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Aegean and Black Sea 2006 Expedition

Do You Have a Sinking Feeling?

(adapted from the 2003 Steamship Portland Expedition)

Focus
Marine archaeology

Grade Level
9-12 (Earth Science/Mathematics)

Focus Question
How can marine archaeologists use historical and archaeological data to draw inferences about shipwrecks?

Learning Objectives
Students will be able to plot the position of a vessel given two bearings from the vessel on appropriate landmarks.

Students will be able to draw inferences about a shipwreck given information on the location and characteristics of artifacts from the wreck.

Students will be able to explain how the debris field associated with a shipwreck gives clues about the circumstances of the vessel's sinking.

Materials
- ❒ Copies of "Last Entries from the Logbook of the Sloop *Hollis Blanchard*," "Grid Reference System for Unidentified Shipwreck Q11WRK5," and "List of Artifacts Retrieved from Unidentified Shipwreck Q11WRK5," one copy for each student group
- ❒ Copies of nautical chart of Hampton Harbor, one copy for each student group (see Learning Procedure)

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

Teaching Time
One or two 45-minute class periods

Seating Arrangement
Groups of two to four students

Maximum Number of Students
30

Key Words
Debris field
Marine archaeology
Shipwreck
Artifact

Background Information
The geographic region surrounding the Aegean and Black Seas has been the stage for many spectacular performances in Earth's geologic and human history. Human activities on the region's stage began during Paleolithic times; artifacts discovered near Istanbul are believed to be at least 100,000 years old. Well-known Aegean cultures include the Minoans (ca 2,600 – 1,450 BC), Mycenaeans (ca 1,600 – 1,100 BC), Ancient Greeks (776 – 323 BC), and Hellenistic Greeks (323 – 146 BC). Istanbul —"the only city that spans two continents"—has been a crossroads of travel and trade for more than 26 centuries. Mariners have traveled the Aegean and Black Seas since Neolithic ("Stone Age" times; 6,500

– 3,200 BC), probably for a combination of purposes, including trading, exploration, and warfare.

Interactions between these cultures and many others were often violent and destructive. So, too, were interactions with geological processes. One of the most dramatic and destructive events was the eruption of a volcano near a small Aegean island called Thera (also known as Santorini), sometime between 1,650 and 1,450 BC. Estimated to be four times more powerful than the Krakatoa volcano of 1883, the eruption left a crater 18 miles in diameter, spewed volcanic ash throughout the Eastern Mediterranean, and may have resulted in global climactic impacts. Accompanied by earthquakes and a tsunami, the volcano destroyed human settlements, fleets of ships, and may have contributed to the collapse of the Minoan civilization on the island of Crete, 110 km to the south.

Interactions with other geological processes may have been equally disastrous. In 1997, geologists William Ryan and Walter Pitman published a theory in which the Black Sea was inundated around 5,600 BC by flood waters from the Mediterranean passing through the Straits of Bosporus at Istanbul. Such a deluge, if it occurred, would have been disastrous for human settlements along the Black Sea shoreline and might have provided an origin for accounts of cataclysmic floods in Christianity and other cultures. Subsequent research has neither proved nor disproved the Black Sea deluge theory, but in 2000, Robert Ballard discovered remains of a wooden structure that may have been part of an ancient seaport 95 meters below the surface of the Black Sea. This may be one of the best places in the world to look for remains of ancient civilizations, because the deep waters of the Black Sea contain almost no oxygen, so the biological organisms that normally attack such relicts cannot live in this environment. Additional support for the idea comes from radiocarbon dating of the shells of freshwater molluscs sampled at the "ancient shoreline" site. These analyses show the age of the freshwater molluscs to be about 7,500 years, while saltwater species from the same area appeared about 6,900 years ago. In other words, the transition from fresh to saline conditions was fairly rapid. More recent analyses of other data conclude that while this flood did occur, it was not as catastrophic as suggested by Ryan and Pitman, and a more severe flooding event took place 16,000 - 13,000 years ago (see http://gsa.confex.com/gsa/2003AM/finalprogram/abstract_58733.htm). Notwithstanding debate about the relative significance of ancient floods, the anoxic waters of the Black Sea may still reveal a great deal about seafaring activities of "Stone Age" peoples. Finding well-preserved marine archaeological sites, studying ancient maritime trade, and exploring the history of the Theran volcano are the primary goals of the Aegean and Black Sea 2006 Expedition.

