

Abstract

Crucial Factors for the Recovery and Conservation
Of
An Archaeological Ship

By

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What factors determine the successful recovery and concentration of a full archaeological ship? While an article by G.D. van der Heide provides guidelines for recovery, he offers no analysis to explain why his issues are valid. Using ten case studies from diverse time periods and geographic locations around the world, this thesis explores van der Heide's issues to determine their significance. The case studies showed that while van der Heide's issues are valid there is no guarantee of a successful project even if they are addressed. There are other issues that are more influential to the outcome of a project, namely the parties responsible for the project and acquiring funding early on. Addressing these two issues increases the chances of having a successful outcome.

Crucial Factors for the Recovery and Conservation
Of
An Archaeological Ship

A Thesis

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by

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To my sister, the professional layman, who put my head in the right place,
and my parents who motivated me. Thanks for the prodding.
To Peter Campbell who set my feet on the road
and Larry Babits who gave me direction.

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INTRODUCTION

Waterlogged artifacts present unique challenges to archaeologists and conservators in their excavation, conservation, and display. Shipwrecks pose multiple recovery and conservation issues due to the size, weight, and multiple components that make up the artifact (Werz and Seemann 1993:38). In the past, it may have been possible to excavate every ship site that was found, but with the growing popularity of diving as a recreational sport, the number of known sites has increased exponentially. There are simply not enough archaeologists, nor funds, available to excavate all sites.

***In Situ* Preservation:**

Currently, the preferred action is *in situ* preservation, a method whereby ships/artifacts are left in their original position and efforts are made to prevent degradation, whether natural or manmade, of the site (Dell 1994:434; Manders 2008:31-33). This method was first used in the 1980s. One of the most notable was the seventeenth century VOC wreck in the Dutch Wadden Sea (Manders 2008:32). Since the 1980s, this method has been used on several other sites including: S.S. *Xantho* in Western Australia, *Stora Sofia* in Sweden, and several Scottish crannogs (McCarthy 2000:146; Lillie et al. 2008:1886; Bergstrand 2010:60). *In situ* preservation was declared the preferred option by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Convention in 2001 (UNSECO 2001:3).

There have been several studies performed that examine *in situ* preservation (Gregory 1998; Nilsson 1999; Brunning et al. 2000; French 2004). These studies show that there are several justifications for why a site should be excavated rather than using *in situ* preservation, which include answering specific research questions, prohibitive costs associated with *in situ*

preservation, and unstable environmental conditions. For sites in fairly stable natural areas (i.e. areas with low vulnerability to mechanical breakdown or great fluctuation in environmental variables), *in situ* preservation is a good option; however, there are many sites where this option is not desirable. Sites in danger of being destroyed because of natural causes (i.e. erosion) or manmade ones (i.e. offshore construction, looting), may be excavated and recovered before they are lost (UNESCO 1995; Van de Noort et al. 2001:96; Manders 2008:34).

Why are ship sites significant?

While there is certainly more to a ship site than the ship, it is the excavation, recovery, and conservation that concerns this thesis. Many issues surrounding these tasks are similar to those involved in any archaeological investigation; however, underestimating the effect of a ship's size and weight is what makes the recovery such a difficult undertaking. The process required to recover, conserve, and display an entire vessel is daunting; it tends to be complicated, long-term, and expensive.

So, why make the effort? Shipwrecks are a unique and important piece of history that should be studied to learn that which might not otherwise be available (van der Heide 1972:167-168). As monuments of the past, ships ought to be respected and preserved for the future. To learn all that is possible, limit potential harm that could be done to a site, and facilitate taking steps needed for the best possible result, certain issues should be addressed as soon as possible, preferably before the vessel is ever touched (van der Heide 1972:161, 167).

The importance of preserving ships is widely acknowledged (Throckmorton 1973; Muckleroy 1980; Ransley 2007; Manders 2008). The reasons for recovering a ship may include: 1) it is an example of a ship form for which archaeologists have few, if any, other examples, 2) it

is a ship that should be studied to learn more about construction techniques, or 3) it is a ship of historical significance that the public has interest in. When stripped of specifics, each reason is ultimately the same: to preserve a piece of the past for the future. Determining if a ship is eligible for excavation is complicated and will be discussed in depth in Chapter 2.

Several projects mentioned in this thesis were started before underwater archaeology was an established discipline and there were no formalized methods and no established professional standards. Science is often bettered by making mistakes, and over time, methods improved and standards have been set for the field by several organizations (Platt 1964:350).¹ Improvements in recovery and conservation technology over time allow for a greater chance of success. More recent projects often utilize knowledge gained during earlier projects. By using this wisdom, future endeavors can have an increased chance of being successful.

Problem Statement:

As each project is unique, it is unlikely to find a single report that discusses every problem that may arise. An article written in 1972 by G.D. van der Heide, called “Wrecks as Ancient Monuments,” is one of the first works to discuss the overall management of a recovery project. The article’s purpose is to stress the importance of archaeological sites, shipwrecks in particular, as sources of information about aspects of human history that may not be available elsewhere. He advocates that even in a rescue situation it is necessary that the ship not be lost due to indecision about how it must be managed (van der Heide 1972:161, 162). Van der Heide lays out his issues as a guide to those wishing to recover a ship, pointing out that ideally the issues should be dealt with before the site is touched. He makes no effort to fully discuss any of the issues, only lists them as “the main conservation problems,” (van der Heide 1972:162) after

¹ See Appendix 1 for various organizations.

stating that at the time there was still much to learn about wood conservation. This thesis attempts to address not only the concerns that van der Heide listed, but also to identify others that have occurred in the past and have a marked effect on the recovery and conservation of a ship.

For the purposes of this thesis, the definition of an ideal successful project is one in which, allowing for uncontrollable variables, the best possible outcome is achieved. Part of this includes slowing deterioration to a point where the material is considered relatively stable with as little damage done to the vessel as possible allowing for future study. A complete failure would be defined as having a marked deterioration of material to the point of the material not being able to provide reliable data for research purposes. This includes insufficiently slowing the rate of deterioration to allow for lasting study and damage to the vessel, including destruction of materials.

What factors aid in a successful recovery of an archaeological ship? According to van der Heide, seven issues are crucial to a project's successful completion:

1. Assessing value and estimating costs.
2. Dealing with water on site.
3. Keeping the ship wet during excavation.
4. Removing the ship from the site.
5. Transporting the ship to its storage/conservation location.
6. Accommodating conservation work and visitors.
7. Choosing conservation treatment and facilities.

Studying these issues, in addition to others, and their impact on a project will allow archaeologists to focus their attention on what is crucial to the successful recovery and

conservation of a ship from an archaeological environment. Following each of the seven points above that van der Heide makes in “Wrecks as Ancient Monuments,” ten international projects where wrecks were found in which the entire remaining hull has been recovered:

| Project | Site Location | Year Found |
|--------------|--------------------------|------------|
| La Belle | Matagorda Bay, TX | 1995 |
| Philadelphia | Lake Champlain | 1935 |
| U.S.S. Cairo | Vicksburg, MS | 1956 |
| H.L. Hunley | Charleston Harbor, SC | 1995 |
| C.S.S. Neuse | Kinston, NC | 1930s |
| Hjortspring | Als, Denmark | 1920 |
| Skuldelev | Skuldelev, Denmark | 1956 |
| Bremen Cog | Bremen, Germany | 1962 |
| Mary Rose | Portsmouth, England | 1971 |
| Vasa | Stockholm Harbor, Sweden | 1956 |

Table 1: Ship Projects

These projects will be studied to determine:

1. Was it possible to solve each issue before the project began? If it was not possible, why not?
2. Does there seem to be a change in success rates over time? If yes, what is (are) the reason(s)?
3. Are there any factors other than van der Heide’s that affect the outcome of the project?
4. What issues seemed to have the greatest impact on the project’s outcome?

Literature Review:

The issues involved with particular projects are included in the various reports, books, and articles published for the projects themselves. The main sources that will be used for each project are included below. Additional sources were also used when necessary in order to more fully explain a subject or for substantiation of facts. When information was not readily available, an attempt was made to contact the responsible parties for additional information. In most cases, information was not available or not forthcoming in the foreseeable future.

American Projects:

The main text about *La Belle* is *From a Watery Grave: the Discovery and Excavation of La Salle's Shipwreck, La Belle*, which outlines the project up to the publication date (Bruseth and Turner 2005). Current information on the *La Belle* project can be found on Texas A & M's Nautical Archaeology website (Hamilton 1998).

The main work for *Philadelphia* is John R. Bratten's *The Gondola Philadelphia and the Battle of Lake Champlain* (2002). This book includes the ship's history as well as information about the recovery and subsequent conservation treatment. In addition to this, the Lake Champlain Maritime Museum was consulted for further information.

There are two books about U.S.S. *Cairo*. The first, Edwin C. Bearss' *Hardluck Ironclad: the Sinking and Salvage of the Cairo* (1980), is a detailed account of day-to-day activities during U.S.S. *Cairo*'s raising and conservation. The second is *The U.S.S. Cairo: History and Artifacts of a Civil War Gunboat* (Joyner 2006), which details some U.S.S. *Cairo* artifacts and includes an abbreviated ship's history.

There are three main books that were consulted for *H.L. Hunley*. The first is *The H.L. Hunley: The Secret Hope of the Confederacy* (Chaffin 2008). The second is *Raising the Hunley: the Remarkable History and Recovery of the Lost Confederate Submarine* (Hicks and Kropf 2002). The third is *The C.S.S. Hunley: The Greatest Undersea Adventure of the Civil War* (Bak 1999). Current information on the *H.L. Hunley*'s conservation can be found on the Friends of the Hunley website: <http://www.hunley.org> (2010).

The only book written about C.S.S. *Neuse*'s recovery is *C.S.S. Neuse: A Question of Iron and Time* (Bright et al. 1981). There is also a Master's Thesis that will be consulted: *The Development of Confederate Ship Construction: An Archaeological and Historical Investigation of Confederate Ironclads Neuse and Jackson* (Campbell 2009). In addition to this, notes from the raising of C.S.S. *Neuse*, written by William Rowland are located in Special Collections, Joyner Library, East Carolina University.

European Projects:

The main work that was consulted about the Hjortspring ship is *Hjortspring: a Pre-Roman Iron-Age warship in Context* (Crumlin-Pedersen and Trakadas 2003). This work contains several articles about the recovery and conservation of the ship.

For the Skuldelev ships, the main work consulted was Ole Crumlin-Pedersen and Olaf Olsen's *The Skuldelev Ships I: Topography, Archaeology, History, Conservation and Display* (2002). This is the first volume of the final report on the Skuldelev ships.

The main work that was consulted for the Bremen Cog was *Die Kogge—Sternstunde der Deutschen Schiffsarchäologie (The Cog—Triumph of German Ship Archaeology)* by Gabriele Hoffman and Uwe Schnall (2003). This is the second volume of the final report. A copy of the

first volume, *Die Kogge von Bremen (The Hanse Cog of Bremen)* by Werner Lahn, Gabriele Hoffman, and Uwe Schnall (1992) was not available. There have been other books and articles published as well that were also referenced (Ellmers 1972; Crumlin-Pedersen 1979).

The final report of the *Mary Rose*, which was the main source used, consists of five volumes of which volume one and five are referenced. These volumes are:

Vol. 1: *Sealed by Time: The Loss and Recovery of the Mary Rose*, by Peter Marsden (2003)

Vol. 5: *For Future Generations: Conservation of a Tudor Maritime Collection*, by Mark Jones (2003)

The main source that will be used for *Vasa* is: *Vasa 1: the Archaeology of a Swedish Warship of 1628* edited by Fred Hocker (2006). This book is the first of the four planned monographs that will be released as the final report of the *Vasa*.

Conclusion

There can be no doubt ships are an important component in providing knowledge about past eras of human history. As such, they should be preserved. For this to happen, several issues must be addressed to ensure a smooth recovery and conservation. Are the issues van der Heide mentions in “Wrecks as Ancient Monuments” as crucial as he implies? Would solving these issues before excavation truly have an impact on a project’s outcome? Is it even possible to resolve such issues before excavation begins? Are the issues van der Heide presents, perhaps, not as crucial as other factors, such as the parties responsible for the project or the funding sources? This thesis will address these questions.

The information presented in this thesis provides important insights to the dynamics that dictate successful recovery and conservation of an archaeological ship, which have been gleaned from past practical experiences. Knowing these dynamics is necessary when planning a project in order to attach an appropriate level of awareness to the more crucial issues that will affect the project's outcome, while allowing other issues to be dealt with on an as needed basis. Having an awareness of these issues, will aid in circumventing any major problems, and will lead to a greater chance of having a successful outcome for a ship recovery project.

CHAPTER ONE:

CASE STUDIES

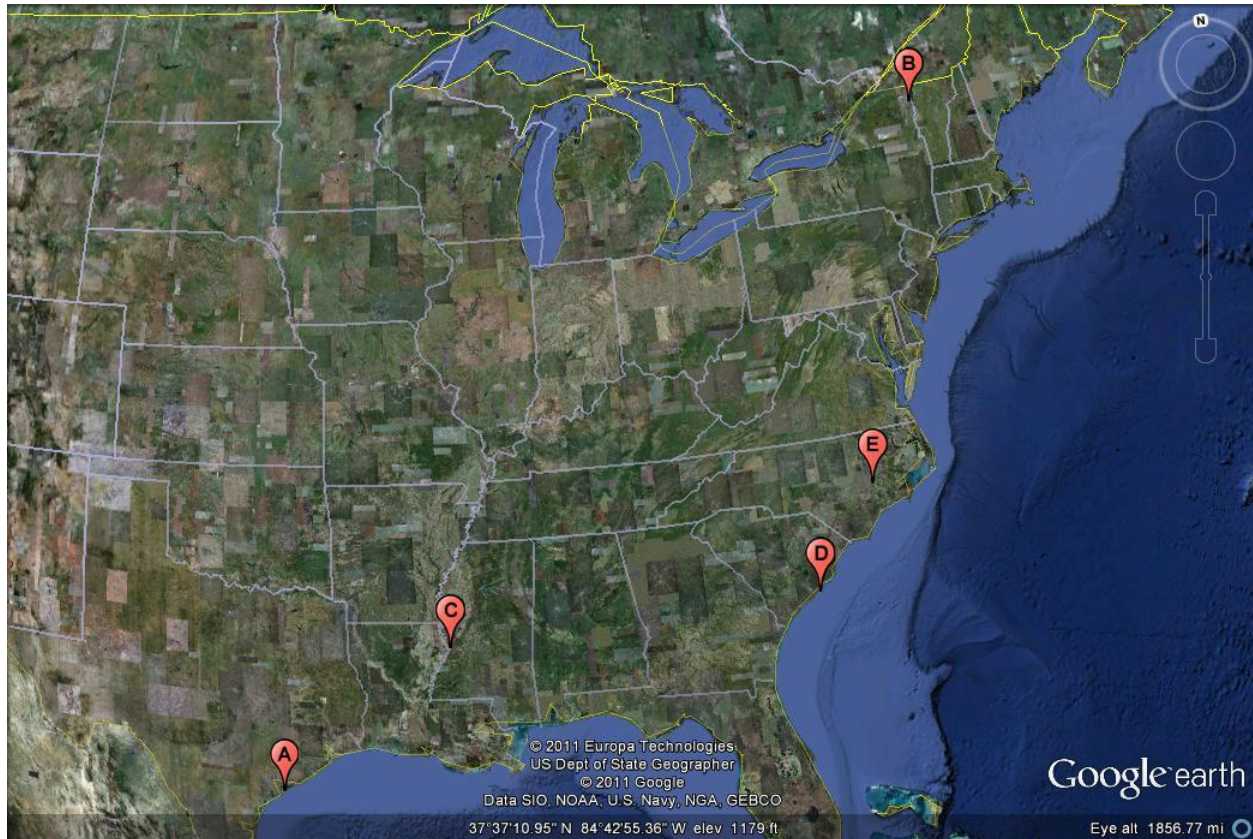
Introduction

A total of five American projects and five European projects were examined for this thesis. The American projects were: *La Belle*, *Philadelphia*, U.S.S. *Cairo*, *H.L. Hunley*, and C.S.S. *Neuse*. The European projects were: Hjortspring, Skuldelev, the Bremen Cog, *Mary Rose*, and *Vasa*. These particular projects were chosen because they dealt with archaeological sites (i.e. a site where a vessel was either lost or abandoned and then re-discovered later) from which the entire remaining vessel was removed and, after conservation, was placed on display for the public, or, if still in the process of being conserved, is planned for display once conservation is complete. Each project had varying levels of success and some, such as *La Belle*, are still undergoing conservation (Hamilton 1998). Not all projects were undertaken by archaeologists, and/or were undertaken before modern professional standards were put into place. Not all records were complete, as information from the recovery or conservation was not available. Below is an overview of each project, including any available ship history. More detailed accounts will be given in the following chapters as they relate to the issue being discussed.

American Projects:

The American projects (see Map 1 for site locations) contain ships that range in age from the late 1600s (*La Belle*) to the mid-1800s (C.S.S. *Neuse*) (Bright et al. 1981:6; Bruseth and Turner 2005:3). All ships, with the exclusion of *La Belle*, were purpose built warships. The

ships range in length from thirty feet (*H.L. Hunley*) to one hundred seventy-five feet (U.S.S. *Cairo*) (Hon and Taras 1988:2; Bak 1999:49). *La Belle* and the *Philadelphia* were wooden ships with iron fasteners, while *H.L. Hunley* was a completely iron vessel (Bak 1999:49; Weddle 2001:3; Bratten 2002:15). Both U.S.S. *Cairo* and C.S.S. *Neuse* were ironclads with wooden bodies and iron armor and fasteners (Bright et al. 1981:7; Quarstein 2006:62).



Map 1: Site location of American projects: A: *LaBelle*; B: *Philadelphia*; C: U.S.S. *Cairo*; D: *H.L. Hunley*; E: C.S.S. *Neuse*

La Belle:

In 1684, explorer Rene-Robert Cavalier, Sieur de La Salle, left La Rochelle, France, on an expedition to establish a permanent settlement in North America that would allow trade with Native Americans at the mouth of the Mississippi River. The fleet of four ships: *Saint-François*,

l'Aimable, *Le Joly*, and *La Belle*, carried three hundred crew members and settlers. They successfully built Fort St. Louis on the east coast of what is now Texas (Bruseth and Turner 2005:3).

The fleet of four broke up by various means. *Saint-François* sprang a leak near Haiti, *Le Joly* went back to France, and *l'Aimable* ran aground (Weddle 2001:4-8). By 1986, *La Belle* was the only ship still near the coast. In January 1686, La Salle took a small contingent overland to locate the Mississippi River, leaving Captain Pierre Tessier in charge of *La Belle* (pictured in figure 1) in Matagorda Bay. After a month, La Salle had yet to return, and *La Belle* was running low on drinking water. Tessier ordered five sailors ashore for water. They took the only remaining ship's boat and never returned (Bruseth and Turner 2005:3-4).



Figure 1: *La Belle* in concrete vat built for conservation (Bruseth and Turner 2005:66)

Disobeying orders to remain in position, Tessier decided to sail to Fort St. Louis, which was located at the other end of the bay, to join the colonists. In the attempt, the ship was caught by a storm. Many skilled sailors had died of dehydration, and the remaining crew lost control of the ship. The ship ran aground in twelve feet of water at the southern end of the bay (Bruseh and Turner 2005:5).

The crew built a raft and went ashore to find fresh water. Tessier stayed on board for several more days, while the crew made several trips to off load cargo to the shore, and then the ship was abandoned. Overtime, the hull settled into the mud bottom until only the rear deck remained above water (Bruseh and Turner 2005:5).

Nearly three hundred years later, Texas Historical Commission archaeologists were able to determine the general area where *La Belle* was located. In 1978, Barto Arnold proposed a ten week search for two of La Salle's ships, *l'Aimable* and *La Belle*, in Matagorda Bay. A magnetometer survey was conducted over zones deemed 'high probability' by geomorphologist Robert A. Morton. Though several anomalies were recorded, none proved to be La Salle's ships (Bruseh and Turner 2005:32-38).

In 1995, the Texas Historical Commission found a wreck later identified as *La Belle* in twelve feet of water. *La Belle* is a *barque longue*, or a light frigate. With a forty-five foot keel and a beam of only fourteen feet, it was not a particularly large vessel (Weddle 2001:3; Bruseh and Turner 2005:40). It was decided to excavate the site with the intent of recovering the remaining ship timbers and its cargo. To do this, a cofferdam was built around the ship, allowing the site to be excavated as if on dry land. The cofferdam eliminated the need for special gear and facilitated recording as visibility in the bay was poor. The site was excavated and the hull removed in 1996-1997 (Bruseh and Turner 2005:39-46, 48, 55, 62-63). The hull was

transported to the Conservation Research Laboratory of Texas A & M University's Nautical Archaeology Program in College Station, Texas, to undergo conservation (Hamilton 1998).

Philadelphia:

In 1776, during the American Revolutionary War, General Benedict Arnold supervised construction of an American flotilla on Lake Champlain. A large part of this fleet was comprised of gondolas, or gunboats. These shallow draft, flat bottomed boats were propelled by rowing or sailing and were ideal for Lake Champlain (Bratten 2002:15, 18-19). *Philadelphia* (pictured in figure 2) was one of these gondolas. Built in only three weeks, it was fifty-four feet long and had a beam of fifteen feet, with one mast (Hagglund 1936:669). The ship was launched on July 30, 1776 and joined the fleet on August 30.

The flotilla was comprised of eight gondolas (including *Philadelphia*), two schooners, and the *Royal Savage* and *Enterprise*. The fleet left Crown Point, New York, August 24 and arrived at Willsboro, New York, the next day. When a storm moved in, the fleet moved to what is now Button Bay, Vermont, for safety (Bratten 2002:29, 30, 47-48).

By September 24, after a few small skirmishes, the fleet, which had grown to fifteen vessels, was anchored between Valcour Island and the New York mainland anticipating engaging the British fleet. When the British approached on October 11, scouts reported that the American fleet was greatly outnumbered (Bratten 2002:49-58). To split the British force, *Royal Savage* and three galleys separated from the others, drawing fire. *Royal Savage* was heavily damaged and taken by the British who then used it to fire upon the Americans. The gondolas were ordered to fall back to the other side of the bay, but much damage had already been done.

After the battle, the American fleet successfully retreated to Schuyler Island for repairs (Bratten 2002:58-61, 67). *Philadelphia* sank from battle damage an hour after the shooting stopped.



Figure 2: Gondola *Philadelphia* on display (Smithsonian Institution 2011)

In 1935, Colonel Lorenzo F. Hagglund found the ship three hundred yards south of Valcour Island. *Philadelphia* was recovered August 9, 1935 and placed on a barge as a floating exhibit that toured the Hudson River and Lake Champlain for several years. In 1961, it was acquired by the Smithsonian Institution, where it became a central exhibit in the National Museum of American History (Bratten 2002:64, 74, 85, 90-91).

U.S.S. *Cairo*:

Construction of U.S.S. *Cairo* (pictured in figure 3), along with seven other City Class ironclads, began in September 1861. Often called Pook's Turtles after their designer, naval constructor Samuel M. Pook, these ships were steam powered, had a shallow draft, and an iron casemate. *Cairo* was commissioned on January 25, 1862 and was 175 feet long by 51 feet in beam (Hon and Taras 1988:2; Quarstein 2006:62, 79, 93).

On April 14, 1862 *Cairo* rescued the crew of *Erebus* when it was set on fire during an engagement at Fort Pillow, Henning, Tennessee. Two days later, *Cairo* was struck by a shell. Fortunately, *Cairo* took very little damage and had no casualties (Bearss 1980:52-53). On December 12, 1862, eleven months after the ship was commissioned, the *Cairo* was sunk by a torpedo in the Yazoo River near Vicksburg, Mississippi. It was the first ironclad sunk by torpedoes in the war (Joyner 2006:7; Quarstein 2006:144).

During 1863, the Union Navy entertained the possibility of raising the ship. In the fall of the same year, Lieutenant-Commander Elias K. Owen was sent to supervise the raising. After being detained by Confederate guerrillas, he sent Ensign Phinias R. Starr to take his place. Starr located *Cairo* in twenty feet of water. The ship was not visible and he was informed that some chains had been removed by Confederate forces. Eventually, recovery was abandoned because the Union had undisputed control over the river and it was unnecessary. Two years later the war ended and the ship was abandoned (Bearss 1980:4-5)

In 1879, the Nash Wrecking Company of St. Louis, Missouri, planned to raise *Cairo*. When the Treasury Department granted permission, there were protests from other companies. When they complained that they should be given an opportunity to bid for the contract, the Nash Wrecking Company contract was voided; another was never awarded (Bearss 1980:5).

