Abstract

FIRE IN THE HOLD:

CONSTRUCTION AND USE OF THE 1628 SWEDISH WARSHIP *VASA*'S GALLEY

by

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The galley of the 17th century Swedish warship *Vasa* is currently the only large 17th century naval galley available for study. It was surveyed by the author in 2008. While the galley's wooden structure remains largely intact to the present day, its fittings and layout are much changed. A digitally-aided reconstruction shows how it was filled with bricks, and that its large cauldron likely hung from a crane suspended from the aft wall.

Documentary sources place the galley closer in historical context to a medieval terrestrial kitchen than to a 17th century kitchen. The galley's smoke bay is much the same as those installed in country houses during the centuries preceding *Vasa*'s construction. In the final analysis, *Vasa*'s galley is an inexpensive construct, valuing frugality over convenience. Yet, it would have been suitable to cook the sort of provisions provided to the crew by the Swedish Navy.

FIRE IN THE HOLD:

CONSTRUCTION AND USE OF THE 1628 SWEDISH WARSHIP *VASA*'S GALLEY

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CONSTRUCTION AND USE OF THE 1628 SWEDISH WARSHIP *VASA*'S GALLEY

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DEDICATION

Dedicated to the crew of *Vasa*, to her cook, and to all those in peril on the sea.

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CHAPTER 1: INTRODUCTION

People need food to live. This need does not diminish at sea, nor has basic need for sustenance changed through the centuries. The 1628 Swedish warship *Vasa* provides a unique opportunity to reconstruct a 17th century warship's galley – the only such structure available for study today. Discovering the means by which sailors were fed can help illuminate the complex social structures aboard ships, as well as what the shipbuilders and naval officials thought about their crews.

"A Cook they hadde..." Chaucer wrote in the fourteenth century. "He coude roste, and sethe, and broille, and frye," (Chaucer 2008:29) as well as boil chickens and bake pies. This portion of the *Canterbury Tales*' prologue goes on to explain which spices the cook brought along, and even hints toward his recipes. While techniques – the same we use today – are named, they are not explained. One knows, presumably, how to boil.

This difference between technique and recipe is important. A cookbook (or Chaucer) could tell modern readers that a chicken was boiled, but if one wants to know how, they will be disappointed. For the most part, archaeological studies of kitchens are needed to determine the physical aspects of cooking.

For many reasons, little is known about the historical methods of cooking aboard ships. Galleys are frequently buried in the depths of a shipwreck, under layers of debris, but not so deep that they are typically found preserved on a wreck. This combination of factors means that very few galleys exist in shipwreck sites. Furthermore, since research begets like research, the lack of published sites means that little is available on which to build. Last, they are prosaic. There is little written in the historical record of the humble galley.

Vasa presents a special opportunity to shed light on galleys of the early 17th century. There are no other large 17th century naval galleys available for archaeological study. Archaeologists are fortunate with *Vasa*, as the level of preservation is extremely high. The wood that would decompose at many sites survived intact thanks to the frigid, anoxic waters of Stockholm harbor. No aspect of marine casualty managed to destroy *Vasa*'s galley, as happened to the warship *Kronan*. While the galley was not found exactly as the fleeing sailors left it (a stanchion had fallen, many artifacts had shifted to port, and the iron had disintegrated), the structure itself was substantially intact.

Vasa: Building and Disaster

From the time of his coronation in 1611, Sweden's monarch, King Gustav II Adolf, had many worries. His rule was imperilled by his cousin Sigismund, King of Poland. His country and its wealth of timber and metal was threatened by foreign powers (Hocker 2006:38).

Gustav Adolf's first decade as king was characterized by turbulent foreign relations and near-continual warfare. By 1621, Sweden had been at war with Poland, Denmark, and Russia. A brief period of peace allowed the king to strategize and prepare for future wars. Gustav Adolf and Axel Oxenstierna, his chancellor, decided to create peace by offensive. A series of forward assaults would create a buffer with which the Swedes could defend their country. It would also increase the tax base – an important consideration when expanding the military (Hocker 2006:38).

In 1621, Gustav Adolf sent 13,000 soldiers across the Baltic to capture the city of Riga (now in Estonia). This style of amphibious assault, in which the navy supported the army in siege warfare, continued for the next several years. These actions eroded the Danish presence in the Baltic and threatened Poland. In response, both countries began expansions of their own, further destabilizing the political situation on the continent (Glete 2000:127).

With both Poland and Denmark knocking at Sweden's door and the continental situation increasingly perilous, Gustav Adolf and Oxenstierna began a modernization project of both the army and navy. This project also entailed modernizing the Swedish state itself, bringing its administration out of an inefficient medieval era. The political modernizations included overhauls of the universities and aristocracy. The clergy was to furnish an account of men available for military service – Europe's first effective conscription program (Hocker 2006:38).

The navy's role during this period of expansion and Swedish power was primarily one of support: transporting troops, blockading enemy ports, and supporting amphibious operations (Glete 2001:201). Despite some initial forays in the late 16th century, naval line tactics were still in their infancy, and so fleet actions primarily consisted of vast melees (Hocker 2006:39).

Before the reforms of Gustav Adolf, Sweden's navy was mostly made up of small ships. Gustav Adolf embarked on an ambitious campaign to build large ships that would carry multiple decks of heavy guns. Hocker (2006:39) characterizes this as the response to a different sort of threat. While a small ship navy can provide broad protection against pirates and commerce raiders, a large ship navy intimidates foreign powers intent on occupation. The first of the ships built under the new plan was named for Gustav Adolf's family: *Vasa*.

By the time *Vasa*'s keel was laid, the Stockholm shipyard employed over 300 craftsmen. These workers did not work for the King, but rather for a contractor employed by the king. This system, called an *arrende*, gave the contractor control of the shipyard as well as an annual sum of money. The contractor was responsible for all administration, as well as purchasing material, hiring employees, and providing maintenance craftsmen (Hocker 2006:40).

The *arrende* under which *Vasa*'s hull was built was effective as of January 1626. It was made with Dutch shipwright Henrik "Hein" Hybertsson and his brother Arendt de Groot. The arrende was valid for five years, during which Hybertsson and Arendt were to build four ships for the crown. Other *arrendenn* covered *Vasa*'s rigging and guns (Hocker 2006:41).

While Henrik Hybertsson was master shipwright on the *Vasa* project, he delegated actual physical construction to two men: Henrik Jacobsson and Johan Isbrandsson. In 1626, failing health led to Hybertsson's resignation, and he died in May 1627. Officially, his wife Margareta Nilsdotter became the shipyard's manager, but in reality Arendt managed the yard's workings.

It is impossible to determine an exact timeline for *Vasa*'s construction. When Hybertsson abdicated his post in the summer of 1626, Hein Jacobsson attempted to widen the ship. He stated in the post-sinking inquest that the ship was too far along to widen as much as was necessary. Hocker (2006:46) suggests that this means *Vasa* had been planked to the turn of the bilge and that the floor timbers were in place.

When the ship was launched (likely spring 1627), it was complete at least as far as the upper gundeck. Superstructure, rigging (including stepping the masts) and interior fittings (probably including the galley) could be built while the ship was in the water. In the spring of 1628, the ship was almost finished. It was towed to the royal palace on Stadsholmen, the royal armory. At the Tre Kronor palace, the ship was finished and armed (Hocker 2006:47).

Shortly before *Vasa* took its maiden voyage, a stability test was performed for Admiral Klas Fleming, commander of one of Sweden's larger naval squadrons. Briefly put, the ship did not fare well. Thirty sailors were tasked with running back and forth across the upper deck. After just three trips, the ship was rolling enough to concern Admiral Fleming. He had the test stopped for fear that *Vasa* would capsize even before it set sail. Unfortunately, no one in Stockholm had the authority to stop the ship's sailing; the king was sending letters ordering the ship put to sea. Admiral Fleming and the ship's captain, Söffring Hansson, knew the ship was unsafe, but could do nothing about it (Hocker 2006:53).

In July 1628, *Vasa* was assigned to the reserve squadron at Älvsnabben, in the archipelago south of Stockholm. When *Vasa* sailed, this squadron consisted of four large ships, all of which were in Stockholm. One – *Äpplet* – was still under construction. Most of the ship's crew and provisions would be loaded at Älvsnabben. Of the roughly 430 (300 of whom were soldiers) persons comprising *Vasa*'s crew, only about 130 sailors were needed to take the ship from Stockholm to Älvsnabben. Many were conscripted men with no experience, led by a corps of professional officers (including a cook) (Hocker 2006:52).

When *Vasa* sailed on 10 August 1628, the ship was not fully crewed. The soldiers were at Älvsnabben, but most of the ship's sailors were probably aboard. There was a second captain, Hans Jonsson, who had originally been slated to command *Vasa*. Admiral Eric Jönsson, the commander of the Älvsnabben squadron, was also aboard. Finally, the crew were allowed to have family and friends aboard from Stockholm to Vaxholm (Hocker 2006:53).

On the afternoon of 10 August, *Vasa* was cast off and warped along the shore. Once far enough to the south, the ship could set sail toward Beckholmen and thence out toward Vaxholm. With the wind on its quarter, *Vasa* fired a salute. As it edged out from behind the harbor's bluffs, the wind increased and the ship heeled. The sheets were let go, and the ship righted itself. A gust pushed the ship farther to port, submerging the lower gundeck ports. The helmsman attempted to steer the ship out of the gust, but to no avail. The water continued to rush in through the port side of the gundeck (Hocker 2006:53).

Admiral Jönsson went below, attempting to haul guns to windward so that the ship might be saved. The rising water forced him to return to the weather deck, though he nearly drowned. During the sinking, the ballast shifted to the hold's port side, which must have hastened the ship's demise. It reached the bottom in 18 fathoms with a port list, its main topmast still above water. There were likely about 30 casualties, though their identities remain a mystery even today (Hocker 2006:54-55).

It did not take long after *Vasa*'s sinking for an inquest to begin. The investigation was a dance of blame-shifting and finger-pointing, as could be expected for such a costly failure. The shipbuilders and the officers blamed each other, and both sides occasionally brought God into the mix (it was the boatswain's defense that he was at Communion, and the builders asserted that "only God knows" why *Vasa* had foundered). In the end, no verdict was recorded, and everyone returned to their work – except for Arendt de Groot, who briefly returned to Holland. Margareta Nilsdotter managed the shipyard until the king ended the contractor system for building ships at the end of 1628 (Hocker 2006:56-58).

Vasa Submerged

For the next 333 years, *Vasa* remained submerged in Stockholm harbor, despite several salvage attempts. These attempts began three days after *Vasa*'s loss, with an English engineer attempting to raise the ship. He did not succeed, but he managed to right *Vasa* onto its keel. Salvage attempts continued without success until 1663, when a salvor named Hans Albrecht von Treileben obtained a permit to salvage *Vasa*'s guns. Treileben and his partner, Peckell, planned to use a diving bell to reach the ship. They began diving in 1664, and raised the first gun on 1 April 1664. By 1665, Treileben's operation had salvaged most of *Vasa*'s armament, and had removed much of the weather deck (Hafstrom 2006:68-92).

Between 1665 and 1961, the ship was not "lost," as is so often reported, but was known throughout the period. It was known to Anton Ludwig Fahnehjelm, who applied to dive on the wreck in 1844, and to the makers of a 19th century harbor chart, who showed the wreck's position (Cederlund 2006a:117). Further ineffective salvage attempts were carried out sporadically through the early 20th century (Cederlund and Hocker 2006a:130).

In the 1950s, Anders Franzén started a personal project to research and locate Sweden's 16th and 17th century wrecks, including *Vasa*. He developed a partnership with the Swedish Navy which gave him access to dive training and assets. Franzén developed a system of locating wrecks, involving a coring device that would raise pieces of wood if dropped onto a wreck.

In 1956, Franzén entered into a partnership with Per Edvin Fälting, a civilian diver. Together, they searched off the docks at Beckholmen, where charts suggested there were raised spots on the bottom. On 25 August, they located a large oak shipwreck off the Gustav V dock. Dives commenced on the wreck site at the beginning of September, and the ship was immediately revealed to be substantially intact and heavily decorated. The navy provided support, finances, and equipment from the beginning. Fälting and three other divers created an airlift and used it to clear the wreck of mud. Rather than attempting immediate salvage, the dive team concentrated on recording the wreck (Cederlund and Hocker 2006a:180-181).

On 18 November 1956, the foremast, which had been standing *in situ*, was salvaged. A painted figure on the mast was destroyed in the process, though it was sketched and photographed before destruction. Five days later, divers recovered the first small artifacts from the ship: some bones and a button. At this point, it was not certain that the wreck was *Vasa*, merely likely. Fälting led a search for conclusive identifying artifacts, but found none in the first season. While there was considerable debate during 1956 as to the identity of the wreck, a consensus had been reached by the end of the year, mostly through exclusion. There were no other large warships that could have been in that site (Cederlund and Hocker 2006a:182-184).

By the end of 1956, plans were well underway for lifting *Vasa*. Neptunbolaget, a salvage company, provided the lifting power, while divers were to dig tunnels under the ship for slings. The ship would be lifted intact from the bottom – essentially the method that was attempted in 1628 (Cederlund 2006b:207).

Vasa had to be cleared of debris and rubble before it could be lifted. This involved airlifts and documentation, a stage that was mostly complete by the end of 1957. A tunnel was dug with a water jet to test the strategy of burrowing under the ship. This was started at the end of the 1957 season, but had to be finished in 1958. The first tunnel was successful, so others were dug in 1958. The tunnels were dug straight down the side of the ship to the bilge, where they turned to follow the hull until the keel. To mitigate risk, tunnels were limited to 75cm wide and 75-100cm high (Cederlund 2006c:235-236).

Finds were marked underwater with copper or paper tags, some of which are still attached to timbers. Many early finds were located during the tunnelling process, including the two small boats found next to the ship. By the end of 1958, 485 dives had been made on the wreck, with 371 finds (Cederlund 2006c:252). On 29 July 1959, the tunnels were complete.

The Neptunbolaget lifting operation started on 13 August 1959. Slings were pulled through the tunnels, and secured to two surface pontoons, one on either side of the wreck. *Vasa* came free of the bottom with minimal lifting, and was towed underwater in a series of lifts to a position off Kastellholmen. The new location was about half the depth as the previous hole, and so it would be easier to prepare the ship for its final lift to the surface.

The time *Vasa* spent at Kastellholmsviken was spent cleaning and documenting the ship, as well as planning the final lift. The plan eventually settled upon was to raise the ship as it lay on the bottom, and then excavate once it was on the surface. Even with this plan, *Vasa*'s weight had to be reduced, and it had to be made mostly watertight.

To reduce the weight and allow for structural reenforcement, the upper gundeck was cleared in 1960. It was covered by beams, deck planks dislodged by salvage attempts, blasting rubble, and more than thirty anchors. Further diving in 1960 concentrated on the wreck site, where many more finds were recovered.

The ship was made watertight by covering gunports, plugging boltholes, and filling plank gaps. A temporary transom was constructed to seal the stern. The sealing operation was completed by 29 March 1961, and the ship broke the surface on 24 April, after 333 years underwater. This moment marked the end of one era for *Vasa*, and the very beginning of the next – archaeological examination and conservation.

Vasa Since 1961

Since 1961, *Vasa* has been the subject of a large conservation and archaeological scheme. As soon as *Vasa* was above the surface, eleven archaeologists began to excavate the ship under the direction of Per Lundström, who would later become director of the National Maritime Museum. Most of these archaeologists were young, students or new graduates. One of these archaeologists, Carl Olof Cederlund, was promoted to curator in 1965, and to senior curator at the National Maritime Museum the next year. He is also the primary author of *Vasa I*, the chief source on *Vasa*.

During the excavation, stainless steel find tags were tacked to timbers for identification. Most of these exist today, though some are barely readable. During initial stages of excavation, drawings were made on waterproof paper, and more than 2400 photographs were taken (Cederlund and Hocker 2006b:299). A sprinkler system ran over the ship to keep finds and timbers from drying out. Over the next months, the ship was excavated and cleaned, with work moving from upper gundeck to lower gundeck to hold, and finally, orlop.

As the hold was being excavated, *Vasa* was moved from the drydock at Beckholmen to the Beckholmen canal. Much of the hold, and all of the orlop, were excavated while *Vasa* was in the canal. The galley was the first space excavated in the hold commencing on 14 June 1961. The large galley cauldron was found 28 June (Cederlund 2006e:361).

By the end of September 1961, excavation was finished and conservation work began in earnest. A temporary house was built over *Vasa*'s pontoon, which served as the museum's ship hall for 27 years. The ship was rebolted to replace the original, but now corroded, iron bolts with more sturdy fasteners.

In 1962, the process of spraying the hull with polyethylene glycol (PEG) started. The ship was sprayed by hand until 1964, when an automated spraying system was installed. Restoration work began – the task of reattaching loose timbers to the ship. This task continued well into the 1970s, and in fact still continues to a certain extent.

The ship hall was expanded in 1968, as the reconstructed ship turned out to be too big for the hall. *Vasa* moved again in the late 1980s to its new home on Djurgarden. The new museum opened in 1990. It houses museum staff, most of the artifact collection, and, of course, the ship itself. A new climate control system is the latest effort in the long conservation process.

The Galley

Apart from the drawings and photographs made during excavation, little attention was paid to the galley in the 47 years between the excavation and the summer of 2008. This is understandable – there have been many worthwhile topics of study, enough for many lifetimes. It was my hope to re-record *Vasa*'s galley with modern techniques and equipment, and to give it the sort of archaeological analysis it has lacked.

Vasa's galley is unique. There are no other 17th century warship galleys available for study. It arrived at the *Vasa* Museum little changed since it was built – a galley "as delivered" by the shipyard. Indeed, it is unclear if the galley fire was ever lit. In that case, the question is obvious: why study it? The answer is simple. The need to eat is among those basic, life-sustaining needs. Archaeologists believe that study of past structures can shed light on the thoughts and beliefs of the builders, and so too it is with *Vasa*'s galley. Examination of the galley can, I believe, help to reveal what the naval and shipyard personnel thought about eating aboard Sweden's newest, most technologically advanced warship.

Scope of Project

The project covers *Vasa*'s galley, and the artifacts associated with it. Construction and design of the wooden and brick structures were analyzed, as was the historical context and the larger cooking-related artifacts found in the galley. The project does not cover sailors' personal food-related artifacts, nor does it cover small ceramic or glass finds from the galley collection. While it is tempting to examine galleys from multiple cultures and centuries, comparisons are undertaken only insofar as they create an historical context for *Vasa*'s galley.

It is not my intention to answer universal questions of cooking in the 17th century, though this work will likely be helpful for research in that direction. Nor is it my intention to answer questions about what *Vasa* sailors ate. That was the subject of a 2006 doctoral dissertation by Ulrica Söderlind (Söderlind 2006). Instead, I focus on how the galley was built and how it was intended to be used. When this information is combined with the available historical sources, it can shed light on how, rather than what, the *Vasa* sailors may have cooked.

Objectives

Current knowledge of 17th century shipboard cooking is extremely limited. Other than *Vasa*'s, there is no surviving large warship galley from the period – at least not one which has been archaeologically published. This was the salient reason for studying *Vasa*'s galley structure. With this in mind, this thesis will explore two questions:

1) How was the galley structure constructed, and how did it work?

2) How was the galley structure used to prepare food aboard *Vasa*?

