ocean explorer
oceanexplorer.noaa.gov

PHAEDRA 2006:

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

This Old Ship

Focus
Ancient and prehistoric shipwrecks

Grade Level
7-8 (Earth Science/Social Studies)

Focus Question
What kinds of information can archaeologists obtain from ancient shipwrecks?

Learning Objectives
Students will be able to describe at least three types of artifacts that are typically recovered from ancient shipwrecks.

Students will be able to explain the types of information that may be obtained from at least three types of artifacts that are typically recovered from ancient shipwrecks.

Students will be able to compare and contrast, in general terms, technological features of Neolithic, Bronze Age, Hellenistic, and Byzantine period ships.

Materials
❒ None

Audio/Visual Materials
❒ None

Teaching Time
One or two 45-minute class periods

Seating Arrangement
Groups of 2-4 students

Maximum Number of Students
30

Key Words
Shipwreck
Underwater archaeology
Aegean
Neolithic
Bronze Age
Hellenistic
Byzantine

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 seafaring 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 investigate several ancient shipwrecks spanning historical periods from about 6,500 BC to about 1,450 AD.

Learning Procedure

1. To prepare for this lesson, review the background essays for the PHAEDRA 2006 Expedition at http://oceanexplorer.noaa.gov/explorations/06greece/. 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. Encourage discussion of this question, but do not provide specific examples or evidence at this point. Briefly discuss an ancient history timeline that includes Neolithic, Bronze Age, Greek Classic, Hellenistic, and Byzantine Periods. If students are familiar with other periods, such as those of ancient Egypt, these may be included as well. The point is to be sure that students have an idea about the sequence and approximate chronology of these periods, rather than attempt to assign a precise range of dates to each period (since, in some cases, there is considerable disagreement among experts about such dates).

3. Tell students that their assignment is to prepare a brief report about at least one known shipwreck from each of the Neolithic, Bronze Age, Hellenistic, and Byzantine periods. Depending upon available time, you may want to assign fewer periods to each student or student group. Reports should include the location of the shipwreck, the approximate date on which the vessel sank, size of the vessel, materials from which the vessel was constructed, artifacts recovered from the wreck site, and what these artifacts reveal about the people who sailed the vessel.

4. Have each student or student group present their reports and lead a discussion of their findings. Students should understand the types of artifacts that are typically found on wreck sites and how these are interpreted by archaeologists as the basis for inferences about cultures with which the ships were associated. Discuss students' perception of the level of technological development and understanding that was associated with the vessels they have investigated. A common assumption is that if a culture lacks certain technological skills, that culture must be inferior to another culture that possesses those skills. Encourage students to consider the other side of the coin: that the "inferior" culture might have possessed other skills and knowledge that are now lost to "modern" people. Building and navigating ships is not a trivial task; any culture able to do this possesses significant technological skills, regardless of what other skills they may or may not have. Of course, we can't know anything about lost knowledge until that knowledge is re-discovered. The potential of recapturing "lost" knowledge is one intriguing reason for studying ancient cultures. Be sure to visit the PHAEDRA 2006 Expedition Web site (http://oceanexplorer.noaa.gov/explorations/06greece/) to learn what has been discovered about new shipwrecks being investigated in deep waters of the Aegean Sea.

   The following notes apply to some of the best-known shipwrecks from the four periods.

Neolithic Period (about 6,500 – 2,900 BC)

Until recently, inferences about "Stone Age" ships could only be based on indirect evidence, such as Neolithic (dated between 4,000 and 3,000 BC) petroglyphs found on rocks and walls throughout eastern Egypt between the Nile river valley and the coast of the Red Sea that 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. Other 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.

Bronze Age (about 2,900 – 1,200 BC)

No Minoan shipwrecks have been discovered (yet). Indirect indication of the importance of maritime shipping is based on evidence of extensive trade with other cultures that could only have been accomplished by sea, since the Minoans lived primarily on islands. Additional evidence comes from images of ships, particularly on the "Thera Ship Fresco" from Akrotiri, that show vessels with rows of oarsmen as well as sails.

Several shipwrecks from other Bronze Age cultures have been found, including:

- The Cape Gelidonya shipwreck, which sank near the southwestern coast of Turkey around 1,200 BC. This vessel was about 10 meters long and built of planks held together with pegged mortise-and-tenon joints (for more information about this type of construction compared to later naval architecture, see http://www.diveturkey.com/inaturkey/serce/hull.htm). Most of the ship's cargo was materials used to make bronze implements, including copper and tin ingots (used to make the bronze alloy) as well as scrap bronze tools to be recycled. Brushwood was used as a packing material to protect fragile cargo during the voyage. Other items that were probably personal possessions of crew and/or passengers included four scarabs and a scarab-shaped plaque, an oil lamp, stone mortars, stone pan-balance weights and a razor.

