

Teaching with Archaeology

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SAA Public Education Committee Mission Statement:

The Public Education Committee exists to promote public education about the past
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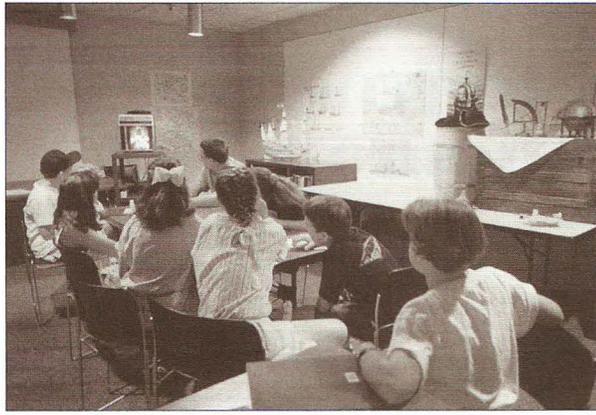
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Cover photos by KC Smith



KC Smith

History Beneath the Sea

*Nautical Archaeology
in the Classroom*

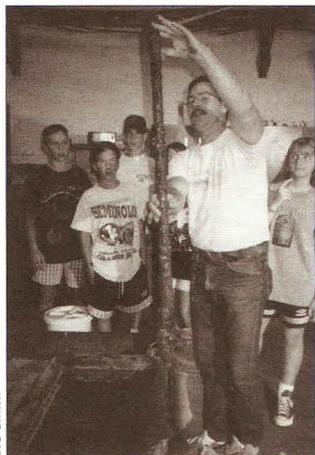
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"Dive into Details" indicates a reading for young people.

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Nautical Archaeology as a Classroom Theme

KC Smith and Amy Douglass



KC Smith

At the end of the 20th century, scientists at the U.S. National Atmospheric and Space Administration (NASA) waited hopefully for a signal from the Mars Polar Lander—an exploratory vessel sent aloft to probe the terrain of a distant planet. Millions of dollars and the best technology had been invested in the project. For unknown reasons, the spacecraft refused to respond, leaving project architects to wonder about its fate.

Now flash back several hundred years and imagine the same anxiety that officials felt as they awaited news of a sailing ship on an equally perilous voyage. The comparison is fair because both expeditions represented efforts to penetrate unknown environments with uncertain knowledge and equipment. While spacecraft may propel people into the future, until the late 1800s waterborne vessels were the most advanced means of exploration and colonization. Indeed, it is impossible to appreciate the global spread of people, products, ideas, or biota without understanding the role played by watercraft. Nor can anyone discount the important advances in science and technology that first appeared in a maritime context.

These are among the ideas that we hope to convey to educators and students in *History Beneath the Sea: Nautical Archaeology in the Classroom*—the first “Teaching with Archaeology” education module prepared by the Society for American Archaeology, Public Education Committee. *History Beneath the Sea* highlights the work of nautical archaeologists, who study material remains, technologies, and traditions relating to ships and the sea—from wrecks and vessel construction to lighthouses, trade routes, and coastal communities. Nautical archaeology is part of the larger discipline of underwater archaeology, which investigates all prehistoric or historic cultural evidence found in a wet environment.

History Beneath the Sea is designed for educators and students: it includes background readings for both as well as classroom activities and resources. Student readings are geared for the secondary level. While the primary subject areas are social studies and language arts, science and math instructors can construct lessons based on the information provided. The volume begins with an overview of nautical archaeology, followed by articles about four notable shipwrecks, presented as two-page summaries for educators and shorter readings, called “Dive into Details,” for kids. Designed to help students improve literacy skills through the use of historical content, “Dive into Details” pages also offer several food-for-thought questions about the reading. An article about artifact conservation is included to encourage educators to incorporate the topic into their nautical archaeology presentations and to introduce students to this important aspect of the archaeological process. The rest of the volume is devoted to educational materials, including a strategy for conducting a simulated excavation in the classroom, additional activity ideas, a list of resources, and a glossary of terms found in the readings.

The “Teaching with Archaeology” education module joins a list of resources that the SAA Public Education Committee has produced in the last decade to promote the use of archaeology in the classroom and to make the discipline more accessible to the public, especially kids. Many of these materials are available on the SAA web site: <http://www.saa.org>. PEC members know that prehistoric and historic cultural sites are keys to understanding not only the past but also the modern world. When young people understand how archaeologists research and interpret cultural resources, they can better appreciate the value of such remains and the need to protect and preserve them.

Exploring Past Cultures From the Depths of the Sea

Toni L. Carrell

Covering nearly three-quarters of the earth's surface, water is the source of all life on the planet. It also is the wellspring of human culture and civilization. Travel by water enabled much of the globe to be explored and colonized; it facilitated the rise and fall of great empires; and it remains today an important avenue for commerce, security, and recreation. A vast physical record of human activity lies beneath the world's oceans, lakes, rivers, and wetlands, preserved in wrecked and abandoned ships, inundated cities and villages, harbor works, and prehistoric and historic shorelines.

Underwater archaeology is a general term for the study of submerged cultural remains, and within the discipline, there are several specializations. Nautical archaeology—the theme of this publication—focuses on ships and seafaring. It encompasses a diverse array of research topics, including shipwrecks, ship construction, nautical technology, nautical traditions, navigation, maritime commerce, exploration and colonization, coastal communities and forts, and the preservation of maritime remains. However, the study of wrecked or abandoned vessels probably is the most common research interest, and the one most well known to the public.

Cross Section of Culture

Shipwrecks often are called time capsules because watercraft had to carry everything that a floating community needed to survive and complete its mission. Numerous factors influenced how well a vessel and its contents survived the process of wrecking and equilibrating with a watery environment. Among these are how and why a vessel sank, the environment in which it settled, and the natural and human disturbances that it experienced over time.

Nonetheless, wrecksites often contain an array of well-preserved remains that enable researchers to reconstruct the vessel's nationality, date, and objectives, and the behavior of the people on board. Nautical archaeologists typically encounter personal effects, pottery sherds, utensils, food remains, vestiges of cargo, weapons, tools, and parts of the ship. They also discover remarkable finds: for example, evidence of "stowaways" such as fleas, bugs, rats, and roaches; or an artifact that provides an indisputable clue such as a cannon or ship's bell inscribed with a date.

To analyze and interpret a ship and its mission, nautical archaeologists study not only the artifacts, but also contemporary records, works of art, and modern manifestations of seafaring customs. They rely on such historic documents as mariners' accounts, letters, and diaries; ship's plans, logs, and manifests; old maps and charts; and governmental, legal, business, and tax records. They also examine paintings, sculptures, and models for clues to the construction of vessels and the identity of their contents. And they may visit modern shipyards and seafaring communities to learn about long-time maritime traditions.

While the essence of archaeology is learning about people, the discipline is firmly connected to scientific methods of research. At the onset of a project, researchers develop questions that they hope to answer and hypotheses that they wish to test. Whether they work on land or under water, archaeologists adhere to strict professional standards when they examine, excavate, and record a site, and when they analyze, interpret, and conserve artifacts recovered from a site.

Understandably, underwater archaeologists have developed special methods for working in wet environments, including technology borrowed from commercial and military diving and other areas of marine science. However, most under-

Archaeologists study people of the past based on objects, structures, food remains, human remains, and other material that populations left behind. From these clues, researchers reconstruct the behaviors and beliefs of bygone cultures, and the ways in which they interacted with their various environments. Underwater archaeologists carry these studies into a specialized arena, where the evidence often is undisturbed and well preserved.

Theme:

- *overview of nautical archaeology*

water archaeology is conducted with standard scuba equipment, manual mapping and recording techniques, photography, videography, and a few mechanical tools. Electronic, robotic, and satellite technologies also are used for locating, pinpointing, and documenting sites.

In addition to knowing technical skills required for field work, nautical archaeologists draw information and expertise from many allied disciplines when they analyze and interpret their finds. It is not uncommon for researchers to consult chemists, conservators, ethnographers, geographers, geologists, geophysicists, naval architects, oceanographers, paleographers, and art historians—to name a few of the scientists who might be drawn into the intrigue of explaining a shipwreck site.

One of the most important steps of an archaeological project is the treatment, or “conservation,” that artifacts receive after they are recovered from a waterlogged environment. Without proper cleaning and stabilization, objects undergo chemical and physical reactions that can lead to their destruction. Conservation ensures that materials from shipwrecks and other submerged sites are available for the public to see and appreciate, and for researchers to study in the future.

However, conservation is a costly and time-consuming process, and it often guides the decisions of nautical archaeologists about how much of a shipwreck will be excavated. In addition, they are aware that future technology may improve the ability to recover and analyze artifacts and data. Consequently, underwater researchers may excavate only as much of a site as they need to answer their research questions.

The final step in an archaeological process is the dissemination of information about how the research was conducted and the conclusions that were reached. In the past, these reports were very scholarly, intended primarily for other scientists. However, in the past decade greater public awareness of and interest in the process of archaeology have prompted researchers to produce popular books, television programs, Web sites, and other media that enable the lay public to experience the excitement and benefits involved in shipwreck studies.

The Ethical Issues

Shipwrecks and other archaeological resources are non-renewable. When they are destroyed, evidence and information that they contain are lost. Archaeology is described as a destructive science because it requires the excavation, or dismantling, of sites and the removal of artifacts from their original context. However, when archaeologists work on a site, they employ standardized, scientific methods to ensure that contexts and features can be reconstructed later in the laboratory.

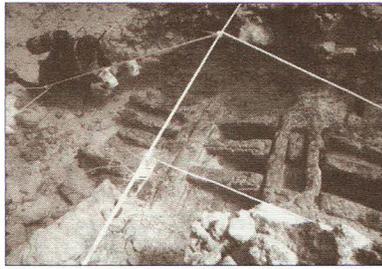
People who are not trained archaeologists also investigate shipwrecks and other archaeological remains, but their involvement often is based on personal financial gain. These people variously are called salvors, treasure hunters, or pot hunters. Because valuable artifacts, rather than knowledge, are the objective of their efforts, they often use methods that destroy subtle but valuable evidence, and they rarely describe their work in publications. Most important, their motives contradict a basic principle of archaeology—that remains and knowledge of the past belong to everyone and should not be exploited for personal profit.

