19 Water Transportation Systems

Basic Concepts

- Define *buoyancy*.
- Identify several water vehicles.

Intermediate Concepts

- Discuss the different routes of water transportation.
- Describe how a boat floats.
- Explain the modes of water transportation.

Advanced Concepts

- Research and determine major sea-lanes used in transoceanic transportation.
- Calculate buoyancy and displacement.

Water transportation has always been an important method of transporting people and goods. It is also the most efficient way of moving goods across the oceans. Water transportation has been in development for many years.

The History of Water Transportation

Over 70% of the earth's surface is covered with water. See **Figure 19-1.** Water has made it possible to transport people and cargo over greater distances than by land transportation. ***Waterways*** are the bodies of water in which vessels travel. A ***vessel*** is another term for a water vehicle. Typically, ***boats*** are water vehicles less than 100′ in length. ***Ships*** are any craft over 100′ in length. Drawings and remains of boats have been found that date back over 5000 years. Not all historians agree, however, that this was the beginning of water transportation. Some believe water transportation was used over 50,000 years ago, when the Aborigines settled in Australia. The spread of civilization to new continents and remote

Figure 19-1. This picture of earth, viewed from space, shows the large proportion of water to land. The continents are patterned with dots of lakes and lines of rivers. Many of these are waterways that have been used in the development of transportation. (National Aeronautics and Space Administration)

parts of the world was only possible by water transportation. Ships and water transportation have been essential to the exploration, settling, and development of our world.

The building of boats and ships has been dependent on the technology that was available to the builder. In the beginning, logs were used to transport people and goods by water. Rafts and dugout canoes were among the first water transporting vehicles. See **Figure 19-2.** Eventually, the early shipbuilders turned to new methods of construction. In Europe and Asia, the builders created wooden frames. Animal skins were then stretched over the wooden frames of the boats. This extended the lives of the boats for a longer journey. Skins were also sewn together, inflated, and used like rubber rafts. Instead of using skins, the Native Americans used bark to construct canoes, similar to the way fiberglass is used today. These boats were powered by hand, using sticks and, later, oars and paddles.

The technology and methods of boatbuilding continued to advance. Boats became larger and able to travel greater distances. These became known as ships. Early ships were constructed of wooden planks sealed

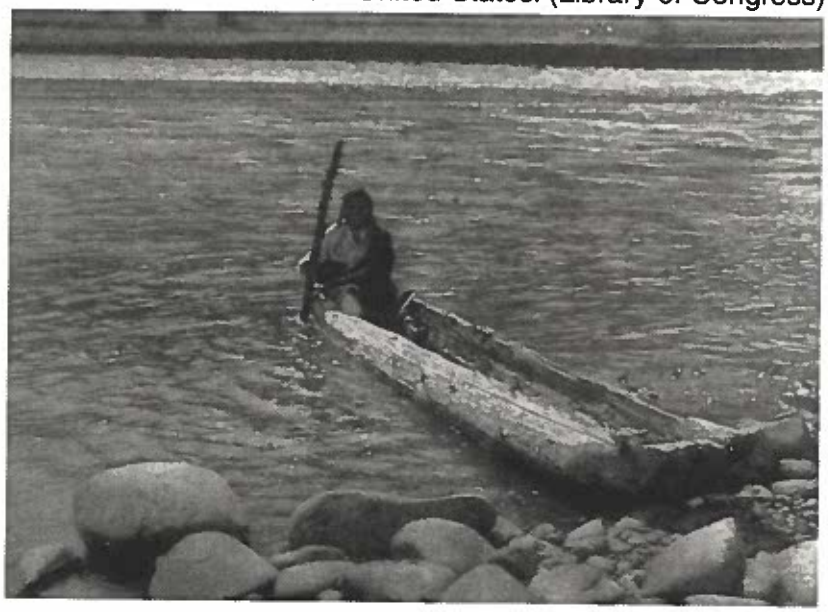
Waterway: A body of water in which vessels travel.

Vessel: A water vehicle.

Boat: A water vehicle less than 100′ in length.

Ship: A water vehicle over 100′ in length.

Figure 19-2. Dugout canoes are made from logs that have been hollowed out. These canoes could carry several people and a small amount of cargo. This photo, taken in about 1910, shows a member of the Nez Perce tribe using a dugout canoe in the northwestern United States. (Library of Congress)



with tar or pitch. Newer ships built by the Phoenicians, Egyptians, and Romans were powered by both human and wind power. The human power was produced by many people rowing large oars. Sail power was first used around 3500 BC. Over time, sails became the sole source of power for ships. See **Figure 19-3.** In the fifteenth through the seventeenth centuries, the development of vessels brought about further improvements. Four- and five-masted ships were built so more sails could be added to propel larger, heavier ships. Some could carry 1000 tons of cargo. The use of sail power remained the popular form of propulsion until into the nineteenth century.

GREEN TECH
The steam turbines used to power larger ships produce carbon emissions. Some organizations are dedicated to creating a more environmentally friendly way to travel using water transportation.

