the cold water is much deeper. Fish such as trout retreat to the cool of deep water in the heat of the summer.

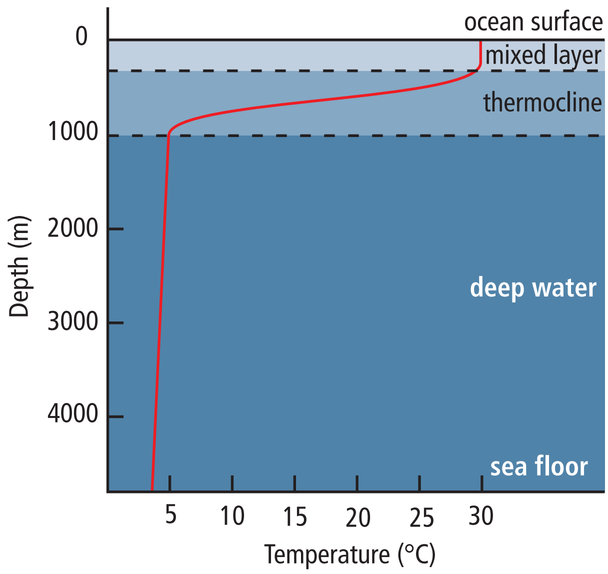


Figure 2.17 Ocean water has different temperature layers at different depths, as the red line in this diagram shows.

Temperature affects the density of ocean water. Cold water is more dense than warm water, and tends to sink. In the oceans, sinking masses of cold water flow downward and move along the ocean floor. These masses of cold water produce **density currents** that flow beneath the surface waters.

Suggested Activity

Investigation 2-2B on page 60.

Water Salinity and Deep Currents

Density currents are also produced by the differences in the salinity (the amount of salt) of seawater. Water with high salinity is denser than water with low salinity. How does the salinity of ocean water change from one place to another? One way to lower salinity is to add more fresh water. For example, seawater is less salty at the mouth of large rivers where fresh water is entering the ocean. Fresh water also enters the ocean where icebergs and glaciers melt, and in regions with high levels of precipitation.

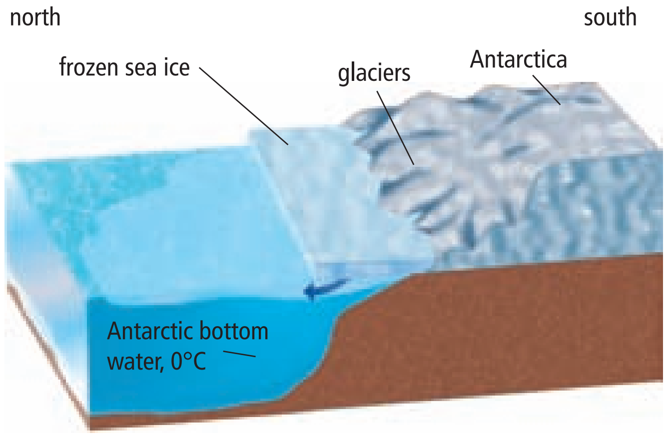


Figure 2.18 Differences in salinity produce density currents.

In contrast, regions with hot, dry conditions and a high rate of evaporation produce ocean water with high levels of salinity. When this dense, salty water sinks it forms a downward-moving density current.

Just as evaporation increases salinity, so does freezing. When water turns into ice, salt is left behind in the remaining water, increasing its saltiness. Dense, salty water, therefore, is produced in oceans cold enough to form ice on the sea surface, such as at the North and South Poles.

Upwelling

Flowing in the opposite direction of density currents are currents called upwellings. **Upwellings** are the vertical movement of water from the sea floor to the ocean surface. Upwellings are most common along coastlines where strong winds blow offshore. These winds push the surface water away from the land. Cold, deep water then rises from below to replace the surface water that has been moved out to sea. Figure 2.19 shows the process of upwelling.

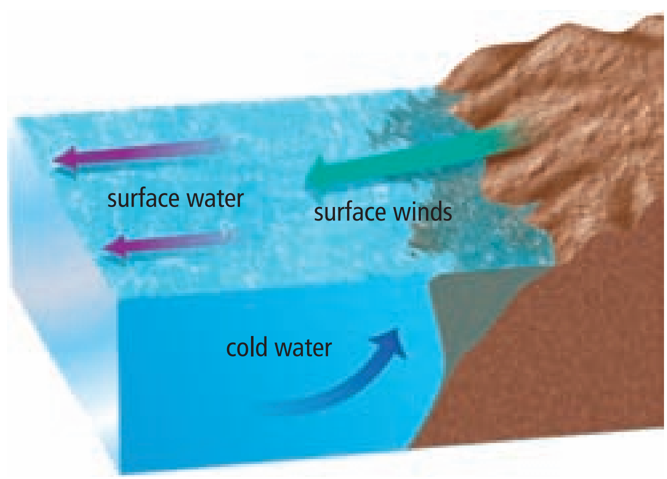


Figure 2.19 Upwelling brings cold water from the depths of the ocean to surface along the shoreline.

Upwellings have an important effect on the ecology of the sea and on human fisheries. The upwelling water contains large amounts of nutrients from the sea floor, such as phosphates and nitrates. Plants living in the surface waters use these nutrients to grow. The plants, in turn, attract fish to these areas. Upwelling on the Grand Banks of Newfoundland and Labrador result from the interaction of the Gulf Stream and the Labrador Current, producing nutrient-rich waters and historically one of the world's most productive fisheries.

Farther south, near the equator, the trade winds blow from east to west. Winds blowing off the west coast of Africa and both North and South America, create the same situation that is found in the Grand Banks. The map in Figure 2.20 shows where the major upwellings occur. Many large commercial fisheries are located near these productive waters.

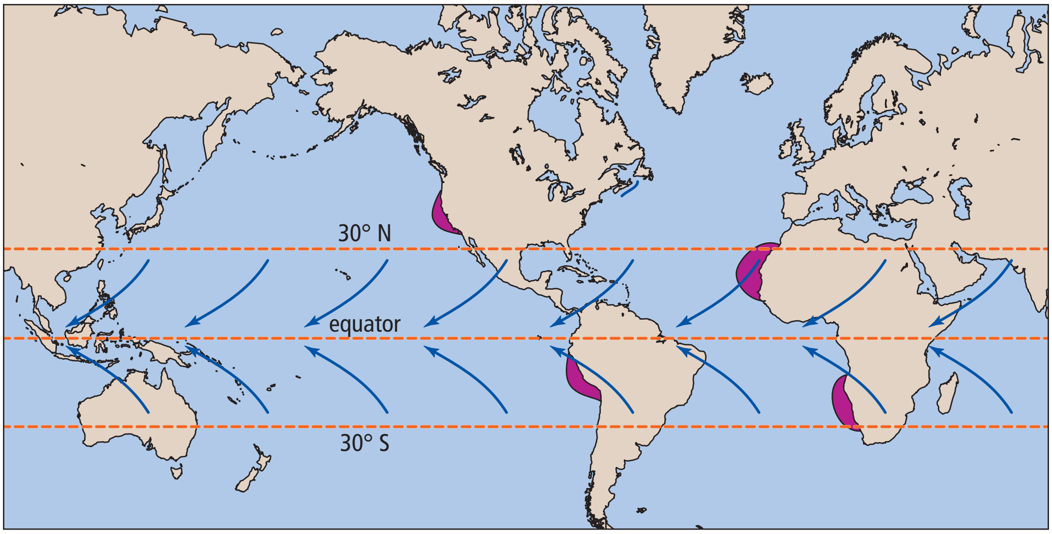


Figure 2.20 The purple areas show the locations of upwellings caused by the trade winds near the equator.

The fishing off the west coast in Peru, in South America, however, is interrupted every few years. A unique weather pattern called El Niño, reverses the winds in the southern part of the Pacific Ocean. The winds temporarily blow from west to east. These winds prevent the upwellings on the coast of Peru with devastating effects on fishing and families who depend on fishing for a living.

Reading Check

1. What is a density current?
2. Sketch and label the three layers of ocean water.
3. Fresh water reduces the salinity of ocean water, making it less dense. Name two ways fresh water can be added to the ocean.
4. What is upwelling of ocean water?
5. Why is upwelling important for marine life?

2-2B Temperature and Water Density

SkillCheck
- Observing
- Measuring
- Modelling
- Evaluating information

Cold water, like cold air, becomes dense and therefore sinks. What happens to the temperature of ocean water the deeper you go? You will explore the answer to that in this activity by plotting a graph of ocean temperature against ocean depth.

Materials

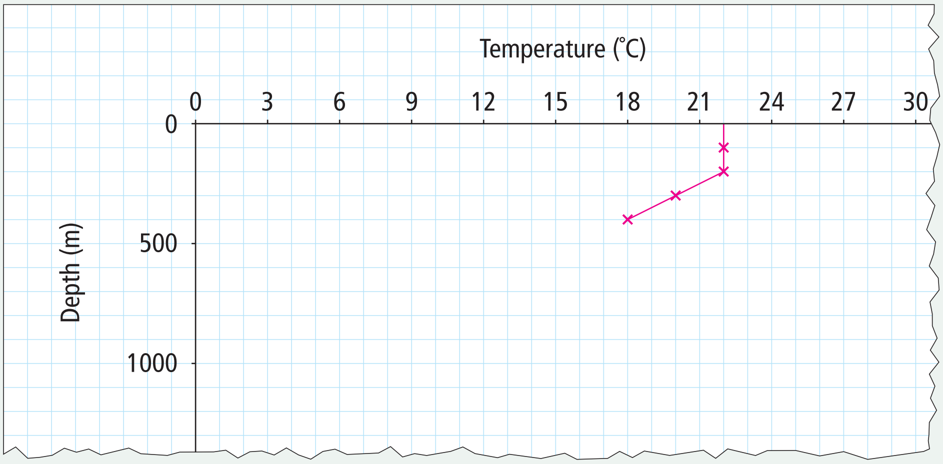
- 1 piece of graph paper
- pencil
- eraser

What to Do

1. Create a graph by plotting the following data points. Be sure to look at the sample graph before beginning.

Depth (m)	Temperature (°C)
0	22
100	22
200	22
300	20.5
400	18
500	14
600	10
700	8
900	6
1000	5
1200	4

2. Connect the points with a straight line.



Plot your data on a graph

What Did You Find Out?

1. What is the relationship between temperature and water depth?
2. Does the temperature of water change at a constant rate as you go deeper?
3. Between what depths is the temperature difference the greatest?
   (a) 0–400 m (b) 400–800 m
   (c) 800–1200 m
4. (a) Which is denser, hot or cold water? Explain why.
   (b) How does density of water affect the water's ability to float or sink?
   (c) What do you think would happen when cold water from the Labrador Current meets the warm water from the Gulf Stream?

Science Watch

World's Largest Flume Tank

Every year, many new designs are created to improve the fishing technology that is used in the oceans. But just how do they know if these new designs will work? Luckily, the province of Newfoundland and Labrador is home to the largest flume tank in the world, and the only one of its kind in North America.

What exactly is a flume tank? To begin, a flume is a channel of flowing water, much like a current. A flume tank is like a massive aquarium tank, but it also has a circulating water channel. This circulating water allows engineers and scientists to simulate underwater and near surface conditions in the ocean. This lets them test model-scale fishing gear in a controlled environment.

The flume tank is 22 m long, 8 m wide, 4 m deep, and holds 1.7 million litres of water. That's more water than could fill over 12 000 bath tubs! It has a glass viewing area to allow people to study the equipment that is being tested.

Figure 2.19 A researcher at the Centre for Sustainable Aquatic Resources observes tests in the flume tank.

The flume tank is located at the Centre for Sustainable Aquatic Resources. It is one of five centres that are a part of the Marine Institute at Memorial University of Newfoundland. The other centres are:

- The Offshore Safety and Survival Centre
- Centre of Marine Simulation
- Centre for Aquaculture and Seafood Development
- Marine Institute International

These centres, along with the Marine Institute's Schools of Fisheries, Maritime Studies, and Ocean Technology make the Marine Institute one of the best places in the world to learn about and study marine environments, industries, and technologies. From studying to be a captain of a freighter, to an emergency rescuer for offshore industries, to being a food technologist in the food industry, the Marine Institute has more opportunities for you to study for an ocean career than you can imagine!

internet connect

To find out more about the Marine Institute at Memorial University of Newfoundland, go to **www.discoveringscience8.ca**

Check Your Understanding

Checking Concepts

1. List the three main causes of an ocean's surface currents.
2. How does the Coriolis effect influence wave and wind motion:
   (a) north of the equator?
   (b) south of the equator?
3. Define thermocline.
4. Describe what happens when cold, dense ocean water meets warmer, less dense water.
5. Describe an example where upwelling can occur.

Understanding Key Ideas

6. Make a graph showing how ocean temperature varies with depth.
7. How is a density current produced?
8. Explain the difference between a surface current and a deep current.
9. Explain why water may have a different density in different parts of the ocean.
10. When upwelling occurs in the ocean, water rich in nutrients comes to the surface. Explain why areas of upwelling might be good places to fish.

Pause and Reflect

As water gets colder, its density increases. However, this is true only up to a certain temperature. Water achieves its maximum density at a temperature of 4°C. When water is cooled to 0°C, its density decreases. Therefore, bodies of water freeze from the top down, rather than from the bottom up. Imagine if these differences did not exist. How would life on Earth be affected if bodies of water, such as lakes and ponds, froze from the bottom up?

2.3 Waves and Tides

Waves, tides, and currents drive the ocean in perpetual motion. This never ending action erodes coastlines, and forms beaches and interesting landscapes. The rise and fall of daily tides connects us with the universe surrounding our world. On occasion, waves also remind us of their destructive power.

Key Terms

bays
breaker
crest
headlands
neap tide
spring tide
swell
tidal range
tide
trough
tsunami
wavelength

Ocean Waves

Surfers ride ocean waves, using the motion of the water to carry them to the shore. What causes waves? You can find the answer in a bowl of soup! If you blow on the soup to cool it, your breath makes small ripples on the surface of the liquid. Ocean waves are just large ripples, set in motion by steady winds.

Ocean waves begin on the open ocean. Their height depends on how fast, how long, and how far the wind blows over the water. An increase in any one of these variables can cause an increase in wave height. Normal winds produce waves of 2–5 m in height. Hurricane winds can create waves 30 m high—two thirds of the height of Niagara Falls! Even on a calm day, there is a steady movement of smooth waves. These smooth waves are called **swells**. They are caused by winds and storms far out in the ocean.

Figure 2.20 Some of the largest waves occur along the coasts of California and Hawaii. The waves in these places have been blown by wind over thousands of kilometres of open ocean —as far away as Japan!

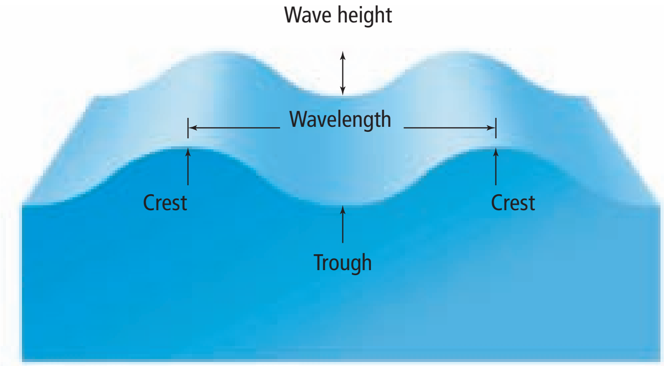


Figure 2.21 Features of a wave

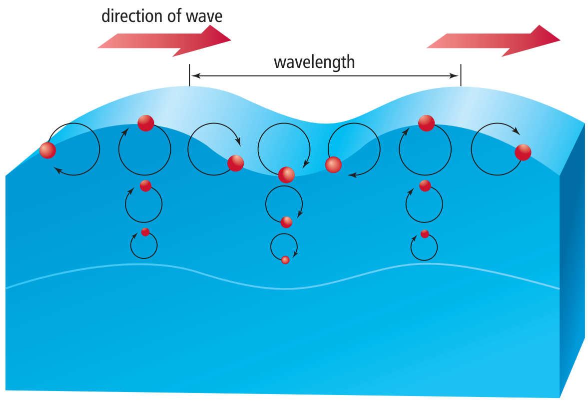


Figure 2.22 Individual particles of water move in circles as a wave passes through the water. The circular motion of each of the particles of water is called an oscillation.

Whether large or small, waves on the water have features in common with all the other types of waves studied by scientists – such as sound waves, light waves, or radio waves. First, waves have height, as shown in Figure 2.21. A wave's height is measured from its **crest** (the highest part of the wave) to its **trough** (the lowest part of the wave). Second, ocean waves also have a **wavelength,** which is the distance from one crest to the next. Third, waves have a speed of motion, which is measured by the time required for one wave to pass a given point.

Breaking Waves

Near the ocean surface, water particles move in a circular motion as wave passes. As each particle moves, it bumps into the next particle and passes its energy along.

When a wave reaches shore, it changes shape (see Figure 2.23). As the trough of the wave touches the beach, it is slowed down by friction. The crest of the wave, however, continues moving at the same speed. The wavelength shortens, and the wave height increases. The crest of the wave eventually outruns the trough and topples forward. The wave collapses onshore in a tumble of water called a **breaker**.

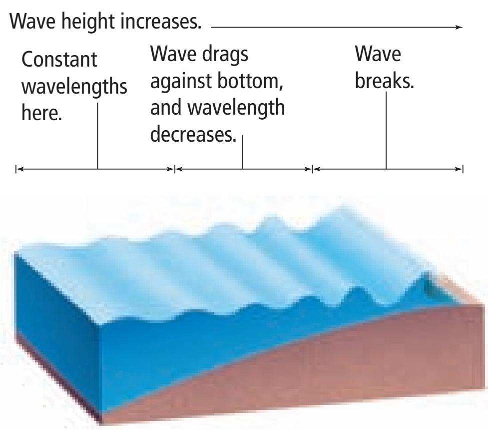


Figure 2.23 The movement of waves as they approach the shore

Figure 2.24 As a wave approaches the shore, its wavelength decreases and its height increases. It collapses onshore as a breaker.

Word Connect

Tsunami comes from the Japanese terms *tsu* meaning "harbour," and *nami*, meaning "wave."