The destruction of shipwrecks and other archaeological resources results in a loss to the collective heritage of present and future generations. Many nations are working to protect sites and collections through legislation, cultural resource management, and educational programs that instill a sense of stewardship and awareness among the public. Museums that adhere to international codes of ethics will not accept artifacts from commercially exploited sites. As the articles in this teaching module demonstrate, shipwreck projects conducted by trained archaeologists can have benefits that extend to the classroom and beyond.

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DIVE INTO DETAILS

KC Smith



Mapping and recording a site are critical steps in a shipwreck project to ensure that details and features can be reconstructed later in the laboratory. Credit: KC Smith.

Going to Sea To Study the Past

Have you ever buried a time capsule—a container filled with objects that reflect who you are or the world in which you live?

Lying on the bottom of oceans, harbors, rivers, and lakes around the globe are thousands of time capsules, deposited intentionally or accidentally over thousands of years. What are they? They are the sunken remains of watercraft that people have used to travel, explore, colonize, trade, and defend themselves. Shipwrecks are like time capsules because a vessel had to carry everything that people on board needed to survive and complete their mission. They contain examples of what a culture made, ate, wore, traded, worked with, believed in, and discarded.

The Study of Ships

Nautical archaeologists are scientists who examine all aspects of ships and seafaring. Trained in history, anthropology, geography, art, science, and foreign languages, they investigate how vessels were built and operated; why and where people voyaged; and tools, customs, and structures related to travel by water. They acquire much of their information by studying wrecked or abandoned ships.

When a ship met a tragic end, various factors determined how well the hull and its contents survived over time. But even after hundreds or thousands of years in the water, wrecks often contain a bonanza of evidence—from personal items, utensils, and food remains to weapons, tools, and parts of the cargo and ship. These artifacts help researchers to determine the vessel's origin, date, and purpose, as well as details about the people on board. Nautical archaeologists also rely on historic documents and artworks to identify, analyze, and interpret the evidence that they find.

Whether conducted on land or under water, archaeology employs scientific methods that adhere to strict standards. At the start of a project, underwater archaeologists develop questions and hypotheses about the site. Although they have developed some special tools and techniques for working under water and locating wrecks, in general they use standard scuba equipment, hand tools to map and

record a site, and a few mechanical devices to remove sediments.

A shipwreck team includes people who have different skills and knowledge. Members usually include a project director, fieldwork supervisor, diving safety officer, mechanic, conservator, photographer, videographer, artist, and divers, who sometimes are students or volunteers. In addition, the project director consults experts in other disciplines, such as chemists, geographers, geologists, naval architects, oceanographers, and art historians, to help with the analysis and research. A very important project member is the conservator, who is responsible for cleaning and stabilizing artifacts after they are recovered. Without proper conservation, waterlogged objects usually will not survive.

A shipwreck project isn't over until the director prepares a scholarly report that describes the research methods, the items that were recovered, and the conclusions that were reached. Many archaeologists also write popular books or arrange for media presentations to share the ship's story with the public. They also work with museums to ensure that artifacts are displayed for people to see.

Now think again about time capsules. How would you feel if someone opened *your* time capsule, removed some of the contents, and scattered everything else on the ground? Would the loss of a few objects really matter?

This is a problem that nautical archaeologists encounter all the time. Shipwrecks often are destroyed by people seeking artifacts to sell or keep. Not only is evidence missing, but the original relationship among the artifacts is disturbed. This makes it difficult, or sometimes impossible, for archaeologists to reconstruct what really occurred.

SOMETHING TO TALK ABOUT:

1. What factors might have affected how well a shipwreck survived over time?
2. What types of historic documents and artworks might help to explain a shipwreck?
3. What can you do to preserve shipwrecks?

Excavation of the Emanuel Point Ship from 1993–97 was performed under rigorous scientific guidelines. At the onset, archaeologists established research questions that they wished to answer concerning 16th-century Spanish shipbuilding techniques, colonization practices, and shipboard subsistence. They selected areas to excavate that were likely to yield the desired information. A framework, or grid, was placed over the site to ensure accurate recording of the finds. Sediments were removed by hand fanning and a variety of tools—from paint brushes to induction dredges. All artifacts and ship elements were measured, drawn, mapped, and recorded with still and video cameras. Sediments were pumped onto a barge anchored over the site and screened to recover even the smallest of items.

Recovered artifacts included parts of the ship, personal effects, tools, cargo, and food. Pottery fragments were among the most abundant items found. Ranging from plain storage vessels for liquids and food to beautifully decorated tableware, the ceramics indicated a mid-1500s date for the site. Aztec pottery, molded in the shape of a human face, helped to link the wreck to the expedition. Historic documents noted that Luna took Aztec mercenaries along to serve as soldiers.

Shoe leather, cooking utensils, hand tools, and hardware suggested the range of personal and practical needs of the passengers and crew. Evidence of the provisions on board included cow, pig, chicken, and sheep or goat bones as well as olive pits, cherrystones, nuts, and seeds from tropical fruits. Divers also recovered hundreds of bones from European black rats and pieces of cockroaches and beetles—stowaways that lived and died in the dreary confines of the hold.

Sixteenth-century vessels usually were armed as protection from marauding pirates and irate natives, and Luna's ship was no exception. No cannons were found, but because the site is only 10 to 12 feet deep, colonists easily could have salvaged these valuable weapons. However, iron and lead shot and stone cannon balls were retrieved, the latter intended to shatter into sharp splinters on impact. The breastplate from a suit of armor also was discovered; made in Europe about 1510, it already was quite old when one of Luna's men brought it to *La Florida*.

Vestiges of the ship were discovered beneath the layers of sediment, sand, shells, and ballast stones. Well preserved under this protective cap, the ship's lower hull revealed clues about early transoceanic vessels. Only about twelve 16th-century wrecks have been investigated in the New World, and the Emanuel Point Ship is the only one known to have been associated with colonization.

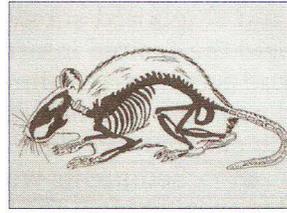
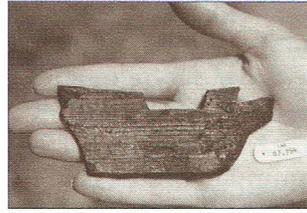
Window into the Past

Shipwrecks occupy a unique niche in archaeology and, in many ways, they are perfectly suited to provide a glimpse into past lifeways. Every historic vessel was a seagoing microcosm of the culture that created it. As relics of a catastrophic event of the past, wrecksites contain artifacts that were in use at the same time and that often provide definitive date ranges.

Although only forty percent of the site was excavated, the Emanuel Point Ship has offered a unique view of the culture and lifeways of 16th-century Spain in the New World. Recovered artifacts reveal what Spaniards believed was important and necessary to start a new settlement. Details about the colonists' daily lives, including their food, animals, dishes, tools, and weapons, have been reconstructed. Study of the ship's timbers and related nautical hardware have provided clues not only about the technology available to transport colonists, belongings, and supplies, but also 16th-century ship construction techniques and naval architecture.

Ocean-going vessels were the pinnacles of technology in the Age of Discovery and Exploration (A.D. 1450–1650), and the Emanuel Point Ship has contributed to our understanding of technological developments that fostered European expansion. Enhanced by historic documents about the Luna expedition, this shipwreck has enabled a clearer picture of life on the edge of the Spanish Empire in the early days of North American colonization.

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(Left) Aztec pottery linked the shipwreck to Luna's expedition. (Center) Archaeologists are fascinated by a wood carving of a 16th-century galleon that they recovered. (Right) Rats and bugs were stowaways on the ship. Credit: Florida Bureau of Archaeological Research.

The Emanuel Point Ship: Clues to an Early Colony

In August 1559, eleven ships commanded by Tristán de Luna sailed into Pensacola Bay, Florida, to establish a colony for Spain. The vessels carried 1,500 men, women, children, servants, slaves, sailors, and soldiers. They also carried all of the food, tools, equipment, and personal supplies needed to build a city in the wilderness. Luna's expedition was one of Spain's earliest and largest attempts to expand its empire into the modern United States.

The fleet arrived in Pensacola Bay after a two-month voyage from Mexico. The colonists chose a high point of land near shore for the townsite, where they planned to build houses, a palace, jail, church, and storehouses. However, on September 19, a fierce hurricane struck that caused all but three of the ships to sink. Because most of the food and supplies had not been unloaded, the colony was doomed. For two years, the survivors held on, but finally they returned to Mexico, and Luna was taken to Spain to explain his failed mission to the King.

A Shipwreck Discovered

In 1992, underwater archaeologists found a shipwreck in Pensacola Bay in 10 to 12 feet of water. Artifacts on the site appeared to be Spanish and to date to the 1500s. To determine whether this was one of Luna's ill-fated ships, archaeologists studied the wreck from 1993 to 1997. Their goal was to uncover, record, and recover enough material to identify the origin and date of the ship and to determine why it sank. They also hoped to answer questions about early Spanish efforts to colonize North America and the ships required for such a task.

The archaeologists selected areas to excavate that were likely to provide the information they needed. A framework, or grid, was placed over the site to ensure accurate recording of the finds. Divers used tools and hand fanning to uncover the wreck, and all artifacts and ship remains were measured, drawn, mapped, and recorded with still and video cameras. Sediments were pumped onto a barge anchored over the site and filtered through a screen

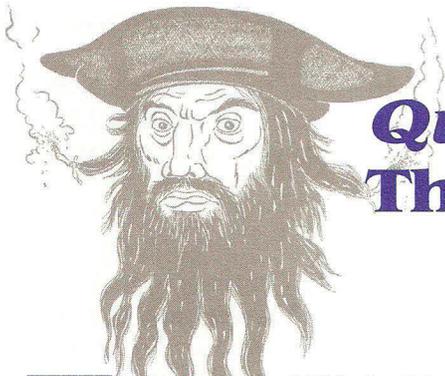
to recover even the smallest of items.

Pottery, one of the most common artifacts found, helped to date the wreck because some of the pieces matched Spanish ceramics made in the 1500s. Aztec pottery from Mexico, molded in the shape of a human face, linked the wreck to the colony. Historic documents stated that Luna had brought Aztec warriors to serve as soldiers. Shoe leather, cooking utensils, and tools revealed the personal and practical needs of the colonists. Evidence of food included animal bones and pits and seeds from vegetables and fruits. (Hundreds of rat bones and pieces of cockroaches and beetles showed that there were "stowaways" on board!) Although archaeologists did not find any cannons or guns, they did recover metal shot and stone cannon balls, which indicated that the ship had been armed. Beneath protective layers of sand, shells, and ballast stones carried in the hull, divers uncovered the lower portions of the wooden ship.