By the late 1700s, sailing ships were being constructed of iron and, later, steel, rather than wood. Along with the iron ships came another new power source. In 1783, a Frenchman, Claude de Jouffroy d'Abbans, added a steam engine to his boat, the *Pyroscaphe.* John Finch was the first American to power a steamboat in the United States. The first successful steamboat, however, was the *Clermont,* built by Robert Fulton in 1807. The *Clermont* used a steam engine to power a paddlewheel. See **Figure 19-4.** The early steam engines were very expensive to operate and not very reliable. Advances in technology, however, led to the development of the steam turbine. The steam turbine was efficient and reliable. Its advantages put an end to sail power for all but recreational boating. The steam turbine was a system that used a steam engine to turn a propeller. In 1839, the first propeller-driven ship was put into service. The use of propellers opened up a large amount of room that had been used for either sails or the paddlewheel. This meant ships could carry more passengers and cargo. At this time, ships also became larger, and the first ocean liners

Figure 19-3. This large sailing vessel is the clipper ship *Three Brothers,* which was 328′ long and 48′ wide. The large sails on the ship harnessed the power of the wind. Large wooded spars called masts supported the sails. The ship is shown in an 1875 color lithograph under full sail, with 30 sails set. (Library of Congress)

Figure 19-4. Steam engines were developed long before other types of heat engines and were extensively used to propel boats on the Mississippi and other major rivers in the 1800s. Today, old stern-wheelers, such as the *Delta Queen*, are used as cruise ships for vacationers on inland waterways. In addition to restored vessels, such as the *Delta Queen*, new boats with the appearance and functions of old steamboats have been built for cruising. The *Mississippi Queen*, in the background, is one such recreated steamboat. (Delta Queen Steamboat Company)

were built. Ocean liners are huge ships built to transport passengers around the world. Some of these ships are very luxurious. This type of ship was used for passenger travel from the early 1900s to around 1950. The number of passengers greatly declined in the 1950s, due to the speed and availability of air transportation.

Today, the shipping of cargo is the main use of water transportation. See **Figure 19-5.** Water transportation plays a part in nearly all U.S. imports and exports. The cargo ships today still use propellers. They are

Figure 19-5. Cargo ships carry billions of tons of raw materials and finished goods each year to ports around the globe. Many are built to carry general cargo. Others are specially designed for standardized shipping containers. Still others are huge floating tanks for oil, gasoline, and other liquids.

no longer, however, steam powered. Diesel engines are used in ships to turn the propellers. Gasoline engines, as well as human and sail power, are only used today in small recreational boats. Even nuclear power is used in some vessels. There are many kinds of vessels in the water transportation system.

Water Routes

Water transportation vehicles cannot operate without water. The main purpose of a waterway is to allow vessels to travel the safest and most efficient route from one port to another. The waters on these routes must be ***navigable***. They must be deep enough and wide enough for the boat or ship to travel through. See **Figure 19-6.** The vessels must be able to float through freely and avoid dangerous situations. If some of the waters are not navigable, serious accidents can occur. The vessel can hit large rocks and sink or run aground in shallow waters. There are two major types of waterways. They are known as sea-lanes and inland waterways.

Navigable: Deep and wide enough for a boat or ship to travel through.

Sea-Lanes

Ships and other vessels rarely collide at sea because they take regular routes when traveling across the ocean. These routes are known as ***sea-lanes***, or trade routes. The use of established sea-lanes allows vessels to travel across the waters, while avoiding other marine traffic. The sea-lanes are not marked like roads. Instead, they are shown on navigation maps and charts. A vessel must be navigated to stay in the proper sea-lane. Navigation of a vessel is simply the guidance of it. Vessels follow the sea-lanes with the aid of navigation equipment, such as compasses,

Sea-lane: A regular route taken by ships and other vessels when traveling across the ocean. Also called trade routes.

Career Connection

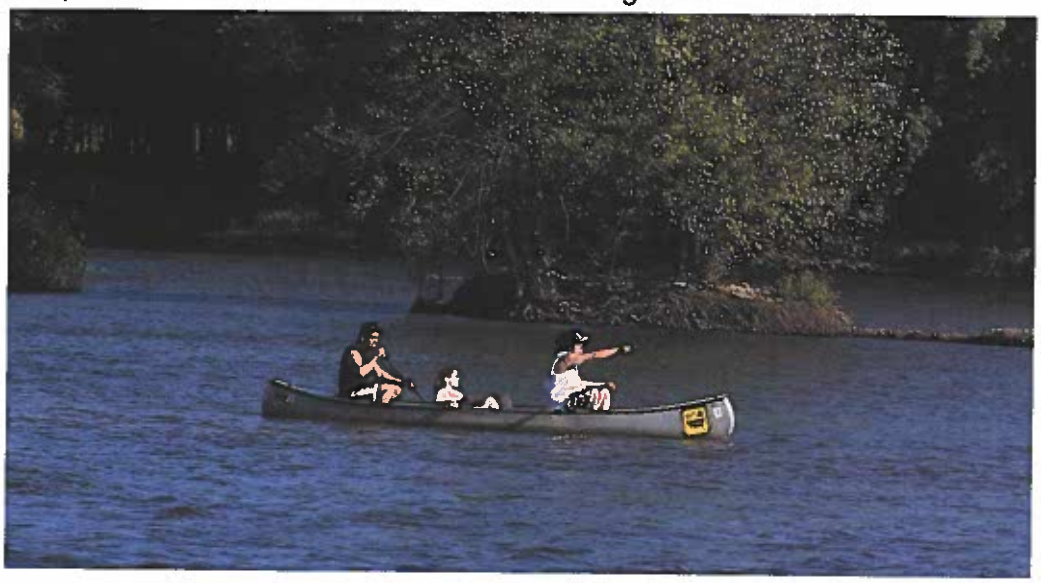
Merchant Marine Sailors

Commercial ships are used to transport goods within the nation and throughout the world. Those operating in the United States or outside the United States, but under the American flag, are known as the merchant marine. The people working on the ships are referred to as merchant mariners. The largest group of merchant mariners is sailors.

