

**A RE-ASSEMBLY AND RECONSTRUCTION OF
THE 9TH-CENTURY AD VESSEL WRECKED OFF THE COAST OF
BOZBURUN, TURKEY**

A Dissertation

by

MATTHEW BENJAMIN HARPSTER

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2005

Major Subject: Anthropology

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Major Subject: Anthropology

ABSTRACT

A Re-Assembly and Reconstruction of
the 9th-century AD Vessel Wrecked off the Coast of
Bozburun, Turkey. (August 2005)

Matthew Benjamin Harpster, B.A., The George Washington University;

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Chair of Advisory Committee: Dr. Cemal Pulak

In 1973, researchers from the Institute of Nautical Archaeology (INA) were led to the site of a wrecked ship by sponge diver Mehmet Aşkın, near his hometown of Bozburun, Turkey. During further monitoring over the following 21 years by INA, the site was identified as a merchant vessel dating from the 9th century AD. The excavation of the site by INA researchers and students from Texas A&M University occurred over four summer seasons, from 1995 to 1998, and yielded approximately 900 whole or nearly-whole amphorae, personal items, palynological material, and approximately 35 percent of the vessel's wooden hull.

This dissertation is a record of the curation, cataloging, analysis and re-assembly of the preserved elements of the Bozburun vessel's hull, as well as a theoretical reconstruction of the entire vessel. The Bozburun vessel is unique as it is the only fully-excavated shipwreck from the 9th century AD, and is, indeed, a valuable source of examples of ship construction in the Mediterranean between the 7th and the 11th centuries AD. This dissertation, after discussing the methods of excavation and cataloging methods, posits the hypothesis that the techniques used to build this vessel represent a transitional stage in shipbuilding technology, combining distinctly old and new techniques. While the builders used embedded edge joinery in the ship's planking, a very old method, they also appear to have used a conceptual framework and standards to design the vessel as well; methods evident in modified forms in Italian shipbuilding treatises from the Renaissance.

DEDICATION

When I finished my master's thesis, I wrote that it had caused me more grief, torment and turmoil than I ever expected a stack of paper to do. One would think I would have learned my lesson, but as my dad has pointed out, I often do things the hard way. For standing beside me through the classes, papers, relationships, long-distance travel, long-distance research, long-distance conferences, and long distance phone calls with good and bad news, this research is for my mom and dad.

ACKNOWLEDGMENTS

Over the course of seven (!) years, many people have earned my respect, trust and gratitude during their association and involvement in a project that will, hopefully, properly reflect their contributions. Predominant among those people are the members of my research committee who not only gave me this opportunity, but the guidance to finish it as well. Dr. Cemal Pulak, my chair, added the supervision of this project to a schedule that already was (and perhaps always will be) very busy and he needs to be recognized for his contributions. I may not have always expressed my gratitude for his help as best I should, but we made it through this together and thankfully in one piece. Thank you very much for your help. I first talked to Dr. Fred Hocker in the Fall of 1996 (nearly ten years ago!?) while writing my M.Phil thesis, and a year later as a new student at Texas A&M he offered me the opportunity to research the hull remains of the Bozburun ship for my dissertation. If I knew then what I know now, the reluctance he encountered might have manifested as a mad dash for the door, and not just introspection. Thank you very much for this opportunity, your guidance, and a spare bed while stuck in Denmark. I'll get a hold of those Sox tickets I owe you. Most likely unbeknownst to him, I first applied to the Nautical Archaeology graduate program to study with Dr. Frederick H. van Doorninck Jr., so although I never had a class with him, he taught me a great deal while serving on my committee. Thank you for your experience, guidance, and for going easy on me during my preliminary exams. I knew I was in a novel educational environment when Dr. Wayne Smith not only let me borrow the keys to his office, but purchased a gray-market flatbed scanner (was that from Bulgaria?) that I could tear up and build into a box camera (which, by the way, does work). Thank you for giving me the chance to try things in an academic environment that made you pull your hair out once or twice, and for backing me up nonetheless. And (particularly!) for writing at least two recommendations while vacationing in Greece. Last, but certainly not least, I want to recognize Dr. David Woodcock, my outside reader in the College of Architecture for agreeing to participate. We kept in intermittent touch for the past five years, but he was always enthusiastic, helpful and motivating any time I stopped by after an extended absence. Thank you very much, and I wish you the best.

Since 2003, I've not only been a student, but a student advisor, and the completion of this study will mark the end of my tenure in that role as well. Drs. Funkhouser and Coleman in the Office of Honors Programs and Academic Scholarships made me part of that indomitable team of people in the Fall of 2003, and I know I will never regret their decision. While working as an Academic Advisor, I've made wonderful and valuable relationships with everyone I've worked with, particularly Dr. Funkhouser, Dr. Coleman, Valerie Cook, Jon Kotinek, Marcella Ellis, Donna O'Connor, Jennifer Veracruz, Ellen Provin, Raghu Sethumadhavan and all the members of the Honors Student Council from 2003 to 2005. Many of us on this team are leaving for other careers, and I feel lucky to have been in the best place at the best time with the best people.

In the Fall of 1998, I was granted the Mr. and Mrs. Ray H Siegfried II fellowship which enabled me to study, travel, and undertake this research. It was an honor to receive, and Mr. and Mrs Siegfried helped make my career goals, and that of other recipients, attainable. Their help is invaluable.

I also know that while pursuing this study, particularly while deciphering the conceptual framework that was applied to the design of this ship, I consistently encountered the research and ideas of Professor J. Richard Steffy. If his work had not uncovered the application of a standard length in the design of the vessel from Serçe Limanı, I am fairly certain this study would be shorter and poorer as a result. If I saw farther, as they say, I did so standing on the shoulders of giants.

For their friendship, their jokes, their personalities and their support, Glenn Grieco, Rebecca Ingram and Troy Nowak have been here, there, and everywhere else to help me in ways great and small. The friendship I found in them will, I hope, continue despite our far-flung destinations.

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INTRODUCTION

The site of the Byzantine-era shipwreck near Bozburun, Turkey, was brought to the attention of George Bass and his team during the first Institute of Nautical Archaeology (INA) survey in 1973 by a local sponge diver named Mehmet Aşkın.¹ The site was located along the rocky coastline at Küçüven Burnu, approximately 36 degrees 43.5 minutes North, and 28 degrees 5.1 minutes East, near the village of Selimiye (fig. 1-1).

The INA survey team was brought to a low-lying amphora mound, approximately 20 x 8 m, situated at the base of a cliff comprising part of the promontory called Bozburun, or “Gray Cape”, in Turkish. The amphora mound, and the archaeological material beneath it, were embedded in a sandy, somewhat stiff sediment that sloped away from the base of the cliff. The shallower end of the site, approximately 26 m deep, consisted of two fairly distinct areas. The first area consisted of a small, low outcrop of rock that jutted out from the base of the cliff for a distance of approximately 5 m. A relatively small amount of archaeological material, primarily amphoras, was found in this area. The second area, which demarcated the upper extent of the amphora mound, was approximately 1 m deeper than the level of this outcrop, and began the gradual slope towards the lower end of the site. The rest of the site extended down the slope, to a depth of approximately 36 m. Other than the rocky outcrop at the base of the cliff, the only other consequential geologic formation on site was a rock or boulder approximately 50 cm high and 1 m in diameter, approximately 4 m from the low outcrop, lying in the upper right corner of the site (fig. 1-2).

Over 440 amphoras were lying exposed at the beginning of the excavation in 1995, but local sponge divers had reportedly removed up to 200 in the years prior to the beginning of the excavation (fig. 1-3).² Some of the amphoras removed by the local divers appeared in nearby restaurants and gardens, but a few were donated to the Bodrum Museum of Underwater Archaeology in Bodrum, Turkey.³ These donated amphoras, in addition to three others raised by INA researchers in the course of monitoring the site, provided a preliminary date of wrecking between the late 9th and the early 10th century AD.⁴

This dissertation follows the style of the *American Journal of Archaeology*.

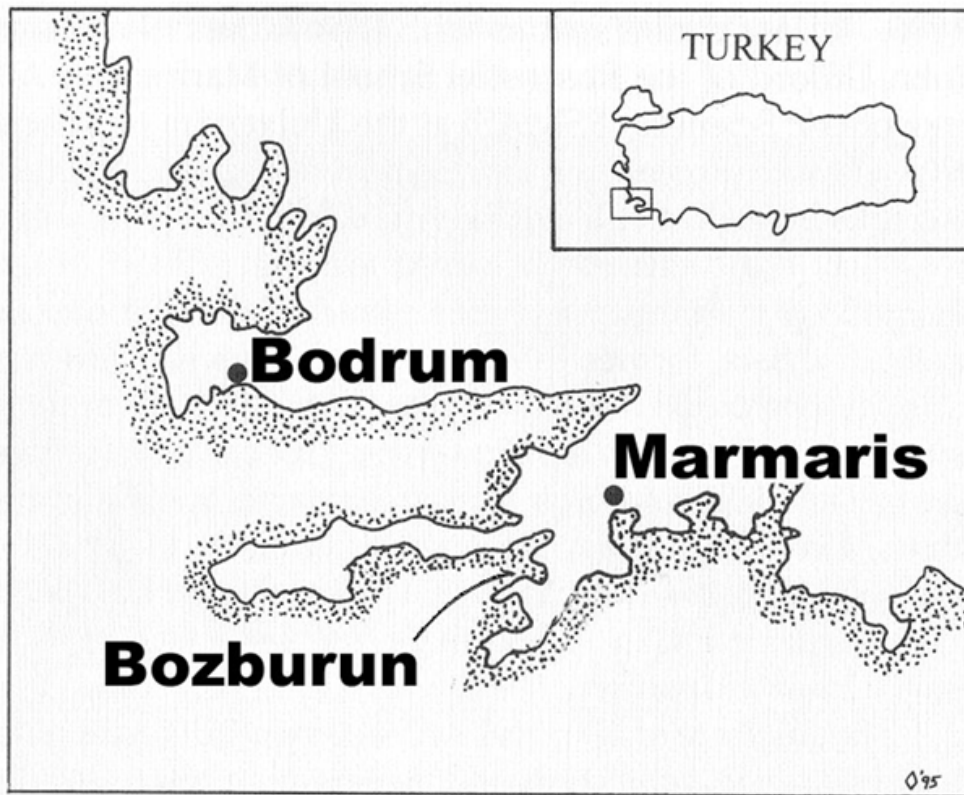


Figure 1-1: Location of Bozburun along the coast of Turkey (INA Archives).



Figure 1-2: Location of boulder at upper end of site (INA Archives).

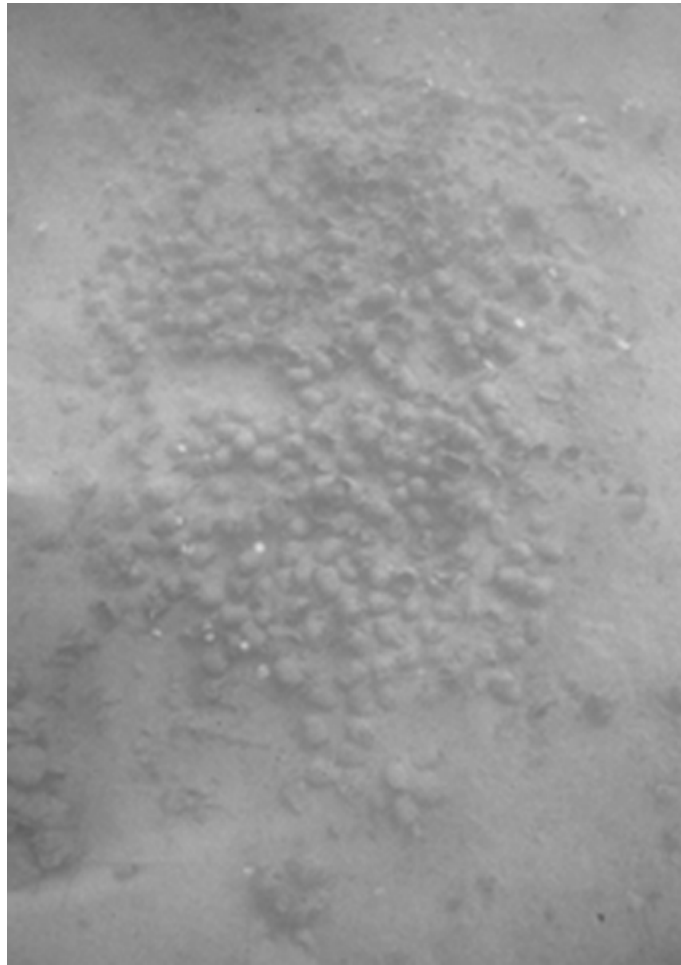


Figure 1-3: Image of Bozburun site prior to excavation (INA Archives).

Due to the compact and fairly dense nature of the amphora mound, the composition of the sediment on site, and the fairly undisturbed nature of the material, it was speculated that this site would contain well-preserved hull remains. Subsequent monitoring and small soundings by a later INA survey team in 1983 supported this theory, as pockets of well-preserved hull material were found distributed throughout the site. In 1994, as the INA excavation at the Bronze Age site of Uluburun near Kaş neared its end, the last survey of the Bozburun wreck site occurred in preparation for its excavation in 1995.

The 30-person excavation team that arrived in Turkey in 1995 began the initial preparation of the site by building a semi-permanent camp 1.5 km away on rented land, and a dive platform immediately over the site, built into and on the cliff face.⁵ This dive platform supported a 45-kilowatt diesel generator and two air compressors, and additionally housed diving equipment, oxygen tanks for decompression, and spare materials for work on site. Diving activity on the site began in July, and by the end of the season, 23 datum points had been affixed both around the site and on the rocky outcrop above, a grid demarcating the 2 m² excavation squares had been fashioned from polypropylene line, and a variety of artifacts had been recovered. This recovered material included amphoras, square hearth tiles, a pitcher, fragments of bowls, as well as two fishing weights.⁶ Two anchors, as well as some disarticulated fragments of wood, were also exposed, but not raised.⁷

The continuation of work in 1996 resulted in the further recovery of nearly 200 whole amphoras, fragments of 300 others, three coarse-ware pitchers, more lead fishing weights, a copper jug, encrusted carpenter's tools, and two fragments of a small blue-green glass goblet.⁸ Due to the large number of amphoras recovered, a basic typology was developed over the 1996 season that assigned the amphoras to three distinct classes.⁹ In addition to the creation of this typology, a number of the amphoras could also be grouped on the basis of graffiti inscribed on their surfaces.¹⁰ Work in 1996 also exposed the first signs of hull remains in situ. At this time, these remains were concentrated only at the upper end of the site and in excavation grid square H11, which was located approximately amidships.¹¹ While the wood exposed at the upper end of the site consisted primarily of disarticulated fragments with few original surfaces, that found in H11 comprised a section of the keel, four floor timbers, four planking strakes, two ceiling strakes, a section of a

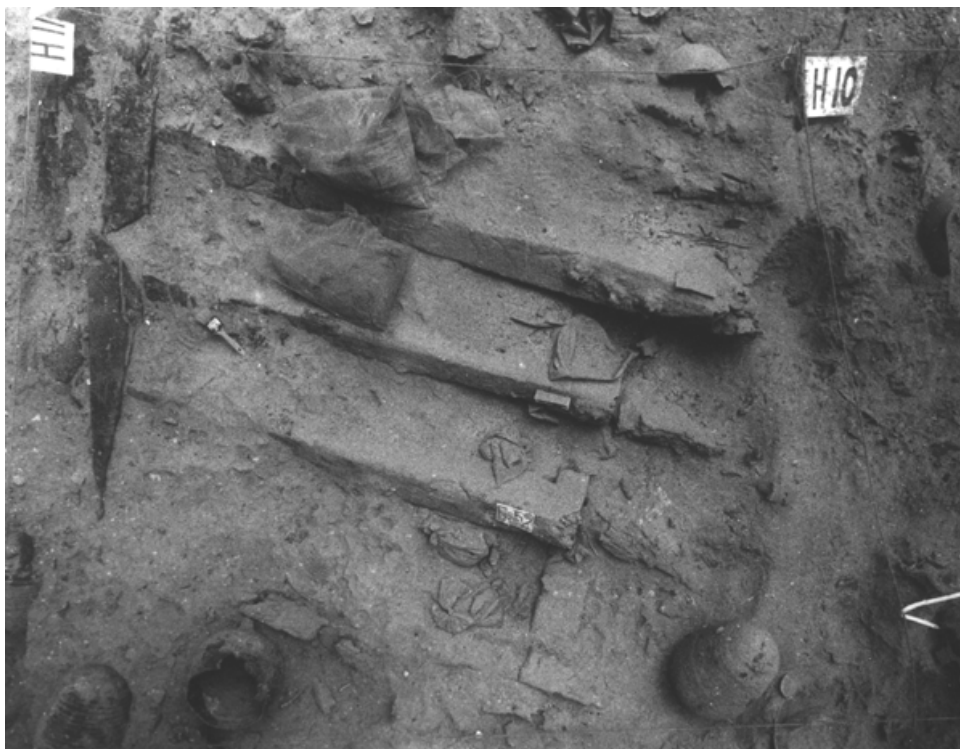


Figure 1-4: Hull remains found in square H11 (INA Archives).

stringer, and possibly a keelson (fig. 1-4).¹² These exposed hull remains also preserved evidence of iron nails, clear tool marks, clean edges and faces, and little damage from *Teredo navalis*.¹³

The 1997 season consisted primarily of the further removal of amphoras as well as a refinement of their typology. More articulated hull material was exposed, including what was left of the stern, and the after 2 m of this material was mapped in place (fig. 1-5). Only a small percentage of the wood fragments found on site were brought to the surface and cataloged.

In 1998, all work on site was completed. Fifty-two people worked both in camp and underwater. Four different amphora classes had been identified, approximately 200 examples of graffiti on amphoras had been found, and macrobotanical and pollen samples had been taken from over 900 amphoras.¹⁴ More coarseware and tableware was excavated, as well as a bronze steelyard, a single oil lamp, more concreted carpenter's tools, and fragments of two anchors.¹⁵ Overall, the only somewhat luxurious artifacts recovered consisted of the base of a third glass goblet, a deer horn, and a hippo tooth.¹⁶ No coins or other personal possessions were found on site. The recovered amphoras provided a preliminary date of wrecking near the end of the 9th century AD, but dendrochronological analysis has indicated that the oak timbers were cut in AD 874.¹⁷

Although various small fragments of ceiling planking, hull planking, and framing came back to camp to be cataloged and stored throughout the 1998 season, the formal recording of hull material in camp began on July 20, 1998. The contents of tray number 1, which had been raised from the site on July 1, initiated a cataloging process that continued in camp until August 23, 1998, when the size of the excavation team dwindled to approximately 12 people. By the close of the 1998 season in September, approximately 90 percent of the preserved hull material on site had been excavated, stored in the small bay next to camp, and then transported back to INA headquarters in Bodrum.

The amphoras, the most ubiquitous and numerous artifacts on site, were found in rows D through M (fig. 1-6). Their distribution and orientation on site tended to reflect their original arrangement stored in rows, and stacked in at least two layers, in the hull. The recovered galley ware, which consisted of eight cooking pots, seven coarseware pitchers,



Figure 1-5: Hull remains found in square D10 (INA Archives).

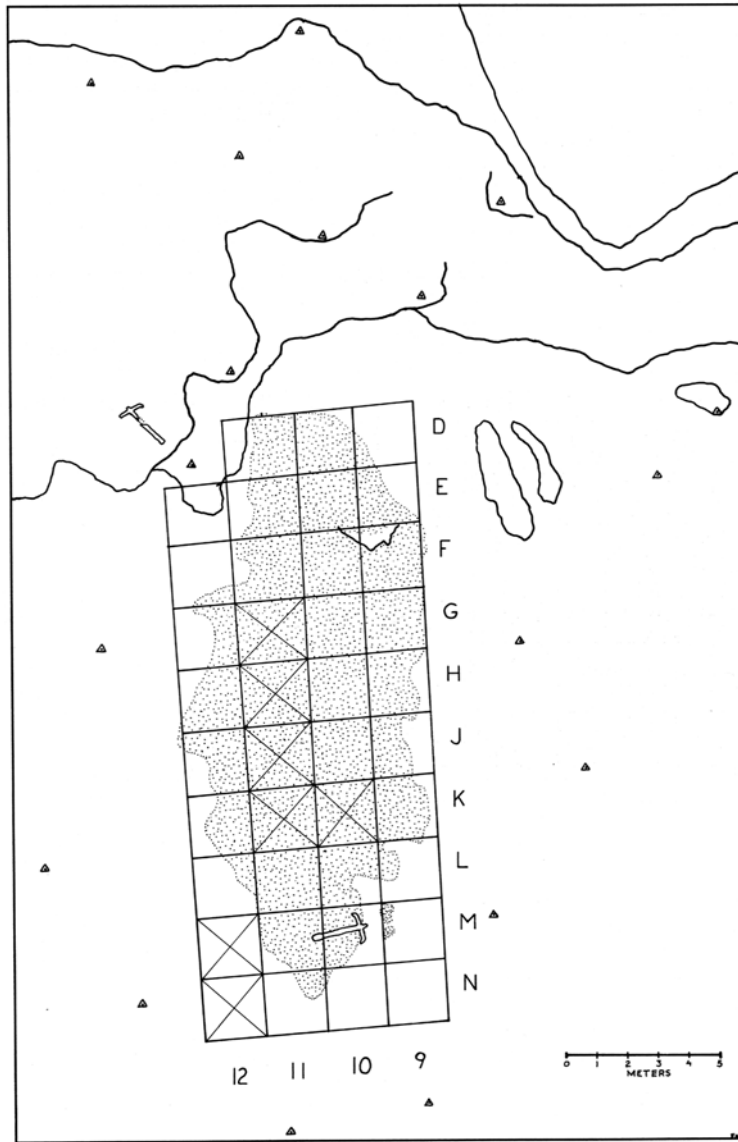


Figure 1-6: Plan of grid squares over site (INA Archives).

two collar stands and two copper jugs, was upslope of the main concentration of amphoras, predominantly in square E11. The distribution of these artifacts coordinated well with the locations of the 12 hearth tiles, and indicated the location of the galley as well as the stern of the vessel. As fragments of an anchor and strands of rope were found downslope in square M10, indicating the bow of the vessel, it was evident that the ship had come to rest on its starboard side on the sea floor relatively perpendicular to the cliff face, and pointing downslope. The deer horn, hippo tooth, oil lamp, glassware fragments and collection on concreted tools were found near the stern of the vessel as well. The bronze steelyard was found near the middle of the vessel, in square G11.

The preserved hull remains included large fragments of the oak keel, stem and sternpost extending downslope in columns 10 and 11, as well as remnants of planking preserved in the same columns between rows E and L. On site, 11 strakes of oak planking were identified on the starboard side. Later analysis has revised that number and also indicated that the third plank in strake five is chestnut.¹⁸ Approximately five strakes of disarticulated oak port planking was also identified in situ. Remnants of 35 floor timbers and 11 futtocks were identified predominantly on the starboard side of the keel, although squares D10 through F10 at the stern contained fragments on the port side as well. Among those framing fragments, remains representing seven floor timbers and three futtocks were of oak, while the remaining framing fragments are pine. Those seven oak floor timbers are now identified as floor timbers 1, midships, and A through E, while the futtocks are associated with floor timber 3, E and H.

Disarticulated remnants of seven oak ceiling planking strakes were preserved on the starboard side of the keel, in addition to five fragments of the oak stringer located approximately 36 cm away from the keel. A large, fairly non-diagnostic fragment of oak on top of floor timbers 42 through 44, directly over the keel, was identified on site as part of the keelson or mast step. A portion of a wale was identified on site, but it did not survive to undergo further cataloging and analysis.

The keel is missing a 22-cm long portion in square F10, while the stem and sternpost are not preserved more than 12 cm higher than the top face of the keel. The majority of the floor timbers and futtocks extend to and somewhat through the turn of the

starboard bilge, but none are preserved above that point. Similarly, the planking is very fragmentary near the preserved extremities of the floor timbers and futtocks. Despite the presence of an inboard stringer on the starboard side, there are no preserved fragments of an outboard starboard stringer, or ceiling planking or stringers on the port side of the keel. No identifiable fragments of deck beams, a mast, a yard, or deck planking were found.

Clearly, between the initial examination of this site in 1973 and the final closure of the nearby camp in 1998, a large number of people expended a great deal of time, money and labor simply to remove the evidence of an accident. It is unknown why the ship was there. Where the ship may have been going, who was on board, and the cause of its sinking can only be speculated.¹⁹ Overall, there was no indication prior to the excavation that this ship represented anything but an ordinary merchant vessel and, following that work, this interpretation has been confirmed. So, other than to satisfy simple curiosity, why was this particular ship excavated?

Between 1905 and 2002, over 100 shipwrecks dating between the 5th and the 13th centuries AD have been identified in the Mediterranean. Of those sites, however, only approximately 21 have undergone a partial or complete excavation. Therefore, simply in light of the small number of excavated wrecks that date to this 500-year period, a fully excavated site can add significant amounts of information on maritime practices during this era. Additionally, those wreck sites are not evenly distributed throughout that 500-year period. the majority of the ships apparently sank between the 5th and the middle of the 7th century and, at present, this site at Bozburun is the only fully-excavated wreck site from the 9th century AD.

Further justification for the excavation of this site is provided by the extensively preserved hull material. Of those Roman or early-medieval wreck sites, only 30 have reported hull remains. Within that group of 30, the hull remains of 14 have been published to some extent, but only 10, at the most, have been the subject of extensive research and analysis. Therefore, current theories regarding trends in ship construction over this 500-year period are based on a handful of wreck sites randomly scattered across five centuries, and on extensive analysis of less than half of them. In general, then, any preserved hull remains from a fully-excavated site dating to this 500-year period are valuable, while the

particular date and extensive hull material from Bozburun make this hull irreplaceable.

Additional importance lies in how it may illustrate changes in ship construction. Since the time of Old Kingdom Egypt, or perhaps earlier, archaeological evidence indicates that ships in the Mediterranean were built by assembling the planking with mortise-and-tenon joints, by lacing the planks together, or by lashing.²⁰ All three methods are indicative of pre-medieval Mediterranean shipbuilding techniques as they join planks together edge-to-edge, penetrating the long, thin edge of the plank as a means of securing it to an adjacent plank. In this way, the joinery is integrated into, or is embedded in, the plank seam. In contrast, planks in the post-medieval era may lie edge-to-edge, but they are affixed only to the framing and not to each other as well.

A mortise is simply a slot cut into a piece of wood. The mortise may be on any face of a timber in question, but in the mortise-and-tenon method applied to hull planking, mortises are cut into the long edges of the planks. Tenons, on the other hand, are slips of wood that fit into the mortises. Usually, a tenon is of the same width and thickness as the mortise, but approximately twice as long as a single mortise is deep. With the mortise-and-tenon method, once the stem and sternpost are attached to the keel, mortises are cut into a rabbet or chamfer on either side of the keel, and tenons are then driven into each of the mortises (fig. 1-7). A matching set of mortises are cut into the lower edge of the first strake, and the entire strake is hammered into place, forcing the tenons into the mortises in strake one. The mortise-and-tenon joints may be further secured by drilling holes on either side of the seam through the planking and the tenons, and then driving wooden pegs into the holes.

This process is repeated along the edges of each strake. Thus, by using mortise-and-tenon joints to affix strakes together, it is possible to assembly most, if not all, of the exterior planking prior to attaching any or most of the internal framing. Using this method of construction, as the strakes of the ship are assembled prior to the frames, the planking determines the interior and exterior dimensions of the ship, and thus the general shape of the vessel. Presently, it is not entirely clear why the mortise-and-tenon method was adopted and used for such a long time throughout the Mediterranean. The hull produced is one that

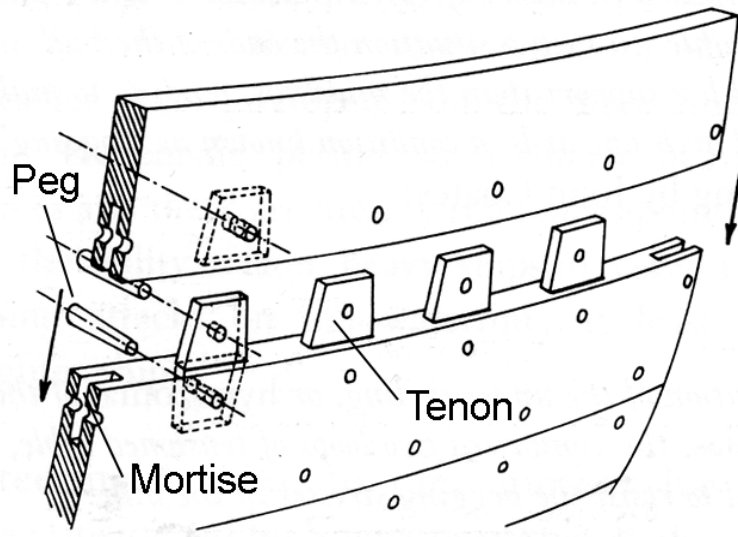


Figure 1-7: Schematic of the mortise-and-tenon method of hull assembly (after Coates 1995, 131).

is very strong, and one that can last a very long time. From a contemporary point of view, however, the mortise-and-tenon method of assembly requires more labor, more skill, more materials and more time.

The lacing process uses natural fiber cordage, instead of mortise-and-tenon joints, to join the planks together edge to edge. A single laced stitch consists of a pair of drilled holes, approximately 0.6 cm in diameter, aligned on either side of a plank seam and a strand of cordage passing through the holes. Prior to the Roman era, each hole is characterized by its inclination and a small triangular notch surrounding it on the interior face of the planking. Later examples were missing this triangular notch. Rather than passing directly through a plank from the interior to exterior face, the holes commonly exited the plank along its vertical edge. In this way, once cordage is passed through a pair of lacing holes and across a plank seam, neither the lacing holes nor the cordage itself is evident on the exterior face of the planking.

In the lacing method, once the stem and sternpost are attached to the keel, lacing holes are drilled into both the upper face of the keel and the interior face of the first strake. To align the first strake along the keel's edge, or to align one plank with another, edge dowels 1.0 to 1.4 cm in diameter or tenons are fitted into the mating faces every 15 to 20 cm. Essentially, the plank and the keel are fitted together via these edge dowels and the cordage is passed through the holes, and tightened down over waterproof wadding. Following the lacing process, small tapered pegs were hammered into the lacing holes to jam the cordage in place and, along with tar applied to the internal face of the planking, to add an additional level of waterproofing to the hull.

The resulting laced pattern has two advantages over other methods using cordage to join planks together edge-to-edge. The lacing reinforces the dowel's abilities to resist and distribute shearing forces, while the regular back-and-forth pattern over the plank seam counteracts any tendency of the planks to separate. As the cordage may still stretch, however, some flexibility is more characteristic of a laced hull than one fashioned with mortise-and-tenon joints.

This flexibility is indicative of vessels lashed together as well. Unlike lacing, which follows plank seams, the lashing process is transversal, and is distinguished by cordage that

travels back and forth from one sheer strake to the other. As the cordage travels back and forth, the strands are embedded in the interior face of each plank, but emerge near the planks' edges to pass over the seams. At each seam, the cordage also passes over a batten or waterproof wadding which increases the tension on the cordage and the integral strength of the hull. Embedded edge joinery such as mortises and tenons are evident in lashed vessels as well, and resist the planks' tendencies to slide fore and aft both during construction and use.²¹ This slippage, however, is combated more directly by the shapes of planks particular to vessels built in the lashed fashion.

As evident in the funerary barge found at Khufu's pyramid or the more utilitarian vessel or vessels represented by the Lisht timbers, planks in lashed vessels are fashioned with distinctive joggles in their edges. These joggles, in turn, interlock with one another to resist this slippage and the hogging and sagging forces acting on a hull.²² Lashed vessels are also distinguished by planks that are particularly thick, in some cases 12 to 15 cm thick.²³

Although these methods were once used on vessels varying from vernacular craft to warships, massive cargo carriers and royal vessels, none are now employed in the Mediterranean.²⁴ Modern wooden ships in the Mediterranean are built by erecting some or all of the frames prior to the planking, rather than vice versa. After the keel, stem and sternpost are erected, a particular number of frames are next affixed in place. The planking is assembled around these frames and affixed to them. As a result, this framing delineates the general dimensions and design of the ship.

At some point in the past, the modern method must have appeared and replaced the methods common in antiquity. Possible reasons why this change occurred will be addressed at the end of this study, but when it occurred is fairly evident. The lacing method reached an apparent nadir in the 6th or 5th century BC, having been eclipsed by the mortise-and-tenon method, and had almost entirely disappeared by the turn of the millennium. The mortise-and-tenon method was still in use in the 4th and 5th centuries AD, but the size, quality and frequency of the joints themselves were decreasing.²⁵ By the 6th and 7th centuries AD, pegs no longer secured the tenons within the mortises, and the joints were playing an insignificant role in the structural integrity of the hull.²⁶

Extensive study of the construction methods employed in building an 11th-century

Byzantine ship found at Serçe Limanı indicates that processes of mensuration and standardization indicative of modern methods were now in use.²⁷ Evidently, the replacement of the older method with techniques similar to those today occurred at some time between the 6th and the 11th century AD. As the extensively preserved material from Bozburun dates to the end of the 9th century AD, about midway through this transitional period, this hull may begin to define how and more precisely when this transition occurred.

More important than the presence or absence of embedded edge joinery in this hull, however, is the manner in which ships after this period may have been conceived in the mind of the shipbuilder. This transition from the antiquated technique employing edge joinery to the more modern method encompasses more than just a shift or a re-alignment of technology. It also encompasses a fundamental change in the way these ships were designed. The older method of the Mediterranean defined the shape of the vessel as an associated series longitudinal curves, guides that manifested in the run of the planks between the bow and stern of the ship. The more recent technique, affixing framing to the keel prior to attaching planking, relies on a series of transverse curves and arcs across the width of the vessel, still defining the overall shape, but doing so only at intermittent sections along its length. This period from the 6th to the 11th century is transitional because an earlier construction technique was disappearing, and because the fundamental elements of ship design were in flux.

Two basic questions will be pursued in this research: how was this ship built and why was it built in that way? In an attempt to answer these questions the preserved hull material from Bozburun had to be first deconstructed and analyzed in its component parts, prior to the process of re-assembling all of the extant remains, and then re-creating the remaining structure. This research, which is a record of this deconstruction and eventual re-assembly, is thus divided into two phases. The first phase of research documents the excavation and recovery of the hull material from the sea floor, the recording and analysis of the individual components, and the catalog of all the recovered timbers. The second phase of this research, discussing a re-assembly of the extant remains and a complete reconstruction of the vessel, analyzes and amalgamates data gleaned from the first phase, presenting the vessel as it may have existed just prior to its destruction. These two phases

of research, however, do not answer both of the basic questions at the center of this study; a better understanding of the structure and design of the ship may be the result, but there is still no understanding of why the ship was built in the manner in which it was. To illuminate why this ship was designed in a particular way, the context of the ship needs to be examined as well. To do this, a corpus of early-medieval shipwreck sites, with brief discussions of their artifacts and associated hull material is included between the two phases of work. Moreover, a brief discussion of the social, economic, and political context of the Bozburun vessel will be included as well, examining how this larger context may be reflected in the structure of the Bozburun hull, and vice versa.

Endnotes

- ¹ Bass 1974a, 3.
- ² Hocker 1995, 6; 1996, 5; 1999, 31, 36.
- ³ Hocker 1999, 36.
- ⁴ Hocker 1995, 3.
- ⁵ Hocker 1995, 4.
- ⁶ Hocker 1995, 7.
- ⁷ Hocker 1995, 7.
- ⁸ Hocker 1996, 7-8.
- ⁹ Hocker 1996, 5.
- ¹⁰ Hocker 1996, 6.
- ¹¹ Hocker 1996, 8.
- ¹² Hocker 1996, 8.
- ¹³ Hocker 1996, 8.
- ¹⁴ Hocker 1998, 5-6.
- ¹⁵ Hocker 1998, 7-8.
- ¹⁶ Hocker 1998, 8; personal communication with Dr. Fred Hocker, Spring 2005.
- ¹⁷ Personal communication, Dr. Peter Kuniholm and MaryAnne Newton, Spring 2003.
- ¹⁸ Personal communication, Dr. Peter Kuniholm and MaryAnne Newton, Spring 2003.
- ¹⁹ Hocker 1998, 11.
- ²⁰ Pulak 1999, 213.
- ²¹ Haldane 1993, 252, 256.
- ²² Haldane 1993, 95.
- ²³ Haldane 1993, 95.
- ²⁴ Pomey 1981, 225-44; see also Casson and Steffy 1991, 18-9; Rival 1991, 188; Wachsmann 1995, 137-40; Steffy 1994, 71-2.
- ²⁵ Steffy 1994, 74.
- ²⁶ Bass and van Doorninck 1982, 56.
- ²⁷ Steffy 1994, 85-91.

METHODOLOGY

Work on Site

Two major tasks are encountered when recovering the submerged hull remains of a ship. The first is the creation of an accurate site plan of all the remains in situ, and the second is the creation and maintenance of a comprehensive inventory of the recovered remnants. When excavating the hull remains found at Bozburun, a widespread system of labeling and the use of the WEB program attempted to complete both of these tasks.

Labeling on Site

The labeling system used on site was one that had evolved over the previous 30 years, and combined elements from earlier systems developed by INA and those employed in the Netherlands for wrecks in the Polders.¹ Each fragment was given a coded tag that identified the purpose of the fragment (plank, frame, keel, etc.), its relation to other fragments around it, and its location in the ship. For example, the 22nd fragment of the first plank in the fifth starboard strake would be affixed with a tag that identified it as that fragment, and only that fragment. To do this, certain standards of labeling were established.

As the stern was exposed first, the numbering of both the keel and the planking fragments began there. For example, the aftermost preserved keel fragment is labeled as fragment 1 and the numbers increase towards the bow of the ship. The highest numbered keel fragment is fragment 42.

The hull planking and ceiling were labeled in a similar manner. To maintain standard shipbuilding conventions, the strakes of the ship were identified as strake 1, strake 2, strake 3, etc..., counting out from the keel. In this manner the preserved remains of 11 strakes were identified in situ on the starboard side, and five in situ on the port side. As in the case of the keel, the aftermost fragment of each identified strake was fragment 1, the next was fragment 2, and so on. However, as the strake of a ship may be composed of more than one plank, the fragments' numbers would start over when the labeling of the next plank began. For example, strake 5 is composed of three planks. The aftermost plank is plank 1, and it is composed of approximately 46 preserved fragments. At the end of that first plank, the fragment numbers would start over at 1, but the attached tags would then identify fragments as comprising part of the second plank in strake 5. Additionally, as the

planking remains were uncovered and excavated in varying states of preservation, it was a common practice to attach more than one tag to a fragment if that fragment was likely to break. For example, one fragment in strake seven is over 1.5 m long and, because of its size and fragility, it was assumed on site that it would not be recovered in one piece. Thus this fragment has four labels on it. Finally, to aid the later process of cataloging and reconstruction, the majority of the planking labels were oriented the same way, that is, from the viewpoint of the centerline of the ship, each label was attached upside down. The labeling of the stringers in situ also followed a pattern similar to that applied to the planking remains.

The framing was also labeled sequentially from the stern of the vessel. However, as the first substantial floor timbers to be uncovered were not in the stern area, but near amidships in grid square H11, the labeling process proceeded in a slightly different manner. Adopting a French technique, we labeled the first frame uncovered Frame 50, under the assumption that there could not be more than 50 frames left in situ from amidships to the stern of the vessel.² Thus, although the frames are still numbered sequentially, the aftermost preserved floor timber was numbered 21, while the foremost floor timber was 58. Just as the strakes are comprised of a number of individual fragments and were labeled appropriately, the framing material also followed the same practice. In this case, the first fragment of floor timber 43, for example, was the fragment encountered closest to or on top of the keel, while the last fragment labeled was that found the farthest outboard. Just as strakes are made up of more than one timber, framing is also composite, made of both floor timbers and futtocks. Thus, it was planned that all identified floor timber fragments would have a 0 prefix before the appropriate fragment number, and all futtocks had a 1 prefix before the fragment number.

So as not to overload the site or the hull fragments with extensive labels, abbreviations were employed on the tags. The 1998 Bozburun Field Manual specified these abbreviations to be used on site:

- KK – any keel fragment
- KS – keelson fragments
- PP – Planking, port

PS – Planking, starboard

CP – Ceiling, port

CS – Ceiling, starboard

SP – Stringer, port

SS – Stringer, starboard

FR – Frame

In the field, however, no stringers or ceiling planking were found on the port side, so those two abbreviations were never used. Additionally, the abbreviations for both the planking and the starboard stringers were changed in practice. The final set of abbreviations used in the field were:

KK – Keel

KS – Keelson

SP – Strake, port

SS – Strake, starboard

CS – Ceiling, starboard

SST – Stringer, starboard

FR – Frame

FRS – Futtock, starboard (used rarely)

MS – Mast Step

UM – Unidentified member

The last abbreviation, UM, was commonly applied to fragments that played a structural role in the hull, but could not be clearly segregated into one of the other categories. Approximately 1030 UM tags were created in the last two seasons of work on site.

A few examples will summarize the labeling system. The label for a fragment from starboard strake six would begin with SS6, followed by the appropriate plank and fragment number. Thus, SS6 1/6 refers to the sixth fragment in the first plank, of starboard strake six. SP1 2/19 refers to port strake one, or the port garboard, and the nineteenth fragment of the second plank. KK 30 denotes the thirtieth fragment of the keel, and FR 35 0/2 referred to the second fragment of floor timber 35. There was some minor confusion over

the labeling of the futtocks. For example, one futtock was labeled FRS 52-2 [Futtock, starboard, frame 52, fragment 2], while another was labeled FR 37S 1/1 [Frame 37, futtock, futtock/first fragment]. No futtocks, in fact, were labeled according to the conventions outlined in the 1998 Field Manual. These differences, however, caused little confusion during the later cataloging process as only 10 futtocks were recovered. Overall, there were very little, if any, contradictions or duplications in the labeling process, most likely because the production and attachment of the labels was reserved for only a few members of the excavation team.

The greatest problem encountered in the labeling was one that could not have been avoided due to the nature of the excavation process. As the preserved hull remains of the ship were not exposed all at once, but over time proceeding from the stern to the bow, problems were encountered when labeling strakes three and four. As both of these strakes attach to the sternpost, they were both correctly labeled as separate strakes. Approximately 2 m aft of the preserved forward end of the stem, however, both strakes taper, merge into, and are scarfed to one plank that reached the stem. The latter plank was consequently labeled as part of strake four, although it is only the third strake outboard of the stem. Overall, this problem is only a matter of nomenclature, and is easily remedied, but greater problems could have been encountered if the ship had a number of stealers or drop strakes in the hull planking.

Although the Dymo tags used to identify the hull remnants labels were affixed to the fragments in 1998, they are still easily legible and, along with the brass pins used to fasten them to the wood, in very good condition. In general, due to the integrity of the wood, the tags have remained on their appropriate fragments, and have only tended to fall off due to the degradation of the fragment itself.

WEB Program

The WEB program, developed by Nick Rule for the *Mary Rose* excavation in 1981, was used to map the site for a number of reasons, the foremost being the program's ease of use. To determine the location of any point on site within three-dimensional space, a minimum of four measurements from set datums to that particular point are required. There was no need for plumb bobs or triangulation on site, and the accuracy of the

measurements could be determined within an hour of gathering the data. Additionally, the use of the WEB program eased the creation of an accurate site plan of all the preserved hull remains, without the need to uncover the entire site at one time.

The in-situ mapping of all the major hull components using the WEB program was similar to the mapping of the amphoras. To provide clear reference points on the preserved hull remains, small 1-cm squares of oilcloth (called *muşamba* in Turkish) were pinned to the upper surface of the timbers at the points to be mapped. These squares served two purposes. First, each square acted as an easily accessible reference point at which measurements were taken. Secondly, since each square stood out in photographs of the timbers in situ, they collectively enhanced the utility of the photographs when drawing the site plan (fig. 2-1). The affixing of the squares on the timbers was not arbitrary. In general, they were placed along one edge of a fragment to be mapped. In the case of the keel, they were placed along the starboard top edge. The WEB data, in conjunction with photography and measurements, was sufficient to produce a fairly accurate plan of the keel prior to its removal from the site.

Similarly, the squares were attached to either the inboard or outboard edge of planking remnants, in locations where the seams between the strakes were easily distinguishable (fig. 2-2). By mapping the locations of the squares on a site plan, examining photographs and field notes, a preliminary site plan of the hull was developed by the Spring of 1999.

Determining where to attach the squares on the floor timbers was slightly more difficult. As the majority of the floor timbers, particularly those from FR 39 forward, had rolled downslope, they were either lying flat on their forward face, or had come to rest, tilted, on their forward bottom edge. In either case, the squares were placed in an effort to glean as much information from the WEB data as possible. Commonly, the squares were affixed to each floor timber along the top, after edge, chosen primarily because it maintained the original cross-sectional shape of the ship, and secondarily because that edge, as opposed to the top, forward or bottom edge, was easily accessible and visible in photographs (fig. 2-3). The resulting WEB data produced a rough sketch of the curve along the top face of the floor timber. That information, in conjunction with photography



Figure 2-1: Detail of the *muşamba* squares on the hull remains while in situ (INA Archives).



Figure 2-2: Detail of the *muşamba* squares demarcating the plank seams (INA Archives).



Figure 2-3: Detail of the *muşamba* squares along the after top edge of the floor timbers (INA Archives).

and on site measurements, produced a fairly accurate representation of the floor timbers on site. The only drawback, and this would be clearly amplified if only WEB data was being used to map the hull remains on site, is the slight ambiguity of determining under water where the curves at the garboard hollow and the bilge begin and end. Otherwise, the entire system produced an accurate and detailed site plan.

Removal of Hull Remains from the Sea Floor

Once the measurements were checked and determined to be accurate to within 1.5 cm, the fragment or timber was removed from the site. Small fragments, particularly pieces of the planking, were lifted and placed in wooden trays to either side of the site. These trays, built of locally cut pine planks secured with brass nails, were submerged with rocks in the bay outside camp for a few days to reduce their buoyancy under water. The majority of the trays were of one size, approximately 2.0 m x .43 m wide x .10 m deep, although custom sized trays up to 2.5 m x .25 m deep were built to carry fragments of the keel. By the end of fieldwork in 1998, 61 trays had been built; at present approximately 55 of these are still in use. Although the pine planks of the trays were still fairly solid, by 2002, the nails in six of the trays had completely eroded, requiring the construction of six new trays.

Each tray was numbered sequentially prior to submersion on site. Once the tray was full, empty flour sacks were nailed over each tray to protect the fragments from water flow while being raised, and then the tray was brought to the surface. Although it was fairly easy to maneuver the full tray underwater with the aid of a lifting bag, passing the tray, and any other heavy hull material, from the water to the diving platform was awkward and difficult. The majority of the trays weighed approximately 23 kg each, and moving them from either the water to the diving platform, or from the platform into a boat, was awkward and rough. A small crane, built well toward the end of the 1998 season, aided this entire process immensely.

These trays, like the amphoras, were stored under water in the shallow bay outside camp until they were transported back to INA Headquarters in Bodrum. An effort was made to create an inventory of every tray once it arrived in camp and to assign Lot Numbers to the fragments in each tray. This was done in an attempt to maintain an accurate record of all the recovered fragments, their location, and to speed up the recording

process that would begin in the Spring of 1999. Between July 1 and August 17, 1998, nine trays were assigned a series of Lot Numbers. While each fragment in tray 1 received an individual Lot Number, the following trays were each designated by one Lot Number representing the entire tray. Advice received in camp and later experience showed, however, that these early inventories would not be applicable.

Although the majority of the hull remains were cataloged following the completion of the excavation, a small but wide variety of material was cataloged in the fall of 1997 and on site in 1998 (fig. 2-4). In 1997, the majority of the hull material cataloged consisted of unassigned framing fragments from the stern of the vessel. At the time of cataloging this material was friable and delicate, and as such, some of this material is now broken and/or missing. In these cases, such as UM 226, 233, and 285, the drawings are now the only records of this material. A wider variety of material was cataloged on site in the summer of 1998. These remnants included stern fragments of the keel, ceiling planking, UM fragments, and preliminary drawings of a number of the floor timbers.

Between September 9 and 21, 1998, the remaining hull fragments were shipped to Bodrum, and placed in storage. By the end of September, 1998, the excavation at Bozburun was complete.

Work in the Laboratory

Laboratory Facilities

Between September 1998, and May 2000, the preserved hull material was stored in a temporary facility located in the lower floor of INA headquarters in Bodrum. This temporary laboratory, measuring approximately 12.8 m x 5.0 m, had access to tap water and electricity, and was illuminated by overhead fluorescent fixtures, desk lamps, and sunlight entering through the floor to ceiling glass windows that comprised the 5.0 x 2.0 m south wall. The majority of the floor space was occupied by three freshwater storage tanks (which held approximately 11 m³) sunk into the floor at the south end of the room. Plywood sheets covered the center tank to provide passage between the work space at the northern end of the room and the door in the center of the south wall.



Figure 2-4: Drs. Brian Jordan and Jeff Royal cataloging a portion of the sternpost.

In an effort to desalinate the hull remains, and to keep odors in the laboratory to a minimum, the water in the tanks was changed approximately every two to three weeks. Although occasional testing showed that the salinity of the water in the tanks did decrease, it never dropped below 300 micro-siemens, as that was the salinity level of the tap water available in the laboratory. No fresh water maker was available at headquarters until 2002, and rain water was too scarce to collect in sufficient quantities.

To remove the water from a tank, a sump pump was submerged at one end of the tank, and the old water was purged to the street in front of headquarters. Filling the tank was accomplished with a hose attached to the spigot outside the laboratory. Draining one of the three tanks, each of which contained approximately 3.6 m³ of water, took approximately one hour, while refilling it required another two hours. All in all the process of changing the water in all three tanks required six to nine hours.

The working space at the northern end of the room contained two tables, each approximately 2 m x 1 m x .80 m with removable tops, and shelving along the eastern wall that held the 36 plastic crates containing small fragments from the Bozburun hull (fig. 2-5). Each removable tabletop was covered with white oil cloth, which is relatively waterproof and easily cleaned for photography.

There were two major problems encountered prior to the beginning of the cataloging process. Although a complete inventory of the 15 trays recovered up to August 24, 1998, had been maintained in the field, it was determined that upon arrival in Bodrum, the fragments within these trays had been moved and re-organized. This was done without a new record being kept.³ Additionally, a certain amount of consolidation of the material had occurred, so that at least three of the trays had been disposed of. A major re-inventory of the three tanks was thus needed, requiring the help of four people over three days.⁴

The second problem encountered was the sunlight entering the room through the south wall. Although it varied each month, the indirect sunlight generally struck the water in the tanks between 7:30 a.m. and approximately 6:00 p.m., approximately ten hours a day. This cycle had apparently been occurring since September of 1998, heating the water in the



Figure 2-5: The northern end of the temporary laboratory.

tanks on a daily basis and encouraging the degradation of the hull remains, evaporation of the water, and algae growth. To retard these processes old sheets were gathered and hung on the windows until the move to the Nixon Griffis Laboratory in May, 2000 (fig. 2-6).

The construction of the new library, computer, and laboratory facilities was an ongoing project throughout 1999 and 2000, and once the new, permanent holding tank was completed in the Griffis facility, all of the storage trays were moved to that space. The new laboratory is a large space divided into two floors only at the western end of the laboratory. The eastern end consists of a large, two-story space with the large tank in one corner, floor to ceiling glass windows and doors in the northeast and southeast walls, as well as a staircase to the second floor. The interior of the new, large polygonal tank measuring approximately 6 m x 2.7 m x .90 m (c. 12.6 m³) was not painted with blue latex paint, but instead lined with blue tile (figs. 2-7, 2-8). To ease the process of changing the water in this tank, both a spigot and a dump valve were installed into its exterior wall (fig. 2-9). The material and the trays from the old temporary tanks were moved to this new tank in May of 2000. Due to space limitations in the new storage tank, however, a smaller, secondary tank was built in May, 2000, to act as a temporary holding tank for all of the framing material that had been moved. This second tank was razed in July of 2000 and replaced by a slightly larger tank at the western end of the room, in which the material stayed until the summer of 2002. By that time, other considerations prompted the construction of another tank, adjacent to this one. This permanent square tank, in the northwestern corner of the room, measures approximately 3.8 m x 3 m x .8 m (9.1 m³) and at present contains nearly all of the framing and keel remnants.

Although the new, large permanent tank at the eastern end of the Griffis facility was built with both a spigot and a dump valve to speed and ease the process of changing the water, the spigot was not plumbed, and there is no drainage in the laboratory. As a result, changing the water in these two tanks requires the same process as that in the temporary facility, and requires approximately nine hours. At present, it only requires six hours to change the water in the large tank due to the constant electricity in the laboratory and fresh water brought by a tanker truck (fig. 2-10).



Figure 2-6: Sheets hung over the windows in the temporary laboratory.



Figure 2-7: The hexagonal tank in the Nixon Griffis Laboratory.



Figure 2-8: The tile lining the hexagonal tank.



Figure 2-9: The dump valve installed on the outside of the hexagonal tank.



Figure 2-10: Delivering water to the Nixon Griffis Laboratory.

window in the northeastern wall, through which the sun shines approximately from 7:30 am to 11:00 am. In this case, 11 m² of canvas was purchased and hung over the window to reduce the sunlight and the temperature in the room.

Organization

Once the hull remains arrived in Bodrum, they were either re-stored in the 36 plastic crates in which they had been held in the field, or placed into one of the three desalinization tanks set into the floor of the temporary laboratory. Within the three tanks, the material was either stored loose, or in plastic bags, or most commonly in the wooden trays. By the end of the 1999 study season, all of the flour sacks that had covered the trays in the field had been replaced with plastic screening. This screening, obtained locally, was cut to the size of the top of the tray and nailed in place with brass nails. Once in place, the screening kept the various fragments within the tray while allowing water to circulate, and could be easily removed and replaced by simply pulling and replacing the nails.

The process of organizing the material began with all the bagged fragments (those with an assigned Lot Number) on March 10, 1999. The majority of the storage bags were also replaced. Any material that was found to be non-diagnostic, unidentifiable, or not labeled was removed and disposed of. This process of cleaning took approximately ten days and approximately 13 kg of wood was discarded.⁵ A record was kept of the approximately 250 fragments lost. At the same time, the material was also grouped by Lot Number. The fragments were stored in 36 plastic crates arranged numerically by Lot from 2659 to 11,682, and each crate was marked with a waterproof label indicating its contents (fig. 2-11).

Once a fragment had been cataloged, the associated Lot Number was circled to indicate its completion (fig. 2-12). At the same time, a computer spreadsheet was maintained, recording the locations of all Lot Numbers and hull fragments, and any changes in the fragments' arrangement. The cataloging of all the bagged fragments stored in plastic crates was finished in the Summer of 2000.

Moving the Hull Remains

The size, weight, and condition of the fragments varied greatly. Some planking fragments were not much larger than .10 m², while the preserved stem fragment was 2.27 m

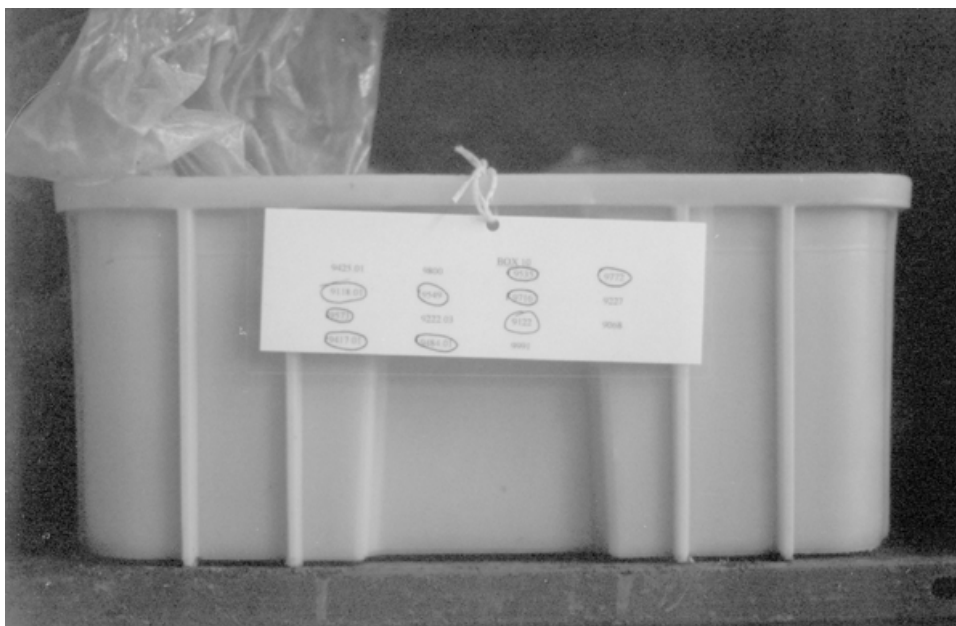


Figure 2-12: A laminated label with Lot Numbers.

x .27 m x .18 m and weighed approximately 122 kg.⁶ Thus, a variety of methods were employed to move and carry this material, as well as support it during the cataloging process.

A small portion of the fragments were so eroded, fragile, or worm eaten that even moving them under water was likely to break them. Generally, these fragments tended to be from the ceiling planking or the stern hull planking, and were relatively thin, flat, and very friable. The best means found to move and carry these remains was to use a thin sheet of closed-cell foam. The foam was submerged in the tank near the fragment and held on the floor of the tank either manually or with a weight. The fragment was then positioned on top of the foam, and the weight holding the foam under water was removed. As the foam rose to the surface carrying the fragment, its rate of ascent could be slowed by simply holding it down with one or two hands. Once at the surface, the foam and the fragment could be carried to a worktable.

As these hull remains are in good condition for their age, the most widely used method of moving and carrying material was by hand. All but the keel and largest frame fragments were light enough to be moved by one person with very little or no damage if handled carefully. Longer planking fragments, often over 50 cm, were carried on their edge as this did not stress any longitudinal splits or allow longitudinal warping that could result in transverse cracks or breaks.

One drawback to carrying long remnants by hand is that the weight is not always evenly distributed across the piece, sometimes causing deformation of planking or scratching or crushing the faces and edges of heavy framing material. One solution to these and other problems was the use of a canvas sling. This sling was made of heavy sailing canvas, measured 1 x 2 m, and had four loops of heavy strapping material attached along each long edge. A wooden pole was passed through all of the loops to carry the sling and material within it. The result was a sturdy, water-resistant rig that was capable of easily carrying heavy framing, while providing even and constant support along its length. One person, for example, could carry and evenly support a 1.6 m-long floor timber fragment. In addition, once the fragment was carried to the cataloging table, it was commonly left in the opened sling during cataloging, since its removal from the sling was generally too awkward.

The advantage was in addition to providing even support during the moving process, the sling also eased the process of rotating the piece from one face to another. For example, rotating the fragment while on the table is simply a matter of enclosing the fragment in the sling, lifting it off the table, and while slightly opening the sling, rotating one face onto the tabletop.

Certain precautions, however, had to be taken when using the sling. The wooden poles threaded through the strapping had to be in place to carry fragments since their use assured the even distribution of weight along the length of the sling. It is best to orient the framing timber in the sling so that its narrowest and longest flat face is on the bottom. In general, this face was the bottom face, since that face created a narrower cross section than either the fore or aft face along the preserved length of the framing fragment. Moreover, if the framing fragment is preserved through the turn of the bilge, then placing the fragment on the bottom face protects the upwards sweep of the timber within the sling. The second factor that had to be considered was that the rough texture of the heavy canvas could easily add unnatural wear and abrasion to the edges of the fragment. The two lower edges of the fragment were particularly susceptible to such wear. It is important, therefore, initially to orient the fragment in the sling in consideration of how much information might be lost during the sling's use.

The most difficult timbers to move and orient were the fragments of the keel. Luckily, all of the keel fragments were cataloged in the old temporary lab, where removal of the fragments from the storage tank only involved two people lifting the tray .50 m from the tank bottom to the floor level. Moving the keel fragments in the new laboratory, particularly from the large eastern tank, required two people to lift the tray 1 m up the wall of the tank and then another two or more people to lower it back to the floor, or carry it to a table.

In either case, once the keel fragment was on the floor of the laboratory, it tended to stay there until its cataloging was completed. Similar to the process of rolling over framing fragments while on the cataloging table, the sling was also used to orient and re-orient the keel during the cataloging process. To roll the keel, wood blocks and foam were placed along either the top or bottom face, depending on which way the keel was to be

rolled, and packed tightly against the sides of the tray (fig. 2-13). Next a padded cover for the tray was placed on top of the exposed keel face, and the sling was wrapped tight around this assembly. Using the sling for leverage, the entire assembly was slowly rolled 90 degrees, so that the keel fragment rested on the padding placed in the tray, then rotated another 90 degrees until the keel fragment rested on the padded cover (fig. 2-14). The sling was unwrapped, and the tray, now upside down, was removed (fig. 2-15). Once completed, the other three faces of the keel fragment were exposed for cataloging.

In comparison to the earlier temporary laboratory, moving the storage trays also tended to be more difficult in the deeper tanks of the Griffis laboratory. The greatest problem that had to be overcome was the inability for one person to both carry and lower the storage trays to the floor of the laboratory. Thus, a rolling dolly was built from a salvaged metal A-frame and scrap pieces of pine. The dolly's frame, which rested on two wooden struts with wheels, had a stationary pulley at its apex. A rope ran through the pulley to a suspended 50 cm x 50 cm platform on which the trays rested (fig. 2-16).

To use the dolly, a tray was first lifted from the water and balanced on the edge of the tank (fig. 2-17). The dolly was rolled into position in front of the tray, and the tray was slid onto the platform (figs. 2-18, 2-19). Once the tray was balanced on the platform, the dolly was rolled back from the tank and to any part of the room. Once in place, the tray was simply lowered to the floor, removed from the platform, and the dolly was rolled away.

Supporting Hull Remains while Cataloging

The only hull fragments that required delicate and/or extensive blocking and support during the cataloging process were the floor timbers. This was due primarily to the fact that many of them were preserved through the turn of the bilge, changing in vertical height as much as .33 m. The framing, in particular the oak floor timbers, also often needed extensive blocking because of the numerous fragments that needed to be supported together in their proper alignment (figs. 2-20).

To create a stable platform upon which the framing material could be supported, a wooden frame stand was built. This stand was padded with 5-cm thick foam and designed to support floor timbers in an upright or upside down manner, without placing undue stress on wood at the turn of the bilge of the hollow at the garboard (fig. 2-21). Another support



Figure 2-13: Foam blocking under the scarf in the stern.



Figure 2-14: Rolling a keel fragment over for cataloging.



Figure 2-15: The carrying tray removed, exposing the keel fragment.



Figure 2-16: The A-frame used to carry wooden trays in the laboratory.



Figure 2-17: Balancing a wooden tray on the edge of the hexagonal tank.

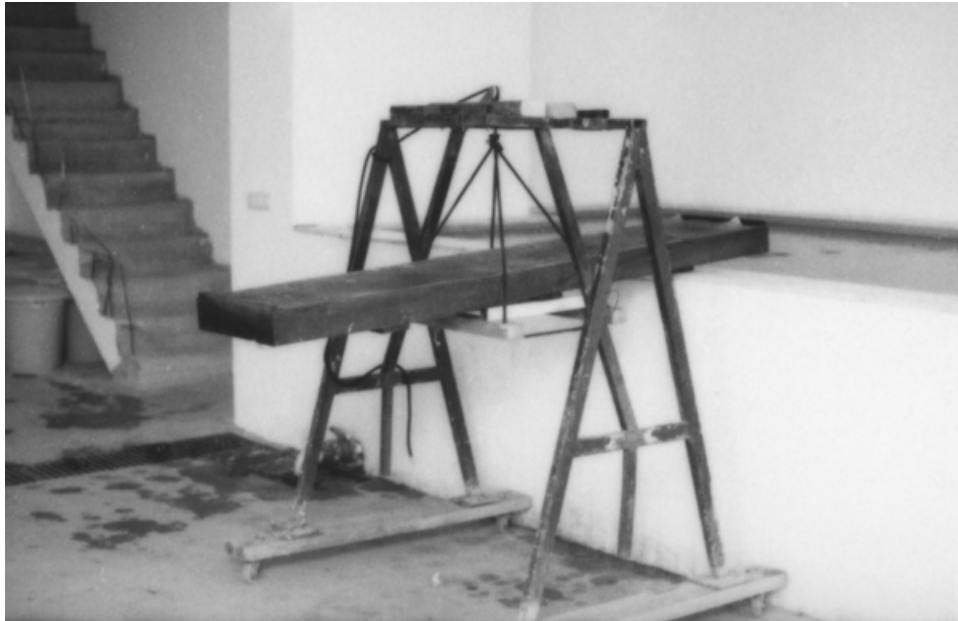


Figure 2-18: Sliding a tray onto the hanging support.



Figure 2-19: Carrying a tray on the A-frame.



Figure 2-20: Supporting a floor timber during the cataloging process.

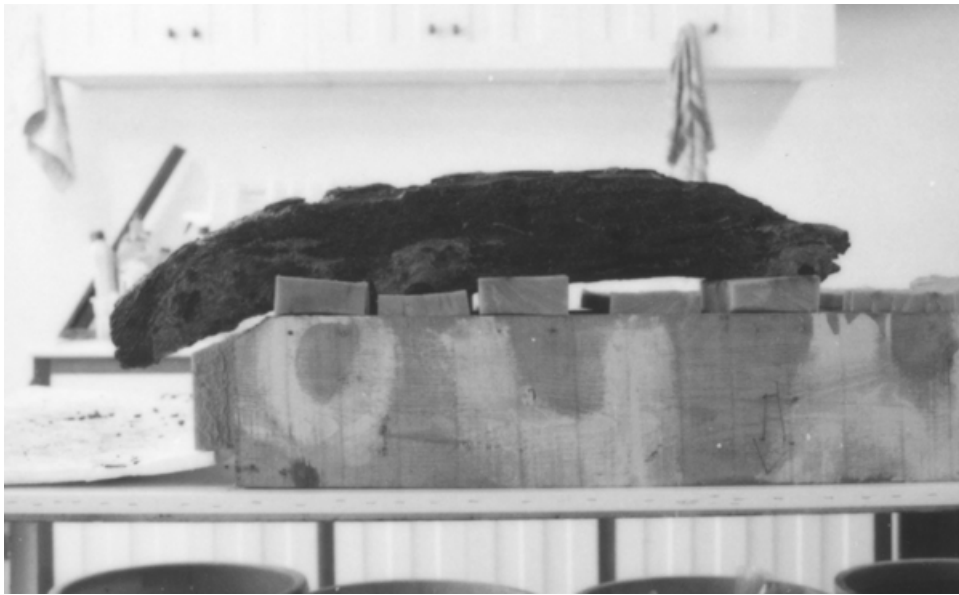


Figure 2-21: Using the frame stand to support a floor timber while cataloging.

was built for floor timbers that were preserved through the turn of the bilge but not at the hollow at the garboard. This latter stand was also built of pine, padded with .05-m thick foam, and was only a wedge designed to keep the floor timber upright when cataloging the top face (fig. 2-22).

Other than the two purpose-built items, a variety of other loose material was employed to support remains during the cataloging process. Blocks of wood of differing lengths were commonly used, as were loose cubes of foam cut to different sizes and shapes. Plastic film canisters had some use as small supports, as did small plastic and glass sample vials. In some rare cases, tiny brass finishing nails or stainless-steel push rods were used temporarily or permanently to keep an assemblage of small fragments in alignment and together in storage.

Drawing Techniques

During the cataloging process, two different types of drawings were created. The first are 1:1 scale tracings on clear plastic sheets that reproduce original surfaces and edges, fastenings, tool marks, grain, measurements, labels, etc., all at full scale. In general, there are two sets of these tracings. One set is composed of those tracings, numbered 1 to 60, done in the field during the summer of 1998. Due to the environmental conditions on site and the differing experience of the artists, however, the information contained in these images varies in quality and, in some cases, the tracings themselves are torn and folded. Some of these tracings, particularly those done in the Fall of 1997, contain information about the hull material that has since been lost, and are thus very valuable. The second set of 1:1 tracings, numbered 100 to 220, are those created during the four seasons of work at INA headquarters in Bodrum, and encompass the majority of the cataloged material. An initial drawback of all of these tracings is their large size but once completed, the information may be recreated and transferred in a number of ways.

The second type of drawings are sketches on catalog sheets that may or may not be to scale, and often contain less detail. Even though these drawings were often created by eye they are rare valuable for fragments with diagnostic properties that do not have a clear context or provenience.

Although a number of different techniques could have been employed to record the

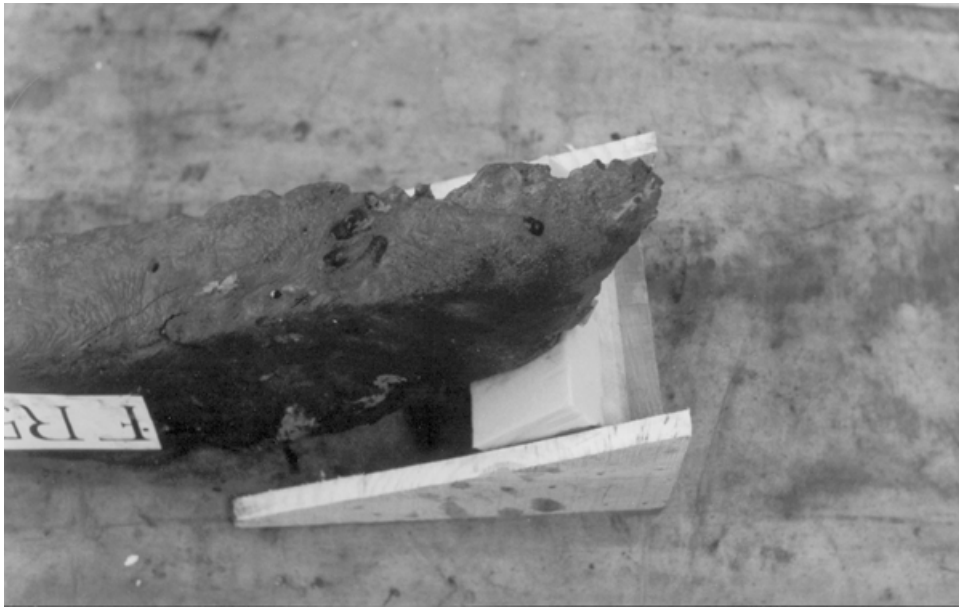


Figure 2-22: Using the small wedge to support a floor timber while cataloging.

Bozburun timbers at 1:1 scale, the method of using a black marker on clear acetate or plastic was quickly adopted (fig. 2-23). When drawing the large flat faces of the keel fragments, and particularly the bow and stern faces of the floor timbers, the acetate was thumb-tacked directly to the fragment. For smaller, less distinct or fragmentary items, or all of the planking material, a pane of glass (1 to 2 m x .50 m w x .005 m) was supported over the item, and the acetate was affixed directly to the glass instead.

In either case, the goal was to keep the point of the marker immediately above the edge being drawn, thus creating an accurate 1:1 scale tracing. The best means of maintaining this alignment was to imagine a line, perpendicular to the drawing surface, extending between the edge being drawn and the pupil of the eye. The point of the marker intersects that line at the surface of the acetate. When the acetate is instead thumbtacked to the surface of the fragment, care must be taken to note that the drawing surface may bend and twist in three dimensions, thus quickly creating parallax error if the eye and the marker are not aligned properly. On the other hand, when the acetate is affixed to a pane of glass, not only does the drawing surface remain flat, it is possible to see a reflection of the pupil in the surface of the glass. As a means of maintaining the proper alignment between the fragment being drawn, the eye, and the marker, the pupil's reflection is maintained immediately over the point being drawn.

The largest pane of glass available was 2 m x .5 m x .005 m. Nonetheless, there were a number of items, particularly planking, that when re-assembled were longer than 2 m, so drawings often had to be completed in two or more stages. For material such as the floor timbers, the various fragments were aligned and re-assembled appropriately and the pane of glass to draw upon was supported above the fragments. If the re-assembled fragment was longer than two meters, then once the first two meters of the drawing were complete, the acetate was removed, and the glass was repositioned over the un-recorded portion. The acetate was then rolled back out, aligned with the portions already drawn, and the drawing was completed.

In the case of the planking, which often retained its curve along the length of the hull, extra steps had to be taken. First, the material was re-assembled with the aid of the site plan. Primarily, once a fragment is found and cataloged, it may be found on the plan and



Figure 2-23: An ink drawing on clear acetate.

marked as “completed” to maintain an up-to-date record of the material cataloged. Additionally, since the site plan retains the sweep of the strakes as found on the sea floor, this sweep may be recreated and recorded at scale during their re-assembly (fig. 2-24). To reproduce the sweep of a plank, a baseline was drawn on the site plan either between both ends of the plank, or (as the length of the cataloging table dictated) a 5.5 m section of the plank (fig. 2-25). A baseline, representing the site-plan baseline but at 1:1 scale, was drawn on the cataloging table. Measurements were then taken from the inboard or outboard edges of the plank to the baseline on the site plan and reproduced at scale on the cataloging table; the fragments could then be aligned appropriately. To draw the plank, one long edge of the glass was aligned with the baseline, as was one long edge of the acetate sheet itself. In this manner, although the glass might be moved three or four times during the drawing process, the glass, acetate, and drawing on the acetate have a number of reference points that were used to maintain the alignment of the drawing.

Although the method of using a black marker on acetate became the standard recording technique for the Bozburun timbers, it was not the only method that could have been used but merely the most familiar. Initially, a series of colored markers were to be used to create the 1:1 drawings, but advice received in Bodrum in 1999 warned against this process, as the colors can fade.⁷ In addition, it was also determined that during the scanning of these drawings, lines drawn with red pigments do not always appear in digitized grayscale images.

Using a laser pointer to increase the accuracy of the marker was also tested, but not used consistently. This technique requires the construction of a small fixture that holds the laser pointer vertically and the marker at a forty-five degree angle. In this case, the laser beam replaces the imaginary line between the edge being drawn and the pupil of the eye, and the fixture holds the marker so that its tip intersects the beam where it meets the drawing surface. As the fixture also has a flat base that rests on the drawing surface, the laser beam – with a little adjustment – can remain perpendicular to the drawing surface. Technically, this method can produce a very accurate 1:1 drawing, however, it requires a bit more preparation and care to practice. For example, a pane of glass is always required when drawing a fragment, and when supported over a fragment, the glass must be kept absolutely

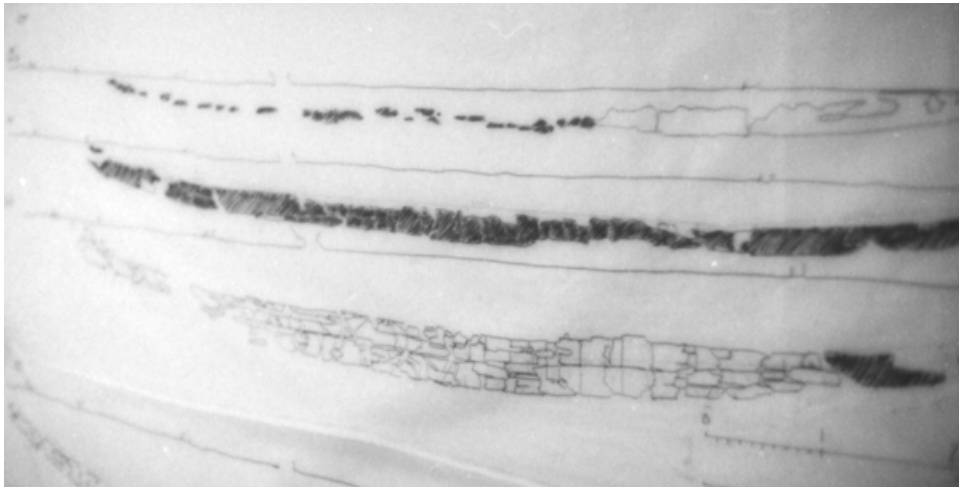


Figure 2-24: Drawings of various planks. The shaded fragments indicate that they have been cataloged.

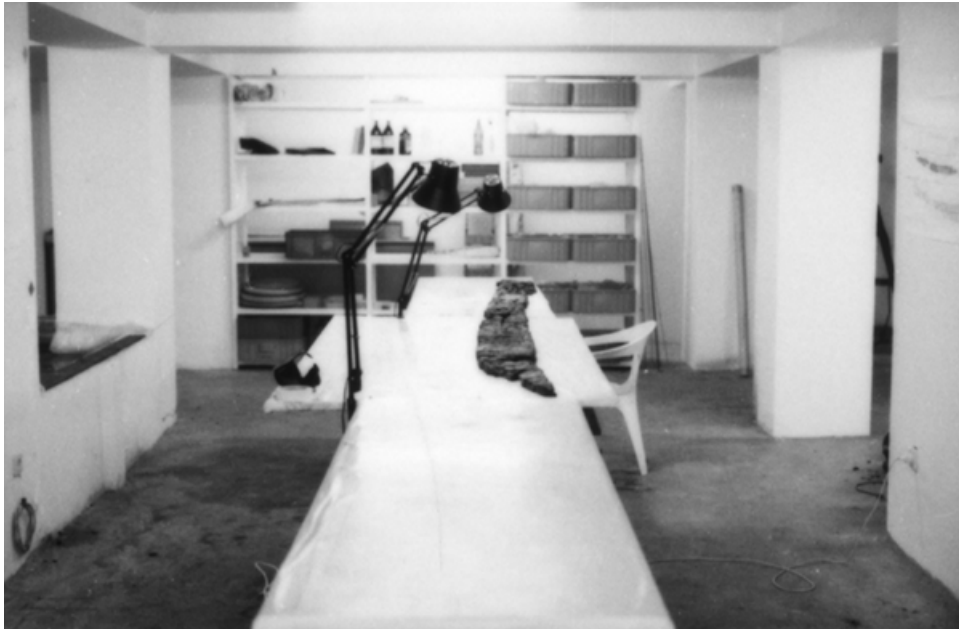


Figure 2-25: The cataloging area in the Nixon Griffis Laboratory.

horizontal. A fixture to hold the laser pointer and the marker must be fashioned in such a manner that after replacing either the laser pointer or the marker, re-adjustment is possible. The laser pointer itself needs to be checked during use to confirm it has not shifted from its perpendicular orientation and, as the marker wears down, it needs to be adjusted appropriately.

Unfortunately, while it is possible to check and to adjust the orientation of the laser pointer against a drawing surface that may be 5 cm away, this is difficult to do when the object may be 20 to 50 cm away. Thus, while a drafting triangle may confirm that the body of a laser pointer is perpendicular to the glass surface, the laser beam may be off by .2 to .3 cm over increased distances. While an error of .2 to .3 cm is not significant, a comparable degree of accuracy is achieved when drawing by eye. Additionally, even if this error is accepted and compensated for, the fixture holding the laser pointer and the marker needs to be used in the same orientation throughout the drawing process. Otherwise, the error is no longer predictable and, if the fixture is turned 180 degrees, the error may double.

Lastly, personal experience indicates that a drawing produced by the fixture is highly accurate, but somewhat lacking in representational value. As it is difficult to alter the line weight, for example, all features in the drawing may have a similar, thick outline. If the goal is to produce a large number of accurate drawings with the knowledge that better, publication-quality drawings will be produced later, then this method is certainly applicable. If the one-to-one drawings will be subsequently used for publication as well, as was the goal in this project, then this method has drawbacks.

The last method considered for recording the fragments was the use of a three-dimensional digitizing arm made by Faro Industries. This arm has a fixed base with a single swivel and two rotating joints along its length that allow the arm to bend and rotate in a variety of orientations and configurations. The end of the arm is composed of a pistol-grip-like handle with control buttons, and a replaceable stainless steel tip. Since the various dimensions of the arm are pre-programmed, the rotation of each swivel, as the arm moves through space, is transmitted to the computer that determines the location of the tip of the arm in three-dimensional space. As the tip of the arm is traced along the edge of the fragment, it is possible to record that edge in three-dimensional space in the computer.

Edges, grain, fasteners, tool marks and the like may be recorded quickly and easily in the computer, and once a fragment is complete, the resulting wire frame model may be color coded, rendered with a surface, and downloaded to other programs such as Rhino or AutoCAD. This technique was successfully used to create a digitized model of the reconstruction of the 4th-century Hjortspring in 18 hours, and has already been used to model the material recovered from the wreck of a 12th-century Cog found at Kolding, in Denmark.⁸

Although this technique has a great deal of potential, and can easily store and present a significant amount of information on a wide variety of media, it was felt to be inappropriate for use on the Bozburun remains. Initially, approximately one-half of the Bozburun material had already been drawn by hand when this method was proposed, and the cost of the arm, the programming, and a portable computer is approximately \$40,000. Moreover, although this arm has been used to document a reconstructed ship, it had not been used to re-assemble a ship still in a fragmentary state. Lastly, electricity in the Griffis laboratory can be erratic, and the hot and humid environment in the laboratory could result in problems with both the computer and the arm itself. Repairing a damaged arm might require its shipment back to the United States.

Catalog Sheets

Rather than keeping a set of notebooks to record the fragments, a generic Timber Cataloging Sheet was developed prior to the 1998 Field Season (fig. 2-26). This sheet, along with instructions in the Bozburun Project Field Manual, was designed so that any member of the excavation team could catalog fragments of the hull in the field. In this way, a process of teaching field techniques was maintained during the summer, 21 percent of the recovered fragments were cataloged prior to the end of the excavation, and a relatively high standard of recording techniques was maintained.

In general, the sheet is divided up into four distinct sections, and the specificity of each section to the particular item increases towards the bottom of the sheet. The top section encompasses information that places the cataloged item within the context of the excavation as a whole; identification numbers, the possible function of the fragment, the initials of the cataloger, and the date cataloged. The next section is primarily for cross-

BOZBURUN TIMBER RECORD		TIMBER NO. <i>SS7 2/10 .P</i>	
		LOT NUMBER: <i>1169</i>	
DATE: <i>6/6/00</i>	CATALOGUER: <i>MB-1</i>	FUNCTION: <i>PLANKING</i>	
MAX DIMENSION: <i>.221m</i>	DRAWING:	PHOTOS: <i>X</i>	SAMPLES:

CONDITION: <i>Thin fragments that fit together; little water damage, some staining. Fragment ends are pinned.</i>	DIMENSIONS:	Wood Type:	Conversion:
	Length: <i>.221m</i>	<i>OHG</i>	
	Width: <i>.093m</i>	Sapwood?	
	Thick: <i>c.027m</i> <i>c.27</i>	Bark?	
JOINERY: <i>Original schemes in lat and ear faces, as well as a partial edge. Edge is c.95° to lat face. No trussing, no seams.</i>			
FASTENINGS: <i>Partial Nail thru: .6cm, Nail Heads?</i>			
MARKS AND COATINGS: <i>Lines on Ear Face and Above Preened Edge. Preened Saw Marks on lat Face, c.40° to Grain. Some dust near Nail thru, little creosote.</i>			

OVER FOR COMMENTS

Figure 2-26: A cataloging sheet for fragment SS7 2/10.P.

referencing the cataloged information with other collected data: drawings, photos, and sample identification numbers. In the middle of the sheet is space for a sketch of the fragment or timber, while the bottom half of the sheet is reserved for an ordered description of the fragment itself. This description is characterized by the specific state of the fragment's dimensions, condition and wood type, the manner in which the timber was fashioned from the rough lumber, as well as a discussion of any joinery, fastenings, marks or coatings evident.

Essentially, the Cataloging Sheet is an attempt to create a form that is not complete until all of the fields have been filled, thereby producing a relatively thorough description of each fragment or timber as a result. It was also hoped that, although each category on the sheet is not necessarily applicable to every item cataloged, the sheet would also serve as a reminder to the cataloger to look for specific characteristics.

Concise explanations of each category are available in the 1998 Bozburun Field Manual, but time and experience have changed the prescribed contents of some of the fields, and narrowed the contents of others. The **Joinery** field originally referred to any surface on the fragment that had been worked to fit against another piece of wood, such as a scarf or a chamfered edge. Over time, however, the presence of original surfaces and treenails were also recorded in this category. In the present catalog, however, treenails are described in **Fastenings** that previously encompassed only metal fasteners. Now treenails, nails, bolts, etc. are described in this section. The **Maximum Dimension** field was included to ease the identification of fragments while in storage, but in practice it has been of little value. Instead, it was determined that a field asking for the waterlogged **Weight** of the fragments, perhaps recorded over intervals of time, would be more helpful, especially when developing and implementing a conservation plan. Other fields identifying the **Excavator**, the **Excavation Square**, and the **Date Recovered** would also aid later research.

The use of these catalog sheets has been ubiquitous throughout the cataloging process of the Bozburun hull, but their application has been somewhat subjective. Not every fragment recovered and stored in Bodrum has one catalog sheet dedicated to it, nor, on the other hand, is there one catalog sheet per Lot Number. In some cases, a bag of

related fragments was assigned one Lot Number, and it is possible to find that none, half, or all of the fragments within that Lot had been cataloged. For example, Lot 8786.03 is a bag of small fragments that as a whole, represent material that has some diagnostic properties, such as nail holes and original surfaces and edges. Individually, however, the fragments are fairly non-descript so all of the fragments were cataloged on one Catalog Sheet. Lot 9985 is a bag of five fragments, of which two were cataloged because of their diagnostic features on two separate sheets. Lastly, Lot 11521 represents a large number of diagnostic fragments, all of which needed to be cataloged, and all of which were recorded on individual catalog sheets.

For the large keel fragments, one sheet was used for each fragment, although that particular fragment may have two to three identification tags on it. This practice was repeated for framing timbers, which also had one catalog sheet when a number of fragments comprised a single timber. On the other hand, planking material was recorded on as many catalog sheets as there were identification tags on the fragment. Fragment SS4 2/7, for example, was also tagged with two additional tags, denoting it as 2/8 and 2/9 as well.

Cataloging Process

To catalog the wood remains of the Bozburun hull, different processes were developed to work with the different types of fragments encountered. The first method outlined is the most straightforward, and applies predominantly to fragments with Lot Numbers or those that, although associated with a larger hull timber, were not re-assembled with the corresponding timber. The second process applies to fragments of the framing, while the third was employed while cataloging the planking remains. All three processes commonly generate cataloging sheets, photographs and drawings of the fragments in question, although there are steps in each that are particular to the type of fragments being examined.

- 1) The inventory was consulted to locate the item to be cataloged.
- 2) The item was found in storage and cleaned of silt and concretion. Nail holes and treenail holes were identified and cleaned as well.

3) If necessary, the fragment was photographed. In 1999, Ilford FP4 Plus 125 ISO black-and-white film was used, but due to the film's lack of availability and its high price overseas it was replaced with Kodak Gold, 36 exposure, 400 speed film, with a Pentax K1000 camera without a flash. As studio lights were unavailable, sunlight, fluorescent overhead lights, and desk lamps were commonly employed. All wood faces were photographed, as well as any specific details such as treenails, treenail holes, tool marks, etc.

4) If a 1:1 tracing was desired, the fragment was placed under a sheet of glass, and traced by hand on clear acetate film. All faces of the fragment were drawn, each tracing was annotated with notes, labels and measurements, and sequentially numbered.

5) The appropriate fields on the Catalog Sheet were completed. Any fragment deemed non-diagnostic was not commonly sketched on the sheet. Otherwise, nearly all fragments were sketched on the Catalog Sheets. If a 1:1 tracing of it had been made, the tracing's number was recorded on the Catalog Sheet in the **Drawing** field.

6) The information in the inventory spreadsheets was modified and the data collected on the Catalog Sheets was entered into the Bozburun database.

Framing fragments were cataloged with the following process:

1) The inventory was consulted to locate the item to be cataloged.

2) A list of the fragments and their locations was written in pencil on a sheet of polyethylene Mylar drafting film. Mylar was used because it is waterproof and may be taken into the storage tank.

3) The fragments were located, cleaned of silt and concretion, and set aside. Nail holes and treenails holes were also cleaned and identified.

4) The fragments were removed from storage and assembled into the preserved timber.

5) Photographs of all four faces, as well as details of particular treenails, tool marks, etc., were taken.

6) All four faces of the assembled timber were traced on acetate film. The tracings were annotated with measurements, labels, notes, and numbered sequentially.

7) The fields on the catalog sheet were completed. A sketch was made of the framing material on the sheet as well.

8) The inventory spreadsheets were modified, and the data on the Catalog Sheets was entered into the Bozburun database.

Cataloging the planking followed this process:

1) The Inventory was consulted to locate all of the fragments comprising the particular strake to be cataloged.

2) A list of all the fragments needed, and the number of the trays in which they were stored, was recorded on mylar.

3) The appropriate trays were removed from the storage tank and the fragments were removed from the trays. The loose fragments were transferred to the tank in the western end of the laboratory.

4) Since a post-cataloging step is to keep all of the fragments of one strake together in storage, the material in one to three trays (depending on the size and number of the fragments to be cataloged) was re-arranged and consolidated into other storage trays. The movement of this material was recorded, and the inventory was updated.

5) The full trays were replaced in the storage tank and the fragments were cleaned.

6) By consulting a site plan and taking scale measurements, the fragments were assembled into their original configuration.

7) The interior and exterior faces of the plank were photographed, as well as any treenails, edge dowels, tool marks, etc.

8) The assembled fragments were drawn at 1:1 scale on clear acetate, annotated with measurements, notes, labels, and the drawing was numbered sequentially.

9) The Catalog Sheets were completed.

10) The fragments were placed into the empty trays, a new record of the fragments' location was kept, and then entered into the spreadsheet.

11) The spreadsheet, and later the database, were updated.

Once the cataloging of the fragment, timber, or strake was completed, it was placed in storage, awaiting conservation procedures.

Endnotes

¹ Hocker 1998, 41.

² Hocker 1998, 41.

³ For example, in the field, tray 5 contained this material:

FR29 0/2	FR29 0/1	UM 238	UM 518	UM 517	SS2 1/1
UM 405	FR29 0/2	FR28 0/1	1 Unknown	SS4 1/1	
SS4 1/1[<i>bag</i>]	SS3 1/1	FR31 0/1	FR31 0/3	FR28 0/2	

Once it was inventoried in Bodrum by May 2, 1999, it contained this material:

FR49-2	FR49-4	4 Unknown	FR49-3		
Outboard end pieces of FR54[<i>bag</i>]	12 Unknown	FR42/5	FR42 0/1	UM 916	
FR49-1	FR29-1	FR49-8	2 Unknown	FR49-7	
3 Unknown	FR28-2	UM 518	FR29-3	FR29	
2 Unknown	UM 405[<i>bag</i>]	FR 29-2			

The following pieces were missing from the tray:

SS2 1/1	UM 518	FR31 0/1	UM 238	SS4 1/1[<i>bag</i>]	SS3 1/1
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⁴ Dr. Ayşe Atauz, Mr. Sam Lin, Miss Meghan Ryan and Mr. Travis Mason were of great help in the making of this inventory.

⁵ In addition to the material discarded in the Spring of 1999, approximately 13 kilograms of hull remains were also redeposited on site during the 1998 season.

⁶ This is the waterlogged weight of fragment KK 40-42.

⁷ Personal communication with Sheila Matthews, Spring 1999. Drawing 101 is the only drawing done in Bodrum in color. Others done in the field were done in a variety of colors, but not with a consistent color code.

⁸ Personal communication with Dr. Fred Hocker, Spring 2002.

TIMBER CATALOG

The following timber catalog is a result of collating and integrating information from the five seasons spent documenting the preserved hull remains from Bozburun, Turkey. Consequently, its format is similar to the organization of the cataloging sheet itself. Following the basic quantitative information (identification numbers, drawing numbers, preserved dimensions, etc...) are long discussions about the condition of the individual pieces, any joinery evident, details of metal fastenings found, purposeful and accidental marks and coatings, and lastly, other relevant characteristics or information. The **Condition** section encompasses not only the structural integrity of the remnants and what surfaces are preserved, but also how gingerly they should be handled in the future. **Joinery**, as it focuses on worked surfaces, examines the cross-sectional shapes of the components, how those shapes may change along their length, edge dowels if present, and any scarfs in the components. Treenails and their details, and metal fasteners, or their holes, are examined in the **Fasteners** section, which discusses their shape, spacing, distribution, angles if appropriate, and amount in each timber. Average dimensions, spacing and angles of the fasteners are mentioned in the text, along with particularly high or low actual measurements. **Marks and Coatings** describes both purposeful and accidental marks, such as saw marks and scribe marks, as well as any coatings preserved on the material, such as pitch, caulking, paint, or unidentified staining. Rust and concretion, although fairly ubiquitous, are mentioned in this section, as are two types of pitch identified during the cataloging process. One type of pitch, called exterior pitch as it was most commonly found on the exterior face of the planking, is fairly dark brown or black, usually found in a thick layer on the fragment, and still malleable enough to take a fingerprint. The second type of pitch identified, called interior pitch simply because it was found most often on the interior of the planking, is reddish-brown, stiff and dry, and commonly coats the material with a fairly thin layer, no more than .5 cm thick. The surface of the interior pitch is commonly crizzled or crackled, while that of the exterior pitch is undulating and slightly resistant to the touch. The last section, **Other Comments**, was included on the cataloging sheet, and is included here, to

document any other characteristics or information that is deemed diagnostic, relevant, or unique.

The Keel and Associated Timbers

Stem

Timber Number:

KK 40-42

Date Cataloged:

April 26, 1999; August 12, 2000

Cataloger:

MBH

Drawing Numbers:

110, 111.

Samples Taken:

Species sample.

Preserved Dimensions:

2.285 m x 27 cm x 14 to 18 cm

Wood Type:

Quercus sp?

Condition:

This fragment was recovered from the seafloor in one piece, representing all the remains of the stem (fig. 3-1). Some breakage has occurred during storage and cataloging, but the majority of the material broken or lost comes from the very forward end of this fragment, which is riddled with worm holes and preserves no original surfaces.

Similar to the sternpost and the keel, this fragment also has friable surfaces and edges due to water penetration, while the interior of the fragment is still solid and dry. It is heavy and fragile, and the faces and edges are prone to wear and breakage during handling due to the weight of the fragment and its awkward shape. Structural integrity varies from the very forward end of the fragment, which is fairly weak due to a great deal of worm damage, to the aft end of the fragment near the scarf, which has little or no worm damage and is thus quite solid. Erosion, too, varies along the length of the fragment, but overall,



Figure 3-1: Drawing of the starboard side of the stem fragment (1:10 scale).

the scarf and all four faces of the stem are in fairly good condition. Enough of the stem is preserved to indicate the gradual rise of the stem's interior face from the keel's horizontal plane. For the fragment's preserved length of 2.285 m, the interior face rises approximately 8 cm to 12 cm (fig. 3-2). Each face also retains enough original surface to distinguish a cross sectional shape and demarcate the rabbet, which is evident on both sides. There is little or no surface pitting evident on the stem. Again, similar to the keel and the sternpost, the varying amounts of water penetrating the stem not only makes it difficult to handle, but will also cause difficulty during the conservation process.

Joinery:

Neither edge dowels in the rabbet nor treenails in the top face are present in this fragment.

Since the majority of both sides are preserved fairly consistently for the aft 1 m of the stem, original surfaces are preserved both in the rabbet and on the surrounding faces. Although the rabbet is farther from the top face of the stem, the stem's cross-sectional shape is very similar to the keel. In this case, the back rabbet line is 4 cm to 5.4 cm below the timber's top face, but the angle of the rabbet, which is 1 cm deep, is still approximately 80 degrees. The descending face of the rabbet is approximately 11 cm wide, while the vertical face of the stem, which meets the chamfer along the bottom edge, is 11 cm wide as well. This chamfer, which is 2.7 cm to 3 cm wide, meets the vertical face of the stem at an angle of approximately 125 degrees, and the bottom face at an angle of 150 degrees. Due to the increasingly poor preservation of the rabbet one meter or more from the aft face of the stem, there is no preserved evidence indicating changes in the inclination of the back rabbet face. Such changes, which surely occurred beyond this point, can only be inferred.

The stem fragment also preserves the upper half of the 52 cm long box scarf present in the forward end of the keel (fig. 3-3). As this scarf mates to the box scarf in the forward end of the keel, it too has three vertical and two horizontal faces of similar dimensions and inclinations. For a detailed description of the design of this scarf, see the **Joinery** section in the following documentation of the keel. Because of the presence of the key between the two fragments, however, there is a 6 cm gap between the two short vertical faces demarcating the horizontal faces of each scarf. Distinctly absent in this half of the



Figure 3-2: Photograph of the stem, illustrating its rise.



Figure 3-3: Photograph of the stem scarf.

scarf is a second pair of fixed tenons. As two pairs of mortises are in the lower half of the scarf in the keel, one pair in each of the two larger vertical faces, coordinating pairs of fixed tenons should be present in the upper half of the scarf as well. Only one pair, averaging 4.5 cm x 4.8 cm, is present, however. The lower vertical face is well preserved, as are portions of the horizontal face nearby, but neither face preserves evidence of the tenons' presence. The vertical face does retain numerous transverse ridges, however, which may represent eroded saw cuts, possibly indicating the purposeful removal of these fixed tenons (figs. 3-4, 3-5).

Fastenings:

In addition to the top half of the bolt hole in the keel scarf, a number of nail holes were also found in the stem fragment. A total of four nail holes were identified in the rabbets, two preserved holes on either side. Two square nail holes, both .5 cm², were found in the port rabbet approximately 33 cm apart. The two nail holes in the starboard rabbet are .5 cm² and .8 cm², and are 53 cm apart. The presence of seven nail holes is also evident in the top face of the stem, but three of these are in a compact group approximately 12 cm in diameter. Moreover, of these seven nail holes, the locations of only four may be estimated due to substantial deposits of concretion that obscure their precise locations. These four holes are spaced approximately every 40 cm.

The top half of the bolt hole in the scarf, matching to the bottom half of the hole in the other half of the scarf in the keel, was identified as well. It is perpendicular to the top and bottom faces of the keel, and passes entirely through the timber. It is 2 cm in diameter, at least 14 cm long, and the only bolt hole found in the preserved stem remnant.

Marks and Coatings:

As on the keel, pitch and concretion are the two most common coatings preserved on the stem. Although no pitch is evident on either the interior face or above the rabbet, it is still prevalent on the starboard and port sides. There is no pitch preserved on the bottom face. Patches of concretion, in comparison to pitch, are more prevalent, as they indicate the presence of nail holes both on the top face of the stem and in either rabbet.

The only tool marks preserved in the stem are similar to those on the keel: saw marks and dubbing marks from an adze. A small group of parallel saw marks are evident 45



Figure 3-4: Photograph of the sawn face of the stem scarf.

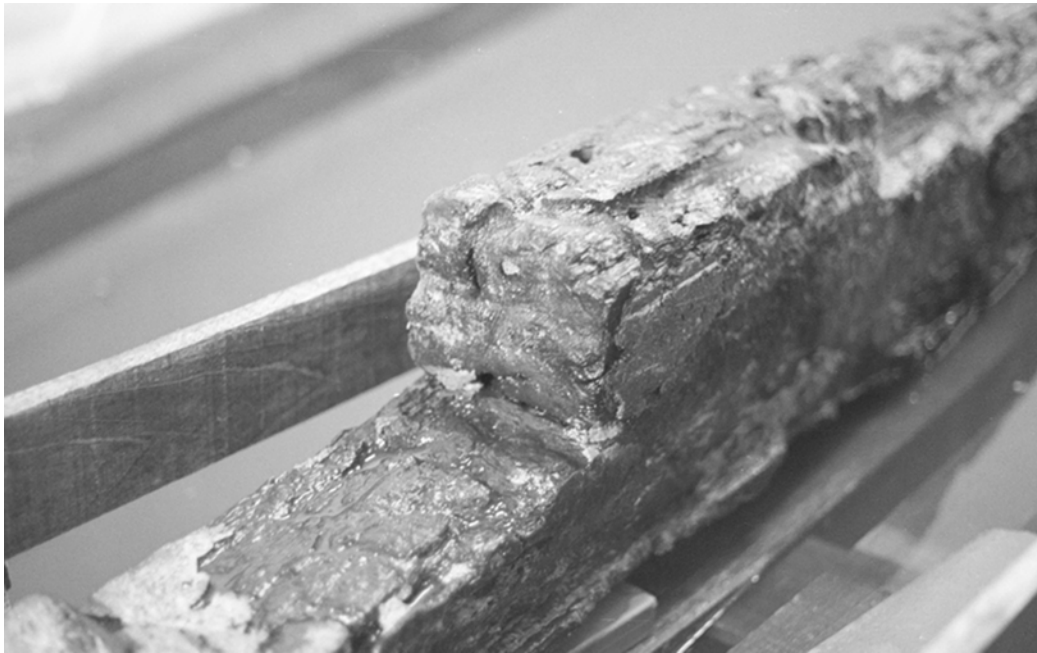


Figure 3-5: Another view of the sawn face on the stem scarf.

cm from the aft end of the stem, along the top starboard edge, while adze dubbing is more widespread across the entire interior face. Only one indentation on the interior face of the stem, caused by a floor timber rolling downslope, is evident but very faint.

Other Comments:

One species sample was taken from this fragment in 1997. It is a small wedge of material, measuring 2.5 cm x 2.4 cm, taken from the top port edge.

Keel

Timber Numbers:

KK 2/3-30, KK 31-39, KK 2-3.P, KK 30-32.P, KK 32-37.P

Dates Cataloged:

April 16 to 20, 1999; August 12 and 14, 2000.

Cataloger:

MBH

Drawing Numbers:

100-109, 218, 219 (with two additional sketches on catalog sheets)

Samples Taken:

None

Preserved Dimensions:

7.286 m x 29 cm x 15 cm to 18 cm

Wood Type:

Quercus sp?

Condition:

The keel, although preserved and uncovered in one large and one small fragment, had to be divided into smaller pieces to ease the process of lifting it from the seafloor, transporting it back to camp and subsequently back to INA headquarters in Bodrum, Turkey (figs. 3-6 to 3-8). As such, fragment KK 2/3-30, which was the smaller of the two fragments (1.39 m long), was placed in a crate and lifted from the site, but fragment KK 31-39 was cut into three smaller pieces underwater with a handsaw. The three fragments were then crated individually and brought to the surface. The longest of the three pieces is 2.0 m

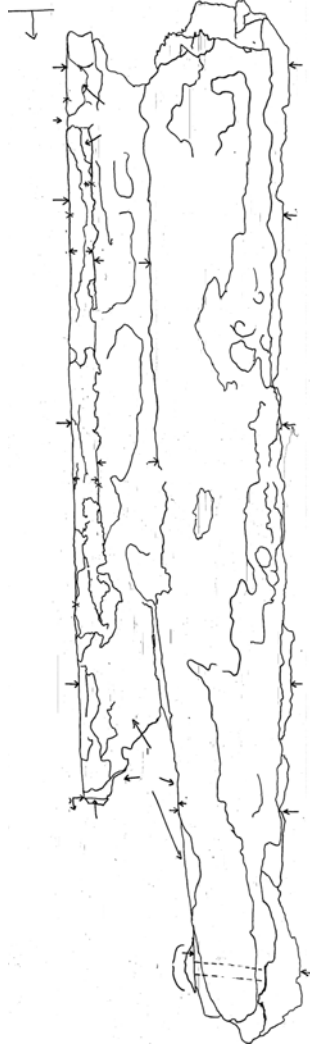


Figure 3-6: Drawing of the starboard side of the first fragment of the keel (1:10 scale)

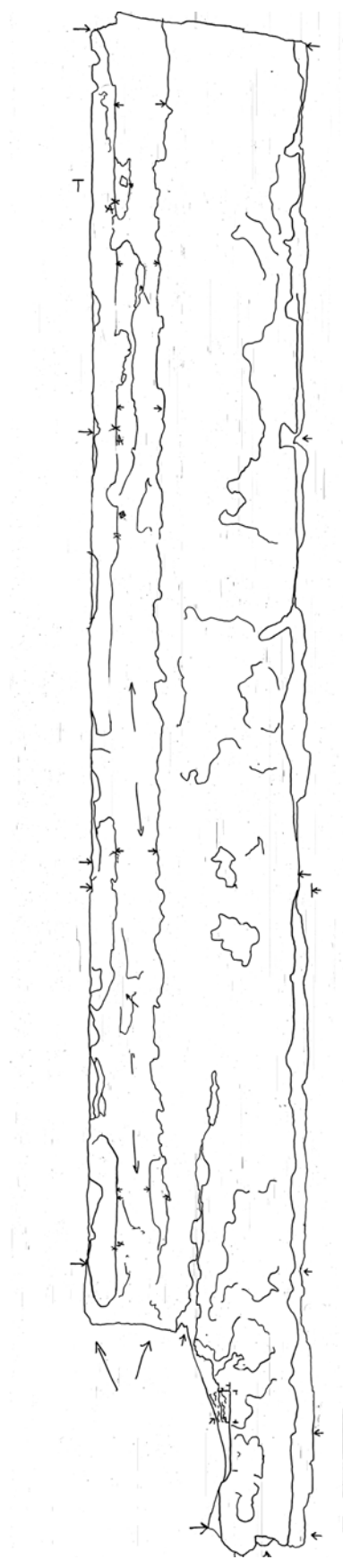


Figure 3-7: Drawing of the starboard side of the second fragment of the keel (1:10 scale).

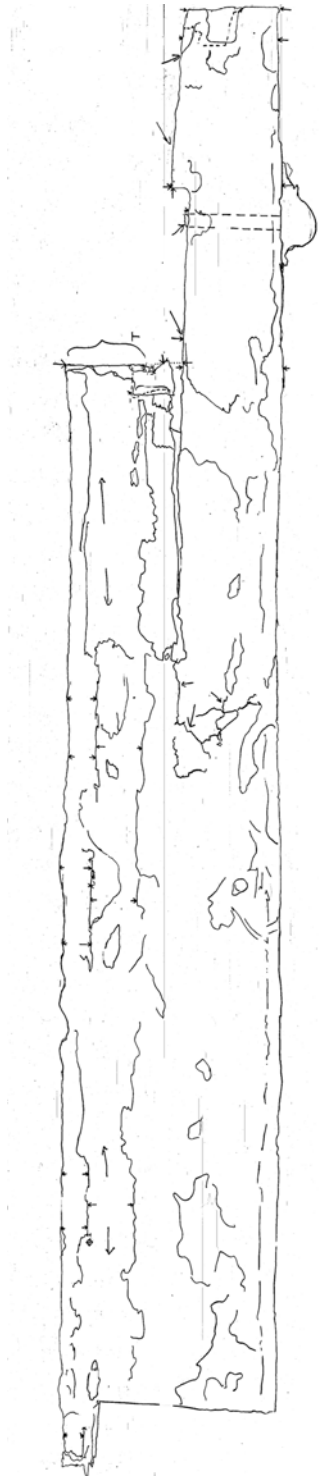


Figure 3-8: Drawing of the starboard side of the third fragment of the keel (1:10 scale).

long, and weighs approximately 122 kilograms. All together, the waterlogged weight of the keel is estimated to be 383 kilograms.

On the whole, despite immersion for approximately 1100 years, the keel is not particularly fragile. Sawing through sternpost fragment KK 1/2 to take a dendrochronology sample still required approximately one hour of work as only the exterior 3 cm to 4 cm were waterlogged. The interior of the sternpost fragment was still dry. A similar dichotomy in the waterlogged state of the keel creates difficulties in both moving and cataloging the keel, and results in the poor retention of original edges while in storage. The surfaces and edges of the keel are only somewhat friable and soft as a result of their waterlogged state, but the weight of the fragment tends to compress and/or crush these edges and faces of the keel when not immersed in water. As such, most of the damage found on the edges of and faces of the keel fragments occurred either while moving the material, or during the cataloging process. This dichotomy in the keel's waterlogged state will also create difficulties during the conservation treatment of this timber.

The preservation of the keel tends to increase in quality proceeding from the sternpost to the stem. This is most likely due not only to the increased amount of sediment burying the vessel at its forward end, but also to the apparent suspension of the stern section of the vessel off the seafloor by the large stone in the aft port quarter of the site. Thus, the amount of worm damage and erosion on the keel decreases towards the bow of the vessel.

For example, on the fragment KK 2/3-30, containing the stern scarf to the sternpost, only the interior, or top face, is well preserved while the starboard and port faces are eroded, cracked, and damaged by *Teredo navalis*. The bottom face is very worn and preserves no original surfaces. The location of the rabbet may be determined, but only discontinuous sections are preserved enough to determine any characteristics. Moving forward in the vessel, fragment KK 31-33 has only slightly better preservation of the rabbet, but both the top and starboard faces are crisp and well preserved. Worm damage is still evident, however, and due to its weight, all four faces and edges are worn. The final two fragments of the keel, KK 34-36 and KK 37-39, have better preservation of all four faces, with some original surfaces on the bottom face, and long stretches of the rabbet well

preserved on both sides. The edges are clean and well preserved, and some bevels are evident along the lower two edges. Although worm damage may be found along the entire preserved length of the keel, at no point is it ever extensive enough to threaten the structural integrity of the fragments, and in general, it is limited to superficial damage in the outer, waterlogged layers of wood.

There is no surface pitting on the preserved surfaces of the keel, but erosion tends to be more uniform than the worm damage. The erosion is predominantly on the bottom and port faces, and is particularly evident on the port side of fragment KK 2/3-30, where the majority of the face has eroded to a concave surface.

In general, some small fragments have broken off during the cataloging process, and when possible, they are stored in the crate with the appropriate keel fragment. Small pieces of the top starboard edge of fragment KK 34-36 have broken off during the cataloging process, as has a fragment from the top, port corner face of KK 37-39, which possesses part of the upper vertical mating face of that keel scarf. KK 37-39 is also likely to break horizontally along its pith, as the lower horizontal faces of the stem scarf were fashioned along, or very close to, the pith in the timber. As a result, the weight of the lower half of the scarf containing the horizontal faces is splitting from the upper half of the fragment. At this time, KK 37-39 is still in one piece, but a great deal of care should be taken when handling this fragment in and out of the water.

Joinery:

The amount of joinery evident on the keel is directly related to its preservation. As such, a full cross-sectional shape of the keel is difficult to find until a point approximately 2.5 m forward of the aft scarf face is examined. At that point, the preserved four faces retain enough original material to reveal that the keel was originally a rough trapezoidal shape with a very slight flange along the top face creating the rabbet. At this aft-most section, approximately 2.8 cm of the keel protruded above the rabbet, on the interior of the ship, and the preserved angles between the top face, which is 15 cm wide, and the two small vertical faces above the rabbet are approximately 93 degrees. At this same section, the angle between the back rabbet line and the starboard vertical face is nearly 95 degrees, but the preservation on the port side was too poor to retain any distinct edges or angles. The depth

of the starboard rabbet at this cross section is only 1.1 cm. The angle between the back rabbet and the rabbet itself is 91 degrees, which means that the face of the rabbet descends approximately 10.5 cm before acquiring a vertical orientation, at which point the keel is 18 cm wide. Below this point, the vertical face descends another 12 cm, maintaining the same width. Sparsely preserved along both bottom edges of fragment KK 31-33 is a small chamfer, which is approximately 125 degrees to either vertical face, and approximately 146 degrees to the bottom face.

The rabbet is better preserved on the port side of KK 34-36, and the angle at the back rabbet line is 75 to 80 degrees from vertical, the rabbet itself is only 1.1 to 1.5 cm deep, and is still approximately 10.5 cm wide. On the starboard side, the angle at the back rabbet line is 80 degrees, the rabbet is approximately 1.5 cm deep, and is 11 cm wide. The chamfers along the two bottom edges are more distinct as well, and appear to be fashioned at approximately 125 to 130 degrees to the vertical face. These characteristics are maintained through the last fragment of the keel, KK 37-39, in which the back rabbet is still approximately 80 degrees from vertical, and is 1.3 cm deep and 9.5 cm wide.

A scarf is preserved at either end of the keel as well. These scarfs are the lower halves of box scarfs, similar to the keel on the 7th-century vessel at Yassı Ada, and there are minor differences between the two scarfs.

The bow scarf in KK 37-39, which the better preserved of the two, is also the more complex. This scarf is composed of three vertical and two horizontal faces, as well as two pairs of mortises. The forward-most, vertical face of the keel is also the first vertical face of this scarf, and it contains the first pair of mortises as well (figs. 3-9, 3-10). This vertical face meets the bottom face at approximately 90 degrees, and then rises 12.5 cm before meeting the first horizontal face of the scarf at a second 90-degree angle. The two mortises in this vertical face, which average 6.5 x 5 x 4.1 cm, are placed side by side approximately 6 cm above the bottom face, and are 2 cm apart. Due to this separation, and their widths, the mortises do not possess exterior faces, but are instead open to either the port or starboard side. The first horizontal face of this scarf extends aft for 25 cm, gradually rising along its length until the thickness of this lower half of the keel is now 15 cm. At this point, this horizontal face meets the second vertical face, again at a 90 degree angle. This second

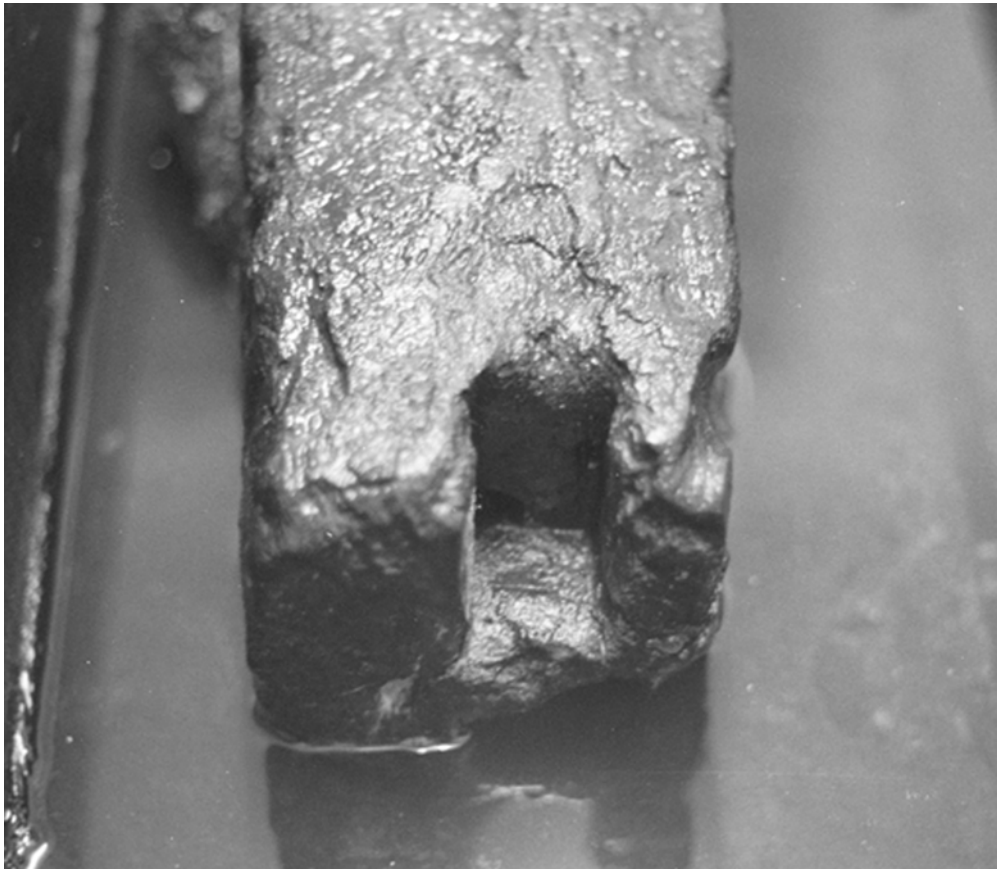


Figure 3-9: Photograph of the mortises in the keel's bow scarf.