In this lesson, students will analyze historical and archaeological data to draw inferences about shipwrecks. While the shipwrecks involved in this lesson are from much more recent times, the analytical techniques are similar to those that would be used to investigate any underwater archaeological site.

Learning Procedure

1. To prepare for this lesson
   - Review the background essays for the Aegean and Black Sea 2006 Expedition at http://oceanexplorer.noaa.gov/explorations/06blacksea/;
   - Download chart n13278i.tif (nautical chart of Hampton Harbor) from http://www.state.ma.us/mgis/noaacharts.htm; and
   - Review the story of the Steamship *Portland* (Step 5, below)

2. Introduce the Aegean and Black Sea 2006 Expedition, emphasizing some of the reasons that scientists are interested in the Black Sea, and the probable existence of undiscovered

marine archeological sites that could reveal a great deal about the history of the Aegean/Black Sea area. Tell students that they are going to assume the role of consulting marine archaeologists investigating shipwrecks, and that they have two assignments. The first is to locate the probable site of a ship that sank many years ago. The second is to use artifacts collected from an unidentified wreck to answer questions about the age of the vessel, its purpose, who was aboard, and why it sank.

3. Distribute one copy of "Nautical Chart of Hampton Harbor" and one copy of "Last Entries from the Logbook of the Sloop *Hollis Blanchard*" to each student group. Explain that the *Hollis Blanchard* was a trading sloop that was lost in the early 1900's somewhere in Hampton Harbor, Massachusetts during a violent nor'easter. Though wreck of the ship was never found, we have the extraordinary good fortune to have discovered the ship's log in an antique shop in Boston. Apparently, the logbook mysteriously came ashore and was picked up by a young boy walking along the beach after the storm. The boy decided it wasn't very interesting, tossed it into an old chest, and promptly forgot about it. Over the following years, the boy grew up, lived a long life, and finally died. His son discovered the old chest while he was cleaning out his father's house, but didn't pay any attention to the contents. The chest was sold to an antique dealer along with many other items. Yesterday, one of our marine archaeologist colleagues happened into the antique dealer's store, spotted the old logbook, and realized what he had found. Today, we will try to pinpoint the probable site of the wreck of the *Blanchard*!

   Have students plot the last five entries from the *Blanchard's* logbook using protractors. Assume that the longitude lines on the chart indicate true north, that bearings are true (i.e., not affected by magnetic variation or compass deviation), and that major landmarks used for coastwise navigation have not changed since the time of the *Blanchard*. Students will have to decipher the captain's abbreviations. If they need help, "GBH" probably stands for Great Boars Head, "ThosRk" is probably Thomas Rock, "WTank" most likely is the old Tank shown on the chart, and "JLite" could very well be the old lighthouse at the end of the jetty. The skipper was clearly in a hurry, since it is customary to use three bearings to establish a position or "fix," but, if he was careful, his notes may still be helpful. Tell students that local weather records show that the wind was blowing at 60 mph out of the northwest at the time these entries were made in the *Blanchard's* log.