Tsunamis

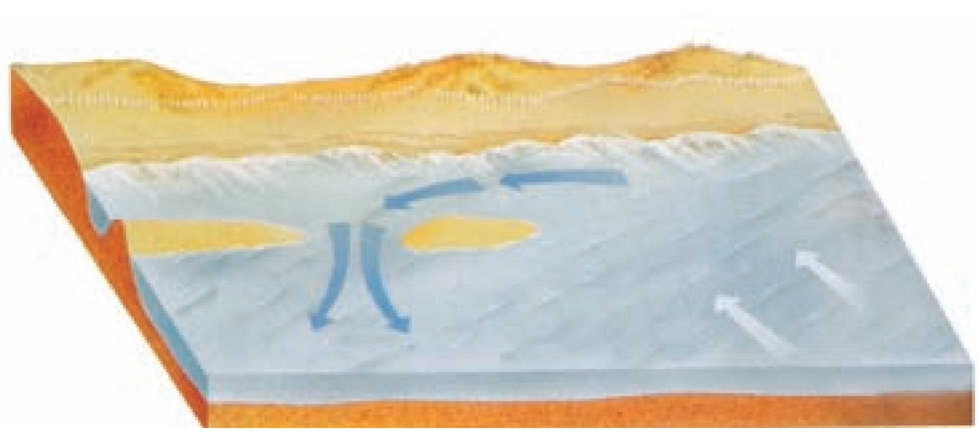
Some of the highest ocean waves are not caused by winds but by earthquakes, volcanic eruptions, or landslides on the ocean floor. These events give the ocean water a push, just as you can make a wave in a bathtub by pushing your hand underwater. Ocean floor events sometimes produce giant waves called **tsunamis** (pronounced SUE-NAH-MEE). The wavelength of a tsunami may be 150 km. It may travel over the open ocean at a speed of up to 800 km/h. When the tsunami approaches land, the speeding water is pushed up into a towering, powerful wave that destroys buildings, coastlines, and can kill many people.

Figure 2.25 On December 26, 2004, a large (magnitude 9.0) earthquake in the Indian Ocean created tsunamis that crashed upon the coastlines of 10 different countries. Over 280 000 people were killed, and over 1 000 000 people lost their homes and communities. This picture shows the aftermath of the tsunami in Indonesia. This town was 250 km away from the earthquake.

How Waves Change Shorelines

Waves shape shorelines by eroding and redepositing sediments. Waves usually collide with the shoreline at slight angles. This creates a longshore current of water that runs along the shore (see Figure 2.26). Longshore currents carry many tonnes of loose sediment. They act like rivers of sand in the ocean. Longshore currents also erode the shoreline.

Figure 2.26 Along shorelines, waves move sediments back and forth.



Along some rocky shorelines, waves may slowly wear away the rocks and eventually form hollows. Over time, these hollows enlarge and become caves. As the caves increase in size, they eventually meet and a sea arch is formed. When too much erosion occurs, overhanging rock may fall off into the ocean. Rock fragments are slowly ground into sediments by the endless motion of the waves. Seawater can also dissolve certain minerals in rock, increasing erosion by chemical action. The combined action of waves and chemical processes can erode areas of rocky shorelines by as much as 1 m in a year.

Did You Know?

Coastlines are areas of land that meet the ocean. Canada has the longest coastline in the world, approximately 243 042 km, or about one seventh of the world's total.

Figure 2.27 Ancient limestone in Arches Provincial Park, Newfoundland and Labrador has been eroded by waves and ice for thousands of years.

How quickly a coastline erodes depends on the force of the waves hitting the land and the type of rock the land is made from. Some softer rock, such as sandstone, erodes more easily compared with harder rock, such as granite. This mixture of hard and soft rock leads to uneven erosion and the formation of headlands and bays.

Headlands and Bays

As waves continuously erode away a shoreline, the rate of erosion can differ in areas where the composition of rock varies. Softer rock (such as sedimentary rock) that is more susceptible to erosion is broken down faster than an area composed of harder rock (such as igneous rock). The areas that are more easily eroded recede faster than other areas, creating **bays** in the coastline that are in between **headlands** (see Figure 2.28).

Because headlands reach farther out into the water than the land next to them, incoming waves hit them before reaching the rest of the shoreline on either side (see Figure 2.29). As a result, headlands receive the main force of the waves, which creates interesting features such as sea stacks (Figures 2.30 and 2.31).

Figure 2.28 Waves erode the shore into headlands and bays, such as shown here in Northern Bay, Newfoundland and Labrador.

After the headlands have absorbed most of the wave energy, the remaining waves refract and spread out, losing some of their power to erode.

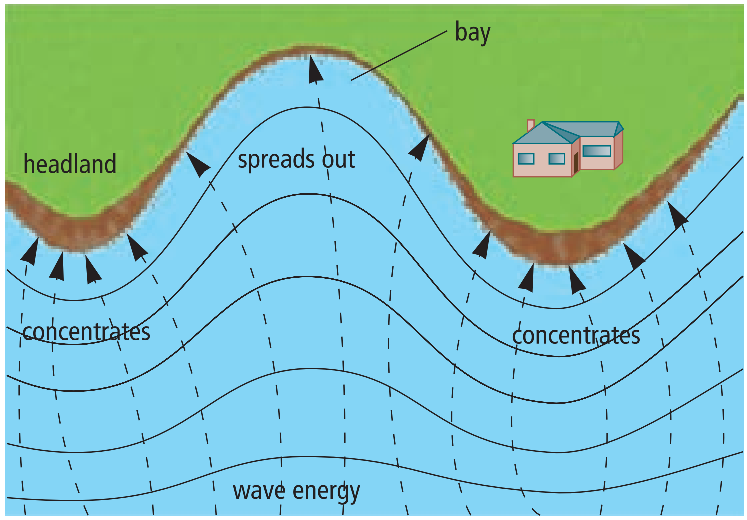


Figure 2.29 Headlands receive a concentrated force of wave energy, allowing the bays to receive a gentler force.

By the time ocean waves reach a bay, the waves are not travelling with the same amount of energy as when they hit the headlands. Once the waves slow down, they also deposit some of the sediments they have eroded from the headlands and elsewhere.

Figure 2.30 The province of Newfoundland and Labrador has many spectacular examples of sea stacks, such as this one on the East Coast Trail. Sea stacks can be formed from eroded headlands or when a sea arch collapses.

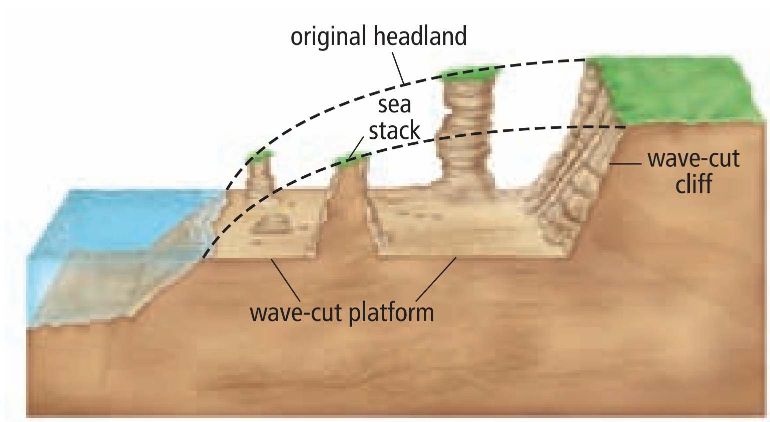


Figure 2.31 The results of headland erosion form interesting features.

How Beaches Are Formed

What happens to all the fragments of rock carried from the coast by crashing waves? As they rub against each other in the surging water, rock fragments are smoothed and ground down into smaller pebbles and grains of sand. Along steeply-sloping shorelines, these rock fragments wash back into the sea. This leaves a shoreline of only bare rock, with scattered boulders and larger stones. Where the shoreline has a gentler slope and calmer waters, smaller rock fragments can settle and build up, forming a beach.

Suggested Activity

Think About It 2-3A on page 72.

Beaches are deposits of sediment that run along the shoreline. The materials that form a beach range in size from fine grains of sand less than 2 mm in diameter to pebbles and small boulders. Most beach sediments are fragments of hard minerals such as quartz. Beaches can also include other minerals of various colours, or fragments of seashells and coral.

Due to the continuous action of waves, beaches are in a constant state of change. In winter, strong winds bring larger waves that remove more sediment from the beach than they deposit. The beach erodes and becomes narrower. Calmer summer weather produces low, gentle waves that deposit sediments on shore, rebuilding the beach.

Figure 2.32 Shorelines with a gentle slope allow the build up of sediment that is deposited by waves, creating sandy beaches such as this one in Sandbanks Provincial Park, Newfoundland and Labrador.

Reading Check

1. What is a swell?
2. How is a breaker formed?
3. What causes a tsunami?
4. What types of erosion happen on a shoreline?
5. How are headlands and bays created?

Suggested Activity

Investigation 2-3B on page 73.

Tides

Ocean beaches are sometimes covered by water, and sometimes they are not. They are covered and uncovered in regular daily cycles by the slow rise and fall of the ocean, called **tides**. The upper and lower edges of a beach are determined by the high-tide mark and the low-tide mark.

Centuries ago, people realized that the cycle of tidal movement is linked to the motion of the Moon. The largest tidal movements, called **spring tides**, occur when Earth, the Moon, and the Sun are in a line (see Figure 2.33A). At these times, the tides are extra high and extra low. The smallest tidal movements, called **neap tides**, occur when the Sun and the Moon are at right angles to each other (see Figure 2.33B). On these days, there is very little difference in depth between high and low tides. The difference in level between a high tide and a low tide is called the **tidal range**.

The link between Earth, the Moon, the Sun, and tides is gravity. Gravity is the force of attraction between two masses. Tidal movements result mainly from the pull of the Moon's gravity on

Explore More

In a few places in the world – including areas in Nova Scotia – there are "singing sands." These special sands make a fiddle-like sound when they are rubbed. Explore more about what exactly makes these sands "sing" by going to **www.discoveringscience8.ca**

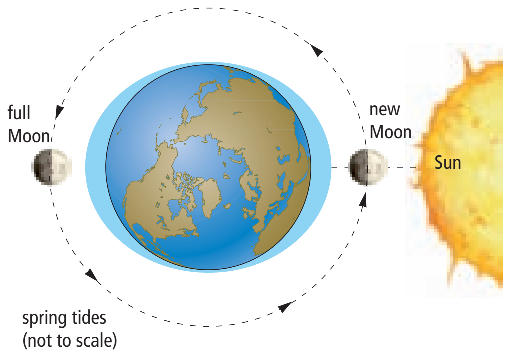


Figure 2.33A Spring tides occur twice per month, at full Moon (when Earth is between the Moon and the Sun) and at new Moon (when the Moon is between Earth and the Sun).

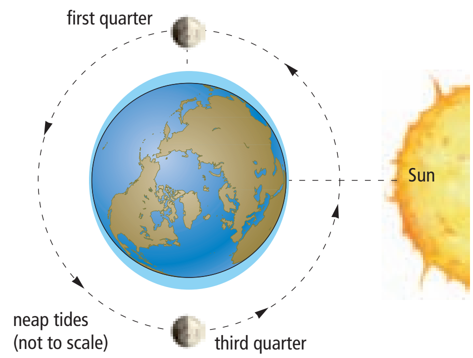


Figure 2.33B Neap tides occur twice per month, during the first-quarter phase and third-quarter phase of the Moon.

Explore More

Aboriginal peoples along the Atlantic coast have relied on low tides for food gathering. Low spring tides expose shellfish-covered rocks that are usually under water. To learn more about the history of Aboriginal fishing on the Atlantic coast, go to **www.discoveringscience8.ca**

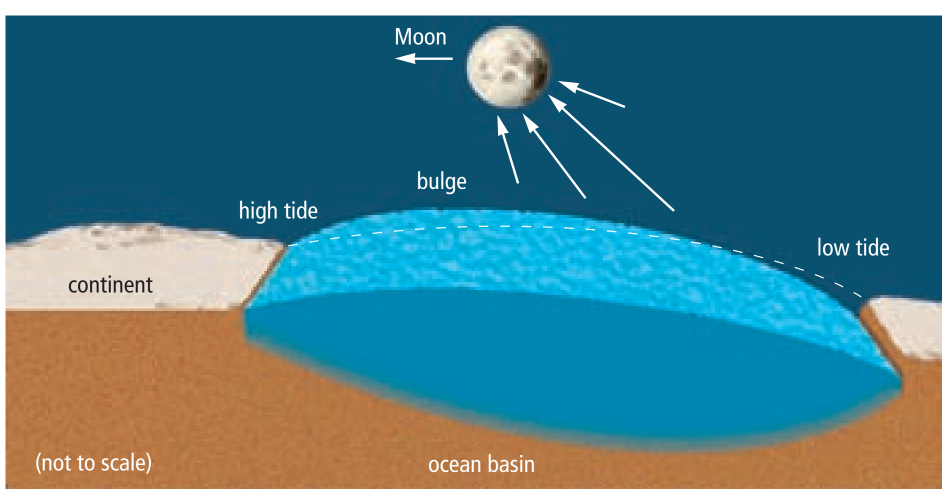
the ocean. The Sun is much farther from Earth than the Moon is. The Sun has less than half as much influence on the tides as the Moon does, despite the Sun's much greater size.

During spring tides, the Sun adds its gravitational pull to the Moon's during the new moon and pulls in the opposite direction during the full moon, producing a large tidal range. During neap tides, the Sun and Moon pull in different directions.

If you look at the water moving up a beach as the tide rises, you may think that the volume of the ocean is increasing. However, the bulge of water that produces a high tide along one coastline draws water away from the other side of the ocean, just like water sloshing from one end of a bath tub to the other.

This movement of water causes a low tide along the opposite coastline (see Figure 2.34). As Earth turns on its axis, different locations on Earth's surface face the Moon. The result is a sequence of high and low tides that follow each other around the world. On many of Earth's shorelines, tides rise and fall about twice a day.

Figure 2.34 The gravitational pull of the Moon shifts water from one side of the ocean to the other.



In mid ocean, the rise and fall of the ocean averages less than 1 m. Along shorelines, the tidal movement is more noticeable. The shape of a shoreline can have a great influence on the size of the tidal range. For example, in the Gulf of Mexico, the tidal range is only about 0.5 m. The Gulf has a narrow passage, or mouth, to the open ocean, and a long curved coastline (see Figure 2.35A). A rising tide that enters the mouth spreads out around the bay, giving a small tidal range. In the Bay of Fundy in Nova Scotia, the opposite occurs. The bay there is long and V-shaped (see Figure 2.35B). Tides enter the wide mouth of the V and pile up as they are funnelled down to the narrow end of the bay. The tidal range in the Bay of Fundy can be as great as 20 m.

Figure 2.35A The Gulf of Mexico has a small tidal range.

Figure 2.35B The narrow Bay of Fundy produces a large tidal range.

Reading Check

1. What is the difference between a spring tide and a neap tide?
2. What is a tidal range?
3. What causes a tide?
4. How does the shape of a shoreline affect the size of a tidal range?

2-3A By the Seashore

Think About It

Question

What features exist along a shoreline due to erosion and depositing of material from waves?

From scenic cliffs to soft sandy beaches, shorelines have unique features due to their composition and the never ending waves that crash upon them. You can learn a lot about what a beach is composed of and what it formerly looked like from the features that presently exist. In this activity, you will research the processes of erosion and deposition that have resulted from wave action and water flow.

What to Do

1. Choose one of the following topics that relate to wave erosion and deposits:
   - beaches
   - shoals
   - sand bars
   - sea caves
   - sea arches
   - sea stacks
2. Using your resource centre and the Internet, locate and record information about the following aspects of your topic:
   - description of your shoreline feature
   - how it is created
   - local examples of your feature
3. After locating and recording your information, create a computer presentation (such as Powerpoint) or use the overhead projector to share your findings with the class.

2-3B Waves and Beaches

Conduct an INVESTIGATION

SkillCheck
- Observing
- Analyzing
- Interpreting
- Communicating

Safety

Materials

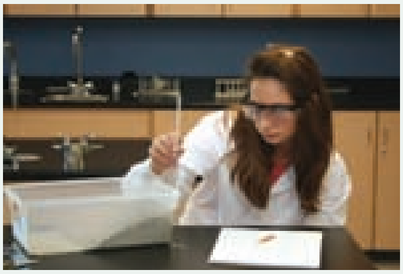
- beaker or measuring cup (500 mL)
- clear plastic or glass pan or small aquarium
- ruler
- small block of wood
- clock or watch
- plastic pail or container
- beach mixture 1 (450 mL sand + 150 mL gravel)
- beach mixture 2 (450 mL gravel + 150 mL sand)
- water

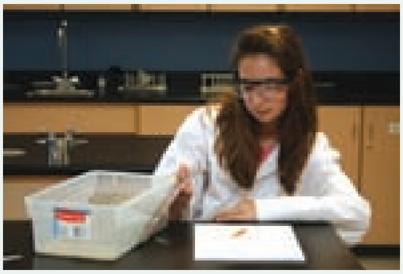
What happens to the material on a beach when waves strike it? Depending on the type of rock and the slope of the coastline, waves can either erode the land or build it up.

Question

How do waves affect beaches? Form a hypothesis about how the slope and materials of a beach will affect its size and shape.

What to Do





1. Using beach mixture 1, build a small beach at one end of the pan or aquarium. Use your ruler to measure the height of the beach at the top of the slope. Record the measurement.
2. Then, measure the width of the beach (from the top of the slope to the bottom of the slope). Draw a side view of the beach to scale and record your measurement.
3. Carefully pour water into the other end of the pan or aquarium until the water level reaches about one third of the way up the beach.
4. Make waves by holding the block of wood in the water and quickly moving it up and down for 2 min. Try to keep the speed and size of the waves constant.
5. After 2 min, draw a side view of the beach to scale. (Use your ruler to measure its dimensions and record this measurement.)

   (a) Label the position of the sand and gravel.

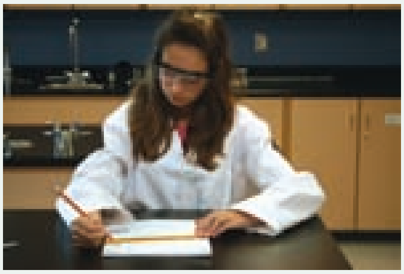
(continued on next page)

(b) Carefully pour off the water into a container provided by your teacher.