In 1956, Edwin C. Bearss, Don Jacks, and Warren Grabau located U.S.S. *Cairo* and began making plans to raise it (Bearss 1980:8). It was found to be in excellent condition and deemed structurally solid (Hon and Taras 1988:2). In the winter of 1959-1960, Operation Cairo, Inc., a non-profit organization, was created to raise and preserve the ship. The organization depended on donations to fund operations (Bearss 1980:106).

After many mechanical setbacks, funding problems, ownership issues, and miscalculations, the ship was finally removed from the river in late 1964 (Quarstein 2006:257). During the lift, cables cut deeply into the hull. To avoid more difficulties, the ship was cut into several segments and removed from the river (Bearss 1980:143). In June 1965, the ship remnants were placed on a barge and moved to Ingalls Shipyard in New Orleans, Louisiana, where it was reinforced and some parts were replaced. Hundreds of photographs and drawings were done of the *Cairo* at this time (Bearss 1980:170, 172).



Figure 3: U.S.S. *Cairo* under canopy (photo taken by Melissa Ashmore)

In January 1966, it was determined that reconstruction of the *Cairo* on a permanent barge would cost \$1.5 million, which had yet to be acquired (Bearss 1980:172). After many objections to placing the ship on a barge were lodged, the plan was changed. The ship would become part of a permanent exhibit at Vicksburg National Military Park (Bearss 1980:174). The ship stayed at Ingalls Shipyard during the exhibit's planning and construction while funding was being located. In autumn 1976, the shipyard gave notice that, because of space restrictions, they could no longer house *Cairo*. The ship had to be prepared and transported on short notice. It reached Vicksburg, Mississippi, on June 19, 1977. In a bout of fortuitous timing, the concrete cradle that would support the ship had been completed. Once the ship was placed in the cradle, formal conservation began some twelve years after it was raised (Bearss 1980:182-186). The site currently includes a wooden support structure and a large canopy over the ship which protects it from some of the elements (Joyner 2006:12).

H.L. Hunley:

During the Civil War, Horace L. Hunley, deputy collector U.S. Customs in New Orleans, Louisiana, decided to design a submarine. It was built at the Park and Lyons machine shop in Mobile, Alabama (Bak 1999:3, 39, 48-52). The main body was originally thought to be composed of a boiler cylinder, but examination revealed that it was purpose built; the tapered bow and stern were made of cast-iron. The overall length of the submarine was approximately thirty feet long (Murphy et al. 1998:93; Bak 1999:49; Hicks and Kropf 2002:227). In August 1863, the submarine, called the Fish Boat, was sent to Charleston, South Carolina, seized by the Confederate Navy, and put through a series of practice dives (Chaffin 2008:111, 117, 135).

The first trial was a disaster. The submarine was caught by the wake of a passing steamer. Because the hatches were still open, it quickly filled with water and capsized, killing five men who had volunteered as crew (Bak 1999:82-84). The ship was turned back over to Hunley in September (Chaffin 2008:146).

In October, the submarine was officially named *H.L. Hunley* (pictured in figure 4) (Chaffin 2008:147). When practice began after the ship was retrieved, Hunley captained a new volunteer crew. On October 15, 1963, during another training run, the submarine dove and never returned to the surface. It was unclear what went wrong, but the theory was that a candle used to determine the presence of oxygen was never lit. Asphyxiation caused Hunley to accidentally open a ballast tank. This, coupled with panic, caused the accident. Eight men, including Hunley were killed (Bak 1999:97-99).



Figure 4: *H.L. Hunley* in water tank (Friends of the Hunley 2010)

During the winter of 1863-1864, a new volunteer crew spent several weeks training. On February 17, 1864, at 8:45 pm, *Hunley* approached *Housatonic* in Charleston Harbor and was spotted by the crew. Under rifle fire, *Hunley* rammed the ship, deployed its spar torpedo, then backed away, and detonated the charge. *Housatonic* sank and after signaling the shore *Hunley* was not seen again. Though some speculation as to what happened to *Hunley* occurred after the sinking, once the war ended, interest died (Bak 1999:127-130, 139).

In 1980, author Clive Cussler began looking for *Hunley* (Bak 1999:144). In 1992, the search for *Hunley* became a joint effort between the South Carolina Institute of Archaeology and Anthropology (SCIAA) and Cussler's National Underwater and Marine Agency (NUMA). After a contentious search in 1994, the two groups split. In May 1995, *Hunley* was found by NUMA, who had continued to quietly search for the submarine (Hicks and Kropf 2002:130,136).

After negotiations, through which the Federal Government kept title to *Hunley*, and possession was given to Charleston, South Carolina, Cussler provided the site's location and several agencies joined together to excavate and raise *Hunley*, and on August 8, 2000 *Hunley* was brought to the surface. It was placed on a barge and taken to the Clemson Conservation Center in Charleston to undergo conservation (Hicks and Kropf 2002:162, 205, 209).

C.S.S. *Neuse*:

The contract for C.S.S. *Neuse* (pictured in figure 5) was signed on October 17, 1862 and construction began shortly after in White Hall, North Carolina (Bright et al. 1981:6). Built for river travel, it was flat bottomed with an iron casemate (Bright et al. 1981:7). It was approximately 150 feet long with an extreme beam of 36 feet (Campbell 2009:63). Construction moved slowly, due to delays in receiving construction materials (Still 1966:4). This was set back

even farther when the ship was damaged during a Union attack in December 1862. After repairing the damage, *Neuse* was finally completed and moved to Kinston, North Carolina, for outfitting in March 1863. Due to iron shortages, it was not until January 1864 that machinery arrived for installation (Bright et al. 1981:8-9).

Though *Neuse* was still incomplete, it was ordered to New Bern, North Carolina, on April 22, 1864 to support a Confederate attack. The ironclad never arrived. Less than a half mile below Kinston, it ran aground, where it was stranded until mid-May. When the river rose high enough to float the ship, *Neuse* returned to Kinston. After the ship was finally completed, the captain was ordered to stay in Kinston for nearly a year (Bright et al. 1981:14-16).



Figure 5: C.S.S. *Neuse* under shelter (photograph courtesy of Don Pierce)

On March 12, 1865 Union troops reached Kinston. After shelling the enemy, C.S.S. *Neuse* was cleared of personal possessions and abandoned. The ship was set afire to stop Union

troops from taking possession (Still 1966:13). The ironclad sank in the Neuse River near Kinston (Bright et al. 1981: 19).

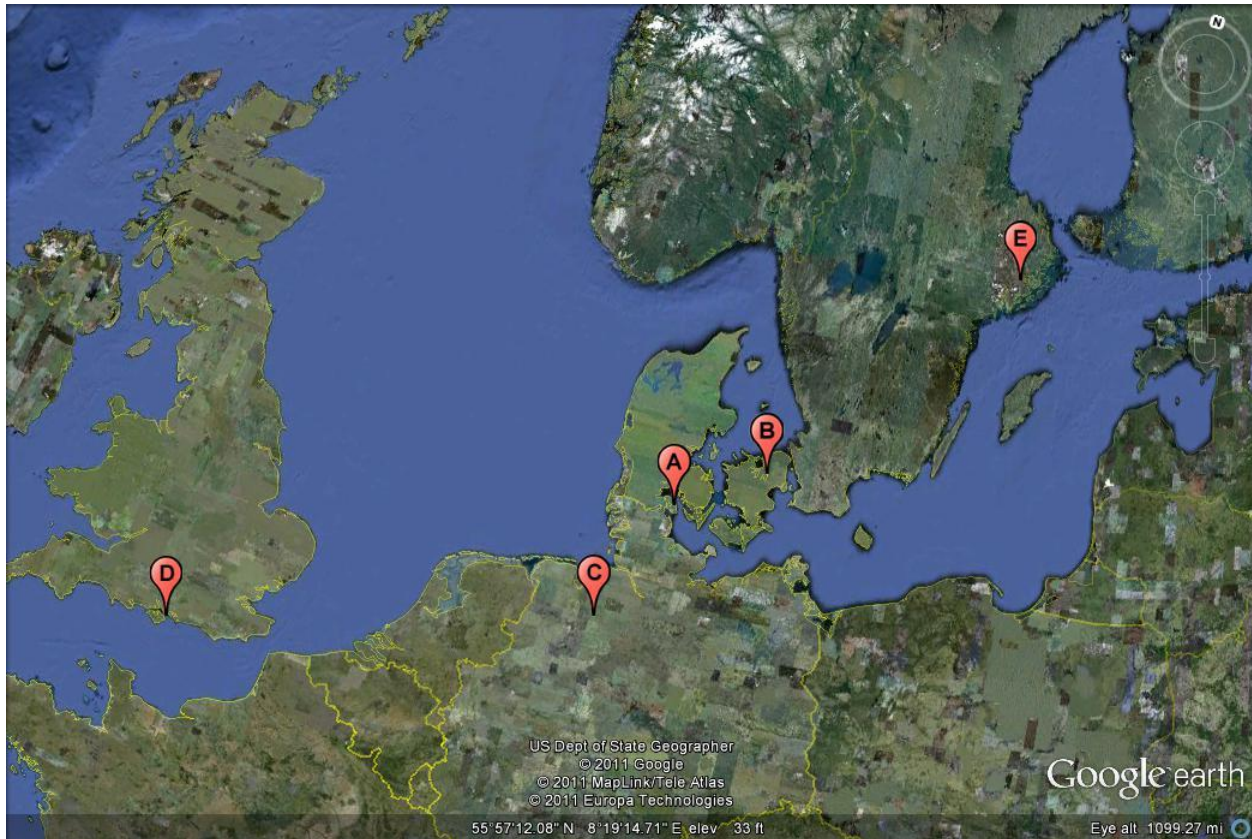
In the 1930s, Henry Clay Casey became fascinated by the wreck and began digging around it. In 1954, local high school students excavated fourteen live Brooke artillery projectiles. After this, community interest in the vessel spurred Henry Clay Casey to satisfy his curiosity. In October 1961, Henry Clay Casey, Lemuel Houston, and Thomas Carlyle made an effort to raise the *Neuse*.

In November 1961, the issue of ownership arose. At the time there were no definitive state laws governing shipwrecks. Decisions were made on a case-by-case basis. For the *Neuse* an agreement was made where the salvors would relinquish their claim on the ship to the County Confederate Centennial Committee, who would provide compensation of \$4000 upon completion of the recovery (Bright et al. 1981:22). Then in February 1962, Helen Cox Muzinich, an heir to the land on which the vessel was found, claimed the ship and all its contents. To strengthen her claim she claimed that permission to recover the wreck was never sought, not given. All work on the ship was halted until a resolution could be found. Eventually Muzinich agreed to withdrawal her claim for the price of \$5000. Once the issue was resolved, the work on the ship began again (Bright et al. 1981:23-25). After months of funding problems, ownership issues, and failed attempts, the hull was finally recovered in the spring of 1963 and left to dry on the bank. Nearly a year later the *Neuse* was placed in Caswell Memorial Park in Kinston (Bright et al. 1981:19, 26). In 1969, a 70x180 foot open sided shelter was built over the hull to protect it. The shelter provided only minimum protection. In 1970 formal conservation began (Bright et al. 1981:27).

There were plans to move the ship to an environmentally controlled area, but flood damage from Hurricane Fran in 1996, made moving the ship farther from the river more vital. Its location in the park was shifted to accommodate the decision. In 1999, Hurricane Floyd caused massive flooding and once again damaged the ship and visitors' center, which housed the artifacts (North Carolina Historic Sites 2011). A climate controlled facility for the ship and the artifacts is planned to occupy two lots in downtown Kinston (Guy Smith 2010, elec. comm.).

European Projects:

The European projects contain ships that range in age from the 4th century BC (Hjortspring) to the early 17th century AD (*Vasa*) (Kaul 2003:175; Hocker 2006:44a). *Mary Rose* and *Vasa* were purpose built warships, as were two of the Skuldelev ships (II and V) and the Hjortspring vessel (Hocker 2006a:53; Marsden 2003:1-3; Olsen and Crumlin-Pedersen 1978:104). The Bremen cog and Skuldelev ship's I and III were trading vessels (Sauer 2003:30-31; Olsen and Crumlin-Pedersen 1978:104). Skuldelev VI was a fishing vessel (Olsen and Crumlin-Pedersen 1978:104). The ships ranged in length from approximately thirty-seven feet (Skuldelev VI) to one hundred thirty-two feet (*Vasa*) (Crumlin-Pedersen 2002a:296; Hocker 2006c:46). All of the ships were wooden with iron fasteners, except the Hjortspring vessel which shows evidence of being sewn (Valbjørn and Rasmussen 2003:64).



Map 2: Site locations of European projects: A: Hjortspring; B: Skuldelev;
C: Bremen Cog; D: *Mary Rose*; E: *Vasa*

Hjortspring:

The Hjortspring boat (pictured in figure 6) was deposited in a pond, on the island of Als, Denmark, during the 4th century BC (Kaul 2003:175; Rieck 2003:14). The sixty-one to sixty-four foot long ship was old and worn when placed into the pond, most likely as part of a weapons sacrifice. It was determined that the ship represented a sacrifice based on the deposition patterns of the ship and artifacts located either inside or adjacent to the ship. Many associated artifacts were weapons, some of which were destroyed, such as a sword blade bent at a ninety degree angle. Weapons sacrifices often included ritual destruction, as well as a ritual stoning which concluded the ceremony. The Hjortspring find included hundreds of fist-sized stones that indicate this activity, lending further evidence that this was a purposeful deposition (Crumlin-Pedersen 2003a:34; Kaul 2003:142).

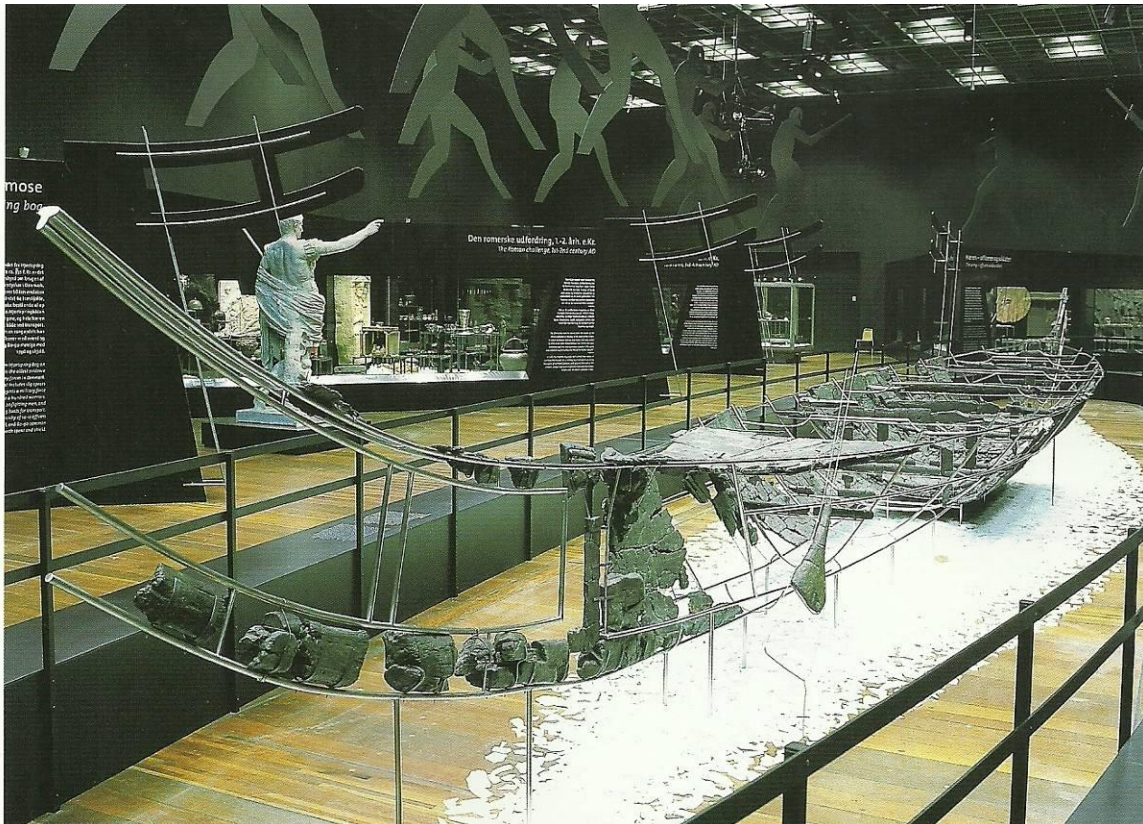


Figure 6: Hjortspring vessel on display (Bojesen-Koefoed et al. 2003:53)

The site was first found in the 1880s by Chresten Nymand, who owned the land. By the time the ship was found, the water table had dropped, turning the area into a bog, an area of soft, waterlogged ground. The owner happened upon artifacts while digging peat, but had no interest in them. In 1920, K. Friis Johnsen, curator of the National Museum, visited the locality (Rieck 2003:12). Excavations took place in the summers of 1921-1922 under the supervision of Gustav Rosenburg, conservator of the National Museum. He discussed recovering the ship in 1921, but decided against it as he felt the museum was not equipped to deal with conservation at the time (Rieck 2003:13-18).

During 1922, the ship was recovered and taken to the Danish National Museum in Copenhagen. Conservation continued until 1932 (Bojesen-Koefoed and Stief 2003:38, 40-43). The pieces were reassembled in a new exhibit room, five years later. After initial assembly and

conservation, problems became evident. The main problem was high humidity in the exhibit space. Though Rosenberg expressed concern over this, nothing was done to alleviate it. It was not until the 1960s that this problem was addressed (Bojesen-Koefoed and Stief 2003:43).

In 1965, Hjortspring was disassembled and work began on re-conserving it. Not all fragments were re-conserved due to funding shortages (Bojesen-Koefoed and Stief 2003:43; Bojesen-Koefoed et. al. 2003:45). The fragments sat in storage crates until 1986, when funding was received. In 1988, the boat elements were remounted as a new display. It is currently displayed on an open frame of metal tubes inside a climate controlled glass case (Bojesen-Koefoed et. al. 2003:45, 47-51).

Skuldelev:

An obstruction known as the *Peberrendan* barrier was built across Roskilde Fjord near Skuldelev, Denmark, in the mid-to-late 11th century (Bondesen 2002:9). The barrier was comprised of five ships most likely deposited to protect Roskilde from unknown attackers. The five ships date to approximately the 1030s and 1040s AD. All show evidence of a long use life before being discarded (Crumlin-Pedersen 2002b:50; 2002c:331-334). The ships were deposited in two different phases. Wrecks I (large trading vessel), III (smaller trading vessel) and V (smaller warship) first and then wrecks II (longship) and VI (fishing vessel) later (pictured in figures 7-11) (Olsen and Crumlin-Pedersen 1978:104; 2002:34; Crumlin-Pedersen 2002a:123, 173, 227, 266, 296). The wrecks were numbered in the order they were found. The wreck numbered IV was eventually identified as part of wreck II (Olsen and Crumlin-Pedersen 2002:27). The first deposition dates to circa 1050-1070 AD and the second to 1060-1080 AD (Crumlin-Pedersen 2002c:333-334).

Local fishermen knew the barrier's location. In the 1920s, they dug a passage through it to accommodate deeper draft vessels (Olsen and Crumlin-Pedersen 2002:23). In 1947, Aage Russell, then curator of the Medieval Department of the National Museum, investigated the barrier, removed a frame, and then abandoned the site after finding no artifacts (Bondesen 2002:24).

In 1956, amateur divers Aage Skjelborg and Hartvig Conradsen removed part of a frame and other small pieces. The National Museum then determined the barrier dated from the Late Viking period, not the medieval era as previously thought. Once the barrier's actual time period was determined, systematic investigation began (Olsen and Crumlin-Pedersen 2002:24).



Figure 7: Skuldelev I on display (Jensen et al. 2002:95)



Figure 8: Skuldelev II on display (Crumlin-Pedersen 2002a:169)



Figure 9: Skuldelev III on display (Crumlin-Pedersen 2002a:226)



Figure 10: Skuldelev V on display (Crumlin-Pedersen 2002a:265)

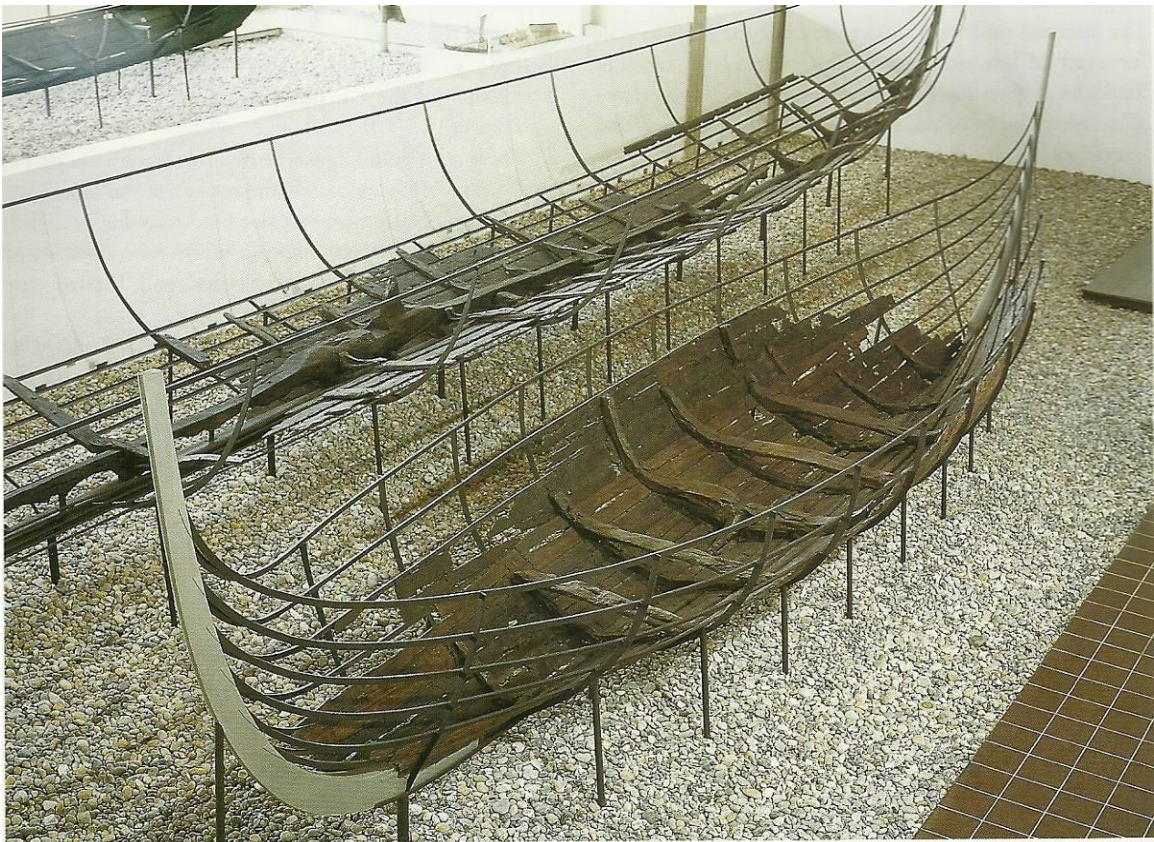


Figure 11: Skuldelev VI on display (Crumlin-Pedersen 2002a:293)

Excavation lasted from 1957-1962 (Olsen and Crumlin-Pedersen 2002:23). The original purpose was to experiment with underwater archaeology which utilized the, then new, scuba technology. Later the focus changed to recovering the ships, including their conservation and display. In 1959, the decision was made to use a cofferdam (Olsen and Crumlin-Pedersen 2002:25, 27).

After excavation, timbers were transported to the National Museum's conservation laboratory where they were recorded and conserved over a fifteen year period, with some undergoing additional conservation to correct problems into the 1990s (Crumlin-Pedersen 2002b:56). The ships were reassembled as exhibits in the new Viking Ship Museum, where they are on display today (Olsen 2002:86).

Bremen Cog:

The Bremen cog (pictured in figure 12) was found in an old bed of the Weser River during 1962, (Crumlin-Pedersen 2000:231-232). The seventy-six foot cog had not been completed before it was deposited. Because the mast had not been set in place, there was no ballast, no decking, and no tar was evident on the planking, it was assumed that the ship was lost in a flood during construction (Fliendner 1985:10; Fliendner 2003:51; Hoffmann 2003a:17). According to dendrochronology, the vessel was constructed circa 1380 AD (Fliendner 2003:50).

