The archaeology of ships and boats

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Boats from bogs in Arctic Norway: depositional contexts and explanatory frameworks in the Late Iron Age and Mediaeval period

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Abstract: A comprehensive assessment of boat-related bog finds from the collection of the Arctic University Museum of Norway (Norges Arktiske Universitetsmuseum, NAU) materialises the entanglement of boat technology and cultural meaning in northern Norway during the Iron Age. Nineteen boat parts and related equipment made of Scots pine (*Pinus sylvestris*) from 17 bog locations have been documented. As the Early Iron Age and pre-Iron Age bog finds have been discussed in an earlier publication (Wickler 2019), this chapter focusses on bog boat finds from the Late Iron Age. The documentation of bog boats has emphasised absolute dating using radiocarbon and dendrochronology, in addition to detailed descriptions and graphic documentation of the objects. Some finds are related to ritual activities which include votive bog offerings and a boat grave. Most of the Late Iron Age boats have sewn planking, a construction technique which predates the use of iron rivets first documented in the Roman Iron Age and which is also associated with indigenous Sámi boats. Hybrid vessels combining sewing with treenails and rivets are also represented. Bog boat remains are discussed in the context of relevant explanatory frameworks in order to evaluate their significance for the development of boat technology and as expressions of northern Norwegian maritime culture.

Introduction

This chapter describes a project undertaken by the author which analysed and dated wooden boat parts and boat-related equipment from bog contexts from the archaeological collections of the Arctic University Museum of Norway (NAU). All of the materials referenced are Mediaeval or earlier in age and originate from Arctic northern Norway. The project has emphasised obtaining reliable radiocarbon age estimates for as many finds as possible, in addition to collecting or creating detailed descriptions of the individual objects and their comparisons with relevant materials sourced from elsewhere in Scandinavia. As finds pre-dating the Late Iron Age were previously published (Wickler 2019), the present study focussed on bog boat material from Nordland and Troms dating to the Late Iron Age, along with several objects from the Mediaeval period (Figure 9.1; Table 9.1). No bog finds from the Late Iron Age have been found in the northernmost region of Finnmark. Most of the analysed objects were discovered while cutting peat for fuel and then given to the museum between the 1880s and 1950s. Two boat finds from the Viking Age, the Øksnes boat grave and Bårset votive offering, were documented by archaeological excavations in the 1930s (Gjessing 1941).

Boat finds are presented by context and type, including those from ritual contexts, boat planks with information on fastening techniques and miscellaneous boat parts and equipment. Also described are two spades initially identified as paddles. Overarching themes of relevance to bog boat finds are also reviewed and evaluated, including ritual deposition of boats in bogs and importance of sewn boats in Late Iron Age northern Norway. Also argued is the need to create models of boat development from a northern Norwegian perspective as an alternative to models with a predominantly southern Scandinavian bias.

Bog boats from ritual contexts

Three bog boat finds from northern Norway are interpreted as being associated with ritual activity. These include a boat grave intentionally placed in a bog at Øksnes in Vesterålen and votive boat offerings at Bårset in northern Troms and Rydningen on the island of Senja. In this section, these contexts are discussed and compared as bases for modelling the importance of bogs as a liminal entity mediating between landscapes and waterscapes of ritual significance.

The Øksnes boat grave

During road construction at the Øksnes vicarage on Skogøya Island in Vesterålen in 1934, the remains of a wooden boat with an estimated original length of 8.0–10.0 m and width of 1.5 m were discovered in a bog *c.* 4.5–5.0 m above sea level (a.s.l.) and *c.* 60.0–70.0 m from the shoreline. Subsequent excavation revealed the boat was buried in the latter part of the Viking Age in a low grave mound with a ring of stones placed around the outer margin (Figure 9.2A). The results of the boat grave excavation were published by Gjessing (1941), who described the burial as the grave of a Norse male,

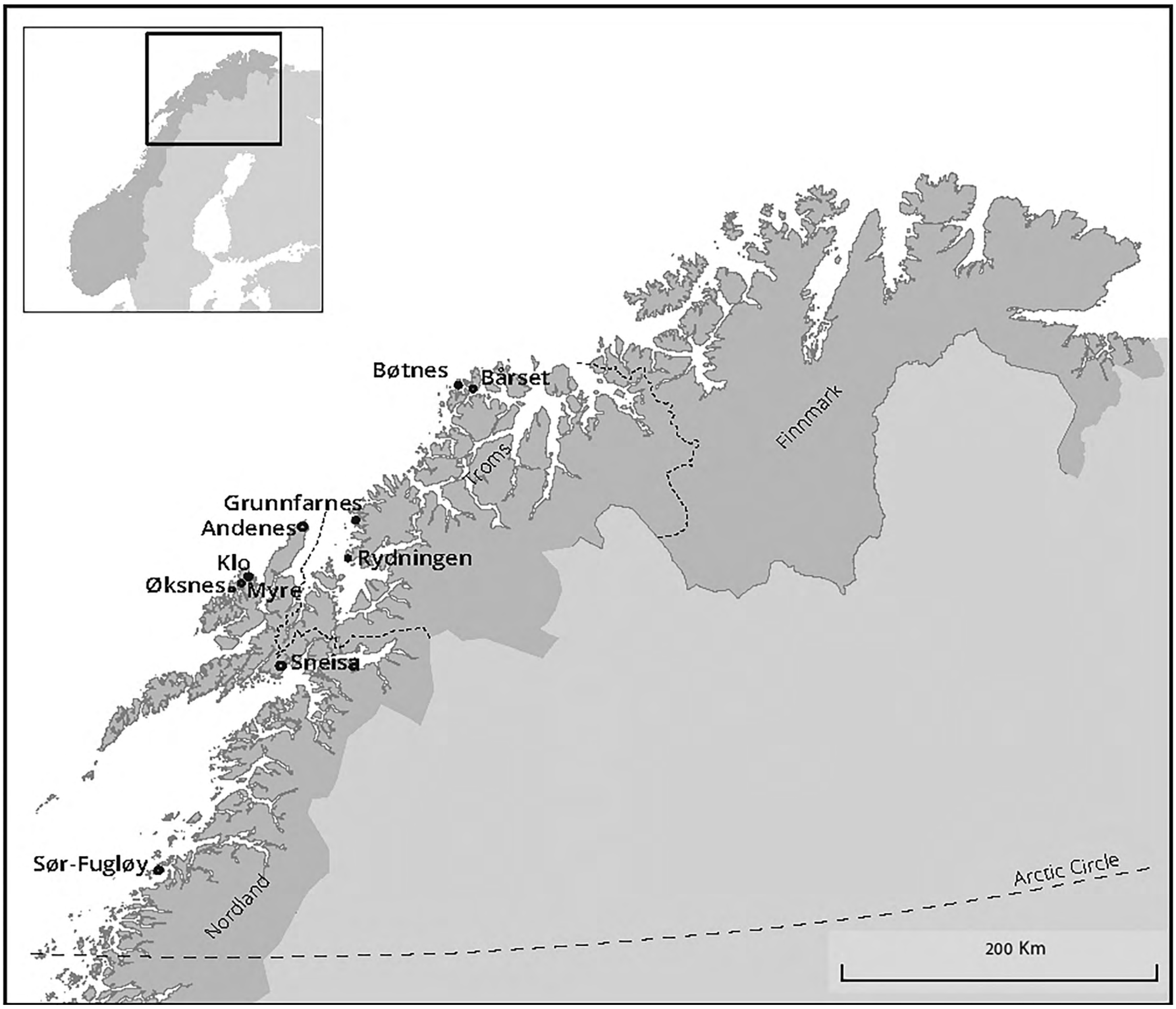

Figure 9.1. Map showing the bog boat find locations mentioned in the text. Illustration: Arctic University Museum of Norway and used with permission.

based on the presence of an axe. Although the bow and stern sections of the boat had been removed by earlier turf cutting, the keel, lower planking and a displaced frame were preserved. Pieces of birch bark found under the boat planks suggested the entire vessel may have been covered with this material (Gjessing 1941: 41). Although skeletal remains were absent, a pillow with feather fill and a woven wool textile pillowcase were found with adhering animal hair originating from a cowhide which had wrapped the body (Figure 9.2B). A radiocarbon date of 888–994 cal AD from the pillowcase agrees well with the typological assignment of the axe found in the grave to the tenth century.

Microscopic analysis of feathers from the pillow fill identified three avian orders: *Anseriformes* (eider); *Suliformes* (cormorant) and *Charadriiformes* (unspecified gull). Downy feathers from gulls (*Laridae*) composed most of the material (Dove and Wickler 2016). Archaeoentomological analysis of the pillow fill revealed remains from a variety of insect species (Panagiotakopulu *et al.* 2018). These included the blowfly, which indicates exposure of the body and the probable timing of the burial. The quantity of fleas among the feathers suggests the pillow under the corpse had been in use for some time before being placed in the grave. The presence of a beetle species which feeds on flowers suggests that flowers were placed on the corpse as part of the burial ritual. The absence of a body and any associated post-burial decay fauna implies it was intentionally removed and disposed of elsewhere.

A 3.1 m section of the boat keel was preserved with a 5.0 cm long scarf for the fore stem on one side. There were no treenail holes for fastening the garboard strake, but a set of eight large treenail holes were placed along the centre of the keel about 10.0–48.0 cm apart, presumably for fastening frames. A single displaced frame fragment with an 8.5 × 4.5 cm profile was found with deep notches for planks and fragments of treenails for fastening the garboard strake. The remains of three strakes on the port side and two on the starboard side were also preserved. Long strands of twisted-wool caulking from additional

Table 9.1. Bog boat radiocarbon and dendrochronological dates.

Catalogue no. (Ts.)	Description	Year	Location	Municipality	Material	Lab no.	Conventional age (BP)	Calibrated ^{14}C age (2 δ)**
3499	broken boat parts—votive offering	1931	Bårset	Karlsøy	pine	T-3802 dendro.—10 planks	1080 ± 80	772–1158 AD dendro. >845 AD
3981b	boat grave	1934	Øksnes vicarage	Øksnes	pine	TRa-2953*(wool textile)	1100 ± 25	889–995 AD
5141	boat keel with sewn bottom plank—votive offering	1954	Rydningen	Senja	pine	TRa-2428* (charcoal) Beta-363164*^{x} (wool)	1760 ± 30 1480 ± 30	234–381 AD 550–644 AD
4145b	thwart	1939	Bøtnes	Karlsøy	pine	Beta-363163*	1510 ± 30	534–640 AD
4145a	rowing oar blade	1939	Bøtnes	Karlsøy	pine	TRa-2425*	1180 ± 25	772–895 AD
3845	boat plank	1936	Sør-Fugløya	Gildeskål	oak	Beta-363162*	1380 ± 30	601–680 AD
6366	multiple boat planks	1962	Grunnfarnes	Torsken	pine	Wk-30117 Beta-363166* dendro.	1627 ± 37 1520 ± 30	365–546 AD 530–608 AD dendro. >800 AD
4682	flooring board	1951	Andenes	Andøy	birch	TRa-2426*	960 ± 25	1027–1158 AD
5412	bailer	1955	Andenes	Andøy	pine	Wk-30113*	752 ± 30	1225–1289 AD
5414a	bailer	1950s	Myre (settlement mound)	Øksnes	pine	—	—	—
Non-boat finds								
709	spade	1886	Sneisa	Lødingen	willow/ aspen	TRa-2424*	805 ± 25	1213–1276 AD
1697	spade	1906	Andenes	Andøy	willow/ aspen	Wk-30112*	572 ± 28	1308–1363 AD

Note: wood samples unless otherwise indicated.
* AMS / ^{x} solvent extraction
** See Bronk Ramsey 2009; Reimer *et al.* 2020. Calibrated with OxCal.

planks show the boat would have had at least five strakes on each side. The planks were thin and about 20 cm wide. Although Gjessing (1941: 46, 72) claims the planks were fastened to one another with reindeer sinews, subsequent analysis has shown that plant fibres were used, potentially from tree roots. Fibre threads were placed through pairs of drilled vertical holes spaced 1.0 cm apart and knotted on the interior (Figure 9.3A). Spacing between hole pairs was about 18.0 cm. The garboard strake was sewn to both the keel and stem, and strakes were fastened to frames with treenails.

Gjessing (1941: 72–73) argued that the boat was built by the indigenous Sámi, partially because he associated sewing which used reindeer sinew with traditional Sámi boat building; this has since been shown to be inaccurate. Gjessing (1941: 74) concluded that the boat could have been a Sámi vessel made to order for a Norse community. Although the basis for this assertion about the ethnic origin of the boat has been questioned (Wickler 2010: 353), elements of the Øksnes grave do suggest a mixture of Norse and Sámi traits, illustrating the hybridised nature of ethnic identity and cultural interaction in the Vesterålen region during the Late Iron Age. Although birchbark is commonly used for wrapping corpses in Sámi burials, the practice was widespread and thus not restricted to the Sámi. Grave mounds and boat burials are commonly associated with Norse burial practices. Sewing has also been used as a basis for identifying the Øksnes boat as Sámi (Westerdahl 1987: 28–31). The potential blend of Norse and Sámi elements in the Øksnes burial challenges commonly held assumptions about material expressions of ethnicity and reveals the complexity of ethnic identity in the region. Entomological evidence that the body was exhumed from the grave may also be linked to ritual practices with ethnic associations, such as the avoidance of haunting by the spirit of the deceased (Jakobsson 2017).

The Bårset boat

In 1931, the remains of a boat were exposed by peat cutting in a bog at Bårset on the large island of Nord-Kvaløy, one of many offshore islands along the outer coast of northern Troms. The find was reported to the Tromsø Museum, and zoologist Soot-Ryan conducted an excavation which was later published by Gjessing (1941). The boat was a rowed

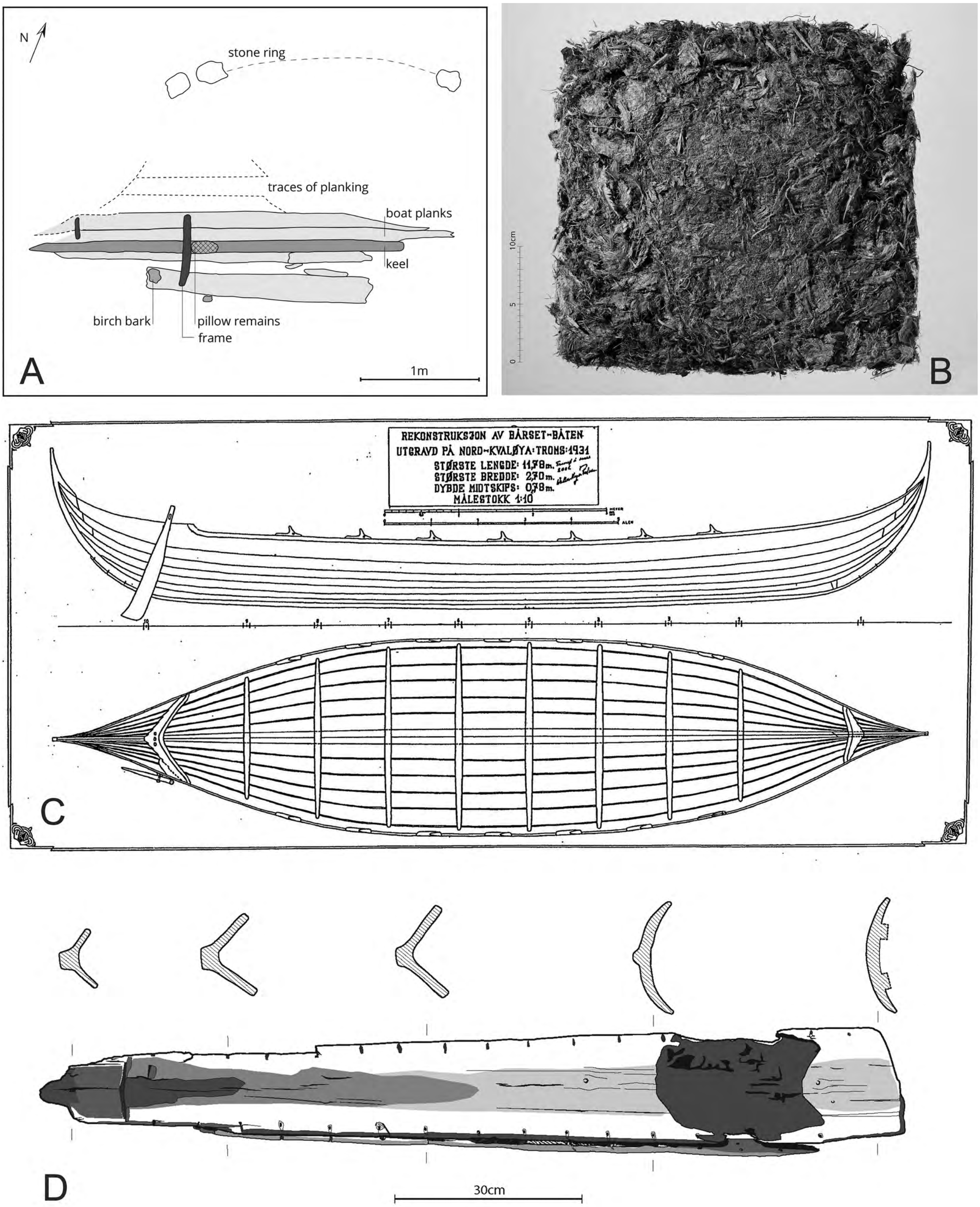

Figure 9.2. Bog boats from ritual contexts: A) plan drawing of the Øksnes boat grave redrawn from Gjessing 1941, Fig. 31; B) feather pillow fill from Øksnes boat grave; C) drawing of 1931 Bårset boat reconstruction; D) top view of Rydningen boat keel with cross-section profiles. Illustrations: Arctic University Museum of Norway and used with permission.

vessel with no evidence of a sail. It was estimated to have been 13.1 m long with a maximum width of 2.6 m and a midships height of 5.7 m. An initial radiocarbon date of 722–1158 cal AD was followed by a dendrochronological analysis of 10 planks, producing an age estimate for boat construction in the ninth century, sometime after 845 AD (Kirchhefer 2000). Although only *c.* 20–25% of the boat was preserved, a reconstruction was drawn at a scale of 1:20 (Figure 9.2C); in 1937, this drawing was used as the basis for constructing a 1:5 scale model. In 1993, a

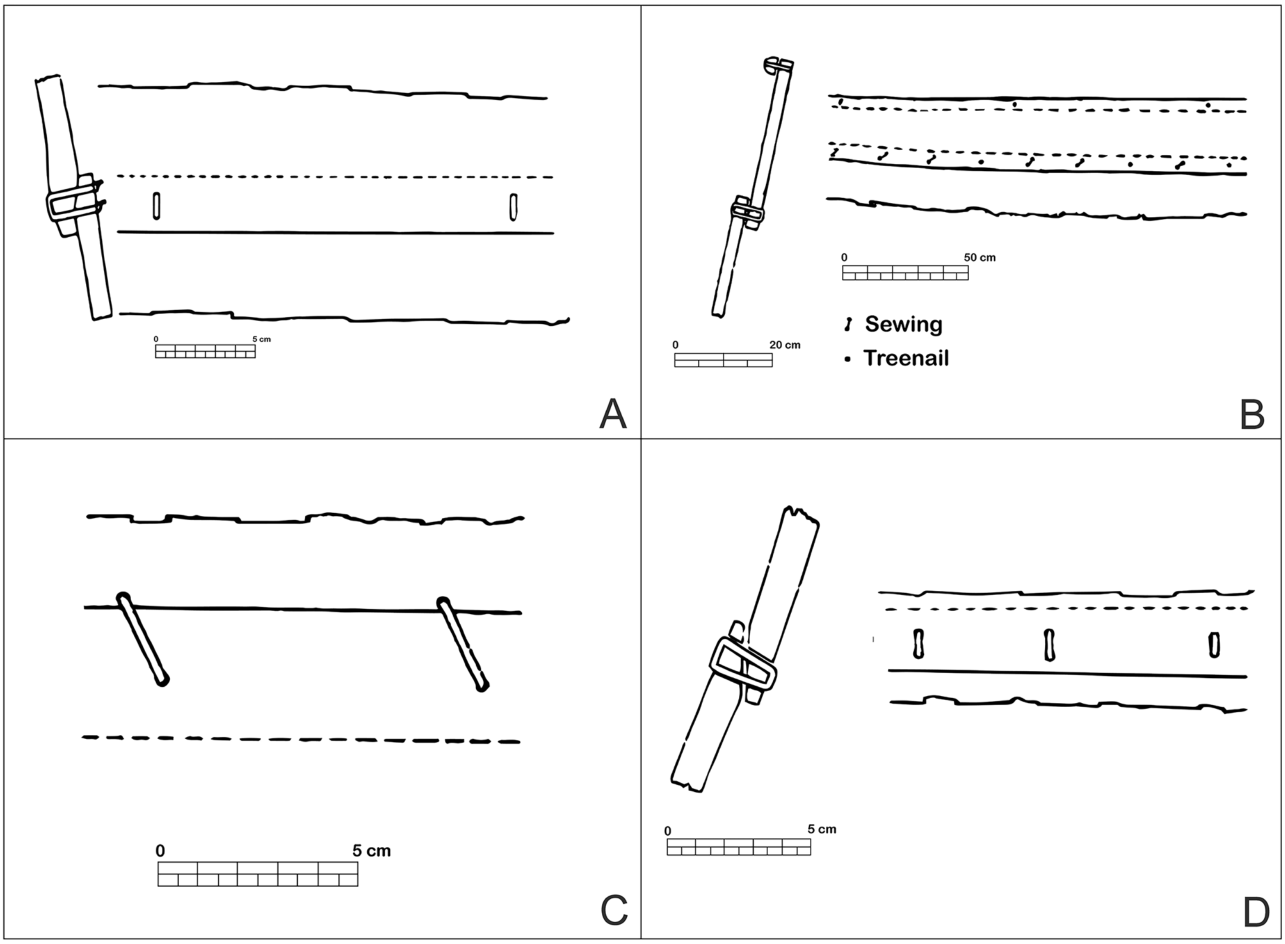

Figure 9.3. Boat stitching seams: A) Øksnes boat plank stitching seam; B) stitching and treenails fastening the upper two strakes on the Bårset boat; C) continuous stitching fastening keel to bottom plank on the Rydningen boat; D) plank stitching seam on the Halsnøy boat. Redrawn from Prins 1986: Figs. 9, 11, 12 and 14 with permission from H. H. T. Prins.

group of experts reanalysed the boat remains to assess the validity of the 1937 reconstruction; this led to a number of its construction details being questioned. A more recent reassessment of the vessel (Pedersen 2002) yielded an alternative reconstruction which added a seventh strake, a feature which harmonises the design to a greater degree with Viking vessels from the same period such as the Oseberg ship and the largest of the small boats from Gokstad.

The following description of the Bårset boat construction focusses on fastening techniques which are relevant for its comparison with other bog boat finds. The frames are *c.* 90.0 cm apart and lashed to raised cleats on the strakes through single holes. The planks are thin (1.5–2.5 cm) with widths ranging from 22.0 to 29.0 cm. Apart from the top two strakes, the boat planks are fastened to one another and to the keel with rivets and caulked with long strands of twisted wool, not hemp rope as claimed by Gjessing (1941: 36). The two upper strakes are fastened together with a combination of stitches and treenails, although rivets are present near the fore and aft stems. The stitches are sewn with plant fibres, potentially from tree roots, between paired holes set at an angle and spaced 1.0–2.0 cm apart (Figure 9.3B). The interval between the stitches/treenails varies 18.0–22.0 cm, although distances of 11.0 cm and 13.0 cm also occur. The gunwale is attached to the interior of the sheerstrake with treenails.

The Bårset boat was intentionally placed in a bog, most likely as a votive offering, and thus is unlikely to have been an abandoned vessel or a wreck which washed ashore. Clearly visible axe marks show the boat to have been partially chopped up and broken apart, with individual pieces subsequently spread over a relatively large area. Loose objects were apparently removed prior to the ritual deposition, including boat parts such as thwarts and floorboards, although one complete oar was recovered. Gjessing (1941: 64–65) remarked on the presence of light-coloured, mostly white, water-rounded stones spread among the boat remains, which he suggested had been thrown at the broken vessel as part of a ritual in which white stones had a magical meaning.

A bog boat votive offering from Rydningen, Senja

A boat keel with fragments of a sewn bottom plank was found in 1954 about one kilometre from the coast at *c.* 150.0 m a.s.l. near the farmstead at Rydningen along the southwest coast of Senja, Norway's second-largest island.

The boat remains had been placed in a large bog hole *c.* 30.0 m wide surrounded by bedrock at a depth of 80.0 cm and 40.0 cm above the base of the bog. The bog hole may have had standing water in it when the boat was deposited. The aft end of the keel section was chopped off, and a 24.0 × 16.5 cm area of the interior surface was carbonized, suggesting a fire was intentionally lit in the area (Figure 9.2D). It can be argued that these actions were associated with a ritual event in which the keel segment was cut to size in advance and ritually deposited in a small bog pool as a votive offering while a fire burned in the keel. Two radiocarbon samples from the vessel were dated. An initial sample taken from the carbonized wood produced a date of 234–381 cal AD. A sample of twisted-wool caulking material produced a significantly younger age range of 550–644 cal AD. The second date is undoubtedly more reliable, given the significant problem of 'old wood' when dating heartwood from long-lived species such as pine, as Wickler (2019: 190) discussed in connection with bog boat finds.

The keel segment is 1.4 m long and was carved out of a pine log extending from a pointed end where the fore stem was attached to a point where remnants of two cleats for lashing frames are visible at the opposite end (see Figure 9.2D). The width of the keel board narrows from 18.6 cm at the aft end where the cleats are located to 18.5–16.1 cm in the midsection and 10.7 cm where there is a scarf for attaching the fore stem. The stem was likely lashed in some manner to the keel scarf, which is 8.0 cm long with a notch 0.5 cm high, although there are no lashing holes. The lashing cleat fragments are 14.0 × 2.5 cm with 4.0 cm between them, but one has been almost completely removed, and the upper portion where the lashing hole would have been is missing from both cleats. The cleats may have been intentionally removed when the aft section of the keel was chopped off. The keel board has a raised keel 2.7 cm wide and 2.0 cm high at the stem scarf; this gradually reduces and transforms into a rounded bottom 30.0 cm from the aft end. The interior height of the keel board is 3.3–3.5 cm.

There are remains of the first strake on one side, which is sewn to the keel board with angled pairs of 0.3 cm holes placed 1.1 cm apart in the plank and single 0.5 cm holes in the keel (Figure 9.3C). The distance between stitching holes varies from 6.0 to 8.5 cm. Wedge-shaped pegs for holding the thread in place are preserved along the interior margins of the stitching holes. The stitching is continuous, using plant fibres twisted together to form a thread which is still in place and well preserved, along with strands of twisted wool used as caulking. The caulking material does not appear to have been impregnated with a sealant such as pine tar.

