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PHAEDRA 2006:

Partnership for Hellenic-American Exploration in the Deep Regions of the Aegean

Looking for Clues

(adapted from the Titanic 2004 Expedition)

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 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 at least three types of evidence that could support inferences about the use of maritime technology in ancient cultures.

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

30

Key Words

Aegean
Shipwreck
Underwater archaeology
Debris field
Artifact

Background Information

"Man hoisted sail before he saddled a horse. He poled and paddled along rivers and navigated the open seas before he traveled on wheel along a road. Watercraft were the first of all vehicles." Thor Heyerdahl, *Early Man and the Ocean* (Doubleday, 1979)

Mariners have travelled the Aegean Sea since Neolithic times (the Stone Age: 6,500 – 3,200 BC). Motives for their voyages ranged from trading to exploration to warfare, making sea-faring prominent in the history of cultures that 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). Remnants of ancient ocean voyages (i.e., shipwrecks) can provide information about trading patterns, sociopolitical networks, technological development and many other unique insights into these cultures, but a variety of factors makes it difficult to find such remnants.

One problem is that interactions between cultures were not always peaceful, and destroying important shipping assets would have been an obvious step toward conquering an opponent.

Another obstacle is the same feature that makes ancient shipwrecks so valuable: their age. In addition to increasing the severity of deterioration by biological and chemical processes, the passage of time also increases the likelihood that ancient shipwrecks will be impacted by natural disasters. The southern Aegean region has experienced numerous severe volcanic events and tsunamis, including the eruption of a volcano near a small island called Thera (also known as Santorini), sometime between 1,650 and 1,450 BC. This eruption is estimated to have been four times more powerful than the Krakatoa volcano of 1883, left a crater 18 miles in diameter, spewed volcanic ash throughout the Eastern Mediterranean, and may have resulted in global climatic impacts. Coupled with earthquakes and a tsunami, the volcano destroyed human settlements, fleets of ships, and may have contributed to the collapse of the Minoan civilization. More recently, the 1650 AD eruption of the Columbo volcano—7 km to the northeast of Thera—produced ash, pumice, toxic gases, and a tsunami that devastated the coasts of surrounding islands.

Even if ancient shipwrecks survive natural disasters (and those caused by humans), finding, exploring and scientifically studying these sites are complicated by the fact that much of the Aegean Sea is relatively deep. Total darkness and an environment that is extremely hostile to humans have, until recently, been obstacles that are virtually insurmountable. Technological advances over the past decade, though, have made deep water archaeology a much more feasible endeavor. The PHAEDRA 2006 Expedition will use the SeaBED Autonomous Underwater Vehicle to search for deepwater shipwrecks, as well as conduct precise geological and chemical surveys in the vicinity of underwater volcanoes in the Aegean Sea. "Autonomous Underwater Vehicle" (AUV) means that this is a self-contained underwater robot that operates without a physical cable or tether such as those used on remotely operated vehicles (ROVs). SeaBED is designed specifically to provide precise maps and high-resolution three-dimensional color images of seafloor features, as well as to carry equipment for measuring physical and chemical properties of the surrounding seawater. Using SeaBED to map and document survey sites frees archaeologists from tedious measuring and sketching tasks and allows them to concentrate on interpreting survey results. For more information about SeaBED, visit http://www.whoi.edu/institutes/doei/general/news_seabed.pdf.

This expedition is an unusual collaboration between four U.S. research institutions and the Greek Ephorate of Underwater Antiquities (Hellenic Ministry of Culture) and Hellenic Centre for Marine Research. Scientists from Woods Hole Oceanographic Institution, Massachusetts Institute of Technology, Franklin W. Olin College of Engineering, and Johns Hopkins University will work with their Greek counterparts to use underwater robots to make detailed archaeological surveys of two ancient shipwrecks in deep water. One of these is believed to be the wreck of a Classical or Hellenistic ship that lies in a depth of about 500 m off the island of Hythnos in the central Aegean Sea. The other is believed to be the remains of a Byzantine period vessel that sank in 110 m of water off Porto Kuofo in the northern Aegean.