The Emanuel Point Ship excavation helped to explain the ill-fated Luna expedition, and it also provided answers to larger questions. The artifacts revealed details about the settlers' daily lives and the items that Spaniards believed were necessary to create a new settlement. The ship's timbers and hardware allowed researchers to reconstruct how the vessel wrecked and provided clues about technology and shipbuilding methods of the day. Combined with historic documents about the expedition, the Emanuel Point Ship has provided a clearer picture of the people and ships that set out on early colonial missions.

SOMETHING TO TALK ABOUT:

1. *If you were planning to start a colony in the wilderness, what supplies, food, and equipment would you take?*
2. *Why are the remains of the ship as important to underwater archaeologists as the artifacts?*
3. *How do historic documents help underwater archaeologists to explain a shipwreck site?*



Queen Anne's Revenge: The Return of Blackbeard

Mark Wilde-Ramsing

In November 1996, the North Carolina Underwater Archaeology Unit (UAU) received a call from Mike Daniel, operations manager of Intersal Inc., a private company searching for shipwrecks in Beaufort Inlet, N.C. Daniel excitedly exclaimed, "I think we've found the *Queen Anne's Revenge*!"

This discovery initiated a three-year archaeological assessment and the ongoing excavation of a shipwreck lying in 20 feet of water, a mile-and-a-half from shore. The archaeological assessment, an initial phase of any underwater project, was guided by several standard questions: What is the wreck's age, vessel type, and country of origin? What is the condition of the remains? What are the working conditions at the site? Archaeologists also hoped to determine whether the site really was the *Queen Anne's Revenge* (QAR)—the flagship of pirate Edward "Blackbeard" Teach. Since 1997, UAU archaeologists and volunteer divers have been gathering information during annual field seasons, and they now strongly suspect that the ship is the *Queen Anne's Revenge*.

Interdisciplinary Research

Intersal Inc. was operating through a permit from the state, which specified that once the company had located a site, it would carefully excavate, collect data, and study and preserve the artifacts according to archaeological standards. However, because of the potential significance of the wreck, Intersal asked state archaeologists to conduct the investigation to ensure that finds would be kept together and be available for public display. After conservation and analysis, the artifacts will be stored and displayed at the North Carolina Maritime Museum in Beaufort.

From the onset of the project, UAU archaeologists have strived to answer questions about the Beaufort Inlet wreck through an interdisciplinary approach. A variety of scientists, scholars, and technicians have been enlisted to provide information and data that typically is outside the expertise of an underwater archaeologist. For example, a marine biologist examined the growth rings of coral growing on the site and determined that the wreck had been exposed for at least fifteen years. This dispelled the belief that the wreckage had been uncovered by two recent hurricanes that struck the area.

Marine geologists employed cartography—the study of maps—to examine the location of the shipwreck and shifts in the location of the inlet since the vessel sank. They compared nearly two dozen historic maps from the early 18th century to the present, using a computerized geographical information system (GIS). From this, they calculated that the entrance to Beaufort Inlet has moved across the wrecksite at least four times. They also determined that, when QAR sank in 1718, the inlet was near where the wreck is located. Historians have found documents confirming the location, including an account by Royal Navy Captain Ellis Brand of HMS *Lyme*, who reported that the ship was "stuck upon the [sand] bar att [sic] the entrance of the harbour and is lost."

Marine geologists also collected valuable data by anchoring a current meter near the site to measure wave height and frequency, and current strength and direction. After analyzing twelve months of data, they determined that the wreck and surrounding sands are unaffected by normal waves and currents. However, during hurricanes, currents on the bottom move sand and smaller artifacts around the site. This information helps to explain how artifacts have been scattered and

Identifying a wreck is a challenging task, especially when the ship is associated with a notable figure or event in history. Underwater archaeologists excavating a site off the coast of North Carolina are relying on an array of experts in many fields to determine whether the remains are those of the Queen Anne's Revenge, flagship of the notorious pirate Blackbeard.

Themes:

- Golden Age of Piracy (1689–1718)
- interdisciplinary research
- interpretation of shipwrecks

Illustration by Robert Deaton.

what happened when the vessel wrecked. Studies of site conditions also helped archaeologists to decide the best times of the year for diving.

With a better understanding of the natural elements affecting the wreck, the UAU team then looked to historians for a scenario of events leading to the *QAR*'s sinking. By studying old documents, historians were able to provide clues about the ship and the types of artifacts that might be present.

Blackbeard's Legacy

In November 1717, Blackbeard captured the French ship *Concorde*, which had been used to transport slaves from Africa to the Caribbean. He renamed the vessel, made it his flagship, and increased the number of cannons on board to at least forty. After seizing several other ships in the Caribbean, he sailed north to the Bahamas and, eventually, Charleston, S.C. There, he and 300 to 400 pirates blockaded the port with *QAR* and three smaller vessels. The rogues captured a dozen ships entering or leaving the harbor, for which they received a ransom of medical supplies from the city.

Blackbeard and his crew continued sailing northward. On reaching Beaufort Inlet, *Queen Anne's Revenge* ran aground and was abandoned. Additional misfortunes prompted the pirate to sail a smaller ship north to Ocracoke, N.C., where he kept a base of operations for several months. However, in November 1718, Blackbeard was killed by a naval expedition from the Virginia colony.

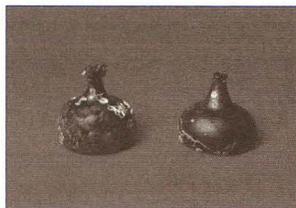
Information from historians has helped to confirm the identity of the *Queen Anne's Revenge*. For example, archaeologists have found twenty-two cannons on the site, an unusually high number. No other wrecks in the Beaufort area are known to have been as heavily armed. In addition, the arrangement of artifacts and hull remains on the seabed suggests that the Beaufort Inlet vessel did not sink in a storm. The wreck is concentrated in a 150- by 50-foot area. Had the ship gone down in a storm, debris would have been spread over a huge area. Moreover, the archaeologists found an anchor 400 feet from the site that appeared to have been used in an attempt to free the ship from the sandbar. These findings fit with the account that Blackbeard ran *Queen Anne's Revenge* aground and abandoned it.

Artifacts also have been important in determining whether the site is the *Queen Anne's Revenge*. Historians, archaeologists, and antique collectors have been consulted to help to identify the age and use of objects recovered from the wreck, which include ship parts and hardware, arms, navigational tools, personal effects, food preparation and storage containers, medical instruments, and cargo items. The assemblage dates to the early 18th century, based on stylistic characteristics, maker's marks on certain artifacts, and the ship's bell, which bears the date of 1709. In addition, the artifacts are similar or identical to materials found on the *Whydah Galley*, a pirate vessel lost a year before the *QAR*.

Many of the artifacts have been subjected to scientific tests to determine their identity, origin, or date. Wooden hull samples and hair from caulking found between the ship's timbers were radiocarbon dated to the 17th or 18th century. Other wood samples from the hull, identified by a botanist, were consistent with the types of trees used to build European vessels during the period. Geologists examined ballast stones to determine the rock types and possible sources, most of which came from the Caribbean. They also analyzed eight flakes of gold and concluded that they did not come from North Carolina. Analysis of sediments from the inside of wine bottles, grenades, and other artifacts also have been undertaken to see whether traces of the original contents can be detected.

Did Mike Daniel locate the *Queen Anne's Revenge*? Only an undisputed artifact—for example, something bearing the name *Concorde*—can prove this for sure. However, by relying on the expertise of many scientists and scholars, underwater archaeologists excavating the site have compiled compelling evidence that the Beaufort Inlet wreck is indeed the flagship of the infamous pirate Blackbeard.

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Artifacts recovered from the QAR include (left) a bronze bell with the inscriptions, "HIS Maria" and "Ano de 1709," (center) cannons, and (right) hand-blown wine bottles. Credit: North Carolina Underwater Archaeology Unit.

Queen Anne's Revenge: The Return of Blackbeard

If someone told you that they had found Blackbeard's shipwreck, how could you prove it?

This dilemma faced underwater archaeologists in North Carolina in November 1996. A private company exploring for wrecks near Beaufort Inlet found a site in 20 feet of water, which it concluded was the *Queen Anne's Revenge* (QAR), a ship commanded by Edward Teach—also known as Blackbeard. In November 1717, the notorious pirate captured a ship that he renamed *Queen Anne's Revenge*, armed with at least forty cannons, and sailed north from the Caribbean to North Carolina. As he tried to enter Beaufort Inlet, the QAR became stuck on a sandbar, and Blackbeard abandoned it. He sailed another ship up the coast and established a base, but his days were numbered. In November 1718, he was captured and killed by a naval expedition.

State archaeologists began to study the Beaufort Inset site in 1997. They had several basic questions to answer about the wreck's age, vessel type, origin, and condition. But the most important question was: Is this the *Queen Anne's Revenge*? Since 1997, archaeologists have spent several weeks each year recovering data about the environment, examining features of the wreck, and recovering telltale artifacts. After each field season, they have worked in the laboratory, conserving and studying the evidence that they have collected. Although the project is still underway, the data gathered so far strongly suggests that the wreck is Blackbeard's flagship.

Outside Advice

From the very beginning, the archaeologists have relied on experts in many fields to help analyze the finds and gather specialized data. For example, a marine biologist examined marine life growing on the site to determine how long the wreck has been exposed. Marine geologists compared nearly two dozen maps from the early 18th century to the present to see whether the harbor entrance has shifted. They discovered that it has changed several times and, when QAR sank in 1718, the inlet was near the wrecksite. Marine geologists also col-

lected data for a year about the effect of waves and currents on the site. They found that the effects are minimal except in hurricanes, when bottom currents move sand and small artifacts around. This has helped to explain what happened when the ship wrecked and how artifacts have become scattered.