Boat remains with similarities to the Rydningen keel which are either contemporaneous or date to the Merovingian Period (550–800 AD) are generally scarce. The closest parallel in terms of construction techniques may be the fragmentary remains of the Halsnøy bog boat from western Norway found in 1896 (Shetelig 1903). A single radiocarbon date of 340–557 cal AD provides a rough age estimate for the boat (Myhre 1980), but as was noted for the Rydningen keel date, this estimate may be too early given the significant problem of inbuilt age for pine. The Halsnøy vessel is a small rowboat around 5.2 m long with a broad bottom board and frames lashed to the planks with 'thin fibres of wood' (Shetelig 1903: 20), likely from roots, through cleats with single holes which are 22.0–24.0 cm long and 2.5 cm high. The planks were sewn together through vertically aligned, paired holes which are 0.2 cm diameter and spaced 4.0–5.0 cm apart; the stitches are discontinuous, and wedge-shaped pegs were used to hold them in place (Figure 9.3D). Planks were scarfed and sewn to the stem with stitching holes perpendicular to the stem and a thick tar impregnated thread fastening planks on both sides through the stem. Strips of a woven wool textile impregnated with tar were used for caulking between the planks and planks and stem. The tar used as a sealant is most likely from pinewood. A recent full-scale reconstruction of the boat represents one possible interpretation of how the boat may have been constructed (Sørnes 2012).

Ritual deposition of boats in bogs: contexts and explanatory models

The ritually associated bog boats from northern Norway can be grouped into two distinct categories: boat graves such as the one from Øksnes and votive boat offerings such as those found at Bårset and Rydningen. Although the intentional interment of individuals in bogs is uncommon, other bog burials have been documented in northern Norway, including the eleventh-century Skoldehamn grave discovered in 1936 on the southern tip of Andøya, not far from Øksnes (Gjessing 1938). Analyses of the well-preserved clothing and other grave items reveal a blend of Norse and Sámi features, features which have been interpreted as an expression of ethnic interaction and coexistence at the time when Christianity was gaining influence in the region (Svestad 2021). Although several boat graves located in bogs are known from western Norway (Gjessing 1941: 40), the Øksnes bog boat grave is unique in northern Norway. Multiple aspects of the grave reflect ethnic hybridisation, and evidence for exhumation of the body represents a highly unusual secondary ritual event. The widely held belief that bogs represent liminal entities which could transcend and mediate the boundary between water and land provides a meaningful context for understanding both Sámi and Norse beliefs and burial practices in the Iron Age.

Although the ritual contexts for the votive offerings of boats in bogs at Bårset and Rydningen may reflect beliefs similar to those associated with bog burials, the intentions and objectives of the ritual acts involved are dissimilar. Votive offerings involve the deposition of objects in specific locations for ritual purposes. As noted earlier, at Bårset, a boat was intentionally broken apart, chopped into pieces with an axe and spread across the bog. Water-rounded stones appear to have been placed among the boat fragments as part of a ritual act. All loose items and equipment, apart from a single rowing oar, were apparently removed from the boat prior to performance of the ritual. In contrast, the votive offering at Rydningen involved a different process, one which prepared a boat keel and attached plank fragment by chopping off the aft end prior to the ritual deposition. The boat keel was carried about a kilometre inland to an elevated bog hole *c.* 150.0 m above the shoreline, where there may have been standing water at the time. A fire appears to have been lit in the keel before it was lowered into the bog hole.

Other votive offerings of boats include the Early Iron Age Danish bog offerings at Hjortspring and Nydam, where boats, weapons and other war booty were sacrificed in a small pond about 3.5 km inland at Hjortspring and a freshwater lake at Nydam (Rieck 1995: 127–128; Crumlin-Pedersen and Trakadas 2003; Holst and Nielsen 2020). In western Norway, the Kvalsund bog offering of a ship and a boat, excavated in the 1920s (Shetelig and Johannesen 1929) and recently dendrochronologically dated to *c.* 780–800 AD (Nordeide *et al*. 2020), highlights the importance of water as a central ritual element with a pit dug into the bog and filled with water to form an artificial pool in which the vessels were deposited. The boats were broken into pieces by hand and placed in the pit along with sharpened wooden objects thrust into the bottom of the pit. Although some scholars still view Kvalsund as a war-related victory offering in the same category as Hjortspring and Nydam (Christensen 2022: 75), the ritual context is distinct. Nordeide (2015: 178–180; Nordeide *et al*. 2020: 7) interprets the find as an offering of a vessel to prevent shipwrecks along an exposed coastline, ritual activity which also has elements of a fertility cult.

Although unlike the Danish offerings and Kvalsund in terms of context, the finds at Bårset and Rydningen highlight the importance of water as a medium of ritual communication. In the case of Bårset, water might link the bog to the sea as part of an extended seascape, whereas the bog pool at Rydningen could have provided a spiritual conduit between the mountains of the interior and the ocean below. Both sites may also be strategically located within a shared Sámi-Norse ritual landscape.

Boat planks with evidence of fastening techniques

Individual boat planks from the Late Iron Age have been found at two bog locations in northern Norway. Although restricted to a single boat part type, these finds provide valuable information on aspects of boat construction such as vessel size and origin, in addition to critical details regarding how planks were fastened to one another and to frames and scarfs.

Gildeskål oak plank

An oak boat plank, originally *c.* 2.2 m in length but now broken into three fragments ranging 58.0–98.0 cm in length, was found at the bottom of a bog at Indre Klauven, Sør-Fugløya, Gildeskål in 1936. The plank has a row of small treenail holes, *c.* 0.7 cm in diameter and 18.9–21.0 cm apart, located on a 1.5 cm wide smoothed surface for the lap between strakes. The plank is 0.7–1.0 cm thick and up to 11.0 cm wide, but it was originally wider, as one edge has been broken off. The plank thickness indicates that it was from a boat about 5.0 metres in length. A single radiocarbon date of 601–680 cal AD provides a rough age estimate, and the number of growth rings is insufficient for dendrochronological assessment. The use of oak indicates that the plank originated from a vessel which was built further south. Although the depositional context is unclear, the lack of waterworn surfaces argues against it being washed ashore.

Grunnfarnes boat planks

At Grunnfarnes on the island of Senja, a group of fragmentary boat planks were exposed by peat cutting in 1962. While the planks are not adjoining, they appear to be from the same vessel, and they were intentionally placed together, potentially for later reuse, at a depth of 27.0–28.0 cm in a 70.0 cm thick peat bog overlying beach sand and stones. A boat frame radiocarbon dated to the Bronze Age–Iron Age transition (598–402 cal BC) was found *c.* 10.0 m to the northwest (Wickler 2019: 192–193). Two plank fragments yielded overlapping radiocarbon dates with a collective age range of 332–574 cal AD spanning the Migration Period. Dendrochronological analysis of a third plank fragment recorded growth rings up until 709 AD, but given the lack of sapwood and the outermost rings of heartwood, it is reasonable to assess the plank as originating from a boat built no earlier than *c.* 800 AD (Kirchhefer 2013). The dendrochronological age estimate suggests that the two earlier radiocarbon dates reflect the 'old wood' problem for planks which were used several centuries later. This interpretation is supported by similarities in form and construction details between the planks.

The three main plank fragments are 1.9, 3.3 and 3.6 m in length (Figure 9.4A). Plank segments with intact edges range 20.0–23.0 cm in width and 1.0–1.5 cm in thickness. Plank thickness indicates they are from a small boat about 5.0–6.0 metres long. Vertical paired stitching holes 0.5–0.6 cm in diameter and spaced 0.7–1.0 cm apart extend along both plank edges with average distances ranging 15.0–17.5 cm between pairs. Although remains of 'rope' were reported in the stitching holes when the planks were found, no definite evidence of this was observed during later examination. However, plant fibres were likely used for stitching. Small wedge-shaped plugs used to hold the thread in place remain in some stitching holes. A concave lap moulding 2.5–3.0 cm wide where caulking was placed is present along the edge of three plank fragments. Rectangular cleats up to 13.0 × 7.5 cm in diameter and 1.5 cm high with single treenail holes *c.* 1.5 cm in diameter for fastening frames are preserved on several planks (Figure 9.4B). The

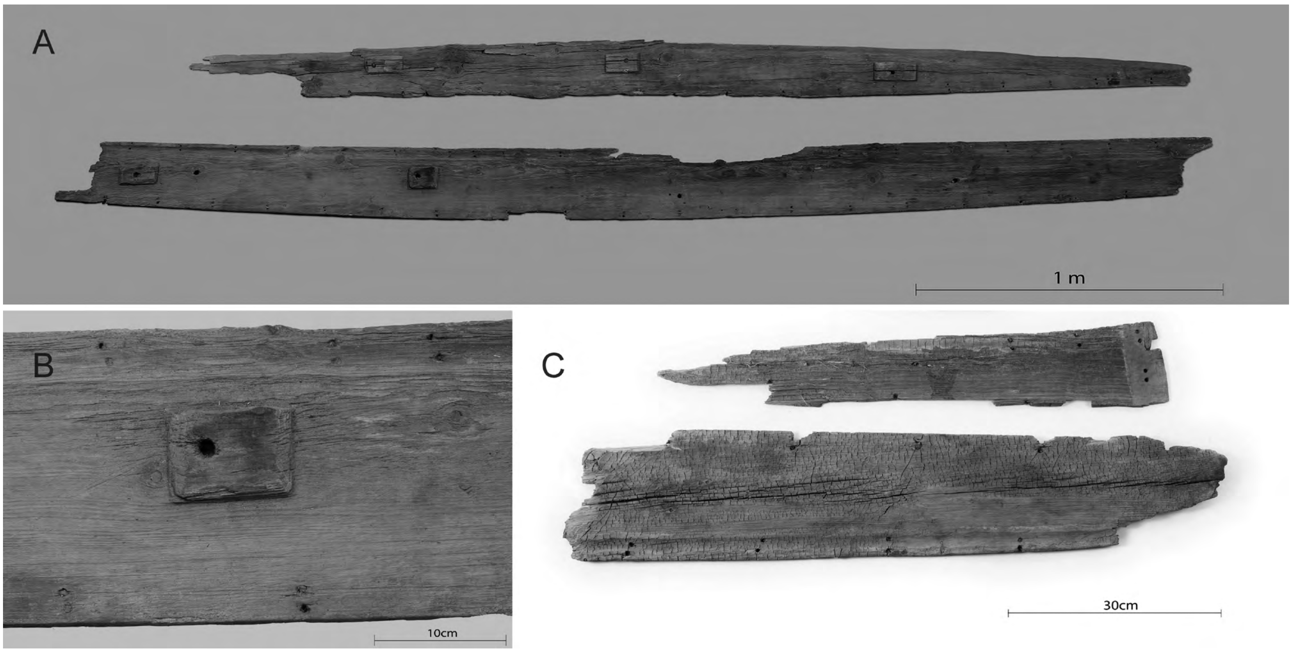

Figure 9.4. Grunnfarnes boat planks: A) the two largest plank fragments; B) closeup view of a cleat with treenail hole and paired stitching holes on the largest plank; C) smaller plank fragments, including a scarf with two pairs of stitching holes. Photos by Adnan Icagic, Arctic University Museum of Norway and used with permission.

distance between cleats is *c.* 82.0 cm, and two additional treenail holes without cleats spaced 77.0–85.0 cm apart were used for fastening frames closer to the stem, which did not require cleats. Scarfs are present on three plank fragments. The most complete is 5.2 cm long with two pairs of stitching holes 0.5–0.6 cm in diameter and 0.7 cm apart (Figure 9.4C).

Sewn boats in the Late Iron Age: northern cultural conservatism or nautical adaptability?

Four of the northern Norwegian bog boat finds from the Late Iron Age have evidence of sewing and other fastening techniques which provide insights into technological innovation and transformation (Table 9.2). The use of rivets as an alternative to sewing for fastening boat planks in Scandinavia is first documented at the Danish Nydam ship votive offering dated to *c.* 190 AD. Although the use of rivets may have expanded during the Early Iron Age in southern Scandinavia, sewing was still common, and it has been suggested that rivets were used in the ships of elite chieftains long before they became common in everyday boats (Christensen 2022: 59). As discussed above, the fragmentary Halsnøy boat, one of a handful of Early Iron Age boat remains in Norway, has sewn planks and lashed frames. While there is some evidence of riveted boats from boat burials in northern Norway by the early Merovingian Period, a significant percentage of these are hybrid vessels which combined the use of rivets with sewing. Hybridized boats of this type continue to be present in burials throughout the Viking Age, along with fully riveted vessels (Lund 2019). Bårset is currently the only bog boat within this category, although sewing is combined with the use of treenails and restricted to fastening the top two strakes.

The other three bog boat finds from northern Norway have sewn planks. The earliest is the Rydningen boat from Senja, which has been dated to the early Merovingian Period. This find is unique and represents the earliest known securely dated evidence for the use of continuous stitching in Scandinavia and Northern Fennoscandia. This type of stitching is also a distinguishing characteristic of traditional Sámi boats such as the bask used in eastern Finnmark (Westerdahl 2010: 331–333; Alava and Rantamäki 2016). The planks from Halsnøy, Grunnfarnes, Øksnes and Bårset are sewn with discrete discontinuous stitches through paired holes, which are vertical with the exception of the Bårset boat, where the paired holes are set at an angle. Small wedge-shaped pegs are driven into the stitching holes to hold the plant fibre thread in place, except for the Øksnes boat, where the stitches are knotted on the interior and lack pegs. The thread used for stitching appears to be exclusively from plant fibres which may be from tree roots, as is common in traditional Sámi boats, although this has yet to be confirmed by archaeobotanical identification. Caulking between planks consists of twisted/twined strands of wool in three of the boats and a tar-impregnated, woven-wool textile in the Halsnøy boat.

There are raised cleats with single holes for lashing frames on the planks of the Halsnøy and Bårset boats, and fragments of similar cleats are found on the Rydningen keel board. In contrast, the planks from Grunnfarnes and Øksnes were fastened to frames with treenails. The Grunnfarnes planks were fastened with treenails through holes both with and without raised cleats. Use of treenails is also a feature on strakes above the waterline on the Kvalsund ship, as well as the small boats from Kvalsund and Gokstad dating to approximately the same period as the northern Norwegian boats, although rivets are

Table 9.2. Construction details of selected bog boat finds in Norway with evidence of sewing.

Boat find	Frame fastening	Plank fastening	Sewing material	Caulking material	Scarf fastening
Halsnøy, western Norway	Single hole lashing	Discontinuous stitch, paired vertical holes	Bast string for rowlock, plant (root?) fibre	Wool textile: (pine) tar impregnated	Stitched to stem with (pine) tar impregnated fibre
Rydningen, Senja	Probable lashing	Continuous stitch, paired angled holes on plank / single hole on keel	Plant fibre (root?)	Twisted wool	Unknown
Grunnfarnes planks, Senja	Treenails	Discontinuous stitch, paired vertical holes	Unknown	Unknown	Sewn: double set of paired holes
Øksnes, Vesterålen	Treenails	Discontinuous stitch, paired vertical holes	Plant fibre (root?): knotted on interior	Twisted wool	Sewn: keel and stem
Bårset, northern Troms	Single hole lashing	Discontinuous stitch, paired angled holes / treenails / rivets	Plant fibre (root?)	Twisted wool	Rivets

used for fastening planks. Integrated cleats are used for reinforcement to insure sufficient plank thickness for treenails, particularly on the lower strakes (Shetelig and Johannessen 1929: 59; Planke *et al*. 2021: 289).

The replacement of frame lashing with treenails during the Late Iron Age is generally viewed as a technological advancement, while retention of support cleats for treenails is regarded as a vestige of an earlier developmental stage in which cleats were lashed to frames. This assessment fits with the notion that light rowed vessels such as those from Kvalsund and Bårset were old-fashioned relics, compared to real Viking ships with sails (Christensen 2022: 118–121). The significant number of sewn boats and the combination of sewing and treenails in northern Norway during the Late Iron Age do not fit the southern Scandinavian model, where sewing first disappears and lashing subsequently appears (Prins 1986: 35). The continuation of sewing in the north has been explained both as a consequence of iron being too costly and scarce for rivet production and as an expression of the conservative nature of northern society (Gjessing 1941: 54, 72; Christensen 2022: 60).

In some analyses, the association of sewing with the Sámi has been used to reinforce the idea that sewing is a primitive trait maintained in northern Norway long after it was abandoned in the south (see criticism in Wickler 2010: 353–354). Iron Age sewn boats with a running seam or continuous stitching found in areas with a predominantly Sámi population also tend to be interpreted as Sámi in origin (Larsson 2007: Ch. 5.4, 2015). Gjessing viewed sewing as a trait rooted in the ancient coastal Sámi culture (Norwegian *sjøfinnekulturen*), and this influenced his interpretation of both the Bårset and Øksnes boats. Westerdahl (1987: 28–31, 2010: 336) has suggested that both the Øksnes and Bårset boats were built by the Sámi. On the other hand, Pedersen (2002: 82–91) found no evidence of Sámi influence in the construction of either the Bårset or Øksnes boats, citing the use of separate rather than continuous stitching, which he claims to be a distinctive Norse trait. These views reflect a false dichotomy between Sámi and Norse boatbuilding traditions based on specific traits which misrepresent the true nature of ethnic interaction and coexistence in northern Norway.

The collective evidence suggests that Iron Age boats in Arctic Norway which are sewn and hybrid boats which combine sewing and rivets are both expressions of a shared Sámi-Norse boat building tradition which extends back to the Early Iron Age. The continued use of sewing in the Late Iron Age was neither conservative nor primitive, but rather, a reflection of active choices made by boatbuilders within multi-ethnic contexts for constructing watercraft which were seaworthy and best adapted to the seafaring conditions in the north.

Miscellaneous boat items

Some boat parts and boat-related objects are relatively small and not fastened down in the boat. These include thwarts placed on frames and floorboards on the bottom of the hull which can be removed easily. Bailers are also essential boat gear. These items are not commonly associated with archaeological boat finds, and their presence in bogs provides a rare opportunity to explore continuity and change in essential items still commonly used in traditional Norwegian clinker-built boats (Figure 9.5A).

Bøtnes thwart

In 1939, a rowing oar blade and a thwart were found about 1 m deep in a bog near the shoreline at Bøtnes on the island of Grøtøya along the outer coast of northern Troms. The finds have been mentioned in several earlier publications (*e.g.* Gjessing 1941: 61–62; Bratrein 1989: 148). The oar blade has been radiocarbon dated to 772–895 cal AD, and although Gjessing (1941: 62) identified it as a steering oar, it is an example of standardisation in rowing oar blade form during the Viking Age (Wickler 2019: 199). The thwart is made of radially cut pine and has been radiocarbon dated to the Merovingian Period (534–640 cal AD). It is 89.0 cm long, 15.0 cm wide and 2.0–2.5 cm thick, with a sub-rectangular cross-section and 8.0 cm end notches with 2.0–5.0 cm bevels on the underside to fit a frame (Figure 9.5B).

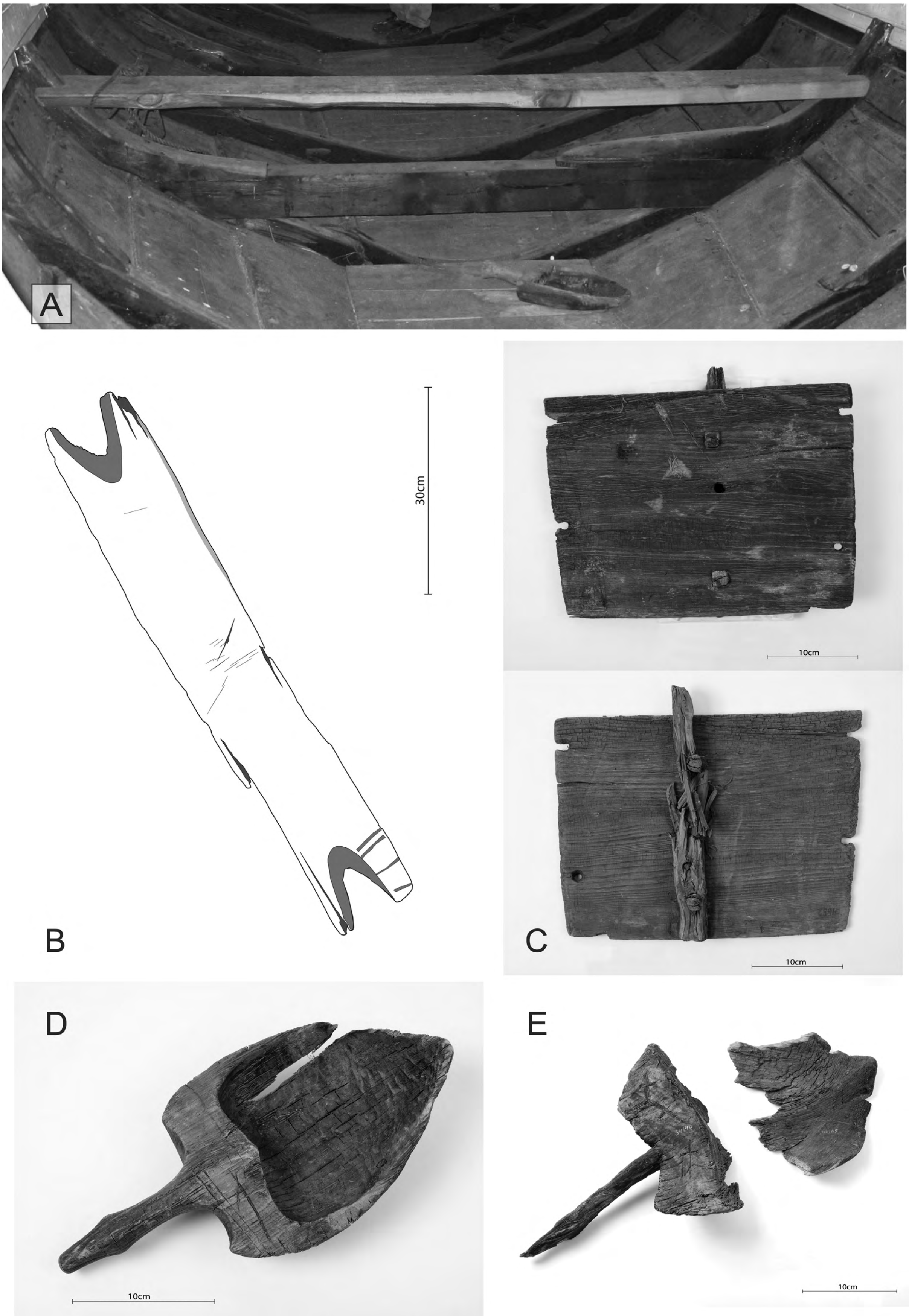

Figure 9.5. Miscellaneous boat items: A) traditional Norwegian clinker-built rowboat with a thwart, floorboards and bailer; B) underside of thwart from Bøtnes with beveled end notches and cut marks in the midsection; C) flooring board from Andenes viewed from top and bottom; D) boat bailer from Andenes; E) boat bailer from Myre settlement mound in Vesterålen. Photo A from Wikimedia Commons distributed under a Creative Commons license; Photos B–E by Adnan Icagic, Arctic University Museum of Norway and used with permission.

The thwart dimensions indicate that it was used in a small boat such as a *færing* with two sets of oars and frames about 1.3 m wide. Knife cut marks on the underside are suggestive of fishing bait preparation. Thwarts are rarely found with boat remains, as they are loose and easily removed. One exception is the two thwarts found in the tumulus over the grave chamber of the Gokstad ship burial from the early tenth century (Nicolaysen 1882: Pl. VII). These are associated with two of the three smaller boats found with the ship. The larger of the thwarts is from the mid-size 8.0 m long boat recently described by Planke *et al*. (2021: 290, Fig. 22). The smaller thwart is from the smallest boat, a 6.6 m long *færing* (Christensen 1959). This thwart is 106.0 × 15.0 × 3.0 cm with a 22.0 cm bevelled notch that closely resembles the Bøtnes thwart.

Andenes flooring board

A pine boat flooring board (Norwegian *plikt*) fragment was found 1.0 m deep at the bottom of a bog near Andenes on the island of Andøya in 1951. A radiocarbon date of 1025–1155 cal AD was obtained from a birch beam attached to the board. Based on the original description of the find, the object was larger and had more intact pieces when it was found than at present. The length was originally 47.0 cm but is now 24.0 cm (Figure 9.5C). It is interpreted as the floorboard from the compartment closest to the fore or aft stem (Norwegian *skottplikt*), and it tapers from 33.5 to 30.7 cm in width towards the stem. The board is 1.4 cm thick, and a fragmentary birch beam 27.5 cm long, 3.3 cm wide and 2.5 cm high is fastened to the centre of the floorboard with treenails. The inner end of the beam is broken off, and the outer end is cut flush with edge of the board. It was originally fastened with three treenails, and two remain in place. Both treenails are 1.5 cm in diameter and 3.0 cm high with wooden expansion wedges driven into them on the underside of the board. They have square 1.5 cm diameter heads flush with the upper surface of the board. There are two treenail holes with a diameter of 1.3 cm along both outer edges where two additional beams were previously located. The upper surface of the board has been smoothed by use wear.

The size of the flooring board indicates that it was used in a small boat. In traditional clinker-built vessels such as the Nordland boat, the flooring boards are placed with the beams resting on a lap joint between planks and against the plank above, although some are placed with the beams resting on the middle of a plank such as a broad garboard strake. Floorboards in Nordland boats were often made of recycled boat planks, and there was always a hole so they could be lifted, often a small one at the end (Eldjarn and Godal 1990: 157). The location of beams on the Andenes floorboard is unusual as there is a centre beam which must have been placed over the keel; this contrasts with traditional boats, where there are two beams closer to the edges which rested on planks.

As with thwarts, very few boat finds have floorboards present, as these were often loose and easily removed or displaced. The numerous floorboards from the Oseberg and Gokstad ships were fastened to the cross beams. There is a single loose flooring board associated with one of the smaller Gokstad boats (Planke *et al*. 2021: 290, Fig. 22). It has two equally spaced beams in the midsection and part of a hole taken out in the middle to lift the board as well as graffiti of stem profiles cut into the upper surface.

Boat bailers

In 1955, a pinewood boat bailer was found about 1.2 m deep in a bog near Andenes on the island of Andøya. It has been radiocarbon dated to 1210–1290 cal AD in the high Mediaeval period. The bailer has a total length of 31.5 cm, width of 15.5 cm and height of 6.5 cm. The handle is 11.0 cm long, 2.0 cm wide and 2.5 cm thick in the centre (Figure 9.5D). It was made from a split log and has a heart shaped rim with rounded bottom and a pointed end which is slightly upcurved in profile. The heart-shaped form has two chambers which reduces the energy required to bail out water. The handle has a semi-circular profile angled slightly downward to optimise grip and avoid slipping during use. A slight bulge near the end of the handle creates the impression of the head and bill of a large goose-like bird in flight. The bailer displays a high level of craftmanship which is both aesthetically pleasing and highly functional. There is also evidence of considerable use wear around the sides of the bailer tip from contact with lap joints between planks on both sides of keel at the same time. Traditional boatbuilder Gunnar Eldjarn (2002) provides a detailed description of the bailer, and he notes that similar early finds are known from Bergen and the Danish Viking Age trading centre of Hedeby.

A second bailer most likely dating to the Mediaeval period was found in a settlement mound cultural deposit at Myre in Øksnes, Vesterålen around 1955. Although this is not a bog find, preservation conditions in settlement mound deposits resemble bogs due to the significant quantities of peat used in house construction. The bailer consists of fragments from the front and back end with a long, thin handle. The back end is 24.0 cm long, 20.5 cm wide and 6.7 cm high with an 18.0 cm long handle. The front-end fragment is 15.5 cm long and 17.5 cm wide (Figure 9.5E). Two owner's mark symbols are carved into the top of the back-end fragment. The first consists of three prongs with lengths of 2.5–3.0 cm radiating from a central point. The prongs are crossed by short perpendicular lines *c.* 1.0 cm from the ends, forming three joined crosses. The second mark is a cross form with two angled lines extending from the lower end to form a three-pronged fork. The use of owners' marks reached its greatest extent in Europe in the late sixteenth century and declined in the seventeenth century, as the use of initials became more common (Cappelen 2005).