In support of these questions, several subquestions were asked: Was the galley used prior to *Vasa*'s sinking? Why was the galley located where it was? Are distances and heights of cooking surfaces and utensils commensurate with the anthropometric data from *Vasa*'s skeletal remains – in other words, does the galley structure fit the people who would have used it?

In the final analysis, *Vasa*'s galley is a simple structure, without the cooking amenities developed in the several centuries before it was built. It resembles nothing quite so much as a medieval terrestrial kitchen, and suggests that *Vasa*'s builders, at least in the case of the galley, preferred to save cost over providing a well-featured kitchen.

CHAPTER 2: A HISTORICAL CONTEXT FOR *VASA*'S GALLEY

Introduction

This chapter is an examination of the technological context in which *Vasa*'s galley existed. Since details of comparable naval galleys have not been published, this chapter attempts to describe the general state of cooking technology in Europe around the early 17th century. It is not the attempt of this chapter to discuss every method or structure that might have been used to cook food at the time, nor is it an attempt to fully summarize culinary technique and ingredients. Instead, it is an overview of several contemporary kitchens in the archaeological and historical records. By examining contemporary kitchen technology, a more complete picture may be developed of *Vasa*'s galley design philosophy and possible inventory of accouterments.

No description of a 17th century naval galley has been published by archaeologists. While a similar structure likely exists, it is still awaiting discovery and excavation. Galleys from other ships of the 16th and 17th centuries, where available, will be discussed later in this chapter, along with a discussion on placement of the galley.

Since maritime kitchens are sparse in the historical and archaeological records, contemporary terrestrial kitchens provide a basis for study and for context. While certain realities of cooking at sea may modify technique, the basic concept of cooking – applying heat to food – remains the same both on land and at sea. Thus, terrestrial kitchens can shed light on galley design decisions and tool arrangement.

Unfortunately, most books covering the last thousand years of cookery feature the ingredients and recipes far more than they feature the kitchen technology. The 18th century is widely studied, but the 16th and 17th centuries have been neglected, likely due to a lack of sources. Many kitchens from dwellings of that time do not survive to the present, making it difficult to study the intricacies of a kitchen's layout. However, enough sources have survived that an idea of kitchen development can be conceived, and to show that while development was not rapid, there was a slow progression of design improvements.

Terrestrial Kitchens

"I shall now turn to an examination of every sort of implement, device, and furnishing proper to a kitchen..." – Bartolomeo Scappi (Scully 2008:122)

The development of the European kitchen from the medieval period into the early modern era is characterized by increasing complexity and isolation: from an open fire in the middle of a one-room hall to a separate room with stone hearth, firebox, oven and chimney. Unfortunately, there are not many surviving kitchens, so it is not easy to construct a definite timeline of cooking technology. Instead, kitchen development must be looked at as a spectrum, as features are introduced or removed from structures.

Medieval Kitchens

As with so many other aspects of medieval history, written records of kitchens are scant and chiefly apply to royalty and other high-status individuals. Occasionally, depictions of cooking appear in art. Many other references to cooking are incidental, written as asides or sidenotes to a text about other topics.

The medieval kitchen consisted primarily of an open fire built in a hearth, in or above which a cauldron rested. In nearly all houses owned by the non-nobility, this fire was in a main room, rather than in a separate room or compartment (Redon et al. 2000:16). Castle kitchens in the archaeological record were detached from the rest of the building – unless there was no room for a separate building – and had their hearths in the center of the kitchen room. Kenyon notes that kitchens were integrated with the rest of the castle building at the end of the middle ages (Kenyon 2005:139).

In addition to the heat above the fire being used for boiling, the heat that radiated from the side of the fire was used extensively to heat saucepans resting on trivets (Henisch 2009:36). Archaeological evidence from Sandal Castle in West Yorkshire shows pottery blackened on only one side, suggesting that it was consistently placed to the side of the fire when in use (Steane 1985:269-270). A reference from the early 13th century suggests that the hot hearthstones were used to cook cakes or flatbreads – "Her cake is burning on the hearthstone, her calf is sucking up all the milk, the earthenware pot is boiling over into the fire..." (Henisch 2009:30).

Baking was accomplished in ovens, but they were not usually owned by individual householders. Instead, bread was purchased from outside bakers or made in a small improvised oven by placing a domed lid over a plate. This assembly was set in hot ashes, and was sufficient to cook small items. Pastries were used as makeshift ovens as well, with the pastry itself sometimes cast away after use (Henisch 2009:124).

Remarkably, in her extensive study of the medieval cook, Henisch (2009) finds no example of protective gloves used during the period. She notes that illustrations sometimes show towels that could have been used for protection, and that 15th-century servers were also told to use slices of bread as potholders (Henisch 2009:194).

<u>Early Modern Kitchens</u>

By the early modern period, kitchens were beginning to evolve beyond the medieval form. In the early 17th century, just as *Vasa* sailed, a French kitchen might have an elevated portion of the hearth for cooking soups. It might also have a portable oven, and a chafing dish for preparing more complicated food than was allowed by the relatively crude medieval methods (Wheaton 1996:101).

Fireplace design began to evolve, as well. Brick replaced stone, and fireplaces sank farther into the wall with the advent of higher chimneys. By the 16th century, some fireplaces had iron firebacks installed between the brick or stone and the fire. The firebacks, which were sometimes richly decorated, protected the fireplace from damage (Pounds 1994:115).

In 1570, Bartolomeo Scappi, personal chef to the Pope, wrote a treatise on cooking and kitchens: *Opera dell'arte del cucinare*. This treatise remains one of the major sources on 16th century cooking and kitchens. He advocates setting fireplaces into the walls on lower floors, and making sure that there are large windows for ventilation and light. In the fireplace itself, Scappi advocates setting iron fastenings into the wall onto which chains may be attached, below which were movable chains for the cauldrons. Scappi also suggests large water tanks, raised areas for frying pans, and plank shelves. Near the shelves should be, he writes, hooks for hanging meat and fowl (Scully 2008:100-101). One of Scappi's illustrations for an ideal kitchen (complete with smiling, waving cook) is reproduced as Figure 2-1.

Heat from the hearth was a major concern for Scappi. He writes that a kitchen should have a short wall protecting the cook from the heat of the fire. That way, the person turning the spits and managing the roasts could avoid burns and discomfort. He also advocates a grill be set up such that it protects the fireplace wall from intense heat (Scully 2008:102).

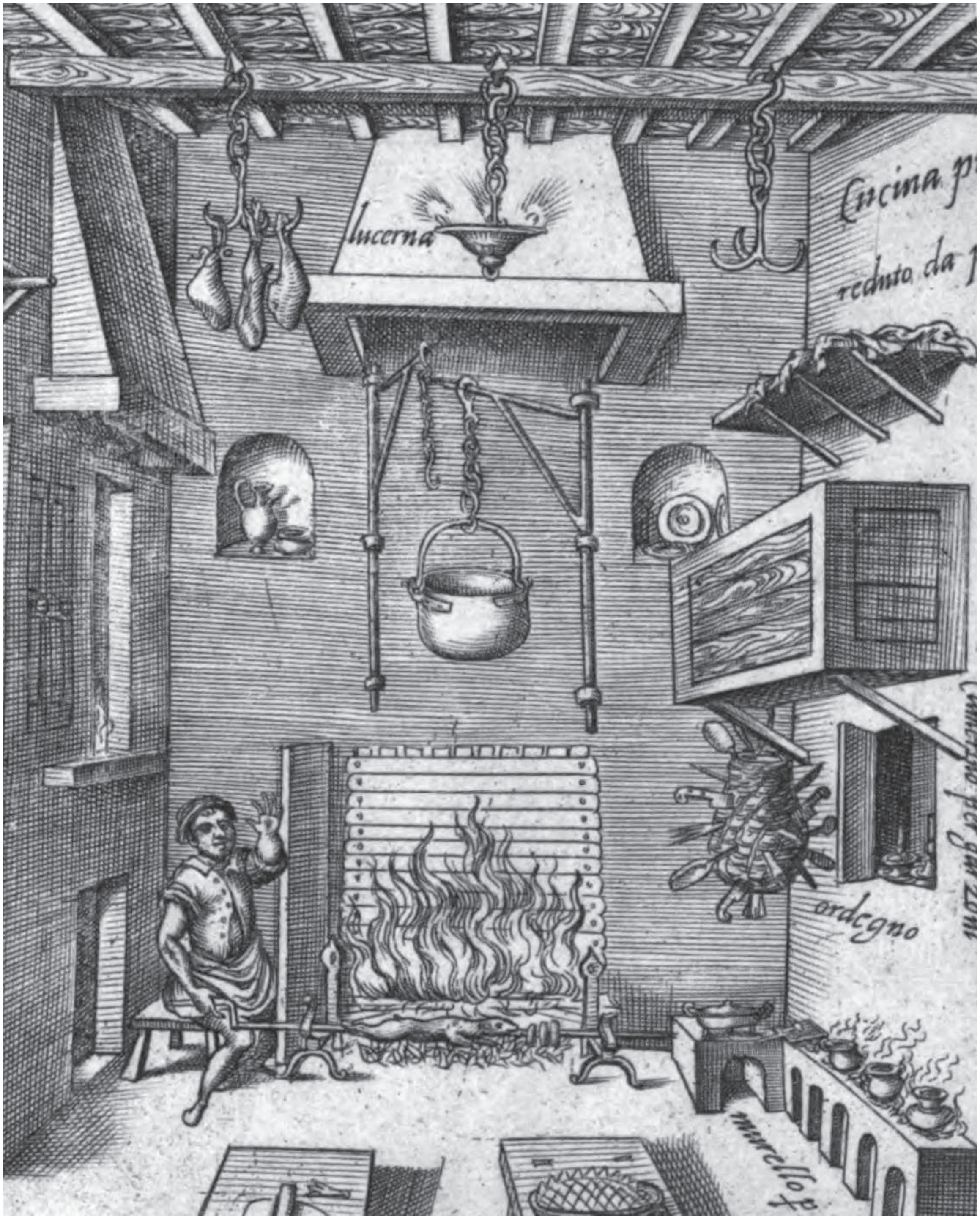

Figure 2-1. Scappi's illustration of an ideal kitchen.
It is well lit from overhead lanterns. It has a high cauldron suspended from a crane, and a fireback to protect the house's structure from the fire burning in the andiron. Smaller chafing dishes are on a counter to the right. The cook uses the heat from the fire's side to roast meat. (Scappi 1570:924)

Scappi was writing about the Pope's kitchen, obviously a much more advanced kitchen than was installed in most homes or buildings. He advocated an oven system not just for baking, but including a small brick tank oven for heating water. This water heating system was supplemented by running water from pipes to a sink in the kitchen for rinsing. Near the rinsing sink was a table with a kneading trough, along with lasagna cutters (Scully 2008:104). Dough preparation – for both lasagna and bread – occupies a large part of Scappi's kitchen, with large tables and specialized gear.

By 1609, less than twenty years before *Vasa* was built, large changes to interior design had been made. A cottage in Sussex, now preserved at the Weald & Downland Open Air Museum, shows an abandonment of the open hall design. Instead, the hearth was covered by a large brick chimney, which also heated the upper floor. The chimney had two fireplaces, one of which was a bake oven. The rest of the house shows remnants of medieval construction – unglazed diamond-section windows, open upper rooms, and wattle-and-daub construction for walls. This stands in sharp contrast to the chimney, which was multi-flued and even included a first-floor vent for smoking meat (Weald & Downland 2002:17-18). This construction suggests that the designers were concerned with building modern, state-of-the-art kitchens, even if the rest of the cottage still possessed many medieval features.

<u>Colonial Kitchens</u>

I examined colonial American kitchens for several reasons. Chief among these is that colonial structures, especially those of the 17th century, represent simpler, vernacular construction, limited by resources and distance. They may also cast more light on lower-status kitchens than many of those surviving in Europe, which in turn may shed light on the sort of technology installed on ships.

Early colonial American kitchens were simple, and were hearth-based. According to Ellen Plante's *The American Kitchen*, these hearths were under "clay-lined wooden chimneys with a green-wood lug pole placed across the hearth's wide expanse to hold hooks that supported kettles and other cookware" (Plante 1995:6). Iron poles were also used, for increased strength and because they did not need to be replaced as often. Simple kitchens would have a single pole set into the masonry, while larger homes might have a movable crane. The crane could swing and allow the movement of pots to different parts of the hearth. The very largest homes, both in England and in the colonies, had two cranes, one on each side (Carson 1968:18).

Early hearths, according to Plante, were large, 2.4 to 3 meters wide. They frequently featured an ash pit and flue to deal with the byproducts of the fire. Occasionally, they had benches near the fire and shelves for tools and utensils (Plante 1995:7). The kitchen itself was usually the largest room in a home, with an average size in Virginia standing at about 7.3 by 4.9 meters (Carson 1968:15).

Items found at the hearth were various, but "not excessive" (Plante 1995:12). Andirons, pots, trivets, utensils, and pans were all kept nearby for use. Lower-status families used hereditary iron cookware, while more wealthy families used copper or brass (Plante 1995:10-11).

Colonial period pots and cauldrons were used for the "one pot meals so typical" of the era (Plante 1995:12). These cauldrons were suspended by chain, hook, or ratcheted bar from the chimney crane or bar. Below the cauldron were the spits, upon which meat was roasted. The spits, kept in a wall-mounted rack when not in use, could fit onto specially designed andirons, which also held the firelogs (Carson 1968:24-25).

Roasting was accomplished with iron gridirons, which were self-supported on legs. If the cook wished to grill more slowly, the gridiron could be placed on a "brandreth," an iron tripod with longer legs. Roasting of fowl was more complicated – colonial cooks used a hemicylindrical Dutch oven made from tin or copper (Carson 1968:28-29).

Other tools found in colonial kitchens included rolling pins, spoons, bowls, ladles, plates and platters. These were usually made of wood, although bowls and platters could be pewter or ceramic. Strainers and sifters were made with wooden bodies and silk or hair mesh. Colanders were pewter, tin or brass. Knives were metal with wooden handles (Carson 1968:31-36).

A 17th century house constructed in Renews, Newfoundland shows that the evolution of European kitchens in the 17th century – the move to more complex hearths and chimneys – arrived in the colonies despite their remote locations. The Renews house had a large hearth: 3.6m by 2m. Rather than a featureless flat hearth floor, the house used a firebox in the corner. The firebox (75cm by 85cm) held the flame and was the source of heat for the fireplace. There was a substantial chimney above the hearth, rather than the medieval-style open bay (Mills 1996:52).

The occupation of the house at Renews has been dated by archaeological evidence to between 1640 and 1680 (Mills 1996:46). While this range postdates *Vasa*, the kitchen's construction casts light on the evolution taking place in kitchen design during the period. Perhaps more importantly, it shows that, even in a colonial setting with its remote location and limited materials, advanced kitchen features were considered a reasonable use of resources.

Smokehoods, Smoke bays, and Chimneys

The presence of chimneys or smokehoods varied with the placement of the kitchen within the house as well as with the status of the owner. Certainly, smoke from hearth fires has always been an annoyance to cooks and residents. By the 12th century, builders were installing stone smokehoods in castles to trap the smoke and move it into a flue or chimney. One of these, built around 1200, survives at Boothby Pagnell in Lincolnshire, England (Pounds 1994:114).

An account of a 14th century kitchen suggests a smokehood above the fireplace, with a large pothook installed for the cauldron. Below the cauldron were burning logs, contained by andirons (Wheaton 1996:23). A 15th-century Dutch illustration shows a fireplace indented into the kitchen wall, with the cauldron hanging from a long pothook. A chimney or flue extends into the ceiling, with no obvious smokehood (Henisch 2009:192).

In some homes, a "smoke bay," or cut-out in the second floor, was installed to insulate the upper floors from the kitchen's obnoxious smoke (Pounds 1994:115). This bay acted as a transitional design between the open fire and a masonry chimney. Frequently, these smoke bays featured passageways to each side, so that one could go from one side to the other without entering the bay (Harris 1993:27). This is the arrangement in *Vasa*'s galley space, which has a smoke bay in the orlop deck rather than a chimney.

An alternative to a smokehood is a taller chimney, which serves to draw more air and thus increases the amount of smoke cleared from the fireplace. By the 16th and 17th centuries, chimneys were built of brick and terra cotta, and were "extravagantly tall" (Pounds 1994:114). As the chimneys got higher, the need for a smokehood lessened, and the front of the fireplace thus became straighter.

Galleys: Maritime Kitchens

The history of galleys – maritime kitchens – has not been well studied. Frequently, the galley does not survive in a shipwreck site, or has become so disarticulated as to be indistinct from general debris. Moreover, there are no galleys in the archaeological record similar to *Vasa*'s, nor indeed any galleys from large 17th century warships. There are several other galleys, however, which provide a basis for comparison, and a small number of documentary sources from the 17th century still exist.

Cattewater Wreck

The Cattewater wreck, an English ship dated to the early 16th century, has a small collection of galley-related finds. A wooden bowl, tripod pitchers, animal bones, and hearth tiles were found clustered around one end of the hull. Redknap (1997:83) hypothesized that the galley or firebox was situated atop the ballast, which now lies south of the site. While there is little information on the galley structure, it is worth noting that the Cattewater ship's galley was tiled, rather than a solely masonry construction.

Oost Flevoland B 71 – a late 16th century karveel

IJselmeerpolders ship B 71, a Dutch ship of the late 16th or early 17th century, illustrates the galley of a small ship roughly contemporary with *Vasa*. The ship was discovered in August 1980 during the construction of a canal, and the hull was raised largely intact. It is a part of a class of smaller inland vessels called *karveels*, which had wide, flat-bottomed hulls.

B 71 was 63 feet in length by 19 feet in beam (Hocker 1991:218)

B 71's living space was located in the forepeak. This living space included a small galley fireplace, centrally located. The hearth was tiled, and raised 65cm off the sole, leaving 1.65m headroom. The galley hearth was simple, consisting of a box containing a layer of bricks covered by a layer of terra cotta tile. A vertical firewall was constructed of 20 tin-glazed earthenware tiles, each 13.5cm square. Smoke was funneled through a smoke hood and into a chimney, neither of which survived for recording (Hocker 1991:213).

Avondster – Mid-17th Century VOC Wreck in Sri Lanka

The *Avondster* was originally an English ship, built some time before 1641. It was purchased by the English East India Company in 1641 as *John and Thomas*, and renamed *Blessing*. The ship served the EIC until 1653, when it was captured by the VOC in the waters off Persia. The VOC renamed the ship *Avondster*, Dutch for "Evening Star" (Parthesius et al. 1999).

Avondster was sent to the Netherlands for refitting, which apparently included its galley, as the bricks found on the wreck are Dutch. After several more ocean voyages, the ship was relegated to regional duty around the Indian subcontinent. *Avondster* sank in 1659 while waiting for a cargo of nuts in Galle harbor, on the southwest tip of Sri Lanka (Parthesius et al. 1999).

Avondster's remains are partially buried, and cover about 40 m by 10 m of seabed. Protruding from the sediment amidships, on the orlop deck just forward of the mainmast, is the galley, which was excavated in 1997 by the project archaeologists. Relatively little wooden construction remained, but the yellow Dutch bricks were well-preserved (Parthesius et al.

1999).

The galley is roughly 1.9m wide by 1.5m long, and its floor consists of one standing brick layer, which was mortared. There is a layer of lead at the edges of the floor. The middle of the floor contains iron concretions from equipment, fastenings, and the fireplace. There were also remnants of lead sheets from the galley walls, which appear to have been 20mm thick from the remains (Parthesius et al. 1999).