6. Rebuild a beach with a slope twice as steep as the first. Measure, record, and sketch the dimensions of the beach.
7. Repeat steps 3 to 5. Then, empty the water and beach materials into a container provided by your teacher.
8. Repeat steps 1 to 7, using beach mixture 2.

(a) Wipe up any spills as wet floors are slippery.

(b) Wash your hands after this investigation.



Analyze

1. Based on your models, describe the effect that wave action has on a beach made mostly of sand compared with a beach made mostly of gravel.
2. How does the slope of a beach affect erosion by waves?
3. How do the materials on a beach affect erosion by waves? Explain your observations by referring to the difference in the mass of grains of sand and pieces of gravel.

Conclude and Apply

4. Based on the results of this investigation, what effect do you think a large storm at sea might have on a sandy beach?
5. Beach erosion is a problem for many seaside communities. Suggest what might be done to prevent a beach from eroding.

2-3B Safeguarding Our Shorelines

Question

How are shorelines changing in Newfoundland and Labrador, and what is being done to protect them?

Newfoundland and Labrador's coastlines are home to many communities as well as attracting thousands of tourists each year. Due to the erosion from waves, storms, winds, and tides, however, the coastlines are forever changing and are sometimes critically damaged. In this activity, you will research an historical event that affected local shorelines. You will not only look at the environmental damage, but also at the destruction of people and property. You will then research and learn about technologies that can help lower damage in future similar situations.

What to Do

1. As a class brainstorm about shorelines that you know have experienced damage because of erosion (from an event or a storm, or just gradual erosion).
2. Using books and newspapers from your library, and the Internet, research a recent or past event that has affected a local shoreline and created damage to property and the environment. Events may include the 1929 Grand Banks tsunami that struck the Burin Peninsula, coastal flooding, extreme high tides, and storms. A documented list of all coastal floods can be found at www.heritage.nf.ca/environment.
3. Find out what technologies exist that could help prevent such damage in the future. You may want to look at such structures as sea walls, breakwaters, jetties, groynes, vegetation.
4. Create a small presentation or poster display, describing the date, event, and the damage that was caused. Share your information with your class.

Wild, Weird, Wonderful

www Science

Wave-Weathered Wonders

Newfoundland and Labrador's coasts are home to hundreds of spectacular examples of how wave action weathers and erodes coastal rock. Below are just a few of these incredible features. How many more examples of coastal formations in Newfoundland and Labrador can you think of?

The Arches


The Arches were once sea caves.

Located north of Parsons Pond on the Great Northern Peninsula, the Arches are a spectacular example of rock erosion by the ocean. Wave action eventually separated this piece of limestone from the coast. The two arches were once sea caves and the continuous wear from waves slowly transformed the caves into arches.

The Spout


Located on the East Coast Trail, the Spout is a popular attraction for hikers.

Located midway between Petty Harbour and Bay Bulls, "The Spout" is a natural wave-driven geyser that exists because of the unique combination of several factors. A vertical crevasse in the rock sits above the sea cave far below. Fresh water run-off from the Spout River flows and fills the crevasse. At the same time, wave action from the ocean is flowing into the cave below and exerts pressure on the fresh water in the crevasse above it. The result is the fresh water being forced out of the crevasse and into the air, making it look like a geyser. When the ocean is rough, the wave action can force a spout up to 50 m high!

The Dungeon


The Dungeon is a huge sea cavern that collapsed. It is located near the tip of the Bonavista Peninsula.

Over thousands of years, the continuous waves of the Atlantic Ocean wore away rock, creating a cavern that was connected by two sea caves. Eventually, the cavern became so wide that it could not support the ground above it, and the roof of the cavern collapsed. Wave action has removed the material from the collapse, leaving a hole that is 250 m in diameter and 15 m deep. It is still connected to the ocean by two sea caves.

The Hole in the Wall

This feature is located near the community of Joe Batt's Arm. Wave and frost action eroded a weak section of rock material, creating a hole in the ocean-side cliff. The hole extends through the other side of the cliff, making it possible to see the valley on the other side.

Check Your Understanding

Checking Concepts

1. How do sea stacks form?
2. Why are shorelines in a constant state of change?
3. Why are we able to predict when the tide will rise and fall?
4. How does a tidal wave differ from a tsunami?
5. Why are tsunamis so destructive when they strike land?
6. Explain why tidal ranges (the difference between the height of high tide and low tide) vary in different areas.
7. A tide table for Corner Brook, on the province's west coast, lists a high tide at 1.45 m and a low tide at 0.58 m. What is the tidal range?

Understanding Key Ideas

8. How are ocean waves similar to sound, light, and radio waves?
9. Explain why headlands receive more force from waves coming to shore than bays do. Use a diagram to support your answer.
10. What causes breakers to form?
11. Why would there be no high and low tides if Earth did not have a moon?
12. You might have noticed that the Moon rises and moves across the night sky a little later each night. This causes the tides to rise 50 min later each day. If the tide rose at 6:20 A.M. one day at coastal town A, how many days would a resident there have to wait for a midday (near 12 noon) high tide to occur?
13. Referring to the maps below, explain why the tidal range in the Gulf of Mexico is so much smaller than that in the Bay of Fundy.

Pause and Reflect

Think back to the description of how tides are created, and then make one or more drawings (as necessary) to help you answer the following question.

What do you think would happen to spring tides and neap tides if the Moon were closer to Earth?

Chapter Review

Prepare Your Own Summary

In this chapter, you discovered the importance of the oceans to life on Earth. Create your own summary of key ideas from this chapter. You may include graphic organizers or illustrations with your notes. Use the following headings to organize your notes:

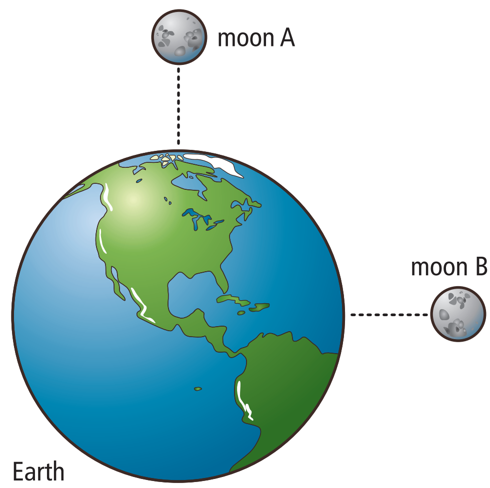
1. Ocean Basins
2. Ocean Currents
3. Waves and Tides

Checking Concepts

1. Explain why the ocean floor is not perfectly flat.
2. Describe three factors that affect surface currents on oceans.
3. How do winds form?
4. What causes waves in the ocean to form?
5. Why is it important for people who make their living from the sea to know the time of high and low tides?
6. What causes a wave to "break?"
7. Imagine two shorelines. One contains mostly limestone and another is made up of granite. Which shoreline will change more quickly than the other? Explain why.
8. Where do you expect to find ocean trenches?

Understanding Key Ideas

9. Why do trenches form at the edge of some continents?
10. As you have learned in this chapter, the Moon has a gravitational pull that affects the water in Earth's oceans. How would the tides be different if Earth had two moons, as shown in the figure below?



11. What processes produce bays and headlands?
12. Explain the difference between spring tides and neap tides.
13. How is a sandy beach formed?
14. How are satellites used to explore oceans?
15. What causes density currents?

16. The data below were collected from samples of water in the Atlantic Ocean. One sample came from near the surface, one from a depth of 750 m, and the third from near the ocean floor.

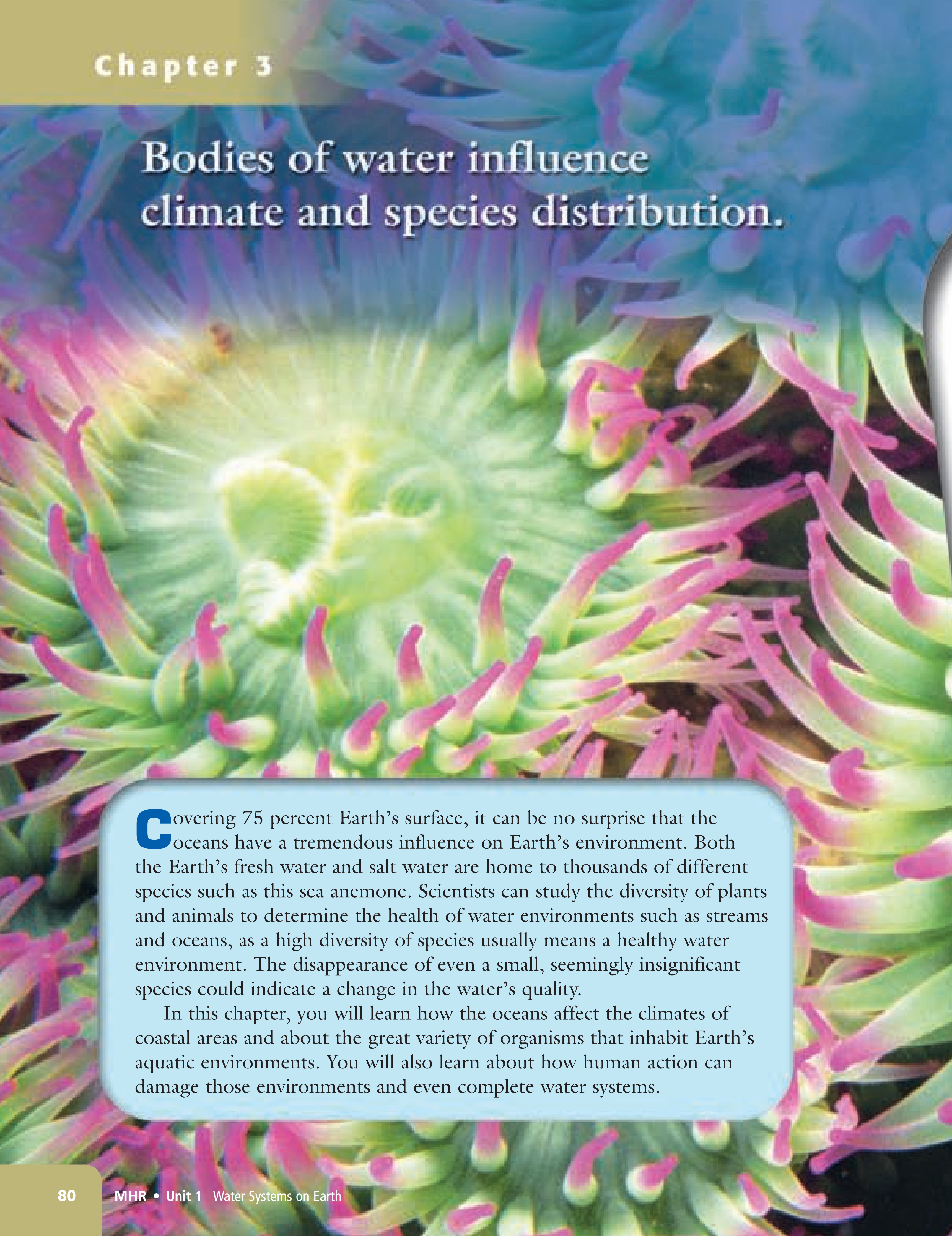
Sample	Temperature (°C)	Density (g/mL)
1	6	1.02416
2	3	1.02781
3	14	1.02630

Which sample do you think came from near the ocean floor? How do you know?

17. What is an upwelling?
18. Where does the sediment on the abyssal plains come from?
19. Name three factors that can either increase or decrease the salinity of the ocean. Explain how and where each of these might occur.
20. Why is the Atlantic Ocean getting wider?
21. How can scientists take pictures of objects at the bottom of an ocean without going down there in submarines?
22. Describe the motion of ocean water that occurs where strong winds are blowing from land offshore over the surface of the ocean. What is the term that is used to name this type of motion of water?
23. How could an earthquake at the bottom of an ocean create hazards for several different countries?
24. If the Sun, Moon, and Earth are lined up in a straight line, how does it influence the tides?
25. Before satellites were available for mapping ocean floors, how did scientists determine the shape of the ocean floors?
26. When an area of Earth's surface is heated by the Sun, the air becomes heated and rises. How does this rising air cause winds to blow horizontally or across Earth's surface?
27. When the Sun heats the surface of an ocean in some regions, large amounts of water to evaporate. How does this evaporation affect the salinity of the water near the surface? How does this change in salinity affect the motion of the water?
28. Which two ocean currents meet near the Grand Banks? How do these currents affect fishing off the Grand Banks?
29. Describe the shape of a shoreline that will produce a large tidal range.

Chapter 3

Bodies of water influence climate and species distribution.



Covering 75 percent Earth's surface, it can be no surprise that the oceans have a tremendous influence on Earth's environment. Both the Earth's fresh water and salt water are home to thousands of different species such as this sea anemone. Scientists can study the diversity of plants and animals to determine the health of water environments such as streams and oceans, as a high diversity of species usually means a healthy water environment. The disappearance of even a small, seemingly insignificant species could indicate a change in the water's quality.

In this chapter, you will learn how the oceans affect the climates of coastal areas and about the great variety of organisms that inhabit Earth's aquatic environments. You will also learn about how human action can damage those environments and even complete water systems.

What You Will Learn

In this chapter, you will
- **describe** how winds and ocean currents influence regional climates
- **describe** the ways in which human activities can alter the water cycle
- **explain** how water quality problems in marine environments can affect all living things

Why It Is Important

Learning how the ocean affects Earth helps us better understand its critical role in our daily lives. Knowing how human activities can affect the quality of Earth's water systems will help you develop a better awareness of the importance of protecting global water resources.

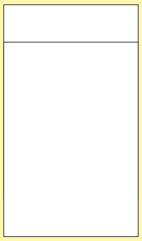
Skills You Will Use

In this chapter, you will
- **evaluate** the effect of human activities on water quality and quantity
- **explain** the role of ocean currents on Earth's climates
- **determine** how aquatic plants are affected by an increase in nutrients
- **evaluate** biotic and abiotic indicators of water quality

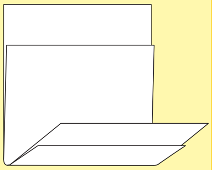
FOLDABLES™ Reading & Study Skills

Make the following Foldable to demonstrate your learning in Chapter 3.

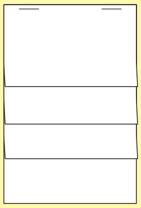
STEP 1 **Collect** 2 sheets of letter-size paper and layer them about 2.5 cm apart vertically. Keep the edges level.



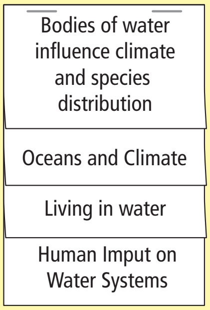
STEP 2 **Fold** up the bottom edges of the paper to form 4 tabs.



STEP 3 **Fold** the papers and crease well to hold the tabs in place. **Staple** along the fold.



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



Show You Know As you read the chapter, take notes under the appropriate tab to *explain* how oceans affect climate, *illustrate* different aquatic habitats, and *describe* how humans have impacted water systems.

3.1 Oceans and Climate

Surface currents in the ocean carry heat from one place to another. Warm currents begin near the equator, where the Sun's heat is more intense. As these warm currents circulate, they affect the climate and sea life of the regions to which they move. Deep, cold ocean currents travel from the polar regions and also influence the climate of various regions, just like the warm surface currents.

Key Terms

climate
convection
specific heat capacity
weather

The weather might be one of the first things you notice after you wake up. It could be raining, or the sun might be shining. Weather is the short-term conditions in the atmosphere at a specific place and time. **Weather** can be described in terms of temperature, wind speed and direction, air pressure, and moisture (precipitation). When weather conditions for a particular region are averaged over a long period of time (for about 30 years), its main characteristics are together referred to as its **climate**. Oceans play a critical role in influencing climates all over the world.

Warm and Cold Currents

If you study a map of the world, you will see that Britain is as far north as Hudson Bay. However, Britain's climate is much milder than the climate near Hudson Bay. In southwest England, the winter seasons are mild enough to allow subtropical palm trees to grow! How can Britain be mild when Hudson Bay is so much cooler? The mild climate is mainly due to the warm waters of the Gulf Stream Current. The Gulf Stream Current starts in the Caribbean Sea and flows north along the east coast of North America and past Newfoundland and Labrador. Then, it turns northeast and crosses the Atlantic Ocean. The Gulf Stream Current carries warm water to Iceland and the British Isles (see Figure 3.1). For places like Iceland, which has 10 per cent of its land covered by glaciers, the warm waters of the Gulf Stream Current means its harbours are ice-free.

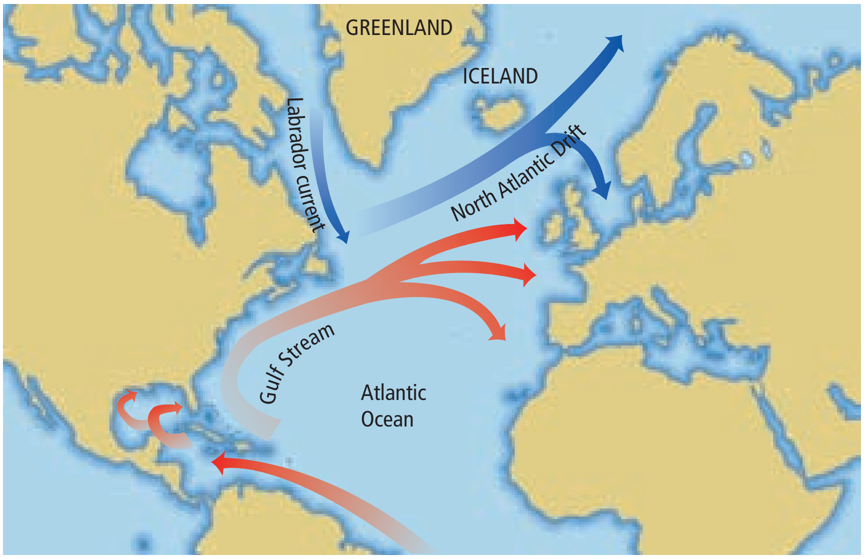


Figure 3.1 Map of the North Atlantic Ocean showing major currents (not to scale).

Suggested Activity

Think About It 3-1B on page 87.