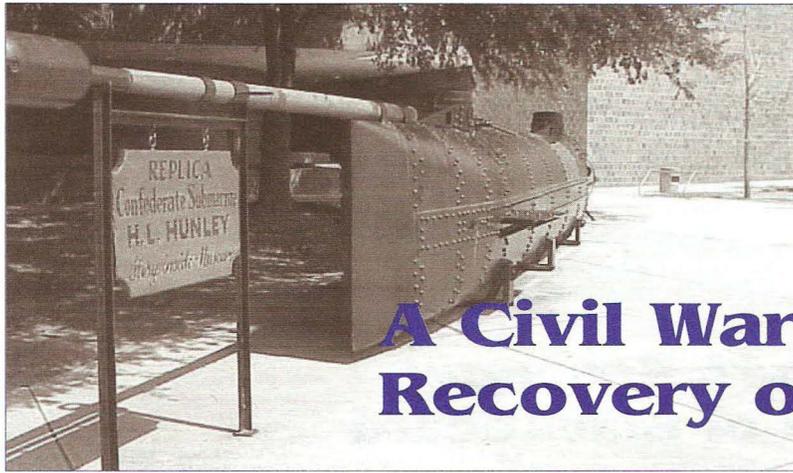
Historians have provided documents that offer clues about the ship, the types of artifacts on board, and events leading to Blackbeard's misfortune. They found a Royal Navy account that said the ship was stuck on a sandbar at the entrance to the harbor. The detail that Blackbeard added guns to the QAR was useful because divers have found twenty-two cannons on the site, an unusually high number for a shipwreck. No other wrecks in the Beaufort area are known to have been as heavily armed.

Artifacts—including ship parts and hardware, weapons, navigational tools, personal effects, food preparation and storage containers, medical instruments, and cargo items—also have provided clues to the ship's identity. Archaeologists have determined that most items date to the early 18th century, and a ship's bell bears the date of 1709. Many artifacts have been subjected to specialized tests to confirm their identity, origin, or date more precisely.

Research will continue until archaeologists understand how the ship was built, what happened when it wrecked, and what life on board was like. But will they ever know for sure if this is the QAR? Only an undisputed artifact—for example, something with Blackbeard's name on it—will prove that. However, with the evidence that they have gathered, they're feeling more certain every day.

SOMETHING TO TALK ABOUT:

1. Why are underwater archaeologists careful and cautious about identifying a shipwreck?
2. What types of experts might be involved in a shipwreck project?
3. What skills could you contribute to a shipwreck project?



A replica of the H.L. Hunley is displayed in front of the Charleston Museum in Charleston, S.C.
Credit: Roger C. Smith.

A Civil War Sub Returns: Recovery of the *H.L. Hunley*

Robert Neyland

In February 1864, the Confederate submarine H.L. Hunley glided into history when it destroyed the Union blockade ship, USS *Housatonic*. It was the first submarine in history to sink an enemy vessel—a feat not repeated until World War I. Although the Hunley perished during the mission for unknown reasons, the story of this episode is hardly over.

Themes:

- Civil War
- technology and science

The *H.L. Hunley* and many other vessels in the Civil War represented a turning point in modern shipbuilding traditions and naval strategies. After Confederates fired on Fort Sumter in Charleston, S.C., in April 1861, setting the war in motion, President Abraham Lincoln initiated responsive measures that included a blockade of the southern coastline and major inland waterways to halt the South's access to supplies. Both the Union and the Confederacy took advantage of recently developed technology—including steam propulsion, iron ship construction, exploding gunshells, and other innovations—to improve their maritime might. The resulting armor-plated vessels that operated on and below the sea spelled the end of wooden sailing ships as effective vessels of war.

The *Hunley* was the last of three experimental submarines built by James McClintock and Baxter Watson, with financial support from Horace L. Hunley and other wealthy merchants. The first design, *Pioneer*, was scuttled in New Orleans to prevent it from being captured by federal forces. The designers moved to Mobile, continued their research, and produced two more machines. *American Diver* (also known as *Pioneer II*) sank in Mobile Bay before it could be tested fully. Named after its wealthy patron, the *Hunley* was built in 1863. According to historical evidence, it was made from a quarter-inch-thick wrought iron boiler with cast iron end caps. The hull was about 30 to 40 feet long, four feet wide, and five feet high. It had hatches at the bow and the stern, glass viewing ports along the top, two breathing snorkels, and dive planes and ballast tanks for submerging and ascending. The nine-man crew turned a hand crank that powered a propellor, driving the craft at a top speed of four knots.

Like its predecessors, the *Hunley* originally was designed to dive beneath an enemy ship towing a torpedo that would be dragged into the side of ship. However, the designers changed the plans and gave it a "spar torpedo"—a long rod with an explosive device at the end that projected from the sub's bow. With this delivery system, the torpedo would be rammed into the side of an enemy ship and detonated, either on contact or as the submarine pulled away.

The *Hunley* was shipped to Charleston in August 1863 to help break the Union blockade of the harbor. However, after two weeks of sea trials, it sank; five men drowned and four men escaped. Nicknamed the "Peripatetic Coffin," the *Hunley* lived up to the title when it sank again six weeks later, killing the eight crewmen, including Horace Hunley. Both accidents were attributed to pilot error.

The *Hunley* was raised once again from the seabed, and a new crew was found. The men practiced for combat for months, sometimes taking the sub several miles offshore. Finally, on the night of February 17, the *Hunley* slipped from its dockage and headed toward its first target, the USS *Housatonic*. Lookouts on the blockade ship spotted something floating in the water that appeared to be a log. They fired small arms at the object because it was too close to hit with the deck guns, but to no

avail. The *Hunley* struck the ship with its spar torpedo, causing the *Housatonic* to sink in less than five minutes. For reasons that remain unclear, the *Hunley* sank nearby after completing its mission.

A Modern Search

Although many people have tried to find the *Hunley* since the Civil War, it was not located until 1995, about three miles off Charleston, by best-selling author Clive Cussler and archaeologists from the National Underwater and Marine Agency (NUMA). Based in Austin, Tex., NUMA is an organization funded by royalties from Cussler's book sales and is dedicated to preserving American maritime heritage by locating and identifying lost ships of historical value. Using electronic equipment that can sense objects below the seabed, Cussler's team found the *Hunley* under three feet of silt, intact and remarkably well preserved.

In 1996, the National Park Service conducted a survey to confirm the sub's identity, assess its physical condition, and make recommendations regarding its future. Researchers concluded that it was, indeed, the *Hunley* and that it was strong enough to be raised from the seabed. They recommended that it should be recovered and placed in a facility where the interior could be excavated and the sub could be studied and conserved. Their report launched a full-scale project to raise the submarine. The South Carolina Hunley Commission formed the Friends of the *Hunley*, a nonprofit organization to help with the recovery and research and to solve the mysteries about the fateful engagement.

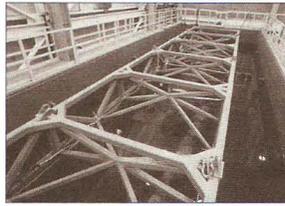
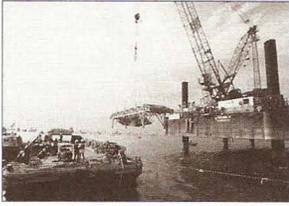
A second study was conducted in the summer of 1999 to examine the site of the battle between the submarine and the blockade vessel. Underwater archaeologists confirmed that a wreck near the *Hunley* was the *Housatonic*. By examining the remains of the blockade ship, they hoped to gain clues about how well materials in the sub would be preserved. While this work was underway, land archaeologists were using historic documents and electronic survey equipment to locate the remains of the submarine's first crew. The sailors had been buried in a mariners' graveyard, which today is situated beneath the football stadium of The Citadel, Charleston's military college. Nearly a month of excavation yielded human remains believed to be several of the crewmen. These remains have been reburied in Magnolia Cemetery in Charleston, the site of the graves of the sub's second crew, including Horace Hunley.

Finally, in August 2000, preparations for the recovery had been completed. The *Hunley* was excavated and lifted from its watery grave during an operation that involved numerous federal and state agencies and sophisticated engineering technology. A team of highly skilled divers placed heavy straps under and around the ship's hull and connected them to a steel framework, or truss, that had been placed over the site. A large ship with a crane hoisted the truss out of the sea and placed it onto a barge that was towed to Charleston Harbor amid great fanfare. At the dock, another crane on tracks transferred the truss into a conservation center with an enormous, specially built freshwater tank, where the *Hunley* will remain while it is being partially disassembled, the interior excavated, and the vessel conserved—a process that may take approximately seven years. Ultimately, the vessel will be reconstructed and displayed with other recovered artifacts in the Charleston Museum. The remains of the sailors inside the sub will be interred in Magnolia Cemetery.

The story of the *Hunley* is an example of how archaeology is needed to interpret history, and how archaeology actually can make history. Recovery of the vessel will further our knowledge of the submarine's story, and it will allow conservators to apply new techniques during the treatment process. Ultimately, generations of Americans will regard the *Hunley* as an example of bravery and sacrifice, of science and technology, and as an example of how history influences us today.

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DIVE INTO DETAILS



(Left) A large crane lifts the submarine from the seabed onto a transportation barge. (Center) On the barge, the vessel is sprayed with water to keep it from drying during transport. (Right) In the conservation center, the sub is placed in a tank filled with chilled, fresh water. Credit: H.L. Hunley Project.

The H.L. Hunley: Return of a Civil War Sub

In February 1864, the Confederate submarine *H.L. Hunley* glided into history when it destroyed the Union blockade ship, *USS Housatonic*. It was the first submarine ever to sink an enemy vessel. Although the *Hunley* and its crew also perished in the mission, the story of this event is not over yet.

The Civil War was a turning point in modern shipbuilding and naval strategies. After Confederates fired on Fort Sumter in 1861, President Lincoln ordered a blockade of the southern coast to cut off supplies. The Union and the Confederacy both constructed vessels that took advantage of recent technology. These new armor-plated vessels effectively ended the use of wooden sailing ships in war.

The *Hunley* was the last of three experimental submarines built by James McClintock and Baxter Watson, financed by Horace L. Hunley and others. The *Hunley* was built in 1863 after the first two vessels sank. The hull was about forty feet long, four feet wide, and five feet high. It had openings, or hatches, at both ends; small glass windows on the top; two breathing tubes; and equipment to help it to sink, float, and maneuver. The nine-man crew turned a hand crank that powered a propellor. The bow was outfitted a "spar torpedo"—a long rod with an explosive device at the end—that was intended to be rammed into an enemy ship.