The cog is a ship type from the Middle Ages. Cogs were typically used for transporting trade goods and had a single mast, a deep hull, and a pronounced rise at the bow and stern. The Bremen vessel has all of these features (McGrail 2001:233; Sauer 2003:30-31. The ship was made of oak planks held together with iron nails, which had corroded away before the ship was found (Hoffmann 2003a:14; Sauer 2003:18).

The ship was removed in pieces in 1962 using both helmet divers and a diving bell. The pieces were stored in water tanks until the Bremerhaven Museum was completed in 1975 (Fliendner 1985:8; Pohl-Weber 1985:16-17; Hoffmann 2003b: 81; Lahn 2003: 66). The museum was designed to allow the public to observe the reassembly and conservation (Hoheisel 2003:73).



Figure 12: Bremen Cog on display (Hoffmann 2003a:16)

After several experiments, it was determined that a two-step process of polyethylene glycol (PEG) impregnation would be most effective. It was feared that rigidity of the timbers, a result of conservation might, make it much more difficult to reassemble. To eliminate this problem, the ship was reassembled before conservation, and suspended in the exhibit gallery (Hoffmann 2001:129; Hoffman 2003b:81, 85; Lahn 2003:69). After reassembly, a steel tank was built around the ship and the first of two PEG baths began. The ship sat in the first PEG bath

from 1985 to 1995, after which the tank was drained and the second bath started. After three years, the steel tank was removed, the cog was cleaned, and made ready for exhibition (Hoffmann 2003b:81, 86-93).

Mary Rose:

In 1509, Henry VIII ascended to the throne of England. He focused on building coastal defenses and began expanding his fleet. During the period of Henry VII and VIII's reigns, there were great political struggles throughout Europe. Of particular concern were the ambitions of the French King. Henry VIII felt it was necessary to expand his fleet in order to protect his kingdom. *Mary Rose* was built and outfitted from 1510-1512 as part of the English Navy's expansion and was a warship with three decks and a surviving keel length of one hundred two feet. The ship was built in Portsmouth and outfitted in London (Marsden 2003:1-3, 93).

Mary Rose was the flagship of the English fleet during the First French War (1512-1514). It engaged in many battles during the war, mostly in the English Channel and off Brittany (Marsden 2003:10-13). In 1515, *Mary Rose* was put into reserve at Dartmouth. It was stripped of most hardware and left with a skeleton crew with minimal maintenance. In 1520, it was again placed into active duty for a meeting to discuss peace between Henry VIII of England and Francis I of France.

In 1522, *Mary Rose* was again on active duty for the Second French War (Marsden 2003:13). After the war's first year, *Mary Rose* was placed in reserve, as it was determined that great ships would not be needed unless France brought up an army. It stayed in reserve from 1522 to 1545, again with maintenance being performed (Marsden 2003:15).

When the Third French War started in 1544, *Mary Rose* was put into active service. In July 1545, *Mary Rose* engaged in battle between English and French forces in Portsmouth

Harbor (Marsden 2003:18). During the battle, the lower gunports were left open and the wind, helped by the weight of the large number of guns on board, caught the ship. The open gunports dipped beneath water level, which flooded the ship, causing it to capsize (Marsden 2003:19-20).



Figure 13: *Mary Rose* during conservation (Jones 2003:plate 6)

The ship was discovered in 1836 by a group of fishermen. Professional divers brought up several of the guns and other artifacts. After a dispute over who owned the material, that was eventually resolved, salvaging ceased (Marsden 2003:21-29). Alexander McKee began searching for the ship again in 1965. It took three years of extensive searching using period maps and diver surveys to locate the site. In 1971, the ship identity was confirmed as the *Mary Rose* (Marsden 2003:30-32).

In 1971, excavation and mapping the ship began; a project that took several seasons to complete. The ship was completely buried and all structure that had been above the bed had deteriorated completely, leaving only about half of the ship. Planning the recovery began in

1978, but it was not until 1982 that the decision was made to go ahead with full recovery (Marsden 2003:35-51). The ship was raised using a lifting cradle with bolts driven through the hull to stabilize it (Marsden 2003:56-57). The ship was lifted and broke surface October 11, 1982 (Marsden 2003:57).

Mary Rose was transported to the Portsmouth City Museum's conservation facilities, and is currently housed in the Mary Rose Tudor Ship Museum in Portsmouth, England (Marsden 2003:37). The ship is not currently on display. A new museum is being built and the ship is scheduled for display in 2012 (Mary Rose Trust 2010:1)

Vasa:

In 1611, Gustavus Adolfus became king of Sweden. By the 1620s, he decided to expand his navy. The 17th Century was a period of growth for Sweden. It transformed from a small state to one of the major players in the European political structure. Part of what allowed Sweden to accomplish this was the expansion of its military (Hocker 2006:35-36). *Vasa* (pictured in figure 14) was the first ship of this expansion. It was a rather large ship at one hundred thirty feet with two gun decks. After the ship was built, a test found it unstable. Before anything could be done, the King ordered the ship to sea (Hocker 2006a: 38-39, 44, 46, 53). In 1628, *Vasa*, flagship of the King's fleet, sank in Stockholm Harbor, Sweden. According to eye-witness accounts, the ship was hit by a sudden gust of wind, which caused it to heel to port. The ship's gun ports had been left open, allowing water to flood the ship (Hocker 2006a:53).

Though there were several attempts to raise the ship, the first just a few days after sinking, none was successful until Anders Franzén became interested in the early 1950s. After a long search, *Vasa* was located in 1956 (Cederlund and Hocker 2006b:174-175; Hafström 2006:69). It was determined that the ship should be lifted as intact as possible to avoid

reconstruction problems if timbers deformed during drying (Håfors 2010:16). After a long process of excavation, lifting, and moving, the ship finally broke surface in 1961 (Cederlund 2006c:290).

The ship was towed to the naval dockyard in Kastellholmen, and excavating the interior began. Thousands of artifacts were recovered during this process, including personal belongings and human remains. Excavation took five months to complete (Hocker 2006:310-400, 410). Once excavation was finished, the project shifted to conserving the ship and artifacts (Cederlund 2006a:422). In November 1961, the ship was moved to the *Vasa* Shipyard, a temporary structure housing the ship until 1988 (Håfors 2010:24, 25). The ship was recorded (a process not completed until 1964), cleaned, and artifact conservation began (Cederlund 2006a:422 429, 439).



Figure 14: *Vasa* on display (Jeffries 2009:54)

The ship's conservation began in 1962, with hand sprayed treatments of a PEG and boric acid solution, with a biocide. For nearly two years, six days a week, the ship was sprayed. In 1964, the ship was placed on a permanent cradle. In the same year, the ship was transferred to the National Maritime Museum in Stockholm. In March 1965, an automated spray system was installed. From 1965 to 1972, the ship was sprayed up to thirty-two times in any twenty-four hour period. After 1972, the number of spraying episodes was incrementally lowered, while the PEG concentration was increased until spraying was stopped in 1979. Once spraying ceased, a surface treatment of PEG spraying and heating was done by hand. After the treatment was completed, the *Vasa's* surface was cleaned and the ship allowed to dry. *Vasa* was moved to its permanent site when the new museum was ready in 1988 (Cederlund 2006a:447, 449, 452; Håfors 2010:34-37, 58-66, 78-80).

Conclusion

The projects used as case studies for this thesis range in age from the fourth century BC (Hjortspring) to the mid-nineteenth century AD (C.S.S. *Neuse*). The recoveries occurred between 1921 (Hjortspring) and 2000 (*La Belle*). Some such as *H.L. Hunley* and *La Belle* are still undergoing treatment, and it will be years before final results can be seen. Nine of the sites were located underwater, the sole exception being the Hjortspring vessel, which was found in a peat bog. All of the American sites are located in the eastern United States stretching from the north to the south borders. The European sites are all located in the northwest quarter of Europe. These ships provide clues about human history that may not be available anywhere else. Their recoveries were all unique and the final outcomes were varied. The factors that influenced each ship's final condition were varied and will be discussed in following chapters.

CHAPTER TWO: ASSESSING VALUE AND ESTIMATING COSTS

Introduction

The question of whether to remove a wreck from the site or to preserve it *in situ* is an important one. According to the UNESCO Convention of 2001, the first option is *in situ* preservation because archaeology is considered a destructive science. Once a site is excavated, all relevant provenience information is gone. In addition to this, funding is finite and limited, as are housing options for artifacts (UNESCO 1995:8). Not every site is suitable for *in situ* preservation.

The best option is to prioritize which sites should be recovered, but any prioritization is highly subjective (Manders 2008:34). How does one choose which sites/ships to excavate and recover, and which to preserve *in situ*? The first step to answering this question is assessing value of the site/ship, including an estimate of cost (van der Heide 1972:162).

A site/vessel's value is an assessment based on significance to both the public and professional communities versus effort of excavation, recovery, conservation, and other factors associated with a project. Value alone may or may not be sufficient to justify recovering a ship. Determining the value of an archaeological site or vessel is a complex and often subjective process. Depending on the party that is assessing value, the ship may be deemed more or less important. The value may also change over time, based on condition of the ship as well as changing ideas.

The definition of 'significance' of an archaeological site has been the subject of several publications over the years (see Moratto and Kelly 1976; Glassow 1977; Klinger 1980; Butler

1987; Delgado 1987; Smith 1990). According to the National Register of Historic Places, for a site to be deemed significant it must meet at least one of four criteria. The criteria are:

1. The site is associated with events that have had a major impact on history
2. The site is associated with an individual that has had a major impact on history
3. The site embodies characteristics that are distinctive to a time period or method of construction, representative of the work of a well-known artisan, have a high artistic value, or be a representative of an important group that has similar features
4. The site has provided or will provide information important about pre-history and history. (The current basis of archaeological knowledge, both theoretical and substantive, is what determines whether the information is important.) (Butler 1987:820-821; Delgado 1987:35).

These criteria encompass factors that are related to both scientific interest and public interest in a site (and by extension, its artifacts). Both need to be taken into account when determining the overall value of a site/object (Appelbaum 2007:87-89). In both of these categories, there are several factors to be considered, which will be discussed later.

Estimating costs is also a large part of assessing value. Even if the value of a project makes it a possible candidate for excavation and recovery, prohibitive costs may make it unfeasible. If the decision is made to excavate and recover a site/ship, having an accurate estimate of costs is necessary when looking for funding options and to produce a budget for the project. Costs associated with most recovery projects will be discussed later.

American Projects:²

Below is information from the American case studies that can be included in the value assessment.

Ship: *La Belle*

Value: The ship dates to 1686 and was captained by Robert Cavelier. The extent of the remains was not known before the project was started. The project managers claim to have no proof that the project would prove to be useful, and would be significant enough to justify the cost. The cargo hold proved to be largely intact. The excavation utilized a cofferdam which increased costs, in addition to costs common to most recovery projects (Bruseth 2005:3-5, 49-51, 54, 60; Donny Hamilton 2001, elec. Comm.).

Ship: *Philadelphia*

Value: It is the United States oldest surviving gunboat and was used during the American Revolutionary War. The Philadelphia city planner Peter Schaufler tried to obtain the ship for the city because it was a unique and significant find. The costs were relatively low because of the size of the boat and the small number of personnel needed for recovery (Hoffman 1984:55; Bratten 2002:15, 87-88).

Ship: U.S.S. *Cairo*

Value: The *Cairo* was an example of a City class ironclad, known as Pook's Turtles. It was the first ironclad to be sunk in the Civil War by torpedoes. Most ironclads were either converted, sunk, or sold for scrap. There are few examples of un-altered ironclads. The ship was well known by the community. The costs included those most common to most recovery projects (Bears 1980:6, 109, 167; Joyner 2006:7).

Ship: *H.L. Hunley*

Value: It was the first submarine to sink an enemy vessel. The sub was never seen after it performed its duty, which caused an air of mystery to surround the legend of the vessel. There was a lot of interest because no historic plans of the sub exist, so no one knew what it actually looked like. The use of a lifting cradle increased the costs of the project, which included those common to most recovery projects (Bak 1999:142; Hicks and Kropf 2002:216-229; Friends of the Hunley 2011).

Ship: C.S.S. *Neuse*

Value: The ship was stationed and outfitted in Kinston, NC which is also where it sank. Most ironclads were either converted, sunk, or sold for scrap. There are few examples of un-altered ironclads. Costs included those most common to recovery projects (Bright et al. 1981:19, 22-24; Guy Smith 2010, elec. Comm.).

² Because not all projects in this thesis are archaeological in nature, value associated with the ship in question may be after the fact observations by the author and were not necessarily discussed explicitly in the sources.

European Projects:

Below is information from the European case studies that can be included in the value assessment.

Ship: Hjortspring

Value: The ship is the oldest surviving plank-built ship in Scandinavia and the only one where the planks and etc. were sewn together. It is also part of the earliest example of a weapons sacrifice, which is also unique because it has only one period of deposition. With others, the areas of weapons sacrifices had several delineated zones of deposition, making them a center of periodic return. In addition, the find allowed for an experimental reconstruction of the ship to be made. Much experimentation has been done using this model, which has given insight into the capabilities of these vessels. It corroborates drawings found of ship types, and also lends some evidence that some of the boats thought to be skin, may have in fact been wood. Costs included those common to recovery projects. In addition, pumps were utilized to lower the water table for ship removal (Bojesen-Koefoed et al. 2003:45; Crumlin-Pedersen 2003b:209-210, 228; Kaul 2003:141, 143).

Ship: Skuldelev I, II, III, V, VI

Value: The ships formed a professionally placed barrier to the fjord, possibly for strategic blocking. They were late Viking era ships. Though the ships were highly fragmented, the site produced a variety of ship types. Costs included building of a cofferdam, in addition to those most common to recovery projects (Olsen and Crumlin-Pedersen 1968:94-95; Olsen 2002:86; Olsen and Crumlin-Pedersen 2002:24, 30; Jensen et al. 2002:71).

Ship: Bremen Cog

Value: It represents a cog type from the Middle Ages that up to now there were no extant examples of. It was a salvage operation because it was found while the river was being dredged. It was built by professionals and was in excellent condition when found. During the 13th and 14th centuries the cog was an extremely important vessel type. It was a new vessel type and had a great impact on the sea-going trade in Europe. Before the Bremen cog was found, the only information known about the type was taken from stylized drawings of the ship on seals. Costs included employing a diving bell, in addition to those most common to recovery projects (Fliedner 1985:7-8; Crumlin-Pedersen 2000:232; Hoffmann 2001:129; Hoffmann 2003a:12; Hoffmann 2003b:85, 89).

Ship: *Mary Rose*

Value: The ship was raised in order to allow the public to see it and to allow for a full record of the ship including the bottom. It is the only 16th century ship to be excavated and recovered for display. It was the largest wooden structure recovered since the *Vasa*. "The hull was revolutionary in its design, one of the earliest carvel constructed warships, and the first known ship to carry gunports." (Jones 2003:1) Costs included the

construction of a lifting cradle in addition to those most common to recovery projects (Jones 2003:1-6; Marsden 2003:44, 51; Mary Rose Trust 2010:1).

Ship: *Vasa*

Value: It was a well-known ship. The locals have always known it was there, and the sinking itself was a spectacular accident caused by a miscalculation in structural design. It is a highly ornate representative of a ship type that was not well documented. It was brand new when it sank and was in extremely good condition due to the environment in which it rested. Costs included a complex lifting procedure utilizing barges in addition to those most common to recovery projects (Barkman 1965:4, 7, 18; Franzen 1972:78; Hocker 2006:20).

Discussion

Of all topics mentioned in this thesis, value is perhaps the most complex. More and more sites are being found and the resources for excavating every site are not available, nor is excavating every site necessary. Since the UNESCO convention of 2001, the preferred method of preservation is to leave the object in place, or *in situ* preservation, if possible (Ransley 2007:222-223). One argument against *in situ* preservation is that it will be years before it becomes apparent whether this method is effective. *In situ* preservation also does not allow for access to the site for academic research (Ransley 2007:223). In order to justify the recovery of a vessel, a strong case must be made that is comprised of many factors which may lead to the conclusion that one site is a more suitable candidate for excavation and recovery than another (Manders 2008:32). Within the limited resources available to recover and conserve a ship, how does one determine which sites are more suitable for recovery? By determining the value of a project, an informed decision may be made.

Value

Assessment of value can be paradoxical. Ideally, all of the information used to assess value should be determined before disturbing a site; however, in some cases it is nearly impossible to make an assessment without disturbing a site in order to view it. For example, determining whether a ship is nearly complete or if the type is rare can only be determined if the ship is uncovered, which requires initial funding and disturbs the site. Disturbing the site can cause an increase in the deterioration rate. The significance of the vessel; whether the site is in danger of being disturbed/destroyed; and the costs associated with the project can all be used to determine its value.

Significance

As mentioned above, a significant site/vessel is one which meets at least one of the four criteria put forth for the purposes of the National Register of Historic Places. This significance can be determined by several different factors that can be described as either scientific or public interest. For the information to be important one must examine the information that already exists in the record. If the information is incomplete, or only available in limited quantities, it is more likely that that information will be deemed important (Butler 1987:820-821; Delgado 1987:35). The definition of importance overlaps with scientific interest.

Scientific interest includes any aspect that is related to information the vessel may add to the archaeological record. Factors that make the vessel interesting scientifically can include: the age, rarity, condition, and completeness. The Bremen cog, for example, dates to circa 1380 AD and is fairly complete. Before the Bremen cog was found, there was no example of the cog type. The only knowledge of the type was found on traders' seals (Ellmers 1985:62). Examples like

the cog can yield enormous insights on the past. The more complete and the better the condition of a find, the more information it can provide to the record. This is also why the age of the vessel is important. The older the find, the less likely that another will be found. They can answer questions about construction techniques, trade, and the proliferation of technology among others.

Public interest is generally tied to the history of a vessel, like the *Vasa*, for example. The location had always been known by the local residents. The ship was lost in full view of the public due to a miscalculation in the design in 1611 (Hocker 2006a:38-39, 44, 46, 53). Public interest can also have to do with sensationalism surrounding the object. The recovery of an artifact such as a ship can generate a large amount of excitement in the community, particularly in smaller towns where an event such as a recovery effort may be highly unusual. It may take the form of spectators witnessing the process, donations to the cause, or in some cases, in a more negative aspect, looting and protesting. Examples include: 1) when the C.S.S. *Neuse* was found in 1961. The public became extremely interested in the process often standing on the banks to watch the recovery and volunteering to assist (Bright et al. 1981:20-21); 2) when the *Mary Rose* was raised the shore was lined with spectators (Rule 1982:227).

Sites in Danger

Another factor that is included in determining value is immediate danger to the site. Dangers can be either man-made or natural. If the site is in an area that is being developed, like the Bremen cog, it may be prudent to recover as much of the find as possible before it is destroyed (Crumlin-Pedersen 2000:231-232; Ransley 2007:224). Sites in tidal areas may be

subjected to mechanical breakdown and are difficult to protect or the cost of the protection *in situ* may be more prohibitive than removing the vessel (Ransley 2007:223).

Associated Costs

Part of the initial question of value is assessing the cost of the project. Several factors are taken into account when assessing the projects' cost. A preliminary plan for the project must be posited in order to know what will constitute the many components of the budget. The assessment must include not only estimated excavation costs and vessel recovery, but also possible conservation costs. In addition, costs associated with personnel, storage spaces, long-term housing of the object, possibilities for future display or research projects, and inflation of costs over time are all components that can be estimated for the overall long-term costs of a project. While the reality of the project may be quite different than the original planning, the assessment of cost at the outset of the project is necessary not only as part of the value assessment, but also in order to begin exploring funding options. Understandably, many of these aspects can only be estimated until more information about the condition of the ship can be determined.

Conclusion

A major concern is whether a particular ship's value makes it worth the cost and effort of recovering and conserving it. This assessment is important because of the limited amount of personnel, funding, and space available for this purpose (van der Heide 1972:162). Once an initial assessment is completed, it may be determined that there are simply not enough positive factors to support the justification of recovering a particular ship to the detriment of a more

suitable candidate. The ship may be too damaged or may not have enough historical significance to justify the time, effort, and cost of recovery and conservation. As part of the assessment estimation of the cost of recovery and conservation should be made. If the decision is made in favor of ship recovery, there are several factors that must be taken into account. These factors are discussed in the following chapters.

CHAPTER THREE:

DEALING WITH WATER ON SITE

Introduction

Curiosity led man to search not only on land but also underwater for evidence of the past. Humans have been exploring underwater since at least fifth century BC when Greek free-divers were used to recover goods from shipwrecks (Goggin 1960:348). There is a story told by Herodotus of a diver named Scyllias who reportedly swam ten miles underwater without surfacing and was the best diver of his day.

As technology progressed, different methods of working underwater came about. One method included the diving bell. Several models of diving bells were created. The earliest documented example was created by Guglielmo de Lorena, in the 16th century. This bell was a watertight, open-bottomed container lowered into the water over the area to be worked, creating an air bubble that allowed the diver to enter the bell for air rather than going to the surface (Goggin 1960:348; Parker 1997:5). Diving bells were limited because air compresses with depth, eventually allowing the bell to fill with water. This problem was later solved later by pumping fresh air into the bell and forcing the water out. Ultimately, this allowed limited underwater areas to be worked dry with only the strength of the air pump limiting the depth (Joiner 2001:1-2, 2-1).

Limitations of diving bells led to inventing other various apparatus that allowed the diver to breathe underwater, eventually leading to helmet diving suits in the mid-1800s. The helmet suits had air hoses that provided surface supplied air. The suits allowed a diver more freedom of

movement than the bell, but they were still extremely awkward and cumbersome (Parker 1997:6-7).

In 1942, Emile Gagnan and Jacques-Yves Cousteau created the aqualung, which combined a metal compressed air tank with a mouthpiece that had a diaphragm to regulate the air. The system allowed divers to go deeper for a longer period with substantial freedom of movement. The aqualung also required less rigorous training than helmet diving gear, making it more popular and allowing underwater work to be more practical (Bass 1966:25).

As with terrestrial archaeology, it took years for interest in underwater sites to coalesce into a scientific discipline. Underwater archaeology is relatively new. It began with archaeologists supervising helmet divers from the surface before the invent of the aqualung in the 1940s (Muckelroy 1980:7; Green 2004:5). When the aqualung became available, archaeologists began learning to dive and were able to perform systematic excavations themselves, using already established terrestrial techniques with a few minor modifications (Green 2004:2, 5). Many underwater archaeology techniques were created by George Bass in the 1960s (Bass 1966; Renfrew and Bahn 2000:331).

To record and recover a waterlogged ship, the presence of water has to be taken into consideration when planning the excavation and recovery (van der Heide 1972:162). The presence of water on site is a major factor when determining specifics of the project, such as: 1) how the site is going to be worked, 2) the type of equipment that is needed, 3) the type of personnel who are needed, and 4) the amount of funding that will be necessary.

American Projects:

The projects were excavated between 1935 and 2000. All of the sites were submerged. *Philadelphia* was the deepest at sixty feet. The C.S.S. *Neuse* was shallowest at less than ten feet, with periodic exposure due to seasonal weather. The *Philadelphia* was found in a lake, and U.S.S. *Cairo* and C.S.S. *Neuse* were found in rivers, all fresh water. *La Belle* and *H.L. Hunley* were found in salt water.

Ship: *La Belle*

Excavated: 1995

Depth: 12 feet

Water Removed? : Yes

Method: Cofferdam, constructed of two walls of sheet piling with a thirty-three foot gap which was filled with sand. The cofferdam extended five feet above the surface of the water.

The inner space was 82x53 feet and had a steel cover for shelter. (see figure 15)

Reason given for method choice: Limit the number of small artifacts that would be lost during excavation in the murky waters of Matagorda Bay (Bruseth and Turner 2005:32, 40, 47-48, 51).