Warm ocean currents affect climate by transferring their heat to the atmosphere. Water has a very high **specific heat capacity**, which means that it takes a large amount of heat to increase its temperature a small amount. Water's specific heat capacity also means that it releases heat slowly. As a result, it takes a relatively long time to cool down. Therefore, large bodies of water act as heat reservoirs in the winter by remaining warmer than the land nearby. The difference in temperature between the water and land affects the weather systems near the shoreline. These systems produce breezes that alter the processes of evaporation and condensation near the shoreline.

While warm currents flow from the equator, cold currents flow from the Arctic and Antarctic regions. Cold currents also affect the climate by drawing heat from the air. For example, the Labrador Current flows south from Baffin Bay along the east coast of Labrador and Newfoundland (see Figure 3.1). This cold current moderates the summer temperatures in the province, keeping the days cool. On the west coast of Canada, a warm current flows northwards from California, resulting in mild, but wet winters.

internet connect

Of all the major Canadian cities, St. John's has the most fog, rain, snow, wind, and cloudy days! To find out more about how the ocean currents affect Newfoundland and Labrador's climate, go to **www.discoveringscience8.ca**

Reading Check

1. What is the difference between climate and weather?
2. Water has a high specific heat capacity. What does that mean?
3. How does a cold current moderate summer temperatures on land?
4. How does a warm current moderate winter temperatures on land?

Figure 3.2 The icy waters of the Labrador Current affect the east coast climate. Cool temperatures and fog are common along the coast of Labrador.

3-1A Learning How Liquids Lose Heat

Find Out ACTIVITY

Teacher Demonstration

The high specific heat capacity of water plays a role in how oceans affect temperatures and climates. In this activity, you will compare the rate at which three different liquids heat up. Your teacher will perform the activity and you will record, and then plot, the data.

Safety

- Be careful when handling hot equipment.

Materials

- graph paper
- hot plate
- 600 mL beaker
- water
- 3 test tubes
- 3 thermometers
- 3 liquids: water, salt water, and vegetable oil
- 3 ring clamps
- ring stand
- watch or clock

What to Do

1. Copy the table below into your notebook. Give the table a title.

Time (min)	Temperature (°C) Water	Temperature (°C) Salt Water	Temperature (°C) Cooking Oil
0			
0.5			
1.0			
1.5			
2.0			

2. Your teacher will set up the activity as shown here. The three test tubes, each with a different liquid, will be heated in the beaker of water.

Procedure Step 2.

3. Your teacher will call out the thermometer readings every 30 s, starting at 0 min when the test tubes are placed into the beaker of water. Record the temperatures for about 5 min.
4. Your teacher will then remove the test tubes from the beaker and let them cool down. Record the temperatures every 30 s for about 5 min.
5. Plot your data on a temperature vs. time graph, with the temperature (°C) on the *y*-axis and the time (min) on the *x*-axis. Make the graph lines for each liquid a different colour.
6. Clean up and put away the equipment you have used.

What Did You Learn?

1. Which liquid heated up the quickest?
2. Which liquid kept its heat the longest (that is, which one cooled down the slowest)?
3. What do the results in your graph suggest about the specific heat capacity of water, salt water, and oil?

The Transfer of Heat Affects Weather

The oceans, the atmosphere, and weather all influence each other. Part of this close relationship is tied to the process of convection. As the Sun heats the surface of the ocean, some of this heat is transferred to the air above. As air over warm ocean water is heated, its air particles become less dense by spreading out and rising upward. When these air particles reach the cooler levels in the atmosphere, they lose their heat and start to come closer together. The denser, cooler air then sinks back toward the ocean surface. Here it gets reheated and the cycle starts again. This process of heat transfer in air is called **convection**. Air is constantly moving up or down, creating weather above the oceans. This movement of air can cover large distances. In Figure 3.3, you can see that as air is heated over the warm waters of the equatorial Pacific Ocean, it rises up near land such as Australia and Indonesia, causing precipitation. As the air begins to cool, it is carried east by upper level winds, where it cools. As the air cools, it becomes denser, and falls near the west coast of parts of North, Central, and South America, creating a dry climate.

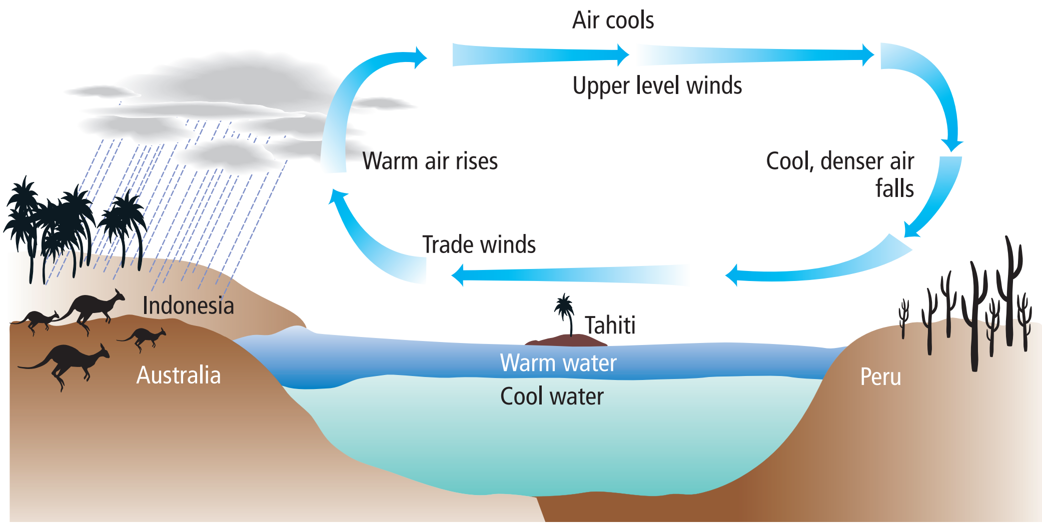


Figure 3.3 The process of convection creates weather patterns over a large area of Earth.

El Niño and La Niña

Good examples of how changes in the ocean can affect climatic change are the phenomena called El Niño and La Niña. The tropical waters of the Pacific Ocean near the equator receive more sunlight than any other area on Earth. Much of the Sun's energy is stored in the form of heat, making these waters very warm. The warm waters are usually carried westward by the Pacific trade winds and allow the deeper, cooler waters to move in and rise up. In springtime, the trade winds slow down, and the Pacific Ocean waters increase in temperature because the

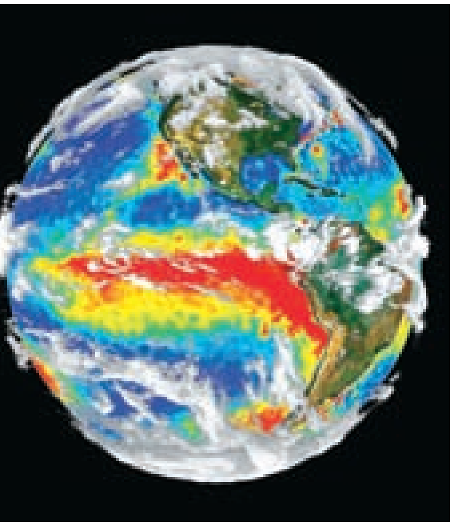


Figure 3.4 This satellite image of the Pacific Ocean during El Niño shows the band of warm water [red] that changes weather patterns.

deep, cool water does not rise. Within a few weeks, the trade winds pick up again and the temperature returns to its normal value.

Every three to seven years, however, the trade winds do not increase after having slowed down. For a period of several months, the surface waters continue to rise in temperature and do not move west, preventing cooler waters from upwelling (rising up). These warmer-than-normal waters lead to unusual weather patterns. El Niño has been responsible for changing patterns of rainfall around the world, and for creating conditions that have led to droughts and fires in Australia, Africa, and Central America. In other areas of the world, such as Peru, Chile, and the western coast of North America, El Niño can bring severe storms and flooding.

A phenomenon that often follows El Niño is La Niña. La Niña is caused by the opposite conditions of El Niño. During La Niña, the equatorial trade winds increase, allowing continuous upwelling of cooler water. These unusually cold ocean temperatures bring reverse conditions from that of El Niño. Heavy rains are brought to Australia, Africa, and South America. Marine life flourishes as the upwelling brings up nutrients that allow microscopic plant organisms called phytoplankton–the main source of fish food–to grow. Scientists are working hard to predict El Niños and La Niñas because of their wide-ranging effects on the world's climates.

Word Connect

El Niño is Spanish for "little boy" and La Niña is Spanish for "little girl."

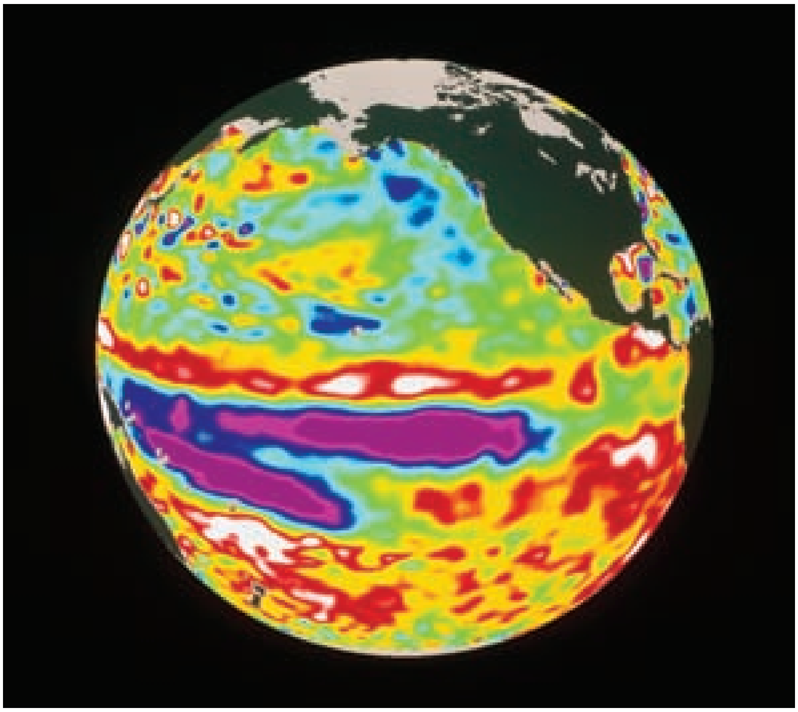


Figure 3.5 Compare this satellite image of the Pacific Ocean during La Niña to the one above during El Niño. Here you can see the band of cool water (in blue and pink) that sits around the equator.

Reading Check

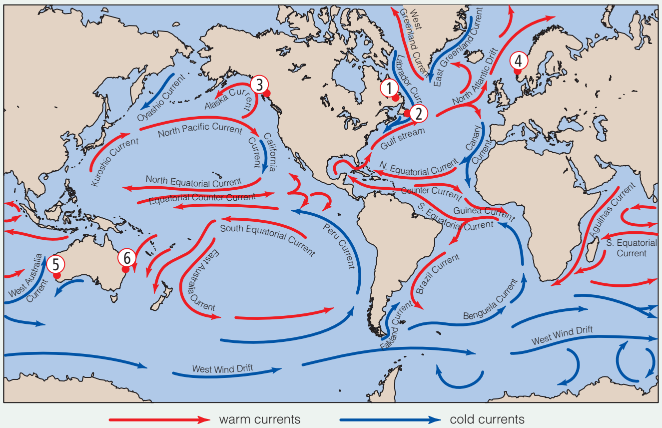
1. What is convection?
2. How does the transfer of heat create weather?
3. What causes El Niño?
4. What causes La Niña?

3-1B Currents and Climate

Think About It

As you have read, the oceans have a great influence on climate, especially along the coasts of continents. Sometimes communities that are closer to the poles than other communities can be warmer due to the effect of currents.

What to Do



The map above has been numbered to show the location of various communities. In the chart below, you will find the corresponding city name, latitude, its minimum low temperature for January, and the maximum high temperature for July.

1. Locate all of the cities on the map.
2. What current runs beside each city? Is it a warm (red arrow) current, or a cold (blue arrow) current?
3. Happy Valley-Goose Bay, NL, and Prince Rupert, BC are only a little over 1° apart in latitude (one latitudinal degree is equal to 110.9 km). Yet, the winters are much colder in Happy Valley-Goose Bay. Why do you think this is?
4. Compare the minimum and maximum temperatures of St. John's, NL and Bergen, Norway. How can you explain the difference in temperatures even though Bergen is almost 13° (about 1 420 km) further north?
5. Compare the minimum and maximum temperatures of Perth and Brisbane in Australia. Why do you think there is little difference between their minimum and maximum temperatures? Why might Perth be slightly colder than Brisbane?

Map Number	City	Latitude	Minimum low –January (°C)	Maximum high –July (°C)
1	Happy Valley-Goose Bay, NL	53.19N	–21	21
2	St. John's, NL	47.37N	–7	20
3	Prince Rupert, BC	54.18N	–2	16
4	Bergen, Norway	60.23N	2	15
5	Perth, Australia	31.56S	17	18
6	Brisbane, Australia	27.23S	21	21

Newfoundland and Labrador: "If you don't like the weather, just wait a few minutes."

Newfoundlanders and Labradorians often start conversations with reference to the weather, and it's no wonder why they do this. The climate of this Atlantic province is as diversified as it is unpredictable.

Labrador: "When the wind is from the East, it's neither good for man nor beast."

Labrador is located on the northeast corner of North America and is also bordered by the cold waters of the North Atlantic. Unlike Newfoundland, much of Labrador is sheltered from the affects of the Atlantic Ocean because some areas are blocked by the Torngat Mountains in the north and the Mealy Mountains in the south. Summer temperatures can be 3 to 5°C warmer than on the coast. The Labrador coast, however, does experience the influence of the Labrador Current which brings cool winds, precipitation, and fog when easterly winds blow the Atlantic air toward land.

Its geographical position makes Labrador a snowy place, with the ground being snow-covered for up to six months, even in the southern section. Churchill Falls often wins the title of the "snowiest place in Canada," receiving over 480 cm each year! Despite its climate being more Arctic than Atlantic, Labradorians are proud of their unique weather.

Newfoundland: "No weather is ill if the wind is still."

It is often said that to understand Newfoundland is to understand the sea, and this could not be more true in relation to the weather of this part of the province. As few communities in Newfoundland are more than 100 km from the ocean, most of the island's population feel the moderating effects of the Atlantic Ocean. The meeting of the Labrador Current with the Gulf Stream Current keeps summer temperatures a little cooler and winter temperatures a little more mild than the rest of Canada.

Newfoundland is also one of the stormiest parts of the North American continent. As storms pass from west to east across Canada, or from south to north as they travel up the east coast of the United States, storms pass over Newfoundland on their way out to the North Atlantic. Newfoundlanders are well seasoned when it comes to tropical storms, silver thaws (also known as "glitter" or "sleet"), and winter blizzards.

There is little doubt that Newfoundlanders and Labradorians are among the most experienced and hearty when it comes to encountering diverse, unpredictable, and often harsh weather conditions.

Check Your Understanding

Checking Concepts

1. Define specific heat capacity.
2. What does specific heat capacity have to do with the effect of oceans on weather and climate?
3. Weather can be described in terms of several measures. Name four.
4. Explain the difference between weather and climate.
5. How can events in the Pacific Ocean such as El Niño affect people living in another part of the world?
6. Describe how the Gulf Stream Current affects the climate of Britain. Include the term "specific heat capacity" in your explanation.

Understanding Key Ideas

7. Why are some currents warm and others cold?
8. Explain how the Labrador Current affects the summer temperatures of Newfoundland and Labrador.
9. What do the Labrador Current and the Gulf Stream Current have to do with the frequency of fog in Newfoundland and Labrador?
10. How can Happy Valley-Goose Bay in Labrador, and Prince Rupert in British Columbia have such different climates even though they are almost on the same degree of latitude (or same distance from the North Pole)?

Pause and Reflect

As you learned in this section, climates of some areas that are far away from the equator are made comfortable by warm water carried to the areas by ocean currents. Write a paragraph describing what would happen to those climates if water had a lower specific heat capacity than it does.

3.2 Living in Water

Not all aquatic environments, or habitats, are the same. Some are salt water, some are fresh water, and some are a mixture of both salt water and fresh water. Aquatic habitats may be warm or cold, shallow or deep, light or dark. The water in the habitat may be moving, as in a stream, or motionless, such as water deep in a lake.

The diversity, or variety of life, varies from habitat to habitat. The ocean environment, for example, is vast. More than one million species of plants and animals are distributed throughout its various habitats. As scientists continue to explore the oceans, they are discovering even more species of marine life.

Key Terms

bioindicator species
bioluminescence
estuary
phytoplankton
wetland
zooplankton

Freshwater Environments

Freshwater environments range from deep, glacier-fed lakes and fast moving streams to shallow, weedy bogs. Some animals spend their entire life in the same body of fresh water. Others need both freshwater and saltwater environments to survive. Salmon, for example, spend most of their life swimming in the open ocean, but return to freshwater rivers to spawn. This section describes the variety of life that is found in lakes, ponds, wetlands, rivers, streams, and estuaries.

Word Connect

"Plankton" comes from the Greek word *planktos*, meaning "wandering or drifting." Because most plankton have very little ability to swim, they rely on currents to transport them around.

Lakes and Ponds

More than 8 percent of the area of Newfoundland and Labrador is occupied by ponds and lakes, making freshwater life an important part of the province's ecosystems. Much of the life in a lake or pond can be found near the shore, where the water is shallow and there are many nutrients for the plants and animals. Insects, plants with roots, and small fish are abundant in this area. In the sunlit waters away from the shore are the small, freefloating organisms called plankton. There are two types of plankton: phytoplankton (plant) and zooplankton (animal). **Phytoplankton** are microscopic plants that produce their nutrients through photosynthesis. **Zooplankton** are tiny animals that eat other types of plankton for food.

Together, these types of plankton form the first link in the aquatic food chain, providing food for everything from insects to fish. Lakes and ponds are also home to amphibians, such as green frogs, and a variety of larger fish in the deeper areas of the water. As well, various mammals and birds may establish a home base along lake or pond shorelines (see Figure 3.6). Beaver and muskrat are two common examples in Newfoundland and Labrador.

Lakes and ponds serve an important purpose in the water cycle by catching and storing run-off. These bodies of fresh water also benefit the environment in many ways, but especially by providing a habitat (home) for a great variety of plants and animals, and supporting rooted plants, which clean the water through natural processes.