Sailors are used on ships to perform maintenance and keep the ship in operating condition. They are also used to keep watch and check water and ship conditions. Sailors report to either the captain or the ship's mate. They often work in 4- or 6-hour shifts, 24 hours a day and 7 days a week. Sailors are usually hired for one voyage at a time, although the voyage may last several months. When they return to port, they must find their next voyage. This means there is little job security, but this occupation allows for much flexibility.

Beginning sailors are required to have only a high school diploma. Many participate in training sessions, however, at union schools. Sailors must receive merchant marine documentation for the U.S. Coast Guard. With work experience, sailors can advance to the rank of able seaman and receive certification from the Coast Guard. Sailors typically begin employment near minimum wage. The median salary for sailors, however, is near $17 per hour.

Figure 19-6. Canoes and other small craft can safely navigate narrow, shallow waterways, such as this river. Large cargo ships, however, must have deep water and sufficient room for maneuvering.



sextants, radio detecting and ranging (radar), computers, satellites, and charts. Ship navigators also rely on various physical landmarks, such as lighthouses, stars, and buoys. Guiding a vessel is not an easy task. The navigator must be very familiar with the waterway, as well as with the vessel. Sea-lanes exist for most routes connecting foreign countries. All the countries affected by the ship's travel have a voice in determining the route of the sea-lane. Surprisingly, there are only a few routes all ships use to travel to and from the major ports of the world. When ships transport cargo between two ports on the same continent, they often use coastal sea-lanes. These sea-lanes are within 20 miles of the coast.

Inland Waterways

Inland waterway: A route taken on canals, rivers, and lakes.

Sea-lanes are routes used on the ocean. There is also a great amount of water travel, however, on other bodies of water. The routes taken on canals, rivers, and lakes are known as ***inland waterways***. Land surrounds all these waters. Inland waterways offer much guidance to a vessel. The vessels have limited routes on which to travel. Inland waterways are used for recreation, as well as for moving cargo.

Purposes and Principles of Water Transportation

Water transportation is just as important as any other form of transportation. It is used to transport both people and cargo. Cargo transported by a vessel includes oil, grain, heavy equipment, iron ore, and many other types of material. Transporting of bulk commodities is a great advantage of water transportation. Water transportation is more fuel efficient, economical, and inexpensive than other forms of transportation when carrying large amounts of cargo. It has contributed greatly to the expansion of our country. We still depend on it to a large extent.

If you have ever seen a large tanker transporting oil or a cruise ship carrying people, you may have wondered how these vessels stay afloat. See **Figure 19-7.** Archimedes first explained the principle that describes the concept of flotation. He stated that when an object is submerged in a liquid, the upward force on the object is equal to the weight of the displaced fluid. This principle explains what is known as buoyancy. ***Buoyancy*** is the upward force the water exerts on objects placed in it. See **Figure 19-8.**

Figure 19-7. This 300,000-ton tanker is made of steel and carries a heavy cargo of crude oil, but it remains afloat because its weight is less than the weight of the displaced water. (Shell Oil Company)

Buoyancy: The upward force water exerts on objects placed in it.

The second half of Archimedes's theory describes displacement. Displacement is the weight of the water the object pushes aside. According to Archimedes's principle, when the amount of buoyancy (upward force) is equal to or greater than the amount of displacement (water pushed aside), as the object is put into the water, it will float. See **Figure 19-9.** On the other hand, if the object displaces less then the upward force, it will sink. Another way to think about displacement is to imagine placing a water vessel into wet concrete. When the ship is removed, the shape of the vessel will remain. If you fill the shape with water and weigh it, you will find the amount of displacement. See **Figure 19-10.**

Figure 19-8. Buoyancy is the reason objects will float in water. It is the power of a fluid to exert an upward force on a body placed in it. Buoyancy is the principle that makes objects appear to be lighter underwater.