Zuiderzee K 45 Wreck – the 1673 "Tjalck"

A vessel about 10 km southwest of the mouth of the river IJssel, thought to be a tjalck by its discoverers, was excavated by the Netherlands Institute for Ship Archaeology at Ketelhaven. The ship, about 20m long, was an armed inland sailing vessel. The ship's artifact collection and equipment led researchers to believe it was a small military vessel, with a likely crew size of around 12. Numismatic evidence dated the wreck to around 1673 (Vlierman 1997:157).

There were two fireplaces aboard the ship. The forward fireplace had associated galley artifacts, including galley utensils, eating vessels, barrels, and food remains. The amidships fireplace had no associated cooking implements. Vlierman (1997:162) suggests that this aft fireplace was used to melt lead for shot.

The galley hearth was fixed to a breasthook, 50-70 cm above the ceiling planks. The firebox was made of oak, with two layers of yellow bricks, and topped by a cast iron plate. The hearth also had a back layer of bricks, in front of which tiles and a cast iron plate had been placed. Vlierman (1997:162) noted that fixing the galley to the stem was common practice for tjalk and wijdschip cargo vessels dating back to the 15th century. This forward galley, it is worth noting, is likely where the fire which destroyed the ship began.

The tjalck's galley had several copper kettles, the largest of which had a capacity of 35 liters. Inside this kettle was a skimmer, a wooden colander, and a dead-eye, which probably fell from aloft during the fire. There was also a 10 liter kettle, which contained the remnants of cow bones and pea soup. Rounding out the collection of copper kettles were two 8 liter kettles. Also found were a bronze saucepan, which had been stored in a starboard-side cabinet along with stoneware. Maiolica, redware, bottles and other eating vessels were found throughout the compartment (Vlierman 1997:163-165). While useful in constructing a picture of galley technology, the tjalck's galley is not directly comparable to *Vasa*'s because of its small size.

Mary Rose – Tudor Warship

Mary Rose, though constructed in a different country and over a century earlier than *Vasa*, nevertheless provides valuable comparitive material for *Vasa*, as it is another large warship with a large crew. *Mary Rose* sank in 1545 during the Battle of the Solent, and was archaeologically recovered 434 years later, in 1979. Fortunately, the galley survived substantially intact.

The galley was in the hold, just forward of the middle of the ship. It featured two cauldrons built into brick furnaces or ovens, one on each side of the keel. Fuel and provisions extended into the next hold section forward of the furnaces. One furnace survived largely intact, which provides an excellent opportunity to study the Tudor galley (Dobbs 2009:124)

Mary Rose's galley was built on a floor of bricks, mortared directly over the ship's gravel ballast. Under the furnace, the floor was one course thick, while there were additional courses forward of the furnace to protect against spilled embers and to provide a surface for pots. Above the floor, the bricks formed a curved wall around the firebox, which was 0.4m deep at the thinnest. Cauldron support bars sat atop this wall, above which was a continuation of the curved wall. The overall effect was a curved furnace in which a cauldron could fit. The entrance to the furnace was in the forward wall, and consisted of a masonry arch roughly 0.45m wide and 0.75m high (Dobbs 2009:124-125)

The galley was enclosed by transverse timber partitions, creating an area 6m fore-and-aft. This compartment was subdivided, the aft area containing the furnaces and the forward area containing a working area. Headroom, formed by the orlop deck beam, was 1.7m (Dobbs 125-127).

The cauldrons were copper-alloy pans, made of eight overlapping panels. These panels were riveted to each other and to the bottom, where there is a strengthening band. The starboard cauldron was found *in situ*, resting inside the circular furnace. It had a capacity circa 600L, or roughly 450L in an operating context. The port cauldron was found upside down in the orlop deck, and was smaller, with a 360L capacity, or roughly 300L in a practical sense (Dobbs 2009:128-129).

Mary Rose's galley also contained many smaller pots and cauldrons, including a hanging kettle, a copper-alloy tripod, a bronze mortar, a possible skimmer, and many other culinary items. Ash boxes and bellows were associated with the furnaces. Just forward of the galley compartment, 776 fuel logs were found. They were approximately 0.90m long, and many had been halved or quartered. Most were birch, along with some poplar and oak. Five partially burnt logs were found in the galley near the starboard furnace, although it is unknown whether the galley fire was lit at the time of *Mary Rose*'s sinking (Dobbs 2009:129).

Documentary Sources

As *Vasa*'s hull was taking shape in Stockholm, John Smith was publishing his *Sea Grammar* in London. Smith's section on the "cooke-roome" reveals nothing about galley construction, but does shed light on galley placement. The galley, he writes, "may bee placed in divers places of the Ship, as sometimes in the Hould, but that oft spoileth the victuall by reason of the heat, but commonly in Merchantmen it is in the Fore-castle" (Smith 1627:12).

Galley placement was the subject of active debate during the early 17th century. Naval tactics of the time were centered around ships' prows, so any obstruction in the bow of the ship was a hindrance, and considering the number of bricks that could be flung about by shot, a constant danger for a warship. On the other hand, a galley placed amidships exposed more of the ship and provisions to the constant heat and smoke of the fire. It also occupied a large portion of the hold which could otherwise be used to carry provisions. Mainwaring cites all these reasons when discussing the placement of the galley in his 1623 book *Seaman's Dictionary* (Mainwaring 1922:131-132).

The second *Mary Rose*, built in 1555 and rebuilt in 1589 (the successor to the more famous archaeologically recorded ship) had its galley moved from the hold to the forecastle (Dobbs 2009:130). A 1618 Commission of Enquiry decided to put it in the forward part of the ship, which would seem to settle the matter for English ships (Lavery 1988:195-196). As is evident by *Vasa*'s amidships galley, the matter was not settled across Europe.

The difference between galley placement in merchantmen and warships is illuminating. The merchantmen were using their holds to transport goods, while the holds of the warships were full of provisions, men, and shot. Both types of ships would benefit from a hold unencumbered by a galley, yet the warships persisted in using valuable real estate in the middle of the ship until the 17th century, when warship galleys began to move forward (as decided by the 1618 Board of Enquiry). Tactics were beginning to change as the broadside gained influence. Instead of ships facing their enemies head-on, they were beginning to fight parallel to each other, and so the space in the middle of the ship was increasingly needed for guns, rather than cooking. Galleys were thus pushed forward to the forecastle, increasing the divide between crew and officers as a prime gathering spot was pushed further away from the officers' quarters in the stern.

A 1636 VOC journal recounts the tale of a galley fire aboard ship. "During the dog watch," the journal says, "the men found a fire in the yacht, that was well under the grating of the galley and the planking was burnt all the way through, and the fire had already reached the deck. To successfully quench the fire, the entire galley had to be destroyed. The cause of the fire was attributed to the lack of salt in or under the sand of the galley" (Leupe 1875:29). From this brief account several facts can be inferred. First is that it was apparently common practice to put sand and salt in the galley as a fire retardant. Second, the galley in question had a "rooster" or grating, under which the fire started. Likely, the lack of salt led to too much heat transmission between the galley bricks and the wooden firebox structure. Once the fire reached the wood, it would have easily spread to the deck.

The 1691 shipbuilding treatise written by Cornelis Van IJk mentions the construction of a loose galley, which was secured to the ship by ropes and rings. His ideal galley was four *voet* wide, and 3 *voet* deep. While the voet is an uncertain measurement, it is roughly equivalent to today's foot. Van IJk mentions that the galley is to be covered with masonry, lead, and copper (Van IJk 1691:304-305); further evidence, along with *Avondster*, of the widespread use of metal sheeting in Dutch-built galleys.

In 1671, Nicolaes Witsen wrote *Architectura navalis et regimen nauticum*, a shipbuilding treatise regarding 17th century Dutch shipbuilding practices. Since the Dutch tradition was that from which *Vasa* was built, it is the closest to a contemporary "builder's manual" that exists today.

Witsen wrote extensively about the construction of galleys. In merchantmen, he identified the galley as the counterpart to the *botlayre*, a room for storing bottles and liquids. The botlayre was set on the port side of the orlop, while the galley was on the starboard. They were of equal length. Notably, Witsen wrote that the galley of a warship is placed athwartships on the ship's bottom, rather than on a side of the orlop (Witsen 1671:59).

Later in the treatise, Witsen set out a long description of the galley's construction. He advocated a hearth tiled with stone – around 140 tiles to the square foot – and a galley fully covered with copper plating. It should be built with posts that are 3.5 inches broad and 3 inches thick, and the whole structure was said to be six feet transverse and four feet longitudinal. The boards were to be 1.5 inches thick on the walls of the galley, and three inches thick on the floor. Finally, there was a five-foot chimney. The chimney was tapered, sixteen inches at the base and twelve at the top (Witsen 1697:91).

As for the contentious issue of galley placement, Witsen suggested that the galley come two or three feet before the mainmast (Witsen 1697:268). Further, he writes, it should have a botlayre against the aft side of the galley, followed by a Master's cabin and a bread-room. Thus, Witsen's suggestion counters the English decision to place the cooking structures in the forepeak.

Conclusion

The development of kitchens in the centuries preceding *Vasa* was one of slow advance rather than of rapid jumps. There was no single revolutionary technological development that defined a new era of kitchen or galley construction. However, slow changes did occur, with developments occurring in kitchen and galley placement, tiling, equipment, and smoke management systems.

Throughout the period examined, kitchens, even low-status colonial kitchens, show a desire to have more complex and higher-status cooking facilities. While very few could afford the kitchens described by Scappi, the colonial kitchens in American were fitted with additional equipment, even when it was presumably inconvenient to do so. In the maritime context, the *Mary Rose* galley contained complicated masonry structures to hold the cauldron, which shows attention to workmanship and convenience by its builders. In the same way, the analysis of *Vasa*'s galley undertaken in this manuscript, when placed in its historical context, can provide part of the understanding of the importance of kitchens to shipbuilders.

CHAPTER 3: METHODOLOGY

The first step toward answering the research questions was a thorough recording of the galley structure and associated artifacts (primarily the large iron cauldron, now in pieces). This research was conducted at the *Vasa* Museum in Stockholm during the summer of 2008. The next step was an analysis of the collected data, which resulted in a reconstructed galley as it likely was when the ship was launched in 1628.

Recording

The wooden galley structure was recorded by total station (an electronic optical surveying system) and by conventional hand methods. Here, "galley structure" means the hearth and the smoke bay, as well as the means by which they were attached to the rest of the ship, and the ends of connected timbers. Though the ship's structure prevents a photograph of the structure in its entirety, it is shown in Figure 3-1.

The galley was recorded first by total station. A total station was used for two reasons. First, it combines accuracy with recording speed. A structure can be recorded very quickly and accurately, and with only one person working. Second, the data collected are in a single coordinate system, allowing galley data to be reconciled with data from the rest of the ship.

When recording with the total station, corners of timbers, fastener holes, empty holes, and intersections of timbers were identified. Where possible, a piece of reflective tape (10 mm x 10 mm) marked the point. Each point was labeled with a unique identification number: a three digit number preceded by an alphabetical prefix (Figure 3-2). This tagging system follows the system used on other *Vasa* recording projects, ensuring no point on the ship can be confused with any other. In this case, the prefix was KB, for *kabyss*, the Swed-

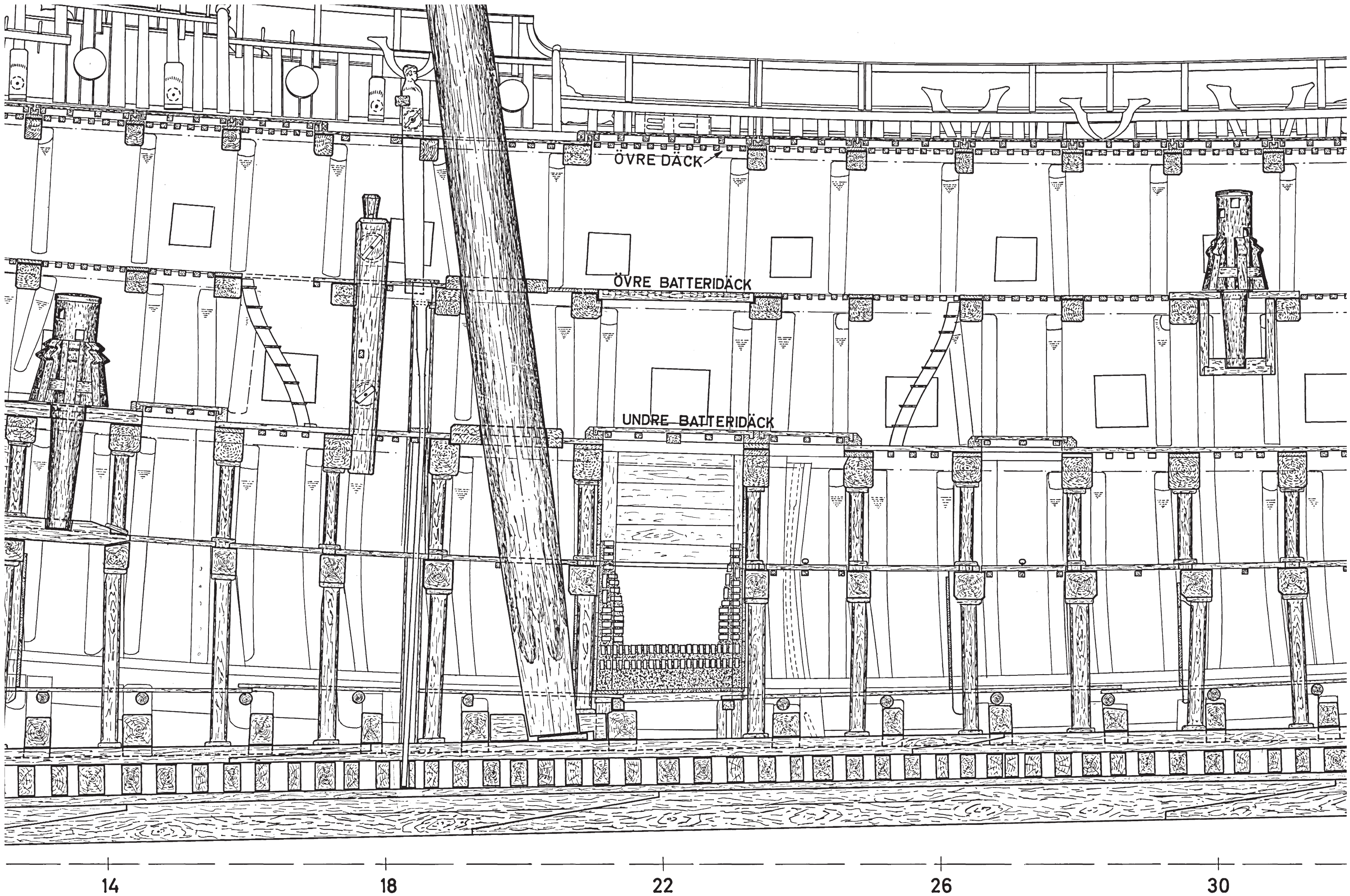

Figure 3-1: Detail of ship's elevation, showing the galley just forward of the main mast. The smoke bay is above it. (SMM)

Figure 3-2: Reflective tape and labels on a galley sill.

ish word for galley. The tags were affixed near the reflective tape to avoid confusion. A brief description of each point was recorded along with its tag number.

The total station used was a Leica TDM-5005. This machine was used in conjunction with the museum's existing geodesy system, which is a system of fixed prisms (Figure 3-3) with highly-accurate known positions. Backsights to these permanent prisms created a known reference point for the total station, which in turn allowed the integration of points into the museum's coordinate system.

Once points were marked with tape and recorded in the catalog, the total station was set up and its position established. The machine was leveled, and backsighted to at least two fixed prisms. After this sight, the total station established its position and gave an estimated error. The position was reestablished if estimated error in any axis exceeded one millimeter.

Figure 3-3: A fixed prism mounted on the lower gundeck.

When using any measurement system, it is vital that its accuracy is known. In the case of the TDM-5005 total station, the nominal error is quite small. There are two errors in each measurement: point error and distance error. Point error is the error along the plane normal to the measurement vector, while distance error refers to the distance between the total station and the measured point.

The total station's point error is 0.5 arcseconds (1/7200 of a degree) (Leica Geosystems 2009:2). Over the operating distances in this project (2 to 5 meters), the point error is thus between 4.84µm and 12.12µm. Since the largest point error is one-eighth the diameter of the average human hair, point error can safely be ignored in this project. The distance measurement error is much larger than the point error: ±0.5 mm. Though the distance error is comparatively large, it is still small when compared to the size of the features being measured. Additional error comes from the adhesive used to attach the reflector to points, and from imprecise targeting of the reflector's center. Cumulative error is on the order of one millimeter.

Over the course of the summer 2008 investigation, 288 total station points were surveyed. Each was named and described in a catalog. Occasionally, a piece of reflective tape could not be placed directly over the desired point. In this case, a correction measurement was recorded with the catalog information.

Occasionally, the electronic survey created data that are inconsistent with visual observations. This is due to the optical illusions so prevalent when working inside a ship. Since there is no flat visual reference inside *Vasa*'s hull, features sometimes appear level or plumb which the total station reveals to be out of true. Though this effect is confusing during analysis and drawing, the total station provides a much more accurate representation of the ship's timbers than would be achieved by hand recording alone.

A total station, while an invaluable tool for recording the location of points and shapes in space, cannot capture detail or nuances such as tool marks, color changes, or the way timbers fit together. For this reason, traditional hand recording was done, in addition to the total station survey. Each of the galley's faces was measured and drawn with tape measure and pencil. For the sake of integrating hand and electronic measurements, the total station control points were measured into the drawing. Features drawn included – but were not limited to – timbers, holes, fasteners, and rust or iron salt stains. The iron salts provide evidence of iron fastenings or tools, and thus were important diagnostic features. Detail drawings were included of particularly complicated structural features.

Figure 3-4: The total station, set up on its plate base in the ship's hold. The blue tubing is part of the museum's air handling system.

When the recording project was completed, the total station points were transferred to a computer and imported into Rhinoceros 4.0, a modeling tool in use at the *Vasa* Museum. Each point was checked against the catalog and named so that the digital "point cloud" matched the point catalog taken during recording. Once the points were correctly named, the correction measurements were applied so that the points accurately described the galley as it exists on board. Finally, each point was assigned to a layer – for instance, all fastener holes are assigned a common layer and display color. The layering process allows each feature of the galley to be turned on or off for ease of analysis and viewing.

Next, each measured drawing was scanned and traced in Adobe Illustrator with a digitizing tablet. Once this step was complete, each drawing represented a vectorized copy of the pencil original. Thus, the drawings were freed from their original size and resolution limitations. Adobe Illustrator files can also be imported to Rhinoceros, a feature which proved invaluable.

The vectorized drawings were imported to Rhinoceros so that the total station recording and the hand recording could be integrated into one accurate representation of the structure. The aligning and positioning of each drawing was a laborious process of scaling, rotation in all three dimensions, and repositioning. Once aligned, the drawings matched the total station points with very little error, in most cases around a centimeter. With the hand drawings aligned and mapped to the digital point cloud, the Rhinoceros model was a three-dimensional representation of the structure which could be rotated and inspected from any angle or distance.