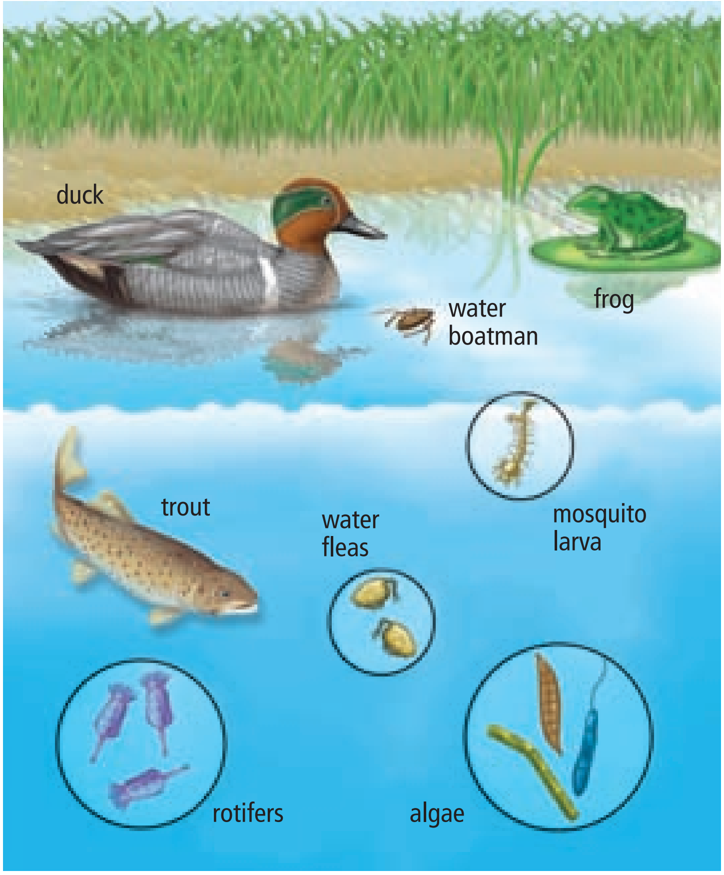


Figure 3.6 A lake habitat contains numerous species.

Life in Rivers and Streams

Most rivers and streams are quite shallow and often contain sediments eroded from the land. Some rivers are clear, while others are so murky (turbid) that you cannot see the bottom. Streams and rivers usually alternate between areas where the water is calm and areas where the water is moving quickly. Riffles (fast-moving water) occur where the riverbed is made of rocks and gravel that is resistant to erosion by the flowing water. Here the water depth is shallow and the speed of the water is faster. Pools form below riffles where the riverbed is made of more fine-grained sediment. The water becomes deeper here, and moves much more slowly.

The types of organisms found in the fast-moving waters of rivers depend on the temperature of the water, its speed, and the amount of sediment in the water (turbidity). Plants such as weeds, mosses, and algae are common in rivers. A large number of insects are also found on or in rivers, and many, such as the caddisfly, lay their eggs along the riverbed.

Figure 3.7 River habitat

Did You Know?

Animals that live in habitats where the water moves very quickly are often small and flat. These adaptations prevent organisms such as the Riffle Beetle from being swept away in the current. Many of these animals cling to rocks or hide under stones.

Did You Know?

Sphagnum moss (peat moss) can can absorb and hold 20 times its own weight in water! This is an example of how wetlands can retain water and release it slowly back to the land.

Figure 3.8 Urban development threatens many wetlands.

Did You Know?

Wetlands make up 18 percent of the province of Newfoundland and Labrador.

In some streams, the bottom is home for snails and worms. The fish in streams, such as brook trout, brown trout, and ounaniche (pronounced wi-na-neesh) feed off the smaller organisms.

Life in Wetlands

One quarter of all the wetlands in the world are located in Canada. A **wetland** is a lowland area that is saturated with water for part or all of the year. For most of the last century, wetlands were not considered a valuable part of nature. As a result, a large percent of the wetlands in most provinces have been lost to industrial and urban residential development. Wetlands have also been lost to recreational use of all-terrain vehicles (ATVs).
It has only been in the past few decades that people have realized the important role that wetlands play in the whole environment. Wetlands contribute to the environment in many ways:

- The vegetation acts as filters for removing pollutants from the water.
- Wetlands hold a huge quantity of water, which helps prevent flooding.
- They act as a resting point for many migrating birds.
- The thick vegetation of wetlands helps keep shorelines stable (they act as buffers) and minimizes erosion.

Life in Estuaries

An **estuary** is an area of wetland that builds up where a river meets the ocean. Nutrients that come from the land, rivers, and the ocean accumulate in estuaries. This makes estuaries ideal environments for both plants and animals. The nutrients are distributed throughout the estuaries by winds, currents, and tides. The action of tides also flushes pollutants and debris out of estuaries. Water in an estuary is "brackish," meaning it is a mixture of fresh and salt water.

The Grand Codroy Ramsar Site on the island of Newfoundland is a 925 hectare estuary. It provides habitat for 19 species of waterfowl and 27 types of rare plants. The importance of this estuary for wildlife was recognized in 1987 when it was declared a Wetland of International Importance.

Bioindicator Species

Did you know that many species that are found in and around freshwater environments can also help us determine the health of the water? Many different kinds of plants, birds, and fish can help us monitor the health of ecosystems. Invertebrates (animals without backbones), such as clams and insects are also useful for this purpose. For instance, changes in the numbers of stonefly, caddisfly, and mayfly larvae that live in streams can tell us about the amount of pollution present in the water. These organisms are called **bioindicator species**. They are generally better at detecting changes in water quality than are testing instruments made by people. They are very sensitive to pollution, so their absence often indicates that the water may be polluted.

Figure 3.9 The Grand Codroy Estuary on the island of Newfoundland is an important home for many species of waterfowl and rare plants.

Saltwater Environments

Oceans form the world's largest aquatic habitat. Oceans differ from lakes not only because they are salty, but also because oceans are deeper and have much more water movement due to tides, currents, and waves.

Even though there is life throughout the ocean and in a variety of ocean environments, the greatest abundance of marine organisms are found in the top 180 m of water. This is the average depth to which light can penetrate in the ocean. Aquatic plants can grow only in the part of the water where light can penetrate. As a result, more than 90 percent of marine life occurs on the continental shelves where the greatest source of food is located.

Almost 10 percent of all sea creatures live in total darkness deep in the ocean. Some of them rely on bioluminescence to find food, attract a mate, or scare away predators. **Bioluminescence** is the ability of certain marine fish and invertebrates to light up part of their bodies through a chemical reaction. Bathocyroe, for example, can produce blue and green luminescence (see Figure 3.10).

Suggested Activity

Find Out Activity 3-2B on page 96.

Did You Know?

Comprising over 3000 square kilometres, the Lake Melville Estuary is the largest estuary in Newfoundland and Labrador.

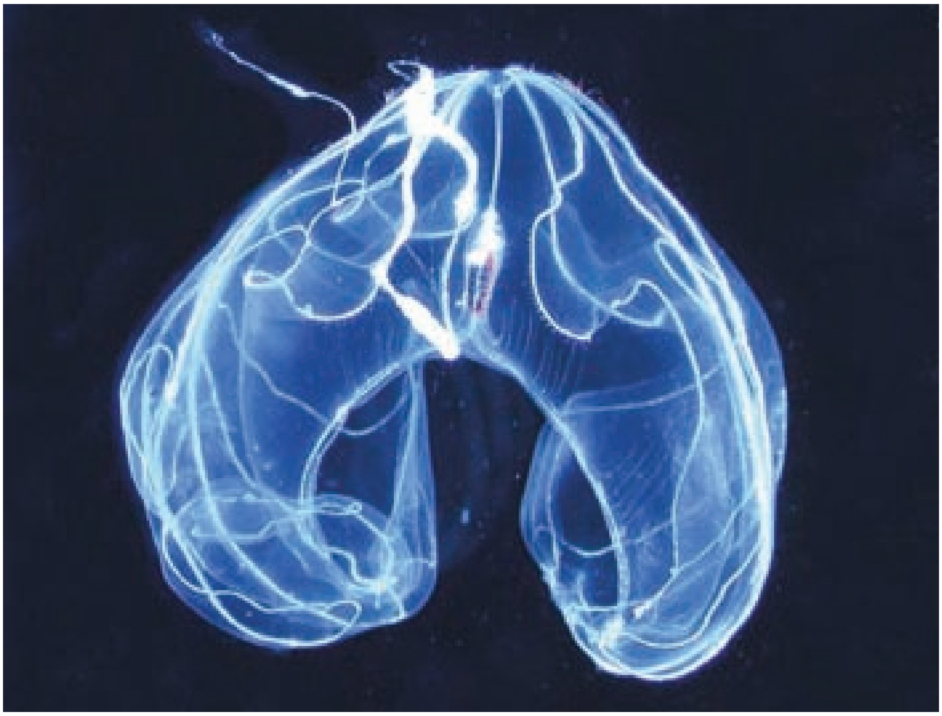


Figure 3.10 Deep water organisms, such as this bathocyroe, often rely on bioluminescence for survival.

internet connect

The heart of an adult blue whale is as large as a small car. Find out more about the blue whale and other ocean creatures by going to **www.discoveringscience8.ca**

The ocean is home not only to single-cell organisms, but also to the largest mammal on Earth, the blue whale. Between those two extremes is a huge variety of life of every shape and size. Shallow warm waters close to the equator are preferred by tropical corals, which in turn, provide habitat for countless small fish and plants. Large fish such as tuna and halibut are found in colder, deeper water. Life can even be found in the darkest, coldest parts of the ocean. Sea sponges and sea cucumbers live on the ocean floor, feeding off the plankton, microscopic plants, dead sea creatures, and other organic (plant or animal) material that drops from the surface layer.

Reading Check

1. Name four types of freshwater environments.
2. Explain three ways in which wetlands are important.
3. Why is an estuary an ideal location for plants and animals?
4. Where is the greatest abundance of life found in the ocean?
5. What is bioluminescence?

3-2A Abiotic Factors

Find Out ACTIVITY

You often hear about the effects of people on marine and freshwater life, but there are also non-human factors that influence where and how organisms live and grow. Non-living factors that affect organisms in an ecosystem are called abiotic factors. They can include such factors as temperature, type of bottom surface in a river or ocean, oxygen availability, amount of sunlight, current speed, and climate. In this activity, you will be researching the effect of abiotic factors on the distribution of a species in a freshwater or marine environment.

Freshwater Species

- caddisfly larvae
- dragonfly larvae
- salmon
- mud trout (Speckled trout)
- American eel
- leeches

Marine Species

- snow crab
- scallops
- halibut
- cod
- capelin
- octopus

What to Do

1. You will work in groups of three or four.
2. With your classmates, choose a species from the list provided above. If there is a species you would like to study that is not listed, be sure to get the approval of your teacher before proceeding.
3. Using resources in your library and the Internet, research the species you have chosen. Topics you should consider are: what part of the freshwater or marine environment they live in; what they feed on; their predators; and how they adapt to living in that part of the water environment. Assign each member of your group a topic to research. Record all of your information in your notebook.
4. As you gather information, begin to look closely at how abiotic factors affect your species. For example, does water temperature affect where they live?
5. After gathering your information, as a group decide how you are going to present your research to your class. You may want to consider a computer, poster, or overhead presentation.
6. Prepare a five minute presentation on how abiotic factors affect the species you have studied.

3-2B Too Much of a Good Thing

SkillCheck
- Recording
- Analyzing
- Interpreting
- Communicating

Safety

Fertilizers are toxic substances. Avoid getting them on your skin and wear protective safety goggles and a lab jacket.

Materials

- six 1 L beakers or canning jars
- 1 L beaker with lid
- 250 mL measuring cup
- graduated cylinder
- chlorine-free tap water (allow tap water to sit for two days to eliminate chlorine)
- pond water
- 8-24-8 uncoloured fertilizer
- masking tape
- stirring rod
- index card
- felt marker
- test kit to measure dissolved oxygen, nitrates, and/or phosphates (optional)
- microscope (optional)

Humans can affect the amount of nutrients that enter aquatic systems. Dish detergent, food, soaps, sewage, and fertilizers are all sources of nutrients that humans often contribute to water systems. How do you think the growth of aquatic plants will be affected by an increase in nutrients?

Question

How do fertilizers affect the growth of aquatic plants? Form a hypothesis.

Procedure

1. Read through the procedure steps and make a data table to record your results.
2. Fill each beaker with 500 mL of chlorine-free tap water.
3. Add 100 mL of pond water to each beaker.
4. Make a solution of plant fertilizer by adding 15 mL of fertilizer to 1 L of chlorine-free water. This is the stock fertilizer solution.

5. Use the masking tape to label each beaker A to F. Add fertilizer solution to the beakers as follows: Beaker A – 1 mL; Beaker B – 2 mL; Beaker C – 4 mL; Beaker D – 8 mL; Beaker E – 16 mL. Beaker F does not get fertilizer solution.
6. To ensure that all of the beakers have the same amount of water, add the following amounts of chlorine-free water to the beakers: Beaker A – 15 mL; Beaker B – 14 mL; Beaker C – 12 mL; Beaker D – 8 mL; Beaker E – 0 mL; Beaker F – 16 mL.

7. Place all of the beakers in sunlight.

8. On the index card, write the word TURBIDITY using the same size letters as shown here. Turbidity measures the clearness of the water. (While a high degree of turbidity is often a sign of polluted water, there may be other reasons for murky water as well.) To measure turbidity, try to read the word on the card by looking at it through the beaker of water.
   - If the print in easy to read, the turbidity measure is clear.
   - If the print is fuzzy, the turbidity measure is slightly cloudy.
   - If the print can be seen but not read, the turbidity measure is very cloudy.
   - If the print cannot be seen, the turbidity measure is opaque (cannot be seen through).
9. At the same time every day, check the colour and measure the turbidity of the water in each beaker. Record your results in your data table.
10. If you have the equipment, measure the dissolved oxygen, nitrates, and phosphates in each beaker. Record your results in your data table.
11. If you have a microscope, look at a drop of liquid from each beaker each day and record the organisms that you see.
12. Continue to record your results for two weeks.

Analyze

1. Which beaker was clearest? Which beaker was the most turbid?
2. How did the increase in the amount of fertilizer added to a beaker affect the growth of algae in the beaker?
3. Do you consider any of the water in the beakers to be polluted? Explain your answer.
4. Which variable was the dependent (responding) variable in this investigation? Which variable was independent (manipulated)?

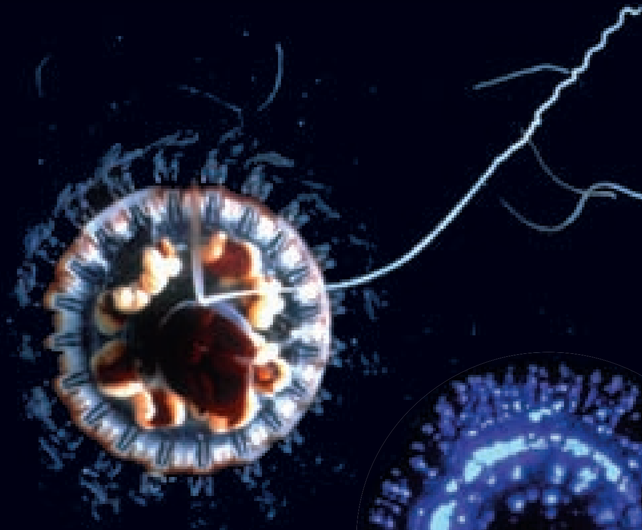
Conclude and Apply

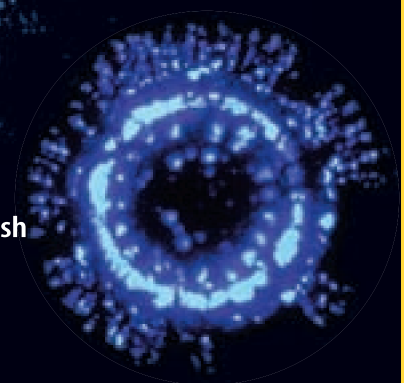
5. The fertilizer that you used in this experiment contains phosphates. Soaps and detergents used to contain phosphates. In recent years, most manufacturers have made them phosphate-free. Why do you think this change has been made?
6. Write a statement explaining how too much plant growth in an aquatic habitat may have negative effects.

NATIONAL GEOGRAPHIC

VISUALIZING BIOLUMINESCENCE

Many marine organisms use bioluminescence as a form of communication. This visible light is produced by a chemical reaction and often confuses predators or attracts mates. Each organism on this page is shown in its normal and bioluminescent state.





▼ **KRILL** The blue dots shown below this krill are all that are visible when krill bioluminesce. The krill may use bioluminescence to confuse predators.

▲ **JELLYFISH** This jellyfish lights up like a neon sign when it is threatened.

◀ **BLACK DRAGONFISH** The black dragonfish lives in the deep ocean where light doesn't penetrate. It has light organs under its eyes that it uses like a flashlight to search for prey.

▲ **DEEP-SEA SEA STAR** The sea star uses light to warn predators of its unpleasant taste.

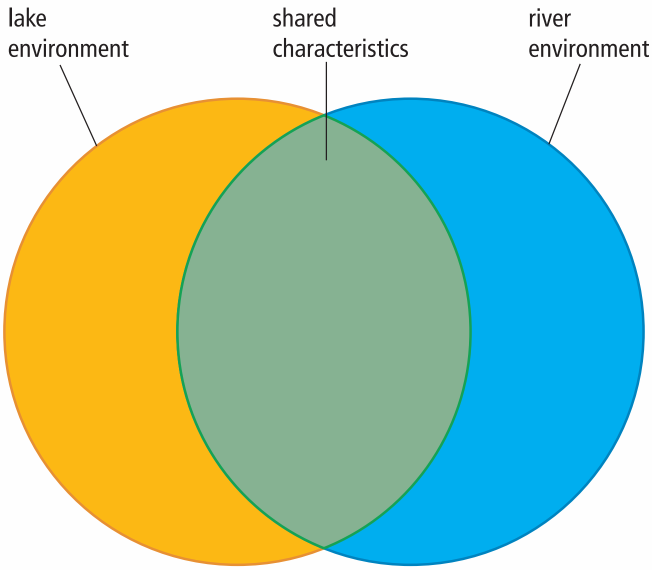
Check Your Understanding

Checking Concepts

1. Name the two types of plankton and what each name means.
2. What role does plankton play in lake and pond environments?
3. (a) What are wetlands?
   (b) What value do the wetlands have?
4. Canada is home to what percentage of the world's wetlands?
5. What is an estuary?

