**Thunder Bay 2010:**
**Cutting-Edge Technology and the Hunt for Lake Huron's Lost Ships**

# Where's the Energy

(adapted from the 2003 Steamship *Portland* Expedition)


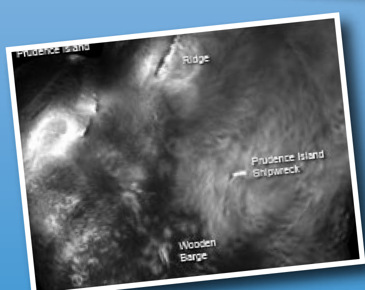


Image captions/credits on Page 2.

**lesson plan**

## Focus
Energy conversions

## Grade Level
5-6 (Physical Science)

## Focus Question
What energy conversions are involved in the operation of a steam engine?

## Learning Objectives
- Students will be able to explain the basic operation of a steam engine.
- Students will be able to identify and describe the energy conversions involved in the operation of a steam engine.

## Materials
- Small plastic bottles with a tops, one for each student group
- Rubber bands, one for each student group
- Sticks (or pencils), approximately 6 inches long, one for each student group
- Small cardboard juice or milk carton, one for each student group
- Tape and scissors
- Empty cardboard paper towel rolls, one for each student group
- Sink or washtub filled with water

## Audio-Visual Materials
- (Optional) Video copies of "Great Ships: The Riverboats" and/or the "Steamboats 'A Comin!" episode of "The Mighty Mississippi" (see Extensions)

## Teaching Time
One 45-minute class period, plus time for student research

## Seating Arrangement
Groups of 2-3 students

## Maximum Number of Students
32

## Key Words
Steamboat
Mechanical energy

Kinetic energy
Potential energy
Chemical energy
Electromagnetic energy
Nuclear energy
Electrical energy
Thermal energy
Energy conversion

## Background Information

*NOTE: Explanations and procedures in this lesson are written at a level appropriate to professional educators. In presenting and discussing this material with students, educators may need to adapt the language and instructional approach to styles that are best suited to specific student groups.*

On October 15, 1871, the steamship *R. G. Coburn* sailed out of Duluth, MN onto Lake Huron bound for Buffalo, NY. In addition to 75 passengers and crew, the ship carried 2,900 barrels of flour, 12,000 bushels of wheat, and 30 (or so) barrels of silver ore. Early in the morning, the *Coburn* rolled sickeningly in waves driven by gale-force winds, and at 4:00 a.m. the ship's rudder broke away. One huge wave destroyed the smokestack and smashed the deck. Shifting cargo damaged the hull so that water slowly filled the ship. The ship finally sank around 9 a.m., taking at least 32 passengers and crew to their deaths (Stein, 2009).

The tragic story of the *R.G. Coburn* is only one of more than 200 tales of ships that have ended their days in northwestern Lake Huron. The second largest of the Great Lakes and the third largest in the world, Lake Huron is notorious for its dense fog banks, violent storms, and rocky shoreline. The area surrounding Thunder Bay is so hazardous to shipping that it has earned the nickname Shipwreck Alley, and now represents one of the nation's most historically-significant collections of shipwrecks. The Thunder Bay National Marine Sanctuary (TBNMS) was established in 2000 to protect this important cultural resource. The present boundaries of the TBNMS enclose 448 square miles that contain 40 known historic shipwrecks. Plans are well underway, however, to expand these boundaries to include 3,662 square miles (Figure 1). Archival records indicate that the expanded boundaries include more than 100 undiscovered shipwrecks which can provide unique opportunities for historians and archaeologists to study the maritime and cultural history of the Great Lakes region, as well as for recreational explorers. Finding the exact location of these shipwrecks is obviously essential to these kinds of uses, as well as to the protecting these resources.