In addition to survey data from my 2008 survey, Rhinoceros was useful for integrating data from the excavation drawings supplied by the *Vasa* Museum. An excellent example is in the case of the iron cauldron. This artifact was broken during conservation. The modeling tools provided in Rhinoceros allowed for a recreation of the cauldron from drawings made in the 1960s. Thus, the cauldron could be digitally placed within the galley model.

Vasa's galley was originally lined with approximately 750 bricks. The bricks were removed shortly after the ship was placed on land, in order to save weight and prevent stress on the wooden structure. They are now in storage on pallets at the museum. The stacks of bricks on the pallets had identical dimensions, meaning the bricks were very close in size – essentially uniform.

To maintain provenience, each brick was marked with painted numbers for identification when removed during excavation. Unfortunately, time has worked against the paint. Nearly all the identification marks have worn away, meaning there is no meaningful location information. Because of the lack of provenience and because the bricks had identical dimensions, not much time was spent recording them. Instead, a representative brick was selected, recorded, and photographed. For the situation of the bricks at the time of excavation, the 1960s drawings and photographs were consulted.

Analysis

Once the physical data were assembled, the analysis began. The goal of the data analysis was to determine the likely state of the galley as it was built in 1628. I attempted to find a reasonable hypothesis for the purpose of all the now-empty fastener holes, as well as for the copper tacks still *in situ*. Finally, the galley was placed within its historical context as nearly as possible.

The analysis began with the placing of artifacts within the structure. Essentially, this meant the 750 bricks and the large iron cauldron. Because provenience information was not available for the bricks, the excavation drawings and photographs were consulted, since they were made before the bricks were removed.

Before the cauldron could be placed, it needed to be "repaired." The cauldron is still located at the *Vasa* Museum, but it broke into several pieces during conservation. Fortunately, it was drawn before it was conserved, and these drawings enabled me to easily make a model of the cauldron.

Digital techniques were as helpful during analysis as they were during recording. Hypotheses were easily testable, such as floor heights and relative sailor sizes. It was a minor effort to insert a "digital cook" to lend a sense of human scale to the project (Figure 3-5). This cook was sized to fit the anthropometric data gathered by the *Vasa* Museum during their skeletal analysis of *Vasa* sailors. The placement of a human Figure serves as a constant reminder that this structure was meant to be used. Thus, details such as arm's reach, height, and relative position of features must all be taken into account during reconstruction and

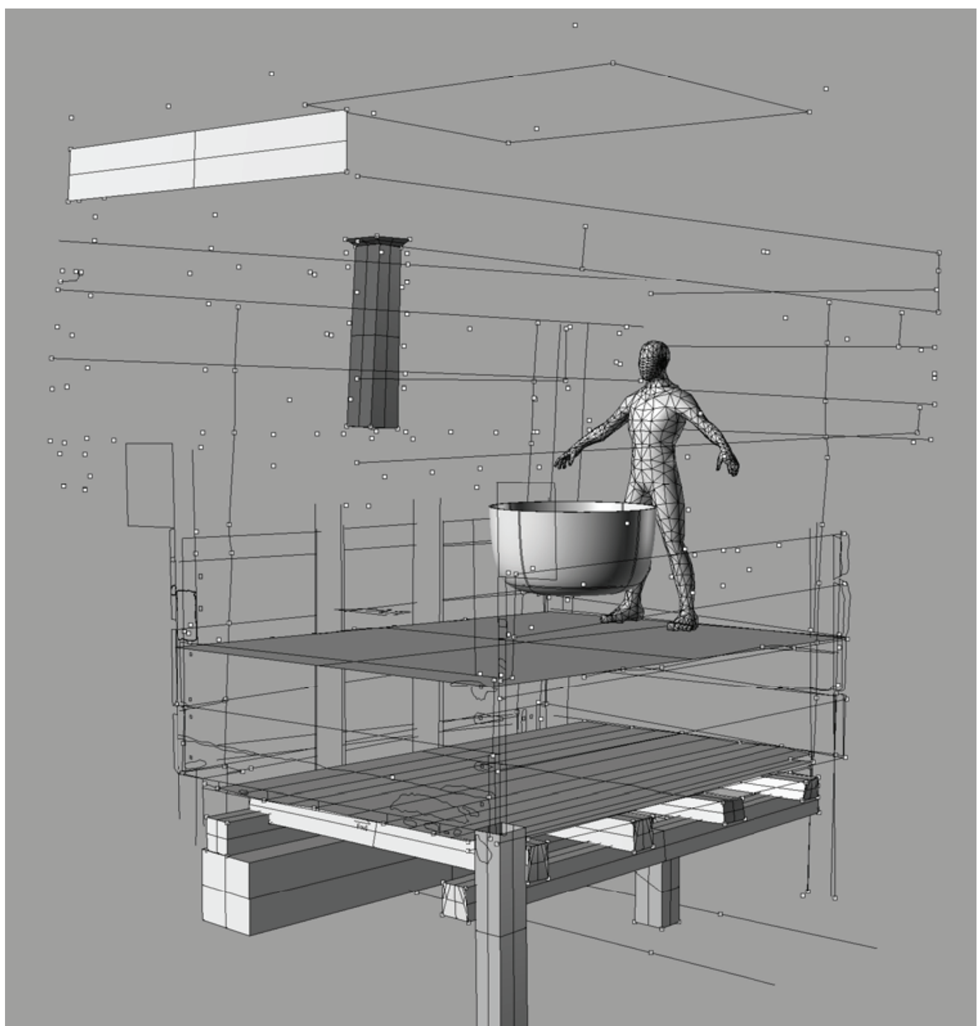

Figure 3-5: This screenshot from Rhinoceros shows the vectorized drawings and the digital cook.

analysis.

The digital drawing enabled easy analysis of features. Measurements between any two features could be accomplished with a single command, even if the features were originally located on different drawings. In many instances, these measurements would not be possible in the actual structure, due to line-of-sight or access issues.

Historical sources – scant as they are – were compiled to give an idea as to what cooking utensils and tools were used during *Vasa*'s period and the centuries prior. This helped assign possible functions to the many (now empty) fastener holes in the galley. Archaeological evidence from terrestrial sites was also consulted to provide context for *Vasa*'s galley.

The historical sources were also used to create a construction context for kitchens in the centuries prior to *Vasa*'s construction. It was hoped that establishing a timeline of kitchen features and construction styles would provide a baseline against which to compare the *Vasa* galley. Construction styles from across Europe and the colonies were used, both maritime and terrestrial. This context allowed the galley to be compared to its "closest neighbors" in construction style.

CHAPTER 4: THE GALLEY IN 2008.

The galley as it exists aboard *Vasa* today is not as complete as the galley the *Vasa* sailors briefly knew. Bricks and artifacts have been removed, and some (though not much) of the wood has degraded. This chapter covers the galley as it existed during my summer 2008 survey. The next chapter will cover the galley as it likely appeared in 1628, including the artifacts no longer aboard the ship.

The ship's galley is located in the middle of the ship, directly under the largest hatch on the vessel. The main portion of the structure is in compartment H5, which is in the ship's hold. The galley is located entirely between orlop deck beams 13 and 14, though it does not fill the whole space between these beams. It is located just before the main mast, and is above the keelson.

The galley is a rectangular structure, extending the entire vertical distance of the hold and orlop decks. The main portion of the structure is at the hold level, while the portion of the galley on the orlop is primarily a large smoke bay, which funneled smoke from the fires up through the large hatch and into the gundecks where it could escape through the gunports or continue up to the weather deck. The main structure, the firebox, was filled with bricks, and is shown in Figure 4-1.

At the hold level, the galley is approximately 2.92 m wide and 2.17 m long. Its immediate compartment is bounded by bulkheads fore and aft. The aft bulkhead is 23.0 cm aft of the galley structure. The forward bulkhead is 2.78 m forward of the galley, making the total compartment approximately 5.18 m long. There is approximately 2.15 m of space to each side of the structure, measured at the galley's floor planks. The total transverse distance is approximately 7.22 m.

Figure 4-1. The galley's firebox, seen from above.
This photograph is taken from aft, looking forward.

The structure is built around four oak stanchions, which extend 4 m from the ceiling planking at the bottom of the hold to the bottom of the hatch opening between the lower gundeck and the orlop. Unlike the stanchions found in the rest of the ship, the galley stanchions do not have collars at the top or bottom. Further, the stanchions are not fastened to the ceiling in any visible way, though they are notched into the deck beams where they meet the lower gundeck.

The stanchions range from 17 to 20 cm thick (longitudinal dimension) and 20 to 23 cm wide (transverse dimension), and are chamfered on each corner. The aft stanchions are installed just aft of a large rider (40 cm square), and are notched slightly into this rider. The rider and the aft stanchions were fastened together with two iron bolts.

Notched into the forward stanchions, 45 cm above the ceiling, there is a sill running athwartships. This timber has a length of 2.9 m, and is 14x15 cm on the ends. It is notched 5.5 cm into the stanchions, and is fastened with a single bolt. Amidships, it is supported by a small stanchion that sits on the keelson (figure 4-2). This stanchion is 14x15 cm, just as the sill is, and runs from the keelson to the top of the beam, a distance of 47 cm. The sill is notched and fastened into the small stanchion, which sits aft of the sill. Thus, the sill's

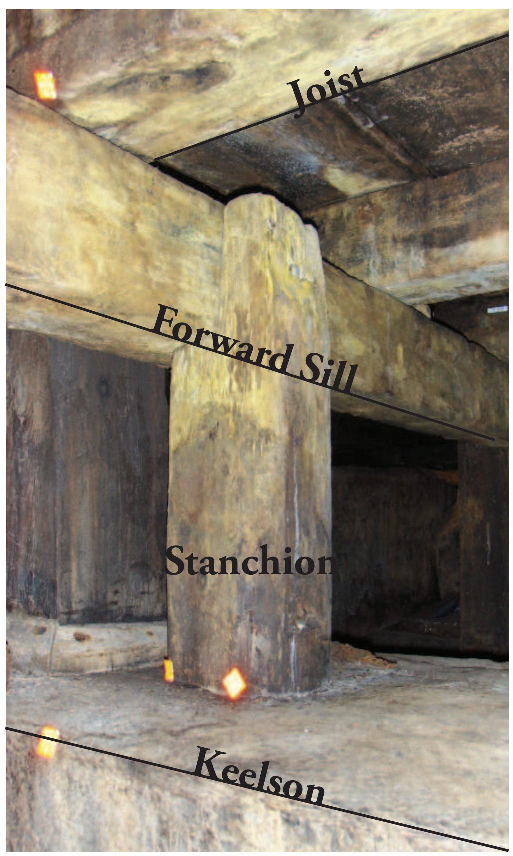

Figure 4-2. The small stanchion atop the keelson, just behind a sill.

forward motion is prevented by the main galley stanchions, and aft movement by the small midships stanchion.

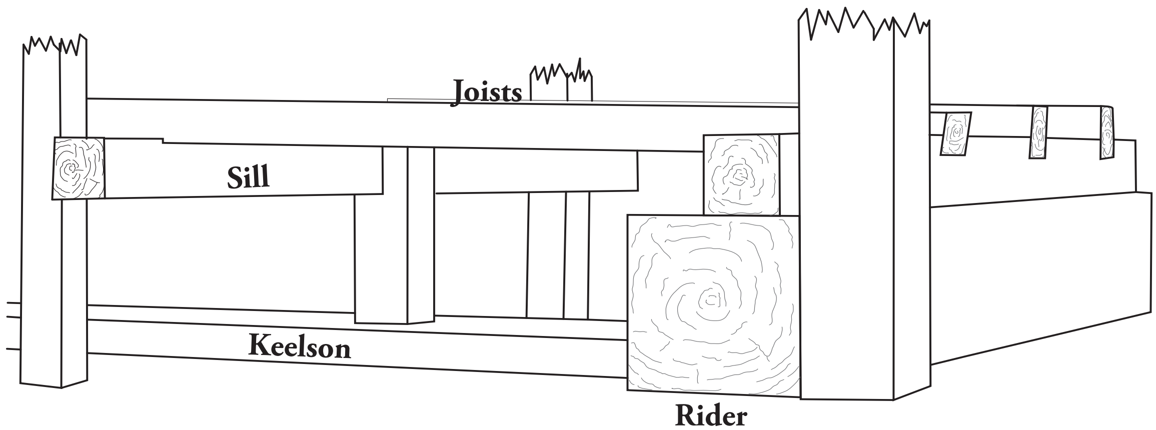

Figure 4-3. A perspective drawing of the galley support structure.
It is shown without planks for clarity. The notching can clearly be seen in the aft sill.

The aft sill rests atop a rider, and at 18 cm square is slightly larger than the forward one. Unlike its forward counterpart, it is not notched into the aft stanchions. Since it is supported along its length by the rider, it does not need a stanchion along its run. Four longitudinal joists sit atop the two sills, forming a “raft” upon which the main galley structure rests. These longitudinal timbers are all 14 cm thick (vertical dimension), and are between 15 and 20 cm wide. They are 2.2 m long, protruding past their support beams to the edge of the galley structure (figure 4-3).

The planks which form the floor of the firebox are fastened to the joists. There are six of these planks, running athwartships. The planks are equal in thickness (4.6 cm) and length (2.88 m), but uneven in width (ranging from 31 to 42 cm). Above the floor planks are the galley walls, which are composed of pine planks. There are walls to each side, but those to

Figure 4-4: Tool marks on the forward port galley wall.

port and starboard are significantly shorter than the forward and aft walls (as seen in Figure 4-1). The port and starboard walls consist of three planks each, and are approximately 67 cm high.

Like the floor planks, the wall planks are even in thickness (4.5 cm) and length (2.1 m), but not in width. To starboard, two smaller planks (16.7 and 18.8 cm) are under a larger plank (32.1 cm). On the port side, the planks get progressively larger from top to bottom. The top plank is uneven in width (9-14 cm, with the wider portion aft), while the next two planks are larger (22 and 32 cm), and even in width across their length. The tops of these side walls show tool marks consistent with adze-finishing (figure 4-4). They are not even: the port wall slopes up as it goes aft, the starboard wall slopes down to aft. In each case, the slope is about 1.4°.

Figure 4-5: The jog in the starboard side of the forward wall.
It is outlined by the bright reflective tape along the forward edge. The shorter side wall of the galley can be seen in the left side of the photograph.

In addition to the planks forming the low side walls, there are planks forming high walls both forward and abaft the galley floor. Both walls have four planks on the hold level (between the galley floor and the orlop deck beams). These walls are about 4 cm thick, and run the entire width of the galley. The planks vary slightly in length as they run up the wall. The bottom forward planks are 2.85 m long, while the upper edge of the forward hold plank is only 2.73 m.

Six centimeters of this 12 cm difference are accounted for by a jog cut out of the wall on the starboard side. To starboard the walls follow the profile of the stanchion with attached side-wall. Thus, there is a jog in the forward wall at the top of the side-wall (figure 4-5). To

