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

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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

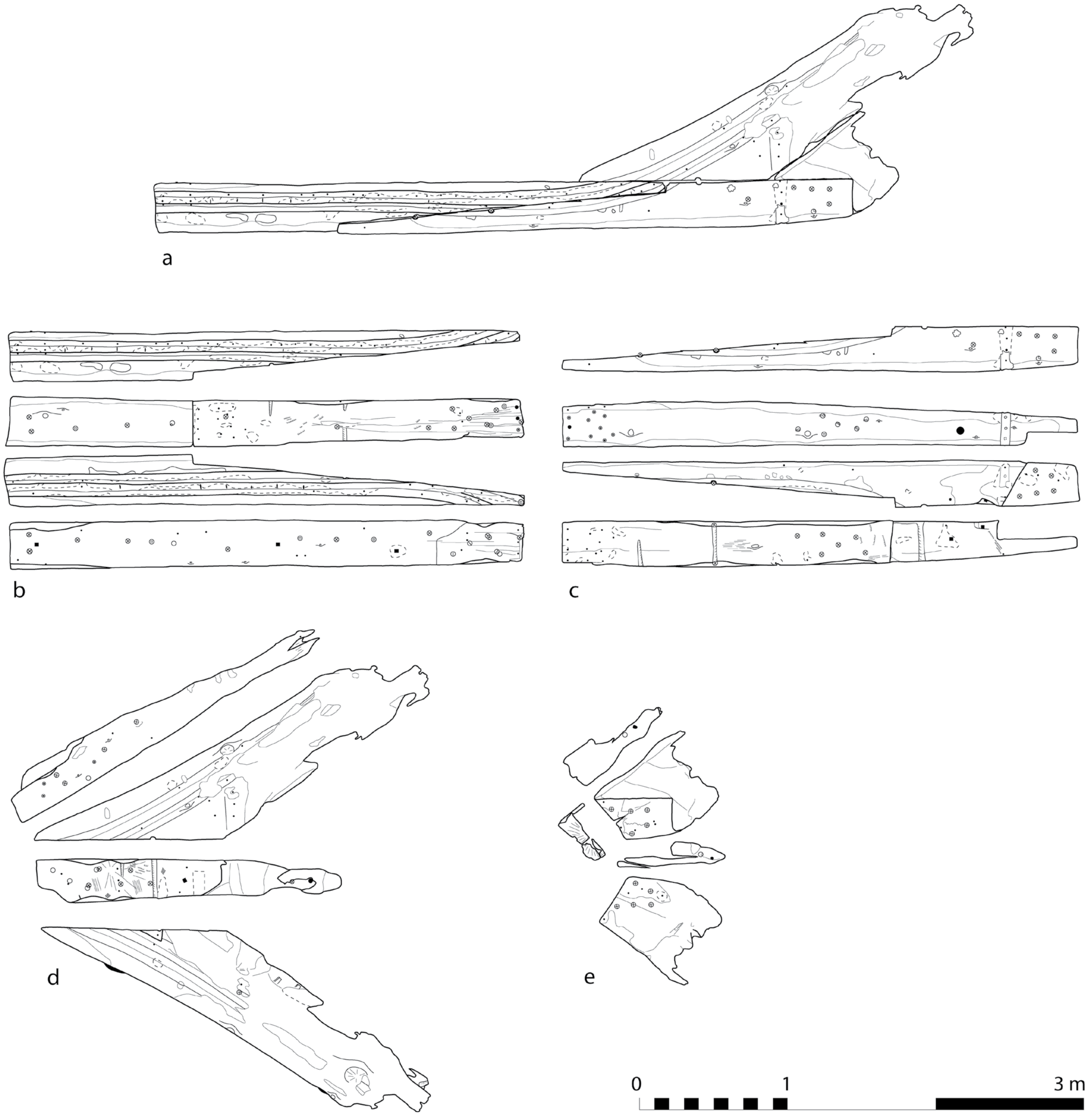

Figure 11.2. Starboard side of the keel and stem assembly of the forward end of the lower hull (a) and individual elements of the same assembly: (b) element 1, (c) element 2, (d) element 4 and (e) element 3. Image by H. Lettany, after Kroes 1995.

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.