Understanding Key Ideas

6. River and lake environments are different from each other. Copy the Venn diagram below into your notebook, and then complete it by listing the characteristics that are different between the two environments, as well as those characteristics that they share.



7. Describe how organisms that live deep in the ocean use bioluminescence.
8. What human activity might cause an algal bloom (an explosion in the algae population) in a lake?

Pause and Reflect

From what you have learned about estuaries in this section, how do you think activities such as residential development (building houses), commercial shipping (transporting goods by boat), and recreation (sport fishing and hunting) can harm estuaries? Write down your ideas under three headings: Effects of Residential Development, Effects of Commercial Shipping, and Effects of Recreation.

3.3 Human Impact on Water Systems

Water is essential to the survival of every organism on Earth. Yet many factors, natural and human-related, can interfere with the water cycle and the quality of the water at various stages of the cycle. When this happens, the life that exists in aquatic environments can change, often not for the better. Human activities are a particular concern because they can lead to rapid and sometimes devastating changes in the water resource on which we all rely, especially clean drinking water.

Key Terms

acid precipitation
aquaculture
invasive species
overfishing

For centuries, people have used rivers and oceans as dumping grounds for garbage, sewage, and other unwanted material such as industrial waste and waste water. We are only learning now that even though organisms living in the water can break down a great deal of the waste materials, we are simply putting too much material into the system.

Water is considered a renewable resource because it is recycled in the water cycle. People get their water from ponds, lakes, rivers, and ground water (water wells). However, in many places in the world, we are using water faster than it can be recycled. In this section, you will learn about some of the different factors that can affect the water cycle and the problems that humans are creating for their water supply, and the marine life in our oceans.

3-3A How Do Your Actions Affect the Ocean?

Think About It

As we go about our day-to-day life, we generally do not think about what impact our activities and actions may be having on the environment, either immediately or at some time later. Yet many of the activities that are part of our daily routine could have a great impact on environments—even those far away from where you live. Being aware of how our actions affect other things in the world is a first step to taking responsibility for their outcomes. Some outcomes can be good and some can be bad.

Consider how your actions might be affecting the ocean. Think of all the things you do from the time you get up in the morning until the time you go to bed at night. Make a two-column table with the headings "Activity" in the left column, and "How It Affects the Ocean" in the right column. Write down as many examples as you can. Share your answers with the class.

Sources of Water Pollution

Pollution is a term that refers to any of numerous types of harmful materials that are released into the environment through natural or human activities. Air, soil, and water can all become polluted. Pollution can be caused directly (point sources) or indirectly (non-point sources).

Point sources

Point sources of pollution are those that come from a small, specific area, such as a landfill leak or a factory or mill pumping waste water into a river. This type of pollution is easy to identify because the material can be traced to the source. Other point sources include oil spills, underground storage containers for gas stations, sewage systems, and waste water treatment plants.

Figure 3.11 Point sources of pollution, such as this factory's waste water, are easier to identify than non-point sources.

Non-point sources

Have you ever noticed the dark, shiny area that runs down the middle of the road? This dark band on the pavement is the result of rubber residue and oil that has leaked from cars and trucks. Eventually, rain washes this material into storm drains and sewers, and the contaminated water is carried to a river and then to the ocean. Just 1 L of oil can pollute 1 million litres of water. It is not just oil that gets washed into storm drains. Pesticides and fertilizers from lawns, farmer's fields, and golf courses, animal wastes from parks and farms, and run-off from city streets and driveways are also problems.

These are all examples of non-point sources of pollution. Non-point sources of pollution are those that come from many different sources, not just one. There are a number of ways that such pollution can get into the water system. This makes non-point sources a difficult type of pollution to control. Many small sources can combine to cause major environmental damage.

Figure 3.12 When human activities negatively impact the environment, all species suffer.

The Effects of Water Pollution

Humans have the greatest effect on the quality of the world's water supply through both population growth and expanding industrial development. Any negative effect on water is, in turn, felt by all the organisms depending on it, including humans.

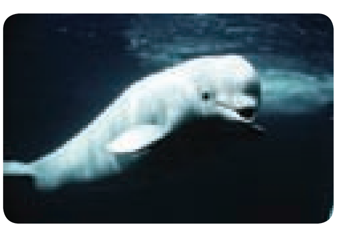
Figure 3.13 Non-biodegradable wastes often get washed up on shores. They are hazardous to both marine and land animals.

Oceans have long been a favourite dumping ground for large amounts of human waste because they are so large and once seemed bottomless. Although there are laws today to try and stop people from doing those things, many problems still exist.

Most pollution in the world's oceans is found along the coasts of continents, which is where most of the world's population lives. Environments such as beaches and estuaries are particularly sensitive because the pattern of water flow can cause pollutants to become trapped. Solid waste is also a major problem in oceans. If the material dumped is non-biodegradable (meaning it cannot decompose naturally), it will float on surface currents of the oceans until it washes up on shore. A plastic coffee cup or bottle may last for tens of thousands of years. Many different types of sea life die each year after becoming tangled up in plastic bags, plastic can holders, and fishing line. Larger mammals such as dolphins and whales often die by mistaking plastic materials for food.

Did You Know?

Beluga whales in the St. Lawrence and Saguenay Rivers have been found with levels of toxins (poisonous chemicals) almost 100 times the levels found in their Arctic Ocean relatives. Marine biologists have traced the toxins to industrial wastes and farm pesticides that are first eaten by the belugas' favourite food, the American eel.



Acid precipitation

Pollutants can also enter water systems when toxic substances are released into the air. Pollution can then fall from the sky in the form of dissolved chemicals. Nitrogen oxides and sulfur dioxide get into the atmosphere as a result of the burning of fossil fuels such as gasoline, oil, and coal. The chemicals combine with water in the atmosphere to form sulfuric acids and nitric acids. When this material falls to Earth, it is called **acid precipitation** (see Figure 3.14). Acid precipitation can be more acidic than vinegar. Winds carry atmospheric pollution from industrial areas to lakes, forests, and oceans, and slowly kill or damage plant and animal life. Although Newfoundland and Labrador does not have a large percentage of industrial activity, the province does receive high amounts of acid precipitation due to the mid-latitude westerlies that blow across Canada and along the eastern seaboard from west to east.

Acidity, the strength of an acid, is measured on a 14-point "pH" scale (see Figure 3.15), which indicates whether a substance is acidic or basic (alkaline). For example, vinegar has a pH of 2.8. Detergents used for washing clothes are basic, with a pH of about 10. Neutral materials, those that are neither acidic nor basic, have a pH of 7.0. Normal rainwater has a pH of 5.6. Precipitation is considered to be "acid" when it has a pH of less than 5.6.

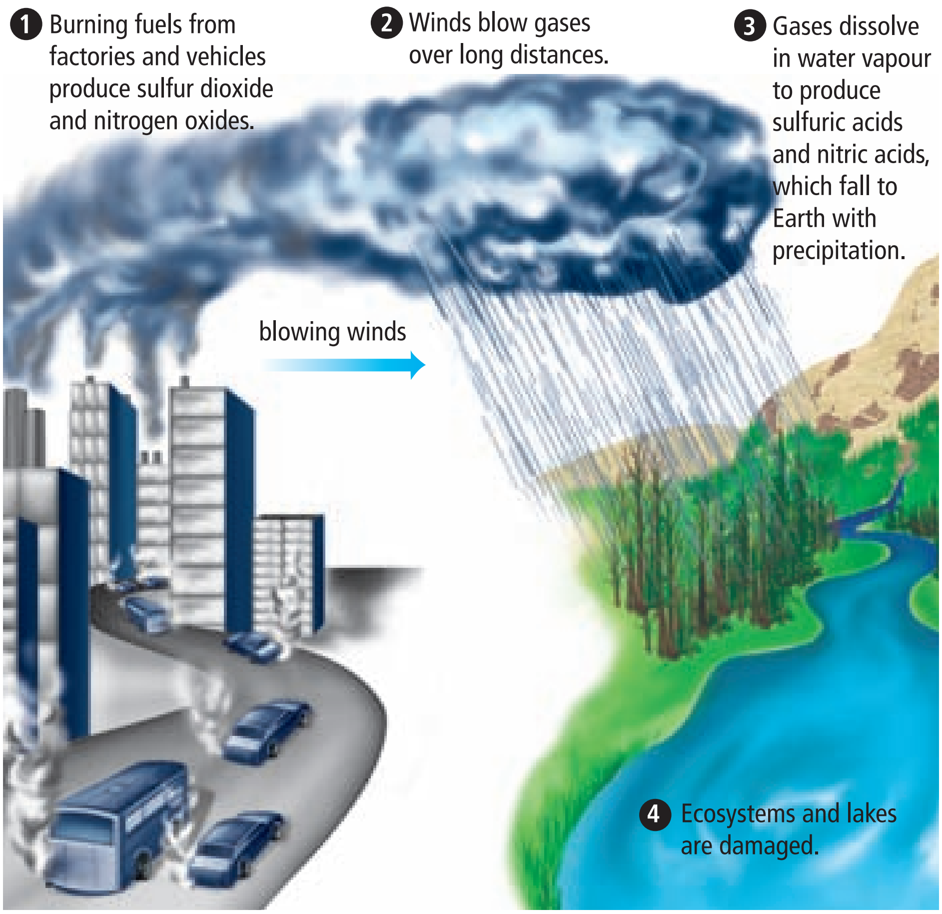


Figure 3.14 Polluting gases enter water systems when acid precipitation is produced.

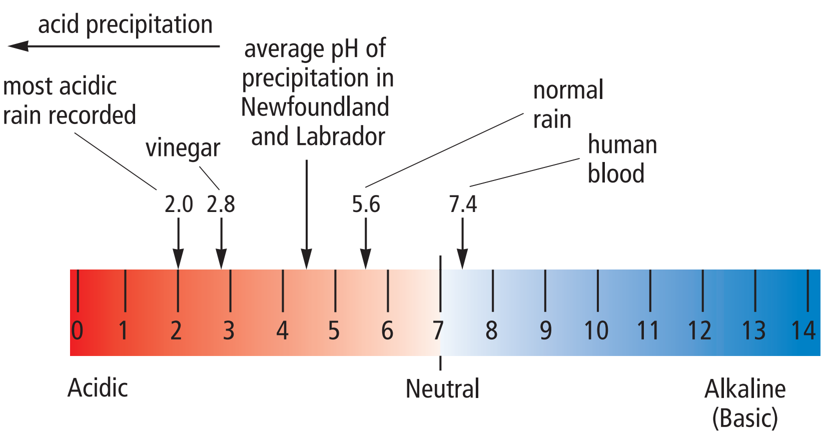


Figure 3.15 The pH scale.

Suggested Activity

Core Lab 3-3B on page 108.

internet connect

More than 80 percent of Canadians, including those who live in Newfoundland and Labrador, live in areas with high acid rain pollution levels. Find out more about acid rain in your area. Go to **www.discoveringscience8.ca**

Reading Check

1. What is the difference between a point source and non-point source of pollution?
2. Give an example of a point source and a non-point source of pollution.
3. Where is most of the ocean's pollution found? Why?
4. How is acid precipitation created?
5. How does atmospheric pollution reach lakes, forests, and oceans?

Offshore Oil Industry and the Marine Environment

When you think of oil pollution in the ocean, it is easy to assume that large offshore oil rigs, such as the Hibernia GBS, would be the main polluters. While occasional leaks and spills do happen, offshore drilling operations contribute 2.1 percent of the total waste oil in the oceans each year. Most waste oil that is found in the ocean comes from drainage from cities and farms, untreated waste disposal from factories and businesses, and recreational boating. While oil rigs may be the lowest contributor, any amount of oil is dangerous to the marine life that exists in the oceans.

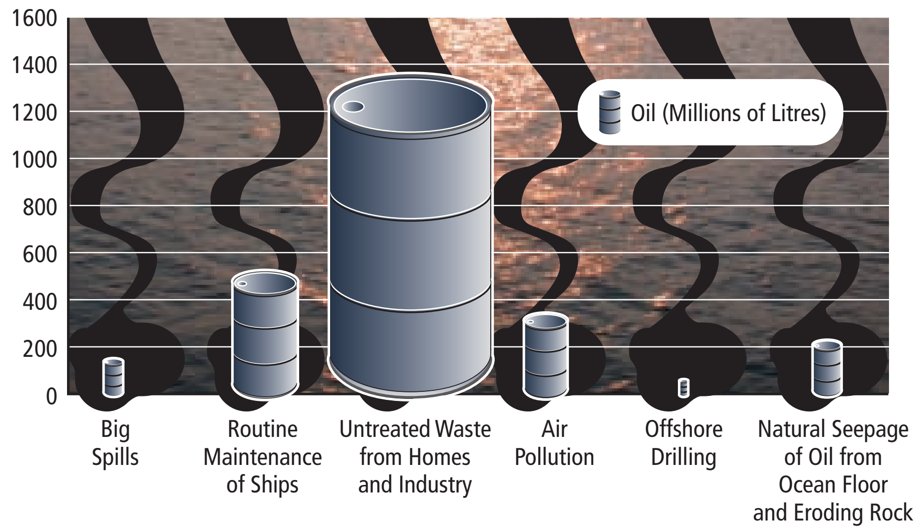


Figure 3.16 Each year, people and industries allow more than 2 672 000 000 L of oil to spill into our oceans.

Suggested Activity

Think About It Activity 3-3C on page 112.

Scientists are also concerned about the effects on marine life that come from the seismic testing that is used to locate oil deposits under the sea floor. Seismic testing sends out a high pressure burst of air, like a shock wave, down through the sea floor. By the rate of travel of the wave through the ocean bed, scientists can determine if there is a possibility of oil. These shock waves, however, destroy fish eggs and larvae, cause fish to leave the area, and disrupt the migration paths of whales. Because the waters off the coast of Newfoundland and Labrador are breeding grounds for many species of fish, and 22 species of whales, seismic testing remains an important topic of concern for scientists.

Invasive Species

On land or in water, animals exist in a delicate food web. This web keeps animal populations in balance. If a new or foreign species is introduced to this web, it can cause damage to the entire food web. New or foreign species are called **invasive species**. In the oceans, cargo ships can introduce a foreign species to a new area as they travel from place to place. Ships all have a compartment called a bilge, which collects dirty water from the ship. When the bilge is full, ships must release this water into the ocean. While most ships have filters to help clean the dirty water before it enters the ocean, it still may contain parasites and organisms that are foreign to an area. These new species disrupt the existing food web, which can throw marine populations out of balance. As a new species, they do not have a natural predator, yet they feed on the native organisms. The population of the invasive species increases, and further disrupts the food web.

An example of an invasive species along the Atlantic coast is the Green Crab in Placentia Bay. The crab's native home is in the waters around Europe and North Africa, and is thought to have been introduced to the Atlantic waters through bilge release. It caused a rapid decline to the native Rock Crab that live in the bay, and eats clams, mussels, oysters, scallops, and even lobsters. In Placentia Bay, the Green Crab does not have any natural predators, meaning that its potential to continue as a local problem in the future is very high.

Figure 3.17 Invasive species, such as the Green Crab, disrupt the natural balance of the ocean's food web in Placentia Bay and other Canadian coastal areas.

Overfishing

When explorer John Cabot arrived off the shores of Newfoundland, he reported that he could scoop up buckets of cod from the ocean from his ship. Five hundred years later extremely low numbers of cod forced the Canadian government to ban cod fishing on the Grand Banks, and put thousands of Newfoundlanders and Labradorians out of work. What happened to all the cod? Through a process called **overfishing**, more cod were continuously taken than could be replaced by reproduction.

A large reason why overfishing can happen is due to new technologies that allow fishing vessels to catch more fish. Large ships, called factory freezer trawlers, can stay out at sea for over a month at a time. They have the capabilities to freeze or can fish right on the ship. This means they do not have to return to port until the ship is full of fish that is ready for consumers. Another example of new technology that can lead to overfishing is sonar technology. It used to be a matter of luck whether a fishing vessel would get a good catch. Now, fish-finding sonar allows vessels to locate fish with much more accuracy, further depleting the population.

The use of trawlers is also a fishing technique that is causing concern among scientists. Trawling is a fishing process where a large net is towed behind a fishing vessel. Vessels either trawl in mid-water, or on the ocean floor. One problem with trawling is that marine life, other than the fish that is wanted, gets caught in the nets. For example, for every one tonne of shrimp that are caught to be sold, three tons of other fish are killed and thrown away. Another issue with bottom-trawling on the sea floor is the wide spread damage to marine life and habitats that occurs as the steel frame that holds the net is dragged along the ocean bottom.

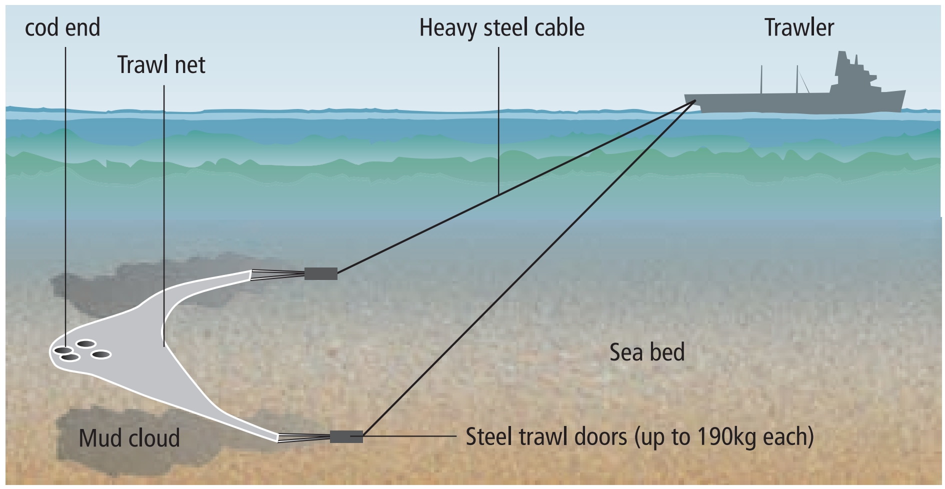


Figure 3.18 Deep sea trawling not only causes damage to the sea floor, but it also can catch other marine life such as dolphins, sea turtles, and many others.