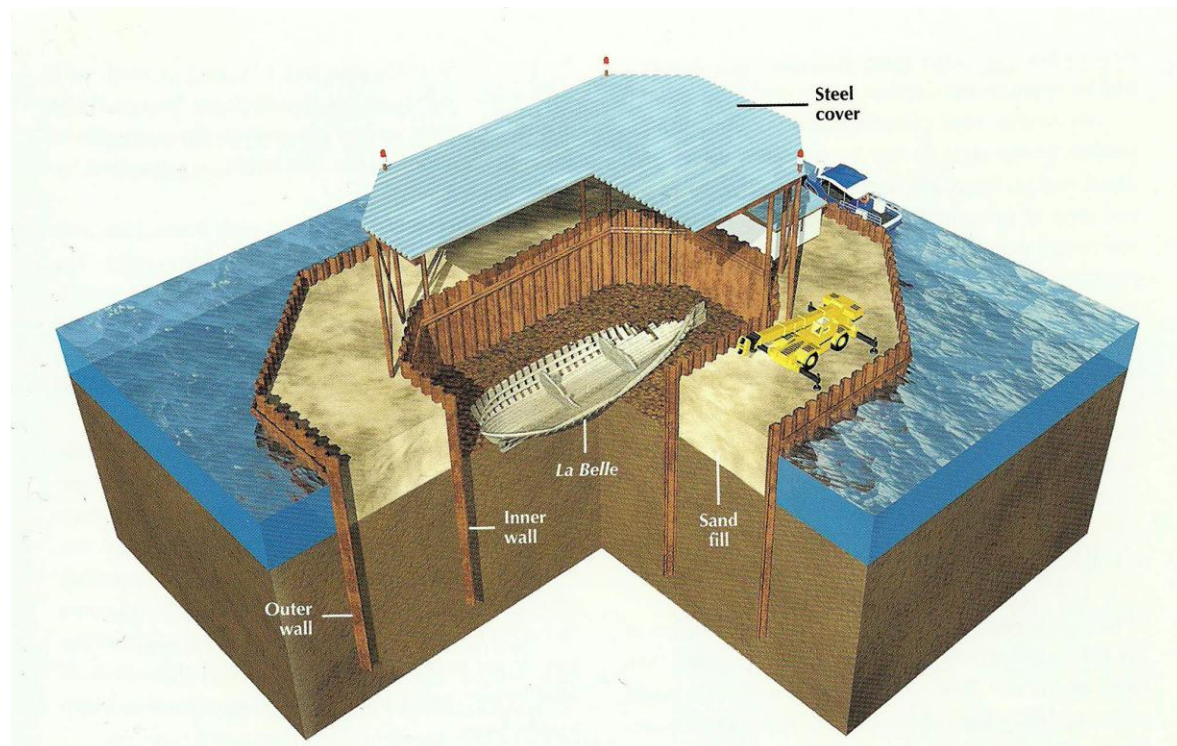


Figure 15: Cut away drawing of *La Belle* cofferdam (Bruseth and Turner 2005:53)

Ship: *Philadelphia*

Excavated: 1935

Depth: 60 feet

Water Removed? : No

Method: Helmet divers

Reason given for method choice: None, but there was no other reliable technology at the time.

This operation was not an archaeological project. There was no site recording done (Hagglund 1936:666; Hoffman 1984:55; Bratten 2002:74, 85).

Ship: U.S.S. *Cairo*

Excavated: 1959-1964

Depth: 36 feet

Water Removed? : No

Method: Scuba divers

Reason given for method choice: Scuba allowed for greater freedom of movement on the site.

This operation was not an archaeological project. There was no site recording done. (Bearss 1980:104, 106; Quarstein 2006:144, 257).

Ship: *H.L. Hunley*

Excavated: 1995-2000 (the ship was exposed, isolated, studied, and then recovered)

Depth: 30 feet

Water Removed? : No

Method: Scuba divers

Reason given for method choice: None. It seems that, in the beginning, scuba would be the least invasive. Cussler's team found the site and did a preliminary excavation in secret to determine if the wreck was indeed *Hunley* (Bak 1999:144; Chaffin 2008:216; Hicks and Kropf 2002:139-189).

Ship: C.S.S. *Neuse*

Excavated: 1961-1963

Depth: 3.17 feet (seasonal low)

Water Removed? : Lowered to accommodate work when possible, though cofferdam failed during excavation

Method: Cofferdam, made from sand removed from wreck

Reason given for method choice: To create more working space for excavators and to control the water on site. This was not an archaeological operation. There was no site recording done (Bright et al. 1981:19-20, 26).

European Projects:

The projects were excavated between 1921 and 1982. Four of the sites were found underwater, with the Hjortspring being found in a peat bog. *Vasa* was by far the deepest at ninety-eight feet. Both Skuldelev and the Cog were partially exposed at the surface of the water.

The Hjortspring and Bremen Cog were found in areas of fresh water, while the others were located in salt water.

Ship: Hjortspring

Excavated: 1921-1922

Depth: Located in a peat bog, an area of wet, spongy soil/soupy mud

Water Removed? : Yes

Method: Water pumps

Reason given for method choice: To allow for a more detailed and precise excavation (Rieck 2003:13-18).

Ship: Skuldelev I, II, III, V, VI

Excavated: 1957-1962

Depth: 0-10 Feet (parts of barrier could be seen at low tide)

Water Removed? : Yes, after initial investigation

Method: Scuba divers and cofferdam

Reason given for method choice: Began excavation using scuba as an experiment in underwater methods. When the objective of the excavation changed to recovery of the ships, a cofferdam was installed to perform the remainder of the excavation dry in order to have a more controlled excavation (Olsen and Crumlin-Pedersen 2002:23-27, 74).

Ship: Bremen Cog

Excavated: 1962

Depth: +5-15.5 feet (parts of ship were exposed above the waterline)

Water Removed? : Yes, half way through

Method: Helmet divers and diving bell

Reason given for method choice: Switched from divers to diving bell to limit loss of material due to murky river conditions (Fliendner 1985:8; Hoffman 2001:129; Pohl-Weber 1985:15-17; Unger 1997:72).

Ship: *Mary Rose*

Excavated: 1971-1982

Depth: 39 feet

Water Removed? : No

Method: Scuba divers and surface supplied air

Reason given for method choice: None. The ship was completely buried and had to be partially excavated to determine that it was indeed *Mary Rose*. The ship was extremely fragile with very little transverse strength. Even if it were possible to drain the water from the site, the ship may very well have collapsed under its own weight (Marsden 2003:30-31, 33-36, 38, 51, 57).

Ship: *Vasa*

Excavated: 1956-1961

Depth: 98 feet

Water Removed? : No

Method: Primarily helmet divers

Reason given for method choice: The ship's depth limited the amount of air a scuba diver could carry and did not allow enough bottom time when compared to surface supplied air used in helmet diving (Franzen 1972: 77; Cederlund 2006b:208-209; Cederlund and Hocker 2006a:218, 290; Hocker 2006a:62).

Discussion

Below is a summary of the relevant data from the case studies, followed by a discussion of information relating to the issue presented in the chapter.

Data:

| Ships | Excavation | | | Method | | | | Greater than 20 ft | Less than 20 ft |
|----------------|------------|-----|-------------------|-----------|---------------|--------------|----------------------|--------------------|-----------------|
| | Dry | Wet | Changed Technique | Cofferdam | Helmet Divers | Scuba Divers | Other | Greater than 20 ft | Less than 20 ft |
| LaBelle | X | | | X | | | | | X |
| Philadelphia | | X | | | X | | | X | |
| U.S.S. Cairo | | X | | | | X | | | X |
| H.L. Hunley | | X | | | | X | | X | |
| C.S.S. Neuse | X | | | X | | | | | X |
| Hjortspring | X | | | | | | water pumps | | X |
| Skuldelev I-VI | | | X | X | | X | | | X |
| Bremen Cog | | | X | | X | | diving bell | | X |
| Mary Rose | | X | | | | X | surface supplied air | X | |
| Vasa | | X | | | X | | | X | |

Table 2: Overview of Chapter 3 ship data

Although all projects discussed in this thesis were wet sites (i.e. sites that were submerged at one point and were waterlogged when found) not all were treated as wet sites during excavation and recovery (see Table 1). Of the ten sites, five were treated as underwater excavations using divers for the entire project (either helmet or scuba). On two sites, water was drained to conduct dry excavation for the entire project. Three were switched from wet to dry excavation in the middle of the project, either by choice or because of cofferdam failure. One used a diving bell to pump water away from limited sections of the site, but did not allow the entire site to dry.

All sites that were drained were in less than twenty feet of water. Sites that were not drained were in more than twenty feet of water. Three of the four excavations conducted as dry excavations used cofferdams to block water from the site. The other site used water pumps to drain the water.

Why choose to remove water from the site?

A quote In George Bass' *Archaeology under Water*, succinctly lists many reasons why the decision may be made to remove water from a site.

The archaeologist has adapted himself to every kind of environment offered on our planet's surface, but none is so alien as that which he meets beneath the surface of its waters. The density of the water makes even a mild current more devastating than most winds he faces in open air; in a racing stream the diver must hold to firm objects to avoid being swept away completely. A muddy river offers a darkness that can be pierced by

no flashlight. And, worst of all, the diver if he is to breathe, must carry his own supply of air. (1966:23)

The very nature of a wet excavation will make recording and removal of artifacts more difficult. During *La Belle*'s excavation, it was thought that the cofferdam allowed collection of extremely fragile artifacts that would not have survived a submerged site excavation due to the methods used (Bruseth and Turner 2005:63). An example of this would be a common piece of equipment used on sites during an underwater excavation called an induction dredge. A tube has air blown into it from the bottom toward the water's surface creating suction which removes sand, mud, and other debris from the site. It is not unusual for small artifacts to be accidentally pulled up through the tube, particularly in low visibility. Often a screen is placed at the outflow to catch debris and sift for artifacts (Peterson 1965:47). Extremely fragile artifacts can be damaged if the airlift is not carefully employed (Green 2004:255).

Depth:

Looking at the ten case studies, a key factor seems to be water depth, although this does not necessarily dictate whether a site can be drained. A common device used to allow water to be removed from the site is a cofferdam. A cofferdam is a temporary structure built from the bed of the sea floor to above the surface of the water. Water is then pumped out of this nearly watertight area, allowing the site to be worked dry. Cofferdams are only fiscally practical in depths less than approximately twenty feet because of the water's weight. In depths greater than twenty feet, the thickness and sophistication of the walls needed to withstand the weight raise the cost exponentially (Broadwater 1997:104).

When using a cofferdam, a great deal of thought is put into design and construction. Size and height of the structure and the weight and dynamics of the water surrounding the cofferdam determine how the cofferdam should be built. In addition to this, the site itself must be studied before designing a cofferdam. Understanding soil types under the site is crucial. If not taken into consideration, they may cause problems during the excavation, from leaking to a catastrophic failure of the cofferdam (Gerwick 1996:1). During excavation of C.S.S. *Neuse*, that is exactly what happened. The sand cofferdam, which was not planned by experts, first leaked badly and then collapsed, flooding the site (Bright et al. 1981:23). Cofferdams are an option that can be used to work a wet site as a dry site if that is the method that is chosen. Depth of the site may or may not be a limiting factor depending on the type of equipment used.

Ship Condition:

Water depth is not the only factor taken into consideration when deciding to remove water from the site. Ship condition is an important factor. In the aforementioned case studies, if the ship is highly fragmentary or fragile, it was more likely that the site was excavated dry. Ship condition also relates to water depth. The shallower the site, the more fragmentary the ship tends to be due to mechanical breakdown of the material caused by the pummeling action of waves. Wave action can also disrupt marine growth which protects some artifacts, although the increase of oxygen caused by this can sometimes encourage marine growth. It can also damage any protective films the artifact has acquired (Gratten 1987:74). Temperature fluctuation can also cause the material to breakdown due to changes in the size of materials, similar to freeze-thaw action causing the breakdown of concrete in northern climates. A ship that is located in any climate that drops below freezing may undergo this breakdown as is the case with most of the

case studies listed above, with the possible exceptions of U.S.S. *Cairo* and *H.L. Hunley*. Highly fragmentary finds generally require stabilization before moving. Obtaining materials to do this and manipulating these materials underwater can sometimes be difficult.

Environmental Conditions:

Another factor which must be considered is water condition. High silt content leads to limited visibility. The fear is that small artifacts will be lost in black water conditions, as was the case with the Bremen cog (Pohl-Weber 1985:17). The loss of small artifacts, or the inaccurate recording of a site, may cause errors in the data making some of it worthless and skewing the information. With the Hjortspring boat, the boggy nature of the site made water removal preferable. The boat was highly fragmented; excavation and removal of all the pieces would have been nearly impossible in the soupy mud (Rieck 2003:14).

Strong water current is another factor that may influence the decision. Strong currents make accurate recording by hand difficult. In addition to any issues that have to be solved on a dry site, the liquid medium makes underwater work more complex (Peterson 1965:39). While wind and rain are problems that can be compensated for on land, any diver who has experienced tidal surge can report there is little that can be done to compensate for water movement. Current can also greatly complicate recovery, making it dangerous for both the artifact and personnel.

It is possible to reduce error using a photogrammetry program to calculate distances with photographs (Green 2002:289). In photogrammetry, photographs including a scale are used to calculate distances between objects with minimal measurements. Photogrammetry has been used since the mid-1800s (Torlegård 1980:2). The calculations involved made this process time consuming until computer programs were developed that could perform calculations

automatically making it a fast and accurate method for measuring irregularly shaped objects (Ogleby and Rivett 1985:v-1). On an underwater site where there may be time constraints and irregularly shaped objects, this method can be highly efficient, but it is only effective with clear photographs and relatively good visibility. One common photogrammetry program is PhotoModeler. The program is readily available online and costs \$1145. There is also an upgrade available for \$445 (Eos Systems 2011).

Use of Underwater Techniques:

Another factor that influences whether water was removed from a site is a reluctance to use underwater techniques, particularly in earlier excavations. Bias towards dry excavation, implying that it is more accurate and can be more thorough than wet excavation, is present in several projects. The bias is most evident at Skuldelev. Once the barrier was deemed to be of great historical significance, excavators switched from wet to dry techniques. They had originally been experimenting with wet excavation as there were no established methods in use at the time (Olsen and Crumlin-Pedersen 2002:27). There were several authors who wrote about the uselessness of underwater archaeology or its lack of discipline early on (Goggin 1960; Leigh 1973; McKee 1973; Ruppé 1988). The opinion was not explicitly discussed in most cases; rather it is implied in the earlier projects. More recent projects do not seem to show this bias as strongly. This seems appropriate because earlier projects were performed when underwater archaeology was still in its infancy. As the discipline grew and the techniques became more established and more scientific, this opinion changed.

Why choose not to remove the water?

Even though most wet sites have less than ideal conditions, it is not always deemed appropriate to remove the water. There may be prohibiting factors that make it undesirable to remove the water. As discussed above, depth is a major consideration. The site may be too deep for methods other than scuba to be used effectively. Also mentioned above, the ship's condition also plays a role. If the find is fragile, it may not be able to support its own weight if the water were to be suddenly removed. In addition, there are several other factors that may influence the decision to not remove the water from the site.

Removing water from a site can be expensive. In the case of *La Belle*, for example, the cofferdam cost more than \$4,000,000. The expense of the cofferdam, especially when added to the cost of powering the bilge pumps to keep the water out, increased the budget dramatically (Bruseth and Turner 2005:51, 57). When funding is limited, this option may not be possible. The cost of lifting an intact vessel may be large, making it important to 'cut corners' wherever possible. In this case, divers using scuba may be a less expensive alternative to working an artificially dry site.

Another reason to not remove the water is availability of equipment. If it is not possible to acquire appropriate equipment, or find a company to loan or built the apparatus, then the decision suddenly becomes moot. If the equipment is available, time constraints may play a role. As with the Bremen cog, using a diving bell was dictated by weather conditions. The area iced up in the winter and the bell could only be moved into place during a limited time window (Pohl-Weber 1985:18).

Other factors may cause time constraints on a project. The longer a project continues the more it costs. This is certainly true if water is removed from the site and there are arrangements

made to keep the ship wet while it is exposed, which in and of itself is another time constraint because while the ship is exposed to oxygen, the deterioration rate will be elevated. If waiting for equipment, a cofferdam to be designed and built, or the right season, costs continue to compound, as will the chances that damage will be done to the ship(s), which is the main concern.

Another reason to not remove the water is that it is simply easier to use divers to perform an excavation and recovery than it is to design and build a cofferdam or find other equipment or water pumps to remove water. Scuba technology is now a staple in underwater archaeology. This has been true since the equipment first became available to the general public, after the cost dropped. In most project accounts where divers were used, it was the only option mentioned as part of the planning, as if others were not even considered.

The use of a diving bell is one application that increases the efficiency of diving. As discussed above, diving bells are only limited by the strength of the air pressure pump used to force water out (Broadwater 1997:104). Boyle's Law states that "for any gas at constant temperature, the volume of the gas will vary inversely with the pressure" (Joiner 2001:2-9). As the bell descends, the air bubble inside the bell will decrease in size as the water pressure increases. If no air is supplied or lost from the bell, then the air pocket will eventually become too small to be practical for the diver to utilize. Using an air pressure pump, the size of the intended air pocket can be maintained and the air can be replenished (Joiner 2001:1-2).

Conclusion

The decision to excavate a waterlogged site wet or dry is based on many different factors. The depth of the site, availability of equipment, and the ship's condition are just a few of many

factors. Not only are the readily observable factors important to the decision, but the effect on several other considerations that are relevant later on in the project, such as: the need to keep the ship wet while being excavated and the method of removal from the site which will be discussed further. All of these factors make the decision whether to remove the water from the site a difficult one that will affect many other areas of the project.

CHAPTER FOUR: KEEPING THE SHIP WET

Introduction

Submerged wood can survive in sound condition for hundreds of years once it achieves a state of equilibrium within its environment (Florian 1987:5). Once waterlogged wood begins to dry, deterioration increases rapidly due to changes in the environment around the wood. When waterlogged wood is dried, the cells collapse due to stresses caused by the surface tension of water placed on the weakened structure of the wood. Cell walls distort causing irreversible damage to the wood structure. Because of this, waterlogged wood generally tolerates very little, if any, drying without first undergoing conservation. Micro-organisms can also infest the wood causing a loss in cellulose, making collapse and shrinkage even more pronounced (Gratten 1987:55-56, 59, 61-62, 65; Kaye et al. 2000:233-234).

Submerged metals can endure for long periods of time depending on conditions. Metal corrosion is based on many factors and can be highly unpredictable. As with wood, metal will reach equilibrium within its environment, and any disturbance (i.e. excavation or salvage attempts) that alters conditions will complicate the corrosion process and may increase corrosion rates (North and MacLeod 1987:68).

As soon as metal comes into contact with oxygenated water, especially seawater, the chemical process of corrosion begins. The transfer of electrons causes metal ions to migrate out of the artifact weakening the metal. Factors that affect corrosion include salinity, temperature, marine growth, and even the spatial relationship between two metal artifacts. Marine growth and the formation of a patina, an oxidized coating, caused by the migration of ions, may actually

protect the artifact and slow corrosion (North and MacLeod 1987:68-70, 76). The processes of the deterioration of wood and iron will be discussed in further detail in Chapter Eight.

Steps must be taken to prevent recovered artifacts from drying out before proper conservation can take place (van der Heide 1972:163). Prevention should start as soon as the object is removed from the water and continue throughout storage until conservation begins. Once dried out, the effectiveness of conservation may be greatly diminished even if the object is re-wet. Preventing ship materials from drying out is a huge factor in the successful conservation of a ship. Distortion of materials renders the information gleaned from them unusable.

American Projects:

Below is information from the American case studies. The information includes when the ship was exposed, if the ship was kept wet, and how it was kept wet.

Ship: *La Belle*

Ship exposed to air: 1997

Kept hydrated? : Yes

Hydration Method: Hand sprayers attached to high pressure water pumps and covered exposed parts of wreck, kept in plastic lined wooden vats with bay water until conservation could take place (Bruseth and Turner 2005:56, 62-63).

Ship: *Philadelphia*

Ship exposed to air: 1935

Kept Hydrated? : No

Hydration Method: None (Hagglund 1949:19; Bratten 2002:83)

Ship: U.S.S. *Cairo*

Ship exposed to air: 1959 (first time)

Kept Hydrated? : Only periodically wet down, allowed to dry out between hydration.

Hydration Method: periodic river rise. After recovery, a system of hoses was placed throughout the ship and periodically rewet (Bearss 1980:106; Joyner 2006:12).

Ship: *H.L. Hunley*

Ship exposed to air: 2000

Kept Hydrated? : Yes.

Hydration Method: Stored in a water tank at Warren Lasch Conservation Center unless active

excavation is being performed. Currently still being stored awaiting conservation (Chaffin 2008:210; Friends of the Hunley 2010; Hicks and Kropf 2003:195-207).

Ship: C.S.S. *Neuse*

Ship exposed to air: 1961 (first time)

Kept Hydrated? : Only periodically wet by river, allowed to dry out between hydration

Hydration Method: Seasonal rising and falling of the water, once removed to the river bank the ship was left to dry (Bright et al. 1981:26).

European Projects:

Below is information from the European case studies. The information includes when the ship was exposed, if the ship was kept wet, and how it was kept wet.

Ship: Hjortspring

Ship exposed to air: 1921

Kept Hydrated? : Yes

Hydration Method: Each timber was wrapped with moist peat and were kept wet until conservation could take place (Bojesen-Koefoed and Stief 2003:38; Rieck 2003:13, 20).

Ship: Skuldelev I, II, III, V, VI

Ship exposed to air: 1959

Kept Hydrated? : Yes

Hydration Method: A sprinkler system was set up during excavation, for transport timbers were packed into airtight plastic bags. Once reaching the conservation lab, the timber was placed into large water tanks until conservation could take place (Olsen and Crumlin-Pedersen 2002: 33-34, 39).

Ship: Bremen Cog

Ship exposed to air: 1962

Kept Hydrated? : Yes

Hydration Method: Timbers were wrapped in plastic after being recorded and stored in a water filled boat. Once reaching the storage area, the timber was placed in vats filled with a 1% Fluralsil solution, which is used as a fungicide, until conservation could take place (Fliendner 1985:8; Pohl-Weber 1985:21; Unger et al. 2001:178-179).

Ship: *Mary Rose*

Ship exposed to air: 1982

Kept Hydrated? : Yes

Hydration Method: While awaiting construction of the ship hall, temporary sprayers were used to

keep the ship hydrated on the barge. Once moved into the ship hall, it was kept wet with an automated system that sprayed cold water on the ship during non-working hours until conservation began (Jones 2003:41; Marsden 2003:57-58).

Ship: *Vasa*

Ship exposed to air: 1961

Kept Hydrated? : Yes

Hydration Method: Kept wet with an automated spraying system during the excavation of the interior and until the conservation began (Cederlund and Hocker 2006b:299-300).

Discussion

Below is a summary of the relevant data from the case studies, followed by a discussion of information relating to the issue presented in the chapter.

Data:

| Ships | Kept Wet | | Method |
|----------------|--------------|----|---|
| | Yes | No | |
| LaBelle | X | | by hand and immersion in tanks |
| Philadelphia | | X | none |
| U.S.S. Cairo | intermittent | | periodically, hose system |
| H.L. Hunley | X | | total immersion in tank |
| C.S.S. Neuse | | X | none |
| Hjortspring | X | | wrapped in peat bundles, wet by hand |
| Skuldelev I-VI | X | | sprinkler system and immersion in tanks |
| Bremen Cog | X | | immersion in tanks |
| Mary Rose | X | | hand sprayed and automated sprinkler system |
| Vasa | X | | automated sprinkler system |

Table 3: Overview of chapter 4 ship data

Of the ten projects, *C.S.S. Neuse* and *Philadelphia* were the only two for which there was no intervention to keep the ships wet before conservation (Bright et al. 1981:26; Bratten 2002:83). *U.S.S. Cairo* was periodically wet down and then allowed to dry (Joyner 2006:12). In all the other projects, great care was taken to keep the ships wet during recovery and storage until

conservation could take place. This was done by spraying or total immersion in water tanks (Pohl-Weber 1985:21; Olsen and Crumlin-Pedersen 2002:33-34, 39; Jones 2003:41; Rieck 2003:20; Bruseth and Turner 2005:63; Cederlund and Hocker 2006b:300; Friends of the Hunley 2010).

Deterioration Done by Drying

As mentioned above, drying of a waterlogged artifact before conservation can cause an incredible amount of damage (this process will be discussed in depth in Chapter Seven). This is particularly true of uncontrolled drying, as was the case with C.S.S. *Neuse* and, to a lesser extent, *Philadelphia*. One reason that *Philadelphia* was not damaged as severely from drying out as *Neuse* was that the ship showed little evidence of deterioration when it was found. *Philadelphia* was recovered from colder, deeper water than *Neuse*, and those conditions preserved the ship (Hagglund 1949:27). The colder the water, the slower the rate of deterioration, due to the lower percentage of oxygen that the water can carry. The lower oxygen levels slow corrosion and inhibits biotic growth (Florian 1987:4-7).