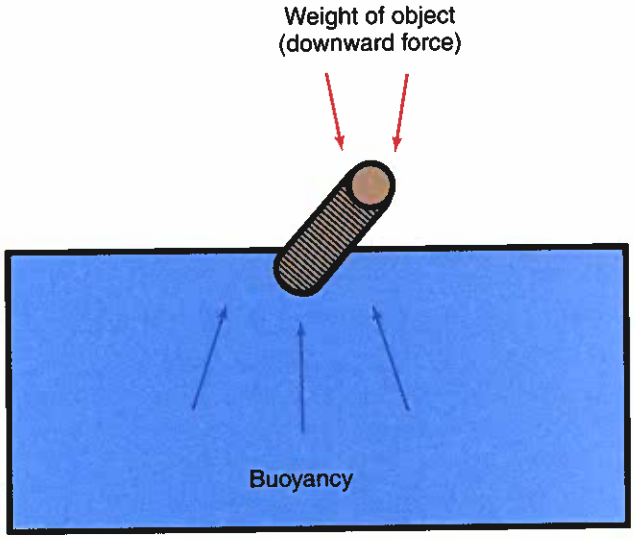
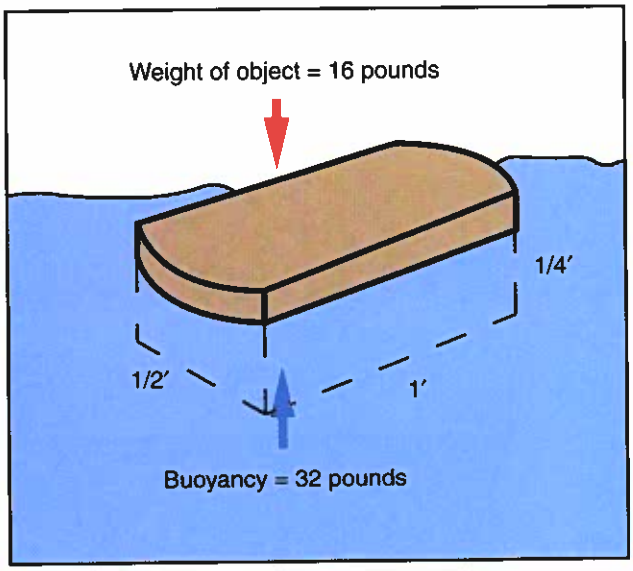


Figure 19-9. Metal will float in saltwater because the buoyancy is greater than the weight of the metal.



STEM Connection

Math: Buoyancy Calculations

When an object is placed in water, the water exerts an upward force on the object. This force is equal to the weight of the water the object displaces. In other words, the force is equal to the weight of the water that would occupy the volume of the object beneath the surface of the water.

The density of water is 62.4 pounds per cubic foot (pcf). This means that a cube of water 1′ long on each side weighs 62 lbs. If you know the weight of a boat, you can calculate the volume of water that needs to be displaced in order for the boat to float.

For example, a fully loaded barge weighs 10,000 tons (or 20 million pounds). To calculate the volume of water that needs to be displaced for the barge to float, use the equation of density:

Density = Weight / Volume

Solve the equation algebraically for volume:

Volume = Weight / Density

Substitute the weight of the barge and the density of water:

Volume = 20,000,000 lbs. / 62.4 pcf
= 320,513 ft^3

If you know the dimensions of the barge, you can also calculate how deep the barge must sink in order to float. Assume the barge is 300′ long and 90′ wide. The volume of a rectangular box is length × width × height. Therefore, you can use the following formula:

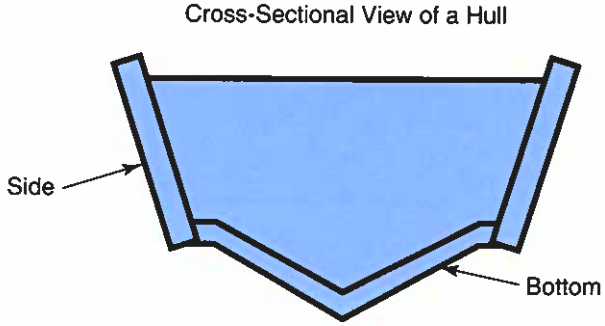
Volume of displaced water = Barge length × Barge width × Depth of water

Rearranging the equation to solve for Depth of water:

Depth of water = Volume of displaced water / (Barge length × Barge width)
= 320,513 ft^3 / (300′ × 90′)
= 11.9′

When fully loaded, the barge must sink 11.9′ deep to displace enough water to equal its weight. If sides of the barge are 20′ deep, the barge will float. If however, the sides are only 10′ deep, the barge cannot displace enough water to support its weight, and it will sink.

Figure 19-10. Boat hulls are designed for great buoyancy.



Modes of Water Transportation

There are many types of water vehicles used to serve several purposes. Several types of vessels have been in existence since the days of Phoenician and Roman shipbuilders. These ships were used for the transportation of people, the movement of cargo, and war. The same types of ships still exist today. Passenger vessels are typically used to transport people

recreationally. Cargo-moving vessels transport goods within and between countries. The armed forces use military vessels in many applications. One of the newest water vehicles is the specialty craft. Specialty vessels are built to handle unique situations, such as breaking ice in the polar regions or examining wreckage at the bottom of the ocean. See **Figure 19-11.** Water transportation vehicles travel in one of two modes. See **Figure 19-12.**

- **Inland water transportation.** This is transporting people or cargo on inland waterways, including rivers, canals, and lakes.
- **Transoceanic water transportation.** This is transporting people or cargo across an ocean.

Canal: A channel constructed to connect two bodies of water.

GREEN TECH

The National Oceanic and Atmospheric Administration (NOAA) is a government organization that is focused on how we have affected the oceans and how we can repair the damage that has been done.

Figure 19-11. An icebreaker is a specialty vessel designed to perform a specific task. The U.S. Coast Guard cutter *Polar Sea* has a heavily reinforced bow to break through thick ice. (U.S. Coast Guard)

Inland Waterway Systems

Inland waterways include any body of water within a landmass. Two important North American inland waterways are the Saint Lawrence Seaway and the Great Lakes. See **Figure 19-13.** Often, inland waterways are connected by canals. A ***canal*** is a channel constructed to connect two bodies of water. Various kinds of vehicles are designed for use on inland waterways.

Figure 19-12. These are the vehicles used in the two modes of water transportation.

