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

Looking for Clues

(adapted from the PHAEDRA 2006 Expedition)

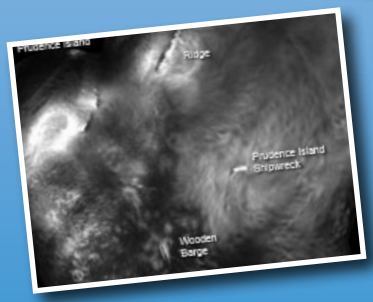

Image captions/credits on Page 2.

lesson plan

Focus

Marine archaeology

Grade Level

5-6 (Earth Science/Social Studies)

Focus Question

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

Learning Objectives

- Students will draw inferences about a shipwreck given information on the location and characteristics of artifacts from the wreck.
- Students will explain at least three types of evidence that could support inferences about the use of maritime technology in the nineteenth century.

Materials

- ❑ Copies of *Inventory of Artifacts Recovered from Three Sites in the Serce Limani Debris Field*, and *Sketch Map of the Serce Limani Debris Field Survey Sites*, one copy for each student group
- ❑ Internet access

Audio-Visual Materials

- ❑ None

Teaching Time

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

Seating Arrangement

Groups of 3-4 students

Maximum Number of Students

32

Key Words

Lake Huron
Thunder Bay
Shipwreck
Underwater archaeology
Debris field
Artifact

Background Information

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

Lake Huron covers 23,010 square miles (59,596 square kilometers) on the border between Canada and the United States, and has been a significant focus of human activity for thousands of years. If the shorelines of its 30,000 islands are included, Lake Huron has the longest shoreline of the Great Lakes and is the second largest by surface area. The lake is also notorious for its dense fog banks, violent storms, and rocky shoreline; hazards that have brought disaster to many ships.

It is not certain when the first boats appeared on Lake Huron. Southern Michigan was probably occupied near the end of the last ice age (about 12,000 years ago), but northern Michigan probably was not occupied until several thousand years later. People in other parts of the world used boats since Neolithic times (the 'Stone Age'; 8,500 – 5,200 years ago; see http://oceanexplorer.noaa.gov/explorations/06greece/background/edu/media/old_ship.pdf for more information), and there is good evidence that boats may have been used when early inhabitants of North and South American migrated from Siberia about 13,000 years ago (see http://oceanexplorer.noaa.gov/explorations/09newworld/background/edu/media/landsea.pdf). Archaic people in Michigan began to utilize fish sometime around 5000 years ago, as indicated by artifacts such as bone or copper fishhooks, spears, notched pebble net-sinkers, and fish bones (especially sturgeon) found in upper Great Lakes sites. The point is, humans probably have been using boats on Lake Huron for a long time.

Physical remains of ancient voyages (i.e., shipwrecks) can provide information about trading patterns, sociopolitical networks, technological development and many other unique insights into early human cultures; but a variety of factors make it difficult to find such remnants. One factor in many coastal regions is that water levels have changed significantly since humans first arrived in North America. The level of Lake Huron, for example, has varied from 55 - 80 m above mean sea level about 9,900 - 7,500 years ago to its present level of 176 m above mean sea level. This means that artifacts from early human activity around Lake Huron may now be more than 120 m below the lake's surface! Recently, archaeologists have discovered evidence of prehistoric hunters on a submerged ridge (20 - 40 m deep) that was above the surface of Lake Huron 9,900 - 7,500 years ago (O'Shea and Meadows, 2009).

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

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

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

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

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

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

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

In addition to changing water levels, a major obstacle is the very thing that makes ancient shipwrecks so valuable – their age. Plant and animal materials used in the construction of ancient boats are rapidly deteriorated by biological and chemical processes, so that only a few (if any) traces remain after thousands of years; unless something interferes with these processes.