The *Hunley* was taken to Charleston, S.C., in August 1863 to help break the Union blockade. During sea trials, it sank twice, killing thirteen men, including Horace Hunley. After it was raised again, a new crew was found that practiced for combat for months. Finally, on the night of February 17, the submarine headed out of the harbor toward its first target, the *Housatonic*. The *Hunley's* torpedo struck the blockade ship, causing it to sink instantly. For unknown reasons, the *Hunley* sank nearby.

A Modern Search

The *Hunley* was located in 1995 under three feet of silt a few miles off Charleston. In 1996, archaeologists examined the vessel to confirm its identity and condition and to make recommendations about its future. They concluded that it was strong enough

to be raised and that it should be placed in a special laboratory, where it could be excavated and conserved. Research continued through the summer of 1999. While underwater archaeologists studied the *Hunley* and the *Housatonic*, land archaeologists located an old mariner's cemetery where the sub's first crew had been buried. They recovered the remains of some of the sailors, which were studied and reburied in Charleston's Magnolia Cemetery, where the second crew had been laid to rest.

In August 2000, everything was in place to bring the *Hunley* to shore. A state-of-the-art conservation lab with a huge freshwater tank had been built. A steel framework, or truss, had been placed above the wreck to enable its lifting. On the day of the recovery, a team of skilled divers placed heavy straps under and around the ship's hull. They connected the straps to the truss, and a crane on a ship lifted the truss out of the water and placed it on a barge that was towed to Charleston. At the dock, another crane transferred the truss to the storage vat, where the *Hunley* will be partially disassembled, excavated, and conserved—a process that will take about seven years. The remains of the sailors inside will be buried in Magnolia Cemetery. After the sub is reconstructed, it will be displayed in a museum.

The story of the *Hunley* demonstrates how history can be explained by archaeology, and how archaeology can make history. The project has provided new information about an event in the Civil War, and, as the submarine undergoes conservation, researchers will apply new treatment techniques. The *Hunley* is a unique example not only of bravery and sacrifice, but also science and technology.

SOMETHING TO TALK ABOUT:

1. Why were men willing to risk their lives as crew members aboard an experimental submarine?
2. Describe how you would feel being a crew member aboard the *Hunley*.
3. What types of artifacts might be found in the sub?



During a dive on RMS Titanic, the author photographed the bow of the vessel (left) and two "bollards" on the poop deck, around which mooring lines were tied. Credit: James P. Delgado.

RMS Titanic: A Wreck to Remember

James P. Delgado

In May 1999, the Vancouver Maritime Museum ended a popular, two-year exhibit entitled "Shipwreck!" that examined how people interact with sunken vessels. Through a variety of media, three principal themes were presented: cultural responses to wrecks—ranging from art and music to the transformation of some sites into icons; the development of lifesaving equipment and institutions; and the ongoing quest of the deep to explore and recover lost watercraft.

Designed for visitors of all ages, the exhibit featured numerous interactive elements, including diving gear to try on; a small ROV (remotely operated vehicle) in a tank of water to manipulate; an underwater archaeology gallery with a simulated shipwreck and artifacts to map; and a simulated laboratory with artifacts to reassemble. While these discovery devices were extremely popular, the most sought-after displays were those dealing with the RMS *Titanic*—in the fore of the public mindset because of James Cameron's epic movie. Indeed, the *Titanic* became such a draw that, midway through the exhibit, the museum removed part of the underwater archaeology gallery and expanded its displays about the famous liner.

A Professional Dilemma

While emphasis on the *Titanic* was a successful marketing ploy, it presented a serious dilemma for me. Not only am I the museum director, but I also am a practicing underwater archaeologist who concurs with many professional colleagues that the aftermath of the *Titanic*'s discovery has been anything but a success story for archaeology.

After the *Titanic* was located in 1985 by underwater explorer Robert Ballard, the salvage firm RMS Titanic, Inc., received exclusive rights to recover artifacts through a U.S. federal court order. During several expeditions to the site, the company retrieved some 5,000 items. Except for bits of coal that were sold to eager collectors, the recovered artifacts have been assembled into a collection, as specified by the court decision, which has been exhibited in many places.

So if the artifacts have remained together and are available for public display, what's the problem? Some underwater archaeologists are concerned that the *Titanic* is not being regarded or studied as a bona fide archaeological site, in the way that older shipwrecks would be treated. Other archaeologists and many members of the public believe that, as the final resting place for more than 1,500 people who died in the disaster, the liner should not be disturbed by salvors seeking memorabilia.

Related to this is the most fundamental issue of all: whether the recovery of scattered debris and personal possessions is ethical, since the salvors personally

Despite enormous public interest and appeal, the discovery and exploration of the RMS Titanic have created controversy for underwater archaeologists. This article examines how one maritime museum used an exhibit to balance the realities of underwater archaeological research with the dilemmas presented by shipwrecks that are salvaged. For classroom educators, the Titanic offers a way to introduce students to the ethics of archaeology.

Themes:

- interpretation of shipwrecks
- public education
- ethics in archaeology

Important Differences:

Underwater archaeology:

the scientific recovery and preservation of submerged cultural resources by trained archaeologists for purposes of study and public display.

Marine salvage:

the sanctioned commercial recovery of sunken goods and ships for recycle or sale.

Treasure hunting:

the pursuit of intrinsically valuable artifacts from archaeological sites for purposes of collecting, trading, or personal financial gain.

profit every time the artifact collection is loaned for display or used in any other commercial capacity. In essence, the controversy pits a basic belief of underwater archaeologists—that research on shipwrecks should be done scientifically by trained personnel who have no interest in personal profit—against a long-held perspective of salvors and treasure hunters—that it is not unethical for anyone to harvest artifacts from shipwrecks for commercial reasons.

Bridging the Gap

How to present the wreck of the *Titanic*, explain the controversy, and offer educational content that provided an archaeological context was a challenge for our museum. Added to this was the fact that many youthful visitors already were “*Titanic* experts,” who wanted more than a simplistic approach. We constantly were impressed by kids’ knowledge of *Titanic* statistics and details about its sinking, thanks to the Internet and other popular media.

We chose to integrate the circumstances of the *Titanic* into the larger exhibit themes. This allowed us to compare the detailed research of archaeological projects with the salvage approach of the *Titanic*. It also enabled us to compare the liner to other wrecks whose fame is based on a major loss of life, media attention, or popular culture. Students were presented with the histories of these and other wrecks, and historical accounts were balanced with factual evidence revealed by archaeological research. Exhibit text and programs explicitly noted that the recovery of artifacts, and not scientific research, was the focus of work on the *Titanic*.

However, the museum did provide discussion points about how an archaeological approach to a wreck could offer unique insights. We described how the process of recording and mapping helps to explain how a floating vessel is transformed into an archaeological site. Models of the *Titanic* breaking apart and sinking, and of the wreck on the seabed, supported this discussion. The preservation of passenger baggage in the deep ocean allowed us to explain how an array of artifacts to study allows archaeologists to examine social and cultural groups.

Explaining the controversy surrounding the wreck was the greatest challenge. Many visitors, young and old, could not see the difference between archaeology and the salvage of the *Titanic*. Others were concerned about disturbing the dead and recovering artifacts, whether an archaeologist was involved or not. For many people, the bottom line was being able to see “real things” from the *Titanic*, regardless of how they were acquired.

Actually, “Shipwreck!” featured several “real things” from the site, all of which had been recovered at the time of the ship’s sinking in 1912. Our decision not to display items raised in recent years angered some visitors. To justify this position, we explained the differences between archaeology, marine salvage, treasure hunting, and the ethics of handling artifacts from wrecks. We also noted that, as a public institution with an archaeological mandate, we could not display items that had not been recovered archaeologically or that lacked a permanent museum in which to house them—thus placing them at risk of being sold or auctioned.

Ultimately, a lesson about shipwreck artifacts was driven home in a way that only real-life situations can provide. Many of the “real things” in our exhibit were loaned by a family involved in the *Titanic*’s recovery in 1912. Others were from private collectors who had acquired them from families of survivors or from people who found them floating in the Atlantic in 1912. Nearly all of these artifacts were taken back by the lenders during the exhibition—to be sold, thanks to a buying frenzy initiated by the *Titanic* movie. We left the cases empty, except for the artifact labels, for some time. We explained that the items had been sold to private collectors from abroad and probably would never be seen in a Canadian museum again. Hopefully, that underscored the seeming fragility of the *Titanic*’s thousands of recovered artifacts and the frenzy that could consume them.

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Sinking Old Myths About RMS *Titanic*

Joseph T. Neville

Everyone knows the story of the *Titanic*. On a moonless night in April 1912, the luxury liner struck an iceberg and sank in the North Atlantic, killing more than 1,500 people. After the sunken vessel was found in 1985, a private company was given the right to retrieve artifacts and other remains, which have been displayed in various locations. However, many underwater archaeologists and members of the public have objected to the visits to the site and the recovery of objects. Why would they disapprove?

The controversy involves several issues. Because the ship is the final resting place of the victims, some people think that it should not be disturbed by salvors looking for personal possessions and memorabilia. Archaeologists are concerned because the artifacts are being recovered for money-making reasons, which conflicts with a basic principle of their discipline. In addition, they believe that the site is not being treated with the same strict standards that are applied to other historic shipwrecks.

On the other hand, for maritime historians and naval architects—people who study seafaring events and ships of the past—the exploration of the *Titanic* has had positive consequences. Photographs, videotapes, and sonar images made of the remains, and clues from recovered objects, have helped to explain how and why the “unsinkable” liner sank.

New Explanations

For years, the iceberg was blamed for cutting a 300-foot-long hole in ship’s hull. This explanation prevailed despite the opinion of naval architect Edward Wilding, who testified at an official inquiry about the disaster in 1912. Wilding said that a 300-foot gash in the ship would have caused the *Titanic* to sink in minutes, rather than hours. He calculated that the area that flooded was less than twelve square feet. Although Wilding’s ideas were ignored by the public and press, recent evidence has convinced modern naval architects that he was right.

By the early 20th century, many ships—including the *Titanic*—were constructed of large metal plates held together by iron rivets, which are bolts

with a cup-shaped head at one end. Red-hot rivets were inserted from the outside of the hull into holes punched in the overlapping plates. On the inside, the end of the rivet was hammered flat to create a watertight seam. The *Titanic*’s hull was held together by more than three million rivets. However, the riveted joints were only half as strong as the plates.

