NATIONAL MARINE SANCTUARIES LESSON PLAN

Shipwreck Alley

Theme

Thunder Bay National Marine Sanctuary

Links to Overview Essays and Resources Needed for Student Research

http://thunderbay.noaa.gov/info/about.html

Subject Area

Physical Science

Grade Level

9-12

Focus Question

How is it possible to reduce dangers to ships from natural hazards in the Great Lakes?

Learning Objectives

- Students will be able to describe at least three major types of vessels that have been used for commercial shipping in the Great Lakes.

- Students will be able to describe at last three hazards to ships that have been responsible for shipwrecks in Thunder Bay and how these hazards might have been reduced.

- Students will be able to apply basic concepts of force and motion to practical problems related to marine safety.

Materials Needed

- Copies of "Thunder Bay National Marine Sanctuary Worksheet," one copy for each student or student group
- Protractor, straightedge, and dividers; one of each for each student or student group working on Problem 2 in the Worksheet
- (optional) Computers with internet access; if students do not have access to the internet, download copies of materi-

als cited under "Learning Procedure" and provide copies of these materials to each student or student group

Audio/Visual Materials Needed

- (optional) Overhead projector with transparency of "Current Affairs, Figure 2," and transparency markers

Teaching Time

One or two 45-minute class periods, plus time for student research

Seating Arrangement

Classroom style or groups of 3-4 students

Maximum Number of Students

30

Key Words

Fresnel lens
Buoyancy
Buoy
Range
Shipwreck
Lighthouse

Background Information

"Shipwreck Alley" is the final resting place for scores of ships that have fallen victim to Lake Huron's murky fog banks, sudden gales, and rocky shoals. In October 2000, the Thunder Bay National Marine Sanctuary and Underwater Preserve was established in a 448-square mile area that includes an estimated 116 historically significant shipwrecks. These range from from wooden schooners more than 150 years old to side-wheel steamers to modern freighters. The cold, fresh waters of Lake Huron slow down natural processes that corrode iron and degrade wood, so even the oldest shipwrecks are often in excellent condition. The shipwrecks of Thunder Bay tell us a great deal about life on the Great Lakes over the past 200 years, and offer opportunities to study the structure, rigging, and other details of sailing ships that are hard to find anywhere else.

In this lesson, students will investigate some of the history of the Thunder Bay area, as well as the physical principles underlying efforts to make the area safer for shipping.

Learning Procedure

1.

If you want to introduce your students to marine protected areas, have them complete the "Water Parks" lesson, or direct them to "MPA Education Poster Site Descriptions" and "MPA Poster Activity Sheet " at *http://mpa.gov/information_tools/education/pdfs/Poster04companion.pdf* and *http://mpa.gov/information_tools/education/pdfs/mpaposter_activity.pdf*. Have each student complete one version of the MPA Subject Review, then lead a discussion to review the answers.

2.

Have each student or student group complete Part I of the "Thunder Bay National Marine Sanctuary Worksheet" and one or more problems in Part II of the worksheet. Information for Part A of this worksheet can be found on the Thunder Bay National Marine Sanctuary and Underwater Preserve website at *http://thunderbay.noaa.gov/info/about.html.*

3.

Lead a discussion of students' answers. The following points should be included in this discussion:

- A maritime cultural landscape includes the natural resources, human communities, culture, and history that are associated with a coastal area. The primary focus of the Thunder Bay National Marine Sanctuary are the region's shipwrecks, but the Sanctuary also emphasizes the larger context that includes the region's lighthouses, lifesaving stations, shipwreck salvage operations, and maritime economic activities.

- The maritime history of the Thunder Bay region is characterized by the use of, and dependence upon, natural resources, including furs, fisheries, forests, farmland, and mineral resources.

- The first recorded use of natural resources in Thunder Bay was by Native Americans during the Woodland period.

- European activity in Thunder Bay probably began during the 1600s with efforts to develop the fur trade.

- Six lighthouses are located in the vicinity of the Thunder Bay National Marine Sanctuary, five of which are still in operation.

- The New Presque Isle Lighthouse is 113 feet high.

- The Middle Island Lighthouse is about halfway between the North Point of Thunder Bay and Presque Isle.

- The original fog signal on the Thunder Bay Island Lighthouse was powered by steam.