   When students have completed charting the five positions, ask each group to speculate on what happened to the *Blanchard* and where her wreck might be. Figure 1 (at the end of this lesson) shows the ten bearings from the logbook, and their corresponding positions within the harbor. Being a sailing vessel, the *Blanchard* was obliged to tack into the harbor, which would have been extremely difficult under the reported weather conditions. Evidently, the skipper hoped to be able to approach close enough to run inside the Inner and Outer Sunk Rocks, and then work his way into the shelter of the inner harbor. Alas, his ship was dismasted just to windward of Old Cellar Rock, and the *Blanchard* was driven onto the rock by the strong northwest wind. Wreckage from the *Blanchard* may lie near the Inner and Outer Sunk Rocks, but it is also possible that the storm pushed the *Blanchard's* remains past the rocks and into the deeper water to the southeast. We can't be confident of a specific location for the wreck of the *Blanchard*; but we have narrowed our search area!

4. Distribute one copy of "Grid Reference System for Unidentified Shipwreck Q11WRK5" and one copy of "List of Artifacts Retrieved from

Unidentified Shipwreck Q11WRK5" to each student group. Explain that a grid system is often used in archaeological investigations to prepare a precise record of a debris field and to document the exact location of artifacts and their relationship to each other (you may want to remind students that they have used grids to express location if they have ever played Battleship, or even Bingo). Have students prepare a brief report, summarizing their interpretation of the artifacts, with specific reference to clues about:

- the specific identity of the wreck;
- age of the vessel;
- the vessel's purpose;
- who was aboard; and
- why the vessel sank.

If students have trouble approaching this problem, suggest that they organize the artifacts by location, including depth below the surface, then consider what the artifacts may suggest with regard to the above questions.

Have each student group make an oral presentation of their conclusions, summarizing their inferences on a marker board or overhead transparency. Lead a discussion of these results. 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 remains 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 2m 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.

Encourage students to 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.

5. Briefly review the story of the *Portland* and the gale of 1898:
   On Thanksgiving Saturday, November 26, 1898, 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 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 thirty miles northeast of Boston. But the *Portland* was apparently unable to make much more progress against the storm.

At 5:45 am 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 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.

Students will probably realize that the "unidentified wreck" has been modeled after the *Portland*, which did have a dining salon on a lower deck forward of the engines, and staterooms on deck around the edge of the ship. Evidence collected during explorations of 2002 suggests that the entire superstructure of the ship may have been swept away by a huge wave, leaving the hull to fill and sink. For purposes of this activity, the mystery wreck has been allowed to keep the forward portion of her superstructure to provide more "artifacts" for student analysis.

[Note: 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. See the 2003 Ocean Explorer Steamship *Portland* Expedition Web site (http://oceanexplorer.noaa.gov/explorations/03portland/welcome.html) for more information.

While the artifacts activity is based on some of the known facts about the *Portland* and her sinking, the wreck of the *Hollis Blanchard* is entirely fictitious. Hollis Blanchard was, however, captain of the *Portland* on her final voyage.

The Bridge Connection

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

The "Me" Connection

Have students write a short essay explaining why exploring for Bronze Age shipwrecks is, or is not, important.

Connections to Other Subjects

English/Language Arts

Assessment

Charts and written reports prepared in Steps 3 and 4 provide opportunities for assessment.

Extensions

Have students visit http://oceanexplorer.noaa.gov/explorations/06blacksea/ to keep up with the latest discoveries from the Aegean and Black Sea 2006 Expedition.

Resources

NOAA Learning Objects

http://www.learningdemo.com/noaa/ – Click on the links to Lessons 1, 2, and 4 for interactive multimedia presentations and Learning Activities on Plate Tectonics, Mid-Ocean Ridges, and Subduction Zones.

Other Relevant Lessons from the Ocean Exploration Program

What's Eating Titanic?

http://oceanexplorer.noaa.gov/explorations/04titanic/edu/media/Titanic04.Rusticles.pdf
(5 pages, 408k) (from the Titanic 2004 Expedition)

Focus: Biodeterioration processes (Physical Science/Biological Science)

In this activity, students will be able to describe three processes that contribute to the deterioration of the *Titanic*, and define and describe rusticles, explaining their contribution to biodeterioration. Students will also be able to explain how processes that oxidize iron in *Titanic's* hull differ from iron oxidation processes in shallow water.