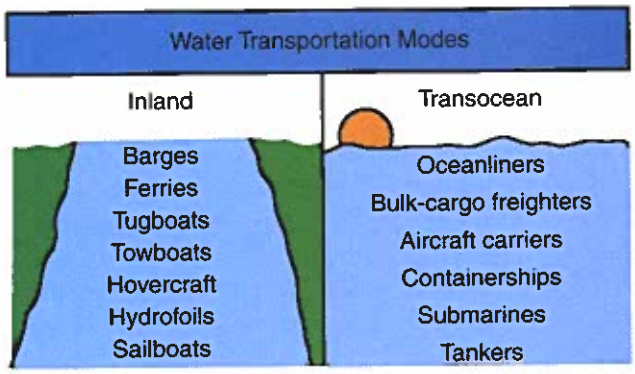


Figure 19-13. The Saint Lawrence Seaway connects the Great Lakes with the Atlantic Ocean. The waterway allows oceangoing cargo ships to serve ports as far west as Duluth, at the western tip of Lake Superior. Port locations are shown as dots on the map.

Technology Link

Construction: The Panama Canal

At times, transportation systems require structures to be built to increase the efficiency of moving goods and people. In some cases, these structures are considered to be amazing feats of engineering marvel. The Panama Canal is one such construction project. It has been regarded as one of the great engineering achievements in the history of the world. This canal is also an enormous resource in the global transportation system. Nearly all ships that cross South America use the Panama Canal. Few ships would choose to sail around South America, adding an additional 8,000 miles to the trip, rather than cut across it. It takes between 8 and 10 hours to cross the canal and requires a toll. The average toll is $45,000, which may seem like an enormous amount of money, but compared to the cost and time it takes to travel around South America, it is economical for ships to pay the toll.

The French started the construction of the canal in the late nineteenth century. They, however, quickly went bankrupt. The United States, several years later, took over the project and completed it in 1914. The construction of the canal required an infrastructure to be built to accommodate the workers and the machinery. Houses and villages with bakeries and other services were constructed to house the 19,000 construction workers who built the canal. The Panama Railroad was also built to handle the movement of the heavy construction equipment. During construction, 239 million cubic yards of earth was moved. This is enough dirt to fill the Metrodome in Minneapolis, Minnesota four times.

The finished Panama Canal is 50 miles long and is 85′ over sea level at its highest point. Ships go through a series of three locks throughout the passage from the Atlantic to the Pacific Oceans. The locks are used to raise or lower the ships to the height of the water on the opposite side of each lock. Ships that pass through the canal must be less than 965′ in length and 106′ in width. Unfortunately, many of the supertankers and large containerships being built today are much larger than the canal will permit. Due to this problem, there is much discussion about either widening the canal or creating an entirely new canal.

Barges

Barges are flat ships with blunt ends that carry very heavy loads of cargo. See **Figure 19-14.** A barge can carry up to five times its own weight. About three-fourths of all the cargo carried by water is transported by barge. A barge is not a very attractive vessel. It is not very fast either. Barges are, however, very safe. The smoothness of their rides and the amount of weight they can carry have no equals. Barges carry liquids, solids, and gases. The most common types of barges are the open hopper, covered dry cargo, liquid cargo, and deck. Such barges can carry coal, ore, oil, and grain.

Figure 19-14. Most barges have no engines. Some other vessel or series of vessels must, therefore, push or pull them. A towboat is pushing these barges. (National Park Service, Natchez Trace Parkway)

Towboats and tugboats

Towboats and tugboats are not often thought of as different from each other. They are, however, very different. A ***towboat*** is designed to push barges. See **Figure 19-15.** A towboat has a wide, flat front end to allow more surface area for pushing barges. ***Tugboats***, on the other hand, are designed to pull barges. They are very powerful. Tugboats are also used to pull ocean liners in and out of ports and help dock and undock other oceangoing vessels.

Towboat: A vessel designed to push barges.

Tugboat: A vessel designed to pull barges.

Hydrofoils

Hydrofoils operate on inland and coastal waters. See **Figure 19-16.** A ***hydrofoil*** is a passenger-transporting vessel, similar to a plane and ship put together. Hydrofoils have been used to transport people across big lakes and up and down rivers, channels, and canals. A hydrofoil has

Figure 19-15. Towboats, such as this one, are used to push barges along the inland waterways. Note the heavy pushing blocks at the front (bow) of the towboat.

Figure 19-16. Hydrofoils lift watercraft out of the water, much like wings lift planes into the air. In either case, power is needed to move the craft forward at high speed. (Turbo Power, United Technologies Corporation)

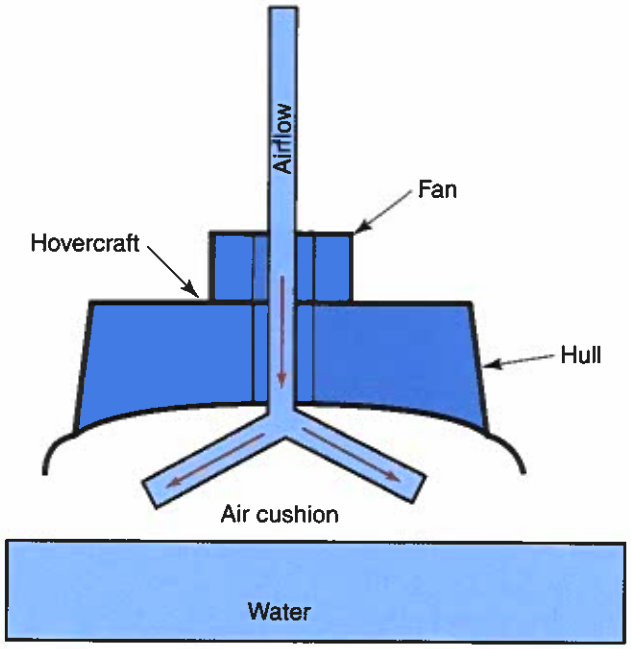
Hydrofoil: A passenger-transporting vessel, similar to a plane and ship put together. It operates on inland and coastal waters.