- Local slogans for the Thunder Bay River (or Alpena) Lighthouse are "Don't kick the can," and "Short on beauty, long on duty."

- The Sturgeon Point Lighthouse was constructed to mark a hazardous reef that extends 1.5 miles out into Lake Huron at Sturgeon Point, just north of Harrisville.

- The *John J. Audubon* was a wooden 2-mast brig, lost when the ship was struck amidships and almost cut in half by schooner *Defiance* on a dark, foggy night.

- The *Isaac M. Scott* was lost during the Great Storm of 1913, along with all twenty-eight of the ship's crew.

- The *New Orleans* struck an obstruction in September 1845, and was run ashore to keep it from sinking. In May 1847, a cylinder head blew out and the vessel had to be towed back to Cleveland for repairs. A month later, the *New Orleans* grounded on a reef between North Point and Sugar Island. On June 14, strong winds battered the vessel until she sank.

- The *Pewabic* was a wooden propeller ship that was lost on August 9, 1865 after a collision with her sister ship, the *Meteor*. The *Pewabic* sank rapidly in 180 feet of water, with the loss of an estimated 125 lives, as well as a valuable cargo of copper.

- To solve Problem 1 in Part II, students should recall that according to Archimedes' Principle, the buoy when completely submerged will be buoyed up by a force that is equal to the weight of water displaced by the buoy. So the buoyancy when completely submerged will be equal to this buoyant force minus the weight of the buoy.

  The weight of the buoy is the volume of steel used in the buoy multiplied by the density of steel. To find the volume of steel used, first find the surface area of the buoy, which will be the surface area of the cylindrical side, plus the surface area of the two ends of the cylinder.

  The surface area of the side is $\pi \cdot D \cdot h = 3.14 \text{ (1 m)} \cdot 3 \text{ m} = 9.42 \text{ m}^2$
  The surface area of one end is $\pi \cdot \text{(radius of the end)}^2$
  $= 3.14 \cdot (0.5 \text{ m})^2$
  $= 3.14 \cdot 0.25 \text{ m}^2$
  $= 0.785 \text{ m}^2$
  So the total surface area of the cylinder is $9.42 \text{ m}^2 + (2 \cdot 0.785 \text{ m}^2) = 10.99 \text{ m}^2$.

  The volume of steel used in the cylinder is the total surface area of the cylinder multiplied by the thickness of the steel used to construct the cylinder, so
  volume of steel $= 10.99 \text{ m}^2. \cdot 6 \text{ mm}$
  $= 10.99 \text{ m}^2. \cdot (6 \times 10^{-3} \text{ m})$
  $= 6.59 \times 10^{-2} \text{ m}^3$.

  So, the weight of the buoy is
  (volume of steel) • (density of steel)
  $= (6.59 \times 10^{-2} \text{ m}^3) \cdot (7{,}850 \text{ kg/m}^3)$
  $= (6.59 \times 10^{-2} \text{ m}^3) \cdot (7.85 \times 10^3 \text{ kg/m}^3)$
  $= 5.18 \times 10^2 \text{ kg}$

  The buoyant force acting on the buoy is equal to the mass of water displaced by the buoy. This is equal to the volume of the buoy multiplied by the density of water. So,
  volume of the buoy $= 3.0 \text{ m} \cdot \pi \cdot (0.5 \text{ m})^2$
  $= 3.0 \text{ m} \cdot 3.14 \cdot 0.25 \text{ m}^2$
  $= 2.36 \text{ m}^3$

mass of water = 2.36 m^3 • 1.0 gm/cm^3
since 1 m^3 = 1 x 10^6 cm^3,
mass of water = 2.36 x 10^6 cm^3 • 1.0 gm/cm^3 = 2.36 x 10^6 gm
= 2.36 x 10^3 kg

So the buoyancy when completely submerged will be equal to
(buoyant force) - (weight of the buoy)
= (2.36 x 10^3 kg) - (5.18 x 10^2 kg)
= 1.842 x 10^3 kg

Since the weight of the anchor system must be twice the buoyancy of the submerged buoy, the anchor system must weigh
2 • 1.842 x 10^3 kg = 3.68 x 10^3 kg.