Several things interfere with the deterioration of shipwrecks in Thunder Bay. Low temperatures tend to slow the rate of biological and chemical deterioration (which is why food keeps longer in refrigerators). Freshwater is much less corrosive to metal artifacts than saltwater. Shipwrecks buried in sediments can be amazingly well-preserved, because sediments often have low levels of oxygen which is required by many deterioration processes. The Ocean Explorer Thunder Bay Sinkholes 2008 Expedition (http://oceanexplorer.noaa.gov/explorations/08thunderbay/welcome.html) explored areas in Lake Huron with very low oxygen levels. Similar areas may contain shipwrecks much older than those discovered to date.

The Thunder Bay National Marine Sanctuary (TBNMS) was established in 2000 to protect one of the nation's most historically significant collections of shipwrecks. The present boundaries of the TBNMS enclose 448 square miles that contain 40 known historic shipwrecks. Plans are well underway, however, to expand these boundaries to include 3,662 square miles (Figure 1). Archival records indicate that the expanded boundaries include more than 100 undiscovered shipwrecks which can provide unique opportunities for historians and archaeologists to study the maritime and cultural history of the Great Lakes region, as well as for recreational explorers. Finding the exact location of these shipwrecks is obviously essential to these kinds of uses, as well as to the protection of these important cultural resources.

To help meet this need, in 2008 a remote sensing survey was undertaken in the northern portion of the proposed expansion area. This survey used a side scan sonar towed from a research vessel, as well as a conventional sonar system mounted on an autonomous underwater vehicle (AUV). The 2008 survey covered an area of about 100 square miles and located two new shipwrecks. The total proposed expansion area is much larger, though, so a third survey strategy is needed to efficiently cover large areas of deep water. As its name suggests, the Thunder Bay 2010: Cutting Edge Technology and the Hunt for Lake Huron's Lost Ships Expedition will use state-of-the-art technology that includes a sophisticated AUV carrying a one-of-a-kind precision sonar system to survey up to 200 square nautical miles in the proposed expansion area. Further investigation of shipwrecks located during the survey will be done by marine archaeologists using technical diving procedures. If particularly interesting wrecks are discovered, these "ground truthing" dives may be done during the

Thunder Bay 2010 Expedition. Most of these investigations, however, will be done after the expedition's conclusion. Explorers do not expect to find wrecks older than a few hundred years in Thunder Bay; but many ancient shipwrecks have been discovered by people who weren't really looking for them!

In this lesson, students will analyze underwater archeological data to draw inferences about an ancient shipwreck.

Learning Procedure

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

   (b) You may also want to review the discussion of the Serce Limani shipwreck on the Institute of Nautical Archaeology's Web site (http://inadiscover.com/projects/all/southern_europe_mediterranean_aegean/serce_limani_turkey/full_report/). If students will not have access to the internet for research, you will also need to download suitable materials, or confirm that such materials are available in libraries to which students have access.

2. Show students a map of the Great Lakes, and locate Lake Huron and Thunder Bay. Highlight "Shipwreck Alley" and briefly introduce the Thunder Bay 2010: Cutting-Edge Technology and the Hunt for Lake Huron's Lost Ships Expedition. Ask students when they believe boats and ships were first used in human history and what kinds of evidence might help answer that question. The best evidence would be physical remains of an ancient boat, which could be dated by examining radioactive isotopes in the remains.

   Indirect evidence might come from paintings or other images that show boats and ships being used. This kind of evidence suggests that boats were in use in Egypt between 4,000 and 3,000 BC (Neolithic or 'Stone Age' period), since petroglyphs found on rocks and walls throughout eastern Egypt between the Nile River Valley and the coast of the Red Sea show a variety of ships being rowed or sailed. Another type of indirect evidence is the appearance of human inhabitants on some of the Aegean islands around 7,000 BC. Since they are islands, settlers could only have arrived there on some type of boat, perhaps from western Anatolia or somewhere even more distant. A third type of indirect evidence has been recovered from excavations of a Neolithic (ca. 4,300 – 3,700 BC) settlement on the island of Saliagos in the Cyclides. Large quantities of fish bones, including those of very large tunas, show a close involvement with marine resources that may have included some type of seagoing vessel, though no

remnants of such vessels or associated equipment (e.g., oars) have been found.

