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AND
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To our significant others
for their patience
past, present, and future.

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PART III

SHIPS AND SHIPWRECKS

CHAPTER 16

EARLY SHIPBUILDING IN THE EASTERN MEDITERRANEAN

MARK E. POLZER

INTRODUCTION

WHEN did cultures in the eastern Mediterranean start building ships? The answer, quite simply, is that we don't know. Some researchers claim that stone implements and skeletal remains found on Crete and Sardinia and in southern Spain testify to seafaring in the Pleistocene by early hominids (Bednarik 1999; Facchini and Giusberti 1992; Johnstone 1988: 3; Martini 1992; Sondaar et al. 1995). While such assertions may one day be proven, they are not yet widely accepted, and methodological questions have been raised about the dating and interpretation of such evidence (Bower 1997, 2010; Cherry 1992). The earliest established evidence for sea trade and, by implication, the use of seagoing watercraft in the Mediterranean are Mesolithic stone tools found in Franchthi Cave in the Argolid (Jacobsen 1969: 343, 1973: 76–77, 82–85; Renfrew, Dixon, and Cann 1965: 225; see additional bibliographical information in Tzalas 1995: 459–462). Studies have shown that they were fashioned from obsidian gathered on the island of Melos in the Cyclades, which lies some 120 km across open sea from the mainland (Aspinall, Feather, and Renfrew 1972: 333; Cann and Renfrew 1964: 111; Renfrew et al. 1971: 242; see Johnstone 1973: 3–4 for a good summary). Those responsible for the obsidian were familiar with the sea and probably had been voyaging among the islands of the Aegean for a long time (Cann, Dixon, and Renfrew 1965: 225; Cherry 1990). What sort of vessels they employed is not known, but scholars have argued for

both dugouts (Basch 1987: 77; Casson 1995: 31; Johnstone 1973: 6; Wachsmann 1998: 74) and reed craft (Johnstone 1973: 4–6; Tzalas 1995), based partly on available building materials and tools but also largely on later representations of descendant craft. The answer, perhaps, is both dugouts and reed craft, and others as well (Marangou 2003).

Indeed, the difficulty in studying the construction of early watercraft is precisely that most of the evidence is in the form of artistic representation—boat depictions decorating pottery, drawn on rocks, painted on walls, and sculpted in various media—that is often difficult to interpret and limited with respect to the details of construction. In order to understand how ancient shipwrights conceived and designed their hulls, and the constructional features—materials, scantlings, joinery, building techniques and procedures—that gave form and functionality to the vessels, we are best served by evidence from the ships themselves. Therefore, in the limited confines of this chapter, we will focus our discussion of early shipbuilding in the eastern Mediterranean on archaeological hull remains provided by shipwreck and terrestrial excavations. Egypt has proven to be the largest repository of early ancient watercraft; to date, archaeologists have found remains from more than 20 ancient boats spanning 2,500 years of Egyptian civilization. It is fitting, then, that we begin our discussion there.

EGYPT

Riverine Craft

Two Predynastic boat models from about 4000 BCE (Hayes 1964: 233; Brunton and Caton-Thompson 1928: 34, pl. 23.33) provide the earliest evidence for watercraft in ancient Egypt, although by then Egyptians probably had been building rafts capable of navigating the main channel of the Nile for at least three millennia (Hendricks and Vermeersch 2000: 35). These early watercraft were simple bundles of reeds lashed together (Casson 1995: 11), but by the mid-fourth millennium BCE, Egyptians were constructing plank-built wooden boats (Ward 2004: 13). Beginning in dynastic times, boat representations by the thousands decorate the tombs and funerary monuments of Egypt's royalty and elite. In times of prosperity, these included both elaborate boat models and full-size boats interred with the deceased, either within or near the tomb and sacred enclosure (Ward 2000: 6–8). The earliest-known examples are 14 wooden boats discovered in 1991 buried in mud-brick, boat-shaped graves at the Early Dynastic enclosures at Abydos (O'Connor 2009: 185–194, with earlier accounts in O'Connor 1991, 1995; O'Connor and Adams 2001). Belonging to one of Egypt's First Dynasty kings, this fleet of boats represents the oldest planked watercraft in the world (Ward 2000: 39). The only boat so far examined has a narrow, shallow, crescent-shaped hull with rounded ends, flat bottom, and angled sides (Ward 2006: 125 fig. 7). Its hull is made from thick planks of local wood, probably