wings called foils. It develops its lift from the buoyancy of the water, just as an airplane receives lift from the air. As the watercraft reaches high speeds, the foils lift it out of the water. The boat is then sailing along at high speeds, just skimming the surface of the water.

Hovercraft

A hovercraft is a vessel that rides on a cushion of air. Hovercraft are also referred to as ***air-cushion vehicles***. Air pressure allows the vessel to hover (remain suspended) in the air a few feet above the water or land. The vessel makes no contact with the water or land. It just rides along on a cushion of air. See **Figure 19-17.** Gas turbine engines drive large, high-speed fans that bring in air. The air is then forced down around the base on all sides. This forms the cushion of air. Hovercraft are used for several different applications, including military, rescue, and recreation.

Figure 19-17. The basic design of the hovercraft. A cushion of air keeps the hull suspended above the surface.



Ferries

Ferries are vessels that move people and vehicles across narrow or small bodies of water. See **Figure 19-18.** Ferries are usually used along coastal waters and on inland waterways. They transport passengers to and from islands and across rivers. One of the most popular is the Staten Island Ferry in New York Harbor. Another important ferry travels between the mainland and Vancouver Island in British Columbia, Canada. A roll-on/roll-off (RO/RO) vessel is the type of ferry used to transport vehicles. These boats allow passengers to drive their cars onboard. Larger RO/RO vessels have several levels, much like a parking garage. These usually operate in areas where time can be saved by transporting automobiles across the water instead of driving around the coastal areas.

Figure 19-18. This ferry carries passengers and vehicles between Victoria, Vancouver Island, Canada and Port Angeles, Washington.

Commercial fishing boats

Commercial fishing boats are used in inland and coastal waters. The type of fishing boat used depends heavily on the type of fish being sought. The three main types of fishing boats are trawlers, seiners, and liners. The main differences between the three are the type of capturing methods they use. Trawlers use trawl nets, which are cone-shaped nets dragged behind the boat. The fish swim into the net. Seiners use seine nets, which are placed around the area and then closed on the fish. Liners are boats in which fish are caught

by hook and line. The lines can be operated mechanically or by fishermen. These boats have storage tanks onboard to carry the fish they catch.

Cruisers

Cruisers are boats that can be used for both inland and transoceanic pleasure trips. See **Figure 19-19.** Cruisers are divided into three classes: Class 1 includes boats 16–26′ in length, Class 2 includes boats 26–40′, and Class 3 includes boats 40–65′. Class 2 and 3 cruisers can be used to travel around the globe. Cruisers can be powered by engines or sails and are used for pleasure cruising in the coastal, inland, and ocean waters. These boats are sometimes referred to as yachts. Yachts have cabins for sleeping, navigation areas, and small kitchens. Large cruisers can have enough space for up to 12 people.

Recreational water transporting vehicles

Other forms of water vehicles are often found in smaller lakes and rivers. Such vehicles are most often used for recreational purposes. Sailing and windsurfing are very big sports along the coastal areas and northern lakes. Sailboats are common water vehicles. Jet skiing has become a popular pastime on the water. Pontoon boats, speedboats, canoes, rafts, and paddleboats are some other examples of water vehicles most often used for leisure. See **Figure 19-20.**

Figure 19-19. Cruisers and yachts are larger water recreation vehicles. Some are large enough to cross oceans. Sails or engines can power yachts. These sailing yachts are berthed at Annapolis, Maryland, on the Chesapeake Bay.

Transoceanic Waterway Systems

Another mode of water transportation is transoceanic waterway systems. ***Transoceanic*** means traveling across the ocean. Many vessels are designed for transoceanic travel. Some of the vessels carry cargo, and others carry people. As mentioned earlier, vessels traveling across the ocean follow sea-lanes (established routes). They stay within the designated sea-lanes by being navigated. Some transoceanic vessels are ocean liners, freighters, tankers, containerships, aircraft carriers, and submarines.

Air-cushion vehicle: A vessel that rides on a cushion of air. Also called a hovercraft.

Ferry: A vessel that moves people and vehicles across narrow or small bodies of water.

Transoceanic: Traveling across the ocean.

Ocean liners

Ocean liners are basically for luxury use. Cruise ships and ocean liners can carry thousands of passengers. Most people travel on ocean liners for a relaxing vacation. Ocean liners are very large and often have several decks. Decks may include bedrooms, swimming pools, restaurants, and game rooms. One of the most famous ocean liners is the *Queen Elizabeth II* from England. There are not many ocean liners in use today. Cruise ships

Figure 19-20. Recreational boats are also a form of water transportation. A—Windsurfing involves a surfboard fitted with a sail. (Howard Bud Smith) B—Sailboats are popular on all types of waterways. (Howard Bud Smith) C—Pontoon boats are used most often on rivers and small lakes.

