Evidence for repairs and hull maintenance from the Yenikapi Byzantine shipwrecks

Michael R. Jones

Abstract: The shipwreck assemblage from the Marmaray Project excavations at Yenikapi (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 Yenikapi 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 Yenikapi 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 Yenikapi 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; Küzer 2022).

The Yenikapi 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 (Pullak 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 Yenikapi ships completed so far provides a fairly detailed picture of their various features.

The Yenikapi 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.
Evidence for repairs and hull maintenance from the Yenikapi Byzantine shipwrecks

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 caulkling 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 Yenikapi shipwrecks² 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 Yenikapi 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 Yenikapi assemblage likely forming its own distinct group (Hocker 2004b: 5–6; Pomey et al. 2012: 305–307). At least 30 of the Yenikapi 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 (Kocabas 2015a: 11–12; Pulak 2018: 243–247). The lack of edge fasteners reported for six of the Yenikapi 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; Kocabas 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 Yenikapi 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 Yenikapi shipwrecks excavated by the Istanbul Archaeological Museums between 2005 and 2008 and documented by the Institute of Nautical Archaeology team at Yenikapi directed by Cemal Pulak. These will be supplemented by published examples of repair features from other first-millennium AD shipwrecks from Yenikapi 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; Belaus and Daly 2022).


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; Kocabas 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 (Yalcin 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 (Kocabas 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) (Kocabas 2008: 104, 117, 126, 135, 136, Fig. 72b, 148, 164, 166, Fig. 80; Güler 2019: 32; Özsaik-Kocabas 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.](image-url)
the jars themselves could have been recycled, a practice documented from other Byzantine shipwrecks (van Doorminck 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. 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 Yenikapi (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 Yenikapi 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 (Pinos 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).\(^2\) 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 Yenikapi 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

---

1. 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).

2. 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.7.1–3, trans. Hopt 1916: 457, n. 5).
Table 12.1. Identified repairs and recycled timbers from the Yenikapı shipwrecks.

<table>
<thead>
<tr>
<th>Shipwreck/estimated date of sinking</th>
<th>Shipwreck type</th>
<th>Repair types</th>
<th>Recycled timbers?</th>
<th>Selected published sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>YK 1 (mid-tenth century)</td>
<td>Roundship</td>
<td>Repair plank and graving pieces in lower hull, freeboard extended in overhaul (new futtocks/strakes added); possibly new iron fasteners added (?)</td>
<td>One recycled graving piece; possibly recycled upper strakes (S 12-14 area)</td>
<td>Pulak 2007, 2018; Pulak et al. 2015</td>
</tr>
<tr>
<td>YK 2 (ninth to tenth centuries)</td>
<td>Longship/ galley</td>
<td>None identified</td>
<td>None identified</td>
<td>Pulak 2007, 2018; Pulak et al. 2015</td>
</tr>
<tr>
<td>YK 4 (ninth to tenth centuries)</td>
<td>Longship/ galley</td>
<td>Repair frames added adjacent to original frames; possible repair plank added to hull (SS 8-2)</td>
<td>None identified</td>
<td>Pulak 2007, 2018; Pulak et al. 2013, 2015</td>
</tr>
<tr>
<td>YK 5 (tenth century)</td>
<td>Roundship</td>
<td>One repair piece treenailed to endpost</td>
<td>None identified</td>
<td>Pulak et al. 2015</td>
</tr>
<tr>
<td>YK 11</td>
<td>Roundship</td>
<td>Repair planks, graving pieces, repair frames, repair fasteners (55 repair pieces)</td>
<td>Recycled ‘sternson,’ recycled ceiling planks (?)</td>
<td>Pulak et al. 2015; Ingram 2018; Pulak 2018</td>
</tr>
<tr>
<td>YK 14</td>
<td>Roundship</td>
<td>13 hull plank repairs identified, besides two probable repairs made during construction; one possible repair frame</td>
<td>All but one hull plank repair were recycled from a coak-built hull similar to YK 14.</td>
<td>M.R. Jones 2013, 2017; Pulak et al. 2015</td>
</tr>
<tr>
<td>YK 23</td>
<td>Roundship</td>
<td>[Partially documented] 20–22 repair and probable repair planks; one or more repair frames (futtocks)</td>
<td>Two possibly recycled hull planks</td>
<td>Pulak et al. 2015; Pulak 2018</td>
</tr>
<tr>
<td>YK 24</td>
<td>Small roundship</td>
<td>Planking repair pieces; replaced endposts, possible repair nails (?)</td>
<td></td>
<td>Pulak et al. 2015; Pulak 2018</td>
</tr>
</tbody>
</table>