After recovery, deterioration of U.S.S. *Cairo* was more severe than it could have been. While there was some effort to keep the ship wet while at Ingalls Shipyard, wetting occurred infrequently. The cycle of wetting and drying actually did more damage to the ship than if it had been left to dry, because the stress of drying was repeated, which further damaged the wood (Kaye et al. 2000: 234; Joyner 2006:12). The extent of damage sustained during storage of the ship was partially responsible for the U.S.S. *Cairo* generally being considered by the professional community to be an example of what not to do (Delgado 1997:82). An example of the damage caused by the wetting and drying cycle can be seen in figures 16 and 17 below. The

first photograph was taken shortly after *Cairo* arrived at Ingalls Shipyard. The second was taken in October 2009 at Vicksburg Military Park. The missing wood from the rudder and stern of the ship was too degraded to integrate into the reconstruction.



Figure 16: U.S.S. *Cairo* at Ingalls, port side rudder (photo courtesy of National Park Service, Vicksburg, Mississippi)



Figure 17: U.S.S. *Cairo* at Vicksburg, port side rudder (photo taken by Melissa Ashmore)³

³ Repair work can be seen in the Vicksburg photograph. Missing wood in the rudder was replaced for aesthetic purposes.

Some projects, like the Hjortspring vessel, demonstrated the negative effect of uncontrolled drying of waterlogged artifacts was known to the European professional community by the 1920s; however, the general public may have had no notion of the damage drying could produce. As *Philadelphia*, *Cairo*, and *Neuse* were initially undertaken by amateurs, not professionals⁴, little thought may have been given to the long term effects that drying might have, particularly if there was no plan for long term conservation. In addition to this, the initial purpose of raising the vessel may have greatly influenced how the ship was treated. Coupled with delays in recovery, particularly in the case of C.S.S. *Neuse*, the conditions mentioned above allowed drying to take place.

The benefit of having kept the wood wet is evident when examining the present condition of the ships. For example, C.S.S. *Neuse* has less than a third of its wood remaining, compared to the amount at the time of the recovery. Loss of wood was due to a variety of factors including looting of the hull, washing away of loose material due to water level changes during excavation, and periodic wetting and drying of timbers which caused accelerated deterioration (Bright et al. 1981:21-26). Wood was also lost in the case of U.S.S. *Cairo*. As can be seen by comparing the photographs above, the amount of surviving wood is much less than what was delivered to Ingalls shipyard. As there is no mention of damage done during transport from Ingalls to Vicksburg, or during conservation, it can be inferred, like *Neuse*, sporadic wetting and drying of the wood caused much of it to be deteriorated to the extent that prohibited its use for re-assembly.

⁴ A discussion of what constitutes a professional versus an amateur is presented in Chapter 9.

Methods of Maintaining Moisture

While still on site, if water has not been drained, keeping the ship wet is not an issue, unless the site is only partially submerged. If the water is drained, sprinkler systems and hand spraying on a regular basis provide a basic means of keeping the ship wet. This can be done using a pump system utilizing water outside the site.

Once large intact vessels, like *Mary Rose* and *Vasa*, are removed from their sites, the only course for keeping them wet is a spraying system. Whether this is automated or done by hand, these systems are effective for keeping the ships wet if done on a regular basis. For smaller intact vessels, such as *H.L. Hunley*, and fragmented ships, water tanks for total immersion are better options. They are more effective and are easier to maintain. Wrapping fragmented pieces in wetted material and plastic makes them simple to transport and works well to keep the moisture in, provided the packages are soaked thoroughly; however, wrapping should only be used if storage is short term or for transportation due to the difficulty of maintaining the level of moisture (Pearson 1987:116).

Conclusion

Keeping the ship wet from the time it is exposed to air until conservation can begin is a vital component in the successful conservation of a ship. Methods of maintaining a moist environment are dependent upon several things. Once the ship begins to dry out, irreparable damage may be done. The damage may be minor, but in some cases can be extreme depending on many factors. The ship's original condition when recovered may also have an impact on how much damage it incurs. Other issues to address are how the ship is removed from the site

(discussed in Chapter Five) and how the ship will be transported to a conservation facility (discussed in Chapter Six).

CHAPTER FIVE:

REMOVING THE SHIPS FROM THE SITE

Introduction

For hundreds of years, ships have been recovered after sinking. Generally, first attempts are made shortly after sinking, though not always. During wars, there are accounts of ships being deliberately sunk to avoid capture by the enemy, but then recovered for use. Navies would often burn salvageable ships before they sank to make them unusable. One example is U.S.S. *Merrimack* which was scuttled, recovered, overhauled, and renamed C.S.S. *Virginia*. Recovering ships, rather than constructing them from scratch, was a way to quickly increase numbers of usable ships (Quarstein 2007:58, 72, 95).

Another reason to recover a ship is to obtain the cargo on board. By the 1st Century BC, there was an established salvage industry of free-divers in the Eastern Mediterranean (U.S. Navy 1998:343). Ship sites in more accessible locations or that had a richer cargo may have intermittent periods of investigation for hundreds of years after their wrecking. The simplest way to retrieve cargo was to use nets, grappling hooks, or to send a diver down to obtain it when possible (Muckelroy 1998:29). Before scuba was invented, it would have been a difficult and extremely dangerous task to enter a ship and retrieve cargo.

Recovery for archaeological study is another reason to remove a ship from its original context and is the topic of this thesis. Some ships listed in this thesis were among the earliest recovered as an archaeological investigation. Archaeological recovery necessitates as little damage as possible being done during the process to maximize information gleaned from it. When a ship is recovered for the purpose of getting to the cargo (i.e. early salvage and modern treasure hunting) damaging the ship is not much of a concern.

Once the ship has been excavated and the decision had been made to recover it, a determination must be made on how to physically remove it from the site (i.e. piece-by-piece or intact) (van der Heide 1972:162). Determining how to remove a ship is a complex issue. Several factors have to be taken into account including the find's condition, site location, and nature of the excavation (which were discussed in Chapters two and three).

American Projects:

Below is information from the American case studies including when the ship was recovered, how it was recovered, and the reason given for how it was recovered.

Ship: *La Belle*

Recovered: 1997

Method: The ship was dismantled and removed from the site piece by piece.

Reason given for method choice: The original plan called for a support structure with straps placed under the hull. But it was thought that the unstable sand under the ship would make it difficult to position supports. In addition, the ship was fairly fragile and timbers would not be able to support their own weight and would need reinforcement. A cradle that could support the timbers would cost too much (Bruseth and Turner 2005:59-62).

Ship: *Philadelphia*

Recovered: 1935

Method: Water jets were used to make holes under the ship and rope slings were placed under it. Using a floating derrick to raise the ship intact from the bottom it was towed to shallow water where the remaining water was pumped out.

Reason given for method choice: None (Bratten 2002:81, 85; Hagglund 1949:29).

Ship: U.S.S. *Cairo*

Recovered: 1964

Method: The ship was raised intact using lifting wires and a floating crane. It was placed on a sunken barge. The barge was pumped empty of water, which allowed it to float, bringing barge and ship to the surface.

Reason given for method choice: The ship was in excellent condition when found and it was determined that the hull could handle the stress of being moved intact. The pilot house was removed first. It was attached securely and may have moved the entire ship pulling it loose (Bearss 1980:107-108, 118, 123, 125, 127, 132, 134, 146; Joyner 2006:12).

Ship: *H.L. Hunley*

Recovered: 2000

Method: The submarine was secured to a steel cradle with straps threaded under the sub. The straps were custom made with bags, which were filled with polyurethane foam after placement to provide cushion and support. The entire cage was lifted onto a barge with a crane.

Reason given for method choice: The entire ship was lifted and removed to a controlled environment for internal excavation (Hicks and Kropf 2003:195-207, 212).

Ship: C.S.S. *Neuse*

Recovered: 1961-1963

Method: Several used due to complications. To raise the vessel, cables were run under the ship and metal drums were used to float it. House movers were hired to pull the ship out of the river.

Reason given for method choice: Location of the ship and weight of vessel (Bright et al. 1981:19, 23, 25-26).

European Projects:

Below is information from the European case studies including when the ship was recovered, how the ship was recovered, and the reason given for how it was recovered.

Ship: Hjortspring

Recovered: 1922

Method: The ship was recovered from the site in pieces, which were sandwiched between two pieces of treated cardboard and moist peat. The entire package was secured by wooden strips, tied together with cord, and sewed into a sack.

Reason given for method choice: The timbers were fragile and highly fragmentary. The pieces were packages for transport (Crumlin-Pedersen 2003a:24; Rieck 2003: 18, 20).

Ship: Skuldelev I, II, III, V, VI

Recovered: 1957-1962

Method: The ship was recovered from the site in pieces. For more fragile pieces, hard board was used like a stretcher which was wrapped in burlap and plastic.

Reason given for method choice: Due to the fragmentary and fragile nature of the timber, wrapping was decided on after first using a synthetic resin to coat the pieces. The resin took too long to apply and set and the material is hazardous. It also tended to soak into the pores of the wood and once hardened, was difficult to remove without damaging the wood (Olsen and Crumlin-Pedersen 2002:38-40).

Ship: Bremen Cog

Recovered: 1962-1965

Method: The ship was recovered from the site in pieces.

Reason given for method choice: The ship was mostly intact and the individual timbers were in excellent condition; however, the iron that held it together was badly degraded, making it highly unstable. Due to the condition it was determined that disassembling the ship would be a better choice than risk damaging the ship by attempting to remove it one piece (Hoffmann 2003a:14; Pohl-Weber 1985:15-19, 21).

Ship: *Mary Rose*

Recovered: 1982

Method: Divers tunneled under the hull and drilled through to attach a cushioned bolt assembly.

The bolt had eye hooks that were attached to adjustable wires. The wires were attached to a lifting frame positioned over the hull. It rested on four hydraulic legs, which when lengthened lifted the hull from the seabed. The entire frame and hull were lifted and moved to a cradle that was sitting on the seafloor a few meters away. The cradle had four docking ports for the legs of the frame and was lined with airbags that would conform to the hull. Once the frame and hull were in place, the entire package was lifted out of the water and onto a barge by a large crane.

Reason given for method choice: Several methods were considered but due to the ship's relatively fragile and complex nature they concluded recovery in a cradle would be the best option (Marsden 2003:51-52, 55-58).

Ship: *Vasa*

Recovered: 1961

Method: The first step was to dig tunnels under the ship to position lifting wires. There were two wires in each tunnel, which were attached to two pontoons at the surface. In each pair of wires, one was attached to the outer edge of the pontoon and one to the inner edge, which held the ship upright when it was moved. The pontoons were sunk to nearly twenty feet. The wires were tightened and the pontoons refloated to pull the ship from the bottom. A month after the tunnels were completed, the first lift was performed. The ship was lifted enough to clear the pit it was sitting in and moved to slightly deeper water where they turned the ship nearly one-hundred eighty degrees, so the bow faced Kastellholmen. The ship was towed a short distance and set down for the night. This cycle of lifting, moving, and setting down was repeated eighteen times in the next month, each time moving the ship closer to Kastellholmen and into shallower water. After the eighteenth lift, the deck was cleared of as much debris as possible, some of the sediment was removed in order to lighten the ship, and the ship was made as watertight as possible. This stage took a year and a half to complete (see figure 18). Once completed, the ship was again lifted, heavier slings were put into place, and the bottom of the ship was waterproofed. The ship was raised to the surface, the water was pumped out, and the ship floated on its keel. A week later the ship was placed into dry dock.

Reason given for method choice: The ship was in amazing condition when found. The oak was still solid enough that divers had a difficult time driving nails into it. It would be have been extremely difficult to disassemble it without causing damage to the wood (Cederlund 2006d:223, 231-264; 2006c:265-266, 276-290).

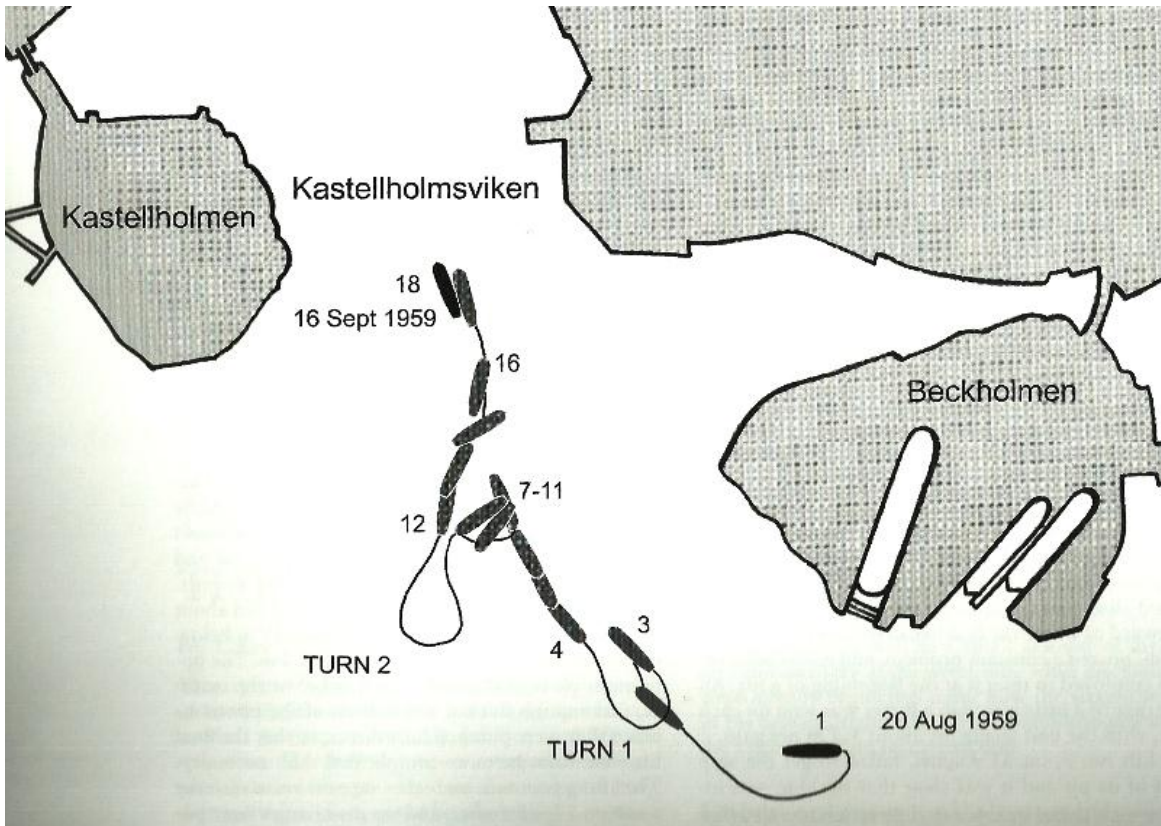


Figure 18: Progress of *Vasa* lifting and movement, number 1 is site location (Cederlund 2006d:263)

Discussion

Below is a summary of the relevant data from the case studies, followed by a discussion of information relating to the issue presented in the chapter.

Data:

| Ships | Method of Recovery | | | |
|----------------|--------------------|-----------------|------------------------|-----------------------------|
| | Piece-by-piece | Lifting Cradles | Cables/ropes one piece | Cables/ropes several pieces |
| LaBelle | X | | | |
| Philadelphia | | | X | |
| U.S.S. Cairo | | | | X |
| H.L. Hunley | | X | | |
| C.S.S. Neuse | | | X | |
| Hjortspring | X | | | |
| Skuldelev I-VI | X | | | |
| Bremen Cog | X | | | |
| Mary Rose | | X | | |
| Vasa | | | X | |

Table 4: Overview of Chapter 5 ship data

There were four methods used to recover the ships listed above. On four sites (*La Belle*; Hjortspring; Skuldelev I, II, III, V, VI; and the Bremen Cog) a piece-by-piece method was used (Pohl-Weber 1985:16; Olsen and Crumlin-Pedersen 2002:39; Crumlin-Pedersen 2003a:23-24; Bruseth 2005:55-56). The vessels' fragmentary nature made other methods impractical or completely impossible. Two ships (*H.L. Hunley* and *Mary Rose*) were placed in lifting cradles to provide support for fragile remains (Marsden 2003:55; Chaffin 2008:221). Three ships (*Philadelphia*, *C.S.S. Neuse*, and *Vasa*) were lifted as one piece using ropes or cables (Bright et al. 1981:23; Bratten 2002:5; Cederlund 2006d:218). The U.S.S. *Cairo* was cut into pieces and then lifted with cables (Bearss 1980:145).

Methods for Removal:

The few options for removing a ship from the site include: removing fragmented pieces or dismantling the ship and removing each timber piece-by-piece, lifting the entire ship as one

element, or dismantling ship parts and removing large stable sections intact. The ship's condition is the greatest factor when choosing a method.

Piece-By-Piece

If the ship is highly fragmented, it may not be possible to retrieve it any other way than piece-by-piece. Another reason to dismantle would be if the strength of the timbers was not sufficient to support the structure of the ship during the stress of recovery. Sometimes the timbers are in excellent condition, but the fasteners are either absent or degraded and are generally easily removed from the wood, as was the case for both *La Belle* and the Bremen Cog (Pohl-Weber 1985:16; Bruseth 2005:62). In both cases, vessel condition was taken into consideration as part of the reasoning for the decision of how the ship would be removed. It was considered preferable to remove them piece by piece in order to avoid problems with structural collapse.

Removal as One Piece

If the ship is mostly intact and is structurally sound, the decision may be made to remove it from the site as one element. This may not be easily done depending on the size and weight of the ship. For a ship the size of *Vasa* for example, logistics of lifting and moving can be difficult (Cederlund 2006c:290). A much smaller vessel, such as *Philadelphia*, would be easier to manipulate (Hagglund 1936:669). Weight may be even more of an obstacle than size. When *Cairo* was salvaged, the ship was accidentally severed because of stress put on the lifting wires due to weight. Only by cutting the ship in pieces was it finally able to be removed from the site (Bearss 1980:145).

When recovering a large, intact object, special equipment is often needed. This is certainly true when recovering an object such as a ship. There are several options for recovering underwater objects. Utilizing buoyancy through the use of air filled pontoons, airlift bags, and even empty metal drums offers a solution to lifting an object as far as the surface if the object is not too large or heavy. In good conditions, these methods are simple, but once conditions begin to deteriorate they become increasingly difficult and dangerous (Green 2004:255, 274). Other methods employ the use of lifting cranes or hoists to bring the object to the surface and to lift it out of the water.

Complications During Removal:

There are several complications that can occur during a vessel's removal from the site. If the wood is extremely fragile great care needs to be taken to reduce the damage. In the case of both the Hjortspring and Skuldelev, for example, the already fragmented pieces were accidentally broken into smaller pieces during removal (Olsen and Crumlin-Pedersen 2002:38-40; Crumlin-Pedersen 2003a:24; Rieck 2003:18, 20). Even if the wood is sound, the structural integrity of the vessel may not support its own weight. In the case of *La Belle*, the ship was disassembled due to poor integrity. Because the wood, especially the tree-nails, were in such good condition, the timbers frequently had to be pulled apart forcefully or the tree-nails sawed through (Bruseth and Turner 2005:59-62). When the *Philadelphia* was brought up, the sides of the ship had to be braced with logs to prevent the sides from collapsing (Hagglund 1949:29).

The biggest complication was under estimating the weight of vessels. For the C.S.S. *Neuse*, the gross underestimation caused serious issues during the recovery. After determining that the first house mover did not have the proper equipment to handle the weight, a different

mover had to be found. Even after the new mover was recruited, the recovery took several attempts because too few cables were used (Bright et al. 1981:19, 23, 25-26). Underestimating the weight was also an issue with the U.S.S. *Cairo*. The original cables used were much too thin for the weight of the vessel causing several failed attempts before thicker cables were employed (Bearss 1980:107)

Conclusion

Removing the ship from the site is carried out to conserve and display it, as well as to study it. Several factors go into choosing the method used including the vessel's condition, the vessel's weight and size, and the site location. Generally when an object is found, great care is taken to ensure that it is kept intact when it is removed from the site. When the object is large and composed of several components, like a ship, this cannot always be the case. Poor structural integrity of the object can cause difficulties in removal. These problems can include danger that the object may collapse due to its own weight, causing damage to itself, or injuring personnel. Once the ship is removed from the site, the next step is to transport it to the storage or conservation location. The method used to transport the ship may be influenced by how the ship was recovered, which will be discussed in the following chapter.

CHAPTER SIX:

TRANSPORTATING THE SHIP TO THE STORAGE/CONSERVATION LOCATION

Introduction

An archaeological investigation is composed of several phases. One phase may include removing artifacts from the site for study. The majority of archaeological sites are in remote locations, making it necessary to transport artifacts from the excavation to an offsite storage/conservation location (van der Heide 1972:164). Wet sites generally require artifacts to be transported even further as they are generally found underwater or in boggy areas, which tend to be more remote (Leskard 1987:117). Even if the site is not located in a remote area, the artifacts may need to be transported for other reasons (i.e. study, documentation, etc.). Location tends to limit the options available for transportation.

The same factors that influence the method used to recover a ship influence how a ship should be transported. The location of the site, size and weight of the ship or its component parts, the condition of the materials (i.e. fragility), and how the ship was removed from the site are factors that are used to choose a transportation method.

American Projects:

Below is information from the American case studies including when the ship was transported, how it was transported, and why it was transported by that method.

Ship: *La Belle*

Transported: Feb 1997-April 1997

Method: By boat and transported

Justification: The site is located fifteen miles from the project headquarters in Palacios, Texas, in the middle of Matagorda Bay. To facilitate transport, timbers were stored temporarily on the top of the cofferdam. Transport over water was necessary. From Palacios the timbers were transported by truck to the lab at Texas A & M in College Station (Bruseth 2005:56, 63).

Ship: *Philadelphia*

Transported: First in 1936-1941, as a travelling exhibit, again in 1961

Method: After the ship was recovered it was placed on a barge as a floating museum that travelled the Lake Champlain area for five years. In 1961, a wooden crate was built around the ship and it was transported by barge and then Coast Guard buoy tender to D.C. It sat in temporary berth at the Naval Weapons Plant for four years and was then moved to the National Museum of American History

Justification: Originally Hagglund wanted to build a house for it on the University of Vermont campus, but when funding could not be secured, he created the travelling exhibit (Britten 2002:84-91; Hagglund 1949: 29).

Ship: U.S.S. *Cairo*

Transported: 1965 and 1977

Method: After recovery the ship was placed on a barge to be transported over water to Ingalls shipyard in New Orleans, Louisiana. The ship was cleaned and restored, but in the process was broken/cut into seventeen pieces. The ship was moved to Vicksburg, Mississippi by truck.

Justification: The ship was stored at Ingalls while a permanent location was identified (Bears 1980:184, Hon and Taras 1988:3).

Ship: *H.L. Hunley*

Transported: 2000

Method: When lifted from the water, the ship was transported by barge to Pier Juliet on the decommissioned Charleston Naval Base on South Carolina. From there, the ship was lifted and moved by crane into Clemson University's Warren Lasch Conservation Center.

Justification: It was the simplest method for moving the sub (Hicks and Kropf 2002:205, 209; Chaffin 2008:223).

Ship: C.S.S. *Neuse*

Transported: 1964

Method: After recovery, the ship was cut into three pieces with a chainsaw because of weight issues and transported through town on a flatbed truck to Caswell Memorial Park in Kinston, North Carolina

Justification: It was the simplest method for moving the ship (Bright et al. 1981:26).

European Projects:

Below is information from the European case studies including when the ship was transported, how it was transported, and why it was transported by that method.

Ship: Hjortspring

Transported: 1922

Method: The fragmented pieces of the ship were wrapped into packets, placed in crates and transported by steamship to Copenhagen, Denmark, where it was taken to the National Museum.

Justification: The timber was extremely fragmented and very fragile. Before it was moved, it had to be reinforced (Bojesen-Koefoed and Stief 2003:38; Crumlin-Pedersen 2003a:23-24, 35; Rieck 2003:20).

Ships: Skuldelev I, II, III, V, VI

Transported: 1962

Method: The ships were placed on rafts and towed to the harbor in Skuldelev. The ships were transported from the harbor to the conservation location in Brede by truck.

Justification: Because the ships were removed in pieces these were the simplest methods of transport (Olsen and Crumlin-Pedersen 2002:41-43).

Ship: Bremen Cog

Transported: 1965

Method: The pieces were removed and placed in plastic. Fragments were stored in a water filled boat and transported by launch to a ship hall in Industrial Harbor for storage.

Justification: The ship was recovered in pieces using a diving bell. The method of transport was simplest (Pohl-Weber 1985:119, 21).