Spades originally identified as paddles

Several objects found in bogs appeared to be associated with boats but proved to be unrelated following more detailed examinations. These include spades originally identified as paddles. Although not boat-related, their description is useful as it points out traits which enable spades, as objects sometimes associated with boat finds, to be distinguished from paddles. Spades are utilitarian objects associated with peat cutting and other tasks typically associated with bog contexts. Wooden spades roughly resemble paddles in their shapes and sizes, so the two are easily confused.

Two spades were found at the bottom of bogs. They were most likely made of willow (*Salix caprea*), although botanical identification cannot rule out aspen (*Populus tremula*). Although originally identified as paddles, the tree species used, general appearance and blade shape make this assignment unlikely. The spades are both radiocarbon dated to the high Mediaeval period, while the most recent pre-modern paddle known from northern Norway is dated to the second millennium BC (Wickler 2019: 190–191). Historically, willow wood (Norwegian *selja*) was used for skis, rake handles and other utilitarian objects, but are not for paddles. The spades are similar to each other in appearance, and both were made from tree trunks with the heartwood centrally placed. The larger of the two spades was found in 1906 at the base of a bog about 2.0 m below the surface in the vicinity of Andenes on Andøya Island, and it has been radiocarbon dated to 1300–1370 cal AD. It is complete, with a total length of 114.0 cm and a 43.0 × 12.0 cm blade (Figure 9.6A). The second spade was found in 1886 below a bog deposit at a depth of 81.0 cm at Sneisa, Lødingen. It is 67.0 cm long with a 23.5 × 10.0 cm blade and an incomplete handle 39.0 cm long (Figure 9.6B).

It is unclear how the spades were deposited, but deposition must have occurred at the start of bog formation in locations some distance from the shoreline. The spades may have been used for turf cutting or moving soil in the general area. Although spades have been found in bogs at other locations, these are the only examples known from northern Norway. Well-preserved oak spades were recovered from the Viking Age ship burials at Oseberg, Gokstad and Tune. These include several from the original burial contexts and a substantial number from grave plundering of the Oseberg and Gokstad mounds during the tenth century (Bill and Daly 2012). At least one of the spades from the Oseberg break-in closely resembles the spade from Andenes, with a total length of 100.0 cm and a blade that is 40.0 × 16.0 cm (Bill and Daly 2012: Fig. 2).

Conclusion

The abundance of well-preserved bog boat finds in northern Norway dating to the Late Iron Age provides a rare opportunity to document a wide variety of boat-related material which is not otherwise present in the archaeological record. It is also striking to consider how many additional bog finds of considerable age were undoubted lost over the years, as they were neither retrieved by the finders nor added to museum collections; this may be due in part to their excellent preservation in bog conditions, which gives objects a misleadingly modern appearance. The study presented here opens a window not only on the extent of the variation in boat construction during the Iron Age in Norway, but also the technological continuity over time. Most importantly, this study expands the material evidence of what boats were like and how they were used in the north.

Arctic Norway has long been viewed as a peripheral and passive recipient of boat knowledge from the south, rather than recognised as a centre of maritime innovation and adaptability in its own right, a status clearly supported by the bog boat evidence. Northern boat-building has also been subject to inaccurate and prejudicial misconceptions, such as the claim that the continued prevalence of sewing was due to a lack of economic resources for boat rivets coupled with societal conservatism. Contrary to these assumptions, the continued practice of sewing and the hybridisation which combined sewing with treenails and rivets were expressions of maritime proficiency and skill, in which vessels were adapted to features along an exposed coastline with demanding seafaring conditions. Boat-building technologies also reflect a shared Sámi-Norse tradition developed over many centuries. Acknowledging this shared identity is more productive than continuing to label specific traits as ethnic identifiers.

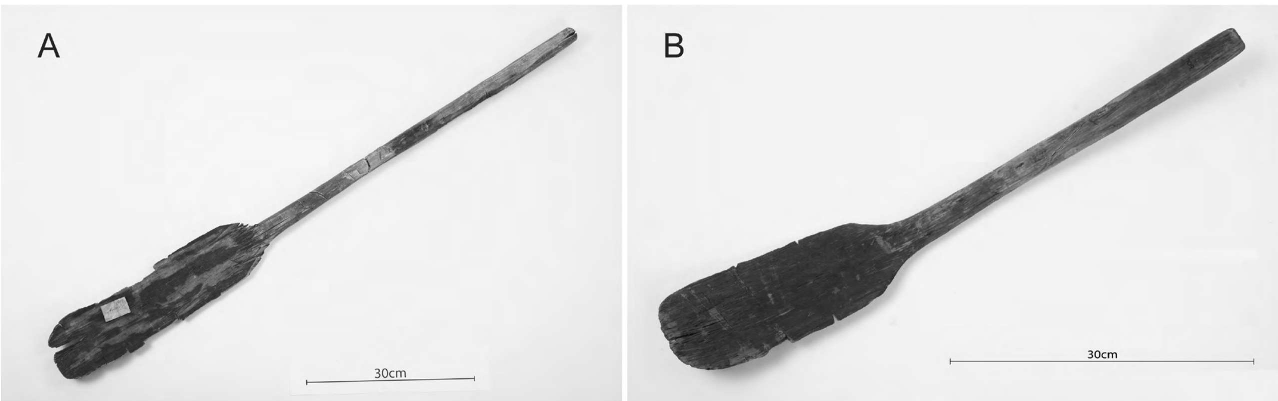

Figure 9.6. Spades found in bogs: A) Andenes, Andøya; B) Sneisa, Lødingen. Photos by Adnan Icagic, Arctic University Museum of Norway and used with permission.

The well-preserved bog boat finds discussed here provide a wealth of new insights into the importance of boats for maritime communities in the north, revealing how elements of nautical technology were interwoven to meet the challenges of the sea.

The key role of boats in both mundane and spiritual aspects of life in Arctic Norway is demonstrated by their ritual deposition in bogs. Insights into the meaning of boat burials and votive offerings of boats are the major contributions of the evidence presented here. A mixture of Sámi and Norse ethnic identities played an important role in ritual expressions such as the Bårset and Rydningen votive offerings. Although boat offerings from the early Iron Age in Denmark and Kvalsund in western Norway represent distinctly different ritual contexts, water is the shared element of central importance in all these contexts.

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10

Gribshunden in perspective: a castle on the sea

Brendan Foley and Martin Hansson

Abstract: The royal Danish-Norwegian flagship *Gribshunden,* launched in 1485, was among the earliest northern European warships purpose-built to carry artillery. However, King Hans employed his vessel as far more than a weapons platform. The ship was his 'floating castle', fulfilling all the various purposes of a land redoubt. At its loss in 1495 enroute to a political summit in Kalmar, where Hans expected to be crowned king of Sweden, it was his mobile seat of government, an instrument combining hard and soft power functions. Recent excavations of *Gribshunden* reveal its martial aspects: artillery, small arms (including several crossbows and hand guns) and personal armour. Soft power is reflected more subtly in other artefacts: silver coins; secular artwork depicting flowers, animals and mythical beasts; and prestige provisions, including copious amounts of exotic imported spices and a large sturgeon. Continuing excavations of the wreck are revealing the structure of the ship itself, while providing insights into the social division of space aboard this royal castle at sea. Combined with archival documents, analyses of all these artefacts deliver deep insight into the people aboard the ship and the late Mediaeval period through which they travelled.

Introduction

In the waning decades of the late Mediaeval period,[1] European adoption of a fundamentally disruptive technology contributed to a re-ordering of the world. Often referred to as a 'floating castle', this innovation fused Mediterranean and northern European design and construction styles to create the artillery-carrying ship (Unger 1981; Gardner 1994; Adams 2003; Eriksson 2020; Adams and Rönnby 2022). Vessels of this type conveyed European explorers on direct voyages to the most distant points of the globe, catalysing a race to seize territory and build colonial empires. Within Europe, ships carrying gunpowder weapons formed the core of emerging nation-states' naval fleets from the end of the fifteenth century. These ships were technological agents in the tumultuous changes sweeping through societies at the dawn of the modern era. Archaeological study of their remains—and more particularly, their contents—offers a portal into the late Mediaeval universe, granting us the possibility of understanding the historical trajectories which led to the world as we now experience it. While the military functions of these warships have attracted ample attention (Cipolla 1965; Padfield 1973; Caruana 1994; Hildred 2011), we contend that their range of uses extended far beyond this narrow utility. However, despite their stout construction, the archaeological record offers scant physical evidence of these machines (Castro 2008; Mearns *et al*. 2016).

The finest archaeological example of a late Mediaeval floating castle is the wreck of *Gribshunden*, flagship of the Danish-Norwegian King Hans (1481/83–1513). This shipwreck presents to archaeologists the opportunity to extend the interpretation of this style of vessel far beyond its use as a warship. Hans employed his new ship as an instrument of royal power in all of its complexity. Scholars of international affairs describe power as 'the ability to get others to do what they otherwise would not' (Nye 1990: 177, citing Dahl 1961). Hard power is coercive because it threatens violence. Soft power is more subtle, and entails economic, cultural and social conditioning. When competently harnessed over time, soft power can be more effective and long-lasting in obtaining political ends. Historical documents and archaeological artefacts relating to *Gribshunden* offer clues about King Hans' hard and soft power tactics in pursuit of his political goals.

The loss of *Gribshunden*

The circumstances of *Gribshunden*'s final voyage and the direct reasons for its loss are worthy of some discussion. The ship sank at anchor following an explosion in the summer of 1495, while the king sailed to a political summit in Kalmar where he expected to gain the Swedish crown. The meeting was a major event along the decades-long trajectory of conflict in the Nordic region. Sailing alongside the flagship was a squadron containing the Norwegian Council and many of the Danish nobility and senior clergy. At the Kalmar summit, Hans would make

[1] The date for the conclusion of the 'Mediaeval period' varies according to region and the scholar discussing the topic. While the Renaissance might have started in the mid-to-late 1400s in the Mediterranean and southern Europe, in the Nordic region, the Mediaeval period is widely considered to have continued until the Protestant Reformation which began in 1517.

every attempt to cajole the Swedish Council into electing him king of Sweden, thereby fulfilling his great ambition to re-unify Denmark, Norway and Sweden into a single political entity: a greater Danish nation-state (Gustafsson 2006). Hans was ready to employ every tactic to bring this to fruition.

For reasons not recorded, *Gribshunden* and some other vessels moored in the protected waters of the archipelago near Ronneby, in the Blekinge region. This was Danish territory at the time. Perhaps Hans intended to visit the town and its church, either by travelling over land or more likely, traversing the shallow waters and narrow passages in a smaller boat. A few written sources of the time briefly recount the events which follow, but each source is problematic in some way, and archaeological evidence does not support many of the contentions made in the accounts. One is a letter written many years after the event by Tyge Krabbe, a Danish nobleman who would have been a teenager in 1495. He claimed to have been present for the events at Stora Ekön, but eyewitness testimony is often flawed. In his short description, he claims the wrong year for the event. He also avers that the fire on the ship claimed many lives; so far, neither human remains nor evidence of fire has emerged from the wreck. Another account comes from *Sturekroniken*, a chronicle in verse of Swedish regent and rival to Hans, Sten Sture the Elder. An inclination towards propaganda is clear; this account describes loss of at least two other ships in the same event. A third, self-contradictory, account was written in a Danish history more than 60 years after the loss of the vessel. Two other versions of events come from Hanse towns, Lubeck and Danzig, but like the others, they are short on details (Huitfeldt 1599; Weinreich 1855; Christensen 1912; Zeeberg 2003; Nordquist 2015; Rönnby *et al*. 2015). Nevertheless, from these passages and the archaeological evidence, we can speculate on the sequence of events which led to the destruction of the ship.

A plausible scenario is that King Hans took the opportunity of the transit from Copenhagen to Kalmar to make stops along the way, in order to show his flag and prized ship in towns throughout his lands. The Stora Ekön anchorage where the ship sank is easily reached from the open Baltic, and the island and nearby mainland provide a lee from all winds and rough seas. Hans and a retinue may have put out in small boats to visit Ronneby, some 10 km distant through the archipelago and up river. The travel to and from town and activities while there would have taken more than a day, leaving time for the crew of *Gribshunden* to perform tasks more easily accomplished while at anchor than in a seaway. Among these tasks might have been maintenance of the gunpowder stores, and repositioning of casks in the hold of the ship. For some reason, an explosion occurred. One source suggests it could have been due to a lightning strike; others say fire broke out and eventually detonated the gunpowder stores. There is no evidence of fire on any of the ship's timbers or artefacts, though future excavation may reveal charring on elements not yet exposed (Foley 2022). The archaeological evidence and disorder of the port quarter suggests an explosion below the waterline, which might have been enough to blast open the hull outright, or might only have sprung planks to permit uncontrolled flooding (Figure 10.1). During the 2022 field campaign, the archaeological team may have discerned the first indirect evidence of this explosion. From the locus of the tiller, two partially deformed lead/iron composite artillery shot both showed flattening and scoring on one side. Perhaps these shot were stored near the source of the explosion, and were flung against the interior of the ship during the event (Jahrehorn 2023).

With continued excavation, it may be possible to identify the exact locus of the explosion which sank the ship. The archaeological evidence may paint a clearer picture of the ship's loss. More importantly, continued study will reveal more facets of King' Hans utilisation of *Gribshunden* before its destruction. Our goal is to propel maritime archaeology beyond the biography of this ship by embracing new interpretative methods, thereby encouraging broader perceptions of shipwrecks.

Castles and ships in archaeo/historiographical trends

Maritime archaeology in Scandinavia has a long history. The excellent preservation of shipwrecks in the Baltic Sea has generated studies of their hulls and construction techniques; the best-known example is the *Vasa*, a seventeenth-century Swedish warship. However, maritime archaeology could be criticised for its practitioners' narrow focus on technical aspects of shipbuilding. Compared to land archaeology, underwater archaeology in Scandinavia has relied on a narrative historical approach seldom grounded in a specific theoretical frame (Cederlund 1995; Eriksson 2020). Only recently have maritime archaeological studies expanded beyond descriptive particulars of ship construction. For example, one scholar has shown how an archaeology of buildings on land can be used as a theoretical and methodological framework when studying social structure and hierarchical spaces onboard ships (Eriksson 2014). This is the rich vein to mine with *Gribshunden* and other sites.

The physical arrangement of *Gribshunden* invites comparison with monumental architecture on land, where a historiographical trajectory similar to that of warships is evident. Though Mediaeval castles have been an important subject for historical, art-historical and archaeological research since the nineteenth century, during most of this period, castles were mainly seen as military structures: defensible strongholds able to resist sieges. Beginning in the 1980s, a more nuanced view of the castle landscape emerged which recognised its importance in society. Scholars increasingly rejected the previous narrow reading of castles as isolated monuments. Instead, castles were argued to have been one of several elements in a complex web of social and economic relationships aimed at organising the use of the natural environment and its resources. In the last 25 years, a still broader perspective on castles has emerged, with far greater notice taken of

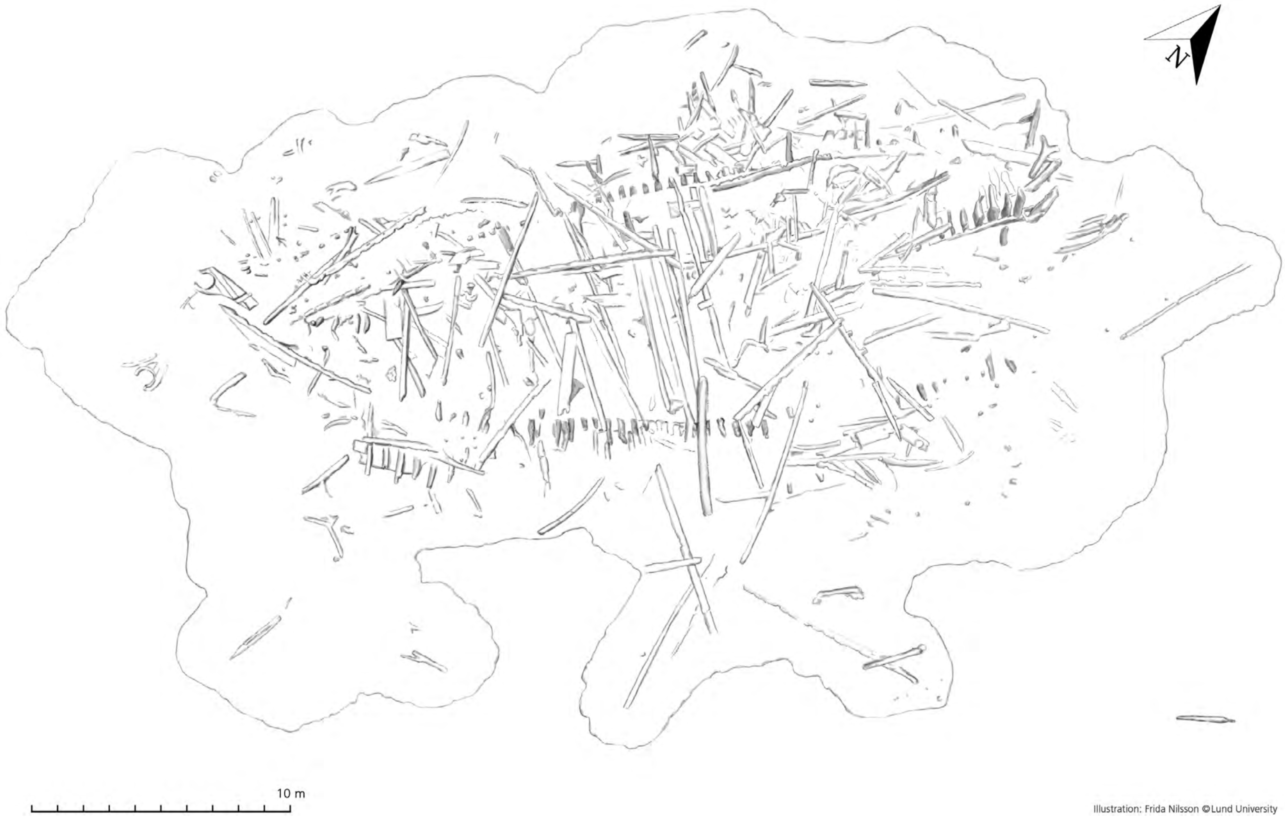

Figure 10.1. Site plan of *Gribshunden* shipwreck, derived from photogrammetric model. Illustration by Frida Nilsson, MediaTryck/Lund University.

castles' soft power functions (Austin 1998; Hansson 2006; Creighton 2009). Castles are increasingly understood as multifunctional loci, just as much administrative and social centres as symbols of military power.

These citadels were secular cathedrals, intended to exalt the lord (of the castle) and convey strength, authority and permanence. Castle builders imagined and created the total environs of the fortress. The layout of castles emphasised not only defensive battlements, but also external sightlines and vistas. Constructed waterways were vital elements of castles: when castles were not positioned directly on shorefronts, their architects incorporated surrounding moats and artificial lakes to improve their defences. In many cases, the waterways enhanced the visual impact of the castles, making them appear as if they were floating (Johnson 2002). Defensive elements such as berms, revetments, plains and water-filled moats also served other ends. Open fields doubled as gardens, tournament grounds and gathering places for events. Watercourses supported wild game, encouraging the nobleman's pastime of hunting. Artificial lakes contributed to illusions, creating the visual effect of the huge stone structures floating on the water's surface. Ultimately, castles were physical expressions of military, political, economic and social authority critical to maintaining elites' status (Hansson 2006, 2015).

Gribshunden can be considered in the same light. It, too, was monumental architecture, though of wood rather than stone. We have begun to reconstruct the physical form of the ship. Digital modelling of the rudder, tiller, tiller arch, stempost, knees and hawse pieces have provided substantial information about the dimensions and appearance of the vessel (Figure 10.2). Each of these elements was sequentially lifted from the seafloor in 2022, placed on underwater supports and 3D-modelled with photogrammetry. A selection of elements was recovered to the surface for further 3D modelling with structured light scanners and photogrammetry in air. The tiller and a gun bed were retained for conservation and further study, and ultimately exhibited alongside the figurehead and other artefacts previously recovered (Figure 10.3). All the other ship elements were replaced in their original positions within the wreck site, with the exception of the tiller arch, which was buried *in situ* to improve its preservation (Björk and Foley 2023). Combining these elements with *in situ* measurements of other structures, we derived key dimensions. The keel length is approximately 25.5 m. The length overall would have been greater: the sternpost raked approximately 15 degrees, and the stem curved upwards from the keel and would have been topped with a forecastle which extended forward from it. The rudder length measures 6.5 m, and the tiller attached near its top. The steeridge (or steering compartment) containing this tiller was possibly positioned on the third deck level. The tiller as preserved is 2.1 m long. The inboard end is broken, but a large rebate provides the socket for an extension. If *Gribshunden*'s steering gear was similar to

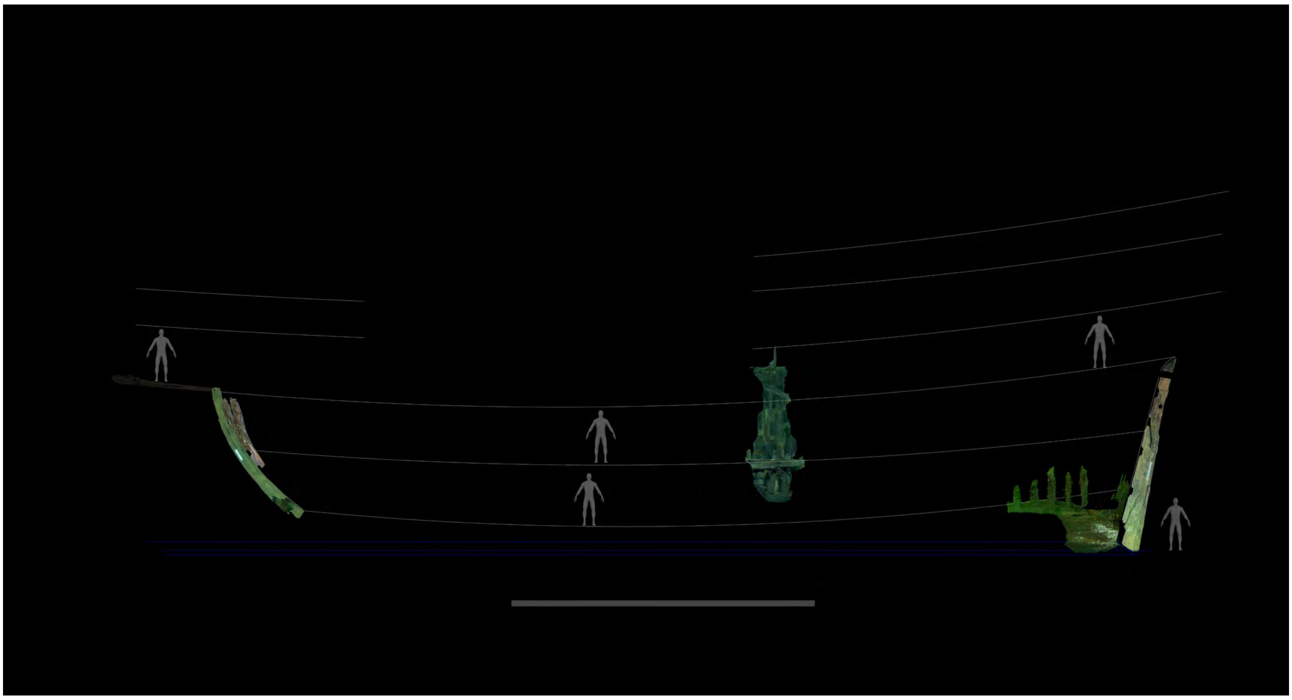

Figure 10.2. Conjectural elevation view of *Gribshunden*, derived from photogrammetric models of key features. Image by Mikkel Haugstrup Thomsen, *Gribshunden* Project, Lund University/Blekinge Museum/Vikingeskibsmuseet.

Figure 10.3. The tiller of *Gribshunden*, prepared for photogrammetric modelling underwater prior to recovery. Image by Brett Seymour, *Gribshunden* Project Lund University/Blekinge Museum/Vikingeskibsmuseet.

that of later warships like *Vasa*, this extension might have connected to a rowle and whipstaff. The whipstaff would have terminated on another deck above the steeridge (Pipping 2000; Harland 2011). The curved forward edge at the head of the rudder would have matched an overhang for that deck. Perhaps yet another deck rose above that level, potentially bring the distance from keel to the upper extreme of the sterncastle to 12 metres or more. For comparison, the sterncastle of the *Mary Rose* (1545) had three decks above steeridge (Marsden 2009). We expect our continued excavation of *Gribshunden* will deliver more information on these points.

The physical structure and hard power aspects of *Gribshunden* are necessary interpretative points; however, they are not the focus of the thoughts presented here. A full examination concerning the military gear found on the wreck and the ship as an integrated weapons system will be published in a dedicated manuscript now in preparation by the authors and their colleagues. In brief, the first archaeological investigations of the ship and the excavations conducted 2019–2022 show *Gribshunden* was a carvel-built hull topped with light lapstrake superstructures (Einarsson and Wallbom 2001, 2002; Einarsson and Gainsford 2007; Rönnby *et al*. 2015; Björk and Foley 2023). In later generations, such a hull would have been pierced with gunports, but none have yet been found on this ship. Instead, several wrought-iron swivel guns would have been positioned in the high castles fore and aft, and along the gunwale of the low waist. While very large contemporary English warships carried as many as 140 or even 225 guns, historical documents suggest *Gribshunden* was equipped with perhaps 68 guns (Oppenheim 1896; Barfod 1990). Remains of 14 guns have been located during archaeological surveys, with 11 of their oak gun beds recovered since 2002 (Figure 10.4). The forecastle topped and projected from a curving stem, while another castle sat over the raked stern. These castles provided elevation from which artillery fired composite lead/iron projectiles about the size of golf balls, 31–47 mm in diameter. The castles also provided some cover for soldiers armed with handguns and crossbows like those recovered in our excavations (Einarsson and Wallbom 2002; Foley 2021, 2022; Björk and Foley 2023). The ship would have presented a formidable appearance, and that was perhaps deterrent enough. The best weapon is the one which never has to be used; there is no record of *Gribshunden* ever engaging in combat actions. While problems persisted with piratical raids at sea, Denmark was not openly at war until some years after this ship sank.

Gribshunden as a floating castle

Hans was ashore when calamity struck *Gribshunden*, but despite this massive setback, he continued on to the weeks-long meeting in Kalmar. Hans' loss is our gain: the detonation consigned to the bottom a royal inventory of objects which together symbolised the authority, wealth and cultural power of a late Mediaeval monarch. From the artefacts recovered in the excavation, we begin to glimpse the mechanisms through which late Mediaeval elites constructed their place in the social hierarchy, and solidified their dominance. Many of the *Gribshunden* artefacts can be described as *barometerobjekte* (Hundsbichler *et al*. 1982), objects characteristic for a specific social strata in society, like the nobility. These objects encompassed not only different types of luxurious and exotic items used for drinking, dining and clothing, but also weaponry and objects which were part of the interior design of castles and manors. Display of *barometerobjekte* was one way the late Mediaeval aristocracy distinguished itself from the rest of the population, but there were other methods. Knowledge of the Latin language was an indicator of social status. Leisure activities such as hunting and high-stakes gambling further distinguished the elite from the masses. Access to rarified spaces, where entry was forbidden to all except the nobility and their servants, was yet another means of maintaining hierarchy (Duby 1977; Crouch 1992; Hansson 2006). *Gribshunden* offers glimpses of all of these practices, especially when compared to land castles, and study of this ship opens a path to a richer maritime archaeological practice in the Nordic region.