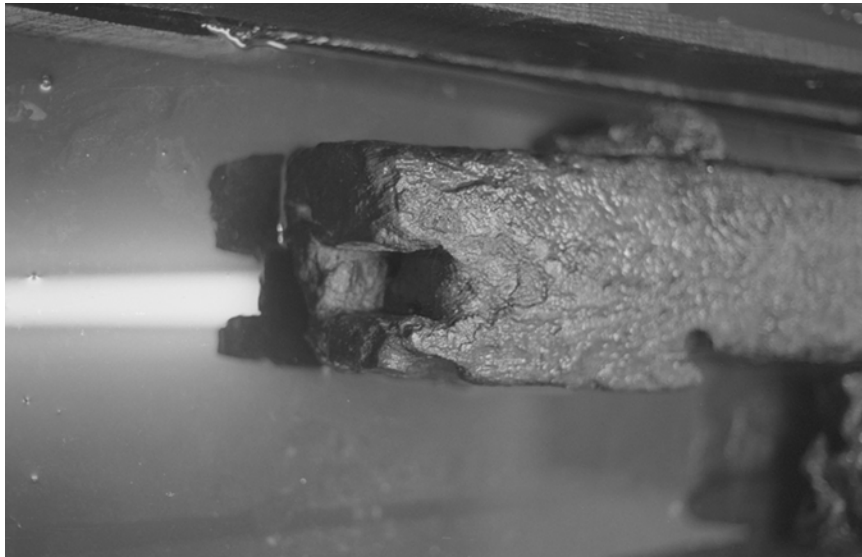


Figure 3-10: Another photograph of the mortises in the keel's bow scarf.

vertical face descends only 2.5 cm before terminating at the second horizontal face, meeting it at a 90 degree angle as well. The 2.8 cm diameter bolt was driven through this second horizontal face, 4.5 cm aft of the short, second vertical face. Approximately 24 cm aft of this short vertical face, the third, and tallest vertical face rises to meet the interior face of the keel, also at a 90 degree angle. It is in this last vertical face that the second pair of mortises were cut, in this case, at the junction between this vertical face and the second horizontal face (fig. 3-11). These mortises are larger than the first pair, averaging 5.8 x 4.5 x 8.2 cm, but similar to the first pair as they are also open along their exterior faces. Above these mortises, the remainder of the vertical face rises another 8 cm before terminating at the interior face of the keel. All in all, this scarf is 48 cm long.

While details regarding the bow scarf are available primarily because this scarf is very well preserved, the design and details of the stern scarf, in comparison, are more tenuous as a result of the poor preservation of the material. As such, knowledge of its design is based on an amalgamation of information gleaned from the preserved material in the lower half of the scarf in the keel, material preserved in the upper half of the scarf in the sternpost, and comparison with the design of the bow scarf.

The preserved material in KK 2/3-30 representing the keel's stern scarf contains two key pieces of information that aid its reconstruction; the location of the bolt hole, and the distance from the bolt hole forward to a vertical face that meets the upper, horizontal, face of the keel. Important characteristics preserved in the upper half of the scarf, in material from the sternpost, are the upper half of the bolt hole, the distance from this hole to an original vertical face approximately 18.5 cm forward, and remnants of a lower vertical face that contains mortises approximately 5 cm deep. By aligning the bolt holes in these two fragments, substantial gaps appear between the vertical faces in both the upper and lower halves of the scarf. Reconciling the gap present in the lower half of the scarf is a matter of extending the lower portion of the keel aft to meet the lower vertical face, and further extending fixed tenons from this reconstructed face into the preserved mortises. Although the walls of these mortises are very eroded, their preserved average depth is 5 cm. This is the same as the preserved depth of the nearly intact mortises in the bow scarf, so it may be assumed that this is the original depth of these mortises as well. Reconciling the gap

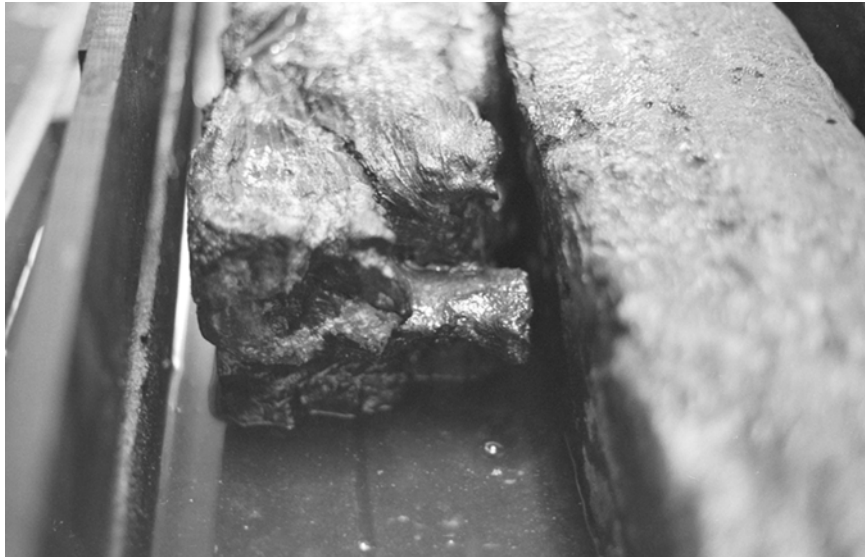


Figure 3-11: The second pair of mortises in the keel's bow scarf.

in the upper portion of the scarf is completed through a similar process. As mentioned, the sternpost preserves an original vertical face approximately 18.5 cm forward of the bolt hole passing through the fragment, and, similar to the lower portion of the scarf, it is possible to reconstruct and extend an upper section of the keel aft as well, to simply fill the space. It is evident that this is the best option as, once reconstructed, this upper, vertical keel face is now approximately 19 cm from the center of the bolt hole in the keel itself, a distance found in the bow scarf as well. It does not appear that there was a key through this scarf, unlike the bow scarf. This is so because, presuming that the design of this scarf is similar to that in the bow, if such a key was present, then a short vertical face should also be present 4.5 cm aft of the bolt hole in the sternpost. No such vertical face is preserved in that location. Moreover, if this short vertical face was farther aft – perhaps 12 cm aft where this preserved face retreats towards the upper face of the keel – then the thickness of this section of the sternpost should be consistent through the remainder of the scarf. This thickness is not consistent, nor is there original surface in this area, further implying the absence of a key.

The stern scarf then, is composed of two vertical faces and a single, inclined horizontal face. The aft-most vertical face is approximately 15 cm high, and contains two fixed tenons, each approximately 5 cm deep, protruding from it. This vertical face meets the inclined horizontal face at an angle of approximately 86 degrees, at which point the horizontal face extends approximately 46 cm forward to the second vertical face. A second pair of mortises is placed at the junction between this second vertical face and the horizontal face of the keel, similar to the bow scarf, but this is supposition as there is no material preserved to indicate any characteristics. As such, these mortises have the same dimensions as the coordinating pair in the bow scarf.

During two separate examinations of the keel, attempts were made to locate both treenails, possibly to affix the floor timbers to the keel, and edge dowels, which may have been used to affix strake one to the keel. In both cases, neither were found.

Fastenings:

Due to the good preservation of the keel, finding metal fasteners was not a particularly difficult task. Two types of metal fasteners were found in the keel; nails used to

affix both the floor timbers and strake one to the keel, and three bolts. All three of the bolts affixed floor timbers to the keel, and two of them also secured the keel scarfs, one in each scarf.

In the top face of the keel, nail holes were identified in three ways. In many cases, a square nail hole left by the nail was still evident within an area of rust and concretion on the top face of the keel. In those cases, the nail hole was cleaned and its dimensions were taken. In other cases, only rust and concretion were evident on the top face of the keel, and despite probing and cleaning with a dental pick, no nail hole was found. In cases such as these, the approximate location of the nail hole was facilitated by black iron staining of the surrounding wood and concretion. In other cases with no staining, the approximate center of the concretion and rust was found and marked. All in all, 17 nail holes were found in the top face of the keel, of which the locations of 6 were estimated. The estimated nail holes are located at frame stations 1, A, B, C, E and G. Other than the midships frame station, which has two nail holes 12 cm apart, all of the other frame stations on the keel have a single nail hole. These preserved holes are spaced, on average, 33.7 cm apart, although distances as high as 45 cm and as low as 24 cm have also been found.

Nail holes were found in both rabbets as well. In these cases, concretion and black staining were more common than in the top face, although cleaning of these areas did reveal the actual nail hole more often than on the top face. What nail holes were found tended to be located either on the rabbet line, or within the first two centimeters below it, an area that was also susceptible to erosion. In the one case where no actual nail hole was found, the location of the nail was estimated by the location of rust and concretion, and the presence of a hard, small inclusion in the rust, most likely the remains of the nail itself.

Generally, the nails in the top face of the keel and those in the rabbets tend to have the same average dimensions. In the top face, the average size was $.6 \text{ cm}^2$, the largest was 1 cm^2 and the smallest was $.5 \text{ cm}^2$. Along both rabbets, all of the preserved nail holes were $.5 \text{ cm}^2$.

In contrast to the nails in the keel, only three bolt holes were identified. These holes, which were at least 30 cm long, averaged 2.6 cm in diameter and passed entirely through the keel. The bolt hole in the bow scarf is 30.5 cm from the forward end of the

keel, the bolt hole though the aft scarf is 25 cm from the aft end of the keel, while the third bolt, near the aft scarf, is approximately 61.5 cm from the aft end of the keel. No other bolt holes were found in this keel.

Marks and Coatings:

The most evident coating present on the keel was pitch. This pitch, which in many cases was still soft and malleable, coats both the port and starboard sides of the keel fairly consistently, and is present on the bottom face as well, but only in scattered areas on fragments KK 2/3-30, KK 31-33 and KK 34-36. The amount of preserved pitch tends to be heavier on the starboard side of the keel, and is found both above and below the starboard rabbet on all keel fragments except for KK 37-39, at the very forward end of the keel. On fragment KK 31-33, this pitch was found in the rabbet as well as in a transverse strip, approximately 4 cm wide, on an interior, horizontal face at the break.

Caulking, which in some cases was preserved along the edges of some of the planking fragments, was not found on the keel or in the rabbet. Internal pitch was found only on one fragment of the keel, KK 30-32.P, which retained some of this internal pitch on its only preserved original face. The fragment itself, however, has no other diagnostic features, so its relation to the rest of the keel is unclear.

Concretion was found in scattered areas both along the rabbets and on the top face of the keel, commonly associated with rust staining at metal fastenings. This concretion, similar to most of the concretion on the rest of the hull fragments, tended to have a hard outer crust, but the interior was commonly a thin, gritty black paste. This concretion only tended to penetrate the wood itself when associated with a fastener hole, otherwise, it tended to accumulate on the surfaces of the wood, making its removal fairly straightforward. Often, it could be removed with a dental pick. The largest concretions were associated with the bolts either in or near each scarf.

Although Mediterranean oaks tend not to retain surface detail very readily once submerged, small collections of tool marks were still evident on the interior face of the keel. Dubbing marks, small facets on the surface of the wood created while shaping or smoothing a face with an adze, were still faintly evident on the interior face of KK 31-33, and on the first horizontal face of the box scarf at the bow. A small group of five or six

parallel saw marks were also preserved on the top face of KK 2/3-30. As the leading edge of this saw blade left a series of low ridges on the surface of the timber, it is also clear that this cut proceeded from the stern to the bow of the vessel. A second, distinct saw mark is also evident in surface of the second horizontal face in the bow scarf, at the junction between this face and the third vertical face, immediately forward of the pair of larger mortises.

More widely spread, however, were unintentional marks that occurred after the ship had settled and begun to degrade on the seafloor. Varying between 3.5 cm and 10 cm forward of the nails at eight frame stations, narrow, transverse indentations are evident on the interior face of the keel as well. These narrow indentations are the result of each floor timber rolling downslope 90 degrees or less, as the fastener affixing each to the keel degraded. As the floor timber rolled forward, it slowly impressed its lower forward edge into the interior face of the keel, causing uneven wear and erosion in some cases, and distinct depressions in others. These indentations are evident forward of eight frame stations on the keel.

Other Comments:

As mentioned above, the long fragment of the keel is in three smaller pieces now as it was purposefully cut to facilitate its removal from site.

Sternpost

Timber Numbers:

KK 1/1-1/4, UM 222

Dates Cataloged:

May 8, 1998; April 21, 1999; August 12 and 14, 2000

Catalogers:

JR, JMM, BAJ, MBH

Drawing Numbers:

39, 108, 109

Samples Taken:

Dendrochronology sample number 12

Preserved Dimensions:

3.548 m long x 26 cm to 30 cm thick x 15 cm to 18 cm wide

Wood Type:

Quercus sp?

Condition:

The four recovered fragments of the sternpost, of which there are now more due to fresh breakage during storage, vary noticeably in their preservation (figs. 3-12, 3-13). The aft-most fragment of the sternpost, UM 222, preserves almost no original surface and is entirely riddled with worm holes. It has very little structural integrity, delicate surfaces and edges, and is fairly undiagnostic. Moving forward through the sternpost, however, the remaining fragments retain increasing levels of original surfaces and edges, as well as other diagnostic features.

The greatest change in preservation is evident in fragments KK 1/1 and 1/2. The after end of this portion of the sternpost preserves discontinuous patches of original material along the top, port, and starboard faces, but the bottom face is friable and heavily eroded. The loss of wood along the bottom face is most likely due to the location of the pith, which approaches the bottom face as the timber sweeps upward. From this damaged after end to a point approximately one meter away, however, the worm damage is considerably lessened, the structural integrity of the fragment is noticeably better, and the erosion is reduced to the point where the sternpost retains its original thickness of approximately 30 cm. Farther towards the bow, the next preserved fragment in the sternpost, KK 1/3-1/4, exhibits problems of preservation similar to fragments of the keel. The exterior faces are friable and soft, due to their waterlogged state, but the interior of the fragment is still fairly hard. This dichotomy results in a heavy and fragile fragment, which, when not immersed, tends to crush its exterior faces and edges. Nonetheless, fragment KK 1/3-1/4 still has original surfaces and edges preserved on the top, port and starboard faces, as well as portions of the rabbets on both sides.

At present, the greatest amount of additional breakage is expected in the most fragile fragments, UM 222, KK 1/1 and 1/2. KK 1/3-1/4 should still be handled with care, but it is not, at this time, in any immediate danger of splitting or breaking during

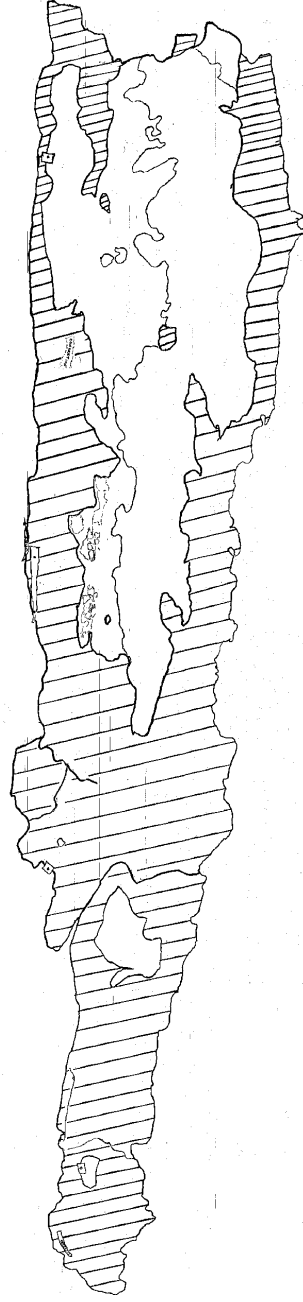


Figure 3-12: Drawing of the starboard side of the first fragment of the sternpost (1:10 scale).

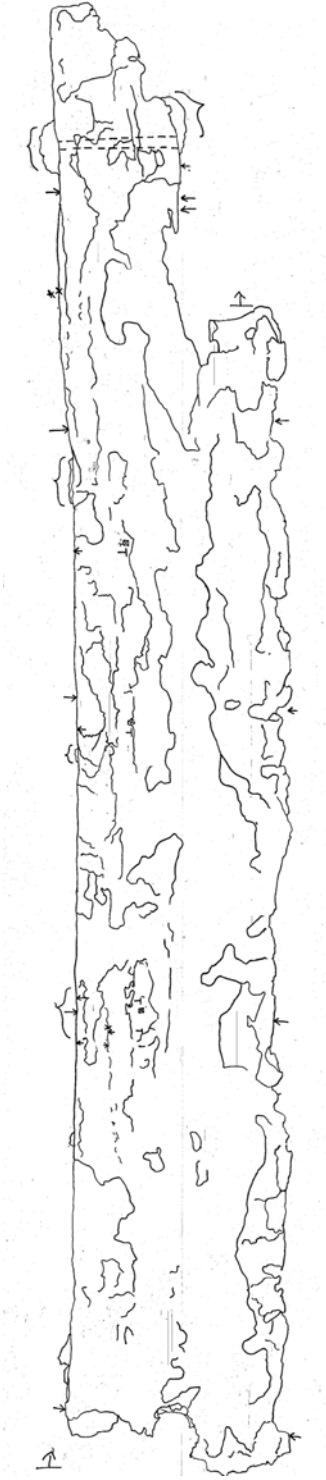


Figure 3-13: Drawing of the starboard side of the second fragment of the sternpost (1:10 scale).

handling. Similar to the keel, the dichotomy in water penetration will create problems during the conservation process.

Joinery:

The fragments exhibit variation in their preservation, but the general upward sweep of the sternpost can still be recorded if the fragments are laid out together. Over its preserved length of 3.548 m, the interior face of the sternpost rises approximately 12 cm. As the bottom face is severely eroded beyond the after end of KK 1/2, however, it is unclear if original thickness of the sternpost, 30 cm, is maintained along that length.

The preserved cross-sectional shape of the sternpost, taken 1.07 m from the forward face, indicates that it was similar in design to both the keel and the stem. The interior face of the sternpost meets the interior vertical faces, which are approximately 5.5 cm high, at a 95 degree angle. The starboard rabbet, which has a preserved depth of .8 cm, is 89 to 92 degrees, and the presence of six nail holes on the port faces of KK 1/1 and 1/2 indicate that the rabbets extended at least 2.6 m aft of the stern scarf. The inclined face of the rabbet descends approximately 11 cm before acquiring a more vertical orientation, at which point the sternpost is approximately 18 cm thick. The vertical face below the face of the rabbet descends another 10 cm along the starboard face of the sternpost before meeting the chamfer along the bottom edge at an angle of approximately 132 degrees. The lower edge of this chamfer, and the bottom face itself, is too poorly preserved to determine any other characteristics.

The upper half of the scarf joining the sternpost to the keel is still preserved, in slightly better condition than the lower half in the keel, and retains enough material and original surfaces to determine some of its characteristics (fig. 3-13). This scarf, similar to the lower half of the scarf in the keel, is composed of two vertical faces and one inclined horizontal face approximately 40 cm long. The lower vertical face, which is approximately 13 cm high, contains two 5-cm deep mortises, which, like other examples, are separated horizontally and open on their exterior walls. This lower vertical face meets the inclined horizontal face, of which only 18 m is preserved around the bolt hole, at an angle of approximately 95 degrees. A 2.0 cm diameter bolt hole passes through this horizontal face

22 cm forward of the junction between the first vertical face and the inclined horizontal face; this hole aligns with a corresponding hole in the other half of the scarf in the keel.

The horizontal face then continues forward an additional 18 cm or so, before joining the second vertical face, again at an angle of approximately 95 degrees. In light of the design of the bow scarf, two fixed mortises, 7 cm deep and 8 cm high, are reconstructed at the base of this second, 14 cm high, vertical face, although there is no preserved material to indicate their presence.

Fastenings:

As in to the keel, both nails and bolts were recorded in the sternpost. Fragments UM 222 and KK 1/1 were both too eroded to preserve any evidence of fasteners, but starting 2.245 m from the forward face of the stern scarf, the first of seven nail head concretions on the interior face of the sternpost are found. Despite probing and cleaning, no distinct nail holes were found in these concretions. Four nail head concretions are present on the top face of fragment KK 1/2, while an additional four are distributed along fragment KK 1/3-1/4. Only the eighth, and forward-most, nail hole preserved in the top face of the sternpost retains any distinct dimensions (.8 cm²). Of the four nail head concretions preserved on the top face of KK 1/2, three are grouped together less than 18 cm apart, while the fourth is an additional 30 cm aft. The nail head concretions in KK 1/3-1/4, and the nail hole itself, are more evenly distributed and average 39 cm apart, although the distances vary from 29 cm to 51 cm.

Groups of these square nail holes were recorded on either side of the sternpost as well. On the port side of KK 1/2, six nail holes, averaging .6 cm², are preserved; none were found on the starboard side. In contrast, in fragment KK 1/3-1/4, in contrast, three square nail holes were found on the starboard side, all .5 cm². These latter nail holes are spaced approximately 23 and 38 cm apart. Of these three preserved nail holes, the middle was driven into the keel at approximately 55 degrees to vertical.

One bolt hole was found in the sternpost as well. This 2.0 cm diameter bolt hole, located in the box scarf to the keel, coordinates with the appropriate hole in the other half of the scarf in the keel itself. Treenails were not found in the top face of the keel, nor were edge dowels found in either rabbet.

Marks and Coatings:

Again, as on the keel, exterior pitch was the predominant coating found on the sternpost. Although fragments UM 222 and KK 1/1 were too worn and damaged to retain any surface coatings, pitch was present on both the port and starboard sides of KK 1/2 in large amounts. On fragment KK 1/3-1/4, pitch was more prevalent on both sides, but not on the top or bottom faces, nor above the rabbet. On fragment KK 1/3-1/4, concretion is evident along the bottom face, both rabbets, and particularly surrounding nail holes. No interior pitch was identified, nor was caulking found in the rabbet.

Scattered adze marks are evident along the top face and the port side of KK 1/3-1/4, near the forward end of the fragment. No saw marks or scribe marks were found.

Other Comments:

During the cataloging process, a vertical strip of pitch approximately 3 cm wide was removed from the starboard side of KK 1/3-1/4, approximately 1.07 m from the forward face of the sternpost. This was done so that an accurate cross-sectional shape of the sternpost could be found.

*Miscellaneous Keel Fragments***Timber Numbers (Lot Numbers):**

(10686), KK 2/1, KK.P

Dates Cataloged:

April 2, 1999, August 2 and 3, 2002

Cataloger:

MBH

Drawing Numbers:

218, 219

Samples Taken:

None

Preserved Dimensions (Largest Fragment):

40.4 cm x 12.5 cm x 9 cm

Wood Type:

Quercus sp?

Condition:

Of the four fragments that are included here, the two in lot 10686 are the most delicate due to their size. Both are less than 10 cm long, are worn and eroded, and although they apparently suffered little worm damage, their diminutive size increases their likelihood of suffering more damage in the future. Of the other two fragments, the larger of the two, KK 2/1, is more prone to damage than the latter, KK.P (figs. 3-14, 3-15).

Through damage and erosion, KK 2/1 has been worn into a 40 cm-long fragment with a rough T-shaped cross section, resulting in an awkward shape with one preserved original horizontal face. As a result of this shape, the edges of the upper face are delicate and friable, and likely to splinter and chip. The preserved material below this face is friable as well and as such, this fragment should be stored upside down, on its preserved horizontal face.

Fragment KK.P is smaller and stouter than KK 2/1, and has similarly preserved material around a bolt hole. The faces and edges of this fragment are more rounded than on KK 2/1, and this fragment tends to be both more solid and heavier due to a greater amount of embedded concretion. Material preserved below its horizontal original face is rounded through erosion, and is friable and likely to splinter.

Joinery:

Because the orientation of these fragments is unclear, the faces on KK 2/1 and KK.P considered to be the fore, aft, port and starboard faces may be incorrect. Nonetheless, both fragments preserve sections of an original horizontal face, presumably representing the upper face of the keel. This horizontal face of KK 2/1, the better preserved of the two horizontal faces, is only 13.9 cm wide. KK 2/1 preserves a fragmentary port face, containing part of a 1 cm deep rabbet as well. Two possible original vertical surfaces are preserved at the apparent aft end of KK 2/1 as well. One of these faces, which is 4.5 cm deep, meets the upper face of the keel at an angle of 90 degrees, while the second vertical face is isolated 5.5 cm forward of the first, in the midst of eroded and damaged surfaces under the upper horizontal face. This second face, which is only 2.5 cm high, may represent a vertical face involved in a scarf or fitting through the keel, but this is only speculation. KK.P preserves part of a presumed starboard face as well, but although 4

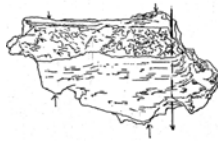


Figure 3-14: Drawing of fragment KK 2/1 (1:10 scale).

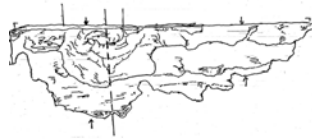


Figure 3-15: Drawing of fragment KK.P (1:10 scale).

cm of the depth of this face is preserved, no rabbet is evident. No scarfs or chamfers, treenails or edge dowels were found in these four fragments.

Fastenings:

Among the four fragments, only KK 2/1 and KK.P preserve evidence of fasteners within them. KK 2/1 contains the only nail holes, three in all, varying between .5 cm² and .6 cm². Two of these holes are in the top face of the fragment, grouped with the single bolt hole, in an area approximately 9 cm in diameter along the midline of the fragment. The third nail hole in KK 2/1 is found in the preserved rabbet, but unfortunately, its inclination is unclear. KK 2/1 and KK.P each have one bolt hole passing through the fragment. The 2 cm diameter bolt hole in KK 2/1 is found among the two nail holes, and is preserved for a depth of 12 cm. The second bolt hole, that in KK.P, tapers from 2.3 cm in diameter to 2.1 cm in diameter.

Marks and Coatings:

The only tool marks evident among these four fragments are found on KK 2/1. Marks from an adze are evident on the top face at the apparent aft end, indicating dubbing along the length of the fragment, but no details regarding the adze blade are preserved. No saw marks are evident on any of these fragments, and only one post depositional indentation is preserved, forward of the fasteners in the top face of KK 2/1.

Rust and concretion are on all four fragments, most particularly on fragments KK 2/1 and KK.P due to the bolts that formerly passed through them, but pitch is only found on KK.P In this case, this pitch appears to be internal pitch, and it is found only on the possible starboard face.

Other Comments:

Despite the paucity of material and diagnostic information associated with the keel fragments in lot 10686, they were retained during the cataloging process due to the location in which they were discovered. According to the lot catalog compiled in the summer of 1998, this material was found in the stern keel scarf. At the time, it was unclear whether the stern scarf had a key or not, so this material was retained. It is now evident, from detailed examination of the material at the stern scarf, that no key was used. Presently, the original purpose of this material is unknown.

Fragment KK.P is considered to be a fragment of the keel as it was stored with KK 2/1 and another large fragment of the keel in the laboratory. It does not, however, have a tag that designates it as a fragment of the keel. As such, this fragment may be part of the sternpost, or it may not be associated with the keel at all. As the only lacuna along the length of the keel occurs under floor timber 6, and that floor timber is not affixed to the keel with a bolt, it seems increasingly unlikely this fragment was originally part of the keel.

KK 2/1, as it preserves part of the rabbet, is clearly part of the keel, but similar to the fragments in lot 10686, its location is unclear as well. First, it is too long to fit into the gap under floor 6, between KK 30 and KK 31. Secondly, once KK 30 and 31 are re-assembled, there is no bolt hole evident in the fragmentary material that mates with the bolt hole in KK 2/1. Lastly, if the preserved rabbet is on the port face, then this small section of the port side of the keel is preserved much better than material 40 cm to either side. On the other hand, if this rabbet is on the starboard side, then the re-oriented fragment aligns even more poorly in the gap in the keel.

Framing Timbers

Associated with this section of the catalog is a new nomenclature for all the preserved framing elements of this vessel. As mentioned earlier, the first floor timbers identified on site were in square H11, just forward of midships. Following a standard practice, the first floor timber uncovered was designated FR 50. Other floor timbers subsequently uncovered were labeled appropriately, counting the number of floor timbers between FR 50 and the next to be labeled. Unfortunately, not all of the floor timbers, forward and aft of FR 50, were uncovered sequentially, and at times it had to be estimated how to designate a particular floor timber. As a result, there are no floor timbers labeled FR 45 through FR 48. For this reason, and to further clarify which floor timbers are forward or aft of midships, a second nomenclature was adopted after the excavation. The floor timber at midships, FR 40, was labeled appropriately, and all floor timbers forward of midships, from FR 41 to FR 58, will now be referred to as floor timbers A through N. The floor timbers aft of midships, from FR 39 to FR 21, are designated by an ascending series of numbers, 1 through 19. Although the letters forward of midships are arranged as expected, A is next to midships and N, far to the right, is the last, the numbers are backwards. FR 39,

next to midships, is floor timber 1 and FR 21, far to the left, is now floor timber 19. As such, when floor timbers or futtocks are listed in this catalog or elsewhere, they will be listed in order from the stern to the bow of the vessel. Meaning, in some cases, that the numbers listed will descend in order, while the letters will proceed alphabetically. This method was adopted because listing a series of floor timbers in other sequences seemed either too protracted or too convoluted. At various points, however, specific floor timber fragments are mentioned in this catalog, and in those cases, the original nomenclature (FR 40 0/3, etc...) is retained, rather than creating a second series of fragment numbers as well.

Additionally, when describing the patterns of breakage in these floor timbers, or changes in their cross-sectional shapes, the general design of the floor timber was divided into five distinct sections. The first section comprises material immediately over the keel, demarcated between the edges of the keel itself, while the second section, in or over the limber hole, is fairly brief. The third section extends from the outboard edge of the limber hole to a point between 50 cm and 60 cm outboard from the edge of the keel. This area encompasses starboard strake one's hollow where present, and is distinguished from the area designated the midbody. This midbody area is defined as extending between the end of starboard strake one's hollow and the beginning of the turn of the bilge. In some cases, particularly floor timbers near the bow and stern of the vessel where no hollow is present, this midbody section extends directly to the limber hole. Beyond the midbody is the sweep through the bilge, which in all floor timbers is the limit of their extent outboard of the keel.

Oak Floor Timbers

Timber Numbers (Lot Numbers):

FR 39, FR 40, FR 40 0/5 (11176), FR 40.P (11142), FR 41, FR 41 0/1 (11404.04), FR 41.P (11206.01), FR 42, FR 43, FR 44, FR 44-1, FR 44-5, FR 44-6, FR 44-P (two fragments), FR 49, FR 49-8, FR 49.P

Dates Cataloged:

April 6, 8, 16 and 26, 1999; May 5, 1999; June 1, 19 and 30, 1999; July 30, 1999; June 5 and 20, 2000; July 31, 2000; August 2, 6, 7, 8, 10 and 11, 2000; September 8, 2000; August 21, 2001; August 1, 2002.

Catalogers:

EAG, MBH

Drawing Numbers:

112, 117, 122, 155-160 (additional sketches on catalog sheets)

Samples Taken:

Dendrochronology samples 27, 65, 67

Preserved Dimensions (average):

2.24 m x .12 m x .14 m

Wood Type:

Quercus sp?

Condition:

Although many original surfaces are evident on the seven oak floor timbers, in comparison to the pine floor timbers, these seven are more fragmentary, delicate, and friable (figs. 3-16 to 3-23). All of them, in various degrees, are eroded and worn, and while *Teredo* damage is evident along the lengths of the timbers, it is particularly destructive at the distal ends of the fragments, beyond the sweep of the bilge. Due to the fragility and friable nature of these fragments, handling and cataloging them can be tedious, and can result in the loss of surface detail. None of the oak floor timbers were recovered in one fragment, and the number of cataloged fragments making up one oak floor timber varies from 3 (floor timber C) to 12 (floor timber D).¹ In general, all of the oak floor timbers are preserved, in either continuous or discontinuous fragments, from the vicinity of the keel to the sweep of the starboard bilge. Floor timber A, for example, has approximately 16 cm preserved over the keel, while floor timbers 1, B, C, D and E retain evidence of, or imply the presence of, port limber holes and the hollow at port strake one. The material preserved over or beyond the port edge of the keel, however, varies in condition. Floor timbers 1 and C preserve material over the keel, and evidence of both limber holes and port strake one's hollow in one large fragment each, while the same items are represented by the assembly of at least four fragments in floor timber E. Floor timber B retains one 35 cm long fragment which may have extended over the keel, and which may also preserve

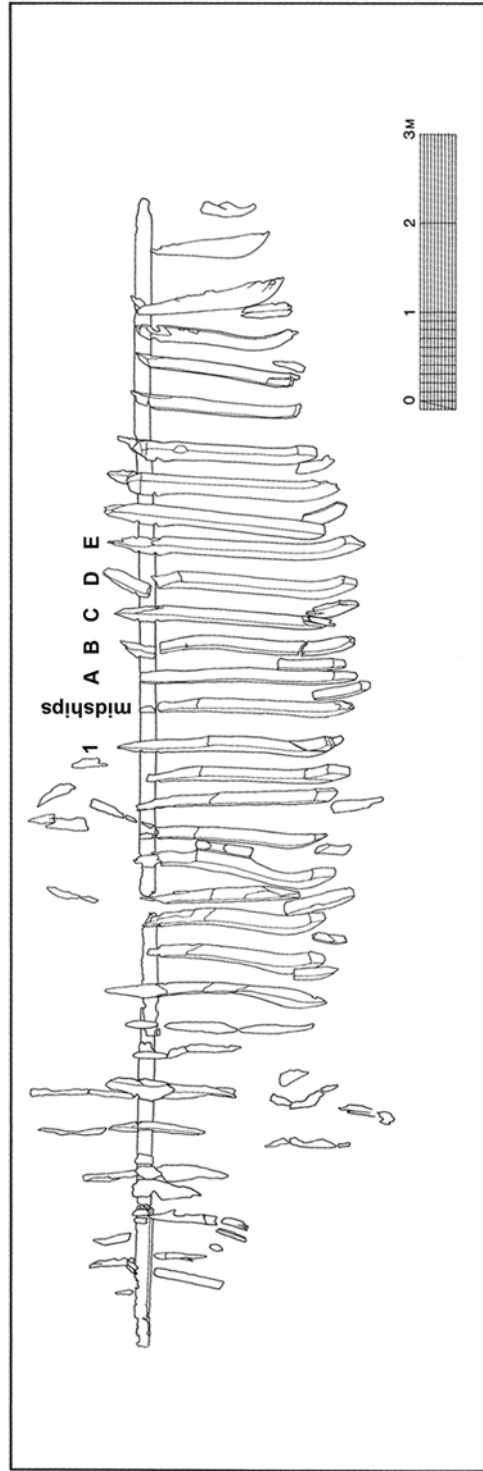


Figure 3-16: Site plan with oak floor timbers labeled.

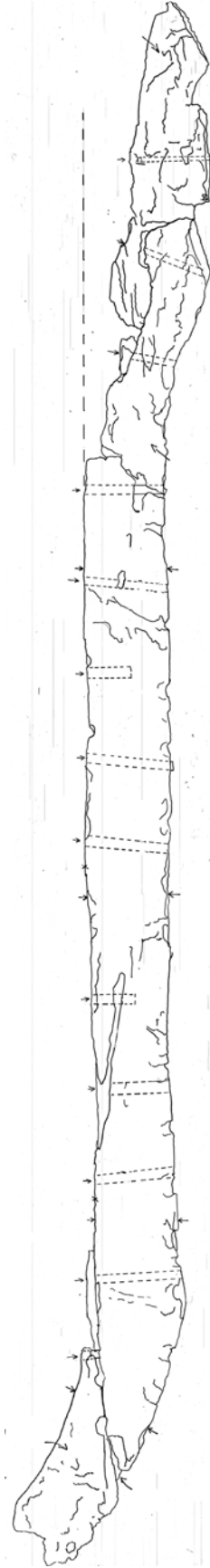


Figure 3-17: Drawing of the forward face of floor timber 1 (1:10 scale).



Figure 3-18: Drawing of the forward face of the midships floor timber (1:10 scale).



Figure 3-19: Drawing of the forward face of floor timber A (1:10 scale).



Figure 3-20: Drawing of the forward face of floor timber B (1:10 scale).

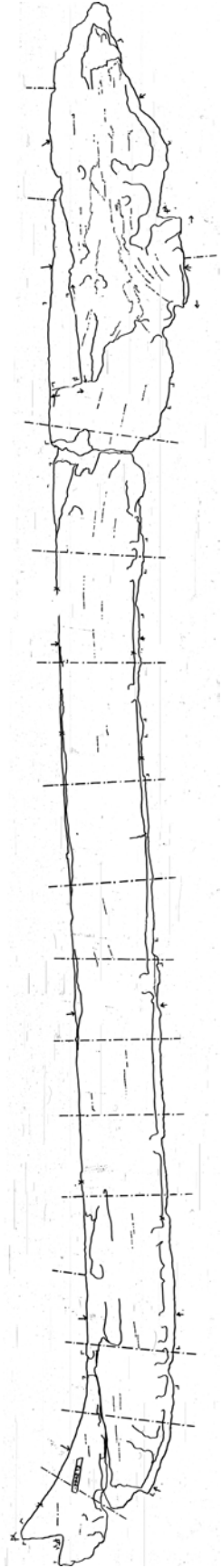


Figure 3-21: Drawing of the forward face of floor timber C (1:10 scale).

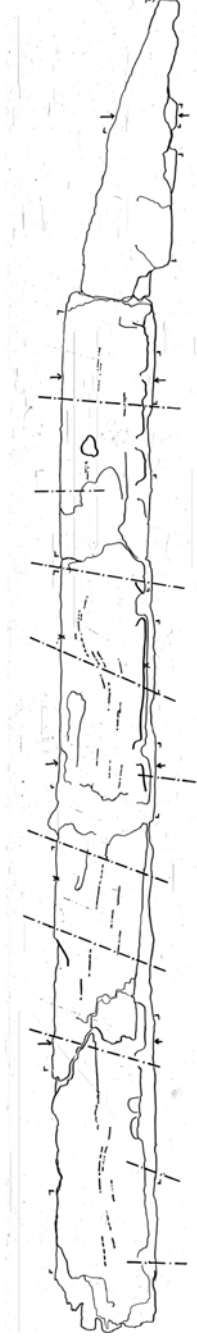


Figure 3-22: Drawing of the forward face of floor timber D (1:10 scale).

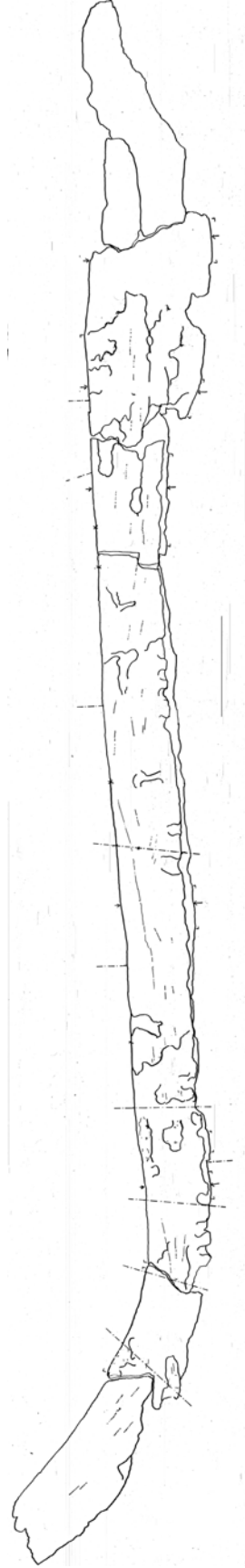


Figure 3-23: Drawing of the forward face of floor timber E (1:10 scale).

evidence of the port limber hole. Floor timber D, in comparison, preserves nearly 60 cm of material beyond the port edge of the keel, possibly preserving the port limber hole, but no material is preserved over the keel itself. The midships floor timber is preserved, and cataloged, to a point just prior to the starboard edge of the keel, although more original material was identified on site over the keel itself. The current location of the preserved material from midships that rested on the keel is unknown.

The condition of the material extending to the starboard side of the keel varies as well, but its preservation is more consistent due to the support and burial of the material in the seafloor. Floor timber C, which may preserve the original thickness of the floor timber over the keel, retains long sections of original surfaces on all four faces, crisp edges, and the largest preserved fragment is approximately 1.7 m long. The longest fragment of floor timber D, however, is just over 1 m long, and despite the preservation of 12 fragments, they cannot be re-assembled into one contiguous part of the original floor timber. Fragments FR 44-2 to FR 44-4 make up the largest portion of floor timber D, and FR 44-1 represents material at the turn of the bilge, but the former cannot be successfully joined to the latter as the broken edges do not match. Fragments FR 44-P.1 to P.4 assemble to form material preserved on the port side of the keel, but the remaining fragments FR 44-5 and 6, and FR 44-P.5 and P.6 do not match any of the extant surfaces. Despite the disarticulate nature of floor timber D and friable and abraded surfaces, however, original material is preserved on all four faces over 80 percent of the material, as well as short stretches of the original edges.

Extant material is present at the starboard bilges of all seven oak floor timbers as well, and the condition of this material appears to be related to the run of the pith through the sweep in the bilge. As the pith in floor timbers 1, A and C extends straight through the bilge instead of sweeping up around the curve, the portions of these floor timbers above the pith have horizontally split from the floor timber extending inboard to the keel. The pith in floor timber E extends straight through the sweep at the bilge as well, but in this case, the distal fragment has broken off nearly perpendicular to the grain, at the beginning of the turn of the bilge. In floor timbers B, D and the floor timber at midships, the pith sweeps up and around the starboard bilge, preserving the structural integrity of this material, and thus the extant bilge material from these floor timbers is preserved in a much larger fragment.

In general, the oak floor timbers tend to be the most poorly preserved at their proximal ends, containing friable surfaces, delicate splintering edges, and structurally weak wood due to *Teredo navalis*. The center portions retain better structural integrity, but in all cases this material should be stored with care, and handled as little as possible. Nearly all the oak floor timbers now have fresh cracks or breaks acquired during the recovery and cataloging process.

Joinery:

All of the oak floor timbers retain enough original material on all four faces to determine their cross-sectional shapes. In all seven examples, the floor timbers are roughly square or rectangular in cross section. As evident from the preserved material of floor timbers C and E, over the keel, the floor timbers were approximately 21 cm to 23 cm molded and 11 cm to 13 cm sided. Moving 50 cm to 60 cm outboard from the center of the keel, however, the molded dimension tapers to between 11 cm and 13 cm, comparable to the sided dimension, which is approximately 11 cm to 13 cm as well. These molded and sided dimensions were maintained fairly consistently along the lengths of all seven floor timbers, to a point just prior to the turn of the bilge. The greatest dimensional change preserved, for example, is in the midships floor timber, which increased approximately 3 cm in both its molded and sided dimensions.² Only one of these floor timbers, floor timber B, retained evidence of a chamfer along one of its preserved edges; all of the other floor timbers preserved edges of an average angle of 93 degrees. This chamfer is intermittently present along the upper aft edge of floor timber B, and was fashioned at approximately 130 degrees to the top face, and 140 degrees to the aft face.

Other items of carpentry or joinery, such as limber holes and scarfs are evident throughout these seven floor timbers as well. The limber holes, which aid the circulation of water through the lowest portion of the bilge to the pump, are roughly triangular in this vessel. They are comprised of one vertical face immediately adjacent to the keel edge, and a second inclined, slightly concave face terminating at the hollow for starboard strake one. In both the port and starboard examples, these two faces tend to meet at a 70 to 80-degree angle. The limber holes on the starboard side of the keel, of which four are preserved, vary

in height from 2.5 cm to 6 cm, while the four preserved port limber holes vary from 1.1 cm to 4 cm high.

At the starboard bilges of the floor timbers 1, A, C and E, the remains of scarfs are present which aided the alignment of the futtocks with the floor timbers (figs. 3-24 to 3-31). Unlike the scarfs on the Serçe Limanı vessel, which are short, flat scarfs across the width of the floor timber, these four preserved scarfs consist of two faces that span the thickness of the floor timber. These two faces are fashioned into a rough L shape, commonly meeting each other at an angle between 70 and 95 degrees. The horizontal portion of the scarf is a flat surface, commonly preserved for a length of 4 cm to 5 cm, which extends outboard in alignment with the floor timber itself. The vertical face of the scarf is a flat face as well, commonly 5 cm to 7 cm high. Although these scarfs are located at the distal ends of the floor timbers, similar to Serçe Limanı, they are located specifically in the middle of the sweep through the bilge, not before or after the turn. In all cases, the junction of the two scarf faces is at least 30 cm outboard from the beginning of the upward sweep in the bilge evident in the lower face of the floor timber, and at least 12 cm higher than this point as well. Placing the scarfs in such a location means that the two faces of the scarfs meet the upper and lower faces of the floor timbers at acute angles, commonly between 40 and 60 degrees. It also means that the outboard end of the horizontal scarf face, in light of the open grain present at the distal ends of floor timbers 1, A, C and E, is very prone to post depositional damage and erosion. Taking such damage into account, it seems likely that the horizontal scarf faces were originally of an equal length to the vertical faces, about 5 cm to 7 cm long. These scarfs, however, were only fashioned in the starboard bilges of floor timbers 1, A, C and E. Material preserved at the starboard bilges of floor timbers B and D, and the floor timber at midships, not only indicates the absence of these scarfs, but that these three floor timbers extended farther up and around the turn of the bilge for an indeterminate distance (fig. 3-32).

Floor timber C, which among the oak floor timbers is best preserved over the keel, also preserves a shallow, inclined ledge on its bow face over the keel (fig. 3-33). This inclined ledge is approximately 4 x 33 cm. The inclined face, which comprises the ledge



Figure 3-24: Photograph of the L-shaped scarf in floor timber A.

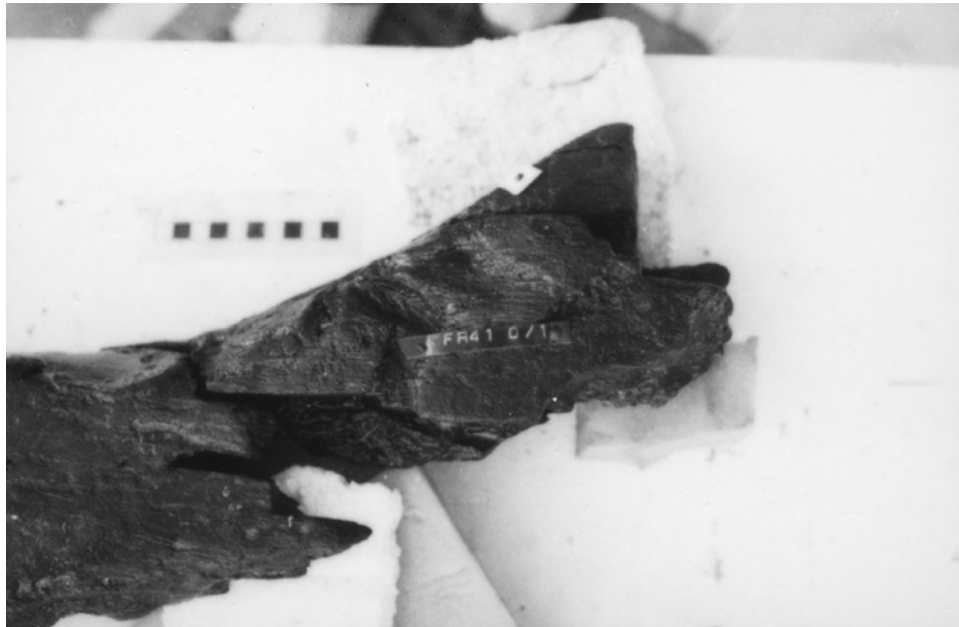


Figure 3-25: Another view of the L-shaped scarf in floor timber A.



Figure 3-26: The L-shaped scarf in floor timber A from above.



Figure 3-27: The L-shaped scarf in floor timber C.

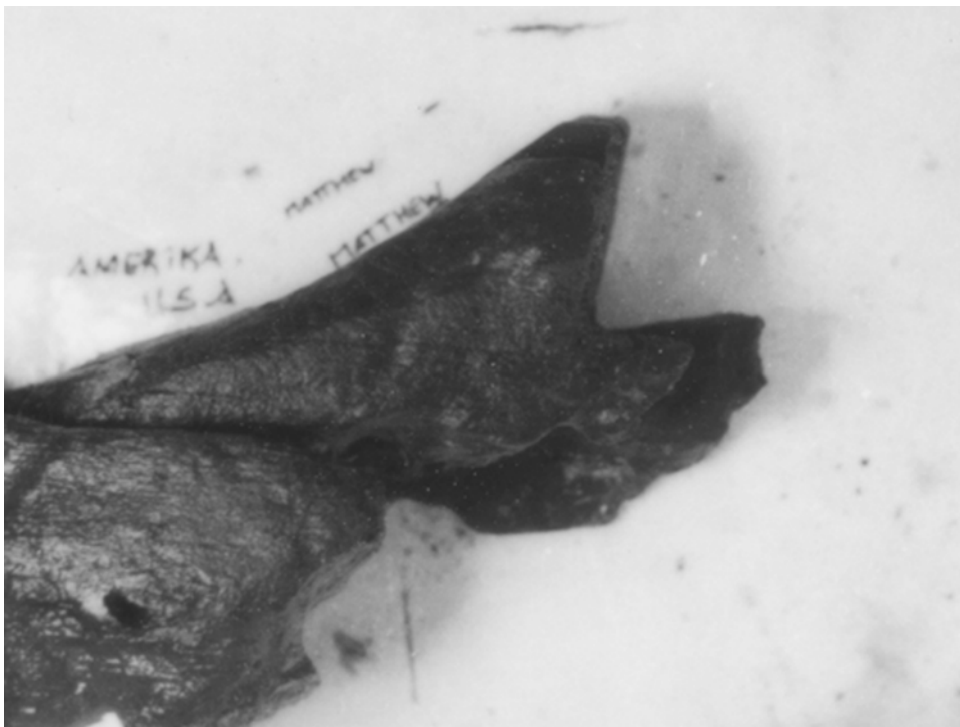


Figure 3-28: The L-shaped scarf in floor timber E.



Figure 3-29: Another view of the L-shaped scarf in floor timber E.



Figure 3-30: The L-shaped scarf in floor timber E from above.

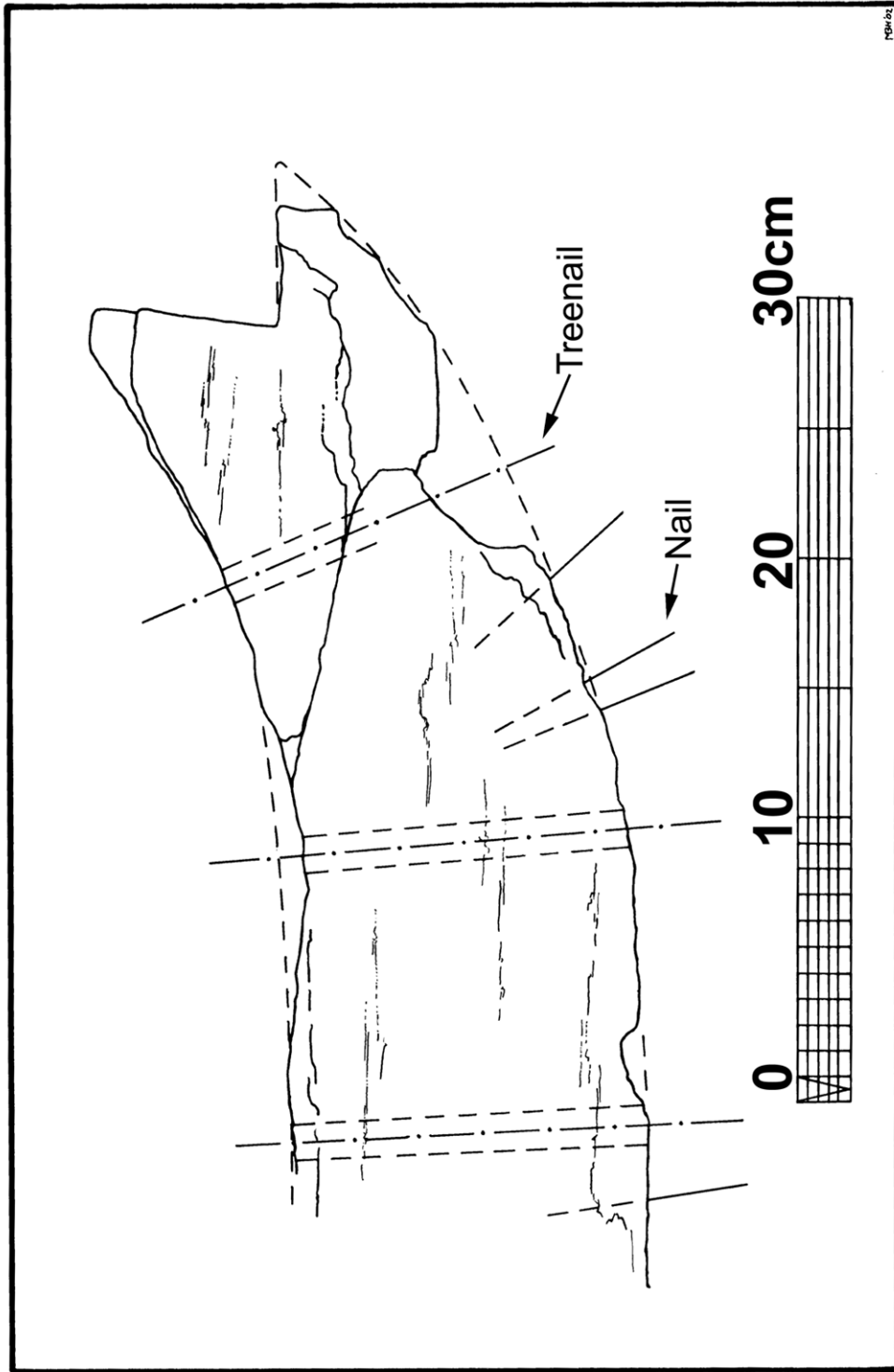


Figure 3-31: Drawing of the L-shaped scarf in floor timber E.



Figure 3-32: Photograph of the bilge curve in floor timber B. Note the grain curving up through the bilge.

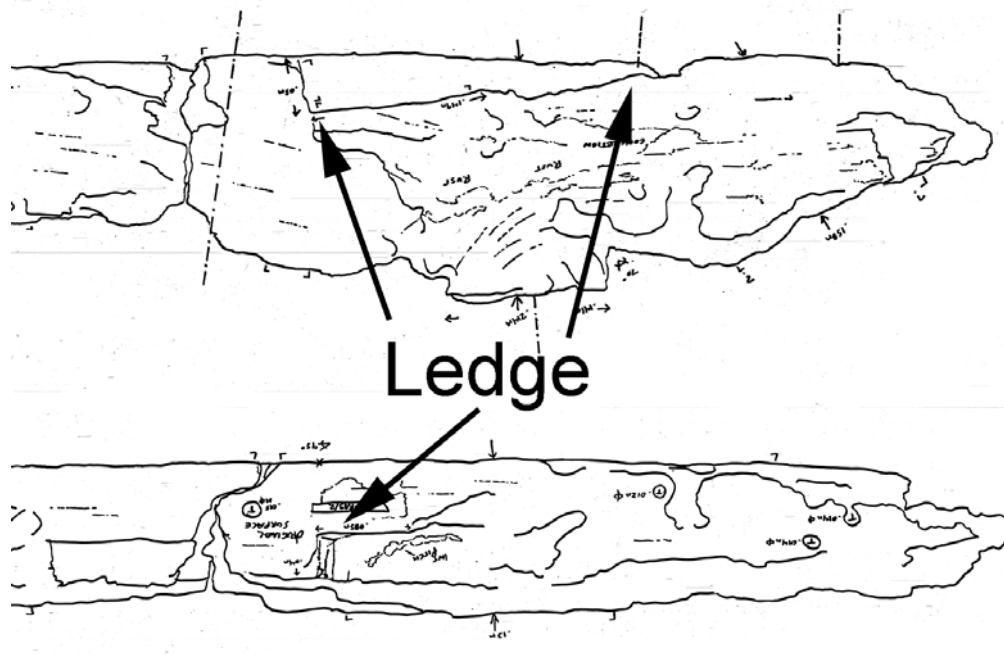


Figure 3-33: Drawing of the ledge cut into the top bow face of floor timber C (Not to scale).

itself, appears to begin approximately 8 cm outboard of the port edge of the keel, along the top face of the floor timber. At this point, this face declines into the floor timber at an angle of approximately 15 degrees, and continues across the midline of the floor timber to a point 13 cm outboard of the starboard side of the keel. A second, nearly vertical face, meets the inclined face of the ledge at this point at an angle of 100 degrees, and then extends upwards approximately 5 cm to meet the upper face of the floor timber. This ledge is best preserved along the starboard 14 cm of its extent. No treenails or metal fasteners are evident in any of its faces, nor does it appear to be a scarf of any kind.

Lastly, a very slight edge is evident on the top face of floor timber 1, spanning the width of the floor timber immediately over the point at which the sweep of the bilge begins. This edge, which is .5 cm high and approximately 10 cm long, is fairly perpendicular to the bow and stern faces of the floor timber. It appears to have been fashioned by an adze, perhaps during a process of dubbing the face adjacent and inboard to the edge, so as to mate this face to a timber resting on top of the floor timber itself.

Fastenings:

In addition to the treenails in the oak floor timbers, nails and bolts are present in the floor timbers as well (figs. 3-34, 3-35). In comparison, however, the placement of the treenails appears to be more methodical and regular than the placement of the nails, although both were employed to affix the planking to the floor timbers. Of the seven oak floor timbers, one has 10 preserved treenails, two have 11, three have 13, and one has 14.³ Moreover, the treenails' average spacing only varies between 14.4 and 18.14 cm. A total of 94 preserved treenails were recorded in the seven oak floor timbers, and of them, 89 are located on the starboard side of the keel. The majority of the preserved treenails are hexagonal in shape, 1.2 cm to 1.5 cm in breadth, but three examples, one each in floor timbers B, C and D, were square in cross section. Of the 89 treenails on the starboard side of the keel, only 76 pass through the floor timbers. Nine are only present on the top face of the floor timbers, while the remaining four are only evident on the bottom face of the floor timbers. Of those nine treenails only evident in the top face, however, one is located 17 cm from the turn of the bilge in floor timber D, while a second is located 16 cm from the preserved end of floor timber C. In light of the poor preservation of the bottom faces of

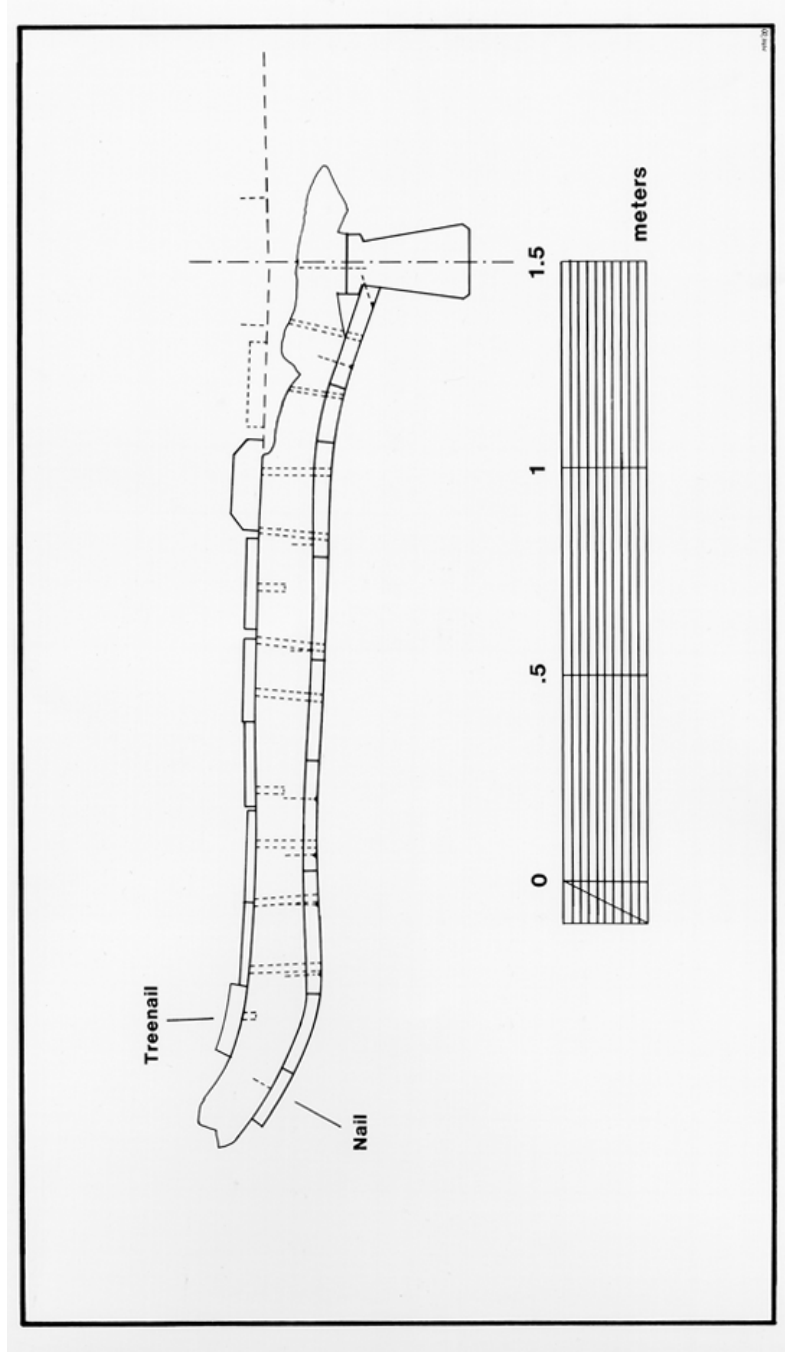


Figure 3-34: Drawing of the cross section of the hull at floor timber 1.

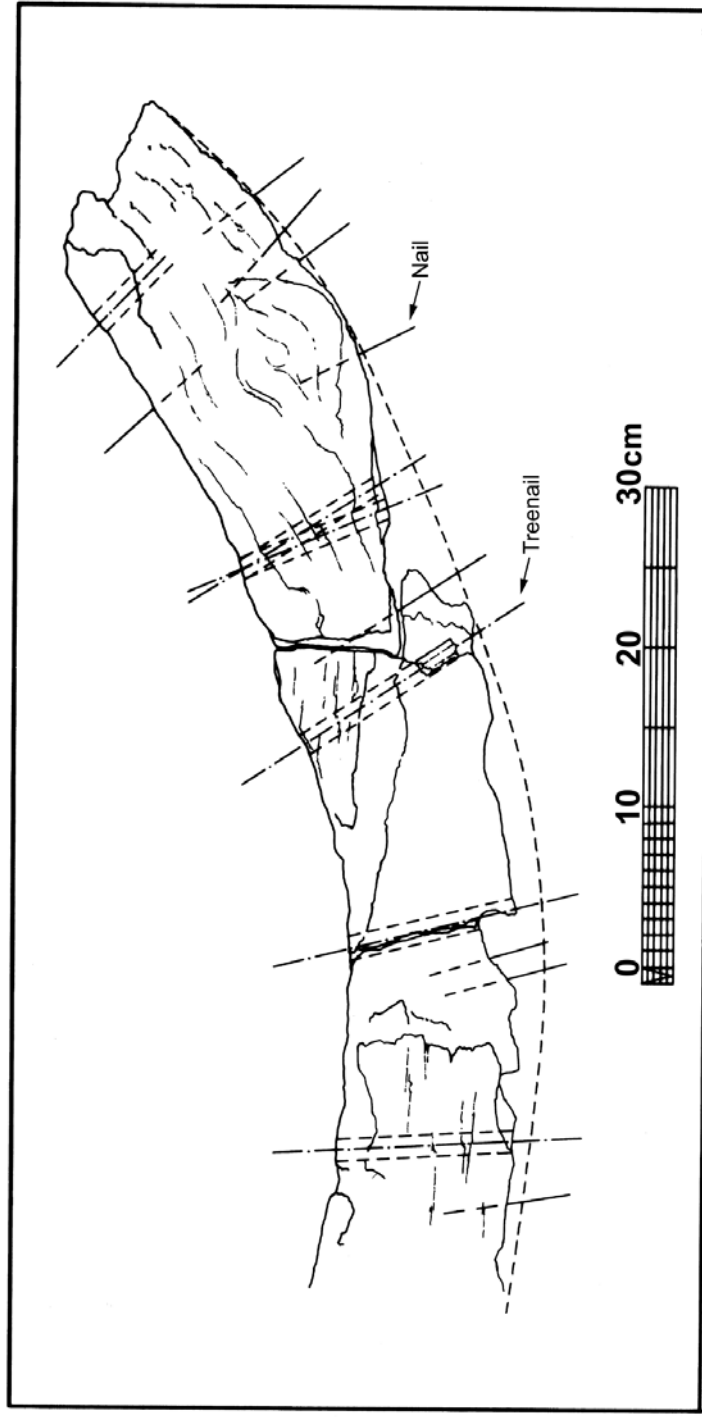


Figure 3-35: Drawing of the assembly of floor timber E and its futtock.

the floor timbers at their extremities, it seems likely that these two treenails do pass through the floor timbers, but damage and erosion has eliminated any evidence of their presence. In general, the treenails are arrayed along the length of the floor timber in a relatively straight line, spaced 14.4 cm to 18.14 cm apart on average, although distances as low as 4 cm and as high as 36.2 cm were recorded.⁴ The only exception to this spacing is found in floor timber A, 54 cm from the starboard edge of the keel, where a group of three treenails is dispersed across the width of the floor timber. Only five treenails, of the 76 that pass through the floor timbers, are not relatively perpendicular to the bottom faces of the floor timbers. Four of these treenails are found in floor timber D, the fifth is immediately over the bilge in floor timber B, and all five are inclined between 105 and 113 degrees away from the keel. As the majority of the treenail holes are nearly perpendicular to the bottom faces of the floor timbers, even in the turn of the bilge, it may be assumed that these holes were drilled from the exterior faces inward. The insertion of the treenails presumably proceeded in the same direction. Only one of the treenails, in the bottom face of floor timber D, is pierced by a nail. As there is another nail hole of equal size 2 cm away, and as this is the only example among 94 treenails, this does not appear to be a particular construction practice. No wedges were found driven into in any of the exposed ends of the treenails.

Of the 108 metal fastener holes preserved in the oak floor timbers, 103 are nail holes, and of these, 97 are beyond the starboard edge of the keel. One nail hole in floor timber C, and two in floor timber E, are preserved beyond the port edge of the keel, while an additional three holes, one each in floor timbers 1, A and C, are preserved over the keel itself. Of those 97 nail holes preserved on the starboard side of the keel, none pass through the floor timbers, and only three, in floor timbers 1, B and C, are present on the top faces of the floor timbers. The dimensions of these three nail holes are .5 cm², .7 cm² and .4 cm² respectively, but only the first and last may bear a relation to each other. Unlike the nail hole in the top face of floor timber B, which is 54 cm from the preserved proximal end of the floor timber, those in floor timbers 1 and C are approximately 1.64 m and 1.35 m, respectively, from the center of the keel. Of the 94 remaining nail holes in the bottom faces of the oak floor timbers, their most common characteristics are their size and relative inclination towards the starboard bilge. The average size and inclination of all 94 nail holes

on the bottom faces of the floor timbers are $.49 \text{ cm}^2$ and 94.9 degrees towards the bilge. Within these two measurements, the average nail hole sizes for each floor timber vary from $.41 \text{ cm}^2$ to $.54 \text{ cm}^2$, while the average angles fall between 81.6 and 92.6 degrees. Even the extreme values within these measurements are not very significant. There are only 4 examples of nail holes $.7 \text{ cm}^2$, the largest identified, and only two examples of the smallest size identified, $.3 \text{ cm}^2$. Moreover, only one nail hole is inclined more than 110 degrees away from the keel, while only four are canted approximately 80 degrees towards the keel.

More divergent among the nail holes, however, is their spacing and distribution along the length of the floor timber. The average spacing between all 94 nail holes on the starboard side of the keel is 13.8 cm , but that spacing varies between averages as low as 9.6 cm (floor timber E) and 24.1 cm (floor timber 1). Additionally, actual spacing values were recorded as high as 40 cm and as low as 1 cm between nail holes. The spacing on floor timber B, for example, varies between 1 and 35 cm over a preserved length of 2.2 m . Moreover, while there are between 10 and 14 treenails or treenail holes preserved per floor timber, floor timber 1 preserves 10 nail holes on the bottom face, while floor timber E preserves 21 . Lastly, unlike the treenails, these nail holes are not arrayed equidistant between the bow and stern faces of the floor timbers. There are five examples of nail holes that are less than 3.5 cm from either edge of the floor timbers, including one nail hole in the midships floor timber that is $.5 \text{ cm}$ from the bottom bow edge. All in all, there is consistency regarding the sizes and inclinations of the nail holes, but their distribution appears to be slightly haphazard.

Of all the preserved metal fastener holes found, only one preserved hole is not found in the top or bottom faces of the oak floor timbers. In the bow face of floor timber 1, over the keel and adjacent to the vertical face of the starboard limber hole, a $.5 \text{ cm}^2$ nail hole is preserved. It does not pass through the width of the floor timber, and does not appear to be related to any extant framing timber.

Other than the nail holes in the seven floor timbers, six extant bolt holes are evident in floor timbers 1, A and E. One of the bolt holes, the 1.6 cm diameter hole in floor timber A, is over the keel, but the other five holes, two each in floor timbers 1 and E and the last in floor timber A, exit the floor timbers through the hollow fashioned for starboard strake

one. All five bolts pass through the floor timbers, and are inclined towards the midline of the vessel. The bolts in floor timber 1, which are both 1 cm in diameter, are 70 and 80 degrees to horizontal, while those in floor timber E, which are 1.4 cm and 1.5 cm in diameter, are between 65 and 68 degrees to horizontal. The bolt in floor timber A, of which there are only fragmentary traces, is 1.0 cm to 1.3cm in diameter, and approximately 55 to 60 degrees to horizontal. As all five bolts enter and exit the floor timbers in the same relative areas, as well as in similar inclinations, it seems likely that they played similar roles in the construction of the hull.

Marks and Coatings:

In general, tool marks are not well preserved and/or represented on the seven oak floor timbers. No marks from hammers or axes are found, and the preserved adze work and saw marks, while consistent, are discontinuous and fairly faint. The most consistent collection of adze marks is found on the distal top faces of the floor timbers, often over the bilge. These marks, which are best represented on all the oak floor timbers other than the midships floor timber, appear to have been fashioned by dubbing diagonally across the face of the floor timber, working the adze both towards the bow face and inward to the keel. Unfortunately, the faceted surface that is apparent over the bilge gradually smooths from wear and erosion and is only faintly evident in small patches near the keel. Unlike dubbing marks evident on the pine floor timbers and some planking, no nick is evident in the blade used to fashion these marks. The only other adze marks evident on these seven floor timbers are faint and partial, and located on the stern faces of floor timbers 1 and B.

Saw marks, evident as collections of parallel striations on the surface of the wood, are also apparent on the oak floor timbers. While well-preserved marks can not only indicate the direction of cutting, but possibly leave evidence regarding the saw's teeth in the wood as well, these marks only preserve evidence of the presence of a saw in the conversion process. Patches of these saw marks, which comprise no more than a dozen striations each, are found most commonly on either the top or bow faces of floor timbers 1, B, C and E. Additional saw marks, in this case aligned transversely across the floor timber, are also found on the vertical face of the L-shaped scarf in floor timber C. While the cross-sectional shapes of some of the oak floor timbers, such as that at midships, clearly implies

the extensive use of a saw in the fashioning of the floor timbers, no extensively preserved corroborative saw marks are found.

In comparison to these tool marks, which were inadvertently left on the surfaces of the floor timbers, there is one, and perhaps a second, intentional mark evident on these timbers as well. The first mark, which appears to have been fashioned by scraping a blunt instrument approximately 1.0 cm wide down the bow face of the midships floor timber, extends over the molded depth of the floor timber from its upper to lower edge (fig. 3-36). This mark, which rises vertically approximately 8 cm prior to curving 25 degrees towards the keel, is located 61 cm from the preserved proximal end of the floor timber. It is the only such mark on the midships floor timber, and the only mark in such a location among the oak floor timbers. The second mark, found on the stern face of floor timber E, is more indefinite. This mark is similar in design to the first, although it appears to have been made with a much narrower and sharper instrument than that employed on the midships floor timber. It appears to span the molded depth of the floor timber as well as rising approximately 8 cm prior to bending abruptly towards the keel of the vessel, but the ends of the mark were either not cut, or not preserved. This latter mark is approximately 78.5 cm to the center of the keel, and 1.14 m to the preserved distal end of the floor timber.

There are traces of pitch found on all the floor timbers, but these patches are generally scattered, and in some cases, appear to represent accidental drops or spills of the sealant, as opposed to a purposeful application. It should also be noted that although internal pitch was the predominant type of pitch identified on the oak floor timbers, external pitch was identified as well in a small 3 cm diameter drop on the top face of floor timber A. The most methodical application of internal pitch appears to occur on the stern faces of floor timbers A, B and C, as well as the floor timber at midships. The pitch, as preserved, is very thin, less than .3 cm thick, tends to have a grizzled or crackled surface, and is no longer malleable. Over the bow and top faces of the floor timbers more internal pitch is evident, but as it occurs in small, oblong patches, it appears to be splatter or spillage. There is, for example, a small trace of pitch on the horizontal face of the ledge in floor timber C, but it is a globular streak of the substance only 9 cm long, and not substantial.

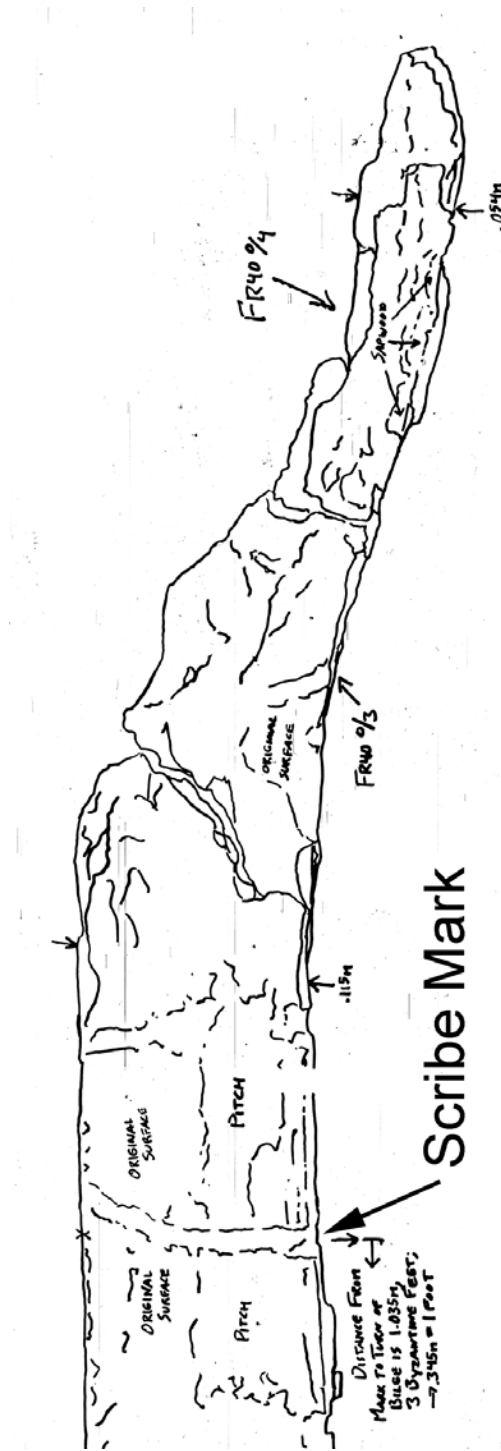


Figure 3-36: Detail of the scribe mark on the forward face of the midships floor timber (Not to scale).

Rust and concretion are evident on the faces of the oak floor timbers as well, but as their creation is related to the presence of iron, their location is almost exclusively adjacent to the nail and bolt holes in the floor timbers. Therefore, the rust and concretion is most predominant on the bottom faces of all the floor timbers and has, on the bottom face of floor timber C, preserved an impression of the adjacent interior planking surface. The only instance of rust and concretion not immediately adjacent to a nail or bolt hole is found on the bow face of floor timber C below the ledge, where a thin but widespread (22 x 6 cm) patch is preserved.

Other Comments:

Three dendrochronology samples have been taken from the oak floor timbers. The first, sample 27 from floor timber A, was removed on June 29, 1999, and the other two samples, 65 and 67, were taken from preserved port and starboard material in floor timber D on August 6, 2002.

Only one of the seven oak floor timbers retains a waney face, an unadulterated surface of the sapwood immediately under the bark itself. This face is evident along the outboard 21 cm of the top stern edge of floor timber 1, and meets the top, worked face, of the floor timber at approximately 95 degrees and the stern face at approximately 145 degrees.

As mentioned above, some of the oak floor timbers are composed of numerous contiguous or discontinuous fragments. Due to the vagaries of preservation, and erosion and breakage both in situ and in storage, not all of the fragments labeled as part of an oak floor timber could always be cataloged as part of the re-assembled floor timber. Floor timber A, for example, is cataloged and drawn as composed of eight fragments, although a total of 17 fragments are labeled as associated with this floor timber. These remaining nine fragments were not cataloged with the re-assembled floor timber as they could not be fitted to the assembled fragments, and they were not cataloged separately as they contained no diagnostic information. In comparison, floor timber D has 12 associated fragments total, and although they too could not all be assembled into one contiguous piece, the fragments were cataloged separately as diagnostic information was evident. The longest preserved starboard section of floor timber D is composed of three contiguous fragments, in addition

to a fourth fragment at the turn of the bilge. On the port side of the keel, an additional four fragments may be re-assembled to form a 60 cm fragment of the floor timber, but of the remaining four fragments, only two mate to each other, and none mate to the re-assembled sections. Nonetheless, these remaining four loose fragments of floor timber D were cataloged separately as they contain diagnostic information.

It should be noted that the futtock associated with floor timber E is labeled as FR 49-8, which is incorrect. It should be labeled FR 49 1/1, as it is not a fragment of the floor timber, but a separate framing timber. Additionally, the midships fragment FR 40 0/5 is correctly labeled as such on the tag attached to the fragment, but an associated tag in its bag is labeled FR 40 0/6. On the top face of the midships floor timber is a small fragment of ceiling planking, labeled as CS4 2/2. Lastly, on the one-to-one drawing of floor timber 1, drawing number 112, the distal fragment FR 39 0/2 is incorrectly placed in the stern and bottom views. It should be approximately 5.4 cm farther outboard, as shown in the bow view.

Pine Floor Timbers

Timber Numbers (Lot Number):

UM 225, UM 226, UM 228 (3328), UM 229 (3329), UM 231, UM 232, UM 233, UM 234, UM 238, UM 260, UM 284, UM 285, UM 289, UM 296, FR 27 0/1 (10027), FR 28-2, FR 29, FR 30 (10027), FR 30 0/2, FR 30 0/3, FR 31, FR 32 0/1, FR 33, FR 33 0/2, FR 35, FR 36, FR 37, FR 37 (10638), FR 38, FR 50, FR 51, FR 52, FR 52 0/1, FR 52 0/2, FR 53, FR 53 0/1, FR 54 (two entries), FR 55, FR 56, FR 57, FR 57 0/1, FR 58

Dates Cataloged:

September 11, 1997; October 24, 29 and 30, 1997; November 24, 1997; July 25, 1998; August 5 and 9, 1998; April 14, 27 and 28, 1999; May 3 and 9, 1999; June 2, 3, 4 and 5, 1999; May 29 and 30, 2000; June 3, 11, 15, 22, 28 and 29, 2000; July 3, 4, 18, 19 and 21, 2000; August 17, 20, 23 to 26, 2001.

Catalogers:

BAJ, EAG, JR, XILA, MBH

Drawing Numbers:

14, 38, 40, 113, 116 to 121, 139, 140, 143, 144, 146 to 150, 153 to 155, 198 to 201, 203 to 206.

Samples Taken:

Dendrochronology samples 1, 2, 28, 64 and 66.

Preserved Dimensions (average):

1.67 m x .125 m x .15 m

Wood Type:

Pinus brutia

Condition:

Of the 34 floor timbers cataloged in association with this vessel, seven are oak and the remaining 27 are pine (figs. 3-37 to 3-57). Unlike the oak floor timbers, as a whole, these pine floor timbers are stronger, apparently more durable, have suffered less wear and erosion, and tend to have crisper and cleaner edges and faces. The quality of this preservation, however, varies along the length of the vessel. Between the aft-most nine cataloged floor timbers, 19 through 11, and the pine floor timbers farther forward, there is a noticeable improvement in the quantity and quality of the material preserved. Floor timbers 18 through 14, for example, were so poorly preserved that they were not initially identified as floor timbers upon discovery. All five floor timbers suffer from a great deal of erosion on three of their four faces (only the bottom is somewhat preserved), and none could yield an accurate cross-sectional shape. As evident from the tables following this section, these five floor timbers are also composed of either a single, very eroded fragment, or numerous discontinuous fragments that cannot be re-assembled. Floor timber 13, of which approximately 65 cm is preserved, has original surfaces only on the inclined face of the starboard limber hole, and portions of the preserved aft face. While the angle between the bottom face and the inclined face of the limber hole is fairly distinct, other edges, and the top and bow faces, are rounded, eroded, and friable. The 37 cm long fragment of floor timber 12 preserves only portions of the bottom face, predominantly concreted areas around nail holes, while the rest of the fragment is severely eroded, friable and splintering. Floor timber 11, which is represented by five fragments, only two of which fit together, is slightly more substantial and solid. Original surfaces are evident on both the bottom and

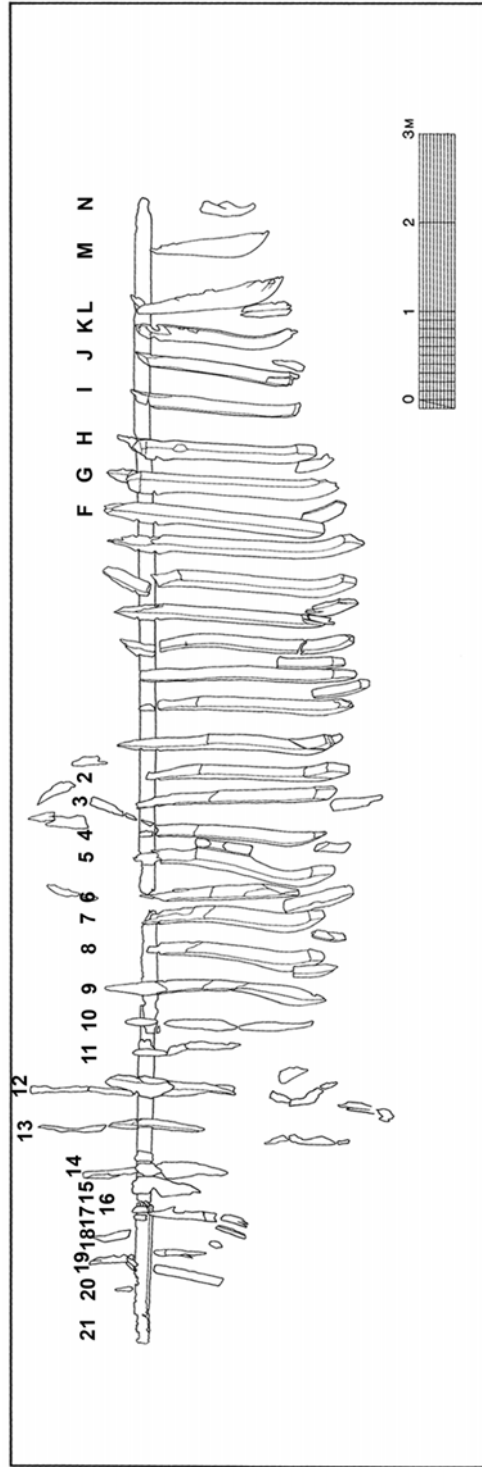


Figure 3-37: Site plan with the pine floor timbers labeled.



Figure 3-38: Drawing of the after face of floor timber 13 (1:10 scale).



Figure 3-39: Drawing of the forward face of floor timber 12 (1:10 scale).



Figure 3-40: Drawing of the forward face of floor timber 11 (1:10 scale).

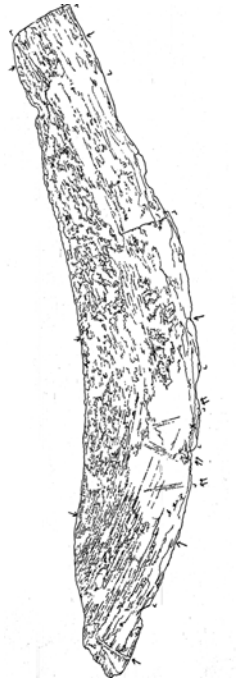


Figure 3-41: Drawing of the forward face of floor timber 10 (1:10 scale).



Figure 3-42: Drawing of the forward face of floor timber 9 (1:10 scale).

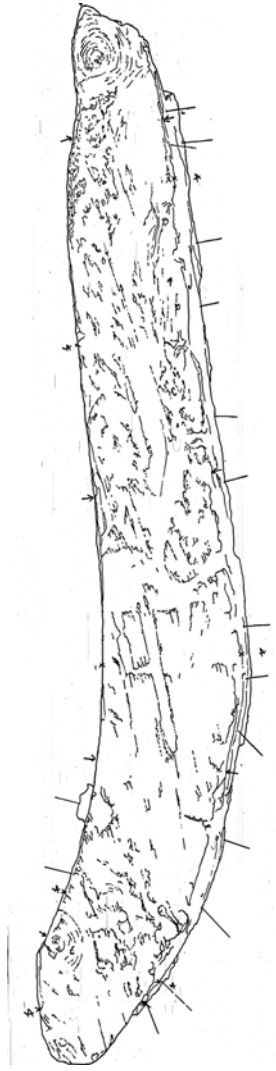


Figure 3-43: Drawing of the forward face of floor timber 8 (1:10 scale).

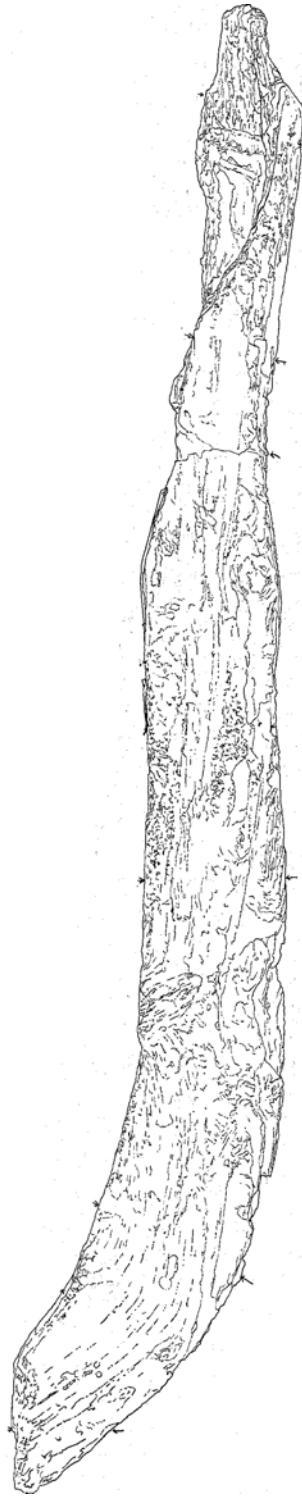


Figure 3-44: Drawing of the forward face of floor timber 7 (1:10 scale).

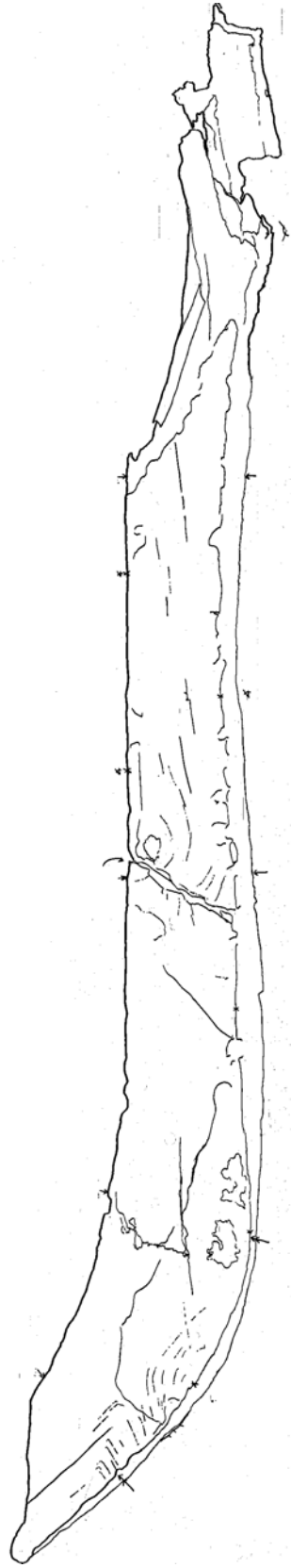


Figure 3-45: Drawing of the forward face of floor timber 5 (1:10 scale).



Figure 3-46: Drawing of the forward face of floor timber 4 (1:10 scale).

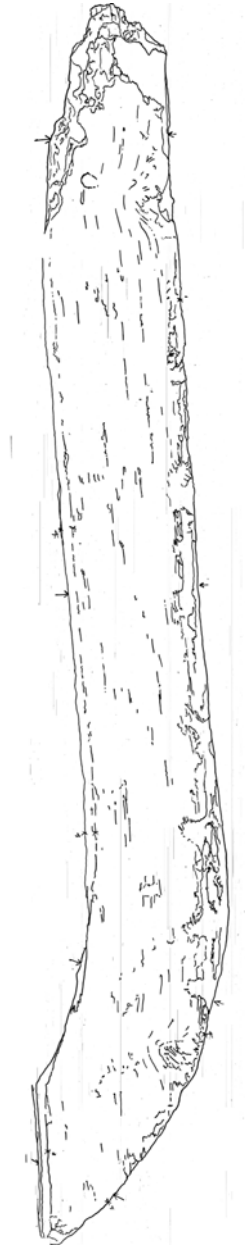


Figure 3-47: Drawing of the forward face of floor timber 3 (1:10 scale).



Figure 3-48: Drawing of the forward face of floor timber 2 (1:10 scale).



Figure 3-49: Drawing of the forward face of floor timber F (1:10 scale).



Figure 3-50: Drawing of the forward face of floor timber G (1:10 scale).



Figure 3-51: Drawing of the forward face of floor timber H (1:10 scale).

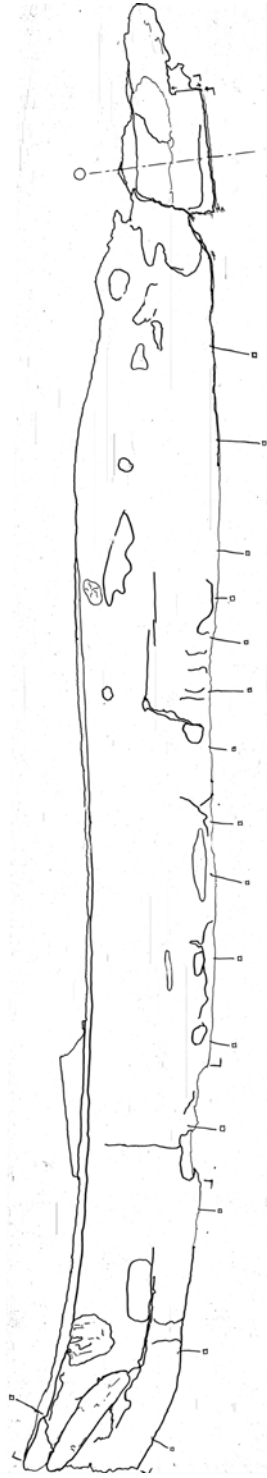


Figure 3-52: Drawing of the forward face of floor timber I (1:10 scale).



Figure 3-53: Drawing of the forward face of floor timber J (1:10 scale).



Figure 3-54: Drawing of the forward face of floor timber K (1:10 scale).



Figure 3-55: Drawing of the forward face of floor timber L (1:10 scale).



Figure 3-56: Drawing of the forward face of floor timber M (1:10 scale).



Figure 3-57: Drawing of the forward face of floor timber N (1:10 scale).

bow faces, which meet at approximately 90 degrees, but in general, the exterior of floor timber 11 is still delicate and friable, with little diagnostic information. The two largest fragments of floor timber 11 are 51 cm and 33.5 cm long. In comparison, the smallest fragment of floor timber 10 is 40 cm long, and although the three fragments of this floor timber are discontinuous, they account for at least 2 m of the starboard side of the floor timber, including a substantial portion of the sweep in the bilge. Approximately 1.45 m forward of floor timber 13, floor timber 9 is comprised of four contiguous fragments, re-assembled into a portion of the original floor timber 2.1 m long, including material at both the bilge and the keel. Worm damage is evident, as are areas of erosion, but original surfaces are present on all four faces, and the edges between the faces are crisp and well preserved. From floor timber 10 forward to floor timber J, the pine floor timbers are consistently heavy and solid, retaining *Teredo* damage only at the extremities of the material, and tend to be friable and splintering only along exposed broken edges and faces. From floor timber K forward to floor timber N, the preservation and condition of the floor timbers fluctuates noticeably. The faces of floor timber K are degraded and eroded, particularly over the outboard 40 cm of the fragment, and the edges are rounded and friable. Floor timber L, in three fragments, and floor timber M, represented by one fragment 1.1 m long, retain original surfaces over three of their four faces, the edges, although soft, are still distinct, and while *Teredo* damage is evident in floor timber L, it is rare in floor timber M. Only one 72 cm long fragment remains from floor timber N, preserving an original surface along its bottom face. The other faces of the extant material from floor timber N are well eroded and damaged by *Teredo*, and the edges are very friable and splintering.

Of the 27 preserved pine floor timbers, all 18 from floor timber 10 forward preserve, at the least, material through the turn of the bilge. Of these 18 pine floor timbers, six are thoroughly represented by one preserved fragment each. All six of these fragments, from floor timbers 8, 4, H, K, M and N, preserve the sweep through the bilge and, in the cases of floor timbers 8, 4, H and K, between 1.4 and 1.9 m of the floor timber inboard to the keel. Floor timber H is the only unbroken floor timber fragment among the pine floor timbers that preserves the sweep through the starboard bilge, the starboard limber hole, and

material over the keel itself. Other floor timbers, re-assembled from two or more fragments, preserve these characteristic items as well. Floor timber 7, preserved in two contiguous fragments, and floor timber 2, preserved in three contiguous fragments, retain material from the starboard bilge to the starboard limber hole, while floor timbers 9, 5, I and J each preserve contiguous material from the bilge to over the keel. The preserved portion of floor timber 3 stretches between the starboard bilge and the keel as well, but other than the 1.7 m fragment from the bilge inboard, the remainder of the material possibly comprising both the starboard hollow and material over the keel is a collection of five discontinuous fragments. Floor timbers F, G and H, which have re-assembled lengths between 2.2 and 2.5 m, preserve material from the bilge to the keel and over both the port and starboard limber holes, but floor timber F, in two fragments, is the only one of these three that preserves all of the inboard material in one fragment. Dendrochronological samples were taken from floor timbers G and H in 1996, so while fragments of the port limber holes are preserved, these fragments cannot be mated to the rest of the preserved floor timber. Floor timber L is similar to floor timbers G and H, in that it too preserves material over both limber holes, however, no material is preserved over the keel itself. Overall, eight floor timbers are represented by one fragment each, varying in length from 36 cm (floor timber 12) to 1.9 m (floor timber H), the preserved portions of floor timbers 7, 6 and F are made up of two fragments each, while seven floor timbers, 10, 5, 2, G, I, J and L, have only three extant fragments each. Of the remaining three floor timbers, the preserved portions of 11 and 9 are comprised of five fragments each, while floor timber 3 is represented by six extant fragments.

Pre-depositional damage may be evident on the top distal face of floor timber 4. Fairly distinct tracks from one or more bark beetles are evident in the surface of a small patch of sapwood extending inboard over the keel. Such damage is shallow, however, and in comparison to post-depositional damage from *Teredo navalis*, is negligible.

As a group, the pine floor timbers increase in structural integrity and preservation towards the bow of the vessel, although floor timber N, the forward-most floor timber found, is still fragile and riddled with *Teredo* holes, and over half of the 21 pine floor timbers have suffered some damage during the cataloging process. Despite their variations in

condition and structural integrity, all pine floor timbers should be handled with care, and as little as possible.

Joinery:

Enough original material is preserved on some or all four faces of each pine floor timber to generate at least one approximate cross-sectional shape for 21 of the 27 pine floor timbers. In the cases of floor timbers 13 through 10, which are discontinuous, heavily eroded and damaged by *Teredo*, the best cross sections are found in association with metal fasteners as the concretion tends to protect original surfaces. Thus, among these four floor timbers, only two cross-sectional shapes over the keel are found, in association with the bolts passing through floor timbers 11 and 10 to the keel. At these sections, floor timber 11 is approximately 14.1 cm high by 8.2 cm wide, while floor timber 10 is at least 17.4 cm high by 9.7 cm wide. Unfortunately, these dimensions are questionable as the top faces are eroded, and outboard of these two sections on the same floor timbers, greater widths are preserved. Outboard sections in floor timbers 11 and 10, and in 13, preserve widths indicating that the floor timbers were originally 11.7 cm (floor timber 10), 12.4 cm (floor timber 13) or 18 cm (floor timber 11) sided.

Between pine floor timbers 9 and M, as their fragments are better preserved, a greater number of cross sections per floor timber can be determined. Where possible, three cross sections of each floor timber were measured; over the keel, 50 cm to 60 cm outboard of the center of the keel, and a vertical section taken through the floor timber immediately inboard of the sweep through the bilge. Six of the pine floor timbers, 9 and F through J, as they are re-assembled into one continuous fragment from the bilge to the keel, yielded all three of these cross sections. As floor timbers 7, 5, 2 and L are preserved only as far inboard as the limber hole, a cross section through the floor timber was taken at the junction between the inclined face of the limber hole, and the bottom face of the floor timber. Since floor timbers 8, 6, 4, 3, K and M do not preserve any remnants of a limber hole, the inboard-most cross section was taken from the preserved faces of the proximal end of the floor timber. The remaining pine floor timber N, due to its heavily eroded and damaged nature, yielded only one cross section, similar to floor timber 12.

Original surfaces over the keel in floor timbers 9, F, G and H retain molded depths between 18 cm and 22 cm. Floor timbers I and J also preserve material over the keel, but in both cases, their top faces are eroded and damaged to such an extent that their preserved molded depths are 10.5 cm and 16.7 cm, respectively. Outboard of this damage over the keel, however, both floor timbers preserve molded depths of 19 cm and 20 cm, so it may be assumed that similar to floor timbers 9, F, G and H, floor timbers I and J have original molded depths of 19 cm to 20 cm. Taking such erosion and damage into account, floor timbers 11 and 10 may have also originally been 18 cm to 20 cm deep over the keel. Although these molded depths over the keel, found in floor timbers 11, 10, 9, F, G, H, I and J, appear fairly consistent along the length of the vessel, the preserved sided dimensions of these floor timbers over the keel indicate greater variation. Based on this dimension, these eight floor timbers may be divided into two groups. Floor timbers 10, G, I and J all preserve sided dimensions over the keel or adjacent to it, between 11.4 cm and 12.6 cm. In comparison, the sided dimensions of floor timbers 11, 9, F and H fall between 15.5 cm and 18 cm. Overall, of the floor timbers preserved over the keel, the cross-sectional shape is rectangular, commonly 18 cm to 22 cm in molded depth, and either between 11.4 cm and 12.6 cm sided, or 15.5 cm to 18 cm sided. No floor timber over the keel is square in cross section, nor is there any floor timber which has a greater sided than molded dimension over the keel.

Changes in the other cross-sectional shapes of the pine floor timbers, from the midbody to the bilge, are governed primarily by the differences in height between the top and bottom faces of each floor timber. Of the 16 floor timbers that yielded two or more cross sections in these areas, the sided dimension of each floor timber remained fairly constant through all 16 studied, while the molded dimension increased in only 12 of the 16 examples. In the most complete examples, the sided dimensions ranged between 11.6 cm, in floor timber G, to 16.2 cm, in floor timber F. Floor timber I is sided 10 cm in the bilge, and floor timber J is 9.3 cm in the midbody, but these two lower dimensions are due to erosion on the fore and aft faces of each floor timber. Other sided dimensions taken on these floor timbers indicate that they most likely averaged approximately 12.5cm sided along their lengths. Overall, from the midbody to the bilge, the greatest change evident in the

sided dimensions of the floor timbers is found in floor timber 2. In this floor timber the sided dimension decreased from 13.3 cm sided adjacent to the starboard hollow, to 11 cm sided in the bilge. The smallest change in the sided dimension is in floor timber F, which decreased from 16.2 cm to 16 cm between the midbody and the bilge, and the average sided change among all 16 floor timbers sampled is 1 cm. The average sided dimension at the midbody, among all 16 pine floor timbers, is 16.1 cm, and the average sided dimension through the bilge, within the same group, is 13.6 cm. Although only 7 of the 16 floor timbers increase in their sided dimension along their length, any decrease in this dimension must be treated with caution, and not assumed to be purposeful. Of the nine floor timbers that decrease in their sided dimension, this reduction is less than 1 cm in six examples, which is not only similar to the change associated with relative increases in the sided dimensions, but it also indicates that the builders most likely strived for relative continuity in the width particular to each floor timber. Of the remaining three examples, floors timbers 2, K and I, the reductions in widths of K and I are attributed to damage and erosion. Only floor timber 2, which decreased in width from 13.3 cm to 11 cm, appears to have been fashioned in that manner.

Changes in the molded dimensions of the pine floor timbers from the midbody to the bilge are directly related to the inclinations of their top faces. As mentioned, 12 of the 16 pine floor timbers that yield two or more cross sections from the midbody to the bilge increase in their molded dimensions, while the remaining four decrease in molded depth over the same area. Of those latter four floor timbers, H, I, J and K, the decrease in the preserved depth of J and K is only partially related to damage and erosion of either one of, or both of, the top and bottom faces. Reconstructing the path of the top face of floor timber J, it is clear that the floor timber tapers along its length towards the bilge, so the extant damage does not account for all 4 cm of molded depth lost at the distal end of the floor timber. Floor timber K is more widely eroded along its length, on portions of all four of its faces, but the very distal end of the floor timber still preserves original surfaces on its top and bottom faces. The top face retains a small collection of saw marks, while the bottom face, surrounding a nail hole, preserves its original inclination relative to the interior planking surface. Together, these two faces are only 11.2 cm apart. Floor timbers H and

I, in comparison, are better preserved along their lengths, and preserve original top and bottom faces over the bilge. As such, both decreased 1.5 cm to 2.0 cm in molded depth from the midbody to the bilge. Floor timber H is unique as it is the only floor timber that, through the sweep in the bilge, has a greater sided than molded dimension, resulting in an almost spoon-like shape at its distal end. These four floor timbers averaged 17.5 cm deep at the midbody, and 14.5 cm deep through the bilge.

The other 12 pine floor timbers, 10 to 7, 5 to 2, F, G, L and M, all increase in molded depth from the midbody to the sweep through the bilge.⁵ On average, the increase in molded depth among these 12 pine floor timbers is approximately 3 cm, but this result includes floor timbers 10, L and M, all three of which are damaged and eroded on their inboard top faces. Excluding these floor timbers, the three of which had an average increase in molded depth of 7 cm, the nine remaining floor timbers had an average increase in molded depth of 2.48 cm. The greatest change in depth, discounting floor timbers 10, L and M, is in floor timber 2, growing from 13 cm deep to approximately 18.5 cm deep, and the smallest change is in floor timber F, increasing only .1 cm over its preserved length. Floor timber 2, of 13 cm molded depth, also had the smallest molded depth at the midbody, while floor timber 7 is the largest, being 18 cm deep. Over the bilge, floor timber F has the smallest molded depth, only 14.4 cm deep, while floor timber 7, 20 cm deep, is the largest. Overall, these nine pine floor timbers floor timbers averaged 15.22 cm in molded depth in the midbody area, and 18 cm through the bilge.

Similar to oak floor timber B, eight of the pine floor timbers preserved one or more chamfers along their top edges as well (figs. 3-58, 3-59). As each chamfer was produced by fashioning an intermediate face between, and diagonal to, the top face and either the bow or stern face, two intermediate angles were generated at the junctions between the face of the chamfer, and the horizontal and vertical faces of the floor timber. Among the nine chamfers preserved, the average upper angle of 137.8 degrees is slightly greater than the lower, of 132.8 degrees. Although collectively, these two averages add to 270.6 degrees, three-quarters of a circle, as they may be expected to, the angles associated with particular chamfers are not always as predictable. Only two of the nine preserved chamfers, on floor timbers 8 and 3, preserve matching angles of 135 degrees each. The remaining angles vary

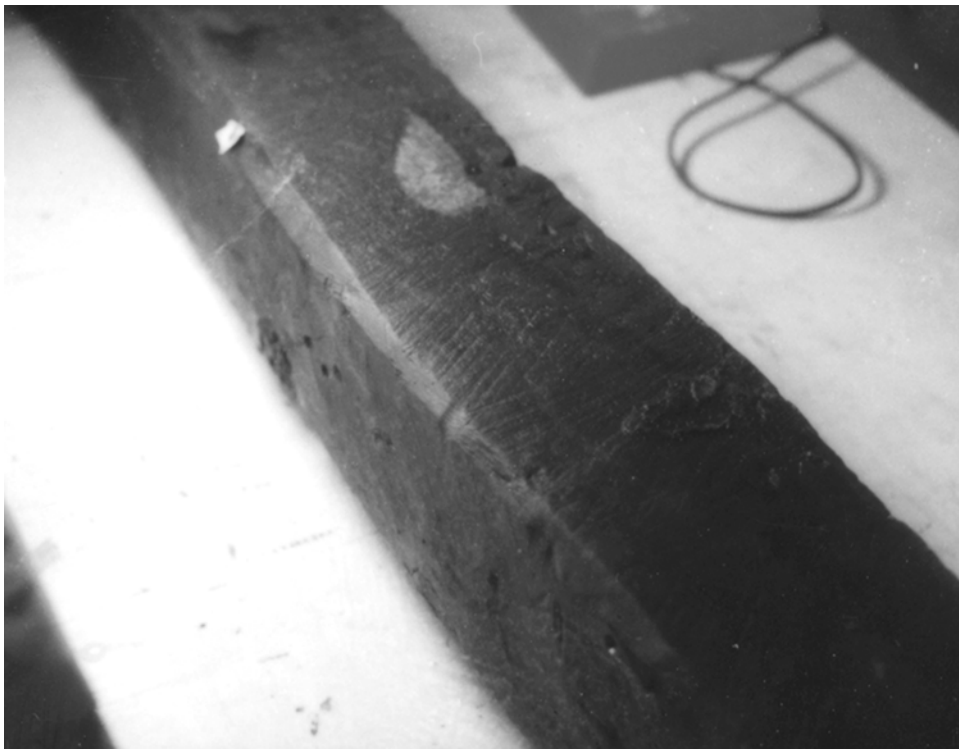


Figure 3-58: Photograph of a chamfer on a pine floor timber.



Figure 3-59: Another photograph of a chamfer on a pine floor timber.

between 160 degrees, in the chamfer along the top stern edge of floor timber 7, to 120 degrees, found on the top stern edge of floor timber 3 and the top bow edge of floor timber F. Two of the remaining five chamfers, on floor timbers G and I, are 270 degrees as well, but they are each composed of a pair of angles, 140 and 130 degrees. Although each chamfer is preserved for a length between 34 cm (floor timber 8) and 1.45 m (floor timber G), the chamfers found on the top stern edges of floor timbers 7 and 5 are the only two that do not exceed 265 degrees along their preserved lengths. The chamfer on the top stern edge of floor timber 3 retains its angle of 280 degrees along its preserved length of 36 cm. Two chamfers, those on floor timbers 2 and F, alter their orientation slightly along their lengths. Both chamfers finish over the bilge at 270 degrees, but that on floor timber 2 begins as 265 degrees, while that on floor timber F begins over the keel at approximately 280 degrees.

These slight variations in the total angle of the individual chamfers reflect similar variations in the angles of the preserved edges of the floor timbers. The overall average angle of all the preserved edges is 89.9 degrees, however, the averages of the individual edges vary between 87.5 degrees, for the port bottom edge, and 92.1 degrees, along the port top edge. Moreover, those averages are made up from a collection of 78 measurements, varying between 75 and 100 degrees. The angle along the starboard bottom edge of floor timber 7, for example, varies between 75 and 95 degrees over a preserved length of 1.45 m.

Thirteen of the pine floor timbers preserve evidence of at least the starboard limber hole along their lengths. In seven of those 13 examples, floor timbers 9, 5, F, G, H, I and J, the entire starboard limber hole is extant; floor timber F also preserves the port limber hole in its entirety. Five floor timbers, 16, 14, 7, 2, and L, retain only the inclined face of the starboard limber hole. Similar to the limber holes in the oak floor timbers, these limber holes are composed of a vertical face adjacent to either keel edge, rising 3.5 cm to 5 cm from the top face of the keel and meeting the inclined, and slightly concave, face at an angle between 50 (floor timber G) and 75 (floor timber H) degrees.⁶ Floor timber 13 is fashioned without a vertical face to its limber hole. Instead, the horizontal keel face of the floor timber meets the inclined face at its apex, at an angle of 145 degrees. This was done because as the rabbet descends from the interior face of the sternpost along its length, the

planking faces of the floor timbers adjacent to the sternpost descend as well, allowing the starboard strake one to meet the rabbet at an angle between 89 and 92 degrees. At the location of floor timber 13 on the sternpost, the distance between the upper, interior, face of the keel and the back rabbet line is approximately 5.5 cm. On floor timber 13 itself, the keel face is 4.4 cm higher than the junction between its lower planking face and the inclined face of the limber hole. Floor timber 13, however, is not the only floor timber that has this discontinuity in heights between the horizontal keel face and the junction between the bottom face and the inclined face of the limber hole. On only one other floor timber, floor timber G, is the horizontal keel face higher than this junction, but as the difference is only .5 cm, it is not a significant design feature. Five of the eleven floor timbers, 5, F, H, I and J, retain an opposing difference in height: the horizontal keel face is lower than this junction. Again, this difference in height is not significant, 2 cm at the most in floor timber H, but it does indicate the individual nature of each of the pine floor timbers.

There is one apparent scarf preserved among the pine floor timbers. Found at the distal end of floor timber F, its purpose, or original design, is not entirely clear. This apparent scarf is composed of two vertical faces roughly perpendicular to each other and to the top face of the floor timber (fig. 3-60). One face, approximately 9.4 cm long, is 6 cm from the bow face and parallel to the long axis of the floor timber, while the second face, perpendicular to the first, is 8.7 cm long. Original surfaces are evident in the areas adjacent to the junction of the two vertical faces, but outwards, the surfaces are questionable (figs. 3-61 to 3-63). It should be noted that outwards of this junction on the first vertical face, the rest of the face is not eroded or receded into the floor timber, but protrudes .8 cm more than the original material near the junction. On the one hand, this indicates that the material preserved on this face is original material, but on the other hand, this original material is not worked, it appears to be broken or split. Essentially, the extant material is a horizontal L shape, projecting the material along the bow face of the floor timber approximately 9.4 cm farther towards the turn of the bilge than the material on the stern face. Whether this horizontal L shape accurately reflects the original design of this material is unclear; this could have been a square hole chiseled through the distal end of the floor timber, around which the stern distal corner has broken away, or it may have been a narrow



Figure 3-60: Photograph from above of the possible scarf in floor timber F.

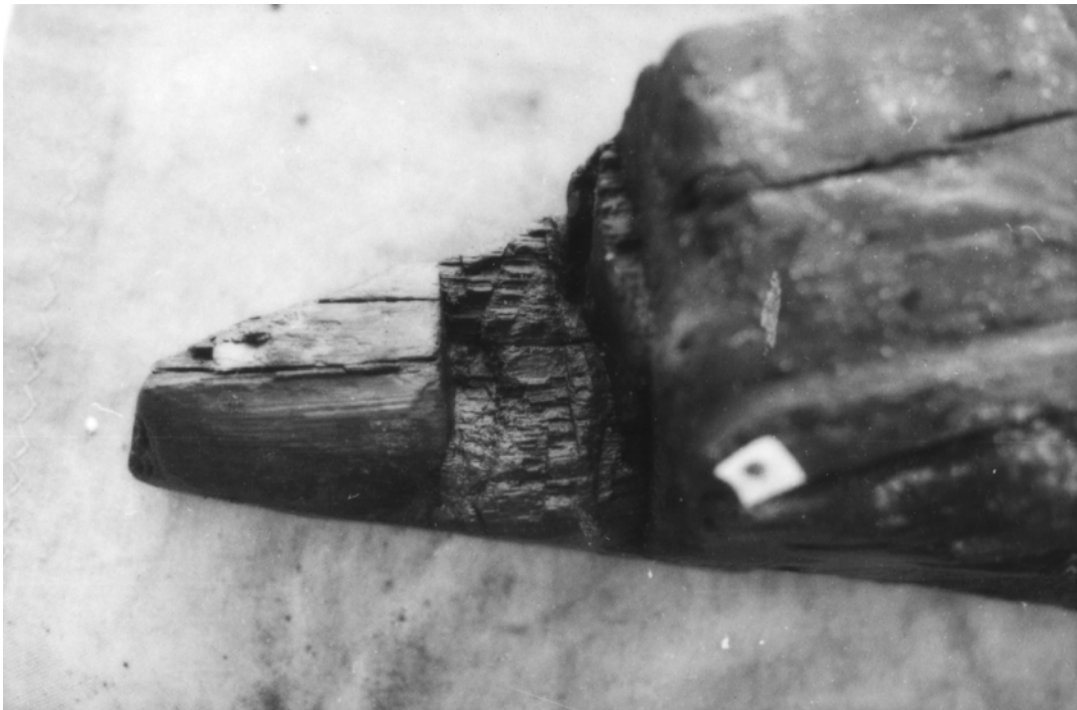


Figure 3-61: Photograph of the possible scarf in floor timber F from the after face.