Ship: *Mary Rose*

Transported: 1982

Method: The ship was placed on a barge inside its lifting cradle and taken to the No. 1 basin of the Portsmouth Naval Base. Once there it was transferred to another barge by winching it across a steel bridge and was placed in Dry Dock Number 3. It became the permanent housing for the ship.

Justification: The ship site was located in open water. Moving it by barge was the only method available (Marsden 2003:57-58).

Ship: *Vasa*

Transported: 1961

Method: The ship was towed by barges on its own keel to the dock.

Justification: Once towed most of the way from the site while still in its lifting cradle, the ship was made water tight and pumped free of water. Once it became apparent that the ship could float on its own keel, it made more sense to utilize this than to employ more cranes (Franzen 1972:80; Cederlund and Hocker 2006a:306).

Discussion

Below is a summary of the relevant data from the case studies, followed by a discussion of information relating to the issue presented in the chapter.

Data:

Because of site locations, every vessel except C.S.S. *Neuse* was transported by ship or barge at some point; *Neuse* was transported by flatbed truck (Bright et al. 1981:26). Several other vessels were also transported by truck from the dock to their storage/conservation and display locations.

Methods for Transportation:

When transporting archaeological material, the first things to consider are the environment the ship is coming from and the location where it will be stored or conserved. If the site is located in open water, a boat would be needed to get the materials to land. Prior to transportation, use of a site on or directly adjacent to the site may be used for storage in order to facilitate ease of transport. For example, when *La Belle* was recovered, the top of the cofferdam was utilized as a storage area until the timbers were transported thirteen miles away by boat to the Palacios Lab on the shore (Bruseth 2005:63). Helicopters or sea planes also offer alternatives, but neither of these are as efficient or cost effective as a boat. If the material must travel overland, which is often the case unless a facility is located on the shore, material will need to be transported by vehicle. Trucks and vans are more versatile than trains, as they can go anywhere needed; though weight may be a prohibiting factor.

The size and weight of material will dictate the boats and vehicles needed. Ships in fragmented condition are much simpler to transport than one in larger heavier pieces. As seen with *Mary Rose* and *Vasa*, moving large, intact vessels is certainly possible; however, the logistics are more complicated (Franzen 1972:80; Marsden 2003:55-58; Cederlund 2006d:223, 231-264; 2006c:265-266, 276-290). Heavy lifting equipment and larger vehicles are needed, so an accurate estimate of the weight is extremely important. For example, the first house mover employed to move C.S.S. *Neuse* did not have the equipment to handle the weight, because it was highly underestimated. The full weight of the ship was close to five hundred tons (Bright et al. 1981:26). The weight also contributed to the ship being cut into three sections for transportation overland. The ship had to be moved over a bridge, which could not support the full weight of a complete vessel (Bright et al. 1981:26).

There are several logistical issues involved in transporting a ship. When transporting over water, depth of the channel must be considered. In addition to weight issues on land, the height of the ship may need to be taken into consideration when planning the route to avoid overpasses or power lines. Support from the local police and other officials is helpful to assist in traffic control.

Protection during Transport:

A more complex issue is protecting materials from damage during transport. The fragility of the object dictates how the materials are packaged. *H.L. Hunley* and *Mary Rose* were both transported strapped into their lifting cradles to prevent damage (Marsden 2003:55; Chaffin 2008:221). The more fragile the pieces, the more care is needed to limit the damage. Maintaining environment is also extremely important in order to keep the artifacts as stable as

possible which will lower the deterioration rate. This can be achieved by using water from the site to immerse/soak materials in, as well as keeping the temperature as constant as possible (Leskard 1987:117).

Waterlogged artifacts need to be kept wet, limiting the type of materials that can be used for protection and packing. All mediums used to pack archaeological materials need to maintain integrity when wet. Polyethylene bags, wooden crates lined with heavy plastic and rigid Styrofoam are often employed for fragmented finds. Large timbers must be supported by rigid materials so they are not damaged (Leskard 1987:118). The weight of packing materials needs to be taken into account when calculating the final load.

Conclusion

The logistics of transporting a ship depends on how the ship was recovered and characteristics of the material. Characteristics include: ship's size, weight, fragility, and type of material. The site location must also be taken into account. Will the ship have to be transported by boat, by truck, or both? It may be as simple as placing plastic wrapped timbers in a small pick-up truck, or as difficult as moving the entire ship on a barge or flat-bed truck (van der Heide 1972:164). In order to arrange transport the destination and route must be planned. Much goes into choosing storage and conservation locations which will be discussed in Chapter Seven and Eight.

CHAPTER SEVEN: ACCOMODATING CONSERVATION WORK AND VISITORS

Introduction

After a ship is recovered, the structure and associated artifacts will be transported to a facility for conservation and storage. Between recovery and conservation, archaeological material needs to be stored in an appropriate facility to limit damage and prevent theft of artifacts while awaiting conservation. A conservation location needs to be identified as early as possible in the planning stage because the transportation cannot begin unless a facility is secured, and a proper facility cannot be chosen until at least a tentative conservation plan has been determined. In some cases, it may not be possible to determine a conservation plan until tests can be performed on sample material. If this is the case, a temporary storage facility may be utilized until a more suitable or permanent location can be found. If a suitable location cannot be obtained another option is for the facility to be purpose built. This option allows for the all the features of the building to be tailored for the project that it is meant to house. This option may or may not be possible due to funding availability or necessity.

Allowing public viewing of the conservation process encourages interest in not only the ship itself but in archaeology and history as a discipline. Increasing the public's interest can have not only the immediate effect of donations to the cause, but may also have a more long term effect on how future projects are viewed. Because conservation is a lengthy process, it may be beneficial to allow the public to view work underway (van der Heide 1972:164).

Whether renting, buying, or building space for a ship's conservation, many factors must be considered including: physical space for the ship, storage of associated archaeological materials before conservation, storage and disposal of chemicals, lab space for workers, and long term availability of the facility. (van der Heide 1972:164).

American Projects:

Below is information from the American case studies including when the ship arrived at the conservation facilities, the site type chosen, and why that site was chosen.

Ship: *La Belle*

Arrived: 1997

Site Type: Initially timbers were stored in wooden vats on top of the cofferdam, and then moved to headquarters in Palacios, Texas, where initial cleaning and conservation was done. The Palacios headquarters was an old boat marina with slips for vessels, crew accommodations, and lab space. After initial treatments, materials were shipped to the lab at Texas A & M. The lab has a 60x30x12 foot re-enforced concrete vat for conservation that was built specifically for the ship. No public viewing is allowed, but information is posted and updated on the Texas A & M website.

Justification: Storage on top of the cofferdam dam was temporary, only lasting until the vats could be moved to the Palacios lab. The Palacios headquarters was chosen due to several factors: 1) it was located directly on the bay, 2) it has the appropriate facilities, 3) the city was providing it free of charge for the project (Bruseth 2005:59; CRL 2008; Donny Hamilton 2011, elec. comm.).

Ship: *Philadelphia*

Arrived: 1935 (for the winter), 1936-1941, 1961

Site Type: 1935: Champlain transportation Company in Shelburne Harbor, 1936-41: barge as a travelling exhibit, 1961: Smithsonian museum

Justification: The original intention was for a museum to be built at the University of Vermont. When funding could not be secured, the ship was installed on a barge as a travelling exhibit. Hagglund offered to sell it to the Smithsonian, who bought the ship in 1961 (Hagglund 1936:669; 1949:29; Bratten 2002:86, 161).

Ship: U.S.S. *Cairo*

Arrived: 1965

Site Type: Cleaned and partially restored at Ingalls Shipbuilding Corporation, breaking it into seventeen pieces. It stayed at Ingalls until the summer 1976, when it was moved to the

Vicksburg National Military Park in Mississippi. It was reassembled and placed on a concrete cradle, where it still sits. In 1980, a canopy was built to roof the ship.
Justification: Ingalls stored the ship while funding was secured and plans were made for the permanent location of the ship. Ingalls offered to house the ship and dismantle it in preparation for conservation (Bears 1980:168, 182; Hon and Taras 1988:3).

Ship: *H.L. Hunley*

Arrived: 2000

Site Type: Converted warehouse at the decommissioned Charleston Naval Base. The lab is an open concrete-walled area with a large water tank. There is a large amount of floor space that can be used for a variety of purposes. Limited public viewing is allowed, but information is posted and updated regularly on the Friends of the Hunley website.

Justification: The warehouse is Clemson University's Warren Lasch Conservation Center. (Hicks and Kropf 2002:162, 205, 209; Mardikian 2004:143; Friends of the Hunley 2010).

Ship: *C.S.S. Neuse*

Arrived: 1966

Site Type: Concrete cradle in Caswell Memorial Park, Kinston, North Carolina. In 1969, a shelter was built over the ship.

Justification: Chosen for permanent site of ship at the time. Currently plans are being made for a new museum that will house the vessel in downtown Kinston (Bright et al. 1981:27; Guy Smith 2010, elec. comm.).

European Projects:

Below is information from the European case studies including when the ship arrived at the conservation facilities, the site type chosen, and why that site was chosen.

Ship: Hjortspring

Arrived: 1922

Site Type: Established museum, National Museum of Denmark

Justification: The ship was excavated and conserved by museum staff. The museum created space for the ship in the basement, which served as both the conservation area and the reconstruction area. No visitors were permitted in the area, until the ship had been mounted (Bojesen-Koefoed et al. 2003:51; Bojesen-Koefoed and Stief 2003:37).

Ship: Skuldelev I, II, III, V, VI

Arrived: 1962

Site Type: Converted warehouse in Brede, just north of Copenhagen, called Ny Vestergade II

Justification: Established a conservation laboratory specifically for the Skuldelev boats. Operated by the National Museum, this lab consists of two impregnation vessels and four large wet storage basins that held the fragments for years due to limited resources (Olsen and Crumlin-Pedersen 2002:41; Crumlin-Pedersen 2002b:53; Jensen et al. 2002:70-72).

Ship: Bremen Cog

Arrived: 1965

Site Type: New museum designed and built with conservation, re-construction and visitation in mind.

Justification: They wanted the process to be viewed by the public. The ceiling was built with reinforcements, allowing the cog to be hung from it. A special tank was constructed that was meant to be disassembled without moving the ship, which also allowed the process to be viewed by the public (Hoheisel 2003:73).

Ship: *Mary Rose*

Arrived: 1982

Site Type: The ship was placed in a dry dock that was part of a decommissioned naval base. The facility was constructed around the ship. It was constructed of a ship hall with equipment to chill water and to filter and re-circulate conservation chemicals and spray the hull.

Justification: The dry dock was an easily accessible docking place. It could be modified as needed and had the space necessary for both conservation work and visitors. In addition to this, a museum to house finds from the ship site was also built to provide a more interactive experience. Currently, a new ship hall and museum is being built in the same location. (Jones 2003:40-43; Marsden 2003:58; Mary Rose Trust 2010:1).

Ship: *Vasa*

Arrived: 1961, 1988

Site Type: Barge with a ship hall built around it, floating into a dry dock. It had a viewing platform for visitors. In 1964, a set of permanent support cradles was installed, which was augmented by a second set in the 1990s. The ship hall had to be altered during reconstruction because it was not large enough to accommodate the ship. In 1988, *Vasa* was towed to Galärvarvet, its current location, as part of the Vasa Museum.

Justification: The size and complexity of the ship made it difficult to move. Building the ship hall around it ensured that the ship would not be damaged during transport and that it could be built to any specifications thought necessary (Franzen 1972:80; Cederlund 2006a:424, 428, 448, 450, 452; Błaad et al. 2009:2).

Discussion

Below is a summary of the relevant data from the case studies, followed by a discussion of information relating to the issue presented in the chapter.

Data:

| Ships | Conservation Needs | | | | Allow Visitors | | Facility | | |
|----------------|--------------------|------|-----------|-------------|----------------|----|---------------|----------------|----------------------------|
| | Wood | Iron | Fragments | Large Piece | Yes | No | Purpose Built | Re-purposed | Permanent Display Location |
| LaBelle | X | | X | | | X | | X | |
| Philadelphia | X | | | X | | X | | X | |
| U.S.S. Cairo | X | X | | X | X | | X | X | X |
| H.L. Hunley | | X | | X | X | | | X | |
| C.S.S. Neuse | X | X | | X | X | | X | | X |
| Hjortspring | X | | X | | | X | | X | X |
| Skuldelev I-VI | X | | X | | | X | X | | |
| Bremen Cog | X | | X | | X | | X | | X |
| Mary Rose* | X | X | | X | X | | X | X (drydock) | X |
| Vasa* | X | X | | X | X | | X | X (drydock) | X |

Table 5: Overview of Chapter 7 ship data
(*iron conservation of fasteners)

The projects required different facilities to conserve and store the materials while allowing for the long term use and possible public access. *La Belle*, Hjortspring, Skuldelev, and the Bremen Cog were recovered in pieces which necessitated facilities that allowed storage and conservation of fragments (Crumlin-Pedersen 2002b:53; Bojesen-Koefoed and Stief 2003:40-42; Hoheisel 2003:73; Bruseth 2005:59). In the case of both *La Belle* and the Bremen Cog, the facility also had to accommodate the re-assembly (Olsen and Crumlin-Pedersen 2002:38-40; Crumlin-Pedersen 2003a:24). Three projects: *La Belle*, *H.L. Hunley*, and the Bremen Cog were kept in large, purpose built tanks (Hoffman 2003b:85; Mardikian 2004:140-143; Donny Hamilton 2011 elec. comm.). *Philadelphia*, *H.L. Hunley*, *C.S.S. Neuse*, *Mary Rose*, and *Vasa* were all recovered more or less in one piece, meaning they were not fragmented or deliberately disassembled (Hagglund 1949:29; Barkman 1965:2; Bright et al. 1981:19; Hicks and Kropf 2002:195-207; Marsden 2003:55; Joyner 2006:12). *Philadelphia*, *U.S.S. Cairo*, *C.S.S. Neuse*,

Mary Rose, and *Vasa* had spray conservation treatments (Barkman 1972:235-239; Bearss 1980:182-184; Bright et al. 1981:135-137; Bratten 2002:90-92; Jones 2003:36, 41-42, 68, 70). *La Belle*, *Philadelphia*, *H.L. Hunley*, and *Skuldelev* were not/are not being treated in the permanent display location (Hagglund 1949:29; Jensen et al. 2002:70-72; Donny Hamilton 2011 elec. comm.; Friends of the Hunley 2011). *U.S.S. Cairo*, *C.S.S. Neuse*, *Skuldelev*, the *Bremen Cog*, *Mary Rose*, and *Vasa* had purpose built museums/locations built for them (Franzen 1972:80; Bearss 1980:168, 182; Bright et al. 1981:27; Crumlin-Pedersen 2002b:53; Hoheisel 2003:73; Guy Smith 2010 elec. comm.).

Choosing Facilities:

There are several factors that must be taken into account when choosing facilities for a project. These factors include the archaeological materials themselves, whether the location should be purpose built versus an established location, and whether public viewing should be available.

Materials

The first thing to consider is the archaeological material itself. Vessel size and condition are two factors dictating the type of facility needed. If the vessel is in one piece such as the *Vasa*, a large open space is needed for conservation (Barkman 1965:2). If the vessel is fragmented, the initial space may not necessitate an open area, but this may change for reassembly and display.

The requirements to develop a conservation plan are very important when designing a space. There has to be physical space to work on materials, storage for chemicals, tanks to hold the ship during conservation, and facilities to accommodate the process. Designing a

management plan based on a specific conservation method allows for a more appropriate decision when choosing facilities. If facilities are being rented, it is necessary to plan for long-term use, due to lengthy conservation processes.

The chemical and equipment needs differ depending on the type of materials being conserved (i.e. wood versus iron). Polyethylene glycol (PEG), the substance most commonly used to treat wood, is corrosive to iron. PEG maybe heated during the conservation process; whereas water used for iron conservation may be cooled to inhibit biotic growth. For iron, the tanks may need to be designed to allow electrolysis. This is certainly not true for wood treatments. These needs must be taken into account when choosing/designing facilities (conservation treatments will be discussed in greater detail in chapter 7).

Purpose Built Versus Established Location

Having a location purpose built for the specific needs of a conservation project can have numerous advantages because the site can be tailor made for the project its intended for. The location could be created by retrofitting a standing structure or by building a new structure entirely. Due to limited funding, this may not be possible and often it is not necessary. In most cases it would be superfluous to build a site solely for the purpose of housing/conserving material from a single archaeological site when an established location could accommodate the materials.

A site that produced a large amount of archaeological material could possibly support a museum on its own, but many simply do not have enough material to warrant their own building. The cost of equipment alone makes building a new site unrealistic in most cases. In certain cases a conservation lab may be created for a specific project and then used for others as well, such as

the Clemson Conservation Center, which houses *H.L. Hunley* (Friends of the Hunley 2011). One reason to construct a purpose built site could be purely logistical. In the case of a ship like *Vasa*, for example, it would be extremely difficult and potentially damaging to move the ship over land.

Public Viewing

Because conservation is long term, allowing the process to be observed is a way to gain public recognition as it can assist in securing funding in the future (van der Heide 1972:164). Public viewing is also an ideal way to promote interest in history and archaeology on a larger scale. If access is possible, providing a viewing platform and guided tours of facilities will make the viewing more memorable and informative. While currently the internet allows the process to be reported and viewed by the public in nearly real time, seeing the process with their own eyes and physically moving through the space is a much more engaging situation than viewing a photograph or reading an article. One positive aspect of using the internet to provide information, whether in addition to or in place of public viewing, is that it allows for the project to be enjoyed by people who may not be able to visit the site.

Conclusion

After recovering a ship, transportation from the site will occur. In order for this process to occur a destination must be selected. Size and condition of the vessel dictates the amount of open space necessary in the facility as well as the equipment needed. Long term facility use is necessary as the conservation process can last from several months to decades. The long term nature of the process leads to the idea that public viewing of the treatment should be

accommodated. While in the past, physical access to the area was important, utilizing the internet can allow information to be available to the public. When choosing a conservation/storage facility the main factors to consider are the size and condition of the vessel, the long term use of the space, and the conservation method. The latter will be discussed in the next chapter.

CHAPTER EIGHT: CHOOSING CONSERVATION TREATMENTS AND FACILITIES

Introduction

History of Conservation

Prior to the 1800s, the primary concern for the care of artifacts was to maintain their aesthetic beauty with restoration being the primary focus. Because of this, much archaeological information about the artifact was often lost or inadvertently altered. The idea of beauty has changed over time sometimes prompting changes to the artifact that were not necessarily appropriate to the artifact, but rather, the time period in which the artifact was altered (Sease 1996:157; Caple 2010:2).

In the 1800s, experimentation in methods of conserving metals developed as the focus of archaeology started to shift from collection to analysis. Once this occurred, the focus also began to shift from restoration and concerns over the 'look' of an artifact to preserving the material's current state which allowed for analysis and study of the artifact (Caldararo 1987:85; Caple 2010:2). The shift to conservation, as it is viewed today, is thought to have started with Friedrich Rathgen's establishment of a conservation lab at the Royal Museum in Berlin in 1888 (Caple 2010:4).

Until the 1980s, long-term conservation was still not a priority to archaeologists (Caldararo 1987:86). Some major reasons for this may have been lack of funding, the development of techniques, or simply a general attitude that conservation was not as important as other issues. Generally, the older a site report, the less likely storage and conservation will be discussed. Archaeologists tended to leave the responsibility of long-term care to conservators

and museum curators after they finished their research. This is sometimes still the case (Caple 2010:7). It was not until the late 1980s, early 1990s, that conservation issues became a common topic in reports. While the lack of discussion may not reflect the popularity of conservation treatments, it may reflect a general attitude towards conservation. It is only in the last thirty years that archaeologists have begun to write prolifically about conservation, particularly of waterlogged artifacts. One of the most well-known conservation manuals, *Conservation of Marine Archaeological Objects*, was written in 1987 by Colin Pearson.

Deterioration Factors

There are several factors that must be taken into consideration when attempting to predict deterioration of materials. Depending on the type of material, these factors may change.

Wood Deterioration

As discussed in chapter three, being submerged in water, particularly sea water, for a long period generally has an adverse effect on artifacts. When wood becomes waterlogged, it is subjected to attack by microbes. The microbes damage the wood before it stabilizes within the environment. There are two primary effects of drying waterlogged wood: shrinkage and collapse. Shrinkage occurs when the water leaves the spaces between cellulose fibers within the cell walls. Collapse occurs when drying stresses crush the cells. Drying stresses are caused by the properties of water. When wood becomes waterlogged, water is drawn between cells and into the pores in cell walls by capillary action. Water has a natural surface tension. In undamaged wood, when the water begins to evaporate, the surface tension compresses the cell until the strength in the cell walls overcome it. This allows air to enter the spaces and the cell

walls are able to rebound. If the cell wall has been compromised by microbial action, as is generally the case with waterlogged wood, the cell walls cannot overcome the surface tension of the water and the walls collapse. This collapse is irreversible. This is why it is so vital to keep wood hydrated until conservation treatment takes place (McCawley 1977:17; Gratten 1987:55; Kaye et al. 2000:233-234; Kozuma 2004:6). Once cells collapse the damage is irreversible (McCawley 1977:18; Gratten 1987:56; Kozuma 2004:6).

Iron Deterioration

Iron corrosion is an extremely complex process through which numerous chemical and environmental factors begin to breakdown the structure of the metal. The primary form of this occurs when metal is placed in water that carries oxygen. The oxygen induces an oxidation-reduction reaction which causes corrosion of the metals. There is also a transfer of electrons which causes metal ions to migrate out of the artifact (North and MacLeod 1987:69). These metal ions can diffuse into the surrounding water and will form concretions on the surface of the artifact. The concretions can actually act to stabilize the artifact by allowing it to reach equilibrium within the environment (North and MacLeod 1987:70, 72). The iron can also be damaged by galvanic deterioration in which a less noble metal will donate electrons to a more noble metal (Hamilton 1996:44).

Bacterial corrosion is another form of deterioration that can occur in iron. One common kind of destructive bacteria is known as sulfate-reducing bacteria. As much as 60% of the corrosion of iron in salt water can be attributed to bacteria. These bacteria reduce sulfates to sulfides. The bacteria use hydrogen in its metabolic processes. In anaerobic environments, such as buried or concreted artifacts, hydrogen accumulates on the surface, making it an ideal habitat

for the bacteria. A byproduct of the metabolic process of the bacteria is hydrogen sulfide which reacts with ferrous iron producing ferrous sulfide and ferrous hydroxide, both of which are corrosive compounds (Hamilton 1996:45).

Salt Deposits

Salts can also migrate into artifact materials. The deposits can increase the rate of corrosion in metals and may make wood less permeable, which makes conservation more difficult. In order to effectively conserve an artifact, the salts should be washed out of the materials. This can be done using fresh water baths, or in metals, with electrolytic treatments (Gratten 1987:67; North and MacLeod 1987:75).

Conservation Treatments

The purpose of conservation is to stabilize an artifact in order to lower deterioration rate as much as possible. It also helps to strengthen the material to limit distortion. Conservation also renders the artifact robust enough for handling, study, or display (Werz and Seemann 1993:38). By stabilizing the artifacts they can be preserved for future use, whether it be academic study, public interest, or for posterity. Conservation facilities must have the equipment and funding necessary for the chosen treatment. If the ship is disarticulated, the sections not undergoing active conservation may be stored at another location until conservation can take place. The chosen treatment will depend on the materials being conserved as well as their condition (van der Heide 1972: 166).

American Projects:

Below is information from the American case studies including the conservation period, the conservation method used, the details of the conservation treatment, the reason why the method may have been chosen,⁵ and a description of the facilities.

Ship: *La Belle*

Conservation Period: 1998-current

Methods: PEG bath and freeze drying

Details: The ship was reassembled after recovery and placed in a 60x30 foot conservation tank.

The ship was soaked in a 30% (aq) solution of PEG 200. The method was changed to freeze drying. A 40x8 foot freeze drier was built at half the cost of the PEG bath and reduced conservation time. The ship was disassembled for freeze drying and the first round was slated to begin in September 2011 and the wood to be finished by 2013.

Justification: PEG is currently the most commonly used method for wood conservation, due to its high rate of success. After the first bath, it was decided that it would be too costly to perform a second bath, so the method was changed.

Facilities Description: Texas A & M University's Conservation Research Laboratory in College Station, Texas (CRL 2008; Donny Hamilton 2011 elec. comm.; Peter Fix 2011 elec. comm.).