- The Uluburun shipwreck, which sank near Kas in southern Turkey around 1,306 BC, was about 15 m long, made of edge-joined cedar planks, and could stow an estimated 20 tons of cargo. Most of the cargo on board was copper ingots, in addition to incense, glass ingots, logs of Egyptian ebony, ostrich eggshells, elephant tusks, hippopotamus teeth, opercula from murex seashells, modified tortoise carapaces, ceramics, and storage jars that contained pomegranates and possibly olive oil. Jewelry found in the wreck included Egyptian objects of gold, silver, and stone and thousands of beads of glass, agate, carnelian, quartz, faience (a type of fine glazed pottery), ostrich eggshell, and amber. Tools included awls, drills, chisels, axes, adzes, a saw, spearheads, arrowheads, daggers, swords, stone maceheads, lead net and line sinkers, netting needles for repairing nets, fishhooks, a harpoon, a bronze trident, and two wooden writing boards. More tin vessels and jewelry were recovered from the wreck than had previously been found throughout the entire Bronze Age Mediterranean.

Classical and Hellenistic Periods (about 500 – 330 BC)

- The Kyrenia shipwreck, which sank off the north coast of Cyprus between 310 and 300 B.C., is estimated to have been about 70-80 years old when she went down, since some of the vessel's planks have been patched (and some of the patches have been patched). The wooden hull was built mostly of Aleppo pine, and measured 47 feet long by 14 feet across. The typical speed of the ship is estimated to have been about four to five knots. The ship's cargo consisted of more than 400 wine amphoras (a type of storage jar used for centuries in Mediterranean countries), as well as about 9,000 almonds which were perfectly preserved in jars within the ship's hull. Twenty-nine millstones were also part of the cargo, but did double duty as ballast at the same time. Four wooden spoons, four oil jugs, four salt dishes, and four drinking cups suggest the size of the crew. A bronze cauldron and several large casserole pots were probably used to prepare meals. Lead net weights found in the bow indicate that the crew fished during the voyage. More than 100 lead rigging rings found in the bow suggest that the ship's single sail had been taken down before she sank (for more information and photographs of the reconstructed vessel, see http://bornova.ege.edu.tr/~ncyprus/shipwreck.html).

- The Porticello shipwreck was discovered on the Italian side of the Straits of Messina by a local Italian fisherman, who subsequently plundered the wreck and in the process destroyed a great deal of archaeological evidence. The vessel is believed to have sailed in the 5th century BC, and is estimated to have been approximately 66 feet long. Items left behind by the looters include a life-size bronze head that is strikingly different from other monumental (life-sized or larger) sculptures from the same period. In addition, lead ingots, amphoras of a type used to transport fine wine, and writing ink formed at least part of the cargo. Since these were relatively expensive items in the 5th century BC, the cargo is believed to have been quite valuable. Other items recovered from the wreck include copper nails, lead sheeting used to patch small leaks in the hull, two black glaze bowls, a small wooden bowl, a terracotta mortar, a jug, a small cooking pot, two black glaze lamps, a lead-tipped awl with a wooden handle, a wooden toggle (used in the ship's rigging when the vessel was sailed into the wind), and the earliest example of a cleat. Archaeologists believe that meals were prepared ashore, since no evidence was found of cooking fires or braziers that have been found in Roman shipwrecks from later periods (see http://ina.tamu.edu/porticello/porticello.htm for more information and photographs).

Byzantine Period (about 300 – 1450 AD)

- The Serce Limani shipwreck sank in a natural harbor on the southern shores of Turkey around 1025 AD. The vessel was approximately 15 m long and 5.3 m wide, with two masts that carried lateen sails and a cargo capacity of about 30 metric tons. It is also known as the "Glass Wreck" because of large quantities of broken glassware scattered over the site. Items recovered from the site include a wooden comb and scissors, cooking pots (one still containing goat or sheep bones), wine amphoras, three large nets with floats, a casting net, a multi-tined spear for catching fish, spare parts for pulleys, wooden rigging elements, lead fish-net weights, axes, a billhook, a mattock, a pick, adzes, a bow drill and bits, chisels, claws for extracting nails, a hammer, a mallet, a plumb bob, a rasp, a saw, assorted tacks and nails, and a set of caulking tools that apparently was being used at the time of the sinking, suggesting that the ship had sought shelter due to a leaking hull.