Figure 4-6: *Vasa* Galley, Aft Elevation. 1:25 Scale

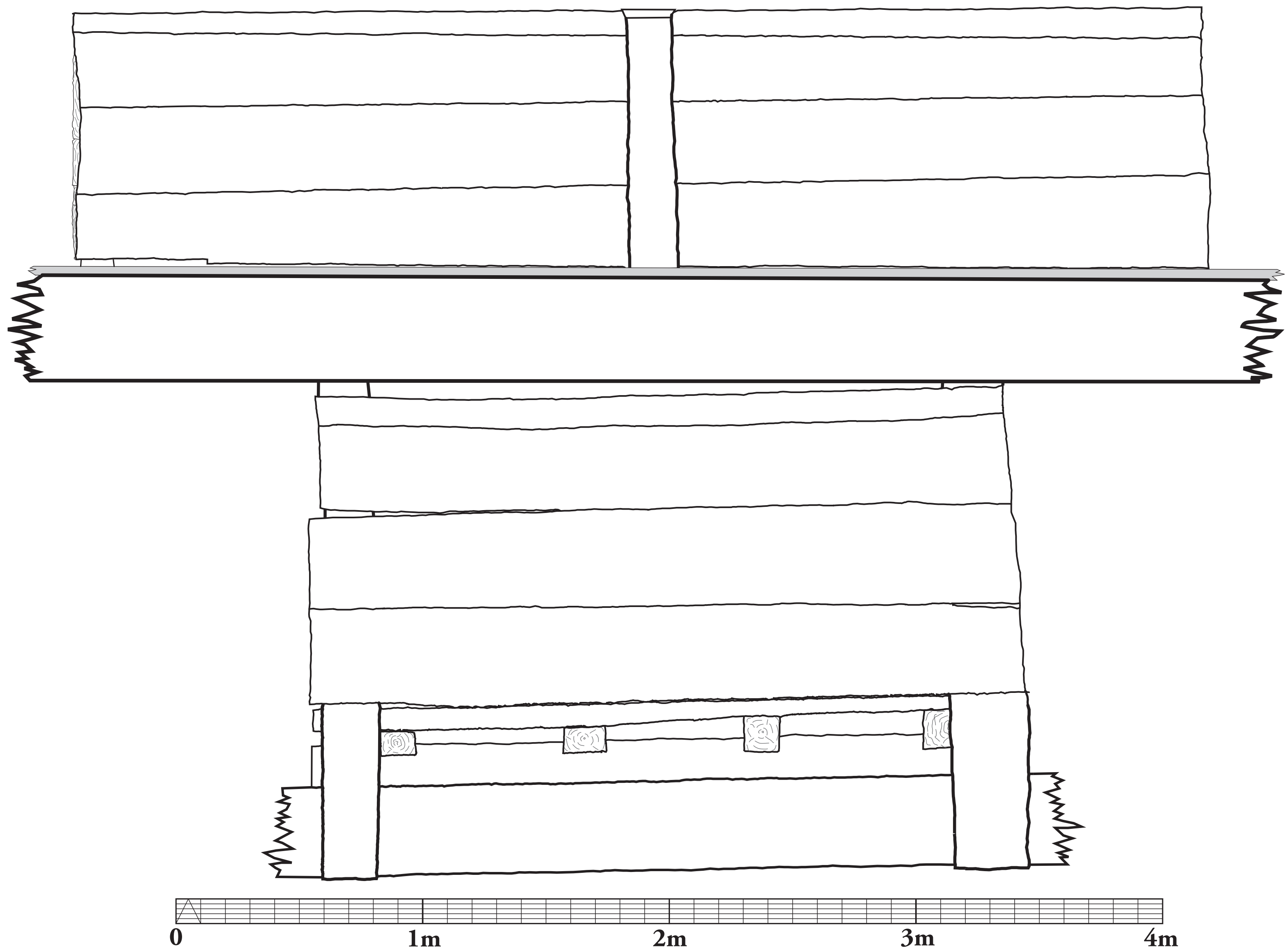

Figure 4-7: ***Vasa*** **Galley, Forward Elevation. 1:25 Scale**

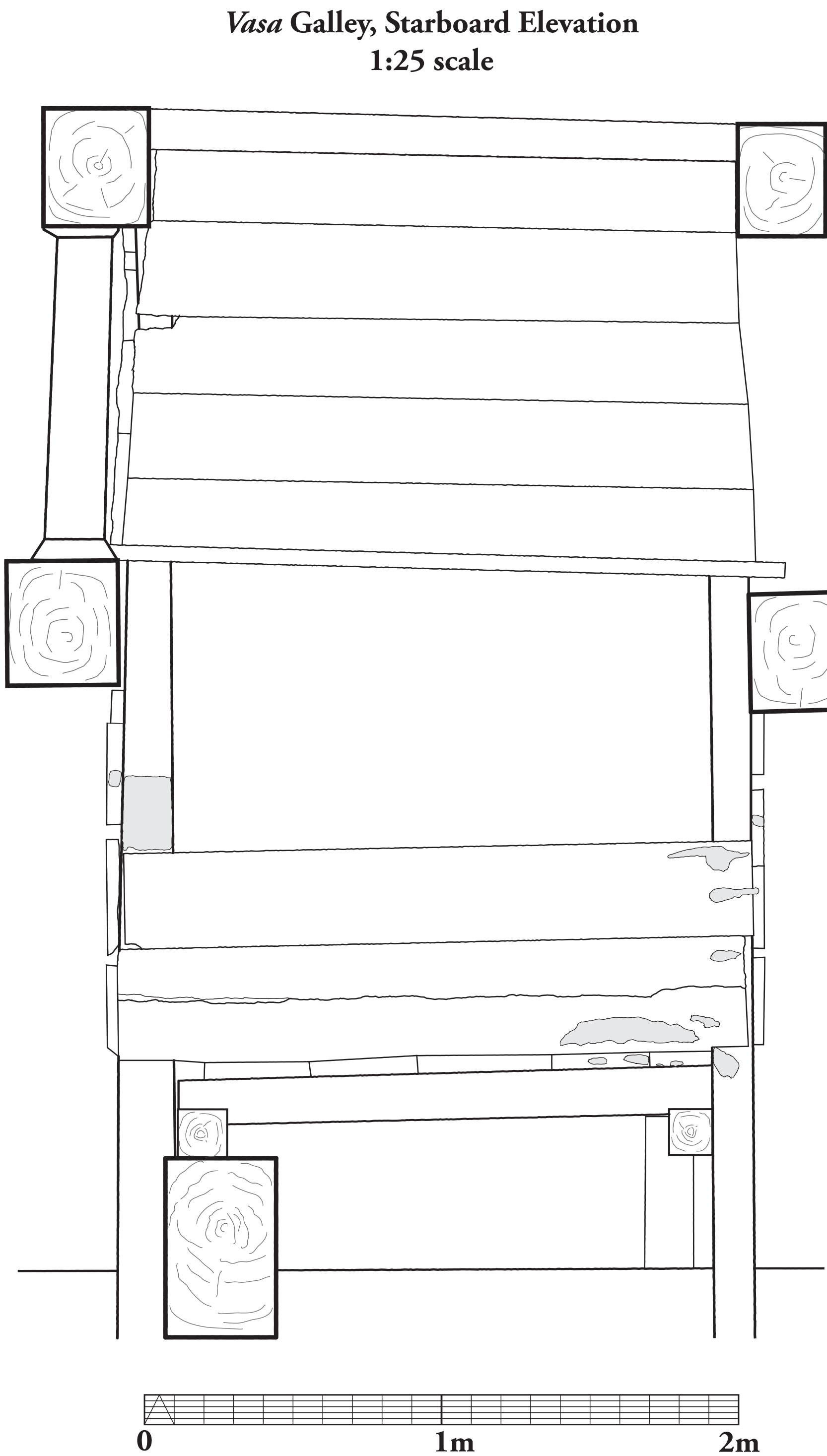

Figure 4-8: ***Vasa*** **Galley, starboard elevation. 1:25 scale.**
Gray shaded areas are areas with iron corrosion products.

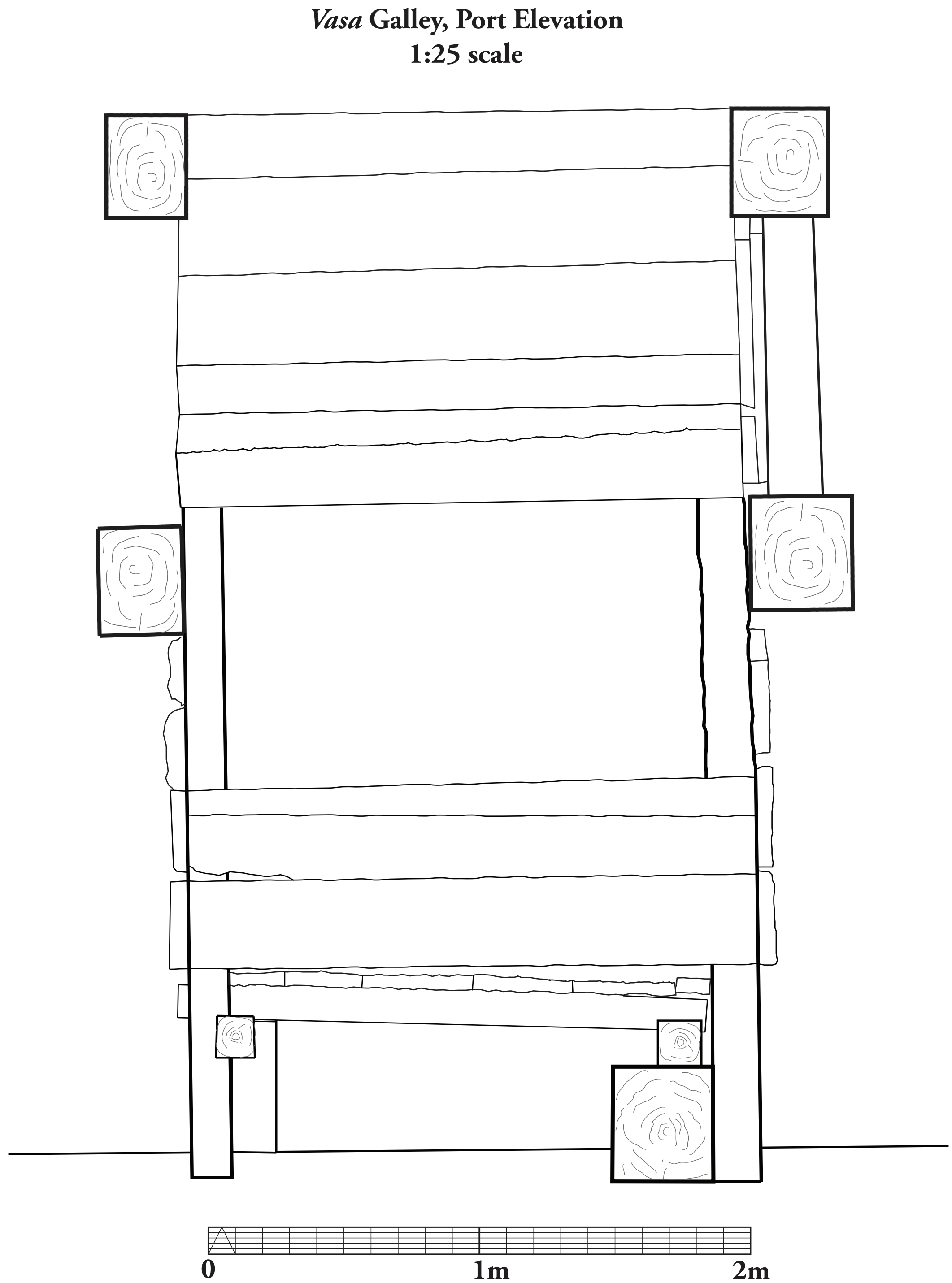

Figure 4-9: *Vasa* Galley, port elevation. 1:25 scale.

port, there is no jog. The wall continues up as if the side-wall continued to the top of the galley. The remainder of the difference likely comes from a slight angle of the galley stanchions, possibly imparted by the slope of the ceiling planks upon which the stanchions rest.

The planks are fastened to the galley stanchions. Several of the aft planks are toe-nailed from the side rather than nailed straight through, particularly on the starboard side. Generally, there are two fasteners connecting each plank to each stanchion.

As mentioned above, both the forward and aft plank patterns are interrupted by the large orlop deck beams. In essence, the beams form a section of the wall roughly 40 cm high. Because the beams contain fastener holes and were not planked over, their galley-facing faces are considered part of the galley structure. In the same way, the galley-facing faces of the orlop deck planks themselves form a portion of the galley structure.

Smoke Bay

The portion of the galley structure on the orlop deck forms a smoke bay (Figures 4-6 through 4-9 show the smoke bay above the smaller lower structure). A rectangular set of walls surrounds an empty space above the hearth. Thus, the smoke from the cooking fires would be (theoretically) contained within the smoke bay and could be funneled up through the large hatch cut into the lower gundeck. From there, the smoke could escape out the gun-decks or could be drawn up and out of the ship.

Essentially, the smoke bay resembles the main galley structure in that it is primarily built around four stanchions. The stanchions are 14 cm wide and roughly 11 cm thick. They are attached to the orlop deck beams, and are notched so that a portion sits on the orlop deck itself. At the top of the stanchion, a similar notch is employed so that they can be fastened to the lower gundeck beam (Figure 4-10).

Figure 4-10: The forward starboard smoke bay stanchion.

Around the stanchions are four walls, composed of softwood planks. Because several of these planks were missing, they were recreated by the *Vasa* Museum and are currently installed on the ship. The walls begin just above the orlop deck planks. Thus, as mentioned, the ends of the orlop deck planks act as a portion of the galley structure.

This smoke bay has the same length as the galley, being bounded fore and aft by deck beams (which can be seen in the port and starboard elevations – Figures 4-8 and 4-9). However, it is substantially wider than the galley (which can be seen in the forward and aft elevations – Figures 4-6 and 4-7). While the galley itself is 2.56 m wide, measured from the outside corners of its stanchions at the orlop deck height, the smoke bay adds just over two meters, for a total width of 4.62 m. While there are deck planks all around the smoke bay on the orlop level, they do not continue into the smoke bay. Thus, there is open space under the lower gundeck down to the hold ceiling planks in the smokehood.

The smoke bay is skewed with respect to the keelson. While the ship sits on a slight angle to the museum, the smoke bay is skewed even more. The starboard wall runs an additional 3 degrees to starboard as it goes forward, while the port wall runs 1.7 degrees to starboard. This 1.7 degree measurement is close to the skew of the galley structure as a whole.

The smoke bay planks are not nearly as well preserved as the rest of the galley structure. This is likely because they are a softwood and thus more prone to erosion. Not all planks survive, and some only survive partially. For example, there is approximately 40 cm missing from the starboard edge of a forward smoke bay plank. The degree to which forward smoke bay planks have degraded can be seen in Figure 4-7, in which the sparse and eroded timbers of the smoke bay are evident.

The recreated timbers in the smoke bay are all clearly identifiable. They are marked "*Vasa* Rek." and are a darker color than original timbers. All the top timbers of the smoke bay (directly below the lower gundeck deck beam) are recreated, except on the starboard wall. The three top timbers in the port smoke bay wall, the bottom two starboard smoke bay planks, and most of the starboard corner of the forward wall are all recreations.

The planks in the aft smoke bay wall are nearly all present, and are well preserved, and, thus, serves an example of the overall smoke bay wall construction. Only the uppermost plank (directly under the lower gundeck beam) is missing. Above the orlop deck beam, there are the 7.8 cm thick orlop deck planks, followed by the smoke bay planks, which have heights of 31.2 cm, 32.7 cm, and 28.1 cm. The small recreated plank filling the gap between the uppermost surviving wall plank and the deck beam is 16.2 cm high. These timbers are illustrated in Figure 4-6.

The planks fit together closely, even after the centuries of erosion. They are joined both to the smoke bay stanchions at the extreme corners and to the main galley stanchions, which intercept the planks about 90 cm along their run. No evidence of a sealant or covering was apparent on the smoke bay walls.

Abaft the aft smoke bay wall, there is a stanchion supporting the lower gundeck. Unlike the galley stanchions, this deck stanchion has a small collar at the top. There is a filler timber in the space created by the collar. This connection between the stanchion and the smoke bay makes it the only one of the surrounding deck stanchions that I consider to be part of the galley structure.

The hatch above the galley is cut into the lower gundeck. It is 2.09 m wide, and 1.97 m long. Along the forward and aft edges of the hatch are four rectangular fastener holes, 20 mm high and 25 mm wide. The port side holes are 22.5 cm from the hatch edge, while the starboard holes are 29 cm. These holes are now empty. There are indentations in the hatch coaming for a grate, which is not currently installed.

Copper Tacks

During the survey, thirteen previously undiscovered copper tacks were found driven into the galley walls. Seven tacks were found in the aft wall: five in the forward wall, and one in the starboard wall. These small tacks had been flattened against the wood, and are deformed (figure 4-11). Their length is less than the plank thickness, as they do not protrude from the other side. Their heads are 5 mm in diameter. Several tacks are flush with the galley walls, while several others are bent over. There is no evidence of any material caught under the tacks. Those in the fore and aft walls are all approximately 60 cm above the galley floor and are remarkably evenly spaced.

Figure 4-11: A copper tack, found *in situ* during the 2008 survey.

The aft wall tacks are spaced 29-30 cm apart. There is a slight downward slope as the line moves to port – the portmost tack is 8.1 cm below the starboardmost tack. The forward wall tacks are likewise spaced at 30 cm intervals, except for a 90 cm gap between two tacks, suggesting that two are missing. The single tack in the port wall is 15 cm above the galley floor, and 63 cm aft of the forward wall. The forward and aft lines of tacks line up consistently, with the forward line 4-5 cm above and 2-3 cm to port of the aft tack line (Figure 4-12).

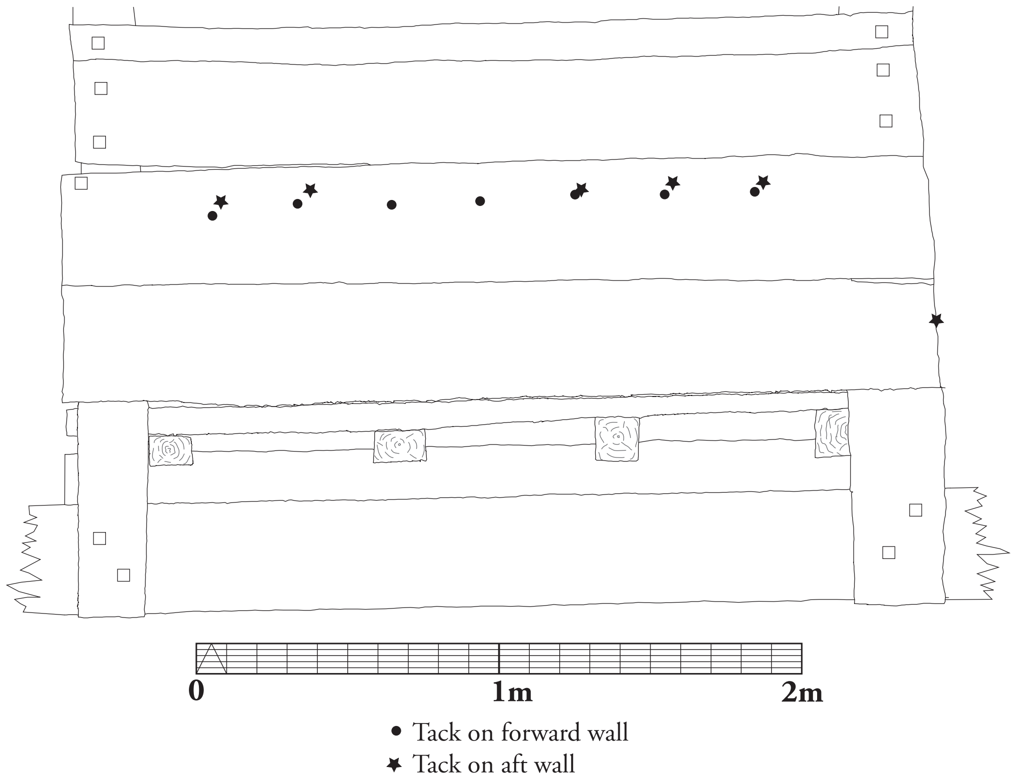

Figure 4-12. This aft elevation shows the placement of the copper tacks. 1:25 scale. Note: all tacks shown are on the interior faces of the walls.

<u>Fastener Holes</u>

In addition to the modern fasteners (using 17th century holes) currently holding the structure together, the thirteen copper tacks currently *in situ* and the four fastener holes at the main hatch, there are an additional 24 holes in the galley structure. Nearly all these holes are rectangular, and measure 20 mm horizontally by 7 mm vertically.

Many of the holes are evident even without close examination or a search for an actual fastener hole. Most exhibit a yellow stain on the surrounding wood caused by iron salts deposited as the iron fasteners corroded while the wreck was under water. While the fasteners themselves are gone, their evidence remains in the wood (Figure 4-13).

Figure 4-13: Stains left in the wood from iron corrosion products. Such stains leave evidence of fasteners and artifacts.

In depth analysis of the fastener holes will be presented in the next chapter, as they are linked to artifacts and galley elements which no longer survive.

Conclusion

The galley's wooden structures are well-preserved. Fastener holes are evident, and most of the structure is in place – only a few smoke bay planks are missing or heavily eroded. It is supported by a series of stacked, notched timbers, supported by the four large stanchions running the entire height of the hold and orlop deck. It is not an integral structural component to the ship – there is no feature of the ship (apart from the crew's stomachs) that relied on the galley for strength.

The galley structure is remarkably simple. There is not an abundance of fastening; most of the bolts in the structure today simply tie planks to stanchions. Gravity and compression hold most of the galley together, as the use of notches shows. Yet, while the structure is sound, the question of its function cannot be answered until a reconstruction has been done. This reconstruction is a reintegration of the galley's wooden structure with the associated finds, along with analysis attempting to make sense of the artifacts not found: the iron and tools that once filled the space – and the empty fastener holes.

CHAPTER 5: THE GALLEY IN 1628

With its missing bricks, empty fastener holes, and eroded smoke bay, *Vasa*'s galley is a shadow of its former self. Obviously, the galley was different when the ship set sail on 10 August 1628, but the specifics of the difference are not immediately apparent. It is impossible to state exactly what the structure looked like on that day, but reasoned conclusions can be made. The first step in the reconstruction is determining which elements were likely different in 1628, and how they differ from the current state.

Some physical reconstruction of the galley has been done since excavation. Recovered timbers have been integrated into the structure, and new timbers have been added to fill holes in the smoke bay. The new timbers are obvious – they are marked, and are of a different color than the original wood.

The extent to which recovered timbers have been added to the structure can be determined fairly easily. During the excavation, photographs and drawings were made. Since these were created before any reconstruction work was attempted, they are a record of the galley as it came off the bottom.

The Wooden Structure

Many of the excavation photographs are of limited utility as far as the wooden construction is concerned. The wood is mostly covered by mud, water, or brick, with little structure visible. Likely, this contributed to the excellent preservation of the softwood galley walls. Since the photos are mostly concentrated on the lower (brick-lined) portion, it is hard to see details of the smoke bay. One picture (Figure 5-1) shows that the forward smoke bay wall above the bricks was missing at the time of the photo.

The drawings are more helpful. They reveal that the port aft galley stanchion had fallen over at some point prior to recovery (Figure 5-2). The drawing also shows that the aft smoke bay was substantially intact, but had fallen down during the centuries under water. The drawing also suggests that the short side walls were in place during the excavation. No drawings apparently exist of the smoke bay walls outboard of the galley.

Figure 5-1: This photo, taken during the excavation, shows the galley fire box. The empty hole where the forward smoke bay should be is visible at the top of the photo. Photograph courtesy SMM.