Ship: *Philadelphia*

Conservation Period: 1961

Methods: PEG 1500 and liquid nylon

Details: The wood was moistened and sprayed with two applications of PEG 1500 at a 30% solution in order to keep the ship flexible for transport to the Smithsonian. The treatment was ineffective. In the 1960s, the ship was given a layer of liquid nylon to seal in the PEG at the Smithsonian. Currently, the Smithsonian is contemplating putting together a symposium to discuss recommendations for further conservation of the vessel.

Justification: The treatment was recommended by the National Park Service.

Facilities Description: Smithsonian museum (Britten 2002:90-92; Paul F. Johnston 2011 elec. comm.).

Ship: U.S.S. *Cairo*

Conservation Period: 1977, 1979-1982

Methods: 1977: Sprayed with hydrozo (used for water-proofing) and pentachlorophenol (used for fungicide and as a wood preservative), 1979-1982: PEG 4000 and copper-8-quinolinolate (control of mold and a preservative)

Details: The 1977 treatment was performed in preparation for a move to Vicksburg, Mississippi. The 1979-1982 treatment was performed six times to curb additional deterioration of the

⁵ Few of the reports/articles revealed why treatments were chosen, rather only stating which treatment was used. Assumptions have been made based on the author's knowledge of conservation.

timber. “This treatment was meaningless (Hon and Taras 1988:7).”⁶ The ship was also treated with insecticide.

Justification: National Park Service decided on this treatment after they acquired the ship

Facilities Description: Initially the ship was stored at the Ingalls shipyard in Pascagoula, Florida.

After this, the ship was moved to Vicksburg National Military Park in Mississippi. The ship was placed in a concrete cradle. The ship was covered with a canvas canopy in 1980 (Bearss 1980:182-184; Hon and Taras 1988:3).

Ship: *H.L. Hunley*

Conservation Period: 2000-current

Methods: Cold, fresh water immersion and impressed current

Details: The sub was placed in a large water tank and immersed in water chilled to 43.5°F. An impressed current system was installed to limit corrosion. The system is comprised of three, 40 foot anode segments which were suspended inside perforated PVC pipes above the sub. Wires are attached to the hull. A charge is passed through a rectifier, which can be adjusted to control the output to the anodes.

Justification: Chilled water slows corrosion and helps to inhibit biotic growth. The impressed current system allowed the corrosion rate to revert to its pre-disturbance levels. Because the vessel is comprised of several pieces, it is thought that unless it is taken apart, treatment may not be as effective in areas that are not as easily accessed. Because of this, an impressed current was being used to limit the corrosion until a more suitable treatment could be determined. In January 2012, the tank was drained to be retrofitted for chemicals to leech out the salt inclusions. The sub will soak for 1-3 months, after which the encrustation layer on the surface will be removed.

Facilities Description: The Warren Lasch Conservation lab is located in a former warehouse on the decommissioned Charleston Naval Base. It was modified into a conservation lab.

The area includes the large cold-water tank *Hunley* is being stored in and working facilities (Mardikian 2004:140-143; Hicks 2012).

Ship: C.S.S. *Neuse*

Conservation Period: 1964, 1971

Methods: Pressure washed, Pentachlorophenol and PEG, linseed oil

Details: The 1964 treatment started with pressure washing to rid the hull of mud and sand. The timbers were treated with a 5% solution of pentachlorophenol (pesticide) and PEG. Only two applications were made resulting in shallow penetration. In 1971, formal preservation began. The vessel's metal was treated before the wood. The rust was removed by hammer, and drill fixed with a cup brush. Manganese-phospholene #7 was used to dissolve remaining rust. The metal was coated with dimetcote #4 (a silicate sealant) and allowed to cure for four weeks. The ship was treated with three applications of linseed oil, two at 1:1 oil/mineral spirits with pentachlorophenol, and the third all oil, allowing one week, two weeks, and then nine weeks to dry, respectively. The oil was applied using a centrifugal pump run off a tractor, with a garden hose and spray nozzle. The final treatment was a light spray mist of diluted wood sealer.

⁶ The report also states that the ship had been extremely damaged both in the recovery and during the storage of it at Ingalls shipyard. Because the ship was left to dry out, the timbers had become distorted and cracked. The PEG merely coated the surface and was easily washed away by the rain.

Justification: The 1964 treatment was a temporary measure. The 1971 treatment was considered semi-permanent and was chosen after tests were done on wood and metal samples taken from the ship.

Facilities Description: Caswell Memorial Park is located in Kinston, North Carolina. The ship is housed under a wooden shelter that was built in 1969, which protects the ship from the elements (Bright et al. 1981:135-137)

European Projects:

Below is information from the European case studies including the conservation period, the conservation method used, the details of the conservation treatment, the reason why the method may have been chosen,⁷ and a description of the facilities.

Ship: Hjortspring

Conservation Period: Initial conservation: January-February 1923, Spring-December 1923; post-treatment: 1928 and Winter 1931/1932; re-conservation: 1967, took five months, 1986, a few months

Methods: Initial conservation: alum-glycerine impregnation, bees wax impregnation, surface coating of tallowseed oil; re-conservation: PEG 4000 impregnation

Details: Initial Conservation: Fragments placed in a packet consisting of perforated lead sheets. After pre-heating in boiling water, packets were placed in a double-walled steam-heated iron vat filled with a 4:1:1 1/4 solution of alum:glycerine:water and boiled for twenty-four hours. The packet was dipped in boiling water to remove any alum crystals from the surface. The packets were then covered in cartridge/oil paper and weighted with lead to dry.⁸ In 1928, the fragments were treated with melted bees wax in order to make them more pliable for the mounting. The wood was placed in packets consisting of a thin sheet of celluloid, linseed impregnated cardboard and a perforated sheet of lead. The packet was held together with iron bands and placed in the bees wax for five hours, the temperature incrementally increased from 158°F to 176°F. The packet was hung over the wax and allowed to drip. As much wax as possible was removed from the surface with turpentine and the remaining was smoothed with a 'flame brush.' In Winter 1931/1932, the surface was cleaned and coated with tallowseed oil.

Re-conservation: In 1967, the previous treatments were washed out with acetone or dimethylformamide. The alum was washed out in 194°F water. The timbers were treated in heated PEG 4000, starting at a solution of 10% and then gradually increased to 96%. Re-conservation took five months and not all fragments were re-conserved at this

⁷ Few of the reports/articles revealed why treatments were chosen, rather only stating which treatment was used. Assumptions have been made based on the author's knowledge of conservation.

⁸ In the report it states that there is no further documentation after the final dip in boiling water, but that the weighted drying most likely took place based on accounts of other artifacts.

time due to lack of funding. Wood was stored until 1986 when reassembly was performed.

Justification: In both cases, the method chosen was the best known at the time. Though there were some concerns about the alum-glycerin method, there was no other alternative that was deemed appropriate. As early as 1947, the surface of the wood was showing signs of improper conservation. Crystals of alum were collecting at the surface. Part of the reason was lack of stable conditions in the basement, where the ship was on display. The ship readily absorbed and desorbed moisture from the air, which caused the crystallization of the alum, prompting the re-conservation of the ship.

Facilities Description: The National Museum basement was used for the conservation and display of the ship. Initially the basement included inadequate climate control and this proved to be detrimental to the ship. After re-conservation and mounting of the ship, a new climate control system was added. In addition, new lights were installed to regulate the amount of light the ship was exposed to (Bojesen-Koefoed et al. 2003:44; Bojesen-Koefoed and Stief 2003:40-42).

Ship: Skuldelev I, II, III, V, VI

Conservation Period: 1962

Methods: Various pre-1962, 1962 series PEG 4000, 1972 series PEG 4000 with tertiary butanol (TBA)

Details: Treatment started with PEG 4000 at a 10% solution with the temperature slowly raised to 140°F and then kept constant. PEG concentration was increased by 15% per month, making the concentration 95% after 6-7 months. While this worked well for the smaller pieces of timber, the larger ones tended to shrink, so the treatment time was stretched to 12-24 months. By 1965, the method was changed. The interior of the wood was in relatively good condition and the PEG 4000 was not penetrating as it should. The new method grouped timbers by condition. The first group was the most degraded and followed the original treatment. The second was less degraded and was treated with cold impregnation. The treatment started with PEG 4000 at a 25% concentration. The wood was immersed for 12 months, with the concentration slowly raised to 50%. This was done at room temperature with a 1% biocide added. The timbers were dried slowly under plastic. When the surface was matte a 50% solution of PEG was poured on top until a white layer of excess PEG accumulated on the surface. The process took 14 years to complete, with varying results. The third group consisted of timbers, mostly oak, that were in good condition. They were set aside for conservation until a more acceptable method could be found. Some of the largest timbers were given a second treatment after the initial hot impregnation caused signs of collapse. The initial treatment was reversed, and the second consisted of hot impregnation at a slower rate than the first followed by a cold impregnation cycle. During drying a 50% PEG solution was poured on the surface.

In 1975, the ships were moved to the new museum. Timbers were re-conserved using PEG 4000 and TBA at 40% at 129°F. It was done carefully because TBA is an alcohol dehydrate and is flammable. The concentration was slowly raised to 66%. At this point timbers were frozen in a vacuum. The TBA turned into a gas and was pumped out into a condenser where it re-solidified, which took three years. The ships were then rebuilt and restored. After final treatment the cores are well preserved, but the surface has collapsed.

Justification: PEG 4000 was chosen because it was the best option and shown to be more resistant to changes in humidity

Facilities Description: A converted warehouse, old factory hall in Brede. It was chosen because it provided space for large scale treatment, it was equipped with two impregnation vessels that could both heat and circulate liquid, and four basins for wet storage (Crumlin-Pedersen 2002b:53, Jensen et al. 2002: 70-77).

Ship: Bremen Cog

Conservation Period: 1981-1998

Methods: PEG 200 and 3000 impregnation

Details: The ship was re-assembled before conservation. A steel tank was installed around the ship in the hall where it is still housed. The first bath consisted of a 40 % PEG 200 solution. At first no biocide was used, but algae began growing. The tank was drained, the ship cleaned, and the tank re-filled with a biocide added. The PEG solution was circulated regularly to inhibit the growth of biotics. The first bath lasted until 1995. The second bath consisted of a 60% solution of PEG 3000 heated to 140°F. The concentration was increased to 70%. The bath lasted three years. The tank was then emptied and de-constructed. They removed excess PEG from the surface of the wood by hand. No surface treatment was done, and the ship was allowed to dry naturally.

Justification: Testing determined that a two-step process of PEG impregnation would be the most appropriate due to the condition of the wood.

Facilities Description: All conservation and reconstruction work was done in the museum hall where the ship was to be displayed permanently. The tank was built around the ship after it was re-constructed so a minimal amount of maneuvering would have to be done after conservation was complete (Hoffman 2003b:81, 84-86, 88-93).

Ship: *Mary Rose*

Conservation Period: 1982-current

Methods: Salt leeching with cold water, followed by PEG impregnation

Details: After sediment was removed, the hull was treated with a 2% solution of hydrogen peroxide to remove surface stains. During cleaning, reconstruction of the removed internal structure, and recording, which took twelve years, cold water was sprayed on the ship to leech out salts and aided in slowing deterioration. Water sprayed on the ship through a system comprised of PVC pipes with jet spray nozzles every approximately three feet throughout the vessel. It was monitored for salt content and biotic levels on a regular basis. The water sprayed constantly except during working sessions, which were a maximum of four, one hour periods per work day. Once this was finished, the ship was placed on a PEG regime. It was a two part process. The first consisted of spraying the hull with PEG 200 (1993-2004). The second was a cycle of PEG 2000 and 4000 (2004-2011). Controlled air drying of the hull commenced and is expected to last until 2016.

Justification: Because of the size of the hull, the spray treatment was the only feasible method for treatment. Cold water was used to slow biotic growth. PEG was chosen because it has the best success rate for conservation of waterlogged wood.

Facilities Description: The ship was placed in a dry dock that was part of a decommissioned naval base. The facility was constructed of aluminum and double layered Treveira

(polyester cloth covered with PVC) (Jones 2003:36, 41-42, 68, 70; Mary Rose Trust 2010:5, 11).

Ship: *Vasa*

Conservation Period: 1962-1979

Methods: PEG in various weights and borax (an anti-fungal agent) mixture for wood. Iron heated in presence of hydrogen gas.

Details: In 1962, hand spraying of PEG 4000 started. When an automatic system was installed in 1965 the PEG 4000 was changed to 1500 to stop the system from clogging. In 1971, the weight was changed to 600 after testing showed it had better penetration. The spraying continued until 1979, starting with a 10% PEG solution with borax that was incrementally increased to 45%. The ship was dried from 1979 to 1988 to a relative humidity of 60%. The ship was reconstructed and restored. In 2000, sulfur salt precipitations began to show on the surface. The sulfur breaks down the wood quickly exacerbated by the high iron content of the wood. In the process of conserving the ship, sulfuric acid was produced in the wood. Spot treatments that alter the pH were used to neutralize the breakouts. Because long term effects of the sulfur treatments are unknown it has been ceased until a more appropriate treatment can be found. The iron, most of which was cast iron, was removed before spraying began. The iron was heated in an oven at 1940°F in hydrogen gas. This restored the iron to the original state and eliminated the chloride compounds.

Justification: Much experimentation was performed on samples before and during treatment.

Because something of this scale had never been attempted before, they had to invent the technique as they went. PEG proved to be the best option for conservation.

Facilities Description: The original ship hall was made of aluminum. It was equipped for conservation of the ship and for the temporary housing of the vessel. The museum is a concrete building designed to maximize protection of the ship. There is an air-lock system in place allowing near perfect control of the interior atmosphere (Barkman 1965:7; 1972:235-239; Hocker 2010:6-7; Håfor 2010:24, 39, 55-56).

Discussion

Below is a summary of the relevant data from the case studies, followed by a discussion of information relating to the issue presented in the chapter.

Data:

All of the ships, with the exception of the *H.L. Hunley*, were treated with polyethylene glycol (PEG) at some point in their conservation. Often PEG is combined with other chemicals

which vary in purpose from drying agents to anti-biotics. The *H.L. Hunley*, because it is comprised entirely of iron, was undergoing a passive cold water treatment to leech out salts and impressed current to preserve the iron until a more suitable method of conservation could be developed. At this time, *H.L. Hunley*'s tank is being retrofitted for a chemical bath to leech out the remaining salts (Mardikian 2004:140-143; Friends of the Hunley 2010; Hicks 2012).

Treatment:

To determine which conservation method should be used on an artifacts, samples should be tested to determine whether the method is appropriate and has the desired effect. If the analysis of samples is not possible, then the artifact's characteristics should be compared to other existing samples that are as similar as possible to obtain an approximation of an appropriate method to be used. There are several treatment methods that are used or have been used over the years. This thesis will discuss two common treatments used for waterlogged wood or iron, namely: polyethylene glycol (PEG) impregnation or bulking and electrolytic reduction, respectively. The appropriate treatment should be determined by analysis whenever possible. Each has its pros and cons, strengths and weaknesses that may make one more suitable for a specific project than another.

Wood Treatment

When a wooden artifact becomes waterlogged the inclusion of salts and deterioration of cell walls due to microbial action damages the wood's structure. If allowed to dry uncontrolled, collapse and warping of the artifacts will occur (Gratten 1987:55-62). There are measures that can be taken to limit the amount of damage that occurs. Depending on the level of deterioration

of the wood, two processes can be used to strengthen the wood before drying. The first is bulking, which is a process where a chemical agent adds strength to the cell walls, without needing to fill the interstitial spaces. The second is impregnation. During impregnation, a chemical agent actually fills cavities, providing solid structural support for highly deteriorated wood (Kozuma 2004:9).

Several bulking and impregnation agents are used with varying levels of success. Currently, the most widely used agent is polyethylene glycol (PEG), which is a non-toxic, water soluble wax. It can be produced and used at different molecular weights making it extremely versatile as it can be used for both bulking and impregnation. Other reasons why PEG is so popular are that it is relatively inexpensive, simple to use, and does not require highly specialized equipment (though for certain applications some sort of heating apparatus may be utilized). It does not require specialized storage facilities. It also has a high success rate, with a low rate of long-term complications, and the treatment can be altered mid-project if necessary with little to no adverse consequences to the artifact. It is mostly reversible, a feature which is considered to be a necessity by the current conservation standards (Werz and Seemann 1993:40; Watkins-Kenney 2010:48). It can be easily combined with other chemicals, such as biocides and drying agents.

PEG can be produced in varying molecular weights from 200 to 8000 to tailor fit the material it will be used on (Werz and Seemann 1993:40). Low weight PEGs (300-600) are liquids that are used for bulking. Generally lower weight PEGs are used for wood in a less deteriorated state. Mid-weight PEGS (1000-1500) have a consistency similar to Vaseline. High weight PEGs (3250-6000) are wax-like and are used for impregnation. For highly deteriorated wood, the most successful application of PEG is a low weight bulking treatment followed by a

high weight impregnation treatment (Hamilton 1996:27; Kozuma 2004:9). By doing this, cell pores and interstitial spaces are filled, which strengthens the cell walls. The empty cavities are then filled which strengthens the entire piece.

As with any other conservation treatment, there are some draw backs of using PEG. Because PEG is water soluble, it is not appropriate for final storage and display conditions over 80% relative humidity as it tends to destabilize (Werz and Seemann 1993:40; Kozuma 2002:11). PEG also increases corrosion rates in iron; therefore, composite artifacts must be disassembled before application. PEG also slightly changes the material's color and can increase the weight (Werz and Seemann 1993:40; Hamilton 1996:28; Kozuma 2004:11).

After a bulking or impregnation agent has been administered, the next step is drying the artifact. There are several methods of doing this. The simplest is uncontrolled air drying. As an additional precaution, some treatments dictate controlled air drying where humidity and temperature is modified and controlled to slow drying. Another method is freeze-drying, or lyophilization, in which the artifact is placed into a below freezing environment. Freezing the artifact eliminates water surface tension, allowing the sublimation of water while cell wall integrity is maintained. It generally requires the introduction of a cryoprotectant. PEG is commonly used (Kaye et al. 2000:235). Generally freeze drying of large objects is expensive and impractical (Gratten and McCawley 1978:157). Currently there is only one large purpose built freeze-dryer, which is located at Texas A & M's Conservation Center (Donny Hamilton 2011 elec. comm.).

Iron Treatment

When metals are extracted and purified by humans, it makes the structure unstable. All metals, except gold, react with the environment to breakdown into more stable compounds (Hamilton 1996:42). Iron is by far the most common metal found on shipwreck sites. When immersed in oxygenated water, iron and other metals are subject to electrochemical corrosion, a chemical reaction where electrons migrate out of the metal causing the buildup of concretions and the metal's breakdown. Metals that are less noble, act as a sacrificial anode to more noble metals in a process known as galvanic coupling. For example, iron will donate electrons to copper. Copper, in turn will donate to silver. This increases the complexity of metal corrosion as spacial relationships between artifacts can greatly affect the process (North and MacLeod 1987:69-72; Hamilton 1996:42). The rate of corrosion increases in salt water because sodium chloride is electronically conductive (Hamilton 1996:42). While the corrosion processes of iron are understood, the complexity of the process makes predicting the effects extremely difficult. Some of the variables that affect the rate of corrosion include: pH, salinity, temperature, proximity to other metals, turbulence of the site, burial. Just as with wood, iron can become stable within an environment. Sometimes stabilization is aided by concretions and patinas that are caused by the migrating electrons. Once the iron is disturbed, the corrosion rates can increase again if proper care is not taken (North and MacLeod 1987:70, 76; Hamilton 1996:46).

By utilizing the electrochemical corrosion in a manufactured environment, corroded metal can be reduced to a more stable state (Sanford 1975:40). Electrolytic reduction is a process where a metal is placed in a solution, usually of water and an electrolyte (usually sodium carbonate) (Hamilton 1996:67). Direct current is applied to the artifact and a sacrificial anode, which is a less noble metal than the artifact. The artifact is grounded at the negative side and the

anode is attached to the positive, encouraging electrons to migrate back into the artifacts. The electrons carry metal ions and the artifact is strengthened, in the case of iron, with stable magnetite. The benefits of electrolytic reduction are that it is relatively easy to set up and run for long periods of time, and it has proven to be an effective method of stabilizing artifacts. In addition, the treatment can be adjusted mid-phase to increase the effectiveness with little to no harmful effect to the artifacts (Sanford 1975:40; Hamilton 1996:56-57).

Location of Vessel after Conservation

When a ship is removed from its stable environment, the rate of deterioration increases rapidly. Storage may take place, followed by conservation. Once conserved, theoretically the deterioration rate should lower dramatically. The primary issue is that unless the environment in which the ship is kept is monitored and controlled, the conservation process may or may not be effective. It has been known for decades that variations in humidity, light, and temperature, (particularly dramatic changes) can create unstable conditions that may cause as much damage as the initial removal from the site (Coremans 1968:32-33).

The facility where a vessel is placed for long-term storage/display after conservation can have a major impact on the effectiveness of the conservation treatment. If the environment is unstable (i.e. fluctuations in temperature and relative humidity) it can compromise the treatment, causing precipitates, breakdown of the treatment chemicals, and stress on the artifact caused by swelling and shrinking. The Hjortspring boat is a prime example. Variation in the humidity of the display area caused crystallization of alum, the original method of conservation, necessitating re-conservation of the vessel (Bojesen-Koefoed et al. 2003:44).

For most modern museums where environmental controls are put in place, this is not an issue; however, if the ship is placed in an unprotected environment it is impossible to control the environment of the vessel. Both U.S.S. *Cairo* and C.S.S. *Neuse* are outside and under canopy and subject to changes through all the variables listed above (Bearss 1980:168, 182; Bright et al. 1981:27). Both ships were studied years after being placed in their permanent locations and both show continual deterioration (Hon and Taras 1988:5-7; Lusardi 2001:1).

Conclusion

Conservation treatments are determined by testing whenever possible. If not possible, past projects can be studied to estimate which treatments may best benefit the material. The most common treatment for waterlogged wood is PEG. It is extremely versatile and has proved to be the most economical solution with the best success rate. For iron, the best method found is electrolytic reduction, which is a relatively simple and inexpensive setup.

When planning a project, choosing a facility for conservation and long-term storage/display is an important decision. Affiliation of the responsible persons with an institution may dictate where the ship is taken. Ideally a site should be chosen which fulfills all project needs. Condition, size, and weight of the materials; method of conservation; whether the location will be temporary or permanent; and how much funding is available are all factors which will dictate the facility that is chosen.

CHAPTER NINE: OTHER ISSUES

Introduction

Van der Heide's article lists several factors that need to be taken into account when planning ship recovery. Each factor presents an issue that can affect a project's outcome and all were explored in this thesis. After examining the ten case studies, it became apparent that while van der Heide's list provides several perspectives, there are many more issues that need to be taken into consideration. The time period of the project, the original purpose of recovery, the parties involved, and securing funding are all factors that affect the outcome of a recovery, which will be discussed here.

The Issues

Below are listed the issues and the relevant ship information as well as a discussion of the issue as it related to the case studies.

Time Period the Project Occurred

As discussed above, methods of archaeological investigation and conservation techniques as they are now understood are relatively recent. Only in the last two hundred years have the disciplines of archaeology and conservation been developed. Before that time the methods employed could, for the most part, not be considered responsible or scientific according to modern standards. Few artifacts excavated prior to the 1800s were properly cared for, certainly

not by current standards. Even well into the 1900s, modern standards of care were not well known, particularly in the United States.

America Projects:

Below is listed the time period of the American case studies.

Ship: *La Belle*

Project Time Period: The project began in 1996 and is currently being conserved (Hamilton 1998; Bruseth and Turner 2005:38, 63).

Ship: *Philadelphia*

Project Time Period: The ship was recovered in 1936 and given to the Smithsonian in 1961 (Bratten 2002:5).

Ship: U.S.S. *Cairo*

Project Time Period: The project began in 1956 with the conservation occurring until 1977 (Bearss 1980:7, 184).

Ship: *H.L. Hunley*

Project Time Period: The search for the sub began in 1995 and the vessel is currently being conserved (Bak 1999:144; Hicks and Kropf 2002:205; Friends of the Hunley 2010).

Ship: C.S.S. *Neuse*

Project Time Period: The project began in 1956 with the conservation occurring in 1970 (Bright et al. 1981:19-28).

European Projects:

Below is listed the time period of the European case studies.

Ship: *Hjortspring*

Project Time Period: The excavation began in 1921, conservation and other post work occurred during the 1920s and 30s; the ship was dismantled and re-conserved in 1966-67 (Niger and Stief 2003:37-43; Rieck 2003:14).

Ships: *Skuldelev I, II, III, V, VI*

Project Time Period: The ships were excavated starting in 1957; the majority of conservation activity took place from 1962-1975 (Jensen, Hjelm Petersen and Strækvern 2002:70, 75; Olsen and Crumlin-Pedersen 2002:23).