Figure 3-62: Photograph of the possible scarf in floor timber F from the bilge.



Figure 3-63: Photograph of the possible scarf in floor timber F from the bottom face.

slot cut across the width of the floor timber, exposed only on the stern face. In either case, its purpose is unclear.

Lastly, original top and bottom faces at the distal end of floor timber K indicate the original inclination of the bottom face of the floor timber against the interior face of the planking. Although the bow and stern faces of the floor timber are fairly eroded, a cross section through this area, 9 cm from the distal end of the floor timber, illustrates that the bottom face is approximately 70 degrees to the stern face of floor timber K.

Fastenings:

Collectively, the 27 pine floor timbers preserve a total of 365 metal fasteners or metal fastener holes on their surfaces; no treenails or treenail holes were found in the pine floor timbers. Twelve of these fastener holes are tentatively identified as bolt holes due to their diameter, between 1.2 cm (floor timber F) and 2 cm (floor timber 10-1), and due to their proximity to the keel. Of these twelve bolt holes, those in floor timbers 11-1, 10-1, 9, 5, H, I and J are immediately over the keel, while the remaining five bolt holes, one each in floor timbers 18-1, 14-2 and 7, and two in floor timber F, are to either port or starboard of the keel. In these latter examples, two bolt holes, those in floor timbers 18-1 and one in F, are preserved on the port side of the keel, while the remaining three are located on the starboard side. Similar to the five bolt holes preserved in the oak floor timbers, these five are also inclined towards the keel, between 77 and 85 degrees, and all exit the floor timbers in either hollow, or adjacent to it. Three of these apparent bolt holes over the keel, in floor timbers 10-1, 9 and I, line up with the three bolt holes found in the keel itself. Two of the remaining four holes, those in floor timbers H and J, change from a round to a square cross section, and taper in size to .9 cm² and .6 cm² respectively. Unfortunately, the last two possible bolt holes in the pine floor timbers, in floor timbers 11-1 and A, exhibit discrepancies with their associated locations on the keel that may only be explained as a result of erosion and damage. At the location of floor timber 11-1 in the keel, no distinct fastener hole was found, but a hard inclusion in the wood, possibly the nail itself, was identified. This inclusion is approximately 1 cm², while the fastener hole in the bottom face of floor timber 11-1 is 1.2 cm in diameter. At the location of floor timber A on the keel, no fastener hole has been identified, only rust and concretion are evident on the top face. The

recorded size of the fastener hole on the bottom face of floor timber A, which may be expanded by erosion and damage, is 1.6 cm in diameter. It is evident that no bolt is present at this location on the keel, as no fastener hole is present on the bottom face indicating that a bolt passed through the keel. It is possible that instead of a bolt, a spike affixed this floor timber to the keel.

Floor timber 9 is unique as it is the only floor timber that preserves both a nail and a bolt hole passing through the floor timber to the keel itself. Both the bolt and nail holes are 1.6 cm in diameter on the top face of the floor timber, but only the nail hole tapers to 1 cm² on the bottom face. No associated nail hole is evident at the location of this floor timber on the top face of KK 1/4, as it is most likely camouflaged by concretion, but it is still somewhat visible on the horizontal face of the scarf itself, indicating the nail penetrated the keel at least 14 cm.

Of the 353 remaining nails or nail holes, nine, and possibly a tenth, are evident on the port side of the keel. Those nine nail holes definitely on the port side of the keel, on the bottom faces of floor timbers 14-1 and G, average .7 cm² and are inclined, on average, 91.7 degrees towards the bilge. The tenth nail hole, in a fragment that may preserve part of the port limber hole of floor timber L, is .5 cm².

Twenty-nine of the nails or nail holes are evident on the top faces of the floor timbers as well. Of these 29 fasteners, eight of them, in floor timbers 18-1, 16-1, 16-2, 15, 13, 9, F and G are over the keel and pass through both the top and bottom faces. Four additional nail holes, not over the keel, pass through the preserved top and bottom faces as well. These four holes, located at the distal ends of floor timbers 13, 12, 11 and 9, pass entirely through the floor timbers, but do so because the top face of each of these floor timbers is significantly eroded away. The remaining 17 nail holes in the top faces of the floor timbers do not pass through to the bottom face, and may be roughly collected into two groups. One group, comprising ten nail holes found in floor timbers 15, 9, 7, 5, G, H and J, are all less than 87 cm from the starboard edge of the keel. The seven nail holes in the second group, in floor timbers 9, 8, 5, 2 and G, are all found over the bilge, and are between 1.29 m and 1.74 m to the same keel edge. Despite this grouping, the sizes and

inclinations of all the nail holes are relatively similar: between .4 cm² and 1 cm², and inclined approximately 93 degrees towards the bilge.

The 314 remaining preserved nails or nail holes are all found in the bottom faces of the pine floor timbers, on the starboard side of the keel. The number of nail holes per floor timber varies, due not only to the differing original lengths of the floor timbers, but their preserved lengths as well. The small fragment of floor timber 12, for example, has only 4 preserved nail holes in its bottom face, while floor timber 2 has 22. This variation, however, is still related in a small manner to a slightly haphazard nailing pattern, as floor timbers F, G and H, which are all preserved from the keel to the bilge, each preserve 15, 18 and 14 nail holes respectively. As a group, these nail holes display similar characteristics to those in the oak floor timbers; undoubtedly, the planking was affixed to both sets of floor timbers with the same collection of nails. The average size of the nails or nail holes in the bottom faces of the pine floor timbers is .59 cm², and their average inclination towards the bilge is 98.4 degrees. As this is a larger sample of nails and nail holes to examine, in comparison to those in the oak floor timbers, the actual values within these two averages vary more and a certain pattern may be discerned. The largest nail hole, for example, is 1 cm², in floor timber J, and the smallest are .2 cm², in floor timbers 15 and 4. The shallowest inclination towards the keel is 82 degrees, nail hole #6 in floor timber G, while the widest angle away from the keel is 140 degrees, in floor timber 3. A nail hole with an inclination between 105 and 140 degrees is found within the outboard 20 cm of the midbody on the bottom faces of floor timbers 10-3, 8, 4, 3, G and J, a distinct contrast to surrounding nails inclined between 85 and 95 degrees. In the cases of floor timbers 4 and G, which possess two such nail holes each, the second such hole in floor timber 4 is 27 cm inboard of the first, while the second in floor timber G is located in the sweep through the bilge. Floor timber 5 has a similarly inclined nail hole as well, 38 cm inboard from the sweep through the bilge. Only one nail hole found in the oak floor timbers, #21 in floor timber E, appears to maintain this pattern.

Nail hole #8 in floor timber 5, 65 cm from the starboard edge of the keel, should be noted as it is inclined 50 degrees towards the stern face of the floor timber.

Unlike the oak floor timbers, the average spacing values among the nails in the pine floor timbers vary less, between 6.72 cm (floor timber 14) and 18.4 cm (floor timber 15),

with an overall average spacing of 10.93 cm. There are ten instances of actual spacing values below 3 cm, four examples of nails side by side in the floor timbers, and the largest single spacing between two nails is in 28.7 cm, in floor timber 9. Again, the nails are not commonly spaced equidistant between the bow and stern faces of each floor timber, despite the absence of treenails affixing the planking to the framing. In the case of floor timber 7, the tendency to drive the nails into the bottom face of the floor timber closer to the stern edge was most likely prompted by problems encountered in attempting to drive the nails directly into the tight convoluted grain surrounding the base of the branch adjacent to the bow face. There are 23 other preserved examples, however, of nail holes 3.5 cm or less from either the bow or stern faces of the floor timbers. In some cases, such as floor timbers 10-3, I and K, the close proximity of these nail holes to either face may be due to the erosion of the adjacent face. In other examples, particularly in floor timber M, it appears that the builder simply miscalculated the sided dimension of the floor timber.

There are two nails driven into the stern face of floor timber 15 immediately over the keel. The two nail holes, .8 cm² and .7 cm², are next to each other near the bottom edge of the floor timber, and do not pass through to the bow face.

Marks and Coatings:

No hammer or axe marks are identified on the pine floor timbers, but this is not to imply that tool marks in general are rare or difficult to identify. The most predominant, and most informative, of the tool marks identified among the 21 pine floor timbers are collections of saw marks found on 12 of them (fig. 3-64). These marks are preserved in varying amounts, from a small patch 15 cm long on floor timber L, to a series spanning the preserved length of floor timber 2. Other than a dozen small marks on the top distal face of floor timber K, all of these marks are all found on the stern faces of these 12 floor timbers and moreover, in all cases where a cut direction may be discerned, the cutting proceeded from the starboard bilge towards the keel (figs. 3-65 to 3-67). Floor timbers 2 and G preserve scattered second sets of saw marks among the first set. These second sets are identifiable along the midbody of floor timber 2, and over the bilge of both, as they indicate a second trimming of the timber from the keel to the bilge. It has not been possible to gather information about either the saw's teeth, or its kerf. Although the actual

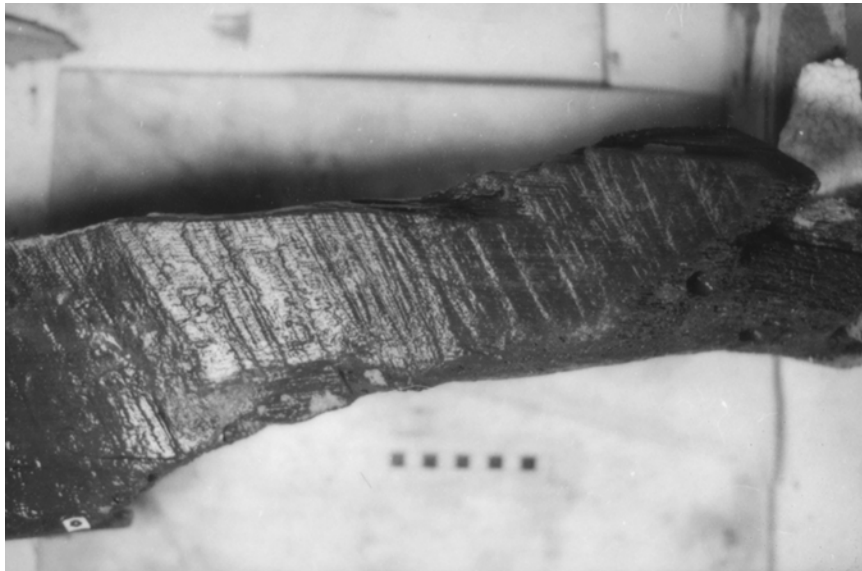


Figure 3-64: Photograph of saw marks on the after face of floor timber 5.



Figure 3-65: Photograph of more saw marks.

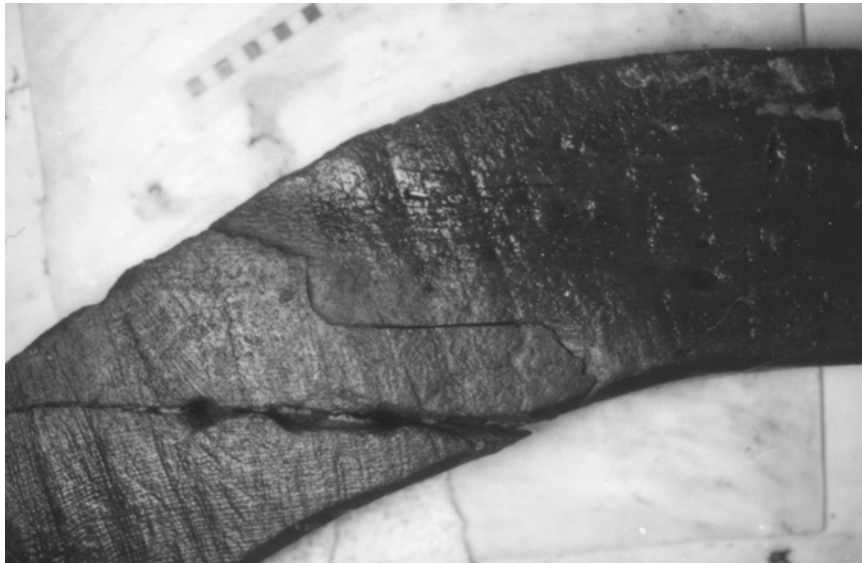


Figure 3-66: Photograph of the same marks.

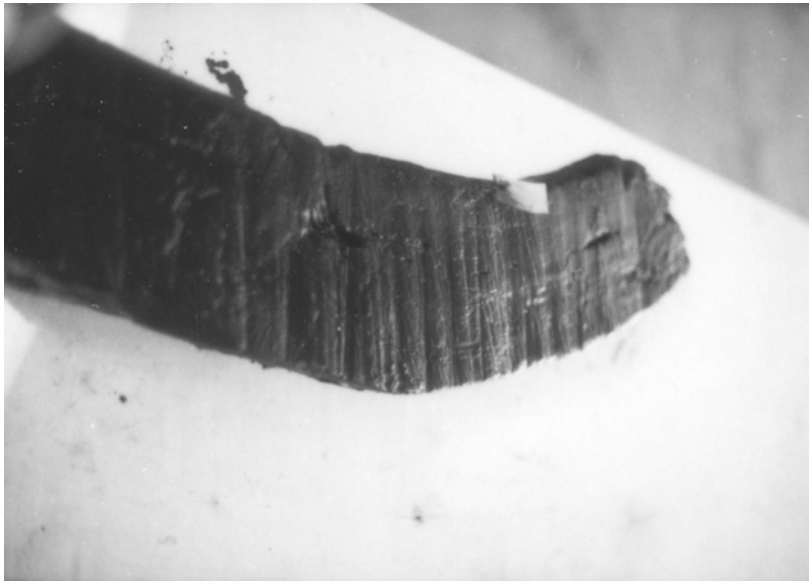


Figure 3-67: The varying angles of the saw marks on one floor timber.

angles of the saw marks varied between approximately 60 to 100 degrees to horizontal, on nine of the floor timbers, 9, 5, 2, G, I, J, K, L and M, the cut angles averaged less than 90 degrees and were all inclined towards the keel. Only on floor timbers 8, 4 and H are the saw marks inclined towards the bilge. On only one of the floor timbers, floor timber I, do the saw marks appear to retain a perpendicular orientation to the contour of the bottom face, thus changing their orientation relative to each other. The saw marks on the majority of the other floor timbers, 9, 5, 2, G, H, I, L and M, are relatively parallel to each other along the preserved length of the fragment, regardless of their location. Unfortunately, not enough saw marks are preserved on the stern faces of floor timbers 8, J and K to determine their alignment relative to each other, or the bottom face of the floor timber. On floor timbers 5, F, G and K, the saw marks become particularly close set and jumbled as the saw proceeded through knots in these timbers. Floor timber K preserves a second collection of similar saw marks 38 cm from the starboard edge of the keel with an alternating orientation, but in this case, there is no knot present. As such, it appears that the builders instead altered the saw's vertical orientation between 75 and 125 degrees on each cut, creating a series of isosceles triangles on the face of the floor timber (figs. 3-68, 3-69).

Dubbing marks from an adze are evident on the pine floor timbers as well, and are evident on a greater number of preserved faces (figs. 3-70, 3-71). Significantly, the adze marks and saw marks are nearly exclusive in their distribution. Twelve pine floor timbers have adze marks preserved on their surfaces, but only one, floor timber 8, has both saw marks and adze marks on its stern face. These marks are only evident at the distal end of the floor timber, where it narrows from 15.8 cm to 12.1 cm. Adze work is evident on the stern faces of floor timbers 5 and F as well, but in these two cases, no saw marks are evident on these faces. Predominantly, the adze work is found on the top faces of nine of the 12 pine floor timbers, 8, 7, 5, 4, 3, 2, F, G and H. While floor timber 3 may be representative of the original state of these floor timbers, as dubbing marks are evident all along its preserved top face, these marks are now most commonly preserved only above the turn of the bilge. Dubbing marks are found on the bottom faces of five of the 12 floor timbers as well, on floor timbers 11, 8, 5, 4 and J, commonly scattered among the nail holes along the midbody of the floor timber. On the bow faces of the floor timbers, adze marks



Figure 3-68: Photograph of the varied angles of saw cuts on floor timber K.

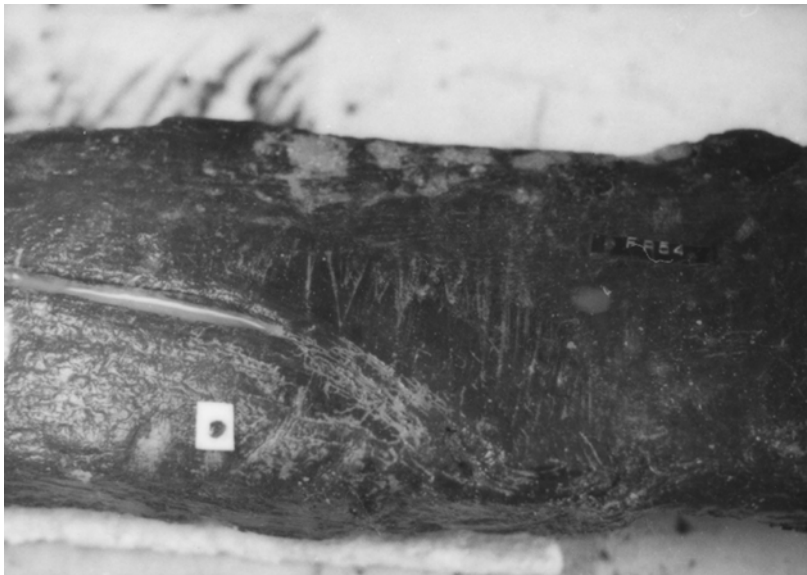


Figure 3-69: Another photograph of the same marks on floor timber K.



Figure 3-70: Adze dubbing evident on the after face of floor timber F.

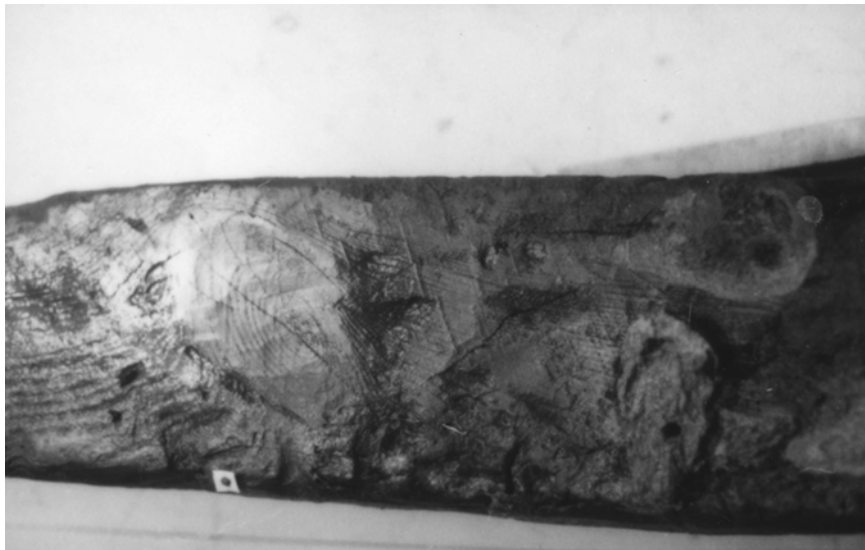


Figure 3-71: More adze work evident on the top face of a pine floor timber.

are evident on 10-3, 4, 3 and 2, but they are most prominent on the latter two; only a handful of marks are evident on floor timbers 10-3 and 4. Similar to the adze work on six of the seven oak floor timbers, the dubbing marks on the top faces of the pine floor timbers also indicate a similar working pattern along the face. Over the bilge, the adze work again appears to proceed both across the face, from the stern to the bow edge, and towards the keel as well. As demonstrated on the top face of floor timber 2, however, this cutting pattern appears to be particular to the concave top face over the bilge, as farther inboard over the midbody, the cutting pattern is reversed. Along this section of floor timber 2, the dubbing proceeded across the top face from the bow to stern edge, and instead worked farther outboard, towards the bilge.⁷ The dubbing pattern on the bottom faces of these floor timbers also indicates that cuts were made across the width of the face, as opposed to along its length, but it is unclear if it proceeded from the bilge to the keel, or vice versa. Of the seven examples of dubbing marks on either the bow or stern faces of the pine floor timbers, all examples appear to indicate that the dubbing proceeded from the top to the bottom edges, although it is unclear if the proximal or distal end was worked first. It should also be noted that there may have been more than one adze in use during the fashioning of the floor timbers, as adze marks on the top faces of floor timbers 8 and G, and all the marks on floor timber 4, indicate that there was a nick in the blade of an adze being used (figs. 3-72 to 3-74). This nick is evident as a small ridge in the middle of the dubbing mark, parallel to the cut of the mark itself. The width of the adze blade cannot be determined.

Other tool marks, on the stern face of floor timber I, are evident, but unfortunately, their cause cannot be determined (figs. 3-75, 3-76). This a collection of gouges, 11 cm long and 6.5 cm high, which are in a pattern of isosceles triangles similar to the saw marks on floor timber J. In this case, however, they are not saw marks. Essentially, the interior of each triangle is depressed from the exterior, meaning that the border of each triangle is a slight ridge rising to the exterior of the cut area. This is not a significant depression, but if these were saw marks, then the ridges on the exterior of each triangle would not face each other, but be all oriented in one direction. It is impossible to tell, but if the interior of each triangle gouge is slightly convex, then these marks may be representative of a poor adzing technique in this small area back and forth across the stern face.

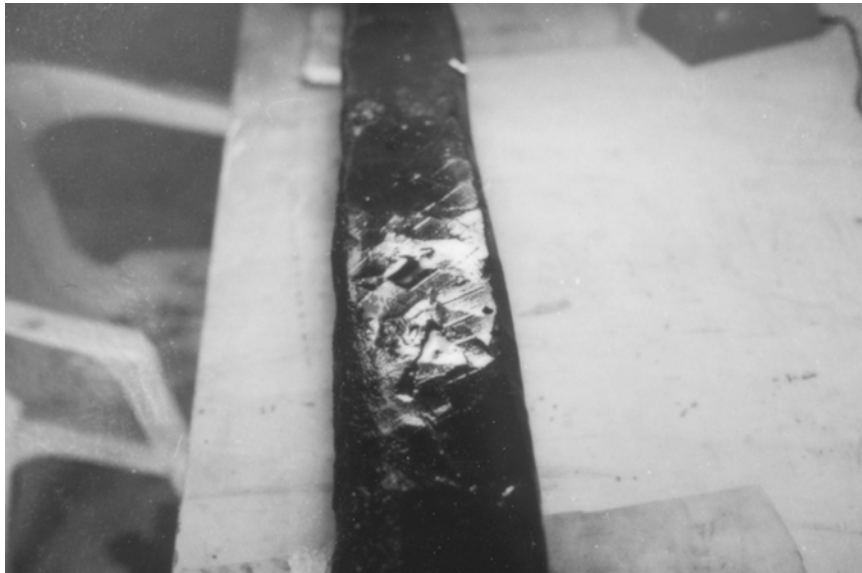


Figure 3-72: Note the ridge in the adze mark, indicating a nick in the blade of the adze.



Figure 3-73: Photograph of similar ridges in adze marks.



Figure 3-74: Another photograph of similar ridges in adze marks.

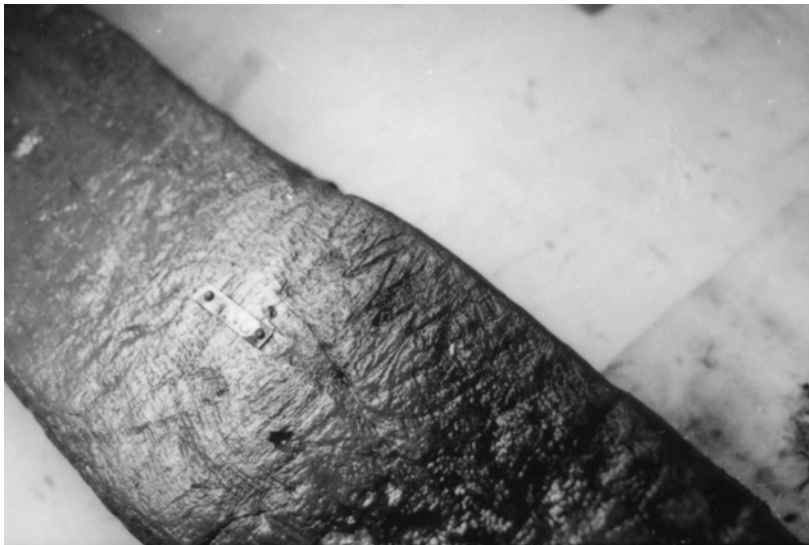


Figure 3-75: Unidentified tool marks in the after face of floor timber I.

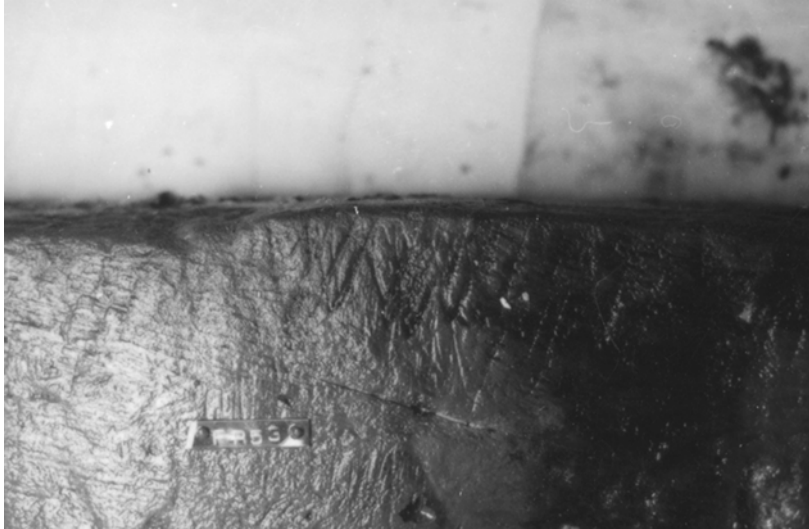


Figure 3-76: Another view of the unidentified tool marks on the after face of floor timber I.

Of an indeterminate use are two round indentations, 1.5 cm in diameter, on the top face of floor timber 9 immediately over the keel (figs. 3-77 and A and B in 3-78). These two indentations, which are 4 cm apart, are slightly offset towards the starboard side of the floor timber, but are located in the immediate vicinity of the nail and bolt hole passing through to the keel. At the most these indentations are only .7 cm deep.

Lastly, chopped out of the waney face at the distal end of floor timber H is a small equilateral triangle approximately 4 cm on each side (fig. 3-79). It is 1 cm deep at the most, and as the center of the triangle is approximately 10 cm from the bow face, the triangle as a whole is slightly aft of the midline of the floor timber. The base of this triangle is roughly parallel with the long axis of the floor timber, so its apex points towards the bow of the vessel. As this mark or cut is in the waney face of the wood, and thus immediately below the layer of the bark, it is possible that it is the remnant of a larger cut in the bark itself that marked the tree for cutting.⁸

Both internal and external pitch are evident on the faces of 12 of the pine floor timbers, but only in small scattered patches, most likely representing spills or accidental drops. Only six patches of internal pitch, on floor timbers 5, 4 and G, are found on the bow faces of the floor timbers, along the midbody and the bilge. Two patches of internal pitch, on floor timbers 5 and 3, and one patch of external pitch, on floor timber I, are found on the top faces of the floor timbers, but none exceed 5 cm in diameter. The pitch, both internal and external, is most prevalent on the stern faces of the floor timbers, but again, these areas are only small drops, none exceeding 5 cm in diameter. Pitch is found on the stern faces of 11 of the 12 floor timbers, from the keel to the bilge, and most commonly near the bottom edges of each. The four patches of pitch evident on floor timbers 3 and K are identified as external pitch, being darker and more malleable than the internal pitch. No pitch of either type is found on the bottom faces; instead, rust and concretion are prevalent. Concretion is also predominant on the top proximal faces of floor timber F and G, as these areas over the keel also have bolt holes in them. Small speckles of rust are evident on the stern face of floor timber 3 as well.

A thin white coating or staining, of an unknown purpose, is found on the stern faces of floor timbers 9 and G. On floor timber G, is it a small area approximately 3.5 cm



Figure 3-77: Photograph of the top face of floor timber 9 over the keel.

**A and B are round indentations
in the top face of floor timber 9.**

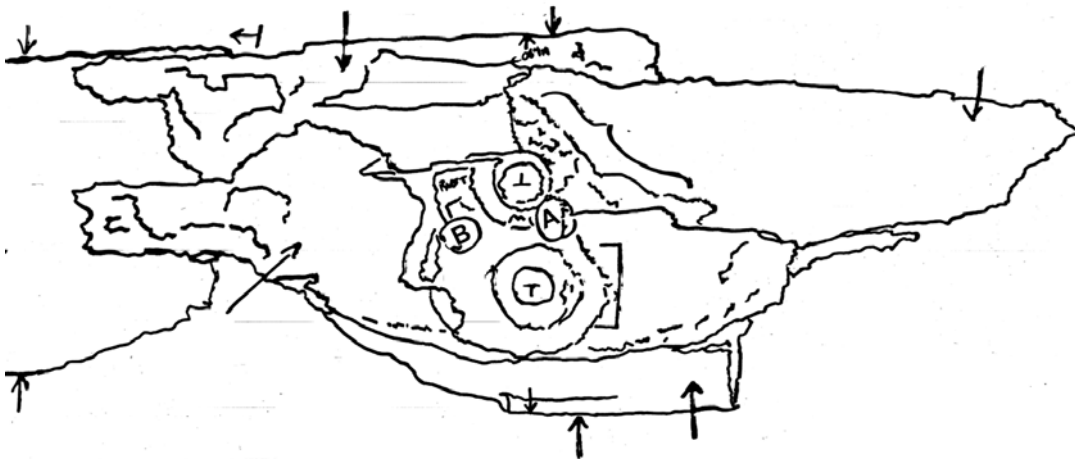


Figure 3-78: Drawing of the same face, note A and B.



Figure 3-79: Photograph of the small triangle chopped out of floor timber H.

in diameter, but on floor timber 9, it appears to be associated with a small piece of wood, possibly a treenail, plugging a hole in the stern face of the floor timber over the bilge. More about this treenail is discussed below.

Other Comments:

Five dendrochronology samples were gathered from the 21 pine floor timbers between 1996 and 2002. The two samples taken in 1996 are from floor timbers G and H, cut through the port limber holes, and were taken while the floor timbers were still in situ (figs. 3-80, 3-81). Floor timber 12, sample number 28, was sampled in 1999, and samples 64 and 66 were cut in 2002, from floor timbers 10 and N.

The treenail located in the stern face of floor timber G is not driven into a treenail hole, transverse to the longitudinal axis of the floor timber. Instead, it appears that it was forced into a hole vertically, 3 cm x 2 cm wide, in an apparent attempt to plug the hole. The hole itself does not exit the floor timber on the bow face, nor is it evident how deep the hole may be. As the white staining or caulking is associated with this plug, the white substance may have acted as another type of sealant, used rarely on the vessel.

Waney faces are much more prevalent on the pine floor timbers. Three definite waney faces, on floor timbers 4, 3, and H, as well as two very faint possible faces on floor timbers 7 and L, preserve the slightly undulating surface of the wood immediately below the bark (figs. 3-82 to 3-84). The waney faces on floor timbers 4, 3 and H, which are between 4 cm and 10.6 cm wide, are each preserved at the distal ends of the floor timbers over the bilge. As it is possible to estimate the location of the pith in these three floor timbers as well, rough diameters of the uncut timber may be approximated.

In addition to the cataloged material that makes up 1.7 m of floor timber 3, an additional fragment of this floor timber over the keel is preserved as well. This fragment, which is 27.2 cm long but only 5.8 cm molded, retains evidence of the nail hole passing through the floor timber to the keel. The transverse nature of the concretion across the top face of this fragment seems to indicate that this nail may have been clenched over the top face of this floor timber. This is the only floor timber that appears to have this characteristic.

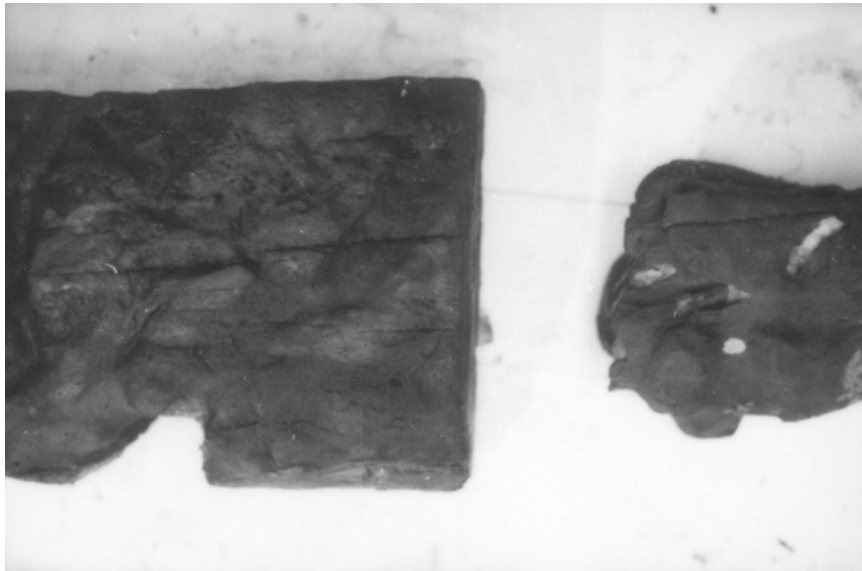


Figure 3-80: Photograph of the sawn face from dendrochronological sampling of floor timber G.

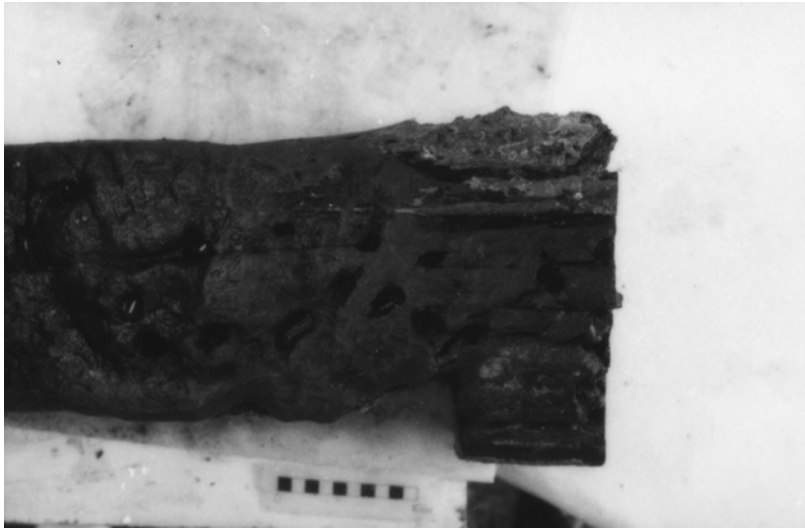


Figure 3-81: Photograph of the sawn face from dendrochronological sampling of floor timber H.

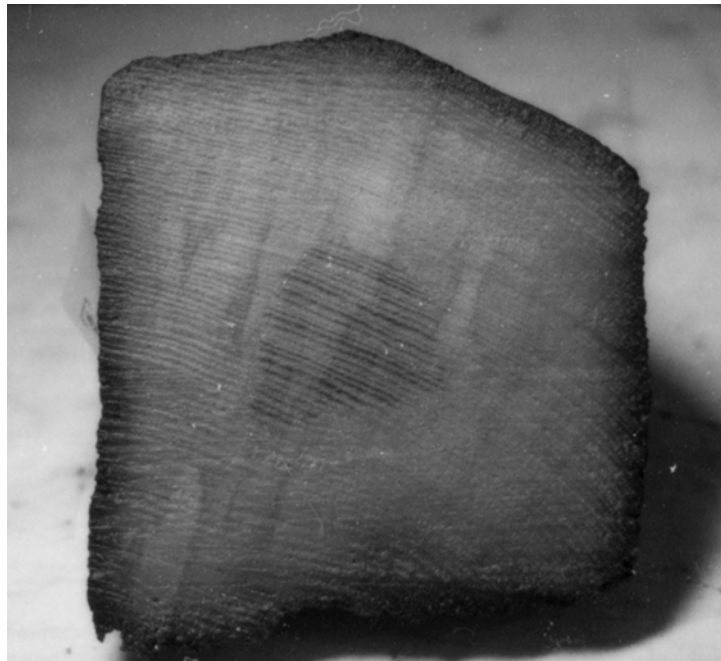


Figure 3-82: Photograph of the cross section of floor timber 4 after dendrochronological sampling. Note the growth rings.

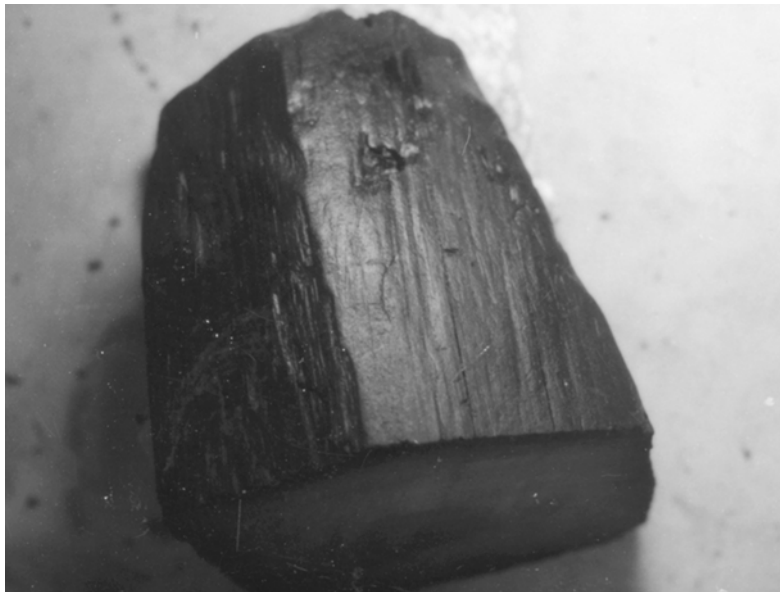


Figure 3-83: Photograph of the waxy face, after dendrochronological sampling.

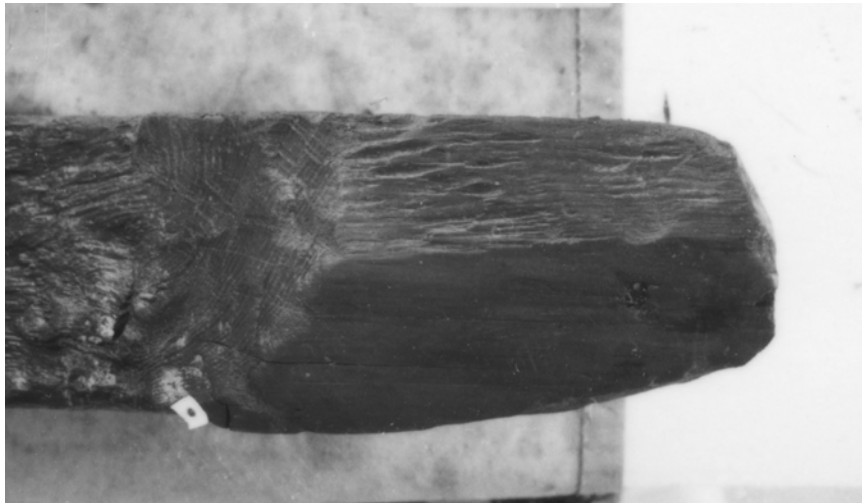


Figure 3-84: Photograph of the same wancy face on floor timber 4.

On one-to-one drawings 116 and 204, it should be noted that the alignments of the fragments in each are not exact. The location and orientation of FR 56/3 was unclear while creating one-to-one drawing 116, but as the fragment appears to preserve part of the port limber hole, it was aligned and oriented in that manner. In one-to-one drawing 204, the presumption has been made that FR 29 0/1 is over the keel, while FR 29-3 is the farthest outboard. If the labeling conventions on these four fragments are correct, then while the drawn alignment of the fragments may be accurate, their spacing is not. It is unclear what the spacing between these fragments should be.

The largest fragment of floor timber G should be handled with a great deal of care as the outboard 70 cm is ready to fracture from the rest of the preserved fragment.

Fragments of floor timbers 12 and 10 were initially labeled with different labels while still in situ, and these labels are still in place. FR 28-2 is also labeled as UM 238, and FR 30 0/3 is secondarily labeled as UM 389.

Futtocks

Timber Numbers (Lot Numbers):

FR 34S 1/1 (11405), FR 36S 1/1, FR 37S 1/1, FR 41S 1/1, FR 42S 1/1, FR 43S 1/1, FR 49-8, FRS 50, FRS 51, FRS 52, FRS 52-2

Dates Cataloged:

May 5, 1999; June 13 and 20, 2000; July 31, 2000; August 10, 11 and 14, 2000; August 19 and 21, 2001; July 11 and 29, 2002

Catalogers:

EAG, FMH, MBH

Drawing Numbers:

143, 145, 151, 156, 161 to 163, 200 to 202, 217

Samples Taken:

None

Preserved Dimensions (average):

.514 m x .103 m x .118

Wood Type:

Pinus brutia and *Quercus* sp?

Condition:

There are a total of ten preserved futtocks among the preserved framing material, and of them, futtocks 4, A, B, C, E, F and G each have one associated fragment (Fig 3-85). Of the remaining three futtocks, futtock 6 has four associated fragments, futtock 3 has eight, and futtock H is composed of two fragments. Futtock H, however, is the only one of these three that possesses diagnostic information on all of its associated fragments; three of the fragments associated with futtock 6 and seven of the fragments associated with futtock 3 do not possess any diagnostic information. As such, although futtocks 6, 3 and H are associated with more than one fragment, futtock H is the only one that is represented by more than one piece of diagnostic material. Overall, since the futtocks are located over the starboard bilges, their preservation does not extend beyond the preservation of the floor timbers themselves. The longest preserved futtock is futtock A, 82 cm long, while the shortest, futtock 3, is only 29 cm long.

These futtocks are spread along the length of the vessel, and as three of the ten, futtocks 3, E and H-1, are oak, the preservation and condition of these futtocks varies from very good to delicate and fragile. Futtocks A, B and F are in the best condition of the ten futtocks. They have suffered little or no *Teredo* damage, original surfaces are evident along all four faces, and each possesses numerous crisp edges as well. Each also feels heavy and solid to the touch. Futtocks A and B are distinct as they appear to possess little or no erosion or damage on their distal ends. Futtock F, in comparison, does appear to have been subject to some damage at its distal end. Futtocks C, E and G preserve original surfaces on all four of their faces as well, but in these three cases, more *Teredo* damage is evident, they tend to be slightly more fragile, and material on the bottom faces of each of these futtocks is more eroded and friable. Futtock 6 is increasingly damaged by *Teredo*, has more friable surfaces and faces, and is suffering from checking and longitudinal cracking along its length. There is also little preserved of the bottom face of futtock 6. Futtock 4 only possesses original surfaces on the inboard ends of the stern and top faces, while futtock 3, which has broken into numerous fragments, is very eroded and fragile and only has original surfaces evident on its top and bow faces. Futtock H, which is represented by two fragments,

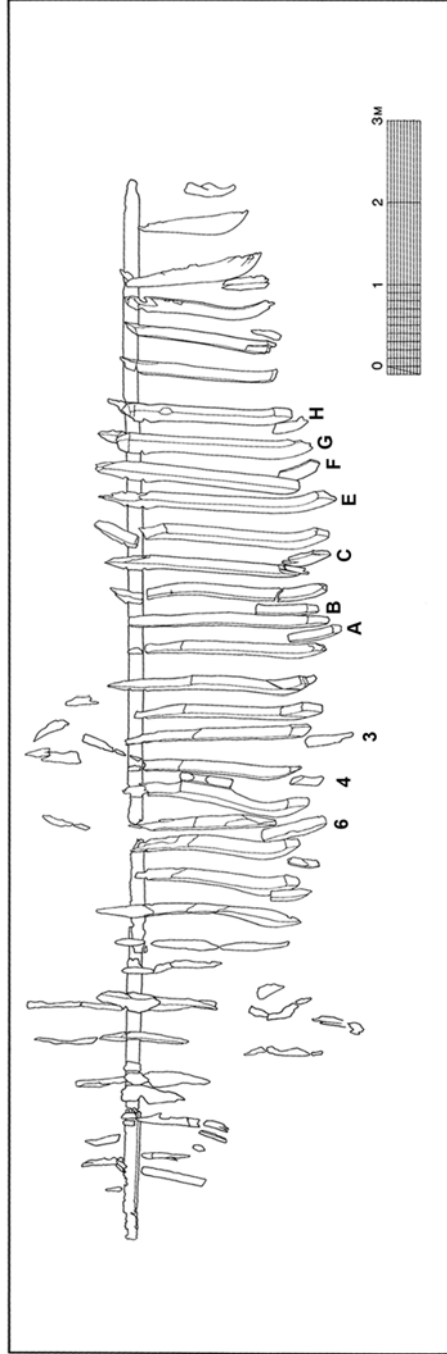


Figure 3-85: Site plan with the futtocks labeled.

suffers from longitudinal cracking and breaking, friable surfaces and edges, and original material is only evident in small patches on the top and stern faces. In general, where the futtocks have broken or eroded, they tend to have additionally suffered from *Teredo* damage, and are now friable and fragile with delicate extremities. Futtocks 3, E and H are additionally prone to surface wear and damage during handling as they are oak, and special care should be taken.

Joinery:

As the longest preserved futtock, futtock A, is 82 cm long, this was the only futtock fragment that produced more than one diagnostic cross section; only one cross section was taken from the other nine futtocks. As such, while it is possible to distinguish tapers and bevels along the faces of the futtocks, due to the paucity of some of the preserved surfaces and their short preserved lengths, it is difficult to distinguish between intentional characteristics, and damage or erosion.

Other than futtock 6, averaging 13.8 cm sided x 12.6 cm molded, all of the other futtocks are consistently deeper than they are wide. As a group, they average 11.8 x 10.3 cm. As futtock 6 is wider than it is deep, it also retains the largest average sided dimension of 13.85 cm. The largest average molded dimension is on futtock C, 13.7 cm. None of the futtocks are square in cross section, only futtock 4, averaging 10.3 x 9.8 cm, is close. Futtocks A and B are clearly trapezoidal, each retaining bottom faces wider than their top faces. Futtocks C and G are trapezoidal in their cross-sectional shapes as well, however, as the bottom faces are narrower than the top faces by only .4 cm at the most, this discrepancy is most likely due to erosion. As two cross sections could be derived from futtock A, minor changes in its cross-sectional shape could be discerned as well. Although its is consistently trapezoidal in cross section, its overall size tapers slightly from the proximal to distal end, and the bottom face retains the greatest change, shrinking from 12.2 cm sided to 9.5 cm sided along the futtock's preserved length.

Discounting futtock H due to its fragmentary state, eight of the nine remaining futtocks retain relatively parallel bow and stern faces along their lengths, while the top and bottom faces, due to the futtocks' locations in the ship, always preserve differing curves. Futtocks 6, A, B, C, F and G retain enough preserved material on their top and bottom

faces to determine that among them, only 6, A, C, F and G were fashioned with a relatively consistent molded depth. The remaining futtock B tapers .9 cm from its proximal to distal end. The molded dimension of futtock 4 tapers in a manner similar to futtock B, shrinking 2.5 cm, but in contrast, its sided dimension increases 7.3 cm towards its preserved distal end. In this case, as the distal material of futtock 4 is also eroded, this increase in its sided dimension was originally even greater. Although it is evident that the bottom faces of the futtocks were shaped with an adze, it is not evident whether this finished face maintained a consistent curve, or was faceted to mate to specific plank faces.

Although the preservation of the futtocks' edges varies, enough are preserved to determine that they average 97.7 degrees, varying between 109 degrees to 87 degrees. Only three of the 32 measured angles were 90 degrees. One chamfer, along the top stern edge of futtock H, is preserved for a length of 13 cm, with two intermediate angles of 46 and 48 degrees. No other chamfers are found on these futtocks.

The proximal ends of five of the futtocks preserve beveled faces, and of these, one is distinctly a scarf. These beveled faces, evident on futtocks 3, B, C, E and F, meets the top face at an angle between 100 and 135 degrees, and spans the width of the futtock in all five cases. In two of these examples, on futtocks 3 and E, as the junction with the bottom face is eroded, this beveled face is, at the most, 7.5 cm deep. The beveled face on futtock B, however, which preserves its bottom face, is 11.6 cm deep. The only one of these beveled faces that is clearly part of a scarf is the face on futtock E, which cleanly mates into the L-shaped scarf at the end of its associated floor timber (figs. 3-86, 3-87). By aligning the beveled face of futtock E with the vertical face in the L-shaped scarf, the top faces of both the floor timber and the futtock align to create a smooth sweep through the bilge. Futtock 3, although it is composed of oak and its preserved beveled face is similar to that on futtock E, does not appear to retain a scarf face as floor timber 3 preserves no L-shaped scarf at its outboard extremity. The proximal end of futtock A is beveled as well, but it is composed of two inclined faces which meet each other at an angle of 80 degrees, and the top face of the futtock between 125 and 140 degrees.



Figure 3-86: Photograph of mate between floor timber E and futtock.

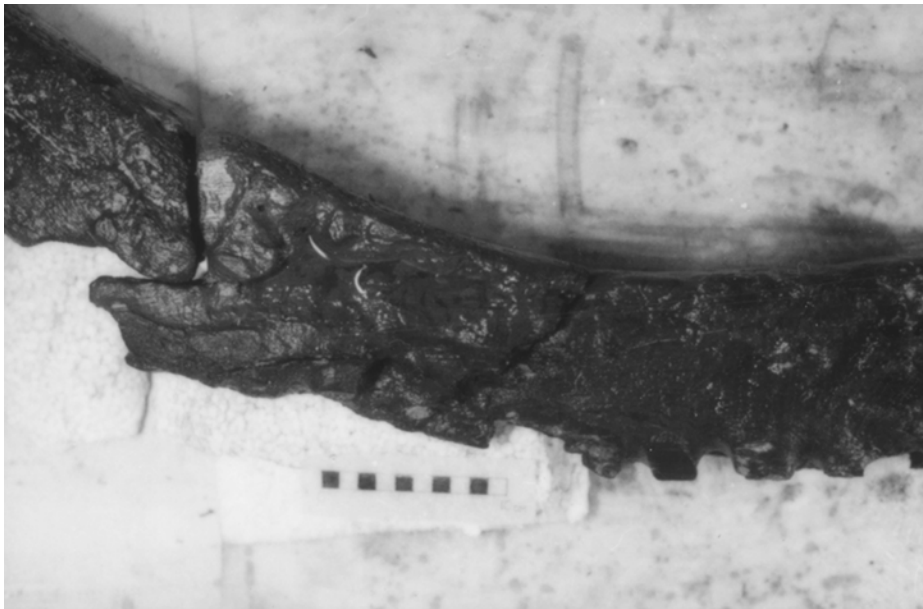


Figure 3-87: Another photograph of mold between floor timber E and futtock.

Fastenings:

Of all the futtocks preserved, only two, futtocks 3 and E, preserve treenails or treenail holes within them. Two of the three treenails found in futtock E, those nearer the proximal end, pass through the futtock, while the third, measuring 1.4 cm in diameter, only appears in the top face. The fourth treenail appears in futtock 3, and passes through the futtock from the stern to the bow face, tapering from 1.4 cm to 1.2 cm in diameter. This is the only example of a fastener aligned in this manner in the framing material, and it does not appear to align with any fastener in either floor timbers 3 or 2.

No bolts are found in any of the futtocks, and of the 50 nails or nail holes that are preserved, only 2 are not found in the bottom faces. No nails or nail holes are preserved in the top face of futtock 3, and as no bottom face is preserved - the fragment is 6.8 cm thick at the most - no nails or nail holes are evident in this fragment at all. Of the two nail holes found in the top faces, one each in futtocks E and H-1, that in futtock H-1 passes diagonally from the top face of the futtock to the stern face at an angle of approximately 45 degrees, while the other only enters the top face of the futtock.

The remaining 48 nails or nail holes vary in size between 1 cm² to .3 cm², each size is found in futtock E, and as a group, average .53 cm². As this average size is comparable to the average sizes found in both the oak and pine floor timbers, it follows that the same collection of nails was used in all three cases. Although these futtocks have a greater disparity of preservation, and the actual nail spacing values vary between 16.7 cm and .7 cm, the average values of each futtock are fairly similar. The largest average spacing is in futtock 6, which is 9.5 cm, while the smallest is in futtock E, only 5.64 cm. Among these 48 nails or nail holes, only two of them, #6 in futtock E and #3 in futtock F, are less than 3 cm from either edge. The rest are commonly arrayed along the center of each futtock. The angles at which these nails were driven into the futtocks, however, display much more variation. The averages among the futtocks range between 73 degrees to 106 degrees, the latter indicating an angle away from the keel, and the smallest recorded angle is 33 degrees, found in futtock C. While on average all the nail holes are canted towards the keel approximately 81.3 degrees, all of the nails in futtock B were driven in at an angle greater than 90 degrees, canted away from the keel. This widespread variation of the nail angles in the futtocks –

they vary between 80 degrees and 120 degrees in futtock E for example – is due to their location at the turn of the bilge.

Two of these preserved nail holes in the bottom faces pass through their associated futtocks. One of the holes, #8 located at the distal end of futtock C, exits the top face as the top face is severely eroded in this area. In this case, the nail hole is only 3.6 cm deep. The other nail hole, #1 in futtock E, is unique as it represents the only nail that passed from a futtock into the associated floor timber. This nail hole exits futtock E along its proximal beveled face, and enters floor timber E in the mating vertical face of the L-shaped scarf. As this is the only example of a fastener between a floor and a futtock, it appears likely that this occurrence is due to the angle and depth of the nail as it affixed the planking to the futtock, and does not represent a purposeful joining of the two framing elements.

Marks and Coatings:

Similar to the pine floor timbers, rust and concretion are most prevalent in small patches surrounding the nail holes on the bottom faces of the futtocks. Concerning the two examples of nail holes not in the bottom faces of the futtocks, no rust or concretion was evident in these areas.

Of the ten preserved futtocks, tool marks are preserved on seven, futtocks 6, 4, A, B, C, F and G. Futtocks 3, E and H-1, most likely because they are oak, have no evident tool marks preserved. No tool marks are evident on futtock H-2 as well.

The distribution of the tool marks on the seven remaining futtocks is similar to the distribution of the tool marks on the pine floor timbers. For example, the only preserved saw marks, on the top face of futtock 4, are the only tool marks evident on this face. The dubbing marks, in comparison, are found exclusively on the top and stern faces of futtocks A, B, C, F and G, as well as only the top face of futtock 6 and only the stern face of futtock 4. A faint adze mark is also evident on the bottom face of futtock B. In other words, no adze work is evident on the bow faces of the futtocks, and the adze and saw marks are nearly exclusive in their distribution.

The dubbing marks on the futtocks also indicate that they were fashioned in a similar manner to the pine floor timbers (figs. 3-88 to 3-91). Where possible, the adze work on the top faces of the futtocks indicates that they were generally dubbed either in a

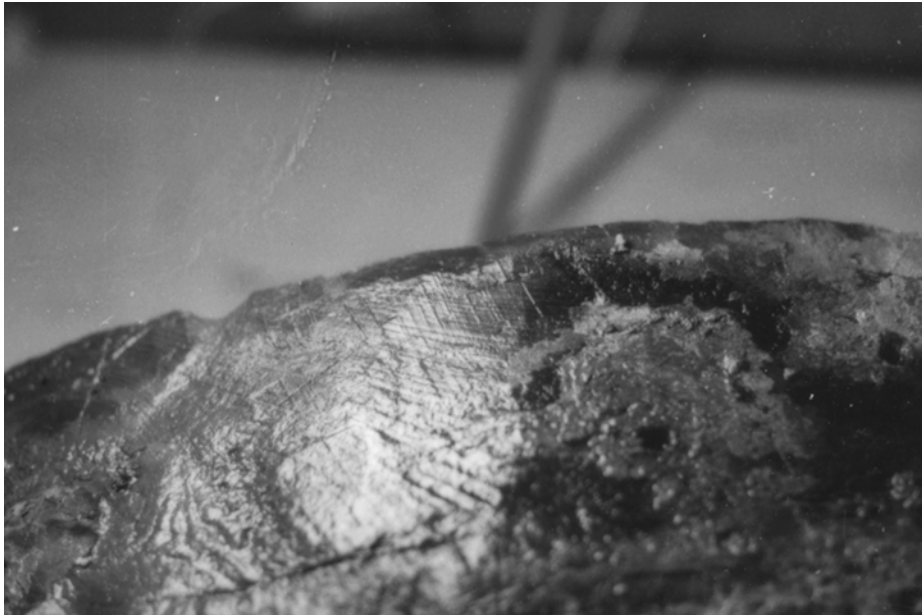


Figure 3-88: Photograph of futtock B illustrating dubbed faces.

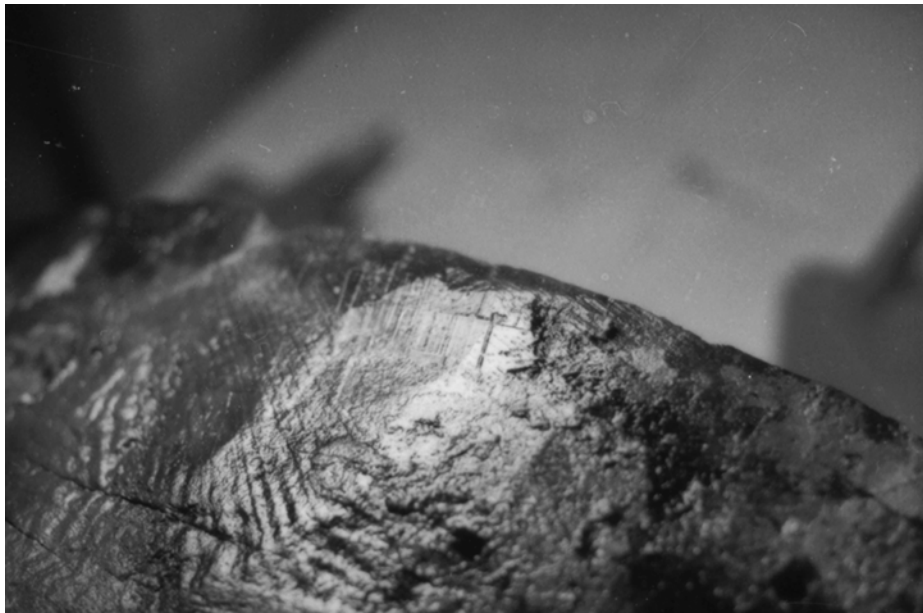


Figure 3-89: Another photograph of futtock B illustrating the dubbed faces.



Figure 3-90: Photograph of dubbed faces on futtock 4.

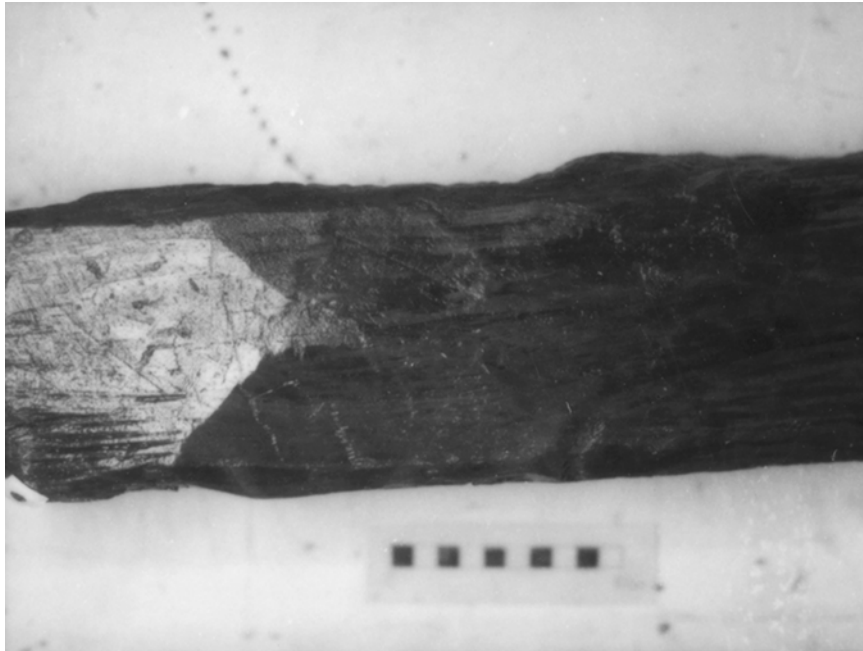


Figure 3-91: Photograph of dubbed faces on futtock 6.

longitudinal or diagonal manner across the face and, at least on futtocks B and C, the dubbing proceeded from the keel outboard. The dubbing marks on the stern faces of the futtocks reveal that they were fashioned in a similar manner to the bow faces of the pine floor timbers; the dubbing proceeded diagonally and down the stern face, although it is unclear if it began at the proximal or distal end of the futtock. The dubbing marks on futtock B indicate that the fashioning of its stern face began at its distal end. Again, a nick appears in the blade of the adze used to generate some of these adze marks (figs. 3-92, 3-93). In this case, this nick is only evident in the marks on futtock F, all of the other adze marks are free of this distinctive ridge. Additionally, some of the widest adze marks recorded indicate that one adze blade, the one without the nick if indeed two were in use, was at least 6.2 cm wide. No scribe marks or hammer marks are evident on any of the futtocks.

There is one incidental indentation or depression evident on the top face of futtock 6. It is roughly square, 8.3 cm x 7 cm, and it is unclear if it was generated during the life of the vessel, during wrecking, or during the excavation process. It appears as if an amphora indented the top face of the futtock, but such damage could only occur long after wrecking, when the integrity of the timbers had become significantly weakened.

Although futtocks 3 and E do not preserve any tool marks, they are the only futtocks that do preserve any pitch on their surfaces. Small drops, or accidental spills, of internal pitch are present on the top, bow, and stern faces of futtock E, as well as the top and proximal beveled face of futtock 3. No external pitch was identified.

Other Comments:

It should be noted that of these ten preserved futtocks, futtock H, made up of two diagnostic fragments, is cataloged as being both oak and pine. At this time both fragments are labeled as futtocks, and it will not be until the reconstruction of this hull that the nature of these fragments will be evident. Of the remaining nine futtocks, two are oak, while the remaining seven are identified as pine. Only one of the oak futtocks, futtock E, is paired with an oak floor timber. Futtock 3 is oak as well, and it is associated with floor timber 3, although floor timber 3 is pine. Additionally, although floor timbers A, B and C are oak, they each have an associated pine futtock. Moreover, although floor timbers A, C and E



Figure 3-92: Photograph of dubbed faces on futtock C.

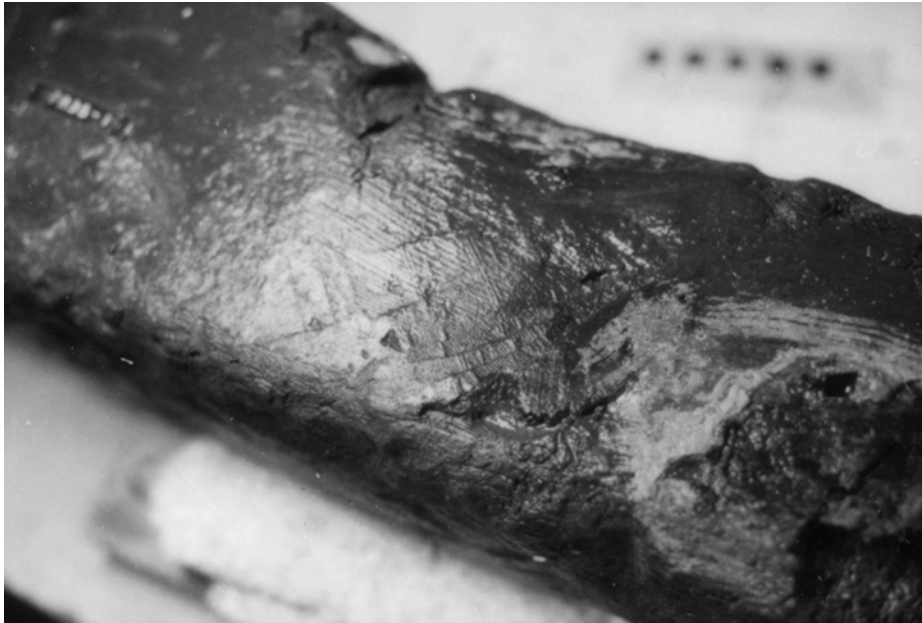


Figure 3-93: Another photograph of the dubbed faces on futtock C.

have an L-shaped scarf preserved at their distal ends, only floor timber E has a futtock that mates to this scarf. Futtocks A and B do not possess mating faces at their proximal ends that fit these L-shaped scarfs.

Futtock 6 is the only futtock among the ten that preserves a waney face. This face is found along the proximal top bow edge, and measures approximately 17 cm long and 4 cm wide. It meets the bow face at an angle of approximately 150 degrees.

Additionally, although floor timber F has joinery at its distal end that may be a scarf, or the preserved fragments of a scarf, the associated futtock possesses no faces that would mate to a scarf of this apparent design.

The futtock associated with floor timber E, futtock E, is mislabeled as FR 49-8. Its proper designation is FR 49 1/1. Although futtocks 6 and 3 are associated with more than one fragment each, only one fragment of each futtock possesses diagnostic material indicating its purpose in the ship. Nonetheless, the other fragments associated with these futtocks are still cataloged, but in two groups of material, not individually.

Starboard Strakes

The labeling method described in the Methodology section was extremely efficient and useful when cataloging the port and starboard planking fragments. The labels generated on site, combined with the accurate site plan, speeded the process of re-assembling each plank in the lab. Complicating factors did arise after the excavation, however, that require explanation. As described earlier, the hull material was not uncovered and labeled in its entirety prior to recovery but, due to the application of the WEB program, it was uncovered, mapped in place, labeled and then removed and stored off site in stages. As such, the excavation of the hull material not only proceeded more efficiently, but more safely as the fragile timbers were not exposed to hazards for an extended period. One drawback to this process is that added complexity or changes in the planking are difficult to compensate for, and must be addressed during the cataloging or reconstruction stage of research. Strake two immediately outboard of starboard strake one, for example, was not evident until July, 1999, when it was determined that a small number of fragments labeled SS1 had a different pith than those immediately inboard. In this case, although the 30 fragments that compose this strake are labeled SS1, and are still identified as such on the

cataloging sheets, they are identified as part of strake two from this point forward. Due to the re-identification of this strake and others during the reconstruction process, a new nomenclature for the starboard planking fragments was developed. As a result, the strakes in this chapter are segregated by their new labels, although the fragment ID numbers are original. For example, strake eleven is indicated as such in this catalog, but the corresponding fragment labels generated on site, and listed in this catalog, all have the prefix SS9A. The original strake label, such as garboard, shutter plank, etc. will also be indicated.

The inability to identify all the planking scarfs underwater also posed minor difficulties while cataloging this material. Integral to the labeling process is the ability to correctly determine when one plank finishes and another in that strake begins; essentially, when the labels should shift, for example, from SS5 2/30 to SS5 3/1. Although the majority of the scarfs were found while the material was still in situ, some along strake nine, for example, were not. As such, although they have been correctly re-assembled as a series of planks comprising a strake, the fragment numbers do not reflect that assembly. In strake nine, for example, the fragment numbers proceed from SS8 2/13 to SS8 2/30, although SS8 2/13 is actually the last preserved fragment in the second plank. Fragment SS8 2/23, the first preserved fragment in plank three, is more properly labeled SS8 3/1.

These problems, however, are no greater than the difficulties posed by the mislabeled futtocks or the disappearance of strake four 2 m aft of the preserved extent of the stem. Moreover, while they may be overcome in the future while working on site, the added time or need to expose all of the planking prior to recovery does not outweigh the added monetary cost or risk to the material. These difficulties are mentioned here primarily to indicate why, in the following catalog, some fragments may have labels that do not adequately describe their proper association. Rather than superimposing a second series identification labels over the first set, a task that seemed both arduous and excessive in light of the current re-identification of the strakes as well, the occasional labeling mistakes will be noted.

Although the planking fragments' labels have not been changed, for the purposes of brevity in this section, certain conventions were adopted when mentioning a variety or succession of fragment labels. When separate fragments in the same strake are mentioned,

such as SS5 1/24 and 1/38, they are listed in increasing numerical order. When such a list incorporates more than one plank from the same strake, such as SS5 1/24, 1/38 and 2/23, then the fragments are listed numerically in their appropriate plank, in increasing order from the first to last plank. If the fragments are a successive series of labels in the same plank, such as SS2 1/20 to 1/25, only those labels demarcating the limits of the series will be mentioned. If the series is incomplete, or there are missing labels in the series, it will be indicated as SS2 2/26, 2/28 and 2/42 to 2/45, for example. Consecutive labels on an unbroken fragment are indicated with a dash: SS7 2/23-2/26. Moreover, some fragments broke after labeling in situ, but prior to recovery, and they are often labeled as SS11 1/12A or 1/12B to indicate that they were one part of the larger fragment labeled SS11 1/12. Fragments that broke while in storage were labeled as SS3 1/19.P, for example, to indicate they are a part of the fragment SS3 1/19.

The locations, orientations and dimensions of planking fragments indicated in this catalog are based on their locations in figure 3-94, not as they were found in situ. Figures 3-94 and 3-95 indicates how the strakes were most likely aligned and affixed to the framing material prior to sinking; the locations of some fragments, as such, are not the same as those seen in the Methodology section, which has a site plan of the material during excavation.

Edge Dowel Joints in the Bozburun Hull Planking

After four seasons of examining the planking material from the 9th-century Bozburun wreck, it is clear that the hull planking was not only affixed together with embedded edge-to-edge joinery, but that it was done so in a manner currently unique to the early-medieval period. The joinery in the edges of the hull planking consists of a series of holes, drilled fairly perpendicularly into the inboard and outboard edges of eight of the eleven preserved starboard strakes, into which dowels were driven into place.⁹ As this system of edge joinery is currently unique for the early-medieval period, and to avoid unnecessary repetition and minutiae in the **Joinery** sections of each strake, a thorough discussion of the dowel joints in the Bozburun planking is presented. Whether these dowel joints are present or absent in certain strakes will still be addressed in the appropriate

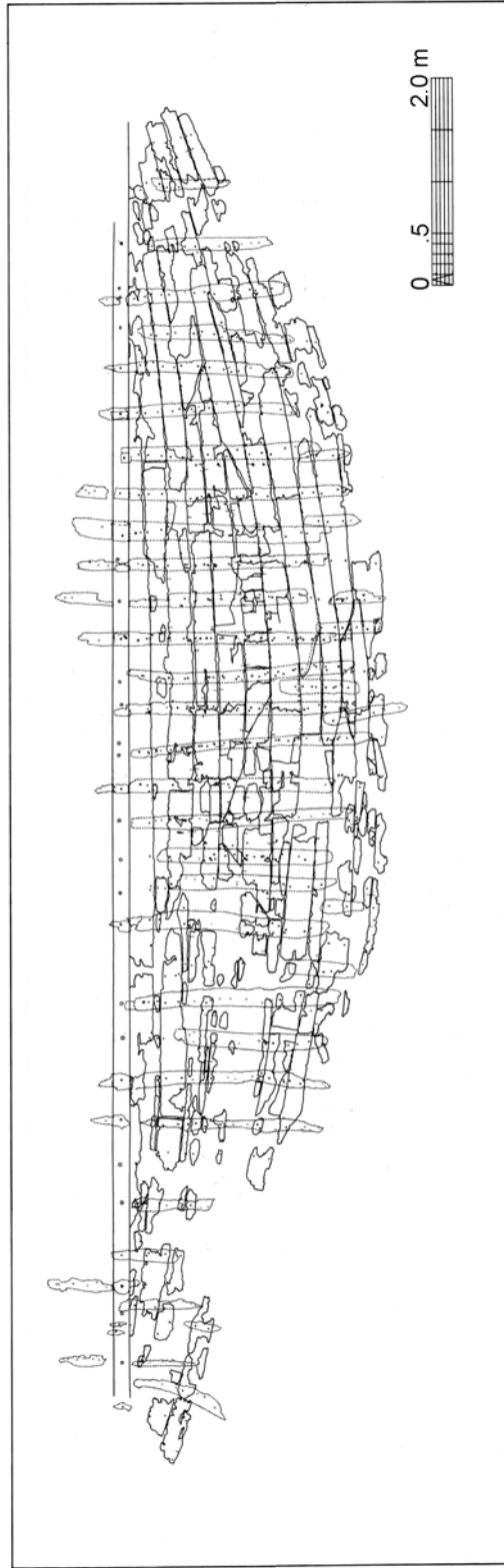


Figure 3-94: Drawing of the re-assembled starboard planking.

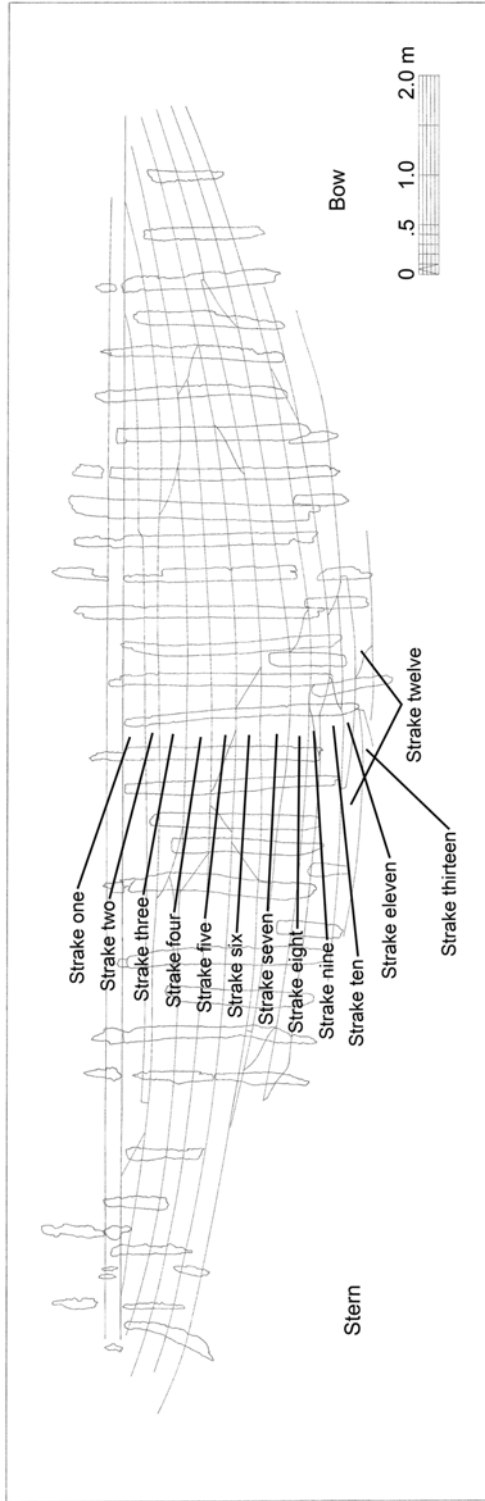


Figure 3-95: New strake numbers of the starboard planking.

catalog entries, but the details of the system, and of particular dowel joints, will be discussed here.

It took four years to assess the full extent of this technique for two reasons. The first reason is that no mortise-and-tenon joints were identified during the excavation, so research began with the preconceived notion that the Bozburun vessel had no methods of edge joinery. As is now clear, this assumption was incorrect. The second reason that it took four years to determine the extent of this technique is that these dowels were very difficult to find. In all but two cases the dowels in the Bozburun hull are oak, similar to the surrounding planking, so after submersion for approximately 1100 years the exposed ends of the dowels and the edges of the planking are nearly identical in appearance (fig. 3-96). These dowels are additionally difficult to find as they fit very tightly into their holes, leaving almost no indication of their presence along the planking edge. The first evidence of this technique found in 1999, for example, was not a dowel still in place in the edge of a plank, but half of an empty dowel hole. Other holes were identified over the following two years, but as such damage is neither consistent nor particularly widespread, mapping these holes resulted in a rather haphazard pattern. By the end of the 2001 season, for example, all of the planking material had been cataloged but only 52 dowel holes had been identified. Only three of these holes aligned with others across a plank seam, and no dowels had been found preserved in the edge of a strake. Working with Dr. Frederick H. van Doorninck Jr. over the summer of 2002, however, a viable method of finding dowels in situ was developed.

This method consisted of submerging the planking fragment vertically in water, keeping the edge to be examined within 10 cm of the surface, while illuminating the fragment's edge with strong raking light. While holding the fragment with one hand, the fingers or thumb of the other hand move along the fragment's edge, clearing away any sediment, grit, or caulking still in place. As the fingers or thumb gently rub the edge of the fragment while cleaning it, the dowel's exposed end grain becomes more abraded than the grain in the surrounding wood, which is parallel to the run of the plank. The abraded end grain tends to absorb more light than the surrounding wood, and any dowels present are

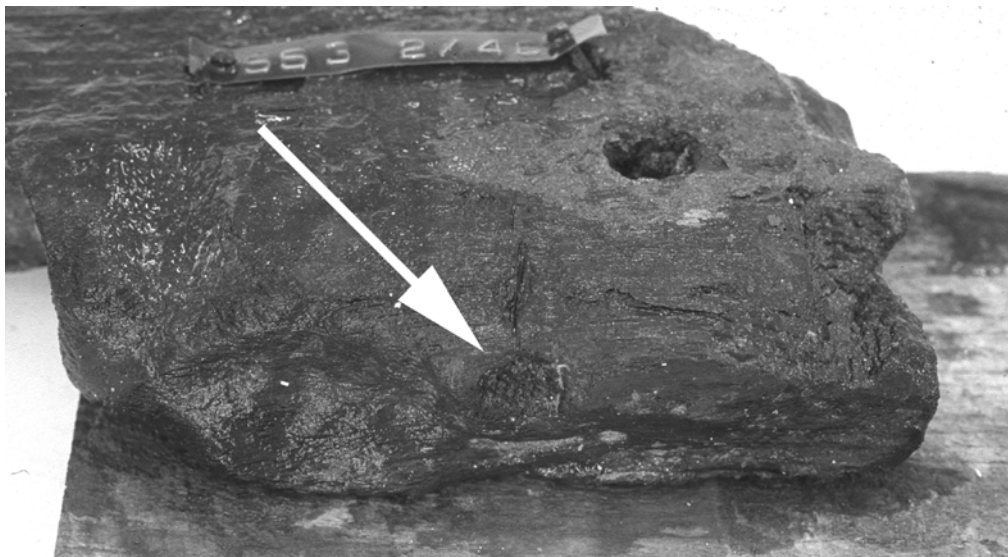


Figure 3-96: The arrow indicates the location of the exposed end of the edge dowel (From Harpster 2005, 89 fig. 3. Used with permission from the *International Journal of Nautical Archaeology*).

revealed as dark circles along the edge of the fragment (fig. 3-97). As both the planking and the dowels of the Bozburun vessel are oak, this discoloration was often the only means of finding the dowels still in place. Presumably, if oak dowels were used on vessels with pine planking or vice versa, this technique may be unnecessary as the discoloration would already be evident.

All of the Bozburun planking was re-examined in August of 2002 using this method, and now a total of 119 dowels or dowel holes may be identified in the preserved planking. Only 66 of these dowels, however, align with each other across a plank seam to create 33 pairs, or complete dowel joints.¹⁰ Twenty-three dowels or dowel holes do not create complete joints because adjacent material across a plank seam is missing; it is still felt, however, that these represent dowel joints that were once complete. There are three additional examples of empty dowel holes that appear to have never been used, all within 50 cm of an adjacent dowel joint. In comparison, 27 additional dowels or dowel holes have no mating dowel or hole across a plank seam although material is still present. This disjunction originally appeared to be due to planking replacements or repairs, but once the Bozburun vessel's re-assembly was complete, it was evident that this was instead a result of the ship's pattern of assembly.¹¹

Overall, these dowels do not exhibit a great deal of variation in size and cross-sectional shape. The dowels averaged 1.2 cm in diameter and were driven, on average, 5 cm into the plank edges, where such a measurement could be taken (fig. 3-98). One dowel was driven only 2.8 cm into the inboard edge of strake four, while another, in the outboard edge of strake seven, was driven approximately 9 cm into that plank (fig. 3-99). Some dowels taper along their lengths, but this taper is so minimal - only 1 to 2 mm - it is unclear if it is purposeful.¹²

All of the dowel holes were drilled, while the dowels were carved by hand. As the planks swelled around the dowels, approximately two-thirds of the drilled holes subsequently changed in cross-sectional shape; some holes, for example, are now square, hexagonal or pentagonal. This process is illustrated most clearly in half of a preserved dowel joint along the outboard edge of strake six. Although the planking fragment split transversely, revealing the interior surface of the dowel hole, part of the dowel is still in

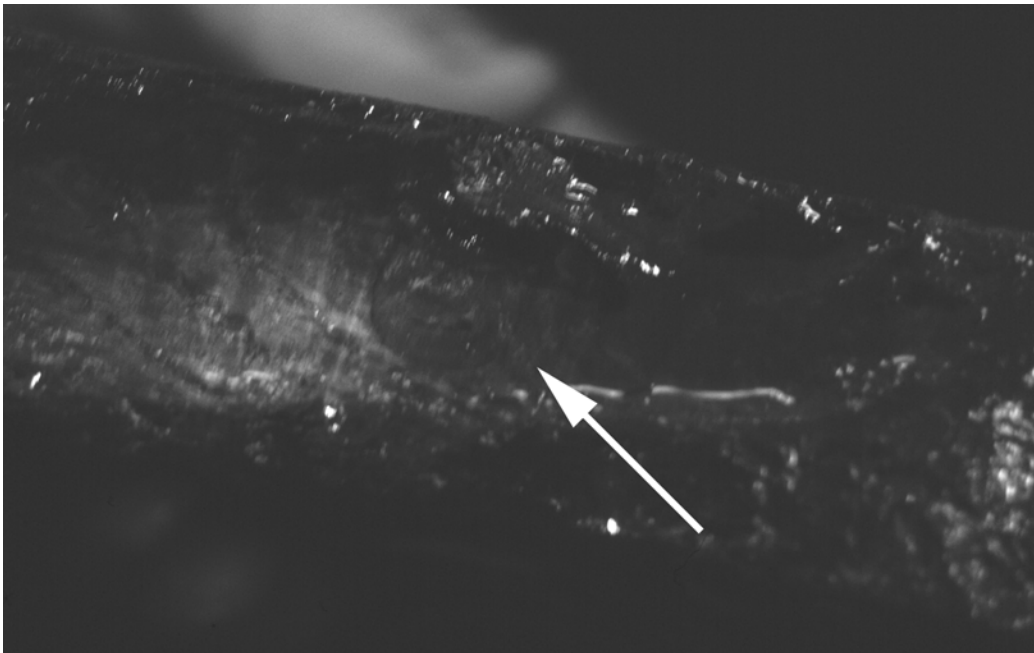


Figure 3-97: Note the dark circle in the edge of the planking (From Harpster 2005, 90 fig. 5. Used with permission from the *International Journal of Nautical Archaeology*).

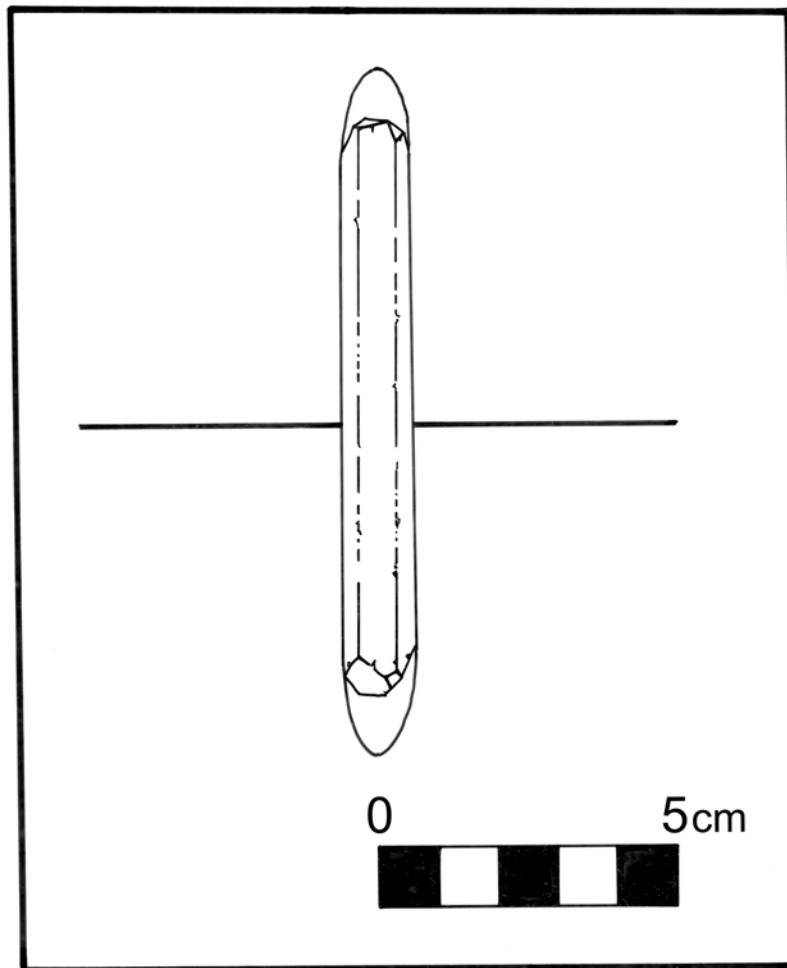


Figure 3-98: Cross section of a generic edge-dowel joint (From Harpster 2005, 91 fig. 7. Used with permission from the *International Journal of Nautical Archaeology*).

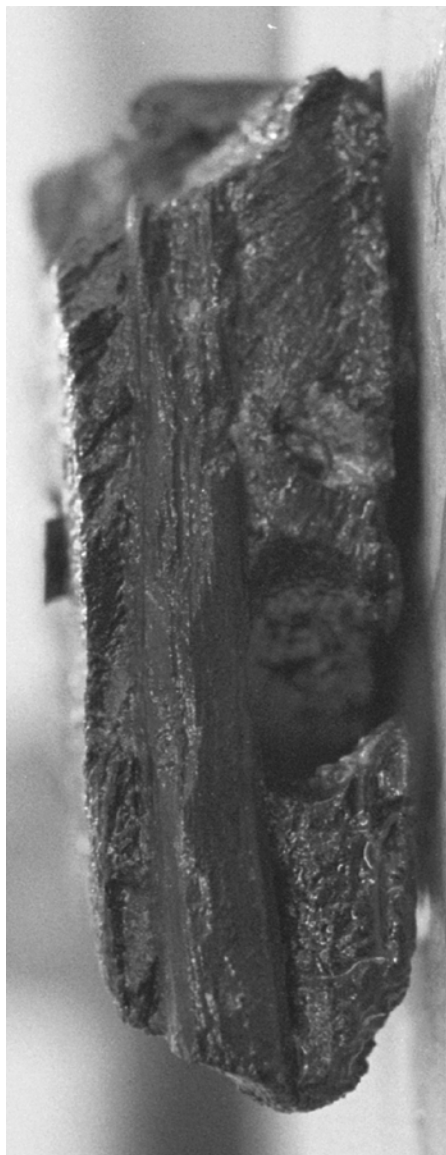


Figure 3-99: Photograph of the edge dowel driven c. 9 cm into the edge of strake seven (From Harpster 2005, 91 fig. 9. Used with permission from the *International Journal of Nautical Archaeology*).

place halfway along the hole's length. Between the dowel fragment and the bottom of the hole, the surface of the hole is still smooth and concave with faint striations perpendicular to its length (fig. 3-100). Between the dowel fragment and the plank edge the surface of the hole is indented into angled faces, reflecting half of the square shape of the dowel itself. The oak plank clearly swelled around this square dowel, indenting the concave surface of the hole to match the angled surface of the dowel. As the dowel was only driven 4.5 cm into a 7 cm-long hole, however, the remaining surface of the hole simply compressed around nothing and retained its original cross-sectional shape.

Other evidence corroborates this pattern of assembly. These faint striations, preserved in at least three other holes, appear only where the holes' surfaces are still smooth and concave, and not angular, and so must be cuts or scrapes from a drill bit passing through the wood. Lastly, the crisp edges and clear, faceted faces on some of the dowels' ends indicate that they not only met little resistance while being driven into place, but they did not always impact with the bottom of the holes (fig. 3-101).

The average spacing between the dowel joints is 59 cm, but actual spacing values vary between 6.5 cm and 2.6 meters (figs. 3-102 to 3-105). It should also be noted that neither the holes, nor the dowels themselves, protrude to either the interior or exterior face of the planking. Moreover, the location of only one of these dowel joints is indicated by a scribe mark, on the interior face of strake eight. No other dowel joints are marked in such a manner.

Just as these dowel joints are not evenly arrayed along the edges of the strakes, they are not evenly scattered throughout the hull. They are found in the inboard and outboard edges of strakes three through seven, and strake twelve. They are also located along the outboard edges of strakes two and ten, and the inboard edges of strakes eight and thirteen.¹³ No dowel joints are found between strake one and the keel or strake two, and none are in either edge of strake nine. Unlike the 7th-century ship from Yassiada, which had mortise-and-tenon joints throughout the hull planking below the waterline, the dowel joints in the Bozburun hull are found only where there is little longitudinal or transverse curvature - predominantly near the midbody of the ship above and below the bilge.

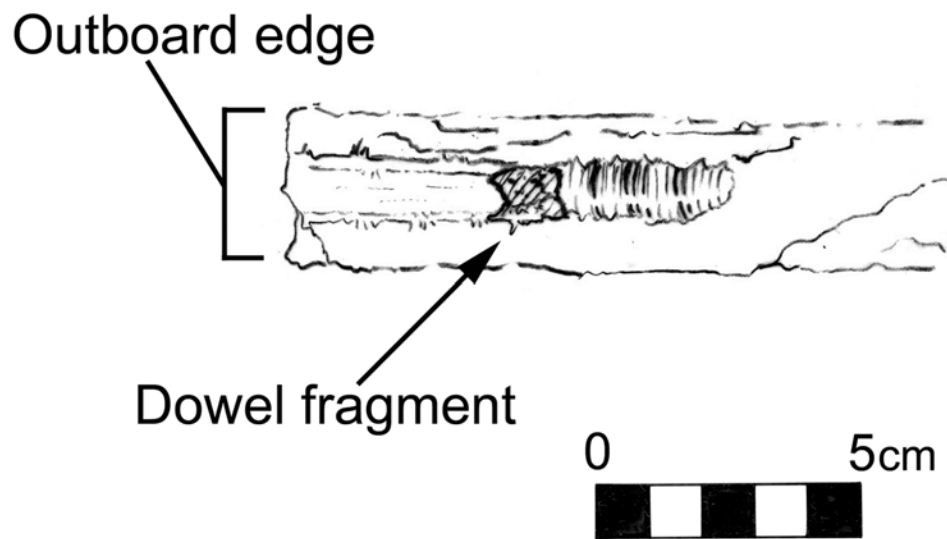


Figure 3-100: Cross section of the dowel joint in strake six (From Harpster 2005, 91 fig. 10. Used with permission from the *International Journal of Nautical Archaeology*).

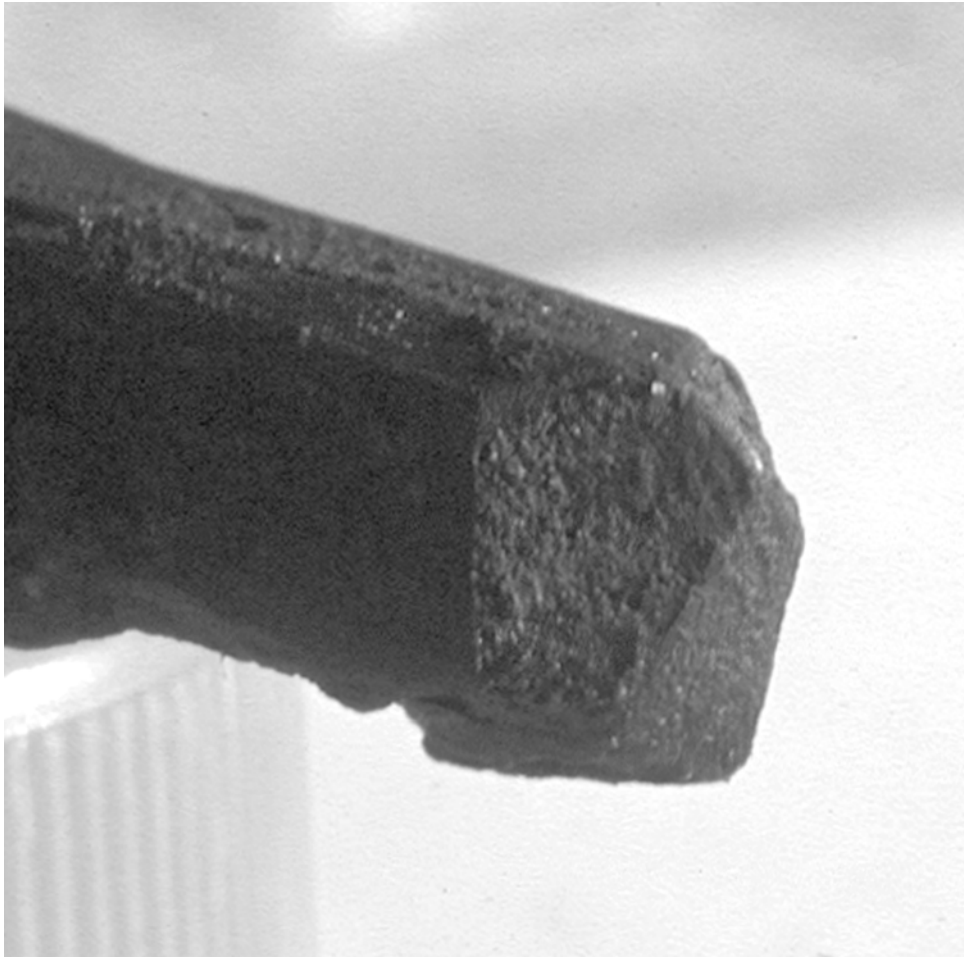


Figure 3-101: Photograph of the faceted end of an edge dowel (From Harpster 2005, 92 fig. 11. Used with permission from the *International Journal of Nautical Archaeology*).



Figure 3-102: Photograph of locations of edge dowels mapped in the Griffis laboratory (From Harpster 2005, 92 fig. 12. Used with permission from the *International Journal of Nautical Archaeology*).



Figure 3-103: Another photograph of edge dowels mapped in the Griffis laboratory.

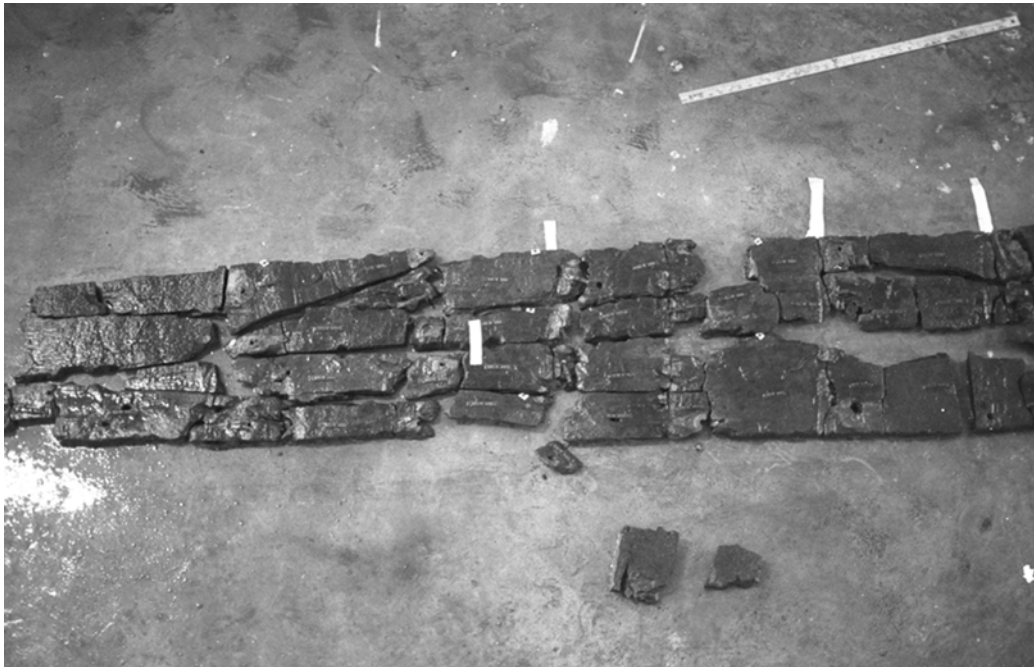


Figure 3-104: The white marks indicate the location of edge dowels in the preserved planking fragments.



Figure 3-105: Another view of the locations of edge dowels along part of strake six.

The dowel joints in the Bozburun ship may be currently unique to the early-medieval period, but they are not without precedent. Similar examples are found in archaic laced vessels from the central Mediterranean, dating between the 7th and 5th centuries BC.¹⁴ While the diameters of these archaic dowels appears to be similar to those on Bozburun, ranging between 1 and 1.4 cm, their spacing along the plank edge is much more compact.¹⁵ The dowel joints in the planking of the archaic Bon Porté vessel are spaced approximately 15 cm apart, for example, while the joints in Place Jules Verne 9 are approximately 20 cm apart.¹⁶ Unlike these earlier examples, however, there is no evidence that any of the planking in the Bozburun vessel was laced together. Four dowel holes with two extant dowels have been identified in the plank edges of the 2nd-century AD Grado vessel as well, but there is no broader interpretation yet of their role in the vessel's structure.¹⁷

Other variations of these dowel joints are found in much later vessels, both inside and outside the Mediterranean Sea. Dowel joints affixed together the planking of 19th-century lake and riverine craft from northern Italy, as well as the keel plank and garboards of the Inebolu Kütüğü, an early 20th-century cargo vessel indigenous to the Black Sea.¹⁸ Edge dowels are found in east-African, Arabian, and west-Indian craft as well, but these types are distinct as typically at least one end of the dowel is exposed.¹⁹ In these cases, the dowel holes are not drilled from the planking edges into the plank, but from the exterior face of the lower plank, upward through the plank seam, and into the adjacent plank above.²⁰ As such, once a dowel is driven into this hole, the exposed end of the dowel is shaved flush with the exterior face of the lower plank.

Overall, it is evident that unlike pegged mortise-and-tenon joints, edge dowels cannot perform as many roles in a hull's structure. A pegged mortise-and-tenon joint aligns planks during assembly, adds a great deal of structural integrity to the hull, withstands shearing and separation forces and, more intangibly, essentially defines how the vessel needs to be assembled. An edge dowel, in comparison, aligns planks and withstands shearing forces, but it adds less structural integrity and clearly does not define a hull's method of assembly. This may be why, before more contemporary methods of assembly became prevalent, they were paired with lacing along a plank seam; the lacing pattern and cordage compensated for the structural failings of the edge dowels. In comparison to un-pegged

mortise-and-tenon joints, however, edge dowels are essentially their equal. Both most likely supply a similar amount of structural integrity – the dowels perhaps slightly more as they fit tightly in their holes – both can withstand shearing forces but not separation forces, and both may align the planks equally well. Perhaps significant, then, is the thin line separating the use of either type of embedded joinery and the question of their relationship to each other. Do the edge dowels represent a further refinement in embedded edge joinery, or are they merely an aberration?

Strake One

Timber Numbers (Lot Numbers):

SS1 1/1, SS1 1/2, SS1 1/10, SS1 1/11, SS1 1/19, SS1 2/1 – SS1 2/3, SS1 2/5, SS1 2/10, SS1 2/12 – SS1 2/19, SS1 2/29, SS1 2/32, SS1 2/35, SS1 2/39, SS1 2/43, SS1 2/46 – SS1 2/47.

Old ID on site:

Garboard strake

Dates Cataloged:

July 25 and 28, 1998; July 2, 5 and 6, 1999; August 29, 2001

Catalogers:

JMM, JR, MBH

Drawing Numbers:

16, 30, 130 and 185, plus drawings on catalog sheets.

Samples Taken:

Dendrochronology samples 24, 60 and 61.

Preserved Dimensions (average):

Plank one: c. 1.4 m x .16 m (at scarf) x .035 m

Plank two: 8.52 m x .24 m x .037 m

Wood Type:

Quercus sp?

Condition:

Strake one consists of two planks, a shorter plank originally 96 cm long and a longer plank originally 8.52 m long. The shorter plank joins only to the sternpost, while the longer

plank is forward, joined to 1.06 m of the sternpost, the entire length of the keel, and 95 cm of the stem. The shorter plank is composed of five preserved fragments, of which only fragments SS1 1/1 and 1/2 fit into the rabbet; none of the fragments fit together. Seventeen fragments make up the longer plank, which, when re-assembled, is nearly complete. It is discontinuous for approximately 10 cm only between fragments SS1 2/3 and 2/5 near the stern keel scarf, otherwise the fragments re-assemble to make over 95 percent of the original plank.

The shorter plank, as it is fairly disarticulated, preserves only 58 cm of the rabbet edge, approximately 44 cm of the outboard edge, and only 6 cm of its diagonal scarf to the second plank. Portions of the interior and exterior surfaces are preserved on all fragments, although the exterior surfaces tend to be more eroded and friable than the interior faces. All of the fragments of the first plank are fairly light, their awkward shapes tend to make them fragile, but there is little significant worm damage to decrease their structural integrity. The fragments' edges and interior faces, where preserved, are still somewhat crisp and distinct, but prone to breakage.

Approximately 8.08 m of the rabbet edge of the longer plank is still preserved, as are 18 cm of the diagonal scarf to the first plank in the strake. Approximately 5.6 m of the outboard edge are preserved as well, predominantly near midships, but there are small sections of the tapered outboard edge to strake two at the forward end of the plank as well. Predictably, the fragments at the aft extremity of this second plank are more friable, delicate, and eroded than fragments farther towards the bow, similar to the preservation of the keel. The aft-most fragments of the second plank, SS1 2/1 to 2/5, are friable with delicate extremities, and tend to be more eroded on their exterior than interior faces. They have discontinuous preserved inboard edges, and the outboard edge of this plank is not found until fragment SS1 2/10, which is 1.93 m from SS1 2/1. Fragment SS1 2/10 is also heavier and more solid than other fragments aft. It has suffered little erosion, worm damage is almost non-existent, and its edges are still fairly solid and crisp. Although this second plank is split longitudinally through fragments SS1 2/11 to 2/17, and fragment SS1 2/18 is prone to splitting transversely, the section of this plank from SS1 2/10 forward to 2/43 is very solid, heavy, and well-preserved. The fragments preserve the rabbet and

outboard edges nearly completely, interior and exterior faces are prone only to splintering, and are otherwise clean with little or no erosion or worm damage. The very forward fragments of this plank, SS1 2/46 and 2/47, are similar to fragments at the aft end of the plank as their edges are friable and splintering but overall, they are still in better shape. They are fairly solid with little worm damage, and the internal and external faces are distinct with little erosion evident. Overall, the preservation of this larger plank is exceptional considering the age of the vessel.

It is this preservation, and the overall weight of some of the fragments, that necessitates their careful management and handling. Fragments SS1 2/3, 2/10, and 2/29-2/32 are between 1 and 1.2 m in length, while fragment SS1 2/17-2/19 is over 1.5 m long. While these fragments are very solid, it is their weight and their long and narrow shape that makes them difficult to handle. Similar to the keel, this weight tends to abrade or crush the edges of these fragments during handling and cataloging, and as these fragments are also very narrow, they are prone to transverse and longitudinal cracking and breaking. As such, these fragments should always be carried on edge in the sling, never horizontally by hand.

Joinery:

Although the combined length of the two planks in starboard strake one is nearly 9.5 m, there is little joinery or carpentry to distinguish this strake. The most significant item is its beveled rabbet edge, of which 8.66 m is preserved. As the exterior faces of fragments SS1 1/1 and 1/2 are slightly eroded, this edge is only 3.3 to 3.5 cm thick in the first plank, but it thickens to as much as 4 cm in the second plank, in fragment SS1 2/10. Along the larger plank, the angle of the rabbet edge to the plank's interior face varies between 115 degrees, in fragments SS1 2/3 and 2/47 at either extremity, and 105 degrees, in fragments SS1 2/12 and 2/16 near midships. As the exterior edge of this strake is approximately perpendicular to its interior face, the cross sectional shape of this plank is roughly rectangular, increasing in width from SS1 1/1, where it tapers into the sternpost, to 24 cm wide at fragment SS1 2/10. The plank width varies between 22.5 and 25.5 cm along 3.85 m of the length to fragment SS1 2/35, where the strake quickly tapers to 15.6 cm wide to mate with the interior edge of strake two (fig. 3-106). This latter width is maintained for the remaining 2.1 m of the strake's length, until the plank finishes 95 cm forward of the bow



Figure 3-106: Photograph of the forward end of strake one, tapering to fit under strake two.

keel scarf. The other joinery of note is the 26 cm long diagonal scarf mating the first plank to the second, approximately 1 m aft of the stern keel scarf. No edge dowels pass from either the rabbet edge of the strake to the keel, or from the outboard edge to strake two.

Fastenings:

There is one possible treenail hole through this plank, near the outboard edge of fragment SS1 2/32 under floor timber D. The hole is 1.2 cm in diameter, and as floor timber D has 13 treenails passing through it, another treenail near the keel does not seem out of place. Unfortunately, due to the floor timber's fragmentary nature over strake one, there is no corresponding evidence in the floor timber to affirm the treenail's presence. There are no other treenails or treenail holes in strake one.

There are a total of 41 metal fastener holes in strake one; 37 are nail holes and the remaining four are bolt holes. The locations of the 37 nail holes indicate that the nails in the strake performed two functions. One collection of 19 nails attached the strake to the keel, while the remaining 18 attached the planking to the framing. Of the 19 nails that attached the strake to the keel, their most consistent characteristic was their size. The nails measured, on average, $.6 \text{ cm}^2$, and varied between $.4 \text{ cm}^2$ and $.9 \text{ cm}^2$. Three round holes, in fragments SS1 2/12, 2/18 and 2/19, measured over 1 cm in diameter, but as no similarly sized holes are found in the starboard rabbet these presumably represent eroded nail holes, and not bolts. The nail holes' inclinations to the rabbet edge varied little; generally, the largest angles occur near midships, decreasing fairly equally towards either extremity. The nail holes averaged 135 degrees to the rabbet edge, and varied between 115 and 150 degrees. The spacing between the nails along the rabbet displays the greatest amount of variation, averaging 45.55 cm but containing values as low as 5.5 cm and as high as 1.4 m. The spacing does not appear to follow any particular pattern, nor do the actual distances increase or decrease consistently towards either extremity. Three of these nail holes, in SS1 2/3, 2/5, and 2/32, coordinate with frame stations 10, 9, and C, respectively, but these are the only three such examples.

The 18 nail holes that pass through the strake to the floor timbers are of a similar average size to those nail holes along the inboard edge, approximately $.63 \text{ cm}^2$. Two floor timbers, 4 and G, were affixed to the strake with two nails each, but only at floor timber G

were the nails dispersed across the width of the plank. The two holes at floor timber 4, in fragment SS1 2/13, are side by side. Fifteen other floor timbers are affixed to the strake with one nail each; it should be noted that the nail hole along the outboard edge of the strake is consistently 5 cm or less from the outboard edge of the strake.

Three of the four preserved bolt holes, all between 1.4 cm and 1.8 cm in diameter, apparently aided the attachment of the strake to the floor timbers as well. The largest bolt hole preserved in the strake, in fragment SS1 2/18, is paired with a nail hole near the outboard edge of the strake to affix it to floor timber 1. A single bolt hole, at the junction of fragments SS1 2/10 and 2/14, aligns with floor timber 6 but unfortunately, no material from this floor timber is preserved over the hole itself. There is no indication, however, that such an attachment did not occur in this manner. Two bolt holes, in SS1 2/10, coordinate with floor timber 7, but only one aligns with the single hole passing through the floor timber. The second hole is only 5 cm away, but as no other bolt hole is evident in the bottom face of floor timber 7, the purpose of the second hole in this pair is unclear.

Marks and Coatings:

Of all the preserved strakes, this one is distinguished by the large amount of pitch preserved along its length. In addition to the nearly complete coverage of the exterior face with a fairly thick layer of exterior pitch, the interior face is substantially coated as well with interior pitch. This 3.1 m-long swath begins on fragment SS1 2/10, but increases to cover the full width of the plank 60 cm aft on fragment SS1 2/13 (fig. 3-107). This coverage ends abruptly at the midships floor timber, on fragment SS1 2/19. Through this area, the pitch is fairly solid and thick, with distinctive ridges and whorls indicating its flow and application. Generally, this pitch is thicker near the inboard edge of the strake, occasionally preserving a distinctive peaked boundary just outboard of a 1 to 2 cm-thick band of uncoated wood (fig. 3-108). Particularly noticeable are the uncoated areas on the interior face around the fasteners for the midships floor timber, as well as floor timbers 1 through 3. More interior pitch is preserved farther forward on fragments SS1 2/35 and 2/39, where the strake tapers to mate to strake two, and on fragment SS1 2/46-2/47, where the toe end of the strake is attached to the stem. The pitch in these areas is similar in appearance and composition to

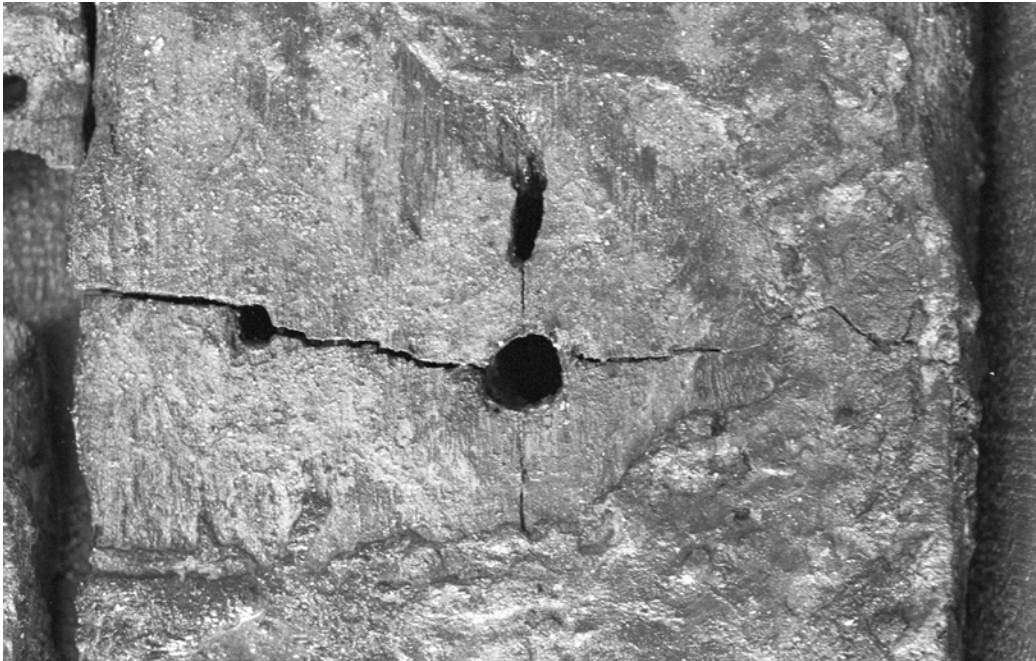


Figure 3-107: Photograph of the interior pitch coating strake one.

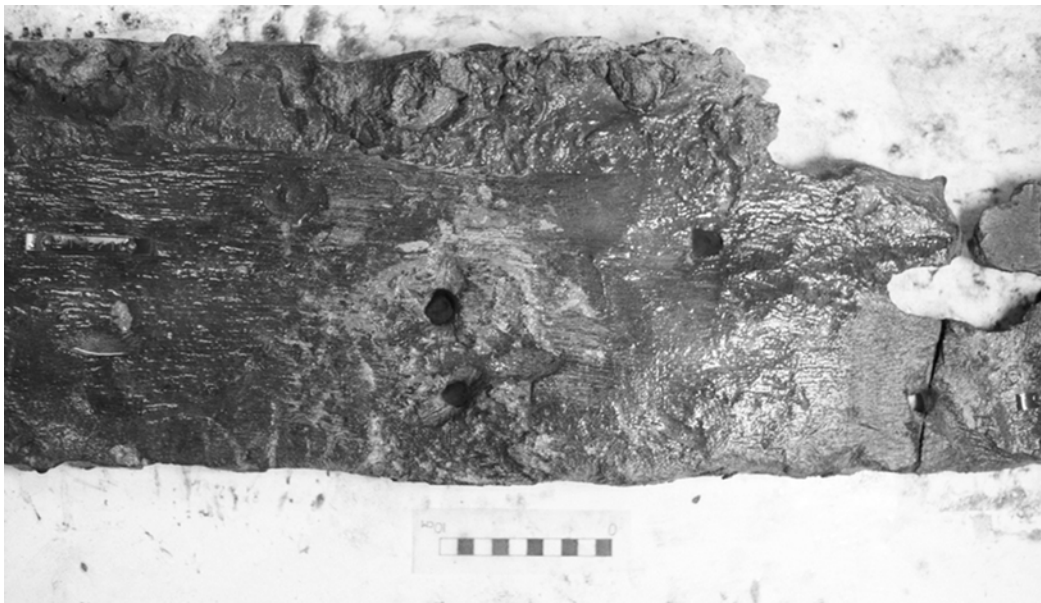


Figure 3-108: Photograph of the heavy coating of interior pitch on strake one. The inboard edge is to the top of the photograph.

that farther aft, preserving the same ridges, whorls, and a short section of the uncoated band of wood near the inboard edge.

Saw marks are found on fragments of both planks, but they are more numerous, distinct, and informative on the first plank, and faint and discontinuous on the second. The marks are fairly parallel and evenly spaced on all preserved fragments of the first plank, but only fragments SS1 1/2, 1/10, and 1/19 indicate that the cut on the interior face proceeded towards the bow of the vessel. Fragment SS1 1/1 is still informative, however, as it indicates that the cut proceeded perpendicular to the outboard edge of the plank and, as saw marks are evident on the outboard face of the fragment, that the cut on the exterior face proceeded toward the bow as well. Saw marks on the second plank of the strake, due to their eroded nature, are much less informative. At best, marks are evident on SS1 2/2, 2/3, 2/5, 2/10, and 2/17, but neither their inclination nor their cut direction can be inferred.