Designing Tools for Ocean Exploration

http://oceanexplorer.noaa.gov/explorations/02galapagos/background/education/media/gal_gr9_12_l1.pdf
(13 pages, 496k) (from the 2002 Galapagos Rift Expedition)

Focus: Ocean Exploration

In this activity, students will understand the complexity of ocean exploration; learn about the technological applications and capabilities required for ocean exploration; discover the importance of teamwork in scientific research projects; and develop the abilities necessary for scientific inquiry.

Submersible Designer

http://oceanexplorer.noaa.gov/explorations/02galapagos/background/education/media/gal_gr9-12_l4.pdf
(4 pages, 452k) (from the 2002 Galapagos Rift Expedition)

Focus: Deep Sea Submersibles

In this activity, students will understand that the physical features of water can be restrictive to movement; understand the importance of design in underwater vehicles by designing their own submersible; and understand how submersibles such as ALVIN and ABE, use energy, buoyancy, and gravity to enable them to move through the water.

Mapping the Canyon

http://oceanexplorer.noaa.gov/explorations/deepeast01/background/education/dehslessons2.pdf
(10 pages, 72k) (from the 2001 Deep East Expedition)

Focus: Hudson Canyon Bathymetry (Earth Science)

In this activity, students will be able to compare and contrast a topographic map to a bathymetric map; investigate the various ways in which bathymetric maps are made; and learn how to interpret a bathymetric map.

Finding the Way

http://oceanexplorer.noaa.gov/explorations/deepeast01/background/education/dehslessons4.pdf
(10 pages, 628k) (from the 2001 Deep East Expedition)

Focus: Underwater Navigation (Physical Science)

In this activity, students will describe how the compass, Global Positioning System (GPS), and sonar are used in underwater explorations; and understand how navigational tools can be used to determine positions and navigate in the underwater environment.

Other Resources and Links

http://oceanexplorer.noaa.gov/explorations/06blacksea – Web site for the Aegean and Black Sea 2006 Expedition

http://www.immersionpresents.org/ – Immersion Presents Web site; click on "Ancient Eruptions!" for more information about the Aegean and Black Sea 2006 Expedition, images, and educational activities

http://www.ngdc.noaa.gov/paleo/ctl/clihis10k.html –Timeline for last 10,000 years from NOAA's Paleoclimatology Web site

http://pubs.usgs.gov/pdf/planet.html – "This Dynamic Planet," map and explanatory text showing Earth's physiographic features, plate movements, and locations of volcanoes, earthquakes, and impact craters

http://disc.gsfc.nasa.gov/oceancolor/scifocus/oceanColor/dead_zones.shtml – Web page from NASA about "Creeping Dead Zones," including SeaWIFS satellite imagery

http://news.nationalgeographic.com/news/2000/12/122800blacksea.html – National Geographic Web site, "Ballard Finds Traces of Ancient Habitation Beneath Black Sea"

http://blacksea.orlyonok.ru/blacksea.shtml – Web site of the Living Black Sea Marine Environmental Education Program in the Russian Federal Children Center Orlyonok

Friedrich, W. L.. 2000. Fire in the Sea. The Santorini Volcano: Natural History and the Legend of Atlantis. Translated by Alexander R. McBirney. Cambridge University Press. 258 pp.

Ryan, W. and W. Pitman. 1999. Noah's Flood: The New Scientific Discoveries About the Event That Changed History. Simon and Schuster. New York.