There is an extensive discussion on the Institute of Nautical Archaeology's Web site (http://ina.tamu.edu/SerceLimani.htm) that illustrates the types of information that archaeologists can obtain from this kind of shipwreck. A few of the key points include:

- Weighing equipment included a Byzantine steelyard, 3 balances, two large sets of balance-pan weights, and glass weights for weighing gold and silver coins. Some of the glass weights bear legible dates, the latest being either 1024/25 or possibly 1021/22.

  This equipment was kept almost entirely in the stern (the traditional location of the captain's quarters) which is consistent with the interpretation that the ship was a trading vessel. In addition, the ship's carpentry tools and weighing equipment were found together in the same wicker basket, suggesting that the captain may have been the ship's carpenter as well as a merchant.

- Meals aboard the ship included meat (pig, goat, and possibly sheep), fish (tunny, tub gurnard, bass and drum), almonds, assorted fruits, and olives. 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).

- Piracy was an ever present danger. Defensive weapons included 11 thrusting spears and 52 javelins, as well as swords. To minimize potential losses to pirates, the normal practice was to keep little coinage on board. Only three gold coins and about 40 copper coins were recovered from the site. A small amount of jewelry, including a half-dozen silver rings and a gold earring, may have served in place of coinage. The presence of three Byzantine lead seals for documents suggests that merchants on board may have used letters of credit instead of hard currency.

- 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, sumac, and wine. There were also several tons of broken glass that appear to 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

The "Me" Connection

Have students write a brief essay describing how information from ancient shipwrecks might prove to be personally beneficial.

Connections to Other Subjects

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

Assessment

Written reports and presentations (Steps 3 and 4) provide 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

Ping!

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

Focus: Sidescan sonar (Earth Science/Physical Science)

In this activity, students will describe sidescan sonar, compare and contrast sidescan sonar with other methods used to search for underwater objects, and make inferences about the topography of an unknown and invisible landscape based on systematic discontinuous measurements of surface relief.

My Friend, The Volcano

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

Focus: Ecological impacts of volcanism (Life Science/Earth Science)

In this lesson, students will be able to describe at least three beneficial impacts of volcanic activity on marine ecosystems, and to explain the overall tectonic processes that cause volcanic activity.

Come on Down!

http://oceanexplorer.noaa.gov/explorations/02galapagos/background/education/media/gal_gr7_8_l1.pdf
(6 pages, 464k) (from the 2002 Galapagos Rift Expedition)

Focus: Ocean Exploration

In this activity, students will research the development and use of research vessels/vehicles used for deep ocean exploration; calculate the density of objects by determining the mass and volume; and construct a device that exhibits neutral buoyancy.

It's Going to Blow Up!

http://oceanexplorer.noaa.gov/explorations/05fire/background/edu/media/rof05_explosive.pdf
(10 pages, 1.6Mb) (from the New Zealand American Submarine Ring of Fire 2005 Expedition)

Focus: Volcanism on the Pacific Ring of Fire (Earth Science)

In this lesson, students will be able to describe the processes that produce the "Submarine Ring of Fire;" explain the factors that contribute to explosive volcanic eruptions; identify at least three benefits that humans derive from volcanism; describe the primary risks posed by volcanic activity in the United States; and identify the volcano within the continental U.S. that is considered most dangerous.

How Does Your Magma Grow?

http://oceanexplorer.noaa.gov/explorations/05galapagos/background/edu/media/05galapagos_magma.pdf
(6 pages, 224k) (from the 2005 Galapagos: Where Ridge Meets Hotspot Expedition)

Focus: Hot spots and midocean ridges (Physical Science)

In this activity, students will identify types of plate boundaries associated with movement of the Earth's tectonic plates, compare and contrast volcanic activity associated with spreading centers and hot spots, describe processes which resulted in the formation of the Galapagos Islands, and describe processes that produce hydrothermal vents.

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://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

H.G. Wells, H.G. 1922. A Short History of the World. Chapter XVII The First Sea-going Peoples. Available online at http://www.bartleby.com/86/17.html

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

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

For More Information

Paula Keener-Chavis, Director, Education Programs
NOAA Ocean Exploration Program
Hollings Marine Laboratory
331 Fort Johnson Road, Charleston SC 29412
843.762.8818
843.762.8737 (fax)
paula.keener-chavis@noaa.gov

Acknowledgements

This lesson plan was produced by Mel Goodwin, PhD, The Harmony Project, Charleston, SC for the National Oceanic and Atmospheric Administration. If reproducing this lesson, please cite NOAA as the source, and provide the following URL: http://oceanexplorer.noaa.gov