Excavation within and reconstruction of the sterncastle would enable a more detailed view of Hans' use of *Gribshunden*. A topic of active speculation is this: where would Hans and his closest companions have berthed and congregated, and can we find archaeological evidence for it? A compartment on the deck above or forward of the steeridge is one possibility. In later periods, this was the location of the cabins occupied by the captain and commodore; traditions must start somewhere. At first glance, the entire stern section of the wreck is a jumbled mess (Figure 10.1). This disruption might have been caused by the explosion which sank the vessel. It might also be due, in part, to the dismantling of this part of the ship during the salvage operations which commenced soon after the loss, when, according to one historical source, many of Hans' possessions were reclaimed (Zeeberg n.d.). We trust that meticulous archaeological investigation will untangle the disorder.

Soft power at sea: social division of space

If Hans utilised his ship similarly to a land castle, then he might have reserved certain spaces for himself or selected companions. Privacy and status of the castle inhabitants were enforced by concentric areas of selective access, from semi-public outside the walls to intimate interior spaces reserved for only the castle owners and their private servants. Put succinctly, spatial distance signified social distance, and proximity was power (Hansson 2006). Detailed understanding of the interior spaces of Mediaeval castles escapes us because the objects contained within them have vanished through the centuries. *Gribshunden* offers the prospect of repopulating those exclusive environs, through the artefacts still contained within the wreck site. On a vessel which carried perhaps 150 people on its final voyage and was only 35 m in length overall, this level of privacy might simply have been impractical and impossible (Weinreich 1855). Whatever the daily social separation might have been at sea, Hans on certain occasions sought interaction with selected individuals.

Evidence for this comes not (yet) from the archaeological remains, but from historical sources. Records of royal expenses relating to Hans' spring 1487 voyage on *Gribshunden* to Gotland are illuminating.

Figure 10.4. Ten of the gun beds recovered from *Gribshunden* during operations in 2002 and 2021. Image by Ruth Rynas Brown, *Gribshunden* Project Lund University/Blekinge Museum/Vikingeskibsmuseet.

The mission's purpose was political: uncertain of the loyalty of the nobleman in Visborg castle, Hans forcibly ejected Ivar Axelsen Thott and replaced him with his own man, Jens Holgerson Ulfstand, a member of one the most powerful families in Denmark in the late fifteenth century (Wallin 1979). King Hans sent a fleet to Gotland, and followed soon after on his flagship. Contrary storm winds caused delay, and the ship waited for better weather outside of Copenhagen. During this lull, the king and his companions killed time with amusements typical of their class. On *Gribshunden*, this diversion was gambling with cards. Accounting records show Hans lost substantial amounts to his comrades, with six payouts, each between two and 16 marks. From the perspective of anyone but the richest aristocrats, these pots were large. For comparison, the three senior officers of *Gribshunden* received a salary of four marks each month; the salary of the admiral of Hans' fleet, Tonnius, was 20 marks each month (Wegener 1864; Ingvardson *et al*. 2022). Hans was not gambling with his ship's officers: the only men who could afford to buy into his table and also had the necessary social stature to do so were nobles.

The card games aboard *Gribshunden* reveal the stratification of Nordic society, and also a means by which members of the wealthiest class differentiated themselves. They show that the king was the first among the nobility, but not at all isolated from them. The fact that noblemen would gamble with the king speaks to their relationships and their wealth. One would not want to win too much from the ruler; at the same time, one could not lose too much, either. To play at that table, one had to be willing to spend. The stakes in these games would have been extravagant to a ship's officer and everyone below that status, but they would not have seemed exorbitant to the people in Hans' social stratum. Appearing in the accounts for Hans' voyages on *Gribshunden* are several wealthy and/or noble Danish families: Ulfstand, Gyldenstjerne, Urne, Walkendorff, Hardenberg and Laxmand (Wegener 1864). As an example of the resources commanded by these clans, Poul Laxmand ruthlessly acquired 900 farms during his lifetime, putting him foremost among landowners in Hans' kingdom. Laxmand's aggressive and possibly underhanded tactics caused outrage, and in 1502, two noblemen stabbed him and threw his body off a bridge in Copenhagen. King Hans did not order the arrest of the assassins. Instead, he insinuated that Laxmand had committed treason by dealing secretly with the (now enemy) Swedes, and seized all of his properties (Dalgård 2000). Ultimately, when gambling with the king, the house always wins.

If Hans or his companions on *Gribshunden's* 1495 voyage carried large amounts of money with them for gambling or other purposes, it has not yet appeared on the wreck. Limited excavation of *Gribshunden* so far has delivered about 200 silver *hvid* coins, most of which were apparently contained in a single pouch or purse (Figure 10.5). This is a rare example of a hoard of 'active money', differing from the usual situations of caches buried as savings or votive offerings (Märcher 2012; Ingvardson 2018). It is also a unique example of coinage certainly sanctioned by the issuing king. This combination of factors is uncommon, and provides new interpretive possibilities.

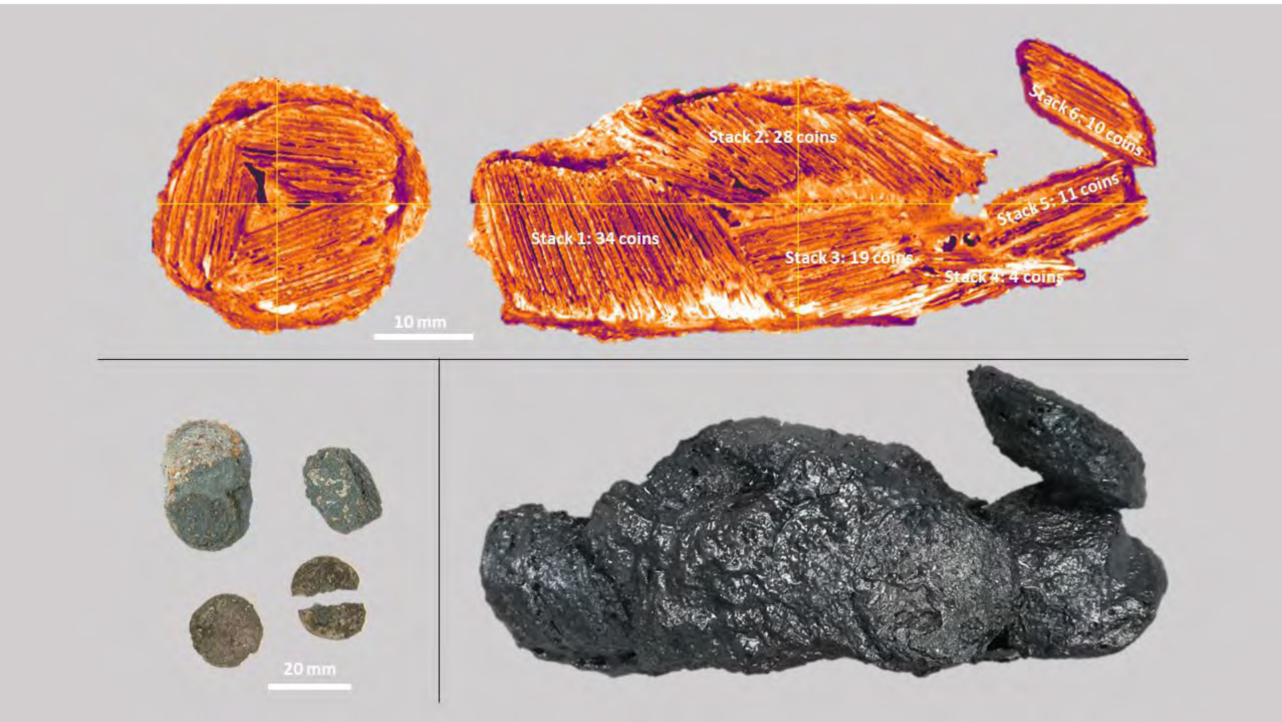

Figure 10.5a. Top: Computed Tomography (CT) image of silver coin concretions from *Gribshunden*. Image: Gitte Ingvardson, Dirk Muter and Brendan Foley. Bottom: small and large concretions. Images by (left) Max Jahrehorn, Oxider and (right) Anders Henk, Danish National Museum.

Figure 10.5b. Left: CT image of coin motif from concretion. Image: Gitte Ingvardson, Dirk Muter and Brendan Foley. Right: A similar Danish *hvid* coin from the Blekinge Museum collection, minted in Malmo during King Hans' reign. Image by Brendan Foley, Lund University/Blekinge Museum.

Gribshunden and soft power: economics

The recovered coins are concreted and badly degraded, too fragile for mechanical separation. To identify them, we have relied instead on Microscale Computer Tomography (μCT). Our interpretation of this purse is that it belonged to one of the officers of the ship, or perhaps a mid-to-upper level mercenary (Ingvardson *et al*. 2022). The first revelation is that the coins in this purse are all from the Danish realm, including Norway and Gotland. Second, the coins were drawn not only from new issues of *hvids*, but from previous regimes. Some of the coins were newly minted during Hans' reign. Others are older, dating from the reigns of Hans' father, Christian I, and possibly his predecessor, Christoffer III. The conclusion which can be drawn is that the Danish kings did not always recall coinage when they ascended to the throne. Even if they devalued their coins by altering the ratio of copper and silver in new issues, they also permitted older coins to stay in circulation. Also notable is that the motifs on *hvid* coins are remarkably similar throughout time, featuring the first letter of the king's name on the obverse: for Christoffer or Christian, a crowned 'k' (in the font of the time, its appearance resembles a modern 'R'), and for Hans, a crowned 'h'. At a glance, it is difficult to discern which king issued the coin, suggesting a desire for continuity in the royal lineage. Another feature of the coins is a blending of high and low culture. Around the outside of both obverse and reverse of Hans' coins, Latin script (abbreviated) spells out the monarch and the city of the mint. For Hans' *hvid* coins minted in Malmo, the obverse inscription read: IOhES:D:G:R:DACIE. Translated and expanded, this read: Johannes [Latin for Hans] (by) Grace (of) God King (of) Denmark. The use of Latin links Hans to the Catholic Church and the Christian god. The reverse read: MOn | MAL | MOI | EnS |. As translated and expanded, this reads: Coin (of the City of) Malmø. The central character of the obverse is the 'h' for Hans, the Danish version of his name, complementing the high status and Latin lettering around the perimeter of the coin (Ingvardson *et al*. 2022). The combination of the Latin and Danish languages is also seen in correspondence between the king and his noble subjects: salutations were penned exclusively in Latin, while the bodies of letters were written in Danish (Christensen 1912).

Gribshunden played a role in the creation of the coins minted in Norway during Hans' reign, and provides a view into the fusion of soft and hard power in late Mediaeval Scandinavia. In spring 1486, soon after taking possession of the ship, King Hans sailed to Bergen, the site of one of the mints Hans had chartered in his coronation *håndfæstning*. Presumably on this and subsequent visits, he or his delegate would have inspected the coin production facilities. The 2019 *Gribshunden* excavation revealed the earliest known coins from the Norwegian mints, establishing their production earlier than 1495 (Wegener 1864; Ingvardson *et al*. 2022). The increase in Hans' coin production is another example of his soft power capabilities. Not only did he establish mints in Norway, he simultaneously created new mints in the Danish cites of Copenhagen and Aalborg. Further, he ordered a dramatic increase in *hvid* production in Malmø. After 1495, he took the additional steps of creating two new silver coins of higher denominations, and eventually, a gold coin. This was a capacity his Swedish rival could not match. Soft power translated into hard power: the new supply of coins financed mercenary armies to fight the Swedes (Kreem 2001; Ingvardson *et al*. 2022).

The 1486 voyage was Hans' first recorded visit to the Norwegian part of his realm after his 1483 coronation in Trondheim/Nidaros. It was a major summer-long excursion, and it provides an apt case study for how Hans employed his new ship as a floating castle. *Gribshunden* was the central site for royal administration functions. Historical sources record that when the king travelled, his baggage train included 'chancellery chests' containing documents necessary for his administration of the country. 'Writing rooms' were always established when the king temporarily settled into a castle or nobleman's manor house to permit the king and his administrators to conduct the business of the state. There must have been similar areas set aside in the ship when Hans was at sea. Surviving letters show that Hans maintained official correspondence while aboard his flagship (Jorgenson 1884; Etting *et al*. 2019). It may be too much to hope that continued excavation will deliver a chest of correspondence, but maritime archaeological conservators suggest that preservation of some written material may be possible on *Gribshunden*.[2]

Gribshunden and the world of the nobility: foodways and art

Gribshunden was the physical political instrument for Hans to show the flag throughout his kingdom. The ship provided the mobility necessary for the king to appear off any coastal city, secure in his own redoubt. Upon arrival in Bergen in 1486 (and again in 1491), the impressive ship provided a base for negotiating economic and trade policies with Hanse merchants. The ship was also a locus for strengthening social bonds among the aristocratic classes and clergy. It accommodated and fed several bishops and noblemen, exactly as would be expected from a castle. At the same time, the ship reinforced stratification within the social ranks. Access to this space was limited to those invited by the king, and not all who accompanied the king to Norway would have been onboard his ship. A who's-who of the powerful in Denmark sailed in a fleet alongside the new ship: 644 nobles and clergy. Some of these men were directed to travel on the king's own ship, while others had to provide their own means of transport, along with the provisions for their retinues (Wegener 1864). This was the accepted routine for royal voyages, including the 1495 sojourn to Kalmar.

The *Gribshunden* excavation provides direct evidence of how food and foodways were utilised in the Mediaeval construction of social status. In 2019, the wreck relinquished a cask containing the skutes and some bones from a sturgeon. The fish was probably caught locally; ancient DNA analysis reveals that it was *Acipenser oxyrinchus*, the species native to the Baltic Sea. Butchering marks on the remains indicate the two-metre-long fish was chopped into several sections. In Mediaeval Denmark, sturgeon was a species reserved solely for the king, and poaching was a capital offense. Presentation and consumption of this fish on *Gribshunden* or in Kalmar would have been a visible example of the king's privilege and authority (Macheridis *et al*. 2020).

Another archaeological example of prestigious foodstuffs on *Gribshunden* comes from the spices and confections recovered in 2021: saffron, ginger, clove, pepper, almonds and other exotic and expensive delicacies. Hans' accounting records from 1487 show that he spent large amounts of money on these food categories, including 36 marks for saffron (Wegener 1864; Larsson and Foley 2023). Spices like these were available around the Baltic in some quantities from at least the middle of the fourteenth century, but they were not widely consumed (Sillasoo *et al*. 2007). The spices on *Gribshunden* show the opulence of the highest elite. Feasting was an essential, compulsory part of major political events, such as coronations. In the process of making treaties, it was mandatory. For example, in 1493, Hans sent an envoy to Moscow to broker a treaty with Ivan III. Russian chronicles note the tsar 'honoured' this envoy by inviting him to dine in his presence (Pape 2022). In England, surviving documents describe the extravagant menus served to celebrate the 1527 treaty between Henry VIII and the king of France (Lehmann 2018). The amount of spices recovered from *Gribshunden* would not be enough for the lavish days-long feasting described in the English documents, but larger quantities may have been conveyed on other ships in the fleet. The spices from the 1495 wreck were not enclosed in any apparent containers, but the observable discrete concentrations of saffron may have been wrapped in light textiles or even paper. Gift-giving is a long-standing method of building social capital (Woolgar 2011). These individual allotments of spices might have been intended as gifts to members of any of the Nordic Councils.

Feasting, gambling and gaming, gift-giving and displays of martial prowess surely would have been activities conducted during the Kalmar summit. Hunting, too, might have been pursued by the participants. *Gribshunden* presents some evidence to support this. The 2021 excavation trench produced a number of crossbows and accessories for them, including several arrows of different designs (Foley 2022). Some of these are interpreted as bolts for hunting. While any crossbow could be used for game, some of the most elaborately decorated Mediaeval crossbows in museum collections were the property of princes and used exclusively for hunting. The tillers of these crossbows were richly inlaid and decorated, and their composite prods were often covered with birch bark embossed with patterns and repeating designs. Finds from *Gribshunden* include two birch bark panels measuring 330 × 110 mm, and pressure-printed with identical motifs.[3] The entire motif has not yet been discerned, but floral elements swirl around a unicorn, and several wild animals and birds adorn the perimeters of the panels (Figure 10.6). These panels were recovered from a locus at the edge of the

[2] Personal correspondence, conservator Max Jahrehorn, Oxider, Kalmar, Sweden, 11 May 2023.

[3] At the time of writing this manuscript, the panels have only just been delivered from conservation. A detailed study of them is now in progress.

Figure 10.6. The unicorn embossed/printed on two identical birch bark panels with floral and mythical animal motifs recovered from *Gribshunden* in 2021. Image by Åke Nilsson, Blekinge Museum.

2021 trench. If excavation were to resume at that area, we speculate that other elements of a hunting crossbow may be present. The elaborate decoration of this weapon is an indication of the visual world in which the Nordic nobility lived. While the stone walls of extant castles in the region are largely muted, stripped of their adornments, the finds emerging from *Gribshunden* provide hints for recreating those environments with *barometerobjekte*.

Conclusion: The future of *Gribshunden* studies

Where does the study of *Gribshunden* as a floating castle go next? The ship can be compared profitably to land castles of the late fifteenth century, particularly the well-preserved stately fortress Glimmingehus. This castle was built in 1499 in Skåne, a region of southern Sweden which at the time was Danish territory. Glimmingehus is considered the best-preserved Mediaeval castle in Sweden (Nilsson 1999; Ödman 2004; Hansson 2009, 2016). It is ripe for comparison to *Gribshunden* because the nobleman who commissioned the structure was Jens Holgersen Ulfstand, King Hans' righthand man. Direct connections existed between Glimmingehus and *Gribshunden*, as Ulfstand likely sailed on the ship and certainly would have been aboard during his installation in Visborg castle on Gotland in 1487. Within his Scanian castle, a ship resembling G*ribshunden* is etched into the wall of the chamber reserved for the lord of the manor.

Overall, the spatial layout of the castle is similar to that of the ship. The lowest levels of the castle held the kitchen and storage spaces. This is analogous to the hold of the ship, in which the multitude of provisions casks have been identified. *Gribshunden*'s galley has not yet been exposed, but the copious amounts of firewood encountered in the 2019 and 2021 interventions suggest that it is located slightly forward of the areas excavated to date. This would correspond to the location of the galley in the *Mary Rose* (Marsden 2009). Slit windows in Glimmingehus' foundation wall have rebates on either side, interpreted as sockets for timbers on which artillery was mounted, similar to gunports on a ship. The next higher level of the fortified manor contains a sort of receiving room on one end the castle hall. On the opposite side of a central staircase are the lord's living quarters, featuring the ship etching. The next highest level contains the great hall, suitable for banquets and other large gatherings. Adjacent to this and directly above the lord's quarters are the chambers of the lady of the house. The fourth, uppermost level of Glimmingehus is termed the 'archers' loft'. The similarity to the forecastle and sterncastle of *Gribshunden* is obvious: on this level, sharpshooters armed with crossbows could snipe at marauders. Above this gallery are the timbers of the roof, which is topped with carved figures at either end, reminiscent of a figurehead on a ship (Figure 10.7).

The similarities between castle and ship extend to the flexible use of private or restricted spaces. In post-Mediaeval seafaring, the captain's quarters were transformed when the ship engaged in battle. That space went from semi-private sanctuary to a common combat arena. The same could happen at Glimmingehus. If a threat emerged, the lord's chamber was transformed into a 'battle scene'. One of the castle's many defensive traps was sprung from this room: hidden firing slits in the walls and overhead chutes for pouring various liquids would turn the central staircase into a killing ground. The division and importance of private spaces varied over time and with circumstance, both onboard the ship and within the castle. Prominently in the case of King Hans and *Gribshunden*, this new style of warship served the same varied purposes as castles on land, but with the added benefit of high mobility. *Gribshunden* was an administrative, economic, cultural and social centre, all while projecting military power throughout the Nordic region. The ship was Hans' essential instrument to knit together his far-flung realm. He relied on it not only for the hard power of its artillery and men-at-arms, but for subtler soft power manifestations of his authority. As we further develop this comparison between land castles and warships, we will gain new insights into the functions and functioning of the floating castle.

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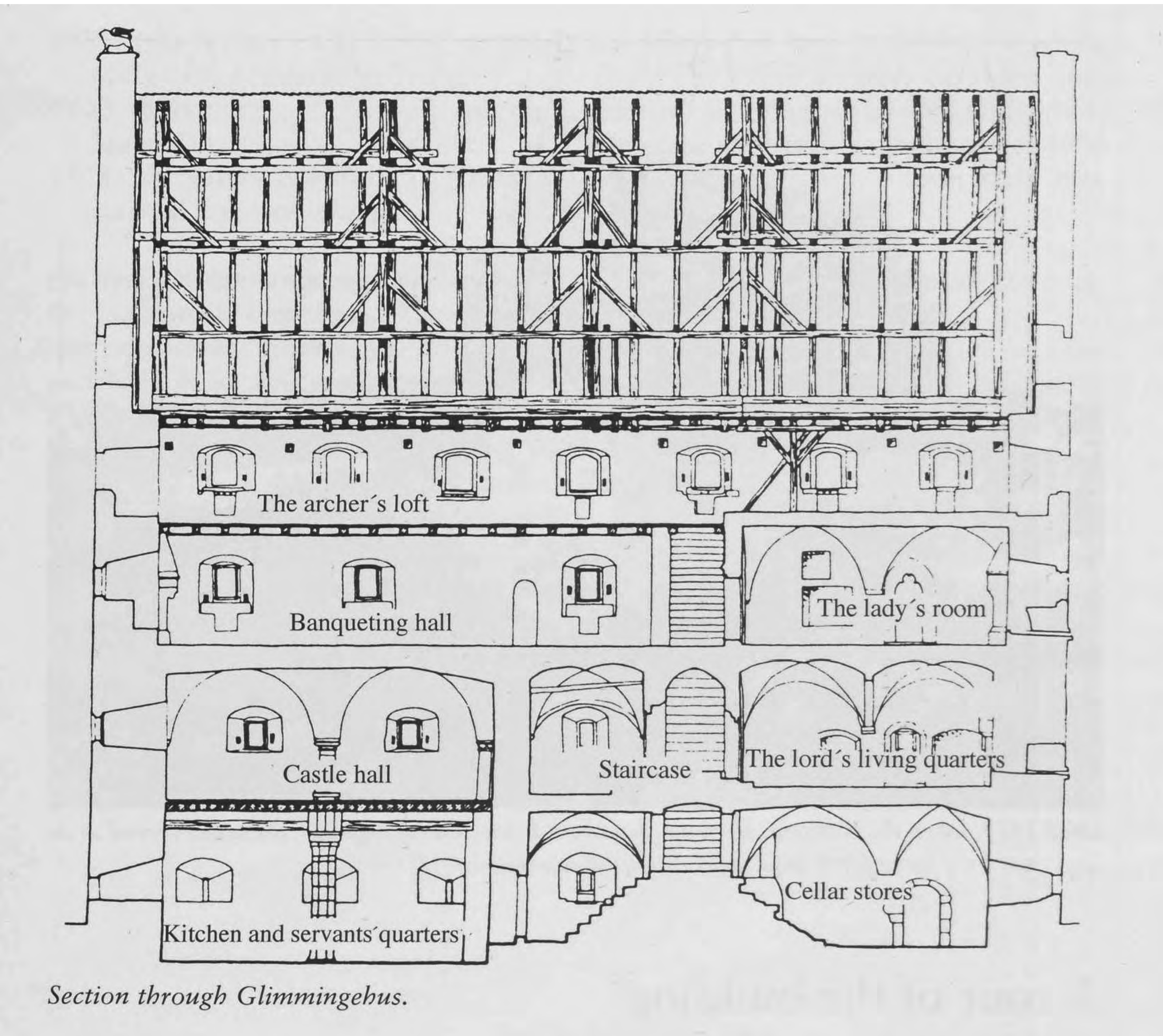

Figure 10.7. Elevation view of Glimmingehus fortified manor, with a floor plan similar in many ways to *Gribshunden*. Image by Agneta Hildebrand, as relabeled and reprinted from Ödman 2004: 16.

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11

New ideas about an old ship: some thoughts on the construction features of the late sixteenth-century *Scheurrak SO1* shipwreck

Hendrik Lettany

Abstract: The *Scheurrak SO1* shipwreck has become known in nautical archaeology as the flagship site of the 'Double Dutch' discourse. Discovered off the coast of Texel (The Netherlands) in 1984, the site delivered much new information about Dutch shipbuilding techniques in the early modern period. One of the peculiarities of the shipwreck was the presence of a double layer of hull planking. Thijs Maarleveld (1994) assessed the building sequence of this construction feature and concluded that, for a brief moment in time at the turn of the seventeenth century, Dutch shipbuilders built larger seagoing ships with a double layer of planking. This was considered necessary since Dutch carvel ships were built in the 'Dutch flush' tradition, to which a strong, self-carrying hull was essential. Although Maarleveld's paper became influential in the discourse on early modern Dutch shipbuilding, further details on the construction of the *Scheurrak SO1* shipwreck were never published. Preliminary results of the (re)assessment of *Scheurrak SO1*'s construction features reveal an image which deviates from earlier observations. Embedded within the historiography of Dutch flush shipbuilding, this chapter presents some construction details from *Scheurrak SO1*'s keel and stem which challenge former hypotheses about the ship's building sequence.

Introduction

Dutch Flush

At the 1982 *International Symposium on Boat and Ship Archaeology* in Stockholm, Richard W. Unger (1985) presented a paper on Dutch shipbuilding technology in the early modern period. Based upon historical research, Unger argued the Dutch building sequence to create flush-planked hulls deviated from other contemporary shipbuilding traditions in Europe. The common understanding up to that point was that in order to create a carvel-built vessel, the frames of the ship needed to be pre-erected. Yet, by studying the now well-known treatise of Nicolaes Witsen (1671) and digging into the written records of French spies who observed the shipbuilding techniques in the Dutch *Noorderkwartier*, he demonstrated that in the seventeenth century, the Dutch built their carvel vessels by first assembling the hull planking. Starting off with assembling the keel, stem and stern, then the first 10 to 12 planking strakes were installed before any timbers were added. The strakes were initially held together by means of temporary cleats, which were removed again once the floor timbers had been fastened. Although the building sequence was quite different from French, English or Iberian carvel vessels, the flush-planked look of the hull would have been quite similar.

Unger was not the first to draw upon the aforementioned sources. Hasslöf (1958, 1963) had used the same material to dispute the dichotomy between shell-first versus frame-first shipbuilding and their association with respectively clinker and carvel-built hulls as proposed by Hornell (1946: 193–194). Hasslöf too had demonstrated that carvel-built vessels were constructed in a sequence that did not begin by pre-erecting the frames, but rather, with assembling the hull as an empty shell. Other authors soon reached the same conclusion (*e.g.* Timmermann 1979). Yet, it was Unger's presentation which sparked the interest of the nautical archaeological community. It led to the further elaboration and verification of his arguments through existing archaeological, historical and iconographical data (*e.g.* Rieth 1984; Hoving 1988, 1991; Vos 1991a), but it also induced new archaeological surveys (*e.g.* Maarleveld 1987; Reinders 1987; Green 1991; Oosting 1991).