To help meet this need, in 2008 a remote sensing survey was undertaken in the northern portion of the proposed expansion area. This survey used a side scan sonar towed from a research vessel, as

**Images from Page 1 top to bottom:**
Existing (yellow) and proposed (green) boundaries of the Thunder Bay National Marine Sanctuary. Locations of some known shipwrecks are indicated. Source: Thunder Bay National Marine Sanctuary

A crew in a support boat releases the line from the Naval Undersea Warfare Center (NUWC) REMUS 600 unmanned underwater vehicle equipped with the Integrated Precision Underwater Mapping (iPUMA) subsystem in Narragansett Bay during the Autonomous Vehicle Fest in May 2008.
http://www.militaryaerospace.com/index/display/article-display/337291/articles/military-aerospace-electronics/volume-19/issue-8/features/special-report/swimming-robots.html

This image was captured by iPUMA, a wide-swath forward-looking sonar used to identify possible targets. Here we see the two wrecks off Prudence Island, as well as features on the surrounding seafloor. To get a sense of scale, consider that the wooden barge is 120 feet long.
http://oceanexplorer.noaa.gov/explorations/08auvfest/logs/summary/media/ipuma_s2_3_sonar.html

Once a shipwreck has been located on a sonar image, archaeologists don SCUBA gear to "ground truth" the discovery. Dives deeper than about 40 m require the use of special breathing mixtures containing helium, oxygen, and nitrogen to reduce some of the safety hazards that accompany breathing ordinary air during deep dives. Source: Thunder Bay National Marine Sanctuary

**Map 1. Great Lakes region, with Thunder Bay National Marine Sanctuary marked with a red dot.**


*US Army Corps of Engineers, Detroit District. From Wikipedia.*

**Figure 1. Existing (yellow) and proposed (green) boundaries of the Thunder Bay National Marine Sanctuary. Locations of some known shipwrecks are indicated. Source: Thunder Bay National Marine Sanctuary**


well as a conventional sonar system mounted on an autonomous underwater vehicle (AUV). See Background Information in the Expedition Education Module for more information about sonar and AUVs. The 2008 survey covered an area of about 100 square miles and located two new shipwrecks. The total proposed expansion area is much larger, though, so a third survey strategy is needed to efficiently cover large areas of deep water. As its name suggests, the Thunder Bay 2010: Cutting Edge Technology and the Hunt for Lake Huron's Lost Ships Expedition will use state-of-the-art technology that includes a sophisticated AUV carrying a one-of-a-kind precision sonar system to survey up to 200 square nautical miles in the proposed expansion area.

Many ships that are now part of the TBNMS were propelled by steam. In this lesson, students will study some of the science behind steamboats, and build a simple paddlewheel boat.

## Learning Procedure

1. To prepare for this lesson:
   (a) Review introductory essays for the Thunder Bay 2010: Cutting-Edge Technology and the Hunt for Lake Huron's Lost Ships Expedition at http://oceanexplorer.noaa.gov/10thunderbay/welcome.html

   (b) Download a copy of "Historic Shipwrecks of the Gulf of Mexico: A Teacher's Resource" from http://www.gomr.mms.gov/homepg/lagniapp/shipwreck/. You may also want to download a copy of "Sunken Treasure" an article about the *R. G. Coburn* from http://view.digipage.net/?userpath=00000043/00008921/00042491/&page=28.

   (c) You may want to consider showing the History Channel production of "Great Ships: The Riverboats" and/or the "Steamboats 'A Comin!" episode of "The Mighty Mississippi," (both available from http://shop.history.com/).

2. Briefly review the story of the *R. G. Coburn*, and introduce students to "Shipwreck Alley" and the Thunder Bay 2010: Cutting-Edge Technology and the Hunt for Lake Huron's Lost Ships Expedition. Discuss the importance of shipwrecks from the standpoint of historical research as well as recreation. Discuss the role of steamboats in development of the United States during the 1800's.

3. Have students construct the model paddlewheel boat described on page 18 of "Historic Shipwrecks of the Gulf of Mexico: A Teacher's Resource" (please note that this activity was adapted from "Water, Paddles, and Boats" by Pam Robson).

4. Lead a discussion of the energy sources and transformations that take place when the model paddlewheeler is operating. Students should recognize that the initial source of energy is the person who winds the rubber band. The rubber band stores this mechanical energy as potential energy. When the rubber band unwinds, the potential energy is changed to kinetic energy that causes the paddlewheel to turn, pushing against the water and causing an

opposite reaction by the boat (the boat moves forward). Ask students to take this sequence farther back: they should recognize that mechanical energy from the person winding the rubber band comes from muscles that are using chemical energy that came from food that ultimately can be traced back to photosynthesis that used electromagnetic energy from the sun).