Sonar images made in 1996 showed that the damage to the *Titanic*’s hull consisted of six thin slits, rather than a huge hole. Evidently, when the ship hit the iceberg, some of the metal plates shifted. This caused rivets to break and seams to open up, allowing water to enter the hull. In some cases, the slits were no wider than a person’s finger. The total size of the openings was about twelve square feet, just as Wilding had calculated. This explanation has been strengthened by tests conducted on several rivets recovered in recent years. The metal used to make the bolts contained impurities, which caused them to be brittle and prone to fracture.

Modern exploration also has helped to explain whether the ship plunged toward the bottom in one piece or broke apart on the surface. By studying photos and using computer models, naval architects now theorize that, as the bow filled with water, the stern rose above the surface. However, the weight of the ship’s heavy engines pulled the stern back to the surface, splitting the ship in two, although the sections still were attached along the bottom of the hull. The bow pulled the stern downward, but at some point the two sections separated.

Why did the *Titanic* sink so fast? The vessel was designed to stay afloat even if four of its forward compartments were flooded. Sonar images show that the thin slits in the hull allowed water into six compartments. As the bow sank lower, the rate of water flooding increased and more compartments became flooded until the ship finally sank.

Although ethical questions exist about how the *Titanic* and its contents have been handled, modern investigations of the site have helped to disprove several myths about the sinking, and historical inaccuracies have been corrected.

Joseph T. Neville is a retired naval captain and an amateur historian and archaeologist.

SOMETHING TO TALK ABOUT:

1. Are peoples’ concerns about the exploration of the *Titanic* and the recovery of artifacts reasonable?
2. Does the fact that knowledge has been gained from visits to the *Titanic* justify the recovery of artifacts?
3. Should individuals who are not trained archaeologists be allowed to recover artifacts from shipwrecks?

the object. Although there is no “cookbook formula” for conservation and each artifact is handled uniquely, certain basic techniques have proved to be effective and are employed routinely.

Typical Methods

If allowed to dry without treatment, waterlogged wood may undergo dramatic distortions. Two conservation procedures are used to ensure that a specimen will not shrink or change shape and that it will remain structurally strong. One procedure involves replacing water in the wood cells with a soluble material that becomes solid at room temperature, such as the wax-like substance known as polyethylene glycol (PEG). Ship's timbers or other large objects may have to soak in PEG for years to ensure complete penetration. The other procedure involves controlled dehydration, either by placing a specimen in a freeze-dryer or in a bath of solvents, usually alcohol. Sometimes, both techniques are used on an object.

Other organic artifacts, such as rope, leather, animal bones, botanical remains, and insect parts, often can be treated with the same techniques used for wood. They are carefully cleaned, dehydrated by freeze-drying or solvents, and, if necessary, consolidated with an appropriate substance.

Ceramics—ranging from plain, unglazed, coarse earthenware to decorated wares with a lead or tin glaze—often are the most common artifacts recovered from shipwrecks. Conservation treatments generally consist of removing soluble salts, marine deposits, and organic stains. Salts are removed by soaking pot sherds in a series of deionized or distilled water baths. Glazed or very friable ceramics may be consolidated by soaking them in some type of resin. Salts also must be removed from glass that has been exposed to seawater to prevent the surface from “spalling,” or flaking away.

Stabilization of iron artifacts from shipwrecks is one of the most challenging problems facing a conservator. Because of its potential to oxidize, iron is among the most corrosive of all materials. A process known as “electrolytic reduction” or “electrolysis” is used on iron artifacts that are relatively intact beneath their coat of encrustation. Artifacts undergo electrolysis until salt levels are reduced to acceptable levels, a process that may take years for anchors or cannons. After electrolytic treatment, iron artifacts are rinsed in a series of water baths, and several coats of tannic acid are applied to the surface to prevent further rusting.

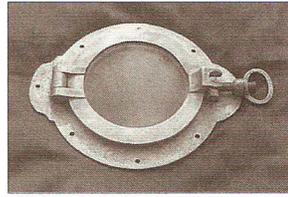
After years of immersion in saltwater, small iron artifacts often have corroded away completely. However, the encrustation that formed around them provides a natural mold that preserves their shape and, sometimes, detailed surface features. After being x-rayed to determine the nature and condition of the original object, an encrustation is broken apart, cleaned, and filled with epoxy. When the epoxy dries, the outer crust is removed to reveal a cast of the artifact.

Conservation of nonferrous objects such as silver, copper, brass, and bronze generally is easier because these metals are more stable and less prone to corroding. Treatments involve electrolysis or immersion in various chemical solutions.

The application of a protective coating usually is the final step in the conservation process. This ensures that an object will be sealed and protected from the detrimental effects of air, moisture, and light. In addition, artifacts always are stored or displayed in a controlled environment to prevent future deterioration.

Artifacts recovered during an archaeological excavation are perhaps the most important and useful forms of data for reconstructing day-to-day life on a ship as well as a vessel's origin, function, ports of call, and manner of destruction. The more data available for analysis, the more complete the picture will be. However, most artifacts cannot endure the stress of being removed from a marine environment, where they have reached a state of equilibrium, without undergoing some form of conservation. Not only does this procedure ensure their survivability, but it also allows vestiges of the past to be displayed for the benefit of the public.

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(Left) All that remains of this piece of armor is the "encrustation" that formed around it while it was under water. The actual metal is gone, but the "encrustation" can be used to make a replica. (Center/Right) A brass porthole looked like new after it had been conserved. Credit: University of West Florida Archaeology Institute.

Preserving Artifacts Through Conservation

Shipwreck artifacts that you see in museums were stinky, unrecognizable lumps when they came out of sea and would have fallen apart without treatment in a special laboratory. What happened to make them so presentable?

The answer is "conservation," which involves cleaning and preserving materials from an archaeological site to ensure that they will survive. Artifacts from shipwrecks present special conservation problems because they are soggy, fragile, and filled with salts from the water. Items from the sea also are covered with marine growth or deposits. Waterlogged artifacts will deteriorate quickly if they are allowed to dry without treatment. Wooden items will shrink and become distorted; metal objects will corrode and fragment into pieces; and glass and pottery will chip and crack.

Conservators are trained experts who know how to clean, stabilize, restore, and reconstruct artifacts. Their goal is to stop the deterioration process, strengthen the item, restore its appearance, and ensure that it won't deteriorate again. Some objects need very little attention—only cleaning in freshwater or a gentle detergent. Other items require more complicated measures to remove salts that they absorbed or a crusty coat, called "encrustation," that formed around them. While there is no "cookbook formula" for conservation, certain techniques that are effective are used routinely.

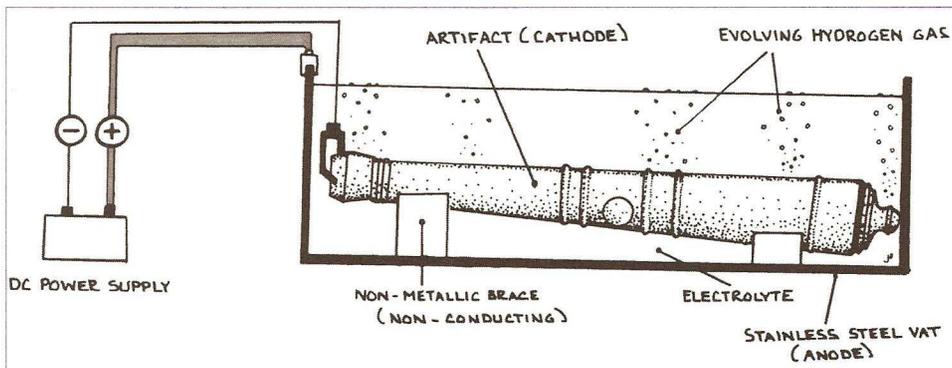
Fragile wooden artifacts are soaked in a substance that penetrates into the cells, replaces the

water, and becomes solid at room temperature. Water also can be removed from wood and other organic materials (leather, bones, rope, seeds) with freeze-drying or soaking in baths of a solvent such as alcohol. Ceramics and glass are soaked in water to remove absorbed salts, and sometimes they are treated with a solution to make them stronger.

Iron artifacts are challenging to conserve because iron corrodes so easily. If they are fairly intact within the encrustation, which can be determined by taking an x-ray, they are treated with "electrolysis." An object is placed in a tank filled with a chemical solution. A low-voltage electrical current is passed through it, which drives out the salts and loosens the encrustation. Afterward, the object is rinsed in water and painted with tannic acid to inhibit further rusting.

Small iron artifacts often have corroded away entirely, but the surrounding encrustation has formed a mold of the original object. Conservators break open the encrustation, clean the inside, and fill it with epoxy. When this dries, the crusty coat is removed to reveal a cast of the artifact. Objects made of gold, silver, copper, bronze, and lead are easier to conserve because these metals do not corrode as much. They are treated with electrolysis or chemical solutions.

Properly conserved artifacts are valuable sources of information. They tell us about people and events of the past, and they are available for study and display in museums for people to enjoy.



Electrolysis is a common way to treat encrusted metal artifacts, especially items made of iron. An object is immersed in a solution of sodium carbonate or sodium hydroxide and attached to a low-voltage power supply. The electric current causes hydrogen bubbles to form at the surface of the artifact. This loosens any encrustation and washes away salts that were absorbed while the object was in the sea. Credit: University of West Florida Archaeology Institute.



Shipwrecks in the Classroom: Plan for a Simulated Excavation

Marco Meniketti

Nautical archaeology offers educators tremendous flexibility in shaping the focus of their lessons because of its interdisciplinary nature. While students are engaged in the excitement of discovery, they learn and apply such skills as data collecting, organizing, and classifying; deductive and inferential reasoning; bibliographic methods; and scientific analysis. Many of these skills are features of state or district curriculum mandates. Students also are exposed to content material relating to social studies, language arts, art, science, and mathematics. Understandably, team teaching makes nautical archaeology a powerful educational tool.

The interactive, hands-on nature of nautical archaeology has multiple benefits for students. It gives them roles in their own education; it is an exciting learning experience; and it addresses multiple learning needs. Archaeology-based projects can be justified because they demand that students practice important skills while absorbing required course content. They also enable individual talents to flourish in many areas. Few curricula offer such diverse and reality-based learning.