The different studies identified a number of construction features which have now become diagnostic for identifying the deviating Dutch building method in the archaeological record. Maarleveld (1992) was the first to create a full overview of these features, and coined the term 'Dutch flush' to refer to this deviating building tradition. With some additions of later research (Maarleveld *et al*. 1994; Maarleveld 2013), the current diagnostic features for identifying a Dutch Flush construction are:

- The presence of *spijkerpennen*, which are small wooden plugs used to fill the nail holes left by removing the temporary cleats.
- The use of a non-interconnected framing system, since frames were not pre-erected.
- Varying dimensions (both length and scantlings) of individual timbers.

- The use of treenails to fasten ceiling planks, timbers and hull planking.
- The presence of 18 to 23 frames within 4 m of the ship's length, or what Maarleveld (2013) referred to as 'the Dutch Flush Index'.

By now, many examples of Dutch Flush ships have been identified in the archaeological record. Although in the late seventeenth century, this building tradition was mainly associated with the *Noorderkwartier* and the northern part of The Netherlands, it is likely that in earlier periods, the Dutch flush tradition was also practiced along the *Maaskant* in the south (Hoving 1988: 216). The earliest known examples of the Dutch flush tradition date to the early sixteenth century. It is notable that one of these early examples was found in Norway, made of local materials (Vangstad and Fawsitt 2020; Sarah Fawsitt, Norsk Maritimt Museum, personal communication). Most known Dutch flush finds, however, have a clear Dutch association.

The Scheurrak SO1 shipwreck and the Double Dutch discourse

In 1980, Thijs Maarleveld was the first underwater archaeologist to be appointed by the predecessor of the Cultural Heritage Agency of The Netherlands (Rijksdienst Cultureel Erfgoed (RCE)). Although his initial responsibility was to catalogue the underwater cultural heritage of The Netherlands, his mandate soon gave way to the organization of actual underwater excavations. This led to the development of the Department of Underwater Archaeology in 1985 (Maarleveld 1981: 1, 1984: 12, 1998: 14, 52). The *Scheurrak SO1* shipwreck was discovered off the coast of Texel in the Wadden Sea in 1984. Amidst the exciting times in which the methodology and practice of Dutch underwater archaeology was being developed, and triggered by specific new research questions inspired by Unger's paper, this find provided a critical opportunity. Its excavation would become a pioneering project for Dutch underwater archaeology in the Wadden Sea. Running parallel to the excavation of the Aanloop Molengat shipwreck in the North Sea, both shipwrecks were the first underwater sites to be excavated by the Dutch government over a period of multiple years.

The *Scheurrak SO1* shipwreck carried a main cargo of grain and has been associated with the Baltic grain trade. Based upon former dendrochronological analysis, the ship appears to have been built in the first half of the 1580s. A trumpet made in Genoa had the date 1589 engraved in it, while a lintstock had a Dutch poem inscribed in it with the date 1590. The latter date was also the outer range of the youngest-dated barrel stave, which had a felling date between 1590 and 1605. This indicated that the ship sank in, or more likely after, 1590. On Christmas Eve, 1593, a severe storm hit the Roads area. Around 40 ships sank that night. Many of them were grain traders, and it has become a popular hypothesis that the *Scheurrak SO1* shipwreck was one of them (Hanraets 1997; Maarleveld 1990; Manders 2001; Vos 2013).

What made the *Scheurrak SO1* shipwreck of special interest for investigation at that time was the fact that the ship's construction was largely well preserved. The bottom survived from stem to stern and up to the turn of the bilge. In addition, the ship's entire starboard side was preserved from stem to stern and from the turn of the bilge up to the bulwark. The starboard had broken off from the bottom and was lying next to the ship's bottom. Both parts only remained attached to one another by the bilge stringer near the bow. The ship was excavated between 1987 and 1997, and analysis of the hull remains met all criteria for interpreting it as a ship built in the Dutch flush tradition. But analysis also demonstrated that the ship had been built with a double layer of hull planking: not a sacrificial layer of pine sheeting, but a double layer of 7 cm-thick oak strakes, creating a sturdy 14 cm-thick hull (Maarleveld 1994: 156). This peculiar feature did not correspond to the characteristic features of Dutch flush known up to that time, indicating a need for further study. How far the double layer of hull planking extends is not known. Based upon excavation data, it is clear that the double layer runs at least as far as the bilge. How far it continues on the starboard side is unclear, yet a loose part of the ship's port side at the height of the main deck demonstrates that in this area, the ship had only a single layer of planking.

Not much earlier, the remains of the Dutch East Indiamen *Mauritius* (1601) and *Batavia* (1628) demonstrated that these ships too had been outfitted with a double layer of hull planking (l'Hour *et al*. 1989: 213, 221–222; Green 1991: 70). The *Batavia* sank on its maiden voyage, indicating that the double layer of hull planking was part of its initial construction. Maarleveld analysed part of the *Scheurrak SO1* construction in order to assess the building sequence of the double-layered bottom, and he would conclude that here too the double layer was part of the initial construction. It was his belief that when economic development at the end of the sixteenth century demanded larger ships, shipbuilders added a second layer of hull planking in their Dutch flush building process. He called this a 'double Dutch solution', in which shipbuilders simply strengthened what was, in their view, the most important part of the ship: the self-carrying hull. Due to the double Dutch solution, shipbuilders were able to increase the scale of their vessels and make them larger and stronger (Maarleveld 1994: 159, 162).

Wendy van Duivenvoorde (2008, 2015) has demonstrated that Maarleveld's interpretation is not entirely valid when it comes to the construction of double-planked hulls by the Dutch East India Company. Based upon bits and pieces collected in historical sources, she notes that building ships with a double layer of planking was a common practice for Dutch ships sailing to the East Indies in the early seventeenth century. Ships were built with a double skin, and when purchased with a single skin, a second layer of planking was added. According to Van Duivenvoorde's research, the main reason for double planking was the need for sturdy ships. Especially in the early years of the Dutch East India Company, the infrastructure abroad was limited, and each repair could cause a delay of multiple months. There were certain advantages to the use of a double layer of (thinner) planking over one (thicker) layer of planking. Not only would it be more difficult to shape the hull with strakes of such thickness, it would also be much easier to make repairs when two thinner layers were applied. Van Duivenvoorde's argument for the use of double-planked hulls provides a much more functional reason than the one brought forwards by Maarleveld. Yet, since the *Scheurrak SO1* shipwreck was clearly not a Dutch East Indiaman, we cannot simply project her interpretation onto it. Nor are Maarleveld's and van Duivenvoorde's discourses mutually exclusive. Yet, it is mainly his assessment of the *Scheurrak SO1* shipwreck that validates Maarleveld's interpretation.

Most scholars who have studied the phenomenon of the double-planked hulls agree it was a short-lived tradition which should be situated around the late sixteenth and early seventeenth centuries (Vos 1991b: 54; Maarleveld 1994: 162; van Duivenvoorde 2015: 204). In recent years, however, evidence has appeared of double (oak) planked hulls from later years. In Germany, the *Hörnum Odde* shipwreck (late seventeenth century) and the *Süderoogsand 1* shipwreck (first half of the eighteenth century) demonstrate double-hulled planks in a fashion similar to Dutch flush (Zwick 2021, 2023: 99–102). The *Stavoren 18* shipwreck in The Netherlands exhibited a double layer of oak planking, covered with a third sacrificial layer made of pine. It was built in the late seventeenth or early eighteenth century and sank in the mid-eighteenth century (Muis and Opdebeeck 2022: 35, 64–65). It has been suggested that after 1650, the only ships with double skins were those meant for whaling (Vos 1991b: 54; van Duivenvoorde 2015: 204); yet it is uncertain whether all of the aforementioned younger shipwrecks should indeed be interpreted as remains of whaling vessels. Notarial archives from Amsterdam also demonstrate that adding an oak doubling layer was not uncommon in the eighteenth century (Muis and Opdebeeck 2022: 71). Although it is at this point unclear whether these later examples should be interpreted in the same way as the double-oak layers used in the late sixteenth century, these new examples do raise questions about the former interpretation, especially since the double Dutch discourse builds upon the idea that the double-oak layers of hull planking reflect only a short period of experiment and innovation in the Dutch flush shipbuilding tradition.

Given these changes in the state of the art, it seems appropriate to reassess *Scheurrak SO1*'s construction. In 2020, an interdisciplinary research project started at Leiden University, in which the *Scheurrak SO1* shipwreck will be assessed from both a maritime archaeological and maritime historical perspective. The archaeological component will focus mainly on the ship's construction, with the excavation data from the 1980s and 1990s field seasons as its main source. In the following section of this chapter, specific attention will be given to the reassessment of the keel and stem assembly from the *Scheurrak SO1* shipwreck.

Keel and stem construction in the lower hull

Former research

At the end of the 1988 field season, the forward end of the lower hull was sawn off and lifted for an in-depth analysis on land (Figure 11.1). The structure was transported to the city of Alphen aan den Rijn, where it was registered and described. In order to understand the relation between the different structural elements, the assemblage was dismantled in a systematic way. First the riders and ceiling planks were removed, then the keelson and next the frames. Finally, the two layers of hull planking were removed. A first analysis of the construction was mainly executed by intern Ronald Koopman, naval engineering student at the Hogeschool Rotterdam and Omstreken. His study resulted in a brief unpublished report (Koopman and Goudswaard 1991), as well as in several loose notes and drawings. These documents provide a useful source of information now, since most of the dismantled timbers were reburied afterwards on lot OZ40 in Zeewolde (Flevoland province), which is elaborated by the RCE as a ship (timber) graveyard. It is notable that not all timbers were reburied, probably only those which were fully examined and drawn by Koopman at that time.

The data provided by Koopman were further elaborated by Thijs Maarleveld and provided the basis for his 1994 article on the building sequence of *Scheurrak SO1*'s lower hull. In this article, Maarleveld delimits a 1 × 2 m section of *Scheurrak SO1*'s portside, which includes ceiling planks, floor and futtock timbers, the inner and outer layer of the double hull planking, as well as the treenails. By treating every element as a stratigraphical unit, a Harris matrix could be created of the stages of construction. The presence of both blind and transecting treenails was especially informative in this regard. Maarleveld's (1994: 156–162) research suggested the keel was first assembled from several units; then, the stem and sternposts were installed, including deadwoods; and next, a double rabbet was applied. The garboard strake of the inner shell was nailed into the upper rabbet and other strakes were added by means of temporary cleats (marked again by the presence of the so-called '*spijkerpennen*'). Next, floors were added by means of dottled plugs. After removal of the clamps, the ceiling was put in place, fastened by treenails which penetrated timbers as well as inner planking. Finally, the outer shell was nailed into the lower rabbet and onto the inner shell. It was fastened to the pieces above (*i.e.* outer and inner planking, floors and ceiling), again, with treenails. It is notable that for many of these latter treenails, care was taken to drill through earlier treenails which fastened the inner planking to the floors and/or the

Figure 11.1. Lifting of the forward end of *Scheurrak SO1's* lower hull. Copyright Rijksdienst Cultureel Erfgoed.

ceiling planks. Maarleveld states that only in a next phase were riders installed.

The remaining timbers, which include the keel and stem assemblage, as well as a number of hull planks, were examined by another intern, Richard Kroes, in 1994–1995. His study also resulted in an unpublished report (Kroes 1995) and drawings, yet further notes were preserved to a much lesser extent than for Koopman's study. Kroes' research focussed specifically on the building sequence of the stem and keel construction, for which he applied a stratigraphical units-approach similar to the one used by Maarleveld. The most interesting outcome of his research was evidence of the keel being repaired in its forward end. Koopman and Maarleveld had already noted that the recovered part of the keel was assembled out of two pieces by means of a nibbed diagonal scarf, yet Kroes was the first one to associate this with repair. According to Kroes, this repair most likely occurred during construction, and not when the ship was already in use.

Reassessment of keel and stem construction

A reassessment of the construction details of the recovered keel and stem assemblage in the forward end of the lower hull, based upon the drawings, reports and notes of Koopman, Maarleveld and Kroes, was executed to gain a better understanding of the repair in relation to the building sequence of the *Scheurrak SO1* shipwreck as proposed by Maarleveld. The available pencil drawings were digitised in Illustrator, which allowed for combining them in their respective relations to one another. Drawings of the two riders which were part of the forward end of the lower hull were also digitised and for the first time confronted with Maarleveld's hypothesis.

The assemblage of keel and stem exists of four main parts (Figure 11.2a). The identification of the different elements has varied in the past. The keel itself is assembled of two pieces joined by a nibbed diagonal scarf. A third element is assembled to the front of the keel by means of a boxing scarf. This element has been referred to as the 'outer stem' (Koopman and Goudswaard 1991: 1), as well as a third part of the keel (Kroes 1995: 3). A fourth element is attached to elements two and three and has been referred to as the 'inner stem' (Koopman and Goudswaard 1991: 1) or stem (Kroes 1995: 3). According to Koopman, the assemblage had a total length of *c*. 570 cm, yet according to measurements of the scaled drawings, the length must have been *c*. 550 cm. It is possible this difference of 20 cm was caused by parallax when the assemblage was manually measured, due to the height difference of both extremities.

The aft part of the keel (Figure 11.2b, element 1), has a total length of 345 cm. Towards the forward end, the

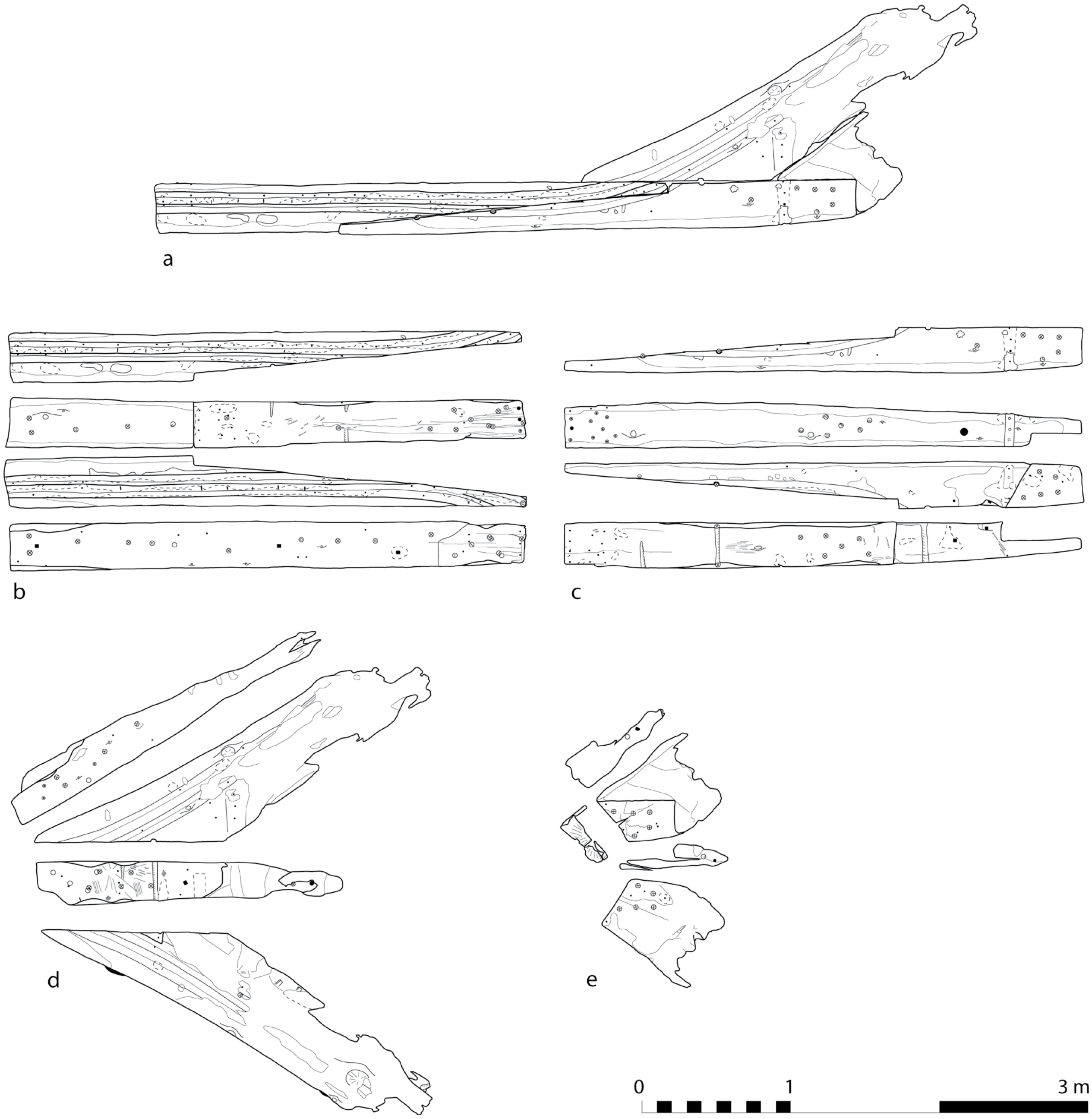

Figure 11.2. Starboard side of the keel and stem assembly of the forward end of the lower hull (a) and individual elements of the same assembly: (b) element 1, (c) element 2, (d) element 4 and (e) element 3. Image by H. Lettany, after Kroes 1995.

upper part of the nibbed diagonal scarf is present, which has a total length of 220 cm. The nib itself has a height of *c*. 5.5 cm. The keel's cross-section in the aft is more or less square-shaped, measuring 33 cm sided and 32 cm moulded. The fastening of this part of the keel does correspond to Maarleveld's description. Treenails were used to connect it to the superposed floor timbers and keelson. On both port and starboard side, two rabbets are present, corresponding to the inner and outer garboard strakes of the double hull planking. Exact depths of the rabbets are not mentioned in any of the reports. Yet, based upon drawings of the aft cross-section, they all appear to measure *c*. 5 cm, except for the lower port rabbet, which measures *c*. 6 cm. Nails, at *c*. 17 cm intervals (± 2 cm, sometimes with an extra nail in the middle), were used to fix the inner garboard strake to the upper rabbet. Nails were also used to fix (preliminarily) the second layer of hull planking to the inner layer, yet to a much lesser extent, and there are no indications the outer garboard was fixed to the lower rabbet in the same way.

While the upper rabbet continues directly from the aft part of the keel into the stem, the lower rabbet crosses the forward end of the keel first (Figure 11.2c, element 2). This part of the keel has a total length of 348 cm. It is 24 cm sided and 32 cm moulded. The aft 220 cm of this element comprises the lower part of the nibbed diagonal scarf which corresponds to element 1. In the front, a vertical boxing scarf is present. Because of the oblique shoulder of this scarf, its cheek has a length of 32 cm at the top and 52 cm at the bottom. Towards the aft, nails were used to fasten this element to the upper part of the scarf, perhaps preliminarily, in order to trunnel the treenail holes. Also in the front, a nail was used to fix the forward part of the keel to the stem. When it comes to the treenails, something notable can be observed. The treenails used to fasten the aft part of the keel (element 1) to the superposing elements do not continue in the forward part of the keel (element 2); instead, they only run as far as the scarf, where they have been excessively dottled with no less than three dottles per treenail. Another six treenails, as well as an iron bolt, transect the forward end of the keel from the bottom, and most of them end blind in the stem (element 4). Two stopwaters transect the keel horizontally from side to side along the seam of the nibbed diagonal scarf. A third stopwater runs from side to side in the seam between the forward end of the keel (element 2) and the stem (element 4).

It is notable that element 4 (Figure 11.2d), which we will refer to as the stem, contains a number of transecting treenails which do not continue in the underlying forward part of the keel (element 2). One blind treenail is present in the stem's bottom face, which does not continue in the underlying element either, consequentially not serving any purpose in the current construction. The stem's bottom face measures 128 cm by 28 cm. The stem is preserved over a length of *c*. 270 cm. It rakes relatively strong over a preserved distance of *c.* 145 cm, while it only reaches a height of 113 cm. Due to significant deterioration, no further construction details can be observed in its upper part. In the lower part, traces of the double rabbet can clearly be observed on both port and starboard side. In its forward face, two blind iron bolts are present, by which element 3 is fastened to it.

Element 3 (Figure 11.2e), which in the past has been referred to as an 'outer stem', is *c.* 24 cm sided and 55 cm moulded. It is connected by means of a vertical boxing scarf to the forward end of the keel (element 2). Five treenails, one of which is dottled, transect the boxing scarf horizontally. Another four nails were also used to fasten the 'outer stem' to the forward end of the keel. A treenail and iron bolt were driven diagonally into the forward face of the 'outer stem' to fasten it to the stem (element 4). Other than the boxing scarf, most of this element is strongly eroded.

An iron strap was nailed onto the construction in its forward part. The strap crosses the stem, the 'outer stem' and forward end of the keel on starboard side. It continues underneath the keel and goes up as far as at least the 'outer stem' on port side. At starboard, the strap has a maximum width of 15 cm, which tapers to 6 cm at the keel's bottom face. Former descriptions of the construction mention the presence of two small wooden laths or battens along port side. One ran underneath the iron strap and would have covered the seam between keel and stem. The other piece would have covered the stopwater in the same area. Neither of these parts appears to have been drawn or photographed, and their shape and extent therefore remain unknown. A triangular notch in the stem's port side close to the stopwater may be associated with this.

Caulking material was present in between scarfs and along all seams and rabbets.[1] A thick layer of organic material was present in between both faces of the nibbed diagonal scarf in the keel. Samples of the caulking material were in the past taken on different locations in the fore-end of the lower hull. Analysis of a number of sub-samples demonstrated that peat moss (*Sphagnum*) was mainly used as a caulking material, although some samples were described as 'amorphous' and one sample as 'other plants' (Cappers *et al*. 2000: 589). Although the exact species of the sub-samples were not determined, samples from the aft end of the lower hull proved to be *Sphagnum cuspidatum*.[2] This species, which grows in wet, acidic, oligotrophic environments, is common in The Netherlands. In the frame of the current research, further botanical and palynological analysis of some of the remaining samples will be executed.[3]

All four parts were assessed for dendrochronological analysis (Jansma and Hanraets 1995). Although both parts of the keel presented well-suited tree-ring sequences, only the aft part (element 1) resulted in a felling date. This felling date, 1585 ±8 (with a non-specified German origin) did not contradict the general assumption this ship was built in the first half of the 1580s (Maarleveld 1994: 155; Manders 2001: 320; Vos 2013: 11), yet it also presented the possibility that the shipwreck could actually be younger. The forward part of the keel (element 2) presented sufficient tree rings for an adequate analysis but did not deliver a match with the available refence sequences. Several dendrochronologists were asked to take another look at the data using current reference sequences, since much has evolved in the field of dendrochronology over the past 25 years. Unfortunately, the sample still did not match any available reference sequence.[4] The stem (element 4) presented 51 tree rings, including waney edge, but did not deliver a match either. What has been interpreted as the 'outer stem' (element 3) was not feasible for analysis because of insufficient tree rings.

[1] According to Kroes (1995: 3), caulking was found in between all scarfs except for the boxing scarf between the forward end of the keel and the 'outer stem'. Yet, when the author collected the available caulking samples, a sample was found originating from this specific area. Cappers *et al*. (2000: 589, sample 58f) also describe this location for one of the studied caulking samples.

[2] Based upon unpublished correspondence between W.J. Kuijper and T.J. Maarleveld, 11 July 1988.

[3] In December 2017, the freezer in which the remaining caulking samples were stored was found to be defective. The samples were not refrozen afterwards, but were stored at 'room temperature' without further intervention. This was still the case at the start of the current research project. The possible impact of this situation on the samples is as yet unclear.

[4] I would like to thank Petra Doeve, Esther Jansma, Kristof Haneca, Aoife Daly and Sjoerd van Daalen for reassessing this specific sample.

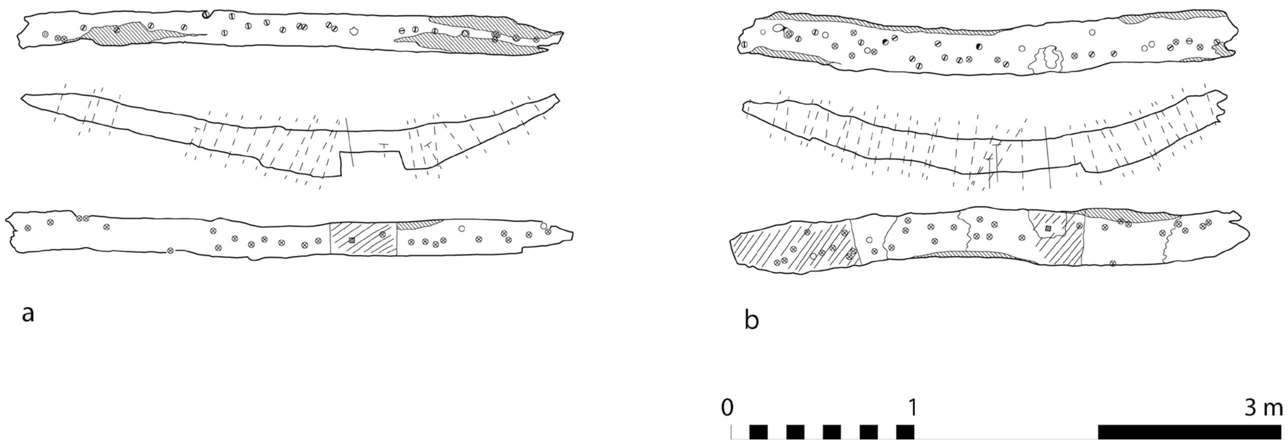

Figure 11.3. Rider 1 (a) and rider 2 (b) from the forward end of the lower hull. Image by S. Mulder, after Kroes 1995.

Reassessment of riders

Two riders (Figure 11.3) were present in the forward end of the lower hull when it was recovered from the seabed. An imprint in the ceiling planks indicated that aft of these two, a third rider might have been present (Koopman and Goudswaard 1991: 1). During excavation, the presence of a third rider was indeed proposed, but the interpretation of one rider was also refuted later when it turned out to be a loose timber from higher up in the ship's construction which had ended up on top of the ceiling planks (Dive report Thijs Maarleveld 19 July 1988; dive report Peter Stassen 30 September 1988). It is unclear as to what extent these statements relate to one another and whether the loose timber is indeed the same as the presumed third rider and/or the cause of the imprint in the ceiling planks.

Structural elements in the forward end of the keel were numbered from aft to front, making the rider closest to the bow rider 2 and the one aft of it rider 1. Rider 1 (Figure 11.3a) is 18 cm sided and 25 cm moulded at its largest extent near the centre and is *c.* 240 cm long. It has a *c.* 34 cm wide and *c.* 13 cm deep notch at the centre of its bottom face, which allows the rider to fit over the keelson. Rider 2 (Figure 11.3b) is situated about 50 cm forward of rider 1. It is 25 cm sided, 20 cm moulded and has an overall length of 265 cm. Rider 2 was notched in the centre of its bottom face too, yet with only a clear indent of *c.* 6 cm on starboard side, again, to make the rider fit over the keelson.