Direct evidence of early prehistoric vessels was first unearthed in November 2002 from the Kuahuqiao ruins, near the Chinese city of Hangzhou, where archaeologists found the remains of a wooden dugout canoe that were dated to about 6,000 BC. Two years later, a 4 meter-long pinewood boat, also dated to about 6,000 BC, was discovered in South Korea. These vessels are much older than those depicted in petroglyphs and were probably confined to short trips inshore or on freshwater bodies.

3. Tell students that they are going to assume the roles of consulting marine archaeologists investigating a shipwreck found near Serce Limani, a natural harbor on the southern shores of Turkey. Their assignment is to analyze artifacts collected from three sites near the ship, and draw inferences about when the vessel sank, the reason for the vessel's final voyage and the types of people who were on board.

4. Provide each student group with copies of *Inventory of Artifacts Recovered from Three Sites in the Serce Limani Debris Field* and *Sketch Map of the Serci Limani Debris Field Survey Sites*. Note that these are based on artifacts that have actually been recovered from this wreck site (see http://inadiscover.com/projects/all/southern_europe_mediterranean_aegean/serce_limani_turkey/articles/). Students should first group the artifacts according to the site from which they were recovered. Students should study the artifacts found at each of the three sites, research the names of unfamiliar items, and develop inferences about the purpose of the vessel and the people who were aboard. Have each student group prepare a short report on their analyses, citing evidence from the debris field to support their conclusions.

5. Lead a discussion of students' results. Key points should include:
   - The ship was a sailing vessel.
   - The large wicker basket found in the stern area of the ship contains many clues. Obviously, the dates on the glass weights suggest that the vessel probably sank around around 1025 AD during the Byzantine Period (about 300 – 1450 AD). This inference is supported by weighing equipment typical of the Byzantine Period. This equipment also suggests that the ship was probably a trading vessel. The stern is the traditional location of the captain's quarters, so it would make sense for the weighing equipment to be nearby since the captain would probably be involved in trading transactions. Why were carpentry tools and weighing equipment found in the same basket? Perhaps the captain was the ship's carpenter as well as a merchant.

- Meals aboard the ship included meat (pig, goat, and possibly sheep), fish (which was caught by the crew using nets and spears), and assorted fruits and nuts. Meals that included pork were apparently restricted to those who lived in the stern, and possibly a bow compartment, and this may have been true of fruit as well. These observations suggest some social stratification among those aboard, an inference that is supported by the fact that a chess set was recovered from the stern compartment while a backgammon piece was recovered from the midships area (the traditional location of the crew's quarters; for additional explanation, see "The 'Gaming Pieces'" by Ken Cassavoy at http://www.diveturkey.com/inaturkey/serce/gaming.htm

- Spears, javelins, and swords may have been defensive weapons, possibly against pirates. There was very little coinage or other 'treasure' on board. The presence of three Byzantine lead seals for documents suggests that merchants on board may have used letters of credit instead of hard currency.

- Caulking tools in the bow area, in contrast to other hand tools found in the stern area, suggest that these tools may be been in use at the time the vessel sank. Perhaps the ship sought shelter in Serci Limani harbor due to a leaking hull.

- The ship's cargo was diverse and included glassware, cooking pots, glazed bowls, jugs and gargoulettes (one-handled jugs with a built-in filter), raisins, and wine. Broken glass was also part of the cargo, and may have been used as ballast in the ship's hold. This would have made good economic and technical sense, since it was a ballast that could be sold to glassmaking factories. Then (and now) much less energy is required to re-melt than is needed to make new glass. Moreover, locally available raw materials may not be suitable for making all types of glass, so having a variety of recyclable glass would increase the probability of being able to find a buyer for this type of cargo.

The BRIDGE Connection

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

The "Me" Connection

Have students write a brief essay describing why knowing about past civilizations and ways of life is important or useful, and how archeological investigations might affect their lives personally.

Connections to Other Subjects

English/Language Arts, Social Studies, History, Physical Science

Assessment

Student analyses, reports, and class discussions offer opportunities for assessment.

