Steamship *Portland*

Ping!

Focus
Side scan sonar

Grade Level
7-8 (Earth Science/Physical Science)

Focus Question
How can side-scan sonar be used to locate objects underwater?

Learning Objectives
Students will be able to describe side-scan sonar.

Students will be able to compare and contrast side-scan sonar with other methods used to search for underwater objects.

Students will be able to make inferences about the topography of an unknown and invisible landscape based on systematic discontinuous measurements of surface relief.

Materials
- ❒ Shoeboxes, one for each student group
- ❒ Plaster of Paris, 1 – 2 lb for each student group
- ❒ Woodworking awl or sharp nail, 3–4 mm diameter
- ❒ Masking tape
- ❒ Pingpong balls, 2 for each student group
- ❒ Wooden dowel, approximately 3 mm diameter, 30 cm long, one for each student group
- ❒ Colored pencils, five colors for each student group
- ❒ Ruler, one for each student group
- ❒ Graph paper
- ❒ Copies of Sonar Simulation Activity, one copy for each student group

Audio/Visual Materials
- ❒ Marker board and markers or overhead projector and transparencies for group discussions

Teaching Time
One 45-minute class period

Seating Arrangement
Groups of 2-4 students

Maximum Number of Students
30

Key Words
Marine archaeology
Portland Gale of 1898
Shipwreck
Sonar
Side-scan sonar
Topography

Background Information
On Thanksgiving Saturday, November 26, 1898, the passenger steamship *Portland* left Boston Harbor with 192 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 1898, 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 1870's, 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 seen near Thatcher Island, about 30 miles northeast 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.

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 east-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.

For 90 years, the location of the *Portland* wreck was unknown, despite intense and continuing public interest. Then in April 1989, members of the Historical Maritime Group of New England found wreckage 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.

In this lesson, students will learn about side-scan sonar, and use mock sonar set-ups to experience some of the difficulties encountered when trying to locate objects or map the ocean floor.

Learning Procedure

[Note: This lesson is adapted from the "Shoebox Bathymetry" activity on the Ocean World website, http://oceanworld.tamu.edu/educators/props_of_ocean/activities/PO_systems.htm.]

1. You may want to download a copy of "The Portland Gale" from http://www.hazegray.org for more information on the *Portland* and the monster storm of 1898. Visit http://oceanexplorer.noaa.gov for up-to-date information on the 2003 Steamship *Portland* Expedition.

2. Prepare "mystery bathymetry" shoeboxes. Mix plaster of Paris, and pour a 1 – 2 cm thick layer into the bottom of each shoebox. Make irregular mounds of plaster in one area to simulate rough topography. Embed one pingpong ball somewhere in the rough topography, and another

pingpong ball in a smoother area. Allow plaster to harden. Punch five rows of holes 3 – 4 mm in diameter in the lid of the shoebox with an awl or nail. Space the holes 2 cm apart over the surface of the lid. Temporarily fasten the lids to the boxes with masking tape.

3. Briefly review the story of the *Portland* and the gale of 1898. Tell students that people searched for the wreck of the *Portland* for over a hundred years, and finally found it for sure using side-scan sonar. Say that sonar is short for "sound navigation ranging," and uses sound waves to locate underwater objects by measuring the time it takes for a transmitted sound wave to be reflected back to its source. The sound wave is transmitted through a transducer, which is analogous to a speaker in a radio. Side-scan uses a transducer housed in a hollow container called a towfish that is towed through the water 10 to 20 feet above the bottom. The transducer emits sound waves to either side of the towfish, and measures the time it takes for the waves to be reflected back to the towfish. These measurements are processed into an image that resembles an aerial photograph, and can be viewed in real-time on a computer monitor aboard the towing vessel. A differentially corrected global positioning system (DGPS) is used to guide the towing vessel along predetermined search paths, as well as to identify points of interest on the side-scan image. This allows searchers to return to any point on the image for further investigation. Side-scan sonar does not depend upon light and can be used under conditions that would make searching by divers dangerous or impossible. Because it typically covers a swath of 60 to 120 feet at about 2 miles per hour, it is a very efficient way to search large areas. For these reasons, side-scan sonar has been used increasingly over the last few years to search for drowning victims.

