Be A Shipwreck Detective!

“Great acts of courage,
senseless tragedy,
the heroism of a captain,
the greed of a stingy shipowner,
the stupidity of a watchman
all find their ways into the history of shipwrecks.”

~ from the Channel Islands National Marine Sanctuary
Shipwreck Database Web site

Shipwrecks are an important part of our nautical heritage. Some of our nation’s most interesting shipwrecks are found in NOAA’s National Marine Sanctuaries, including the remains of the Civil War ironclad, U.S.S. Monitor. Some shipwrecks are hazardous to other vessels. Nautical charts produced by NOAA’s Office of Coast Survey show the location of known shipwrecks and other hazards to navigation.

In September 2003, NOAA’s Ocean Exploration Program visited a newly discovered shipwreck in the Stellwagen Bank National Marine Sanctuary on the coast of Massachusetts. Underwater archaeologists studied the wreck to learn more about what happened to cause the ship to sink. Now it’s your turn to be a Wreck Detective!

What You Will Do

Examine information about items found in and around the Stellwagen Bank shipwreck, and draw conclusions about the ship, who was aboard, and why the ship sank.
What You Will Need
- “Grid Reference System for Unidentified Shipwreck Q11WRK5” and “List of Artifacts Retrieved from Unidentified Shipwreck Q11WRK5”
- Imagination

How to Do It
1. Your first task is to organize information about where the artifacts were found on the shipwreck. The “List of Artifacts” gives a grid location for each item and how deeply artifacts were buried (so “22 inches from surface” means the object was buried 22 inches into the sea bottom). Archaeologists often use a grid system to precisely record the exact location of artifacts and their relationship to each other. You have already used grids to express location if you have ever played Battleship, or even Bingo.

2. As you look at the description of each artifact, think about how deep the artifact was below the surface, and what other artifacts were found nearby. Then consider what the artifacts may suggest about:
   - the specific identity of the ship that sank;
   - age of the vessel;
   - the vessel’s purpose;
   - who was aboard; and
   - why the vessel sank.


Want to Do More?
2. For another shipwreck activity see “Lost at Sea: Sunken Slave Ship” activity from Newton’s Apple episode 1502. You can access this activity from http://www.ktca.org/newtons/15/sunken.html

This activity is adapted from “Wreck Detectives,” a lesson from the Ocean Explorer Steamship Portland Expedition (http://oceanexplorer.noaa.gov/explorations/03portland/background/edu/media/portlandwreckdetectec.pdf); by Mel Goodwin, The Harmony Project, Charleston, SC.
List of Artifacts Retrieved from Unidentified Shipwreck 211WRK's

<table>
<thead>
<tr>
<th>Grid Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E₁₀–E₂₃</td>
<td>Heavy metal structure, diamond shaped, partially buried</td>
</tr>
<tr>
<td>&amp; F₁₉–F₂₃</td>
<td></td>
</tr>
<tr>
<td>D₁₀</td>
<td>Gentleman's gold ring, 22 inches from surface</td>
</tr>
<tr>
<td>E₁₄</td>
<td>Heavy mahogany chair, velvet upholstery, 40 inches from surface</td>
</tr>
<tr>
<td>D₁₀</td>
<td>China plate, 100 inches from surface</td>
</tr>
<tr>
<td>G₁₀</td>
<td>China chamber pot, 20 inches from surface</td>
</tr>
<tr>
<td>D₁₃</td>
<td>Silver flatware, engraved letter “P,” 100 inches from surface</td>
</tr>
<tr>
<td>F₁₄</td>
<td>China cup, 100 inches from surface</td>
</tr>
<tr>
<td>D₁₀</td>
<td>Brandy flask, 20 inches from surface</td>
</tr>
<tr>
<td>F₁₄</td>
<td>Domed skylight, 16 inches from surface</td>
</tr>
<tr>
<td>D₁₃</td>
<td>Carved mahogany headboard, 28 inches from surface</td>
</tr>
<tr>
<td>F₁₃</td>
<td>Ebony piano keyboard, 22 inches from surface</td>
</tr>
<tr>
<td>C₁₉–C₂₄</td>
<td>Massive paddlewheel, partially buried</td>
</tr>
<tr>
<td>G₁₀</td>
<td>Child's rocking chair, mahogany, 24 inches from surface</td>
</tr>
<tr>
<td>D₁₃</td>
<td>Lady's dress shoe, 26 inches from surface</td>
</tr>
<tr>
<td>G₁₀</td>
<td>Shaving straight razor, 22 inches from surface</td>
</tr>
<tr>
<td>H₁₇</td>
<td>Silver buckle, 28 inches from surface</td>
</tr>
<tr>
<td>D₁₃</td>
<td>China chamber pot, 24 inches from surface</td>
</tr>
<tr>
<td>E₁₁</td>
<td>Carving knife, 92 inches from surface</td>
</tr>
<tr>
<td>D₁₀</td>
<td>Man's leather dress shoe, 24 inches from surface</td>
</tr>
<tr>
<td>B₁₃</td>
<td>Carved wooden plank, letters “RTLAND,” left side broken</td>
</tr>
<tr>
<td>E₁₁</td>
<td>Silver serving platter, 92 inches from surface</td>
</tr>
<tr>
<td>E₅</td>
<td>Rusted iron mass, possibly chain</td>
</tr>
<tr>
<td>F₂₁</td>
<td>Heavily rusted iron mass, possibly tools, 100 inches from surface</td>
</tr>
<tr>
<td>E₁₁</td>
<td>Ship's wheel, 12 inches from surface</td>
</tr>
<tr>
<td>D₁₀</td>
<td>Small mahogany chest of drawers, 28 inches from surface</td>
</tr>
<tr>
<td>E₃₃</td>
<td>Rudder, partially buried</td>
</tr>
<tr>
<td>G₁₀–G₂₄</td>
<td>Massive paddlewheel, partially buried</td>
</tr>
<tr>
<td>E₁₇ &amp; F₁₇</td>
<td>Smokestacks</td>
</tr>
</tbody>
</table>