Shipwrecks studied by Istanbul University (selected evidence based on published sources)

<table>
<thead>
<tr>
<th>Shipwreck</th>
<th>Shipwreck type</th>
<th>Repair types</th>
<th>Recycled timbers?</th>
<th>Selected published sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>YK 12</td>
<td>Small roundship</td>
<td>Three repair planks</td>
<td>None identified</td>
<td>Kocabas 2008, 2015; Ozsait-Kocabas 2018, 2022</td>
</tr>
<tr>
<td>YK 20</td>
<td>roundship</td>
<td>Probable repair planks and frames</td>
<td>Recycled or re-cut mast step; probable recycled hull planks with coaks on site plan; irregular graving pieces; replaced keel?</td>
<td>Güler 2019: 32, 50–51, S. 36</td>
</tr>
</tbody>
</table>
Evidence for repairs and hull maintenance from the Yenikapı Byzantine shipwrecks

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 12.3. 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.
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.
Evidence for repairs and hull maintenance from the Yenikapı Byzantine shipwrecks

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 grave 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 scars. 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.

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. 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).
areas of the planking and frames were also repaired with a mix of resin (probably pine pitch) mixed with grass or hair. 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

---

Footnote: 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 added ‘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 water 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 graveling 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, or perhaps it was used as a military training or training area. It was clearly not 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 (Peringe 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 Yenikapi excavation area; no securely dated Medievaal shipsheds have been identified in Anatolia before the thirteenth century stone shipsheds at Alanya (Redford 2015: 549). During the sieges 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 Yenikapi shipwrecks**

Wood rot by bacteria or fungi appears to have been a serious problem for the older oak-built merchant ships,
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,
Evidence for repairs and hull maintenance from the Yenikapı Byzantine shipwrecks

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.1 Lorenzen 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 (Lorenzen 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; Kocabag 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

---

1 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 (Kunholm 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 Capadova in Romania, most likely from the southwestern Black Sea region (Ważny 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 ‘caulkers (kalaphita) 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 (calafate).

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 Symtomoi Chronikai to attempts to salvage a bronze statue lost in the Bosporus (Cameron and Herrin 2018: 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, 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 arayncèles 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.

Acknowledgements

I am grateful to INA Yenikapı Project Director Cemal Pulak, the former Istanbul Archaeological Museums directors Ismail Karamut and Zeynep Kızıltan, and current director Rahmi Asal for the opportunity to work on the fascinating Yenikapı shipwreck material. Post-excavation work on YK 14 and YK 23 was made possible by INA-Bodrum Research Centre (INA-BRC) director Tuba Ekmekçi-Littlefield, conservation laboratory directors Asaf Oron and Esra Altanmat, and the staff of the INA-BRC. The Istanbul Archaeological Museums’ Yenikapı excavation team staff, especially Gülbahar Baran-Çelik and Sırrı Çölmekçi, were essential in the completion of this research, as was the INA YK project excavation team, particularly Mehmet Çiftlik, Rebecca Ingram, Ilkay Ivgin, Orkan Köyağasoğlu and Sheila Matthews. I am grateful to the current and former Koç University students who have assisted in the project since 2018, especially Savannah Bishop, Jelena Čelebič and Günçü Öçgüden, who have worked on the YK 23 timbers for multiple seasons. Funding and equipment for the 2009–2023 research seasons was provided by the Institute of Nautical Archaeology, Koç University’s Mustafa V. Koç Centre for Maritime Archaeology (KUDAR) and Research Centre for Anatolian Civilizations (RCAC), the Honor Frost Foundation, the American Philosophical Society and Texas A&M University.

References


Michael R. Jones

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 spolía recycled from architectural elements, are currently under study by Cemal Pulak and Orkan Köyağasoğlu of the Institute of Nautical Archaeology; see Çölmekçi 2007, Kızıltan 2007, 2010 for published examples.
Evidence for repairs and hull maintenance from the Yenikapı Byzantine shipwrecks


Rival, M. 1991. La charpenterie naval romaine [Roman naval carpentry]. Marseille, France: CNRS.


Interpreting underwater archaeological sites