A

B

C

are much more common. They are smaller. Some are a quarter of the size of an ocean liner. Cruise ships can dock at smaller ports around the world. They are primarily used for vacation purposes, rather than for transporting people to a final destination.

Bulk-cargo freighters

Bulk-cargo freighters are ships designed to carry very large quantities of cargo. Freighters usually have a series of holds, or storage areas, below the main deck. See **Figure 19-21.** Several different kinds of cargo can be carried, each in a different hold. Freighters carry such goods as coal, ore, oil, grain, sugar, cotton, and cement. The cargo is referred to as dry bulk or liquid bulk. An ore, bulk-cargo (OBO) freighter carries coal, grain, ore, and oil. An advantage to such a vessel is its ability to carry several types of cargo at one time. As it unloads a hold at one port, it can fill that hold up with something else and continue on its route.

Tankers

A tanker is a vessel designed to carry liquids. It has tank-shaped holds (sections) for carrying oil, petroleum products, chemicals, wine, and even molasses. The most common tanker is that for transporting oil. A tanker is constructed of two or three long tanks, which are divided into sections. By dividing the tanks in sections, the liquid will not move so much during transport. This makes the ship easier to handle and less likely to capsize. Because the cargo on a tanker is liquid, large pumps and hoses are used for loading and unloading. Large ocean tankers can carry up to 2 million barrels of oil.

Containerships

Containerships are very large and carry cargo stored in containers before loading. See **Figure 19-22.** If you took several milk cartons and stacked them in a rowboat, you would have the same concept, on a much smaller scale, as a containership. The containers are airtight, permanent, reusable, watertight, and fitted with at least one door on the end. Some containers are made of steel, but most are made of aluminum because it is a lighter metal that does not rust. The containers vary in length. Some are the size of a semitrailer. Containerships save time and money in the loading and unloading of cargo.

Figure 19-21. A bulk-cargo carrier has a series of holds that look like containers. These carriers are also called ore, bulk-cargo (OBO) ships because they carry ore, bulk-cargo, and oil.

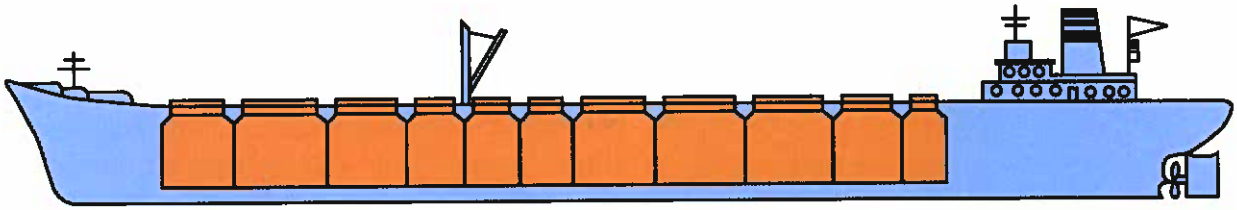
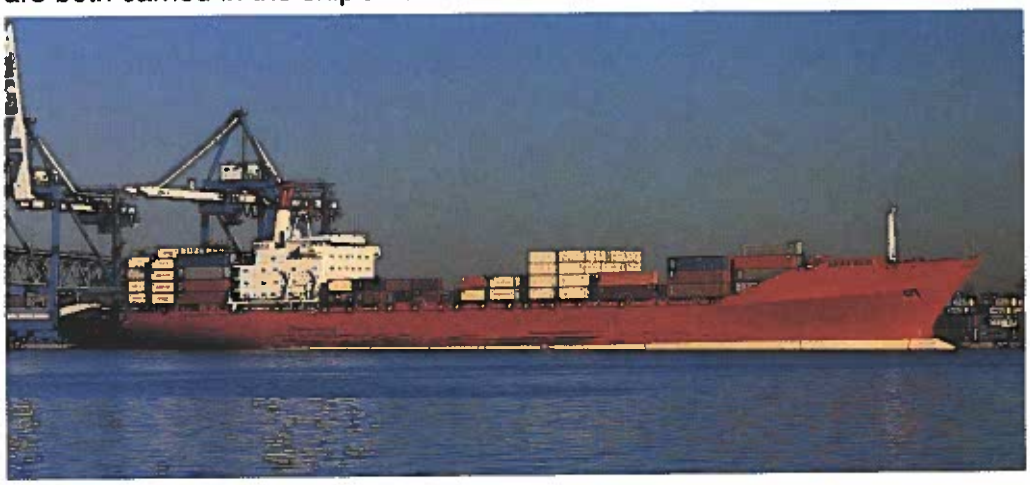


Figure 19-22. Containerships carry standardized metal boxes, called containers, which make cargo storage and handling more efficient. Containers are both carried in the ship's hold and stacked on its deck.



GREEN TECH

Containerships have also been known to affect the environment adversely. Because of the way the ships are balanced while loading and unloading, they may pollute the water with oil.