5. Tell students that their assignment is to prepare a written report on the basic principles of a steam engine, including an analysis of the energy sources and conversions involved when a steam engine is operating. An alternative to a written assignment is to give students a series of questions to research as a basis for group discussion.

   Lead a discussion of students' research results. Most of the following points should emerge during this discussion:
   - The basic elements of a steam engine are a source of steam (usually a boiler fired by wood, coal, or other combustible fuel), a device that is moved by the steam (such as a piston inside a cylinder or a turbine), and a means for converting the motion of the device into useful work. Steam engines of the 1800's had many more features that made them more efficient.
   - The source of energy for steam engines can be fossil fuels, wood, nuclear reactions, or sunlight (one type of solar generator uses a parabolic mirror to focus the sunlight onto a pipe containing water that is heated to produce steam). Students should realize that the energy in wood was produced by photosynthesis. This is also true of many fossil fuels which are the remains of once-living plants and animals. Methane gas, however, may be produced by bacteria independently of photosynthesis.
   - Energy conversions typically involved in the operation of a steam engine are conversion of chemical energy (in fuels) to thermal energy, conversion of thermal energy to mechanical energy (by increasing the motion of water molecules), and sometimes conversion of mechanical energy into electrical energy (in the case of an electric generator).
   - Early steam engines used steam to move a piston inside a cylinder. This produced a back-and-forth motion, which was okay for pumps, but not as useful for propelling boats or turning machinery. Many devices were built to convert back-and-forth motion to rotary motion. The *Portland* used what is known as a "walking beam engine" to make this conversion. A large diamond-shaped beam was mounted on an A-frame structure. One end of the beam was connected to a rod attached to the piston of the steam engine. The other end of the beam was attached to a second rod that drove a crankshaft, which in turn caused the paddlewheels to rotate, propelling the ship through the water.

- The piston-cylinder type of steam engine was replaced by engines that used steam to turn turbines. This is the type of steam engine found in many electrical generating plants today.
- James Watt is often credited with developing the first steam engine, but Hero of Alexandria (who lived more than 2,000 years ago) documented many of the principles upon which the steam engine is based. The first operating steam engine was built in 1712 by English engineer Thomas Newcomen (visit http://technology.niagarac.on.ca/people/mcsele/newcomen.htm for a description of the Newcomen engine). Newcomen's engine was simpler than the systems described above: steam from the boiler was let into the space between the inside of the cylinder and the piston. The other end of the piston was attached to the pump by means of a rod. Water was sprayed onto the cylinder to cool the steam. As the steam cooled, its volume decreased, and caused a vacuum to form inside the cylinder. The piston was sucked down into the cylinder by the weight of the air on top of it, then was pulled back by the weight of the pump attached to the rod. Steam was let into the chamber again, and the cycle repeated.
- Robert Fulton is often credited with building the first operating steamboat in the early 1800's, but Johnathan Hulls of London patented a steam-driven tugboat in 1736. John Fitch of Connecticut built a steam-driven paddle boat in 1786, but rowboats could outrace it. Fulton's credit probably should be for developing the first commercially viable steamboat.

## The BRIDGE Connection

www.vims.edu/bridge/archive1200.html/ – Information, activities and links about marine archaeology.

## The "Me" Connection

Tell students to imagine that they are living 100 years in the future. Have them write a short essay comparing and contrasting the history of steamboats with the history of the airplane.

## Connections to Other Subjects

English/Language Arts, Social Studies, Earth Science

## Assessment

Written reports, models, and class discussions provide opportunities for assessment.

## Extensions

Watch the History Channel production of "Great Ships: The Riverboats" and/or the "Steamboats 'A Comin! " episode of "The Mighty Mississippi," (both available from http://shop.history.com/).