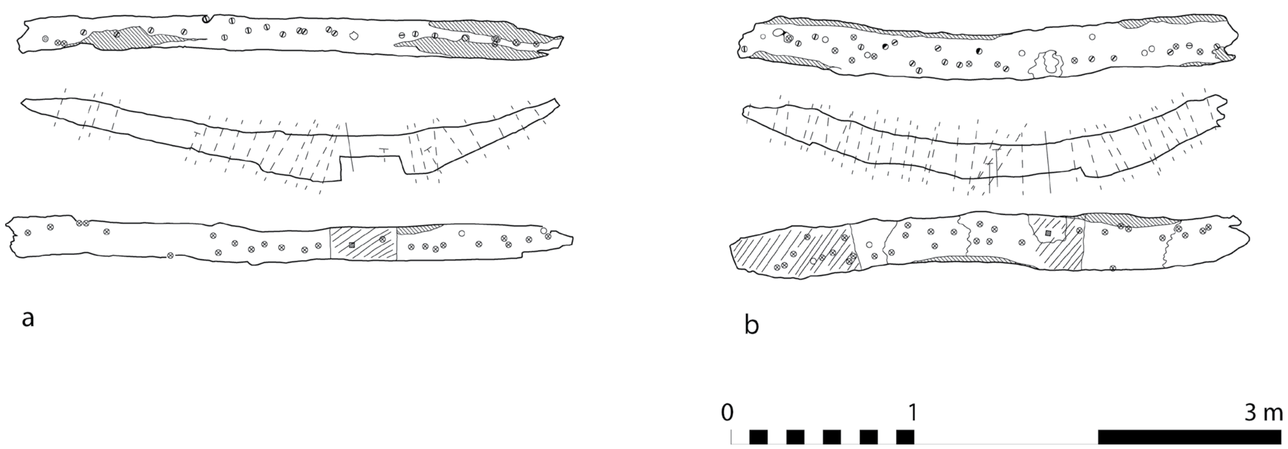

Figure 11.3. Rider 1 (a) and rider 2 (b) from the forward end of the lower hull. Image by S. Mulder, after Kroes 1995.

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.

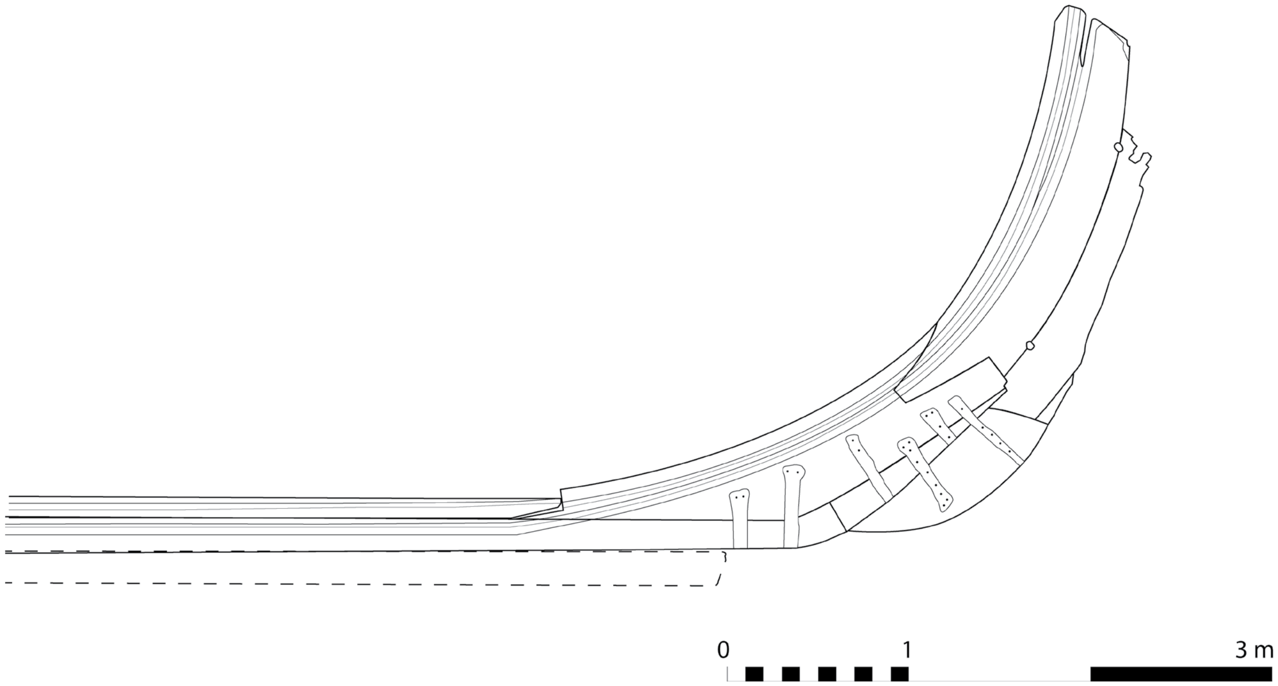

Figure 11.4. Starboard side of the keel and stem assembly of the *B&W1* shipwreck. Image by H. Lettany, after Lemée 2006: 237.