Adze work, in comparison, is more prevalent on the second plank, and absent on the first. This adze work is evident between fragment SS1 2/10 and the forward end of the plank, where it is not obscured by the interior pitch. Although it is unclear what direction this dubbing proceeded, the work extends over both the width and the length of the plank, maintaining a fairly even, faceted pattern across its surface (fig. 3-109). There is no evidence to indicate that there was a nick in the edge of the blade used to dub this plank, nor are any dubbing marks evident on the plank's exterior face.

Other Comments:

Three dendrochronology samples were cut from strake one, one in 1999 and two in 2002. Sample 24, cut from fragment SS1 2/42, aided the dating process, as did sample 61, cut from SS1 2/36A. Sample 60, from fragment SS1 1/2, did not yield enough rings.

There is only one repetition of ID numbers on strake one. Two different fragments are labeled as SS1 2/17. One is smaller, only 37 cm long, while the second, immediately forward of the first, is much larger and is concurrently labeled as SS1 2/17, 2/18, and 2/19. Fragment SS1 2/17-2/19 is both heavy and fragile as it is slowly splitting transversely through the two fastener holes associated with floor timber 1. This planking fragment should be handled very rarely.

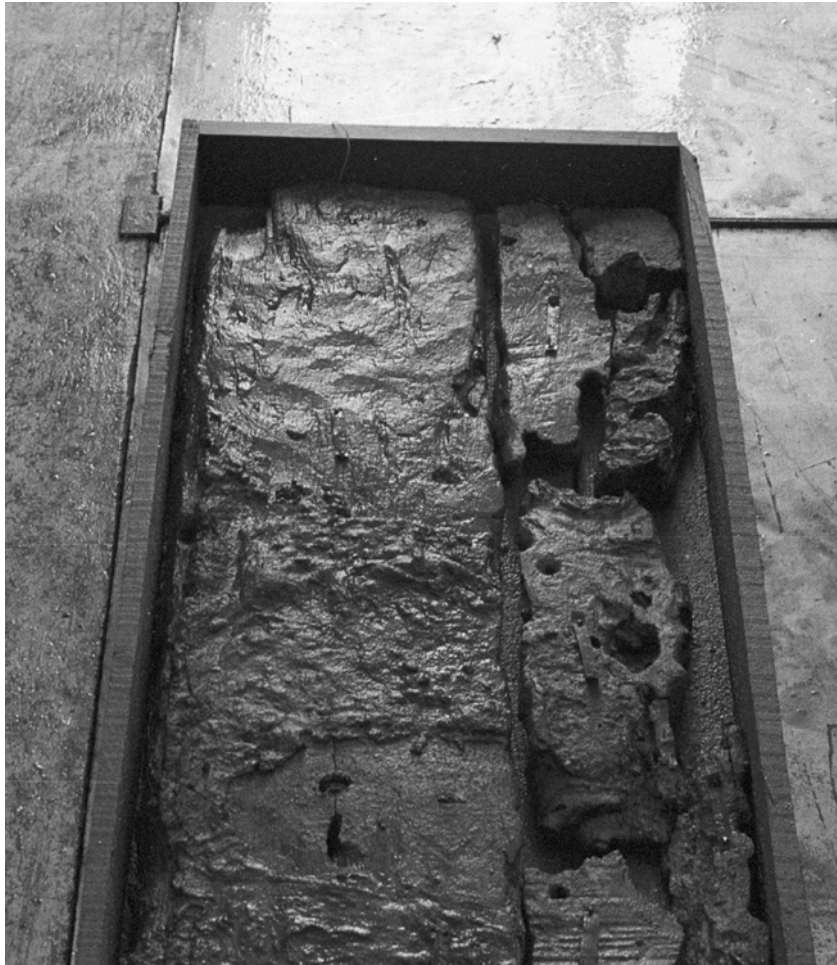


Figure 3-109: Photograph of the dubbing marks along the interior face of strake one.

*Starboard Strake Two***Timber Numbers (Lot Numbers):**

SS1 2/4, SS1 2/6 – SS1 2/7, SS1A 2/9, SS1A 2/11, SS1A 2/19 - SS1A 2/21, SS1 2/24 – SS1 2/28, SS1 2/30, SS1 2/31, SS1 2/33, SS1 2/33A, SS1 2/34, SS1 2/36, SS1 2/36A, SS1 2/37, SS1 2/40, SS1 2/42, SS1 2/44 – SS1 2/45, SS1 2/48, SS1 2/49, SS1 2/50 – SS1 2/51, SS1 2/53

Old ID on site:

Shutter plank.

Dates Cataloged:

July 11 and 13, 1999; July 13, 16 and 17, 2001

Catalogers:

MBH

Drawing Numbers:

127, 131, 183, 185, plus additional drawings on catalog sheets

Samples Taken:

Dendrochronology sample number 24.

Preserved Dimensions (average):

Plank one: 5.45 m x .097 m x .035 m

Plank two: 3.32 m x .22 m x .036 m

Wood Type:

Quercus sp?

Condition:

Starboard strake two is reconstructed as two planks, although the fragmentary and disarticulated nature of the first plank may conceal evidence indicating that the strake was originally composed of more (fig. 3-110). The first plank, with 20 associated fragments, extends forward from floor timber 12 to floor timber E, where it is butt scarfed to the second plank that extends an additional 3.32 m forward to join the rabbet. The second plank, of 10 fragments, preserves 80 cm of an originally 1.02 m-long inboard rabbet edge to the keel.



Figure 3-110: Photograph of strake two fragments laid out in the Griffis laboratory.

The fragments of the first plank tend to be eroded, friable, and somewhat undiagnostic due to their small size. SS1A 2/20, which is the largest fragment of this plank, is only 35 x 11.5 cm. Of the 20 associated fragments, only 17 could be accurately placed on the fragment plan. The original locations of the remaining three, fragments SS1A 2/27, 2/28, and 2/29, are unknown. Nine fragments fit back together, but only in three separate groups; the largest group is 69 cm long, composed of fragments SS1A 2/30, 2/31, 2/33, and 2/33A. The preserved fragments are fairly evenly dispersed along the plank's original length, from SS1A 2/4 at the aft end to SS1A 2/37 near the forward scarf, but these fragments only represent, at most, 3.3 m of the plank's original design. Overall, the fragments making up this plank retain original surfaces and edges, and have fairly good structural integrity due to little or no worm damage. The extremities of some fragments, however, particularly SS1A 2/20 and 2/36, are still friable and splintering and should be handled with care.

Other than a 6 cm gap between fragments SS1A 2/51 and 2/53, the fragments of the second plank form one contiguous piece. The majority of the fragments of this strake, between SS1A 2/40 and 2/51, are solid and heavy, and retain clean faces and edges. SS1A 2/53, damaged predominantly along its aft broken edge, is somewhat more fragile, but its two preserved edges and faces are still fairly coherent. The greatest amount of damage and erosion occurs along the inboard edge of the plank, prior to reaching the rabbet. Although this inboard edge was originally 2.2 m long, it is now composed of small portions of the original edge, interspersed with gaps, fragile and splintering faces, and friable and broken edges. The outboard edge of the plank, in comparison, is more coherent, only interrupted between fragments SS1A 2/50 and 2/53. Due to the proximity of the tree's pith, the fragments in this plank tend to split longitudinally; this weakness has already affected the collection of fragments between SS1A 2/45 and 2/51, and is threatening SS1A 2/40, 2/42, and 2/44.

Joinery:

Other than the inboard rabbet edge on the second plank, the rest of the edges of this strake are fairly perpendicular to the interior and exterior faces. The cross-sectional shape of the first plank, then, is a rectangle 3.1 to 3.9 cm thick, and varying between 8 cm

and 11.5 cm wide. The second plank changes in cross-sectional shape from a rectangle to a trapezoid near its forward end, to accommodate the rabbeted inboard edge. This second plank widens from 9.5 cm where it joins the first plank to approximately 22 cm wide just 9 cm forward of this scarf, to match the distinctive taper along strake one's outboard edge. The rest of the plank varies between 21 and 23 cm wide, until the inboard edge mates to the stem rabbet. As the outboard edge tapers to meet the stem from that point forward, the inboard edge, which is 3.4 cm to 3.8 cm thick, adopts an inclination of approximately 110 degrees from horizontal in SS1A 2/53 to mate into the stem rabbet.

Due to the paucity of fragments along this strake, only seven oak treenails are preserved along its length, all within the first plank. Among these possible treenails, which average 1.4 cm in diameter, three are located aft, two in fragment SS1 2/20 and one in 2/21, while the remaining four are under oak floor timbers. One of the four treenails, in fragment SS1A 2/36, coordinates with floor timber E, but the remaining three in fragment SS1A 2/27, two of which may not be treenails, are more difficult to coordinate. The exact location of SS1A 2/27 is unclear, but as SS1 2/26 is just aft of floor timber A, presumably the treenails in SS1 2/27 align with floor timber A itself.

The number of edge dowels in the first plank is very low as well, but not due to the paucity of material. One edge dowel and two dowel holes are associated with strake two, but only two form complete dowel joints with the inboard edge of strake three. The edge dowel in SS1A 2/20 mates to SS2 1/20, while the second complete dowel joint is formed by one of the two edge dowel holes in SS1A 2/34, and the coordinating edge dowel in SS2 2/50. The second edge dowel hole in SS1A 2/34, which is represented by a partially eroded hexagonal hole, has no coordinating dowel along the inboard edge of strake three. As the inboard edge of strake three is missing material in that area, it appears most likely that this last dowel joint is incomplete because of lost material, not because the joint was only partially completed. As no more edge dowels or dowel holes are found along the inboard edge of strake three, it is clear that these three dowel joints were the only three that joined this plank of strake two to the inboard edge of strake three.

One possible edge dowel is evident in the second plank of strake two, along the inboard rabbet edge of SS1A 2/49, but there is no coordinating edge dowel or dowel hole

along the starboard rabbet. No material is missing from the starboard rabbet in this area, so the purpose of this dowel joint remains unknown. This is the only definite instance of a “blind” dowel joint in the preserved material.

Fastenings:

All 35 preserved fastener holes in strake two represent nails, there are no preserved bolt holes. Of these preserved nail holes, 32 represent nails that affixed the planking to the framing, while the remaining three passed from the planking into the starboard rabbet. Those holes along the rabbet edge of the plank average $.76 \text{ cm}^2$, and increase in inclination to the interior face from 150 to 134 degrees towards the bow. None of the nail holes along the inboard rabbet edge of the second plank align with the locations of the floor timbers.

The other 32 nail holes vary between $.5 \text{ cm}^2$ and 1.0 cm^2 , although there are two eroded holes 1.1 cm in diameter as well. Overall, these 32 nail holes average $.69 \text{ cm}^2$. As dictated by the width of the planks, only seven floor timbers, the frame chock and F through K are affixed to strake two with two nails arrayed transversely across the plank. The second plank is affixed to floor timber M with three nails, while the remaining floor timbers along the first plank are affixed with only one nail each.

Marks and Coatings:

Unfortunately, the poor preservation of the first plank in strake two has left no tool marks on the preserved faces. The second plank, in comparison, preserves a large collection of saw marks; adze marks are non-existent. These distinct saw marks, which are arrayed from SS1A 2/40 to 2/49, vary between 70 and 75 degrees to the keel, and indicate the cutting proceeded from the forward to aft end of the plank (figs. 3-111, 3-112).

Other than rust and concretion, which tend to be ubiquitous throughout this planking material, the only other coating evident on strake two was external and internal pitch. The external pitch is evident on the external faces of the fragments in both planks, and coated the preserved faces fairly evenly, but not as thick or undulating as the external pitch on strake one. Internal pitch is evident as well, but preserved predominantly along the edges of the second plank, in apparently purposeful applications. Its distribution, however, extends only to SS1A 2/49, 90 cm from the forward end of the plank. Unlike strake one, no internal pitch was applied along the inboard edge, near the rabbet, nor are the outlines of



Figure 3-111: Photograph of the saw marks on strake two.



Figure 3-112: Another photograph of saw marks on strake two.

any floor timbers evident in the pitch's application. The pitch is evident only in small, seemingly accidental, drops on fragments of the first plank.

Other Comments:

Due to the disarticulated nature of the fragments in the first plank, its exact design is unclear and the preserved fragments may represent more than one plank. Without more sampling, however, the number of planks will be unknown. It is clear, however, that the disarticulated fragments that lay between the first and third strakes do represent a separate strake. This is evident as the alignment of these fragments' piths is different than the alignments found in both the first and third strakes. One 6-cm wide dendrochronology sample, number 24, was taken from fragment SS1A 2/42. It should be noted that the distance between fragments SS1A 2/51 and 2/53 on the one-to-one drawing is hypothetical, while that on the fragment plan is more accurate. Lastly, the tag on fragment SS1A 2/20 is oriented upside down.

Starboard Strake Three

Timber Numbers (Lot Numbers):

SS2 1/4, SS2 1/10 – SS2 1/19, SS2 1/21 – SS2 1/22, SS2 1/24 – SS2 1/25, SS2 2/26 – SS2 2/71, SS2 2/73 – SS2 2/79

Old ID on site:

Starboard strake two

Dates Cataloged:

June 25, 1999; August 13 and 17, 1999; June 5, 2000; July 4, 7, 10, 11 and 12, 2001

Catalogers:

MBH

Drawing Numbers:

123, 139, 179, 180 and 182

Samples Taken:

Dendrochronology samples 21, from SS2 2/62-2/63, and 43, from SS2 1/12-1/13.

Preserved Dimensions (average):

Plank one: 4.42 m x .27 m x .034 m

Plank two: 1.45 m x .10 m x .032 m

Plank three: 4.14 m x .26 m x .038 m

Plank four: 3.32 m x .19 m x .031 m

Wood Type:

Quercus sp?

Condition:

The 73 fragments that make up the four planks of strake three vary in size, fragility, and overall condition. The smallest, and most fragile, fragments are the ten accumulated at either end of the strake: SS2 1/2, 1/3, 1/4 and 1/10 at the aft end and 2/74 to 2/79 at the bow. Other than SS2 1/4 and 1/10, the remaining eight are small, light, friable, and delicate, with eroded exterior faces and poorly preserved edges. SS2 1/4 and 1/10 are larger in size, but otherwise share the remaining characteristics. Neither these ten fragments, nor the remaining 63, are particularly damaged by *Teredo navalis*. The other six fragments in the first plank possess better-preserved interior and exterior faces, as well as larger portions of both the inboard and outboard edges. Longitudinal cracking is evident through fragments SS2 1/12 to 1/14, but it does not continue farther forward into fragments UM 868 and SS2 1/17. The four preserved fragments of plank two, which appears to have been originally 1.45 m long, are fairly solid and retain clean but slightly friable edges. Internal and external faces are in good shape and are only slightly eroded; no longitudinal cracking is evident.

Plank three, which is the longest and best-preserved of the four planks, is composed of 41 preserved fragments. Reflecting the general pattern of preservation along the length of the ship, these fragments increase in quality and size towards the bow of the vessel. The first six fragments of the strake, SS2 1/20 to 1/25, tend to be fairly small, light and delicate, with some longitudinal cracking and well-eroded inboard and outboard edges. The overall preservation improves, however, from SS2 2/26 forward. More of each edge is preserved, and the edges themselves are crisper and more diagnostic, while the internal and external faces are less eroded and less friable as well. Generally the most delicate and friable surfaces are the transverse broken edges, while worked edges and faces are possess more structural integrity. Longitudinal cracking has split fragments SS2 2/26, 2/28 and 2/42 to 2/45, and threatens fragment SS2 2/35. Portions of both edges in this area are evident, but tend to be

more widely spaced toward the forward end of the plank, until fragments SS2 2/55 and 2/56, which preserve no outboard edge, and little original inboard edge.

Plank four has the greatest dichotomy in preservation, containing both the longest preserved fragment in the strake, as well as a collection of six small, light and disarticulated fragments near the bow. Other than these fragments near the bow, the rest of the preserved plank is composed of fairly solid fragments, with some erosion on both edges but well-preserved faces. The transverse broken edges are generally the most delicate and friable. Labels SS2 2/65 to 2/68 and 2/71 are on one 1.43 m-long fragment which is both heavy and delicate, with friable edges and a loss of structural integrity due to longitudinal cracking. Similar longitudinal weakness affects the preservation of the following three fragments, while the remaining fragments closer to the stem are eroded and disarticulated.

Joinery:

Strake three is the last strake to preserve material that mates to a rabbet. In this case, although the inboard edge of fragment SS2 2/79 no longer preserves any specific bevel to mate to the rabbet in the stem, the single nail hole in the fragment exits the interior face near the inboard edge, at an angle of approximately 140 degrees to horizontal. This fragment, however, is the only fragment in strake two that retains such characteristics.

Three S-scarfs are preserved along the length of the strake. Originally 39 cm long, one S-scarf near floor timber G, between planks three and four, is now represented entirely by 25 cm of a preserved edge in plank four. The two other S-scarfs represent the conjunction of three planks between floor timbers 5 and 4. One S-scarf, the longest in this strake, is between planks one and two, and intersects with the third S-scarf, which joins planks one, two and three. As plank two is scarfed only along the outboard 85 cm of plank one, and as plank two is 10 cm wide at the most, both planks one and two are also scarfed to plank three across the third S-scarf (fig. 3-113). Essentially, while one half of the scarf edge is formed by plank three, the inboard portion of the other half is formed by plank one, while the outboard portion is formed by plank two. As such, the S-scarf between planks one and two is 1.22 m long, and that between planks one, two and three is 48 cm long. No original scarf edges are preserved in plank three. Plank one, however, still retains 14 cm of its scarf face to plank three, as well as 54 cm of the inboard edge of the S-scarf to plank



Figure 3-113: Drawing of the scarf arrangement in strake three.

two. Plank two, in turn, retains 60 cm of the long S-scarf to plank one, and 19 cm of its portion of the S-scarf to plank three. Two of these S-scarfs, that at floor timber G and that between plank three and planks one and two, are inclined in a similar manner; the outboard edge of the scarf is closer to the bow than the inboard edge. The third scarf, that between planks one and two, is inclined in the opposite manner.

Portions of seven dowel joints are preserved in the fragments of strake three, three along the inboard edge to the first plank of strake two, and four on the outboard edge to the second plank of strake three; none pass through the three S-scarfs. Four of these dowel joints are represented by extant dowels, two are represented by broken holes, while the last, in fragment SS2 2/54, is a dowel hole that never appears to have been used. This hole, unlike those holes in SS2 2/42 and 2/47, is complete and empty, and does not align with any portion of a dowel joint in the second plank of strake two. These dowel joints average 1.2 cm in diameter.

Fastenings:

Of the 13 treenails or treenail holes preserved in this strake, only one, that in SS2 2/64, is not in plank three. The treenails vary between 1.2 and 1.8 cm in diameter, averaging 1.45 cm, and nine of them may be paired with another treenail, treenail hole, or nail hole across the strake's width. Treenails in fragments SS2 2/27, 2/45 and 2/57 are paired with one or more nail holes, while treenail pairs are in fragments SS2 1/22 and 1/25, 2/36 and 2/38, and 2/47 and 2/48. The remaining four treenails, in fragments SS2 2/43, 2/44 and 2/64, are isolated since coordinating material across the strake is missing.

Forty-nine nail holes are preserved along the length of strake three, and there are no preserved bolt holes. Among the nail holes, 41 are still square while the remaining eight are eroded and now round, commonly between 1.1 and 2.0 cm in diameter. The average size of the square holes is .7 cm², but actual values range between .5 cm² and 1.0 cm². The nail holes are most commonly arrayed along the length of the strake near either edge, with one pair of nails at each floor timber. Eight nail holes, however, are located in the middle of the strake; one, that in fragment SS2 1/17, is associated with a pair of nail holes aligned with floor timber 6. This is the only instance of three nails affixing strake three to a floor timber. Nail holes and treenail holes are associated with the floor timber at midships, and floor

timbers 3, 2, C and H. At both midships and at floor timber C, a pair of nail holes arrayed across the width of the plank is adjacent to a pair of treenail holes. In contrast, floor timber 2 appears to have been affixed in place by two nail holes side-by-side near the outboard edge, and a single treenail along the inboard edge. Floor timber 3 has a pair of treenail holes across the width of the plank, with one added nail hole inboard in fragment SS2 1/22, while floor timber H is affixed to the strake with a single nail inboard and a treenail outboard. The preserved nail hole in SS2 2/79, which is .6 cm² and inclined 140 degrees to horizontal, is the only extant hole associated with the stem rabbet. No other similar holes are preserved at either end of strake three.

Marks and Coatings:

External pitch is evident on the exterior faces of all but three of the 73 fragments in strake three. In some cases, it is eroded and scattered along the exterior face of the fragment, but predominantly so because the preservation of the exterior face of the fragment is eroded as well. Overall, exterior pitch is nearly ubiquitous along the length of this strake, preserving a surface similar to that found on strake one, occasionally containing distinct ridges and whorls indicating its flow. The internal pitch, in comparison, is present, but only in compact areas. Small and faintly preserved applications are evident on fragments SS2 1/14 and UM 868, as well as fragment SS2 1/15, but its appearance on planks three and four seems more deliberate. It coats the interior faces of fragments SS2 1/22, 2/28 and 2/44 near their outboard edges, as well as fragments SS2 1/24, 2/43, and 2/47 along the inboard edge; the last is a preserved area 10 x 4 cm in size. Its appearance closer to the forward end of the strake is more substantial. On fragments SS2 2/51, 2/54 and 2/55, meandering vertical strips of internal pitch extend down the faces of the fragments, occasionally preserved from the outboard to the inboard edge. These strips are from 15 to 21 cm long, and vary from approximately 2 to 6 cm wide. They do not delineate particular areas of the plank, nor do they outline the edges of floor timbers. A similarly sized patch is preserved on SS2 2/56 as well, but not in a distinct vertical strip. On plank four, the internal pitch is evident again in applications along the edges of fragments SS2 2/65-2/68 and 2/69-2/70. On the first fragment, the pitch is preserved in a strip 27 cm long along the outboard edge, and three patches 13 cm, 16 cm, and 20 cm long along the

inboard edge. Presumably, these inboard patches were originally one long strip approximately 50 cm long and 3 cm wide. Coordinating with the aft-most application of internal pitch on fragment SS2 2/65-2/68 is the strip along the outboard edge of fragment SS2 2/69-2/70, which is immediately outboard. This is a similarly sized area, approximately 20 x 3 cm. Rust and concretion are evident on all planks of this strake, commonly appearing in small areas surrounding the preserved nail holes and occasionally staining the wood itself.

There is no preserved adze work evident on any plank of strake three, but saw marks are fairly common and evident from the very forward to the very aft preserved fragments. Although more of plank three is preserved, the saw marks are not as widespread, distinct, or diagnostic. Where they are present, on approximately 12 fragments, they tend to be fairly faint and eroded, and appear only in small preserved groups (fig. 3-114). Despite their rarity, however, they all tend to be approximately 90 degrees to the keel, and in all cases, the cutting proceeded from the forward to the aft end of the plank. The saw marks preserved on planks one and four, despite their increased incidence and quality, provide no additional characteristics. The marks on plank one tend to be more commonly inclined 110 degrees away from the bow, or fairly perpendicular to the keel, although some instances of marks 60 to 70 degrees towards the bow are preserved. Plank one was cut from the after to the forward end of the plank. Plank four retains a combination and proportion of inclined saw marks similar to those on plank one, but similar to plank three, its cutting proceeded from the forward to after end of the plank. No saw marks are preserved on plank two.

In addition to a small collection of faint saw marks, fragment SS2 2/40 also preserves a series of square and trapezoidal indentations on its interior surface, the cause of which is unknown. These seven to ten indentations are approximately 1.7 x 1.7 cm on each side, and are concentrated in a 5 cm-wide band running vertically down the interior face of the fragment. As the edges of the indentations are somewhat rounded and there is little splintering, these indentations do not appear to be modern wear or damage.

Other Comments:

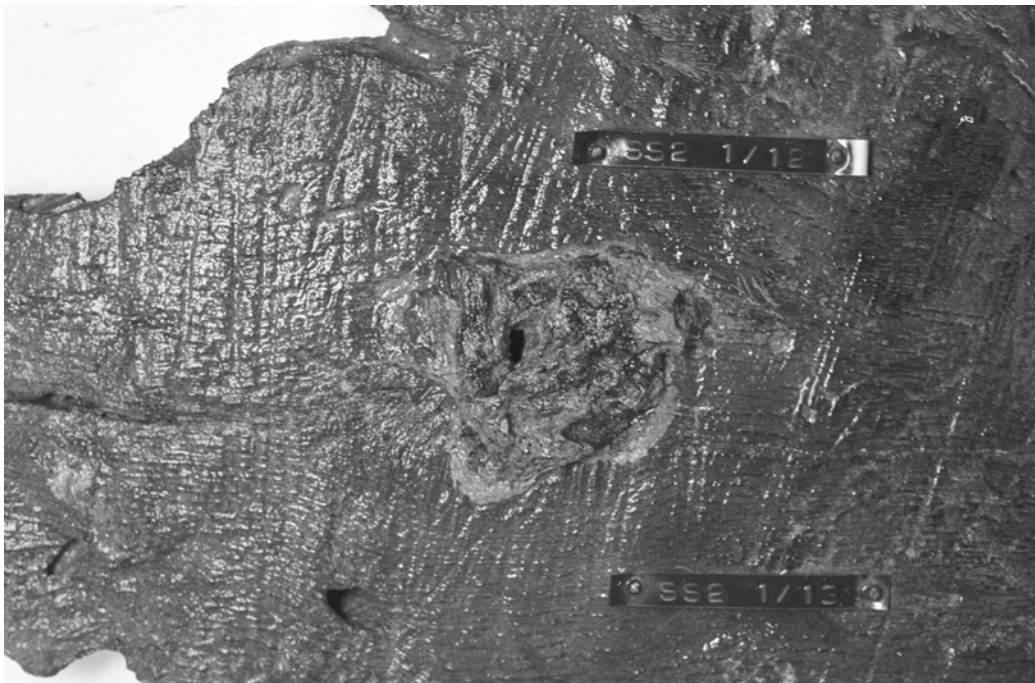


Figure 3-114: Photograph of the saw marks on strake three.

Two dendrochronology samples were taken from this strake in 1999. Sample 21 encompasses the forward 18.4 cm from fragment SS2 2/62-2/63 in June, while sample 43, from fragment SS2 1/12-1/13, was taken in September. Sample 43 may be from the same tree as samples 26 and 35, from the second plank in strake 7. No species samples were taken from this strake.

As it was clear during the labeling process on site that this strake contained numerous fragments that might break during later handling and cataloging, many fragments in strake three are still identified by more than one label. Tags SS2 1/12 and 1/13 are on the same fragment, as are 1/24 and 1/24A, 2/26 and 2/27, 2/28 and 2/28A, 2/33 and 2/35, 2/52 and 2/53, 2/62 and 2/63, and 2/69 and 2/70. The longest preserved fragment in this strake, located in plank four, is identified as SS2 2/65, 2/66, 2/67, 2/68 and 2/71.

The fragmentary nature of the strake, and the small size of some of the fragments, also made the accurate placement of some fragments difficult during the one-to-one drawing process. The locations of these fragments have since been corrected on the planking fragment plan, and as such, the alignments of the fragments on the one-to-one drawings are superceded by these later drawings. It should also be noted that on drawing 182, the three nail holes along the inboard edge of fragment SS2 2/41 are in fact treenail holes, and have been drawn as such on later plans.

Lastly, the exposed face of the edge dowel present in fragment SS2 2/50 preserves a roughly .7 cm² indentation on that face. The square is demarcated diagonally from corner to corner, into four triangular sections, each declining towards the center of the square as if a nearly-blunt nail head was impressed into it. The indentation does not appear to be natural, or a result of breakage; it almost appears as if the end of the treenail was marked for a particular, presently unknown, reason.

Starboard Strake Four

Timber Numbers (Lot Numbers):

SS3 1/4 – SS3 1/5, SS3 1/10 – SS3 1/24, SS3 1/26 – SS3 1/34, SS3 1/36, SS3 2/1, SS3 2/4 – SS3 2/10, SS3 2/12 – SS3 2/46, SS3 1/19.P, SS3 1/29.P, SS4 2/42 – SS4 2/49

Old ID on site:

Starboard strake three

Dates Cataloged:

July 20, August 6, 1998; April 6, 8 and 9, June 25 and 27, 1999; May 28, 2000; July 20, August 5, 10, 12, 13 and 14, 2001.

Catalogers:

EAG, JC, JR, MBH

Drawing Numbers:

2, 51, 124, 129, 193, 195 to 197, 220, 181

Samples Taken:

Dendrochronology samples 16, 51 and 53

Preserved Dimensions:

Plank one: 4.26 m x .20 m x .034 m

Plank two: 5.2 m x .22 m x .037 m

Plank three: 2.5 m x .22 m x .032 m

Wood Type:

Quercus sp?

Condition:

The 71 preserved fragments that make up the three planks of strake four vary in size from 8.9 cm (SS3 2/12) to 88 cm in length (SS4 2/42), and in condition from fragile and well-eroded to fairly solid. The damage, disarticulation, and erosion is the most predominant along the first plank, as many of the fragments retain so few original edges that they cannot be realigned into one contiguous plank. The few fragments of plank one that may be realigned, SS3 1/13 to 1/32, only account for the forward 1.4 m of the plank. The remaining plank material is only represented by five fragments, SS3 1/4, 1/5, 1/10, 1/11 and 1/12, near floor timbers 15 through 12. Of the realigned material, it has suffered the most from longitudinal damage due to the proximity of the plank's pith. No material from the middle of the forward end of the plank is preserved, it has all split and eroded away from either edge. The inboard and outboard edges themselves are in fair shape, somewhat eroded, fragmented, and friable, but the fractured interior edges are the worst, being both splintering and delicate. The exterior faces are fairly solid, having been protected by the pitch, but erosion is still evident near the fragments' transverse breaks.

The interior faces have suffered similar erosion near the broken edges as well, and are additionally friable and slightly splintering.

Discontinuity is evident in the second plank as well, but only at its aft end. The forward 4.74 m of this 5 m plank is composed of a continuous series of 35 reassembled fragments while the last fragment, SS3 2/1, is separated from the rest by a gap of approximately 34 cm. Longitudinal damage is prevalent along the middle of this plank as well; the disarticulation of the fragments, however, is not a result of this weakness. This damage is evident in two sections, a long weak section between fragments SS3 2/9 and 2/32, and between fragments SS3 2/35 and 2/44. Longitudinal splits and wear have weakened the plank's fragments, but has not yet resulted in the loss of any material. Portions of the inboard and outboard edges are preserved as well, but so little of the inboard edge is evident it is nearly non-existent. The inboard edge is eroded, friable, and delicate, and preserves almost no diagnostic information. In light of the fairly good preservation of the outboard edge of strake three, this damage seems incongruous. The outboard edge of plank two in strake four, in comparison, is much more coherent. The fragments themselves are often preserved completely to their outboard edges, and the edge itself preserves its original faces and inclinations. The internal face of the second plank is fairly coherent, with little surface pitting and erosion predominantly found near the broken edges. The external face is similar, retaining the most damage near the ends of the plank.

Plank three, in comparison to plank one, preserves a larger proportion of representative material along its length, but it too is very disarticulated. The largest preserved fragment in the strake, SS4 2/42, is isolated from SS4 2/44 by approximately 50 cm, while SS4 2/48 does not join to 2/47 or 2/49 to either side. The plank's preservation decreases in quality towards the forward end of the plank as well. Despite the large gap between SS4 2/42 and 2/44, the fragments themselves are still coherent and fairly solid; SS4 2/42, due to its awkward shape, is tricky to carry and maneuver, but it still retains structural integrity. Some splintering and sparse pitting is evident along the interior faces of SS4 2/42 and 2/44, but this damage is not widespread. The remainder of the preserved internal faces along the plank's length decrease in quality and condition towards the bow, but not as noticeably as the exterior face. On the very forward fragment of the plank, SS4 2/49, the

exterior face is eroded and friable, retaining very delicate edges and almost no diagnostic information. The edges of this plank too vary from a well-preserved diagonal scarf edge in SS4 2/42, to non-diagnostic in SS4 2/45-2/49. Similar to plank two, the inboard edge is more fragmentary and eroded than the outboard edge, but overall, neither is preserved to a large extent.

Joinery:

No material from either hood end of strake four is preserved, so there is no evidence pertaining to the manner in which this plank was affixed to either the stem or stern. The only joinery or carpentry of note are the two diagonal scarfs between the three planks, and the dowel joints in the inboard and outboard edges.

Both of the diagonal scarfs in this strake are inclined in the same direction; the outboard edge of the scarf is closer to the bow than the inboard edge. Of the two scarfs, the first between planks one and two is the larger, originally 34 cm long, although only scant edges of it are now preserved. Only 5 cm of the aft edge is still preserved on fragment SS3 1/34, which aligns with the 7 cm preserved of the forward edge on fragment SS3 2/1. The forward scarf, near floor timbers I and J, is better preserved and retains 19 of the original 20 cm-long edge on SS4 2/42. The entire scarf edge on SS4 2/42, however, is 49 cm long, as the inboard portion mates to the second plank in strake four, and the outboard portion mates to the fifth plank in strake five. Both strakes four and five taper towards the forward end of the ship until their combined width has narrowed to approximately 28 cm, the same width as fragment SS4 2/42.

Portions of 25 dowel joints are present along planks one and two of strake four; 14 along the outboard edge, ten along the inboard edge, and the remaining one, in fragment SS3 1/36, in the diagonal scarf between planks one and two. Fourteen are still round in cross section, five are hexagonal, and three each are pentagonal or square. Collectively, they average 1.2 cm in cross-sectional width. Among the portions of these 25 dowel joints, nine along the outboard edge align with dowel joints along the inboard edge of strake five, while only three dowel joints along the inboard edge of strake four are complete, due predominantly to missing material along the outboard edge of strake three. Missing material accounts for the incomplete nature of ten dowel joints along strake four; only the

incomplete dowel joint in fragment SS3 1/31-1/32 is such due to the apparent replacement of material in strake three. Two of the dowel holes along plank two, in fragments SS3 2/31 and 2/33, are empty and complete, having never apparently been used. As such, they are similar to the single empty hole in fragment SS2 2/54 but in these two latter cases, their disuse was compensated for by the production of two additional dowel joints nearby. Approximately 9 cm aft of the empty hole along the inboard edge of fragment SS3 2/31, a square dowel is evident, mating to the other half of the joint in fragment SS2 2/47. Similarly, a second dowel is present approximately 3 cm aft of the empty dowel hole in the outboard edge of fragment SS3 2/33. This latter dowel joint in SS3 2/33 is unfortunately incomplete due to missing material across the plank seam in strake five, but it was nonetheless originally in use. No dowel joints are found in the third plank of strake four.

Fastenings:

A total of 19 treenails or treenail holes are preserved along the length of strake four. All preserve a hexagonal or nearly hexagonal shape, and vary between 1.1 to 1.5 cm in cross-sectional width. Only four treenails or treenails holes are not aligned with another fastener in the planking. Three of these treenails, in fragments in SS3 1/23, 2/8A and 2/14, have no other aligned fasteners due to missing material along the inboard portion of the strake. The last treenail, in SS2 2/48, is similarly isolated due to a loss of material along the outboard portion of the fragment. The distribution of the 15 remaining treenails indicates that other than at midships, where there is a pair of treenails, only one treenail is associated with each floor timber, driven through the plank 4.5 to 9.8 cm from the outboard edge. No treenails or treenail holes are preserved in plank three.

As indicated by the preserved holes left in strake four, all of the metal fasteners that affixed this strake to the floor timbers were nails; no bolts were used. All in all, 45 nail holes are present in the three planks of strake four, varying in shape between well-preserved square holes and eroded holes now round in shape. Similar to other examples, the square nail holes average $.65 \text{ cm}^2$, while all 45 holes, including the eroded examples, result in an overall average size of $.78 \text{ cm}^2$. Discounting the disarticulated fragments in plank one, as too much material is missing to identify a particular pattern, throughout planks two and three, nearly every metal fastener is at least half of a pair of fasteners associated with a floor

timber. Those four nail holes that are not, in fragments SS3 2/4, 2/24, 2/42 and 2/44, are such due to missing material, not due to an aberration in the pattern. Overall, if a nail hole is not paired with another nail hole, it is always paired with a treenail or treenail hole. There are six examples of nail holes associated only with other nail holes – one of which, in fragments SS4 2/45 and 2/47, is a collection of three – and eight examples of a nail hole paired only with a treenail hole. Lastly, there are four examples of nail holes paired not only with another nail hole, but aligned with at least one treenail hole as well. Along the length of strake four, then, nearly every floor timber was attached to the strake with at least two fasteners.

Marks and Coatings:

Of the 71 preserved fragments in this strake, only two fragments, SS3 1/16 and 2/1, do not have exterior pitch on their exterior faces. The remaining 69 fragments retain exterior pitch on their exterior faces, although erosion may limit the extent of this coverage. Internal pitch is not as prevalent as external pitch, but it is nonetheless preserved on 25 of the fragments from all three planks. On the majority of these fragments, the extant internal pitch appears to represent only accidental drops or spills as their extent is commonly less than 7 x 4 cm. The application of the internal pitch evident on SS3 1/22, 1/29, 1/30, 1/36, 2/4, 2/8, 2/13 to 2/16, 2/31 to 2/32, and 2/42, however, appears to be more purposeful. The internal pitch on SS3 1/22 and 1/29 is concentrated around the treenails evident in each fragment, while that evident on fragments SS3 1/36 and SS4 2/42 is lining the outboard and, in the case of SS4 2/42, scarf edges of the fragment. Fragments SS3 2/4, 2/8, and 2/13 to 2/16, all just aft of midships, are particularly well-coated with internal pitch, possibly associated with the heavy application of internal pitch along strake one in a similar location. Fragment SS3 2/31-2/32 retains an application of internal pitch as well, in a tapering vertical strip 20 cm long and 4 cm wide at the most. As it maintains a distinct forward edge but a faded after edge, this strip of internal pitch presumably demarcates the location of the aft edge of floor timber D. Two fragments in the first plank of strake four, fragments SS3 1/14 and 1/17, retain internal pitch on their internal faces as well, but in both cases, the pitch is stained white for an unknown reason. Due to the proximity of these

two fragments to floor timber 9, which also has white staining or a white sealant on its surface as well, all three substances are most likely the same product.

The saw marks preserved on the fragments of strake four vary less in inclination and relative preservation than those on strake three (fig. 3-115). Overall, the majority of the saw marks on strake four are approximately 90 degrees to the inboard edge of the fragment, so they tend to incline towards the bow in plank three and away from the bow in plank one, but scattered examples of saw marks between 75 and 115 degrees are evident. One fragment, SS4 2/42, appears to preserve a small collection of marks inclined approximately 45 degrees to the bow, but these are a unique example. Only in a few cases, predominantly on the fragments forward of midships, are the saw marks faint and difficult to find. More commonly the preserved marks are distinct, parallel, and straightforward to identify. The cutting of the internal faces of planks two and three proceeded from the forward to aft ends of the planks, while the cutting of plank one proceeded in the opposite direction, towards the forward end of the plank. No adze work is preserved along the length of strake three.

Other Comments:

Three dendrochronology samples were cut from strake four, one in 1998 and two in 2002. The first, sample 16, was retrieved from SS3 1/5, the second was cut from SS3 1/4, while the last was cut from SS3 1/33-1/35. Among them, only samples from SS3 1/5 and 1/33-1/35 yielded enough rings to aid the dating process.

Due to the poor preservation and disarticulate nature of plank one, and the fragmentary nature of plank three, approximately 32 fragments have been cataloged without a precise knowledge of their location along strake three. Some of these fragments, such as SS3 1/20, 1/22 to 1/24, and 1/27 to 1/32, are drawn in a particular arrangement on drawing 197, but this drawing is only an approximation of their original orientation. A more precise arrangement may be found on the fragment plan. Moreover, similar to strake three, 11 fragments of this strake are labeled with more than one tag. Among these fragments, SS3 2/19-2/22 is the only one identified by three different tags, while SS4 2/49 is also listed as UM 585. The first plank of strake three is also notable for fragments SS3 1/15 and 1/16, which split transversely across the plank at a 45-degree angle, due to the apparent presence of the base of a branch growing from the inboard edge of the plank.

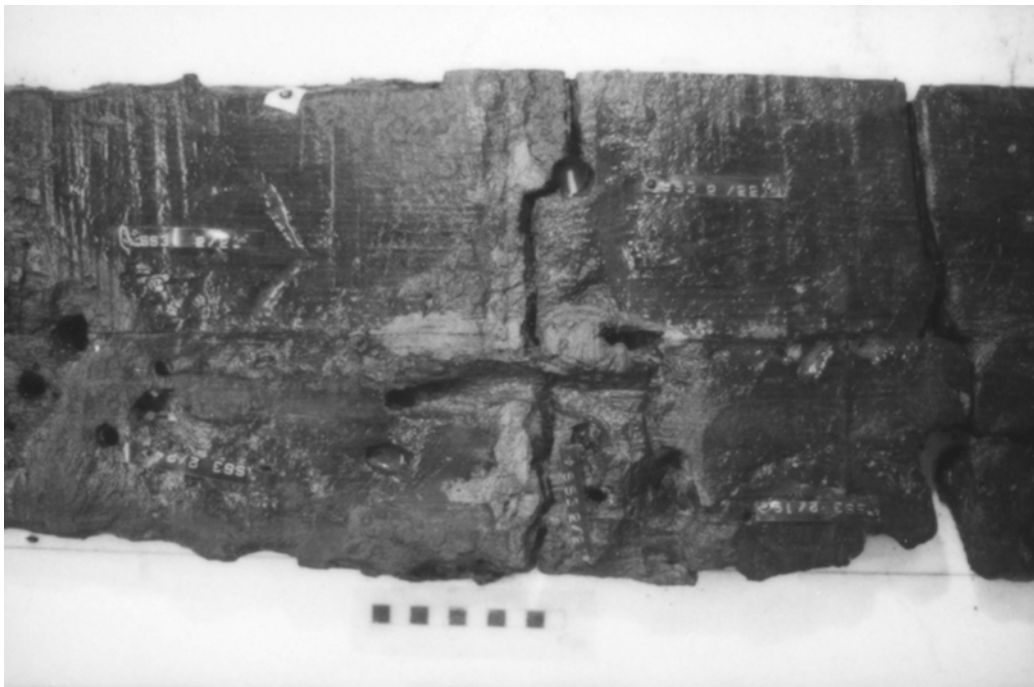


Figure 3-115: Photograph of the saw marks on strake four.

This branch was removed prior to the fashioning and affixing of the plank in place, but the grain, which crossed the plank at 45 degrees, remained and created weakness in this area. One other possible structural weakness along the second plank is preserved as well, in fragment SS3 2/7. This fragment is noted for a distinct, partially round absence along one broken edge, an absence that may have once represented a weakness due to a knot still in place in the plank. Once the ship wrecked and the planking broke apart, stress focused around this knot, fracturing this fragment from the next around this weak area.

Starboard Strake Five

Timber Numbers (Lot Numbers):

SS4 1/2 – SS4 1/3, SS4 1/10 – SS4 1/20, SS4 1/22 – SS4 1/25, SS4 1/31, SS4 1/33, SS4 1/35 – SS4 1/43, SS4 2/1 – SS4 2/4, SS4 2/6 – SS4 2/10, SS4 2/12 – SS4 2/27, SS4 2/29 – SS4 2/35, SS4 2/37 – SS4 2/41

Old ID on site:

Starboard strake four

Dates Cataloged:

June 26, 1999; August 2, 3, 4, 5 and 27, 2001.

Catalogers:

MBH

Drawing Numbers:

125, 126, 188 - 192, 194, 208

Samples Taken:

Dendrochronology samples 17, 20, 23, and 41

Preserved Dimensions (averages):

Plank one: 5.6 m x .20 m x .031 m

Plank two: 1 m x .21 m x .032 m

Plank three: 4.4 m x .22 m x .030 m

Wood Type:

Quercus sp? and *Castanea* sp?

Condition:

This strake consisted of three planks at the time of the ship's sinking. One plank was aft of floor timber 3, the second, being only 1 m long, stretched between floor timbers 3 and 1, while the last extended forward from floor timber 1 to floor timber J, where it mated to the outboard half of the diagonal scarf in the third plank of strake four. All in all, the strake originally extended approximately 10 m from the sternpost to the forward diagonal scarf. Unfortunately, only 20 fragments are preserved from the first plank, nine from the second plank, and 42 from the third. Of the first two fragments of this strake, SS4 1/2 and 1/3, both are relatively solid, although their edges are friable and, in the case of SS4 1/3, the extremities are delicate. Neither is affected detrimentally by worm damage, although slight erosion on the exterior faces tends to weaken both fragments.

The remaining 18 fragments of plank one, from SS4 1/10 to 1/35, are all fairly similar in preservation. No fragment is over 30 cm in size and none of the fragments preserve both the inboard and outboard edges of the plank. The longest representative section of this first plank is made up of only two fragments, SS4 1/14 and 1/15, which is 48.6 cm long. Worm damage is generally minimal along all of the fragments of the first plank; more structural integrity is lost due to erosion and splitting. Due to the fragmented nature of this plank, many of the fragments are relatively small and light with friable edges and occasionally delicate surfaces. Most commonly the fractured edges of these fragments are more delicate than the worked edges.

The nine fragments of plank two are similar in condition and preservation to those in plank one; they are relatively small and light – the largest surviving fragment is only 40 cm long – there is minimal worm damage, and the fractured edges tend to be more friable and delicate than the worked edges. More worked edges are preserved in plank two, however, including the remains of the aft scarf face to plank one. Moreover, as these nine fragments may be realigned into one substantial piece of the original plank, it is also clear that this small plank was also prone to longitudinal splitting.

Although a larger percentage of the third plank of strake five is preserved, there are still lacunae and tenuous joins along its length. Material is missing, for example, between fragments SS4 2/3 and 2/4, near the aft end of the plank, and the joins between fragments SS4 2/25 and 2/27, and SS4 2/32 and 2/33, are across eroded fractured edges, not cleanly

mated faces. There are similar gaps in the condition of the inboard and outboard edges as well. The inboard edge is well preserved and clean from fragment SS4 2/1 to 2/25-2/26, but is eroded and fractured from that fragment forward to SS4 2/33, where it continues on to SS4 2/38. The outboard edge is preserved in a number of sections, from SS4 2/1 to 2/3 along the diagonal scarf, and SS4 2/8 to 2/17, but it disappears entirely until fragment SS4 2/25, where it survives in short, slightly rounded sections along the rest of the plank to fragment SS4 2/39. Generally, erosion evident on the internal or external faces is present due to damage sustained during the wrecking or post-depositional stage. Longitudinal splitting, for example, follows a diagonal path across the width of the plank, from the inboard edge of SS4 2/2 to the outboard edge at SS4 2/19. This splitting, similar to other examples, is due to the location of the pith along the plank, and similar longitudinal splitting is present from fragments SS4 2/32 to 2/41. Most commonly, this damage fractures the fragments into only two pieces across the width of the plank, although among fragments SS4 2/12 to 2/15 the plank appears to have been either extraordinarily weak, or have been subjected to acute stress after wrecking, as the plank is fractured into eight fragments in the space of only 40 cm. There is little worm damage along the length of the plank; it is present, but a greater loss of structural integrity is due to splitting and fracturing during the wrecking and post depositional processes.

Joinery:

No hood ends of this strake are preserved, so there is no evidence illustrating the joinery involved in mating this plank to the stem or stern rabbet. Moreover, although three planks make up this strake, only small sections of the two diagonal scarfs are preserved. Only 19.5 cm is preserved of the forward half of the diagonal scarf between planks three and four. This preserved scarf edge along plank four is still fragmentary, composed of four different fragments. No material preserves the aft half of this diagonal scarf edge in plank one. No portion of the scarf between planks two and three is preserved on plank two, but plank three retains 48 cm of that scarf edge, distributed along fragments SS4 2/1, 2/2, 2/3 and 2/5 (fig. 3-116). At the forward end of strake five, where it drops out and mates to strake four, only 5 cm of the aft half of that diagonal scarf is preserved on strake four. In comparison, 29 cm of the mating edge is preserved on the third plank of strake three (fig. 3-



Figure 3-116: Photograph of the diagonal scarf edge of plank three in strake five.

117). Of these three diagonal scarfs, the latter two are inclined in a similar fashion towards the bow of the vessel; the outboard edge of the scarf is closer to the bow than the inboard edge. Despite the paucity of preserved material in the third preserved scarf, that between planks one and two, it is evident that it is inclined in the opposite manner; the inboard edge of the scarf is closer to the bow than the outboard edge.

In contrast to the small number of preserved treenails in this strake, the 21 portions of dowel joints preserved in strake five is comparable to the 25 preserved in strake four. Among those 21 dowel joints, 11 are in the inboard edge of the strake, eight are along the outboard edge, and the remaining two are in fragments SS4 2/2 and 2/3, along the diagonal scarf edge to plank three. They vary in size from .9 cm in diameter to a rectangular dowel 1.7 x 1.1 cm, and in shape from predominantly round to hexagonal, square, rectangular, ovoid, and D-shaped. They average 1.2 cm in cross-sectional width, and of the five that do not align with another dowel in another plank or strake to form a complete dowel joint, four are incomplete due to replaced planking material. The fourth plank in strake six appears to have been replaced, thus the dowel in the outboard edge of SS4 2/41 has no mate, similar to the three dowels along the scarf edges of SS4 2/2 and 2/3. These three dowels, which cross the diagonal scarf between planks two and three perpendicularly, do not have any associative material across the scarf to mate to in plank two. As the dowel joints in strakes four and six that surround plank two do not have coordinating dowel joints, this short plank in strake five appears to be a repair. The last dowel joint, along the inboard edge of SS4 2/2, is missing material across the strake seam in plank three to mate with, but presumably, this was once a complete dowel joint.

These three partial dowel joints at the diagonal scarf in SS4 2/2 and 2/3 are notable not only because they are the only three examples of dowel joints that cross a scarf seam perpendicularly, but the two in SS4 2/2 are particularly interesting as the second dowel appears to have been driven into a hole drilled through the first dowel. It is unclear what the relationship between these two dowels was, and if this possible repair is related to the presence of plank four as a repair as well, but it is clear that dowel A, the larger of the two, passes into dowel B, the smaller of the two. Dowel B, which was originally round and approximately 1.1 cm in diameter, was driven into place first. Some time afterwards, a



Figure 3-117: Photograph of the diagonal scarf edge of plank three in strake four.

second hole was drilled adjacent to dowel B, partially cutting into its outboard half. Dowel A, a much larger rectangular dowel measuring 1.7 x 1.1 cm, was then driven into this second hole, thus partially obscuring dowel B. These three dowels along the edge of the diagonal scarf between planks four and five are the only dowel joints oriented along a scarf edge in strake five.

Fastenings:

This paucity of preserved material also results in a lack of preserved treenails. Of the 14 treenails or treenail holes identified in strake five, 11 are in plank three, two are most likely in plank two, while the last, in fragment SS4 1/18, is in plank one.²¹ As planks one and two are so fragmentary, the only reliable information regarding any patterns associated with these treenails can be gleaned from plank three. In that collection two treenails, in fragments SS4 2/4 and 2/25-2/26, are not paired with any other fasteners; the latter may be isolated in such a manner because its identification as a treenail is questionable. There is only one pair of treenails associated with a floor timber, in fragment SS4 2/21, as all other treenails associated with floor timbers are paired with nails. Among those treenails paired with nails, only that in SS4 2/16 is aligned with more than one nail. All the treenails in strake four are hexagonal in cross section, and average 1.3 cm in cross-sectional width.

The small number of well-preserved fragments in strake four also results in an equally small percentage of preserved nail holes and data about them. A total of 32 nail holes are preserved along the length of strake five, 15 each near the inboard and outboard edges and the remaining two in the middle of the strake. Altogether, they average .73 cm in cross-sectional width, although six of the nail holes are now round and eroded. Removing these six, the remaining 26 average .63 cm², a size comparable to the other nail holes found throughout the planking. Unfortunately, 11 of the 32 nail holes are associated with missing material across the plank's width. As such, while it may be assumed that they were originally one of a pair of fasteners, no information on this pairing is now available. The other 21 nail holes display a fastening pattern similar to that in strake three: every nail hole is one of at least two fasteners affixing the planking to the associated floor timber. Four pairs of fasteners, near the extremities of the strake, are made up of nails only. A fifth pair of nail holes in fragments SS4 2/6 and 2/7 are aligned with one treenail hole in SS4 2/8,

while the series of four aligned nail holes in fragments SS4 2/12, 2/13 and 2/16 are aligned with a treenail, also in SS4 2/16. Lastly, seven nail holes, even two of which with questionable identifications, are aligned or associated with a treenail hole nearby.

Marks and Coatings:

External pitch predominates along the external face of nearly all of strake five, but internal pitch is evident only on the internal faces of 25 of the 71 preserved fragments. As the preservation of the external pitch is directly related to the preservation of the fragment itself, the external pitch of some fragments, such as SS4 1/17 and 1/18, is worn and damaged due to the erosion and breakage of the fragment itself. In most cases, however, the external pitch is still well preserved and fairly pliable, with some ridges and whorls intact. The internal pitch, similar to examples on strake four, is thin and faded on some fragments, while still distinct and widespread on others. The internal pitch evident on nine fragments appears to represent accidental applications, particularly an ovoid drop of pitch on SS4 2/22, while the remaining applications appear to seal either the inboard or outboard strake seams or, such as that on SS4 1/41 and 2/41, scarfed edges. Although some internal pitch appears to be associated with fasteners in the planking, such as a treenail in SS4 1/15 or a series of nail holes in SS4 2/17, there are no distinct edges or sharp demarcations in the internal pitch to indicate it was applied on or near floor timbers.

Of the three planks representing strake five, saw marks are evident on the internal faces of all of them. Nearly all of the preserved saw marks are distinct and easily identifiable, but not necessarily grouped into large collections. All the saw marks on plank one are similar in inclination and cut direction. They are inclined between 90 and 115 degrees away from the bow, and in all cases, the cut proceeded towards the forward end of the plank. The cutting of the interior face of plank two proceeded in the same direction, towards the forward end of the plank as well, but the saw marks are distinguished from those on previous planks by their almost perpendicular orientation to the keel. The saw marks evident on the third plank of the strake, in comparison, are not only inclined less than 90 degrees, as low as 50 degrees on fragment SS4 2/17, but the cutting of the interior surface of the plank proceeded towards the stern of the vessel as well, unlike the previous planks.

Only two fragments of strake five preserve evidence of adze work. Fragments SS4 2/2 and 2/31 preserve dubbing marks across its interior face that appear to have been fashioned parallel to the length of the plank; no nick in the blade of the adze is evident. There is not enough evidence to indicate in which direction the cutting proceeded.

Other Comments:

As the first plank of strake five has such a large number of isolated fragments, and a relatively small number of original edges, the exact location and alignment of many of these fragments at the time of their cataloging was unknown. As such, they are placed on the fragment plan in the same location that they were mapped in on the seabed. One-to-one drawings 188, 189, 191, 192, and 208, moreover, illustrate nearly all of these fragments in isolation, having made no attempt to draw them in an appropriate orientation to the surrounding fragments in the strake. Drawing 125 illustrates fragment SS4 1/2 in isolation as well, but was done so to record the full size and shape of the fragment prior to cutting a dendrochronology sample.

Fragment SS4 2/4 is illustrated in drawing 194 immediately forward of fragment SS4 2/3. This is an incorrect location. Fragment SS4 2/5, which mates to SS4 2/3, was found in the summer of 2002, and it, along with fragment SS4 2/4, is placed correctly on the fragment plan. Two fragments of this strake are labeled with more than one tag. Fragment SS4 1/38 is also labeled as SS4 1/39, while fragment SS4 2/7, is also identified as 2/8 and 2/9.

Four dendrochronology samples, numbers 17, 20, 23 and 41 were taken from strake four; samples 17 and 41 from the same fragment, SS4 1/3. Samples 20 and 23 were taken from fragments SS4 1/2 and 2/20, respectively, in June of 1999. Other than its aid in dating the vessel, the sample from SS4 2/20 also revealed that the third plank of strake five is chestnut, not oak. This is the only sample that indicates that chestnut was used in the construction of this vessel.

The portion of the dowel joint in fragment SS4 2/3 is particularly informative as the interior face of the fragment has eroded away, exposing the interior surface of the dowel hole, as well as the interior portion of the dowel itself, still in place. In this case, the dowel was driven completely into the hole and subsequently impacted with the bottom of the

hole. Additionally, the hole itself compressed around the dowel, acquiring a hexagonal cross-sectional shape.

Starboard Strake Six

Timber Numbers (Lot Numbers):

SS5 1/1 – SS5 1/4, SS5 1/11 – SS5 1/14, SS5 1/16 – SS5 1/17, SS5 1/19, SS5 1/23 – SS5 1/25, SS5 1/27 – SS5 1/39, SS5 1/42 – SS5 1/46, SS5 2/1 – SS5 2/30, SS5 3/1 – SS5 3/11, SS5 3/13 – SS5 3/18

Old ID on site:

Starboard strake five

Dates Cataloged:

July 17, 21, 24 - 26, and 28, 1999

Catalogers:

MBH

Drawing Numbers:

124, 132 – 135.

Samples Taken:

Dendrochronology sample 56

Preserved Dimensions (average):

Plank one: 6 m x .22 m x .034 m

Plank two: 2.16 m x .24 m x .028 m

Plank three: 2.86 m x .22 m x .031 m

Plank four: 4 m x .20 m x .03 m

Wood Type:

Quercus sp?

Condition:

Similar to the fragments in other strakes from the Bozburun vessel, the 72 preserved fragments of the four planks in strake six are noted for their general absence of widespread worm damage. Where worm damage is evident, it is predominantly found near the strake's extremities, and is often in conjunction with heavily eroded material as well. The first few fragments of strake six, SS5 1/1 to 1/4, for example, exhibit friable and delicate faces due

to erosion as well as *Teredo* damage. These fragments at the aft end of plank one are some of the most delicate and fragile among all the preserved planking material. Their internal and external faces are eroded, pitted and friable, and erosion has eliminated almost all traces of original surfaces and edges. In all cases, these planking fragments should be handled as little as possible. When they are to be lifted from the water and examined, they should be lifted and supported using a piece of closed-cell foam as described in the Methodology chapter.

The remaining fragments of plank one, SS5 1/23 to 1/30, still have somewhat friable edges and faces, but overall, they have less worm damage and more overall structural integrity. Portions of inboard and outboard edges are preserved, as well as 5 cm of the diagonal scarf to plank two. Much of the plank is still fairly disarticulate, however.

Plank two retains none of the original scarf edge to plank one, however, long sections of the outboard edge are preserved, as are shorter sections of the inboard edge, as well as 16 cm of the diagonal scarf edge to plank three. In comparison to plank one, plank two has much more structural integrity, as well as a much higher percentage of preserved material; approximately 80 to 90 percent of the plank is represented. The inboard edge of the plank is fairly fragmented and eroded, preserving very little diagnostic information, and there are gaps between fragments SS5 1/37 and 1/38, and 1/38 and 1/42.

The integrity and quality of the material increases in plank three, with fairly solid fragments, better structural damage, and little or no worm damage. Erosion, where evident, is confined predominantly to fractured and broken edges; the fashioned edges, where preserved, tend to stay fairly coherent. Sections of the inboard edge are preserved, for example, but the edge as a whole is still fragmentary and disarticulate in comparison to the outboard edge. The aft end of the plank, from fragment SS5 2/12 to 2/30, has suffered from longitudinal splitting, most likely due to the location of the plank's pith.

Plank four preserves the largest fragment in this strake; SS5 3/5 - 3/9 is one fragment 1.35 m long. This fragment, and those aft, are solid and heavy and retain little structural damage. They have good internal and external faces, clean edges, and little friable surface area. The fragments farther forward in the plank, SS5 3/10 to 3/18, tend to retain

slightly more friable fractured edges and surfaces, as well as the threat of longitudinal splitting, but overall, they are still fairly coherent.

Joinery:

The only item of joinery that distinguishes this strake from those inboard is the small joggle cut in the outboard edge of the fourth plank (fig. 3-118). This joggle is approximately 3 cm deep, and was fashioned to fit the outboard edge of strake six around the toe end of the third plank in strake seven. Clearly, this portion of strake seven was in place prior to the insertion of the fourth plank of strake six. All other items of joinery in strake six, the scarfs, treenails, and edge dowels, are similar to those in other strakes.

Strake six is partitioned into four planks by the presence of three scarfs, an S scarf between planks three and four near floor timber H, and two diagonal scarfs dividing planks one and two and planks two and three (fig. 3-119). The first diagonal scarf, that between planks one and two near floor timber 4, was originally 42 cm long. Now, however, no original scarf edge is preserved along plank two, although the scarf's shape is still evident, and only 4.7 cm is preserved on plank one. The scarf between planks two and three, near floor timber A, originally extended 47 cm across the strake, although now only 17 cm of the scarf edge is preserved on plank two, and 23 cm is preserved in plank three (figs. 3-120, 3-121). Among these three scarfs, the S scarf and the first diagonal scarf are inclined the same way; the outboard edge of the scarf is farther from the bow than the inboard edge. The second diagonal scarf is inclined in the opposite manner.

The majority of the 24 partial dowel joints in the edges of strake six are square, the remaining examples are round, hexagonal, ovoid and D-shaped. None of the preserved dowels or dowel holes are rectangular in cross section. Four of the dowel joints, in fragments SS5 1/21, 1/32, 1/43 – 1/45 and 2/19, are incomplete due to missing material across the strake seam in either strake four or six. Of the remaining 20 joints, eight mate to material in strake six, seven mate to material in strake four and four join together the planks of strake five across the diagonal scarfs. Plank one is joined to plank two via a dowel joint between fragments SS5 1/30 and 1/31, while plank two is joined to plank three by the ovoid dowel from fragment SS5 1/46 to 2/2. This latter join happens to be the only complete dowel joint that is still intact; the dowel has not broken and fragments SS5 1/46



Figure 3-118: Photograph of the small joggle along the outboard edge of strake six.

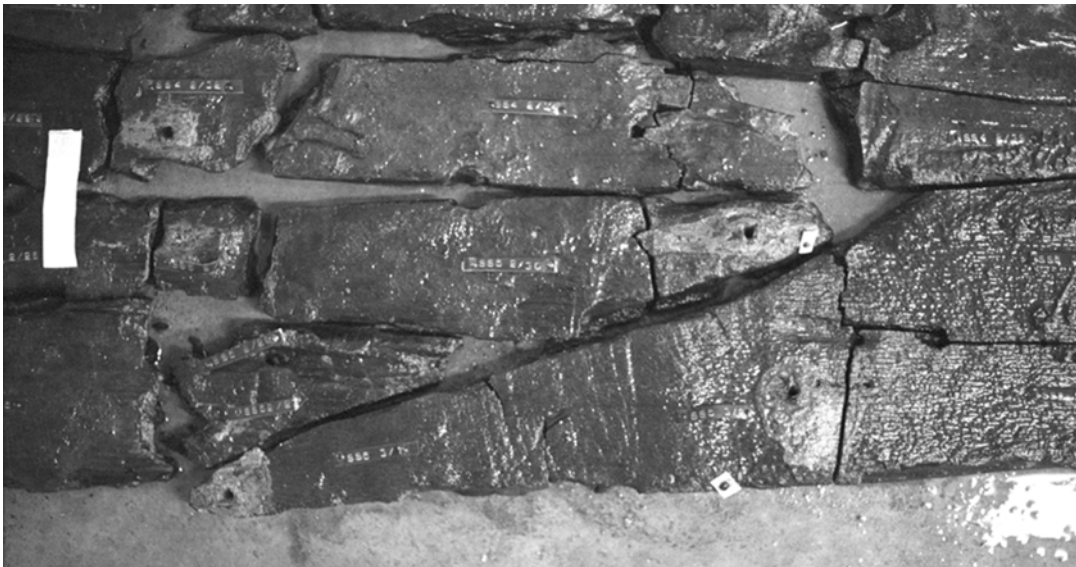


Figure 3-119: Photograph of the S-scarf between planks two and three in strake six.



Figure 3-120: Photograph of the diagonal scarf between planks two and three in strake six.



Figure 3-121: Another photograph of the same scarf.

and 2/2 are still joined together across the scarf seam (figs. 3-120, 3-121). In both of these cases, the dowel joint is perpendicular to the plank seam, and not the scarf seam. Moreover, no dowel joints pass across the S scarf to plank four. Extant material in fragment SS5 2/1 also indicates that a dowel joint passed from strake six to strake five at this point as well, securing the toe end of the plank to the outboard edge of strake five. Altogether, the dowel joints average 1.5 cm in cross-sectional width.

Fastenings:

There are a total of 19 preserved treenails or treenail holes along the length of strake six. All extant treenails or treenail holes are hexagonal, and average 1.4 cm in cross sectional width, although that width varies from 1.2 to 1.8 cm. Only three of these treenails, in fragments SS5 1/24, 1/38 and 2/23, are not part of a pair of fasteners due to missing material. All other examples are one of a collection of fasteners associated with a floor timber. In comparison to strakes four and five, each of which only had one pair of treenails associated with a floor timber, strake six has six pairs of treenails associated with floor timbers; five of which do not have any additional nail holes nearby. In contrast, there are only three isolated treenails, and two pairs of treenails, that are paired with a nail hole. Assuming that the three treenails associated with missing material were once part of a pair as well, then the pattern established in strake three remains; at least two fasteners are associated with each floor timber along each strake. Moreover, the treenails within strake six display a fairly consistent pattern to their distribution. No treenail or treenail hole is closer than 3.1 cm to either edge, or farther than 9.5 cm from either edge. Most commonly, the treenails were driven through the strake between 5 and 7 cm away from either strake seam.

The more segregated pairing of the strake's fasteners is evident in the distribution of the 36 nail holes as well. Among them, seven holes have no adjoining hole across the plank due to missing material, while of the remaining 29, only five are paired with a treenail or a pair of treenails across the plank. The remaining 24 are evenly distributed among 12 pairs of nail holes at each frame station; there is no group of three or more nails at one floor timber. Including the seven examples of now round, eroded nail holes, all 36 average .68 cm in cross sectional width. One nail hole is preserved along the outboard edge of the

fourth plank of strake six, 4 cm aft of the small joggle. This nail hole, which is .5 cm², coordinates with another nail hole through the toe end of the third plank in strake seven. By aligning these two nail holes, it is clear that the tapered forward end of strake seven was toe nailed to the outboard edge of strake six. There are no recorded bolt holes in strake six.

Marks and Coatings:

Along the length of the strake, the amount of external pitch is directly related to the preservation of the external faces of the fragments. As such, on the first few degraded fragments of plank one external pitch is present but only in small areas, due to erosion of the external face. Similar circumstances lead to similar losses of external pitch on other fragments, such as SS5 2/10, 2/11 and 2/15, but generally, the external pitch is ubiquitous along the external faces of the fragments. Internal pitch is evident along the internal faces of the strake as well, in numerous areas that appear to represent purposeful applications. Some fragments, such as SS5 1/16, retain small drops of the sealant, while many more fragments preserve internal pitch along either the inboard, outboard, or scarf edges. Fragments SS5 1/1 – 1/2, 2/4, 2/19, 3/4 and 3/15 retain strips of internal pitch along their outboard edges, fragments UM 405, 1/29, 1/32, 2/7 – 2/9, 3/3, and 3/5 – 3/9 retain similar strips along their inboard edges, while fragments SS5 1/29, 1/31 and 1/32 preserve more internal pitch along their scarf edges as well. The vertical strips of internal pitch on fragments SS5 1/32 and 1/33 – 1/35 should be noted as they appear to bracket the uncoated area surrounding the two treenails affixing floor timber 3 to the plank. The internal pitch on fragments SS5 3/3 and 3/4 is interesting as well for two small lines of the pitch extend from either edge inward, at approximately 120 degrees, to meet at the center of the plank. It is unclear why the pitch is applied in this pattern; the hard edges of the pitch may indicate that it spilled around a hard-angled object, but the nature of the object is unknown.

Surprisingly diagnostic saw marks are preserved on the first few fragments of plank one, indicating that the cutting of the inboard face proceeded towards the forward end of the plank, and that the saw marks were generally perpendicular to the edges of the plank itself (fig. 3-122). After SS5 1/4, however, no more saw marks are preserved on plank one. The saw marks evident on planks two and three are similar as in both cases, the cutting of



Figure 3-122: Photograph of saw marks on strake six.

the internal faces of the planks proceeded towards the aft end of the planks and the saw marks themselves are particularly parallel, distinct, and very closely set together with regular spacing. The only differences between the two sets of saw marks are their inclinations; those on plank two are 120 to 125 degrees away from the bow of the vessel, while those on plank three are inclined 80 to 85 degrees towards the bow. Saw marks are preserved on plank four as well, although these tend to be fewer in number, faint, and particularly varied in inclination. The marks on SS5 3/1 and 3/2, for example, are inclined approximately 80 degrees towards the bow, those on fragment SS5 3/15 are perpendicular to the bow, while the scattered marks evident on SS5 3/5 – 3/9 vary between 75 and 100 degrees. It is unclear which direction the cutting proceeded, but presumably, all these marks were made during the same sawing procedure.

Adze marks are evident on strake six as well but, similar to strake five, only in small collections. Both sets of dubbing marks, on fragments SS5 1/37 and 2/7 – 2/9, are preserved near the worked edges of the fragment, and in both cases it appears that the dubbing proceeded across the width of the plank and not along its length. Whether the dubbing began or finished at the outboard or inboard edge is unknown. No nick is evident in the edge of blade used.

Other Comments:

Only one dendrochronology sample was retrieved from strake six. Sample 54, cut in 2002, was taken from fragment SS5 3/11.

Nine fragments from this strake, eight from the first plank, are not illustrated on the one-to-one drawings as their locations were unclear during the cataloging process. The last fragment not illustrated, SS5 1/39, fits into plank two near its forward end but, similar to the preceding eight fragments, its proper location is also unknown. Five other fragments, SS5 1/23, 1/24, 1/27, 1/28 and 3/14, are illustrated on their appropriate one-to-one drawings as well, however, their locations on those drawings are estimated.

It was evident during the labeling process on site that this strake was made up of numerous disarticulated and fragile fragments and so, many fragments are identified by two labels. Fragment SS5 1/1 is also labeled as 1/2, SS5 1/4 and UM 406 are on the same fragment, as are labels SS5 1/33 and 1/35, 1/43 and 1/45, 2/6 and 2/8, 2/17 and 2/18,

2/23 and 2/25, 2/24 and 2/26, and 2/27 and 2/28. Three fragments have more than two labels on them: SS5 2/7 is also identified as 2/7A and 2/9, SS5 3/5 is also labeled 3/6 through 3/9, and fragment SS5 2/16 is also labeled as 3/17 and 3/18.

Fragments SS5 1/46 and 2/2 are unique in this collection of plank material as they are the only two fragments still attached by a dowel joint. The two fragments are joined across a diagonal scarf between planks two and three, near the outboard edge of each plank. The dowel itself is approximately 1.3 cm in cross-sectional width, and ovoid in shape.

Starboard Strake Seven

Timber Numbers (Lot Numbers):

SS6 1/1 – SS6 1/8, SS6 1/10 – SS6 1/40, SS6 1/42 – SS6 1/63

Old ID on site:

Starboard strake six

Dates Cataloged:

June 25, 1999; August 3, 5, 12 and 27, 1999

Catalogers:

MBH

Drawing Numbers:

123, 137, 138 and 208, plus 11 others on catalog sheets.

Samples Taken:

Dendrochronology samples 18, 39, 40, 50, 52 and 54

Preserved Dimensions (averages):

Plank one: 1.3 m x .06 m x .032 m

Plank two: 1.3 m x .095 m x .035 m

Plank three: 6.36 m x .21 m x .034 m

Plank four: 2.44 m x .19 m x .031 m

Wood Type:

Quercus sp?

Condition:

Upon wrecking strake seven was composed of four planks, the longest of which, plank three, extended from floor timber 5 forward to floor timber L. Altogether, 64

fragments are preserved from these four planks, which re-assemble to represent over 90 percent of planks two and three, approximately 30 percent of plank four, and 20 percent of plank one.

Plank one does not begin at the sternpost but rather between strakes six and eight at approximately floor timber 12, where it proceeds to widen and continue forward 1.3 m. Only four fragments from this plank are preserved, all of which are relatively small, light, delicate and friable. Fragment SS6 1/1, for example, has no diagnostic information other than the empty dowel hole passing transversely through it. Fragment SS6 1/3, the largest of the four fragments, is only 16 cm long and preserves portions of its inboard and outboard faces, as well as portions of both edges. Fragments SS6 1/3 and 1/4 are also the only two fragments of plank one that fit back together, the rest of the plank is represented by the remaining two disarticulated fragments.

Plank two, extending along the five fragments from SS6 1/5 to 1/8, is much better represented by the extant material. All of its planking fragments are fairly solid and structurally coherent, and retain clean faces and edges. There is little worm damage evident, and generally, although all of the fragments should be handled with care, only SS6 1/8 is in imminent danger of breaking apart.

Plank three, the longest of the four planks, is heavily fractured but still retains a great deal of diagnostic information. The first few fragments of the plank, from SS6 1/10 to 1/15, have suffered from erosion and retain delicate edges, although their internal and external faces are still crisp. By fragment SS6 1/17, erosion is still evident along internal broken edges, but the inboard edge has improved in quality and preservation. More structural integrity, better-preserved edges and cleaner faces are evident in fragment SS6 1/20 and the following fragments, but from SS6 1/22 forward, the fragments also suffered from a longitudinal split. This longitudinal split results in numerous splintering and friable internal edges in the remaining fragments in the plank, although the surrounding fragment material is fairly solid and free of other damage. Erosion is evident, but it is predominantly found along broken internal edges. The inboard and outboard edges suffer from intermittent gaps and eroded sections, but most evident is the lacuna between fragments SS6 1/49 and 1/51. The broken edges in this area are friable and splintering, and generally,

only small portions of the inboard or outboard edges are preserved. SS6 1/49 is particularly fragile and light, and prone to wear.

The remaining four preserved fragments of the strake, SS6 1/58 to 1/63, represent plank four. Similar to the previous three planks, the broken edges of this plank tend to be more friable and delicate than the worked edges. The inboard and outboard edges tend to be only partially preserved, but where they are evident, they are still diagnostic. There is little or no worm damage evident along plank four, while the internal and external faces are still coherent and clean.

Joinery:

Although strake seven does not extend from the stem to the sternpost, it is still made up of a number of planks. Of the four planks in the strake, only planks three and four mate to each other via a diagonal scarf; planks one and two and two and three meet at butt scarfs. At the butt scarf between planks one and two, which was originally 8 cm wide, only 6.2 cm now remain along plank two on fragment SS6 1/5. The other butt scarf, originally just over 12 cm wide, is still preserved fairly intact on fragment SS6 1/8 on plank two, but no remains of the scarf are preserved on plank three (fig. 3-123). Very little remains of the diagonal scarf between planks three and four. Only 11.5 cm of the 57 cm scarf edge is preserved on plank three, along fragment SS6 1/57, while only 12 cm is preserved on plank four, along fragment SS6 1/59. This diagonal scarf is inclined similar to the nearby scarf in strake six; the inboard edge of the scarf is closer to the bow than the outboard edge.

In conjunction with this diagonal scarf is the joggle mentioned in the description of strake five. Along the inboard edge of this diagonal scarf, the forward end of plank three tapers to a point that tucks under the coordinating scarf edge of plank four. Unlike other diagonal scarfs in this vessel's planking, however, the inboard edge of plank three is not flush with the adjacent inboard edge of plank four; at this point, the toe end of plank three intrudes approximately 3 cm inboard towards strake six. To accommodate the toe end of plank three in strake seven, the fourth plank in strake six has the single 3 cm-deep joggle along its outboard edge.

There are 22 portions of dowel joints in the inboard and outboard edges of strake seven. Thirteen of these are round, four are hexagonal, four are square, and the last is



Figure 3-123: Photograph of the butt scarf in strake seven.

pentagonal. Altogether, these dowel joints average 1.21 cm in cross-sectional width. Of the 14 portions of dowel joints along the inboard edge, eight mate to coordinating material in strake six. Among the remaining six along the inboard edge, only the edge dowel in SS6 1/1 is part of an incomplete joint due to missing material; the remaining five meet a blank edge due to the replaced fourth plank in strake six. Of the eight portions of dowel joints along the outboard edge of strake seven, in contrast, only one, that in SS6 1/62 – 1/63, coordinates with a dowel joint in strake eight. The other seven portions of dowel joints along the outboard edge of strake seven all meet a blank inboard edge, possibly indicating that three of the four planks of strake eight are replacements. Although a dowel passes from the scarf edge to the inboard edge of SS6 1/57, it is assumed that this dowel did not cross the diagonal scarf to join the third and fourth planks but rather, it passed across the strake seam to affix the toe end of the plank to strake six. No coordinating dowel joint is now evident in the fourth plank of strake six as this plank was replaced during the vessel's lifetime.

Fastenings:

Among the 18 treenails, two are not associated with an adjacent treenail or nail due to missing material. The remaining treenails constitute part of a pair at the least or, at the most, part of three treenails coordinating with three adjacent nail holes as well. Fifteen treenails represent six pairs of treenails and, in fragments SS6 1/26 and 1/27, a group of three treenails as well. Of these six pairs, only one pair, that in fragments SS6 1/46 and 1/47, is not aligned with any nail holes as well; all of the remaining groups of treenails have at least one adjacent nail hole as well. As such, assuming that the two isolated treenails in SS6 1/56 and 1/57 were originally part of a pair, and there is nothing to suggest that they were not, the fastening pattern evident in strakes four through six is represented here as well. Each floor timber is associated with at least one pair of fasteners. Two of these treenails, one each in SS6 1/27 and in 1/31, are pierced by nail holes through them. The 17 treenails average 1.38 cm in cross-sectional width, and vary in size from 1 to 1.5 cm in width.

Among the 43 preserved nail holes in strake seven, a large percentage are now eroded and round in cross section. Twenty-three nail holes are still square, and they average

.67 cm², but combined with the remaining 18 now-round nail holes, the average size increases to .93 cm in cross-sectional width. Five of the nail holes, in fragments SS6 1/13, 1/20, 1/48, 1/52 and 1/60, are missing a presumed fastener across the plank due to missing material, but six others are isolated as well, although no material is missing. Three of these isolated nail holes, in fragments SS6 1/5, 1/6 and 1/62 – 1/63, are such as the strake is too narrow to permit more than one fastener across its width. The three other isolated nail holes in SS6 1/16, 1/32 and 1/58, in contrast, are isolated for presently unknown reasons. Twenty-nine of the 30 nail holes remaining are each associated with a floor timber. There are ten pairs of nail holes and three groups of three, the latter associated with floor timbers at midships, A and B, and seven of these 13 groups are aligned with at least two treenails as well. The five pairs of nail holes that are not aligned with treenails all occur near the extremities of the strake, either forward of floor timber I or aft of floor timber 3. All in all, 93 percent of the fasteners in this strake are part of a pair associated with a floor timber.

One of the two remaining nail holes in strake seven is located at the forward toe end of plank three, at the inboard edge of the diagonal scarf. This nail hole, which passes transversely through the plank from the scarf edge to the inboard edge, aligns with a similar nail hole near the joggle along the outboard edge of the fourth plank in strake six. These two nail holes, once aligned, indicate that the toe end of the third plank in strake seven was nailed to the outboard edge of strake six. The final nail hole in strake seven appears on the external face of fragment SS6 1/38 – 1/40 and the inboard edge of the fragment as well, as it passes diagonally from the external face through that edge towards the outboard edge of strake six.

Marks and Coatings:

External pitch is evident on the external faces of all but four of the fragments of strake seven. Among those four fragments without any external pitch, they are all relatively small, light and eroded. While external pitch is evident on the remaining fragments of the strake, it should be noted that where the external face is eroded, the external pitch is similarly damaged. As such, 18 percent of the fragments of this strake display scattered or eroded applications of external pitch on their exterior faces. Damage or erosion on the internal faces of the fragments results in similar wear on the internal pitch, but generally,

there is a much smaller percentage of internal pitch along the length of the strake. Four fragments, SS6 1/17, 1/20, 1/42 and 1/45 – 1/47, have applications of internal pitch that appear to be accidental in nature. Each has only one or two small drops of the sealant on their preserved internal faces, none of which are greater than 6 cm in size. Similar to the apparent use of the internal pitch on strake six, strake seven also retains applications of the internal pitch near strake seams, fasteners, and adjacent to floor timbers as well. Three fragments from the strake, SS6 1/13 – 1/16, 1/33 and 1/56, preserve horizontal strips of the internal pitch near their inboard and outboard edges. In comparison, fragments such as SS6 1/8, 1/10 or 1/11, preserve internal pitch over the majority, if not all, of their internal faces. Lastly, some fragments tend to retain internal pitch passing near or over nail or treenail holes, while other fragments maintain a distinct space around the fasteners in which no internal pitch is evident. Fragments SS6 1/33 and 1/52 to 1/56 retain pitch on their internal faces that not only coats over 60 percent of the preserved surface, it is also present surrounding nail and treenail holes, indicating it was in place prior to the addition of the associated floor timber. In comparison, the light and heavy applications of the internal pitch on fragments SS6 1/26 to 1/29, 1/34A to 1/37, and 1/38 to 1/40 are each situated no closer than 5 cm to the fasteners associated with a particular floor timber. In these latter cases, it appears that the internal pitch was applied after the floor timber was in place.

Strake seven has only one collection of adze marks along its length; all concentrated in plank two. Evident on fragments SS6 1/7 and 1/8, the adze marks are distinct and easily identifiable and, on fragment SS6 1/7, their order of cutting can be discerned. The dubbing marks evident on SS6 1/7 consist of two overlapping collections of marks, all of which are diagonal to the length of the plank, and perpendicular to each other. The first series of marks was created by dubbing across the internal face of the plank in diagonal passes that swept from the aft to the forward end, while the second series of marks was created in the opposite manner; diagonal passes from the forward to aft end. The dubbing marks evident on fragment SS6 1/8 are all collected at the forward end of the plank, surrounding the two eroded nail holes near the butt scarf. It is unclear in what direction, if there is only one direction, this adze work proceeded. There is no nick evident in the edge of the adze blade used.

Saw marks are more prevalent along the length of the strake, although in some cases they are no more informative (figs. 3-124). No saw marks are preserved on planks one and two, although proceeding to plank three, the saw marks on fragments SS6 1/12 and 1/14, and 1/13 – 1/15 present conflicting information. The marks evident on SS6 1/12 and 1/14, and 1/16 and following fragments, are inclined between 75 and 90 degrees towards the bow, and indicate that cutting proceeded from the forward to the aft end of the fragment. The marks preserved on fragment SS6 1/13 – 1/15, which is outboard of fragments SS6 1/12 and 1/14, are inclined 120 to 125 degrees from the bow, and the cutting proceeded from the aft to the forward end of the fragment. As no other fragment in the immediate vicinity of SS6 1/13 – 1/15 has similar saw marks, it appears that SS6 1/13 – 1/15 is a small addition or repair to the outboard edge of plank three in strake six, immediately forward of the butt scarf to plank two. Although there are a few instances of saw marks inclined as low as 65 degrees towards the bow, in fragments SS6 1/34 and 1/45 – 1/47, no other saw marks along the length of plank three indicate a similar patch or repair occurred. Saw marks are similarly distinct and well preserved on plank four. Their inclination tends to vary more along the shorter length of the plank, varying between 60 and 90 degrees towards the bow, but overall, they are fairly consistent and all indicate that the cutting of this face proceeded from the forward to the aft end of the plank.

Other Comments:

Six dendrochronology samples were cut from this strake; three in 1999 and three in 2002. Samples 18, 39 and 40 were cut from fragments SS6 1/61, 1/6 and 1/14 respectively, while samples 50, 52 and 54 were cut from SS6 1/27, 1/24 and 1/14, respectively. Among the six samples, only those retrieved from fragments SS6 1/24, 1/27 and 1/61 yielded enough rings to aid the dating process.

A sizeable portion of the fragments in this strake are identified by more than label. Only one fragment has three labels; SS6 1/38 is also identified as 1/39 and 1/40. The remaining eight fragments are identified with two labels apiece: SS6 1/20 and 1/20A, 1/26 and 1/27, 1/30 and 1/31, 1/34A and 1/36, 1/35 and 1/35A, 1/45 and 1/47, 1/52 and 1/55 and 1/62 and 1/63. Another sizeable portion of the fragments in this strake have indefinite locations, but in this case, 11 of these were still drawn at one-to-one scale on the



Figure 3-124: Photograph of saw marks on strake seven.

appropriate drawings. These 11 fragments, SS6 1/3 to 1/6, 1/10 to 1/12, 1/42, 1/44, 1/49 and 1/58, were still illustrated with the rest of the re-articulated fragments as their approximate, but not exact, location could be established. Of the five remaining fragments, only SS6 1/7 and 1/53 have been illustrated at one-to-one scale on a separate drawing. Lastly, fragment SS6 1/8 should be handled with particular care as the forward end of the fragment surrounding the two fastener holes is ready to break into two pieces.

Starboard Strake Eight

Timber Numbers (Lot Numbers):

SS7 1/1 – SS7 1/3, SS7 2/1 – SS7 2/16, SS7 2/19 – SS7 2/31, SS7 2/33 – SS7 2/41

Old ID on site:

Starboard strake seven

Dates Cataloged:

June 26, August 17 and 18, 1999; June 26, 27 and 29, July 2 and 27, 2001

Catalogers:

MBH

Drawing Numbers:

128, 177, 178, 208

Samples Taken:

Dendrochronology sample 26, 30, 35, 36 and 44

Preserved Dimensions (averages):

Plank one: 1.2 m x .21 m x .035 m

Plank two: 4.72 m x .255 m x .031 m

Plank three: 4.53 m x .262 m x .034 m

Plank four: 1.4 m x .151 m x .031 m

Wood Type:

Quercus sp?

Condition:

Due to the scanty preservation of strake eight aft of floor timber 9, it is unclear how many planks originally composed this strake. At the time of the material's recovery in 1998, however, material making up four planks was recovered. Three fragments represent plank

one, located between floor timbers 12 and 10, 23 represent plank two, extending between floor timbers 10 and C, 6 fragments make up plank three, while only 4 preserved fragments make up plank four, from floor timbers M to N. Altogether, planks two and three are well represented and are 70 to 80 percent complete, but planks one and four, in comparison, are very fragmentary. No hood ends of the strake are preserved.

Although strake eight presumably extended between the stem and sternpost, the absence of any material aft of floor timber 12 or forward of floor timber N mitigates against interpretation of the strake beyond these points. As a result, fragments SS7 1/1 to 1/3 are identified as part of plank one. The three fragments are fairly solid, although SS7 1/1 is the most delicate and friable of the three having suffered the most erosion while in situ. Unlike SS7 1/2 and 1/3, 1/1 also has no original edges; 1/2 and 1/3 do preserve small sections of the scarf edge to plank two, but no inboard or outboard edges. None of these three fragments fit together. All three fragments preserve traces of the interior and exterior faces, although those faces are best preserved in SS7 1/3.

Plank two, which is approximately 4.72 m long, is distinctly better preserved and represented in the archaeological record than plank one. There are small lacunae along its length due either to dendrochronological samples or non-contiguous edges, but the only significant absence is via the missing fragments SS7 2/17 and 2/18, near floor timbers 2 and 1, composing .854 m of the plank. All of the fragments in plank two are stronger and better preserved than those in plank one, but their relative level of preservation – similar to other strakes – increases towards the bow. Fragments SS7 2/1 to 2/7 preserve only scanty remains of the inboard or outboard edges, but the edges' frequency and quality tends to increase towards the bow. Interior and exterior faces are more predominant as well, although they are interrupted by longitudinal splits tracing the plank's pith. Interior and exterior faces are well-preserved, and there is little or no damage from *Teredo navalis*.

Plank three, preserved in six fragments, retains the most diagnostic information in strake eight; it also contains one of the largest preserved planking fragments recovered. This large fragment, SS7 2/23-2/26, is approximately 1.8 m long and preserves scattered inboard, outboard and scarf edges. Its interior and exterior faces are solid and only slightly friable, and it has little or no damage from *Teredo navalis*. What damage is evident (rounded

edges or corners) was incurred during the cataloging process while moving the fragment. The remaining five fragments in plank three maintain a similarly high level of preservation along their inboard and outboard faces, but any original edges, in comparison, are friable or non-existent. Only a small .057-m long portion of the scarf edge to plank four is preserved. While all six fragments in the plank should be handled with care due to their length, the narrow fragments forward of SS7 2/23-2/26 are prone to bend or twist along their length as well.

Of the four remaining fragments that compose plank four, only one, SS7 2/40-2/41, is particularly diagnostic. Fragments SS7 2/37 to 2/39 are small and light, preserve little original surface along their interior or exterior faces, and only retain one good edge on SS7 2/38. Approximately .22 m long, SS7 2/38 is the largest of these three fragments but it preserves so little diagnostic information that its original orientation is unclear. Fragment SS7 2/40-2/41, in comparison, is both larger and better preserved. It retains few original edges, but its interior and exterior faces are clean and the fragment is not afflicted by longitudinal splitting. None of the fragments in plank four preserve noticeable worm damage.

Joinery:

Among the four preserved planks that compose strake eight, planks one and 2 and 2 and three are joined via S-scarfs. Plank four is joined to plank three by a diagonal scarf. The preservation of these scarfs, however, varies greatly along the strake's length. The S scarf between planks one and 2 is implied by the presence of curved scarf edges preserved in the fragmentary material near the inboard and outboard edges of the plank. Only .165 m remain of the scarf in plank one, in fragments SS7 1/2 and 1/3, while .085 m is preserved in fragments SS7 2/1 and 2/2 in plank two. The second S scarf, in comparison, is nearly complete in fragments SS7 2/20, 2/22 and 2/23-2/26. Both S scarfs are oriented in a similar manner, as the outboard end of each scarf is inclined towards the bow. In comparison, the diagonal scarf is inclined towards the stern. The presence of this diagonal scarf is very tenuous, however. Of the scarf, which may have originally been .33 m long, only a .057-m long edge hints at its presence on fragment SS7 2/36 in plank three, while no material indicates its presence in plank four. As there is no radical change in the location of

the pith relative to the plank, and no tool marks are preserved to indicate a possible disjunction, the presence of this diagonal scarf between planks three and four is circumstantial.

Along the preserved length of strake eight there is only one extant edge dowel. This dowel, in the inboard edge of SS7 2/40-2/41, is .014 m square and aligns with the .016 m diameter dowel hole in the outboard edge of SS6 1/62-1/63. Despite the presence of seven other edge dowels or dowel holes along the outboard edge of strake seven, there is no other indication of mating dowels or dowel holes along the inboard edge of strake eight. Discussion relating to this disjunction is in the section on the assembly of the ship.

Fastenings:

Unlike other strakes farther inboard, strake eight is the first to be affixed to the floor timbers apparently only with nails. Similar to strake seven, there are round fastener holes preserved in strake eight, but as all nine align with nail holes in the adjacent oak or pine floor timbers, they must represent eroded nail holes.

As strake eight is affixed to the floor timbers apparently only with nails, it thus has a much higher number of nail holes than strakes farther inboard. Fifty-three nail holes are extant in the preserved fragments, including the nine now-round eroded nail holes mentioned above. The 44 still square nail holes average .0066 m square while the eroded nail holes average .013 m in diameter; overall, they average .0078 m in width. Only four of these nail holes, two associated with the S scarf between planks two and three in fragment SS7 2/23-2/26 and one each in fragments SS7 2/27 and 2/29-2/31, are inclined towards the keel. Among the 53 nail holes, 21 are along the inboard edge, 24 are along the outboard edge, while five are situated between two nail holes at floor timbers 10, 9, A, G and N. The other nail holes are either preserved in one of 13 extant pairs or individually. Among those 11 isolated nail holes, two are not part of a pair either because a fragment's location is indefinite or because material is missing. An isolated nail hole in SS7 2/40-2/41 is isolated at its frame station due to the narrowing of the plank.

Marks and Coatings:

Among all of the preserved fragments in strake eight, only fragment SS7 2/39 does not preserve exterior pitch on its exterior face. In all other cases, particularly larger solid

fragments such as SS7 2/23-2/26, the exterior pitch is fairly thick, resilient, and still fairly protective of the wood. Eleven of the fragments also preserve internal pitch on their internal faces. On six of those fragments the application appears accidental. The drops or smears are small, isolated, and unrelated to diagnostic details on the fragments. On other fragments, however, the internal pitch is prevalent enough to imply that its presence is purposeful. Strips of internal pitch, up to .18 m long and .02 m wide, were applied to the inboard edges of fragments SS7 2/13, 2/14, 2/23-2/26 and 2/27-2/30, while fragments SS7 2/14, 2/23-2/26 and 2/29-2/31 retain internal pitch along their outboard edges as well. Internal pitch also covers the internal faces of SS7 2/19-2/22 and 2/27-2/30 in patches up to .12 m long. These patches, situated between frame stations, may indicate that this pitch was applied to the internal face of strake eight after it was affixed in place. Other than rust or concretion near the nail holes, no other purposeful or accidental coatings appear on the faces of strake eight.

Although the general level of preservation increases towards the forward end of the strake, the number of preserved tool marks does not. No adze marks are evident anywhere along strake eight, but saw marks are prevalent on planks one through three, and absent on plank four. On plank one, all of the saw marks are similar: the cutting proceeded from the stern to the bow end of the plank and the blade was inclined towards the stern, at 60 to 80 degrees to the run of the plank (fig. 3-125). This evidence, along with the scanty preservation of an S scarf, distinguishes plank one from plank two. Approximately 90 percent of the saw marks on plank two are either perpendicular to the plank's run or inclined, at the most, 110 degrees towards the bow. The only exception are marks on fragment SS7 2/11 which are inclined towards the bow, on average, 45 degrees to the plank's run. These marks are also distinguishable as they characterize a small section of saw marks that appear to run counter to the general cutting direction. As evident on fragments SS7 2/5 and 2/19-2/22, the cutting of plank two appears to proceed from the bow to the stern end of the plank. On fragments SS7 2/9 and 2/11, the cutting appears to have proceeded in the opposite direction, while marks on SS7 2/14 appear to have been generated by cutting in both directions. The saw marks evident on plank three are very similar to the majority of those preserved on plank two, they are either perpendicular or

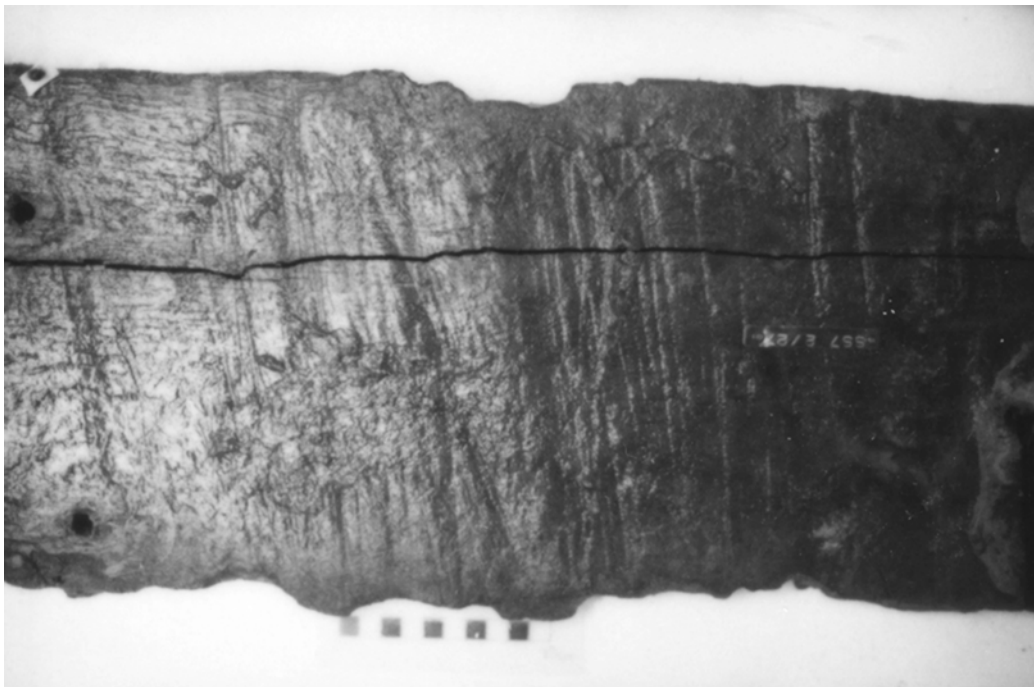


Figure 3-125: Photograph of saw marks on strake eight.

inclined up to 110 degrees towards the bow, and the cutting proceeded from the bow to the stern end of the plank. Only on the most forward fragment in plank three, SS7 2/33-2/35, does this inclination increase to approximately 120 degrees. Plank three also preserves a unique sawn ridge on SS7 2/23-2/26, indicating that the cutting of the plank stopped .34 m from the plank's aft end, leaving this small raised ridge on the surface. The remaining interior surface was instead cut with an axe (figs. 3-126, 3-127).

On the four fragments of plank four, no saw marks are preserved. Fragment SS7 2/40-2/41 does, however, preserve the only scribe mark retained on any of the planking fragments. This mark, which extends .08 m perpendicularly from the inboard edge, indicates the presence of the only edge dowel in strake seven, immediately below it. There are no other scribe marks on strake eight, nor is there a coordinating mark on SS6 1/62-1/63, immediately inboard.

Other Comments:

Five dendrochronology samples, numbers 26, 30, 35, 36 and 44 were taken from strake eight in 1999. Samples 26, 35, 36 and 44 as they were taken from fragments SS7 2/4, 2/5, 2/18 and 2/26, are naturally identified as the same tree; at this time, they are also tentatively identified as the same tree that produced fragment SS2 1/12-1/13.²² Sample 30, from fragment SS7 1/3, does not correlate to any other sampled material.

As many of the fragments in strake eight are long and delicate, numerous tags were applied to the fragments prior to recovery. As a result, seven fragments are identified with more than one identification number; the majority of these are in plank three. The largest fragment in the strake is labeled SS7 2/23, as well as 2/24 through 2/26. Labels SS7 2/27 and 2/28 are on the same fragment, as are labels SS7 2/29 and 2/31, and SS7 2/33 and 2/35. Two fragments in plank two have multiple labels; SS7 2/9 is also identified as 2/11, while SS7 2/19 is also identified as 2/22. Fragment SS7 2/40 is the only fragment in plank four with an extra label. It is also identified as SS7 2/41. Two fragments are labeled as part of strake eight, although they are not drawn at one-to-one scale as their locations were too indefinite. SS7 2/9.P is apparently part of SS7 2/9, although it is unclear how; the associated excavation tag records that it was found in square E11 LR3. A second fragment is only generally labeled as SS7.P, which apparently came from "above SS7 2/32".

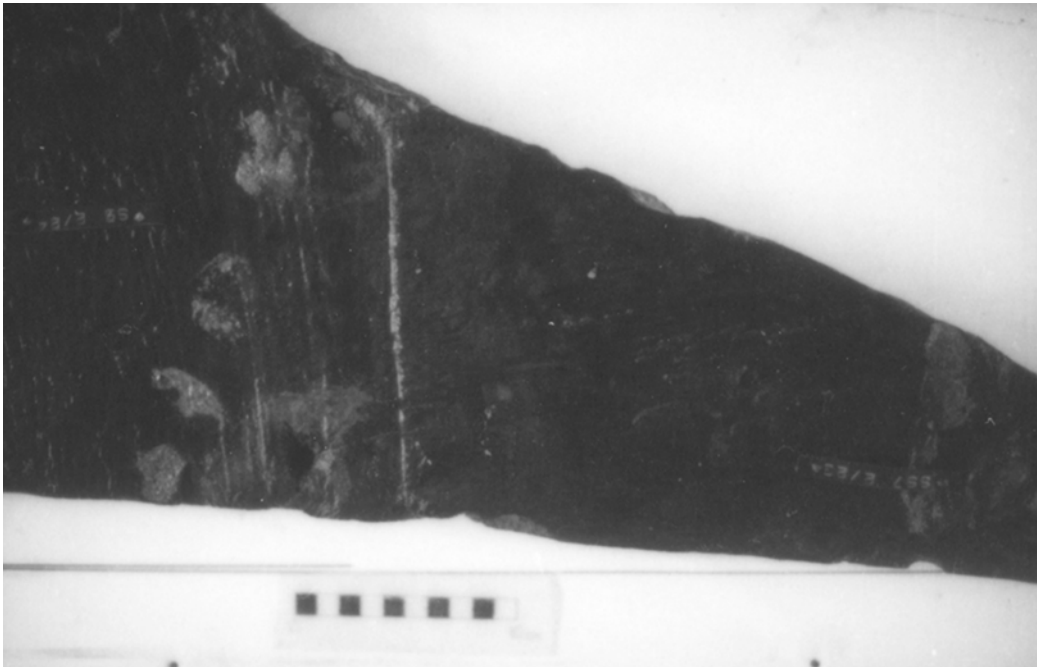


Figure 3-126: Photograph of the scarf and the tool marks at the after end of plank three in strake eight.

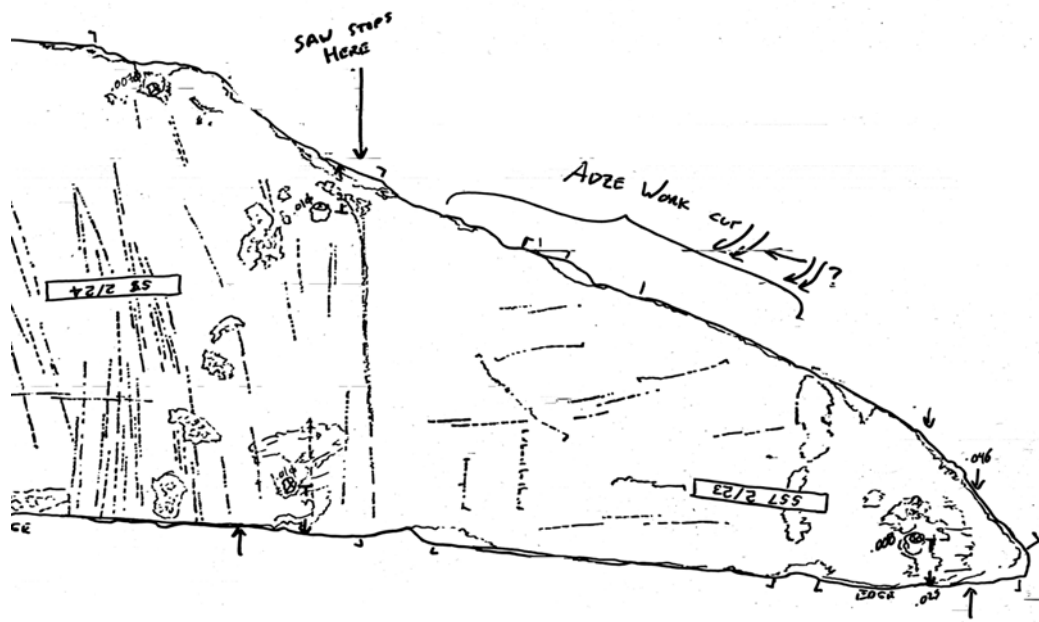


Figure 3-127: Drawing of the same area, illustrating the junction between the saw marks and axe marks.

The locations of three fragments in plank three, SS7 2/37 to 2/39, are hypothesized on one-to-one drawing 178 due to their small size and lack of diagnostic information. During the cataloging process it was difficult to even estimate their proper location and orientation. The same may be said of fragment SS2 2/8 in plank two on one-to-one drawing 177. Three other fragments, also on one-to-one drawing 177, are in locations that approximate their proper orientation in strake seven, but are still slightly askew. These three fragments are SS7 1/2, 2/1 and 2/2.

Starboard Strake Nine

Timber Numbers (Lot Numbers):

SS8 1/1 – SS8 1/3, SS8 1/5 – SS8 1/6, SS8 1/8 – SS8 1/14, SS8 2/1 – SS8 2/13, SS8 2/23 – SS8 2/27, SS8 2/30 – SS8 2/33

Old ID on site:

Starboard strake eight

Dates Cataloged:

June 26, August 18, 1999; June 18, 19, 21, 23, August 28, 2001

Catalogers:

MBH

Drawing Numbers:

128, 170 to 172, 207, plus added sketches on catalog sheets

Samples Taken:

Dendrochronology samples 19 and 38.

Preserved Dimensions (averages):

Plank one: 3.02 m x .14 m x .031 m

Plank two: 3.35 m x .17 m x .034 m

Wood Type:

Quercus sp?

Condition:

As evident from the diagonal scarf preserved at the aft end of plank one, strake nine originally consisted of at least four planks. No apparent material from strake nine is preserved aft of that diagonal scarf, however, so the first cataloged plank in strake nine

extends approximately 3 m from floor timbers 10 to 2. The second plank extends 3.4 m to floor timber H, beyond which approximately 2.4 m of plank three is represented by 4 fragments.

Fragments SS8 1/1 to 1/5 are indicative of the preserved condition of the rest of plank one. Other than fragment SS8 1/4, which is missing, the fragments' internal and external faces are clean, well preserved, and display little worm damage. Other than lacunae along the plank's length due to missing fragments - SS8 1/7 is missing as well - all of the fragments retain diagnostic information. Nail holes and crisp edges are evident, as are tool marks. Notably, the inboard edge is distinctly more eroded and friable than the outboard edge which is still fairly crisp; in both cases, however, their preservation is still patchy and scattered. Some fragments, such as SS8 1/6 and 1/8, are more delicate and prone to damage as they are smaller and lighter, but overall, the fragments in plank one are fairly strong and coherent. Similar to other strakes, plank one in strake nine is also prone to longitudinal splitting, but it has only succumbed in SS8 1/2, 1/3, 1/12 and 1/13.

Seven fragments represent plank two, including SS8 2/8-2/12, which, at 1.79 m long, is the longest planking fragment recovered. Similar to plank one, plank two has little worm damage and in general the inboard edge is more friable and delicate than the outboard edge. This is most notable on fragments SS8 2/6-2/7 and 2/8-2/12. More of the outboard edge is preserved than the inboard edge but such preservation is, again, rarely extensive. All of the interior and exterior faces preserve diagnostic information on clean surfaces, and have suffered from little wear or worm damage. Fragments SS8 2/2 to 2/7 are damaged by longitudinal splitting, damage which abruptly ceases at fragment SS8 2/8-2/12. Despite its resilience, however, SS8 2/8-2/12 has also suffered from the most wear and erosion: the forward 43 cm of the fragment retain almost no original surfaces or edges.

The damage incurred on fragment SS8 2/8-2/12 is indicative of the remaining fragments in strake eight that compose plank three. There is little evident worm damage along the length of the plank but overall, the faces and edges are distinctly more delicate, friable, and retain less diagnostic information. Only two fragments, SS8 2/23 and 2/24, represent over 60 cm of the plank, but SS8 2/25-2/26, which preserves over 1 m of the plank, has little pertinent information; only 11 cm of its outboard edge are preserved, for

example. Fragment SS8 2/30, the forward-most preserved fragment in strake nine, has well-preserved internal and external faces but no original edges.

Joinery:

Strake nine is notable predominantly for its shape. Unlike other strakes inboard, strake nine tapers significantly from its extremities towards midships. At floor timber 9, plank one is 21 cm wide, but narrows to 12 cm wide at floor timber 1. Plank two tapers towards midships as well; from 20 cm wide at floor timber G to 10 cm wide where it is scarfed to plank one. Plank three, in comparison, is highly disarticulate but appears to taper more conventionally towards the bow of the vessel.

Three scarfs are evident along the preserved length of strake nine, but as material at the junctions of planks one and two and two and three are fragmentary or missing, interpretations of these scarfs vary in accuracy. The best-represented scarf, at the aft end of plank one, is predominantly a diagonal scarf although its edge has a slight concave curve into fragment SS8 1/1. Of that edge, which originally represented an approximately 36 cm-long scarf, only 21.2 cm is still original. The most poorly-represented scarf, that between planks two and three, is preserved only on SS8 2/23. As this fragment preserves original edges that intersect at a 20 degree angle, the 11 cm that represent part of a scarf edge presumably also represent a diagonal scarf crossing the strake. The original length of the scarf or its complete design, however, are unclear. The last scarf, between planks one and two, appears to be a three-planed scarf. A three-planed scarf, composed of three scarf edges, is similar to a diagonal scarf as all three edges are diagonal to the plank's run. The scarf edges, however, vary in their inclination to each other and thus create a scarf edge with mating surfaces in three different planes. Although no material from plank one preserves a scarf edge to plank two, fragment SS8 2/1 preserves 6.5 cm of one of the three original scarf edges, as well as material immediately outboard that clearly represents a second. These two faces were inclined approximately 148 degrees to each other. Assuming that the scarf was fairly symmetrical in design, the third inboard scarf edge would have met the middle edge at approximately 148 degrees as well.

There are no extant edge dowels in strake nine, nor are there any preserved edge dowel holes. As there are no edge dowels or associated holes along the outboard edge of

strake eight, their appearance along the inboard edge of strake nine would be unexpected. The inboard edge of strake ten still preserves an extant edge dowel hole in SS9 1/4 although there is no coordinating edge dowel or dowel hole in fragment SS8 1/2. Reasons for its absence will be discussed in the section addressing the vessel's assembly.

Fastenings:

There are no extant treenails in strake nine. Five treenail holes, however, are still evident along plank three. Among them, four are aligned into two pairs, associated with floor timbers C and D, while the fifth, associated with floor timber A, is paired with a .9 cm square nail hole along the outboard edge. The five holes average 1.3 cm in diameter. Unlike the round fastener holes in strake eight, all of these holes are associated with an oak floor timber and more likely represent treenail holes. Unexpected, however, is the absence of coordinating treenail holes in the associated floor timbers. Floor timber D is not preserved over strake nine, but A and C are and do not retain treenail holes aligning with those in this strake. In both cases, such holes may be present but masked by the eroded and splintered nature of the two floor timbers at their distal extremities.

Interpreting the five round fastener holes mentioned above as nail holes, there are a total of 40 nail holes in strake nine. They vary in size from .5 cm square to 1 cm square, and average .71cm square. Due to the tapering shape of strake nine, eight nail holes are isolated along its length. These nail holes, in fragments SS8 1/5, 1/6, 1/9, 1/11, 1/13, 1/14, 2/1 and 2/2, are positioned relatively equidistant between the two extant edges of the strake. Among the remaining 32 nail holes, four are isolated due to missing material, but the remaining 28 all segregate into coordinating pairs. There is no set of three nail holes preserved along the strake at one frame station, nor are the two holes in any pair found near the same strake edge.

Marks and Coatings:

External pitch is preserved on the external face of every fragment in strake nine. In many cases, the amount of preserved pitch is commensurate with the preservation of the fragment itself; as the fragments' preservation is generally very good, the pitch itself is usually still soft and malleable with little damage. Internal pitch is evident on four fragments, SS8 1/1, 1/5, 2/1 and 2/25-2/26. In all four of these cases, the amount and

appearance of the internal pitch indicates that its application was most likely an accident. The internal pitch is generally thin and crizzled and, other than the patch on SS8 2/25-2/26, is no larger than 3 cm. Rust and concretion are evident on the strake's fragments, but sparsely.

Despite the high level of preservation among the fragments in plank one, only six of the 12 fragments in the strake preserve any saw marks. Even among those six, the marks evident on SS8 1/2, 1/5, 1/12 and 1/14 are still fairly faint and indicate only their inclination. The marks preserved on fragments SS8 1/1 and 1/13 are the most diagnostic, indicating that the cutting of plank one proceeded from the stern to the bow end of the plank. Where the saw marks are evident, their inclination declines from 70 to 90 degrees to the plank's run at SS8 1/1, to approximately 60 to 80 degrees towards midships. The saw marks on plank two are more prevalent and diagnostic overall, and indicate a similarly limited range of inclination towards the stern of the vessel. The saw marks on SS8 2/1, 2/5 and 2/6-2/7 all incline approximately 70 to 85 degrees, while those on fragments SS8 2/2 and 2/3 are perpendicular to the plank. The marks on fragment SS8 2/8-2/12 vary the most, from 65 degrees towards the stern to approximately 95 degrees towards the bow. The cut direction, however, appears to change along the length of the plank. On fragments SS8 2/2 and 2/3, the cutting appears to proceed towards the stern of the vessel. Fragment SS8 2/6-2/7 preserves marks that appear to have been created by cutting in both directions, while fragments SS8 2/5 and 2/8-2/12 appear to have been fashioned by cutting the plank towards the bow. This confusion in interpreting the saw marks is apparent on plank three as well. The preserved marks indicate a wide range of motion while cutting the plank, varying the saw's angle to the plank's run from 75 degrees towards the stern of the vessel to over 100 degrees towards the bow end of the plank. It is impossible to correlate the varying saw angles with the cutting direction, but as marks on SS8 2/25-2/26 demonstrate that the cutting proceeded towards the stern end of the plank and the marks on SS8 2/30 indicate the opposite, those cuts inclined towards the stern may have been fashioned while cutting in that direction. The other saw marks, those inclined towards the bow, may have been fashioned in the opposite manner.

No adze marks, hammer blows, or scribe marks are preserved on the fragments in strake nine.

Other Comments:

Strake nine is a key strake as it, unlike other strakes farther inboard, is the first strake that a majority of the floors and futtocks are attached to. As such, it is a transitional location at which the ship is turning the bilge and where the vertical walls of the craft are attached to the bottom of the vessel. It is not the only strake that embodies such an important junction, futtock C is attached to strake eight and many of the floor timbers extend to strake ten as well to distribute load, but strake nine – with a multitude of fasteners for floors and futtocks – is the first to play this role.

Two dendrochronology samples were taken from strake nine, both in 1999. Unfortunately, the samples from SS8 2/1 and 2/31 both yielded too few rings to be of any value other than indicating the wood's genus.

Strake nine may be distinct because among its preserved fragments, there are only two that retain little or no diagnostic information and thus were not drawn. These fragments, SS8 2/32 and 2/35 have no original edges and are no more than 18 cm long. SS8 2/8-2/12, in comparison, is one of the largest preserved planking fragments and as such, is identified by five different labels from SS8 2/8 to SS8 2/12. Fragment SS8 2/6 is also labeled as SS8 2/7, while SS8 2/25 is also identified as SS8 2/26. Fragment SS8 2/25-2/26 is also similar to SS8 2/23, 2/24 and 2/30 as their locations along strake nine are only approximate. It should lastly be noted that the join between SS8 1/8 and 1/9 is a very rough and inaccurate fit. The two faces meet, but they do not mate together well.