**NOTE:** Extensive debris around main wreck, mostly large timbers and pieces of heavy equipment; several lifeboat remnants outside main wreck. Less obvious structural debris in quadrats numbered 25 and higher; these quadrats contain mostly silt down to the apparent hull of the vessel at approximately 140 inches.
On Thanksgiving Saturday, November 26, 1888, the passenger steamship "Portland" left Boston Harbor with more than 190 passengers and crew bound for Portland, Maine. The "Portland" was a state-of-the-art, luxury ship with velvet carpets, mahogany furniture, and airy staterooms. By 1888, paddlewheel steamboats had revolutionized transportation in the United States. Faster and more reliable than sailing ships, paddlewheelers could also maneuver in waters that were too shallow for sailing ships. By the 1870s, many people routinely boarded steamboats to travel between port cities. But the paddle-wheelers had a serious flaw: they were built long and narrow (the "Portland" was 281 feet long and 62 feet wide), and this shape combined with a shallow draft (the "Portland"'s keel was only 11 feet below the water line) made these ships extremely unstable in high seas.

When the "Portland" steamed out of Boston Harbor, she ran straight into a monster storm moving up the Atlantic coast with northeasterly winds gusting to 90 mph, dense snow, and temperatures well below freezing. Facing a roaring northeasterly wind, the captain could not turn back, to have done so would have placed the ship broadside to wind and waves that would surely have capsized her. The only choice was to continue to head northeast into the waves, and hope to ride out the storm. Four hours after her departure, a vessel believed to have been the "Portland" was reportedly seen near Thatcher Island, about 30 miles north east of Boston. But the "Portland" was apparently unable to make much more progress against the storm.

At 5:45 a.m. on the morning of November 27, four short blasts on a ship's steam whistle told the keeper of the Race Point Life-Saving Station on Cape Cod that a vessel was in trouble. Seventeen hours later, life jackets, debris, and human bodies washed ashore near the the Race Point station, confirming that the "Portland" and everyone aboard had been lost in one of New England's worst maritime disasters. The loss of the "Portland" underscored the inherent instability of sidewheel paddleboats. Sidewheelers were gradually replaced by propeller-driven boats, which have a lower center of gravity.

For 90 years, the location of the "Portland" wreck was unknown, despite intense and continuing public interest. In April 1899, members of the Historical Maritime Group of New England found wreckage in water more than 300 feet deep that they were certain had been the "Portland." Because of the depth, however, the discoverers were unable to obtain photographs or other evidence that could confirm their find. Thirteen years later, on August 29, 2002, the U.S. Commerce Department's National Oceanic and Atmospheric Administration (NOAA) confirmed that the wreck of the "Portland" had been found within NOAA's Stellwagen Bank National Marine Sanctuary. Using side-scan sonar and a remotely operated vehicle (ROV), scientists obtained high-quality video and side-scan images in a joint research mission of the Stellwagen Bank National Marine Sanctuary and the National Undersea Research Center at the University of Connecticut.

Massive storms during late October and November are not particularly unusual in the New England states. At this time of the year, large cold air masses from Canada cross the midwestern states on a regular basis. At the same time, the Atlantic Ocean retains its summer heat and these warm waters sometimes spawn hurricanes. When the cold moving cold air masses encounter the warm, humid oceanic air, the result is what New Englanders call "Nor'easters" storms that are often severe, and are often the cause of maritime disasters.

The Story of the Steamship "Portland"

The large paddlewheels near the middle of the ship clearly suggest a sidewheel paddleboat. This was a large vessel for a paddlewheeler, over 280 feet. The diamond shaped metal structure is probably the main engine of a walking beam engine, a common design in ships of this type. The fact that this was a large paddlewheeler narrows its probable vintage to between 1890 and 1910. Artifacts in quadrats D10, D13, and G10 suggest that men, women, and children may have been aboard, and these areas may have been staterooms. The fact that artifacts in these areas were close to the surface suggests that these staterooms were on or near the deck of the vessel.