A third survey area will focus on a portion of the Aegean seafloor that scientists believe was unaffected by the Theran eruption and may consequently contain very ancient shipwrecks that have not yet been discovered. This area is close to the Columbo volcano, but has never been explored. To learn more about volcanic processes in this area, surveys will precisely map the seafloor and gather chemical data that will provide clues about volcanic activity as well as unusual geologic features such as cold seeps and volcanic vents.

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

Learning Procedure

1. To prepare for this lesson, review the background essays for the PHAEDRA 2006 Expedition at http://oceanexplorer.noaa.gov/explorations/06greece/. You may also want to review the discussion of the Serce Limani shipwreck on the Institute of Nautical Archaeology's Web site (http://ina.tamu.edu/SerceLimani.htm). 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. Introduce the PHAEDRA 2006 Expedition, and discuss some of the reasons that scientists are interested in finding shipwrecks in the Aegean Sea. 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 6000 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 role 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://ina.tamu.edu/SerceLimani.htm).

   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

http://www.vims.edu/bridge/archive1200.html – Activities and links about shipwrecks

The "Me" Connection

Have students write a brief essay describing why investigation of ancient shipwrecks are (or are not) worth the time, money, and risk involved, and how such investigations might affect their lives personally.

Connections to Other Subjects

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

Assessment

Student analyses and reports offer opportunities for assessment.

Extensions

Have students visit http://oceanexplorer.noaa.gov/explorations/06greece/ to keep up with the latest discoveries from the PHAEDRA 2006 Expedition

Resources

NOAA Learning Objects

http://www.learningdemo.com/noaa/ – Click on the links to Lessons 1, 2, 4 and 5 for interactive multimedia presentations and Learning Activities on Plate Tectonics, Mid-Ocean Ridges, Subduction Zones and Chemosynthesis and Hydrothermal Vent Life.

Other Relevant Lessons from the Ocean Exploration Program

The Volcano Factory

http://oceanexplorer.noaa.gov/explorations/06blacksea/background/edu/media/06blacksea_volfactory.pdf
(from the Aegean and Black Sea 2006 Expedition)

Focus: Volcanism at tectonic plate boundaries (Earth Science)

Students will be able to explain the processes that result in the formation of volcanoes at tectonic plate boundaries

Wreck Detectives

http://oceanexplorer.noaa.gov/explorations/06blacksea/background/edu/media/06blacksea_wreckdectectives.pdf
(from the Aegean and Black Sea 2006 Expedition)

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.

Entering the Twilight Zone

http://oceanexplorer.noaa.gov/explorations/02mexico/background/edu/media/gom_twilight.pdf
(6 pages, 468k) (from the Gulf of Mexico 2002 Expedition)

Focus: Deep-sea habitats (Life Science)

In this activity, students will be able to describe major features of cold seep communities, and list at least five organisms typical of these communities and will infer probable trophic relationships within and between major deep-sea habitats. Students will also be able to describe in the process of chemosynthesis in general terms, contrast chemosynthesis and photosynthesis, and describe major deep-sea habitats and list at least three organisms typical of each habitat.

Other Resources and Links

http://oceanexplorer.noaa.gov/explorations/06greece/ – Web site for the PHAEDRA 2006 Expedition

http://ina.tamu.edu/vm.htm – The Institute of Nautical Archaeology's Virtual Museum

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

http://ina.tamu.edu/Sercelimani.htm – The Byzantine Shipwreck at Serce Limani

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

http://sara.theellisschool.org/shipwreck – the Uluburun Shipwreck Web site

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

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
- Understanding about scientific inquiry

Content Standard B: Physical Science

- Properties and changes of properties in matter

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 hazards
- Science and technology in society

Content Standard G: History and Nature of Science

- Science as a human endeavor

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 6.

The ocean and humans are inextricably interconnected.

- *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 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.
- *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

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Student Handout

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

Quantity	Item	Site
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
1	gaff boom	0,2

Student Handout (page 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 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)	1,1

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

Student Handout
Sketch Map of the Serce Limani Debris Field
Survey Sites