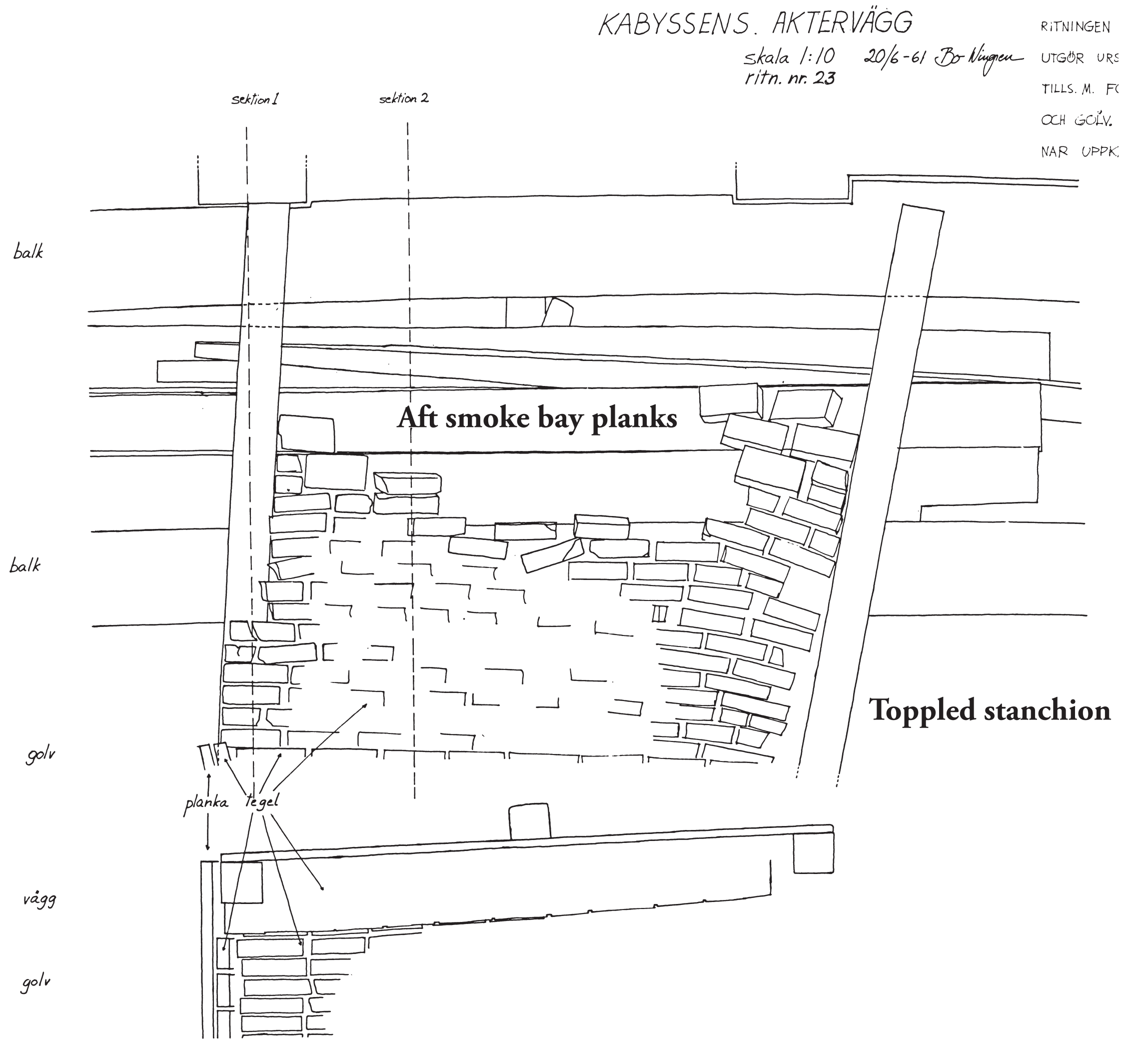

Figure 5-2: This portion of an excavation drawing shows the toppled port aft stanchion and the mostly-intact aft smoke bay.
Though it was originally 1:10 scale, it is not so reproduced here.
Drawing made by Bo Wingren (SMM).

From the photograph and the drawing (Figures 5-1 and 5-2), it is apparent that the galley's wooden structure was in very good shape when it was excavated. Though some pieces had fallen, the wood was mostly intact and in place. Because the wooden structure was *in situ* when the ship was recovered, there has been little restoration or recreation, aside from propping up the fallen stanchion and replacing smoke bay planks. Thus, it may be safely said that *Vasa*'s galley was originally in substantially the same configuration as it is now – at least as far as wood is concerned.

Bricks

There are approximately 750 bricks in the *Vasa* Museum's collection. When found, the port side of the galley floor was smashed, and these fragments make an exact brick count difficult. The bricks are stored stacked on pallets in the museum's collection storage facility (Figure 5-3).

Figure 5-3. This pallet of bricks (find 27621) is one of the galley brick collections. (SMM).

When they were removed from the galley, the bricks were labeled with painted numbers. As mentioned in Chapter 3, time has not been kind to these numbers, and nearly all have flaked away. With this loss of coding comes a loss of provenience information. Because the bricks are extremely similar in size and no longer have distinguishing marks, one representative brick was recorded in detail (Figure 5-4). The bricks are 300 mm in length, 165 mm in breadth, and have a depth of 80 mm. They are mostly of a light yellow or tan color, though some have stains from rust or mud. None appear to have soot stains.

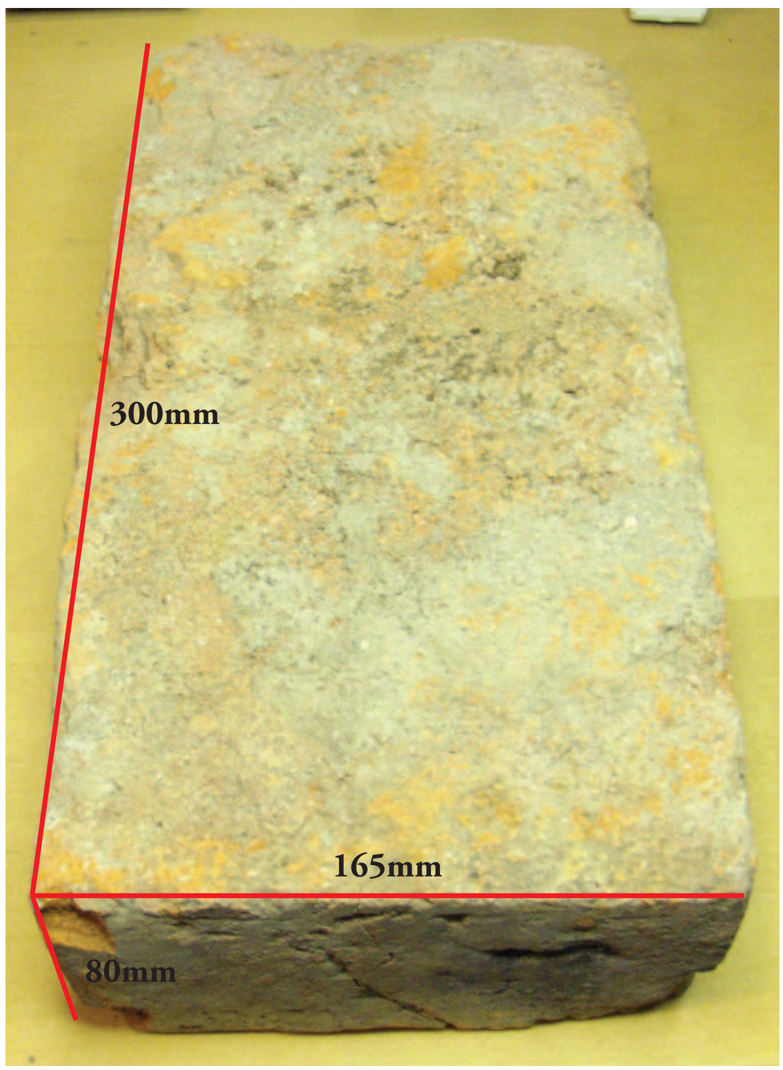

Figure 5-4. Representative galley brick.

Fortunately, notes and drawings of the bricks' layout were made during excavation. The excavating archaeologists drew the bricks' situation in both plan and profile, providing a complete picture of the galley masonry.

Two courses of bricks formed the galley floor. The bricks were on their side, with the narrow (300 mm x 80 mm) side facing up and the long edge running athwartships (Figure 5-5). Between the courses was a 6 cm layer of mortar or clay (Svensson 1963). Under the lower course, there was a 30 cm layer of clay and sand between the bricks and lower planks. A sample of this material is stored in a jar as find number 22448. This stratigraphy of clay, bricks, and mortar accounts for the entire distance between the bottom galley planks and the

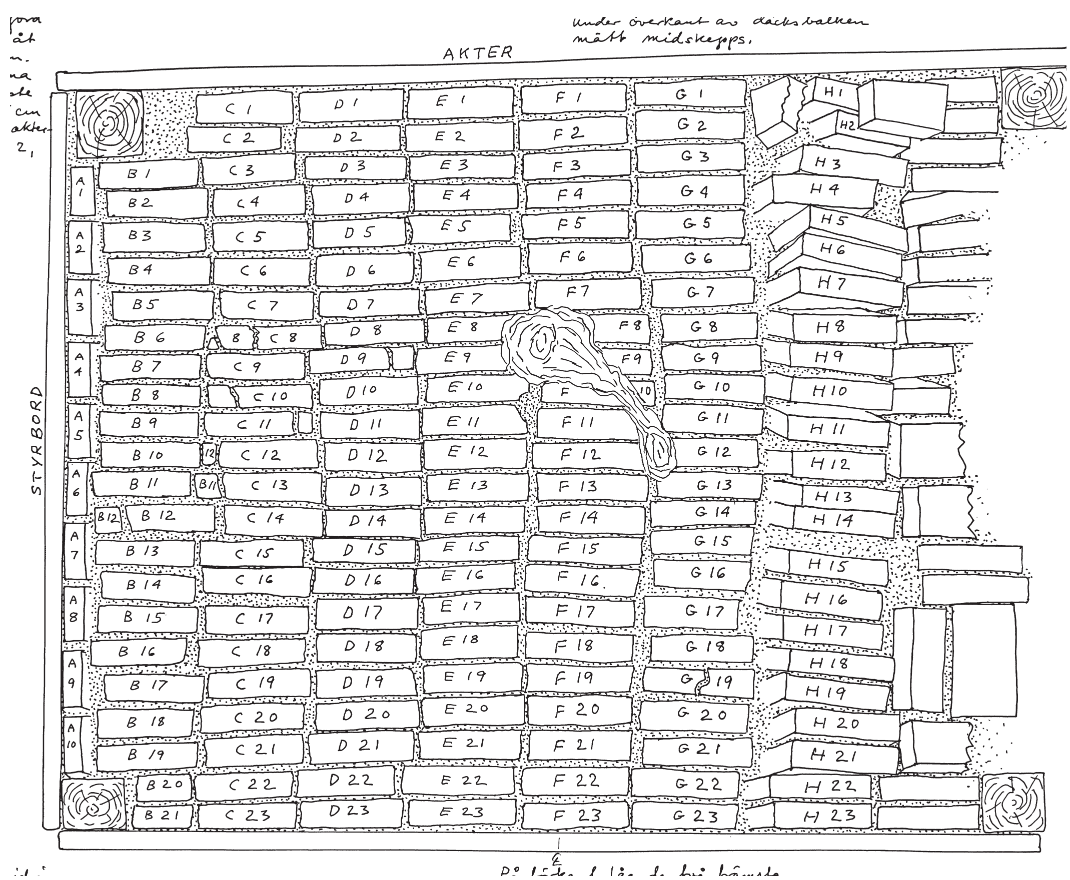

Figure 5-5: Plan view of the galley floor made during excavation. Drawing not to scale. (SMM)

top of the side wall. Thus, the lower galley box was filled with bricks.

The fore and aft walls were each covered with bricks. Starting directly atop the floor layer, there were two courses, each two bricks thick, with the 300 mm edge running athwartships. Above these, there was a course of bricks running perpendicular to the lower. The fourth and fifth courses were just like the first two. Up to the top of the orlop deck beam, there were two courses of vertical bricks, in front of which were five courses running athwartships. Figure 5-6 is the excavation drawing of this wall arrangement, drawn November 1961.

The bottom four courses on the fore and aft walls covered the galley stanchions, while the upper courses were cut to avoid them. Mortar was between all of the bricks and served to

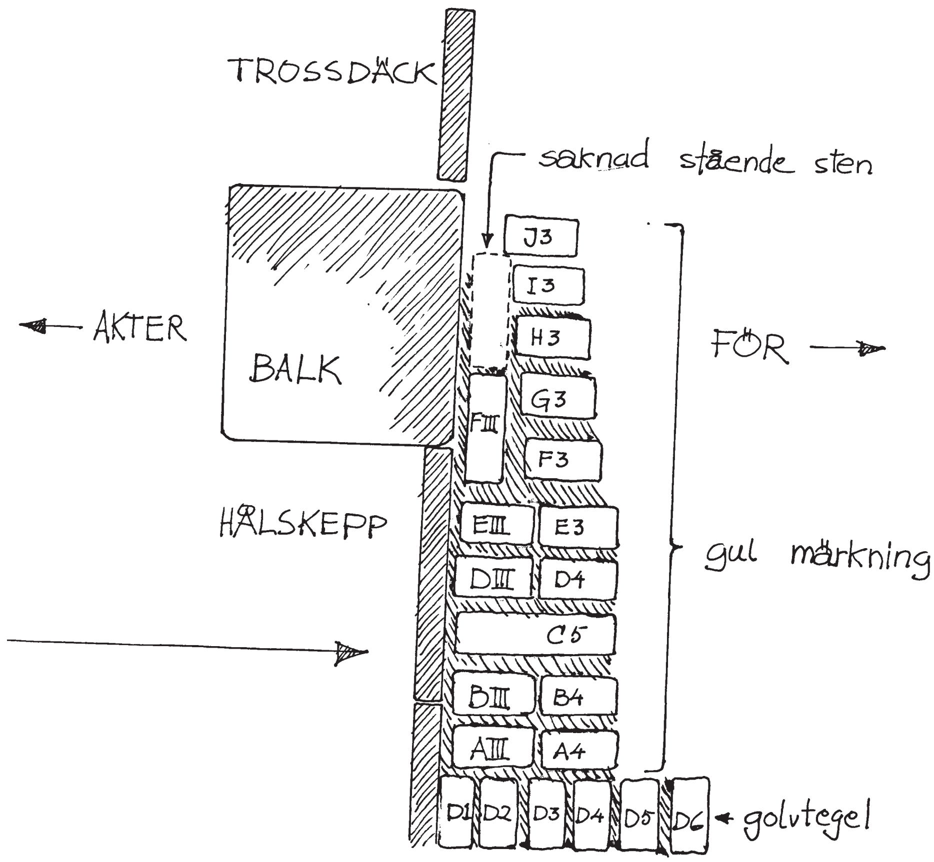

Figure 5-6: Detail of excavation drawing 49, showing a profile of the aft brick wall. The markings on the bricks no longer exist. There was a missing vertical brick, indicated by "saknad stäende sten". (SMM)

fill gaps, as can also be seen in Figure 5-6.

Clay Layer and Associated Artifacts

As mentioned above, there was a 30 cm layer of clay and sand under the brick floor. There were four artifacts found in the clay layer, all of which are contained in find number 14550. They consist of a fragment of wooden tool shaft, a nut, a stone ball/weight, and a piece of flint. The collections database has a note regarding this group of artifacts, saying they are "of more than dubious character." No explanation is given for the note, nor are photographs present to explain the situation. It may be that the artifacts were arranged in a dubious shape or arrangement. Alternatively, these artifacts may have been present in the clay long before it was installed.

Iron Cauldron

The largest artifact associated with the galley is an iron cauldron – find 12366. While it is currently broken as a result of conservation (Fred Hocker 2008, pers. comm.), drawings, photographs, and measurements were made during excavation. The cauldron was found in the port bilge, along with a large quantity of iron shot and ballast. Likely all these artifacts shifted to port during the foundering along with the ballast.

According to the drawings (Figure 5-7), the cauldron's mouth diameter is 890 mm, narrowing to 720 mm near the base. The depth is 450 mm, and the wall thickness is 10 mm. The collections database says that four iron bars were found with the cauldron, along with hooks. I could not locate these bars and hooks in 2008; they may not have survived conservation.

Photographs taken of the cauldron *in situ* (Figures 5-8 and 5-9) show one of the

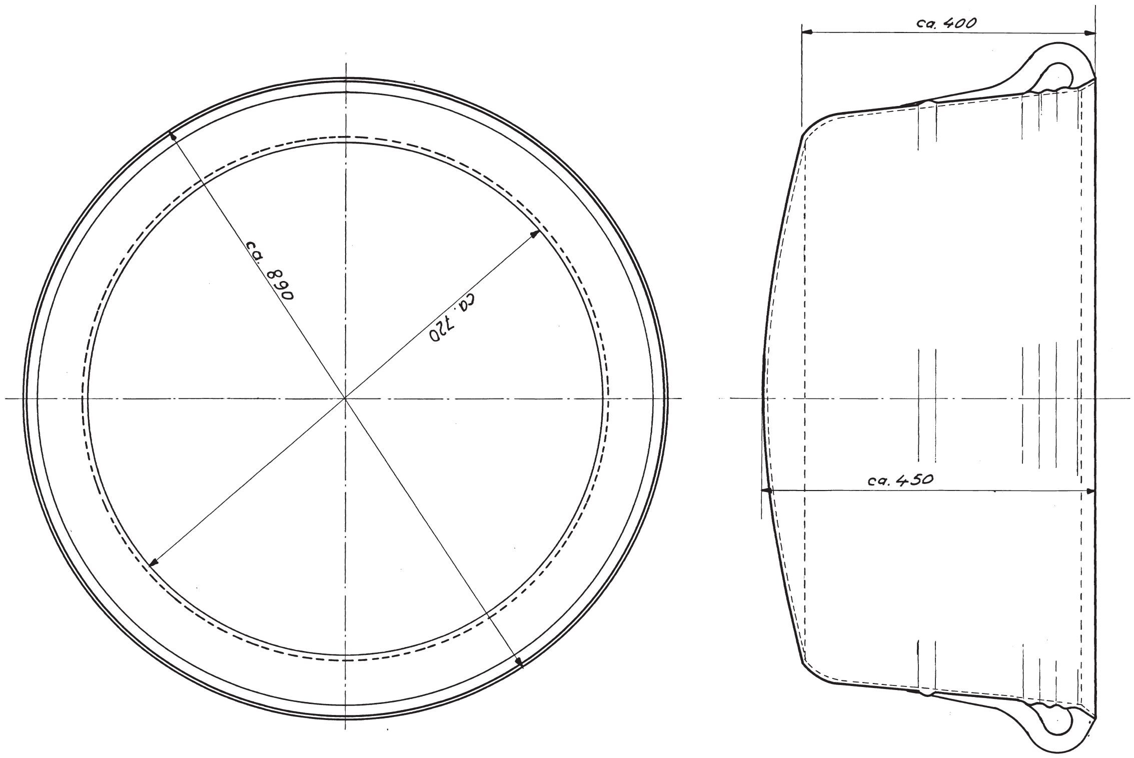

Figure 5-7: ***Vasa*** **drawing 98a, which shows the intact cauldron.**
The drawing as presented here is not to scale. Measurements in millimeters. (SMM)

Figure 5-8: ***Vasa*** **photo 0661-2. Cauldron** ***in situ*****, with hooks and bar. (SMM)**


Figure 5-9: ***Vasa*** **photo 661-5. Cauldron with iron hangers. (SMM)**

iron bars and two hooks. The photo shows a long bar threaded through a handle attached to the cauldron, and some sort of fitting further down the bar. This may be another cauldron handle, or it may be some other sort of fitting. Unfortunately, none of the hooks or bars have survived. A search of the artifact magazine during the 2008 survey did not locate any iron hardware or fittings associated with the cauldron.