Many countries, including Canada, have put laws in place to prevent overfishing and bottom trawling in waters that are under their control. The problem remains, however, that in international waters, there is very little regulation over how vessels catch fish, or how much they catch. This means fishing vessels from some countries overfish in the open waters, and ignore the consequences of what they are doing to the marine environment.

Aquaculture

Also called aquafarming, **aquaculture** is the growing and harvesting of marine species in a controlled marine area. Aquafarms are usually built in sheltered marine areas such as in a bay. Species such as salmon, rainbow trout, codfish, shellfish, and aquatic plants are cared for until they can be shipped to market. There are so many aquacultures now that they supply one third of all the fish people consume in the world. When created and maintained properly, aquacultures are a way to reduce the fishing pressure on wild fish. With the growing number of aquacultures in the world, however, they are also creating problems for the marine life that surrounds them. Farmed fish sometimes escape out into the open waters. If a large number of fish escape, or if the escaped fish are foreign to that area, they can cause serious damage to the existing marine life. Diseases and parasites are another issue that can affect aquacultures and be spread to wild fish in the oceans.

Figure 3.19 Aquacultures, such as this rainbow trout farm in Milltown, Newfoundland and Labrador are increasing in numbers as wild fish stocks continue to be depleted in the oceans from overfishing.

Reading Check

1. Why is seismic testing for oil a concern for ocean scientists?
2. Where does most of the oil that ends up in the ocean come from?
3. Why can invasive species be harmful?
4. Name two types of technologies that have led to overfishing.
5. Describe one positive and one negative aspect about aquacultures.

Explore More

The conditions of our oceans are becoming a focus for many action groups around the world. In Newfoundland and Labrador, Ocean Net is dedicated to helping reverse the pollution of the world's oceans. Find out more about what Ocean Net is doing at **www.discoveringscience8.ca**

3-3B Water Health Test

Core Lab

SkillCheck

- Observing
- Interpreting
- Analyzing
- Communicating

Safety

- Conduct this investigation only under the supervision of your teacher
- Remain in shallow water at all times.

Materials

- field guide of aquatic organisms
- plastic spoon
- magnifying glass
- deep pan
- long-handle dip net
- rubber boots
- pencil
- notebook
- water testing kit

In order to find out about the health of a freshwater or saltwater environment, biologists need to examine the water. They must observe what sorts of organisms live in the ecosystem, and run tests on the water for levels of pollution. In Lab A, you will be studying a local stream to see if it is healthy. In Lab B, you will be studying the quality of a marine environment.

LAB A – Freshwater Environment

Part 1: Bioindicators

Work in a group of four or five students. Under the supervision of your teacher, you will visit a local stream to sample the bottom sediments. The bottom sediment will include different kinds of organisms that can be used as indicators of water quality.

Procedure

1. Using the long-handle dip net, take a sample of the bottom sediment and place it in the pan. The sediment may include mud, gravel, and small stones. Do not dig too deeply. Only sample the first 2–3 cm of sediment. Also add some water to the pan.
2. With your magnifying glass, examine the sediment in the pan. Gently move the sediment around and use your field guide to identify the organisms. Record your observations in your table. After completing your observations, carefully return all organisms to their natural habitat.
3. The best place to look for bioindicator species is in shallow parts of the stream where there is gravel or rocks. Gently turn over some rocks to see what organisms may be underneath. Try looking in several shallow parts for different species and carefully collect them with the long-dip handle net. CAUTION! Some streams can be very dangerous. Only visit a stream that your teacher has approved, and with the whole class.
   Biological Indicators: Collect and identify 10 organisms (they do not have to be the same). Refer to the biotic index chart and assign each organism a number of points.

Organism	Points	Organism	Points
1.		6.	
2.		7.	
3.		8.	
4.		9.	
5.		10.	

Part II Abiotic Tests

You will use a water testing kit to examine several water qualities.

Procedure

1. Create a chart in your notebook like the one below.

   A. General Weather Conditions:
   B. Air Temperature: ________ 0°C.
   C. Water Temperature: ________ 0°C
   D. Water pH: ____________
   E. Turbidity: __________
   F. Dissolved Oxygen: __________ mg/L
   G. Phosphates: _______µg/L

2. Measure the air and water temperature. Record your results.
3. Follow the instructions in the kit for measuring pH levels. Record your results.
4. Make a qualitative measurement of the turbidity of the water simply by looking at how cloudy or "muddy" the water looks (make sure that you are not so close to another group that their activities are stirring up the water you are testing). Then, follow the instructions in the kit for measuring turbidity. Record your results.
5. Follow the instructions on the dissolved oxygen kit to determine how much oxygen is in the water. Record your results.
6. Follow the instructions in the kit for measuring phosphates. Record your results.
7. Wash your hands after this investigation.

Analyze – Bioindicator Species

1. How many species of organisms did you identify?
2. How many of each species were there in your sample?
3. Based on the bioindicator species, calculate the total biotic index of the stream using the chart on the next page.
4. Based on your total biotic index, what is the water quality rating for this stream? Use the following guide to help determine the quality:

   0-10: very poor water quality
   11-16: poor to intermediate water quality
   17-22: intermediate water quality
   23-30: good water quality

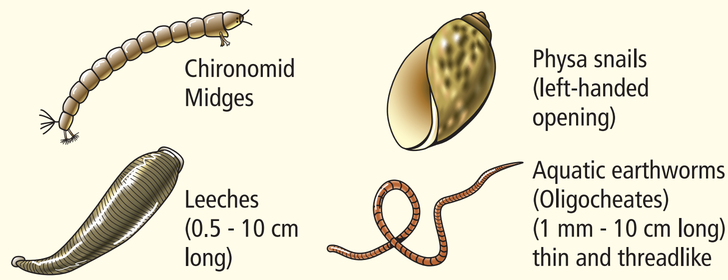
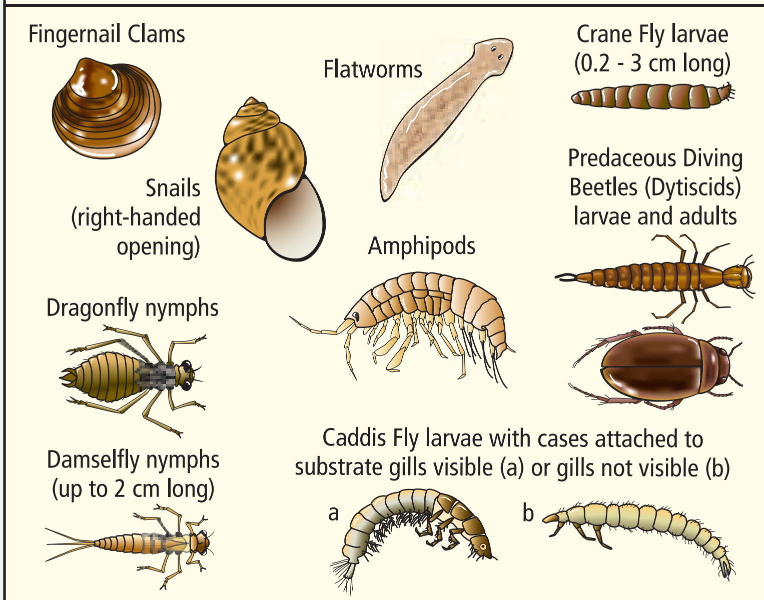
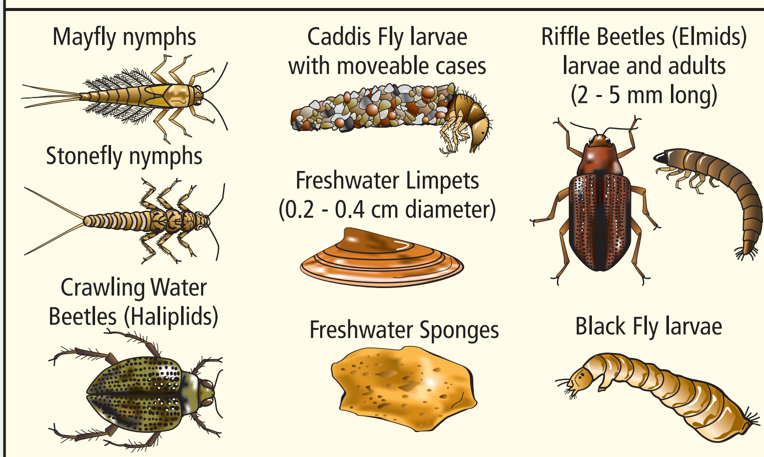
Analyze – Abiotic Factors

5. Based on the abiotic measurements, how would you rate the water quality of your local stream?
6. Each group will prepare a five minute presentation on their findings and their overall conclusion on the water quality of the stream. You may want to use charts or diagrams to present your findings.

Conclude

7. Did all groups come to the same conclusion about the quality of the stream? Did any groups find anything different?
8. Why might bioindicator species be more reliable than abiotic water testing to determine the quality of a freshwater system?

3-3B Water Health Test

Biotic Index for Water Quality	
 Chironomid Midges; Physa snails (left-handed opening); Leeches (0.5 - 10 cm long); Aquatic earthworms (Oligocheates) (1 mm - 10 cm long) thin and threadlike	High Tolerance of Pollution 1 Point
 Fingernail Clams; Snails (right-handed opening); Flatworms; Crane Fly larvae (0.2 - 3 cm long); Predaceous Diving Beetles (Dytiscids) larvae and adults; Amphipods; Dragonfly nymphs; Damselfly nymphs (up to 2 cm long); Caddis Fly larvae with cases attached to substrate gills visible (a) or gills not visible (b)	Moderate Tolerance of Pollution 2 Points
 Mayfly nymphs; Stonefly nymphs; Crawling Water Beetles (Haliplids); Caddis Fly larvae with moveable cases; Freshwater Limpets (0.2 - 0.4 cm diameter); Freshwater Sponges; Riffle Beetles (Elmids) larvae and adults (2 - 5 mm long); Black Fly larvae	Low Tolerance of Pollution 3 Points

Inquiry Focus

LAB B – Saltwater Environment

Work in a group of four or five students. Under the supervision of your teacher, you will visit an ocean to sample and test the water. You will use a water testing kit to examine several water qualities.

Safety

- Conduct this investigation only under the supervision of your teacher
- Remain in shallow water at all times.

Materials

- rubber boots
- pencil
- notebook
- water testing kit (should include tests for temperature, salinity, dissolved oxygen, pH, and turbidity)

Procedure

1. Measure the air and water temperature. Record your results.
2. Follow the instructions on the dissolved oxygen kit to determine how much oxygen is in the water. Record your results.
3. Follow the instructions in the kit for measuring pH levels. Record your results.
4. Follow the instructions in the kit for measuring salinity levels. Record your results.
5. Wash your hands after this investigation.

Analyze

1. Based on the abiotic measurements, how would you rate the quality of the ocean water?
2. Each group will prepare a five-minute presentation on their findings and their overall conclusion on the water quality of the ocean. You may want to use charts or diagrams in your presentation.

Conclude

3. Did all groups come to the same conclusion about the quality of the stream? Did any groups find anything different?

3-3C Not An Easy Decision

In making decisions about activities that happen in the ocean, it is not always easy to get different groups and people to agree on one action. In this activity, you will be examining and playing the roles of the different people and groups that are involved when a new oil rig is proposed off the shores of Newfoundland and Labrador. You will find that it is not always easy to decide who is right and who is wrong.

What to Do

1. Form groups of 5 with your classmates.
2. Your teacher will come around and letter you from A to E.
3. According to your letter, you will be assigned the following roles.

   A's – Marine biologist. Your concern is the marine life and habitats that may be harmed by the building of a new offshore oil rig. You have scientific facts and figures that support your arguments. Be ready to counter-argue business arguments about profits and jobs.

   B's – Oil company president. You are in charge of the oil company that wants to build the offshore oil rig. You have estimates on the number of jobs and money that will be brought to the province as a result of the oil rig being built and put into production. You need to be prepared to counter-argue environmentalists and scientists.

   C's – Premier of Newfoundland and Labrador. You have a very tricky role of balancing the needs of your province (jobs and money) with the need to protect fisheries and marine life. You are not only responsible to your people, but you also have to be environmentally responsible too. You are in your job because of public opinion, so you don't want to lose your popularity.

   D's – Environmentalist. You are dedicated to helping marine life. You have seen oil slicks that have killed or hurt many seabirds and marine animals. Be ready to have evidence to support your arguments.

   E's – Fisher. Your business is tied to the sea, so you want what is best for marine populations. Yet a new oil rig would give you the possibility of earning money during the winter season. You must carefully think about all the arguments and your own personal needs.
4. You will be given a research period in the library. Using books, newspapers, and the Internet, find information that will help you argue your cause about the possible oil rig. Record all of your supporting information in your notebook.
5. Go over the rules of debating with your teacher.
6. Each member of the group will be given one minute to make a statement regarding their position on the proposed oil rig. Roles C and E may not have a position until they hear the arguments.
7. Using good debating manners, disagree or agree with their point. Each member of the group must have equal opportunity to speak.
8. After 15 minutes, the teacher will call an end to the debate. At this time you will take a vote in each group as to whether the oil rig will be built or not.

Analyze

1. How many groups decided to build the oil rig? How many groups decided that it should not be built?
2. What were the strongest arguments for each side of the debate?
3. In making big decisions such as whether to build this offshore oil rig, what other factors influence our decisions other than scientific facts?

Pollution in the Open Ocean

Over 500 years ago, when Christopher Columbus and his crew were sailing across the Atlantic Ocean, they thought they were nearing land because they saw a mass of floating vegetation. They soon discovered that they were nowhere near land, and were seeing a large growth of floating seaweed similar to that shown in the photograph below. The seaweed looked like tiny yellow grapes so Columbus named it sargazo for "sea grapes." The area is now known as the Sargasso Sea.

The part of the seaweed that Columbus thought looked like little yellow grapes are really small, air-filled sacks, that cause the seaweed to float

Nearly 500 years later, Australian yacht captain, Ian Kieman was excited because a yacht race was going to take him to the famous Sargasso Sea. However, when he arrived there, he was shocked at what he saw. The once beautiful Sargasso Sea was littered with garbage with everything from empty toothpaste tubes to plastic bags. How did rubbish get to the Sargasso Sea and what makes it stay there, in the middle of the ocean?

The rubbish remains in the Sargasso Sea for the same reason that the seaweed stays there. The Sargasso Sea is surrounded by ocean currents that form a loop as shown in the map below. The Gulf Stream flows across the Atlantic Ocean becoming the North Atlantic Drift. Part of that current joins the Canary Current which connects with the North Equatorial Current. The currents form a continuous loop. Anything that is carried from any of the land masses and drifts to the inner edge of the loop reaches a very calm sea. There is so little motion of air or water inside the loop and most things that reach the centre remain there.

The conditions in the Sargasso Sea are so calm, that sailing ships sometimes became trapped there due to lack of wind.

As you have read, plastics are a major problem in ocean pollution. Even the tiny polyethylene (plastic) pellets that are used in the manufacture of many items are a common pollutant. In one survey, researchers calculated that every square kilometre of the Sargasso Sea contained between 3000 and 4000 floating pellets. Marine life ingest these pellets as they think they are food. One dead sea turtle was found to have over a thousand pieces of plastic in its stomach and intestines.

Another serious pollutant in the Sargasso Sea is tar balls. These balls form when spilled oil clumps together and floats on the ocean surface. The oil accumulates when there are oil spills, when tankers clean their cargo holds, and from run off from rivers that flow into the ocean.

When yacht captain, Ian Kierman returned to Australia after his yacht race, he was so disturbed about the conditions in the Sargasso Sea that he started a "Clean Up Sydney Harbour Day" at home. Soon he expanded the organization and formed "Clean Up Australia Day." Then he worked with the United Nations Environment Programme to form a "Clean Up the World Weekend." Today approximately 35 million people in 100 countries participate in Clean Up the World Weekend each year.

Questions

1. Why is the Sargasso Sea calm?
2. How can cleaning up a harbour near your home be a way to help reduce pollution in the Sargasso Sea?

Science Watch

Think Globally, Act Locally: Watching Our Waterways

For generations, Aboriginal people have used the rivers of Newfoundland and Labrador for transportation, as a food source, and as a supply of drinking water. The first European explorers travelled into the Canadian wilderness using rivers as highways. Even today, the economy of the province remains closely linked to its rivers, which are used for generating electricity, and providing people with a wide variety of recreational activities.

How can we show our appreciation for the rivers that contribute so much to our lives? One way is to hold a celebration. The United Nations has designated September 25 as World Rivers Day. Every year on that day, millions of people in countries around the world join together to celebrate their waterways. The person who first came up with the idea is Mark Angelo, who was head of the Fish, Wildlife, and Recreation Program at the British Columbia Institute of Technology in Burnaby in 1980. He, with the support of others, wanted to find a way to help the public understand the importance and fragile nature of the rivers around them. Their focus was just local at first, but soon people all across Canada were holding events to celebrate their rivers. Before long, that one good idea started by a single person turned into a worldwide environmental event.

Another way we can show our appreciation for rivers is to monitor them to ensure they stay healthy. Because there are so many rivers in the province, many of which are very long, it takes numerous people to check them. Newfoundland and Labrador has many non-profit organizations that are dedicated to monitoring and restoring the health of rivers and streams. Such groups as ACAP (Atlantic Coastal Action Program) Humber Arm Environmental Association, Inc., the Upper Lake Melville Environmental Society, and SPAWN (Salmon Preservation Association for the Waters of Newfoundland) all dedicate time to monitoring the province's rivers and streams. Some of the features they monitor are listed below.

Feature	Description
Water quality	Testing can reveal whether dissolved minerals and chemicals are present, or exist in unsafe amounts, in the water.
Stream invertebrates (spineless animals that live on river bottoms)	The amount and types of invertebrates in a river or stream indicate the quality of stream water and whether the water provides a good habitat for animals.
Riverbank vegetation	The quantity and types of vegetation living on the edges of rivers and streams indicate the health of the waterway as a habitat for plants and animals.
Salmonids	Monitoring the quantity and health of small fish can indicate whether the water in a river or stream is clean, and whether the watershed that feeds the river is free from pollutants.