Eating utensils recovered from more than 80 inches below the surface suggest a dining area, located on a lower deck. Engraved silver flatware and the carved wooden plank are valuable clues, suggesting that the name of the vessel may have begun with the letter “P” and ended with the letters “rtland.” Many of the artifacts suggest wealth and luxury. This vessel almost certainly carried some wealthy passengers.

Think about the size of the debris field. Ships that sink suddenly (such as those sunk in battle) often have a rather small debris field. Ships that sink with lots of movement, on the other hand (such as ships sunk in storms) are likely to have larger debris fields. This ship has an extensive debris field, suggesting that a lot of motion, possibly due to a storm, was involved in her sinking.
Shipwreck Alley

Thunder Bay National Marine Sanctuary / Grades 9-12 / Geography, Physical Science, Math

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 least 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.

Links to Overview Essays and Resources Useful for Student Research

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

Materials

- Copies of the "Thunder Bay National Marine Sanctuary Worksheet" found at the end of this lesson, one copy for each student or student group. [Click here for a separate printable copy of the worksheet](http://oceanservice.noaa.gov/education/library/shipwreck_alley.html). Click here for separate printable copies of worksheet appendix A, and appendix B

- 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 materials cited under “Learning Procedure” and provide copies of these materials to each student or student group.

Audio/Visual Materials

- (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
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 sidewheel 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, direct them to the MPA education poster “Site Descriptions” and the “MPA Poster Activity Sheet” at http://mpa.gov/pdf/helpful-resources/education/Poster04companion.pdf and http://mpa.gov/pdf/helpful-resources/education/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.

   Click here for a separate printable copy of the worksheet. Click Here for separate printable copies of worksheet appendix A, and appendix B

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

\[ \pi \cdot D \cdot h = 3.14 \times (1 \text{ m}) \times 3 \text{ m} = 9.42 \text{ m}^2 \]

The surface area of one end is \( \pi \cdot \text{radius of the end}^2 \)

\[ = 3.14 \times (0.5 \text{ m})^2 \]
\[ = 3.14 \times 0.25 \text{ m}^2 \]
\[ = 0.785 \text{ m}^2 \]

So the total surface area of the cylinder is 9.42 m² + (2 • 0.785 m²) = 10.99 m².

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

\[ \text{volume of steel} = 10.99 \text{ m}^2 \times 6 \text{ mm} \]
\[ = 10.99 \text{ m}^2 \times (6 \times 10^{-3} \text{ m}) \]
\[ = 6.59 \times 10^{-2} \text{ m}^3. \]

So, the weight of the buoy is

\[ \text{(volume of steel)} \times \text{(density of steel)} \]
\[ = (6.59 \times 10^{-2} \text{ m}^3) \times (7,850 \text{ kg/m}^3) \]
\[ = (6.59 \times 10^{-2} \text{ m}^3) \times (7.85 \times 103 \text{ kg/m}^3) \]
\[ = 5.18 \times 10^2 \text{ kg} \]

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,

\[ \text{volume of the buoy} = 3.0 \text{ m} \times \pi \times (0.5 \text{ m})^2 \]
\[ = 3.0 \text{ m} \times 3.14 \times 0.25 \text{ m}^2 \]
\[ = 2.36 \text{ m}^3 \]

mass of water = 2.36 m³ • 1.0 gm/cm³

since 1 m³ = 1 x 10⁶ cm³, mass of water = 2.36 x 10⁶ cm³ • 1.0 gm/cm³
\[ = 2.36 \times 10^6 \text{ gm} \]
\[ = 2.36 \times 10^3 \text{ kg} \]

So the buoyancy when completely submerged will be equal to

(buoyant force) - (weight of the buoy)
= (2.36 x 103 kg) - (5.18 x 102 kg)
= 1.842 x 103 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 103 kg = 3.68 x 103 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 103 kg) - (80 kg)
= 3.6 x 103 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 (http://www.exploratorium.edu/snacks/giant_lens/index.html).

The Bridge Connection

The Bridge is a growing collection online marine education resources. It provides educators with a convenient source of useful information on global, national, and regional marine science topics. Educators and scientists review sites selected for the Bridge to insure that they are accurate and current.

www.vims.edu/bridge - Click “Ocean Science Topics” in the navigation menu on the left, then “Human Activities,” then “Heritage,” 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://science.howstuffworks.com/question244.htm - A brief explanation of 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

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 6. The ocean and humans are inextricably interconnected.

- Fundamental Concept c. The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.

- Fundamental Concept d. Much of the world’s population lives in coastal areas.

- Fundamental Concept e. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (such as point source, non-point source, and noise pollution) and physical modifications (such as changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

- Fundamental Concept f. Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).

Shipwreck Alley Lesson Plan

Student Worksheet - Thunder Bay National Marine Sanctuary

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?
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/m³;
- the density of water in Thunder Bay is 1.0 gm/cm³; 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?

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Shipwreck Alley Lesson Plan

Student Worksheet - Thunder Bay National Marine Sanctuary

Part II, Problem 2: Current Affairs: Figure 1
Shipwreck Alley Lesson Plan

Student Worksheet - Thunder Bay National Marine Sanctuary

Part II, Problem 2: Current Affairs: Figure 2