Starboard Strake Ten

Timber Numbers (Lot Numbers):

SS9 1/1 – SS9 1/8, SS9 1/10 – SS9 1/20, SS9 2/1 – SS9 2/15, SS9 2/18 – SS9 2/20

Old ID on site:

Starboard strake nine

Dates Cataloged:

June 25, 26 and 27 2001, August 27, 2001

Catalogers:

MBH

Drawing Numbers:

127, 173, 174, 176, 208

Samples Taken:

Dendrochronology samples 25, 55 and 58.

Preserved Dimensions (average):

Plank one: 3.44 m x .25 m x .033 m

Plank two: 1.1 m x .12 m x .032 m

Plank three: 3.65 m x .21 m x .033 m

Wood Type:

Quercus sp?

Condition:

Preserved in three planks that extend 7.7 m between floor timbers 8 and L, strake ten is composed of 35 fragments that vary in condition between very good and fairly fragile. Similar to other strakes, the general level of preservation increases from the aft end forward, culminating in fragment SS9 2/8-2/12 which is long, solid, heavy and approximately 1.7 m long. Due to the varying level of preservation, the fragments at the very aft end of plank one, SS9 1/2, 1/3 and 1/4, are fairly solid, but still light and fairly friable. No original edges are preserved on the three fragments, and original surfaces on the exterior and interior faces are good, but not constant. These three fragments fit together, but due to the lacuna at fragment SS9 1/5, they do not align with SS9 1/6. Fragments SS9 1/6 and 1/7, similar to SS9 1/2 to 1/4, mate together to make a larger fragment of plank one but again, due to the patchy preservation of this end of the plank, they do not align with SS9 1/11 farther forward. SS9 1/6 does not preserve any inboard edges, but due to the re-assembled size of this element of the plank and the outboard edge preserved on SS9 1/7, it is evident that the plank was approximately 27 cm wide at this point. Overall these two fragments are heavier and more solid than the three previous fragments, the interior and exterior faces are well-preserved and diagnostic, and the fragments are not prone to splitting.

Although SS9 1/11 is isolated as fragments SS9 1/8 to 1/10 are missing, as is fragment SS9 1/12, it still represents the increasing level of the plank's preservation. The

fragment is heavy and solid with a long section of the outboard edge still preserved, as well as little wear or erosion on the interior face. Some wear is evident on the exterior face, and the broken edges are still delicate, but overall, this fragment is better preserved and more diagnostic than fragments SS9 1/2 or 1/4. Fragments SS9 1/13, 1/13A and 1/15 all mate together to form another isolated element of the plank similar to SS9 1/2 to 1/4 but, despite their smaller size and greater delicacy, retain more diagnostic information. Fragments SS9 1/16 to 1/20 all fit together to form the largest preserved element of plank one, approximately 1.04 m long, but unfortunately this item does not mate to SS9 1/13 to 1/15. Among these fragments, only SS9 1/19 is small and light and very susceptible to breakage. The other four fragments all retain at least one original edge – SS9 1/18 at the forward end of the plank has both the inboard and outboard edges – and all are fairly strong and solid. Their internal and external faces are diagnostic and have suffered from little wear or erosion.

The second plank of strake ten is both better preserved and more complete than plank one, but it also the shortest preserved plank of the strake, composed of just six fragments extending only 1.1 m. Fragments SS9 2/1 to 2/3 are small, light and delicate and do not mate to each other, but SS9 2/4 through 2/6, in comparison, are stronger and heavier and preserve diagnostic information. Internal and external faces on the latter three fragments are all better preserved and have suffered from little wear or erosion, while SS9 2/5 and 2/6 retain diagnostic edges as well.

The condition of plank three, containing the largest preserved fragment of strake ten, represents the best-preserved fragments of the strake. Preservation of contiguous fragments is exemplified in plank two, but the lack of breakage in plank three is unparalleled. Fragments SS9 2/7 to 2/9, representing a distance of 1.61 m, are all solid and heavy, with little or no worm damage and well-preserved inboard and outboard edges. None are threatened by splitting, and only small sections of the edges or broken faces are friable and delicate. The faces of SS9 2/10 and 2/11 are similarly well-preserved, but each is distinguished by a lack of preserved edges and a susceptibility to split. The lacuna forward of SS9 2/11 is filled by SS9 2/12, 2/13 and 2/15 which mate together, but do not align with surrounding fragments fore and aft. These three fragments are also notable as

their preservation is distinctly more degraded than fragments aft; their faces have suffered from wear and erosion, their edges are rounded, and no original inboard or outboard edges appear to be preserved. Fragment SS9 2/18 is similarly preserved, as is SS9 2/19 and 2/20, although the latter two are also larger, more solid and heavier. None of the fragments in plank three have noticeably suffered from worm damage.

Joinery:

Strake ten, similar to strake nine, tapers slightly from its extremities towards the middle of the vessel. The widest preserved section of plank one is at fragments SS9 1/6 and 1/7, where the plank is 27 cm wide, and the plank tapers noticeably towards the midships floor timber, where it is scarfed to plank two. This tapering is accented by plank two which, as it is only 12 cm wide, only represents the inboard half of the entire strake. The outboard half is represented by strake eleven, which will be discussed next. This tapered shape is repeated in plank three which is 24 cm wide at floor timber M and narrows to 18 cm wide where it is scarfed to plank two. The unexpected shapes of strakes nine and ten is most likely due to their location at the turn of the bilge. Particularly evident outboard of strake ten, the remaining preserved strakes are each fairly unconventional in shape, essentially maintaining carefully-crafted edges and scarfs to maintain a watertight shell but not graceful, longitudinal strake edges.

Also diagnostic of strake ten and other strakes outboard is the number and variety of scarfs preserved in the planking material. Within strake ten, two scarfs are preserved between planks one and two and two and three. These three planks most likely do not represent all the planks that originally comprised strake ten but unfortunately, no scarfs are preserved at the aft or forward ends of planks one and three. The diagonal scarf between planks one and two is of a conventional design, inclined towards the stern at approximately 170 degrees and preserved for 30 cm. The scarf between planks two and three, in comparison, is the first of its kind preserved in the Bozburun material. It is essentially a curved or arcing scarf, extending forward – and inclined opposite to the first scarf – in an almost parabolic cut (fig. 3-128). Due to its length, plank two only mates to its inboard 19 cm while the remaining 18 cm outboard mates to plank eleven. Why the builders created



Figure 3-128: Photograph of the parabolic scarf between planks two and three in strake ten. The alignment of plank two (to the right of the photo) is too high and should be aligned with the lower edge of plank three.

this arcing scarf at this location is unclear; a diagonal scarf similar to the first would have fulfilled the same purpose.

Six edge dowels are preserved among the fragments of strake ten; perhaps notable, they are all in plank one. They average 1.1 cm wide and vary in shape from round to square to pentagonal; there are two of each cross-sectional shape. Among them only one, that in fragment SS9 1/4, is found along the inboard edge while the remaining five are along the outboard edge. Two of the edge dowels in plank one align with edge dowels in strake ten. The forward edge dowel in SS9 1/11 aligns with the dowel in fragment SS10 1/6, while that in SS9 1/13 aligns with an edge dowel in SS10 1/6A. Of the remaining four potential dowel joints, two are incomplete due to the loss of material across the plank seam, while the edge dowel in SS9 1/4, similar to that in SS9 1/13-1/15, butts to a blank plank edge; no edge dowel is present.

Fastenings:

The first plank is notable also because it retains the only six treenail holes of strake ten. These holes, in SS9 1/4, 1/11, 1/13A, 1/18, 1/19 and 1/20, average 1.3 cm in diameter and are all along the inboard edge of the plank. Among them, three align with another fastener either nearby or near the outboard edge of the plank – in each case the treenail is matched with a nail along the outboard edge, not another treenail. The other three treenails do not align with another fastener due to the loss of material. The single treenail in fragment SS9 1/19 is particularly uncommon as a nail passes through it as well.

Similar to strake nine, both floor timbers and futtocks are attached to strake ten. As a result, there are not only a multitude of nail holes remaining in the strake, but there are also odd patterns and combinations that, without the framing material superimposed, appear to be slightly haphazard. In some cases, two pairs of nail holes are uncharacteristically close together; re-assembly of the hull material, however, indicates that a futtock was affixed adjacent to the floor timber. In other cases, there is a collection of three fasteners preserved when only two would have been sufficient. A series of three associated nail holes in SS9 2/7-2/9 is just such an example. All 40 nail holes average .87 cm², varying between .5 cm² in two fragments to an eroded nail hole in SS9 1/6 1.6 cm across. There are two collections of three nail holes each, that mentioned in SS9 2/7-2/9 and the second in

fragment SS9 1/6. The remaining 34 nail holes are composed of 10 pairs of nails at frame stations and 14 isolated nails. Only five of the isolated nails, however, are such due to missing material. The remaining nine are either paired with one of the first three aft-most treenails or, particularly in the second plank, the plank is too narrow to require two nails for attachment to the framing.

Marks and Coatings:

Regardless of the fragments' preservation, external pitch is preserved on the external faces of all the fragments in strake ten. Clearly, the amount of external pitch preserved varies depending on the fragment's condition, but even where the pitch is patchy or scattered due to erosion or damage, approximately 80 percent of the external face of the fragment is still coated. Internal pitch, despite its softer consistency, is predominant along strake ten as well, either as a purposeful or accidental application. Internal pitch appears to be an accidental application on six of the fragments, SS9 1/7, 1/18, 1/13, 1/20, 2/2 and 2/3, as the amount is relatively small and distributed in a scattered manner. The internal pitch on nine of the fragments, in comparison, appears to be more purposeful. On fragments SS9 1/11 and 2/5, for example, internal pitch lines either the inboard or outboard edge, indicating a possible waterproofing of the plank seam. On fragment SS9 1/11, moreover, the internal pitch is preserved in a swath 27 cm long and 14.5 cm wide. Similarly-sized swaths are present on SS9 1/3, 1/6 and 2/4 as well. On fragments SS9 1/16 and 1/17, the internal pitch appears to be applied in a pattern. On the outboard edge of SS9 1/16 and the inboard edge of SS9 1/17, the internal pitch is applied 17 cm or more along either edge. These swaths, which are 5 to 6 cm wide, then taper to a single stripe, perpendicular across the plank, approximately 11 cm wide. The forward edge of this stripe, almost on SS9 1/18, is faded and uneven but the aft edge of the stripe, which demarcates an area without any internal pitch or fastener holes, is very crisp and straight. This pattern seems to indicate that the internal pitch at the forward end of plank one was perhaps applied around an object.

Although the condition of strake ten improves noticeably from the aft to the forward end of the strake, tool marks are few and far between along its length. There are no adze, axe, hammer or scribe marks preserved along the entire length of strake ten, and

only six instances of saw marks. All of the preserved saw marks, on fragments SS9 1/3, 1/6, 2/7-2/9, 2/10-2/12, 2/11 and 2/20, were created while cutting the appropriate plank towards its aft end. No preserved saw marks indicate any sawing that proceeded towards the bow of the vessel. Other than a few examples of saw marks on SS9 2/7-2/9 that are inclined either at approximately 70 degrees towards the stern or 35 degrees towards the bow, the majority of the preserved saw marks are inclined between 80 degrees towards the bow or stern of the vessel; there is very little variation.

Other Comments:

Three dendrochronology samples were taken from strake ten. The first, number 25 from SS9 2/19, was cut in 1999, while the other two, numbers 55 and 58, from fragments SS9 1/16 and 1/6, were removed in 2002. All three yielded a sufficient number of rings to aid the dating process.

Due to the poor preservation of strake ten at its extremities in planks one and three, there are fragments drawn in approximate locations, lacunae and missing fragments. Fragments SS9 2/1 and 2/2, at the aft end of plank two, are drawn in only their approximate locations, and 2/2, as its orientation was unclear when it was drawn, was rotated 180 degrees for the re-assembly plan in figure 3-95. Fragments SS9 1/6, 1/7, 2/13, 2/14, 2/15, 2/18 and 2/19 are similarly illustrated on drawings 174 and 176 in their approximate locations and orientations. Fragments SS9 2/19 and 2/20 were originally labeled as UM 796 and 436, respectively, while labels SS9 2/7, 2/8 and 2/9 are on the same fragment, similar to labels SS9 2/10 and 2/12.

Starboard Strake Eleven

Timber Numbers (Lot Numbers):

SS9A 1/1, SS9A 1/4, SS9A 1/9 – SS9A 1/10

Old ID on site:

Starboard strake nine A

Dates Cataloged:

June 26, 2001

Catalogers:

MBH

Drawing Numbers:

175

Samples Taken:

None

Preserved Dimensions (average):

2.135 m x .092 m x .031 m

Wood Type:

Quercus sp?

Condition:

The three fragments of strake eleven represent a strake originally approximately 2.13 m long. As the strake is relatively short and found near midships, the preserved fragments - which only represent 1.48 m of the original length - are all solid and fairly strong, with well-preserved faces as edges. Similar to other strakes inboard, the inboard edge displays a bit more erosion and damage than the outboard edge, but both are still diagnostic. The inboard and outboard faces are not friable, and only the broken edges are delicate and prone to splintering. Neither fragment SS9A 1/1 or 1/9 are prone to longitudinal splitting, unlike SS9A 1/10, which may cleave in the future. Throughout the three fragments, worm damage is minimal or non-existent.

Joinery:

The fragments of strake eleven have no edge dowels. Moreover, as the strake is so short, the only joinery of note are the two scarf edges at either end. The aft scarf edge that tucks under fragment SS10 1/9 in strake twelve is a 5.5-cm long straight edge inclined 65 degrees to the inboard edge of strake eleven. The forward scarf is composed of one curved edge that mates to strake ten, and a butt scarf face that tucks under fragment SS10 1/17 in strake twelve (fig. 3-129). This curved scarf face in strake eleven mates to the outboard 18 cm of the arcing scarf face that delineates the aft end of plank three in strake ten. The butt scarf face, which is a straight face 5.5 cm long and inclined at 90 degrees to the previous curved scarf edge and the outboard edge, mates to a similarly-sized edge in fragment SS10 1/17.



Figure 3-129: Photograph of the butt scarf in strake eleven.

Despite the strake's short length, it does retain a tapered shape more common to the rest of the Bozburun planking. The aft end of the strake, aligned with floor timber 2, is 5.8 cm wide. It widens to 14.4 cm wide near floor timber B 1.5 m forward, and proceeds to narrow again towards its forward extremity, to 5.5 cm.

Fastenings:

No treenails, or treenail holes, were identified in strake eleven. Due to the plank's size, it also has only eight nail holes preserved along its length. The nail holes, which average .73 cm², are arrayed along the inboard edge, outboard edge and middle of the plank, but as the plank is 14.4 cm wide at the most, no holes are aligned in pairs. Two holes in SS9A 1/1, near the forward break edge, are approximately 5 cm apart; another two, in SS9A 1/9, are 8 cm apart, but both sets are aligned longitudinally and not transversely. All eight holes are inclined approximately perpendicularly through the plank.

Marks and Coatings:

All three fragments in strake eleven are well-covered with external pitch on their external faces. Internal pitch is evident on strake eleven as well, but only on fragment SS9A 1/9. The internal pitch preserved, however, was deliberately applied. Across the width of SS9A 1/9, approximately 75 cm aft of the forward scarf edge, is a wide swath of internal pitch 22.5 cm wide. As this internal pitch is adjacent to nail holes, but not over them, it appears to have been applied after the floor timbers and futtocks were in place.

Unlike other strakes farther inboard, except perhaps strake one, the majority of the preserved tool marks on strake eleven are dubbing marks and not saw marks. Saw marks are present on fragment SS9A 1/1, inclined approximately 70 degrees towards the stern of the vessel, but it is unclear which way the cutting proceeded. The adze work, in comparison, is prevalent across 70 percent of SS9A 1/9 and 50 percent of SS9A 1/10. The internal faces of both fragments are slightly dished and predominantly faceted, indicating the passage of the adze's blade; the blade did not have a nick in it. The dubbing appears to have proceeded from the outboard edge forward and down towards the inboard edge. No hammer blows or scribe marks are preserved on the strake.

Other Comments:

Fragments SS9A 1/2 and 1/3 are missing and create a lacuna between SS9A 1/1 and 1/4. On drawing 175, the length of this space was unknown and indicated as such on the drawing. Once figure 3-95 was completed, it is now clear that these two missing fragments once represented approximately 65 cm of the strake's original length. Additionally, labels SS9A 1/4 and 1/9 are on the same fragment.

Starboard Strake Twelve

Timber Numbers (Lot Numbers):

SS10 1/1 – SS10 1/3, SS10 1/6 – SS10 1/6A, SS10 1/9 – SS10 1/10A, SS10 1/12 – SS10 1/13, SS10 1/15

Old ID on site:

Starboard strake ten

Dates Cataloged:

July 17 to 18, 2001.

Catalogers:

MBH

Drawing Numbers:

186

Samples Taken:

None

Preserved Dimensions (averages):

Approximately 2 m x .16 m x .032 m

Wood Type:

Quercus sp?

Condition:

Strake twelve is composed of thirteen preserved fragments that, unfortunately, have varying amounts of diagnostic information. At best, fragments SS10 1/13 or 1/15 retain original edges, fastener holes and tool marks, but the value of this information is diminished by the majority of fragments that are missing edges, that are stricken with friable and splintering faces, and are too small to represent large trends within the strake. Other than partial diagnostic information about a scarf, for example, it is really only clear that the

preserved fragments of strake twelve are all portions of one plank. Fragments SS10 1/1, 1/3, 1/6A, 1/9 and 1/10, for example, have no original edges, and are all small, light, delicate, and prone to breakage. Fragment SS10 1/10A, in particular, is composed of two small fragments of wood, 8 cm and 6 cm long, held together by the ID tag. Due to their small size and light weight, all the fragments of strake twelve should be rarely handled, and if so, with a great deal of care.

Only two of these thirteen fragments, SS10 1/13 and 1/15, mate together across a broken edge. The remaining eleven may share portions of a longer original edge, but as they do not mate together it seemed fruitless to re-create the design of the original strake on acetate during the cataloging process. As a result, all of the fragments of strake twelve are illustrated on drawing 186 as individual fragments, not as components of a larger item.

Joinery:

Although through a reconstruction it is evident that strake eleven tucks under strake twelve at fragment SS10 1/9, no preserved scarf edges are present on SS10 1/9 itself. Of the two scarfs that are evident in strake twelve, then, only the butt scarf in fragment SS10 1/15 near midships may be discussed at this point. This 4-cm long scarf face mates to the inboard portion of a 9-cm long butt scarf face in fragment SS11 1/10 (fig. 3-130). As the scarf face in SS11 1/10 is longer than that in SS10 1/15, both strakes twelve and thirteen taper dramatically to fit to this longer face. Strake twelve near futtock 5 is approximately 19 cm wide, while approximately 1.5 m forward at the butt scarf to strake thirteen, it has tapered to approximately 5 cm wide. No labeled fragments forward of this point are a part of strake twelve.

Surprisingly, among the thirteen fragments of strake twelve, there are seven extant edge dowels or dowel holes. All seven average 1.1 cm in diameter, and vary in shape from round to square to a single pentagonal dowel in SS10 1/6. Four are along the outboard edge, the remaining three are along the inboard edge, and only two clearly align with another dowel or hole in a contiguous fragment. The dowel holes in SS10 1/6 and 1/6A align with extant dowels in SS9 1/11 and 1/13, respectively. The remaining five edge dowels or dowel holes in strake twelve are missing any contiguous material across the plank seam.



Figure 3-130: Photograph of the scarf in strake twelve that encompasses planks from strakes eleven and twelve.

Fastenings:

Predictably, such a fragmentary and disarticulated collection of fragments has very few preserved treenails; only one extant treenail and one treenail hole are evident among these thirteen fragments. The treenail hole, in SS10 1/10A, is 1.5 cm in diameter while the treenail in SS10 1/13 is 1.2 cm in diameter. As the strake has dramatically tapered at fragment SS10 1/13, that treenail is isolated and only mates to fasteners in other strakes. It is unclear which fasteners the treenail hole in SS10 1/10A aligns with in other strakes.

Similar to the small number of treenails or treenail holes preserved in strake twelve, there are only seven nail holes among the thirteen preserved fragments of the strake. In all likelihood, the rust and concretion that impregnated the surrounding wood in each fragment may have contributed to their preservation. As the fragments are disarticulated, it is evident if the nail holes are along the inboard or outboard edge, but not which fasteners they align with. As such, four nail holes are along the outboard edge, two are along the inboard edge, and the last, in one of two fragments labeled SS10 1/1 is isolated. All seven nail holes average .81 cm square.

Marks and Coatings:

Just as all thirteen of the fragments of strake twelve have external pitch on their external faces, nine have internal pitch preserved on their internal faces as well. In all nine cases, however, as the fragments themselves are relatively small, it is difficult to determine if the internal pitch was applied in an accidental or purposeful manner. Perhaps only the internal pitch on fragments SS10 1/10 and 1/15 may be purposeful, as the pitch on each lines the preserved edge of each fragment.

The delicate and friable nature of the majority of strake twelve's fragments mitigates against numerous and/or diagnostic tool marks. As such, only fragments SS10 1/1, 1/9 and 1/10 preserve saw marks; in no case is it evident in which direction the fragment was cut. Only the saw marks on fragments SS10 1/9 and 1/10 may be compared to the fragments' preserved edges: they are inclined between 70 and 90 degrees towards the stern of the vessel. No hammer blows, axe or adze marks are evident on strake twelve.

Other Comments:

The disarticulate and fragile nature of strake twelve expectedly created minor problems both during its excavation and cataloging. During the excavation stage, the light and fragile fragments apparently regularly moved during the mapping process, as there are two fragments labeled as SS10 1/1. In addition, breakage is also evident due to the presence of fragments labeled both SS10 1/6 and 1/6A, and SS10 1/10 and 1/10A; it appears that after labeling the former, the latter fragment broke from the larger fragment and was immediately labeled as such.

Such small and delicate fragments are also prone to breakage and disappearance during the management and cataloging phase of research. It is clear from the preserved sequence of labels, for example, that fragments SS10 1/4, 1/5, 1/7, 1/8, 1/11 and 1/14 have disappeared. They may have originally been similar to the smaller fragment labeled SS10 1/10 - those held together via the label - and once the label fell off, the fragment itself was crushed or lost.

Starboard Strake Thirteen

Timber Numbers (Lot Numbers):

SS11 1/1 – SS11 1/3, SS11 1/5 – SS11 1/17, SS11 1/20 – SS11 1/23

Old ID on site:

Starboard strake eleven

Dates Cataloged:

July 15 and 17, 2001; August 28, 2001

Catalogers:

MBH

Drawing Numbers:

184, 186, 207

Samples Taken:

Dendrochronology samples 57 and 59.

Preserved Dimensions (averages):

Plank one: 2.28 m x (original width unknown) x .03 m

Plank two: .51 m x .18 m x .03 m

Plank three: 3.7 m x .29 m x .03 m

Wood Type:*Quercus* sp?**Condition:**

The 28 preserved fragments of strake thirteen constitute a larger percentage of the strake than the 13 fragments of strake twelve, but they are still similarly disarticulated and fragmentary. Unlike strake twelve, the fragments of strake thirteen are illustrated on drawing 184 in their approximate locations although there are still numerous lacunae along its length. Evident, however, are the approximate outlines of three preserved planks in the strake. The first, extending 2.28 m from futtock 8 to midships is composed of fragments SS11 1/1 through 1/9, the second plank, which is very short, is represented by fragment SS11 1/10, while the third plank, extending between the midships floor timber and K, only has 14 preserved fragments

Fragments SS11 1/1 to 1/3 all mate together, although their joins are fairly loose due to their delicate and eroded nature. All of their faces and edges are friable and delicate, and worm damage has eliminated the majority of their diagnostic information. Small sections of the inboard edge, however, are still evident on all three fragments. The outboard edge, in comparison, is entirely missing. Fragments SS11 1/5 and 1/6 are similar in condition to SS11 1/1 to 1/3, as they too are fragmentary, light and delicate, and as worm damage has partially destroyed the diagnostic aspects of the fragments. Their internal faces, however, are slightly better preserved as are the small sections of the inboard edge still present. These latter two fragments, unfortunately, do not mate to either the assembly of SS11 1/1 to 1/3, or to fragments SS11 1/7 through 1/9.

Fragments SS11 1/7 to 1/9 represent a clear improvement in preservation. Unlike fragments aft, these three have well-preserved internal and external faces as well as long sections of both the inboard and outboard edges. The faces are clearer, less afflicted by worm damage, and more robust while the edges are crisper and more diagnostic.

The fragmentary and disarticulated nature of strake thirteen indicates that fragment SS11 1/10 represents plank two, although it seems likely that originally, the plank was represented by more than one element 51 cm long. Nonetheless, SS11 1/10 continues the gradual improvement in preservation evident in plank one. Fragment SS11 1/10,

represented by three fragments that mate together, is fairly large and heavy, with clear diagnostic faces and edges. The fragment is not friable or affected by worm damage, and it is unlikely to split along its length. It has, moreover, inboard and outboard edges as well as two scarf edges. The first scarf edge is a butt scarf to SS10 1/15 and SS11 1/9, but the second is a small, 8-cm long fragment of an S scarf to fragment SS11 1/11 and plank three.

The fragments of plank three vary greatly in preservation. Fragment SS11 1/11, which contains part of the S scarf to plank two, is small, light and delicate, with little diagnostic information save the presence of the scarf edge. Fragments SS11 1/12, 1/12A, 1/12B and 1/13 are similar, as they are still fairly light and friable. Again, other than the presence of an outboard section of the S scarf to plank two on fragment SS11 1/12, these fragments contain little diagnostic information. The two fragments that compose SS11 1/14-1/17, in comparison, are almost an anomaly along plank three's length. These two fragments mate together to form an element approximately 1 m long that is solid, heavy and fairly diagnostic. It preserves clean edges and faces, as well as portions of the inboard, outboard and scarf edges. It has suffered from little worm damage, but it may be prone to splitting along its length.

The absence of fragments SS11 1/18 and 1/19 creates a lacuna from SS11 1/14-1/17 to SS11 1/20, a gap that not only sets off SS11 1/14-1/17 as an anomaly in plank three, but also highlights the degraded preservation of fragments SS11 1/20 through 1/23. Moving forward, these five fragments (SS11 1/20 mates to SS11 1/20A) display increasingly poor faces, worm damage, eroded and rounded edges and, in the case of SS11 1/20 and 1/20A, the likelihood of splitting.

Due predominantly to the worm damage in these fragments but also to their friable nature, these fragments should be handled and moved very rarely.

Joinery:

Similar to strake twelve, the disarticulate and fragmentary nature of strake thirteen has eliminated much of the joinery evident along its length. The two scarfs alluded to above, the butt scarf between planks one and two and the S scarf between planks two and three, may be discussed. The butt scarf face on plank two is curious because its 9-cm long face mates to scarf faces on both strakes thirteen and twelve. The butt scarf face on strake

twelve, on fragment SS10 1/15, is approximately 5 cm long while that on strake thirteen, on fragment SS11 1/9, is 4 cm long. The outboard edge of strake twelve mates to the inboard edge of strake thirteen, but the outboard edge of strake thirteen, at least for 7 cm, mates to a portion of this scarf face in fragment SS11 1/10. How much of the first plank of strake thirteen originally tucked under the second strake is unclear, but the general arrangement of the scarf appears similar to the manner in which strake eleven tucked under a portion of strake twelve.

The second scarf in strake thirteen, near the midships floor timber, is clearly an S scarf, although only the inboard and outboard portions of the scarf are preserved. A small, 8-cm long portion of the inboard part of the scarf is evident on fragments SS11 1/10 and 1/11, while 6 cm of the outboard section on plank three is preserved on SS11 1/12. As the middle of the scarf, and the associated fragments, are missing, it is unclear what the original length of this scarf was, although it is currently estimated to be 35 cm long.

If the first scarf between planks one and two may have an inclination, it is opposite that of the second scarf. The S scarf is inclined towards the bow, while the outboard portion of the butt scarf is inclined towards the stern.

Only one extant edge dowel and one edge dowel hole are preserved in the fragments of strake thirteen. The edge dowel is located in SS11 1/9, and is evident only along the outboard edge; it does not pass entirely through the fragment. The contiguous edge on SS11 1/10, however, does not have a coordinating edge dowel. The edge dowel hole is found in fragment SS11 1/2, along the inboard face. In this case, coordinating material in strake twelve is missing. Both the edge dowel and the edge dowel hole are 1.3 cm in diameter.

Fastenings:

The slightly better preservation of strake thirteen over strake twelve results in a larger number of nail holes that may be grouped into coordinating pairs; among the 29 nail holes preserved, there are eight clear pairs of nail holes at frame stations. No treenails or treenail holes, however, are evident. One of these nail pairs, in fragments SS11 1/10 and 1/11, crosses over the S scarf between planks two and three. Of the remaining 13 nail holes, two in fragments SS11 1/7 and 1/9 are isolated as the plank has narrowed

considerably. The remaining eleven may have originally been isolated due to a narrow plank as well but now, due to missing material, that conclusion is only speculative. Altogether, the nail holes average .77 cm².

Marks and Coatings:

External pitch, similar to other strakes inboard, is present on the majority of the external faces of the fragments in strake twelve. The preserved pitch, however, has succumbed to the erosion and damage that has affected many of the fragments as well so, in many cases, this external pitch is present on the external faces only in a patchy and eroded manner. Internal pitch is evident on two fragments and in both cases, its application appears to be purposeful. On fragment SS11 1/9, for example, a small strip of internal pitch traces the inboard edge of the fragment, coordinating with the internal pitch coating the majority of SS10 1/15 immediately inboard. A 22-cm long swath of internal pitch is also present along the small preserved section of outboard edge on fragment SS11 1/14-1/17.

Eleven of the 28 fragments of strake twelve preserve saw marks on their internal faces; no adze, axe, hammer blows or scribe marks are evident. In many cases, these saw marks, which are predominantly preserved between fragments SS11 1/5 and 1/20, are fairly clear and distinguishable, although they are still few in number. All of the identified examples are inclined between 70 and 90 degrees towards the bow of the vessel. On planks one and two, the cutting appears to have proceeded towards the stern of the vessel, while the marks on SS11 1/14-1/17 indicate that on plank three the cutting proceeded towards the bow.

Other Comments:

The greatest difficulty while working with strake twelve is its disarticulate and delicate nature. It is difficult to determine the alignments and orientations of many of the fragments as they may be lacking inboard edges or joins to contiguous fragments. Moreover, there are numerous lacunae along the strake's length due either to the three missing fragments or damage and erosion while in situ. The three missing fragments are SS11 1/4, 1/18 and 1/19. Their original shapes and orientations are unknown. Although no ID numbers are repeated along the strake's length, there are two examples of fragments

that broke during the labeling process. Fragments SS11 1/12 is segregated into SS11 1/12A and 1/12B as well, while SS11 1/20 is grouped with fragment SS11 1/20A. It should also be noted that due to the absence of any fragments in plank one that define its outboard edge, the original or preserved width of plank one is unknown.

Port Strakes

Port Strake One

Timber Numbers:

SP1 1/1, SP1 1/4, SP1 1/14, SP1 1/17 - SP1 1/25, SP1 1/28, SP1 1/31 - SP1 1/33, SP1 1/35 - SP1 1/38

Old ID on site:

Port garboard

Dates Cataloged:

July 23 and 27, 1998; March 26, 1999; April 16, 1999; June 25, 27, 29 and 30, 2002

Catalogr:

BAJ, EAG, JAP, MBH

Drawing Numbers:

11, 23, 210 to 213 and additional drawings on catalog sheets.

Samples Taken:

None

Preserved Dimensions (averages):

Largest preserved element: 2.54 m x .23 m x .04 m

Wood Type:

Quercus sp?

Condition:

Among the 16 fragments of port strake one, the majority are similar to the rest of the fragments from the port side as they are disarticulated and fairly small. Five fragments from the strake, SP1 1/4 and SP1 1/20 - 1/25, are still diagnostic, solid, and representative of long stretches of strake one (fig. 3-131). Those isolated and disarticulated fragments, SP1 1/1, 1/14, 1/17-1/19, 1/28, and 1/31 - 1/38, are fairly light and friable as a whole. Their interior faces are eroded and delicate and in some cases, such as fragments SP1 1/28, 1/31,



Figure 3-131: Drawing of fragments of port strake one (1:10 scale).

and 1/35, their external face is entirely eroded and missing. Their edges, however, vary greatly in preservation. All the fragments that retain an edge retain a section of their inboard, rabbet edge to the keel. No outboard edges, in comparison, are preserved among these 11 fragments. Unfortunately, because all the planking fragments in this strake are fairly disparate, it is unclear how many planks originally composed strake one.

Fragments SP1 1/4 and SP1 1/20 - 1/25 are much more diagnostic and representative of the strake. Fragment SP1 1/4, which is composed of four fragments that mate together to form an element 1.52 m long, is fairly solid and heavy, with well-preserved internal and external faces. The five fragments have little worm damage, and although the edges are rounded and somewhat worn, sections of the inboard, outboard, and a small scarf edge are still preserved. The inboard edge, however, preserves no evidence of a rabbet. Fragments SP1 1/20 - 1/25 all mate together to form a 2.54-m long element of the strake, a fragment aligned under floor timbers C to G. Although the fragments themselves vary in size, they are all well-preserved, the internal and external faces are solid and diagnostic, and they are relatively free of worm damage. Similar to SP1 1/4, inboard and outboard edges are preserved as well as a scarf edge. The aft end of this fragment, on SP1 1/20-1/21, is delicate and eroded, but this erosion quickly dissipates 10 cm towards the forward end of the plank.

Joinery:

The most evident element of joinery preserved among the strake fragments is the remnants of the rabbet edge to the keel. The largest preserved section of the rabbet is evident on fragments SP1 1/20 - 1/25, although portions are evident on SP1 1/14 and 1/17-1/19 as well. In all cases, the inboard rabbet is inclined between 110 and 120 degrees to the strake's interior face; these are values comparable to those recorded on the starboard strake one. Unfortunately, while on starboard strake one it was also possible to illustrate that this inclination decreased near midships, not enough material is preserved from port strake one to demonstrate a similar change in inclination. It should be noted, however, that while starboard strake one's rabbet edge was approximately 105 degrees to its interior face near midships, the port strake's rabbet - as measured on fragment SP1 1/20-1/21 - is 120 degrees to its interior face.

Other than the rabbet, however, the only other joinery of note are the two small scarf edges preserved along the outboard edges of the strake. The first, a diagonal scarf preserved along the inboard edge of SP1 1/4, is approximately 10 cm long and inclined 130 degrees to the remaining outboard edge. The second scarf, on SP1 1/24-1/25, is a short butt scarf that appears to accommodate the toe end of a plank in strake two. The outboard edge is interrupted by this 4-cm long face jutting outboard at an angle of approximately 100 degrees, then continues forward 90 degrees from this scarf face so that the strake's width begins to gradually shrink towards its forward extremity. Unfortunately, no extant material from strake two preserves a mating face to this scarf face.

There are no edge dowels or edge dowel holes evident in the fragments of strake one.

Fastenings:

There are no preserved treenails, or treenail holes, in this strake. Its disarticulated nature, and the absence of correlating framing material, also mitigates against correctly aligning many of the 31 nail holes preserved in the strake's material. As such, there are only three pairs of nail holes preserved, all of which are in fragment SP1 1/4. Among the remaining 25 nail holes, 11 pass from the exterior face of the plank, through the rabbet, and into the keel. These 11 holes exit the rabbet edge at an angle varying between 40 and 50 degrees to that edge, and average .64 cm² in size. On fragments SP1 1/17-1/19 and 1/20 through 1/25, where such measurements may be taken, they are spaced 40.5 cm apart on average, although that varies from 25 cm to 63 cm at the most. Only one nail hole in the rabbet, that in SP1 1/20-1/21, is aligned with another nail hole fastening the plank to a floor timber.

The remaining 14 nail holes that fasten the floor timbers to strake one are predominantly found along the outboard edge of the strake, none closer than 2.6 cm to the outboard edge. There are no preserved pairs among these nail holes, and of the 3 that are missing contiguous inboard or outboard material, it is unlikely that the missing material contained an associated nail hole. Overall, the nail holes average .78 cm².

Marks and Coatings:

Unlike starboard strake one, port strake one preserves little exterior or interior pitch along its surfaces. What external pitch is present is worn and eroded, and found only in patches along the exterior face of the plank. The near-absence of internal pitch is a more dramatic difference. The internal pitch present on starboard strake one preserved not only the original depth of the rabbet, but the whorls and eddies that formed as the pitch was applied. On port strake one, the only internal pitch evident is on fragments SP1 1/20 - 1/25, in a thin, faint and worn strip 64 cm long along the rabbet edge. No other internal pitch is evident.

Saw marks too, are few and faint. Near the aft end of the strake, they are only evident on fragments SP1 1/1 and 1/4; they are still fairly diagnostic, however. Both sets of marks indicate that the cutting proceeded from the stern to the bow end of the plank, and the saw was inclined from 80 degrees towards the bow to approximately 110 degrees towards the stern. No more saw marks are evident along the length of the plank until fragments SP1 1/31 - 1/33 and SP1 1/35 - 1/37. These examples indicate that the saw was inclined approximately 60 to 80 degrees towards the bow, and the cutting, in this case, proceeded towards the stern of the vessel.

Fragments SP1 1/14 - 1/25 have no preserved saw marks, but do retain adze marks. No nick in the blade of the adze is evident, but the familiar faceted face is present on all eight fragments. The dubbing appears to proceed across the width of the strake, but it is unclear if the work began closer to the bow or stern end of the strake. It is the presence of this dubbing that may indicate that port strake one was composed of at least three planks. Plank one, which is represented by fragments SP1 1/1 and 1/4, is characterized by saw marks proceeding towards the bow, while plank two is distinguished in fragments SP1 1/14 - 1/25 by the dubbed internal face. Plank three, near the bow, is evident in fragments SP1 1/31 through 1/37 by new saw marks that proceed towards the stern.

No hammer blows, axe or scribe marks, or paint is evident on port strake one.

Other Comments:

Strake one is most notable for its preservation. In comparison to other port strakes, it preserves both the most material and the most information. It is still, however, fairly disarticulate and fragmentary. Disregarding fragments SP1 1/4 and 1/20 - 1/25, the

remaining fragments of strake one are fairly delicate and small, and should be handled with particular care. As this material, in comparison to starboard strake one, is also much more uncommon, it should all be handled very rarely to minimize the potential loss of information.

It is unclear when material from strake one was labeled, but it is unique that four fragments that mate together are all labeled as SP1 1/4. No problems resulted from this shift in nomenclature, but it should be noted for future study.

Lastly, as strake one is composed of small and delicate fragments, it is inevitable that some were lost. Fragments labeled SP1 1/2, 1/3, 1/5 through 1/13, 1/15, 1/16, 1/26, 1/27, 1/30 and 1/34, all of which were presumably extant on the sea floor, are now missing.

Port Strake Two

Timber Numbers (Lot Numbers):

SP2 1/1 - SP2 1/4, SP2 2/5, (10025)

Old ID on site:

Port strake two

Dates Cataloged:

July 26 and 27, 1998; August 8, 1999

Catalogers:

BAJ, JMM, JR, MBH

Drawing Numbers:

19, 20, 21, 39 and 139

Samples Taken:

Dendrochronology sample 37

Preserved Dimensions (Largest Fragment):

.31 m x .09 m x .034 m

Wood Type:

Quercus sp?

Condition:

The three delicate and friable fragments of strake two retain some portions of their interior faces, but little of their exterior faces. Only fragment SP2 2/5 preserves a small section of an edge, although it is unclear which edge it is. There appears to be little worm damage among these three fragments.

Joinery:

No edge dowels or scarfs are preserved.

Fasteners:

Two fragments retain two nail holes. The first, in fragment SP2 1/3, is an eroded hole now 1.2 cm in diameter while the second, in SP2 2/5, is .5 cm². It is unclear if either of these nail holes is near the inboard or outboard edge, or how they may align with other fastener holes, as no edges or framing material is preserved. No trenails or trenail holes were identified.

Marks and Coatings:

Little external or internal pitch is preserved; that on the exterior is eroded and scattered, while only a small drop of internal pitch is present near the nail hole in fragment SP2 1/3. A few, faint saw marks are evident on the internal faces of SP2 1/3 and 1/4, but both their inclination and their cutting direction are unclear.

Port Strake Three

Fragment Numbers (Lot Numbers):

SP3 1/1 - SP3 1/4, (10025)

Old ID on site:

Port strake three

Dates Cataloged:

August 25 and 28, 1998

Catalogers:

JMM, JR

Drawing Numbers:

18, 27 - 29

Samples Taken:

None

Preserved Dimensions (Largest Fragment):

.59 m x .16 m x .033 m

Wood Type:

Quercus sp?

Condition:

Strake three preserves four fragments, as well as the largest fragment among these remaining eleven so it is, in a relative sense, the best-represented strake outboard of port strake one. The four fragments of the strake, however, are still fairly delicate and friable. Erosion is evident on all internal and external faces, and none of the fragments preserve any original edges. Many of the broken edges are still friable and splintering.

Joinery:

No edge dowels or scarfs are extant in these four fragments.

Fasteners:

Three nail holes, however, are preserved in fragments SP3 1/2 and 1/3. All three average .55 cm² in size; unfortunately, none align with each other. No treenails or treenail holes are evident.

Marks and Coatings:

Eroded and patchy external pitch is preserved only on SP3 1/3, and no internal pitch is found. Similar to strake two, faint saw marks are evident on all four fragments but their inclinations and cutting directions are unknown. No adze, axe, scribe marks or hammer blows are evident on these four fragments.

Port Strake Four

Fragment Numbers (Lot Numbers):

SP4 1/1 - SP4 1/3, (10025)

Old ID on site:

Port strake four

Dates Cataloged:

July 21, 23 and 28, 1998

Catalogers:

BAJ, JAP, JMM

Drawing Numbers:

9, 12, 33

Samples Taken:

None

Preserved Dimensions (Largest Fragment):

.367 m x .152 m x .029 m

Wood Type:

Quercus sp?

Condition:

Fragment SP4 1/1 is the best-preserved of the three fragments that compose strake four. It is fairly heavy and solid, but its faces are still eroded and friable. This fragment, similar to the others in strake four, preserves no original edges. All of the faces of the fragments in strake four are delicate, friable and eroded, and their extremities are delicate and splintering.

Joinery:

No scarfs or edge dowels are evident among the three fragments of strake four.

Fasteners:

Two nail holes are preserved in the three fragments of strake four. These two nail holes, in fragments SP4 1/1 and 1/2 are both .6 cm² but they do not align with one another. There are no treenails or treenail holes extant.

Marks and Coatings:

External pitch is better preserved on strake four than on strake three; it covers the external faces of all three fragments. The only internal pitch present is a small accidental drop on fragment SP4 1/1. A few faint saw marks are evident on SP4 1/1 and 1/2 but, similar to other strakes inboard, both the inclination and cutting direction are unclear.

Port Strake Five

Fragment Numbers (Lot Numbers):

SP5 1/1 (10025)

Old ID on site:

Port strake five

Dates Cataloged:

July 28, 1998

Catalogers:

JAP

Drawing Numbers:

26

Samples Taken:

None

Preserved Dimensions:

.312 m x .172 m x .035 m

Wood Type:

Quercus sp?

Condition:

Strake five is the most poorly represented strake on the port side, composed of only fragment SP5 1/1. This fragment, also labeled as UM 295, retains a better-preserved external face than internal face, although both are still afflicted by erosion. No original edges are preserved, and the broken edges are, similar to the faces, eroded and delicate.

Joinery:

No joinery, such as scarfs or edge dowels, is evident.

Fasteners:

The fragment does preserve two nail holes. The first, eroded to 1 cm in diameter, is aligned across the fragment's width with the second, which is .6 cm². It is still unclear, however, which fastener hole is associated with the inboard or outboard edge. No treenails, or treenail holes, were identified.

Marks and Coatings:

Fragment SP5 1/1 has no internal pitch, but the external face is covered with pitch and scattered spots of concretion as well. No tool marks are preserved on either face.

Ceiling Strakes

Unlike the majority of the planking material preserved from this wreck site, the fragments of the ceiling strakes are very delicate, fragmentary, and disarticulated. As will be

evident from the following brief catalog, they appear to have been fastened to the floor timbers very sparingly so this investigation was hampered by both their buoyancy and the heavy amphorae cargo weighing down upon them. The first contributed to their absence, while the latter contributed to their destruction. What material remains, unfortunately, illustrates little and a great deal of its interpretation, presented in the following chapter, is based predominantly on the fragments' locations in situ.

Ceiling Strake Two

Fragment Numbers (Lot Numbers):

CS2A 1/1 - CS2A 1/4, CS2A 1/10 (10295, 10299)

Dates Cataloged:

August 9 and 10, 1998; April 12, 1999

Catalogers:

BAJ, JMM, JR, MBH

Drawing Numbers:

59 plus additional drawings on catalog sheets

Samples Taken:

None

Preserved Dimensions (Largest Fragment):

.167 m x .082 m x .037 m

Wood Type:

Quercus sp?

Condition:

The four ID tags associated with ceiling strake two represent approximately 22 oak fragments, nearly 15 of which are labeled as part of CS2A 1/10. None of the fragments are more than 17 cm long, and all have fairly well-eroded exterior faces. No original edges are preserved, and the fragments' broken edges are fairly delicate and friable. The internal faces of fragments CS2A 1/1, 1/2 and 1/4 preserve a great deal of original surface, but there is little diagnostic information contained on any single fragment. The 15 or so fragments of CS2A 1/10, in comparison, are all delicate, eroded, friable, and contain little or no diagnostic information.

Joinery:

No joinery, such as treenails, scarf edges, and edge dowels are preserved in ceiling strake two.

Fastenings:

No nails or bolts, or associated holes, are evident in any of the fragments from ceiling strake two.

Marks and Coatings:

No tool marks are evident, although the upper edges of the floor timbers below the fragments impressed themselves into the exterior faces while in situ, resulting in deep gouges on the fragments' external faces. A light coating of pitch, approximately .2 cm thick, is evident on the internal faces of the majority of the fragments.

Other Comments:

These fragments are also part of lots 10295 and 10299.

*Ceiling Strake Three***Fragment Numbers (Lot Numbers):**

CS3 (2x), CS3 1/1 - CS3 1/5, CS3 1/8, CS3 2/6 - CS3 2/8, (10293, 10295, 10298 and 10524)

Dates Cataloged:

August 9 and 11, 1998; April 6, 1999

Catalogers:

BAJ, EAG, JR

Drawing Numbers:

61

Samples Taken:

None

Preserved Dimensions (Largest Fragment):

.243 m x .109 m x .03 m

Wood Type:

Quercus sp?

Condition:

The 11 ID tags of ceiling strake three, labels CS3 (2x), CS3 1/1, 1/2, 1/3, 1/4, 1/5, 1/8, 2/6, 2/7 and 2/8, represent approximately 37 extant fragments. The oak fragments are delicate, splintering and friable, and many have suffered from erosion on one or more of their faces. Fragments CS3 1/1 - 1/5 preserve only portions of their original bottom face, and no surface of their upper face. Fragment CS3 1/8, in comparison, has a well-preserved upper face but no lower face, while the remaining fragments have no original faces at all. No original edges are preserved.

Joinery:

No scarfs, treenails or edge dowels are preserved in any of the fragments.

Fastenings:

There is no evidence of fasteners such as nails or bolts.

Marks and Coatings:

Pitch is evident on fragments CS3 1/1 - 1/5 and 2/8, but only on the bottom face. None is evident on any upper faces. Fragments CS3 1/1 - 1/5 also preserve faint saw marks on their bottom faces, but the cuts' inclinations and their direction of travel is unknown.

Other Comments:

The fragments' labels indicate that there are at least two planks in ceiling strake three, but both where and how they join is unknown. These fragments are also associated with lots 10293, 10295, 10298 and 10524.

Ceiling Stake Four

Fragment Numbers (Lot Numbers):

CS4, CS4 1/1 - CS4 1/8, CS4 1/10 (10293, 10295 and 10632.01)

Dates Cataloged:

August 15, 1998; April 12, 1999

Catalogr:

JMM, MBH

Drawing Numbers:

62 plus additional drawings on catalog sheets

Samples Taken?

Species and pitch samples.

Preserved Dimensions (Largest Fragment):

.279 m x .179 m x .025 m

Condition:

Thirteen oak fragments comprise ceiling strake four, varying in size from approximately 28 cm long to less than 7 cm long. Four unspecific fragments, labeled only as CS4 in lot 10632.01, have no diagnostic information, just a thin coating of pitch. The remaining nine fragments, CS4 1/1 - 1/8 and 1/10, have small portions of their interior surface preserved, but the exterior face is far too eroded to even examine for data.

Joinery:

No treenails or edge dowels are evident among these nine fragments, but one possible butt scarf is preserved at the forward end of CS4 1/10, indicating that at least two planks originally comprised this strake.

Fastenings:

No fasteners or fastener holes are preserved in ceiling strake four.

Marks and Coatings:

No pitch is evident on any of the preserved fragments. A few faint saw marks are evident along the butt scarf edge, but neither their inclination nor cutting direction is evident.

Other Comments:

These fragments are also cataloged in lots 10293, 10295 and 10632.01.

Ceiling Strake Five

Fragment Numbers (Lot Numbers):

CS5, CS5 1/1.P, CS5 1/15 - CS5 1/16, CS5 1/33, (9682, 10295, 10313)

Dates Cataloged:

August 8 and 9, 1998; April 9, 1999; June 26, 1999

Catalogers:

BAJ, JR, KEW, MBH

Drawing Numbers:

125 plus additional drawings on catalog sheets

Samples Taken:

None

Preserved Dimensions (Largest Fragment):

.167 m x .096 m x .02 m

Wood Type:

Quercus sp?

Condition:

Among the 14 fragments of ceiling strake five, the best-preserved is fragment CS5 1/33, a knot plug from the strake approximately 11 cm in diameter. It has clean faces, little surface damage, and no worm damage. No original edges are preserved. The rest of the fragments from the strake noticeably descend in condition. The three fragments in CS5 1/15 have some original surfaces on their internal faces, but their bottom surfaces are completely eroded. The eight fragments in CS5 1/1.P and CS5 1/16 contain one or two areas of original surfaces, while no original surfaces are preserved on the two fragments in CS5. Overall, no original edges are found, and all of the fragments are relatively small, light and delicate.

Joinery:

No scarfs, trenails or edge dowels are evident on any of the fragments in strake five.

Fastenings:

No nails or bolts, or associated holes, are preserved in strake five.

Marks and Coatings:

Faint traces of pitch are preserved on fragment CS5 1/1.P, but the degraded nature of the fragment precludes any ability to determine where or why the pitch was applied. Fragment CS5 1/33, being the best-preserved, retains some saw marks across its internal face, proceeding from the bow to stern of the vessel, but their inclination relative to an edge cannot be determined. No other tool marks are evident among the fragments of strake five.

Other Comments:

These fragments are also indexed in lots 9682, 10295 and 10313.

*Ceiling Strake Six***Fragment Numbers (Lot Numbers):**

CS6 1/4, CS6 1/9, CS6 1/10

Dates Cataloged:

August 8, 9 and 10, 1998

Catalogers:

BAJ, JMM

Drawing Numbers:

57, 58 plus additional drawings on catalog sheets

Samples Taken:

None

Preserved Dimensions (Largest Fragment):

.252 m x .12 m x .058 m

Wood Type:

Quercus sp?

Condition:

Fourteen fragments represent ceiling strake six, 11 of which are very eroded, worm eaten, and delicate. Those 11, all cataloged as CS6 1/4, have no original surfaces or edges. Of the remaining three fragments, CS6 1/9 still retains diagnostic information. Its exterior face is badly eroded and worm damaged, but its interior face is fairly solid and clean. It has no preserved edges but in comparison to CS6 1/10, which has poorly preserved faces and no edges, fragment CS6 1/9 is distinctly better.

Joinery:

No scarfs, trenails or edge dowels are evident. One portion of the interior face appears to be chamfered at an angle of approximately 40 degrees, although this may also be the result of damage during the wrecking or settling process.

Fasteners:

One possible eroded nail hole, 1.2 cm in diameter, is preserved in CS6 1/9. It is unknown what other fasteners, either within ceiling strake six or in other ceiling strakes, this may align with.

Marks and Coatings:

Very light traces of pitch are preserved on what may be the exterior face of CS6 1/9, although this is uncertain. No traces of pitch are found on other fragments. A small group of possible adze marks are also found on the interior face of CS6 1/9, near the chamfered surface. No other tool marks are preserved on the remaining fragments in the strake, however.

Other Comments:

The two fragments in CS6 1/10 are additionally cataloged as CS6 1/10A and 1/10B.

*Ceiling Strake Seven***Fragment Numbers (Lot Numbers):**

CS7 1/1 (10295)

Dates Cataloged:

August 9, 1998

Catalogers:

BAJ, JR

Drawing Numbers:

None

Samples Taken:

None

Preserved Dimensions (Largest Fragment):

.14 m x .09 m wide

Wood Type:

Quercus sp?

Condition:

Ceiling strake seven is represented by ten small and delicate fragments, all cataloged as CS7 1/1. None preserve original surfaces or edges, and only two of the fragments mate together via a broken edge. All are friable and splintering, and have little or no diagnostic information.

Joinery:

No scarfs, treenails or edge dowels are preserved among the fragments of CS7 1/1.

Fasteners:

No nails or bolts, or associated holes, are evident.

Marks and Coatings:

A few of the fragments have small, scattered and eroded areas of pitch on their surfaces.

Stringers

The number and locations of the preserved fasteners in the framing material indicates that originally the Bozburun vessel had, prior to the turn of the bilge, two stringers on either side of the keel. The first starboard stringer, that described below, was located approximately 57 cm from the centerline of the vessel. The second, of which there is no preserved material, was affixed to the framing c. 1.2 m outboard of the first; presumably, both stringers were relatively identical in design and size.

*Starboard Stringer***Fragment Numbers:**

SST 1/1 (10293), 1/2

Dates Cataloged:

July 29, 1998; August, 2004

Catalogers:

JR, MBH

Drawing Numbers:

35 plus additional drawing on catalog sheet

Samples Taken:

None

Preserved Dimensions:

1.735 m x .21 m x .065 m

Wood Type:

Pinus sp?

Condition:

This element of the inboard starboard stringer, which is composed of four fragments, is large, heavy, and difficult to maneuver without inflicting damage. The faces

and edges are impressionable and friable, but the wood itself is still fairly solid. Approximately 80 percent of its interior face retains original surfaces, but the bottom face is badly eroded and afflicted with *Teredo* damage. The fragments' original edges, although still present somewhat, are also afflicted with *Teredo* damage and, despite those original surfaces, retain little diagnostic information. The broken edges are delicate and splintering, and particularly prone to additional breakage.

Joinery:

No scarfs, treenails or edge dowels are evident in the three fragments from the first starboard stringer. Still evident, however, is a 5-cm wide chamfer along the upper, outboard edge of the stringer that meets the top face at 35 to 40 degrees, and either side at 40 to 50 degrees. This chamfer appears on all four fragments. As this chamfer did not mate to another timber, it was most likely fashioned to cushion impacts between the cargo and the stringer.

Fastenings:

Four nail holes are extant along the preserved length of the stringer. All three measure between .7 and .8 cm², and three of the four pass through the stringer to attach to the floor timber below. The fourth nail hole, located between floor timbers H and I, is only present on the top face of the stringer and indicates that an additional structural element, perhaps a stanchion, was attached to the stringer's interior face. No bolts or bolt holes are evident in the fragments.

Marks and Coatings:

Rust and concretion are evident surrounding the three nail holes mentioned above, but no pitch is apparent on any of the preserved faces. No saw marks, adze dubbing, or scribe marks are evident as well.

Mast Step

That this fragment was labeled as the mast step in situ was a somewhat serendipitous act. While on site, and even now, it has little or no diagnostic information other than its size and location and as such, it could have been labeled with a UM label, or as part of a pump or a keelson (figs. 3-132, 3-133). Its presence, first noticed in 1996, led the excavators to the conclusion that it represented a keelson aligned with the keel. This



Figure 3-132: Photograph of the top of the largest fragment of the mast step.

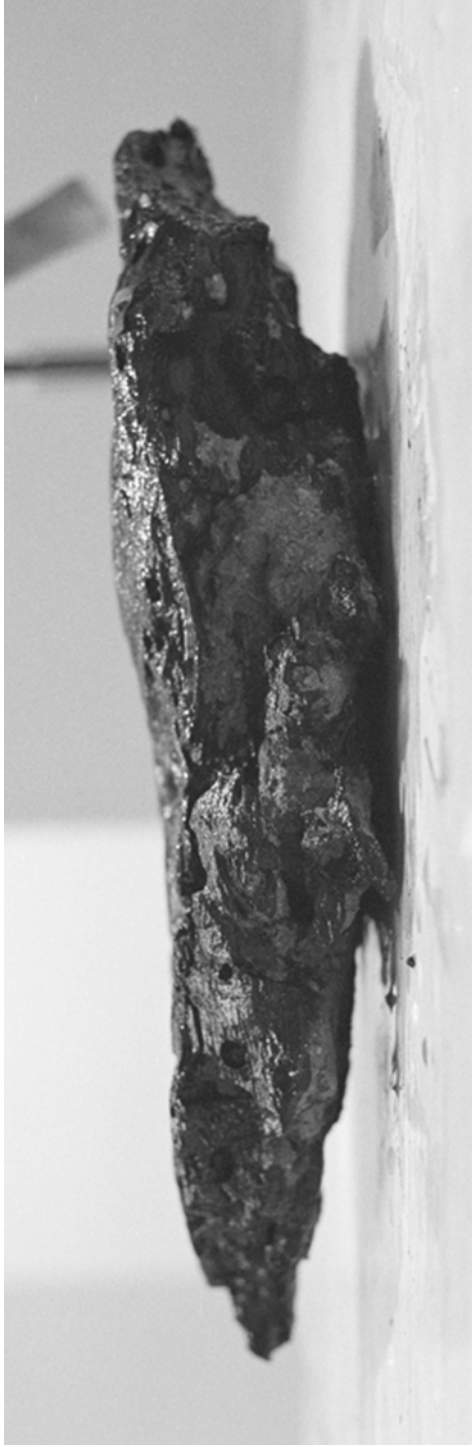


Figure 3-133: Photograph of the side of the largest fragment of the mast step.

conclusion, due to the paucity of fastener holes and corroborating evidence, has since been discounted. It has also been argued that this fragment may be part of a pump assembly, a conclusion that seems unlikely. The fragment itself sits on top of the floor timbers instead of the keel and, despite its size, retains no evidence of the two vertical shafts needed to house the elements of a chain pump in use during this period. Without the lines plan in Chapter 5, moreover, it was also unclear until now that it aligns approximately with the hull's center of lateral resistance. In other words, it is in the ideal location for a mast step.

Mast Step

Fragment Numbers (Lot Numbers):

MS 1/3

Dates Cataloged:

July 13, 2002

Catalogers:

MBH

Drawing Numbers:

216

Samples Taken:

None

Preserved Dimensions:

.544 m x c. .279 m x .055 - .09 cm

Wood Type:

Quercus sp?

Condition:

Due to the elevation of the two fragments in MS 1/3 above the sea floor, they were exposed to a variety of hazards prior to their burial. In addition to the settling cargo, these two fragments were exposed to passing nets, anchors, and particularly *Teredo*. As a result, little if any original surface survives, except on the bottom, and both ends are broken and eroded. As such, the only possible original surface is the bottom face, which is still fairly flat. The exterior faces of both fragments are still riddled with worm holes, and are friable,

delicate and splintering. Due to its weight and size, the larger of these two fragments should be handled rarely and only when necessary.

Joinery:

Other than the flat face on the bottom of the fragment, no scarfs, edges, treenails or edge dowels are evident throughout fragment MS 1/3.

Fasteners:

No nails or bolts, or their associated holes, are extant.

Marks and Coatings:

Due to the fragment's eroded and friable surface, no tool marks are preserved across its surface. No pitch, either external or internal, is evident as well. The few, long indentations evident on the top face were incurred during storage, and are not part of the mast step's original structure.

Other Comments:

Unfortunately, without any preserved edges or fastener holes, the exact alignment of MS 1/3 is unclear. The fragments' approximate location is evident in Figure 2-4, a location that was used during the reconstruction of the ship.

Endnotes

- ¹ Floor timber A is cataloged in eight fragments, but 17 labeled pieces are associated with this floor timber.
- ² This floor timber had relatively small preserved dimensions near the keel (8 x 12 cm) so the resulting dimensions near the bilge (.11 x .155 m) are not very divergent.
- ³ Floor timber D, which consists of disarticulate fragments and which may be incomplete, only has 10 preserved treenails.
- ⁴ The average center-to-center spacing of the treenails in floor timber D is .138 m, but this average is drawn from only the longest contiguous set of treenails in the floor timber, a collection of six measurements.
- ⁵ Floor timber 6 only yielded one cross section, .133 m deep by .141 m wide, through the midbody. As such, it is not included in determining changes in the molded or sided dimensions; its dimensions also fall within the extremes of the midbody molded and sided dimensions.
- ⁶ Floor timber 9, which preserves both faces of the limber hole, is broken at the apex of the limber hole. As such, its re-assembled design results in a 36 degree angle at the apex of the limber hole.
- ⁷ Personal communication, Dr. Fred Hocker, Summer of 2000.
- ⁸ Personal communication, Mr. Troy Nowak, Summer of 2000.
- ⁹ Similar joinery was most likely used in the port planking as well, but the port planking fragments are so poorly degraded that no edge dowels were identified.
- ¹⁰ The 83 dowels or dowel holes mentioned in Harpster (2005) counted the 33 complete dowel joints as one dowel each and not two separate halves as is done here, and did not include the three dowel holes that never appear to have been used.
- ¹¹ See Harpster (in press) for a published version of this hypothesis.
- ¹² Even the 9 cm-long dowel in strake seven only tapered approximately .2 cm along its preserved length.
- ¹³ The outboard edge of strake thirteen is not preserved, but it is currently assumed that it did have dowel joints in it as well.
- ¹⁴ Bound 1985, 49, 51; see also Pomey 1995, 460.
- ¹⁵ Bound 1985, 52, 56; see also Pomey 1995, 473, 476; personal communication with Mr. Mark Polzer, Spring 2002.
- ¹⁶ Bound 1985, 52; see also Pomey 1995, 473, 476.
- ¹⁷ Personal communication, Drs. Carlo Beltrame and Dario Gaddi.
- ¹⁸ Bonino 1969, 51, fig. 3; see also Damianidis and Çoban 1999, 137, fig. 5.
- ¹⁹ Prins 1986, 84, 86; see also Vosmer et al 1992, 11, 13, 15, 18, 38 and 50; Adams 1985, 31-4.
- ²⁰ Prins 1986, 86 fig. 53; see also Vosmer et al 1992, 11.
- ²¹ Of the two treenails in plank two, one – that in SS4 1/43 – is definitely identified as such, while the second – in SS4 1/38-1/39 – is only tentatively identified as such.
- ²² Personal communication with Dr. Peter Kuniholm and Maryanne Newton, Spring 2002.

A CORPUS OF LATE-ROMAN AND EARLY-MEDIEVAL SHIPWRECK SITES

Discussion

The following collection of late-Roman and early-medieval wreck sites in the Mediterranean represents, in its most elemental sense, a collection of comparative archaeological data. As all of these sites retain some collection of cargo or, at the very least, items carried on board a ship, it is possible to quantify that data and collate the sites that contain similar cargo or similar items. The 7th-century site at **Grael B**, for example, contains a steelyard very similar to one recovered from the 7th-century site at **Yassiada** and the steelyard from Bozburun. Amphorae on **La Palu** and **Fos-sur-Mer** share inscriptions bracketing a cross, while amphorae from **Keratidhi** and Bozburun are instead marked with a **Λ** and an **E**.

This corpus of wreck sites may also represent the paucity of primary data available about shipbuilding during this period. Of the approximately 118 sites described, only 30 report the presence of what may or may not be hull remains. Among those 30 sites, the hull material of only 14 has been investigated and published. The amount of available information associated with those 14 sites is, however, not uniform. There is only a brief description of the fragments preserved at **Lara Limnionas**, the hull of **Serçe Limanı (1973)** was under investigation for nearly a decade, while the **Yassiada 7th-century** hull has been hypothetically rebuilt. Those 14 sites - **Agay**, **Bataguiet**, **Dor 2001/1**, **Dor D**, **Fos sur Mer**, **Lara Limnionas**, **Pantano Longarini**, **Pisa D**, **Serçe Limanı (1973)**, **Tantura A**, **B**, **C**, **Yassiada 4th century**, and **Yassiada 7th century** - are, moreover, not equally distributed among the centuries encompassed by this corpus. Nine sank between the 5th and the 7th centuries, only **Yassiada 4th century** was earlier, while the remaining four date between the 7th and 11th centuries. These 14 sites are randomly scattered geographically as well. The largest number of sites with hull material is found off the coast of Israel, while only one site, **Lara Limnionas**, is off the coast of Greece.

When applied to an historical context, interesting patterns emerge.¹ After the Muslim arrival in the 7th century, for example, there is a distinct decrease in the apparent

frequency of wrecked ships throughout the Mediterranean Sea. Approximately 19 sites date between the middle to late 6th century, while only 12 date to the middle or late 7th century.² A virtual nadir is reached in the 8th and 9th centuries when the archaeological record implies that international shipping appears to be at a standstill. Other than a 9th-century amphora, with parallels in the Black Sea and at Bozburun, found in **Keratidhi Bay**, Cyprus, the other four sites securely dated to the 8th and 9th centuries were found in a cultural context that matched some or all the cargo on board the wrecked vessel.³ Comparatively, the 10th and 11th-century commercial activity exemplified in the Cairo Geniza reflects a parallel increase in sites with cargo in a foreign context. It may be argued, then, that the archaeological material reflects a trend commonly attributed to this period: the Mediterranean system of commerce was upset by the Muslim arrival in the Mediterranean and there was not a recovery until the 10th or early 11th century.

Enlightening, however, are particular details of the historical trends illuminated by the archaeological record. Judging solely by this corpus, the 10th century economic recovery appears to be a result of the Muslim conquest of Sicily in 902.⁴ For example, while the Byzantine amphora at **Keratidhi Bay** may represent the only international commerce during the 9th century, the dates of **Agay**, **Bateguier**, **Esteou**, and **Serçe Limanı (1973)** all coordinate with the Muslim occupation of Sicily from 902 to 1061. All four of these Islamic cargoes sank in non-Islamic contexts and among them three are in the western Mediterranean.⁵ Not only does this distribution imply that the preponderance of 10th and 11th-century buyers and traders were European, but that the Muslim conquest of Sicily fueled a European demand for Islamic goods from Alexandria.⁶

The Muslim loss of power on Sicily in 1061, however, did not signal the end of this increased commercial activity in the Mediterranean. Byzantine Y-shaped iron anchors from the 11th-century sites at **Cape Graziano** and **Plemmirio E** off Sicily attest to this continual activity as readily as later records in the Cairo Geniza do.⁷

Maritime activity in the shadow of a foreign power is evident in this corpus during earlier periods as well. During the 5th century, as Constantinople was losing its presence in Italy and as the Visigoths and Vandals threatened territory throughout the western Mediterranean, commercial traffic at Sicily appears to have continued unabated. Six

Byzantine sites along the Sicilian coast date to the 5th century. One, **Marzamemi J**, apparently sank in the latter half of the 5th century or the early 6th century, despite the Vandal King Gaiseric terrorizing Sicily and southern Italy with his own fleet.⁸ A seventh site from the same period, **Pisa D**, sank far from a Vandal threat, but deep within Ostrogothic territory nonetheless.

Sites off the coast of Sicily in the 6th century represent maritime activity as well, but with a different focus. Justinian's armies, under the leadership of Belisarius, managed to retake most of Italy by 540, but the effort was too strained and too far from Constantinople. By 560 the Ostrogoths had regained control of the majority of the country but in general, Italy had been ravaged and many cities had withstood numerous sieges in the 20 years of fighting.⁹ Five sites off the coast of Sicily represent maritime activity, but activity more likely related to Belisarius' armies or Justinian's caesaropapism. Carrying components of a Byzantine basilica possibly bound for Libya, **Marzamemi B** sank off Sicily between 525 and 550, a period similar to Belisarius' overthrow of the Vandals in North Africa and his later landing on Sicily.¹⁰ Other sites off Sicily, such **Capo Passero** with its roof tiles and **Cefalu** with numerous amphorae bearing *dipinti*, inscriptions, and graffiti, may have been supplies for Belisarius' armies.¹¹

Five 7th-century sites in the eastern Mediterranean may represent a similar amalgamation of activities. Amphorae and other objects on board the **Yassiada 7th-century** vessel have close ties to the Church.¹² As the Emperor Heraclius appealed to the Church for aid during his campaigns against the Persians after 622, it has been theorized that the cargo on board this ship came from the Church to re-supply Byzantine troops in Palestine and Syria.¹³ The early 7th-century vessel at **Datça** in Turkey, as well as three sites on Cyprus, **Cape Andreas 17**, **Episkopi Bay** and **Keratidhi Bay**, are also characterized by the presence of amphorae similar to those found on the **Yassiada 7th-century** vessel. As a result, these latter three sites may also represent similar voyages bringing ecclesiastical goods to the Byzantine military. It is tempting to theorize further that commercial goods were still available along the Syrian and Palestinian coast, as a return voyage with an empty hull would have surely lost the vessels' owners money.

Not all 7th-century sites, however, appear to be related to re-supplying Byzantine troops. **Tantura A** off the coast of Israel, which had local and foreign types of amphorae on board, may have been built and operated during the first half of the 7th century AD while the Persians were occupying that coastline. A radiocarbon date of **Tantura C**, wrecked nearby, may indicate a similar date of construction and usage, while 7th-century ceramic material at **Lara Limnionas** off Cyprus has parallels in Constantinople.

The archaeological record, however, is not the only record that may illuminate activities in the Mediterranean during this period. Textual and historical sources not only document more voyages, but indicate continued activity near or across political and military frontiers as well. Hagiography of 7th-century events in the eastern Mediterranean, for example, describe the grain ships that fought off the Avars attacking Thessalonica in 618.¹⁴ Saint Artemios, while in Constantinople in the 7th century, cured a trader from Chios, two sailors, a shipbuilder and a *naukleros* from Rhodes.¹⁵ In 616, two ships returned to Alexandria from Sicily full of grain to feed immigrants fleeing the Persian invasion farther east while in 617, Saint John the Almsgiver traveled from Alexandria to Rhodes, and finally to Cyprus.¹⁶

Even during the 9th century, with a dearth of archaeological information, similar commercial activities are still evident. The Byzantine State maintained government posts related to shipping, trade, and in particular, foreign merchants.¹⁷ The deacon Maurus traveled on board an Italian merchant vessel, from Constantinople to Ravenna, between 830 and 850.¹⁸ Even the Emperor Theophilus sent emissaries to Abd al-Rahman II in Cordova, between 839 and 840.¹⁹ These activities occurred despite the presence of Cordovan Muslims on Crete between 827 and 960; a group known for piratical raids on passing ships as exemplified by their capture of Joseph the Hymnographer in 842.²⁰

By the end of the 12th century, on the eve of the third Crusade, the Muslim traveler Ibn Jubayr could tramp on Christian vessels from Spain to the eastern Mediterranean and back delayed only by the weather. He and his companions were even saved from a foundering ship by the intervention of King William II of Sicily, the great-grandson of Roger de Hauteville who sponsored part of the first Crusade.²¹ Perhaps most important is Ibn Jubayr's observation near the Frankish fortress of Kerak, outside Jerusalem, describing

the commercial traffic through the area. Muslim caravans continued to travel through Frankish territory – indeed, right by the fortress – as did Frankish merchants through Muslim territory; in both cases their activities were secure and uninterrupted despite the warring armies nearby.²²

McCormick's recent research collating a collection of textual material indicates that the movement of people, letters and goods across boundaries, such as the examples above, was much more prevalent during the 8th and 9th centuries than previously thought or reflected in the archaeological record.²³ Between 750 and 850, for example, there are only four maritime archaeological sites in the Mediterranean. Between 850 and 950 there are only five sites. It may be argued, then, that the overall amount of maritime activity during those 200 years may have stayed approximately the same. McCormick's research, however, indicates that maritime activity doubled during the second half of the 8th century, and doubled again by 825.²⁴ The Muslim invasion of Crete in 827 certainly dampened this rise, but to a level of activity still greater than that approximately 75 years earlier.²⁵ By 900, maritime activity in the Mediterranean had risen back to a level nearly equal to that in 800.²⁶ In short, the following archaeological sites should be seen as representative of discrete events that, in only the barest sense, reflect greater changes around them. As such, they and their associated finds may be collated to indicate trends but, due to their disparate nature, the validity of those trends needs to be qualified against a much more comprehensive historical backdrop.

Corpus

Agay

This site was brought to the attention of Pierre Danneyrol and Alain Visquis, the two subsequent investigators of the site, in the early 1960's by a local fisherman who had snagged some pottery in his nets.²⁷ The site is located along the south coast of France, about 300 meters to the East of Cape Dramont, at a depth of approximately 50 meters. By 1972, the excavation resulted in the recovery of seven basalt grinding stones, amphorae, oil lamps, and a variety of North African pottery, in addition to the exposure of one hull.²⁸ Two or three anchors were also identified on site, but it is unclear if these were raised.²⁹ Later work on site in 1973 and 1975 revealed some copper cauldrons and casserole dishes,

the exposure of a second hull, as well as two humeri, two femurs, and a left tibia, all apparently from one individual in the second hull.³⁰ The larger of the two hulls, the first found, has been identified as a merchant vessel while the smaller hull may be the merchant vessel's boat.

The ship was first estimated to have sunk at some point in the 9th century AD.³¹ Examination of the oil lamps, however, insisted on a later date, and the site is presently dated to some time between the end of the 9th century and the opening of the 11th century AD.³²

Of the two craft, the smaller hull is more poorly preserved. Approximately 4 meters of the keel are present, but there is no preserved keelson.³³ The keel is apparently made up of four pieces, each approximately 1.2 m long, which were attached to each other with a flat scarf.³⁴ The one illustrated scarf was affixed together with seven nails along a length of 18 cm.³⁵ Notable along the length of the keel are two St Andrews' crosses inscribed on the interior face of the keel, near midships.³⁶ The sternpost, which was not preserved, was affixed to the keel with a flat scarf, while the stem, of which an undisclosed amount was preserved, was apparently attached to the keel with one or more mortise and tenon joints.³⁷ There is a slight rabbet along the keel, which appears to be approximately 5 mm in depth in the accompanying drawings.³⁸ Ten floor timbers and three possible futtocks may be discerned on the site plan, but the text reports that 14 frames were found on site.³⁹ Sections of five starboard strakes are evident, as well as two fragmentary port strakes.⁴⁰ The starboard planking also contained a preserved batten, approximately 1.5 cm square, between strakes 2 and 3.⁴¹ There is no discussion of the assembly of the smaller craft, but it appears to be relatively straightforward. There are no mortise-and-tenon joints reported in the planking and the planking is not illustrated as nailed to the keel. The floors, on the other hand, are nailed to keel with one nail each. It appears that the keel, stem, and sternpost were assembled, then a particular number of floor timbers were nailed to the keel. It is possible that after floor timbers near amidships were affixed to the keel, the batten was nailed to these floor timbers as well as to the keel itself. The resulting sweeps in the batten could then have been used as a guide to shape the remaining floor timbers at the extremities, but this is not confirmed or supported by the published evidence. Regardless

of when the batten or all of the floor timbers were attached, the first three strakes were definitely attached to the erected floor timbers, and not vice versa.⁴² Following the attachment of the first three strakes, the futtocks were most likely attached next, followed by the remaining planking.

The investigators reported that the preserved hull material of the larger vessel, which is estimated to have been 25 m long by 7 m wide, was in very good condition.⁴³ By the end of the 1972 season, 14 frames of the larger hull had been exposed, as well as some ceiling planking.⁴⁴ Later work on site revealed an additional 12 frames.⁴⁵ In all, the 26 frames alternate between floors, with associated futtocks, and half frames. There are 12 definite floor timbers, eight sets of half frames, and six additional framing elements at the extremities that are unidentified. No keel was identified on site in the 1970's. Re-examination in 1996, however, brought the keel's presence to light.⁴⁶ Approximately 4.5 m of the keel is still preserved, 10.5 cm wide and 17.5 cm high.⁴⁷ This later re-examination also indicated that the cross-sectional shape of the ship is very similar to that at **Bataguiér**; both appear to be flat-bottomed with a distinct turn at a bilge strake. Unfortunately, it is unclear which extremity is the bow or stern, so the port and starboard sides cannot be inferred. Nonetheless, there are approximately eight preserved strakes on the west side of the keel, and two on the east side.⁴⁸ The strakes were not joined together edge to edge, and were all nailed to the interior framing. Due to this vessel's apparent similarity to Bateguier, however, it may be assumed that the methods of assembly were similar. After the keel, stem, and sternpost were assembled, some or all of the floor timbers were attached to the keel. Once enough planking had been affixed to these floor timbers to support the half frames, it is likely that these framing elements were attached next. Then, once the sixth or seventh strake had been affixed to the floor timbers and half frames, the futtocks were fitted and inserted.

Bataguiér

During a systematic survey of the Bay of Cannes in 1973, the Société d'Archéologie Subaquatique came across the presence of approximately 15 globular jars resting in a small group on the sea floor.⁴⁹ This collection of material was nearly 600 m to the west of Saint Marguerite Island in Bataguiér Bay, at a depth of approximately 54 m.⁵⁰ Investigation

revealed the presence of other, smaller jars within this group, while examination of the jars themselves resulting in finding oil lamps and fragments of copper cauldrons within a number of them.⁵¹ The larger jars were approximately 1 m in diameter, 1.2 m in height, and contained nearly 1000 l of liquid.⁵² The smaller jars, on the other hand, contained approximately 50 l.⁵³ Preliminary work in 1973 exposed numerous pots, pitchers, jugs and glass ware, as well as a left and a right femur from two individuals.⁵⁴

In 1974, directed by Jean-Pierre Joncheray, divers further investigated the wreck and the nearby area, and excavated a trench across the site. Due to disturbance of the site from passing anchors and fishermen's nets, the extent of the wreckage stretched over 100 m in length but it was concentrated in an area 24 x 11 m.⁵⁵ By the end of that season's work, approximately 500 objects had been plotted *in situ*, and 360 had been recovered.⁵⁶ The cargo included millstones, copper cauldrons, and a wide variety of pottery. The pottery included the large and small jars as well as amphorae, tréfoil pitchers, basins, covered casserole dishes, oil lamps and gargoulettes.⁵⁷ Due to the similarities between the cargo at this site and the cargo recovered at Agay, Bataguier was preliminarily dated to *ca.* AD 980 back in 1973.⁵⁸ Although Carbon 14 dated the two femurs to approximately AD 560 to 600, other material from the wreck has been dated typologically to *ca.* AD 950, a date that is still associated with this site.

Probing into the sediment in the mid 1970's revealed the presence of hull material extending over an area 20 x 6 m.⁵⁹ No other details of the hull, however, could be gleaned from the site at this time as a diving accident in 1979 ceased all investigation of the site. No re-examination occurred until Anne and Jean-Pierre Joncheray and Marie-Pierre Jezegou returned to the site in May of 1993.⁶⁰ Working with COMEX, this visit to the site, which occurred with divers and an ROV, verified that many of the ceramics on site were still well preserved.⁶¹ A few more details of the hull material, as well as a preliminary cross-section of the ship, are now available as well. Oriented north to south, approximately 11.35 m of the vessel is preserved, retaining a maximum width of 4.3 m.⁶² The reconstructed cross-section of the ship indicates that it has a flat bottom, distinct bilges that turn at approximately 135 degrees, as well as L-shaped floor timbers that appear to alternate along their length in an

arrangement similar to that on the 11th-century vessel from Serçe Limanı.⁶³ It is unknown if any more investigation of this site has occurred since 1993, or if any more is planned.

Cape Andreas 17 and 24

The archaeological material at sites 17 and 24 was discovered in 1969 off the northeast coast of Cyprus by the same archaeological expedition from Oxford University that found at least two other early medieval sites in the immediate area. The survey, which was continued in 1970 and 1971, found these sites approximately .4 to .5 km from the mainland, off the northern coast of the second island in the chain of the Klidhes, at a depth of approximately 20 m.⁶⁴

The material from site 17 is very close, geographically and typologically, to material from site 24. As such, while in 1969 the two sites were discussed separately, in 1973, they were grouped together as one possible collection of material.⁶⁵ This grouping of the material does not result in any drastic changes in interpretation or dating, but it has meant that one item that was associated with site 24 in 1969 was subsequently associated with site 17 in 1973.⁶⁶

As a whole, the archaeological material is composed primarily of terracotta boxes, which may be sarcophagi, and a small variety of amphora types.⁶⁷ Of the amphorae recovered for study, many are of a Byzantine type common on Cyprus, while others are the piriform variety, also found on the 7th-century wreck at Yassiada.⁶⁸ Moreover, in addition to these amphora fragments, five anchors, each of a different design, are also associated with site 17. Although four of these anchors are single-holed stone anchors, the fifth is a small Y-shaped iron anchor, with a preserved shank 55 cm long, and arms preserved in a span 62 cm wide.⁶⁹ No hull remains are associated with either site.

Cape Graziano

The east coast of Filicudi island, one of the Lipari islands north of Sicily, was the subject of underwater surveys in 1961 by the Club Méditerranée, Gerhard Käpitan and Luigi Bernabo Brea in 1968 and 1975, and in 1977 by a team of four divers, again including Gerhard Käpitan.⁷⁰ Along the edge of a generally rocky ledge surrounding Cape Graziano, at a depth between 25 and 50 m, a collection of archaeological material dating between the 3rd century BC to cannon from the 18th century AD was surveyed and mapped in place.⁷¹

Among this collection of material is late-Roman pottery and amphorae, as well as four iron anchors of late Roman or early Byzantine date. The amphorae are very similar to north-African Dressel 26 types of the 4th or 5th century AD.⁷² The arms of three of the anchors, numbers four through six, are perpendicular to the shank, an anchor design very similar to those found on the 7th-century wreck from Yassiada.⁷³ Moreover, the length of one of the anchors' shanks, find number four, is 2.58 m, a length comparable to anchors found on the Yassiada wreck as well.⁷⁴ The arms of the fourth anchor, number two, are attached to the shank at an obtuse angle, and in this case, the anchor is similar to the Y-shaped iron anchors recovered from the 11th-century site at Serçe Limanı.⁷⁵ Just like the anchors found at Cape Andreas 23-26, these anchors do not necessarily represent the presence of wrecked vessels, but only the presence of seafaring activity in the area during this time. In light of the widespread nature of the ceramic material in situ, and the lack of hull remains, such a conclusion seems more plausible.

Capo Passero

Lying at a depth of 10 to 12 m off the northwest coast of Sicily, this site was primarily identified by a pile of broken roof tiles scattered among the rocks. It has been presumed that there were more amphorae and tiles at the site at one time, but it may have also been subject to recent looting by the local fishermen and divers nearby. Nonetheless, part of a Byzantine amphora has dated the site to approximately AD 400 to 650. Some iron concretions are visible among the tiles, but nothing more is the cargo or the hull is known.⁷⁶

Cefalu

By 1975, it was evident to researchers on Sicily that a late-Roman or early-medieval wreck, as indicated by the presence of 6th to 7th-century AD amphorae fragments, was present off the north coast of Sicily at Cefalu.⁷⁷ By 1982, with the pressing need to create a research center to study this site and approximately 100 others identified along the northeast coast of Sicily, Gianfranco Purpura carried out a more detailed survey of the early-Medieval site at Cefalu to determine the full extent of the material in situ.

In addition to a sword with a wooden sheath, iron tools, at least three iron anchors as well as fragments of ceramic pitchers, dishes and frying pans, amphorae of approximately eight different types were found on the site as well.⁷⁸ One amphora, apparently carrying

wine, has parallels in the Black sea - as does one pitcher - while numerous other amphorae have parallels in the eastern Mediterranean.⁷⁹ One amphora fragment, from a Scorpan VIII B, apparently preserves a red *dipinti* of υΥΧ, a second is inscribed with an A on the side and XXX across the shoulder, while a third of the Scorpan XXIZ type has a Greek graffito of ασηπρια.⁸⁰ Other amphorae are marked with graffiti or inscriptions such as IEREUS, DIMES, ΑΘΥ, NES, and VINU[M] SYLVAN.⁸¹ The site is currently dated to the 6th or 7th century by amphora typologies.

As a result of Purpura's examination in 1982, information regarding wood preserved at the site is available as well. Nine beams and at least seven vertical stanchions are preserved over a 35-meter distance, indicating to the author that substantial remains of the ship are preserved much deeper in the sediment.⁸² Moreover, Purpura also concludes that the relatively slim shape of the vessel, at least 35 meters long by approximately 6 meters wide, could indicate that this was not a cargo vessel, but a *dromon*.⁸³ He reconciles the presence of the associated amphorae and the galleyware by hypothesizing that they served the needs of the crew, and were not cargo per se.⁸⁴ The relatively wide spacing of the beams, however, the apparent size of the indicated structure, and the rough-hewn nature of the wood could also lead one to interpret the preserved structure as not that of a ship, but of a wooden quay.⁸⁵

Datça

This Byzantine wreck site is located approximately 50 m northeast of the tip of Iskandil Burnu, or "Sounding Point", at the very western end of the Datça Peninsula. Following information gathered from local sponge divers, investigators on the 1981 Institute of Nautical Archaeology survey found an amphora mound, approximately 8 m long and 4 m to 5 m wide, situated between 25 and 35 m deep.⁸⁶ Members of the 1982 survey team revisited the site to conduct a further preliminary examination that year, and found more ceramic material associated with the wreck site, approximately 8 to 10 m upslope.⁸⁷ A similar visit was made again in 1983, this time to augment the photomosaic made in the previous two visits, and to test a new metal detector on the site.⁸⁸ During those three visits, a total of eight amphorae, four jugs or juglets, a *kedera* or cooking pot, a closed casserole dish, one fusiform container, and the base of a glass goblet were recovered.⁸⁹ The

amphorae collected varied between five different types: egg-shaped or globular, cigar-shaped, hourglass or piriform, carrot-shaped, and one amphora of a previously unidentified, miscellaneous type.⁹⁰

As no coins or other similar objects were recovered from the site, any dating of this wreck can only be done through typological analysis of the ceramic material.⁹¹ As a result, this site may be only preliminarily dated to the end of the 6th or the beginning of the 7th century.⁹²

In 1984, this site became the subject of a Master's Thesis by Manuela Lloyd, who pursued the topic in an effort to glean as much information regarding this ship as possible from the limited material recovered. As no hull material was brought to the surface, and the amphora mound was never completely excavated or moved to examine any hull remains preserved below it, her conclusions regarding this hull are limited to size and capacity.

Lloyd postulated that based on the size of the amphora mound and the extent of the wood exposed below that material, the ship was approximately 18 m long and at least 4 m in beam.⁹³ Determining the approximate capacity of the hull, however, required a greater amount of extrapolation. First, the assumption was made that because the globular and cigar shaped amphorae were the majority of the amphorae found on site, they were the primary cargo of the ship.⁹⁴ Thus, the total weight of the ship's cargo left on the seafloor was approximately 8.23 tons.⁹⁵ However, although the estimated size of the Datça vessel is similar to the 7th-century vessel from Yassiada, the estimated capacity is not. So, additional logical assumptions were then included in her calculations to eventually determine that the original cargo of the ship upon sinking was approximately 30 tons.⁹⁶ Unfortunately, as no hull material was recovered there is no information regarding the wood used, or possible methods of construction.

Dor 2001/1

During the annual survey work in the Dor / Tantura harbor along the coast of Israel, the joint expedition sponsored by the Leon Recanati Institute for Maritime Studies (RIMS), the University of Haifa, Dr. Christopher Brandon and the Nautical Archaeology Society (NAS), Dr. Kurt Raveh, Aqua Dora and Dr. Ya'acov Kahanov uncovered this site in approximately 1 m of water.⁹⁷ Following two weeks of preliminary survey and excavation

in November of 2001, a second season occurred in the summer of 2002, revealing much more information about the site.

The site is approximately 70 m offshore, oriented northwest to southeast, and was buried under 1.5 m of sand. A great deal of pottery was found during the excavation, but due to the active nature of the lagoon, it is unclear if it associated with the wreck.⁹⁸ Amphora fragments, similar to those recovered from the 7th-century site at Yassiada, were found in the area as well, but again no immediate association is clear.⁹⁹ Two layers of *kurkar* building stones, however, remained in situ, still neatly stowed in three rows.¹⁰⁰ As amphora or pottery typology may be misleading, the only dating of this site is based on carbon 14 analysis of hull fragments, indicating a date between the 3rd to 6th century AD.¹⁰¹

The current extent of the hull is 11.2 x 2.7 m, including fragments of the false keel, keel, keelson, 32 frames, planking, ceiling, a beam and a stringer, and part of the mast step.¹⁰² The total length of the ship is estimated to be approximately 13.5 m. Preliminary investigation indicates that the framing – most of which was apparently of one piece – was nailed to the keel with multiple nails, while the planking and ceiling was similarly affixed to the framing.¹⁰³ By the end of the 2002 season, although none of the hull had been dismantled, it was proposed that this ship was built in a modern “frame-first” manner as no mortise-and-tenon joinery had been discovered.¹⁰⁴ An additional two season of work on this site, in 2003 and 2004, are planned to determine the true nature of this ship.

Dor D

The discovery of this wreck site, along with eight others, occurred between June and October of 1991, during the survey of the harbor at Dor by the Dor Maritime Archaeology Project.¹⁰⁵ During that survey these nine sites were identified in a compact area measuring approximately 85 m in diameter.¹⁰⁶ These wreck sites are located less than 200 m south of Tantura Lagoon, in which an additional four early Medieval wreck sites have been surveyed and partially excavated. To distinguish these nine sites from the others nearby, those wrecks within Tantura Lagoon are called Tantura A through Tantura D, while these nine sites are known as either DW (Dor Wreck) 1 through DW9, or Dor A through Dor I. Of the nine sites found in this area at least four date to the late 6th or early 7th century, but only one, Dor D (DW4), appears to have been examined recently.¹⁰⁷

Very few artifacts are associated with this wreck site. Other than a compact group of three stone anchors to the west of the preserved hull material, Dor D is distinguished primarily by the presence of a ballast pile and hull material.¹⁰⁸ The preserved hull material comprises a collection of 14 planking fragments, one of which was sampled and dated by Carbon 14 analysis to AD 420 – 500.¹⁰⁹ Although no evidence of framing or a keel was found, staining and scribe marks on the planking material indicate that the sided dimensions of the framing ranged from 8.5 to 14.2 cm sided, and the frame were spaced approximately 23 cm apart.¹¹⁰ Overall, the total length of the vessel is estimated to be between 15 m and 20 m.¹¹¹

Except for one mortise-and-tenon joint in plank seven near a diagonal scarf, all of the mortise-and-tenon joints were unpegged.¹¹² These joints, found in ten of the fourteen preserved plank fragments, averaged 6.3 x .5 x 3 cm.¹¹³ The tenons were noticeably smaller than the mortises, and commonly filled only 60 percent of the mortise width.¹¹⁴ These tenons not only tapered along their length, but along their thickness as well, and were only .3 to .4 cm wide near their ends.¹¹⁵ Due to the distribution of the mortise-and-tenon joints in the preserved planking, and that these tenons were commonly loose in their mortises, the conclusion has been drawn that these joints could not have served as the primary method of joining the hull strakes together. Essentially, some sort of supporting structure, possibly framing, needed to be in place prior to the assembly of the planking material, while the play in the mortise-and-tenon joints aided the maneuvering of the planks upon this supporting structure.¹¹⁶

This conclusion, however, does not account for the presence of the scribe marks on the interior surface of the planking, and also makes a particular assumption about the process of planking a hull. The scribe marks on the interior face of the planking of Dor D, similar to those marks found on the 7th-century wreck at Yassiada, denote the locations of the framing on the pre-erected planking; if framing was in place first, then such marks would be unnecessary.¹¹⁷ Moreover, the conclusion seems to have been drawn that planks are fitted together by roughly cutting them to shape, in this case with mortise-and-tenon joints in the edges, and then shifting the unfinished plank back and forth a short distance to determine where it will best fit. Commonly, spiling planks, with or without mortise-and-

tenon joints, onto a pre-existing structure is not such a haphazard process. The plank may be roughed to shape, but its edges are cut to specific contours that fit in the necessary space. Essentially, although there is a process of gradually shaving and fitting the new plank to an existing contour, there is no process of shifting the plank fore and aft, as much as the 5 cm that these joints would allow, as the plank is cut to fit only one location. Additionally, if this shifting fore and aft was part of the process of construction, once the first plank in a strake is fitted in place, then there is no need to continue shifting the following planks to fit them in place as well. Presumably, the next plank in that strake could only fit in one location, scarfed immediately against the first plank already in place. For that matter, if the joints were designed to allow play fore and aft during the construction process, essentially holding the plank in place as it was fitted to frames and adjacent planks, why not use external clamps instead? Clearly, as the investigators write, these planks illustrate that the shift from the edge-joined to the frame-first construction technique was not a simple linear one, and that more investigation, and information, is required.

Episkopi Bay

Located on the southern coast of the island of Cyprus, Episkopi Bay was the subject of an underwater survey in the summer of 2003 between June 30th and August 8th. Cooperating with the excavation inland at Episkopi Bamboula carried out by Dr. Gisela Walberg at the University of Cincinnati, Justin Leidwanger, Toby Jones, Troy Nowak, Emilia Vassiliou, Elena Stylianou and Chris Parks surveyed two areas along the bay's coastline near Kourion and Cape Zevgari.¹¹⁸ Divers carried out their work from the shore or from a local fishing boat, conducting swim line surveys parallel and perpendicular to the shore to a depth of approximately 25 m.¹¹⁹ Approximately 74 artifacts were recovered, catalogued, and brought to the local museum at Kourion for conservation.

Investigation in the first area surveyed the mole near Kourion and the cliffs nearby, but the only clue that the area was used in the late-Roman or Byzantine era was the reported presence of Byzantine graffiti in a cliff overlooking the bay.¹²⁰ Material in the second area revealed a much wider chronological span of activity, from the late Archaic period to the Ottoman era.¹²¹ Near Cape Zevgari, at site AK-S3, the investigators surveyed a 5th- or 6th-century site with approximately 150 fairly intact amphorae necks, possibly representing the

wreck of a small trading vessel.¹²² In addition to a collection of sherds from LR1 amphorae, some of which are identical to those excavated from the 7th-century site at Yassiada, one late-Roman amphora with parallels found only on Cyprus and the Levantine coast was uncovered as well in areas AK-N1 and AK-N2.¹²³ More important, perhaps, is the identification of four samples of 8th-century amphorae near area AK-N2, nearly identical to examples from Saraçane in Istanbul.¹²⁴ In light of the small number of wreck sites or jettison identified from the 8th century, any material indicating maritime trade during this period is valuable.

Esteou

Following the discoveries of Agay in 1962 and Bateguier in 1973, the wreck site at Esteou is further evidence of the Muslim presence off the coast of France in the 10th century AD. This site, which was found in September of 1975, is east of Marseilles and southeast of the island of Esteou, in approximately 10 to 26 m of water.¹²⁵ The site was further examined and partially excavated in 1976, raising approximately 62 objects and exposing some hull material.¹²⁶ No dendrochronological or radiocarbon dating of the exposed material seems to have occurred, so the current date of the wreck, in the 10th century AD, appears to be based solely on typological parallels of the ceramics.¹²⁷

Among the objects recovered were millstones, gargoulettes, oil lamps, two amphorae, pitchers, wooden tool handles and an amphora stopper, as well as a number of concretions that were later cleaned and cast in silicone rubber.¹²⁸ These castings produced an axe, an adze, a brushhook, a chisel, various nails and an iron. Hull material was evidently exposed on site, the only site plan indicates its orientation and arrangement, but no identification of the timbers appears to have occurred.¹²⁹ Material that may be fragmentary planking and framing came to rest on a sandy seafloor, but all that is evident is that nails may have been used to assemble these components. No other details of this hull are apparent.

Fiumicino 1

During the construction of the Leonardo da Vinci airport in 1959 at Fiumicino, near Rome, five vessels came to light. In addition to this one, which is characterized as a

transport vessel used in ports and rivers, a sister ship was found, as were two medium size craft, and a small fishing boat.¹³⁰

Fiumicino 1 was initially recorded and conserved in the early 1960s, but since that time, some of the frames have cracked and parts of the vessel have distorted. By using German photographs taken of the vessel in 1976, however, a new set of lines was produced and a subsequent model was constructed.¹³¹ It was through the analysis of the vessel's construction that the ship is dated to the 4th or 5th century, apparently no artifacts are associated with this wreck.

The ship, which is estimated to have been approximately 17 m long by 5.6 m in beam, was built by affixing some of the planking together with un-pegged tenons prior to bolting some or all of the floor timbers to the keel.¹³² The overall structure of the hull, with a flat bottom and curved stern, as well as a mast step set far forward of the center of effort, have convinced the investigators that this craft could have been a *navis caudicaria*, which was commonly towed from the banks of the Tiber river.

Fos-sur-Mer

Found on the southeast Mediterranean coast of France near Marseilles, this wreck was first exposed due to the construction of a new jetty which had shifted the local currents. Although it is unclear how long the wreck site had been exposed, the material was first found on April 11, 1978, by the divers Alain Gazagne and Michel Petot. The material was in shallow water, 2.5 m deep, and approximately 200 m from the shoreline.¹³³

Initial appraisal of the material in situ revealed two Merovingian belt buckles which loosely dated the wreck to the opening of the Middle Ages in France. Later analysis of the recovered cargo, however, fixed the date of the wreck at some time between the second half of the 6th and the opening of the 7th century.¹³⁴

Direction des recherches archéologiques sous-marine (DRASM) carried out preliminary salvage work on the site between June 28 and September 4, 1978, but research and excavation between 1978 and 1979 was carried out under the direction of Marie-Pierre Jezegou.¹³⁵ In addition to identifying four different types of amphorae and two types of amphora bodies, a variety of differing amphora sherds and toes were recovered. Many of these were apparently not contemporaneous and thus made dating difficult.¹³⁶ Other

recovered objects included a single Type II Hayes African oil lamp, two sherds of clear glass, Byzantine ceramics, pseudo-Christian ceramics, coarse ware, and six coins.¹³⁷ Three additional coins appeared to be Merovingian.¹³⁸

In addition to cargo and personal artifacts, a preserved section of the hull, approximately 9.5 x 4.5 m, was uncovered.¹³⁹ This preserved hull material included portions of the keel and keelson, a mast step, 13 floor timbers, 13 half frames, 11 futtocks, planking, wales, ceiling planking and a well preserved bilge pump.

There are discrepancies concerning the construction of this ship. Naturally, the keel, stem and sternpost were assembled and affixed together first, but it is unclear what step was taken next.

Jezeqou's publication from 1980 never specifically described the order in which the ship was built, so it must unfortunately be inferred. As such, it may be assumed that her order of explanation in which the various elements of the ship were attached to each other parallels the relative order of construction.¹⁴⁰ As such, in 1985 she reported that certain frames were attached to the keel after the placement of the keel, stem and sternpost.¹⁴¹ Further inquiry into her publications and the framing and fastening pattern of this ship reveal that, unlike her conclusions, affixing the framing to the keel was likely not the next step in construction.

Information regarding the framing elements of Fos-sur-Mer, their fastening to the keel, and their pattern of distribution is sparse, so assumptions need to be made. Jezeqou writes that both floor timbers and half frames were used in the construction of this ship.¹⁴² Although she does not explain it, there appears to be a pattern to their arrangement. Examining the illustrations accompanying her 1980 work, it appears that the vessel from Fos-sur-Mer was built with alternating floor timbers and half frames. This pattern, however, can only be extrapolated from the general plan of the preserved hull material, and the illustrations of seven frame stations in the ship.¹⁴³

Jezeqou also writes in 1983 that all of the floor timbers and some of the half frames were nailed to the keel of the ship.¹⁴⁴ She slightly clarified this statement in 1985 by reporting that all of the floor timbers, but one in the stern, and five of the half frames were nailed to the keel.¹⁴⁵ In neither case, however, does she specify which half frames were

nailed to the keel, and which were not. The general plan of the preserved hull material does not designate the location of fasteners, and of the seven frame stations illustrated, only frame station 98 is drawn as bolted to the keel.¹⁴⁶ None of the other illustrated frame stations appear to be fastened in such a manner. Figure 1, which is a longitudinal cross section of the stern of the vessel, provides the most information (Fig. 4-1). Jezegou wrote in 1985 that iron bolts pass through the keelson, the framing material and the keel, affixing all three together.¹⁴⁷ She goes on to write that a similar construction was observed in the bow, and concludes that the keelson was affixed in place as the framing was attached to the keel.¹⁴⁸ Thus, from her point of view, the framing was erected prior to the addition of the planking.

Jezegou also argues that neither some nor all of the hull planking could have been erected prior to the assembly of framing material because of the small number of mortise-and-tenon joints recorded in the planking. According to her 1983 publication, she identified four mortise-and-tenon joints in 1978; two in the stern and two in the bow.¹⁴⁹ In 1979, two samples of planking from the port side were examined. While mortises were identified in one plank of the two contiguous fragments, none were found in the opposing fragment, convincing Jezegou that they served no purpose.¹⁵⁰ She went on to argue that the planking must have been re-used.

However, similarities in the pattern of mortise-and-tenon joinery in the contemporaneous Yassiada 7th-century ship from the coast of Turkey are evident. As the mortise-and-tenon joints on Yassiada were used primarily to fit the strakes together and to create the shape of the hull, they are more prevalent at the stern and bow of the vessel, rather than near amidships.¹⁵¹ In many cases, the distances between these joints in the stern ranged between 35 and 50 cm, while near amidships, they were spaced approximately 90 cm apart. Thus, during the excavation of the Yassiada 7th-century vessel, the likelihood of finding a mortise-and-tenon joint at either the stern or bow of the vessel was greater than finding it near amidships. During an excavation in which only select fragments of material were excavated and the rest was recorded underwater, such as the excavation at Fos-sur-Mer, the overall possibility of finding a mortise-and-tenon joint decreased, but was still more likely to occur near the extremities of the vessel. Additionally, just as recorded on

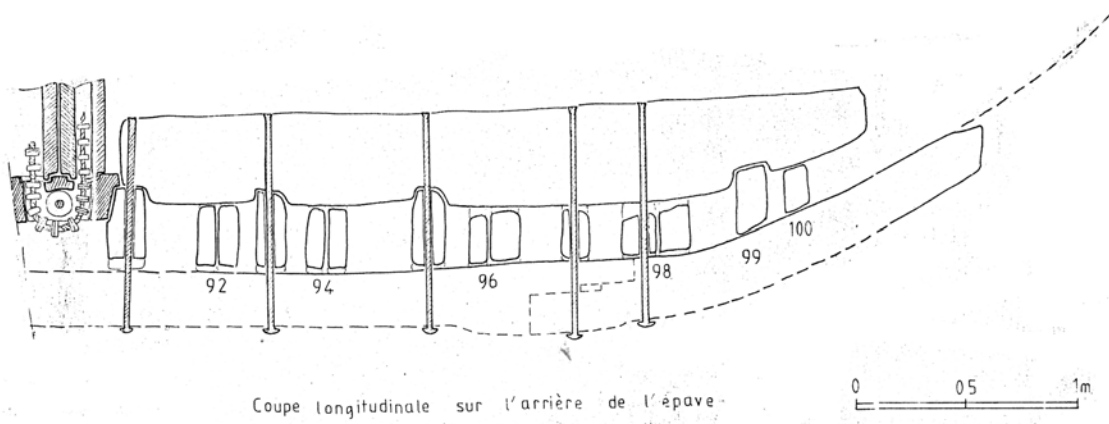


Figure 4-1: Drawing of the longitudinal cross section of the Fos-sur-Mer vessel (After Jezegou 1983, fig. 1).

material from Fos-sur-Mer, there are instances of mortises in one plank from Yassiada that do not have a corresponding mortise in a contiguous plank.¹⁵²

Additionally, the similarities between the framing pattern on the Yassiada vessel, and the apparent framing pattern on Fos-sur-Mer should also be noted. The framing on the Yassiada vessel consisted of short and long floors, as well as half frames, all of which alternated along the length of the vessel. The keelson on Yassiada too, is similar in construction to that from Fos-sur-Mer. Just like the preserved stern construction on Fos-sur-Mer, bolts were driven up from the bottom of the keel, and passed through the keel, floor timbers, and keelson.¹⁵³

Thus, Jezegou's conclusion that the vessel from Fos-sur-Mer was built in a purely frame-first manner, one in which some or all of the framing was erected prior to the addition of planking, should be called into question. Following her line of reasoning, and drawing certain assumptions about fastening patterns, results in a rickety assemblage of hull components. While the floor timbers, keel and keelson were all apparently bolted together, the proximal ends of the half frames were secure only because they were wedged between the keel and keelson. The half frames would, in all likelihood, simply fall to the ground unless they were all sufficiently braced.

After the keel, stem and sternpost were assembled then, it seems much more likely, considering the preserved evidence and similarities to the 7th-century vessel at Yassiada, that a particular number of strakes were erected prior to the insertion of some of the floor timbers. Once these floor timbers were in place, possibly nailed to the keel, more planking with or without mortise-and-tenon joints could be added. Once a sufficient number of strakes had been assembled, then the half frames could be affixed to the existing hull planking, and eventually, the keelson would be added and bolted through to floor timbers to the keel.

Grazel

Near the end of the 19th century, dredging operations commenced along the short canal that connected the pond at Gruissan, 11 km southeast of Narbonne, with the Mediterranean.¹⁵⁴ The dredging continued to clear the silting canal through the turn of the century, allowing the local fishermen to continue their work, until the winter of 1904 when

the collapsing banks revealed the presence of archaeological material.¹⁵⁵ At this time these artifacts, consisting of coins and bronze objects, were dated to the early-Byzantine era.¹⁵⁶

In 1974, to combat the continued silting in the same canal, more dredging occurred, revealing more objects from the deposit found in 1904, as well as a second deposit of material 300 m to the northwest.¹⁵⁷ This second deposit, now identified as Grael A, consisted of fragments of Dressel 1A amphorae and at least one fragment of 1st-century AD black glaze fineware.¹⁵⁸ The first deposit, called Grael B, contained a variety of bronze objects, including bowls and covers, hinges, nails, a cross, balance pans and a steelyard, as well as 28 coins.¹⁵⁹ Altogether, combining the material found in 1904, individual coins found at various times in the bank of the canal, and the material found in 1974, 33 objects and 101 coins are associated with the Byzantine site at Grael B.¹⁶⁰ Typological analysis of these objects, and examination of the coins, indicate that this site dates to the first half of the 7th century AD.¹⁶¹

Due to the concentrated nature of these finds, it seems most likely that they indicate the site of a shipwreck, and not spilled or jettisoned cargo. Whether any further examination of this site since 1974 has occurred, or if any hull remains have been uncovered, is unknown.

Keratidhi Bay

Two seasons of survey, in 1983 and 1984, by the Underwater Research Group from the University of London turned up as many as five early Medieval and Medieval sites along the western coast of Cyprus.¹⁶² Two of those possible sites, at Thalassines Spilies and Lara Limnionas, are discussed elsewhere. The other three sites are located in Keratidhi Bay.

This small bay, which was extensively examined with numerous swimline surveys across its width, is the southernmost of the sites examined on the survey.¹⁶³ The survey found that there are large concentrations of pottery, including galley ware, near the center of the deep bay, as well as a number of stone anchors.¹⁶⁴ Interestingly enough, although the small bay is well protected and would make an adequate natural shelter, the pottery found suggests a hiatus from the 1st century to the early 7th century.¹⁶⁵ After a possible pseudo-Koan amphora from the 1st century, the next earliest material recovered from the bay

represents a possible wreck carrying an amphora very similar to the Type II globular amphorae found on the Yassiada wreck from the early 7th century.¹⁶⁶

A second possible site in Keratidhi Bay is represented by the presence of a fragmentary 9th-century amphora. This amphora, which has close parallels in the Chersonesos, is significant as it preserved an oval stamp bearing a retrograde Λ and Ε on one of the handles.¹⁶⁷ The amphora type from the Black Sea is often characterized by graffiti or stamps bearing these two letters, which may represent the name ΛΕΟΝ.¹⁶⁸ A number of amphorae bearing similar graffiti, a lambda and an epsilon, were also recovered from the Bozburun wreck.

The third site, and the latest of the Medieval sites in Keratidhi, is represented by three fragments that may conform to an 11th or 12th-century type of amphora.¹⁶⁹ Very little is published regarding this material.

Unfortunately, it is unclear how many partial or whole amphorae of these various types were found on the floor of the bay, so it is unclear what the extent of these sites might be. As there is little additional information regarding the nature of the sea floor itself, it is additionally difficult to determine if hull material might be preserved.

Lara Limmionas

This site on the west coast of Cyprus, which is the northernmost of the sites surveyed during the summers of 1983 and 1984 by the Underwater Research Group of the University of London, contained a great deal of pottery and 15 stone anchors.¹⁷⁰ Of this large collection of material, however, only two representative samples of pottery were recovered. The second of the two is a fragment of a tulip shaped bowl dusted with mica.¹⁷¹ Similar material has been found in a 7th-century context at Saraçane in Istanbul, leading the researchers to conclude this fragment has a similar date.¹⁷² Unlike the other sites at Keratidhi and Thalassines Spilies, however, this site may have some preserved hull fragments. Following a great deal of natural scouring of the shore, three local divers found several timbers, two of which they pulled up and left on the nearby beach.¹⁷³ These two timbers, which have been catalogued, photographed, and identified as a futtock and a plank fragment, were subsequently reburied nearby. Due to their vicinity near the small mica dusted bowl, it seems to have been assumed that these timbers may date to the 7th-century

as well.¹⁷⁴ It is reported that the futtock was fastened with iron bolts as well as treenails, but in contrast, the planking fragment was apparently affixed with bronze spikes. The planking fragment was also sheathed in layers of lead, fabric, and pitch.¹⁷⁵ Further publication on these timbers is forthcoming, but at present, nothing more of this material is known.

Marzamemi B

During a series of surveys conducted by Piero Gargallo and Gerhard Käpitan in 1958 along the southeastern coast of Sicily, this team came across a series of marble-carrying shipwrecks off Cape Pachynus.¹⁷⁶ The largest of these wrecks is that found at Isole delle Correnti, but just north, at Marzamemi, two more wrecks carrying architectural elements were found.¹⁷⁷ One of these wrecks is now known as the Church wreck at Marzamemi B. Although the site was dated to some time between the 6th to 10th century upon discovery, later analysis of the architectural elements narrowed the date of the vessel's sinking to some time in the second quarter of the 6th century, during the reign of the emperor Justinian.¹⁷⁸

A choir screen of white Proconnesian marble, which aided the secure dating of the wreck, is one of many partially finished items that were once en route to the construction of a Byzantine basilica, possibly in Apollonia, Sabratha, or Cyrenaica.¹⁷⁹ In addition to the components of the basilica, which included at least 28 columns, bases and capitals, components of the choir screen and the ambo, the remaining material recovered consisted of early-Byzantine pottery (one with a Christ orans), the remains of a pithos, broken galleyware, amphora sherds, a wine thief and a bronze steelyard weight.¹⁸⁰ Despite three seasons of excavation over the summers of 1964 to 1966, the only fragments of the hull found consisted of splinters of wood and numerous concreted iron nails.¹⁸¹

Marzamemi J

In light of the success of previous underwater expeditions and surveys in southeastern Sicily, both from Oxford University and from elsewhere, another expedition team set out in 1976 to locate and survey archaeological sites in these shallow waters. This team too traveled from Oxford University, placed their camp about 2 km north of the village of Marzamemi, and began work in July of that year.¹⁸² In some cases, the sites they investigated were previously unknown to researchers, while in other cases, their work

proceeded with information gleaned from the personal notes of Gerhard Käpitan who surveyed this coast in the 1960s. This site, identified as Marzamemi J, was found to the west of a previously identified wreck site, known as Marzamemi E.¹⁸³ During investigation of the area southwest of Marzamemi E, ballast stones and a pile of amphora sherds were found. Upon investigation, it was evident that these sherds represented a separate wreck site, and dated from the 5th or 6th century.¹⁸⁴ Not all of the sherds came from one type of amphora, and it appears that no one type of amphora dominated the material, leading the investigators to conclude that these sherds did not represent cargo but more likely material from the ship's stores.¹⁸⁵ Further searches of the area failed to reveal further tumuli, and no hull material was found.