Educational Impact

Integrating archaeology into the curriculum targets specific skills and course content with clear academic goals. Archaeological simulations in the classroom directly impact two categories of learning outcomes. First, a "static" set of criterion-based objectives is addressed: 1) learning the principles of archaeology; 2) understanding archaeological processes (for example, site formation); and 3) imparting specific knowledge content. A second category of objectives operates in the realm of adolescent cognitive development: 1) critical thinking skills; 2) group cooperation; and 3) dynamic knowledge synthesis and critical thinking. These cognitive skills transfer across disciplines.

Each set of educational objectives can be met in meaningful, authentic ways that are grounded in nautical archaeology. Social studies classes in various grades have units on ancient history, world history, the Age of Exploration, and American history. Nautical archaeology can reinforce and highlight specific course material by using real or fictitious shipwrecks from appropriate historic periods. In science classes, teachers can ask students to focus on group research skills, experiments, and scientific writing. Students can use the computer lab to create interactive programs or explore Internet resources for information on wrecks or historic events (figure 1).

Implementing Archaeological Lessons

A very effective approach is to embed nautical archaeology as a unit within a larger content theme and to tailor shipwreck lessons to meet existing requirements. Teachers do not have to be shipwreck experts; rather, the simulation strategy allows a teacher to become a learning facilitator, enabling students to structure the subject being taught by questioning, experimenting, and discovering relationships. The key is to identify the core curriculum content around which the archaeological unit will be built.

Teachers looking for creative, hands-on curriculum enhancement will find that nautical archaeology can be incorporated into social sciences, language arts, and other subjects with rewarding outcomes—due in part to its wide appeal. This article presents a simulated shipwreck excavation strategy that can be implemented successfully with students of varying ages, social backgrounds, and academic abilities.

Themes:

- excavation techniques
- interpretation of shipwrecks

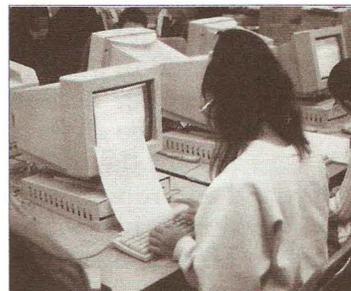


Figure 1: As part of this simulation activity, students created an interactive shipwreck story using Hypercard, which allowed animation and text to accompany the graphics. Credit: Marco Meniketti.

A Model Activity



Objectives

Students will

- use a simulation activity supporting curriculum content to reinforce key concepts;
- understand the value of recovering cultural resources through archaeology;
- develop inferential and critical thinking skills while integrating data from diverse sources; and
- work in cooperative groups to share information.

Subjects and Skills

- history, geography, language arts
- inferential and critical thinking
- map reading, drawing, measuring, scaling, researching
- group learning

Age Level

Grades 6 to 12, although the activity can be adapted to different levels

Materials

- a model shipwreck constructed by the teacher
- a fish tank or other large container that can hold water
- (optional) a disarticulated shipwreck buried in six inches of sand
- miniature artifacts such as anchors, cannons, or pottery
- student “scenario packets,” prepared in advance by the teacher
- butcher paper for a site map
- measuring tapes, string, trowels or large spoons, sealable plastic bags, index cards or labels, (optional) line levels
- student journals or data recording sheets

Vocabulary

- *artifact*—an object made or modified by humans, including the ship
- *cultural resources*—important historic sites and artifacts
- *excavation*—the scientifically controlled recovery of artifacts and associated data
- *site formation processes*—environmental and human effects that cause the deterioration, dispersal, or burial of a wrecksite

Procedure

Note: the following procedures are based on simulated shipwreck activities that I have presented successfully in classroom settings. The directions are not precise because the unit can be tailored according to content requirements, long-term objectives, and classroom composition. Teachers will have to devote several days preparing for the activity.

Depending on the learning environment and content emphasis, shipwreck units can extend from two to five weeks. Although standard fifty-minute periods are sufficient to present information and activities, block schedules are easier and allow time for cleaning up. Lessons easily can be built around any of the wrecks discussed in this publication, and Web sites can be accessed for additional information (see “Resources,” pg. 27). Prior to the “disaster” that befalls the ship, students can be given an assignment to prepare for a voyage by listing materials necessary for the undertaking. This creates a wonderful opportunity for geography and anthropology lessons as they plan the venture, and students also learn about explorers, historic technologies, and contemporary foods.

Mathematics comes into play as students try to determine the crew's needs on an extended voyage and the ship's cargo capacity. Language arts teachers can ask students to write voyage diaries, explorers' accounts of geographic and cultural discoveries, or narratives from the perspective of indigenous peoples encountering Europeans for the first time. Such assignments reinforce content, and they also fill time when teams are not excavating, since only one group can excavate at a time.

Materials for a simulated wreck are readily obtained from hobby or hardware stores. The ship destined for sinking, which the teacher constructs, should be made of cardboard or wood. Myriad books provide pictures to serve as guides for constructing the model (see "Resources," pg. 26).

The model ship (figure 2), complete with artifacts, is sunk in a water-filled tank in the classroom. Students should observe the sinking and be asked to conjecture about factors that might affect the wreck's disposition before archaeologists find it. (Over time, various site formation processes cause a vessel to deteriorate and become buried. Among these are the cause and depth of the wreck, nature of the seabed, weather, currents, marine organisms, and human activity.) In the case of the classroom wreck, the deterioration can be helped along by the teacher when students are away. After a pre-determined period, the water should be siphoned from the tank to allow the excavation phase to begin. If organizing a wet-site activity is impractical, a dry version can be presented, in which students study a wreck that already is buried. In either case, students must string a grid over the site to create separate units that they will excavate in small groups. Each group is responsible for a specific unit.

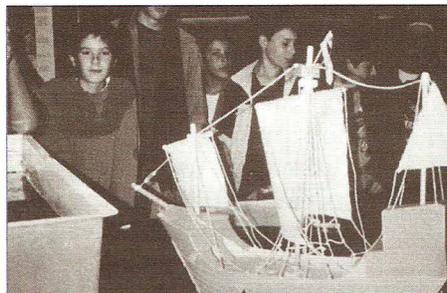


Figure 2: A cardboard and wood model of a ship type common to the 16th century is about to be sunk in a large tank. The model is filled with artifacts that students will excavate. Credit: Marco Meniketti.

To add further mystery and prompt creative sleuthing, the ship should not be unidentified; rather, students are informed that it could be one of several ships. Appropriate documents detailing several vessels and their histories (such as government dispatches, cargo lists, and survivors' accounts) are provided in a "scenario packet," prepared in advance by the teacher. The ships and histories can be fictitious but representative of historic events relating to the curriculum. Information in the documents purposely is kept incomplete to encourage deductive reasoning. Authentic-looking "documents" can be created by using period lettering, printing on parchment-like paper, and burning the edges. Younger students' attention can be increased by having them wear white cotton gloves to handle the "documents," as archivists do when they work with old materials.

During the excavation, the importance of careful measurement and note taking should be emphasized. Artifacts from each unit are stored in separate baggies, which are labeled to identify the excavators, unit, and date of work, and recorded in the students' journals to underscore the importance of documentation. Student teams also are responsible for a specific portion of a site map. Producing a larger-than-life map, hung on the wall, helps students to visualize the site and gives them a chance to practice scaling techniques and illustration (figure 3). As the map takes shape, students think critically about the finds; they are interpreting data; and they often undergo an "aha" moment that is visible and heartwarming. Moreover, the map makes a wonderful display for parents' night.



Figure 3: Students created a scaled-up site map as they excavated the simulated shipwreck. The task of positioning artifacts in their appropriate units, or grid squares, required students to measure, scale, use X and Y coordinates, and draw. Credit: Marco Meniketti.

Excavated artifacts help students to whittle the list of possible ships. For example, I have used small brass cannons as artifacts, which students compared a data sheet showing cannons in chronological order to try to determine the age of the ship. They then compared their suspected age of the guns to details in the "scenario packet." Sharing information and open discussion are essential since each group, excavating a separate unit, has unique data required by everyone to solve the puzzle.

Assessment

Students excavate the ship remains and, through careful analysis, match the archaeological evidence to documentary clues in the "scenario packet" to reduce the list of likely candidates. Students argue their conclusions, supported by evidence, in written reports. (An inexpensive binding job of these papers can be the

start of a student archaeology library available for future classes.) Agreement between data and conclusions should be assessed in open discussions.

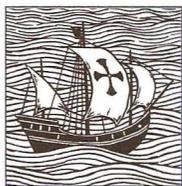
After the excavation is complete and the artifacts have been analyzed, a mini-conference—complete with name tags, podium, and other trappings of a real symposium—gives students the opportunity to present their reports and argue their conclusions. The conference also serves as a wrap-up for the unit. Students should be evaluated on the basis of the group site map, inferential support of conclusions, strength of arguments in written papers or discussion, measurements, and cooperative effort. Ample flexibility should be given for students who express themselves with special talents—for example, computer graphics or photography.

Conclusion

This activity not only simulates many aspects of an archaeological investigation, but it also requires students to weigh evidence in search of a best argument. Ultimately, as students apply scientific methods to authentic and real problem-solving situations, the archaeological experience becomes especially meaningful. The variations of a simulated classroom shipwreck excavation are endless. All that is required is a teacher who understands the value of using nautical archaeology in the classroom and who is willing to spend time “up front” to organize an activity that can be repeated with success each school year.

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Beyond the Excavation



The classroom shipwreck excavation can serve as a point of departure for creative teachers at every level. Some possible extensions are suggested below.

- ***Display or “publish” student products relating to the excavation***

Students interested in photography or art can be encouraged to document the excavation with photos or artifact drawings, which can be displayed near the site map. Kids with a knack for writing can submit stories about the project to the school or local newspaper.

- ***Create a museum exhibit***

Because public display of artifacts is an objective of archaeology, have students create an exhibit for the classroom or media center that features their excavated artifacts, complete with interpretive text and graphics panels. The exhibit can be set up on a table or counter, or students can use backboards or make a diorama. The exhibit can be displayed on parents’ night, with the kids acting as docents.