The anchor system will include 20 meters of anchor chain. Since the chain weighs 4 kg/m, the total length of chain will be 80 kg. So the required weight at the bottom of the chain must be
(total weight of the anchor system) - (weight of the chain)
= (3.68 x 10^3 kg) - (80 kg) = 3.6 x 10^3 kg

Be sure students understand that this must be the NET weight of the bottom anchor; that is, the weight of the anchor in air, minus the mass of the volume of water that the anchor displaces.

- Refer to Figure 2. To solve Problem 2 in Part II, students should realize that the closest point on the range line is point B, found by constructing a line through point A that is perpendicular to the range line. Next, students should realize that in 30 minutes the current will move the vessel 1.0 nautical mile toward the southeast to point C. To counteract the current and arrive at point B, the vessel must be steered in the direction indicated by line CB. The angle between line BC and line AC is approximately 20°. Since line AC represents a course of due east (090°), line BC represents a course that is 20° less, or 070°. The distance from point B to point C is 2.0 nm. So, to arrive at point B in 30 minutes, the vessel will have to make a speed of (2.0 nm) ÷ (0.5 hr) = 4.0 nm/hr = 4.0 kn.

- Students should identify the Fresnel lens as the invention that caused the greatest transformation in lighthouse technology. They should understand that a Fresnel lens consists of a concentric array of circular prisms surrounding a central convex lens called a bulls-eye. Light entering the lens is concentrated by the prisms and bulls-eye onto a central path. If a light source is placed behind the bulls-eye, light striking rows of prisms close to the bulls-eye will be refracted (bent) onto a path that is perpendicular to the lens surface. These prisms are called dioptric prisms. Light that strikes rows of prisms farther away from the bulls-eye will be reflected as well as refracted onto the same path. These outer prisms are called catadioptric prisms. You may want to include the Exploratorium "snack" on Fresnel lenses (*www.exploratorium.edu/snacks/giant_lens.html*).

The Bridge Connection

http://www.vims.edu/bridge – Click "Ocean Science Topics" on the "Site Navigation" menu, then "Human Activities," then "Archeology" for resources on marine archeology and lighthouses.

The Me Connection

Have students write a brief essay in which they describe the cultural landscape of their community, identify natural and cultural resources of particular importance or significance, and recommend appropriate ways to protect these resources.

Extensions

Visit *http://thunderbay.noaa.gov/history/maritime.html* for more information about Prehistory and Native American History, Settlement and Early Transportation, Lighthouses and Life-Saving Stations, Vessel Types, and Economic Activities in the Thunder Bay region.

Resources

http://mpa.gov/ – Web site for the National MPA Center, with definitions, program descriptions, list of MPA sites, virtual library, tools, and links to regional information centers

http://www.boatnerd.com/swayze/shipwreck/ – The Great Lakes Shipwreck File: Total Losses of Great Lakes Ships 1679 - 1999 by Dave Swayze, Lake Isabella, MI *http://thunderbay.noaa.gov/history/vessels/vessels.html* – "Vessel Types" page of the Thunder Bay National Marine Sanctuary and Underwater Preserve website

http://thunderbay.noaa.gov/history/lighthouses.html – "Lighthouses and Life-Saving Stations" page of the Thunder Bay National Marine Sanctuary and Underwater Preserve website

http://www.porttechnology.org/journals/ed10/download/PT10-09_1.pdf – article about history of buoys & lighthouses

http://science.howstuffworks.com/question244.htm – A brief explanation of Fresnel lenses

http://www.lanternroom.com/misc/freslens.htm – A short article about Augustin Fresnel and lighthouses

www.exploratorium.edu/snacks/giant_lens.htm – Exploratorium "snack" on Fresnel lenses

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

Content Standard E: Science and Technology

- Abilities of technological design
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science

- Historical perspectives

Links to AAAS "Oceans Map" (aka benchmarks)

5D/H3 – Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

NATIONAL MARINE SANCTUARIES WORKSHEET

Thunder Bay Subject Review

Part I

1. The Thunder Bay National Marine Sanctuary and Underwater Preserve is focussed on understanding the region's maritime cultural landscape. What is a "maritime cultural landscape?"

2. The maritime history of the Thunder Bay region is characterized by the use of, and dependence upon __________.

3. What is the first recorded use of natural resources in Thunder Bay?

4. When did European activity probably begin in Thunder Bay, and for what purpose?

5. How many lighthouses are located within or near the Thunder Bay National Marine Sanctuary and Underwater Preserve? How many are still used as navigational aids?