Vasa's Galley As It Was

Taken synoptically, the 2008 survey, the 1960s excavation, and the find record provide a picture of the facts surrounding the galley as it was built. The wooden structure as it currently exists aboard the ship was essentially how it was in 1628 – wood erosion notwithstanding. The wooden box was filled with approximately 30 cm of sand and clay, on top of which were two courses of bricks separated by a 6 cm layer of mortar or clay. A midships section of the reconstructed brick arrangement is provided as Figure 5-10, and a plan as Figure 5-11.

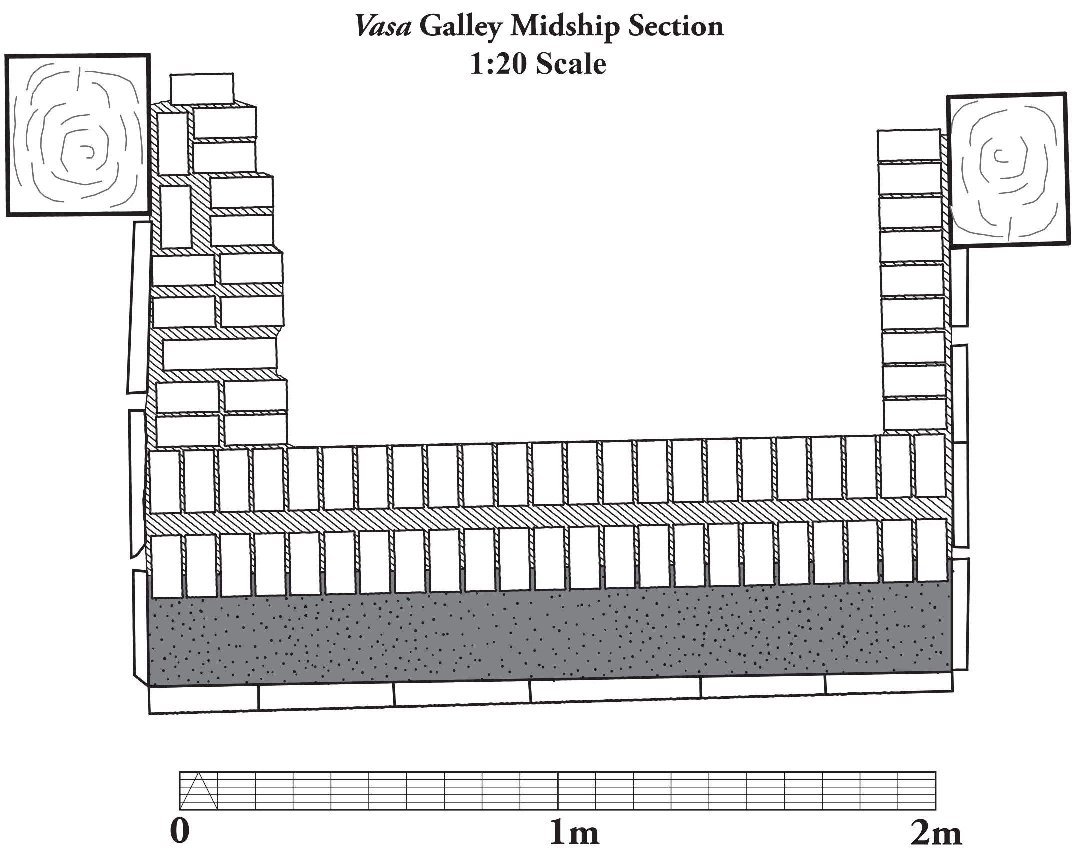

Figure 5-10. This drawing combines the 2008 survey with the depictions of the bricks *in situ* drawn by Wingren during excavation. The diagonal hatching represents clay and mortar, while the stippling represents the addition of sand to the sub-brick layer.

A cursory glance at the drawings and descriptions of the galley suggests that the brick floor was flat from port to starboard, with the side walls at the height of the floor. Since the

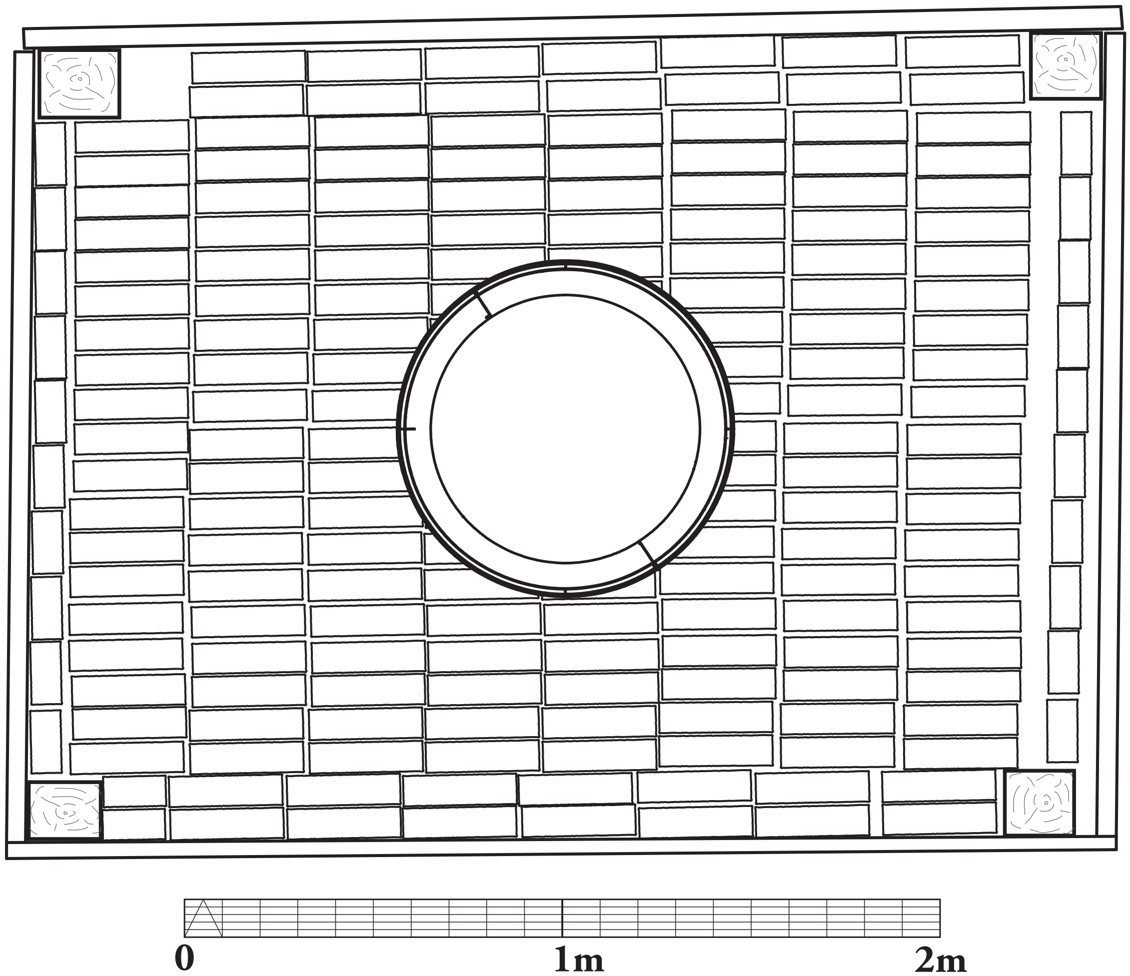

**Figure 5-11. A plan of the reconstructed galley floor.
Gaps would have been filled with clay and mortar. The cauldron is included for scale.
The lines of brick to port and starboard would have been raised 6 cm above the rest of the floor to provide a lip.**

bricks have been removed from the current galley, it is an easy error to make. An inspection of one of the galley photos reveals the error in this method of thinking. *Vasa* excavation photo 652-166 shows the bricks from above. The left side of the photo (Figure 5-12) focuses on the relationship between the bricks and the side wall. It can be seen that there is a single line of bricks stood on end. This line is up against and slightly lower than the side wall. The rest of the floor is a bit lower than the first line. Though it is not shown, a similar arrange-

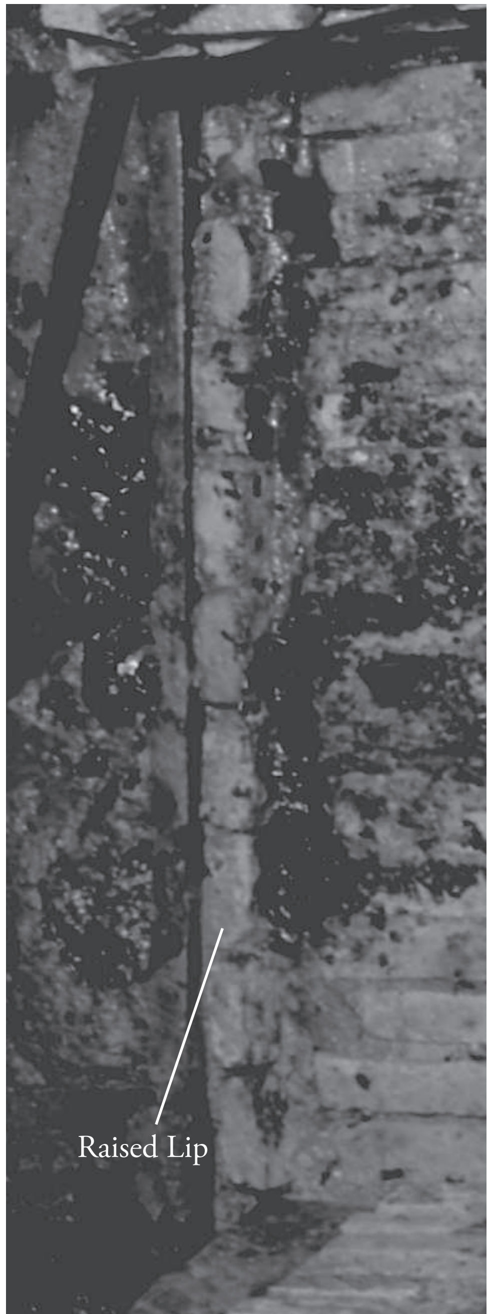

Figure 5-12. This detail of an excavation photo illustrates the difference in height between the side wall and the brick floor. (SMM)

ment likely existed on the other side. Unfortunately, this discovery means that the measurements given for the thickness of the sand and clay substrate are likely incorrect – closer to 25 cm rather than the 30 cm given in the find log. It is understandable, however, that errors might have occurred when trying to take measurements of clay in the muddy and wet ship shortly after it was raised.

There is a further clue to the location of the galley floor, one which corroborates the theory that it was lower than the side walls. The copper tacks discovered in the 2008 survey and described in the previous chapter are close to no known feature in the wooden structure. They are, however, roughly 6 cm lower than the side walls, which would be about level with the main galley floor as shown in Figure 5-10. The effect, thus, is a brick floor with a lip, which would help to prevent ashes and sparks from sliding out of the hearth.

Since the tacks were in the wood behind the bricks, they must have been installed before the masonry. Due to their physical placement within the structure, they were likely associated with the bricklaying process. String may have been stretched between them to level the floor. Dr. Fred Hocker at the *Vasa* Museum suggested the idea to me during the 2008 survey, and the data have reenforced his suggestion.

The biggest mystery surrounding the galley is the function of the fastener holes. Positions of these are shown in Figures 5-13 and 5-14. There are 28 of these holes, mostly measuring 20 mm x 7 mm. Four are associated with the main hatch. These likely fastened an iron grating. The other 24 holes are mostly enigmatic. Most of the iron disintegrated during *Vasa*'s 333 years under water. What was left was removed with the bricks, and has not survived. Since so little iron was left, even during the excavation, pictures and drawings are of little assistance. They show several indistinct iron marks on both the fore and aft walls. There is no detail suggesting form. Photos tell the same story, showing clumps falling down the walls. One very large rust clump in the middle of the galley floor was probably an andiron, due to

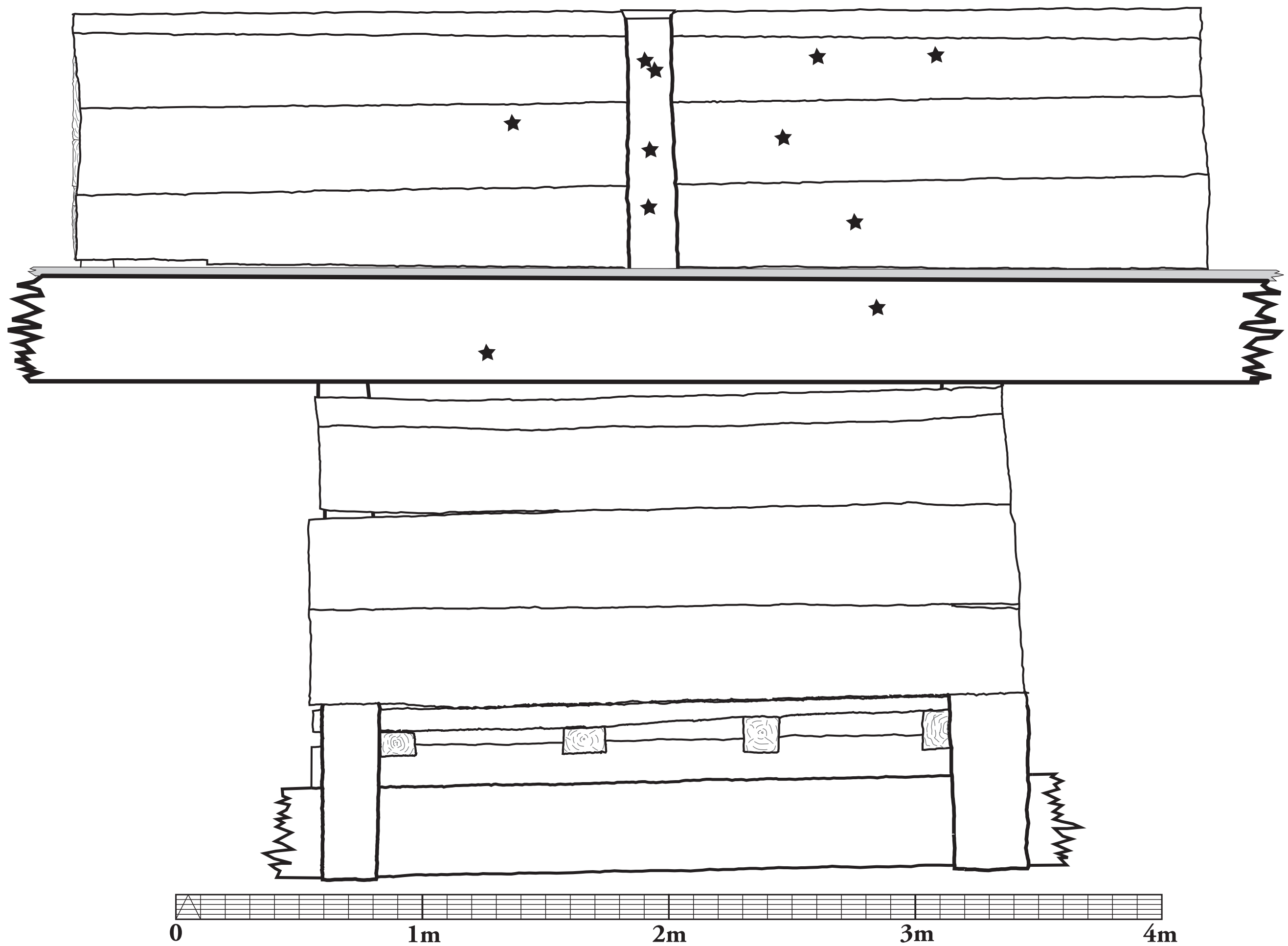

Figure 5-13. Fastener holes, Aft Elevation. Stars denote the location of fastener holes. 1:30 scale.

Figure 5-14. Fastener holes, Forward Elevation. Stars denote the location of fastener holes. 1:30 scale.

its central location.

The only surviving iron galley hardware is the large iron cauldron, as described above. Unfortunately, the hanging hardware has not survived. It is clear from the photographs that there were bars running through the cauldron's handles. Because of the orientation of the handles, two bars would be needed. These would need to be strong, as the 180L cauldron would contain 180 kg of water when full, in addition to the weight of the iron.

The weight of the iron as originally constructed is subject to some speculation. The Rhinoceros model based on the cauldron drawings contains 15052 cubic centimeters of iron. Iron's density is 7.874 g/cc, but the cast iron alloy in the cauldron would likely be less dense. Even at a conservative density of 7.0 g/cc, the cauldron would still weigh well over 100kg, making the total weight of the full cauldron somewhere around 300kg.

Formidable supports would be needed for this heavy kettle. Two thick iron bars could have been used, each run through the handles and fastened to both sides of the galley. This arrangement would logically suggest four fastener holes, aligned in a rectangle.

The location of the cauldron fasteners depends on the location of the cauldron. For it to be used effectively, its mouth would need to be about waist-high for someone standing on the galley floor. To solve this puzzle, the "digital cook" was created. This 3D human model was sized to fit the average *Vasa* sailor – about 5'4" (1.6 m) (Fred Hocker 2008 pers. comm.). The digital cook, placed into the model, provided an instant sense of scale for the model (Figure 5-15).