- ***Develop related activities with other teachers at school***

Teachers can bridge disciplines by asking colleagues to incorporate shipwreck-related projects. Science or chemistry teachers can present simple conservation activities, and woodshop instructors can allow students to build parts of the ship. Advanced language teachers can assign the translation of “documents” into appropriate languages, and art instructors can have students create amphoras and vases found in ancient wrecks by wrapping papier-maché around soda bottles.

- ***Participate in Archaeology Week/Month***

Most states annually recognize archaeology or cultural heritage at a specific time of year. The shipwreck activity can be planned to coincide with this event to further student interest and capitalize on public awareness.

Classroom Ideas for Further Exploration

Ship Shape

Photocopy pictures of boats and ships over time, divide the class into groups, and distribute the sets of illustrations. Ask teams to compare and identify features of watercraft that are similar and different. In open discussion, ask groups to share their observations and discuss the following questions.

- How has the design and propulsion of ships changed over time?
- How would function affect the shape of a ship?

Language of the Sea

Explain that nautical traditions appear in many aspects of modern life (e.g., literature, movies, clothing, superstitions), including common parlance. Share the expressions below and ask students to research others.

- *Between the devil and the deep blue sea* (to be stuck in a difficult position). On wooden ships, caulking was forced into seams between hull planks—a difficult but necessary task to keep the vessel from leaking or sinking. Located below the waterline, the hardest seam to caulk was called the “devil” because it was so hard to reach.

- *Learn the ropes* (to learn a new skill). A new crewman on a sailing ship had to learn the names of the many ropes and lines that worked the sails and yardarms.

- *Scuttlebutt* (gossip). A “skuttlebut” was a small cask of water on deck where sailors gathered to quench their thirst and engage in chitchat.

- *Taken aback* (to be stopped or surprised unexpectedly). If the wind shifted suddenly, it could cause sails to be laid flat against the mast, effectively stopping the ship.

- *Toe the line* (to straighten up and do right). When mustering for inspection, barefoot sailors placed their toes behind a seam in the deck planking to ensure that they were lined up properly.

Firsthand Details

In open discussion, ask students to state details that they would like to know about an ongoing shipwreck project. From this, formulate four or five specific questions to pose to underwater archaeologists. Divide the class into groups. Instruct teams to use the Internet to identify and select an existing shipwreck project that they must contact by email to present the questions. (Most shipwreck projects have Web sites.) In class presentations, allow groups to share the answers and other information that they have gathered about the project. Meaningful questions might include:

- What are your research objectives?
- What have you found, and what do you expect to find?
- What is the significance of the project?
- What are the most interesting or revealing artifacts?
- How much of the ship’s hull remains?

Other Extensions

- Ask students to read a book about a sailing voyage or seafaring episode (e.g., *Two Years Before the Mast*, *Horatio Hornblower*, *Captains Courageous*, *Moby Dick*) and write a summary of the story.

- Invite an underwater archaeologist to speak to the class, then ask students to research and write a short report about a shipwreck project.

- Invite a boat captain, fisher, navy officer, or member of U.S. Coast Guard Auxiliary to talk to the class about the design and use of modern boats and ships.

- If you live near water, take students, or assign them to go, to a nearby marina to observe modern watercraft. Ask them to express their observations through some form of artwork (drawing, painting, photo, clay model).

- Encourage students to select maritime or underwater archaeology topics if they compete in the statewide history fair.

Ship Shape: possible answers

Question 1: the introduction of sails, a rudder on the stern, armor plating, different types of power, and new construction materials; the elimination of oars; the addition of decks and above-deck cabins; an increase in vessel size and the number masts and sails.

Question 2: exploration vessels were small and fast; cargo ships had large, wide holds; warships had multiple decks for guns; treasure galleons were sturdily built to carry lots of weight; clipper ships had many sails for speed; steamboats had flatter bottoms; modern racing boats are sleek with lots of sail area.

Classroom Resources for Nautical Archaeology

Books for Mature Readers

- Baker, William A. et al. *The Lore of Sail*. New York: Facts on File Publications, 1982.
- Bass, George F., ed. *Ships and Shipwrecks of the Americas. A History Based on Underwater Archaeology*. London: Thames and Hudson Ltd., 1988.
- Delgado, James P., ed. *Encyclopedia of Underwater and Maritime Archaeology*. London: British Museum Press, 1997.
- Muckelroy, Keith, ed. *Archeology under Water. An Atlas of the World's Submerged Sites*. New York: McGraw-Hill Book Company, 1980.
- Throckmorton, Peter, ed. *History from the Sea. Shipwrecks and Archaeology*. London: Mitchell Beazley International Ltd., 1987.
- Tritton, Roger et al. *The Visual Dictionary of Ships and Sailing*. New York: Dorling Kindersley, Inc., 1991.

Books for Young Readers

E = elementary • *UE* = upper elementary • *S* = secondary

- Ballard, Robert D. *Exploring the Titanic*. Toronto: Madison Press Books, 1988. [UE/S]
- Blackman, Steve. *Ships and Shipwrecks*. New York: Franklin Watts, 1993. [UE/S]
- Bernier, Marc-André and Robert Grenier. *Les archéologues aux pieds palmés*. Quebec: Les Editions Héritage, Inc., 1996. [E; French only]
- Delgado, James P.
Native American Shipwrecks. Danbury, Conn.: Franklin Watts, 2000.
Shipwrecks from the Westward Movement. Danbury, Conn.: Franklin Watts, 2000.
Wrecks of American Warships. Danbury, Conn.: Franklin Watts, 2000.
[All books: UE/S]
- Humble, Richard. *Submarines and Ships*. New York: Viking, 1997. [UE/S]
- Kristof, Emory et al. *Undersea Treasures*. Washington, D.C.: National Geographic Society, 1996. [E]
- Lerner Geography Department. *Sunk! Exploring Underwater Archaeology*. Minneapolis: Runestone Press, 1994. [S]
- Macaulay, David. *Ship*. Boston: Houghton Mifflin Company, 1993. [S]
- Platt, Richard. *Shipwreck*. New York: Alfred A. Knopf, 1997. [UE/S]
- Smith, KC.
Exploring for Shipwrecks. Danbury, Conn.: Franklin Watts, 2000.
Shipwrecks of the Explorers. Danbury, Conn.: Franklin Watts, 2000.
Ancient Shipwrecks. Danbury, Conn.: Franklin Watts, 2000.
[All books: UE/S]

Teaching Manuals

Cleary, Marie and Mark J. Meister, eds. *Cargoes from Three Continents: Ancient Mediterranean Trade in Modern Archaeology*. Boston: Archaeological Institute of America, 2000.

Mathewson, R. Duncan. *If Shipwrecks Could Talk*. Hudson, N.H.: Delta Education, Inc., 1995.

Prentice-Hall, Inc. *The Wreck of the Henrietta Marie*. Upper Saddle River, N.J.: Prentice-Hall Interdisciplinary Explorations series, 1997.

Organizations

Advisory Council on Underwater Archaeology (ACUA), c/o Society for Historical Archaeology, P.O. Box 30446, Tucson, AZ 85751-0446; <http://www.sha.org>

Archaeological Institute of America (AIA), 656 Beacon St., Boston, MA 02215-2006; (617) 353-9361; <http://www.archaeological.org>

Institute of Nautical Archaeology (INA), P.O. Drawer HG, College Station, TX 77841-5137; (979) 845-6694; <http://www.nautarch.tamu.edu>

Web Sites

The sites below represent a small sample of Web pages relating to the following topics.

Underwater Archaeology Links

<http://www.adp.fsu.edu/uwdirect.html>

<http://www.pophaus.com/underwater>

Maritime Museum Sites

<http://www.bobhudson.com/Smiths>

Emanuel Point Wreck

<http://dhr.dos.state.fl.us/ep>

<http://www.uwf.edu/archaeology/projects/uw/epse/epse.htm>

<http://scholar.coe.uwf.edu/delunaexpedition>

Queen Anne's Revenge

<http://www.dcr.state.nc.us/QAR/default.htm>

<http://blackbeard.eastnet.ecu.edu/main.html>

H.L. Hunley

<http://www.history.navy.mil/branches.org12-3.htm>

http://www.hunley.org/html/Recovery/recovery_main.htm

<http://juniorhistorypress.com/index.html>

RMS Titanic

<http://www.encyclopedia-titanica.org/index.html>

<http://www.theteachersguide.com/Titanic.html>

Vocabulary

Terms used in this volume

archaeological site—a place where human activity or occupation occurred

archaeology—the scientific study of past cultures based on artifacts and other evidence that people left behind

artifact—an object made or modified by humans

ballast—heavy materials such as stones or iron placed in the lower part of a ship for stability

bow—the front or forward end of a ship

ceramics—objects made of clay that have been fired at a high temperature

conservation—the documentation, cleaning, and treatment of an artifact to ensure its stability and survival

excavation—the scientific recovery of artifacts and related data

feature—an element of an archaeological site that is larger and more complex than a single artifact, such as a ballast mound or a burial

grid—a network of squares placed over a site to assist excavation and recording

hold—the inside of a ship below deck, where cargo and ballast are carried

hull—the frame or body of a ship

induction dredge—an excavation tool that uses suction to remove sediments

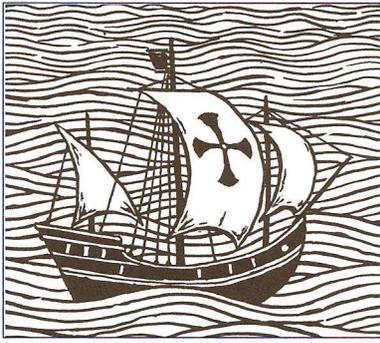
radiocarbon dating—a scientific method of dating that indicates how much time has passed since an object lived

remote-sensing survey—the use of electronic equipment to search for and find archaeological remains without the need for excavation

run aground—when a vessel becomes temporarily or permanently stranded on the bottom

survey—an initial assessment of an archaeological site that involves limited testing and recovery of diagnostic artifacts

stern—the back or rear end of a ship



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**A teaching module
about nautical archaeology
for secondary grades**

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details about the discipline
- **The Emanuel Point Ship**
a Spanish colonial wreck
- **Queen Anne's Revenge**
Blackbeard's ill-fated flagship
- **H.L. Hunley**
a Confederate submarine
- **Titanic**
the ethics of shipwreck research
- **Artifact conservation**
preserving objects for the future
- **Shipwrecks in the classroom**
lesson plan and activity ideas
- **Additional resources**
sources for further exploration