Both riders were fastened to the underlying elements by means of treenails and an iron bolt. In both cases, the iron bolt transects the rider from its upper face downwards, fastening into the underlying elements. Rider 1 is connected to the underlying keelson, floor timber and the aft part of the keel where it ends blind. It is notable this is the location of the nibbed diagonal scarf in the keel, and the iron bolt thus does not fasten both parts of the keel to one another. For rider 2, the iron bolt transects the underlying keelson and floor timber. Although it does not end blind in this floor timber, it does not seem to continue in the stem. Kroes (1995: 4) does mention the presence of a nail in this area of the stem, for which the origin or function is unaccounted. It is not unlikely this presumed nail is actually a trace of the bolt's end, but there are no images to confirm this. Other than the iron bolts, a large number of treenails were used to fasten the riders to the rest of the construction. Due to small inaccuracies[5] in the drawings, it is unclear exactly how many treenails were used and to which underlying elements they connect; however, it is clear that for riders 1 and 2, the number of treenails exceed respectively 20 and 30. Most of these treenails are wedged on the rider's upper face. However, both timbers do also present blind treenails—three for rider 1 and two for rider 2—that enter from the bottom face.

Rider 2 was sampled for dendrochronological analysis in the past; yet despite its feasible tree-ring series, it did not match any of the available refence sets at that time (Jansma and Spoor 1991: 3). Reassessment of the same series in the frame of the current research project did demonstrate an origin for rider 2 in Southern Norway, with a felling date between 1590 and 1600 (Doeve 2021: 15). This may mean that the construction date, which in the past was believed to fall in the first half of the 1580s, should be adjusted to the early 1590s, or that rider 2 was only added to the construction at a later stage.

Discussion

The above reassessment of keel and stem reveals several features which can clearly be associated with an alteration of the initial construction. The relation between the nibbed diagonal scarf in the keel and some of the treenails is especially telling in this regard. Four treenails which run through the upper part of the scarf stop abruptly at the level of the scarf itself and do not continue in the lower

[5] As can be seen in Figure 11.3, the pencil drawings of the recovered ship timber is not always as detailed as desired. When looking at the top, side and bottom view of the recorded riders, it is difficult to conclusively link the locations of treenails on all three views of the same timber.

part. Three of these treenails have been dottled on the inside of the scarf. Three more treenails run through the stem, but again, they do not continue in the forward part of the keel. One of these treenails therefore does not have any purpose, since it ends blind in the stem's bottom face. These seven treenails initially must have continued in the keel but were shortened when the forward end of the keel was put in place. We can presume the aft end of the keel initially was longer, and for some reason, this part was later removed.

A similar conclusion was drawn by Kroes (1995: 3). He points out adze marks in the scarf as an extra argument. In the forward part of the keel (element 2, the part that was added only after the initial construction), the adze marks are very neat and clean. In the aft part of the keel (element one, or the initial part of the keel that was altered), the adze marks are much rougher and plentiful. Kroes interprets this as possibly indicating that element 1 had to be worked in a more difficult position—for example, upside down—when the keel and stem were already in place. Although this could be true, we also cannot exclude the possibility the difference in finish simply is the result of different shipbuilders working on the same construction. Nevertheless, what is not in doubt is that the keel was indeed altered.

Yet there is even more to the alteration of the keel. When the outer keel rabbet is observed, it is found to cross the forward end of the keel—*i.e.* the altered part—and thus must have been added only after the initial construction was changed. Again, this was noted by Kroes (1995: 6). He interpreted this as indicating the keel had been altered during construction, and and that only after this modification the two layers of hull planking were added. Kroes's reasoning was likely influenced by Maarleveld's paper on the Double Dutch solution in early modern shipbuilding. Maarleveld had argued that both layers were part of the ship's initial construction and were put in place at the very beginning of the building sequence; 'it was only in the next phase that riders were added', while it remains unclear when elements such as futtocks, knees and beams would have been added (Maarleveld 1994: 159). This would indeed correspond to Witsen's discussion of the Dutch flush sequence, where the riders were only added when the ship's bottom was already finished and the futtocks and top timbers were in the process of being installed (Hoving 1994: 116–119). Yet the question is whether this can simply be extended to the *Scheurrak SO1* construction.

The answer appears to lie in a detail of the riders. These elements were never before incorporated in an analysis of *Scheurrak SO1*'s building sequence, yet their assessment influences the former hypotheses. As discussed above, both riders had a number of blind treenails in their bottom face. The riders, however, were fastened from the inside of the ship outwards; it would have been inefficient to enter treenails from the outside of the hull just to fasten these elements. This means the blind treenails were not meant to fasten the riders, but were part of fastening another element in the ship's bottom—yet only after the riders were already in place. The diagnostic features of the Dutch flush building sequence are clearly present in the *Scheurrak SO1* shipwreck, so we do know that the (inner) hull planking must have been assembled first. The floor timbers and ceiling planks all lie underneath the riders and thus must have been put into place before the riders. This means the only element which could have been added after the instalment of the riders is the outer layer of hull planking. Maarleveld's analysis of the building sequence demonstrated the outer layer of hull planking was fastened with treenails which ran through all of the above lying elements, all the way up to the ceiling planks. However, if the rider at that point was already in place, perhaps some of these treenails did indeed continue into this element, hence, the blind treenails. An alternative explanation for the presence of the blind treenails could be reuse, with the riders having served a different purpose before being used in this construction. Yet, this seems less likely, given that rider 2 is currently the structural element with the youngest felling date within the *Scheurrak SO1* shipwreck.

The new observations shed a different light on the former interpretations of the *Scheurrak SO1* building sequence; however, the question remains how we should interpret them. A first thought would be that the keel and stem were indeed repaired. Different than Kroes' interpretation, this repair would have occurred when both layers of hull planking were already in place, and to some extent, new strakes of outer planking were added during this repair. There is, however, one notable feature in the altered keel which seems too specific to be a coincidence: the location of the scarf in relation to the keel rabbets. It is placed in such a way that the inner layer of hull planking is not affected at all, while the outer layer of hull planking does run over the new part of the keel. It is a construction that, in a way, resembles the altered keel of the *B&W1* shipwreck (phase 1 *c.* 1583; phase 2 *c.* 1607), a Dutch built *verlanger* (Lemée 2006: 237–240). The Dutch word *verlanger* refers to the lengthening of ships, a practice that was common in the early modern Netherlands. A ship would be cut in half and pulled apart, after which both parts were reworked into a longer variation of the old ship by adding an extension in the middle. In the case of the *B&W1* shipwreck, the only archaeological example of such a ship to date, the ship was given a new layer of hull planking over its old one. This resulted in a ship with two layers of hull planking in the fore and aft, and only a single layer of hull planking in the middle. Interesting in the context of this analysis is how the keel and stem (Figure 11.4) were adjusted in the process of lengthening the ship. To give the lengthened ship longitudinal strength, among other strategies, a new keel was added underneath the old keel. The lower part of the original keel was cut away to just underneath the inner garboard strake. The new keel, which was added underneath, extended *c.* 130 cm further underneath the stem than the original keel did, and it was given a second rabbet, just underneath the rabbet of the original keel.

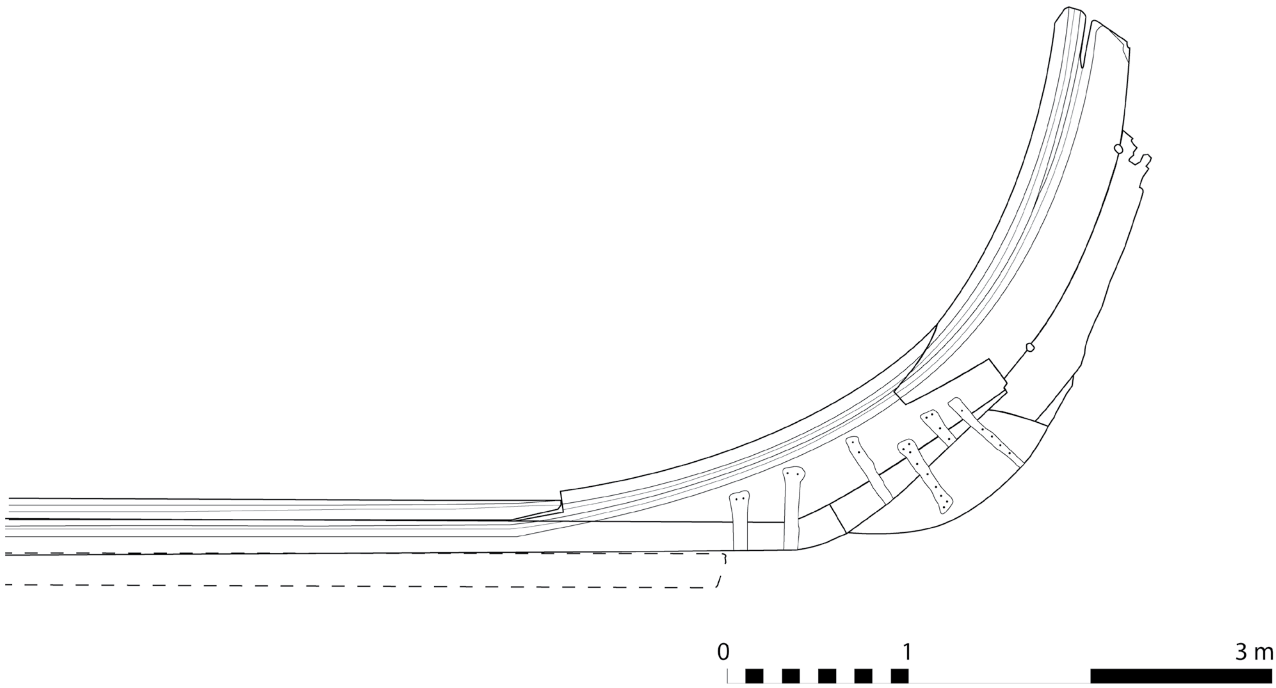

Figure 11.4. Starboard side of the keel and stem assembly of the *B&W1* shipwreck. Image by H. Lettany, after Lemée 2006: 237.

The original keel was fastened to the stem by means of a diagonal scarf, of which only the final 26 cm remained, while the lower-lying remainder had been cut away and replaced by the new keel. In front of the stem, a cutwater or gripe had been added, existing of multiple pieces. Both the new keel and the parts of the gripe were fastened to the stem by means of iron straps.

Although very different in execution, the underlying idea of the alteration of the *B&W1* keel and stem in the forward end of the hull in a way resembles what can be observed in the *Scheurrak SO1* construction, especially if we compare it with Witsen's description of the keel and stem construction. Witsen (1671) meticulously describes the construction of a 134–foot pinas, built according to the Dutch flush method (Hoving 2012). Although it is important to remember the *Scheurrak SO1* and *B&W1* shipwrecks date from late sixteenth and early seventeenth century and Witsen's publication to the latter half of the seventeenth century, the information that Witsen provides about the stem and keel construction can be observed in earlier seventeenth century shipwrecks as well. An example is the *Vasa* (1628), which was built according to Dutch design (Rose 2014: 239–243). Witsen (1671: 149) describes how keel and stem are connected by means of a boxing scarf and are afterwards rabbeted. His description does not mention any other timbers which are part of this construction. Later in his book, he does explain the meaning of *looze voor-steven* and *sny-water*, which correspond to gripe and cutwater. His description is very similar to what can be observed in the *Vasa*, and here a gripe was added to the lower half of the stem's forward face, which ends together with the stem in the boxed keel.

Lemée (2006: 240) demonstrates that part of the gripe of the *B&W1* shipwreck was only added when the ship was lengthened. It is therefore not unlikely that the initial keel-stem construction may have been similar to what Witsen describes, yet with a nibbed diagonal scarf instead of a boxing scarf (Figure 11.5a). When the ship was lengthened, the lower half of the keel was removed. In order not to affect the original layer of hull planking, care was taken to remove the keel only to the point where the present rabbet began (Figure 11.5b-c). A new and longer keel was then placed underneath the old keel and stem, and the gripe assembly was added as well (Figure 11.5d). A second rabbet was added for the outer planking of the now-lengthened hull. This second, outer rabbet did cross the elements of the new keel (Figure 11.5e). The second building phase was finalised by adding iron straps around the construction (Figure 11.5f).

The construction details of the *Scheurrak SO1* shipwreck clearly demonstrate that the keel and stem construction was adjusted here as well. The cut off and dottled treenails in the upper part of the diagonal nibbed scarf, as well as a blind treenail in the bottom face of the stem, show that a part of the original keel must have continued more towards the bow but was removed. The blind treenails in the riders demonstrate that the ship's bottom had already been constructed when this alteration was executed. It is possible the second layer of hull planking was already in place, but was replaced or fastened again as part of the repair in the stem and keel. However, the fact that the rabbet of the inner layer of hull planking was not affected by the modification, while the outer rabbet crosses the modified parts, resembles what we can see in the *B&W1* shipwreck, and it raises the question of

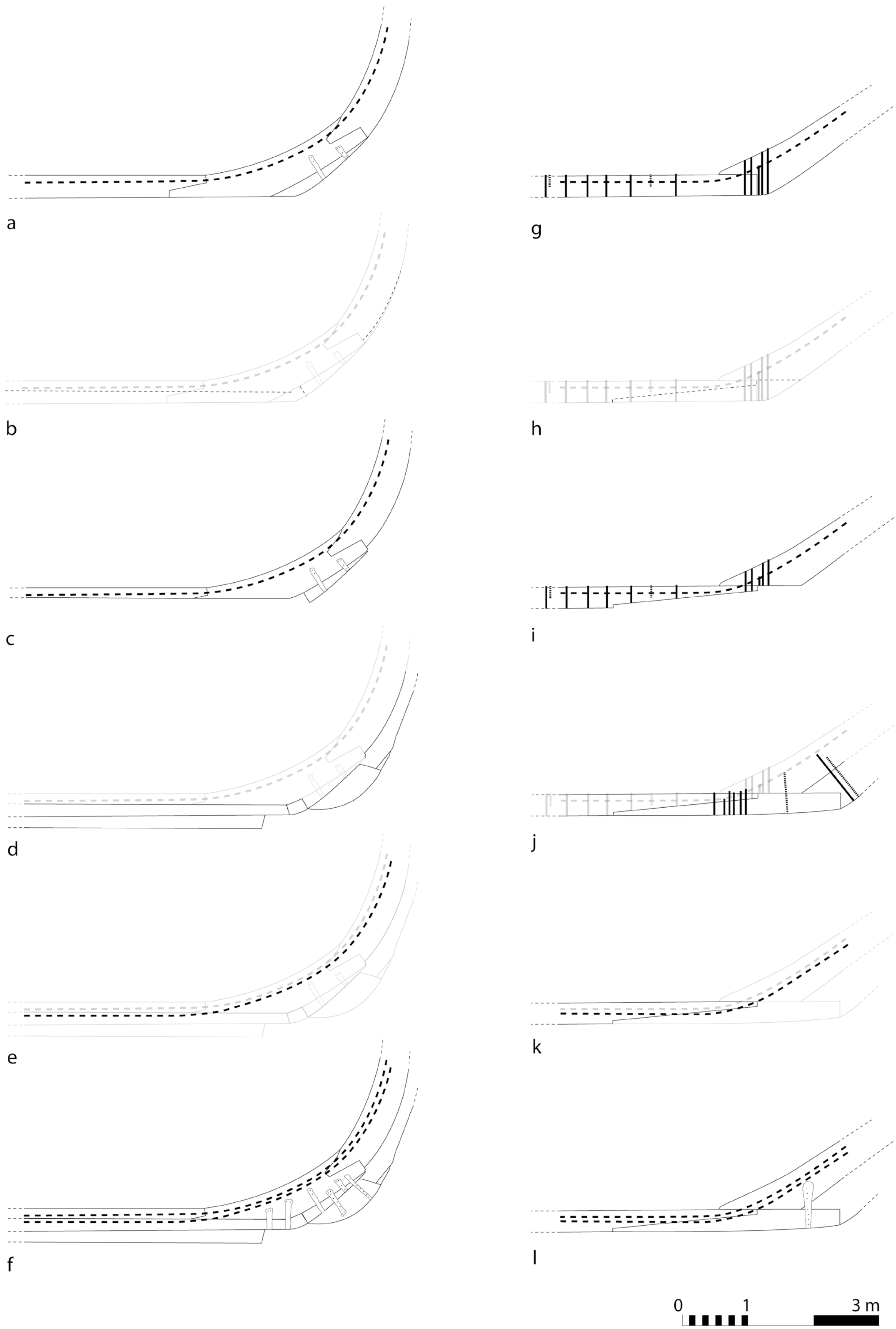

Figure 11.5. Hypothetical initial stem and keel construction of (a) the B&W1 shipwreck and (g) the *Scheurrak SO1* shipwreck, and the consequential steps of the second building phases ((b) through (f) and (h) through (l)). For *Scheurrak SO1*, treenails (black) and iron bolts (dashed) are indicated as well. Image by H. Lettany.

whether the second layer of hull planking there could have been a later addition. For the sake of reasoning, let us presume the stem and keel were initially built with a boxing scarf as described by Witsen (Figure 11.5g). For an unknown reason, the forwardmost part of this construction was then adzed away. In this process, the initial scarf and part of the treenails were removed. Yet, similar to the *B&W1* shipwreck, care was taken not to affect the rabbet of the original layer of hull planking in the process (Figure 11.5h-i). A new element was then added as part of the keel, one that protruded more to the front than the original keel had and which was fastened with new treenails and an iron bolt (Figure 11.5j). It is plausible that element 3 was also added at this point in the modification process. In the past tentatively interpreted as an 'outer stem', this element more likely served as a gripe and should be interpreted as such. A second rabbet was then added just underneath the original rabbet. Contrary to the original rabbet, the second rabbet therefore crosses the modified part, the new keel (Figure 11.5k). At the very end of the process, an iron strap was added to fasten the old and new parts together (Figure 11.5l).

Although the execution of the alteration of keel and stem in both the *B&W1* and *Scheurrak SO1* shipwrecks is different, the conceptual idea seems to correspond. This does not mean the second layer of hull planking from the *Scheurrak SO1* shipwreck served the same function as that of the *B&W1* shipwreck. In the past, similarities between both shipwrecks have been highlighted, especially in regards to the fastening of the outer layer of hull planking. In both cases, the treenails used to fasten the outer layer of planking are organized in such a way they transect—or are close to—the treenails used to fasten the inner layer of hull planking to the timbers and ceiling planks. Yet at this point, it is indeed difficult to prove or disprove whether the *Scheurrak SO1* shipwreck was lengthened. Maarleveld, when asked about this by Lemée, saw no reason to believe that *Scheurrak SO1* would have been a lengthened ship (Wegener Sleeswyk 2003: 44; Lemée 2006: 227). Similarities between both shipwrecks, however, suggest the second layer of hull planking in the *Scheurrak SO1* shipwreck was a later addition.

The reason why, in this specific context, a second layer of hull planking would be added at a later stage is as yet unclear. It is known that the Dutch East India Company added additional hull planking to ships which were sailing to Asia. Whaling ships were given an extra layer too, as were warships, for protection against the impact of ice and round shot, respectively (van Duivenvoorde 2015: 204). Yet none of these circumstances seem to apply to the *Scheurrak SO1* shipwreck, which carried a cargo of grain probably originating from the Baltic and likely meant for the Mediterranean. Although lengthened ships are known to have been involved in this specific trade in the late sixteenth century, there is presently no evidence to determine whether *Scheurrak SO1* was indeed a lengthened vessel. Despite the fact a clear interpretation is currently not possible, the observation that *Scheurrak SO1*'s construction reflects two separate building phases is important. It allows us to challenge former hypotheses which have become entrenched in the field of maritime archaeology over time. As a consequence, new questions related to the interpretation of these observations can and should be raised, in order to develop further our understanding of the maritime past. It is the aim of the *Scheurrak SO1* project to raise these questions and to embed and elaborate the technological observations discussed in this chapter within their wider historical context. Additionally, the new insights in the construction of the *Scheurrak SO1* shipwreck demonstrate the potential of using legacy data within the field of maritime archaeology; new information can be gained by (re)assessing old datasets based upon specific research questions. This is not always an easy task, since archaeological practices related to recording and data management may have changed significantly since the initial excavation campaigns. As a consequence, the study of such data becomes a historical study of sorts in its own right. Yet, it is this kind of archaeological detective work which enables us to extract new information from known archaeological sites, and to develop new ideas about old ships.

Conclusion

The use of two layers of thick oak hull planking has been archaeologically observed in a number of shipwrecks. Maarleveld, who studied part of the *Scheurrak SO1* construction, associated this phenomenon with a deviating shipbuilding tradition that created flush hulls in the early modern Netherlands, known in nautical archaeology as Dutch flush. It was his belief that, when the need for larger ships occurred at the end of the sixteenth century—a time of growing globalization and increasing maritime trade—shipbuilders used the second layer of hull planking as a 'double Dutch' solution to build larger seagoing vessels in the Dutch flush tradition. This implies the ships were initially built with a double layer of hull planking and the outer layer was not a later addition. Maarleveld's proof was the analysis of a part of the *Scheurrak SO1* hull, which indicated a building sequence in which the double-layered bottom was built before any other elements were added.

Reassessment of the keel, stem and riders from the forward end of *Scheurrak SO1*'s lower hull now challenges Maarleveld's interpretation. Blind treenails in the riders show these elements were already in place when outer planking was added, replaced or refastened. Construction features in the stem and keel construction demonstrate this part of the construction was altered. It is possible the outer layer of hull planking was part of the initial building sequence, as suggested by Maarleveld, and the outer planks were only replaced or refastened during repair of the area. Similarities with the alteration of the same area in the *B&W1* shipwreck, however, suggest the outer layer of hull planking was added only when the keel and stem construction was altered, and thus it reflects a second building phase. The fact that the inner rabbet is not affected by the modification of the keel, while the outer rabbet transects the modified part, can especially motivate this interpretation.

Many questions, however, remain. The parts of the stem and keel construction which are part of the modifications did not yield any dendrochronological results. Therefore, the time span between the initial building and the modification remains unclear. However, if rider 2 was part of the initial building and the modification of stem and keel happened afterwards, the 1590–1600 felling date would push the hypothesis of the *Scheurrak SO1* wrecking in 1593 to its limits. This would mean the ship was either adjusted shortly before it sank, or it sank at a later date. Samples from the outer layer of hull planking are currently not available, and therefore, it cannot be conclusively associated with a first or second building phase. The blind treenails in the riders, however, do indicate that the modification of the forward end of the lower hull was not limited to keel and stem, but also affected the outer layer of hull planking in this area.

If indeed the outer layer of hull planking reflects a second building phase and was not a 'double Dutch solution', it remains as yet unclear what the purpose of this second layer of planking was. Despite similarities between the *B&W1* and *Scheurrak SO1* shipwrecks, there is no decisive evidence to prove or disprove whether *Scheurrak SO1* was a lengthened ship. It is unclear why a merchantman associated with the Baltic grain trade would be given a second layer of hull planking after its initial construction. This question is subject to current study within the framework of the *Scheurrak SO1* research project.

In order to find additional answers, the excavation data from the *Scheurrak SO1* shipwreck will be further assessed and archival research will be executed. In addition, a revisit to the *Scheurrak SO1* site is currently being organized. This campaign, organized by Leiden University with the support of the RCE, will aim to collect specific samples for dendrochronological analysis and make focussed observations based upon the current hiatuses in the *Scheurrak SO1* excavation data in order to answer the questions posed above. By uncovering a very limited part of the site, 26 years after its initial excavation, the aim is to shed new light on the interpretation of the *Scheurrak SO1* construction specifically and gain new insights in early modern Dutch shipbuilding in general.

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12

Evidence for repairs and hull maintenance from the Yenikapı Byzantine shipwrecks

Michael R. Jones

Abstract: The shipwreck assemblage from the Marmaray Project excavations at Yenikapı (Istanbul, Turkey)—Constantinople's Theodosian Harbour—provide an unparalleled source of information on Byzantine ship construction technology and maritime trade. Many of these vessels are a source of surviving evidence for hull maintenance and repairs: most show some signs of repair, while many were substantially overhauled or rebuilt. Hull repairs potentially provide evidence for economic concerns related to the operation of ships, including the duration and nature of ships' careers, salvage activity and the prevalence of recycling ship timbers and other components. Many of the Yenikapı vessels appear to have had long sailing careers, with some hulls showing extensive use of recycled ship timbers, while others were repaired with newly cut timber. Significantly, repair timbers can also obscure evidence for the original construction methods of vessels. This chapter examines indirect evidence for marine salvage from the Theodosian Harbour and presents an updated survey of hull repair methods and timber recycling identified in the Yenikapı shipwreck assemblage, with an emphasis on shipwrecks studied by the Institute of Nautical Archaeology. Such shipwrecks recovered from terrestrial sites play an essential role in the interpretation of Mediaeval shipwrecks documented underwater across the Mediterranean.

Introduction

Between 2004 and 2013, the Istanbul Archaeological Museums conducted rescue excavations associated with the Marmaray Project, an expansion of Istanbul's rail and subway lines in the city and its suburbs. The largest excavation area, covering approximately 58,000 square metres, was begun in Istanbul's Yenikapı district, along the southern Sea of Marmara shore in the location of the Theodosian Harbour, one of Byzantine Constantinople's most active harbours between the fifth and tenth centuries AD (Figure 12.1) (Gökçay 2007: 166; Asal 2010; Kızıltan 2010: 1–2). The excavation area spanned the original 800–metre harbour basin, the outlines of which are still visible in the modern city's street plan and the course of surviving mediaeval walls (Mango 1993: 121; Dark and Özgümüş 2013: 30–31; Semiz and Ahunbey 2014). The site's Byzantine-era deposits contained thousands of artefacts, remains of wharfs and other harbour installations, and at least 37 shipwrecks dated from between the fifth and tenth century AD, besides many loose ship timbers and items of ships' equipment. These remains provide an unparalleled source of information on Byzantine ship construction technology and maritime trade (Çölmekçi 2007; Koyağasıoğlu 2022; Külzer 2022).

The Yenikapı shipwrecks include both a variety of round ships, or sailing vessels typically used as cargo carriers, and the oldest substantially preserved galleys (or 'long ships') excavated in the Mediterranean (Pulak *et al.* 2015: 39, 42, 45, 62). Several hull reconstructions and a number of interim reports have been completed on the eight shipwrecks (YK 1, 2, 4, 5, 11, 14, 23, and 24) studied by the Institute of Nautical Archaeology team (*e.g.* Ingram 2013, 2018; M.R. Jones 2013, 2017; Pulak *et al.* 2015; Pulak 2018) and the 27 shipwrecks studied by a team from Istanbul University (*e.g.* Kocabaş 2008, 2015; Turkmenoğlu 2017; Özsait-Kocabaş 2018, 2022). Although further research will reveal more details, the hull documentation of the Yenikapı ships completed so far provides a fairly detailed picture of their various features.

The Yenikapı shipwreck assemblage includes extensive evidence for hull maintenance and repairs, including both the addition of new repair timbers and the use of repurposed timbers salvaged from other vessels. Several were substantially overhauled or rebuilt, a process that often obscures original construction features but, on the other hand, can provide evidence for the service life and sailing careers of individual vessels. While references to the age of vessels and maintenance materials and methods are found in textual sources and are occasionally shown in artistic depictions, there is relatively little detailed information from the period on how repairs were actually made (*e.g.* Rival 1991: 309; Meiggs 1998: 467–471; Pryor and Jeffreys 2006: 151, Fig. 11).