6. How high is the New Presque Isle Lighthouse?

7. Middle Island Lighthouse is about halfway between what two locations?

8. What provided power for the original fog signal on the Thunder Bay Island Lighthouse?

9. What are local slogans for the Thunder Bay River (or Alpena) Lighthouse?

10. Why was the Sturgeon Point Lighthouse constructed?

11. What type of vessel was the *John J. Audubon*? When and how was the vessel lost?

12. What type of vessel was the *Isaac M. Scott*? How was the vessel lost? Were any mariners lost with the ship?

13. What were two mishaps suffered by the *New Orleans* before the final mishap that caused the vessel to sink? What was the final mishap?

14. What type of vessel was the *Pewabic*? What caused the *Pewabic* to sink? What valuable cargo was the *Pewabic* carrying?

Part II

The many shipwrecks that are part of Thunder Bay's history have resulted in major efforts to reduce the hazards faced by mariners who sail on Lake Huron. One of the most prevalent efforts has been the installation of "aids to navigation" (ATONs) that mark hazards and provide guidance to safe routes into ports and harbors. One of the oldest and most familiar ATONs is the lighthouse. The Colossus of Rhodes and Pharos of Alexandria (two of the "Seven Wonders of the World") were lighthouses used to mark the entrances to the harbor on the Greek island and the Nile estuary. Like modern lighthouses, the basic idea was to have a bright light that is high enough to be seen from far off shore. Often, lighthouses also include sound producing devices for fog, radio beacons, weather instruments and other equipment. The markings on lighthouses allow them to be identified during the day, while the color and flashing pattern of the light provide identification at night.

Buoys are another familiar ATON that consist of various types of floating markers anchored to the bottom. Most buoys are shaped like cylinders ("can" buoys) or cones ("nun" buoys), and have specific colors that correlate with the buoy's purpose. Can buoys are green, have odd numbers, and are used to mark the left side of a channel (when entering from offshore). Nun buoys are red, have even numbers, and mark the right side of a channel (when entering from offshore). Buoys painted with red and green stripes mark the center of a channel (the top color indicates whether it is best to pass to the left or right of the buoy). Yellow buoys are used on the Intracoastal Waterway in the United States; orange and white buoys are regulatory or informational; black markers are state or private buoys; and blue and white markings are used on mooring buoys. Some buoys have devices that make sounds so they can be identified under foggy conditions, including bells, gongs, whistles, and horns. Many buoys also have lights that may be green, white, yellow, or red, depending on the buoy's function. The lights may be steady ("fixed") or flashing.

Ranges are a third type of ATON that are not as familiar as lighthouses and buoys. Ranges are structures built onshore to indicate the center line of a channel, and are always found in pairs. The two elements of the range are built at different heights, with the highest structure farthest from the water. When the two structures appear to be lined up, one on top of the other, a mariner's vessel is in a safe channel.

Problem 1: Buoy Oh Buoy!

Your assignment is to design an anchor system for a can buoy to mark the left side of a narrow channel in Thunder Bay. The buoy will be a cylinder with a height of 3 meters and a diameter of 1 meter. The buoy will be constructed of steel plate having a thickness of 6 mm. The weight of the anchor system should be twice the buoyancy of the buoy if the buoy were completely submerged (as in a severe storm). The anchor system will include a bottom weight and anchor chain. The buoy will be deployed in an area where the bottom depth is 20 meters. How heavy should the bottom weight be to meet these requirements?

For purposes of your calculations, assume:

- the density of the steel used to construct the buoy is 7,850 kg/m^3;
- the density of water in Thunder Bay is 1.0 gm/cm^3; and
- the anchor chain will be absolutely vertical when the buoy is in place, with no slack chain between the buoy and the anchor, and will weigh 4 kg/m.