Yanko-Hombach, V. 2003. "Noah's Flood" and the late quaternary history of the Black Sea and its adjacent basins: A critical overview of the flood hypotheses. Paper presented at the Geological Society of America Annual Meeting, November 2–5, 2003, Seattle, WA (abstract available online at http://gsa.confex.com/gsa/2003AM/finalprogram/abstract_58733.htm).

http://ina.tamu.edu/ub_main.htm – Web site with information about the excavation of a Bronze Age shipwreck at Uluburun, Turkey

http://projectsx.dartmouth.edu/history/bronze_age/ – Dartmouth University Web site, "Prehistoric Archaeology of the Aegean," with texts, links to other online resources, and numerous bibliographic references

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/ – Web site 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 Web site

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"

National Science Education Standards

Content Standard A: Science As Inquiry

- Abilities necessary to do scientific inquiry
- Understanding 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
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Natural and human-induced hazards

Content Standard G: History and Nature of Science

- Historical perspectives

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1.
The Earth has one big ocean with many features.

- *Fundamental Concept b.* An ocean basin's size, shape and features (such as islands, trenches, mid-ocean ridges, rift valleys) vary due to the movement of Earth's lithospheric plates. Earth's highest peaks, deepest valleys and flattest vast plains are all in the ocean.
- *Fundamental Concept e.* Tectonic activity, sea level changes, and force of waves influence the physical structure and landforms of the coast.

Essential Principle 2.
The ocean and life in the ocean shape the features of the Earth.

- *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 6.
The ocean and humans are inextricably interconnected.

- *Fundamental Concept a.* The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and nearly all Earth's oxygen. It moderates the Earth's climate, influences our weather, and affects human health.
- *Fundamental Concept b.* From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.
- *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 f.* Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).
- *Fundamental Concept g.* Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

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.

- *Fundamental Concept f.* Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

Send Us Your Feedback

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

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Student Handout

Last Entries from the Logbook of the Sloop *Hollis Blanchard*

11/27/06, 6:10 pm - GBH bears 330, ThosRk bears 260

11/27/06, 6:30 pm - GBH bears 325, ThosRk bears 225

11/27/06, 6:55 pm - WTank bears 280, JLite bears 205

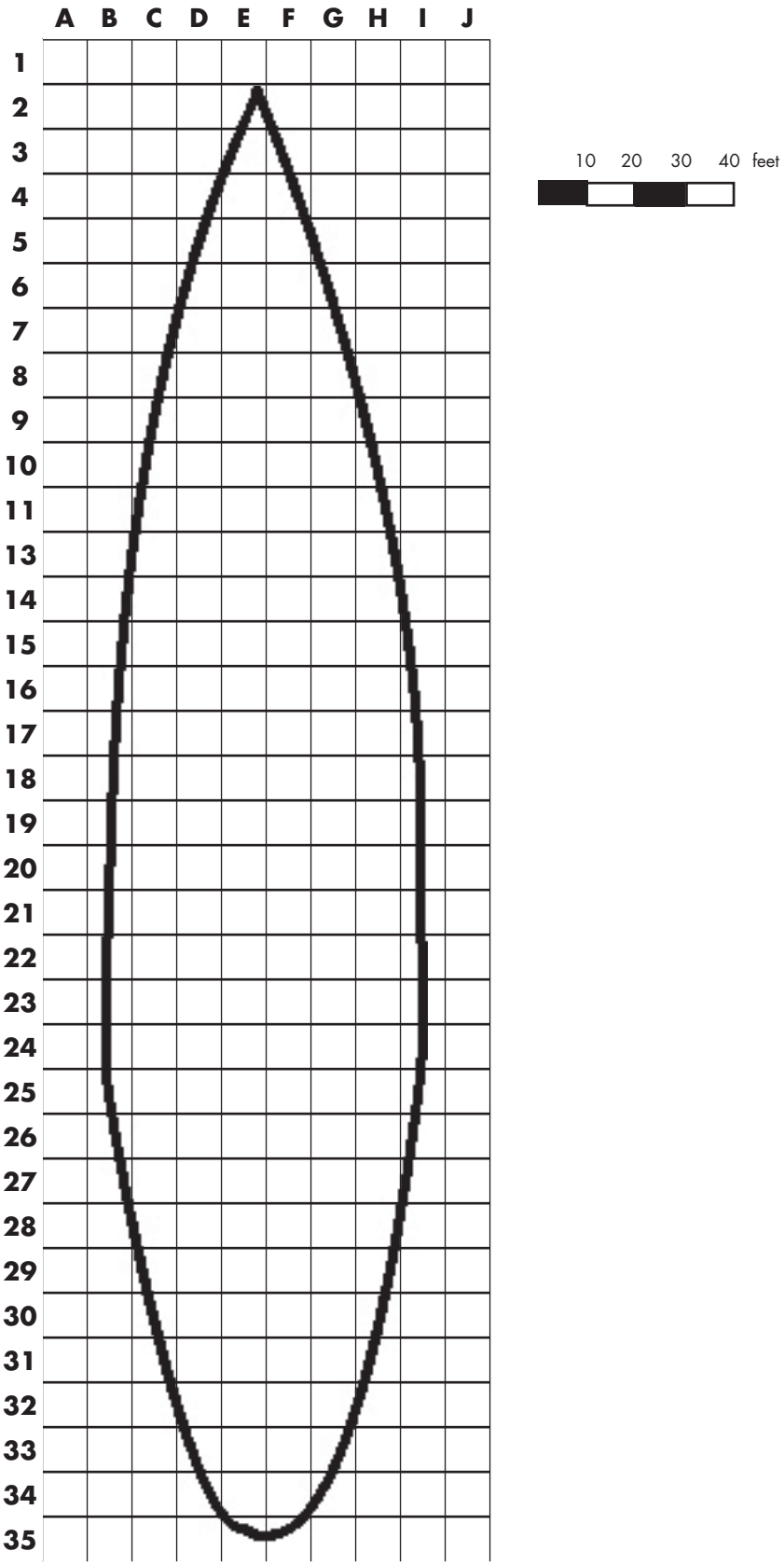
11/27/06, 7:15 pm - WTank bears 300, JLite bears 225