Hull repairs are often noted in archaeological reports on individual shipwrecks, and their importance for understanding a vessel's construction and career is often

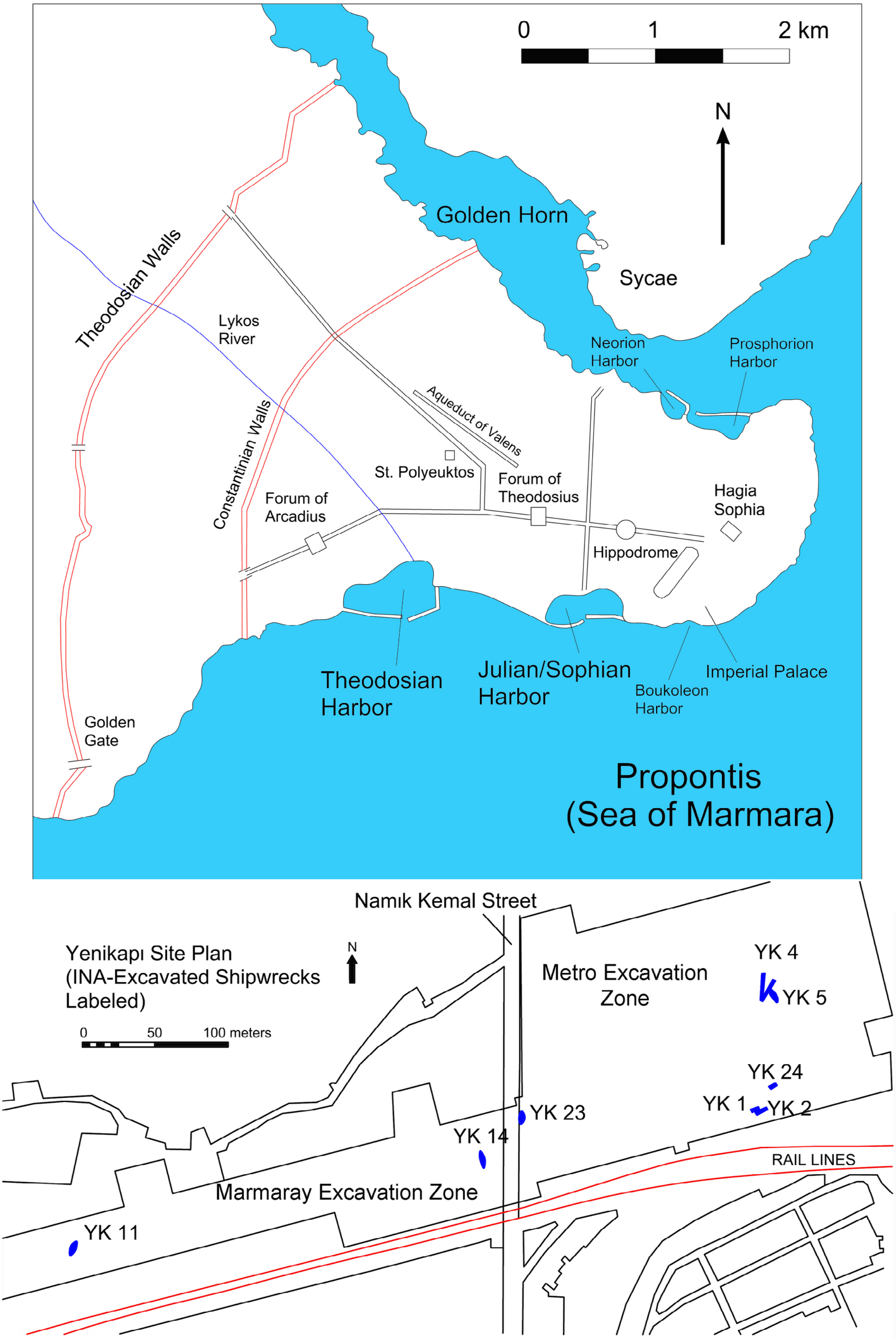

Figure 12.1. Map of Constantinople (after Müller-Wiener 1977: 58, Abb. 38; Treadgold 1997: 674; and Mango 2002: 64), the Theodosian Harbour and the Yenikapı Excavations. Adapted from Kocabaş 2008: 184–185 and Gökçay 2010: 135, Fig. 1.

recognised (Steffy 1999: 395). However, such repairs on Byzantine-period ships have not yet been studied systematically, particularly for a group of shipwrecks that can potentially be identified as products of a distinct shipbuilding industry or regional tradition.[1] The identification of hull repairs and maintenance activities can be difficult with fragmentary hull remains, and repair materials such as pitch or caulking deposits are easily damaged or lost (*e.g.* Steffy 2004: 165; Israeli and Kahanov 2014: 375, Fig. 18). Often, repairs can only be identified when the shipwreck is dismantled, especially in hulls in which planking edge fasteners were employed. The Yenikapı shipwrecks' rapid burial in waterlogged sediments, followed by full excavation and dismantling, has allowed the detailed documentation of wear and damage which occurred during the service life of a number of ships, as well as how shipwrights and crews conducted repairs, major overhauls, and salvage of derelict vessels. Such evidence is better preserved at Yenikapı than at most Mediterranean shipwreck sites discovered underwater.

The systematic study of hull repairs may provide answers on how long ships were sailed before they were no longer considered worthwhile to repair. Textual evidence offers some clues: for example, the *Rhodian Sea Law* and some later Mediaeval law codes distinguish between the cost of a 'new' *vs*. an 'old' ship, and Byzantine and Islamic maritime law includes extensive rules on the monitoring of the safety of vessels.[2] Archaeologists often note the presence of repairs, and they sometimes speculate on the age of the hull in a general way ('new' or 'old', for example), but, with many shipwrecks, it is difficult to reach more specific conclusions without detailed documentation, usually requiring the full dismantling of the hull, and the use of dendrochronology and other dating methods.

The study of hull repairs also contributes to research on the 'shell-to-skeleton transition' of shipbuilding technology in first-millennium AD Mediterranean vessels, a period which saw a shift from constructing shell-first or shell-based hulls, which involve the assembly of most of a ship's hull planking before the insertion of frames, to frame-first or frame-based hulls, whose design was determined by frames pre-erected on the ship's keel. This change likely occurred due to a combination of different economic, environmental and cultural factors which varied by region, with the Yenikapı assemblage likely forming its own distinct group (Hocker 2004b: 5–6; Pomey *et al.* 2012: 305–307). At least 30 of the Yenikapı shipwrecks can be considered shell-based or mixed construction vessels,[3] in which the lower hulls were built planking-first with edge fasteners, while pre-erected frames were used to design their upper hulls (Kocabaş 2015a: 11–12; Pulak 2018: 243–247). The lack of edge fasteners reported for six of the Yenikapı shipwrecks under study by Istanbul University (YK 10, 17, 27, 28, 29, and 31) suggests the use of either frame-based or bottom-based construction methods (perhaps using temporary cleats) (Hocker 2004a: 77; Kocabaş 2008: 168–175, 2015a: 12; Pomey *et al.* 2012: 296–297; Pulak 2018: 280–281). Repairs to hull planking can obscure or remove original construction features, particularly planking edge fasteners, which are cut and caulked over in Byzantine hulls, unlike the practice of using 'patch tenons' for ancient mortise-and-tenon hull repairs (Steffy 1999: 397–398; Beltrame and Gaddi 2007: 142, Fig. 11). A first-millennium AD hull lacking edge fasteners on many of its plank seams can therefore resemble a frame-based hull, even if it was built using a shell-based method and 'structural philosophy' (Hocker 2004b: 6). In some cases, the hull construction methods used for a shipwrecks could have easily been misidentified due to the presence of major repairs (Pomey *et al.* 2013; Israeli and Kahanov 2014: 376, Fig. 18; Ingram 2018: 131, 136–138; Pulak 2018: 251–252).

Repairs can also offer insights into the practices of timber recycling and salvage. Shipwreck hull elements sometimes include timbers salvaged from other ships, often small pieces used as ceiling planks (*e.g.* Steffy 1985: 95, Ill. 17). The Yenikapı shipwrecks allow a comparative examination of this practice in a group of vessels that operated in the same region, and may have been built locally. This chapter will examine the hull repairs and timber recycling documented on six of the Yenikapı shipwrecks excavated by the Istanbul Archaeological Museums between 2005 and 2008 and documented by the Institute of Nautical Archaeology team at Yenikapı directed by Cemal Pulak. These will be supplemented by published examples of repair features from other first-millennium AD shipwrecks from Yenikapı and other sites.

Salvage and maintenance activities in the Theodosian Harbour

Ship maintenance and the salvage of sunken or derelict vessels was likely common around the Theodosian Harbour and the neighbouring Julian Harbour further east along Constantinople's southern shore. Both were excavated as expansions of existing natural harbours, supplemented with stone and marine concrete quays and breakwaters; marshy areas along the Marmara coastline were also filled in order to provide more territory for construction (Mango 2001: 17–21; Külzer 2022: 78). The

[1] See Postiaux 2015 for the most comprehensive treatment of hull repair methods based on ancient shipwreck evidence. However, the study focuses primarily on the Roman and pre-Roman evidence and includes only a selection of the most recent Byzantine and early Islamic shipwreck finds (see Postiaux 2015: 1:185–189, for a list of shipwrecks discussed in the text). Other authors discuss relevant pre- and post-Mediaeval evidence for repairs and maintenance that can be usefully compared to Byzantine vessels (*e.g.* Steffy 1999, 2004; Lemée 2006; Beltrame and Gaddi 2007; Belasus and Daly 2022).

[2] Ashburner 1976: 63, 91–92. See Ashburner 1976: ccivii–cclxxxviii, and Khalilieh 2006: 205–223 for references to salvage law in Roman and Mediaeval legal codes, and Khalilieh 2005 for a summary of safety standards for Mediaeval Islamic and Byzantine ships.

[3] See Pulak 2018: 243–247 for a discussion of the different terminology used to discuss 'mixed' or 'intermediate' construction vessels.

southern Marmara shore installations were much easier for vessels sailing from the southwest against the prevailing winds and currents to reach and could accommodate the largest, deep-draft cargo ships of late antiquity, including ships carrying the state-subsidised *annona* grain shipments to the capital; shipwrecks YK 22 and 35, dating to the fifth and sixth centuries AD, likely represent this largest class of vessels (Magdalino 2000: 215; Kocabaş 2015a: 23, 29, 31; Külzer 2022: 79).

As with many Roman port installations, the Theodosian Harbour did not continue to operate as designed in later centuries. Siltation from the Lykos River, which emptied into the northern end of the harbour, contributed to a gradual shrinkage of the basin, although dredging—documented by Byzantine sources for the Julian and Neorion Harbours—was also likely practiced at the Theodosian Harbour based on a recent geological study (Yalçın *et al.* 2019: 371–372). Refuse dumping and deliberate infilling also reduced the harbour's area and depth; shipwreck YK 3's rubble and stone cargo was perhaps intended as fill for some section of the waterfront (Kocabaş 2008: 152–156; Perinçek 2010: 214; Kızıltan and Baran Çelik 2013: 191–196; Polat 2016: 395, Res. 3; Onar 2020). Occasional high-energy events (storms or tsunamis) may have been responsible for thick layers of marine sand that rapidly buried many of the site's shipwrecks, some of which appeared to be relatively new when they sank (Perinçek 2010: 198–215).

Since most of the Yenikapı shipwrecks were shallow-draft vessels, shoreline areas or simple wooden slipways were likely adequate for most maintenance work, and vessels could have moored at wooden piers (*skalai*), remains of which were excavated across the Yenikapı site. Towing and beaching vessels was also likely a common practice. Transverse holes were cut into the keels and endposts of a number of the Yenikapı vessels, either singly or in pairs, including YK 1, 14 (two holes), 23 and 24 (single holes), in a disarticulated keel timber found under YK 5 (Pulak *et al.* 2015: 52), and at least seven of the shipwrecks studied by Istanbul University (YK 8, 9, and 12: two holes; YK 6, 7, 15, and 20: one hole) (Figure 12.2) (Kocabaş 2008: 104, 117, 126, 135, 136, Fig. 72b, 148, 164, 166, Fig. 80; Güler 2019: 32; Özsait-Kocabaş 2022: 80, Fig. 3.2, 3.4–5). The holes are typically 4–6 cm in diameter, and are only rarely attested on shipwrecks outside of Yenikapı as, for example, on the St. Gervais 2 shipwreck (Pulak *et al.* 2015: 52). A particularly worn, 40 cm-long area on the probable bow end of the of the YK 14 shipwreck at the keel/endpost transition could be wear related to beaching (see figure 12.2) (M.R. Jones 2013: 166, Fig. 3.27–28, 2017: 260, Figs. 7–8).

Most of the Yenikapı shipwrecks buried in thick sandy layers towards the site's eastern end contain few or no artefacts, which would be expected if they were found and salvaged after a storm: the ninth-century shipwreck YK 14, for example, was apparently picked clean, without even ballast stones remaining, although others such as YK 5 had a few objects on board (Perinçek 2010: 191–192; Pulak *et al.* 2013: 23, 56). Valuable objects were sometimes lost in the harbour as well (*e.g.* Kızıltan and Baran Çelik 2013: 64–74, 122–138; Baran Çelik 2016). Four shipwrecks were found with largely complete cargoes, including YK 1, a small tenth-century ship whose amphora cargo shifted when the vessel capsised, covering and preserving the ship's starboard side from the turn of the bilge to the caprail (Kızıltan and Baran Çelik 2013: 154–218; Polat 2016; Özsait-Kocabas 2018: 357–358). YK 1's cargo and equipment, particularly two wrought-iron 'Y'-shaped anchors, would have been particularly valuable and well worth salvaging (Ashburner 1976: 77; Pulak *et al.* 2013: 31–33); even if the contents of the amphoras were spoiled,

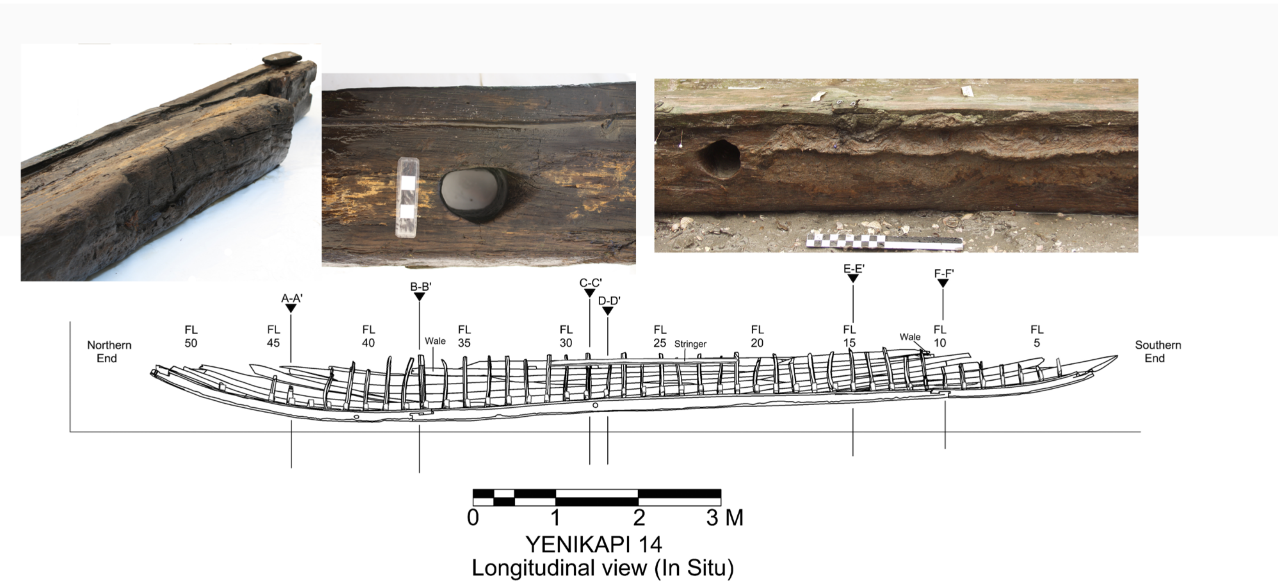

Figure 12.2. Examples of 'towing holes' from shipwrecks YK 14. The inset photograph to the upper left shows wear to the keel of YK 14 at the keel/stem-post transition at the forward end (Keel 3). This may have been caused by beaching or running aground. Figure by M. Jones, INA.

the jars themselves could have been recycled, a practice documented from other Byzantine shipwrecks (van Doorninck 1989).

Timber types used in the Yenikapı shipwrecks

Construction techniques and the cost and quality of timber and other materials naturally influenced the number and types of repairs necessary for a vessel, and often provide some indications of a ship's intended service life (Steffy 1999: 395; Belasus and Daly 2022: 214). Some ships were robustly built, with high quality timber and fastenings to last as long as possible, while others were built with whatever timber was most available or economical, even green timber in some documented cases, and may have been intended to last only a few years. Generally, the roundships or cargo vessels appear to have varied in quality. The earlier ships (fifth to seventh centuries) are built with pine hulls, frequently with oak keels, endposts and frames, recommended by Theophrastus (*Hist. Pl.* V.7.1–3) and common choices for Mediterranean cargo ships in antiquity; cypress species were also used in the earlier ships.

After the seventh century, oak construction tends to dominate, although chestnut (*Castanea* sp.), elm (*Ulmus campestris*), ash (*Fraxinus excelsior*) and sometimes Oriental plane (*Platanus orientalis*) were also employed (Liphschitz and Pulak 2010; Akkemik 2015: 183–185; Pulak *et al.* 2015: 45, Fig. 5; Pulak 2018: 277). The main oak type used in the INA-documented shipwrecks was identified as *Quercus cerris*, or Turkey oak, by Nili Liphschitz of Tel Aviv University.[4] This species is abundant in Anatolia and the eastern Mediterranean, but is more porous and susceptible to shrinkage and rot than the white oaks generally favoured for ship construction. Some literary sources and Mediaeval ship construction contracts recommend or stipulate against its use; Liphschitz and Pulak suggest that this could help explain the copious amounts of pitch on some of the oak hulls from Yenikapı (*Vitr*. 2.9.8; Liphschitz and Pulak 2010: 170; Lipke 2013a: 187–188; Pulak 2018: 277). YK 1, 5, 23 and 24 were built entirely of Turkey oak, with timbers of other species added to YK 1 only in a later overhaul phase (Liphschitz and Pulak 2010: 166–168). The builders of the later Yenikapı roundships may have opted for a lower-quality material which was easier to obtain locally or cheaper to import. Ships built of this timber likely required repairs sooner than those built of more water-resistant wood species.

Higher quality timbers of Black or Calabrian pine (*Pinus nigra*), were used for hull planking of the YK 2 and YK 4 galleys; some hull planks of 11–12 m in length and over 35 cm in width were recovered from these shipwrecks (Liphschitz and Pulak 2010: 168–169). Oriental plane (*Platanus orientalis*) was utilised for most frame and keel timbers on the galleys, although elm, an excellent hardwood timber, was also used. Oriental plane is said by Theophrastus to be a poor shipbuilding timber, but may have been utilised due to its lightness—an advantage for galley construction—or the large number of curved compass timbers available from this species; it seems to have been the timber of choice for the galleys' frames (Liphschitz and Pulak 2010: 168–171).[5] Akkemik's (2015: 48–53, 56–61, 92–95, 136–139) wood identifications from galley wrecks YK 13, 16, 25, and 36 showed similar results, but a wider variety of softwoods were used for stringers and hull planks, including fir and two species of cedar, and small numbers of elm, hornbeam, walnut, oak and chestnut timbers were employed. Rowed warships would have required frequent maintenance and likely had a shorter lifespan than merchant ships, but performance characteristics were perhaps even more important for these vessels.

Hull repairs found on the Yenikapı shipwrecks: a preliminary study

The examples of hull repairs that follow are taken from a group of eight shipwrecks studied by the Institute of Nautical Archaeology team (Table 1), supplemented with published examples of repairs and recycled timbers from other shipwrecks from the Yenikapı site.

Seven of the eight seventh-to-tenth century shipwrecks studied by the Institute of Nautical Archaeology team clearly exhibit evidence for hull repair or maintenance (YK 1, YK 4, YK 5, YK 11, YK 14, YK 23, YK 24) (Figure 12.3). While the galley YK 2 and the cargo vessel YK 5 (with a single repair to its preserved endpost) appear to have been new or nearly new when they sank, the other six vessels had all undergone significant repair and maintenance activities, including the application of pitch and caulking to damaged areas of the hull, the addition of repair timbers or more complex overhaul episodes.

Repair evidence may be the result of single or multiple episodes. Sometimes it is clear that one repair was made before another: a 'repair to a repair' is present on at least one ship (strake PS 6 on YK 14) (Figure 12.4), and some repair timbers appear to be more worn than others. However, often the sequence cannot necessarily be established, or it is based on impressionistic evidence. Planking edge fasteners are useful for identifying hull planking repairs and recycling: when hull planks were

[4] The identification of oaks from archaeological samples to the species level is questioned by a number of scholars, who state that it is impossible to determine the difference between white and red oaks (including the Q. *cerris* species) microscopically. However, it is also acknowledged that Turkey oak was the main red oak species available in Anatolia and most likely used widely (Lipke 2013a: 187–188; Akkemik 2015: 5–6, 196, 198).

[5] Bartolomeo Crescentio Romano (1607: 4) describes Oriental plane as 'an excellent wood that behaves particularly well in water' (Braudel 1995: 1:142). Ancient authors describe Oriental plane as being used for 'bentwood' (wales or compass timber?), which, along with elm, is described as 'tough and strong', although 'That made of plane-wood is worst, since it soon decays' (*Hist. Pl.* V.VII.2–3, trans. Hort 1916: 457, n. 5).

Table 12.1. Identified repairs and recycled timbers from the Yenikapı shipwrecks.

Shipwreck/estimated date of sinking	Shipwreck type	Repair types	Recycled timbers?	Selected published sources
YK 1 (mid-tenth century)	Roundship	Repair plank and graving pieces in lower hull, freeboard extended in overhaul (new futtocks/ strakes added); possibly new iron fasteners added (?)	One recycled graving piece; possibly recycled upper strakes (S 12-14 area)	Pulak 2007, 2018; Pulak *et al*. 2015
YK 2 (ninth to tenth centuries)	Longship/ galley	None identified	None identified	Pulak 2007, 2018; Pulak *et al*. 2015
YK 4 (ninth to tenth centuries)	Longship/ galley	Repair frames added adjacent to original frames; possible repair plank added to hull (SS 8-2)	None identified	Pulak 2007, 2018; Pulak *et al*. 2013, 2015
YK 5 (tenth century)	Roundship	One repair piece treenailed to endpost	None identified	Pulak *et al*. 2015
YK 11	Roundship	Repair planks, graving pieces, repair frames, repair fasteners (55 repair pieces)	Recycled ‘sternson,’ recycled ceiling planks [?]	Pulak *et al*. 2015; Ingram 2018; Pulak 2018
YK 14	Roundship	13 hull plank repairs identified, besides two probable repairs made during construction; one possible repair frame	All but one hull plank repair were recycled from a coak-built hull similar to YK 14.	M.R. Jones 2013, 2017; Pulak *et al*. 2015
YK 23	Roundship	**[Partially documented]** 20–22 repair and probable repair planks; one or more repair frames (futtocks)	Two possibly recycled hull planks	Pulak *et al*. 2015; Pulak 2018
YK 24	Small roundship	Planking repair pieces; replaced endposts, possible repair nails(?)		Pulak *et al*. 2015; Pulak 2018
Shipwrecks studied by Istanbul University (selected evidence based on published sources)				
YK 12	Small roundship	Three repair planks	None identified	Kocabas 2008, 2015; Ozsait-Kocabas 2018, 2022
YK 20	roundship	Probable repair planks and frames	Recycled or re-cut mast step; probable recycled hull planks with coaks on site plan; irregular graving pieces; replaced keel?	Güler 2019: 32, 50–51, S. 36

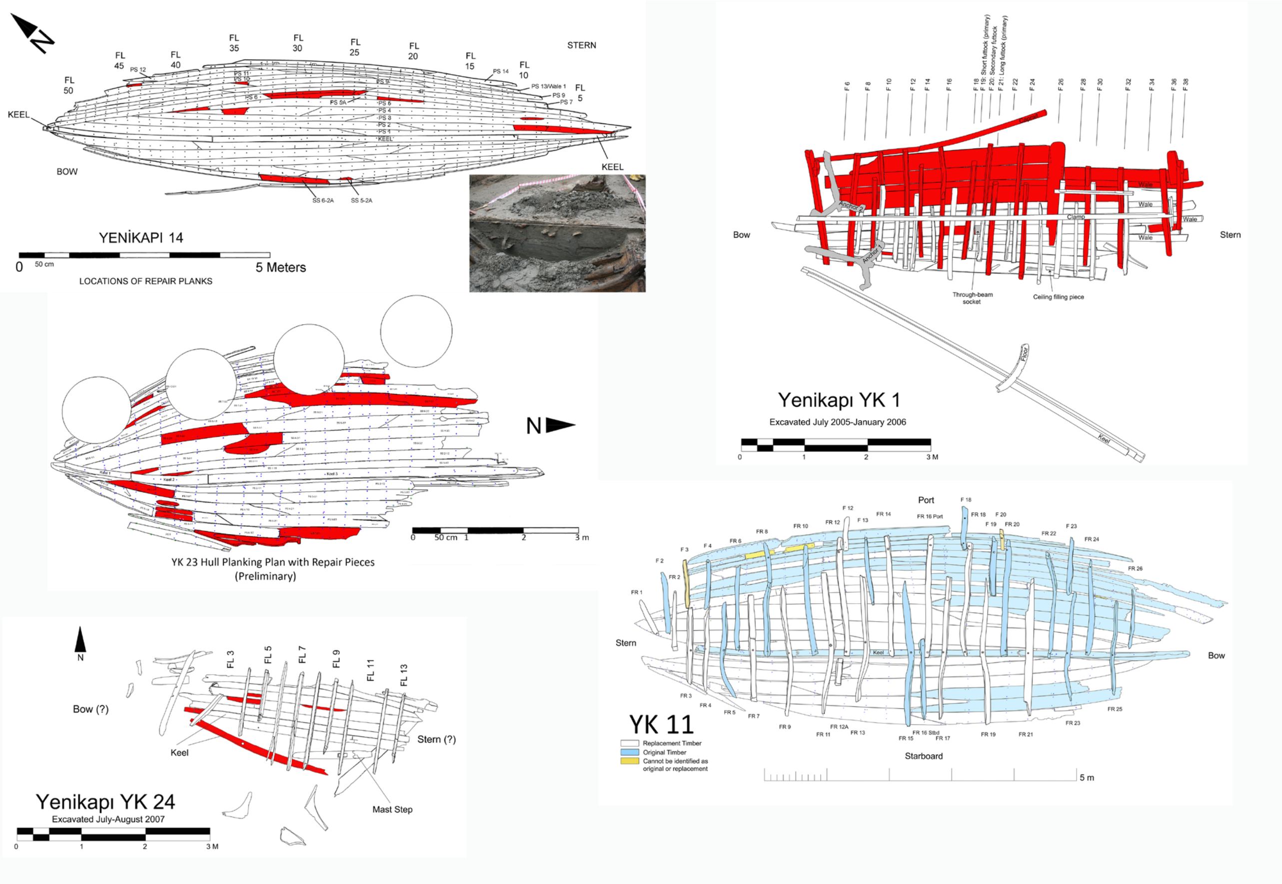

Figure 12.3. Yenikapı roundship wrecks studied by the Institute of Nautical Archaeology, with identified repairs or additions shaded. The inset on the YK 14 plan shows the stratigraphy in the hull, indicating it was buried without cargo. The YK 23 plan is a preliminary plan of hull planking repairs; some repairs indicated in the area of the concrete pillars are considered probable repairs due to the damage inflicted on the hull. Site plans by S. Matthews/INA. Adapted by M. Jones, except for the YK 11 plan; copyright R. Ingram.

recycled from edge-fastened derelict ships, the coaks or tenons were necessarily cut on the planks to be recycled. Misaligned, cut planking edge fasteners on recycled repair pieces, or cut edge fasteners on original plank seams, are usually strong indicators of hull repairs and can be easily identified if the hull is dismantled.