## Other Relevant Lesson Plans from NOAA's Office of Ocean Exploration and Research

**Wreck Detectives**
(7 pages, 259 kb) (from the Aegean and Black Sea 2006 Expedition)
http://oceanexplorer.noaa.gov/explorations/06blacksea/background/edu/media/06blacksea_wreckdectectives.pdf

Focus: Marine archaeology (Physical Science)

In this activity, students create a model of a Bronze Age shipwreck site, use a grid system to document the location of artifacts recovered from a model shipwreck site, use data about the location and types of artifacts recovered from a model shipwreck site to draw inferences about the sunken ship and the people who were aboard, and identify and explain types of evidence and expertise that can help verify the nature and historical context of artifacts recovered from shipwrecks.

**Ship of the Line**
(9 pages, 293k) (from AUVfest 2008)
http://oceanexplorer.noaa.gov/explorations/08auvfest/background/edu/media/shipline.pdf

Focus: Maritime History/Physical Science/Social Science

In this lesson, students will be able to describe general characteristics and technologies used in 18th century naval ships; draw inferences about daily life aboard these ships; and explain at least three ways in which simple machines were used on these vessels.

## Other Resources

*The Web links below are provided for informational purposes only. Links outside of Ocean Explorer have been checked at the time of this page's publication, but the linking sites may become outdated or non-operational over time.*

http://oceanexplorer.noaa.gov/10thunderbay/welcome.html – Web site for the Thunder Bay 2010: Cutting-Edge Technology and the Hunt for Lake Huron's Lost Ships Expedition

http://thunderbay.noaa.gov/welcome.html – Web site for the Thunder Bay National Marine Sanctuary

Stein, Janis. 2009. Sunken Treasure. Huron Shore 2(1):26-28; available online at http://view.digipage.net/?userpath=00000043/00008921/00042491/&page=28

http://celebrating200years.noaa.gov/edufun/book/welcome.html#book - A free printable book for home and school use introduced in 2004 to celebrate the 200th anniversary of NOAA; nearly 200 pages of lessons focusing on the exploration, understanding, and protection of Earth as a whole system

http://thunderbay.noaa.gov/welcome.html – Links to Lesson Plans from the Thunder Bay National Marine Sanctuary; includes grades K - 2 Boat Builder Activity, grades 3 - 5 Photomosaic Activity, grades 3 - 5 Mapping Activity, grades 6+ Mapping Activities, Steamships and Energy Conversions, and Make Your Own Putt-Putt Boat

http://monitor.noaa.gov/publications/education/rov_manual.pdf – Directions for making a simple underwater robot; from NOAA's *Monitor* National Marine Sanctuary

"Historic Shipwrecks of the Gulf of Mexico: A Teacher's Resource" - http://www.gomr.mms.gov/homepg/lagniapp/shipwreck/

"Sunken Treasure" an article about the *R. G. Coburn* - http://view.digipage.net/?userpath=00000043/00008921/00042491/&page=28.

*Water, Paddles, and Boats (Science Workshop)*, Pam Robson, Franklin Watts Ltd., 1996.

## National Science Education Standards

**Content Standard A: Science As Inquiry**
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

**Content Standard B: Physical Science**
- Motions and forces
- Transfer of energy

**Content Standard D: Earth and Space Science**
- Structure of the Earth system

**Content Standard E: Science and Technology**
- Abilities of technological design

**Content Standard F: Science in Personal and Social Perspectives**
- Natural hazards
- Science and technology in society

## Ocean Literacy Essential Principles and Fundamental Concepts

**Essential Principle 2.**
**The ocean and life in the ocean shape the features of the Earth.**
*Fundamental Concept Fundamental Concept b.* Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.

**Essential Principle 4.**
**The ocean makes Earth habitable.**
*Fundamental Concept a.* Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean.
*Fundamental Concept b.* The first life is thought to have started in the ocean. The earliest evidence of life is found in the ocean.

**Essential Principle 6.**
**The ocean and humans are inextricably interconnected.**
*Fundamental Concept d.* Much of the world's population lives in coastal areas.
*Fundamental Concept f.* Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).

**Essential Principle 7.**
**The ocean is largely unexplored.**
*Fundamental Concept a.* The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.
*Fundamental Concept b.* Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.
*Fundamental Concept d.* New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

## Send Us Your Feedback

We value your feedback on this lesson.
Please send your comments to:
oceanexeducation@noaa.gov

## For More Information

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