Extensions

1. Have students visit http://oceanexplorer.noaa.gov/10thunderbay/welcome.html to keep up with the latest discoveries from the Thunder Bay 2010: Cutting-Edge Technology and the Hunt for Lake Huron's Lost Ships Expedition.

2. Visit the Ocean Explorer Web site for the PHAEDRA 2006 Expedition (http://oceanexplorer.noaa.gov/explorations/06greece/) for more information about explorations to learn more about ancient seafaring cultures.

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

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

Focus: Marine archaeology (Physical Science)

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

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

Focus: Maritime History/Physical Science/Social Science

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

Other Resources

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

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

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

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

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

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

http://thunderbay.noaa.gov/shipwrecks/spangler.html – Web page from the Thunder Bay National Marine Sanctuary about the wreck of the *Kyle Spangler*

http://www.hal.state.mi.us/mhc/museum/explore/museums/hismus/special/schooner/Default.htm – Web site for the Michigan Historical Museum's Special Exhibit, "Schooner in the Sand: Unlocking the Secrets of a Great Lakes Shipwreck"

http://www.qaronline.org/ – Web site about investigating a shipwreck that may be the pirate Blackbeard's *Queen Anne's Revenge*

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

Macaulay, D. 1993. Ship. Houghton Mifflin Company. Boston.

National Science Education Standards

Content Standard A: Science As Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard E: Science and Technology

- Abilities of technological design

Content Standard F: Science in Personal and Social Perspectives

- Natural hazards
- Science and technology in society

Ocean Literacy Essential Principles and Fundamental Concepts

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

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

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

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

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Student Handout
Inventory of Artifacts Recovered from Three Sites in the Serce Limani Debris Field

Quantity	Item	Grid Cell
1	comb and scissors	1,4
4	chess pieces	1,1
47	wicker baskets containing glazed bowls	1,2
29	wicker baskets containing jugs and gargoulettes	0,2
57	sealed ceramic jars containing raisins	0,2
3	wine amphoras	1,4
16	pig bones	1,4
58	fish bones	0,2
3	axes	0,2
1	sealed ceramic jar containing olives	1,4
1	set of caulking tools	1,4
1	mattock	0,2
5	backgammon gaming pieces	1,2
1	pick	1,2
11	thrusting spears	1,2
2	sealed ceramic jar containing dates	1,4
1	casting net	0,2
1	multi-tined spear for catching fish	0,2
15	anchors, various sizes	1,4
1	wooden mast	1,4
63	wine amphoras	0,2
3	large nets with floats	0,2
13	parts for pulleys	1,2
7	wooden rigging items	0,2
19	lead fish-net weights	1,2
11	pig bones	1,1
3	gold coins	1,1
40	copper coins	1,1
7	cooking pots (one still containing goat or sheep bones)	0,2
52	javelins	0,2
3	swords	1,1
17	fish bones	1,1
23	wicker baskets containing glassware	0,2
31	wicker baskets containing cooking pots	1,2
6	silver rings	1,1
1	gold earring	1,1
1	sealed ceramic jar containing almonds	1,1
13	wine amphoras	1,1
1	sealed ceramic jar containing dates	1,1
39	wicker baskets containing broken glass	0,2
1	wooden mast	0,2

Student Handout
Inventory of Artifacts Recovered from Three Sites in the Serce Limani Debris Field ~ Page 2

Quantity	Item	Grid Cell
1	gaff boom	0,2
1	sealed ceramic jar containing olives	1,1
3	Byzantine lead seals used to stamp documents	1,1
1	Large wicker basket containing:	1,1
	1 Byzantine steelyard	
	1 hand axe	
	1 adze	
	3 balances	
	2 large sets of balance-pan weights	
	1 bow drill and bits	
	5 chisels	
	2 claws (for extracting nails)	
	1 hammer	
	1 mallet	
	1 plumb bob	
	3 rasps	
	1 saw	
	assorted tacks and nails	
	glass weights for weighing gold and silver coins (some with legible dates; the latest is either 1024/25 or possibly 1021/22)	

Note: large quantities of broken glass are scattered throughout the debris field

Sketch Map of Serce Limani Debris Field Survey Sites