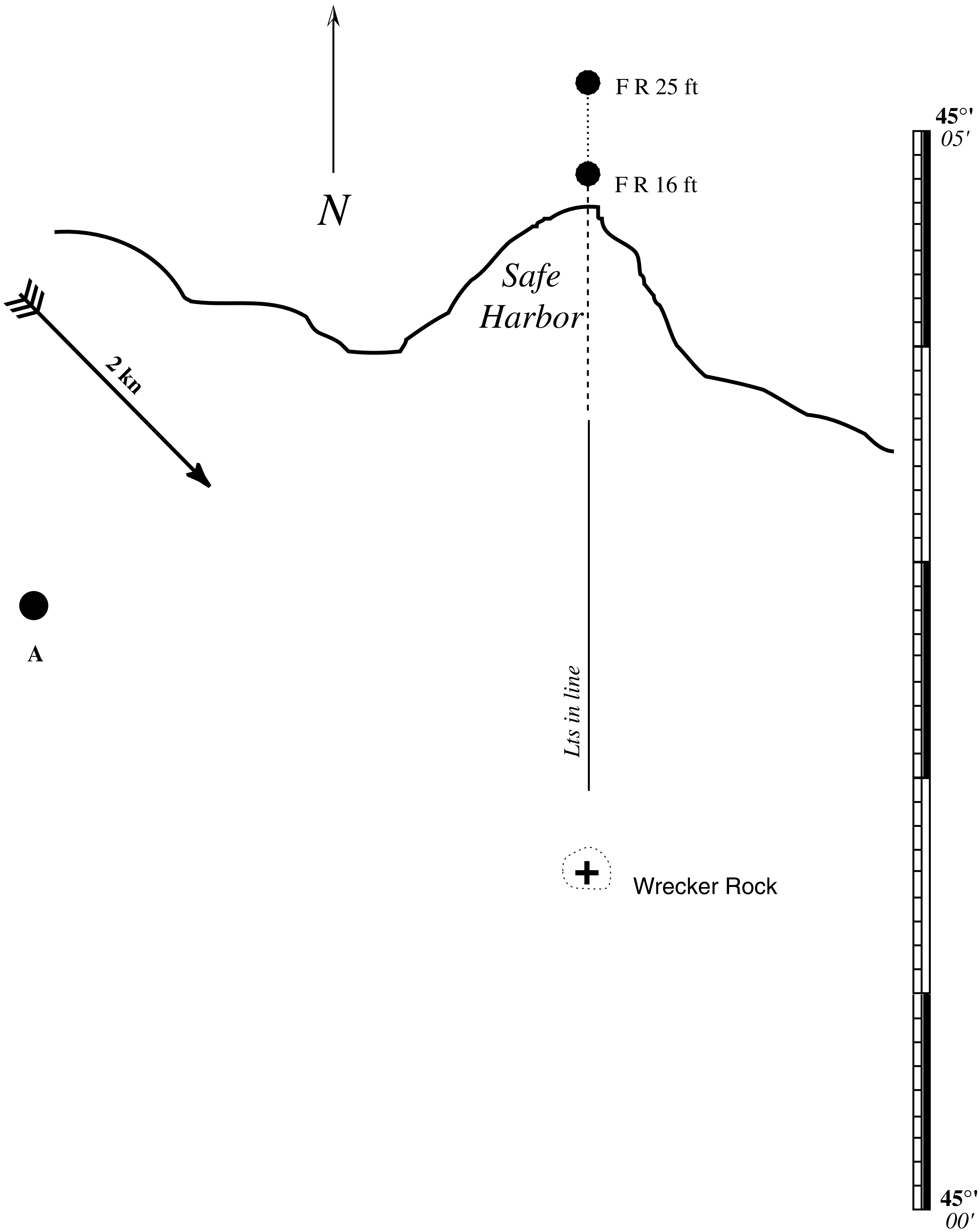
Problem 2: Current Affairs

Refer to Figure 1. You are skipper of a motor vessel located at point A. You want to anchor in Safe Harbor. To enter the harbor, you have to line up the two range lights shown on the chart. There is a 2 knot (a knot is one nautical mile per hour) current setting to the southeast (135°). What course should you steer, and what speed should you make in order to reach the closest point on the range in 30 minutes? You can use the latitude scale on the right side of the chart to find distances, since one minute of latitude is equal to one nautical mile.

Problem 3: Shine Your Light

Until the 19th century, lighthouses were basically a source of light, ranging from candles to a bonfire, mounted on a high platform. Even though some of these platforms were quite elaborate (like the Colossus of Rhodes), the basic idea was fairly simple. In 1822, though, lighthouse technology took a giant leap forward thanks to a new invention. What was this invention, and how does it work?

Current Affairs
Figure 1



Current Affairs
Figure 2