Pantano Longarini

The marshy plain of Pantano Longarini, along the south coast of Sicily, was purchased by the farmer Francesco Spatola in the early 1960's for its possible use as farmland. During his drainage of the marshes in the winter of 1963 to 1964, bulldozers uncovered a large deposit of wood approximately 600 m from the modern shoreline.¹⁸⁶ Unaware of either the age or previous use of the timbers, some of it was salvaged and brought to the nearby shipyard at Marzamemi to be sold. Andrea Patania and Gerhard Käpitan recognized the significance of the find, however, and upon reporting their suspicions to Mr. Spatola, the site was summarily reported to the Department of Antiquities in Syracuse.¹⁸⁷

Käpitan completed a preliminary survey and test trench of the submerged site in 1964, at which time he removed wood samples for radiocarbon dating. These samples dated from approximately AD 500.¹⁸⁸

In light of Mr. Spatola's attempts to use the marshes as farmland, the site was drained of excess water, and the excavation began in 1965, under the supervision of Professor Bernabo Brea.¹⁸⁹ Although the bulldozers had destroyed approximately 15 m of the starboard side of the vessel, possibly including the stem and a name plate inscribed in Greek, approximately 9.1 m of the stern section of the vessel remained intact.¹⁹⁰ The investigators assigned unique ID numbers to each of the exposed timbers, the extremities of the timbers were triangulated in situ, and a sketch of the site was developed from that

information. Following that process, each timber was also recorded at scale, identifying preserved tool marks and nail holes.¹⁹¹ In light of poor weather, a lack of funds, and Mr. Spatola's insistence to complete his project, the investigation finished with the removal and storage of the timbers at the end of the 1965 season.¹⁹²

Upon the exposure of the hull, it was immediately evident that this material preserved only a narrow longitudinal section of the original ship. Apparently, only a small part of the hull below the presumed waterline was found, and no material from the keel was found at all.¹⁹³ On the other hand, it has been presumed that upon wrecking and partial burial on the shore, the exposed timbers were soon salvaged by locals.¹⁹⁴ Thus, the excavated material preserved a stern section of the hull rising from the last two or three submerged strakes to a level possibly just below the deck.¹⁹⁵ Also immediately apparent to the investigators was a construction alluded to in late-Roman mosaics but never before found, a transom stern.¹⁹⁶

Other than the presence of the transom stern on this vessel, which was apparently made to support both the quarter rudders and a cabin, this wreck material is also significant as it, similar to the 7th-century material from Yassiada, only has mortise-and-tenon joints in the hull planking below the waterline.¹⁹⁷ These tenons, of pistachio wood, were fitted loosely into mortises spaced approximately 1 m apart along the planks of this vessel.¹⁹⁸ Thus, it has been presumed that the mortise-and-tenon joints in this vessel were utilized in the same manner as in later vessels, essentially, to aid in the alignment and setting up of the vessel prior to the attachment of the framing.¹⁹⁹

Throckmorton feels that the ship was built in a shell first manner similar to the 7th-century ship at Yassiada. As all of the preserved planking below the waterline wale GWL was tenoned together, he feels that the keel, stem, and skeg were assembled first, then the lower shell of planking was built next.²⁰⁰ He then writes that as this shell was complete, the frames, floor timbers, and futtocks could be fitted and affixed in place. However, as the next step in the construction process after the assembly of the lower planking was just to attach the waterline wale GWL, it is more likely that only the floor timbers were attached at this time. Once GWL was in place, then the half frames could be assembled, as well as the transom. As no remains of either a sternpost or skeg were found (their presence is only

assumed), the only preserved support for the transom is the tenoned planking and wale GWL, both of which extend below the transom construction, and are nailed to it. With the completion of the transom planking, then the four supporting timbers on the interior of the transom could be added, as well as the additional planking and wales up to wale FLS.²⁰¹ The through beams are represented by the preserved timber GXM, and as these sit on wale FLS, they were affixed next, to be followed by the remaining planking, futtocks, and upperworks.²⁰²

As mentioned previously, a significant feature of this wreck is the presence of the transom stern. This significance is due not only to the fact that the presence of transoms on late Roman or Early Byzantine ships was previously only assumed from mosaics, but also because this is the only preserved transom from antiquity on a seagoing vessel.²⁰³ Certain questions may be raised, however, regarding the reconstruction of this craft.

For example, although the reconstruction includes a keel and a skeg (or deadwood, as the case may be), it is interesting to note that although these timbers would have been below the preserved material, they were not found. Additionally, there is the reconstruction of the deadwood itself. According to Throckmorton's set of lines, the shaded area (Fig. 4-2) represents the deadwood on his reconstruction.²⁰⁴ But, he also argues that this deadwood did not support a stern rudder, as there is no rudder post. Instead the ship had two quarter rudders.²⁰⁵ If this is so, then the presence of the deadwood at the stern of the vessel becomes superfluous, and one may question why it is there. While it may be possible to argue that this deadwood rotted away, although material above it was preserved, it is easier to theorize that this deadwood was never present.

Primarily, the deadwood, if there was no stern rudder, served no function. From Throckmorton's re-assembly of the frame stations, it is evident that the framing material did not taper down onto the vertical faces of the deadwood, but rather crossed over almost horizontally.²⁰⁶ Secondly, the planking material too appears to meet this deadwood at a nearly 90 degree angle. This is particularly evident in the re-assembly of the framing material immediately forward of the transom construction.²⁰⁷ So if there was no deadwood, then how could the stern of the vessel have been built?

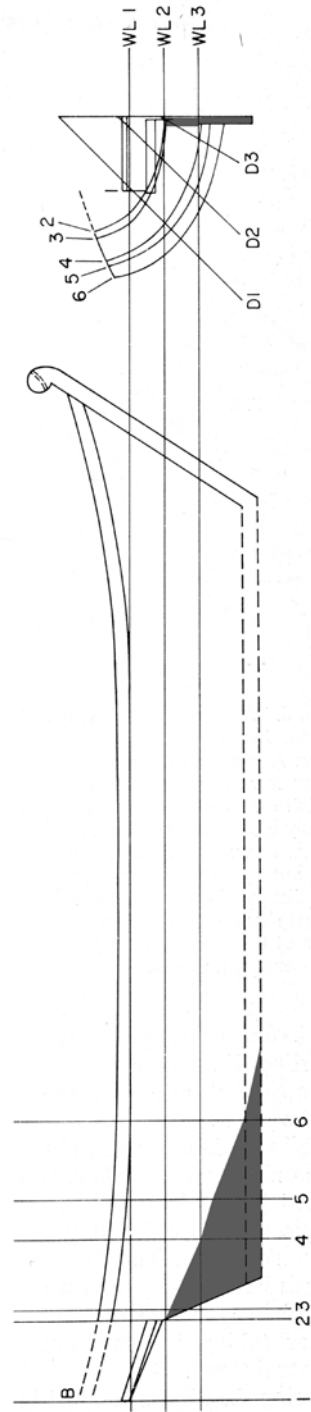


Figure 4-2: Throckmorton's lines of the Pantano Longarini vessel. The shaded area indicates the location of the skeg (After Throckmorton 1973, 258).

It seems easier to view this ship as one that was not built to cross the Mediterranean, but rather one that was used primarily on the rivers and marshes throughout the southeastern tip of Sicily. This is certainly the environment in which it was found, and the woods used to build this craft may be found in southern Italy.²⁰⁸ If this is so, then the ship was more likely built with a flat, somewhat rockered bottom, with either a relatively shallow keel or keel plank. In addition, the bow of the vessel could be composed of the vertical stem, or alternatively, the craft could be double ended with a transom at the bow as well.²⁰⁹ It should be noted that the stem drawn on Throckmorton's site plan bears some similarity in size to the supporting timbers over the transom, and mirrors their location fairly accurately.²¹⁰

If indeed this was the design and use of the vessel, then its order of assembly is still relatively the same. After the fabrication of the keel, which may have had some rocker along its length, the bottom planking was tenoned together and supported at its extremities. Next, the floor timbers were affixed to the keel, followed by nailing wale GWL in place. Lastly, the appropriate transom construction was built at either end of the vessel, the appropriate supporting timbers were added, and followed with the addition of more framing and planking material.

As to a possible cargo, although some fragmentary sherds of amphorae similar to those from Yassada were found in situ, the craft might have functioned as a horse ferry.²¹¹ A horse was apparently drawn on the now lost plaque that apparently bore the name of the vessel.²¹²

Pisa – Wreck D

The exposure of this wreck site along with 15 other ships, the remains of harbor structures and an apparently complete cross section of artifacts associated with life along the ancient waterfront, began in December 1998. The foundations were being laid for a new headquarters to manage the Tyrrhenian line of the Italian state railway, when the sheet piling being installed cut through archaeological material preserved deep in the sandy levels of the shoreline.²¹³ Emergency investigations began to reveal the material buried in the area of the intended rail yard, and from December 1998 to October of 1999, financial and cultural responsibility for these artifacts laid with both the State railway, and the

Superintendence of the Archaeological Patrimony of Tuscany.²¹⁴ By October of 1999, however, the state railway, hoping to finish their work and perhaps uncertain of the financial responsibilities of curating the hundreds of artifacts, moved their new headquarters to the Pisa Central Station. In December of that year, all aspects of the excavation were in the hands of the Superintendence in Tuscany.²¹⁵

Of the 16 wreck sites identified in the harbor area, eight are in various states of survey and recovery. Of those eight shipwrecks, three have been identified as cargo ships, three are river craft, there is one oared vessel, as well as this vessel which sank upside down. In all, these eight wrecks span a period from the 1st century BC to the late 5th or early 6th century AD.²¹⁶

This wreck from the late Roman or early Byzantine period, wreck D, is located in the northwestern corner of the site, approximately 7 to 10 m from the sheet piling. It is currently dated to the late 5th to early 6th century by the appearance of iron nails in its construction, and the apparent lack of mortise-and-tenon joints in the hull planking above the waterline.²¹⁷ It is estimated to be approximately 14 m long and no more than 6 m wide.²¹⁸ Unfortunately, there was no cargo to excavate from the vessel, and artifacts found in associated levels around the wreck range in date from the 1st to the 6th century AD.²¹⁹ Analysis of six wood samples indicate that the planking was of both stone pine (*Pinus pinea* L.) and silver fir (*Abies alba* Miller), while the framing was made of holly oak (*Quercus ilex* L.).²²⁰ No dendrochronological analysis of these or other samples seem to have been completed.

In general, the uncommon nature of Wreck D, that it is upside down, lends additional value to its preservation. There are no other wreck sites from this period that may or do preserve much material above the waterline. Although only a preliminary, on-site analysis of this material has been completed and published, it is clear that further work will be of great value.

At this time, it is evident that there are at least two levels of cross beams in the vessel. There appear to be five beams in the lowest level, the level first exposed to the investigators. From the bow of the vessel, the first beam possibly demarcates the forward extent of the hold, one near amidships is paired with a mast partner beam, the third and

fourth support a hatchway, while the purpose of the fifth may be similar to the first.²²¹ In addition to the cross beams on this level, a longitudinal beam runs across the access hatch to the hold, supported along the centerline of the ship on cross beams one through four. One vertical stanchion for this longitudinal beam is still preserved, and is located at the junction between the first cross beam and the longitudinal beam itself. The second level of cross beams, approximately 3 strakes above the first, consists of eight beams, five near the bow and three near the stern. None are located near amidships as cross beams one through four in the lower level appear to demarcate the extent of the 6.8 m long access hatch for the cargo space within the vessel. The five cross beams in the second level near the bow, as well as those three in the stern, seem to support decking. The extent of this decking, in both the bow and stern of the vessel, appears to be approximately 4 m long, and these cross beams support carlings, upon which decking was attached. Additionally, the fourth cross beam from the bow on this level also seems to support a forward bulkhead. The investigators report that the mast shrouds may have been attached to these cross beams, and that there are two layers of planking above the waterline.²²² It is also reported that a section of the mast is still preserved either at or near the mast partner beam, and that probing has indicated the presence of more decking, apparently with a camber, near amidships as well.²²³ The illustration also indicates that above the decking at the bow, framing material continues upwards for an undetermined distance. It is presently unclear if this material above the deck is still in situ, and if not, what further information is available.

Plemmirio E

Perhaps inspired by earlier surveys conducted nearby by Gerhard Käpitan in the 1960s, an expedition from Oxford University set out in 1968 to conduct visual underwater surveys along the Plemmirio peninsula in southeastern Sicily.²²⁴ Over a period of six and a half weeks, approximately four wreck sites in addition to a variety of unassociated material was located both near the peninsula and south, at Ognina.²²⁵ West of Capo Murro di Porco and south of the city of Terrauzza, a heterogeneous collection of pottery was found in approximately 10 m of water.²²⁶ This pottery ranges in date from the 2nd century BC to the 1st century AD, but an iron anchor, apparently from the early Medieval period was also found in the area.²²⁷ The anchor bears a resemblance to the Y-shaped iron anchors found

on the 11th-century vessel from Serçe Limanı. The investigators feel that the anchor was not abandoned by a vessel mooring in the area, but rather represents the location of a foundered vessel.²²⁸

Pontelagoscuro

Little is known of the hull remains of this craft. It was first uncovered in 1953 on the right bank of the Po River, during the dredging of clay at Fornaca Navarra, and was subsequently recovered in pieces.²²⁹ Investigation of the material by Bonino, which may be re-assembled to represent 7 m of the original craft, indicates that the planking was apparently held together edge-to-edge with treenails or dowels, very similar to the planking on the later Bozburun vessel.²³⁰ Moreover, the craft appears to have been of the *sandon* type, a craft typical of the Po Delta region which originated in the late-Roman or Medieval eras.²³¹

Serçe Limanı (1973)

Discovered in 1973 during an Institute of Nautical Archaeology survey off the southwestern Turkish coast opposite the Greek island of Rhodes, this site was uncovered in approximately 33 m of water at the base of a steep cliff.²³² The ship, approximately 75 m from the northeast shore of Serçe Limanı and aligned northwest to southeast, had settled on its port bilge.²³³ Excavation of the site began in June of 1977 and continued until August, 1979, when the cargo, the personal items and the remaining hull material had been raised and transported to the Bodrum Museum of Underwater Archaeology.

Among the items recovered from the site were eight Y-shaped iron anchors, several iron swords, 89 piriform amphorae, gargoulettes, terracotta bowls, glass balance pan weights, three balance scales, a steelyard and galleyware such as a two-handled terracotta pot.²³⁴ Particularly notable is the large collection of early-Medieval glass recovered from this site; its presence was one of the primary reasons for the site's excavation. This glass, which was apparently being carried in baskets, was composed of two types: two tons of raw glass cullet and one ton of broken or misshapen glassware.²³⁵ The excavation produced approximately 80 intact glass items, but continuing research and reassembly has since produced 200 fairly complete vessels as well as over 300 vessel profiles.²³⁶ Also particularly important is the combination of the Islamic glassware, glass weights and gargoulettes with

Byzantine material such as coins, balance-pan weights, and amphorae. Such a mixed collection on one vessel represents the improving relations between the two societies during the early 11th century, relations solidified by a peace treaty in 1027.²³⁷ The preliminary date of the vessel, from the late 11th to early 12th century, was estimated by glass fragments and amphora sherds.²³⁸ The final date of the vessel, *c.* AD 1026, is based on amphora parallels, the Byzantine coins of the Emperor Basil II, and an inscribed date on one of the four Islamic glass weights.²³⁹

This site is significant for its collection of early-Medieval glassware, one of the largest collections in the world, as well as its preserved hull material. Fragments of the keel and keelson, the stem and sternpost, as well as 36 frames, ceiling, hull planking and one wale, were recovered from the site.²⁴⁰ Other than the keel, which was made of elm, all of the recovered material is of pine.²⁴¹ The framing is distinct because it is not composed of a series of symmetrical floor timbers, but of asymmetrical timbers that alternate in orientation along the ship. On one side of the keel, a floor timber ends immediately prior to the turn of the bilge while on the other side, the same floor timber continues through the bilge and upwards for an undetermined distance.²⁴² Other than the tail frames and framing material beyond the tail frames, the framing is composed of these asymmetrical timbers. This hull material is additionally significant because unlike earlier vessels excavated in the Mediterranean, this ship is the earliest built by erecting some of the framing prior to affixing any of the planking in place. Moreover, no systems of edge joinery between the hull planks have been detected. Although since 1979, the date of this excavation's completion, other theories surrounding earlier vessels such as Dor 2001/1, Dor D, Fos-sur-Mer, and Tantura A have proposed that they too were built in a "frame-first" or "skeleton-first" manner, the Serçe Limanı vessel was the first example of a vessel built in this manner from antiquity.

While the presence of this vessel is significant, as it represents the disappearance of older construction methods in the Mediterranean, it is the process followed in its construction that is equally important. Set units of measurement, approximately 32 cm in length, were used in a variety of manners to determine both the scantlings of the timbers on the ship, and the layout of the ship as well. The average dimensions of the keel and framing, for example, were 16 cm deep (half of one unit) and 12 cm wide (three-eighths of

one unit).²⁴³ The ship was approximately 15.36 m (48 units) long and 5.12 m (16 units) in molded beam.²⁴⁴ To design the midships frame, the builders projected a rectangle 2.56 m wide (eight units) and 1.92 m high (six units) from the upper corner of the keel. From the lower corner of the rectangle away from the keel, they measured in two units (64 cm) horizontally, then joined that point to the upper corner opposite the keel. Next, the builders measured 4 cm (one-eighth of a unit) upwards along that diagonal and marked that point. By tracing a second diagonal approximately from the edge of the keel to this first point found on the diagonal, the builders essentially demarcated the design of the midships frame.²⁴⁵ All that remained was to round the sharp corner, and this template could then be applied to build the framing.

These set units of length were also used to determine the locations of key frames along the length of the ship. Once the midships frame was in place halfway along the straight portion of the keel, a second frame, identical in design but oriented in an opposite manner, was affixed in place 32 cm (one unit) forward of midships. Another pair of floor timbers, 4 and E, were affixed in place 1.28 m (four units) forward and aft of midships and its partner, respectively. With the addition of six more floor timbers near the center of the vessel, all of the required standing framing was in place and the planking of the vessel could begin.²⁴⁶

In addition to reassembled examples of the glassware, personal items such as a toiletry kit and a chessboard, the conserved hull remains are now on display in the Bodrum Museum of Underwater Archaeology.

Tantura A

Beginning in the year 1976, the lagoon at Tantura (ancient Dor), along the coast of Israel, became the subject of surveys and investigations that resulted in the discovery of four early Medieval period shipwrecks.²⁴⁷ Although other investigative dives occurred, it was in 1983 that Shelley Wachsmann and Kurt Raveh first came across the ship timbers that lead to the discovery of Tantura A.

In that 1983 dive, in addition to finding some strakes and ceiling planking, numerous Byzantine pottery sherds were also uncovered in the immediate vicinity.²⁴⁸ Further investigation of the lagoon occurred in 1985 with a larger team composed of

researchers from Haifa University's Center for Maritime Studies, as well as members of the Nautical Archaeology Society in Britain.²⁴⁹ As a result of the dynamic nature of the lagoon and a storm, however, only a small portion of hull remains were uncovered.²⁵⁰ Although at the time, it was assumed that the material uncovered in 1983 and 1985 were of the same wreck, research in 1994 proved otherwise.

Coastal construction had shifted the currents running north to south through the lagoon, and by 1994 the previously studied hull was now beneath two meters of sand.²⁵¹ Test trenches were dug across the site until the fourth trench revealed the timbers only partially exposed in 1985, at which point the excavation proceeded.²⁵² The investigators excavated three Palestinian bag-shaped amphorae as well as four fragments of an *Eastern sigillata* plate.²⁵³ However, the excavation also revealed that these hull remains comprised only two floor timbers and fragments of two planks.²⁵⁴ Luckily, more survey of the lagoon uncovered a much larger series of hull timbers and Byzantine pottery approximately 60 m to the north.²⁵⁵ Although it was unclear at the time, further research has determined that these two collections of timbers are from the same ship.²⁵⁶

Regarding the nomenclature of this site, at various times, three different names may be found associated with this collection of material. The hull remains that were found in 1985 and later rediscovered in 1994 were often called Trench IV. The larger collection of material revealed 60 m to the north of Trench IV was referred to as Trench VI or as Tantura A. At this time, as Trench IV and VI comprise material from the same wreck, Tantura A is commonly used. The material briefly uncovered in 1983 never appears to have been rediscovered.

All of the hull material from Tantura A has been dated by ceramic typologies and Carbon 14 dating. Three different types of Byzantine amphorae were found while excavating trenches in Tantura lagoon: Palestinian bag-shaped amphorae, Gazan amphorae, and the piriform amphorae also found on the 7th-century vessel from Yassiada.²⁵⁷ It should be noted, however, that only the bag-shaped amphorae were found in situ with material from Trench IV, and Sibella did not specify what kind of Byzantine pottery was associated with Trench VI.²⁵⁸ In addition, while the Gazan and piriform amphorae may date from *ca.* AD 550 to 638, the bag-shaped amphorae may date from the 8th century.²⁵⁹ A Byzantine

date, however, is still commonly associated with Tantara A for three reasons. First, an unspecified type of Byzantine amphora sherd had become embedded in the mastic on the planking of Trench VI.²⁶⁰ Secondly, the four fragments of the Eastern sigillata plate found to the south of Trench IV date to the 6th to 7th century, and lastly, the Carbon 14 dating suggests that the keel in Trench VI was cut between AD 415 and 530.²⁶¹

Among the material preserved in Trenches IV and VI, approximately 25 percent of the hull of Tantara A is preserved.²⁶² This includes portions of the keel, one post, eight floor timbers, eight hull strakes, and two ceiling planks.²⁶³ The keel, which is preserved for a length of 5.2 m, has a rectangular cross section and bears no evidence for a rabbet.²⁶⁴ The floor timbers, which are not preserved beyond the north face of the keel, were recessed to fit onto the keel and were bolted to it.²⁶⁵ All in all, staining from concretion and preserved bolt holes on the interior face of the keel indicate that the original vessel had approximately 24 floor timbers, and measured nearly 12 x 4 m.²⁶⁶ The hull strakes were nailed to the framing at every station, as was the ceiling planking.²⁶⁷ Although a complete examination could not be made as none of the preserved material was removed from the site, no mortise-and-tenon joints were found in the exposed planking edges, or in the keel.²⁶⁸ In addition, Wachsmann also notes the presence of charred hull planking at the extremities of the vessel, apparently indicating the process of bending wet planks over an open fire.²⁶⁹

No description regarding the methods of building this vessel have been published, so the basic order of construction needs to be inferred. The published evidence indicates that the keel and posts were assembled first, followed by the floor timbers, which were bolted to the keel. Once the majority of the floor timbers were affixed to the keel, or at least those at the extremities were in place, then the planks, which had been soaked and heated, were nailed to the floor timbers. It is unclear how the garboard was affixed to the keel. Once the planking had continued to the turn of the bilge, more framing material could have been affixed in place, followed by more planking and the remainder of the vessel.

It has been argued that this vessel is the earliest Mediterranean hull that was built without mortise-and-tenon joints.²⁷⁰ As none were found in either the exposed portions of the keel or the exposed edges of the planks, this is a possible conclusion. On the other

hand, the research regarding this vessel is in an incomplete state, very similar to the data from Fos-sur-Mer. The hull material at Fos-sur-Mer was only surveyed and examined in situ, and very little was recovered. Jezegou claims that Fos-sur-Mer was built in a frame first manner as well, because the two mortises found in the hull planking were superfluous, and served no apparent purpose. Thus she, similar to Wachsmann, appears to conclude that the information gleaned from the examined part of the hull reflects patterns on the unexamined, and missing, portions of the hull as well. While it needs to be understood that extrapolation plays a role in all levels of research of this type, the nature of the material examined still needs to be taken into account. For example, if indeed the use of mortise-and-tenon joinery was being relegated to aligning planks at this time, as opposed to a structural function, then on a small coasting vessel such as this, mortise-and-tenon joinery would be most likely found only at the extremities of the hull. Unfortunately, these are the areas in which, other than the garboard, there is no surviving planking material. Essentially, the absence of mortise-and-tenon joints on the exposed planking edges only indicates an absence of their need along those edges, not an absence of their need throughout the hull.

Tantura B

Systematic survey and investigation of the lagoon at Tantura (ancient Dor), along the coast of Israel, began in 1976. In 1983, Shelley Wachsmann and Kurt Raveh, while investigating the harbour, came across hull remains that lead to the discovery of Tantura A. That vessel was summarily surveyed and investigated during the season spent working in Tantura Lagoon in 1995. During the hydraulic probe survey in 1995 that relocated the Tantura A material, however, four other shipwrecks were also found. Tantura B, in Trench VIII, is one of those wrecks.²⁷¹

Unlike Tantura A, Tantura B has no defined cargo.²⁷² A small collection of other items, however, were recovered and researched. One Abbasid oil lamp, five bivalve shells, rope, wooden toggles, three wooden roundels, and other possibly decorative wooden objects were recovered from this site.²⁷³ The combination of these items and one radiocarbon test has dated this material to *ca.* AD 680-850.²⁷⁴ Four stone anchors, which have not been dated, were also uncovered in Trench VIII, less than 2 m away.²⁷⁵

Similar to Tantura A, Tantura B is also oriented northwest to southeast, and the preserved material may represent only about 25 percent of the original hull.²⁷⁶ That preserved material, which covers an area approximately 12 x 5 m, includes a keel, a keelson with a mast step, two riders, floor timbers, half frames, hull strakes and ceiling planking.²⁷⁷ Unfortunately, the bow and stern of the vessel have yet to be determined. The oak keel measured 9.5 cm molded and 10.4 cm sided, while the dimensions of the Aleppo pine keelson decreased from 18 to 15.7 cm molded and 20.2 to 12.2 cm sided.²⁷⁸ A possible rider, which was preserved for approximately 1.76 m primarily near the keelson's scarf and mast step, was of oak.²⁷⁹ Of the 39 frame stations identified on site, 30 pine frames were still preserved, retaining an alternating pattern of floor timbers and half frames.²⁸⁰ Twelve strakes of planking were preserved in situ, seven strakes on the west side of the keel and five on the east side, and all, other than strake six, were pine.²⁸¹ Strake six has been tentatively identified as oak.²⁸² No mortise-and-tenon joinery has been found in the planks of this vessel, and the strakes were commonly affixed to the framing with square iron nails.²⁸³

The complete shape and length of this vessel has yet to be determined, but analysis considering the location and design of the mast step, and the run of the planking, indicates that Tantura B may have been approximately 18 to 23 m long, and approximately 5 m wide.²⁸⁴ The preserved framing material indicates that it had a shallow draft and a flat bottom, while its overall design suggests that it may also have carried two lateen rigs.²⁸⁵

Tantura C

During the hydraulic probe survey of Tantura Lagoon (ancient Dor) carried out by researchers from the Institute of Nautical Archaeology and the Center for Maritime Studies at Haifa University in 1995, three early Medieval shipwrecks were uncovered. The first, **Tantura A**, had been the subject of a longer search, and has been dated to the mid 6th to early 7th century.²⁸⁶ Tantura B, which was also found during the survey in 1995, is dated to *ca.* AD 680 to 850.²⁸⁷ The last early Medieval wreck found in 1995 is Tantura C.²⁸⁸

This site was found at the end of the 1995 season, in Trench IX, after the majority of the staff had left, and was apparently surveyed in one day.²⁸⁹ Although the depth of the

site is unclear, the material is located in a natural channel and was covered by approximately 50 to 70 cm of sediment.

Two graffiti, a cross and a Δ , had been carved into the ceiling planking, and two ashlar blocks still sat in place adjacent to a bulkhead.²⁹⁰ The pottery associated with the site, which may have come from the Palestinian coast, consisted primarily of amphora sherds and other fragmentary ceramics, dating from the late 8th to early 9th century AD.²⁹¹ A radiocarbon test of this hull, however, dated it to AD 553 to 645.²⁹²

It is estimated that approximately one third of the vessel was uncovered and surveyed, resulting in an estimated length of 12 to 15 m overall.²⁹³ Although it is clear that one extremity of the hull was uncovered, the fragmentary remains do not reveal whether the extremity is the bow or the stern. Nonetheless, portions of a false keel, keel, keelson, frames, stringers, and hull and ceiling planking were still preserved in situ. The dimensions of some of the longitudinal timbers, however, seem to imply a lightly timbered vessel. The keel was approximately 10 x 17 cm, and the keelson was smaller, approximately 10 x 14 cm.²⁹⁴ The preserved rabbet was no more than .3 cm deep.²⁹⁵ The three preserved stringers appear to have small dimensions as well. The first stringer, immediately adjacent to the keelson, was 6.5 x 5 cm, while the following two measured 6 x 6.5 cm and 1.4 x 6.5 cm.²⁹⁶ Surprisingly, these stringers were attached to the framing with 1 cm² nails, which in the case of the third, or most outboard, stringer, leaves only .2 cm of wood remaining on either side of the nail hole.²⁹⁷

Due to the brief period of time on site, only a scattering of other measurements could be made. The floor timbers averaged 8.1 cm sided, and a portion of the second strake was 11.5 cm x 2.5 cm. The planking appears to have been affixed to the framing with .6 cm² nails. No mortise-and-tenon joinery was found.

Although more research was carried out in Tantura Lagoon in 1996, no new information regarding this material has appeared.

Tantura D

This vessel is the fourth of four early Medieval vessels uncovered at Tantura Lagoon between 1994 and 1996. The lagoon at Tantura (ancient Dor) is one of the few safe, natural harbours along the southern coast of Israel, and has been in and out of use since the Bronze

Age.²⁹⁸ Beginning in 1976, the lagoon also became the subject of archaeological survey and investigation.

In 1996, the last season that a joint team of investigators from the Institute of Nautical Archaeology and the Center for Maritime Studies at Haifa University would work in this harbor, a hydraulic probe survey uncovered the presence of hull material in Trench X.²⁹⁹

A section across the site revealed 8th to 10th-century pottery associated with the hull, and as no radiocarbon tests or dendrochronology has been performed, this is currently the best date for this material.³⁰⁰ The preserved material included sections of a keel, floor timbers, stringers, a mast step, as well as preserved rushes or reeds that may have acted as dunnage.³⁰¹ An analysis of this hull's construction is currently taking place, but preliminary analysis of the timbers' species reveal that the mast step, stringer, one hull plank and one ceiling plank are Aleppo pine, while one of the floor timbers is Tamarisk.³⁰²

Yassiada (4th-century)

Peter Throckmorton, Honor Frost, John Carswell, Kemal Aras and a small group of sponge divers completed the first survey of the seafloor around the island of Yassiada, near Bodrum, Turkey, in July of 1958. Among the archaeological material found were stacked plates, Rhodian amphorae, cannon balls, cooking pots, an oil lamp and numerous types of Byzantine amphorae.³⁰³ Following survey work in 1958 and 1959, a visit to the site by George Bass in 1960, and an excavation of the adjacent 7th-century site between 1961 and 1964, the excavation of the late 4th-century wreck site commenced in 1967.³⁰⁴

In addition to the discovery of a late 16th or 17th-century site partially lying on top of the 4th-century material, a site undoubtedly associated with the cannon balls found in 1958, the researchers also excavated three types of amphorae from among the preserved cargo of approximately 1100.³⁰⁵ Galleyware, including plates, a bowl, pitchers, cooking pots and two small storage amphorae were found at the deeper end of the site near the stern, as were four oil lamps and two steelyards.³⁰⁶ A total of eight coins were found during the two seasons of excavation, but as none preserved any diagnostic information, this site is dated only by typological parallels of the ceramics.

It was in 1974 that excavation at this site resumed, then quickly finished with the outbreak of hostilities on Cyprus after three weeks of diving.³⁰⁷ Despite this short final season, a large collection of new information was gathered regarding the preserved remains of this vessel's hull. All in all, the preserved remains included fragments of the keel, stem, sternpost, 48 frames, 20 port strakes, four port wales, and fragments of four starboard strakes.³⁰⁸ All of that material, other than the majority of the port strakes, has been raised for study; the remaining material was left in situ and extensively photographed.³⁰⁹

In most respects, the construction of this vessel is similar to examples in previous centuries. It has distinctive hollows and curves, displaying a wine-glass shaped cross section, and most likely had long, curving overhangs fore and aft.³¹⁰ The floor timbers, which were affixed to the keel, alternate along the length of the vessel with half frames that were affixed only to the planking. Distinctive, however, are the mortise-and-tenon joints preserved in the hull planking as they indicate the beginning of a long-term decrease in their quality and quantity. Rather than retaining a rectangular design, the mortises in the edges of these planks tapered in width, reflecting a similar taper in the tenons themselves.³¹¹ Moreover, the tenons, although they were still secured in place with pegs, also occupied less space within the mortise, supplying a certain amount of play to each joint. Additionally, the mortise-and-tenon joints were much more widely spaced along the length of the vessel, varying between 15 cm near scarfs, to as high as 32 cm in other areas.³¹² While planking from the keel to the first wale was secured together via these joints, it is also evident that after affixing the fifth strake in place, the half frames at midships were then inserted into the partially completed hull.³¹³ This is evident as outboard of the fifth strake, no mortise-and-tenon joints were fashioned in the hull planking underneath this pair of half frames, indicating the framing material was in place before the planking.³¹⁴ This hull material is now in a transitory state of conservation as during immersion in polyethylene glycol in 1986 a fire destroyed the conservation lab surrounding the conservation tanks. The timbers were subsequently removed from the solidified polyethylene glycol in 2000, and are now in storage in the Nixon Griffis' Conservation Laboratory at INA headquarters in Bodrum, Turkey.

Yassiada (7th-century)

The shipwreck site at Yassiada was first brought to the attention of George Bass by Peter Throckmorton in 1960.³¹⁵ Bass visited the site that year, and the excavation began the following summer, in 1961. The entire excavation required four seasons of work, from 1961 to 1964.

This Byzantine shipwreck was one of many found in the immediate area. Approximately 12 m away to the south was a late 4th-century Roman wreck, while an Ottoman wreck, dating from the 16th or 17th century, was found partially burying the late-Roman material.³¹⁶ The dating of the Byzantine shipwreck was determined by the approximately 70 coins recovered from the wreck site. The majority of the gold and copper coins preserved date from the reign of the Emperor Heraclius (AD 610-641), and the latest preserved coin dates to the 16th year of the Emperor's reign, AD 625-626.³¹⁷ Thus it was presumed that the ship sank soon after the minting of that coin.

In addition the coins, approximately 680 amphorae were also raised and studied, as well as galleyware, 24 oil lamps, fishing implements, three steelyards with associated weights, various iron objects and sections of 11 iron anchors. Preserved hull remains extended over an area 16 x 6 m.

Those preserved hull remains consisted of portions of a keel, sternpost, floor timbers and half frames, wales, clamps, beams, knees, and ceiling and hull planking.³¹⁸ As the ship came to rest on the sea floor on the port bilge, nearly all of the preserved material is from the port side of the ship. Only scattered pieces of approximately the first five hull strakes from the starboard side of the ship are preserved, as well as short fragments of only frames 22 and 23.

There were two basic stages in recording this preserved material. The first stage consisted of mapping this preserved material under water. With experience acquired from the work at Cape Gelidonya, it was decided in 1961 that it would be best to first remove all of the cargo on top of the preserved hull, then record the hull in its entirety in situ prior to removal from the sea floor.³¹⁹ As a result, although all of the fragile wood was now exposed to possible damage or loss, numerous photographs recorded in plan and in detail the precise locations of every exposed fragment. Extensive labeling and measurements on the sea

floor also aided later re-assembly of the material. The second stage in the recording of this material took place after the majority of it had been brought to the surface in 1963. This stage consisted of one-to-one and one-to-ten drawings that recorded the dimensions of the fragment, locations and orientations of nail holes, original surfaces, cross sections and scribe marks, as well as other details.³²⁰

Essentially, the Yassiada vessel was built using the mortise-and-tenon method. Once the keel, stem, and sternpost were assembled, the shipbuilder then built and affixed the first five to seven strakes to each other, prior to inserting the first set of floor timbers.³²¹ The alternating angles of the scarfs indicate that the shipwright affixed the strakes to each other in an alternating pattern. For example, the forward plank of strake two was attached first, while in strake three, the aft plank was attached first.³²² Between the keel and the garboard, the mortise-and-tenon joints were spaced approximately 2.25 to 2.5 m apart, while between the first seven strakes, there was greater variation. In the stern area of the vessel, the center-to-center spacing of the mortise-and-tenon joints was 35 to 50 cm, while near amidships, the joints were separated by as much as 90 cm.³²³ There are no pegs driven through the tenons to secure them in place, and in general the tenons did not fit tightly into the mortises.

Once the first five to seven strakes had been affixed to each other, then the first set of framing elements was added to the hull. Although there are a variety of possible framing patterns for the Yassiada vessel, extensive research with a hull model determined that the builder most likely used short and long floor timbers, as well as half frames, when building the ship.³²⁴ In this case, the first set of framing elements consisted of the short floor timbers.

As the short floor timbers were no more than 2.8 m in length, and did not extend to or around the turn of the bilge, these components were cut from straight rough timber.³²⁵ Each floor timber was nailed to the keel at every third frame station, and in turn, the planking was nailed to the outer surfaces of the floor timber.

Following the attachment of the short floor timbers to the keel, more strakes were added to the partially assembled ship. These strakes, which swept out and around the turn of the bilge, were still edge joined to each other with mortise-and-tenon joints. In this case,

the builder stopped adding strakes when he reached strake ten, and at this point, the long floor timbers were affixed to the keel.³²⁶ Every second long floor timber was nailed to the keel and again, the planking was in turn nailed to the exterior faces of these floors. Those long floor timbers that had not been nailed to the keel were instead drilled for later attachment with bolts. Following the attachment of these long floor timbers to the keel, strakes 11 through 16 were added, again edge joined with mortise-and-tenon joints. No strakes above strake sixteen had mortise-and-tenon joints in their long edges.

Next, the shipwright affixed the half-frames to the keel and the strakes. Although the preserved evidence is unclear, the reconstruction model indicates that the half-frames most likely met over the keel, rather than stopping prior to that point. It is surmised that each pair of half-frames was nailed together through a diagonal butt joint, although only one of each pair was nailed to the keel itself.³²⁷ Following this, all of the futtocks extending above the long and short floors were clamped in place against the planking, and nailed in place. The futtocks were not attached to the floor timbers.³²⁸

Following the attachment of the futtocks, the keelson as well as the inner stem and sternpost were constructed and affixed to the hull. Where the floors were nailed to the keel, the keelson and inner posts followed suit and were in turn nailed to the floors. In contrast, the keelson and inner posts were bolted to those long floors that had been drilled earlier. These bolts passed up into the hull from the outer faces of the keel, stem or sternpost, and passed through every other long floor into the keelson and inner posts.³²⁹ At this point, the primary structure of the hull was complete.

The ceiling planking, which was made of both finished planks and half logs, was nailed to the interior faces of the framing. Following the completion of the ceiling, the wales, clamps and beams were added to the ship. Similar to some of the ceiling planking, the wales were also just half logs, and were left rough on the exterior of the ship.³³⁰ Each wale was affixed to the framing by straight and clenched nails that alternated at every other frame. All of the nails were driven from the interior of the ship.³³¹ After the second wale was attached to the exterior of the ship, the remaining top timbers were attached to complete the framing, followed by the clamps opposite the wales. These clamps were both nailed to one third of the framing, and bolted through to the exterior wales. The second

clamp opposite the second wale also acted as the shelf for the through-beams and deck beams.³³²

Once the second clamp had been attached and the beams were in place, the remaining two wales were attached to the top timbers. The deck, hatchways, coamings, deckhouse and waterways were affixed, and the four remaining strakes that fit between the four wales were nailed into place.³³³

Endnotes

¹ It needs to be acknowledged that interpreting the archaeological record and applying it to an historical context, particularly one involving inherently moveable objects such as ships, may be fraught with difficulties. The most applicable argument against such a practice is the knowledge that while the archaeological record may reflect the past, not all objects from the past have either been preserved or necessarily found. As such, lacunae in the record of maritime activity may be interpreted as either a lack of maritime activity or a lack of evidence indicating that activity; the two interpretations are not the same. Moreover, it may be argued that in one manner, the paucity of sites from North Africa reflects a lack of investigation, while the plethora of information from Italy, Turkey and Greece reflect the opposite. In contrast, such data may instead reflect the higher percentage of sport divers or sponge divers along the northern Mediterranean coast and their absence along the southern coast. Or it may instead reflect differing coastal conditions, and thus differing levels of preservation. Whether this northern-coast bias also reflects differing levels of activity in antiquity is harder to determine. On the one hand, the majority of the ports in the Mediterranean occur along the northern and Levantine coasts, while the southern Mediterranean is distinguished primarily by Morocco, Carthage and Alexandria separated by long sinuous stretches of exposed coastline. The majority of the goods passing through North Africa, it may be argued, exited one of these three ports to enter one of innumerable destinations along the northern coastline and vice versa; seafaring along the northern coast, then, was more prevalent and widespread. On the other hand, a wreck site is the result of an accident - commonly the ship striking the land - and the high number of sites along the northern coast may not necessarily reflect increased traffic in antiquity but merely increased risk along that coastline. Fewer wrecks have been identified along the southern Mediterranean coast possibly because fewer catastrophic wrecks occurred there, or the events left little or no trace in the archeological record. It may even be argued that fewer wrecks do not indicate fewer vessels on the sea, but better seamanship.

In the end, for the sake of brevity, this research will place this corpus of material into an historical context not in spite of the issues outlined above, but in acknowledgement of them and with the awareness of the ephemeral nature of the results. Resolving such issues is relevant to a different work and requires not only a greater amount of data about the archaeological material itself, but a whole host of other information regarding the environments in which the sites were found.

² These numbers do not include sites such as **Cape Kiti**, **Marmara**, or **Porto Longo** which are only broadly dated to the Byzantine period.

³ **Tantura B** and **D**, off the coast of Israel, are associated with Palestinian material, while the **Museum Material**, a collection of Byzantine plates, apparently came from a site near Marmaris on the western coast of Turkey. The tumulus of material at **Cape Andreas 10**, off the coast of Cyprus, contains artifacts dated to the 8th century, but it is unclear which and how many. **Scoglia della Formica** is only broadly dated to the 9th to 11th centuries, so no firm conclusions may be drawn and while 8th century bag-shaped amphorae were found at **Tantura A** and **C**, the sites are still dated to the 5th to 7th centuries. Only perhaps **Mljet**, from the second half of the 9th century in the Adriatic, may represent some Islamic cargo in a non-Islamic context; the researchers attempt to argue, however, that the possibly Islamic glass object may have come from a Byzantine or Byzantine -related workshop. See Han and Brusic (1978, 281).

⁴ See EI² (1986, IX, 582-91) "Sikilliya".

⁵ The site at **Scoglia della Formica** may be included in these four sites as well, but it is only loosely dated between the 9th and 11th centuries.

⁶ That the Muslim conquest of Sicily took a difficult 70 years of gradual warfare may belie the local Byzantine awareness of the island's commercially strategic position. See "Sikilliya" EI² IX (1986, 582-91).

⁷ Goitein 1967, 43-4.

⁸ Tierney and Painter 1983, 68.

⁹ Tierney and Painter 1983, 76.

¹⁰ Tierney and Painter 1983, 76.

¹¹ As **Cefalu** may not be a wreck site but instead the site of a quay from antiquity, the harbor may represent a supply station gathering goods from a variety of sources in the eastern Mediterranean; thus the wide variety of markings on the amphorae.

¹² Van Alfen 1995, 51.

- ¹³ Van Alfen 1995, 52.
- ¹⁴ Abrahamse 1967, 272.
- ¹⁵ Crisafulli et al., 1997, 85, 87, 105, 153 and 185.
- ¹⁶ Dawes and Baynes, 1948, 223, 225.
- ¹⁷ See Bury (1962, 73); see also the description of the βουλλωται and see also the πρανδιοπραται in Freshfield (1938, 19-20) in the *Book of the Eparch*. Amphorae in the Bodrum Museum of Underwater Archaeology imply that the majority of this trade was from the Black Sea, and thus unaffected by the Muslims on Crete, but the plethora of other activities between Constantinople and Italy or the Franks in textual sources certainly indicates that travel and trade through the Aegean did not cease. See McCormick (2001, Appendix 4) for his list of 828 maritime voyages or activities that occurred between 700 and 900.
- ¹⁸ McCormick 2001, 915.
- ¹⁹ McCormick 2001, 918-20.
- ²⁰ Ševčenko 1998, 101.
- ²¹ Broadhurst 1952, 337-8.
- ²² Broadhurst 1952, 300-1.
- ²³ McCormick 2001, 431-43.
- ²⁴ McCormick 2001, 435 table 14.3.
- ²⁵ McCormick 2001, 436 chart 14.1.
- ²⁶ McCormick 2001, 435 table 14.3.
- ²⁷ Visquis 1973, 157.
- ²⁸ Visquis 1973, 157, 160.
- ²⁹ Visquis 1973, 158. Three anchors appear in the site plan, but only two are mentioned in the text.
- ³⁰ Arnaud et al. 1980, 54; see also L'Hour et al. 1985, 111.
- ³¹ Visquis 1973, 157.
- ³² Visquis 1973, 157; see also Darmoul 1985, 152; L'Hour et al. 1985, 111.
- ³³ Darmoul 1985, 153 and pl. 1.
- ³⁴ Darmoul 1985, 153 and pl. 2.
- ³⁵ Darmoul 1985, 153 and pl. 2.
- ³⁶ Darmoul 1985, 153 and pl. 2.
- ³⁷ Darmoul 1985, 153.
- ³⁸ Darmoul 1985, 153.
- ³⁹ Darmoul 1985, 153 and pls. 1 and 2. Plate 2, a detail of section A, illustrates a floor timber that was apparently omitted in the overall site plan.
- ⁴⁰ Darmoul 1985, 153 and pl. 3.
- ⁴¹ Darmoul 1985, 153.
- ⁴² Darmoul 1985, 155.
- ⁴³ Pomey et al. 1988, 39.
- ⁴⁴ Visquis 1973 157, 158.
- ⁴⁵ Darmoul 1985, 153.
- ⁴⁶ Jezegou and Joncheray 1997, 36.
- ⁴⁷ Jezegou and Joncheray 1997, 36.
- ⁴⁸ Darmoul 1985, pl. 4. It was reported in 1997 (Jezegou and Joncheray 1997, 37) that 17 strakes are evident on site, but their locations are unclear.
- ⁴⁹ Joncheray 1974, 327. Vindry writes (1980) that only ten of these large jars were found at this time.
- ⁵⁰ Vindry 1980, 221; see also Arnaud et al. 1980, 53.
- ⁵¹ Joncheray 1974, 327.
- ⁵² Vindry 1980, 222.
- ⁵³ Vindry 1980, 222.
- ⁵⁴ Joncheray 1974, 328; see also Arnaud et al. 1980, 54.
- ⁵⁵ Vindry 1980, 221; see also Joncheray 1976, 87; Pomey et al 1988, 49.
- ⁵⁶ Vindry 1980, 221; see also Joncheray 1976, 87.
- ⁵⁷ Joncheray 1976, 87.
- ⁵⁸ Joncheray 1974, 328.
- ⁵⁹ Joncheray 1976, 87; see also Vindry 1980, 221.

- ⁶⁰ Jezegou and Joncheray 1997, 33-4.
⁶¹ Jezegou and Joncheray 1997, 35.
⁶² Jezegou and Joncheray 1997, 35.
⁶³ Jezegou and Joncheray 1997, 35.
⁶⁴ Green 1969, 10 and figs. 3, 6 and 15.
⁶⁵ Green 1969, 14, 16; see also Green 1973, 161.
⁶⁶ See Green 1969, 25 fig. 13, item 1 (CA69 24/1); 1973, 163 fig. 21.
⁶⁷ Green 1969, 16.
⁶⁸ Green 1969, 23 figs. 11, 13 and 25; see also Green 1973, 161 and 163 figs. 21-3.
⁶⁹ Green 1969, 28 fig. 15.
⁷⁰ Kăpitan 1977, 40; see also Kăpitan 1978, 269.
⁷¹ Kăpitan 1978, 270.
⁷² Kăpitan 1977, 46.
⁷³ Kăpitan 1978, 273-4; see also Bass and van Doorninck Jr. 1982, 126-31.
⁷⁴ Kăpitan 1978, 273; see also Bass and van Doorninck Jr. 1982, 126.
⁷⁵ Kăpitan 1978, 271.
⁷⁶ Parker 1992, 121.
⁷⁷ Purpura 1983, 93.
⁷⁸ Purpura 1986, 140.
⁷⁹ Purpura 1983, 96, 101.
⁸⁰ Purpura 1983, 101-2. In figure 11 (Purpura 1983, 102) the *dipinti* also appears to be $\text{UV}\chi$ rather than $\text{UY}\chi$.
⁸¹ Purpura 1993, 169-71.
⁸² Purpura 1983, 94-5.
⁸³ Purpura 1983, 95.
⁸⁴ Purpura 1983, 95.
⁸⁵ The large stones indicated by Purpura (1983, 93-5 and fig. 4) to be ballast may be additional structural elements of the quay.
⁸⁶ Lloyd 1984, 1,5 and 59.
⁸⁷ Lloyd 1984, 7.
⁸⁸ Lloyd 1984, 10.
⁸⁹ Lloyd 1984, 14-57.
⁹⁰ Lloyd 1984, 14, 20, 26, 29, 34. In Lloyd (1985), her article reports that there were six different types of amphorae, although her thesis only classifies five.
⁹¹ Lloyd 1984, 70.
⁹² Lloyd 1984, 70.
⁹³ Lloyd 1984, 59.
⁹⁴ Lloyd 1984, 61.
⁹⁵ Lloyd 1984, 63.
⁹⁶ Lloyd 1984, 64.
⁹⁷ Kahanov 2003, 15.
⁹⁸ Mor 2003, 16.
⁹⁹ Mor 2003, 16.
¹⁰⁰ Mor 2003, 16.
¹⁰¹ Mor 2003, 16.
¹⁰² Mor 2003, 16.
¹⁰³ Mor 2003, 16 and pers. comm.
¹⁰⁴ Mor 2003, 16 and pers. comm.
¹⁰⁵ Raveh and Kingsley 1992, 309.
¹⁰⁶ Raveh and Kingsley 1992, 309.
¹⁰⁷ Raveh and Kingsley 1992, 309.
¹⁰⁸ Raveh and Kingsley 1992, 312-3.
¹⁰⁹ Kahanov and Royal 2001, 257.
¹¹⁰ Kahanov and Royal 2001, 261 and table 3.
¹¹¹ Kahanov and Royal 2001, 264.

- 112 Kahanov and Royal 2001, 262.
113 Kahanov and Royal 2001, table 4.
114 Kahanov and Royal 2001, 262.
115 Kahanov and Royal 2001, 262.
116 Kahanov and Royal 2001, 264.
117 Bass and van Doorninck 1982, 71.
118 Leidwanger 2004, 17-8.
119 Leidwanger 2004, 17.
120 Leidwanger 2004, 20.
121 Leidwanger 2004, 23-4.
122 Leidwanger 2004, 25-6.
123 Leidwanger 2004, 23.
124 Leidwanger 2004, 23.
125 Ximenes 1976, 139, 142.
126 Ximenes 1976, 142.
127 Ximenes 1976, 148.
128 Ximenes 1976, 142-5, 147.
129 Ximenes 1976, 140.
130 Boetto 2003, 66.
131 Boetto 2003, 67.
132 Boetto 2003, 67.
133 Jezegou 1983, 1.
134 Jezegou 1983, 2, 30.
135 Jezegou 1983, 3; 1985, 139.
136 Jezegou 1983, 21.
137 Jezegou 1983, 21-4.
138 Jezegou 1983, 25.
139 Jezegou 1983, 7.
140 Jezegou 1983, 12-5.
141 Jezegou 1985, 141.
142 Jezegou 1983, 10-11.
143 Jezegou 1983, figs 2-6.
144 Jezegou 1983, 12.
145 Jezegou 1985, 140.
146 In her 1985 publication, frame station 87 has been re-drawn, this time as affixed to the keel. Frame station 80 is reproduced for the first time, also illustrated as bolted to the keel.
147 Jezegou 1985, 141.
148 Jezegou 1985, 141.
149 Jezegou 1983, 13.
150 Jezegou 1983, 14.
151 Bass and van Doorninck Jr. 1982, 56.
152 Bass and van Doorninck Jr. 1982, Reassembly Drawing II, planks 5-8.
153 Bass and van Doorninck Jr. 1982, 77; see also Jezegou (1983) figure 1.
154 Yché 1906, 466.
155 Yché 1906, 466.
156 Yché 1906, 469.
157 Rogers 1981, 23.
158 Rogers 1981, 25-6.
159 Rogers 1981, 28-35.
160 Rogers 1981, 35.
161 Rogers 1981, 37-8.
162 Giangrande et al. 1987, 185.
163 Giangrande et al. 1987, 185-6.
164 Giangrande and Richards 1985, 161.

- 165 Morris and Peatfield 1987, 200.
- 166 Morris and Peatfield 1987, 200 and fig. 3.
- 167 Morris and Peatfield 1987, 200 and pl. LVIII.
- 168 Morris and Peatfield 1987, 200.
- 169 Morris and Peatfield 1987, 200.
- 170 Giangrande et al. 1987, 185, 192; see also Morris and Peatfield 1987, 203.
- 171 Morris and Peatfield 1987, 203.
- 172 Morris and Peatfield 1987, 203.
- 173 Giangrande et al. 1987, 192.
- 174 Morris and Peatfield 1987, 203.
- 175 Giangrande et al. 1987, 192.
- 176 Gargallo and Casson 1962, 196.
- 177 Gargallo and Casson 1962, 197.
- 178 Gargallo and Casson 1962, 197; see also Kăpitan 1969, 127.
- 179 Kăpitan 1969, 133; see also Parker 1992, 267.
- 180 Kăpitan 1969, 126, 128, 130, 133.
- 181 Kăpitan 1969, 133.
- 182 McWilliams et al. 1977, 70-1.
- 183 McWilliams et al. 1977, 72, map 2.
- 184 McWilliams et al. 1977, 73.
- 185 McWilliams et al. 1977, 73.
- 186 Throckmorton and Kapitan 1968, 185.
- 187 Throckmorton and Kapitan 1968, 185.
- 188 Throckmorton and Kapitän 1968, 185.
- 189 Throckmorton and Kapitän 1968, 185.
- 190 Throckmorton and Kapitän 1968, 186; see also Throckmorton and Throckmorton 1973, 244.
- 191 Throckmorton and Throckmorton 1973, 248.
- 192 Throckmorton and Throckmorton 1973, 249.
- 193 Throckmorton and Kapitän 1968, 186; see also Throckmorton and Throckmorton 1973, 255.
- 194 Throckmorton and Kapitän 1968, 186.
- 195 In Throckmorton and Throckmorton (1973) figure 4 depicts the location of at least one through beam, and figure 5 illustrates the preserved bottom planking below wale GWL.
- 196 Throckmorton and Throckmorton 1973, 262-3.
- 197 Throckmorton and Throckmorton 1973, 263-4; see also Muckelroy 1978, 66.
- 198 Throckmorton and Kapitän 1968, 187; see also Throckmorton and Throckmorton 1973, 263.
- 199 Throckmorton and Throckmorton 1973, 263; see also Muckelroy 1978, 64; Throckmorton 1987, 88, 92.
- 200 See Throckmorton and Throckmorton (1973, 263) in which the stacked wood at the stern of the vessel is called the skeg. This construction might also be called deadwood, as it is merely supporting the framing leading up to the transom.
- 201 Throckmorton and Throckmorton 1973, 247 fig. 4. Two of what may have been four supporting timbers for the transom are represented by FLK and FLI.
- 202 Throckmorton and Throckmorton 1973, 247 fig. 4.
- 203 Throckmorton and Throckmorton 1973, 262.
- 204 Throckmorton and Throckmorton 1973, 258.
- 205 Throckmorton and Throckmorton 1973, 264.
- 206 Throckmorton and Throckmorton 1973, 254 fig. 13, 256 and 257 fig. 15; see also his set of lines.
- 207 Throckmorton and Throckmorton 1973, 254 fig. 13.
- 208 Throckmorton and Kapitän 1968, 187.
- 209 Howard Chapelle apparently examined photographs of the transom from Pantano Longarini, and felt that it was not the stern, but rather the bow of the vessel. See Throckmorton and Throckmorton (1973: 254). Throckmorton also notes that the best parallel he could find for this stern construction was a Chinese Junk, a vessel that is commonly flat-bottomed and double ended.
- 210 Throckmorton and Throckmorton 1973, 245 fig. 2.
- 211 Throckmorton and Throckmorton 1973, 262.

- 212 Throckmorton and Throckmorton 1973, 260.
- 213 Polo Navacchio SpA, 14; see also Bruni 2000, 22.
- 214 Polo Navacchio SpA, 16-7.
- 215 Polo Navacchio SpA, 17.
- 216 Bruni 2000, 41.
- 217 Bruni 2000, 50. Two arguments are made in association with this theory. The first is that although iron nails were used in the 1st century BC, their use did not completely supplant bronze nails until the 5th century AD or so. The second argument is that a similar absence of mortise-and-tenon joints above the waterline is also documented on the 6th-century vessel from **Pantano Longarini**.
- 218 Bruni 2000, 49.
- 219 Bruni 2000, 50-1.
- 220 Bruni 2000, 84 table IV.
- 221 Bruni 2000, 68 fig. 38. The assumption is being made here that the bow, which was apparently better preserved with iron facing on it, lies at the western end of the wreck site.
- 222 Bruni 2000, 49.
- 223 Bruni 2000, 49.
- 224 Green et al. 1969, 25.
- 225 Green et al. 1969, 25. See **Ognina** elsewhere in this corpus.
- 226 Green et al. 1969, 31-2.
- 227 Green et al. 1969, 31, 41.
- 228 Green et al. 1969, 31.
- 229 Berti 1986, 24-5.
- 230 Berti 1986, 25.
- 231 Berti 1986, 25.
- 232 Bass and van Doorninck, Jr. 1978, 119, 121.
- 233 Bass and van Doorninck, Jr. 1978, 119, 121.
- 234 Bass and van Doorninck, Jr. 1978, 124-127; see also van Doorninck, Jr. 1989, 253; Bass, et al. 1984, 169.
- 235 Van Doorninck, Jr. 1990, 58.
- 236 Van Doorninck, Jr. 1990, 59.
- 237 Van Doorninck, Jr. 1990, 58.
- 238 Bass and van Doorninck, Jr. 1978, 119; see also Bass et al. 1984, 161.
- 239 Bass and van Doorninck, Jr., 1978, 126.
- 240 Bass and van Doorninck, Jr., 1978 fig. 2.
- 241 Steffy 1994, 85.
- 242 Bass et al., 2004, 154.
- 243 Bass et al., 2004, 167.
- 244 Steffy 1994, 87.
- 245 Steffy 1994, 88.
- 246 Steffy 1994, 89.
- 247 Wachsmann 1995, 4; see also Wachsmann 1996, 19.
- 248 Wachsmann 1995, 4; see also Wachsmann 1996, 20; Wachsmann and Kahanov 1997, 3.
- 249 Wachsmann 1995, 4; see also Wachsmann 1996, 20.
- 250 Wachsmann 1995, 4; see also Wachsmann 1996, 20.
- 251 Wachsmann 1995, 4.
- 252 Wachsmann 1995, 4; see also Wachsmann 1996, 20.
- 253 Sibella 1995, 15-6.
- 254 Kahanov and Breitstein 1995, 10.
- 255 Wachsmann 1995, 5; see also Wachsmann 1996, 20; Wachsmann and Kahanov 1997, 4 fig. 1.
- 256 Kahanov and Breitstein 1995, 11-2.
- 257 Sibella 1995, 14-5.
- 258 Sibella 1995, 15.
- 259 Sibella 1995, 14.
- 260 Wachsmann 1995, 6; see also Wachsmann 1996, 21-2; Wachsmann and Kahanov 1997, 4 fig. 2.
- 261 Sibella 1995, 16; see also Carmi and Segal 1995, 12.

- 262 Wachsmann and Kahanov 1997, 5.
- 263 Kahanov and Breitstein 1995, 10; see also Wachsmann and Kahanov 1997, 5. The two ceiling planks are located in Trench IV, and it is unclear if the eight floor timbers include the one (or two?) found in Trench IV.
- 264 Kahanov and Breitstein 1995, 10.
- 265 Kahanov and Breitstein 1995, 11; see also Wachsmann and Kahanov 1997, 5. It is reported in 1995 that the floor timbers were nailed to the keel, not bolted.
- 266 Wachsmann and Kahanov 1997, 5.
- 267 Kahanov and Breitstein 1995, 10 fig. 1; see also Wachsmann and Kahanov 1997, 5.
- 268 Kahanov and Breitstein 1995, 11; see also Wachsmann and Kahanov 1997, 5.
- 269 Wachsmann and Kahanov 1997, 6.
- 270 Wachsmann and Kahanov 1997, 6.
- 271 Wachsmann and Kahanov 1997, 9.
- 272 Wachsmann et al. 1997, 5.
- 273 Wachsmann et al. 1997, 5-6.
- 274 Wachsmann and Kahanov 1997, 9.
- 275 Wachsmann et al. 1997, 6.
- 276 Wachsmann et al. 1997, 4.
- 277 Wachsmann et al. 1997, 4-5, fig. 3.
- 278 Kahanov et al. 2004, 119.
- 279 Kahanov et al. 2004, 120; see also Wachsmann et al. 1997, 7.
- 280 Kahanov et al. 2004, 120.
- 281 Kahanov et al. 2004, 121.
- 282 Kahanov et al. 2004, 121.
- 283 Kahanov et al. 2004, 122.
- 284 Kahanov et al. 2004, 123.
- 285 Kahanov et al. 2004, 123.
- 286 Wachsmann and Kahanov 1997, 4-5.
- 287 Wachsmann and Kahanov 1997, 9.
- 288 Wachsmann and Kahanov 1997, 10.
- 289 Royal and Kahanov 2000, 151. The abstract at the beginning of the article states that there were several days of recording on site, not one.
- 290 Wachsmann and Kahanov 1997, 10 fig. 11.
- 291 Royal and Kahanov 2000, 153.
- 292 Wachsmann and Kahanov 1997, 10.
- 293 Royal and Kahanov 2000, 153.
- 294 Royal and Kahanov 2000, 151.
- 295 Royal and Kahanov 2000, 151. In light of the fact that this rabbit is visible in a photograph (See Wachsmann and Kahanov 1997, 12 fig. 11), it seems unlikely that this rabbit is only .3 cm deep.
- 296 Royal and Kahanov 2000, 151, 152. These measurements may be incorrect, as in 1997, Wachsmann and Kahanov referred to these stringers as "heavy". See Wachsmann and Kahanov (1997, 10).
- 297 Royal and Kahanov 2000, 152.
- 298 Wachsmann et al. 1997, 3.
- 299 Wachsmann et al. 1997, 7.
- 300 Wachsmann et al. 1997, 7.
- 301 Wachsmann et al. 1997, 7 fig. 18.
- 302 Wachsmann et al. 1997, 7, 10.
- 303 Frost 1963, 158-69.
- 304 Bass and van Doorninck Jr. 1971, 27; see also Bass and van Doorninck Jr. 1982, 3, 9.
- 305 Bass and van Doorninck Jr. 1971, 27, 34.
- 306 Bass and van Doorninck Jr. 1971, 36-7.
- 307 Van Doorninck Jr. 1976, 115.
- 308 Van Doorninck Jr. 1976, 115, 124 fig. 1.
- 309 Van Doorninck Jr. 1976, 115-6.
- 310 Van Doorninck Jr. 1976, 119 fig. 5.

- 311 Van Doorninck Jr. 1976, 122.
- 312 Van Doorninck Jr. 1976, 123.
- 313 Van Doorninck Jr. 1976, 126.
- 314 Van Doorninck Jr. 1976, 126.
- 315 Bass and van Doorninck Jr. 1982, 3.
- 316 Bass and van Doorninck Jr. 1982, 4.
- 317 Bass and van Doorninck Jr. 1982, 145-54.
- 318 Bass and van Doorninck Jr. 1982, 55.
- 319 Bass 1975, 73.
- 320 Bass and van Doorninck Jr. 1982, 38-9.
- 321 Bass and van Doorninck Jr. 1982, 73.
- 322 Bass and van Doorninck Jr. 1982, 73.
- 323 Steffy 1994, 80.
- 324 Bass and van Doorninck Jr. 1982, 73.
- 325 Bass and van Doorninck Jr. 1982, 73.
- 326 Bass and van Doorninck Jr. 1982, 75.
- 327 Bass and van Doorninck Jr. 1982, 76.
- 328 Bass and van Doorninck Jr. 1982, 77.
- 329 Bass and van Doorninck Jr. 1982, 77.
- 330 Bass and van Doorninck Jr. 1982, 78.
- 331 Bass and van Doorninck Jr. 1982, 79.
- 332 Bass and van Doorninck Jr. 1982, 79.
- 333 Bass and van Doorninck Jr. 1982, 80.

HOW WAS THE BOZBURUN VESSEL BUILT?

This chapter is the first of two that attempts to determine how this ship was built. The previous chapters discuss how the material was excavated and cataloged, the essential deconstruction and analysis of the component parts, but this chapter, in contrast, is the first synthesis of the collected information. It is not, however, the only such synthesis. A ship is created in both a tangible and intangible manner and as such, this chapter addresses the tangible aspects of the Bozburun vessel's construction as indicated by the archaeological evidence: the fashioning and assembly of the ship's timbers. The next chapter examines more intangible aspects of the assembly process, such as any methodology or design influences that may have affected the ship's final design.

The building of this vessel, first and foremost, needed people. The workmen, shipwright and eventual owner all played roles in the creation of this ship. As such, it is important to note that while the previous chapters also concentrated particularly on the wood of the ship, this and the following chapters addressing both how and why this craft was built recognize that the Bozburun vessel was a manifestation of human needs and demands. People's mistakes and foibles are expressed in this vessel, and while its construction is the result of the effort of perhaps less than a dozen people, it still reflects a much broader cultural and historical context as well. This chapter, then, while addressing the tangible aspects of how this craft was built, is also an introduction to the human processes that created this craft and the contexts and cultures that surrounded those people.

Wood

It is unclear precisely where the wood for this vessel may have come from, but it is evident what kind of and approximately how much wood was needed to build the Bozburun vessel. In addition to the oak, the species of which is unclear, the shipwright also used pine (*Pinus brutia*) and chestnut (*Castanea* sp.), in the ship's construction. To build the entire ship, the shipwright may have used approximately 35 tons of wood.

Transforming each log into the appropriate timber, however, required a variety of tools. Some of the implements, such as saws, axes or adzes, an auger, a bow drill, and a scribe or an awl, left nicks, gouges or dubbed faces that indicate their use and a few of their

characteristics. Other tools, such as hammers, mallets, dividers, chisels and planes played a role either fashioning or assembling timbers, but there is no evidence of their presence other than the completed ship.

Tools

Among the tool marks preserved on the framing and planking material from Bozburun, a very large portion allude to the use of one or more saws in the vessel's construction. Some of the saws, as they cut planks approximately 30 cm wide, not only had to have been 60 cm or more in length, but also needed a frame to maintain the blade's tension and to prevent it from buckling during use.¹ This rectangular frame provided a rigid structure that the saw blade stretched across lengthwise; the use of twisted rope or sinew could adjust the tension in the frame as needed. Numerous images of their use indicate these saws were fairly common in the Roman era and, as illustrated in a painted image from Qusayr Amra, apparently known in early-Islamic Palestine as well (fig. 5-1).²

Although the preserved marks on the Bozburun timbers indicate the direction and inclination of the sawing, and may imply the size of the saw itself, the timbers do not reveal any details of the saw's cutting edge. There are no impressed marks of the saw's teeth in the wood, nor is the saw's kerf evident in any manner. The teeth on earlier Roman saws were set in alternating inclinations and their pitch varied from seven to twelve to the inch.³ A more contemporaneous fragment of a saw blade from the 11th-century Serçe Limanı vessel, however, is pitched with 1.4 teeth per inch, or 3.6 teeth per centimeter.⁴

Although such saws could be used by one workman, the size of the Bozburun timbers necessitated two workmen, in an arrangement similar to that illustrated in figure 5-2, for accuracy and efficiency. The sawyer on top of the timber pulled the blade up via a handle and, walking backwards, guided the blade while it cut the wood. The lower sawyer supplied the power. This illustration provides an possible depiction of how timbers were supported as well. On the left, opposite the two sawyers, the log or plank is supported by a rigid trestle and on the right, the two crossed supports indicate the presence of a temporary crutch - one that may be easily moved or removed when needed. This arrangement mirrors that seen in later 15th-century depictions and 20th-century Cairo, and may have been the practice when sawing wood in the Roman era as well.⁵



Figure 5-1: Photograph of a painting in the early-Islamic structure at Qusayr Amra, illustrating the use of a frame saw (From G. Lattanzi).

The various round holes found in the timbers of the Bozburun vessel, those for edge dowels, treenails or bolts, were most likely created with an auger although a bow drill was available as well. It is clear that an auger was used to drill some of the dowel holes, since four of the holes retain parallel striations on their surfaces, indicating the passage of a bit that cut and bore its way through the wood instead of pulverizing and grinding. A bow drill, however, was used to fashion at least two of the edge-dowel holes as dictated by the vessel's order of assembly. One of these holes, that between the aft toe end of plank three in strake five to plank three in strake four, must have been drilled in one pass once both planks were in place but after the midships floor timber was in place. As the midships floor timber was approximately 7 cm away from the hole, only a bow drill could have fashioned this dowel hole.

An auger is a fairly simple device, with a metal gouge or spoon bit affixed perpendicularly to, and halfway along the length of, a wooden handle to which power was applied.⁶ A bow drill, in contrast, had a bit attached to a similar wooden shaft, but the shaft itself had no handle. Instead, a string was looped once around the shaft and subsequently attached to either end of a slightly curved handle. As the handle was held perpendicular to the bit's shaft, and moved back and forth with one hand, the string spun the bit and wooden shaft butted against a nave held in the other hand. To use an auger, the workman positioned the bit and twisted the handle either clockwise or counterclockwise to slowly cut and bore into the wood. As a gouge or spoon bit was symmetrical in design and sharpened on the majority of its edges, it could bore a hole in wood while turning in either direction. The direction the auger's bit turned, however, had to remain constant once begun and could not alternate between clockwise and counterclockwise. This was so because a spoon bit cut into, down and through the wood as it rotated, creating shavings in the middle of the hole that could be removed. In contrast, bits in a bow drill did not commonly bore a hole, but grind a hole through a substance by reducing it to fine particles while reciprocating back and forth; thus the bow drill's use in working stone as well.⁷

The size of the edge dowel and treenail holes indicate that the bit of either the auger or the bow drill was approximately 1.2 to 1.4 cm in diameter. As evident from the concave bottom of an edge dowel hole in fragment SS10 1/13, the auger bit used on some of the

dowel holes was a spoon bit similar to examples found in early-medieval tool kits from northern Russia and Mastermyr, Gotland.⁸ It may have also been similar in shape to the auger bit from the 11th-century Serçe Limanı vessel.⁹

It is unclear if a spoon bit was used to bore the treenail holes as well, but due to the bit's ability to carve off and hold shavings during use - thus easing the cleaning of a deep hole - it seems more practical than a bit that would leave a bung of wood that needed to be worked around. Additionally, as the auger and spoon bit were already in use boring similar-sized holes, it seems excessive to have used another type of bit when the spoon bit would serve just as well.

The dowel and treenail holes could have been bored with a hand auger, but the three larger and deeper holes through the keel were more likely fashioned with a breast auger. Rather than having its bit set perpendicularly to a handle which the workman turned to drive the auger down into the wood, a breast auger separated the application of the two forces.¹⁰ The breast auger's bit was affixed to a longer, vertical wooden shaft from which, approximately halfway along its length, two wooden handles extended. The top of the shaft was capped with a loose nave that spun freely. By placing the nave against the chest and turning the handles, the workman used his body weight or pressure from his legs to drive the bit into the wood while his hands turned the bit. Such augers are depicted as part of the shipbuilding process on the 11th-century Bayeux tapestry and in a 13th-century English manuscript depicting Noah's construction of the Ark.¹¹

The dished and faceted faces evident on some of the planking and frame timbers indicate that an adze and/or an axe was used during the construction of the Bozburun vessel. Both axes and adzes have an iron blade in varying shapes and sizes affixed to one end of a wooden handle. The adze blades from the 7th-century ship from Yassiada and the 11th-century Serçe Limanı ship, for example, were held in place with an iron strap that passed from either side of the handle over the tang of the blade.¹² The handle is affixed to the blade opposite the blade's cutting edge, and the handle itself may be straight, slightly curved, or re-curved for efficiency.

The blades may also be fashioned for particular uses. Some medieval axe blades were short and wide for shaping and finishing faces, or long and thin with a straight cutting

edge for felling trees, while other edges were curved and flared.¹³ The double-ended axe blades with curved edges from the 7th-century Yassıada wreck, for example, were probably used to cut down trees and clean the rough logs, or for splitting boards.¹⁴ Adze blades during the medieval period, in comparison, varied less in shape. Some edges were straight, or were turned down at the corners, but those excavated from the 7th-century site at Yassıada and the 11th-century site at Serçe Limanı were crowned.¹⁵ The most evident difference between an axe and an adze is the alignment of the blade's cutting edge with the tool's handle: an axe blade is parallel with the handle while an adze's blade is perpendicular to the handle.

Axes, as is evident from the variety of types known in the medieval period, had a variety of uses. In addition to their use in warfare, they felled trees, stripped bark, chopped logs, and finished planks for barrels and ships, as well as spokes for wheels.¹⁶ Indeed, their appearance in medieval illustrations is commonplace.¹⁷ Essentially, an axe was an implement that could both fell a tree and finish its surfaces for later use. An adze, on the other hand, could not do both. Adzes could strip bark off a felled tree, but they were more commonly used to finish timber and plank faces, and required a bit more experience and skill. In skilled hands, the finished timber or plank retained little evidence of their presence.

Distinguishing between the marks left by the two tools is difficult, particularly when the tools are used for similar purposes and the marks are on eroded wood. The saw and axe marks on the interior face of the third plank in strake seven, for example, indicate that instead of sawing through the end of the baulk to remove the plank, a workman instead chopped through it with an axe. As a result, the saw marks end abruptly 34 cm from the aft end of the plank at a small ridge, followed by a slightly faceted face characterized by faint axe marks.¹⁸ These marks, however, were identified as adze marks until the analysis of the vessel's construction was complete. As it is difficult either to distinguish between the two tool's marks, or to eliminate from consideration one of the implements, it is assumed that both were used in this ship's construction.

A scribe or an awl would have been a short, sharpened rod of iron or steel with a handle at one end. The best example of a scribe mark is on the interior surface of fragment SS7 2/40-2/41 which apparently indicates the location of an edge dowel along the inboard

edge of the fragment. Other possible scribe marks are found on floor timbers 9, E and G. The midships floor timber preserves a mark on its forward face, immediately above the outboard end of the garboard hollow, but this mark was not made with a scribe or awl as it is 1 cm wide.

Without preserved tool marks, conclusions regarding the characteristics of any hammers, mallets, chisels and planes used to build the vessel are tenuous. Hammers or mallets would have been essential to drive bolts, nails, treenails, edge dowels, forelock and bolt keys, wedges, scarf keys and a variety of other items, as well as to power chisels or gouges. A pair of dividers is useful when transferring measurements, such as spiling a plank or multiplying an odd length. The chisels flattened and refined the mating faces between the scarfs of the keel and stem and stern, as well as between the floor timbers and futtocks. They may have cut the open mortises in the stern scarf, and possibly refined the bevel of the keel's rabbet. Planes or scrapers, in comparison, may have played a role when fitting, shaping, refitting, and refining plank edges as they were affixed to the ship.

Metal Fasteners

No concretions from the Bozburun excavation have been x-rayed or cast, but the preserved evidence indicates that all of the metal fasteners used to assemble the Bozburun vessel were either iron nails or bolts. Consistently, the fastener holes found throughout the hull were characterized by concretion adhering to the surrounding surface and/or rust staining. Occasionally a hard inclusion is encountered in a nail hole, but these inclusions reveal nothing diagnostic.

The preserved square nail holes indicate that the nails averaged approximately .5 cm² near their heads, but examples as large as .9 cm² and as small as .3 cm² were found. No accurate lengths could be gleaned from the preserved timbers, but those that passed from the planking into the framing or the keel must have been approximately 12 cm long. The nails that affixed the floor timbers to the keel, which could be classified as spikes, were approximately 40 cm long and tapered from approximately 1.4 cm² near their heads to 1 cm² where they entered the keel. No nail or spike head impressions were found. Although it certainly occurred, there is evidence that the shipwright or workmen drilled pilot holes for the nails.

The preserved round bolt holes indicate that the bolts that affixed three floor timbers to the keel were approximately 2.6 cm in diameter and at least 55 cm long. Impressions in the surfaces surrounding the bolt holes on floor timber 9 indicate that the associated washers were approximately 3.5 cm in diameter. Until the concretions are cast, it is currently assumed that these were forelock bolts. Other bolt holes in floor timbers 1 and F are 1.2 cm to 1.6 cm in diameter, and were approximately 40 cm long.

Fashioning the Bozburun Timbers

Fashioning the keel was a heavy, labor-intensive process. When complete, the oak keel was a single piece of wood 7.4 m long, approximately 29 cm moulded, and tapering from 18 cm sided on the bottom face to 15 cm wide on the top face. The shipwright also fashioned it with a slight rocker along its length; it rose 10 cm at the bow and 13.5 cm at the stern. It also possessed two precisely fashioned box scarfs, approximately 46 to 48 cm long, and rabbets extending the length of the keel and varying in inclination from 75 to 89 degrees. It weighed 300 to 340 kg, so moving the keel was most likely restrained to an essential minimum.

To fashion the keel from a rough log both larger and heavier than the final product required planning and preparation. The log itself must have been at least 7.5 m long and at least 30 cm in diameter. Primarily, although the majority of this vessel was built of oak that was readily available, mistakes made in the shaping of the keel could mean additional hours or days spent finding, felling, and transporting another oak log similar in size and quality. Regardless of how little these workmen were paid, if at all, such a process was still a waste of time, wood and labor. Before the log could be reduced, the general dimensions of the keel had to be laid out on the log itself prior to cutting. Once the bark had been stripped off with axes, the shipwright could indicate both the cross-sectional shape of the keel on either end and the long edges that the workmen needed to follow while reducing the log. Reducing the log to the keel's rough dimensions required the frame saw, possibly the largest saw on site if more than one was present. Once the log was erected on the trestles, which must have been a fairly precarious process, it was better to align the log with the vertical saw blade than angle the saw blade during use; essentially, it was best if the saw remained vertical. This meant that, on the one hand, the workmen did not need to continually check

the inclination of the blade and on the other hand, both workmen pulled the saw at an efficient angle. The first cuts defined the sided dimensions of the keel, and were most likely slightly inclined towards each other. Essentially, the log now had one rough face narrower than the other. The narrower face represented what would be the top of the keel, while the wider face would become the bottom. Once these two cuts were completed, the shipwright marked the rocker of the keel's upper and lower faces on one side, the partially finished log was shimmed appropriately, and the top and bottom faces were roughly cut to shape as well. There are no preserved saw marks on the bottom face, but a small collection on the top face indicate that it was cut towards what would be the forward end of the keel. Now that the keel was roughly trapezoidal, unfortunately, it had to be slid, shoved, hauled, and tumbled into place for further work.

Once the keel off the stocks and lying on the ground, the shipwright laid out each box scarf to be fashioned. The forward- and aft-most vertical faces of each scarf were already cut as the terminal faces of the keel itself, while preserved marks in the bow scarf indicate that the upper vertical faces in the bow and stern – 48 cm and 46 cm away, respectively – were cut with a saw. The beveled faces that extend forward and aft from the keel's extremities were also cut with a saw although, as indicated by the dubbing marks evident on this face in the bow scarf, they were later carefully adzed to create a flush fit. Once the two mortises in the upper vertical face of the stern scarf had been chipped out with a chisel, half of the keel scarfs were complete. The bow scarf, as its design was complicated by the key, still needed more work. In addition to creating two more pairs of mortises in this scarf, a workman also had to saw out a second inclined face approximately 2.5 cm lower than the first to accommodate the scarf's key.

Building the various sections of the stem and sternpost would have proceeded in a similar manner, but more logs would have been used. After the workmen and the shipwright cleaned the logs of bark and marked their surfaces, they roughly cut the shapes of the appropriate timbers then laid them out on the ground in their approximate locations in relation to the keel. Four or five timbers may have been cut to be assembled into the stem and sternpost, but two needed scarfs that corresponded with those at the forward and after ends of the keel.

These corresponding scarfs were outlined on the appropriate timbers, and their creation followed a similar path. Taking note of the outlined tenons, workmen sawed the vertical faces first, followed by the inclined faces between them. Next, work with a hammer and chisel transformed the blocks protruding from each vertical face into pairs of tenons. On the lower vertical face of the sternpost, a pair of open mortises was fashioned instead. No preserved marks indicate the tools' use, but the shipwright undoubtedly used adzes to clean the scarfs' faces now as well as later as the timbers were fitted to the keel.

So far, the shipwright and workers had consumed perhaps five or six oak logs in the creation of this vessel. One was transformed into the keel, while the stem and sternpost most likely required an additional four or five logs as they were most likely not made of one timber each. To create the oak floor timbers and futtocks, another five to eight logs were transformed into components of this vessel. Similar to creating the keel, stem and sternpost, fashioning the oak floor timbers was an involved process that required planning as well.

Primarily important to the shipwright were the logs' shapes. Each log not only had to be at least 4 m long and 35 cm in diameter, one end of the log had to incorporate a branch at least 23 cm in diameter extending from the log at approximately 45 to 50 degrees (fig. 5-2). The lengths of the logs were dictated by the proposed beam of the ship, while the minimum diameter – and the hope for a straight pith – was governed by the shipwright's desire to incorporate various elements of the floor timber into one component. The middle of each floor timber, an area approximately 1.38 m long, encompassed its thickest part immediately over the keel, as well as the triangular limber holes and concave garboard hollows to either side. To either side of this middle section, the oak floor timbers extended another 1.035 m to the bilges. The branches on each oak log were critical because the oak floor timbers, unlike the pine floor timbers, were asymmetrical in design but identical to each other. While one end of each oak floor timber would have a short upsweep through the bilge that ended with a L-shaped scarf, the opposite end would have a longer arm that extended through and above the bilge.¹⁹ This similarity is because the oak floor timbers were fixed in place near the center of the vessel. The pine floor timbers, in comparison, varied more in shape as they were closer to the stem and sternpost.

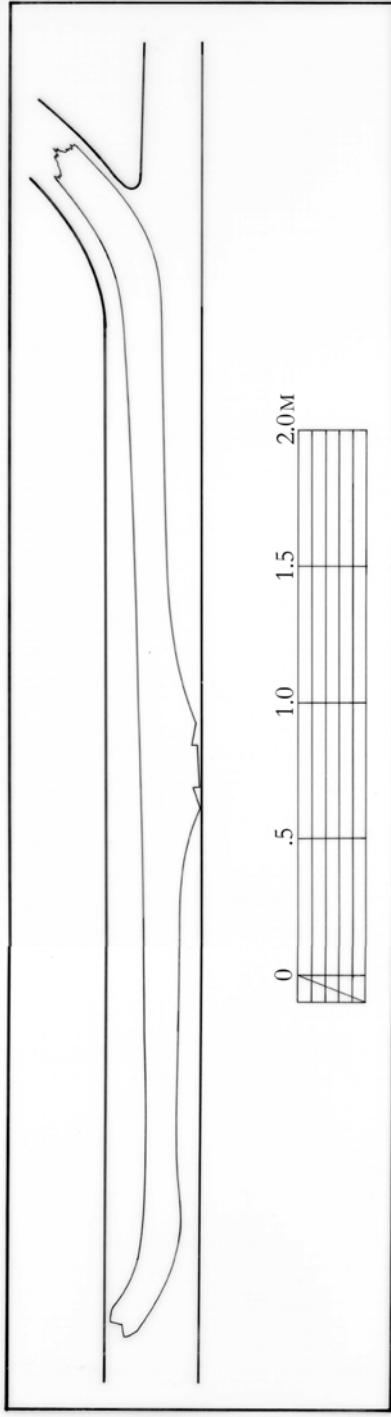


Figure 5-2: Illustration of converting an oak log into a floor timber.

Once five to eight logs were found, felled and dragged to the building site, each log was first cut by siding the log lengthwise. Sawing logs less than 30 cm or so in diameter, such as ones that produced floor timbers 1 and B, meant cutting away less of the log to leave a baulk wide enough for the resulting floor timber.²⁰ Other logs, such as those that produced floor timbers at midships, A, C, D and E, were sawn lengthwise to leave a similar baulk of wood, but a baulk that was approximately 24 to 25 cm wide – twice the final width of the finished oak floor timbers. In either case, after the workmen had sawn two rough faces off a log and began erecting the next log on the trestles, the shipwright laid out the molded shape of the floor timber on the log's exposed heartwood. The curves at the garboard hollows and the bilges were inscribed, the flat over the keel was marked, and the width and depth of the limber holes to either side of the keel were traced out.

With the shipwright's guides in place, the workmen began to fashion the molded shapes of each floor timber. To reduce quickly the logs to the approximate shape desired, they sawed off the extraneous wood over the top and bottom faces of each floor timber first. Next, particularly to complete the faces through the bilges and the garboard hollows, each sawn face was smoothed and finished with an adze.²¹ They sawed rather deep (c. 5 cm) triangular limber holes into each floor timber on either side of the keel, and dubbed a chamfer into the top after edge of floor timber B. Since floor timber B was fashioned from a narrower log, this chamfer may have been cut to even out an intermittent waney face along that edge.

All of the oak logs selected to be floor timbers were, at this point, similar in shape and almost complete. To finish, the workmen cut the thicker logs – and the shipwright had at least three – along their piths to produce floor timbers at midships, A, C, D and E.²² By cutting these thicker logs in half, each log could produce two floor timbers approximately 12 cm wide.

The shapes of the felled logs that produced the 27 pine floor timbers were important, although the logs chosen ranged greatly in size and shape. Some logs, such as those which produced floor timbers F and 2, were similar in size to the oak logs, although they did not incorporate a branch at one end. The grown timber that produced floor timber M, in comparison, was approximately 22 cm in diameter and no less than 1.3 m long.

The shipwright and workmen proceeded in a similar manner to produce the pine floor timbers, although their production did not necessarily occur at the same time. Unlike the oak floor timbers, which were all affixed to the keel prior to affixing the planking in place, the shipwright and workmen affixed the pine floor timbers in place at various stages in the vessel's construction. In some cases, the shipwright determined the molded shapes of some of the pine floor timbers by projecting how one or two planks, not yet affixed in place, would run over their surfaces. In other cases, the planking was already in place and indicated the molded shape of the floor timber.

Regardless of when a pine floor timber was fashioned, once the shipwright had chosen the appropriate log, the workmen again sawed off two vertical faces to side the log and expose the sapwood (figs. 5-3 and 5-4). At least four wood baulks initially twice as wide as the resulting floor timbers and fashioned at least seven pine floor timbers the same way they had produced five of the oak floor timbers. After fashioning the molded shapes with saws, the workmen finished the exposed faces of each floor timber with adzes. While trimming the top faces over the bilges, the workmen tended to work down and across each face, dubbing diagonally towards the bow and slowly working towards the keel as well. Over the midbody of the floor, on the other hand, they changed position and instead trimmed the face by dubbing diagonally towards the stern as well as outwards towards the bilge.²³ To produce two nearly identical floor timbers from this finished baulk, each was cut in half with two cuts proceeding from each bilge and meeting at the center of the floor timber.²⁴ Sometimes, such as floor timbers 5 and K, the finished baulk was upright when sawn in half.²⁵ The workmen cut other baulks in a slightly more complex manner. After finishing one cut to the keel, the baulk was rolled over and finished by cutting it in two, producing floor timber G and H.²⁶ After sawing their baulks in half the workmen finished floor timbers 5 and G by adzing chamfers along one of their two top edges while others were left intact.²⁷

The shipwright made at least three of the pine floor timbers from logs too small in diameter to produce floor timbers in this manner. In other words, these three logs produced only one floor timber each.²⁸ Once the workmen had sided the log, the molded shape was sawn out. Workmen again used adzes to clean and finish the floor timbers but

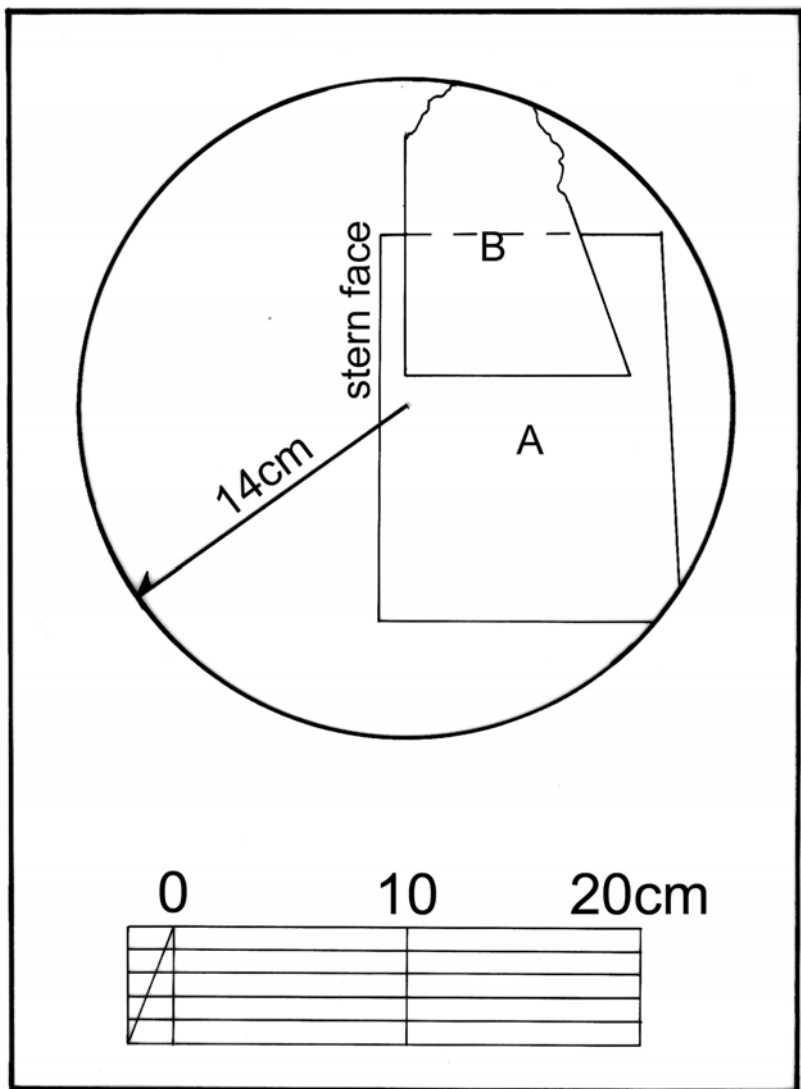


Figure 5-3: Cross section illustrating the conversion of floor timber 4.

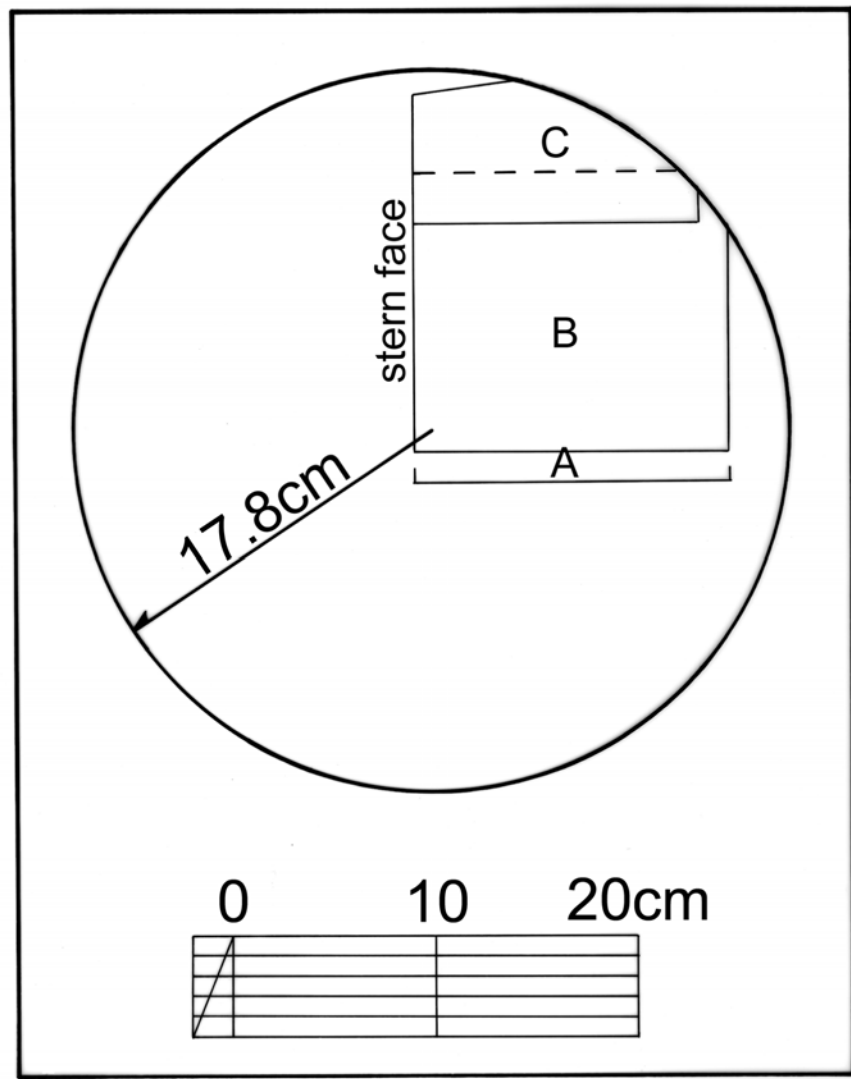


Figure 5-4: Cross section illustrating the conversion of floor timber H.

for an unknown reason left one face on each floor timber rough with saw marks. The bow face of floor timber F and the stern faces of floor timbers L and M retain saw marks, and a distribution of tool marks similar to the seven floor timbers mentioned above, even though these floors were fashioned in a different manner. The sawn face present on floor timbers 5, 4, 2, G, H, J and K remained during the final process of sawing each baulk in half to produce two floor timbers. As the workmen produced floor timbers F, L and M from one log each, there was no final step that necessitated additional sawing.

The shipwright apparently maintained this predilection during the creation of other pine floor timbers as well. The workmen and shipwright fashioned floor timbers 7 and 3 in much the same way as the preceding ten pine floor timbers. The molded shape of the floor timbers was roughed out and then workmen used adzes to trim and smooth the faces, but again, one face on each was rough with saw marks. These two floor timbers may have been produced from a wider baulk, as the pith in each is traced along their bow faces, but the bow faces are adzed smooth while the stern faces are left rough with saw marks. Again, why the final sawn face along the pith was further cleaned with an adze but the opposite face was not is unclear, particularly when these two floor timbers could have been fashioned precisely in the same manner as floor timbers 5, 4, 2, G, H, J and K. Altogether, the shipwright and workmen converted approximately 25 pine logs into pine frame material while assembling the vessel.

For the workmen and shipwright, ripping the logs for the ceiling and planking was a fairly straightforward process. After locating the pith at either exposed end of the log, they bisected the log through the pith, marked the approximate track of the pith along the log's length, and then projected one or two cuts parallel to that track along the log's surface. Their goal was to rip as many 3- to 4-cm thick boards from each oak log available. Dendrochronological analysis of the preserved planking indicates, for example, that plank one in strake two, plank four in strake five, plank two in strake seven and plank three in strake nine all came from the same tree.²⁹ Initially, as the workmen ripped the logs, they merely had to stack the boards nearby so that the shipwright could comb through them and examine their grain for the best pieces. Thinner and poorer pieces were saved for the ceiling and possibly deck planking.

How the shipwright and workmen fashioned the remaining timbers, unfortunately, cannot be elucidated. The shipwright and the workmen still needed to reduce rough logs to boards, blocks and beams into elements such as the outboard stringers, mast step, deck clamps, carlings and even the mast, and the workmen with adzes, hammers and chisels still needed the shipwright's input, but the content of that input, and methods required, are unknown. As the design of these items will be hypothetical, any discussion of their construction will have little value.

Assembling the Bozburun Vessel

Even while fashioning the framing and planking material, the shipwright and workmen could have begun to assemble the ship's components. As the scarfs at either end of the keel were finished, as were the corresponding scarfs in the lowest timbers of the stem and sternpost, these three timbers could be assembled first. With supports under either end of the keel, the shipwright and workmen could maneuver the sternpost onto the stern keel scarf by sliding it into place over the supporting struts. The stem, on the other hand, required more maneuvering. Due to its design, its aft half had to be carried over the forward half of the keel's scarf until its protruding tenons almost impacted with the keel scarf's far vertical face. At that point, the workmen lowered it onto the keel and further shoved it aft to slide the tenons into place in the keel's mortises. The shipwright, however, had to fit and refit each component to ensure a tight joint. Consequently, after the first fitting, he marked and dubbed the scarf's mating faces to fashion flush joins and made the workmen remove and replace each component. Since the extant remains of the stem weigh approximately 122 kilograms, the complete component must have been both heavier and more awkward to manipulate. Accidents were certainly possible during this tedious process, and one such accident may be responsible for a pair of tenons missing from the aft end of the stem. The corresponding mating face in the keel contains a pair of mortises to enclose the tenons, but no tenons are extant on the stem scarf itself. The preserved marks indicate they were sawn off. It is possible that they were damaged or broken off during the assembly process, and it was fastest simply to saw down the face to make it flush. Nevertheless, after these three timbers were fixed together, the shipwright and workmen

most likely laid them back down on one side on the ground, and fixed the remaining portions of the stem and sternpost in place.

With the backbone of the ship joined together, the shipwright could mark out the locations and inclinations of the rabbet and the chamfers along its bottom edges. Creating the chamfers along the bottom face was only a matter of consistently dubbing off the remaining corners at approximately 125 degrees to either side face, and possibly finishing the dubbed faces with a scraper. Creating the rabbet, in comparison, was more involved. After indicating a 2.8-cm thick flange above the rabbet along the keel, the workmen then adzed along the keel's exposed face, dubbing a rabbet approximately 1.3 cm deep next to the flange. Along the stem and sternpost, the shipwright increased this flange's thickness to 4 to 5 cm. Unlike some rabbets, this rabbet's lower face extended approximately 10.5 cm from the rabbet line, not merely encompassing a narrow face that would mate to the garboard's inboard edge. At this point, the workmen did not finish the inclination of the back rabbet face that the garboard's top face would seat against, however. This face, which at this time was relatively straight, was left rough. Fashioning the chamfer and rabbet on the opposite side followed the same process; the assembled keel, stem and sternpost was rolled over, the flange was indicated, and the rabbet was dubbed out. Once the chamfers were cut and the rabbets were fashioned on either side, the entire assembly could be rolled upright and carried onto the stocks. The stocks were at least 50 cm high, so that bolts could be driven up through the keel and floor timbers, and so that workmen could work underneath the emerging hull during its assembly. Preserved evidence indicates that the top face of the keel, and most likely the stem and sternpost as well, was dubbed to finish its interior faces, and this probably occurred at this time.

The shipwright and workmen next fashioned the seven oak floor timbers into the appropriate molded shapes. The workmen, guided by the shipwright's plans, could now begin framing the vessel by affixing the midships floor timber in place halfway along the length of the keel.³⁰ The L-shaped scarf in the turn of one bilge was oriented to the port side of the vessel, while the longer end – that which passed through the bilge and upwards – rested on the starboard side. Once the keel was centered between the limber holes of the floor timber, and temporary struts were shored up below either bilge to support it, the

midships floor timber was fixed in place with one nail. The workmen next affixed a second oak floor timber immediately aft with another nail. This second floor timber, floor timber 1, was affixed in place oriented opposite the midships floor timber; that is, the workmen placed its L-shaped scarf in the starboard bilge while the longer arm was on the port side. The opposite orientation of floor timber 1 was preferred for two reasons. First, these two timbers acted in concert to define most of the cross-sectional shape of the vessel amidships. Second, by alternating the L-shaped scarfs to either side of the vessel, potentially weak junctions alternated with much more robust structure.

After affixing floor timber E (the oak floor timber farthest forward) in place, the workmen next bolted floor timbers 9 and I to the keel near either scarf. Again, both floor timbers had been fashioned to the appropriate shape by the shipwright and workmen but, unlike the oak floor timbers, these were symmetrical and bolted to the keel. The workmen appear to have worked with floor timber 9 first. They not only nailed it to the keel prior to drilling the bolt hole through the floor timber and the keel with a breast auger, but they also appear to have started drilling the hole through the floor timber at two incorrect locations.³¹ Whatever the causes of these mishaps, they were either avoided or solved before floor timber I was similarly drilled and affixed in place with little apparent difficulty. The bolt through floor timber I also passed through the stem keel scarf, fixing the scarf together as well. The workmen now only had to affix the tail frames to the stem and sternpost, and the initial framing of the vessel was complete.

The forward and aft tailframes, as they each consisted of pairs of half frames, were nailed to the keel at their appropriate locations. In this case, the inboard end of each half frame was nailed to the keel, but they were not nailed to each other as well.

Although the shipwright partially defined the shape of this vessel with these five floor timbers and four half frames, the shapes of the remaining components incrementally designed each another. No more floor timbers were fixed in place until the workmen treenailed the third plank in strake three to the three oak floor timbers already in place (fig. 5-5). The workmen did not affix strake one in place first as that space provided a convenient place to sweep out sawdust and scraps.

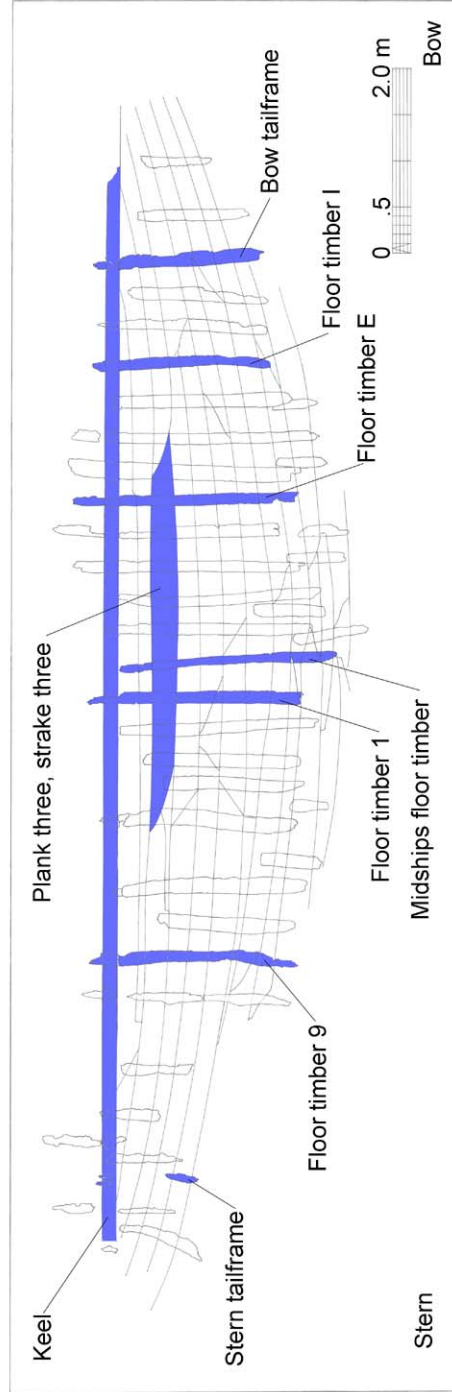


Figure 5-5: Step one in re-assembling the Bozburun hull remains. Blue timbers are newly added to the structure.

To affix plank three of strake three in place, the workmen did more than simply shore the plank up under the floor timbers, auger the treenail holes, and drive the treenails home. They also partially maintained a practice that was, by this period, significantly different from its application centuries earlier. As mentioned in the Introduction, shipwrights built craft in the ancient Mediterranean by affixing some or all of the planking together edge-to-edge prior to inserting some or all of the framing timbers. In some cases, the planking was secured with pegged mortise-and-tenon joints. In other cases, the system involved aligning the planks via dowels in the edges, then securing the planks with cordage laced across the plank seam. These two systems of embedded joinery not only aided in shaping and building the craft, but also added significant structural integrity to the ship itself. Outside the Adriatic Sea, the lacing system may have nearly disappeared by the turn of the millennium but, as indicated by evidence in the 7th-century ship from Yassiada, mortise-and-tenon joinery was still utilized for another 600 years.³² Mortise-and-tenon joints in the 7th century, however, underwent change in their application. Rather than locking planks together to resist transverse and shearing forces, and to strengthen the hull, those on the 7th-century Yassiada ship were restricted to the assembly process. At the bow and stern, through the curves in the bilge and below, they aided and maintained the alignment of the planks during their assembly.³³ As no floor timbers or half frames were yet in place, this was almost the only means of achieving and maintaining the complex curves in these areas. The mortise-and-tenon joints present through the middle body of the Yassiada vessel, in comparison, were spaced farther apart because they temporarily held the planks in alignment until the floor timbers were in place. Once the floor timbers were in place and attached to the planking, however, the embedded mortise-and-tenon joints in the 7th-century Yassiada ship had no further use.

By fashioning embedded edge dowels in the planking of the Bozburun vessel, the workmen were employing what may be the last iteration of this ancient practice. Since floor timbers and the tailframes were in place prior to the planking, there was no need for any sort of edge joinery near the bow and stern because the planking could be affixed directly to the framing already in place. The edge dowels present near midships, in comparison, played a role similar to the mortise-and-tenon joints throughout the Yassiada vessel. During

assembly, they temporarily held the planks in place as they were affixed to the already standing floor timbers.

As the workmen prepared the third plank in strake three for assembly, however, they were not concerned about this tradition. Their job was to build this ship and to do so, they understood that the presence of these edge dowels dictated the order in which the planking could be assembled. The third plank of strake three, for example, was in place prior to the second plank in strake four because it was easier to affix an outboard plank to an inboard one while assembling them with edge dowels. This, in turn, meant that the planking through the middle body of the vessel was affixed in place from strake three outwards to the bilge. To begin this process, after the third plank in strake three had been cut, they augered dowel holes along its inboard and outboard edges. Other than the dowel holes near plank scarfs, the locations of the other holes were fairly arbitrary and they only had to maintain a fairly regular spacing along either edge. Next, the plank was shored up under the framing just outboard of the end of the garboard hollow, the treenail holes were augered, treenails were driven to fix the plank in place, and the temporary shores were removed.

Plank two in strake four followed, but the workmen needed additional steps to prepare it. Once it was cut to shape, the workmen held it up to the third plank in strake three and marked the locations of corresponding edge dowel holes along the loose plank's inboard edge.³⁴ Once completed, the plank was removed and the workmen bored dowel holes along both edges with an auger. As they attempted to affix plank two of strake four in place, however, they found that one dowel hole – that near floor timber C on the starboard side – had been drilled at the wrong location. The plank was removed, a new hole was drilled, and the plank was then seated in place. With at least four edge dowels between these planks in strakes three and four, the workmen could now hammer the seam tight. The dowels temporarily supported the plank along its inboard edge, just as a few struts supported its outboard edge. In addition to nailing these planks to floor timber I, more treenail holes were drilled through the plank and the oak floor timbers, treenails were driven into place, and the supporting struts were removed.

The workmen affixed floor timber 5 in place and prepared the first plank in strake four next. Floor timber 5 needed to be in place at this early stage as it supported the aft end of the third plank in strake three, and spanned the diagonal scarf between planks two and three in strake four. After slipping a dowel into the toe of the aft diagonal scarf in plank two, the first plank in strake four was seated in place, attached across the scarf, supported with struts, and then nailed to floor timbers 9 and 5 (fig. 5-6). Mistakes were made drilling the edge-dowel holes in this starboard plank as well. It had at least three holes along its inboard edge although the first and second planks in strake three, which would be contiguous but were not yet in place, would have no edge-dowel holes. This mistake, while a result of carelessness on the part of the workmen, did not appear to concern the shipwright. Incorrect dowel holes were drilled along the outboard edge of the second plank in strake four, near floor timber C, as well as in the outboard edge of strake seven. It appears that the shipwright was more concerned with the presence of the edge dowels for support during the assembly process, than predetermining the precise location and viability of each joint. It was, moreover, easier to drill the holes in the edges of the planks prior to affixing them in place and the find they were not needed, than to drill the holes once the plank was affixed to the framing timbers.

The first two planks of strake five are unique among the planking material for the workmen doweled them together prior to affixing them to the standing floor timbers. Unlike the edge dowels in other strakes and scarfs, those that crossed this scarf were perpendicular to the scarf edge, not either edge of the strake. Two of the edge dowel holes, moreover, did not exit either strake edge. Once they were joined, however, the workmen could proceed with this strake just as they had with the second plank in strake four. It was lifted up against the erected floor timbers, the locations of the edge-dowel holes along the outboard edge of strake four were marked on strake five and, once on the ground, the appropriate dowel holes were drilled along its inboard and outboard edges. It was while placing this strake in place that the workmen found an incorrectly drilled dowel hole along the inboard edge of strake five. Rather than remedying this by drilling a new hole along the inboard edge, they instead drilled a hole along the outboard edge of strake four approximately 3 cm forward of the old one. Strake five was then lifted into place, slid onto



Figure 5-6: Step two in re-assembling the Bozburun remains. Green timbers are already in place, while blue timbers are newly added to the standing structure.

dowels protruding from the outboard edge of strake four, and shored up along its outboard edge. The workmen affixed floor timber A in place at this time as it would span the diagonal scarf between planks two and three in strake six. Floor timber J, in comparison, supported the forward toe end of strake five. Once floor timbers A and J were nailed to the keel, treenail holes were drilled through the oak floor timbers, treenails were driven into place, and the strake was additionally nailed to all of the erected pine floor timbers (fig. 5-7).

The workmen attached the planks of strake six with a process similar to that of strakes four and five. Once the third plank in strake six, the to be first attached, was cut to shape, it was held up to the outer edge of strake five and the locations of the edge dowels were marked. The dowel holes along the inboard and outboard edges were drilled and, after sliding the plank onto the protruding edge dowels in strake five, the workmen shored up the plank and affixed it to the erected floor timbers. While repeating this procedure aft to attach the first plank in the strake, a workman also attached the after toe end of plank three to the outboard edge of strake five. As there was an edge dowel along the inboard edge of the third plank between floor timbers F and G, floor timber H did not yet need to be added to support the forward end of this plank. The toe end was affixed in place with an edge dowel. For possibly the first time on this vessel, however, this dowel hole was drilled with a bow drill since the hole's proximity to the midships floor timber precluded the use of an auger. Once the workmen had completed attaching the first and third planks, they installed the intervening second plank in the strake, added edge dowels across each diagonal scarf to the adjoining planks, and inboard to strake four as well (fig. 5-8).

Prior to adding strake seven, possibly because they were adding floor timber 4 or attempting to affix the second plank of strake six in place, the workmen found they had to repair their vessel even before it was complete. For reasons unknown, they removed the forward end of the first plank in strake five, leaving a one-meter gap next to the diagonal scarf. The two edge dowels that once joined the first plank to the second were sawn through, as were another four in the strakes surrounding the damaged section. An edge dowel in the middle of the diagonal scarf was plugged by drilling a larger hole in it and hammering a larger dowel in place. To keep the alignments of the surrounding planks tight, workmen treenailed a temporary clamp to the exterior of the ship, extending from strake

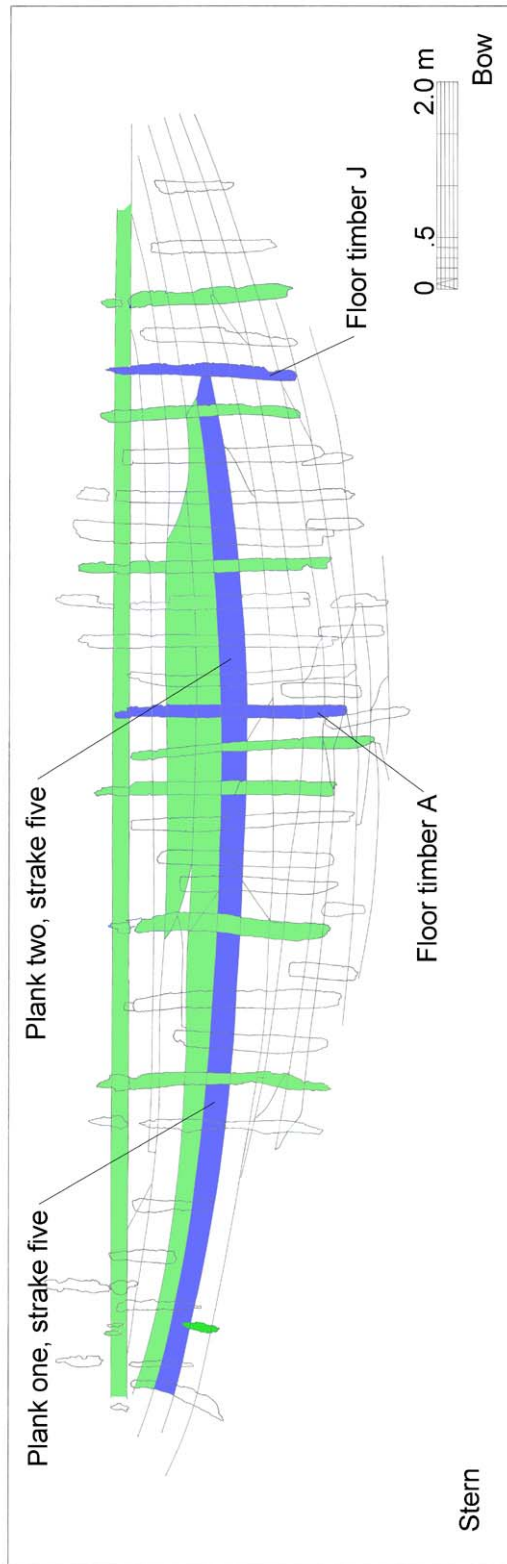


Figure 5-7: Step three in re-assembling the Bozburun remains.

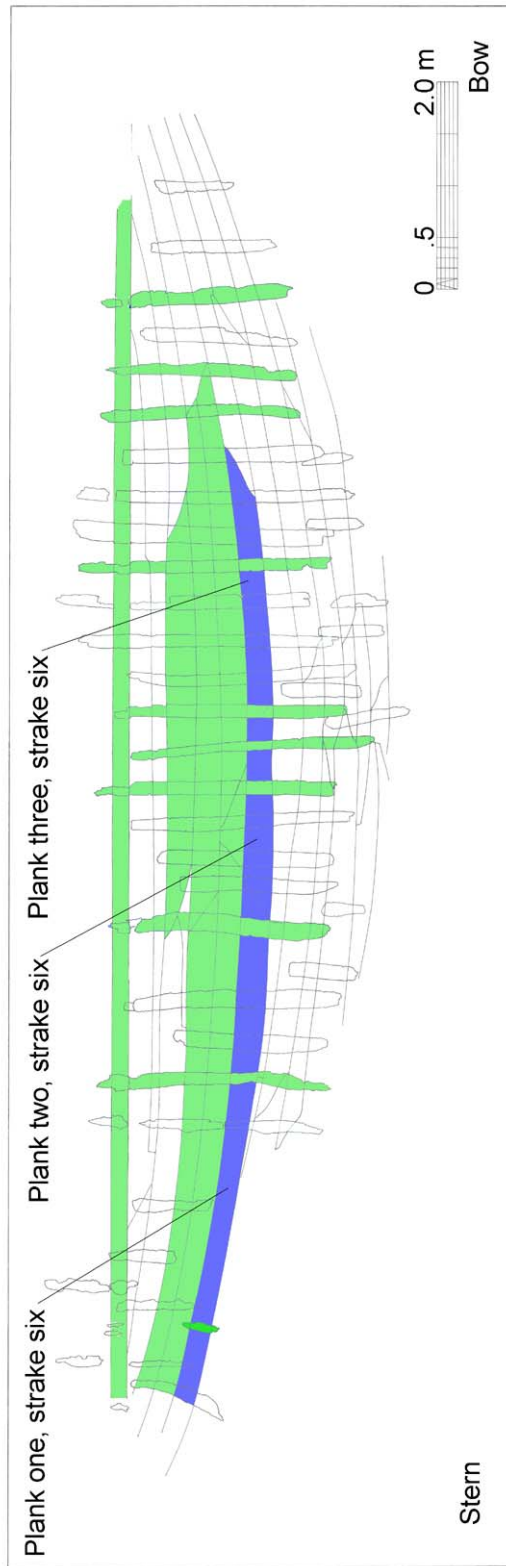


Figure 5-8: Step four in re-assembling the Bozburun remains.

three to strake six. Next, before patching the gap, they again used the bow drill to drill a new edge-dowel hole through the toe end of plank two in strake five into the outboard edge of strake four. After driving a dowel into this new hole, the patch was fitted and held in place with two additional temporary clamps nailed to the exterior of the hull (fig. 5-9). Once this repair was completed, the workmen nailed floor timber 2 in place, removed the temporary clamp treenailed in place, and added floor timber 3 as well. Next, they proceeded to attach strake seven to the increasing number of standing floor timbers (fig. 5-10).