Questions

1. Why are rivers an important part of the economy of Newfoundland and Labrador?
2. How does vegetation on the side of a stream contribute to the health of that stream?
3. People all over the world share environmental concerns over issues such as the pollution of waterways. What do you think it means to "think globally, act locally"?

Check Your Understanding

Checking Concepts

1. List two ways humans can affect water quality.
2. Describe two human activities that affect the quantity of water in a water system.
3. (a) What is the difference between point sources of pollution and non-point sources?
   (b) Give three examples of each.
4. Why is a point source of pollution easier to control than a non-point source?
5. How does acid precipitation affect more than just the people living in the area it falls onto?

Understanding Key Ideas

6. The world's oceans are very large compared to the world's land masses, but why is it not a good idea to use the oceans as a garbage dump?
7. How has technology influenced the process of overfishing?
8. If a species is suddenly added or removed from an ecosystem, what can happen?

Pause and Reflect

In this section, you have read about the value of Earth's water resources and what can happen if water quality is damaged. Just as important for humans and all living things is the availability of clean water. Once in a while, some areas in Newfoundland and Labrador have water restrictions. This means that normal water use must be cut back to prevent the supply from running out. What would you do if the water supply in your area became extremely low and you had to limit your consumption? In your notebook, draw a table like the one below and give it a title. Then, fill in the table with the activities from the data chart provided, deciding how you would categorize each activity (essential, limited, or non-essential).

Activities That Use Water		
Essential (activities that cannot be stopped)	Limited (activities that can be continued with limited amounts of water)	Non-essential (activities that can be stopped completely until water supply is refilled)

Amount of Water Used for 10 Typical Activities

Activity	Average Amount of Water Used Per Day (L)
Eating/drinking	~2
Washing hands	1
Brushing teeth	4
Flushing toilet	19
Shower	114
Bath	151
Washing the car	76
Watering the lawn	1900/hour
Washing dishes (machine)	57
Laundry (machine)	114/load

Chapter Review

Prepare Your Own Summary

In this chapter, you investigated how the ocean affects different climates, various aquatic environments, and how changes in water quality can affect living things. Create your own summary of key ideas from this chapter. You may include graphic organizers or illustrations with your notes. Use the following headings to organize your notes:

1. Oceans and climate.
2. Living in water.
3. Human impact on water quality.

Checking Concepts

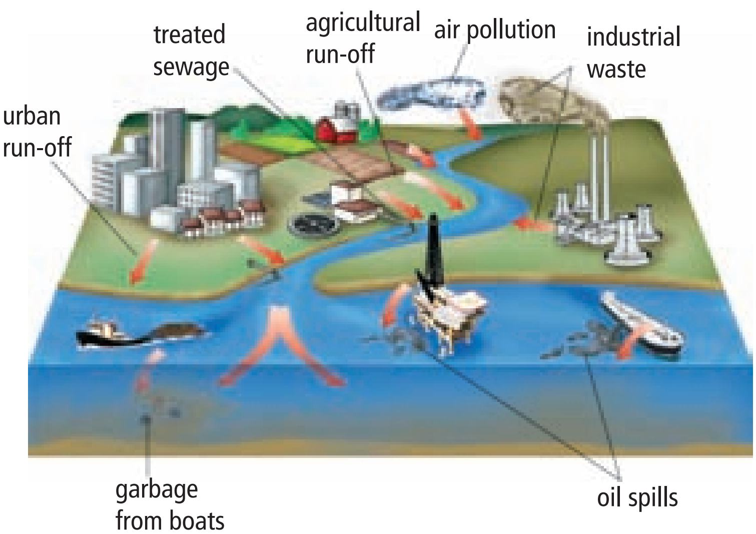
1. List four ways that wetlands contribute to a healthy environment.
2. If estuaries make up only a small percentage of Newfoundland and Labrador's area, why are they so important?
3. Why do most marine organisms live in the uppermost zone of the ocean?
4. What is meant by a point source of pollution?
5. List three non-point sources of pollution.
6. Why can we not just leave it to natural processes to decompose pollutants dumped in the oceans?
7. Describe how acid precipitation becomes part of the water cycle.
8. What effects can acid precipitation have on the natural environment?

Understanding Key Ideas

9. St. John's, NL sits at 47.37° latitude. Thunder Bay, ON is at 48.22°. While the average coldest temperature for St. John's in January is –7°C, it is –20°C in Thunder Bay. What explanation can you find to explain the temperature difference?
10. The Funk Island Ecological Reserve that is located 60 km off the Northeast coast of the island of Newfoundland, is an island that has been designated as ecologically important because of the number of seabirds that nest there. It is so important that only scientists and researchers are allowed to go on the island. Why do you think it is important to keep most people away from the island? What damage could happen if people were allowed to go on the island all the time?
11. The Newfoundland and Labrador Environment Protection Act states that no person shall "...apply, abandon, deposit, empty, pour, pump, dump, discard or otherwise dispose of used oil or used grease on public or private land, including a highway, road, lane, trail, bridge, parking area or quarry, for any purpose, including dust suppression; ...". What damage could pouring used oil along the side of a highway cause to the environment?
12. Imagine that you suspect the river in your community to be polluted. List the steps you would take to determine if the river is polluted or not.

13. Copy the table below into your notebook and give the table a title. Then, using the diagram below to guide you, fill in the table. List as many sources of ocean pollution as you can, identify whether the source is point or non-point, and suggest how the pollution problem might be solved.

Ocean Pollution		
Source of Pollution	Point or Non-point	Suggestion for Solving Problem
1.		
2.		
3.		



14. Why can your drinking water be affected by pollution in areas thousands of kilometres away from you?

15. In the search for offshore oil, companies must first use seismic testing, and then they must do exploratory drilling to see if there is enough oil to extract and make a profit. How would both of these procedures cause damage to aquatic life and habitats?

Pause and Reflect

In 1982, a United Nations committee developed the Law of the Sea treaty. This treaty or agreement tried to set rules for all coastal countries to follow in using the world's oceans and its resources. It also laid out responsibilities for looking after the oceans. Not all countries of the world agreed to the treaty. Do you think all countries should have to sign an agreement? Write a mock letter to the United Nations explaining your point of view.

Unit Summary

1 The water cycle plays a vital role on Earth.

- Water is distributed throughout the world, in the oceans, on the land, and in the ground. (1.1)
- Ocean water is different from fresh water. (1.2)
- There is a limited supply of usable fresh water. (1.3)

2 Oceans control the water cycle.

- Features of the ocean basins were created by tectonic processes. (2.1)
- Technology allows humans to explore the ocean to tremendous depths. (2.1)
- Ocean currents are created by a number of factors. (2.2)
- The effects of water can directly or indirectly change the surface of Earth. (2.3)

3 Bodies of water influence climate and species distribution.

- Ocean waters influence the world's climates. (3.1)
- There are a variety of freshwater and saltwater environments on Earth. (3.2)
- Bodies of water influence species distribution. (3.2)
- Humans are affecting the quality of water on Earth. (3.3)

Key Terms

- atmosphere
- crevasse
- density
- drainage basin
- freezing point
- glacier
- global warming
- gravity
- ground water
- hydrosphere
- iceberg
- lithosphere
- run-off
- salinity
- water cycle

Key Terms

- abyssal plain
- bays
- breaker
- continental shelf
- continental slope
- Coriolis effect
- crest
- density current
- headlands
- neap tide
- ocean current
- ocean ridges
- spring tide
- swell
- thermocline
- tidal range
- tide
- trench
- trough
- tsunami
- upwelling
- wavelength

Key Terms

- acid precipitation
- aquaculture
- bioindicator species
- bioluminescence
- climate
- convection
- estuary
- invasive species
- overfishing
- phytoplankton
- specific heat capacity
- weather
- wetland
- zooplankton

Project

Being at Home at the Bottom: Designing an Underwater Community

In this unit, you have learned much about the importance of the oceans on our planet. Humans have studied them from research vessels on the water's surface, from satellites high above Earth, and from submarines and remote-controlled vessels thousands of metres down. Some submarines can stay under water for a few months. The one thing humans have not yet done is live under the sea for years at a time.

Problem

Your challenge is to design an underwater community that you and several other adventurers could live in year round. The purpose of the facility is to serve as a research station so that people can learn much more about the ocean environment. In making your design, you will need to consider all you have learned in this unit about ocean currents, temperatures, and salinity, marine organisms, and the nature of the ocean floor. Your community must be located somewhere on the bottom of the Atlantic Ocean, but where in the Atlantic is completely up to you.

Criteria

You must complete three drawings.

- A vehicle specially designed to take people and supplies from the ocean's surface down to the community.
- A self-contained research facility.
- The community itself.

Procedure

1. Working in a group with two or three other classmates, decide what you would like to study at the bottom of the ocean. Look through the unit again if you need some ideas.
2. Decide where you would like to be located in the ocean. Research some locations that would be suitable for the focus of study you have chosen. Use a variety of sources to help you decide, such as maps, atlases, libraries, and the Internet. Your teacher will give you some guidance, or go to www.discoveringscience8.ca for suggestions.
3. Decide the number of people you will need in your community and what occupations and skills those people should have. Remember that your community must be able to meet all the needs of your underwater crew. Therefore, you must have plans for emergencies and accidents.

Report Out

1. Present your designs to the class. Compare your design and location with what your classmates chose.
2. Answer each of the following questions with a brief paragraph in your notebook:
   (a) What was the hardest thing to plan for in your underwater community?
   (b) When you compared your community with other groups' designs, did you notice anything you were missing? What would you change in your design to make your community better?
   (c) What did you learn from this activity:
      (i) about the ocean?
      (ii) about working in groups?

Wrestling Energy from Waves

Using the energy of oceans to provide electricity has been a tempting idea for years. Some researchers have estimated that if we could capture just a couple of hours' worth of the wave energy that pounds the coastlines of the world on any given day, we would have enough energy to power all the households in Newfoundland and Labrador for a whole year. Until recently, however, technology did not exist that could make this possible. Now, more than 100 companies around the world are racing to be the first to safely, efficiently, and cheaply harness the energy of the oceans.

Background

Using the oceans as a source of energy is appealing for two important reasons: ocean water is in good supply and the amount of energy available is tremendous. The main challenge is in designing the best way to harness that energy in a way that is not too costly, or does not harm the environment.

Currently, scientists are concentrating on three sources of energy from the oceans:

Energy Source	Description
Ocean currents	The force of undersea currents moves paddles or blades around a wheel, converting the energy of the currents into electricity.
Ocean waves	Floating machines transfer wave energy into electricity.
Tidal currents	Spinning wheels (turbines) convert tidal power to electricity.

Tidal power station in La Rance, France

Find Out More

Choose one source of ocean energy from the table and research the methods used to convert the energy to electricity. Use the Internet (start at www.discoveringscience8.ca), magazines, and newspapers. In addition, you may want to contact Memorial University (the Department of Physics and Physical Oceanography).

Report Out

Create a poster to display the results of your research. Be sure to include some information on historical attempts to harness ocean energy.

Organize a debate on the pros and cons of trying to use ocean energy. Consider the following factors:

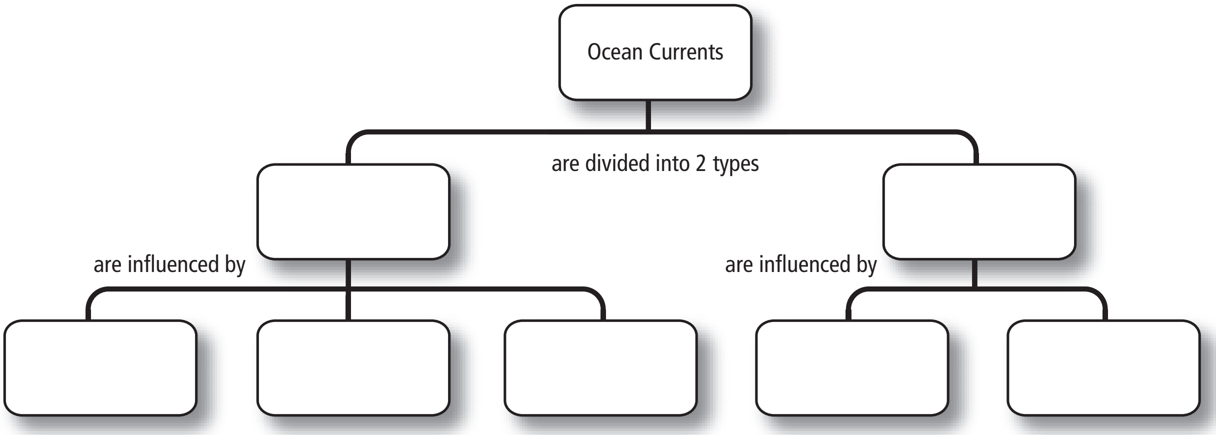
(a) environment (Will the method affect sea life in any way?)

(b) transportation (How will the method affect water transportation?)

(c) recreation (Will the method affect people's enjoyment of the beach or water?)

Visualizing Key Ideas

1. Copy and complete the diagram below using the following vocabulary: surface current, Coriolis effect, uneven heating in the atmosphere (winds), temperature, salinity, deep water current, shape of continents



Using Key Terms

2. Copy the following table into your notebook. Then, write each term from the vocabulary list below in the appropriate column.

Found Only in the Oceans	Found on Land and in the Oceans

(a) abyssal plain
(b) continental slope
(c) mountains
(d) volcanoes
(e) tectonic processes

3. Classify each of the following descriptions as being a point source of pollution or a non-point source of pollution. Put a check mark in the appropriate column.

	Point Source of Pollution	Non-point Source of Pollution
(a) An ocean tanker spills thousands of litres of oil.		
(b) Oil and grease run off from city streets.		
(c) Fertilizers from farms leak into rivers.		
(d) A landfill leaks toxins into groundwater systems.		
(e) Industrial waste flows through storm sewers into rivers.		

Checking Concepts

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4. Where is most of Earth's fresh water located?
5. What is the main difference between water found in the ocean and water found in a lake?
6. How is water naturally stored in the ground?
7. What is happening to most glaciers today?

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8. What are the large, flat areas of ocean basins called?
9. Name three types of technology that are helping us to explore ocean basins.
10. Name three factors that affect surface currents in the ocean.
11. Describe what happens when cold, dense water meets warm, less dense water.
12. Define and illustrate the following wave features:
    (a) wave length
    (b) wave height
    (c) crest
    (d) trough

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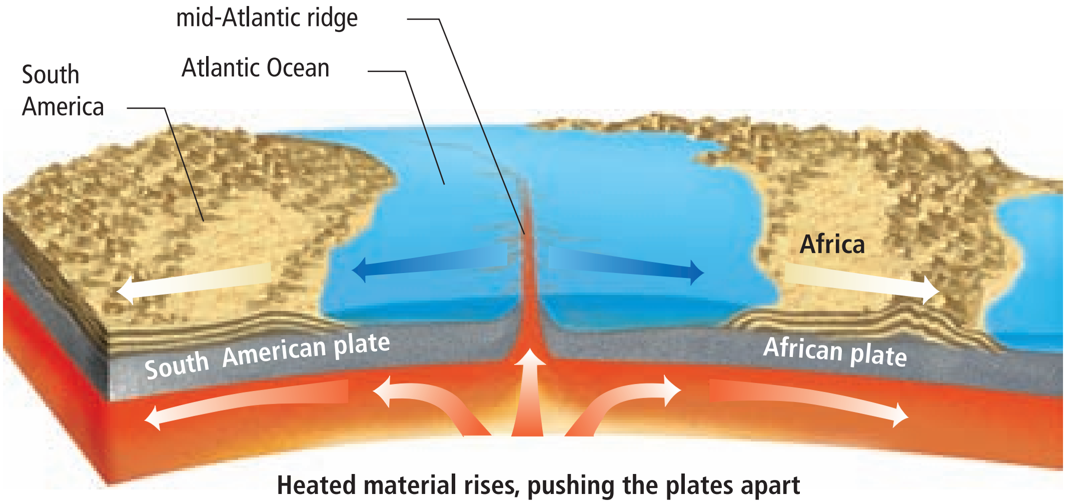
13. Compare and contrast weather and climate.
14. How are ocean currents related to climate?
15. What are wetlands?
16. How is acid precipitation created?
17. Name three problems that humans have created in the Atlantic Ocean.

Understanding Key Ideas

18. Besides erosion by rivers, describe two other ways the surface of the land can be changed by water. Give examples from Newfoundland and Labrador's coast.
19. Describe how the shape of a headland compares with the shape of a bay.
20. Explain the following statement: "Climate is affected by ocean water's high specific heat capacity."
21. (a) Explain the connection between weather and climate.
    (b) Predict what would happen to climates if ocean currents suddenly stopped.
22. Outline the similarities and differences between wetland environments and estuary environments.
23. The salinity of ocean water at the equator is high because the Sun causes water to evaporate, leaving salt behind. If this was the only process acting on ocean water, there would be far more salt than water in oceans. Explain why this is not happening.

24. The figure below shows the location of South America and Africa on opposite sides of the Mid-Atlantic Ridge. The continents are about the same distance away from the ridge. The oldest rock on the ocean floor is about 200 million years old, and can be found at the continental margins. What do the present locations of South America and Africa suggest about their locations 200 million years ago?



Heated material rises, pushing the plates apart as they produce new sea floor material.

25. Winds have a great effect on the surface currents of the oceans. Deeper down in the ocean, however, the effect of wind is minor, but there is still much movement of the water. Write a short paragraph describing the factors that cause currents in deep ocean water.
26. Explain why weather along a coast is different from weather farther inland.
27. What factors affect the variety and productivity of plants and animals in a freshwater environment?

28. As you have learned in this unit, most glaciers around the world are receding (because they are melting). The table below shows the amount a particular glacier has receded over a five-year period.

Year	Amount Glacier Has Receded (m)
2001	3.0
2002	2.5
2003	4.0
2004	6.8
2005	7.3

(a) Graph the data for the receding glacier in a properly labelled graph.

(b) Connect the dots with a smooth line. What does the slope of the line indicate about the amount the glacier has receded in recent years?

(c) Why do you think the glacier has receded by different distances each year?

(d) With a different coloured pen from what you used in (b) above, draw a straight "best-fit" line through the points. The slope of the line will give you the average rate the glacier has receded during this period of time. Calculate the average using the formula: slope = rise/run. What is the average rate the glacier has been receding per year?

(e) If the glacier is 2.0 km long right now, how long will it take to completely disappear if its average rate of receding does not change?