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

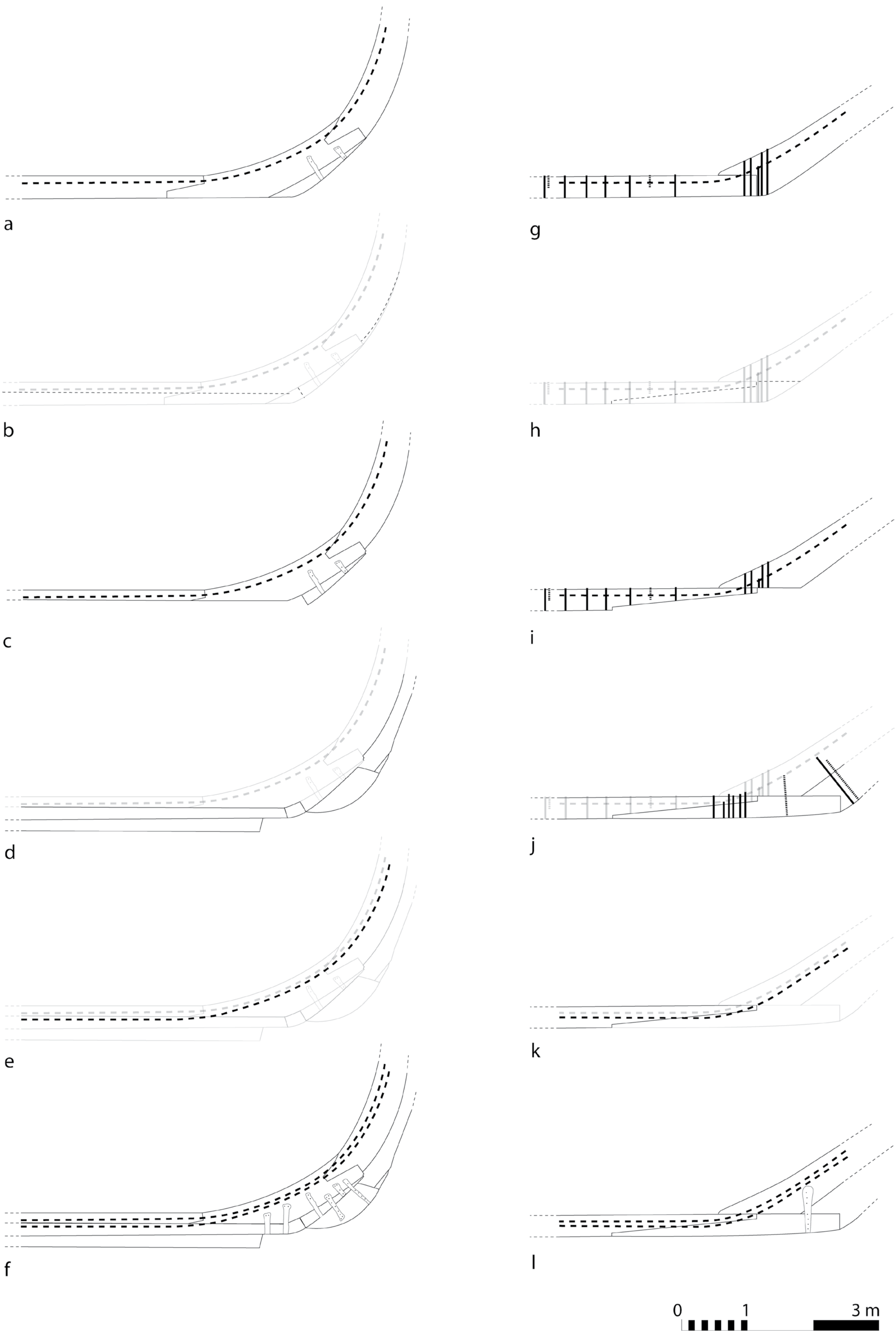

Figure 11.5. Hypothetical initial stem and keel construction of (a) the B&W1 shipwreck and (g) the *Scheurrak SO1* shipwreck, and the consequential steps of the second building phases ((b) through (f) and (h) through (l)). For *Scheurrak SO1*, treenails (black) and iron bolts (dashed) are indicated as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

Acknowledgements

This chapter finds its origin in the interdisciplinary research project 'The *Scheurrak SO1* shipwreck in the Maritime Cultural Landscape of the Early Modern Netherlands, 1550–1650'. This is a collaboration between the Faculty of Archaeology and the Faculty of Humanities of Leiden University, with the support of the Cultural Heritage Agency of The Netherlands. I would like to thank my supervisors, Prof Dr Martijn Manders and Dr Roos van Oosten for their support and feedback. I would like to thank Christian Lemée for allowing me to rework his drawing of the *B&W1* shipwreck for the purpose of this chapter. Finally I would like to thank Sophie Mulder, Isabella Nouvelot, Ingrid Kras and Grace Alonzo for their help with digitising several of the pencil drawings in Illustrator as part of their internship. Figure 11.3 in this paper is part of their work.

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12

Evidence for repairs and hull maintenance from the Yenikapı Byzantine shipwrecks

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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