4. Tell students that their assignment is to map an unexplored and invisible landscape. Distribute one copy of "Sonar Simulation Activity" to each student group. When students have completed their bathymetry graphs, have each group show their graphs to the entire class and report their conclusions about the mystery landscape. After each group has reported their conclusions, have them open their box, and compare the actual topography with their predictions.

5. When all groups have made their presentations, ask students how their investigations could be improved. Students should realize that this activity does not simulate side-scan sonar, or even conventional sonar; it is more like the centuries-old method used by mariners who lowered a lead weight attached to a measured line until the weight touched the bottom (or some object resting on the bottom). A conventional sonar system would provide a continuous record of depth directly beneath a ship. This would improve resolution along the search path, but there would still be gaps between the paths that are much greater than the area actually imaged. Side-scan sonar would fill in these gaps, and give an almost continuous picture of the search area. Students should also realize that rough topography can obscure objects being searched for, so better resolution is especially important when there are boulders, reefs, or other irregular objects in a search area.

The BRIDGE Connection

http://www.vims.edu/bridge/archive1200.html/

The "Me" Connection

Ask students to imagine that they are asked to locate a small boat that has sunk in a nearby body water, and write a short essay describing the procedures and equipment they would use to complete this task.

Connections to Other Subjects

English/Language Arts, Earth Science

Evaluation

Experimental notes and oral reports prepared in Step 4 provide opportunities for assessment.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest *Portland* Expedition discoveries.

Resources

Bachelder, P. D. and M. P. Smith. 2003. Four Short Blasts. The Gale of 1898 and the Loss of the Steamer *Portland*. The Provincial Press. Portland, ME.

http://www.hazegray.org/ – Website with information on naval ships, photos, etc., and a page about the *Portland* Gale of 1898

http://score.rims.k12.ca.us/activity/bubbles/ – Marine archaeology activity guide based on investigations of the wreck of a Spanish galleon; from the Schools of California Online Resources for Education website

http://www.historytv.com/classroom/admin/study_guide/archives/thc_guide.1378.html – Study guide for history channel program on steamboats on the Mississippi

http://www.gomr.mms.gov/homepg/lagniapp/shipwreck/ – US Department of the Interior Minerals Management Service publication, "Historic Shipwrecks of the Gulf of Mexico: A Teacher's Resource"

http://www.usatoday.com/weather/movies/ps/perfectstorm.htm – USA Today website with information about extreme storms

National Science Education Standards

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

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 & Social Perspectives
- Natural hazards
- Risks and benefits

For More Information

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Student Handout

Sonar Simulation Activity

1. Assign a different color to each of the five rows of holes on your shoebox.

2. Select one row (it doesn't matter which one). Insert the wooden dowel into each hole in the row and measure the depth from the surface (lid) by marking it with your finger, pulling the dowel out, and measuring the distance with your ruler. Record this measurement on your graph paper in the appropriate color. The x-axis of your graph paper should correspond to the numbers of the holes in each row (the first hole should correspond to number 1 on the x-axis, the second hole to number 2, etc.). The y-axis of your graph should correspond to the depth measurements.

3. Continue doing Step 2 until the depth through all holes in the first row has been measured. Connect the dots on your graph with the appropriate color.

4. Based on this one row of measurements, predict what the topography is like inside your shoebox. Record your predictions.

5. Repeat Step 2 on the next row of holes using a different color pencil. Record data on the same graph used for the first row, using the appropriate color.

6. Examine your data for the second row. Are they the same? What does this new information reveal? Record any changes in your predictions.

7. Repeat Steps 5 and 6 for the remaining three rows of holes. Now wait for further instructions from your teacher.