Due to its length, the first plank in strake seven must have been fairly awkward to manage during assembly. The shipwright knew, however, that this length was necessary as its outboard edge indicated the points at which the bilges in the floor timbers aft of midships would begin. Consequently, the workmen fashioned this plank in a number of stages that were not applied to previous strakes. After they had roughed out the general shape of the plank and smoothed the inboard edge, it was temporarily held in place against the standing frames with at least six struts along its length. The presence of these temporary struts is indicated by six nail holes or treenails in the plank that do not align with fasteners in the floor timbers. The locations of the dowel holes along the inboard edge were marked, the plank was removed, dowel holes were drilled along both edges, and the shipwright then spiled the plank's outboard edge to follow a particular curve. This spiling process could have been accomplished in a number of ways. They may have used a wide flexible ribband and a compass or dividers to transfer the necessary widths from the floor timbers to the plank. Alternatively, as the outboard edge of the plank met midships and floor timbers 9 and I at the point where the turn of the bilge began, it may have been a process of transferring these three widths from the floor timbers to the plank surface at the appropriate stations and then joining the three points with a flexible batten. It may have been done by eye as well. Nonetheless, once the shipwright was done, the workmen lifted the plank back into place, hammered it onto the dowels in the outboard edge of strake six, and then proceeded to affix it to the twelve standing floor timbers between 10 and L.

Floor timbers 7, C and D were nailed to the keel next, again alternating the L-shaped scarf in each oak floor timber to either side of the vessel. To maintain the pattern



Figure 5-9: Step five in re-assembling the Bozburun remains.

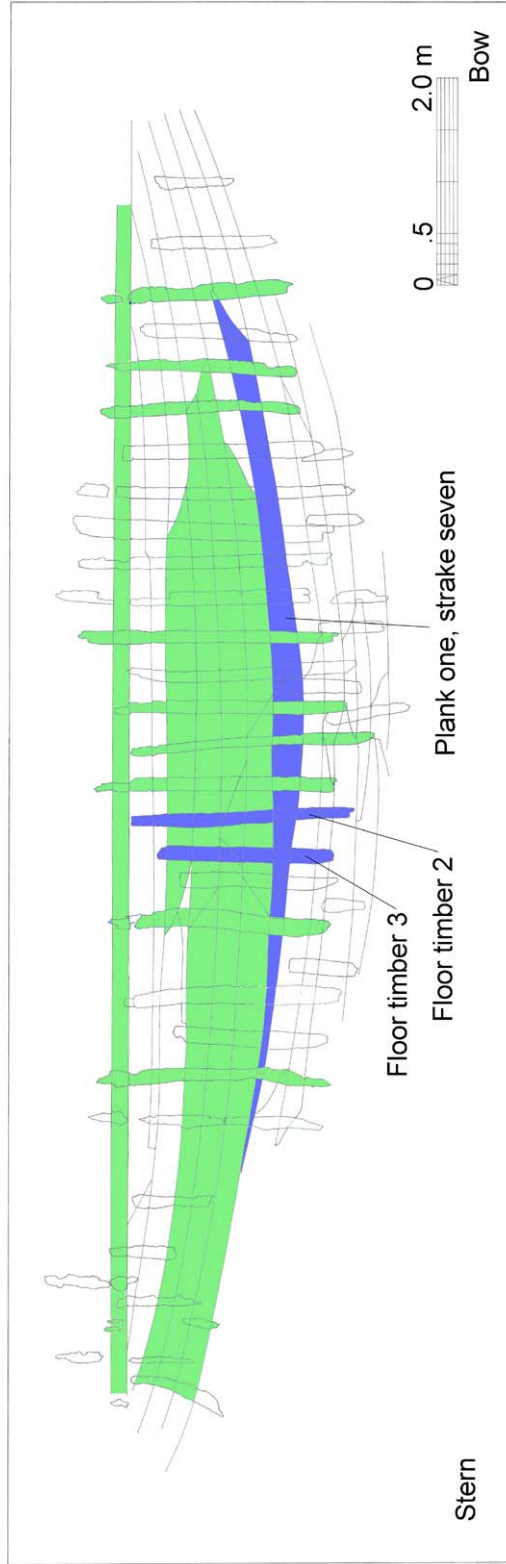


Figure 5-10: Step six in re-assembling the Bozburun remains.

established by the midships floor timber, 1, A and E, the L-shaped scarf in floor timber C was placed at the starboard bilge while that in floor timber D was to port. The workmen then fastened the appropriate planks in strakes three, four and five to the floor timbers with treenails.

By this point, approximately 30 percent of the timbers that were preserved and excavated centuries later were now in place. The shipwright and workmen had assembled the port and starboard planking along the stern and midbody of the vessel, from the garboard hollow outboard to the turn of the bilge. Approximately half of the floor timbers were nailed or bolted to the keel and, with the presence of the tailframes at the bow and stern, the general shape of the lower half of the vessel was apparent. The shipwright had fashioned dowel holes in the edges of all the planks currently in place, and the workmen had affixed each plank with a combination of treenails and nails. With the exception of the first planks in strakes three and six, the shipwright had even oriented the piths in all the assembled planks towards the interior of the vessel.³⁵ This practice would ensure that as the planks were submerged and swelled, they would expand away from the pith near the center of each plank and compress the plank seams.

Prior to fashioning and assembling planks at the bow and stern, the workmen added another temporary clamp to the hull's exterior. Across the forward scarf of the third plank in strake six, they nailed and treenailed a short 70-cm clamp extending from strake four outboard to strake seven. The workmen could now shore up plank four in strake six against floor timbers I, J and L. Sliding it over the temporary clamp, they marked its edges to fit the scarf and adjacent planks. Having fashioned and fitted the plank in place, the workmen nailed the toe end of the first plank in strake seven to the outboard edge of this last plank in strake six (fig. 5-11).

One distinct difference between this plank and others assembled previously, however, is the absence of edge dowels. In order to fit this plank in place, for example, the dowels protruding from the edges of the adjacent planking had to be sawn off. It is additionally clear that this was not a later repair as there are no extraneous nail holes in the floor timbers above it.

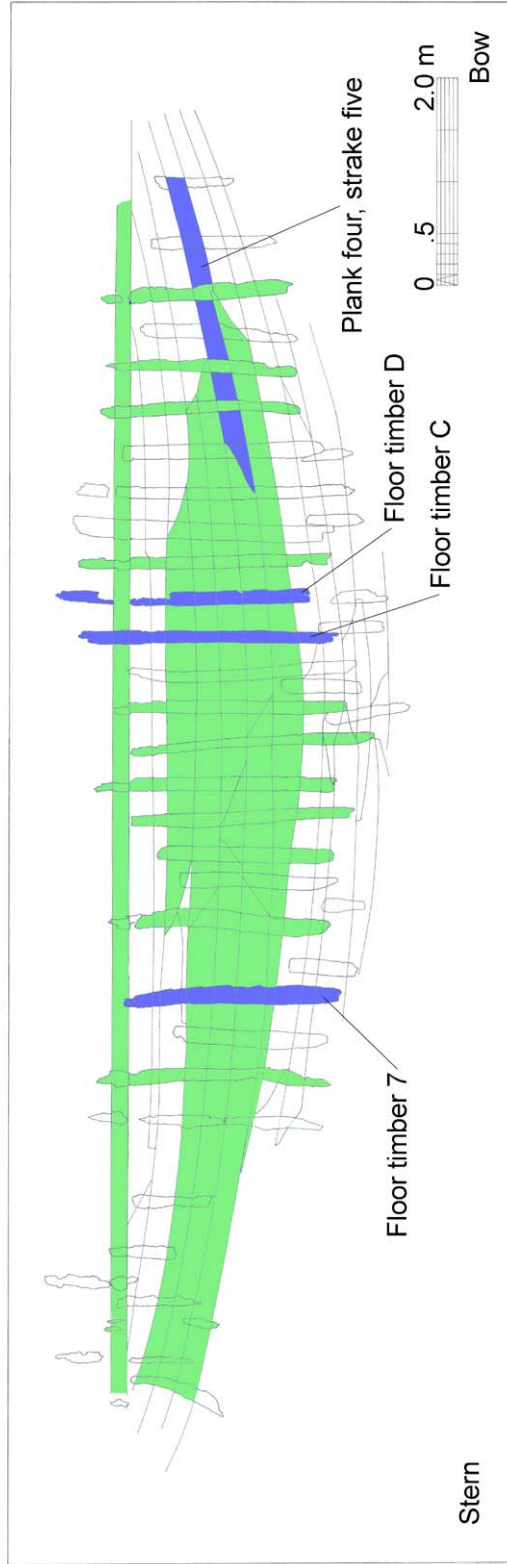


Figure 5-11: Step seven in re-assembling the Bozburun remains.

These incomplete edge-dowel joints are some of the 27 incomplete examples found throughout the preserved planking. In some cases, the third plank in strake four, the first and fourth planks in strake three, and planks in strakes eight, nine and ten had no edge-dowel holes to correspond to those in the adjacent planks as a sufficient number of floor timbers had already been erected. Strakes eight, nine and ten also planked the turn of the bilge, however, which complicated the process of adding edge-dowel joints. In planks with distinct curves, particularly those near the bow and stern and through the turn at the bilge, the alignment and drilling of the appropriate dowel holes might have involved more trial and error, and wastage, than was necessary due to the precision needed to fashion them. Additionally, when working at the turn of the bilge, the workmen might drill a hole too far and penetrate the exterior face of the plank.

The shipwright and workmen fashioned floor timbers G and H and nailed them in place to span the diagonal scarf between planks three and four in strake six, and once the second temporary clamp was removed they followed a fairly straightforward process of fashioning the planking that fit between strake six and the stem. The workmen prepared plank three in strake four, which essentially acted as the forward-most plank in strake five as well, by carefully cutting a long diagonal scarf across its aft end and nailing it in place against floor timbers I, J and L (fig. 5-12). To support strake two and the aft end of plank four in strake three, floor timber F was fashioned and fitted in place next. It may have also been added at this time as once more planking was added, it would be increasingly difficult to move these heavy timbers into place. Planks one and four in strake three were fashioned next, fitted against the stem or sternpost and plank three, and nailed into place (fig. 5-13).

Since the first plank in strake two was relatively straight and only had two edge-dowel holes along its outboard edge, and as the garboard was still absent, the workmen could fashion and affix it in place fairly quickly (fig. 5-13). Next, the forward-most plank in strake two was nailed into place along the stem and up against floor timbers E, F, G, H, I, J and L. The workmen then fashioned floor timber K and nailed it to the keel and the assembled planking. Once the shipwright and workmen had fashioned the second plank in strake seven, affixed its forward toe end to floor timber K and added the short plank

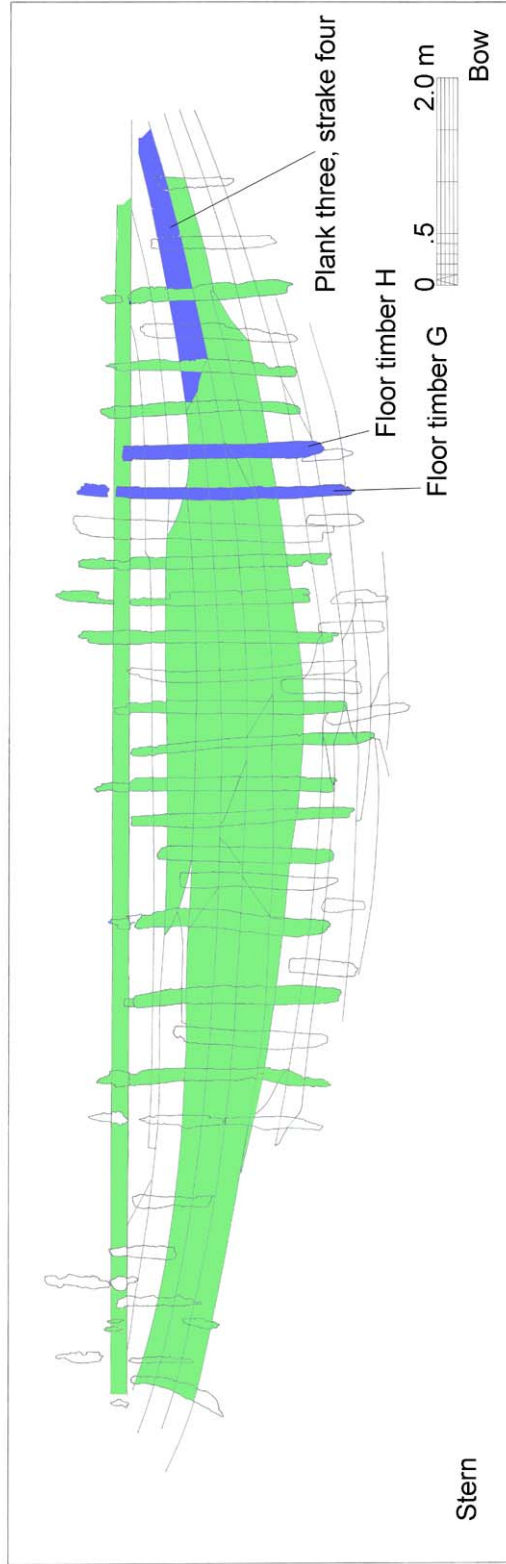


Figure 5-12: Step eight in re-assembling the Bozburun remains.

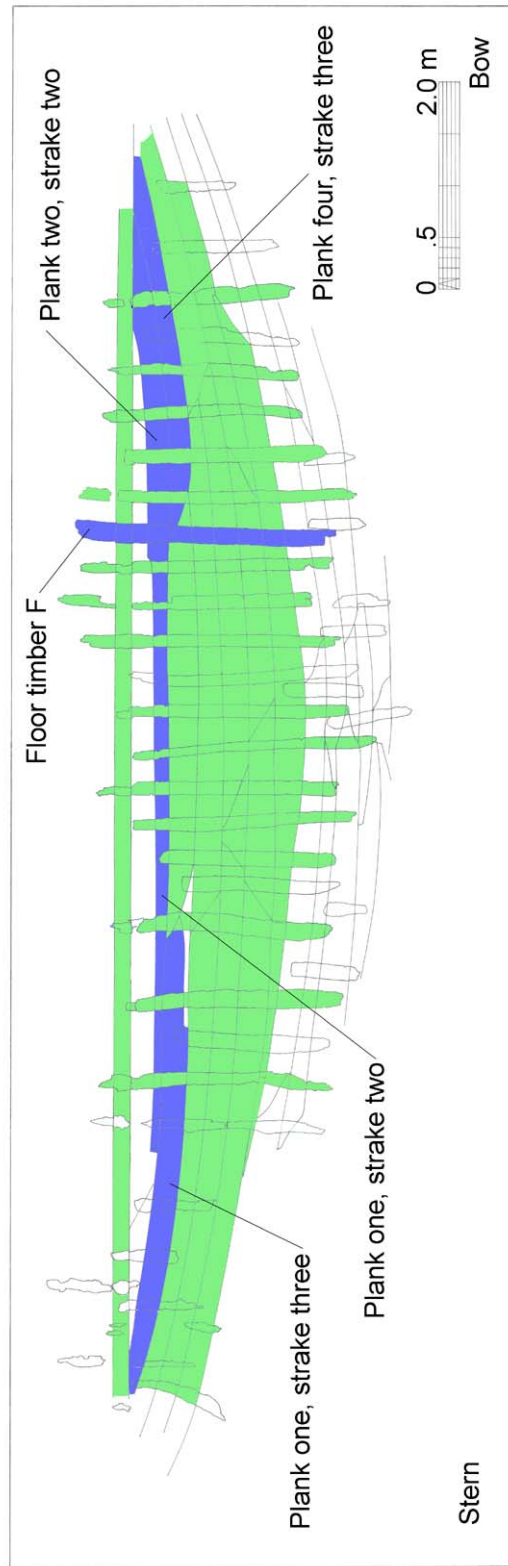


Figure 5-13: Step nine in re-assembling the Bozburun remains.

between planks one and two in strake four, all the bow and stern planking below the bilge was now complete (fig. 5-14).

The shipwright and workmen could maintain this pace of construction while affixing strake eight in place as well. They removed the rest of the temporary clamps beneath the repair in strake five and added floor timber B before proceeding (fig. 5-15). After fitting plank three in strake eight in place, attaching its aft toe end to floor timber B, floor timbers M and N were fashioned and nailed to the assembled structure. The workmen next attached plank two of strake eight and plank two in strake three. Similarly, once plank one in strake eight was nailed in place, finishing the strake, the workmen fitted floor timbers 8 and 6 in place, and nailed them to the keel and erected strakes (figs. 5-16 to 5-18).

Now that all of the needed floor timbers were in place, the shipwright and workmen were able to begin the construction of the mast step assembly. They began by affixing two longitudinal timbers approximately 2.4 m long between floor timbers 1 and F. As treenail holes are evident adjacent to the keel in floor timbers A and E, but are not evident in the garboard, it appears that the workmen first fixed these two timbers to these floor timbers prior to adding strake one. These two longitudinal timbers acted as guides that would later keep the timber with the mast's socket from slipping transversely and distribute the forces generated by the mast and sail through part of the hull's structure. Until the mast was stepped, however, the shipwright and workmen left the rest of this structure alone and continue to frame and plank the hull.

With much of the aft planking already attached to the sternpost, the shipwright and workmen could fashion and fit floor timber 11, and those farther aft, in place fairly easily (fig. 5-19). More importantly, they could also begin to plank the sides of the craft above the turn of the bilge. As illustrated by the slightly haphazard planking pattern evident in strakes nine, ten, eleven and twelve, these strakes were attached to the hull's structure after the adjacent plank runs were complete, not before. The discontinuous nature of their runs is exacerbated by the rising and shifting turn at the bilge, which was sharper near midships than towards the bow or stern.

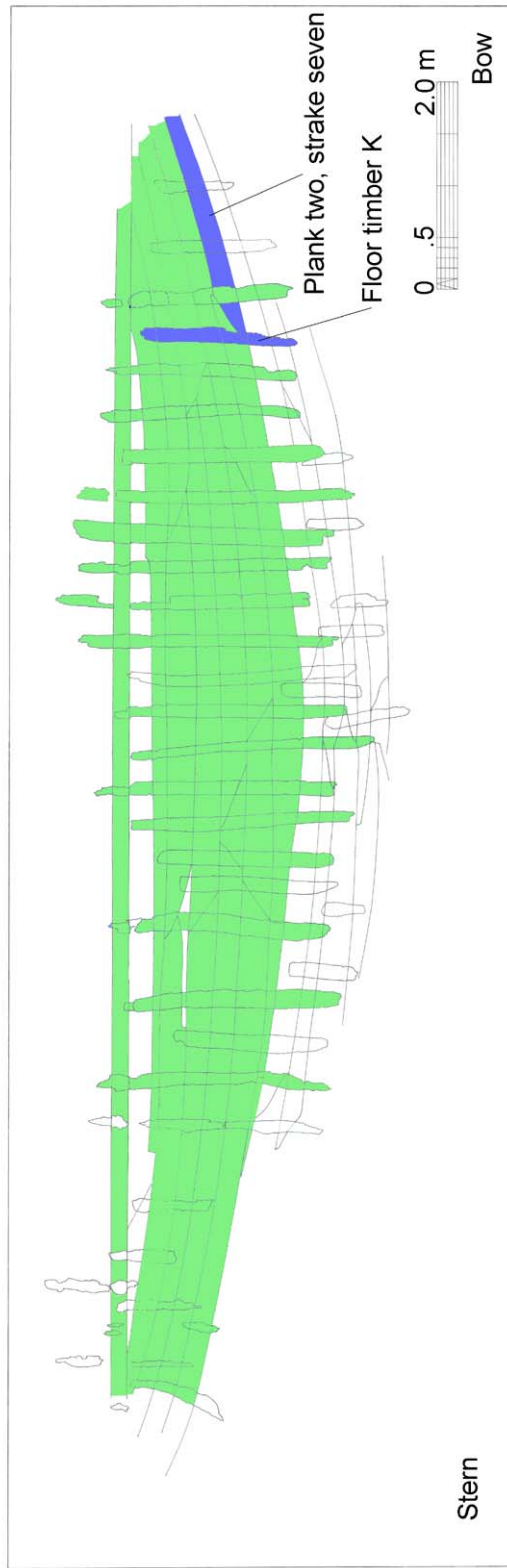


Figure 5-14: Step ten in re-assembling the Bozburun remains.

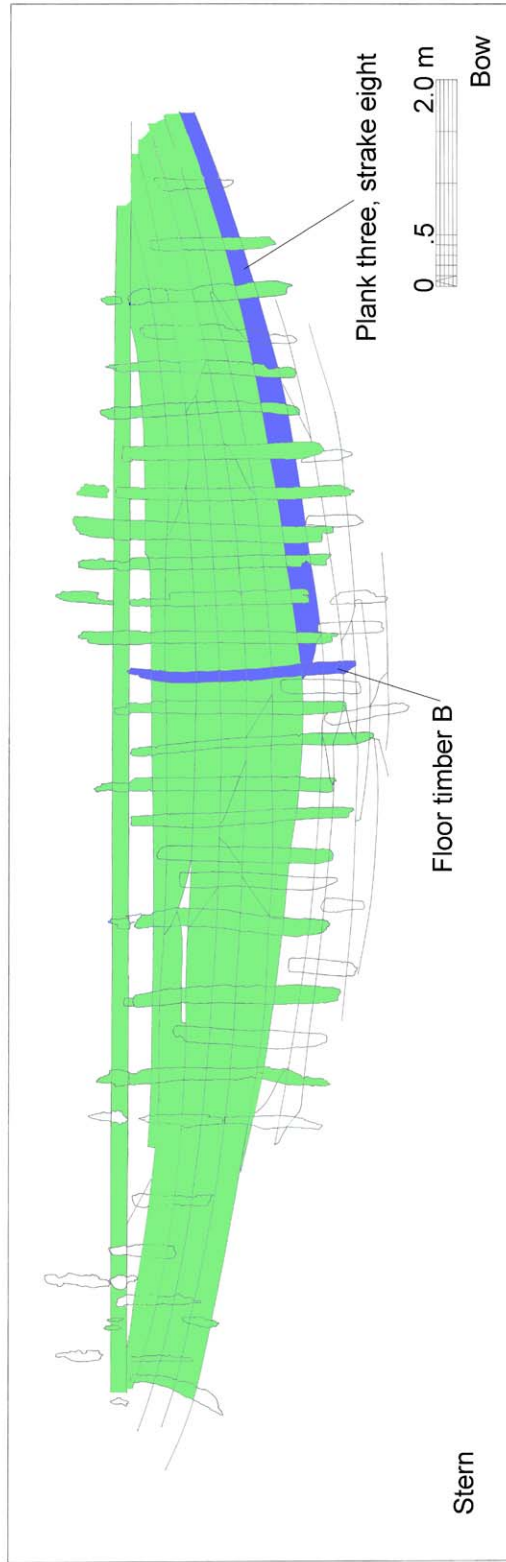


Figure 5-15: Step eleven in re-assembling the Bozburun remains.

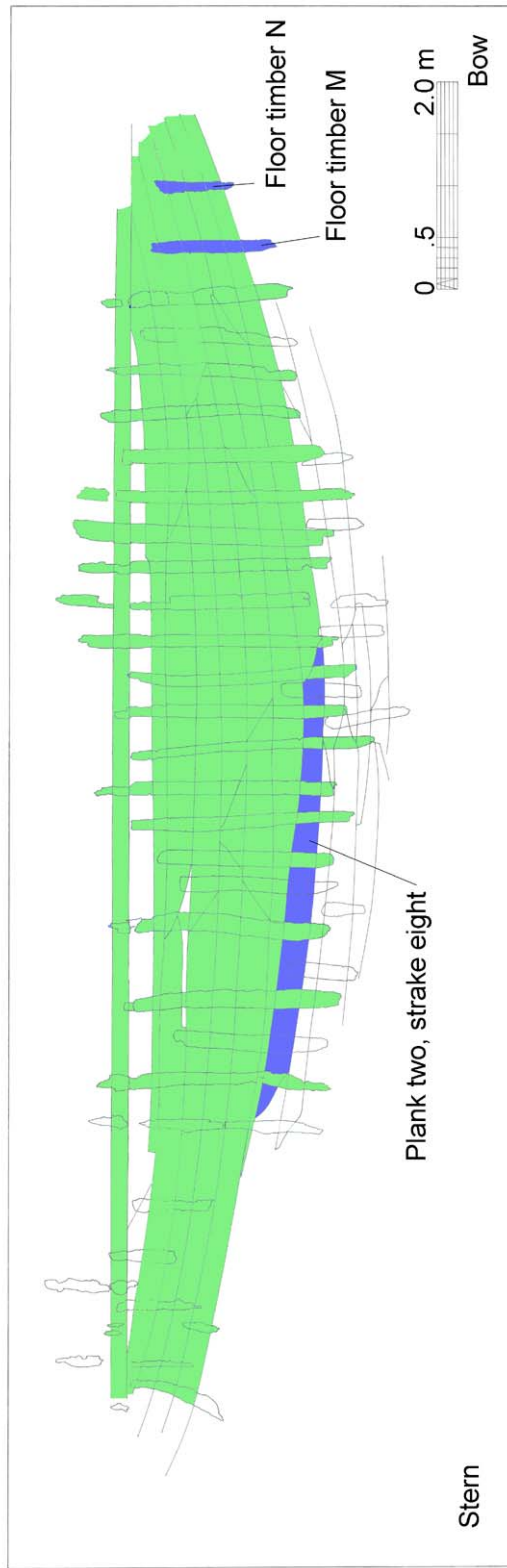


Figure 5-16: Step twelve in re-assembling the Bozburun remains.

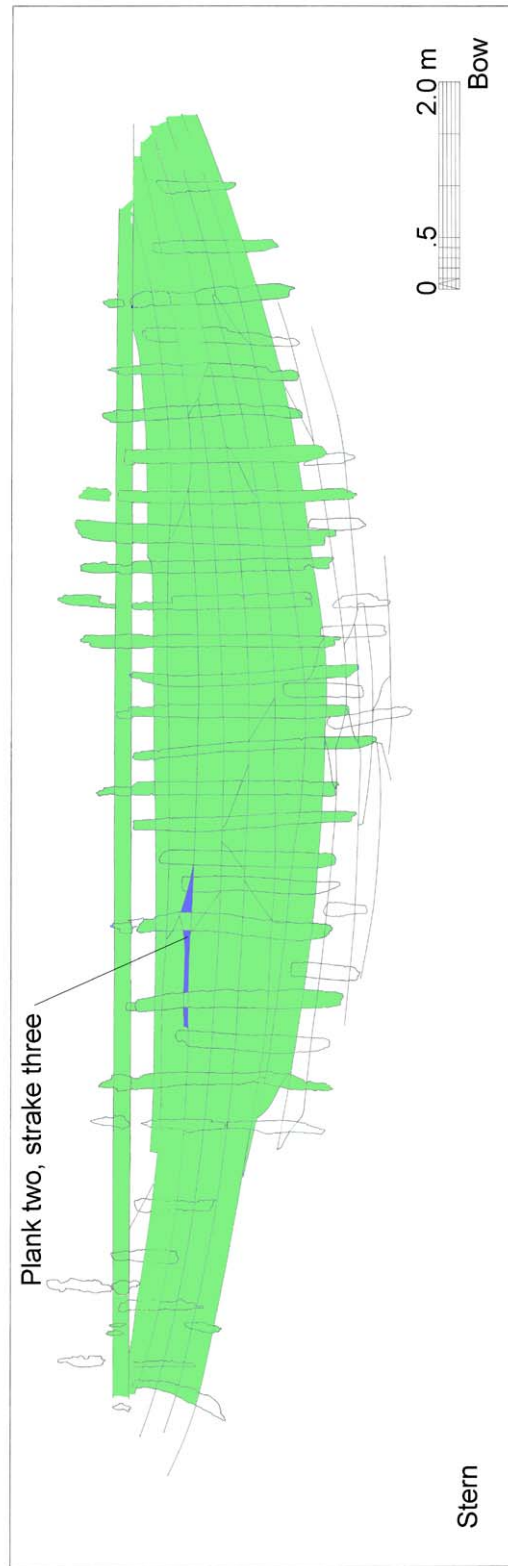


Figure 5-17: Step thirteen in re-assembling the Bozburun remains.

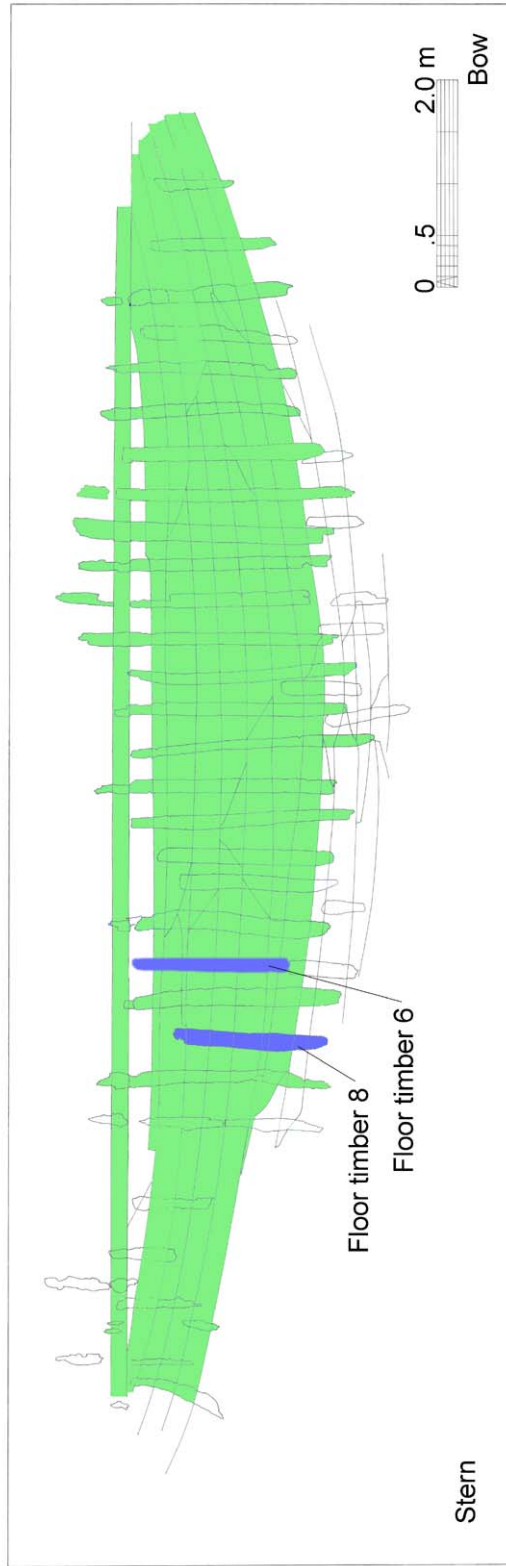


Figure 5-18: Step fourteen in re-assembling the Bozburun remains.

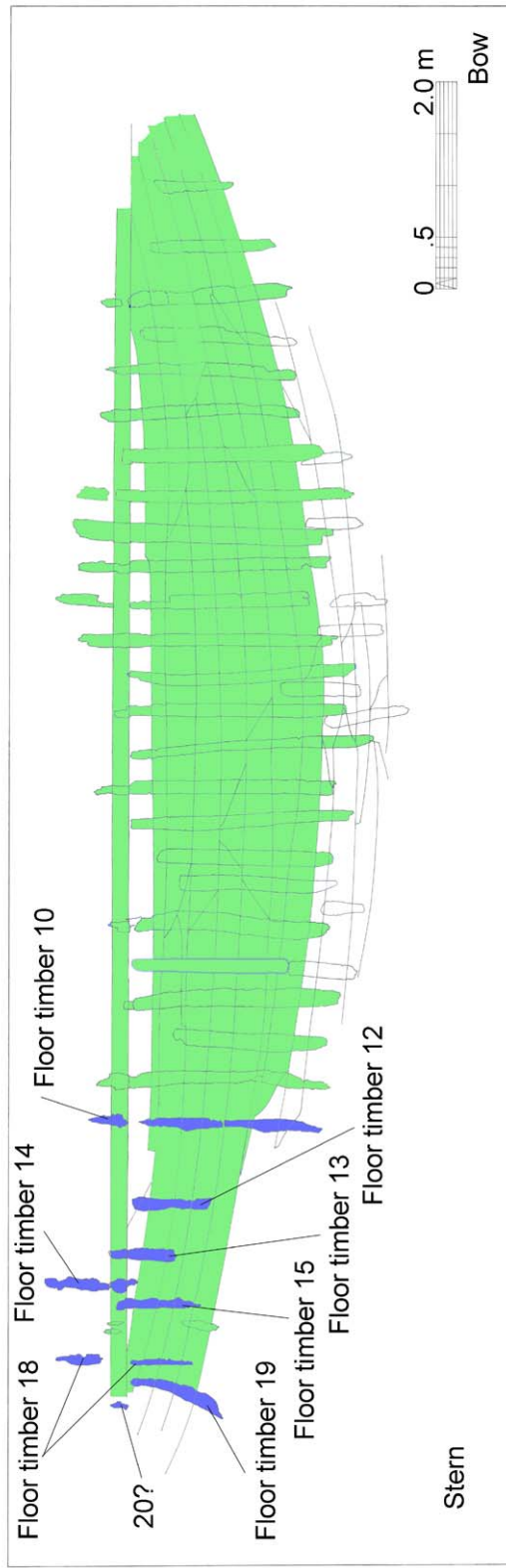


Figure 5-19: Step fifteen in re-assembling the Bozburun remains.

By this point, the midships floor timber, B, D and the majority of the pine floor timbers extended through the turn of the bilge and upwards, providing some preliminary support for strakes fourteen and higher. The shipwright and workmen most likely added the futtock immediately aft of floor timber B at this point as well, to add additional structure and perhaps to define more of the hull's shape farther above the bilge (fig. 5-20).

To fill in the gap at the turn of the bilge, it appears that the workmen first added strake thirteen and then strake twelve to close this gap. As planks in both strakes are affixed together by edge dowels, it seems likely that the workmen used the inboard edge of strake fourteen to define the run of strake thirteen, which in turn defined the run of strake twelve. Attaching the planks to each other and to the framing would have been a process of spiling the plank and drilling the edge-dowel holes, and gradually sealing the turn of the bilge. Once these two strakes were in place, the shipwright added the futtocks associated with floor timbers 6, 5, A, C, F and H (fig. 5-21). Unexpectedly, the two futtocks associated with floor timbers A and C did not fit into the exposed L-shaped scarfs at the outboard ends of these two floor timbers. Instead, these two pine futtocks each overlap floor timbers A and C by 20 cm. The futtock for floor timber H, in contrast, does not overlap its corresponding floor timber to either side, but was instead fashioned to fit partially underneath the floor timber at the bilge, apparently because the floor timber's shape did not match the turn in the bilge.

The four planks in strake nine were added next. Plank two in strake nine was installed first, followed by planks one and three, and the strake was completed with plank four at the bow. The nibbed and tapered planks in strake ten were added next, to seal up the turn of the bilge (fig. 5-22).

All the futtocks and top timbers were in place before the level of the planking reached the top of the hold, approximately 1.7 to 1.8 m above the top of the keel. By that point, the workmen and shipwright might have affixed a wale and a corresponding shelf clamp across the standing framing timbers, similar to the structure on the 7th-century Yassiada vessel, adding longitudinal and torsional strength and acting as a support for deck beams. The shipwright and workmen then began coating the interior surfaces of some of

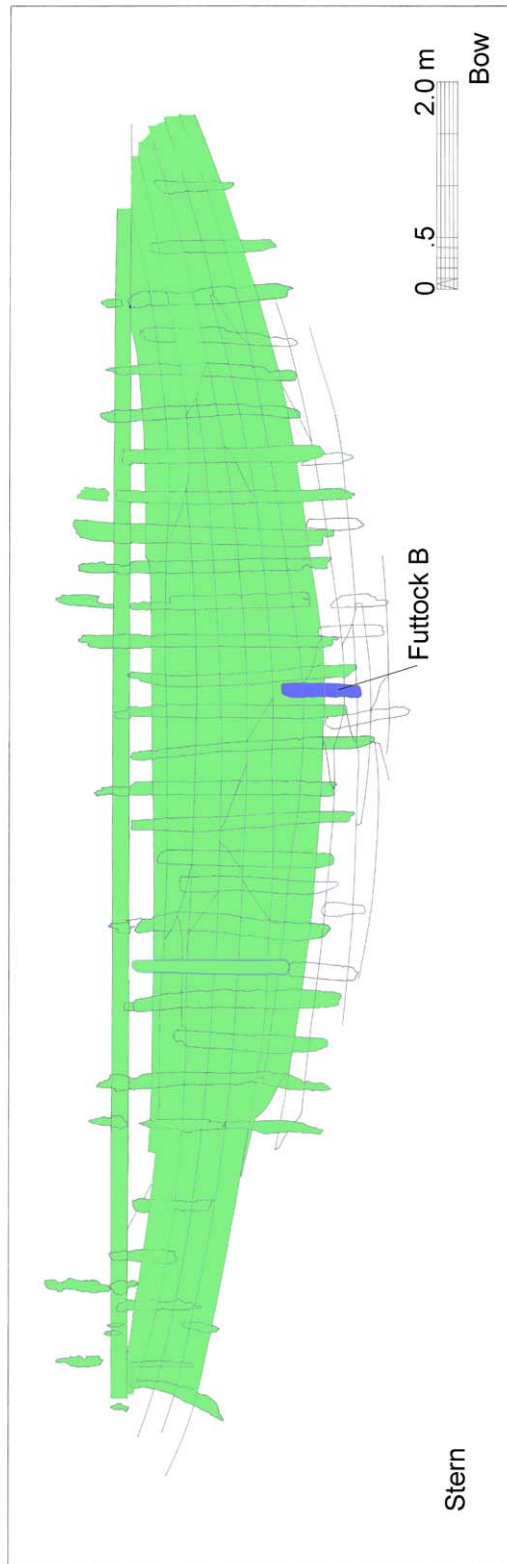


Figure 5-20: Step sixteen in re-assembling the Bozburun remains.

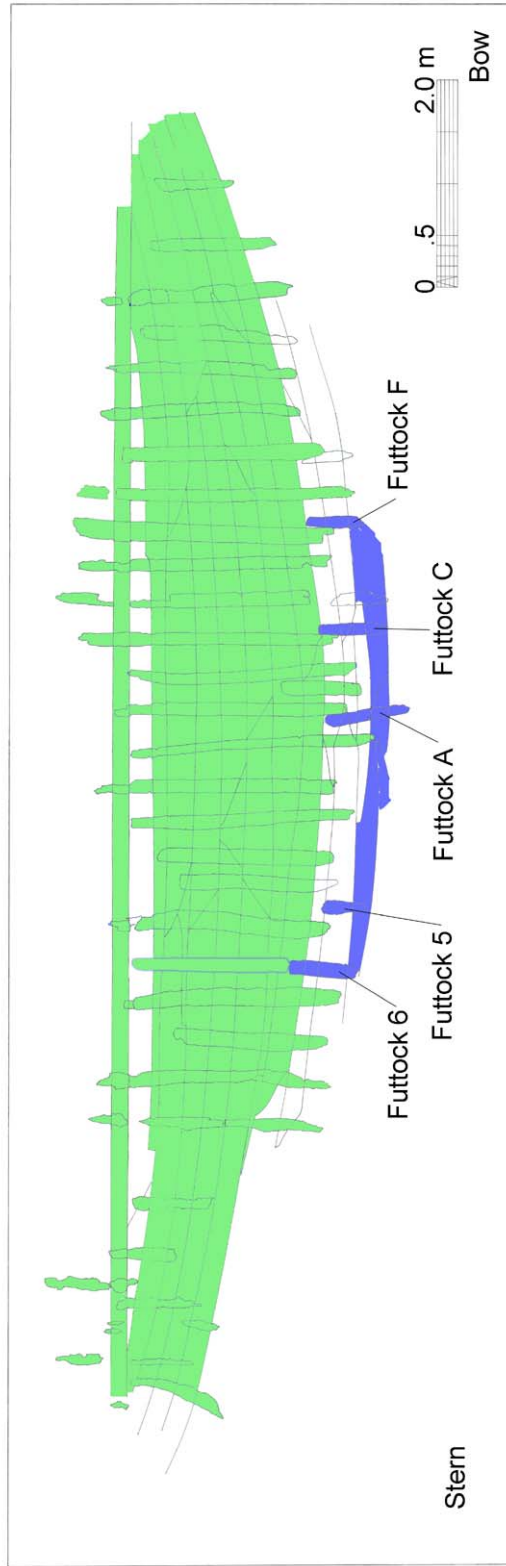


Figure 5-21: Step seventeen in re-assembling the Bozburun remains.

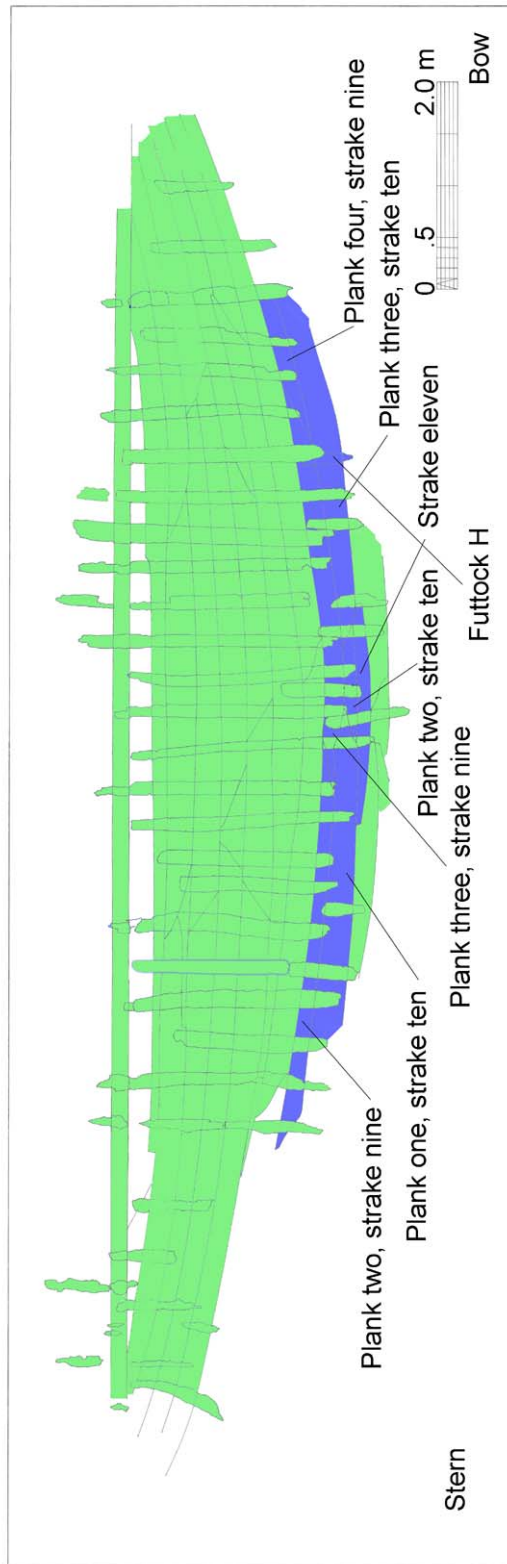


Figure 5-22: Step eighteen in re-assembling the Bozburun remains.

the plank and scarf seams with tar. Afterwards they began to fashion the deck beams and stringers.

To create the stringers, the few preserved fragments indicate the workmen sawed one log, at least 5.4 m long, in half lengthwise and then reduced each half to a thick timber approximately 21 cm wide and 6 to 8 cm thick. To finish each half, the workmen then adzed a 5-cm wide chamfer into its top edge. Once the tar had been applied, the stringers were fitted and affixed in place. The inboard stringers were subsequently nailed to floor timbers 5, B, G, H, and J between 55 and 62 cm away from the keel while each outboard stringer was nailed to floor timbers 5, 2, C, and G 1.1 to 1.2 m farther outboard, just before to the turn of the bilge. The ceiling planking, some of which was removable, was most likely fashioned from leftover or recycled scraps of planking and fitted in place at intermittent stages from this point forward.

Once the workmen and shipwright began erecting the top timbers and clamps of the vessel, they most likely added many temporary struts and cross-spawls throughout the ship's emerging structure. The external struts would remain in place almost until the ship was launched, but now that the workmen could begin to incorporate a few deck beams, some of the spawls were undoubtedly taken down. The deck beams, of which no identifiable fragments survived, may have been sawn from grown timbers, smoothed with adzes and finished with chamfers on their lower edges. Slight mortises may have been carved into each beam to securely seat them over the clamp, while the distal ends of each beam could have been bolted to the adjacent futtock with a forelock bolt. One of the first deck beams may have been added immediately above floor timber 9, to begin to define the extent of the ship's galley.

The Ship's Galley

As indicated by the small spill of galley ware in square E11 and the 12 hearth tiles found on site, the galley itself was not very large, probably less than two meters square. Indeed, as other research has indicated that the crew most likely ate their meals elsewhere on board, this galley was defined predominantly by the hearth tiles supported above the floor timbers and a small rack or bulkhead nailed to the top face of floor timber 9 immediately aft of them.³⁶ The preserved nail holes in the top face of floor timber 9

indicate that this rack or bulkhead was nailed in four locations to the top of this timber, and was most likely similarly attached to the bottom of the associated deck beam above. An additional nail hole in floor timber 8 immediately over the turn of the bilge implies that perhaps a support for the galley's bulkhead, or part of the structure that supported the hearth tiles, was affixed here as well.

Due to the absence of casserole dishes and cauldrons, it appears that the crew members commonly prepared a small number of individual meals for themselves, heating and supporting the small pots on the cooking stands and possibly making sauces in the small copper jugs.³⁷ While the pots and their stands appear to have been acquired as a set, as were the two copper jugs, the ceramic juglets may have been brought on board in an ad hoc fashion.³⁸

Sail and Rigging

As only fragments of the mast step and approximately 33 cm of cordage were recovered during the excavation, developing the vessel's sail and rigging plan is based predominantly on the preserved fragments of the mast step, iconographic representations and the hull's center of lateral resistance (fig. 5-23).³⁹ Numerous representations indicate that vessels during the 9th century, and later, carried lateen sails in place of the square rig more common in antiquity.⁴⁰ These representations illustrate elements such as yards, blocks, halyards, braces, mastheads, shrouds, tackles and sails, but their stylization negates any attempt to interpret accurately the relative size of the sail to the rest of the vessel. In the case of the Bozburun ship, these representations certainly imply that it carried a lateen rig, but the sail's size was estimated by comparing the Bozburun hull to the 11th-century Serçe Limanı hull which displaced approximately 57 tons.⁴¹ This later ship, which had a harder turn of the bilge and a greater internal volume, required an estimated 100 m² of sail for propulsion.⁴² The Bozburun ship, which displaced 55 tons, was not as boxy as the 11th-century ship and has an estimated sail size of approximately 86 m². As such, it has a luff approximately 17.8 m, a leech of approximately 13.1 m, and a bunt of approximately 12.6 m.

Accurately placing the sail over the hull requires aligning the hull's center of lateral resistance with the sail's center of effort to create a balanced rig. The center of lateral

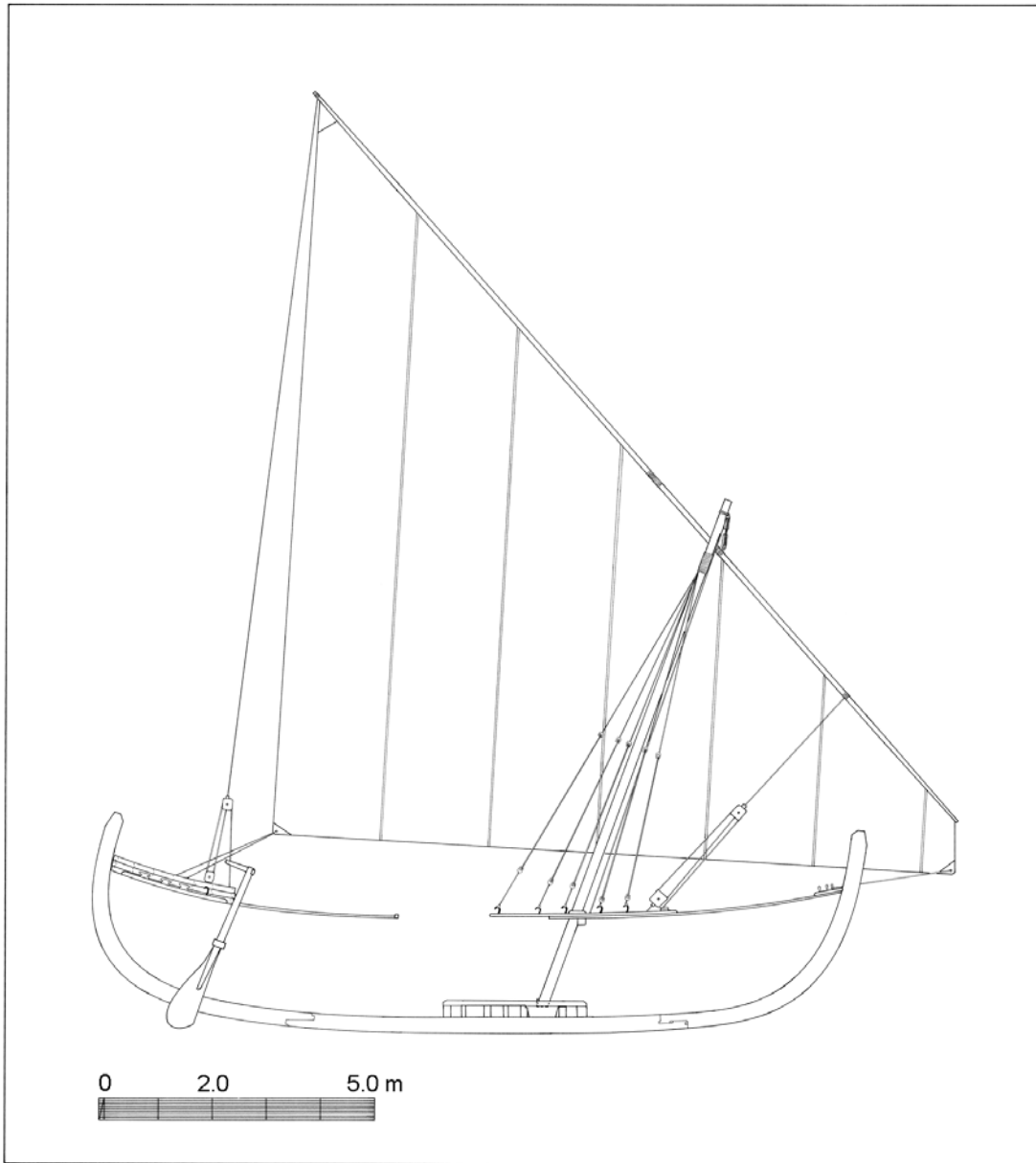


Figure 5-23: Drawing of the proposed rig and rudder design of the Bozburun vessel.

resistance is the point along the length of a hull at which forces directed at the side of the vessel are focused. In some cases, this point is located near the widest point in the hull below the waterline. Similar to this center of lateral resistance in the hull, the sail contains a center of effort. This is the focus of the wind's force on the sail. In a lateen sail, such as that on the Bozburun vessel, this is the point slightly forward of the approximate center of the trapezoid, or an area called the centroid. A craft with a single sail is considered balanced when the sail's center of effort is slightly forward of the hull's center of lateral resistance; once balanced, only a minimal effort is required to steer the ship effectively. If the center of effort is behind the center of lateral resistance, the ship is heavy, drag is increased, and too much force is required to steer the vessel.

Aligning these two points, using a sail 86 m² in size, and assuming that the mast intersects the sail's yard at a point approximately 40 percent of its length, or 6.88 m from its forward end, both the mast height and inclination may be estimated fairly accurately. By leaving the majority of the yard's weight aft of the mast, the inclination of the yard (and the efficiency of the aerofoil generated) may be adjusted with a tack attached to the lower half of the yard, rather than one at either end to maintain tension across the sail. Two lines were still often used, and depicted, to keep the after end of the yard from springing away in rough seas.⁴³

The mast's height may be estimated by the amount of the sail's yard that extends forward of the mast. To wear a lateen-rigged vessel from one upwind heading to another, the lower forward end of the yard is brought across the deck immediately forward of the mast. The sail then luffs by loosening the windward sheet. As the ship turns from one heading to another, the wind blows the sail across to the other side of the vessel as the yard is carried across the deck. Once the new heading is found, the new windward sheet is tightened and the clew end of the sail springs forward.⁴⁴ As a result, if the forward 40 percent of the yard on the Bozburun vessel needs to be carried across the deck to wear the ship while sailing, then the point at which the mast supports the yard can be no less than 6.8 m above the deck itself. If it was lower, the tip of the yard would scrape across the deck, damaging the equipment and slowing what is already an involved process. This point may

be higher, but more than 7 m above the deck could excessively raise the ship's center of gravity.

Determining the height and inclination of the mast is now a matter of aligning three points. The sail's center of effort is aligned with the hull's center of lateral resistance, just as the point at which the mast intersects the yard is 6.8 to 7 m above the deck. The result is a mast approximately 10 m high, inclined forward at approximately 70 degrees.⁴⁵

As linen is widely available across the Mediterranean basin, and is relatively light as a sail, it was most likely the fabric used to create the sail on the Bozburun vessel. As linen has the tendency to stretch when wet, however, strips of leather or hide could be attached to the sail over each seam, to minimize this stretch and further strengthen the sail.⁴⁶ At the corners of the sail, to withstand additional wear and stress from the attachment of lines, pieces of seal or hyena hide were also sewn into place.⁴⁷ As for the sail's mast and yard, fir would have been preferred. The wood is lighter than pine, tends to have a relatively straight and knot-free grain, and was preferred in the ancient world for the looms of oars.⁴⁸

The Bozburun vessel's shipwright had a variety of natural fibers to choose from to wind the cordage for rigging or lashing, or the cables for the anchors. Theophrastus and Herodotus attest to the use of papyrus (*Cyperus papyrus*), but halfa grass (*Demostachya bipinnata*), date palm fibers (*Phoenix dactylifera*), doum palm (*Hyphaene thebaica*), and particularly esparto grass (*Stipa tenacissima*) from Spain are identified in the archaeological record.⁴⁹ Macrobotanical analysis of the 33 cm of cordage recovered from the Bozburun site, however, indicate that the black leaf fibers of the European fan palm (*Chamaerops humilis*) were used to create some of the cordage on the vessel.⁵⁰ Similar to examples from other sites, these short fragments were also wound, or laid, to the right.⁵¹

The amount of cordage needed was based on the number of shrouds, sheets, braces, and lanyards required to efficiently operate the ship's single sail. On the Bozburun ship, the shrouds are approximately 8.3 m long and the heart thimbles they run between are 3 m apart.⁵² To determine the approximate length of cordage required for the shrouds on the Bozburun vessel's mast, the distance between the heart thimbles should be subtracted from the total length of each shroud. Approximately 5.3 m of cordage is required for each shroud, so at least 85 m of cordage will be required for the 16 shrouds steadying the mast.

Assuming the lanyards pass between each pair of heart thimbles four times, each shroud needs 12 m of cordage to pass between the two thimbles, plus approximately 2 m that may be led into each lanyard. Approximately 224 m of cordage will be needed for the lanyards that adjust the 16 shrouds.

No identifiable fragments of blocks or sheaves were recovered during excavation, but because blocks may swing and impact the hull of the ship, they are generally made of hard, durable materials. One of the block fragments from the 11th-century Serçe Limanı vessel was made of Ulmeceae, while most of the recovered sheaves were of boxwood.⁵³ As a significant portion of the recovered hull material from Bozburun is oak, it certainly seems possible that the sheaves and blocks were of oak as well.

The design of the blocks on the Bozburun vessel could have varied greatly. As cordage has to pass through the blocks for efficient use, it may be assumed that some of the sheaves on the Bozburun vessel were 1.5 cm to 2 cm wide, similar to the diameter of the rope excavated. Lines involved in the running rigging, particularly the halyard passing through the tackle at the mast head to raise and lower the sail were most likely larger in diameter. On the 11th-century Serçe Limanı ship, for example, a 2-cm to 2.5-cm diameter line passed through a triple-sheaved block in the foremast tackle, while a thicker line passed through a similar triple-sheaved block on the mainmast tackle.⁵⁴

All in all, the Bozburun vessel was most likely equipped with at least four single-sheaved blocks and two triple-sheaved blocks, each with oak bodies and boxwood sheaves, as well as cleats and belaying pins scattered around the deck and at the base of the mast. The two triple-sheaved blocks were paired at the mast head to serve as the tackle that raised and lowered the yard. Due to their importance, the weights of the yard and sail, and the wind's force on the sail, the halyard passing through these blocks was probably about 2.5 cm in diameter. In addition to the 8.3 m of line that passed from the mast head to the deck, an additional two meters were required between the two blocks, as well as a spare 50 m of line so that the yard may be lowered to the deck. A sail this size of heavy linen cloth reinforced with leather and seal hide might have weighed approximately 86 kg, while the yard may have weighed approximately 122 kg.⁵⁵ Assuming a pair of triple-sheaved blocks

were in the tackle at the mast head, then the sailors only had to haul approximately 35 kg in slack wind to raise the yard and sail.⁵⁶

The two single-sheaved blocks were arrayed at the lower end of the yard, to serve as one of two tacks that controlled the inclination of the yard. The tack that ran through these blocks was approximately 1.5 cm in diameter – as was all of the remaining running rigging on the vessel – but it was not the only tack on the ship. Attached to the forward point of the sail was a pair of lines, called tacks as well, that ran forward of the sail to further control the side-to-side movement of the leading corner of the sail. A pair of sheets ran aft from the clew of the sail, to adjust the sail's tension and profile. As there was one sheet each to port and starboard, the slack leeward sheet had to run from the stern of the vessel around the forward edge of the yard, and then aft to the sail's clew. While tacking, the leeward sheet was drawn tight as the luffing sail shifted to a new orientation and the windward sheet, in comparison, would go slack. For the running rigging, approximately 50 m of 1.5-cm diameter line was needed, in addition to 22 m of 2.5 cm diameter line.

The Quarter Rudders

The preserved evidence that indicates the design and size of the Bozburun vessel's rig is meager at best, and the result is only a representation of the original rigging structure. The Bozburun vessel's quarter rudders, for which no archaeological evidence survives, are based on additional extrapolation and educated guesses.

Although the evidence regarding rudders from the 6th to the 11th centuries is extremely sparse, there is no doubt that the Bozburun vessel was steered by a pair of quarter rudders, and not a single pintle-and-gudgeon rudder attached to the sternpost.⁵⁷ Mosaics, illuminations, graffitos, paintings, reliefs and sculpture indicate that quarter rudders were used in the Mediterranean prior to the loss of the Bozburun vessel at the end of the 9th century, as well as long afterwards to the 14th or 15th centuries.⁵⁸ The precise shape and mounting of the quarter rudders, however, is unclear.

Roman rudders were balanced rudders, as there was a relatively equal amount of the rudder blade on either side of the steering shaft, and they are commonly distinguished from later rudders as their blades are relatively flat in cross section. Representations indicate that there are five possible methods of mounting the rudders on either side of the vessel, all of

which involve the vessel's through beams. The rudders' shafts may be mounted in front of, behind, or between a pair of through beams, but the shaft always appears to enter the water between 30 and 45 degrees from vertical.⁵⁹

From the early-medieval period and onwards, quarter rudders are not only longer and thinner, and more asymmetrical as the majority of the rudder blade is aft of the rudder's shaft, but they have also acquired a more wing-like cross-sectional shape.⁶⁰ These modifications do not necessarily eliminate the variety of mounting systems that may be used, but the two that appear to have remained in use from the Roman era are the box mount and the aft mount designs.⁶¹ Both mounts used a pair of through beams to support the rudder, but the two beams in the former method are in the same plane immediately above the waterline, and are augmented by additional timbers that create a square jig through which the rudder's shaft passes.⁶² The through beams of the aft mounting method, in comparison, are on different horizontal planes, and the lower beam of the pair is slightly aft of the upper. In this arrangement, the rudder's shaft sits in notches carved into the aft faces of each beam, and is lashed in place for security. The Bozburun quarter rudders, to conform with period representations and the general technological trend through the early-medieval era, probably had a longer, asymmetrical tapered shape and were box-mounted near the vessel's waterline.⁶³

The rudders, mast and items associated with the rig of the Bozburun vessel were most likely made, assembled, and tested after the hull had been finished, tarred and floated. In the meantime, once the beam over floor timber 9 for the galley bulkhead, and the mast partner beams between the top timbers of floor timbers D and F for the mast, were in place, the majority of the work to be accomplished in the shipyard was complete. As the planks were ripped from the baulks of wood, the shipwright spiled the rough planks, added them to the hull's structure with embedded edge dowels, and then treenailed and nailed the planks into place. Below the waterline, pine tar was payed on the exterior of the hull planking while on the interior, the workmen nailed a clamp in place extending between floor timbers 16 and N. This clamp, in addition to adding longitudinal stiffness, also supported two aft through beams that secured the quarter rudder on either side of the vessel. Immediately aft of these two beams, they nailed ceiling planking in place to define a

small cabin at the stern of the vessel. Similarly, a low roof was added above the cabin, extending aft from the deck beam at the aft tail frames to the sternpost. After all the deck beams were in place, the decking was nailed down and its seams were caulked. To finish, sawdust and chippings were swept out of the hull, the rough faces of the rabbets were cleaned and strake one was seated, nailed and treenailed into place. Before the ship was launched, preserved bolt holes indicate that the forward and after ends of the longitudinal mast step timbers over floor timbers 1 and F were bolted through the garboard at this time. Next, the raw hull was tarred, floated, allowed to soak and swell, and pumped dry.

Now that the ship was in the water, the mast step assembly could be completed and the mast could be stepped. Once the mast was slipped between the mast partner beams, the shipwright and workmen estimated the location of the socket between the two longitudinal timbers fixed to floor timbers 1, A, E and F. First, they sawed away a section of floor timber D over the keel. Next they fashioned a large oak block to fit into this gap and extend aft over floor timbers B and C as well. This block is now partially represented by the degraded mast step fragment discussed in the Timber Catalog. Before fitting this block in place, the inclined ledge on the forward face of floor timber C was carved away to aid the block's alignment. The block was lowered into place, treenailed to the top faces of floor timbers B and C, and finished with a socket on its top face for the mast. The mast was stepped with the tackle and associated halyard already in place, the sail and rigging was completed, and the ship was ready for delivery.

The ship the owner received probably looked similar to that in figures 5-24 to 5-26. With approximately 35 percent of the original hull preserved on the sea floor, the ship's structure above the turn of the port and starboard bilges is conjecture, but it may have been approximately 14.3 m long overall, 13 m along the waterline and 4.9 m in beam at the waterline. Its estimated hold was 1.55 m high and extended 10 m between the tailframes. The lateen sail and boxy cross section probably resulted in a fairly hard ride, but the deep keel and rather flat sides would resist any tendency to slip downwind.

Its 31-ton capacity could easily carry more than the weight of the approximately 900 amphoras and associated items excavated from its hull on the sea floor. Research indicates that the tar used to waterproof the hull was probably imported to the construction

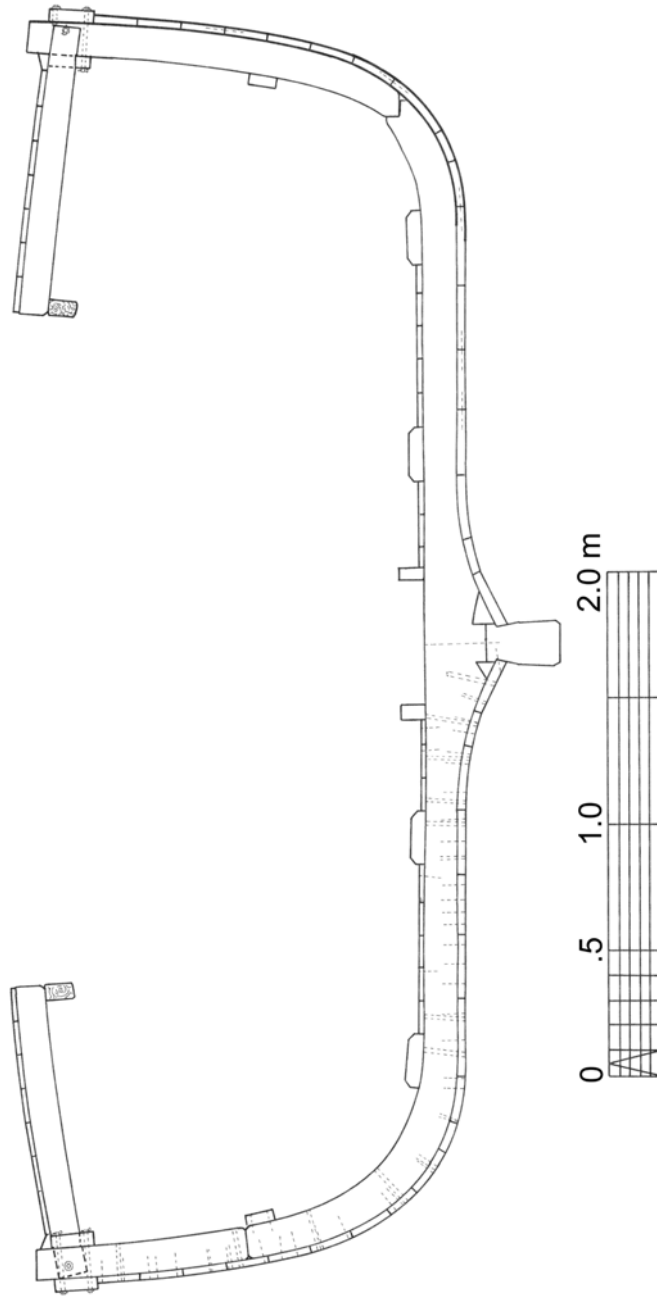


Figure 5-24: Proposed cross section of the Bozburun vessel at midships.

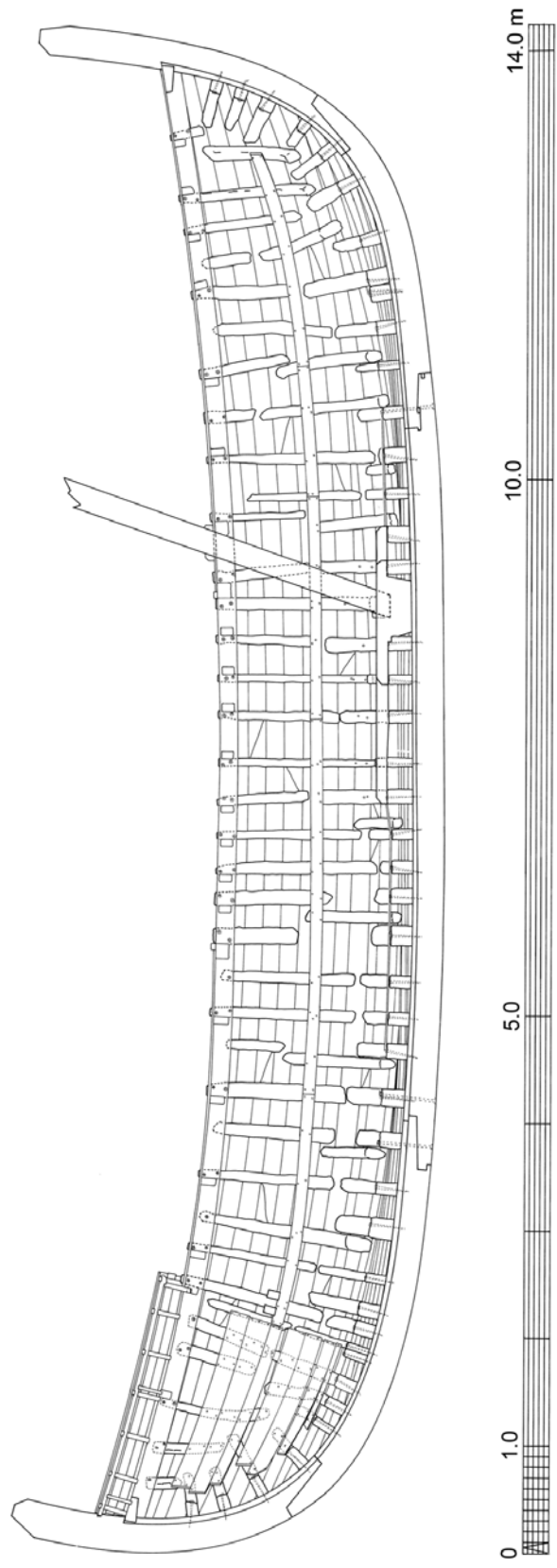


Figure 5-25: Longitudinal cross section of the reconstructed port side of the Bozburun vessel.

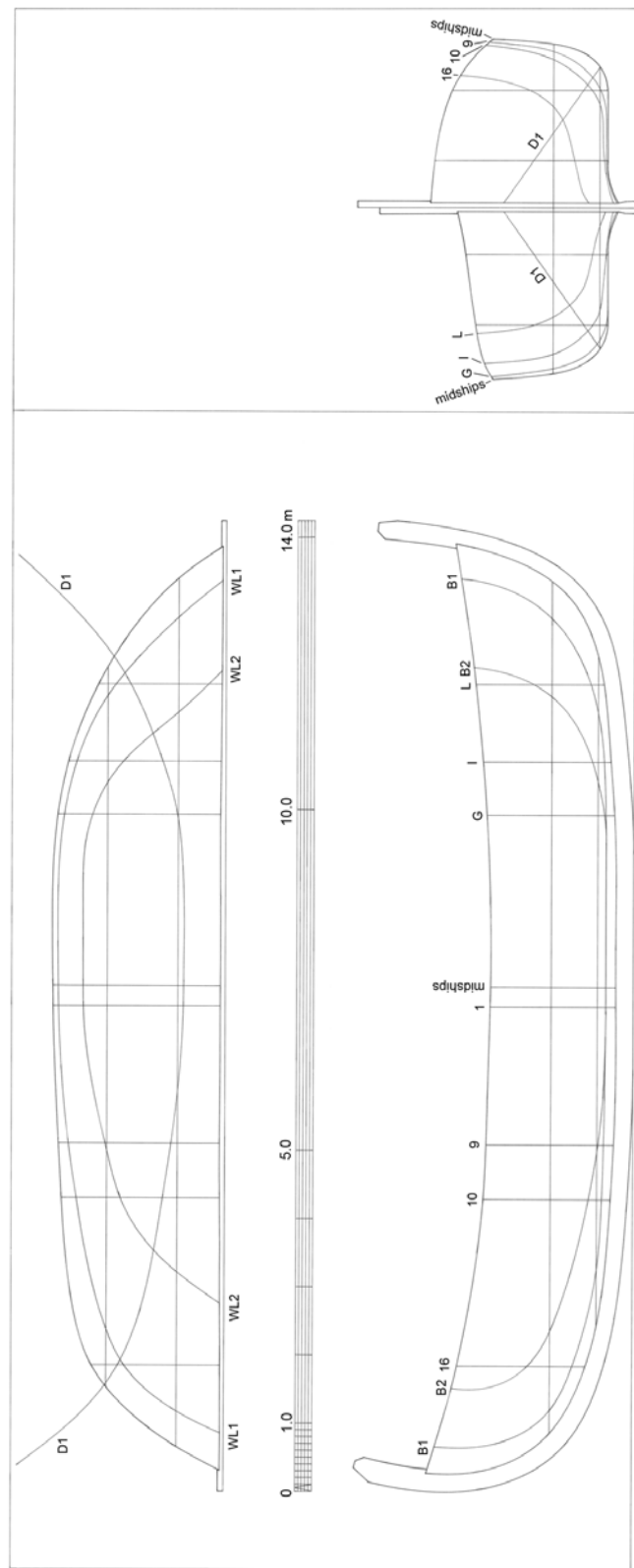


Figure 5-26: Proposed lines of the Bozburun vessel.

site from an area farther inland, possibly central Anatolia, but it is more than likely that the remaining components of the hull were all made from materials available near the construction site.⁶⁴ The galley was small but practical, and had enough space to store its wares and prepare the food for the crew of eight. The owner or captain may have found it awkward to enter the cabin at the stern, having to maneuver around the through beams supporting the quarter rudders, but as a cooking pot found on site in the stern area indicates, it was at least enough space to eat and possibly sleep just before the ship sank.⁶⁵

Endnotes

- ¹ A saw comparable in size to a modern hand saw, made of Roman hammered iron, would only buckle during use. The largest hand saw recovered from the Roman era appears to be a 33 cm-long example from Hohenrain-Ottenhausen, in Goodman (1966, 116).
- ² Goodman 1966, 119 figs. 122-4; image used courtesy of Giovanni Lattanzi.
- ³ Goodman 1966, 116-7.
- ⁴ See Hocker in Bass et al. 2004, 309.
- ⁵ This late 8th-century image from Qusayr Amra may be an interpretation of a 6th-century image in Discorides' *Codex Cantabrigie*. See Mercer (1975, 152 fig. 142 B).
- ⁶ Later examples have spiral cutting bits as well. See Goodman 1966, 170-1.
- ⁷ Mercer 1975, 182, 212. One of the bow drill bits from the excavation of the 11th-century Serçe Limanı site were designed to cut in only one direction. See Hocker in Bass et al. 2004, 302 #T11.
- ⁸ Goodman 1966, 123 figs. 128, 166. That these bits were most likely used to bore through wood similar in hardness to the Bozburun oak planking may be additionally pertinent.
- ⁹ See Hocker in Bass et al. 2004, 301 #T10.
- ¹⁰ Goodman 1966, 172.
- ¹¹ Mercer 1975, 179, fig. 162; see also Goodman (1966, 172) who also refers to the same image of Noah building the Ark.
- ¹² Bass et al. 1982, 241; see also Hocker in Bass et al. 2004, 298.
- ¹³ Goodman 1966, 28.
- ¹⁴ Bass et al. 1982, 239.
- ¹⁵ Bass et al. 1982, 241; see also Hocker in Bass et al. 2004, 298.
- ¹⁶ Goodman 1966, 27-9.
- ¹⁷ Goodman 1966, 27.
- ¹⁸ This is fragment SS7 2/23-2/26. These marls are most likely axe marks because if they were made with an adze, this face of the plank would have already been already exposed to the workmen wielding the adze. If so, then the plank was already sawn from the lumber, and there is little reason to smooth only the last 34 cm of the plank. It is more logical that the sawing stopped, perhaps because the log's supports could not be moved, and the log was then chopped through to remove the plank. It is additionally likely that an axe was used as the marks are across the face of the plank, and not aligned along its length.
- ¹⁹ In the remnants of the floor timbers at midships, B and D, the grain within the floor timber follows the curve itself through the turn of the bilge. In contrast, the starboard bilges of floor timbers 1, A, C and E are distinguished by short preserved sections that trace only half of the curve through the turn of the bilge and end in an L-shaped scarf. The grain in these latter floor timbers does not follow this turn and instead runs straight out the end of the floor timber; the curve is sawn across the run of the grain. Other evidence indicates that these floor timbers continued across the keel and were not pairs of half frames. Floor timbers 1, B, C, D and E are preserved either across the width of the keel or beyond to the port side. Other than the midships floor timber, the location of each oak floor timber was also distinguished on the keel by only one nail hole. Half frames would have either been affixed to the keel independently, leaving more than one nail hole at each frame station, or they would have first been affixed together and then affixed to the keel as one unit. The latter arrangement is also untenable as only floor timber 1 preserves a nail hole that would fit this arrangement, but the floor timber's extant remains already extend across the keel, revealing that it is not a half frame. The station at the midship's floor timber is distinguished by two nail holes, but the midships floor timber is preserved across the keel in situ. Additionally, dendrochronological analysis indicates that the wood from floor timber C, from either side of the keel, was cut from the same tree while the cross sections of those elements indicate a similar conversion as well.
- ²⁰ The distal cross section of floor timber 1 not only encompasses the pith, it also preserves a waney face on its top after edge. While the tree may have been less than 20 cm in diameter at the distal end of the floor timber, it must have been 20 cm or more in diameter to produce the various components of the floor timber at midships.
- ²¹ Adze work is prevalent not only on the after faces of floor timbers 1 and B, but also on the top faces near or over the bilges on each oak floor timber except that at midships. The predominant trend among the oak

floor timbers is the almost exclusive appearance of saw or adze work on a floor timber's faces. While saw marks are very uncommon on the top face, adze work is not. No adze work is found on the forward face of any oak floor timber, while saw marks are common. Essentially, the marks imply that at this stage, adze work followed the creation of rough sawn faces.

²² The cross sections from each of these floor timbers indicate that during the conversion process, they were all sawn from one half of a rough log, since the pith is either divided along one face, or was very near one face. This face, moreover, is commonly distinguished by the presence of saw marks but never adze marks, indicating that it was fashioned perhaps as a final step before attachment to the keel but after the rest of the floor timbers had been cleaned and finished with an adze.

²³ The preserved adze marks over the bilges of nine of the pine floor timbers indicate this dubbing pattern but only floor timber 2, with a large collection of preserved adze marks over the midbody as well, indicates the proceeding change in position.

²⁴ The distribution of the tool marks on seven of the pine floor timbers, and apparently their conversion, is similar to that of the oak floor timbers. Again, the saw and adze marks are almost mutually exclusive in their distribution; only floor timber 8 has both adze marks and saw marks on the same face. Moreover, only floor timber K has saw marks on its top face. This distribution implies that once the floor timbers were sawn to shape, each face was then trimmed and finished with adzes, thus eliminating the saw marks. Saw marks that are consistently present on the stern faces may imply that, similar to the oak floor timbers, they were created as a final step prior to attaching the floor timbers to the keel but after the other faces had been cleaned with an adze.

Regarding the cutting direction, all of the preserved marks that reveal a cutting direction indicate that this last cut proceeded from the starboard bilge to the keel. Since floor timbers 5, 4, 2, G, H, J and K were presumably fashioned in much the same way as to the oak floor timbers, and all seven preserve saw marks that were produced by cutting towards the keel, each baulk must have been cut in half with two cuts proceeding from either end to the center of the timber.

²⁵ The saw marks on these two floor timbers are inclined towards the keel. To cut in this direction with a two-man frame saw, the baulk had to be oriented in an upright position.

²⁶ Dendrochronological analysis indicates that these two floor timbers came from the same log (Personal communication, Maryanne Newton, 2004). The saw marks on the after face of floor timber G indicate that one half of the baulk was sawn in an upright manner, while the marks on H indicate that the other cut was made while the baulk was upside down.

²⁷ Seven pine floor timbers, 5, 4, 2, G, H, J and K preserve pith locations and tool marks in configurations that imply a conversion process similar to that employed for the seven oak floor timbers. The only difference is that the final sawn face, among these seven pine floor timbers, is the after face rather than the forward face.

²⁸ The location of the pith could not be located in all of the preserved remnants of the pine floor timbers; in many cases, the wood was too eroded or friable to find the grain. Thus, it is evident that the pith in floor timbers F, L and M runs relatively along the center of each and does not approach either vertical face.

²⁹ Personal communication, Dr. Peter Kuniholm and MaryAnne Newton, Spring 2002.

³⁰ The framing began with the midships floor timber because although there is no other framing in place, the midships floor timber could still be affixed to the keel in the correct location along the length of the vessel. Although no portion of the midships floor timber is preserved over the keel, its original alignment is evident by the nail hole located 3.63 m from the forward face of the keel, and 3.77 m from the aft face of the keel. The shipwright and workmen, however, were not concerned with the location of the fastener, but instead the location of the after face of the floor timber. Since the width of the midships floor timber is approximately 14 cm, adding half of that (7 cm) to the distance from the forward face of the keel and subtracting it from the distance to the after face of the keel, it is evident that the after face of the floor timber was 3.7 m from either end of the keel.

³¹ The nail and bolt holes are adjacent to one another, and are parallel to the run of the keel. In comparison to these, there are two shallow indentations on the top face of the floor timber perpendicular to the run of the keel, each approximately 1.5 cm in diameter, which may represent holes that were begun at the incorrect locations.

³² Bass and van Doorninck 1982, 83-4.

³³ Bass and van Doorninck 1982, 83-4; see also Steffy 1994, 84.

- ³⁴ No scribe marks were found on the exterior faces of the planking material, therefore the shipwright presumably marked the edges of the planks prior to drilling the holes. Only one scribe mark indicating the location of an edge dowel has been found on the interior face of the planking, in fragment SS7 2/40-2/41.
- ³⁵ The pith in the first plank in strake three migrates, from stern to bow, from the exterior to the center of the plank. An 80-cm section of the pith in the aft end of the second plank is also centered, but the remainder of the pith is traced along the interior face of the plank. The pith in strake six migrates regularly from the exterior to the center of the plank and back along its length.
- ³⁶ Danis 2002, 89-90.
- ³⁷ Danis 2002, 89.
- ³⁸ Danis 2002, 91-2.
- ³⁹ Gorham 2000b, 16 fig. 9.
- ⁴⁰ See Matthews (1983, 30-40) and the images and illuminations from various Psalters and manuscripts from the 9th to the 11th centuries, as well as Ray (2001, 34 fig. 12, 44 fig. 18, 45 fig. 19, 49 fig. 23, 51 fig. 25, 60 fig. 33, 61 fig. 35) for slightly later images.
- ⁴¹ See Steffy in Bass et al. 2004, 169.
- ⁴² See Matthews in Bass et al. 2004, 182 and 185 fig. 11-11
- ⁴³ See Ray (2001, 34 fig. 12 and 44 fig. 18) for representations that indicate that a lateen's yard was not hung evenly from the mast. Later depictions tend to indicate this imbalance more prominently which may be a result of artistic license or actual practice.
- ⁴⁴ For a more detailed explanation and a series of illustrations of this process, see Landström (1968, 83).
- ⁴⁵ Approximately 17 percent of the mast's height is below the deck, comparable to the 11th-century Serçe Limani ship (18.3 percent), the 15th-century Longonovo boat (16 percent), and Bonino's reconstruction of the 15th-century *Nave Latina* (15 percent for the mainmast and 13 percent for the foremast) in the *Fabbrica di galere*. See Matthews in Bass et al. (2004, 182 and 185 fig 11-11), and Bonino (1978, 10 fig. 1 and 16, fig. 5).
- ⁴⁶ Casson 1971, 234.
- ⁴⁷ Casson 1971, 234.
- ⁴⁸ Meiggs 1982, 119.
- ⁴⁹ See Fitzgerald in Oleson et al. 1994, 211-4; see also Lipke 1984, 14.
- ⁵⁰ Gorham and Bryant 2001, 291 fig. 9 caption; see also Jones 1995, 60. This fiber is mislabeled as the sub-family Chamaedorea in the text of the 2001 article (Gorham 2001), a second article in the INA Quarterly (Gorham 2000) and in Gorham's Ph.D. dissertation (Gorham 2001a). Chamaedorea is incorrect because it is native to Central and South America, while the sub-family Chamaeroidia is correct as it is native to the Mediterranean.
- ⁵¹ See Fitzgerald in Oleson et al. 1994, 211-4. As fan palm fibers are still used in furniture making to replicate the use of horse hair stitching, it is evident that the cordage on the vessel was black and had a slightly coarse texture as well. See Jones (1995, 60).
- ⁵² This is approximately 36 percent of the total length of the shrouds.
- ⁵³ See Matthews in Bass et al. 2004, 177.
- ⁵⁴ See Matthews in Bass et al. 2004, 175 #R5 and 177.
- ⁵⁵ On *Kyrenia II*, the 63-m² sail of heavy linen weighed approximately 61 kg, or approximately .96 kg per square meter of linen. An 86-m² sail of similar linen would weigh 83 kg, without the added leather binding and patches. The weights of the leather and patches were estimated. The weight of the silver fir yard was determined in a similar manner. Silver fir was used on *Kyrenia II* as well, and that vessel's 11.6-m yard weighed approximately 80 kg, or 6.8 kg per meter of yard. A 17.88-m yard on the Bozburun vessel, in comparison, would weigh approximately 122 kg.
- ⁵⁶ Assuming that the safe working load of a 2.5-cm diameter halyard of European fan palm is 45 percent of the safe working load of a modern manila rope of the same diameter (see Shaw 1967, 401), then this weight is within the estimated safe working load of the halyard as well. The tensile strength of modern manila rope is available from Wall Industries Inc. (www.wallrope.com/r/manila.htm), and the listed tensile strength of manila rope 2.4 cm in diameter is 3673 kg per foot. This figure is divided by five to determine the safe working load (735 kg per foot) of the modern manila rope, then multiplied by .45 to determine the safe working load of the ancient rope (330.57 kg per foot).
- ⁵⁷ Mott 1997, 54.
- ⁵⁸ Mott 1997, 22, 24, 26, 31, 114 and 116.

HOW WAS THE BOZBURUN VESSEL DESIGNED?

To state an almost elementary fact, the components of the Bozburun hull had to be reassembled on paper to understand how they were originally assembled. That reassembly, in turn, required the Timber Catalog with its long discussions on characteristics such as tool marks and timber widths. This chapter, moreover, would have been impossible without the two preceding it. The shipwright who designed this ship designed it as a whole, as an assemblage of components with particular orientations and shapes that fulfilled a host of requirements dictated by his surroundings. To understand any standards or methodologies integrated into the shipwright's design and the ship's construction, the ship first had to be reassembled on paper and examined as an entire structure, rather than a collection of separate timbers.

Just such an examination indicates that the shipwright used carpentry, experience, and a set of instructions to build the Bozburun vessel. These instructions – or perhaps a rule of thumb – governed the design and structure of the Bozburun ship through the creation of a conceptual framework of intersecting guidelines. The following chapter discusses not only a proposed design of this framework, but its possible development and change over time as well. Based on multiples of a set length (ca. 34.5 cm), it was a tool that enabled the shipbuilder both to design the ship and manifest the ideas and demands of the ship's eventual owner. Using this framework, the shipbuilder could predetermine the locations of key framing timbers in the hull's structure and, by transposing this framework to those key stations, predict the span and inclination of particular floor timbers prior to construction. Pragmatically, these instructions could have saved a significant amount of time, labor and money. More importantly, the shipwright's possible application and use of these instructions represents a very early iteration of the later science of naval architecture.

The Midships Floor Timber

The shipwright most likely began with a simple sketch to build the conceptual framework that governed the cross-sectional shape of the ship at various stations. Such a drawing may have comprised a rectangle representing a framework approximately 3.45 m long and 2.02 m high, divided into three sections with two additional vertical lines, 69 cm to

either side of the centerline. The lower half of the rectangle was divided into three sections as the shipwright added two more horizontal lines across its width, at heights of 11.5 and 23 cm above the baseline. To finish, he marked two intermediate widths on the baseline, approximately 4.3 and 25.8 cm away from either vertical edge, and joined these marks to the top of the centerline with four diagonal lines. When complete, the sketch most likely looked very similar to the framework in figure 6-1.

Since the shipwright worked in units based on a standard unit of about 34.5 cm, however, this conceptual framework outlined on paper was, from his point of view, a rectangle ten of his units wide and five units high plus approximately 30 cm for the height of the keel. The vertical middle section of the rectangle was four units wide, the horizontal lines were one-third and two-thirds above the baseline, while the intermediate width marks were one-eighth and six-eighths (or three-quarters) of a unit from each vertical edge.

The midships floor timber was designed within this framework by first extending identical bilge curves from either end of the line one-third of a unit above the baseline. Second, at the intersection of the same horizontal line and each vertical line demarcating the four-unit wide center section, additional curves to the baseline and the keel's rabbet outlined the garboard hollows (fig. 6-2). The shipwright had, in this way, not only defined the molded shape of the midships floor timber, but all seven oak floor timbers as well, and had begun a process that would eventually shape the rest of the ship (fig. 6-3).

But why did the shipwright need to regulate the design of the midships floor timber, and other key floor timbers, so carefully? Although this set of instructions was surely not the first of its kind, an experienced shipwright would have been capable, presumably, of developing the molded shape of the midships floor timber by eye, as had surely been done in the past. Why were these instructions now necessary?

On the one hand, there is the matter of designing the ship. Although from a conceptual standpoint, designing and building a ship in a plank-first manner may be more difficult, the builder is more likely to create a hydrodynamic shape as the planks are assembled. Curves and bends in the hull of a plank-first vessel are the result of cumulative changes in each plank, thus they tend to be more gradual and natural. In addition, the planks themselves can only be designed in a longitudinal manner and can only change and

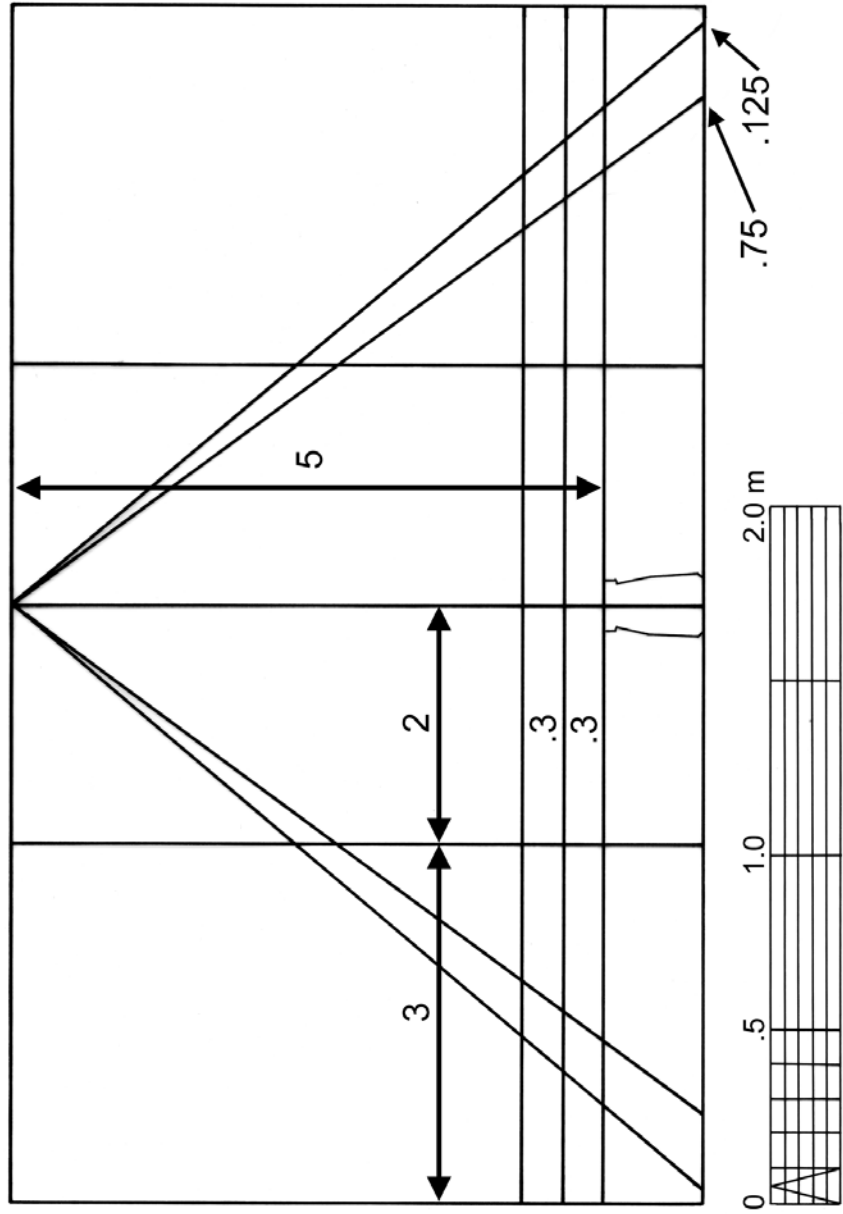


Figure 6-1: Proposed design of the conceptual framework used to design the Bozburun vessel.

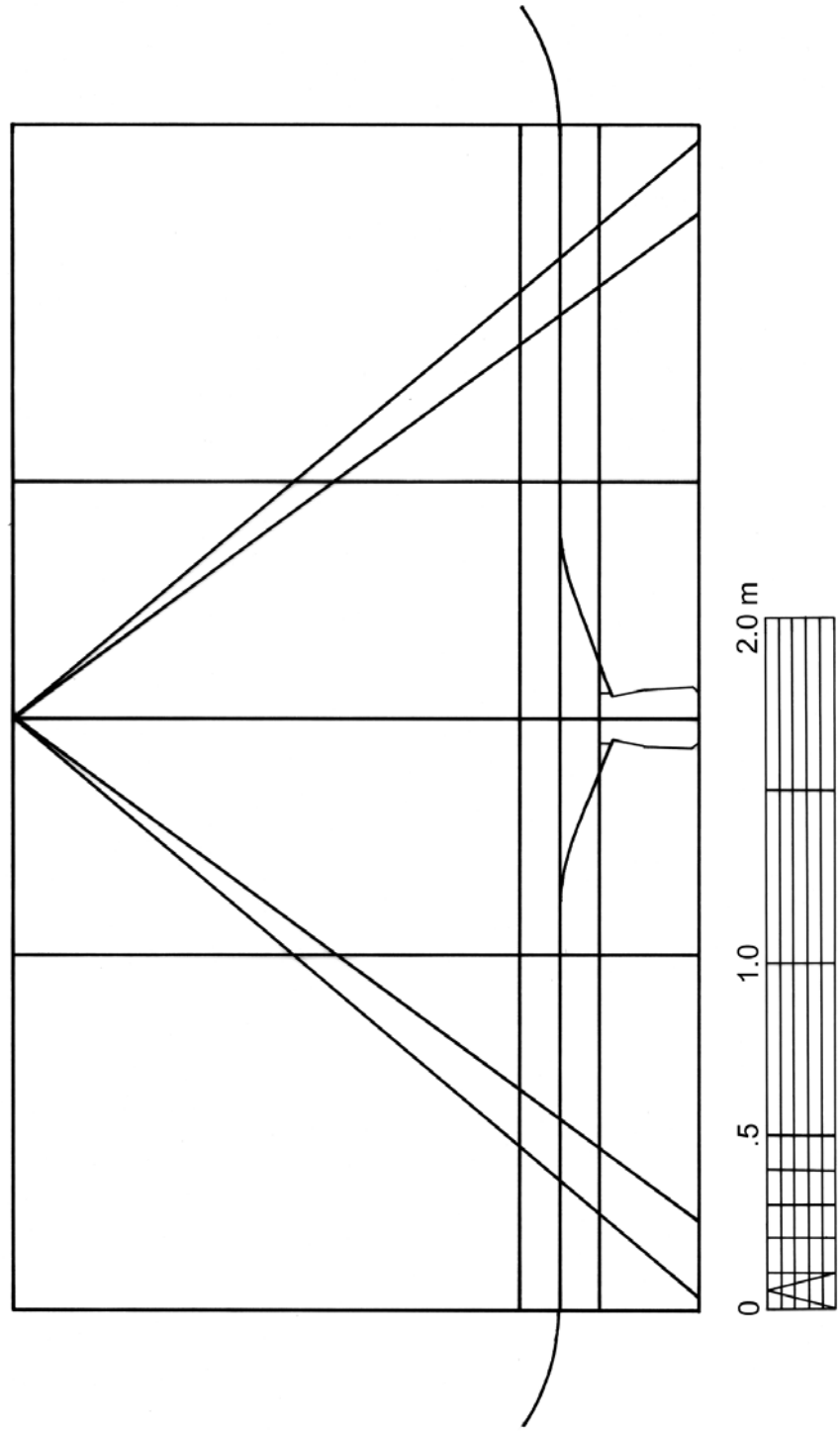


Figure 6-2: Adding curves to the conceptual framework.

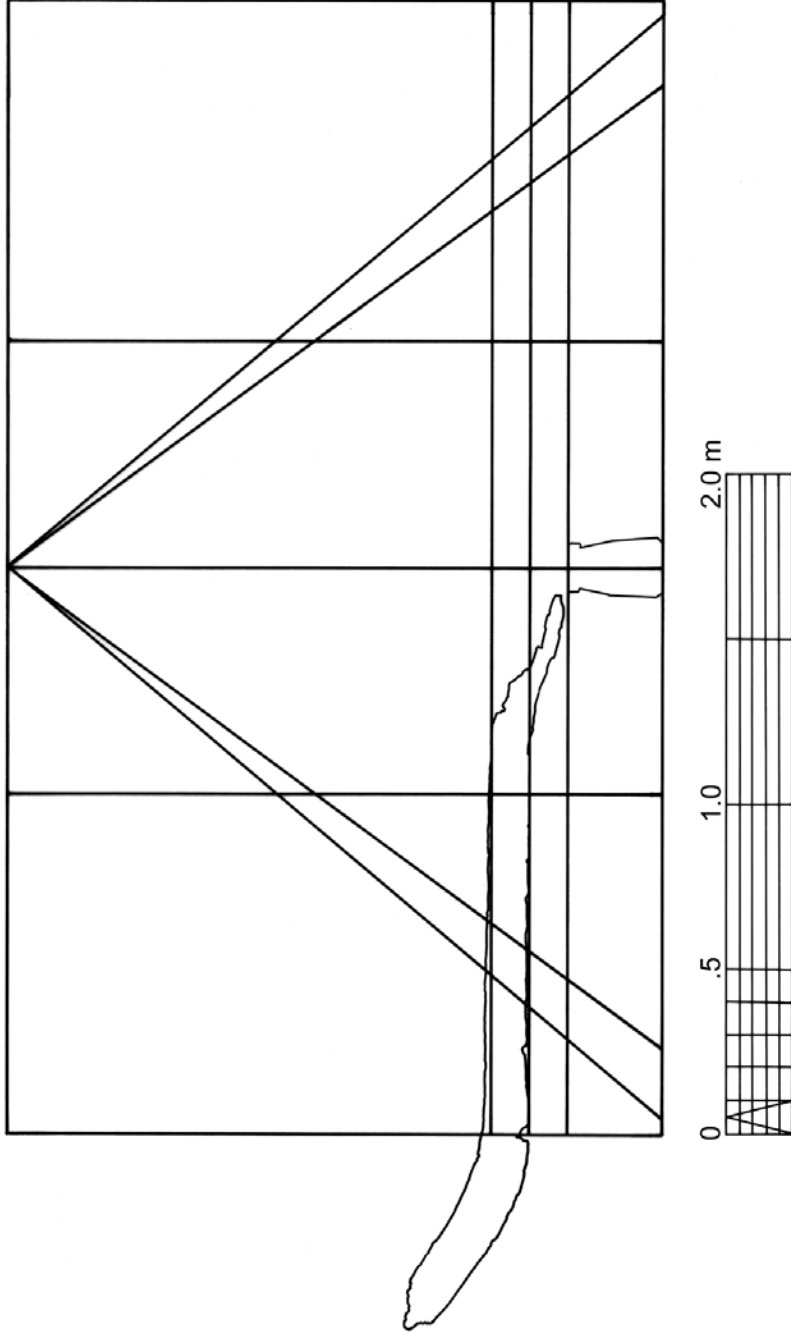


Figure 6-3: Superimposing the midships floor timber over the conceptual framework.

twist in that direction as well, the same direction in which the ship travels. Lastly, building a ship in a plank-first manner means that as the ship is built, there is no intervening step between designing the vessel and creating its shape. The very components from which the ship is constructed manifest the final shape of the hull; there is no process of extrapolation.

Building in a frame-first manner, on the other hand, requires the builder to create transverse frames that impart hydrodynamic curves to the planking. The difference lies in the fact that by building a ship plank first, the shape of the hull is created first but in a gradual manner. Building a ship frame first means that thin transverse sections of the hull are created first, which are then translated into a planked hull with a fair, hydrodynamic shape transversely and longitudinally. The second method separates the processes of shaping and waterproofing a hull, while the first unites them.

As frames or floor timbers represent a series of transverse sections through the longitudinal curves of a hull, aligning each frame or floor timber appropriately and attaching the planking should result in the hull shape desired. This is the essential reason why a conceptual framework was employed. It provided a series of repeatable guidelines and rules that governed the characteristics of the very components that shape the ship. Without it, floor timber shapes might bear little relation to each other, and their stations on the keel might be inappropriate to their shape.

A conceptual framework also made it possible to reproduce easily the midships floor timber, which was critical in this process because it was the widest floor timber in the hull. All of the other floor timbers or frames derived their shapes from its curves. The standard length of about 34.5 cm and the conceptual framework that regulated the design of the midships floor timber, in turn, represents both the ability to predict the design of the midships floor timber, and the ability to easily reproduce the same hull shape when building other vessels.

There is also the matter of defining the internal space within the vessel. Since this was a cargo ship, gentle sweeping curves, a soft turn at the bilge and noticeable deadrise would not have contributed to an efficient and flexible internal space. Awkward corners and odd angles would have resulted in empty space in which no bulk cargo could have been easily carried. Unless small luxury items could be secured and traded, this empty space

could equal a loss in revenue. The relatively flat floor timbers of the Bozburun ship, however, produced more cargo space that could carry a larger amount of material. Moreover, long before the ship was built, the approximate volume of the hold could be more easily determined.

The Primary Floor Timbers

This ship needed more than a relatively flat cross-sectional shape at midships to become a merchant vessel. It also needed a hull with cargo space that utilized this efficient shape. In many cases, making a ship longer, deeper or wider are viable means of increasing capacity, but in this case the builders employed a different technique. Similar to an oil tanker or a container vessel, the cross-sectional shape of this vessel at midships was replicated along a short length of the ship by the seven oak floor timbers with the matching cross-sectional shapes. While this technique creates a cargo vessel with an efficient use of space, however, the use of this technique for a sail-powered, wooden vessel carries its own set of problems. Primarily, the cross-sectional shapes of the floor timbers are not being derived from planking or battens that create a hydrodynamic shape; they are instead derived from a need for a large rectangular space inside the vessel. Unless a balance is found between the need for cargo space and a efficient sailing characteristics, an unsuccessful merchantman will be the result.

The builders of this vessel, then, were faced with three particular questions that relate to finding this balance: how much of the length of the vessel can be devoted to an identical cross-sectional shape to maximize cargo space; at what point does that shape begin to taper and at what point must the planking begin to curve and twist more radically to meet the stem and sternpost? To answer these questions, the builders had to define both the cross-sectional shape of the vessel at each of these locations, and demarcate each location along the keel's length. The shipwright accomplished this process by adapting the midships' conceptual framework to design what may be called, in this case, the vessel's primary floor timbers.

In the Bozburun vessel, these are floor timbers that are distinguished from other floor timbers because they play a role in both the design and structure of the hull. In this case, the primary floor timbers are 9, 1, E and I. As floor timbers 1 and E are duplicates of

the midships floor timber, they define the extent of the ship's hull that retains the original cross-sectional shape to maximize cargo space. The conceptual framework, then, plays a role in their design as well as defining their locations along the keel. The builders, for example, affixed floor timber 1, which is the aft primary floor timber, one unit (ca. 34.5 cm) aft of the midships floor timber. As indicated previously, the long arm of floor timber 1 was oriented opposite the long arm of the midships floor timber so that the two floor timbers would act in concert to define the complete cross-sectional shape of the ship through the turn of the bilge. Floor timber E, which is the forward-most primary floor timber, was nailed to the keel five units (ca. 1.725 m) forward of the midships floor timber, or half of the distance between the bilges on the midships floor timber. This distance is commonly referred to as the center flat. This floor timber oriented its long arm opposite that of the midships floor timber. Once floor timber D was nailed in place approximately 40 cm aft of E, these four floor timbers defined the extent of the hull with the widest cargo space. Similar configurations are often referred to in much later shipbuilding treatises and may be called the hull's dead flat.

Floor timbers 9 and I played a slightly different role. Similar to floor timbers 1 and E, they too served to maximize cargo space, but due to their locations they could not also retain the original cross-sectional shape of the midships floor timber. Had that been the case, cargo space would have been increased, but the resulting curves in the hull would have been too severe to bend planking around easily. The resulting hull shape, once planked, might have also been too inefficient hydrodynamically for the owner's needs. As such, floor timbers 9 and I began to define the narrowing shape between the parallel midbody and the stem and sternpost, but their diminished beam and slightly increased inclination also illustrates how hull shape increases in importance towards either end of the ship. In short, the shapes of these two floor timbers represent one of many compromises the shipwright had to make between the demands of the owner and the demands of the sea.

This compromise in the hull was embodied in the instructional guidelines sketched by the shipwright. The primary floor timbers 1 and E are distinctive because they have the same cross-sectional shape as that of the midships floor timber. Outlined on the guidelines, the bilge curves of these three floor timbers begin and end at the same points (figs. 6-4, 6-

5). The bilge curves in floor timbers 9 and I, on the other hand, begin at a point that is both higher and closer to the keel. On the guidelines, this point is the intersection of the horizontal line one-third of a unit above the line along the keel top, and the diagonal line extending from the top of the centerline to the intermediate mark one-eighth of a unit from either vertical edge (figs. 6-6, 6-7). As the distance between these two points is approximately 77 percent the length of the baseline, it is also possible that this point represents a narrowing line that is three-quarters the length of the baseline.

As in the case of primary floor timbers 1 and A, the guidelines also contain the instructions dictating where to place these two primary floor timbers. In this case, the shipwright measured the length of the line between the point that defined the beginning of the bilge curve and the top of the centerline. Floor timbers 9 and I were then affixed in place forward and aft of the midships floor timber at a distance equal to 1.5 times this length.

The Tailframes

Tailframes are indicative of the compromise between the desire for cargo space and a hydrodynamic hull. As they reflect the shape of the midships floor timber or frame, their locations essentially push the cross-sectional shape at the hull at midships towards the stem and stern of the vessel. The result is a vessel with increased cargo capacity. Beyond the tailframes at either end of the vessel the framing derives its shape from the planking most commonly because the planking was in place first.

Importantly, since tailframes are erected fairly early in the construction process, they too needed to have a cross-sectional shape carefully adapted from the shape of the midships floor timber. Thus, the shipwright again used his conceptual framework to define the tailframes' shapes and locations along the keel. Similar to the primary floor timbers 9 and I, the bilge curves of each tailframe were both higher and closer to the keel than those of the floor timbers through the dead flat and, again, a similar process was used to dictate where the appropriate bilge curves began. In this case, the tailframes' bilge curves began at the point where the horizontal line two-thirds of a unit above the baseline intersected the diagonal line extending from the top of the centerline to the intermediate point six-eighths, or three-quarters, of a unit from either vertical edge (fig. 6-8). Similar to the primary frames

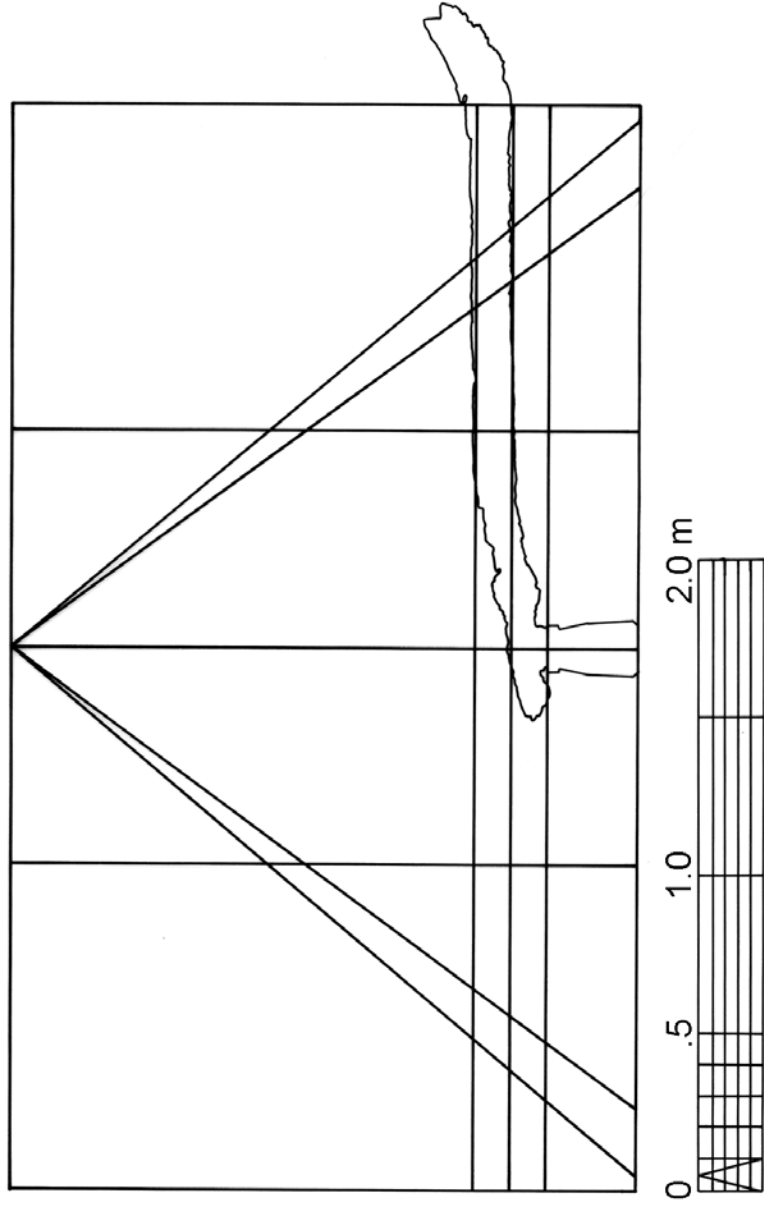


Figure 6-4: Superimposing floor timber 1 over the conceptual framework.

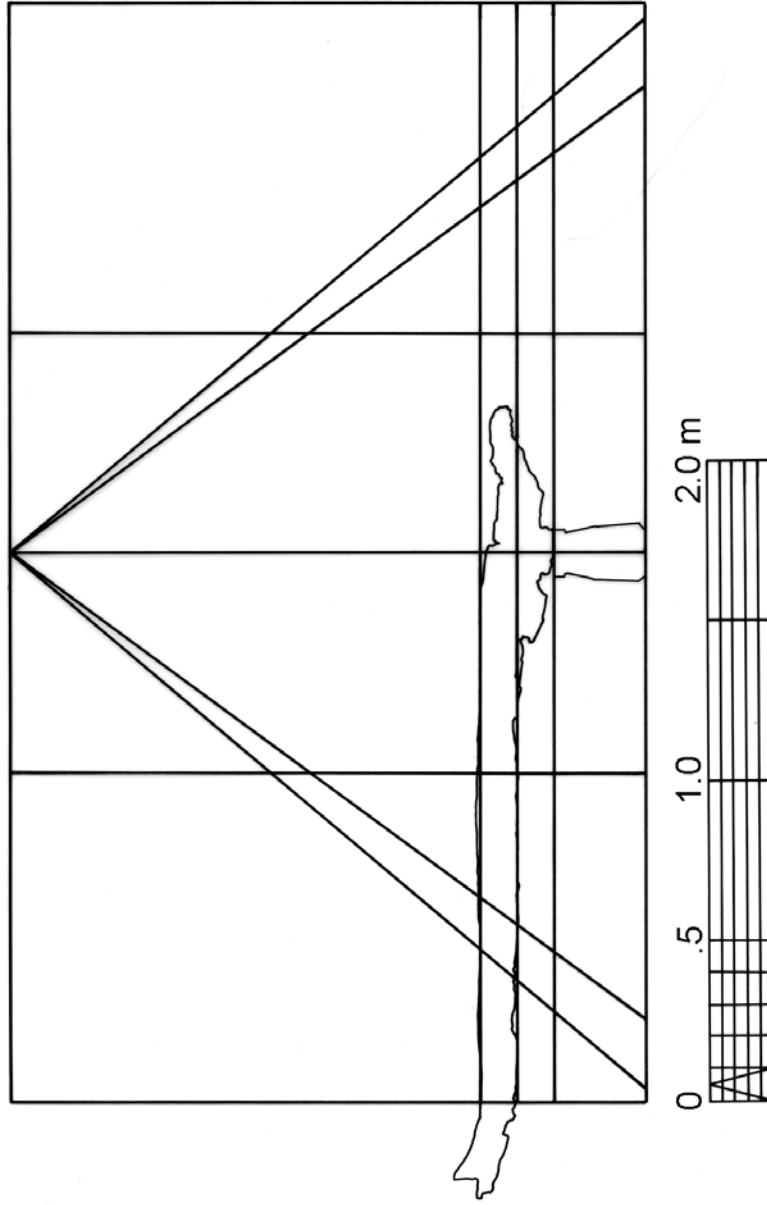


Figure 6-5: Superimposing floor timber E over the conceptual framework.

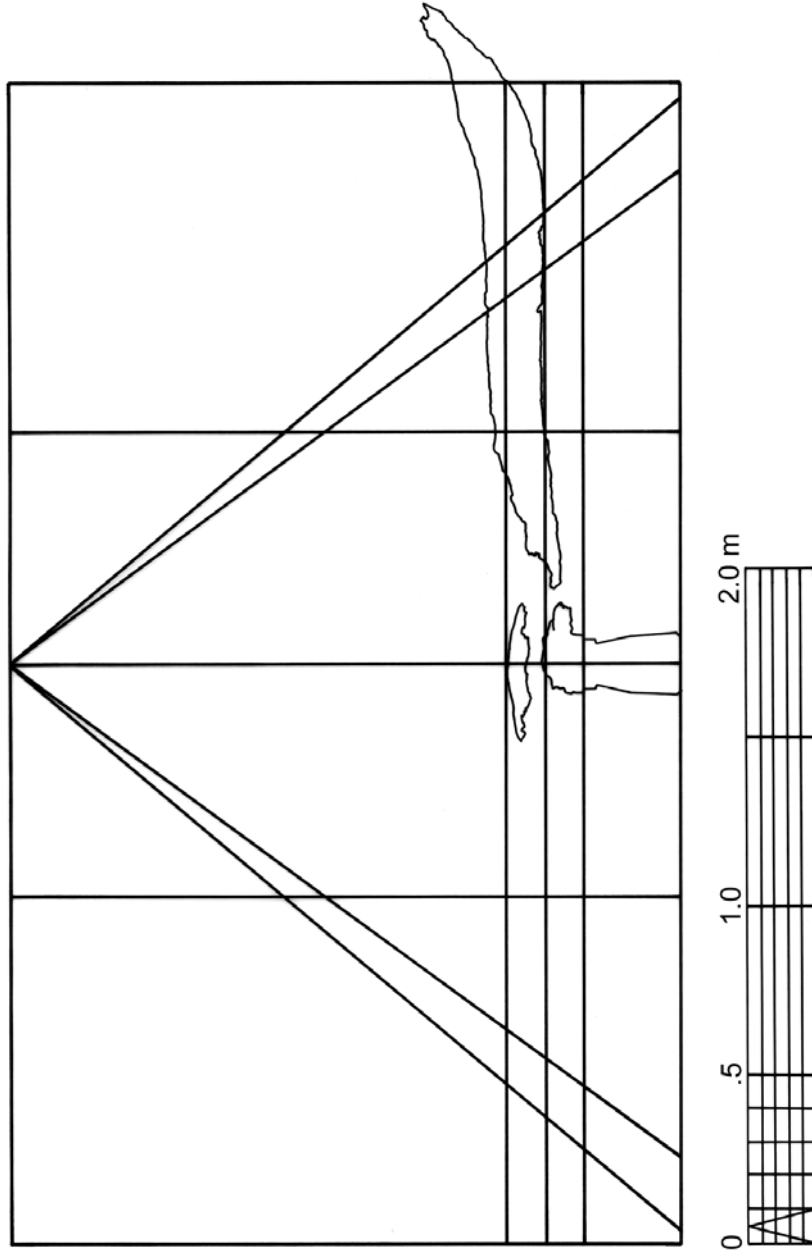


Figure 6-6: Superimposing floor timber 9 over the conceptual framework.