11/27/06, 7:35 pm - Dismasted! WTank bears 340, JLite bears 195

Have mercy on our souls

Student Handout

Grid Reference System for Unidentified Shipwreck Q11WRK5



Student Handout

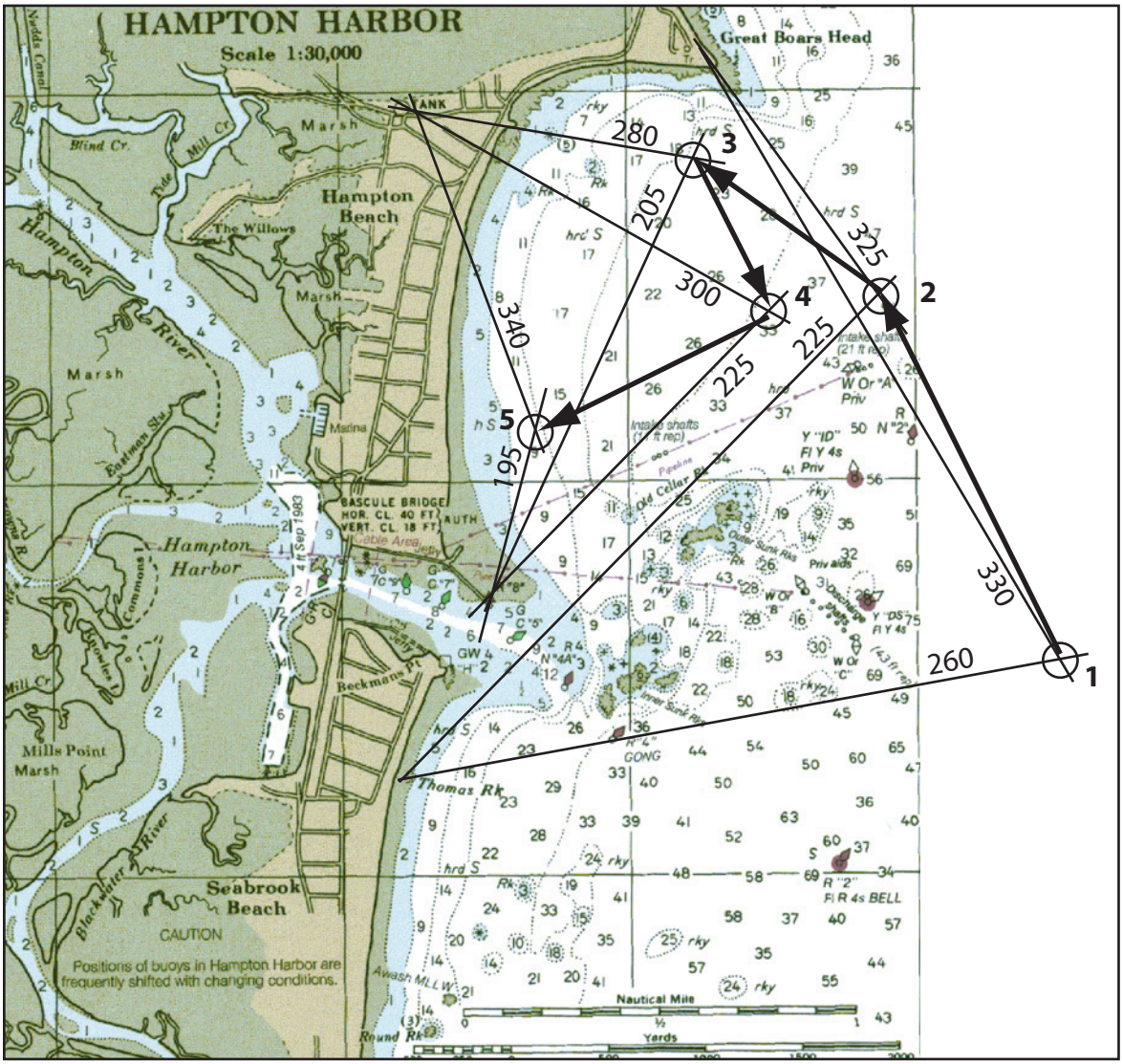
List of Artifacts Retrieved from Unidentified Shipwreck Q11WRK5

Grid Reference	Description
E19–E23 & F19-F23	Heavy metal structure, diamond-shaped, partially buried
D10	Gentleman's gold ring, 55 cm from surface
E14	Heavy mahogany chair, velvet upholstery, 1 m from surface
D10	China plate, 2.5 m from surface
G10	China chamber pot, 50 cm from surface
D13	Silver flatware, engraved letter "P," 2.5 m from surface
F14	China cup, 2.5 m from surface
D10	Brandy flask, 50 cm from surface
F14	Domed skylight, 40 cm from surface
D13	Carved mahogany headboard, 70 cm from surface
F13	Ebony piano keyboard, 55 cm from surface
C19-C24	Massive paddlewheel, partially buried
G10	Child's rocking chair, mahogany, 60 cm from surface
D13	Lady's dress shoe, 65 cm from surface
G10	Shaving straight razor, 55 cm from surface
H17	Silver buckle, 70 cm from surface
D13	China chamber pot, 60 cm from surface
E11	Carving knife, 2.3 m from surface
D10	Man's leather dress shoe, 60 cm from surface
B13	Carved wooden plank, letters "RTLAND;" left side broken
E11	Silver serving platter, 2.3 m from surface
E5	Rusted iron mass, possibly chain
F21	Heavily rusted iron mass, possibly tools, 2.5 m from surface
E11	Ship's wheel, 30 cm from surface
D10	Small mahogany chest of drawers, 70 cm from surface
E33	Rudder, partially buried
G19-G24	Massive paddlewheel, partially buried
E17 & F17	Smokestacks

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 3.5 m.

Teacher Answer Key

Figure 1



1 Probable position determined from bearings

Probable sailing track of the *Hollis Blanchard*

325 Bearing line