Ship: Bremen Cog

Project Time Period: The project began in 1962; conservation took place from 1973-2000 (Fliendner 1985:8; Lahn 2002:66; Hoffmann 2002:102).

Ship: *Mary Rose*

Project Time Period: The project began in 1969; conservation began in 1982. Currently the ship is being undergoing controlled drying (Jones 2003:1, 69; Marsden 2003:33, 55; Mary Rose Trust 2007).

Ship: *Vasa*

Project Time Period: The project began in 1957; the conservation began in 1962 and continued until 1979 (Cederlund 2006a:447, 449, 452; Cederlund 2006d:220)

Discussion:

The assumption is that due to the nature of scientific study, generally the older a project, the less standards of practice that were present and that generally, there is also less technical knowledge about the processes involved in the deterioration of material leading to greater deterioration of the vessel after recovery. The first book that addressed the conservation of waterlogged artifacts was published in 1861 by C.F. Herbst. The causes of deterioration of waterlogged materials were not still well understood (Sease 1996:158). Even today, it is extremely difficult, if not impossible, to predict how and at what rate an artifact, particularly one composed of metal, will deteriorate simply because there are so many variables involved. Once the professional community began to adhere to a set of standards, the probability that a project was/is treated in a manner which produces the best possible results went up dramatically.

Lack of standards/knowledge alone does not necessarily dictate whether a project is a failure. There are many other factors that affect the final product of a project. For example, no effective treatment was ever performed on *Philadelphia*. While the ship is still deteriorating, the condition in which the ship was found and the current controlled climate in which it is kept have assisted in slowing the deterioration rate. Hjortspring was treated properly according to the

standards of the day: it was kept wet until chemical conservation took place shortly after recovery. The first treatment proved to be inadequate and was washed out as soon as it became apparent that the treatment was failing. As knowledge progresses, old treatments can be corrected. Current knowledge can provide longevity even if a previous treatment was not the most successful and can also compensate for a lack of knowledge in the past.

Parties Involved in the Project

The beginning of archaeology and conservation, like many other disciplines, had its roots with men and women who were not trained *per se*, but who had real-world experience. It has only been in the last several decades, particularly when dealing with underwater archaeology, that a separation has been drawn between professionals and amateurs. Standards of practice are laid out in several places including: the UNSECO conference, guidelines of the Society of Historical Archaeology, American Institute of Archaeology, the Society of American Archaeology, the Register of Professional Archaeologists, the American Institute of Conservation, the International Institute for Conservation, and the Smithsonian Institution.

What constitutes a professional versus an amateur? Archaeological and conservation societies outline a professional as one who possesses the knowledge and experience necessary to most responsibly handle and treat the archaeological record. They also advocate the importance of following a set of ethics and standards of performance. The ethics and standards generally include:

- 1) Discouraging the buying and selling of material remains.
- 2) Cultivating the practice of accurate data collection including provenience information.
- 3) Encouraging dissemination of research in a timely manner.

4) Discouraging research done for research's sake by conducting research that adds to the knowledge of the collective.

5) Promoting public awareness.

All of these principles are put in place in order to preserve the knowledge and material culture for future generations. Archaeologists, museum staff, and conservators are self-proclaimed stewards of the materials, undertaking the responsibility to gain the necessary experience and knowledge to allow for the archaeological record to last (AIC 1994; AIA 1997; UNESCO 2001; SHA 2003; ICOM 2006; Smithsonian Institution 2007; SAA 2011; RPA 2012a; RPA 2012b).⁹

With the explanation of what characteristics a professional should embody in place, the definition of an amateur can be described as one that does not possess those characteristics. Amateurs are described by the professional community as being anything from well meaning, but ignorant, history buffs to malicious, money-hungry poachers. The characteristics that could be ascribed to them are varied and numerous and can include:

- 1) Motivations are not necessarily for research purposes that add to the knowledge of the past but rather for monetary gain.
- 2) Public interest is not a high priority.
- 3) Artifacts are generally focused on as a singular object rather than being part of an assemblage which leads to loss of information as spatial relationships between artifacts in an assemblage may provide even more information.
- 4) Though they may be aware of the long-term effects possible if no conservation takes place, they may not have the resources necessary to perform the conservation, let alone

⁹ There was no mention of specific academic degrees recommended to denote a professional by the archaeological organizations. The conservation organizations mention education in various disciplines as a necessity in order to have a rounded knowledge background.

having the experience or knowledge to judge the correct treatment of conservation that would be most suitable.

While these assessments may not be valid in all cases, archaeologists and conservators seem to have the attitude that undertaking these projects should be left up to the professionals.

American Projects:

Below is listed the parties involved in the American projects.

Ship: *La Belle*

Responsible Parties: Texas A & M University, Texas Historical Commission (Hamilton 1998; Weddle 2001:3; Bruseth and Turner 2005:40).

Ship: *Philadelphia*

Responsible Parties: Colonel Lorenzo F. Hagglund and then Smithsonian Institute (Bratten 2002:75, 86).

Ship: U.S.S. *Cairo*

Responsible Parties: Three local men: Edwin Bearss, Don Jacks, and Warren Grabau; and National Park Service (Bearss 1980:3, 104, 165; Joyner 2006:10, 12).

Ship: *H.L. Hunley*

Responsible Parties: NUMA, Hunley Commission, SC Institute of Archaeology and Anthropology, National Park Service, Naval Historical Center (Clemson University (Hicks and Kropf 2002:126, 162; Chaffin 2008:223).

Ship: C.S.S. *Neuse*

Responsible Parties: Three local men: Henry Clay Casey, Lemuel Houston, Thomas Carlyle; and County Confederate Centennial Committee (Bright et al. 1981:19).

European Projects:

Below is listed the parties involved in the American projects.

Ship: Hjortspring

Responsible Parties: National Museum (Rieck 2003:14)

Ships: Skuldelev

Responsible Parties: National Museum (Olsen and Crumlin-Pedersen 2002:24)

Ship: Bremen Cog

Responsible Parties: German Maritime Museum (Hoheisel 1985:51)

Ship: *Mary Rose*

Responsible Parties: Mary Rose Trust (2011)

Ship: *Vasa*

Responsible Parties: National Maritime Museums of Sweden (Hocker 2006c:13)

Discussion:

In general, projects that were supervised by archaeologists and involved other experts (i.e. conservators, geologists, engineers, etc.) from the start of the project tended to have better results than those supervised by amateurs. For example, both U.S.S. *Cairo* and C.S.S. *Neuse* are generally considered failures by the archaeological community (Delgado 1997:82). Both projects were initiated by locals with no knowledge of archaeological techniques. The U.S.S. *Cairo* project was started by a historian working for the Vicksburg National Military Park. He was looking for the ship using period maps and a simple compass after local accounts of the ship's position did not agree with the historical account (Bearss 1980:3). The C.S.S. *Neuse* project was started by locals as a private venture to gain a profit from selling the ship and its contents (Bright et al. 1981:19).

A professional archaeologist would more likely have the knowledge necessary to successfully recover a ship. An archaeologist would more likely have the backing of an established institution that would have a better chance of securing funding and would also have ties to other professionals necessary for the conservation and display of the ship which will lead to a more successful outcome.

Original Purpose of Project

When an archaeological site is addressed, whether by a professional or an amateur, there is an original purpose for disturbing the site. It is not always the original intention to recover the ship from a site. The decision may be made during excavation. This is true whether the original purpose was to simply recover artifacts for sale, as was the case with the C.S.S. *Neuse*, or if the original exercise was to test new techniques, as was the case with the Skuldelev site. There are many reasons for this change in purpose including: a different party taking control of the site, finding more than expected, and finding something unique to the historical significance.

American Projects:

Both *La Belle* and *H.L. Hunley* were projects that were undertaken as archaeological projects. The *Hunley* was also a matter of historical significance. For *Philadelphia*, historical interest was the main factor that led to its recovery. For U.S.S. *Cairo* and C.S.S. *Neuse*, though there was historical interest in the vessel, the main original purpose of the projects was profit through sale of the artifacts.

European Projects:

All of the European recovery projects studied were conducted as archaeological projects. In the case of the Bremen Cog, this project was prompted by dredging of a shipping lane and was conducted as a rescue operation.

Discussion:

If the original purpose of disturbing the site was to collect artifacts for sale to the public, items that are deemed unsellable or not profitable may be discarded including large parts of the vessel itself. In general, the parties that have this purpose also do not account for long-term care or conservation. Whether this is due to ignorance of the high rate of deterioration that will be present in the artifacts/ship or because they simply do not care because they do not intend to keep the artifacts, the loss of the material can be extensive.

Even if the original purpose was for archaeological study, the recovery of the ship may not have been part of the original plan. If the find proves to be a more significant find than previously thought, the purpose may change from simply excavation of artifacts to including recovery of the vessel. As a rule, archaeological projects are attended with more care and there is more attention to detail. If an amateur initiates a recovery project, they may find themselves overwhelmed. As mentioned previously, delays due to poor planning can cause negative affects to the project. In some cases, such as with both the U.S.S. *Cairo* and the C.S.S. *Neuse*, professionals took over responsibility due to ineffective handling of the project (Bright et al. 1981:19; Joyner 2006:12). Though handed over to professionals for the remainder of the project, the damage to the ships may prove to be too severe to reverse.

Securing Funding

Part of determining whether a project should be undertaken includes an accurate assessment of the cost of the project. Securing funding is necessary in order to perform many, if not all, parts of a project. There are several avenues from which to obtain funding. Private

donations, donations from organizations (both monetary and services), and government funding are all sources of funding.

American Projects:

Below are listed the funding sources for the American case studies.

Ship: *La Belle*

Funding Sources: State of Texas (small part), private funds covered the rest (Bruseh 2005:47-49); for the most part funding was secured before it was needed.

Ship: *Philadelphia*

Funding Sources: Hagglund financed the recovery and housing of the vessel until the Smithsonian took it over (Bratten 2002:77, 86).

Ship: U.S.S. *Cairo*

Funding Sources: Edwin Bearss, Don Jacks and Warren Grabau, private donations, State of Mississippi (Joyner 2006:10, 12); funding was secured as it was needed, with many delays while waiting for approval.

Ship: *H.L. Hunley*

Funding Sources: NUMA, Federal and South Carolina governments, in-kind state government services, private donations, tours of the conservation center, and private funding (Hicks and Kropf 2002:130; Monk 2006).

Ship: C.S.S. *Neuse*

Funding Sources: Henry Clay Casey, Lemuel Houston, Thomas Carlyle, donations, County Confederate Centennial Committee, State of North Carolina (Bright et al. 1981:19; Guy Smith 2010, elec. comm.); funding was secured as it was needed, with many delays while waiting for approval.

European Projects:

Below are listed funding sources for the European case studies.

Ship: Hjortspring

Funding Sources: National Museum in Copenhagen, donations to the Association of the Friends of the National Museum and the Augustinus Foundation (Bojesen-Koefoed et al.

2003:45; Rieck 2003:14). Initial funding was procured immediately with a lag waiting for the second course of conservation.

Ships: Skuldelev I, II, III, V, VI

Funding Sources: Private foundations, engineering firm Christiani & Nielsen, Ministry of Cultural Affairs, City of Roskilde (Crumlin-Pedersen and Olsen 2002). Funding was approved as needed.

Ship: Bremen Cog

Funding Sources: Bremen Focke-Museum, City of Bremen, donations (Bardewyk 1985:5); funding was approved as needed.

Ship: *Mary Rose*

Funding Sources: Mary Rose Trust, funding was nearly all donations with very little government funding, though there was some services donated (Marsden 2003:51); funding was approved as needed.

Ship: *Vasa*

Funding Sources: Donations, ticket costs for exhibit, National Maritime Museum of Sweden (Hocker 2006c:12, 14); funding was approved as needed.

Discussion:

Procuring funding is one issue that certainly should be addressed at the beginning of a project. The first step is determining an accurate estimation of costs necessary in order to know how much funding is needed. Lack of funding can cause delays in every step of the project or, in the worst cases, total failure. A lack of funding was the primary reason for the length of the recovery process for the *Neuse* (Bright et al.:20-27). Lack of funding was also why re-conservation of the Hjortspring boat could not be completed at one time (Bojesen-Koefoed et al. 2003:44).

Funding can be found in numerous places. In addition to government grants at both the local and federal levels, funding can be sought at institutions associated with the archaeologists that are the principal investigators of the project. Private donations are also an important resource that can be utilized, particularly if the project has generated a lot of public interest. For

some projects, charging admission for viewing the vessel during conservation can also raise funds.

Conclusion

Several other factors affecting a project's outcome from those listed by van der Heide are evident when studying the case studies used in this thesis. Not addressing these factors, as well as the others, can cause unnecessary harm to archaeological materials and an increased rate of deterioration. While there may be additional and unique problems that become apparent in studying other projects, the issues discussed in this thesis are the most common. The evaluation of which factors have a greater impact than others will be answered in the next chapter.

CHAPTER TEN: FINDINGS AND CONCLUSION

Introduction

Archaeological sites are a precious and limited resource for gathering information about the history of humanity. Most, though not all, archaeological sites contain mostly the discarded aspects of human culture. Refuse piles, privies, discarded equipment and weapons, and items that were lost are the items that comprise most archaeological sites. The full picture is rarely seen and may be only pieced together through comparison of several locations.

Ship sites are unique as they represent a site that is a singular event. However as Ernle Bradford said:

No archaeological land-site is ever likely to be as perfect as a ship which has sunk at a given moment and place, with all her life intact about her, and with only the ordinary detritus of subsequent centuries lying above her. Cities and palaces get changed, get built upon, get ransacked, get forgotten as the houses and villages of later men spring up on the same site; but a ship encapsulated in the ocean, preserved by her lonely environment, suffers little. (107)

Ship sites, particularly wrecking sites, can provide a snapshot of daily life. All the material culture associated with a sailors' lifestyle, the type of food they ate, even their religious beliefs can be discerned from the artifacts found on a ship site. This explains why so many underwater archaeology authors advocate preservation of ships.

The increasing number of sites that are being located coupled with the limited resources available to allow excavation, recovery, and conservation of the sites (both artifacts and the ships

themselves) lead to the question of which sites to address and which should be preserved *in situ* to await a time when further study may be possible. Whether the ship is preserved *in situ* or is excavated and then recovered steps must be taken to limit the damage that is done to the ship in the process. If the decision is made to recover a ship, the potential threats to the vessel increase dramatically. The several factors discussed in this thesis are all important and affect the outcome of a recovery project.

The Issues

Many of the issues discussed in the thesis were listed in G.D. van der Heide's article "Wrecks as Ancient Monuments," one of the first works to discuss the issues associated with the process of ship recovery. The other issues became apparent through examination of case studies. Many of the issues are interconnected because they deal with similar aspects or one affects the details that another issue encompasses.

Assessing Value and Estimating Costs

One of the first questions to address when confronted with the possibility of recovering a ship is whether it should in fact be recovered. There are more sites found than there are resources to deal with them. The question becomes: which sites should be excavated, which recovered, and which preserved *in situ*? The idea of the value of a site/vessel is extremely complex. There are many factors that are taken into consideration when determining value including: significance to both the public and professional communities, the estimated cost (including projected long term costs) of the project, and the effort/difficulty involved. This process is, without a doubt, unavoidably subjective. As part of determining the value of a

particular project, an accurate assessment of the cost is extremely important. An estimate of costs can include: personnel, excavation, recovery, conservation, long-term storage and or display (which should also allow for inflation), and transportation.

Dealing with Water on Site

When planning a project involving a waterlogged site, the presence of water on the site must be taken into account. The site can either be worked as a wet site or as a land site by removing the water from the site. It may be decided to remove the water from the site because of the difficulties associated with working in the underwater environment such as the water conditions. Other factors may go into this decision including: the fragility of the find, the availability of equipment and depth of the site.

Keeping the Ship Wet

To limit the deterioration that affects a waterlogged ship, the materials must be kept hydrated until conservation can occur. If the ship site is treated as a wet site this is a concern that is only necessary after the ship is out of the wet environment. If the site is treated as a dry site, a system must be put in place to ensure that the ship is kept hydrated. The reason the materials must be kept hydrated is to limit irreversible damage to the artifact. Once an artifact dries the effectiveness of conservation treatment is greatly diminished, even if the object is re-wet.

Removing the Ship from the Site

After excavation of a ship site the decision may be made to recover the remnants of the ship itself in order to preserve it. If the ship is recovered, the method is dictated by many factors

including if water was removed from the site and the condition of the ship itself. The way it is removed also influences how the ship is transported.

Transporting the Ship

If recovered, a ship must be transported away from the site to a location where either the vessel is stored or conserved. The method of transport for a ship is dictated by where the site was located and how the ship was removed from the site. Sites in remote locations may make the logistics of transport more difficult. The same factors that dictate how a ship is recovered have to be taken into consideration when planning transport.

Accommodating Conservation Work and Visitors

Many details must be taken into account when choosing a location for conservation. The location must have space for the vessel, the storage of chemicals, and for workers. The location must allow for storage of archaeological materials before, during, and after conservation; disposal of chemicals; and it must be available long term. The needs for each individual project must be taken into account when choosing a location. In addition, the location should allow for public visitation during the process of conservation in order to allow for public awareness and promotion of not only the museum/ship, but also of archaeology and history as a discipline.

Choosing Conservation Treatment and Facilities

Facilities appropriate for the conservation of a ship must be tailored to the particular project. One of the most important considerations is the conservation method that is chosen. The conservation method is determined by the type of material and the condition of the material

that is to be conserved. For example, if the ship is fragmented, the space could be different than if the vessel was in one piece. If the material is wood versus iron, different equipment is needed and the space must accommodate this.

Time Period the Project Occurred

One theory is that the older a project, the less technological knowledge and standards would be present in the project, and therefore, the less successful the project. However, this does not seem to be the case. There does not seem to be a correlation between the time period and the success of the project. Though it is true that knowledge was not as advanced as it is now, this may or may not have had a detrimental effect on the project. The same is true for standards of practice.

Parties Involved in the Project

The party that undertakes a project can have a huge impact on the methods that are used throughout a project and how it is conducted. An amateur may be ignorant to the damage that can be done to the materials by not taking proper care when removing them from the site or neglecting conservation after recovery. An amateur may also not have the necessary funding to complete the project and may have to stop in the middle. A professional should have the knowledge to properly and safely address the site and artifacts, up to and including recovery of the vessel. They also have contacts that can allow them to provide the proper after treatment for the artifacts. In addition, most professionals have associations with institutions that have the ability to secure funds for the project.

Original Purpose of Project

For a professional, the purpose for recovering the ship would be to learn about the past. With an amateur this is not necessarily the case. Though not always true, it is common for laymen to recover artifacts to sell, or simply for the pleasure of owning it. In other instances, a love of history is what drives an amateur to recover artifacts. Unfortunately, far too many do not have the knowledge necessary to properly excavate, recover, and conserve the vessel. Without experience, valuable information can be lost and irreparable damage can be done to artifacts.

Securing Funding

A project cannot happen if funding is not secured. An assessment of the costs associated with the entire project including long-term care should be made as soon as possible in order to secure sufficient funding. If this funding is not secured, it may be necessary to halt the project. By securing funding early in the process, potentially harmful delays can be prevented.

The Most Crucial Factors

There are few factors that can be considered crucial to a project. Though one would think that the time period in which the ship is recovered would have the greatest influence on the outcome, the case studies show that this is not necessarily the case. Methods may improve over time and different techniques adopted, but conservation treatment was generally performed to the standards and technology of the day. When conservation methods began to show problems (i.e. continued deterioration, precipitate of chemicals on the surface, flaking of the outer surface, etc.), they could be reversed and re-conservation could occur, not allowing the ship(s) to be greatly damaged in the process.

A greater factor in the successful outcome of a project is who was involved with the recovery. If someone who was not well versed in archaeological excavation and recovery initiates a project, much information is generally lost. The general public may not realize that spatial connections between artifacts are important or they may not understand why it is necessary to keep waterlogged artifacts wet. An example of the public's ignorance to proper archaeological investigation was apparent when the *Cairo* project was undertaken. Artifacts were brought up at an alarming rate and volunteers started cleaning everything in an attempt to make them look clean and uncorroded; they did not understand that the contents of bottles may provide information as to the lifeways of the crew, or that cleaning a glass negative which had a picture on it would destroy the image (Joyner 2006:3). A well-meaning, but uninformed public can inadvertently destroy more information than they save. While it seems that barring the public from the site may be an option that would alleviate this problem, on most sites, funding shortages might make volunteers a necessary evil. The damage can also continue long after a recovery. If proper actions are not taken to conserve the artifact, it will eventually be destroyed. When the artifact consists of something like an entire ship, the damage can be even more pronounced as the weight, size, and complexity of the ship make recovery and conservation more difficult. The knowledge of experts in the various areas relating to the excavation, recovery, and conservation of a ship are invaluable when undertaking such a momentous task.

If a professional considers a project, the first thing to determine is value. Does the ship project merit the time, effort, and cost that it will demand? The professional will invariably always answer yes to this question, but providing the justification for this is more difficult. As discussed earlier, value can be measured in many ways and it is extremely subjective. The historical significance of a vessel needs to be determined. Public interest can be a large factor,

especially when securing funding. The scientific aspects of the project are also extremely important. Several questions must be answered: Can the ship answer any significant questions? How complete is it and what condition is it in? Is the ship type rare or are there already examples of it available? How much will the project cost, including: personnel needed, equipment needed, projected excavation time frame, projected method of recovery, possible conservation treatments, conservation and storage space, and long-term display options? Are there any factors that make the site unsuitable for *in situ* preservation? All of these questions need to be answered to determine whether a ship should be recovered.

Once it is decided to recover a ship, the most important factor is acquiring funding early in the project. Funding seems to be the one factor that has the most influence on all the other decisions. As discussed above, not having funding in place can cause devastating delays in every aspect of a project. The best case scenario when funding is lacking is a holding pattern, as was the case with Hjortspring (Bojesen-Koefoed et al. 2003:44). Having sufficient funding already in place also allows more flexibility for altering of plans if necessary.

The other eight issues listed in this thesis can be compensated for if proper planning and funding are in place before the project begins. If one recovery plan is not working, the contingency can be used or another plan drawn up. If conservation is proving inadequate, a new method can be found. Adapting to dynamic situations is another reason why having experts in the various fields relating to the project is vital. These factors are all interdependent, all decisions affect all other decisions, and if not handled well, mistakes are compounded.

Conclusion

Science is often improved by making mistakes (Platt 1964:350). The ten projects studied in this thesis have shown many examples of problems that could have been prevented by proper planning or that would have benefited from the expertise of a professional. Knowing whether a ship has enough value to be worth the time, effort, and cost of recovering rather than preserving it *in situ* is extremely important. Having a plan in place and proper funding are two things that can only increase chances of success. G.D. van der Heide and many others believe that shipwrecks are a unique and important piece of history that should be studied to learn that which might not otherwise be available. By dealing with issues as early as possible, and by utilizing the wisdom gained by past attempts, future endeavors will have an increased chance of being successful, which will provide tangible, lasting examples of the history and innovation of the past.

APPENDIX:

ORGANIZATIONS

The following is a list of professional organizations that have a code of ethics and/or a set of professional standards which archaeologists, museum staff, and conservators are expected to adhere to:

-American Institute for Conservation of Historic and Artistic Works (AIC)
(<http://www.conservation-us.org>)

-Archaeological Institute of America (AIA) (<http://www.archaeological.org>)

-International Council of Museums—Committee for Conservation (ICOM-CC)
(<http://icom.museum/>)

-International Institute for Conservation of Historic and Artistic Works (IIC)
(<http://www.iiconservation.org>)

-Register of Professional Archaeologist (RPA) (<http://www.rpanet.org>)

-Smithsonian Institute (<http://www.si.edu>)

-Society for American Archaeology (SAA) (<http://www.saa.org>)

-Society for Historical Archaeology (SHA) (<http://www.sha.org>)

-United Nations Educational, Scientific, and Cultural Organization (UNESCO)
(<http://www.unesco.org>)

The full codes of ethics and sets of professional standards for each organization can be found on their websites. They are similar for the most part and include the following basic tenants:

1. A professional should not encourage the sale, trade, or purchase of cultural material.
2. A professional should encourage public awareness of cultural heritage.
3. A professional should strive to disseminate research materials in a timely manner.

4. A professional should advocate and encourage the long term preservation and care of sites and collections.
5. A professional should ensure that accurate data is collected during investigations and that this information is properly curated for future research.

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