Other signs of recycled or repair timbers are also apparent in the Yenikapı shipwreck assemblage. These include tool marks indicating the use of different tools or fabrication methods for the piece—for example, YK 23's hull includes some hull planking repairs with adze-dubbed surfaces that are inserted in a hull with primarily sawn hull planking. The use of flat or butt scarf ends, rather than the diagonal, 'S' or 'Z' scarf ends in hull planking typical of Roman and Byzantine ships of this period, often indicates a hull repair. Other common characteristics of hull planking repairs include the use of atypical fasteners in a hull, for example, the exclusive use of iron nails to fasten a timber when treenails are the majority of fasteners; differences in the preservation of original and repair planks (often including evidence for wood rot or shipworm damage on the original sections of the plank); irregularly shaped hull planks, especially along plank seams (graving pieces); or gaps in plank seams filled with thick deposits of pitch or caulking due to a poor or loose fit of repair timbers. 'Mismatched' fastener holes found during the dismantling of a shipwreck sometimes indicated locations of repair pieces: for example, a larger number of nail holes may be present in a frame to which a repair plank was later fastened (although caulked holes in hull timbers could have served other purposes as well, such as the use of temporary shores or cleats, or even mistakes made during construction). Similarly, timbers made of unusual wood types in a hull could correspond to repairs: Akkemik (2015: 203–205) notes small numbers of anomalous wood types in specific hulls (YK 6, 7, 8, 9, 12, 18, 19, 20, 21, YK 27, YK 31, YK 35-ceiling) and suggests these are likely repairs, but (rightly) notes this cannot always be proven. The specific context of such features must always be closely examined in order to identify hull repairs. In the descriptions below, only clearly identified repair pieces will be discussed in detail, although specific damaged pieces, fasteners, caulking and resin deposits or other features could also be considered evidence of repair or maintenance episodes.

Figure 12.4. Examples of repairs from the Yenikapı shipwrecks: (a) Floor timber FL 44 from YK 14's hull. Note the caulked drilled holes next to the frame's location, which may be from an original frame, now removed; the timber's unique cross section and hook scarf are different from other frames on the ship. M. Jones, INA. (b) YK 24 Keel 3 timber, with the scarf for an endpost, Keel 4, which likely replaced more complex keyed hook scarfs normally used to join keel timbers. M. Jones, INA. (c) YK 14, PS 5-1A/5-2 scarf, at which an original plank piece was repaired with a worn, recycled timber. M. Jones, INA. (d) YK 11, end of the 'sternson,' recut from a keel timber (note the rabbet cut into the timber). R. Ingram, INA. (e) YK 4, replacement ash floor timbers in the midship area of the hull during excavation. M. Jones, INA. (f) YK 23, hull plank PS 4-1, with replacement piece PS 4-1A inserted in a rotten area (note the score mark and surface charring is missing on the repair piece). J. Čelebič, INA; (g) YK 14, replacement hull planks PS 2-1/1-2 and PS 3-1A, both recycled from a coak-built roundship similar to YK 14. M. Jones, INA. (h) A 'repair to a repair' (hull plank PS 6-2/1-4) from the hull of YK 14. A split in the plank (which was located at the turn of the bilge, and may have consequently been subject to more wear) was caulked. PS 6-2/1-4 was recycled from another ship (note the caulked treenail holes from its original use). The opposite end of the plank also had a repair piece installed into its scarf end (PS 6-2/5). Image by M. Jones, INA.

Hull repairs to Yenikapı cargo vessels

YK 14 dates to the first half of the ninth century and was originally about 14.5 m in length and 3.5–4.0 m in beam. YK 14's hull was built primarily of Turkey oak (*Quercus cerris*), with smaller numbers of timbers fashioned from sessile oak (*Quercus petraea*), sycamore maple (*Acer pseudoplatanus*) European ash (*Fraxinus excelsior*) and Oriental beech (*Fagus orientalis*), with a wider variety of wood types used in the wooden coaks (M.R. Jones 2017: 256–258). These species are fairly typical of the post-seventh-century Yenikapı merchant ships, although there is more variety in YK 14's hull than many of the other vessels.

YK 14's hull planking was edge-fastened with hardwood coaks (planking edge fasteners), while frames were fastened to the planking primarily with oak treenails supplemented with iron nails, more often used towards the ends of the ship or at the hull's sharp turn of the bilge. Iron nails constitute only a small proportion (*c*. 13.8%) of the overall number of fasteners in the surviving hull, which suggests an attempt to economise in the ship's construction. Some nail holes were also suspected repairs based on their location and condition in rot-damaged areas; Steffy suggests that similar repairs were made to the hull of the Serçe Limanı ship, but admits that this interpretation is an impression based on unusual fastener patterns rather than conclusive proof (Steffy 2004: 165; M.R. Jones 2013: 147–157).

YK 14 suffered extensive damage from dry rot or a similar organism; such damage can be caused by different species of bacteria and fungi (Blanchette 2000; M. Jones 2015: 16–17). Most of the damage occurred under frames, since many of the heavy caulking and pitch repairs in the hull relate to plugging damage around treenail holes or rotting plank seams, particularly in the turn of the bilge area and at the waterline along the lower edge of the first wale, where rotten areas were plugged with 2–3 cm thick deposits of resin and caulking (M.R. Jones 2013: 285–287, Table 3.8). Some plank seams appear to have been re-caulked, based on cut marks on planking edge fasteners at the seams and gouges in the keel rabbet stuffed with caulking (M.R. Jones 2017: 263, Fig. 13, 264, Fig. 17).

Twelve repair pieces were identified in YK 14's hull, all of which were recycled from another vessel. This identification is based on the presence of cut treenails or 'blind' treenail holes plugged with caulking and cut coaks or dowels on the neighbouring plank seams. The repair pieces range in length from 29.40 cm to 1.85 m, and 11 of the 12 originate from the hull planking of a vessel similar to YK 14, built with wooden coaks as planking edge fasteners. Several are graving pieces, used in rotten areas on the seams which were too large to repair using pitch and caulking alone, or repair pieces set into the ends of diagonal scarfs. Most of the repair pieces were installed at the turn of the bilge area of the hull, which may have been exposed to more wear or changes in moisture, and all but one were clearly salvaged from one or more vessels built using similar construction methods as YK 14: the recycled pieces are oak or elm planking originally edge-fastened with coaks. Some nails in the turn of the bilge area appear to have been driven into or next to rotten areas, perhaps during maintenance episodes.

Floor timber (FL 44) may also be a repair, based on its trapezoidal cross section (different from the other frames) and a hook scarf on its end for an in-line futtock, a unique feature on the ship. A series of plugged drilled holes were found in the hull planking under this frame, indicating it was either replaced or was perhaps shifted slightly during construction (Figure 12.4a).

YK 14 was repaired almost entirely with recycled hull planks from a vessel built using similar methods (oak planking edge-fastened with coaks), besides extensive recaulking and application of pitch for waterproofing (Figures 12.4c, 12.4g, 12.4h). It was likely used for at least several years. It is unclear whether the repairs were installed in a single episode or multiple episodes, but the latter possibility seems more likely, based on the nature of the repairs. Low-quality or unseasoned timber may have required such maintenance within a shorter time (Liphschitz and Pulak 2010: 179; Belasus and Daly 2022: 213)

YK 23 was a larger cargo vessel, about 15 m in length and 5 m in beam, most likely built in the later eighth century (based on radiocarbon dates); it may have sunk in the early ninth century based on the dating of copper coins found in the hold of the ship (Pulak 2018: 252). YK 23 was built with larger, good-quality oak timbers and a slight 'wine glass' shape to the hull: hull planking is a robust 3 cm thick on average, and the ship was built with heavy frames with cross sections of 13 × 10 cm arranged in a pattern of alternating floors and pairs of half-frames; frames were fastened to the hull planking exclusively with iron nails (Pulak 2018; 269–275). The hull planking was edge-fastened with coaks spaced on average 50 cm apart. The coaks appear to have been used up to the ninth strake, although they may have been installed up to the first wale (Strake 12) before repair planks were added; some identifications of repairs in this area are inconclusive due to damage from construction machinery.[6] Original hull planks were sawn, with regularly-spaced coaks, while the repair pieces are more irregular, and in some cases display adzed rather than sawn surfaces.

Although the hull's study is ongoing, YK 23 was clearly an old ship when it sank: over 20 repair planks and at least two probable repair planks have been identified (Figure 12.4f), in addition to at least one probable repair futtock at the turn of the bilge (F 15); rotten and shipworm-damaged

[6] The other Yenikapı roundships under study by INA were built with planking edge fasteners up to the first wale (Jones 2017: 276–277; Pulak 2018: 249, 258), as well as many of the ships studied by Istanbul University (*e.g.* YK 12) (Özsait-Kocabaş 2022: 257, Fig. 4.157).

Figure 12.5. View of the preserved starboard side of YK 1, including strakes added during the overhaul of the ship, to the right. Copyright INA.

areas of the planking and frames were also repaired with a mix of resin (probably pine pitch) mixed with grass or hair.[7] Only two of the catalogued repair planks are likely reused from another vessel.

YK 24 was a small, flat-bottomed hull, perhaps a small cargo or utility vessel with an original length of about 8.0 m and a beam of 2.5 m; it is tentatively dated to the tenth century AD (Pulak *et al.* 2015: 57). It was built of Turkey oak and has a hull edge-fastened with coaks at regular intervals, similar to other contemporaneous small vessels from the site. Although poorly preserved in comparison to other vessels of its size from the site, three graving pieces and a larger repair plank are apparent in the hull, along with a large number of iron nails used to fasten planks to frames, some of which could have been driven in later overhauls or maintenance of the vessel (Pulak 2018: 262). Most significantly, the endposts appear to have been replaced during an overhaul: while the main keel timber was original and still connected to the garboards with coaks, the curved sections had been removed at the ends (Figure 12.4b). The original scarf ends, almost certainly keyed hook scarfs, had been replaced with weaker three plane scarf ends fastened with treenails and nails (Pulak 2018: 262).

YK 1 was a small merchantman built of oak, with planking edge-fastened with coaks and in-line frames primarily fastened with treenails, similar to many of the other ninth-to-tenth-century wrecks from the site (Figure 12.5). The bottom of the hull was missing aside from a disarticulated rockered keel and one floor timber, but its starboard side was preserved to the caprail by the ship's amphora cargo (Pulak *et al.* 2013: 31–33). YK 1's hull shows clear evidence for a single major overhaul episode, using a heterogenous collection of timbers, besides other hull repairs.

Four small repair planks and graving pieces were installed in the starboard side of the lower hull, with three around the waterline area (strake 6) where a through-beam was likely installed amidships. At a certain point in its career, the sides were extended by three strakes (S12-14) to

[7] About 70% of the hull has been recorded as of July 2023. All of the ship's hull planking has been cleaned and documented, so the identification of hull planking repairs should be considered more accurate than the identification of repair frames, since the framing documentation is not yet complete.

increase the vessel's cargo capacity and freeboard; plugged holes in strakes 13 and 14 may indicate that they were recycled hull planks. Roughly adzed 'secondary frames', fastened exclusively with iron nails, were added to the hull in order to fasten the new strakes, while the 'primary' futtocks were cut down. A pair of grooved timbers for a removable weather strake were installed. The additional strakes were of a variety of wood types, including Oriental plane (*Platanus orientalis*), Turkish pine (*Pinus brutia*) and poplar (*Populus nigra/alba*), and showed variations in workmanship (Liphschitz and Pulak 2010: 167–168; Pulak *et al.* 2015: 61). The many nails in the lower hull, some driven through or near treenails, may have been added when the freeboard was extended (Liphschitz and Pulak 2010: 167).

YK 11, a small merchantman (reconstructed dimensions: 11.2 m length, 3.8 m beam, with an estimated cargo capacity of *c*. 8 tonnes) was likely built in the second quarter of the seventh century based on artefact finds and radiocarbon dates (Figure 12.4d) (Ingram 2018: 104). It likely had the longest sailing career of all of the ships documented by the INA team, perhaps spanning a few decades. The ship was almost certainly abandoned as a derelict, and any useful upper hull timbers above water may have been salvaged; it was found in marshy area of the site, most likely shallow water at the time, where large amounts of refuse was dumped (Ingram 2018: 104).

The hull was constructed of pine planking fastened with unpegged mortise-and-tenon joints, with oak frames and keel, and repairs of pine; the hull was built with a framing pattern of alternating floors and pairs of half-frames typical of many late antique merchant ships. Essentially, YK 11's hull consists of more repairs than original pieces: 28 of 47 hull planks were replaced (not including 11 graving pieces), or 60% of the planking, while 16 of the 36 frames (44%), including nine of 13 surviving floor timbers, are replacements (Ingram 2018: 111, 131–132). FR 21, a repair floor timber, was originally bolted to a keel scarf. Later, it was removed, and the replacement was nailed—a weaker connection. Ingram suggests it was done away from a home port, one of a 'series of major repairs rather than one massive overhaul' (Ingram 2018: 121, 130–131). Most repair pieces were cut from new timber, but a curved sternsom fastened over frames in the keel area (Ingram 2018: 121, 122–123, Figs. 27–28, 131), three hull planks, a stanchion block and ceiling plank were recycled from other vessels.

Repairs to Galley YK 4

The five or six galley shipwrecks from the site are remarkably similar in their construction; large, high quality softwood timbers, most often Calabrian pine (*Pinus nigra*) were used for hull planking and wales, while keel timbers and frames were made from Oriental plane (*Platanus orientalis*), a hardwood type perhaps chosen due to availability of curved timbers. Iron nails and (occasionally) bolts, as well as treenails were used as hull fasteners, and coaks were used in hull planking, although they were smaller and more widely and irregularly spaced than those used in roundship hulls of the same period (Pulak *et al.* 2015: 63). The hulls themselves may have been up to 30 m in length and 4 m in beam, and likely had a maximum of 25 rowers per side; they most likely represent *galeai* or *monoreis*, single-banked warships lighter than the bireme *dromons* more frequently mentioned in Byzantine sources (Pryor and Jeffreys 2006: 190; Pulak *et al.* 2015: 62, 69).

Both YK 2 and YK 4 studied by the INA team are dated to the eighth-to-tenth centuries based on stratigraphy and AMS radiocarbon dates (Pulak 2018: 263–264). While YK 2 was apparently a relatively new ship when it sank (Pulak *et al.* 2015: 62), YK 4 was repaired in a number of areas. Large ash (*Fraxinus excelsior*) floor timbers were placed amidships, most likely as additional reinforcement for the location of the mast step (Figures 12.3, 12.6), as well as at either end of the hull (Pulak *et al.* 2015: 68; Pulak 2018: 266). Some of these frames were fastened with treenails smaller in diameter than those used in the original hull (9–10 mm as opposed to 12–15 mm) and with fewer iron nails than usual for original frames. Several futtocks in the turn of the bilge area and possibly one short hull plank (SS 8-2) also appear to have been repairs.

The presence of several war galleys in the Theodosian Harbour, intermingled with the wrecks of merchant vessels in what was apparently a commercial harbour, is unexpected. Perhaps the ships were berthed or beached in a designated 'naval' section of the harbour, were seeking shelter opportunistically when a storm or other disaster occurred, or were simply abandoned in a convenient spot (Perinçek 2010: 206–208; Pulak 2018: 238). Ancient warships were typically housed in slipways or shipsheds in complexes away from commercial harbours (Blackman and Rankov 2013; Kislinger 2022), but there is no such evidence within the Yenikapı excavation area; no securely dated Mediaeval shipsheds have been identified in Anatolia before the thirteenth century stone shipsheds at Alanya (Redford 2015: 549). During the siege of 673–677 AD, Theophanes records that the Byzantine fleet was mustered in the 'Harbour of Kaisarios' (another name for the Theodosian Harbour) before sailing out against the Arab fleet, but this does not necessarily mean they were normally stationed there; the Neorion Harbour on the Golden Horn was apparently used as the main naval harbour for warships from the sixth century (Mango and Scott 1997: 493; Magdalino 2007: 20, 94–95; Kislinger 2022: 11). YK 4 was likely considered an older galley, and was perhaps being held in reserve for use in case of emergency, a common practice in navies throughout history, or for salvage and recycling of parts to repair newer ships (Koivikko 2017: 150–151).

Conclusion: observations on the repair pieces used in the Yenikapı shipwrecks

Wood rot by bacteria or fungi appears to have been a serious problem for the older oak-built merchant ships,

Figure 12.6. Site plan of YK 4, with identified repair frames shaded. Image by S. Matthews, INA; adapted by M. Jones.

especially YK 14; shipworm damage was also a major problem for some of the ships, particularly for YK 23. Pine resin and caulking materials—usually grass but sometimes hair—was generously applied in all of the roundships, with repair pieces were installed in the most severely affected areas. Repair fasteners, usually iron nails, were probably used to reinforce specific areas of these hulls, especially around rotten or loosened treenails, but conclusively proving the use of individual nails as later repairs is not always possible. The builders of the newer roundships from Yenikapı such as YK 5 and possibly YK 14 seem to have tried to minimise the number of iron fasteners used in the hull's initial construction. Iron bolts were commonly used in Roman and late antique ships, but are uncommon in the Yenikapı merchant vessels after the seventh century, being used mainly to fasten keel and endpost timbers. Iron nails were used sparingly on YK 14, primarily to fasten frames at the keel and turn of the bilge. The large number of nails used as frame fasteners in older hulls may indicate later hull maintenance rather than features of the initial construction (Liphschitz and Pulak 2010: 167; M.R. Jones 2013: 148–157, Table 3.1). Similarly, there is no evidence of lead sheathing, either covering the entire hull or used as repairs to leaky hull sections, although it was commonly used in earlier ships (Steffy 1985: 87; Postiaux 2015: 1:185–186, 2:Pl. 21.2, 27.2, 28.3, 29.1, 31.3, 37.2, 39).

The expected service life of Byzantine ships remains an open question. The *Rhodian Sea Law* (seventh century AD) specifies only that a ship with its tackle should be valued at 50 gold *solidi* per 1,000 *modii* of capacity, while an 'old' ship would be valued at 30 *solidi* per 1,000 *modii* (Ashburner 1976: 63–64). A later Venetian law divide ships into three categories: under five years old, between five and seven years old, and over seven years old (Ashburner 1976: 64). Lane (1992: 263) estimates that Venetian ships were expected to last 10 years on average, citing specific instances in which merchant vessels were scrapped after eight, 14, and 15 years of service. Evidence for repairs to the Serçe Limanı hull led Steffy to suggest the ship had a career of 'a decade or two', although 'it is impossible to raise such a statement above a suspicion' (Steffy 2004: 165).

Dendrochronological analyses of shipwreck hulls can sometimes aid in the identification of hull repairs when new timbers (rather than recycled ones) were used. For example, dendrochronologically dated hull timbers from the eleventh century Skuldelev 1, 2, 3, and 5 shipwrecks indicate periods of up to 20–30 years between the felling dates of original hull timbers and repairs (Crumlin-Pedersen and Oleson 2002: 65–68). The service life of Mediterranean ships was almost certainly shorter,

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especially for warships, due to the warmer and more saline conditions than those in the Baltic, which result in more exposure to shipworms and other damaging marine organisms (Lipke 2013b). Unfortunately, most of the oak-built Byzantine ships studied so far from Yenikapı were constructed primarily with younger hull timbers: only a small number of sampled timbers from the YK 14 and 24 shipwrecks have the 40–50 growth rings necessary for dendrochronological dating, although timbers from the YK 23 shipwreck are more promising.[8] Lorentzen *et al.*'s study of the sixth-century Dor 2001/1's timbers employed 'wiggle-matching', or a combination of AMS radiocarbon dates of small groups of growth rings in timber cross sections and cross-references with radiocarbon dates on short lived materials, including matting and rope; they conclude that the ship had not sunk on its maiden voyage but was 'likely in service for a relatively short period of time', perhaps up to a decade, before its sinking (Lorentzen *et al.* 2014a: 676–677, 2014b).[9]

War galleys would have required more maintenance than merchant ships, and may have had even shorter careers: Venetian galleys of the fifteenth-to-sixteenth centuries were considered fit for service for eight or nine years, but might have lasted as little as three or four (Lane 1992: 263). Lipke (2013a: 195) estimates that well-maintained ancient triremes probably had a service life of eight to 14 years, and a career of 20 years would have been exceptional; structural properties of wood, the presence of mortise-and-tenon joints or other edge fasteners in planking (which serve as moisture traps) and hogging and sagging limit the lifespan of wooden ship hulls, especially the long and narrow hulls of galleys (Lipke 2013a: 185–186). However, older warships also had some limited uses, as demonstrated in a passage from Liutprand of Cremona on the attempted capture of Constantinople by the Rus in 941 AD:

> 'After [Emperor] Romanus [Lecapenus] had spent some sleepless nights lost in thought while Igor was ravaging all the coastal regions, Romanus was informed that he possessed some dilapidated galleys which the government had left out of commission on account of their age. When he heard this he ordered the *kalaphatai*—that is, the shipwrights—to come to him, and he said to them, 'Hurry without delay, and prepare these remaining galleys for service. Place the devices which shoot out fire [i.e., siphons for Greek fire], not only in the prow but also in the stern and on both sides of the ship'. When the galleys had been outfitted according to his orders, he manned them with his most competent sailors and ordered them to proceed against King Igor.'[10]

While galleys could be maintained to their peak level of performance for only a few years, Liutprand of Cremona's reference indicates that older ships (perhaps including YK 4?) were kept 'mothballed' in storage for reuse as second-line warships, perhaps specifically for defence of the city in an emergency. It is likely that such vessels were also cannibalised for spare timbers and fasteners as well, a common practice with warships and military vehicles in later periods (Koivikko 2017: 150–151).

As shown by the hull repairs on YK 11, YK 14, YK 20, YK 23, and likely YK 1, ship timbers were sometimes cannibalised from derelict hulls. Generally, recycled timbers appear to have been smaller planking pieces—under 1.85 m, and often much smaller—or timbers of large diameters or with useful curved shapes: the latter include the curved keel timber recycled as a 'sternson' for YK 11, a stanchion block from the same shipwreck, and probably the mast step with re-cut notches from shipwreck YK 20 (M.R. Jones 2013: 313, Table 3.9; Kocabaş 2015b: 106–107; Güler 2019: 50–51, S. 36). Perhaps longer pieces without rot damage or other weaknesses were rare: with the possible exception of YK 1, repair pieces cut from new timbers were almost always used to cover large hull areas and for completing the major overhauls apparent in the hulls of shipwrecks YK 1, 11, and 24. It is usually unclear which repairs came first, but different repair episodes can sometimes be distinguished through careful examination. Overall, repair pieces cut from new timbers are far more common than those recycled from older ships in the hulls discussed here, but, in the case of YK 14, recycled pieces were used for nearly all of the hull planking repairs.

The salvage and recycling of ship components likely took many forms. Law codes and textual references to salvage divers indicate that shipwreck salvage from the shore to depths of up to 15 fathoms occurred in the Byzantine period; the salvage of shipwrecks in the in the Theodosian Harbour must have been simpler.[11] While ships' fasteners were probably less valuable as equipment

[8] T. Ważny and B. Lorentzen, personal communication, 18 July 2018. One disarticulated plank found under the YK 14 hull was dated through dendrochronology to the early ninth century (cited in Jones 2013: 54, n. 213). Over 295 of *c.* 4,000 sampled wooden wharf pilings from the Yenikapı site have also been incorporated into existing oak chronologies (Kuniholm *et al.* 2015: 47–48). Current research suggests that they come from a source also utilised for timber repairs to Hagia Sophia and in a Byzantine fort at Capidava in Romania, most likely from the southwestern Black Sea region (Wazny *et al.* 2017: 178–181).

[9] See also Lorentzen *et al.*'s (2014a, 2014b) 'wiggle-matching' study of the nineteenth-century Akko 1 shipwreck, also built of oak: the ship's estimated service life (under 10 years) is similar to that of Dor 2001/1.

[10] Excerpt from Liutprand of Cremona, *Antapodosis*, vol. 136, cols. 833–834, tenth century AD (from Geanakoplos 1984: 113). *Kalaphatai* was the term used for 'caulkers' in the early modern period (see Kahane *et al.* 1988: 513–514). Pryor and Jeffreys (2006: 150) note that the first known usages of the Mediaeval Greek terms for 'caulker' (*kalaphatēs*) and 'caulking (*kalaphatizein*) occur in Egyptian papyri dating to the 560s, and occur in the tenth-century *De ceremoniis* in reference to an inventory for naval expeditions to Crete in 911 and 949; Pryor and Jeffreys also state that the term was misunderstood by Liutprand of Cremona in the tenth-century *Antapodosis* to mean 'shipwright' (*calafata*).

[11] A professional guild of *urinatores* or divers is attested at the port of Ostia in the early Imperial period (Oleson 1976: 22–23). Byzantine-period references to salvage diving include the *Rhodian Sea Law* 3.47 (trans. Ashburner 1976: 119) and an eighth-century reference in the *Parastaseis Syntomoi Chronikai* to attempts to salvage a bronze statue lost in the Bosporus (Cameron and Herrin 1984: 119). The salvor typically received a percentage of the item's value, from one-tenth of the value for objects brought up to one cubit from shore to half of the value for objects retrieved from 15 fathoms.

than iron anchors, masts, rigging tackle or ships' boats,[12] the limited use of iron fasteners in some of the Yenikapı hulls such as YK 14 and YK 5 suggest that they may have been valuable enough to scavenge from derelict hulls. Perhaps the Theodosian Harbour's economic life included junk-dealers or other scavengers similar to the *arayıcılar* of nineteenth-century Istanbul, who scoured Topkapı Palace's garbage dump for valuables (Theodorelis-Rigas 2019: 264).

The anaerobic/low oxygen conditions in the deposits at Yenikapı allowed exceptional preservation of shipwrecks and organic remains, including essential materials such as pitch and caulking associated with hull repairs and routine maintenance activity. These remains are found within the original harbour and waterfront area, which potentially can provide more contextual information on urban life than isolated finds of shipwrecks which sank in transit to their destination. Constantinople's Marmara shore harbours were active work areas and would have been used in part for repairs and ship maintenance as well as opportunistic salvaging of shipwrecks and abandoned derelicts. The Yenikapı excavations can shed light on the working methods and everyday conditions of maritime industries. The efforts of typical captains, fishermen and sailors to keep their vessels, and by extension, their livelihoods, afloat can now be better understood with these finds.

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[12] Ashburner 1976: 76–77, 79–80. Few iron anchors have been found during the Yenikapı excavations, but several hundred three-hole stone anchors, including some examples of *spolia* recycled from architectural elements, are currently under study by Cemal Pulak and Orkan Köyağasıoğlu of the Institute of Nautical Archaeology; see Çölmekçi 2007; Kiziltan 2007, 2010 for published examples.

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