The digital cook brings to light an important consideration: the cauldron cannot be so high that it cannot be stirred or watched. This means the mouth must not be higher than

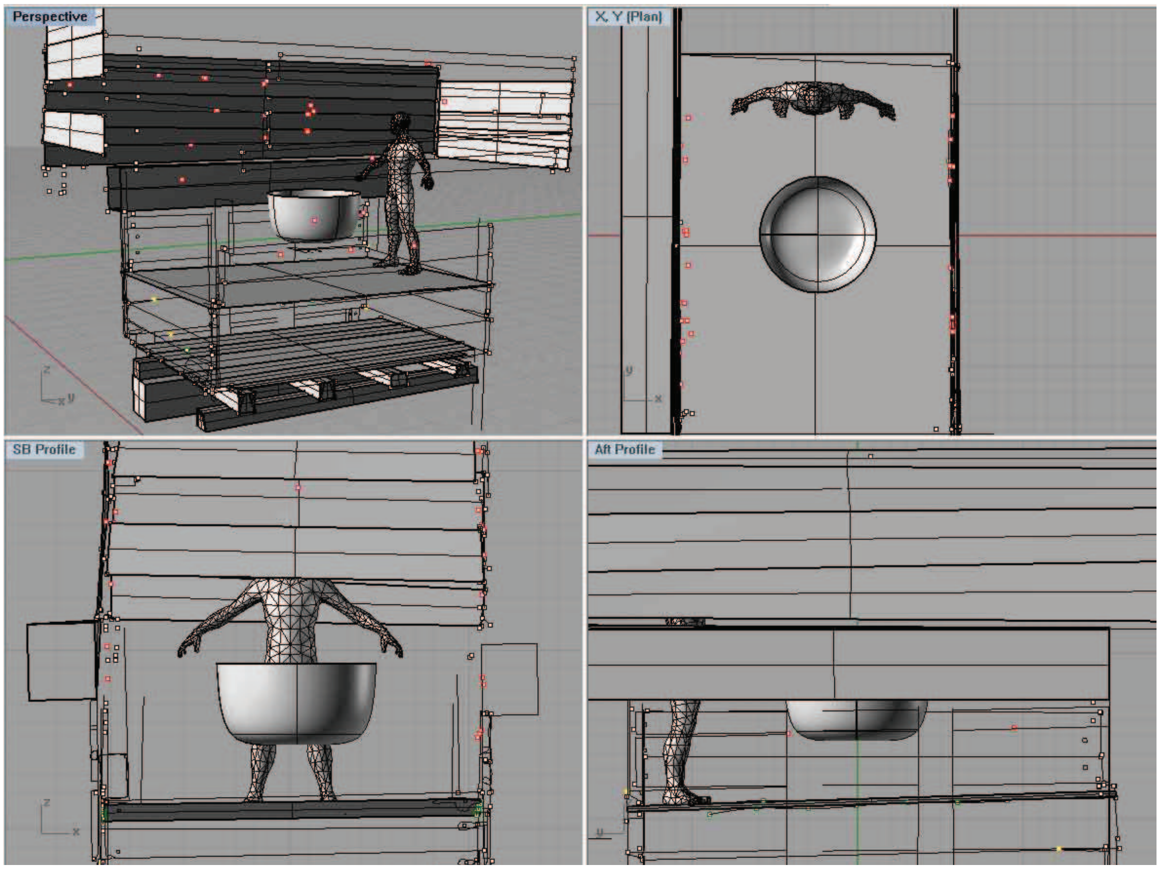

Figure 5-15. This screenshot from Rhinoceros shows the galley model in progress. As can be seen, the digital cook stands at a representation of *Vasa*'s iron cauldron.

about 90 cm from the brick surface. In the simplest arrangement, the cauldron's support bars would run straight from wall to wall through the handles. This would provide the easiest construction, but would not allow for any adjustment of the cauldron's height above the fire. This was not necessarily a problem, as the *Mary Rose* galley showed. *Mary Rose*'s cauldrons sat in bowls, with no controls for adjusting cauldron height at all. Therefore, the simplest arrangement aboard *Vasa* could indeed be possible.

Unfortunately for the simplest arrangement (bars run through handles and directly mounted to the walls, illustrated in Figure 5-16), there is no rectangle of fastener holes about 90 cm above the brick floor. There are *two* fastener holes, which are roughly level with

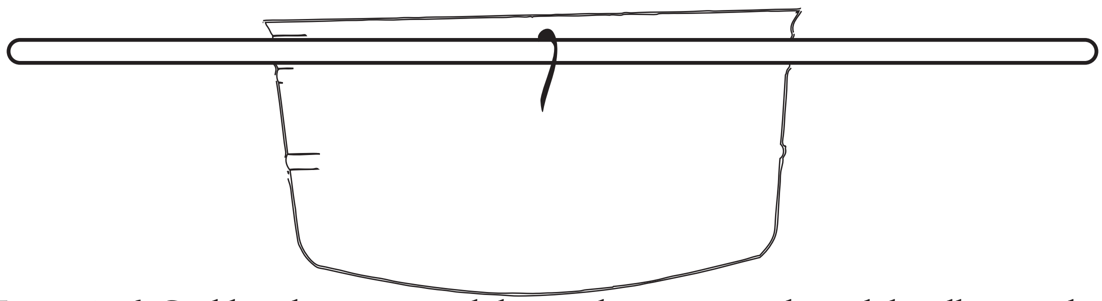

Figure 5-16. Cauldron hanging possibility #1: bars running through handles, attached to brick walls. Not to scale.

each other. They are, however, only 83 cm apart horizontally, 6 cm closer together than the cauldron requires. Thus, it is unlikely that the cauldron was suspended directly from bars mounted in the galley walls.

The cauldron could have been suspended from chains, which would have been attached to bars or cranes mounted in the galley walls (illustrated in Figure 5-17). Again, this requires a rectangle of four fastener holes, higher up on the walls. There is such a rectangle, mounted about head height on the digital cook. This is a promising height, as it would al-

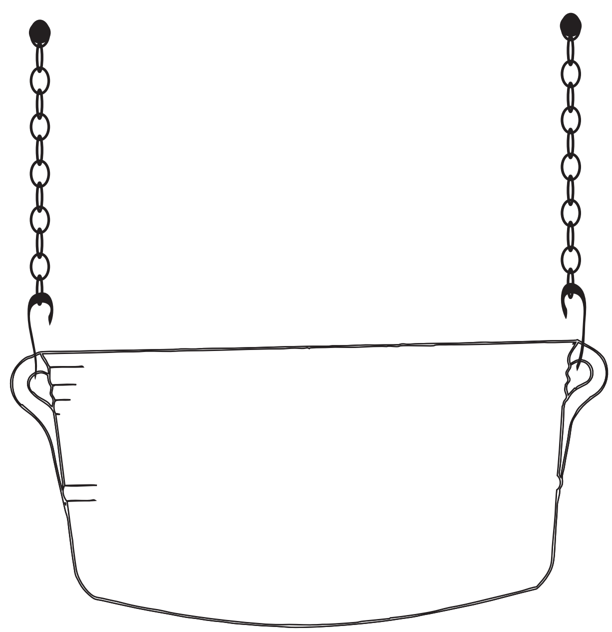

Figure 5-17. Cauldron hanging possibility #2: chains attached to handles, running to bars which are affixed to brick walls. Not to scale.

low him to work on the chains and bars as well as pass underneath them to access the other side of the galley. The fastener holes are roughly 1.1 m apart on the aft wall and 1.3 m apart on the forward wall. This discrepancy is worrying, but not outside the realm of possibility. Chains can handle a large degree of unevenness in measurements.

If the cauldron was suspended from chains, the bars in the handles are immediately brought into question. They would not have been needed for the chain arrangement, so their presence is curious. They can be explained, however, by ergonomics. The cauldron would not have been mounted all the time. A heavy swinging iron object would have been dangerous in large seas, for example, and would need to be stowed. The handles are small, and would not easily accommodate hands. One person could not easily carry the cauldron – again, it weighed at least 100kg. The bars may have been carrying tools rather than mounting hardware. Two crewmembers per bar would have brought the cauldron down to a manageable 25kg per person.

The problem with using the four fastener holes described above is that they are located in the smoke bay, in the soft pine planks. As these holes are located above the bricks, it seems unlikely that the 300kg cauldron would be suspended directly from the thin, soft, pine planks.

The last reasonable possibility for the cauldron's support are holes in a vertical line along the aft smoke bay wall. The distance from the bottom hole to the middle is 23 cm, and from middle to two holes at the top is 32 cm. These holes could have been for mounting a bracket for a crane. They are in the smoke bay and above the bricks, which would ordinarily give minimal support for the cauldron. However, these are directly in front of the orlop deck stanchion and its filler piece. Long fasteners could have been driven through the planks and filler and directly into the stanchion, giving the possibility of spikes or bolts up to 30 cm in length. The holes are consistent with a crane supporting a heavy cauldron: two holes at the top where the crane's arm intersects the bracket, and fasteners along a long vertical bracket for extra support. This would also place the cauldron along the ship's centerline, exactly where one would prefer to place 300kg of hot iron and water.

All in all, the most likely scenario is that the cauldron was suspended from a crane. The crane was likely mounted from the vertical holes in the smoke bay, with fasteners driven through the smoke bay planks and filler into the orlop deck stanchion. The top of the crane would have been about 30 cm over the head of the average *Vasa* sailor, and would have provided a range of motion not granted by simple chains or a rigid bar (Figure 5-18). The cauldron could also have been suspended from a bar running between the fore and aft brick walls, but this possibility is ruled out by the walls' uneven heights.

Between the galley hatch and the cauldron crane, 8 of 28 fastener holes have been accounted for. The function of the remaining 20 are more speculative. Since there were no other iron fittings remaining, it is impossible to say with certainty what went in the holes. There are three low holes in a line on the forward wall, 68 cm apart (for a total of 1.36 m). They are 46 cm above the brick floor. These may have been for a long low shelf, or a bench.

The last 17 holes are truly unknowns. They are not in a discernible pattern or pairing. Likely, these holes were for hanging equipment such as bread peels, ladles, and pots. Indeed, one bread peel was found in the galley compartment. Registered as find 13006, the peel is 1.02 m long, and probably hung from one of the galley fasteners when not in use. The

Vasa Galley Starboard Midship Elevation, reconstructed.
1:20 scale.

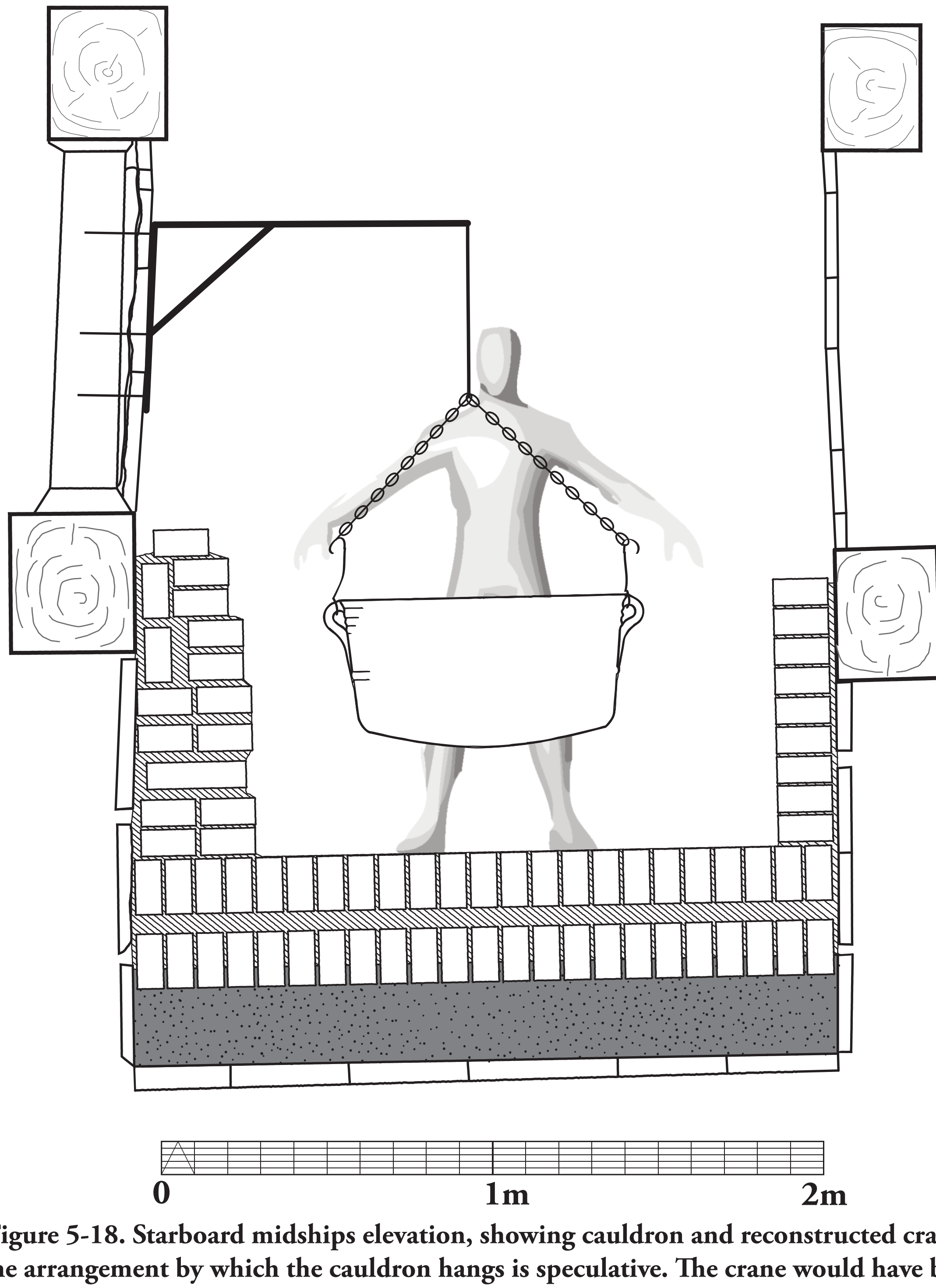

Figure 5-18. Starboard midships elevation, showing cauldron and reconstructed crane. The arrangement by which the cauldron hangs is speculative. The crane would have been fastened through the planks and into the stanchion, as shown. The andiron and fire are not shown. The digital cook is shown for scale.

fastener it would have occupied is unknown.

Vasa's Galley in its Historical Context

As far as its construction is concerned, *Vasa*'s galley resembles nothing so much as a terrestrial medieval kitchen. It occupies a central location in the ship, just as a medieval kitchen occupied a central location in the dwelling. It used a smoke bay rather than the more advanced hood or chimney. There is no evidence of a thick iron fireback, as was used in terrestrial kitchens beginning in the 16th century.

Certainly, *Vasa*'s galley bears no resemblance to the lavish kitchen described by Scappi in 1570. There was no lasagna cutter aboard *Vasa*, nor was running water installed. *Vasa*'s galley did not have an oven of any kind, unless it was to be installed at a later point (which seems extremely unlikely given the simplicity of the structure), or unless it was the sort of medieval-style improvised oven made from pastry (Henisch 2009:124).

When put in the context of other galleys, *Vasa*'s is simple. It does not have the recessed cauldron structure like *Mary Rose*, nor the tiles and chimney of the Oost Flevoland B 71 vessel. In terms of safety, *Vasa* did not contain the prodigious amount of lead that was installed on *Avondster*.

However, *Vasa*'s galley builders did not ignore safety. They used a very thick layer of clay mixed with sand – nearly the thickness of an entire brick course. This would have insulated the flammable galley floor planks from the heat of the hearth fire. As was discussed earlier, fires were a constant hazard in galleys. *Vasa*'s designers probably attempted to mitigate this risk by the small brick lip to either side. Still, in any kind of a heavy sea, ashes and sparks could have easily surmounted the 6 cm lip and escaped the hearth. Presumably the fire would have been extinguished in that situation.

Both Witsen and Van IJk suggest using copper sheeting in the galley. *Vasa* does not have this, probably to save on cost. Likewise, the cauldron is made of iron rather than copper, a strange choice. *Mary Rose* and the Zuiderzee K 45 tjalck both used copper cooking vessels. All in all, there appears to be a decided lack of metal used in the galley, even assuming most of it has corroded away. Again, this is likely to save on cost.

Vasa was massively expensive, and constructed with great attention to detail in many ways. The guns were custom cast for the ship, a costly proposition. Money was spent where it mattered. The conclusion, therefore, is that the galley simply did not matter very much to the builders. The arrende system provided the shipbuilders with a fixed sum to build *Vasa*, and thus a temptation to cut costs where possible. Officers ate separately from the crew, so they were less likely to complain about a cheap galley that they did not have much use for.

Vasa's galley is humble, simple, and likely built on the cheap. It was almost certainly finished some time after spring 1627, once the ship was in the water. At the very least, the bricks were laid once the ship was in the water, as they would need to be levelled to the ship as it floated. With its notched post structure, it could have been entirely built while the ship was afloat, in a relatively short time.

Conclusion

In all likelihood, *Vasa*'s galley was never used; there has never been any solid evidence to support the conclusion that the fires were ever lit. Had it been used, it would have been a simple affair. A cook standing in the galley firebox atop the bricks would have lit a fire in an andiron. The large cauldron would have been able to make 180L of whatever he chose, so long as it was vast. Smaller quantities of food would have been cooked either over other fires (there is no reason that only one fire could have been lit at a time) or by placing a vessel next to the main fire. Flatbreads or very small items could have been cooked directly on the hot bricks. A man standing on the hold floor next to the firebox could have comfortably used a peel to manipulate this food.

Still, the culinary options would have been limited, especially when compared to the advances in cooking technology shown in Scappi's book. The single cauldron, while very large, is smaller than either of *Mary Rose*'s cauldrons. While there was some clever design shown in *Vasa*'s case (like the lip at the edge and the notched-post construction), it was all clever design at no cost. There is not a single aspect of the galley that suggests expense or extravagance.

While food is important to all people, it seems that quality cooking for *Vasa*'s crew was not very important to the designers of *Vasa*'s galley. This is hardly surprising. It is hidden away in the center of the ship, where only the common soldier and sailor would ever have much contact with it. To its designers, it likely represented a source of profit rather than a source of food. After all, they would never have to use it.

For the crew, however, it would have been a source of food. During the 17th century, cereals, vegetables, and peas were increasingly used aboard Swedish warships, at the expense of meats (Söderlind 2006). A single large cauldron would have been ideal for cooking a soup or broth made with these bulk ingredients.

Even considering its simple construction, the galley is well designed. It would likely be very usable, suggesting that the designers had at least some thought toward the crew. This may also be a consequence of the contractor system: good enough to be accepted, cheap enough to make money. The simple galley thus provides the ultimate sharp contrast to *Vasa*'s highly decorated, extremely ornate exterior.

Obviously, conclusions drawn from *Vasa*'s galley are difficult to generalize without at least one similar galley for comparison. It is my hope that more large warship galleys will be located. Should this occur, there are several areas in particular that need further research.

The foundation layer of clay and plaster must be examined carefully. Fire spreading from galleys was a constant concern, and information about fire prevention techniques might be found in the foundation layer. Likewise, metals found around the bricks might suggest fire prevention, or like *Vasa*'s copper tacks, building techniques. Archaeologists studying galleys may learn more about masonry techniques and the craftsmen who built the structure by recording similar tacks, or any other material found behind the brick wall.

Finally, a galley with a long use life would be incredibly useful as a comparison to *Vasa*. The effect that smoke and years of cooking have on the structure needs to be documented and analyzed. *Vasa* is a "like-new" galley, just as it was delivered from the yard. The baseline *Vasa* provides may be useful in determining what archaeological features are cooking-related, and which were provided by the builders. Certainly, *Vasa*'s galley will not be the last word on 17th century naval cooking, but it is my hope that it will be the first word.

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APPENDIX: COPYRIGHT PERMISSION LETTER

Eric Ray
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1 December 2009

Martina Siegrist Larsson
Informatör / Information Officer
Statens Maritima Museer
P.O. Box 27131 | SE-102 52 Stockholm

Dear Martina Siegrist Larsson:

This letter will confirm our recent email conversation. I am completing a master's thesis at East Carolina University regarding Vasa's galley. I would like your permission to reprint drawings and photographs from the Vasamuseet archives in my thesis, which are identified in the thesis as the property of SMM.

The requested permission extends to any future revisions and editions of my thesis, including non-exclusive world rights in all languages, and to the inclusion of my thesis in library collections. It also includes the prospective availability of my thesis by UMI. These rights will in no way restrict republication of the material in any other form by you or by others authorized by you. Your signing of this letter will also confirm that SMM owns the copyright to the material.

Sincerely,

Eric Ray

PERMISSION GRANTED FOR THE USE REQUESTED ABOVE:

____
Martina Siegrist Larsson

Date: ______________________