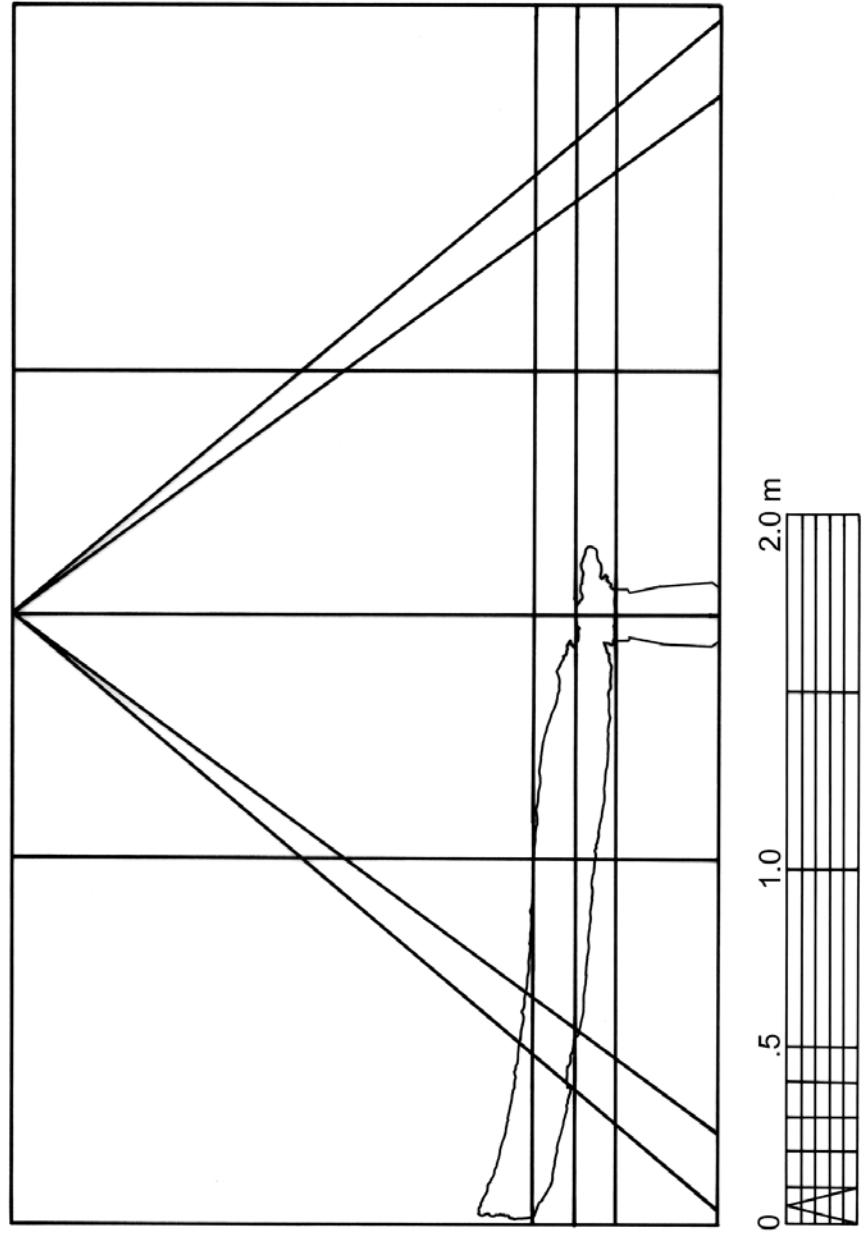


Figure 6-7: Superimposing floor timber I over the conceptual framework.

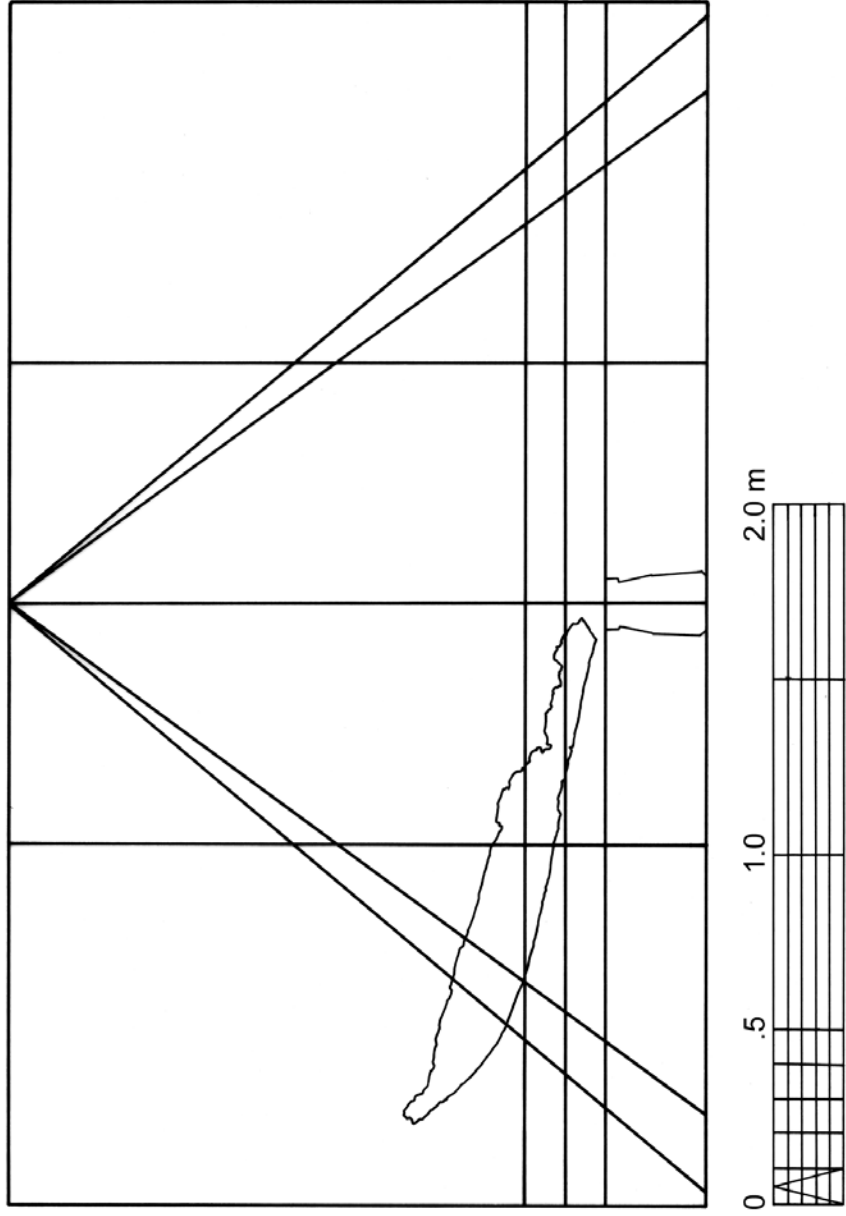


Figure 6-8: Superimposing floor timber L over the conceptual framework.

9 and I, the distance between these two points is approximately 62 percent the length of the baseline, or a distance possibly representing two-thirds the length of the 10 foot baseline.

The locations of the tailframes on the keel were based on multiples of the center flat of the vessel, similar to floor timber E. The forward tailframe L was 1.25 times the center flat forward of midships while the aft tailframe 16 was 1.5 times the center flat aft of floor timber 1.

It should be pointed out that the preceding discussion, while illuminating the details of this conceptual framework and associated instructions, may have created a false impression of the order of construction. Essentially, the only event that must precede all others is the attachment of the midships floor timber to the keel. Only then could the locations of the primary floor timbers and tailframes have been determined, but that does not mean that they had to be fixed to the keel one at a time. Once the midships floor timber was set in place, it would be a simple matter for the shipwright to design the primary floor timbers and tailframes, lay out their appropriate locations on the keel, and have a small gang of workers follow instructions.

Standard Lengths

The Bozburun vessel's shipwright appears to have used a conceptual framework and a set of instructions to organize the layout and thus, its shape. When, where and how this pattern developed is unfortunately unclear. But there is an additional problem as well. Although it is apparent that a straightforward series of proportions was used to construct this vessel and to determine the locations of the key framing elements of the hull, what distinguishes this system from coincidence? There is no official Byzantine-era standard length of 34.5 cm, so what does this length represent, and what are its origins?

The Byzantine foot, descended from Roman and Greek linear measurements, existed within a larger system of mensuration. The Roman foot could be multiplied by two or four to demarcate a pace (*gradus*) or double-pace (*passus*), respectively, or even by 120 to equal a furrow (*actus*).¹ Comparatively, it may be divided by four to equal one hand (*palmus*), or by 16 to make its smallest division, the finger (*digitus*).² The Byzantine foot retained these multiples and divisions as well and its smallest division was one-sixteenth of its length, or 1.95 cm. The Roman finger, however, was 1.84 cm long. A difference between these two

lengths is noticeable, but the difference is evident only because 21st-century measurements have much smaller divisions (i.e., the millimeter), and the difference also is comparatively minor. All in all, the difference between the Roman and Byzantine finger is approximately 0.1 cm, or six percent. The expansion and contraction of the official feet of the Greek, Roman and Byzantine empires, for example, may not be due to changes in the length of 16 of these fingers, but only due to changes in the measured length of one finger, multiplied 16 times. In other words, to shift from the Greek to the Roman foot, each of the 16 fingers demarcating the official length need only shrink less than one millimeter in length. Comparatively, the length of one finger only needs to expand .11 cm to make a Roman foot equal a Byzantine one.

But it is unlikely that in a shipyard, the shipwright or laborers would have a rule or ell calibrated to an official standardized length. Instead, they would estimate a length of two fingers by simply measuring two of their own fingers. Likewise, the shipwright may have estimated his Byzantine “foot” by measuring a distance equal to four of his own palms. If the shipwright’s palm was slightly larger than the official length of a Byzantine palmus (7.8 cm), then a longer foot in the shipyard would be the result.³

What is initially significant, then, is that this measurement is evident in the Bozburun hull’s structure. The distance from the scribe mark on the bow face of the midships floor timber to the beginning of the turn of the starboard bilge is 1.035 m, or three of these Bozburun feet. Similarly, the distance from that scribe mark to the center of the vessel is 69 cm, or two Bozburun feet. The midships floor timber, and thus all seven oak floor timbers, rise one-third of a Bozburun foot above the keel, while the keel itself is 21.5 of these feet long. It is equally significant that the length of the Bozburun foot remains constant as well. Many people, it seems, may have assembled this vessel but only one designed it.

Design Parallels

The shipwright’s unit of measure represents a fundamental component necessary to a larger system of design. The presence of the former implies the presence of the latter, but it does not, unfortunately, guarantee it. Essentially, there is no means of stating unequivocally that this conceptual framework was employed in the design and assembly of

the Bozburun vessel. There are a number of design and assembly characteristics, however, that support this theory.

The apparent instructions for the design and construction of this merchant ship should be summarized. The shipwright used a standard unit length of ca. 34.5 cm as a basis for the conceptual framework in which the ship was designed. This conceptual framework, which is merely an intersecting collection of straight lines, dictated both the shapes and locations of eight key framing timbers in the Bozburun hull. Just as it defined the length of the center flat of the ship as ten times the standard unit, it also established a keel length that is 2.15 times the center flat, or twice the center flat plus 1.5 feet. Following the attachment of the midships floor timber to a point halfway along the keel's length, the locations of the primary floor timbers were demarcated. Floor timber 1 is one unit aft of midships, floor timber E is half the center flat length forward, while 9 and I are 1.5 times the length of their diagonal forward and aft of midships. Lastly, the forward tailframe is 1.25 times the center flat of the ship, or 12.5 feet, forward of midships, while the aft tailframe is 1.5 times the center flat, or 15 feet, aft of the aft primary floor timber (figs. 6-9, 6-10).

Conceivably, this pattern of multiples could be coincidence. The pattern they follow, however, does not distinguish a random collection of floor timbers and framing along this ship. Instead, they highlight framing essential not only to the shape of this vessel, but its assembly as well. None of the planking, for example, could have been affixed in place until the midships floor timber, 16, 9, 1, E, I and L were in place. Moreover, the distances and proportions prescribed in these instructions are not difficult to determine or to remember. No complex calculations are involved and they only require using the original standard length of 34.5 cm and multiplying the center flat length, which is conveniently ten units, by 0.1, 0.5, 1.25, 1.5, or 2.15. If the set length of 34.5 cm and a particular series of multiples is permanently scribed on an ell or some other device, then the rest of the ship may be reproduced with a drawing and a piece of string at least 3.5 m long. In fact, this may be the most telling evidence that this ship was built based on a set of instructions and not just by a coincidental series of measurements. As brief as it may be either to write or verbally explain these instructions, it is even more straightforward to see them in drawings. Simply enough, these guidelines may be easily practiced as they require no specialized tools

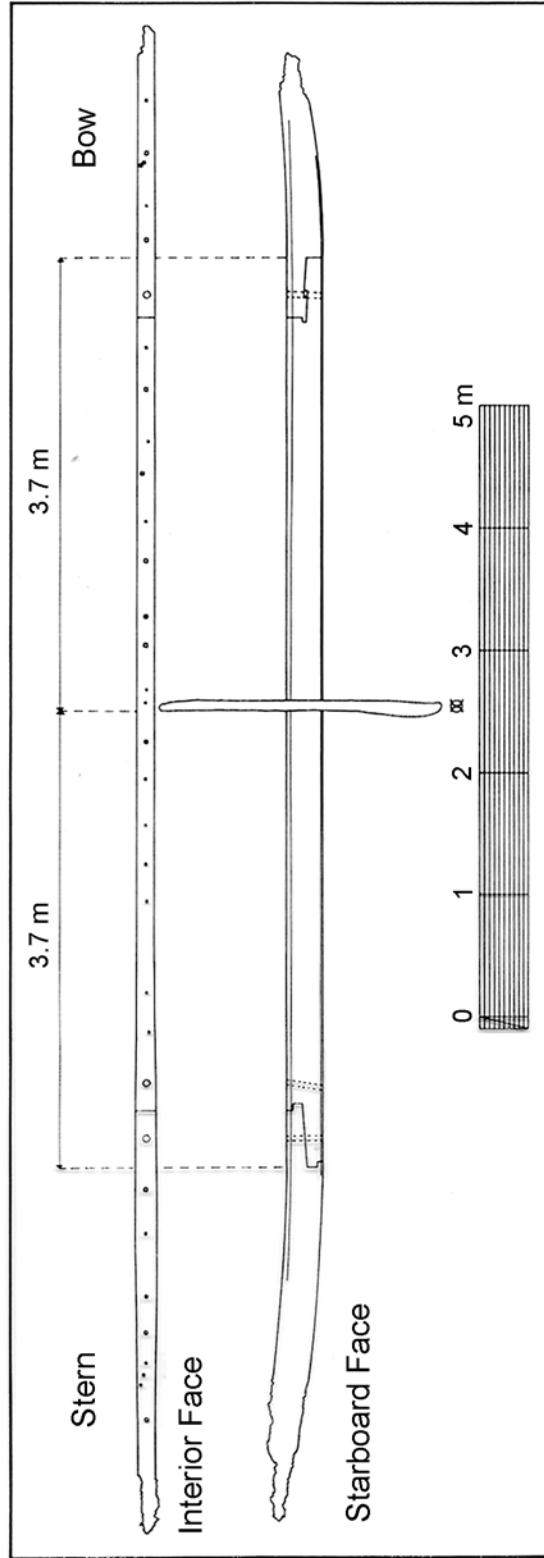


Figure 6-9: Drawing illustrating the alignment of the midships floor timber halfway along the length of the keel.

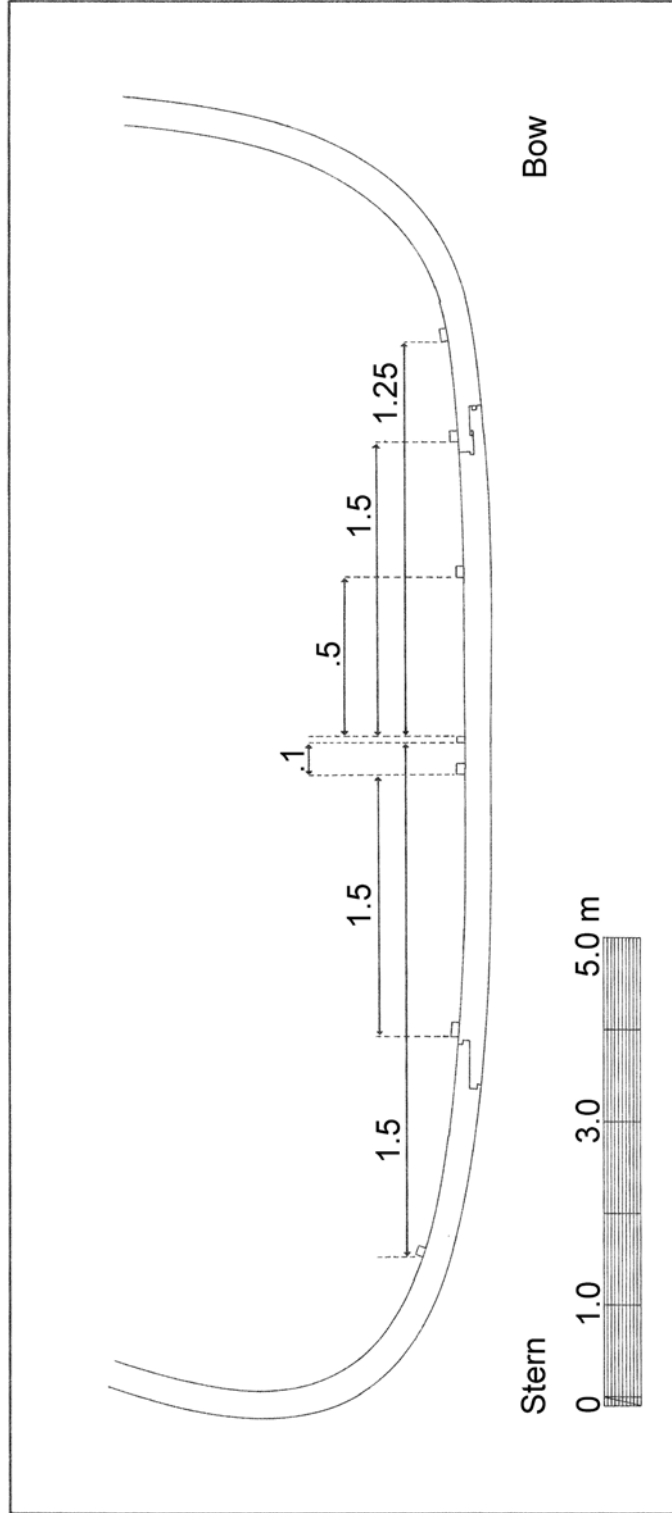


Figure 6-10: Locations of key framing timbers in the Bozburun vessel, and their proportional relationship to the vessel's center flat.

or skills, and they may be easily transmitted and reproduced. All that is required is a standard unit of length, the center flat of the vessel defined via the midships floor timber, and the correct proportions.

In the end, perhaps the best evidence that the design and layout of the Bozburun vessel was based on a set of instructions, and a successful set at that, is if these guidelines had been applied elsewhere. Numerous design parallels between the seven oak floor timbers on the Bozburun vessel and the framing on the Serçe Limanı ship have already been highlighted, and it seems that the application of these guidelines is another parallel. With slight developments, the instructions used to distribute the floor timbers and the tailframes throughout the Bozburun vessel may also be applied to the distribution of the floor timbers and tailframes on the Serçe Limanı vessel.

To begin with, there is the similar tripartite division of the midships floor timber in the Serçe Limanı vessel. A short center section, located over the keel and without deadrise, is bracketed by two arms extending to either bilge. In the Bozburun vessel, this center section was four units wide while either arm extended an additional three units to either bilge. In total, this center flat was ten units wide. In the Serçe Limanı craft, the center section was one unit – or 32 cm – wide, while the arms on either side were 4.5 units long.⁴ Although the proportions are different, the total length of the center flat on the Serçe Limanı ship was ten units as well. Additionally, its midships floor timber, just like that in the Bozburun ship, is located at a point that is halfway along the length of the keel.⁵ Moreover, the evidence indicates that this floor timber was the first affixed in place.⁶

Next, there are the locations of the primary floor timbers. On the Bozburun vessel, these primary floor timbers, represented by floor timbers 9, 1, E, and I, were affixed to the keel at specific distances that are multiples of the vessel's center flat. On the ship from Serçe Limanı, these primary floor timbers are represented by the full frames 4, A and E.⁷ Frame A, similar to floor timber 1 on the Bozburun vessel, is identical to the midships frame on the Serçe Limanı vessel and it is also located one standard unit from the midships frame. In this case, however, the unit is 32 cm and not 34.5 cm, and frame A is forward of the midships frame while floor timber 1 was aft of it.⁸

The primary frame E in the Serçe Limanı hull is affixed to the keel one-half the center flat length forward of the midships frame.⁹ This is not only the same multiple of the center flat used to determine the location of floor timber E in the Bozburun hull, but it is also oriented in the same manner – forward of the midships floor timber. Unlike floor timber E in the Bozburun hull, however, the bilge curve in frame E of the Serçe Limanı ship begins at a point that is 2 cm closer to the keel and higher than the midships frame.¹⁰ The location of primary frame 4, which has no parallel in the Bozburun ship, was determined in the same manner. In this case, it is one-half the center flat length aft of frame A.¹¹ As this frame too was both 2 cm higher and closer to the keel than the midships frame, frames 4 and E essentially define both the parallel midbody of the Serçe Limanı ship and how the hull narrows towards either post.¹²

Again, similar to those in the Bozburun ship, the locations of the two tailframes on the Serçe Limanı vessel were determined by particular multiples of the center flat length between the bilges at midships. On the Bozburun vessel, the forward tailframe was 1.25 times this length forward of the midships floor timber, while the aft tailframe was 1.5 times this length from the aft primary floor timber. On the Serçe Limanı vessel the center flat length is used, as are the same multiples, but the application of the multiples is reversed. The forward tailframe P, for example, is approximately 1.5 times the center flat length forward of frame A, while the aft tailframe 12 is approximately 12.5 times the center flat length aft of midships (fig. 6-11).

Thus, a similar set of instructions seems to have been used in the construction of the Serçe Limanı vessel. The midships floor timber, again with a tripartite division based on multiples of a standard unit of length, is at the center point of the keel's length and it was in place first. Secondly, the Serçe Limanı hull has primary frames that demarcate both the extent of the dead flat and how the hull begins to narrow to either post. The locations of these primary frames on the keel, moreover, were determined with a multiple that is one-half the center flat length – the same formula used in the Bozburun craft. Lastly, the locations of the tailframes on the Serçe Limanı vessel were also governed by particular multiples of the center flat length at midships. The differences lie in applying slightly different approximations of the Byzantine foot, the location of the primary frames, and the

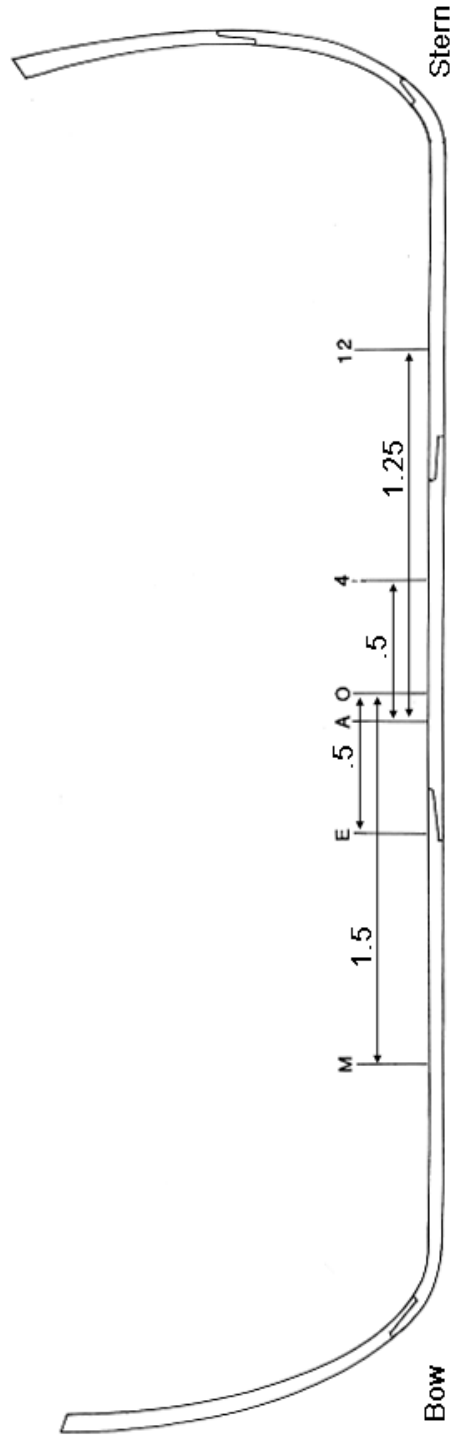


Figure 6-11: Locations of the key framing timbers in the Serçe Limanı vessel, and their proportional relationship to the vessel's center flat (After Steffy 1994, 88).

reversal of the multiples governing the locations of the tailframes; overall, the two systems are still fairly similar. Why frame A was placed forward of midships, instead of aft, is unknown. The possibility that the identities of the two floor timbers were reversed – that midships is indeed the aft primary floor timber and vice versa – was explored and determined to be unfounded. Such a reversal results in lengths that do not follow the prescribed pattern.

The presence of this system in the vessel from Bozburun indicates that at the end of the 9th century, a shipbuilder was using a standard length and a conceptual framework to predetermine the design, volume and layout of his vessels. The presence of a similar system in the 11th-century vessel from Serçe Limanı indicates more. On the one hand, the continued use of the system indicates its utility, adaptability, ease in transmission and success; with only minor changes, the same essential system was in use more than a century later. On the other hand, the system's presence in the 11th century also indicates its spread from at least one shipyard to others over time. Such a spread further indicates the utility and repeatability of the system, but also leads one to question where this system may have spread following the 11th century.

Where Did This System Go?

Following the system's dissemination is a matter of identifying its essential components and finding similar combinations of those components, but also accounting for change and development over time. Two of the three components of the system, the tripartite division of the midships floor timber and a series of proportions to apply to the center flat length at midships, have at their core the third component: a standard denominative length. Finding later examples of this system, then, are dependent on the identification of these three components in arrangements similar to, or presumably more elaborate than, the system found in the vessels from Bozburun and Serçe Limanı.

Unfortunately there is little comparative data to examine for a long period after the early 11th century. A number of early-medieval or medieval vessels have been excavated and researched, or are currently undergoing that process, but the available data regarding their construction is either preliminary or too general to use in a viable comparison. The 13 late-Roman to early-medieval vessels found in the Sea of Marmara, for example, will certainly

comprise an extremely valuable collection of comparative material.¹³ Due to the preliminary stages of their research and the possible length of time needed to complete the excavations, however, it is unclear when it will be evident if the system's features are present in these vessels. The first Contarina vessel, from approximately 1300, was very well preserved upon discovery in 1898, but it has been subsequently lost in a fire; all study of this vessel now relies on a model and a publication from 1900.¹⁴ Despite these drawbacks, research has revealed that the keel length, vessel breadth, and height of the second wale over the bottom planking were all based on proportions of the Venetian foot.¹⁵ Moreover, the location of the second wale, three Venetian feet above the planking, reflects the use of a reference height alluded to in later Venetian treatises called the *trepie*.¹⁶ The Logonovo boat from the early 15th century is still extant in the Museo Archeologico Nazionale in Ferrara, but its original design has been altered by the restorative activities of a shipbuilder.¹⁷ The 16th century, known as the Age of Exploration, has provided a much larger number of wreck sites that may be examined, but their remains are also in varying states of preservation and study.¹⁸ In other words, archaeological material dating to the period between the 11th and the 16th century or so is present, but the associated research is not only in varying states of completion, it has also commonly begun without the knowledge of this system. The most accurate source for comparative data may be the archaeological record but, unfortunately, it is not the most consistent or prolific source. Instead, particularly in the late 15th and early 16th centuries, a different and well-researched source of information on ship construction is available: documentary evidence.

The earliest examples of such evidence, related to the activities of the 12th-century monastery of Saint John in Patmos, record the length of the monastery's vessels in cubits, a measure equal to approximately 1.5 Byzantine feet.¹⁹ While the length of a vessel may be easily converted to contemporary measurements, determining the volume of these vessels in Byzantine *modii* – a process that requires estimating the breadth and depth of the vessels' hold – results in only very approximate dimensions.²⁰ Slightly later documents require less extrapolation and guesswork. Research into a 13th-century notarial document from Brindisi has resulted in line drawings of a vessel from that era, while the early 14th-century Venetian document, *Zibaldone da Canal*, contains seven illustrations of lateen-rigged merchant

vessels.²¹ The early 14th-century manuscript of Michael of Rhodes, which has been in private hands until recently, contains discussion relating to ship construction and design as well.²² By the middle of the 15th century, a new series of documents appeared that inventoried existing ships, and discussed the design and construction of new ships as well. The mid-15th-century *Trombetta* treatise by Zorzi da Modon, along with the *Fabrica di galere* written about 40 years earlier, the *Ragioni antique* of ca. 1480, and the *Istruzione sul mododi fabbricare galere* of Pré Teodoro di Nicolo are some of the earliest records of the design process.²³ In them, methods to determine the curves of the stem, sternpost and midships frame are outlined through the use of either offsets or arcs, in addition to the system of *partizioni* that calculates the diminishing molded shapes of framing along the length of the ship.²⁴ What is particularly significant in some of these treatises is the presence of a standard unit of length, multiples of the vessel's center flat length that delineate the design and layout of the vessel, and the tripartite division of the floor timber at midships.

At the core of all the Italian treatises is the use of the Italian foot as a standard unit of length. This length, the *pie*, may be divided into quarters, thirds or its smallest unit, the *once* or inch. In the *Trombetta* manuscript, one *paso* (pace) equaled five *pie* (feet) or seven *palmi* (palms), while the abbreviations *g* or *q* and *z* or *s* equaled one-quarter and one-third of the Italian foot, respectively.²⁵ The presence of this standard unit and its multiples and divisions in the Renaissance-era treatises indicates that these designers too sought efficiency, repeatability and predictability when designing their ships. Indeed, these denominations are implicit to the purposes behind the treatises themselves, and it may be argued that the builders of the Bozburun and Serçe Limanı vessels sought similar goals. Moreover, not only are the divisions of the Renaissance Italian foot the same as those of the Greek, Roman or Byzantine foot – indeed the Italian *uncia* and the Roman *digitus* are both one-sixteenth of their respective feet – but the length of the standard unit used on the vessel from Bozburun is nearly identical to the Renaissance Italian foot of 34.7 to 34.9 cm.²⁶ As craftsmen during these periods apparently did not use units smaller than one-sixteenth of a foot, for all intents and purposes these two measurements are identical.

This standard unit of length is the basis for the prescribed lengths or proportions to determine the designs and layouts of these Renaissance-era vessels. In some cases, such as

the *Trombetta* manuscript, the distances between timbers are specified: the forward tailframe should be seven paces and 1.5 feet forward of midships, the height of the transom is 8.5 feet and the keel should rise 0.33 feet where it is scarfed to the sternpost.²⁷ A series of proportions may be derived from these rules, but in the case of the *Fabrica di galere* the proportions themselves are specified. The length of the keel is 2.45 times the beam, the height of the second deck is half the beam, while the depth of the hold is 0.28 times the beam.²⁸ In essence, the presence of these proportional rules in the Renaissance-era treatises demonstrates another figurative parallel between these later vessels and the vessels from Bozburun and Serçe Limanı; all the essential rules are present to aid the process of designing the ship. There are explicit similarities as well: the proportions used to determine the keel lengths and the locations of the primary framing and the tailframes on the Bozburun and Serçe Limanı vessels are based on the width of the vessel between the bilges at midships. In both cases, multiples of the center flat length are applied to the design of the vessel to determine the locations or dimensions of key elements in the vessel's structure. In Italian treatises, multiples of the beam are applied to the vessel's design in the same manner; witness the proportions in the *Fabrica di galere*. Indeed, the design of the vessel at midships plays such an integral role in the overall design of these Renaissance-era vessels that commonly, detailed drawings and descriptions are included in these treatises that pertain solely to designing the midships floor timber or frame. Such images indicate the care and precise manner required to design the framing at midships – this structure, after all, is the structure upon which the design of the vessel rests – but they also illustrate a tripartite division evident in the midships floor timber in the Bozburun vessel as well.

In the Bozburun vessel, this tripartite division is evident as a 1.38 m-long symmetrical section that encompasses the floor over the keel, the limber holes, and the hollows for the garboards, bracketed by 1.035-m long arms that reach to the beginning of the turn of either bilge. Since the arms of the floor timber extending from the hollows to the bilges are horizontal, any deadrise apparent in this design is encompassed in the center section as well. In the Serçe Limanı vessel, a corresponding center section is evident immediately over the keel. In this case, however, it is only 32 cm wide, and the limber holes are located immediately outboard of the center section. The deadrise, in this case, is

encompassed in the arms extending from the center section to the bilges. It is this redistribution of function that allowed this center section to gain additional significance with the increasing complexity of later vessels' designs. Essentially, with the additional size of the vessels diagrammed in the Italian treatises, processes such as the *mezzaluna* were valued by the shipwrights as a means of predicting the narrowing and rising molded shapes of the framing. But these processes also required space within the design of the framing to accommodate the narrowing or rising predicted. As the design of the frames progressed from the midships floor timber towards the extremities, such accommodations had to be included within the design of the midships floor timber as no other floor timber was either wider or lower. Thus, while the rising of the floor timbers was contained in the arms on either side of the center section, the narrowing was contained in the center section itself. The tripartite division of the midships floor timber was a distinct segregation based on function: the rising of the floor timber was confined to the arms extending to the bilges, while the narrowing was manifested by the diminution in width of the center section over the keel.

The transmission of the systems evident in the Bozburun and Serçe Limanı vessels was not absolute. The essential components, the standard unit of length, the multiples of the center flat and the tripartite division of the midships floor timber are apparent in both the middle Byzantine and Renaissance-era methods. Indeed, the continued use of tailframes from this era forward is a distinct parallel. Due to changes in scale, however, developments in the methods were inevitable. In the *Trombetta* manuscript's description of a galley's design, for example, is the only one that indicates that the placement of the midships floor timber, as well as the distribution of what may be primary framing, was similar to the placement and distribution of the corresponding framing on the Bozburun vessel. The manuscript indicates the use of four frames amidships, one located in the middle of the galley, two forward and one aft.²⁹ Presumably, since these four frames are distinguished from the remaining framing forward and aft of them, and since they are located near the middle of the vessel, they may be very similar, if not identical, in shape. Such placements and similarities are paralleled in the midships and primary floor timbers in the Bozburun and Serçe Limanı vessels. Their midships floor timbers are located at the

middle of their keels and the primary framing, located near the middle of the vessel, is also very similar in shape to their midships floor timbers. No other treatise, however, seems to indicate a similar means of distributing of the framing material.

Moreover, there is a subtle difference between the proportional systems evident in the Renaissance-era treatises and the systems in the Byzantine-era vessels. Among the latter, the distance between the bilges approximates the actual beam of these ships at the waterline. This is so both because these two Byzantine-era vessels are smaller and have rather hard turns at their bilges. Thus, while this span between the bilges along the midships floor timber does not correspond to the actual beam of the ship at the waterline, it is, nonetheless, a rather close representation. In the Renaissance-era vessels this length, called the floor, is similarly present, but it in no way represents the true beam of the ship at the waterline. The *Fabrica di galere*, for example, specifies that the floor of a square-rigged vessel should be 9.75 feet wide, but the beam should be 26.5 feet wide.³⁰ This is due to the increased scale of the vessel and a use that inhibits a design with a similarly hard bilge. Both systems use a transverse measurement integral to the framing at midships, but due to changes in design and scale, the location of that measurement has shifted.

Where Did This System Come From?

Determining that these methods and components apparently spread from the eastern Mediterranean westwards in the Renaissance era, however, only addresses half of a larger question. It may be possible that a system spread via Greek master-builders employed in the Italian shipyards, but where did it originate?³¹

Finding an answer, or even a partial answer, is perceptibly more difficult than following the dissemination of this system for two reasons. The first reason lies in the archaeological record. There may be a large number of underwater sites that date between the 4th and the 11th century but only a very small number have been the subject of extensive research and publication. The comparative data prior to the 11th century may be larger than that available afterwards, but there is still a similarly small amount of material overall. Moreover, the paucity of material available for study after the 11th century is somewhat offset by the presence of Renaissance-era treatises which not only illuminate basic methods

of construction, but the design process as well. Prior to the 11th century, there are no treatises on ship design to offset the scarcity of archaeological material.

The second reason that this is a measurably harder task is because the system evident in the Bozburun vessel is most likely an amalgam of structures and methods that had their origins elsewhere. It has been suggested, for example, that the asymmetrical floor timbers in the Bozburun and Serçe Limanı vessels are descendants of earlier examples found in Roman-era lake and riverine craft from Europe.³² Such craft are characterized by flat or nearly-flat bottoms, very hard turns at their bilges or chines, nearly-vertical sides and a series of L-shaped asymmetrical floor timbers affixed in an alternating fashion along the length of the craft. As similar asymmetrical floor timbers are absent in typical Mediterranean ship construction, the knowledge and practice of this construction technique presumably followed the Danube river valley through eastern Europe to the Black Sea, where it was adapted for open-water vessels. Although such an adaptation could have occurred, only the shape, and not the methodology, was maintained. The floor timbers in the earlier flat-bottomed vessels of central and western Europe, unlike the floor timbers in the Bozburun and Serçe Limanı vessels, did not act as the components that initially defined the shape of the vessel. Almost universally, such asymmetrical floor timbers acted only as a means of imparting support to the bottom or sides of the vessels; similar to Mediterranean vessels, the exterior planking still defined the transverse and longitudinal curves of the ship while the framing merely reflected that shape. In contrast, the floor timbers in the Bozburun and Serçe Limanı vessels were the primary components that defined the shape of the hull.

It may be similarly argued that, due to the apparent presence of standard measures in these flat-bottomed vessels, the rules regarding the conceptual framework in the Bozburun and Serçe Limanı ships developed from these craft. De Weerd has asserted that the lengths of the planks in the flat-bottomed, 2nd-century AD Zwammerdam barges found in the Netherlands, and the spacing of their asymmetrical floor timbers, is based on the Roman *pes monetalis* of 29.54 cm.³³ He has, moreover, theorized that the initial order of these vessels' assembly is similar to the order proposed for the Bozburun vessel: the midships floor timber was affixed at a point halfway along the keel or keel plank.³⁴ His

examination of the early-Medieval Utrecht and Waterstraat street vessels, reveals similar parallels.³⁵

De Weerd's arguments, however, may only be partially applicable. His conclusions have been challenged by Arnold, who points out that de Weerd employed no standard method to find the distance between two adjacent floor timbers: apparently the forward edge, middle, or after edge of the framing could be employed to find corresponding lengths.³⁶ Arnold argues that a correct measurement is only between two corresponding faces: the distance from the aft face of one floor timber to the aft face of the next, for example. Such an argument is viable, but only if one also assumes that the floor timbers in flat-bottomed vessels played a role in designing the shape of the craft. As floor timbers in flat-bottomed craft did not play this role – i.e., their location was not critical to the vessel's design – their exact location along the length of the vessel could be more fluid. In other words, de Weerd may be correct but only to a certain extent. The *pes monetalis* may have been employed to demarcate the locations of the floor timbers but those demarcations, in turn, may have been only loosely followed as the locations of the floor timbers are not integral to the vessel's design. A larger criticism rests with the nature of the crafts' proposed complex order of assembly. Why not simply begin at one end of the craft and affix the floor timbers to the planking at regular intervals?³⁷

More pertinent, perhaps, is Arnold's demonstration of the apparently widespread use of standard lengths in Roman-era Mediterranean craft, but not Gallo-Roman craft as asserted by de Weerd. Of the ten Roman-era Mediterranean craft he examines, five have an average spacing between floor timbers of approximately 25-30 cm, close to the Roman foot of 29.54 cm. The average spacing of four other vessels was 45-50 cm, a distance similar to the Roman cubit of 44.31 cm, while the floor timbers of one vessel were spaced approximately 60 cm, or approximately two Roman feet, apart.³⁸

Similarly, Bockius' analysis of the two 1st-century AD craft from Oberstimm, Germany, illuminates an apparent use of the *pes monetalis* to dictate the frame spacing of these two river craft.³⁹ Höckmann, moreover, has identified a similar application of the *pes monetalis* in the drawings of the two Nemi vessels published by Ucelli, although the very small scale of the drawings brings up rather pertinent questions of accuracy.⁴⁰ The early 7th-

century AD Port Berteau II wreck, found along the river Charente in western France, appears to have used a distance of 60 cm between two crossbeams as the basis for the vessel's length, breadth, and depth, as well as the distance between the two mast partner beams.⁴¹ The early-Roman boat from Barland's Farm on the Severn River in England, found in 1999, may have been built around a standard measure of approximately 28 cm.⁴²

The 4th-century AD vessel from Yassiada may constitute a tenuous, but different, parallel as well. After the first five hull strakes were assembled with mortise-and-tenon joints, a pair of half-frames were affixed in place at midships.⁴³ These half frames are notable because they effectively defined the rest of the cross-sectional shape of the ship above the fifth hull strake – a methodology similar to that applied on much later vessels – and because they appear to have been affixed in place halfway along the length of the keel.⁴⁴ More importantly, they may represent the earliest example of a hull partially shaped in a transverse manner.

It appears, then, that the extant remains of approximately 20 Roman-era vessels, both from the Mediterranean and central and Western Europe, indicate that standard lengths may have been employed during the construction process. The application of these standards appears to relate only to the vessels' assembly, and not their design, but the apparent presence of a standard length indicates that if a design process was not yet in place, its appearance may have been imminent.

This design process or rule of thumb may not have originated, however, in the shipbuilding sphere. In the discussion of shipmasters' rights and obligations in the 4th- and 5th-century Theodosian Law, for example, a statute published in 399 indicates that if a shipmaster is to participate in his compulsory public service (transporting the grain dole to Rome), his ship must be built to a particular capacity.⁴⁵ Another statute, from 439, dictates that no vessel less than 2000 measures in capacity may be withdrawn from public service, an act punishable by confiscation of the vessel.⁴⁶ Similarly, a statute from 450 states that no river vessel less than 40 barrels – or *cypae* – on the Tiber may be built or repaired to carry the grain dole to Rome.⁴⁷ The Rhodian Law of Jettison, reiterated in Justinian's 6th-century *Digest*, writes of how a vessel capable of carrying 2000 amphorae may charge freight either by a flat rate or by item.⁴⁸ The Rhodian Sea Law from the 8th or 9th century indicates that

the value of a ship is based on its capacity. A new vessel is worth 50 *solidi* per 1000 *modii*, while an older vessel is worth 30 *solidi* per 1000 *modii*.⁴⁹

These statutes indicate that in the Roman and Byzantine Empires there was a process of determining the capacity of a ship's hold. In comparison, the rule of thumb employed to design the Bozburun and Serçe Limanı vessels is the reversal of that process. Rather than measuring the length, breadth and depth of an existing structure, the conceptual framework dictates those measurements, and it is around those measurements that the structure is built. It seems a simple matter of logic for a shipbuilder to deconstruct a method that measures an existing ship and then reverse the process to create a duplicate. It follows that with some experimentation the same process could predict the design of an entirely new ship. Admittedly, there is a certain circularity to this argument for the Empire's method of estimation may have developed from an even earlier rule of thumb, but the possibility of a connection or development between the two processes certainly calls for more investigation.

The evidence is sparse, but threads of this design process may have roots in the Roman Empire. Portions of the Roman system of mensuration may have been applied to the assembly of vessels found at sites from Britain southward to the Mediterranean. In comparison, multiples of a standard length of 34.5 cm were applied to the design and assembly of the Bozburun craft. Moreover, the Roman state had methods in place to determine a hold's capacity in either liquid or dry measures. The Bozburun vessel, in turn, was designed with a method that both predicted its hull shape, and which could also be used to determine the hold's capacity. Essentially, the conceptual framework and its rule of thumb may be a later iteration of the Roman method of measuring a vessel's capacity – or even a version of a Roman method of design – but this hypothesis, while tempting, is quite tenuous.

Conclusions

Clearly, a number of significant conclusions are evident. At the elemental level, there is the sequence of construction of the Bozburun vessel. Since some of the framing defined part of the shape of this ship, there is a distinct departure evident from earlier methods. Analysis of the construction of the 7th-century vessel from Yassiada, even with its

vestigial mortise-and-tenon joints, indicates that its shape was still defined to a great extent by the planking assembled prior to the framing. Such a fundamental change indicates first, that the shift from the shell-based to frame-based manner in the Mediterranean occurred prior to the 9th century and second, that this shift may have been faster than previously suspected. The continued use of the edge dowels demonstrates perhaps the last iteration of embedded edge joinery, but it no longer solely defined the manner in which this ship was assembled. The presence of the proportional rule in the Bozburun design indicates additional changes. Not only had this shift in methods taken place, but repeatability, efficiency and predictability were inherent in the new methods.

The importance of this new method is evident by its application to the construction of the Serçe Limanı vessel. The presence of any kind of proportional rule in this 11th-century vessel would indicate the applicability and utility of such a practice, but the presence of a similar practice as that applied to the design of the 9th-century Bozburun vessel validates not only its utility, but its continued use and dissemination.

The components of this proportional rule and a similar use of tail frames in Renaissance-era treatises and manuscripts demonstrate a clear continuity through a 600-year period. Such continuity has been suspected since these treatises were created by western designers who may have learned their techniques from Greek master-builders. Not until now, however, has archaeological evidence been available to support these suspicions. Moreover, with this new evidence, the antiquity and pedigree of the methods in the Renaissance-era treatises is now more firmly established. The increasing variation in the Renaissance-era practices, which have at their heart this method, further demonstrates the utility of this geometric rule as well as its adaptability; both galleys and merchant craft could be designed through variations in the practice.

More fundamentally significant, however, is that the method itself is essentially new. While this chapter has investigated what this proportional rule is, how it works and how it developed, the last chapter investigates the fundamental question of why this rule may have developed.

Endnotes

- ¹ Adam 1994, 41.
- ² Adam 1994, 41.
- ³ I am indebted to Dr. Frederick van Doorninck Jr. for pointing out this rather elegant solution to what had become a lengthy problem.
- ⁴ See Steffy in Bass et al. (2004, 167) Table 10-1, the molded breadth of the midships floor timber.
- ⁵ See Steffy in Bass et al. 2004, 155. Unfortunately, it is unclear whether the center of the floor timber or one edge of the floor timber is at this point.
- ⁶ See Steffy in Bass et al. 2004, 155.
- ⁷ See Steffy in Bass et al. 2004, 155-6.
- ⁸ See Steffy in Bass et al. 2004, 155
- ⁹ It should be noted that in Steffy's discussion of the assembly of the Serçe Limanı vessel, he notes that frame E is 4 units forward of frame A. It should be noted, however, that since frame A is 32 cm forward of the midships frame, frame E is *also* 5 units forward of midships. See Steffy in Bass et al. (2004, 155).
- ¹⁰ See Steffy in Bass et al. 2004, 156.
- ¹¹ Again, similar to frame E, frame 4 is 4 units aft of the midships frame (See Steffy in Bass et al. 2004, 155), but it is also 5 units, or half the center flat length, aft of frame A.
- ¹² Steffy refers to this structure as the deadflat instead of the parallel midbody. See Bass et al. (2004, 155).
- ¹³ Güsenin 1999a, 19.
- ¹⁴ Bonino 1978, 13; see also Steffy 1994, 91.
- ¹⁵ Bonino 1978, 13-5. The keel was 47.5 Venetian feet long and the breadth was 14.7 Venetian feet.
- ¹⁶ Bonino 1978, 15.
- ¹⁷ Steffy 1994, 93.
- ¹⁸ Steffy 1994, 128-42.
- ¹⁹ Antoniadis-Bibicou 1966, 130-1.
- ²⁰ Antoniadis-Bibicou 1966, 131.
- ²¹ Ray 1992, 3 n. 1.
- ²² See the recently launched website, <http://dibinst.mit.edu/DIBNER/Rhodes/index.html>.
- ²³ Ray 1992, 3 n. 1.
- ²⁴ Alertz 2003, 213-4.
- ²⁵ Anderson 1929, 136.
- ²⁶ Lane 1979, 245; see also Zupko (1981, 196), where he lists feet varying between 32.5 cm and 34.7 cm in 19th-century Italy; the latter lengths varied depending on both location and application.
- ²⁷ Anderson 1929, 140.
- ²⁸ Bellabarba 1988, 116; see also the Michael of Rhodes manuscript on line at <http://dibinst.mit.edu/DIBNER/Rhodes/index.html>, page 135b: Galley of Flanders, Measurements.
- ²⁹ Anderson 1929, 139.
- ³⁰ Bellabarba 1988, 113.
- ³¹ Alertz 1995, 143; also note that the roots of such Italian terms as *scherma*, *paraschuxula*, *parascena* and *panixelo* have Greek origins.
- ³² Van Doorninck Jr. 2002, 902.
- ³³ De Weerd 1987, 396-9; see also De Weerd 1990, 75.
- ³⁴ See de Weerd (1990, 75) regarding the order of construction and the number of other vessels that appear to follow this pattern.
- ³⁵ De Weerd 1987, 147-63.
- ³⁶ Arnold 1990, 273. In the cases of the Utrecht and Waterstraat street vessels, de Weerd's conclusions are based on 1:20 scale drawings of the craft, rather than measurements of the preserved material.
- ³⁷ De Weerd 1987, 147-63.
- ³⁸ Arnold 1990, 274.
- ³⁹ Bockius 2002, 42-7.
- ⁴⁰ De Weerd 1990, 75.
- ⁴¹ Rieth 2003, 117.

⁴² McGrail 2003, 127-8.

⁴³ Van Doorninck 1976, 126

⁴⁴ Van Doorninck 1976, fig. 1.

⁴⁵ Pharr 1952, 395.

⁴⁶ Pharr 1952, 495; these 2000 measures are 2000 *modii*, or measures of grain.

⁴⁷ Pharr 1952, 540.

⁴⁸ Mommsen et al. 1985 I:422.

⁴⁹ Ashburner 1976, 63. Ashburner (1976, clii-iv, 64) also argues that the capacity referred to in the Rhodian Sea Law, and the capacity by which the ship is valued, is the vessel's displacement and not the hold's capacity. His logic seems a little convoluted at times, and draws on later Italian statutes and 13th-texts, and never draws a clear distinction between capacity and displacement. As the Sea Law indicates that capacity (in either of Ashburner's definitions) was measured in *modii*, which is a dry measure of grain used in the Theodosian Code and the *Digest* of Justinian to define a hold's capacity, and as the displacement of a vessel may change (thus requiring a re-assessment of value?), it seems more logical that a ship's value is based on its capacity and not its displacement. After all, if the vessel's displacement was to be estimated once sea-borne, and without removing the vessel from the water, the interior of the ship's hold was presumably the space measured. Such a process would, in turn, result in the hold's capacity, and not the vessel's displacement.

WHY WAS THE BOZBURUN VESSEL BUILT IN THIS MANNER?

It is now evident how the Bozburun ship was built, and the methodology behind it, but what are the possible reasons *why* this ship was built in this manner? Why had this geometric or proportional method been applied to its design, unlike earlier ships? Perhaps the best way to investigate these questions is to examine again what the longitudinal and transverse assembly techniques represent. As mentioned at the beginning of this study, some shipbuilders in the Mediterranean prior to the 7th century AD essentially built their vessels from the outside inwards. That is, after the keel, stem and sternpost were assembled, some or all of the planking was next affixed in place. By fixing the planking in place prior to some or all of the framing, the exterior shape of the ship was defined first via the longitudinal planking. Consequently, the shape of the ship took precedence over the utility of the internal space generated. Using more modern methods, hinted at in the vessels from Tantura and Dor and clearly illustrated later in the Bozburun and Serçe Limani vessels, other builders from the 6th century onwards assembled some ships from the inside out. The framing, which demarcates the internal space of the ship as a series of transverse shapes, was assembled prior to affixing the planking in place; thus it is the inside of the vessel that began to take precedence over, and defined for the most part, the exterior shape of the ship. In a manner of speaking then, different shipwrights shifted their techniques at different times over the space of a century; some in Palestine apparently changed before others closer to Constantinople. But it may be said that ships built prior to this shift may be defined as vessels with shapes that were predominantly determined in a longitudinal manner. In contrast, vessels built after this shift – ships built from the inside out – are essentially defined as vessels with shapes that were predominantly defined in a transverse manner.¹ Such definitions are certainly similar to the “shell-first” and “frame-first” distinctions, but are most readily associated with the conception of active and passive framing as defined by Basch.² A ship with passive framing is one with a shape that is defined in a longitudinal manner, while active framing in a vessel indicates the ship’s design was defined in a transverse manner. Vessels such as the 4th-century BC ship from Kyrenia

or the early-Roman craft from Zwammerdam are vessels with shapes defined longitudinally. *Victory* or the Serçe Limanı vessel have shapes defined transversely.

The manner in which these vessels are defined, however, does not just relate to methods of construction, it relates to how these vessels were conceived. It is possible now, for example, to visualize how a vessel from antiquity was built, and defined as well, from the outside inwards in a longitudinal manner. It is similarly possible to visualize the opposite path, building and defining a vessel from the inside out in a transverse manner. But the process of categorizing a vessel as one or the other is just a typological construction employed to understand a much more fundamental process: how these vessels were conceived in the minds of the builders. Essentially, just as vessels in antiquity were built from the outside inwards, and their shapes were defined in a similar way, it is possible to perceive how this reflected the builders' conception of these vessels as well. Ships with shapes defined in a more modern, transverse way, however, were conceived of in the opposite manner; the builders conceived of the design of these ships from the inside out.

A shipbuilder's shift in techniques, then, embodied a shift in thought as well. It has been argued in the past that this technological shift, and this new manner of conceiving a vessel's shape, was a long process stretching from the 4th to the 11th century. The culmination of this process, as illustrated in the past by the Serçe Limanı vessel, was the development of construction methods common today. This argument assumes that as construction methods changed in a gradual fashion, the conception of these vessels must have changed gradually as well. I believe, however, that this is incorrect. Although a gradual decrease in the quality and quantity of mortise-and-tenon joints is evident in ships from the 4th to the 7th century, their use at the bow and stern and in the garboard indicates that the conceptualization of these vessels had not changed. As a change in form or design follows a perceived failure in function, some shipbuilders in the 7th century continued to conceive the design of a vessel in a longitudinal manner because there was no perceived failure in their form.³ In other words, there was no external demand for change. As the vessels from Tantura and Dor hint at, in contrast, some shipbuilders had changed the way they conceived of their vessels' designs and assembly nearly a century earlier. In these cases, the change in form may have been fueled by a perceived failure in design, and a demand for

new forms. The source or sources for these new demands is unknown, but may encompass economic, social, or technological factors. Nonetheless, the era from the 6th to the 7th centuries embodies, on the part of some builders, both a technological shift and a fundamental conceptual change.

The geometric or proportional method applied to the design of the Bozburun vessel, however, represents something more than a way to speed its assembly. Its presence represents a response to an emerging demand for vessels that are not only built in the longitudinal manner, but ones with a multipurpose, utilitarian cargo space and predictable characteristics as well.

The source of this demand or need may have been the newly arrived Muslim Empire. The Byzantine Empire, with roots in Rome and Greece, was a culture based on the individual ownership of resources, primarily land. Land in the Mediterranean basin could be demarcated, tilled, sown and cultivated for the olives, wheat, grapes, barley and other crops the climatic zones could support. Land was also needed for pasture and grazing animals such as sheep, goats, cattle and horses. Water running through the territory could be harnessed to turn mills, to irrigate crops, to wash and clean or, via an aqueduct, directed to supply a city. An individual could, with acreage in a good area, raise crops, animals, a family and a household that was entirely self-sufficient; it was essentially a Roman or Byzantine ideal. The household was sedentary and stable, it was not a drain on others' resources and, if the conditions were right, it could even supply goods for the State as well. The Roman and Byzantine cultures then, had an agricultural or terrestrial basis: land led to self-sufficiency or over-sufficiency, supply for others and, in turn, an agglomeration of monetary and political power. Emperors presented land as an incentive for military participation or a reward for military achievement and commonly, it was land and its associated riches that brought its owners to the throne. Land and farming practices enticed Cincinnatus away from further political and military glory; a fable that emphasized the actions of the ideal Greek citizen. Military conquest in the Mediterranean was, after all, an attempt to control valuable land. It was land, and the ability to cultivate its tangible and intangible resources, that brought power to the individual in the Roman and Byzantine empires.

The movement of goods from one plot of land to another, whether that land was owned by the State, the Church, or a family, and whether that movement was based on trade, supply or gifts, was an ancillary practice that occurred primarily because an ideal agrarian balance could not be achieved throughout the Roman or Byzantine state: not all land could be self-sufficient. The agents who moved these goods across the Mediterranean, the *negotiatores*, *mercatores* or *navicularii*, were precisely that, agents moving goods for the profit of landowners. Their role in Roman and Byzantine culture was one of support and their ability to accrue power, since they had no land, was hampered.⁴

Unlike the Byzantine Empire, with economic and ideological roots in the Roman Empire, the Muslim state had its economic basis in the mercantile practices of pre-Islamic Arabia. These mercantile practices were integral to pre-Islamic Arabia, and thus the Islamic state, because the culture in Arabia was lacking the very factor that the Byzantine culture could rely upon: land. In comparison to Greece and Asia Minor, the land from which Islam sprung was desolate (Fig. 7-1). Only scattered oases could provide enough water to grow crops for food or to support herds, and these oases were too disparate and far-flung to create a political system.⁵ Lacking natural resources, the people in pre-Islamic Arabia created cultural resources such as clans and tribes instead; in other words, there was no sense of self-sufficiency as an ideal, only group-sufficiency. Abandoning society and one's tribe in pre-Islamic Arabia not only meant abandoning cultural and familial support, but most likely life as well. This lack of natural resources fostered both the nomadic lifestyle of the majority of the tribes in pre-Islamic Arabia and the caravan trade as well. The nomadic lifestyle allowed the tribes to take advantage of seasonal wells, oases, and markets where goods could be traded, bought and sold, while the caravans did what the land could not: bring needed resources to the people with demands for them. The basis of a tribal chief's power was that of a provider, someone who was able to oversee a tribe's vitality by finding grazing land, defending its wells and entertaining visitors. Moreover, wisdom and generosity brought more prestige than riches and flocks.⁶ Tribal power, in turn, was commonly based on trade agreements, the spread of a tribe's economic influence and the abilities of the chief, not necessarily the control of natural resources or military conquest. The basis of the tribal power of the Quraysh, the tribe of the Prophet Muhammad, was

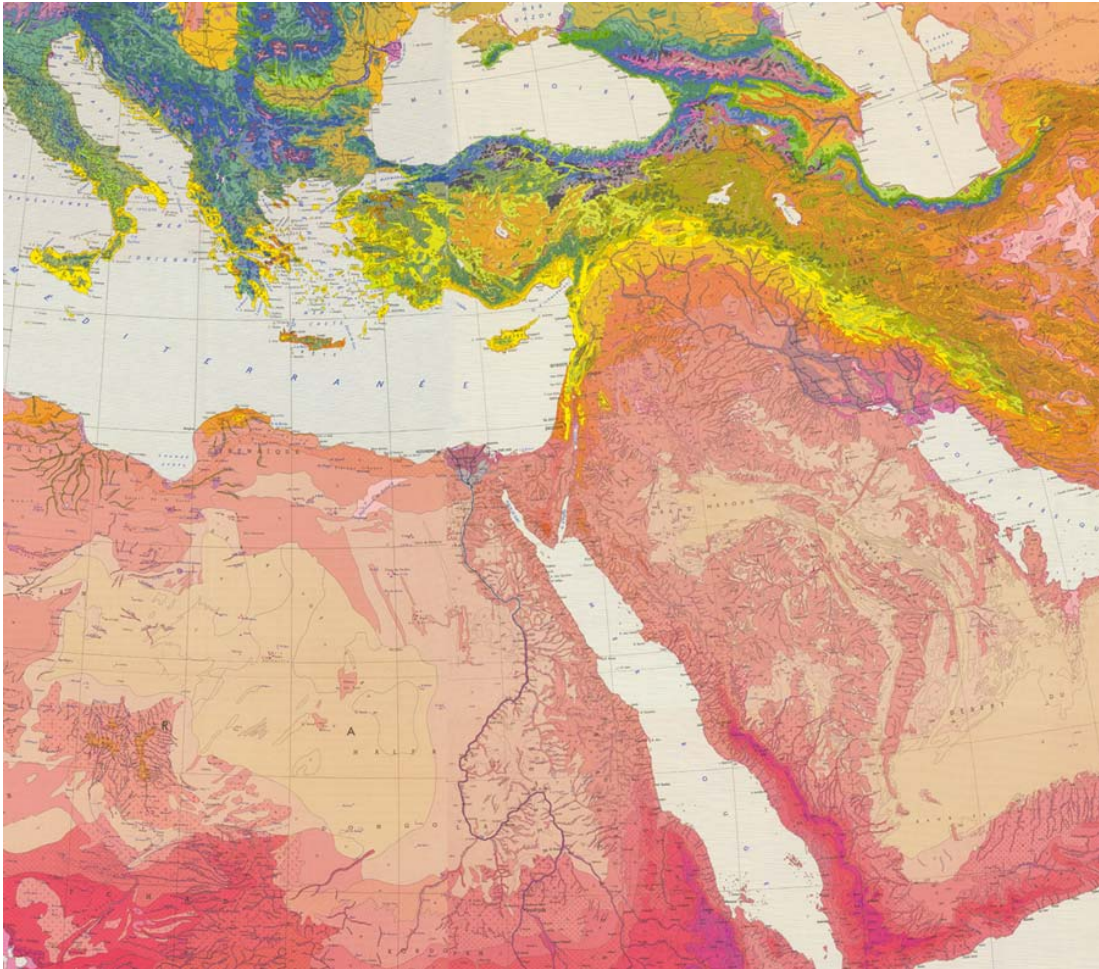


Figure 7-1: Climate map of the near east, illustrating the contrast between the arid climates of Arabia and Egypt with those of Asia Minor, Greece and Italy (After Lalande 1968).

economic since they controlled both the *haram* of Mecca, one of the largest trading centers in south-central Arabia, and the routes leading to the city. In the early Islamic state then, self-sufficiency or a reliance on privately owned land was an entirely alien concept. Private landowning and self-sufficiency carried little power or influence since, fundamentally, they were practices that would not sustain the clan or tribe and essentially placed self-sufficiency before group-sufficiency. Commerce and trade, on the other hand, displayed initiative that not only brought tangible and needed goods to the tribe, but intangible individual power, such as the ability to sustain a group. Power in the early Islamic state was vested not in land or sedentary individual practices such as agriculture, but in trade and commerce.⁷

Following the Muslim arrival on the shores of the Mediterranean, a fundamental cultural shift from one dominant culture to another may have taken place. Merchants in Mediterranean port cities such as Tunis, Alexandria, Acre, and Tyre suddenly found themselves either exposed to, or living in, a culture that did not regulate their actions, but celebrated their activities and granted greater social status. By the mid-8th century, the southern Mediterranean coast from Spain to Palestine was inhabited by a culture that saw commerce and trade as an integral part of society. Moreover, as it was likely a culture clamoring to trade for the raw materials, goods and services available in the societies inhabiting the northern coast of the Mediterranean, independent merchants and their commerce crisscrossing the sea would be a natural economic result.⁸ Whereas people and cultures in the Mediterranean once strove for land and its intangible benefits to accrue power, now the same groups sought commercial activities to accrue similar benefits. Venice, Amalfi and Naples in Italy acted as middlemen between the rival Byzantine and Muslim empires and as such, their rise as powerful city-states in the Mediterranean was predestined. It was in Italy that the traditional Muslim contract was transformed into the *commenda*, the basic legal instrument of overseas ventures, and Amalfi, by the 10th century, had the power to rebuff the threats of Pope John VIII and the Byzantine Patriarch Nicholas Mysticus.⁹ Constantinople, which was once the locus of trade in the Mediterranean, found itself shifted to the periphery. Unlike Italy which appears to have wholeheartedly adopted these economic practices, it was only the gradual percolation of these economic tendencies through the Byzantine State's strict regulations that allowed merchants and shipowners in

Byzantium to take advantage of them. The same economic habits and practices that had once sustained Constantinople's dominance in Mediterranean trade now hampered them.

Hand in hand with this cultural shift was not only a rise in the number of ships needed, but a fundamental change in the needs of shipowners as well.¹⁰ In light of the emphasis on free commerce and trade that most likely prevailed in the Mediterranean, shipowners sought vessels that were essentially aquatic trucks: inexpensive ships with a large utilitarian, multipurpose space that could carry a wide variety of goods, enter a variety of ports, be sailed by a small crew and repaired with a minimum of skill. In other words, shipowners, faced with new opportunities to accrue power via their practice, saw failure in the design and construction of older styles of vessels and demanded changes to meet their new needs. The geometric or proportional rule that shipwrights applied to the design and assembly of their ships in this era was their response to these demands, as it allowed the shipwrights to design functional ships with numerous predictable characteristics (cost, labor, capacity, and hydrodynamic capabilities) and an emphasis on their cargo space. Its appearance in the Bozburun vessel, for example, coincides with the earliest evidence for the use of tailframes, as these framing timbers play a key role in designing the ship and increasing the vessel's cargo space. Moreover, as the rule is applied to vessels built from the inside out, it is perhaps an acute example of a more fundamental emphasis on the importance of the vessel's internal space over its external shape.

Essentially, the Bozburun vessel was built with a proportional rule and edge dowels because only by using those methods could a shipbuilder meet the demands placed by potential shipowners. Those demands, in turn, were most likely fueled by the new economic atmosphere prevalent in the Mediterranean, an atmosphere that arrived via the Islamic Empire.

Endnotes

¹ Steffy (1995, 418-9) presents this very argument by comparing the vessels from Kyrenia and Serçe Limanı, but it is unclear if his view has won adherents, and if not, why not.

² Basch 1972, 16.

³ Petroski 1992, 22-33.

⁴ The merchants who defended Thessalonike with ad hoc weapons against the naval attacks of the Avars in 618, for example, were never apparently rewarded for their actions. See Abrahamse (1967, 272).

⁵ Kennedy 1986, 22.

⁶ Kennedy 1986, 19.

⁷ See Goitein (1962, 309-10) where he lists the sultan, military officials, members of the Royal household, *amirs* and *viziers* as some of the people listed in the Cairo Geniza owning merchant vessels. Muhammad was a trader prior to his apotheosis, as was the first caliph, Abu Bakr. In comparison, the Emperor Theophilus burned the merchant vessel full of goods bought by his wife, stating, “Commerce is reserved for humble people,” and “God made me an emperor, not a *naukleros*.” See Lopez (1976, 349).

⁸ McCormick 2001, 568, 791; see also Goitein (1962, 42-8, 61, 66, 70, 344) for the 11th-century free trade zone depicted in the Cairo Geniza.

⁹ Citarella 1967, 308-9; see also Udovitch 1962, 207.

¹⁰ This cultural shift and resulting commercial emphasis may have pushed shipowners to change their practices as well. McCormick (2001, 566), finding that more vessels in the 8th and 9th centuries began to sail around the clock (2001, 491-4, 497), theorizes that new opportunities for profit may have pushed the shipowners to change their habits in such a manner.

CONCLUSIONS

The excavation of the Bozburun wreck site began with a straightforward premise that had complex underpinnings. Ships from the 6th century and earlier were built around a longitudinal methodology that governed their conception, design and assembly; embedded edge joinery in their hull planking, in turn, was a distinguishing characteristic of that methodology. Ships built from the 11th century onwards were constructed around a transverse methodology, and had no embedded edge joinery in their hull planking. Between the 6th and the 11th centuries, then, shipbuilders in the Mediterranean began to abandon the use of embedded edge joinery, either as an integral part of the ship's structure or as an aid during assembly, and fundamentally shifted the manner in which they approached their work. It was, over the space of four centuries, a shift that marked the apparent abandonment of shipbuilding techniques associated with the classical and early-medieval Mediterranean, and the creation of a methodology that would eventually aid the construction of ships that could sail to China and around the world. Since the ship that sank near Bozburun did so in the 9th century, in the middle of this four-century period, its hull could begin to illuminate how this shift occurred, and perhaps why as well.

In 1998, when the excavation of the hull occupied the majority of the final season, the prevailing opinion on site was that this ship was not built with embedded edge joinery and may, as such, represent the earliest example of a ship built in a more modern transverse method. The disappearance of embedded edge joinery and the associated shift in assembly methods, therefore, occurred prior to the 9th century AD. Until 1999, that opinion was unchallenged since no kind of embedded edge joinery was detected in the Bozburun vessel. After the discovery of the first edge dowel hole that year, and more each year until 2002 when 119 extant dowels or dowel holes were identified, that premise became more and more tenuous while the nature of the ship's construction became more of a paradox.

Early in this study, an assumption was that the presence of any type of embedded edge joinery essentially negated the need to install some or any framing prior to the planking. Essentially, ships could not be built and designed in both a longitudinal and transverse manner. A paradox arose because the embedded edge dowels in the Bozburun

hull – a construction feature which implies a longitudinally designed ship – were distributed in a manner that indicates that some framing had been installed prior to the planking. The framing distribution, in turn, indicates that this ship was designed and built in a transverse way. As a result, there should not have been a need to use embedded edge joinery in the assembly of the ship but its presence in the hull was undisputable. The apparent paradox, then, revolved around the interpretation that the Bozburun vessel was built with a confluence of two methodologies that were initially interpreted to be fairly exclusive in application.

This confluence, however, occurred because shipbuilding traditions were in a state of flux. In the 1st-century BC ship from Madrague de Giens, for example, the embedded mortise-and-tenon joints in the hull planking played three roles.¹ First, as the tenons fit tightly in the mortises and are pegged in place, the mortise-and-tenon joinery played an integral role in the strength of the ship's hull. Second, the joints kept the planks in alignment during the assembly process. Third, the presence of the pegged mortise-and-tenon joints defined the ship's method of assembly; their prevalence and distribution essentially dictated that the ship could not have been assembled in any other manner. In the 7th-century ship from Yassiada, the unpegged tenons, which fit loosely in the mortises, only played two of these roles. They added little structural integrity to the hull, but still kept the planks in alignment and defined the ship's method of assembly.² It may be said that the spirit of much older practices was still evident, even if the same techniques were not. In the 9th century, the embedded edge dowels in the Bozburun vessel demonstrate a near-abandonment of the earlier techniques that inspired their use. By this time, the dowels added negligible strength to the hull, and certainly did not define the vessel's method of assembly. Their only role was to align temporarily the planks before they were affixed to the framing.

These edge dowels, however, do more than validate the prevailing theory that the primary function of edge joinery shifted from that of strengthening the vessel to assembling the vessel.³ The Bozburun ship, when added to the typological continuum of vessels from the ancient Mediterranean, clearly indicates that there was no clean break between assembly methods that did or did not employ embedded edge joinery. There was, instead, a gradual

dissolution of the edge joinery technique from the collection of techniques associated with the longitudinal construction methodology. Essentially, joinery embedded in planking edges may have been one of a variety of methods of temporarily aligning and securing planks together during the assembly process in the 9th century. Its eventual disappearance in the 11th century indicates that as old methods of assembly mixed with new, this technique was tested, applied, and shunted aside possibly by cheaper and more efficient clamps or cleats that were affixed to the internal or external faces of the planks.

The apparent paradox in the Bozburun vessel's assembly, then, is a paradox only if the application of embedded edge joinery is seen as immutable and, in turn, the longitudinal and transverse methodologies are felt to be incompatible. Instead, once it is acknowledged that embedded joinery, such as mortises and tenons or these edge dowels, are precursors to temporary external clamps in the 11th or 12th centuries a continuum, and not a break, from one assembly methodology to another is evident. The Bozburun vessel, then, was conceived, designed, and initially constructed in a transverse manner, but after the floor timbers and tailframes were in place, the planking played a role in this vessel's shape as well.

In the course of this investigation, however, the unexpected occurred. Integral to the shift from the longitudinal to the transverse methodology was an associated shift in the way shipbuilders practiced their craft. In other words, once shipbuilders began to change the way they conceived their work, their entire approach to the science of ship design and assembly changed as well. What was unexpected during the course of this research was not only how fundamental this change was, but that this intangible change would be evident through the analysis of the Bozburun hull's design and assembly.

Using a longitudinal methodology, the ship's planking creates a watertight structure – the essence of what a hull is – while incrementally building the ship's hydrodynamic shape at the same time. Building a ship with the transverse methodology means that the process is divided into two phases. The transverse framing defines the majority of the ship's internal space and its hydrodynamic shape, while the planking adds a watertight shell to that internal structure and shapes the extremities. While it is unclear precisely what processes were used to design a ship with the longitudinal methodology, it is clear that as the transverse methodology was applied, old processes of design needed to change.

The design process that emerged, and that evident in the Bozburun vessel, was one that rigidly controlled the shape of the framing since the frames were now the components that defined the emerging shape of the ship. It was also a design process that, out of necessity, was easily taught, transmitted, and repeated – thus the use of a standard linear measurement and a simple series of proportions. That this process was applied so early in the shift from a longitudinal to a transverse methodology is understandable. Attempting to pass on a new method of design and assembly without a well-defined process would seem to be a fairly haphazard procedure. It, moreover, also indicates that there may have been a pressing need both inside and outside the shipbuilding community to utilize this process.

Understanding how the Bozburun vessel was built has, in turn, clearly illuminated how the shift from one construction methodology to another occurred. Indeed, the time, money and labor discussed in the introductory section appear to have paid off, since there is now a clearer understanding of the development of ship design and assembly during this period from the 6th to the 11th century. What the assembly of the Bozburun vessel only hints at, however, is why it was built in this particular manner.

This is so because the Bozburun ship is a final product. It is a result and a manifestation of intangible needs and demands, and while it may serve as an example from which a technological trend may be inferred, it may indicate little or nothing about the surrounding forces that drove that trend. Instead, it was the historical context of the Bozburun ship that stimulated such a trend, enforced its characteristics, and led to its construction in a particular manner.

This context was, as was the confluence of the two shipbuilding methodologies, the result of commingling forces that initially appear to be incompatible. The economic and political context developed by the staid and insular Byzantine Empire and prevalent in the Mediterranean since the 5th century, was being fundamentally altered by the expansion of the Muslim empire along its shores. In the Byzantine context, shipping and trade were tools used by wealthy individuals and the church to sustain either themselves or the empire. They were not, however, a respected or viable means of acquiring wealth itself. In the Muslim empire, trade, shipping, barter and the acquisition of wealth by the middle class was not only respected and encouraged, it was at times necessary. It was, moreover, a context

slowly spreading from the Muslim shores throughout the Mediterranean, fostering shipowners' independence, and encouraging the pursuit of wealth and power through trade. Emperors and caliphs battled yearly on religious and military grounds, yet they adopted each other's architectural styles and loaned craftsmen across their borders.⁴ The 7th-century Armenian historian Sebeos compared the invading Muslims to the fourth beast of Daniel's prophecies yet in the 8th century, Byzantine churches and religious officials remained unscathed in Muslim territory.⁵ Likewise, despite the presence of increased tariffs and restrictions on both sides, merchants from each empire were able to travel to and trade in the opposing empire.⁶ There was, in other words, an ideological opposition on both sides that was being undermined by the practical realities of everyday life.

The Bozburun vessel, then, represents the awkward, and brief, combination of not only two construction methodologies but of two economic systems as well. The following centuries saw the abandonment of embedded edge joinery such as mortises-and-tenon joints or edge dowels and the prevalent use of temporary clamps instead. The design process evident in the Bozburun hull was altered slightly to design the 11th-century craft from Serçe Limanı, and was further modified and adapted to build larger and more complex ships in the 15th and 16th-century Italian arsenal. The Muslim trade contract became the Italian *commenda*, while the wealthy merchant princes of Venice, Amalfi and Naples along the edges of the Byzantine empire arose from the spread of a Muslim context that rewarded economic power as much as it respected military ability.

In the end, the Bozburun vessel reflects changes in the people that built it as well. In the 9th century, the master shipwright most likely had many roles in the shipyard. In addition to overseeing the vessel's assembly and taking part in its construction, this person most likely hired and paid the woodsmen, sawyers, laborers, woodworkers, riggers and sailmakers, brokered prices with the ship owners, and designed the vessels as well. The shipwright may have some prominence based on his abilities, but it was neither recorded nor rewarded by the Empire. The application of a predictive design process, however, had long-term effects, particularly once these methods were recorded, modified, and applied to larger vessels in the 15th-century Italian arsenal. Those who applied these processes, for example, emerged as ship designers or naval architects who became distinct personages

both in the arsenal and in Italian life. While other crafts such as rigging, caulking, woodworking, rope making and sail making remained practical endeavors closeted in craft guilds, Greek shipwrights such as Theodoro Bassanus and Nicolo Palopano ascended in society, creating a class and bureaucratic hierarchy previously absent in the shipbuilding sphere.⁷ Their capabilities as a designer, and not the craftsmen's skills, were rewarded, and their vessels, once built, were often kept in storage to act as models for other designers.⁸ Rather than participating in a ship's construction, as their predecessors may have done, they skirted the social line between expert craftsmen and intellectuals, sending their sons to school to learn Latin and mathematics. Meanwhile, the humanist Vettor Fausto further blurred the distinction between the art and practice of ship design by dabbling in it while lecturing on Greek and translating Aristotle's *Mechanica*.⁹

Conceptually, the 9th-century craft from Bozburun was on the cusp of the later methods that would characterize Renaissance-era ship design. It was built with a last vestige of an assembly technique that characterized ancient and classical ship construction, yet also embodied a predictive design process that became the hallmark of vessels built in the Italian arsenal. Its builder, unknown now, passed on a design process that gave later practitioners the ability to build larger and grander ships, and become celebrated for their skills. Its owners, unlike their predecessors, could profit from the growing commercial freedom in the Mediterranean, but their profits were negligible in comparison to the rising political power embodied by merchants in cities such as Naples and Amalfi. The Bozburun vessel and its construction, then, signals the gradual replacement of the old with the new.

Endnotes

¹ Rival 1991, 198-9

² Bass and van Doorninck 1982, 83-4

³ Steffy 1994, 84.

⁴ Note the architectural similarities between the Church of the Holy Sepulchre and the Dome of the Rock, and also note the loan of Byzantine architects and mosaicists to the caliph Abd al-Malik in the 7th century (Gibb 1982, 51-6). Also see Gibb (1982, 57-8) for other instances of commercial cooperation between the two empires.

⁵ Kaegi 1969, 146; see also Schick 1995, 223-4. See also Schick's tables on pages 113-7, which attest to the various levels of Christian activity in Muslim Palestine until 813.

⁶ Lopez 1959, 73-4; see also Bury 1962, 73, 88; Freshfield 1938, 19-20.

⁷ Lane 1979, 55-6.

⁸ Lane 1979, 56; see also Lane (1979, 63) regarding Matteo Bressan's vessels

⁹ Lane 1979, 64.

REFERENCES

- Abrhamse, D.Z.F. 1967. "Hagiographic Sources for Byzantine Cities, 500-900 AD." Ph.D. diss., University of Michigan.
- Adam, J.P. 1994. *Roman Building: materials and techniques*. London: Batsford.
- Adams, R. M. 1985. "Construction and Qualitative Analysis of a Sewn Boat of the Western Indian Ocean." M.A. thesis, Texas A&M University.
- Agourdis, C. 2002. "Ενάλτια Αναγνωριστική Έρευνα στον Αργολικό: Ερευνητική περίοδος 2000." In *ΕΝΑΛΙΑ VI*, edited by Y. Lolos, 32-9. Athens: H.I.M.A.
- Alertz, U. 1995. "The Naval Architecture and Oar Systems of Medieval and Later Galleys." In *The Age of the Galley*, edited by R. Gardiner, 142-62. London: Conway Maritime Press.
- Alertz, U., 2003. "The Venetian Merchant Galley and the System of *Partisioni* – Initial Steps towards Modern Ship Design." In *International Symposium on Boat and Ship Archaeology 9*, edited by C. Beltrame, 212-221. Oxford: Oxbow Books.
- Anderson, R.C., 1929. "Italian Naval Architecture about 1445." *Mariners' Mirror* 11: 135-63.
- Antoniadis-Bibicou, H. 1966. *Études d'Histoire Maritime de Byzance a propos du "Thème des Caravisiens"*. Paris: S.E.V.P.E.N.
- Arnaud, G., S. Arnaud, A. Ascenzi, E. Bonucci and G.Graziani 1980. "On the Problem of the Preservation of Human Bone in Seawater." *IJNA* 9: 53-65.
- Arnold, B. 1990. "Some Objections of the Link between Gallo-Roman Boats and the Roman Foot (*pes monetalis*)." *IJNA* 19: 273-7.
- Ashburner, W., ed. 1976. *The Rhodian Sea Law, edited from the manuscripts*. Aalen: Scientia Verlag.
- Ashley, C.W. 1944. *The Ashley Book of Knots*. New York: Doubleday and Company, Inc.
- Ballard, R.D., F.T. Hierbert, D.F. Coleman, C. Ward, J.S. Smith, K. Willis, B. Foley, K. Croff, C. Major and F. Torre. 2001. "Deepwater Archaeology of the Black Sea: The 2000 Season at Sinop, Turkey." *AJA* 105: 607-23.
- Basch, L. 1972. "Ancient Wrecks and the Archaeology of Ships." *IJNA* 1: 1-58.

- Bascom, W. 1976. *Deep Water, Ancient Ships*. New York: Doubleday.
- Bass, G. 1974a. "Discovery 73" *AINA Newsletter* 1.1: 1-4.
- Bass, G. 1974b. "Turkey: Survey for Shipwrecks, 1973." *IJNA* 3: 335-8.
- Bass, G. 1975. *Archaeology Beneath the Sea*. New York: Walker and Company.
- Bass, G. 1986. "Underwater Surveys, 1985." *AnatSt* 36: 214-5.
- Bass, G. 2002. "Log of the Submersible Survey 2001." *INA Quarterly* 29: 3-10.
- Bass, G. and F.H. van Doorninck, Jr. 1971. "A Fourth-Century Shipwreck at Yassi Ada." *AJA* 75: 27-37.
- Bass, G. and F.H. van Doorninck, Jr. 1978. "An 11th Century Shipwreck at Serçe Liman, Turkey." *IJNA* 7: 119-32.
- Bass, G. and F.H. van Doorninck, Jr. 1982. *Yassi Ada I, A Seventh-Century Byzantine Shipwreck*. College Station: Texas A&M University Press.
- Bass, G.F., S. Matthews, J.R. Steffy and F.H. van Doorninck, Jr. 2004. *Serçe Limanı, an Eleventh-Century Shipwreck. Volume I*. College Station: Texas A&M University Press.
- Bellarbarba, S. 1988. "The Square-Rigged Ship of the *Fabrica di Galere* Manuscript." *Mariners' Mirror* 74: 113-30.
- Benoit, F. 1962. "Nouvelles épaves de Provence (III)." *Gallia* XX: 147-76.
- Bockius, R. 2002. *Die Römerzeitlichen Schiffsfunde von Oberstimm in Bayern*. Mainz.
- Bonino, M. 1969. "Argomenti di Archeologia Navale in Piemonte." *BollSPABA* 23-24: 50-69.
- Berti, F. 1986. "Rinvenimenti di Archeologia Fluviale ed Endolagunare nel Delta Ferrarese." *BdA* 38-39: 19-38.
- Bound, M. 1985. "Early Observations on the Construction of the Pre-Classical Wreck at Campese Bay, Island of Giglio: Clues to the Vessel's Nationality." In *Sewn Plank Boats, Archaeological and Ethnographic papers based on those presented to a conference at Greenwich in November, 1984*. *BAR-IS* 276, edited by S. McGrail and E. Kently, 49-65.
- Bouzek, J. and F. Kordač. 1963. "Examination of Amphora Fragments from an Early Mediaeval Shipwreck from the Black Sea." *Listy Filologické* 86: 256-8.

- Bruni, S., ed. 2000. *Le navi antiche di Pisa, Ad un anno dall'inizio delle ricerche*. Firenze: Edizioni Polistampa.
- Brusic, Z. 1972. "Podmorska Arheološka Istraživanja kod Nina." *Jugoslavenska Akademija Znanosti I Umjetnosti Institut u Zadru*. Zadar.
- Bury, J.B. 1912. *A History of the Eastern Roman Empire from the Fall of Irene to the Accession of Basil I*. London: MacMillan and Co., Limited.
- Bury, J.B. 1962. *The Imperial Administrative System in the Ninth Century, with a Revised Text of the Kletorologion of Philotheos*. New York: Burt Franklin.
- Cariolou, G.A. 1997. "KYRENIA II: The Return from Cyprus to Greece of the Replica of the Hellenic Merchant Ship." In *Res Maritimae, Cyprus and the Eastern Mediterranean from Prehistory to Late Antiquity*, edited by S. Swiny, R.L. Holfelder and H.W. Swiny, 83-97. Atlanta: American Schools of Oriental Research.
- Carlson, D. 1999. "The 1999 Excavation Season at Tektaş Burnu, Turkey." *INA Quarterly* 26: 3-8.
- Carlson, D. 2003. "The Classical Greek Shipwreck at Tektaş Burnu, Turkey." *AJA* 107: 581-600.
- Carmi, Y. and D. Segal. 1995. "How Old is the Shipwreck from Tantura Lagoon? The Radiocarbon Evidence." *INA Quarterly* 22: 12.
- Casson, L. 1971. *Ships and Seamanship in the Ancient World*. Princeton: Princeton University Press.
- Casson, L. and J.R. Steffy, eds., 1991. *The Athlit Ram*. College Station: Texas A&M University Press.
- Citarella, A.O. 1967. "The Relations of Amalfi with the Arab World before the Crusades." *Speculum* 42: 299-312.
- Citarella, A.O. 1968. "Patterns in Medieval Trade: The Commerce of Amalfi before the Crusades." *The Journal of Economic History* 28: 531-55.
- CMS News, 1979. "Side Scan Sonar Survey (Nov. 1978)."
- Cook, J.M. and D.J. Blackman. 1971. "Archaeology in Western Asia Minor, 1965-70." *AR* 1970-1971: 33-62.

- Crisafulli, V.S., J.W. Nesbitt, and J.F. Haldon, eds., 1997. *The Miracles of St. Artemios: A Collection of Miracle Stories by an Anonymous Author of Seventh-Century Byzantium*. Leiden: E.J. Brill.
- Damiandis, K.A. and H. Çoban. 1999. “‘Pereme Kütügü’ from Inebolu: The Last ‘Shell-First’ Construction Survived in the Black Sea.” In *Tropis V, 5th International Symposium on Ship Construction in Antiquity*, edited by H. Tzalas, 129-39. Athens.
- Danis, D.M. 2002. “An Analysis of the Galley Ware from a Ninth-Century Shipwreck at Bozburun, Turkey.” M.A. thesis, Texas A&M University.
- Darmoul, A. 1985. *L’Homme Méditerranéen et la Mer*. Tunis.
- Dawes, E. and N.H. Baynes. 1948. *Three Byzantine Saints*. Oxford: Basil Blackwell.
- De Weerd, M.D., 1987. “Sind ‘Keltische’ Schiffe Römisch? Zur Angeblich Keltischen Tradition des Schiffstyps Zwammerdam.” *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz* 34: 387-410.
- De Weerd, M.D. 1990. “Barges of the Zwammerdam Type and their Building Procedures.” In *Maritime Celts, Frisians and Saxons*, edited by S. McGrail, 75-6. London: Council for British Archaeology.
- Eiseman C.J. and B.S. Ridgway. 1987. *The Porticello Shipwreck, A Mediterranean Merchant Vessel of 41-385 B.C.* College Station: Texas A&M University Press.
- Engvig, O.T. and P. Åstrom. 1975. “The Cape Kiti Survey 1973.” In *Hala Sultan Tekke II, Studies in Mediterranean Archaeology XLV:2*, 5-37. Göteborg.
- Engvig, O.T. and M. Beichmann. 1984. “Underwater Activities and the Situation at Cape Kiti, Cyprus.” *OpAth XV*: 16, 181-6. Stockholm.
- Fernandez-Miranda, F. and A. Rodero Riaza. 1985. “El Yacimiento Submarino de Favaritx (Menorca, España).” In *VI congreso internacional de Arqueología Submarina, Cartagena 1982*, 175-88.
- Fitzgerald, M. 1995. “A Roman Wreck at Caesarea Maritima, Israel: A Comparative Study of Its Hull and Equipment.” Ph.D. diss., Texas A&M University.
- Freshfield, E.H. 1938. *Roman law in the later Roman Empire: Byzantine guilds, professional and commercial; ordinances of Leo VI, c. 895, from The book of the eparch, rendered into English*. Cambridge: Cambridge University Press.

- Frey, D. 1972. "Sub-Bottom Survey of Porto Longo Harbour, Peloponnesus, Greece." *IJNA* 1: 170-5.
- Frost, H. 1963. *Under the Mediterranean, Marine Antiquities*. Englewood Cliffs: Prentice-Hall, Inc.
- Frost, H. 1966. "The Arwad plans 1964, A Photogrammetric survey of Marine Installations." *Revue d'Archéologie et d'Histoire* XVI: 3-28.
- Gargallo, P.N. and L. Casson. 1962. "Exploring off the Coast of Sicily." *Archaeology* 15: 193-7.
- Garnett, R., and J. Boardman. 1961. "Underwater Reconnaissance off the Island of Chios, 1954." *BSA* 56: 102-13.
- Giangrande, C. and G. Richards. 1985. "Cyprus Underwater Survey." *Progress in Underwater Science* 10: 159-64.
- Giangrande, C., G. Richards, D. Kennet, and J. Adams. 1987. "Cyprus Underwater Survey, 1983-1984. A Preliminary Report." *AnnRepCypr*, 185-97.
- Gibb, H.A.R. 1982. *Studies on the Civilization of Islam*. Princeton: Princeton University Press.
- Gibb, H.A.R., J.H. Kramers, E. Lévi-Provençal, and J. Schecht, eds., 1960. *Encyclopaedia of Islam*. Leiden: E.J. Brill.
- Goitein, S.D. 1967. *A Mediterranean Society, The Jewish communities of the Arab World as Portrayed in the Documents of the Cairo Geniza*. Vol. I. Berkeley: University of California Press.
- Goodman, W.L. 1966. *The History of Woodworking Tools*. New York: David McKay Company, Inc.
- Gorham, L.D. 2000a. "The Archaeobotany of the Bozburun Byzantine Shipwreck." Ph.D. diss., Texas A&M University.
- Gorham, L.D. 2000b. "Grapes, Wine, and Olives: Commodities and Other Cargo of the Bozburun Byzantine Shipwreck." *INA Quarterly* 27: 11-7.
- Gorham, L.D. and V.M. Bryant. 2001. "Pollen, Phytoliths, and other Microscopic Plant Remains in Underwater Archaeology." *IJNA* 30: 282-298.
- Green, J.N. 1971. "Cape Andreas: A Survey of a Tile Wreck." *Estratto da Prospezioni Archeologiche* 6: 61-4.

- Green, J.N. 1973. "An Underwater Archaeological Survey of Cape Andreas, Cyprus, 1969-70: A Preliminary Report." In *Marine Archaeology, Proceedings of the Twentythird Symposium of the Colston Research Society – held in the University of Bristol April 4th to 8th, 1971*, edited by D.J. Blackman, 141-79. London.
- Green, J.N., S. Wittaker, D. Squire, and P. Sutor. 1970. "Cape Andreas Expedition, 1969." *The Research Laboratory for Archaeology, Oxford*. Cyprus: The Research Laboratory for Archaeology.
- Güsenin, N. 1999a. "Récents découvertes sur l'île de Marmara (Proconnèse) à l'époque byzantine, Épaves et lieux de chargement." In *Archaeonautica, Construction navale maritime et fluviale, Proceedings of the Seventh International Symposium on Boat and Ship Archaeology*, edited by P.Pomey and E. Reith, 309-16. Paris.
- Güsenin, N. 1999b. "From Ganos to Serçe Limanı: Social and Economic Activities in the Propontis during Medieval Times Illuminated by Recent Archaeological and Historical Discoveries." *INA Quarterly* 26: 18-23.
- Güsenin, N. 2001a. "L'Épave de Çamaltı Burnu I (Ile de Marmara, Proconnese): Resultats des Campagnes 1998-2000." *Anatolia Antiqua* IX: 117-33.
- Güsenin, N. 2001b. "Çamaltı Burnu I Wreck." In *Istanbul University's Contributions to archaeology in Turkey (1932-2000)*, edited by O. Belli, 252-6. Istanbul: T.C. Istanbul Üniversitesi.
- Haldane, C.W. 1993. "Ancient Egyptian Hull Construction." Ph.D. diss., Texas A&M University.
- Han, V. and Z. Brusic. 1978. "Une Découverte Sous-Marine du Verre Médiéval dans l'Adriatique." In *Annales du 7^e Congrès International d'Étude Historique du Verre*, 271-82.
- Harpster, M. 2002. "A Preliminary Report on the 9th-Century AD Hull Found near Bozburun, Turkey." In *Tropis VII, 7th International Symposium on Ship Construction in Antiquity, Pylos 1999*, edited by H. Tzalas, 409-18. Athens.
- Harpster, M. 2004. "The Hull Material from Bozburun, Turkey: Managing the Wreck." *Mediterraneum IV, Tutela e valorizzazione dei beni culturali ed ambientali*, edited by F. Maniscalco, 273-8. Naples: Massa Editore

- Harpster, M. 2005. "Dowels as a Means of Edge-to-Edge Joinery in the 9th-Century AD Vessel from Bozburun, Turkey." *IJNA* 34: 88-94.
- Harpster, M. (in press). "Further Research on the 9th-century AD Vessel from Bozburun, Turkey." In *Tropis VIII, 8th International Symposium on Ship Construction in Antiquity, Hydra 2002*, edited by H. Tzalas. Athens.
- Harpster, M. (in press). "Proportional Rules in Early-Medieval Ships: the evidence from the Bozburun and Serçe Limanı vessels." In *International Symposium on Boat and Ship Archaeology 10*, edited by F. Hocker.
- Hentschel, F. 2004. "In Search of Ancient Shipwrecks: 2003 Submersible Survey, Turkey." *INA Quarterly* 31: 10-6.
- Hocker, F. 1995. "The Byzantine Shipwreck at Bozburun, Turkey." *INA Quarterly* 22: 3-8.
- Hocker, F. 1996. "The Bozburun Byzantine Shipwreck Excavation: 1996 Campaign." *INA Quarterly* 23: 3-9.
- Hocker, F. 1998. "Bozburun Byzantine Shipwreck Excavation: The Final Campaign 1998." *INA Quarterly* 25: 3-13.
- Hocker, F. 1999. "Cargo Stowage, Jettison and Wreck Formation Processes: Information on Middle Bizantine Commerce from the Ninth-Century Bozburun Shipwreck." In *Archaeologia Delle Acque*, edited by L. Fozzati, 28-38. Forli: Una Citta.
- L'Hour, M., P.Pomey, L. Long, F. Richez, D. Samson, J. Penhoat and M. Vital. 1985. *Archéologie Sous-Marine sur les côtes de France*. Rennes: Ouest France.
- Humphrey, J., J.P. Oleson and A.N. Sherwood. 2003. *Greek and Roman Technology, A Source Book*. London: Routledge.
- Jézégou, M.-P. 1983. "L'Épave Byzantino-Mervingienne de Fos-sur-Mer." M.A. Thesis, Université de Provence.
- Jezegou, M.P. 1985a. "L'Epave II de l'anse Saint-Gervais a fos-sur-Mer (Bouches-du Rhone): un Navire du haut Moyen-age Construit sur Squelette." In *Tropis,, 1st International Symposium on Ship Construction in Antiquity*, edited by H. Tzalas, 139-46.
- Jezegou, M.P. 1985b. "Elements de Construction sur Couples Observes sur une Epave du haut Moyen-Age decouverte a Fos-sur-Mer (Bouches-du-Rhone)." In *IV congreso internacional de Arqueologia Submarina, Cartagena 1982*, 351-6.

- Jézégou, M.P and J.P. Joncheray. 1997. "Les Épaves Sarrasines d'Agay et de Cannes." *Archéologia* 337, 32-9.
- Joncheray, J.P. 1974. "Researches off Saint Raphaël and Cannes, 1973." *IJNA* 3: 327-8.
- Joncheray, J.P. 1976. "1974 Excavations at the wreck of Bataguiet (early Middle Ages)." *IJNA* 5: 87-8.
- Jones, D.L. 1995. *Palms throughout the World*. Washington D.C.: Smithsonian Institution Press.
- Kaegi, W.E. 1969, "Initial Byzantine Reactions to the Islamic Conquest." *Church History* 38: 139-49.
- Kahanov, Y. and S. Breitstein. 1995. "A Preliminary Study of the Hull Remains." *INA Quarterly* 22: 9-13.
- Kahanov, Y. and J. Royal. 2001. "Analysis of Hull Remains of the Dor D Vessel, Tantura Lagoon, Israel." *IJNA* 30: 257-65.
- Kahanov, Y. 2003. "The Dor D Wreck, Tantura Lagoon, Israel." In *Boats, Ships and Shipyards, Proceedings from the 9th International Symposium on Boat and Ship Archaeology*, edited by C. Beltrame, 49-56. Oxford: Oxbow Books.
- Kahanov, Y., J. Royal, and J. Hall. 2004. "The Tantura Wrecks and Ancient Mediterranean Shipbuilding." In *The Philosophy of Shipbuilding*, edited by F. Hocker and C. Ward, 113-27. College Station: Texas A&M University Press.
- Kapitän, G. 1969. "The Church Wreck at Marzamemi." *Archaeology* 22: 122-33.
- Kapitän, G. 1972. "Sicily: Punta Secca (Cape Scaramia or Sclambri, Ragusa)." *IJNA* 1: 199-202.
- Kapitän, G. 1977. "I relitti di Capo Graziano (Filicudi): Scoperte dalla spedizione NACSAC nel 1968." *SicArch* X, 34: 40-53.
- Kapitän, G. 1978. "Exploration at Cape Graziano, Filicudi, Aeolian Islands, 1977." *IJNA* 7: 269-77.
- Katzev, M.L. and S.W. Katzev. 1989. "'Kyrenia II': Building a Replica of an Ancient Greek Merchantman." In *Tropis I, 1st International Symposium on Ship Construction in Antiquity, Piraeus 1985*, edited by H. Tzalas, 163-75.
- Kennedy, H. 1986. *The Prophet and the Age of the Caliphates*. London: Longman.

- Lalande, P. 1968. *Carte de la Végétation de la Région Méditerranéenne*. New York: UNESCO.
- Landström, B. 1961. *The Ship*. Garden City: Doubleday.
- Lane, F.C. 1979. *Venetian Ships and Shipbuilders of the Renaissance*. New York: Arno Press.
- Lavery, B. 1984. *The Ship of the Line*. Vol. 2. Annapolis: Naval Institute Press.
- Leidwanger, J. 2004. "Episkopi Bay Survey, Cyprus, 2003." *INA Quarterly* 31: 17-27.
- Liddell, H.G. and R. Scott. 1948. *Greek-English Lexicon*. Oxford: Clarendon Press.
- Linder, E. 1979. "Side-Scan Sonar Survey (Nov. 1978)." *CMS News* 3: 1-2.
- Liou, B. 1973. "Direction des recherches archéologiques sous-marines." *Gallia* 31, 571-608.
- Lipke, P. 1984. *The Royal Ship of Cheops*. BAR-IS 225. Greenwich: National Maritime Museum.
- Lloyd, M. 1984. *A Byzantine Shipwreck at Iskandil Burnu, Turkey: Preliminary Report*. M.A. thesis, Texas A&M University.
- Lloyd, M. 1985. "The Shipwreck at Iskandil Burnu." *INA Quarterly* 12: 4-5.
- Lopez, R.S. 1959. "The Role of Trade in the Economic Readjustment of Byzantium in the Seventh Century." *Dumbarton Oaks Papers* XIII: 69-85.
- Lopez, R.S. 1976. "Beati Monoculi: The Byzantine Economy in the Early Middle Ages." in *Cultus et Cognition. Festschrift Alexander Gieysztor*, edited by Stefan Krzysztow Kuczynski, 341-52. Warsaw: Panstwowe Wydawn.
- Marx, R.F. 1974. "Lebanon: Byblos, Sidon and Tyre areas." *IJNA* 3: 332.
- Matthews, S. 1983. "The Rig of the Eleventh-Century Ship at Serçe Liman, Turkey." M.A. thesis. Texas A&M University.
- McCormick, M. 2001. *Origins of the European Economy, communications and commerce, A.D. 300 – 900*. New York: Cambridge University Press.
- McGrail, S. 2003. "How Were Vessels Designed before the Late-Medieval Period?" In *Boats, Ships and Shipyards, Proceedings from the 9th International Symposium on Boat and Ship Archaeology*, edited by C. Beltrame, 124-31. Oxford: Oxbow Books.
- McWilliams, R. 1977. "Oxford Expedition to South East Sicily, Italy, 1976." In *Bulletin of the Oxford University Exploration Club*, New Series 3, edited by C.M. Perrins, 69-80. Oxford: Oliver and Son

- Medas, S. 2003. "The Late-Roman "Parco di Teodorico." Wreck, Ravenna, Italy: Preliminary Remarks on the Hull and the Shipbuilding" In *Boats, Ships and Shipyards, Proceedings from the 9th International Symposium on Boat and Ship Archaeology*, edited by C. Beltrame, 42-8. Oxford: Oxbow Books.
- Mercer, H.C. 1975. *Ancient Carpenters' Tools*. Doylestown: Horizon Press
- Milne, G. 1996. "Blackfriars ship 1: Romano-Celtic, Gallo-Roman or *Classis Britannicae*?" *IJNA* 25: 234-38.
- Mommsen, T., P. Krueger and A. Watson. 1985. *The Digest of Justinian*. Philadelphia: University of Pennsylvania Press.
- Mor, H. 2003. "The *Dor (Tantura) 2001/1 Shipwreck* A Preliminary Report." *RIMS News* 29: 15-17.
- Morris, C.E. and A.A.D. Peatfield. 1987. "Pottery from the Cyprus Underwater Survey, 1983." *AnnRepCypr*, 199-212.
- Mott, L. 1997. *The Development of the Rudder, A Technological Tale*. College Station: Texas A&M University Press.
- Muckleroy, K. 1978. *Maritime archaeology*. London: Cambridge University Press.
- Niermeyer, J.F., ed., 1976. *Mediae Latinitatis Lexicon Minus*. Leiden: E.J. Brill.
- Parker, A.J. 1979. "Method and Madness: Wreck Hunting in Shallow Water." *Progress in Underwater Science* 4: 7-27.
- Parker, A.J. 1992. *Ancient Shipwrecks of the Mediterranean and Roman Provinces*. BAR-IS 580. Oxford: Tempus Repartvm.
- Petroski, H. 1994. *The Evolution of Useful Things*. New York: Vintage Books.
- Pharr, C., ed., 1952. *The Theodosian Code and Novels and the Sirmondian Constitutions*. London: Oxford University Press.
- Polo Navacchio SpA-Phoenix Srl., ed. 2002. *Le navi antiche di Pisa, I modelli: intreccio tra tecnologia, arte e mestiere*. Pisa: Siena.
- Pomey, P. 1981. "l'Épave de Bon-Porté et les bateaux cousus de Méditerranée." *Mariners' Mirror* 67: 225-244
- Prins, A. H. J. 1986, *A Handbook of Sevm Boats, the Ethnography and Archaeology of Archaic Plank-built Craft*. Greenwich: Trustees of the National Maritime Museum.

- Pulak, C. 1985a. "Turkish Coastal Survey Yields Wrecksite Inventory." *INA Quarterly* 12: 2-3.
- Pulak, C. 1988b. "Turkish Underwater Survey." *INA Quarterly* 15: 10-1.
- Purpura, G. 1983. "Il Relitto Bizantino di Cefalu." *SicArch* 16: 93-103.
- Purpura, G. 1986. "Rinvenimenti sottomarini nella Sicilia Occidentale." *Bollettino d'arte. Supplemento* 38-39: 139-60.
- Purpura, G. 1993. "Rinvenimenti sottomarini nella Sicilia occidentale (1986-1989)." *Archeologia subacquea* I: 163-84.
- Rackham, H., trans. 1963. *Natural History*. Pliny. Cambridge: Harvard University Press.
- Raveh, K and S. Kingsley. 1992. "The Wreck Complex at the Entrance to Dor harbour, Israel: Preliminary Details." *IJNA* 21: 309-15.
- Ray, L.E. 1992. "Venetian Ships and Seafaring up to the Nautical Revolution: A Study Based on Artistic Representations of Ships and Boats before ca. 1450." M.A. thesis. Texas A&M University.
- Reith, E. 2003. "Essay to Restore the Capacity Process of a Shipyard in the Early-Medieval Period: an Example of the *Port Bertheau II* wreck, Charente-Marini, France." In *Boats, Ships and Shipyards, Proceedings from the 9th International Symposium on Boat and Ship Archaeology*, edited by C. Beltrame, 113-8. Oxford: Oxbow Books.
- Rival, M. 1991. *La Charpentenrie Navale Romaine*. Paris: Centre National de la Recherche Scientifique.
- Rogers, G.B. 1981. "Les Épaves de Gruissan, le Trésor de l'Anse Saint-Roch a Antibes." *Archaeonautica* 3: 23-52.
- Royal, J.G. and Y. Kahonov. 2000. "An Arab-Period Merchant Vessel at Tantura Lagoon, Israel." *IJNA* 29: 151-3.
- Schick, R. 1995. *The Christian Communities of Palestine from Byzantine to Islamic Rule*. Studies in Late Antiquity and Early Islam 2. Princeton: The Darwin Press.
- Ševčenko, N.P. 1998. "Canon and Calendar: The Role of a Ninth-Century Hymnographer in Shaping the Celebration of the Saints." In *Byzantium in the Ninth Century: Dead or Alive?*, edited by L. Brubaker, 101-14. Aldershot, Hampshire.

- Shaw, J.W. 1967. "A Double-Sheaved Pulley Block from Kenchreai." In *Hesperia* 36.4: 389-401.
- Sibella, P. 1995. "The Ceramics." *INA Quarterly* 22: 13-6.
- Simpson, D.P., ed., 1968. *Cassell's New Latin Dictionary*. New York: Funk and Wagnalls.
- Sophocles, E.A. 1983. *Greek Lexicon of the Roman and Byzantine Periods*. Hildesheim: Georg Olms.
- Spondylis, E. 2002. "Αναγνωριστική Έρευνα Ι.Ε.Ν.Α.Ε. Δυτικών Ακτών Νοτίου Παγασητικού, Έτους 2000." In *ΕΝΑΛΙΑ* VI, edited by Y. Lolos, 24-31. Athens.
- Steffy, J.R. 1994. *Wooden Ship Building and the Interpretation of Shipwrecks*. College Station: Texas A&M University Press.
- Steffy, J.R. 1995. "Ancient Scantlings: The Projection and Control of Mediterranean Hull Shapes." *Tropis III, 3rd International Symposium on Ship Construction in Antiquity*, edited by H. Tzalas, 417-28. Athens.
- Tierney, B. and S. Painter. 1983. *Western Europe In the Middle Ages, 300-1475*. New York: Alfred A. Knopf.
- Throckmorton, P., ed., 1987. *The Sea Remembers, Shipwrecks and Archaeology*. New York: Weidenfeld and Nicholson.
- Throckmorton, P. and G. Kapitän. 1968. "An Ancient Shipwreck at Pantano Longarini." *Archaeology* 21: 182-7.
- Throckmorton, P. and J. Throckmorton. 1973. "The Roman wreck at Pantano Longarini." *IJNA* 2: 243-66.
- Udovitch, A. 1962. "At the Origins of the Western *Commenda*: Islam, Israel, Byzantium?" *Speculum* 37: 198-207.
- Udovitch, A. 1967. "Credit as a Means of Investment in Medieval Islamic Trade." *JAOS* 87: 260-4.
- van Alfen, P.G. 1996. "New light on the 7th-c. Yassi Ada Shipwreck: Capacities and Standard Sizes of LRA 1 Amphoras." *JRA* 9: 189-213.
- van Doorninck Jr., F.H. 1976. "The 4th Century Wreck at Yassi Ada, An Interim Report on the Hull." *IJNA* 5: 115-31.

- van Doorninck Jr., F.H. 1989. "The Cargo Amphoras on the 7th Century Yassı Ada and 11th Century Serçe Limanı Shipwrecks: Two Examples of a Reuse of Byzantine Amphoras as Transport Jars." In *Bulletin de Correspondance Hellénique Supplément XVIII: Recherches sur la Céramique Byzantine*, edited by V. Déroche and J.-M. Spieser, 247-57. Paris.
- van Doorninck Jr., F.H. 1990. "The Serçe Limanı Shipwreck: An 11th-Century Cargo of Fatimid Glassware Cullet for Byzantine Glassmakers." In *I Uluslararası Anadolu Cam Sanatı Sempozyumum 26-27 Nisan, 1988*, 58-63. Istanbul.
- van Doorninck Jr., F.H. 2002. "Byzantine Shipwrecks." *The Economic History of Byzantium*. 3 vols. Edited by A.E. Laiou, 899-905. Washington D.C.: Dumbarton Oaks.
- Vindry, G. 1980. "Présentation de l'épave arabe du Batéguier (baie de Cannes, Provence Orientale)." In *Colloques International du Centre National de la Recherche Scientifique* 584, edited by G. Demianis d'Archimbaud and M. Picor, 221-6. Paris.
- Visquis, A. 1973. "Premier Inventaire di Mobilier de l'épave dite "des jarres" a Agay." *Cahiers d'Archéologie Subaquatique* II: 157-9.
- Vosmer, T. A., R. Margariti and A.F. Tilley. 1992, *A Survey of Traditional Vessels of the Sultanate of Oman, the Omani Dhow Recording Project Field Research, 1992*. Privately printed.
- Wachsmann, S. 1995. "The 1994 INA/CMS Joint Expedition to Tantura Lagoon." *INA Quarterly* 22: 3-8.
- Wachsmann, S. 1996. "Technology Before Its Time: A Byzantine Ship from Tantura Lagoon." *The Explorers Journal* 74: 19-23.
- Wachsmann, S., and Y. Kahanov. 1997. "Shipwreck Fall: The 1995 INA/CMS Joint Expedition to Tantura Lagoon, Israel." *INA Quarterly* 24: 3-18.
- Wachsmann, S., Y. Kahanov, and J. Hall, 1997. "The *Tantura B* Shipwreck: The INA/CMS Joint Expedition to Tantura Lagoon." *INA Quarterly* 24: 3-18.
- Ward, C and R.D. Ballard. 2004. "Deep-water Archaeological Survey in the Black Sea: 2000 Season." *IJNA* 33: 2-13.
- Ward-Perkins, J. and P. Throckmorton. 1965. "The San Pietro Wreck." *Archaeology* 18: 201-9.

APPENDIX A

COEFFICIENTS AND DIMENSIONS

Estimated Displacement at LWL: 56 tons

Freeboard at LWL (at midships): 90 cm

Estimated Tonnage: 31.5 tons

Waterplane Coefficient: .71

Midships Coefficient: .81

Block Coefficient: .56

Prismatic Coefficient: .68

	Meters	Feet	Boz Feet
LOA	14.24	46.71	41.27
LWL (overall)	13.14	43.11	38.08
LWL (molded)	12.5	41.01	36.23
Length of keel	7.41	24.31	21.47
Breadth (max)	5.12	16.79	14.84
Breadth (molded)	5.0	16.40	14.49
Breadth (molded, LWL)	4.76	15.61	13.79
Breadth of floor	3.45	11.31	10.00
Depth of Hold	1.55	5.08	4.49

VITA

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Texas A&M University: August 1997 – August 2005.

Anthropology Ph.D., August, 2005.

University of St. Andrews: September 1994 - June 1997.

M.A. in Maritime Studies, June 1997.

M.A. title, “Possible Effects of the Muslim Invasion on Shipping and Shipbuilding in the Eastern Mediterranean.”

The George Washington University: September 1990 - May 1994.

B.A., Classical Archaeology and Anthropology, May 1994.

Academic Advisor, Student Development Coordinator, August 2003- present.

Advise undergraduate students regarding graduation with Honors, develop and implement student opportunities and programs, recruit, serve as liaison to colleges and departments, advise Honors Student Council.

Committee Head, Ad hoc Honors Scholars Committee, Spring 2004.

Responsible for organizing committee, setting agenda and goals, meeting deadlines and submitting report regarding new Honors College curriculum to Honors Advisory Committee.

Instructor, Department of Anthropology, Texas A&M University, 2001-2003.

Developed and taught undergraduate course, History and Archaeology of the Medieval Near East, as a series of comparative lectures highlighting the history of both the Byzantine and Islamic empires, and illustrating specific events with archaeological evidence.

Teaching Assistant, Ship Reconstruction Lab, Texas A&M University, Fall 1998.