Military craft

Military water vehicles help to protect the nation and its interests around the world. The largest military craft is the aircraft carrier. An aircraft carrier is a very large ship with a padlike deck. Aircraft carriers carry fighter jets for the navy. The large deck allows the jets to take off and land. See **Figure 19-23.** The *Nimitz* class, which is the

Figure 19-23. An aircraft carrier is a "floating airport," with a large deck that provides room for planes to take off and land. Planes are stored and maintained on a large hangar deck below the flight deck. This is the aircraft carrier *Harry S. Truman.* (U.S. Navy)

Figure 19-24. Nuclear-powered submarines, such as the *USS Key West*, can remain submerged for months at a time. The tall structure is known as the conning tower, or "sail." (U.S. Navy)

largest type in the U.S. Navy, is over 1000′ long (over three football fields) and weighs 97,000 tons, fully loaded. These carriers can carry 85 aircraft and a total of 5680 people. Two other types of U.S. warships include cruisers and destroyers. Destroyers are smaller and faster than cruisers. Both can be used for surface combat, as well as antisubmarine and anti-aircraft attacks. The military also has amphibious vehicles for landing troops and combat vehicles on land.

Submarines

Submarines are vessels that can submerge and travel underwater. See **Figure 19-24.** These vessels are used to explore the ocean and for military purposes. The first American submarine was the *Turtle*, built by David Bushnell in 1775. The *Turtle* was designed to be used in the American Revolution and could hold one person. Today, military submarines can hold 140 sailors and are over 370′ long. Many military submarines are nuclear powered and can stay underwater for months at a time. Military purposes, however, are not the only uses for submarines. Sight-seeing tours and amusement parks use submarines to allow visitors a view of the ocean.

Submarine: A vessel that can submerge and travel underwater.

Figure 19-25. Submersible craft are used for a variety of tasks underwater, such as charting the sea bottom, underwater archaeology, and marine biology studies. Most are unmanned, although some larger submersibles carry one or more crew members and function as small submarines. This unmanned submersible, being launched from a U.S. Navy minesweeper, is used to neutralize floating mines. (U.S. Navy)

Submersibles

Submersibles are small craft designed to explore shipwrecks and used for charting the ocean. See **Figure 19-25.** Submersibles use ballast tanks to submerse and rise. These vessels are equipped with specialized tools to complete the jobs they are given. For example, a submersible exploring a sunken vessel would be equipped with lights, a video camera, and a robotic arm to pick up objects.

Other transoceanic vessels

Icebreakers are a type of vessel used to clear frozen waters. The front, or bow, of an icebreaker is specially designed to be rammed on top of the ice. The weight of the vessel or ship then causes the ice to break. These ships are used to open Arctic sea-lanes. Lighter aboard ship (LASH) vessels are large ships that can carry both containers and barges. The ships are unique because they are equipped with an onboard crane so they can load and unload themselves.

Summary

Transporting people and cargo by water has been around for thousands of years. The water transportation system is an efficient form of transportation. Vessels travel in one of the two modes of water transportation: on inland waterways or across the ocean. Traveling across the ocean, a vessel follows a pathway, or route, called a sea-lane. Sea-lanes are comparable to highways on land.

Vessels can carry passengers or cargo. Passenger vessels on inland waterways include ferries, hovercraft, and hydrofoils. Transoceanic passenger vessels are ocean liners and cruise ships. The largest use of water transportation is for transporting cargo. Ships such as tankers, freighters, and containerships can carry large amounts of cargo at a lower cost than most other forms of shipping.

Buoyancy and displacement are important principles and concepts of water transportation. The upward force of water is buoyancy. Displacement is the amount of water the vessel moves. If the buoyancy is equal to or greater than the displacement of an object, the object will stay afloat.

Key Words

All the following words have been used in this chapter. Do you know their meanings?

air-cushion vehicle
boat
buoyancy
canal
ferry
hydrofoil
inland waterway
navigable
sea-lane
ship
submarine
towboat
transoceanic
tugboat
vessel
waterway

Test Your Knowledge

Write your answers on a separate sheet of paper. Do not write in this book.

1. *True or False?* Water transportation was invented 250 years ago.
2. Write the definition of *waterway*.
3. Cite the definition of the word *vessel*.
4. The _____ was the first steamship.
   A. *Monitor*
   B. *Pyroscaphe*
   C. *Turtle*
   D. USS *Indianapolis*

5. *True or False?* Steam power eventually replaced sail power as a main source of power in vessels.
6. *True or False?* Transporting cargo is the main use of water transportation today.
7. What is the purpose of a sea-lane?
8. State the definition of *buoyancy*.
9. Paraphrase the two principles that keep a ship afloat.
10. If you throw an object weighing 20 lbs. into the water and the weight of the water it displaces is 40 lbs., will the object sink or float? Explain.
11. List the two modes of water transportation.
12. *True or False?* A lake is an example of a transoceanic waterway.
13. What major engineering feat allowed 8000 miles to be saved when traveling from New York to Los Angeles?
14. A(n) _____ is used to move people over small bodies of water.
    A. towboat
    B. ocean liner
    C. ferry
    D. containership
15. An ocean liner is known for transporting _____.
    A. passengers
    B. cargo
    C. both A. and B.
16. Name three types of vessels under each mode listed in Question 11.
17. Recall and describe two military vessels.

STEM Activities

1. Take part in a boat hull design competition. The object is to design and build a boat hull for maximum buoyancy. As a group, determine material limitations. Test the boats by loading them with pebbles or other materials until they sink. Weigh the pebble load to determine the winner.
2. Obtain a world map and locate the major ocean-shipping routes.