tamarisk, cut in joggled shapes and held together with woven straps lashed through transverse rows of V- and L-shaped channels (O'Connor 1991: 12; Ward 2003: 20–21). While complete recordings of this and the other hulls must await full excavation, the reported features are broadly defining and demonstrate, through their survival in later funerary boats, a religious adherence to traditional forms and specific, even standardized, methods (Ward 2000: 140).

One such descendant craft, discovered in 1954, is the magnificent funerary boat of Khufu, Egypt's Fourth Dynasty ruler responsible for constructing the Great Pyramid at Giza (AbuBakr and Mustafa 1971; Jenkins 1980; Lipke 1984, 1985; Nour et al. 1960). The papyriform boat, like the pyramid, was a deliberate display of conspicuous wealth and power. It is an elegant and complex vessel constructed from almost 40 tons of imported Lebanese cedar and measuring over 43 m in length and 5.6 m in beam (Lipke 1984: 25, 97, 102). Like the Abydos boat, it has a flat bottom, formed by eight symmetrically placed planks, and angled sides that continue the planking symmetry (Lipke 1984: 104; Steffy 1994: 25). Builders first constructed the shell of the hull from thick planks with elaborately joggled edges (see Lipke 1984: 66 fig. 42). They inserted hardwood tenon coaks between plank edges to align them (Lipke 1984: 25, 64), and then tied the planks together at their ends and in other strategic areas of stress with ligatures (Lipke 1984: 66 fig. 42; Mark 2009: 138–145). Builders closed the seams by lacing ligatures—or woven straps (see Mark 2009: 138)—transversely from sheer to sheer over large, wooden battens and through rows of V-shaped channels cut into the interior side of the planks, but never penetrating their full thickness (Figure 16.1a). Edge mortises and lashing channels are the same standard size as those in the Abydos boat (Lipke 1984: 78).

Builders stabilized the hull by installing deck-level through-beams notched into the sheer strakes and trimmed flush with their outer surface (Figure 16.1b) (Lipke 1984: 107). They clamped the beams in place with notched longitudinal side stringers lashed around the beams to hold-downs (Figure 16.1c) (Lipke 1984: 21 fig. 11). These stringers provide much of the hull's longitudinal strength (Mark 2009: 147–148). A central carling, notched along its upper face to fit up under the beams and supported from below by stanchions resting on floor timbers, further buttresses the deck beams and distributes hull stresses (Figure 16.1d–f). Builders lashed together the entire assembly with ligatures (Lipke 1984: 119, 75 fig. 48, 123 fig. 73).

Another four funerary boats, discovered in 1894 buried outside the Twelfth Dynasty pyramid of Senwosret III at Dashur (Arnold 2002: 106–107; de Morgan et al. 1895: 81–83, pls. XXIX–XXXI; Ward 2000: 101–102) have been recorded and studied in detail (Creasman 2005; Haldane 1984; Ward 2000: 84–102). Like the Khufu boat, these vessels were built almost entirely of imported cedar (Ward 2000: 84–85), but include many timbers fashioned from the recycled planking of other, larger ships (Creasman 2005: 36, 130; Reisner 1913: 86; Ward 2000: 98–100; Ward and Zazzaro 2009: 41). This practice is also documented in early New Kingdom dockyard records (Glanville 1931–1932). However, at only about 10 m long and 2 m wide, the Dashur boats are much smaller and beamier than the Khufu and Abydos vessels (Ward 2000: 84 table 8). Their hulls have a crescent shape and full, rounded sections

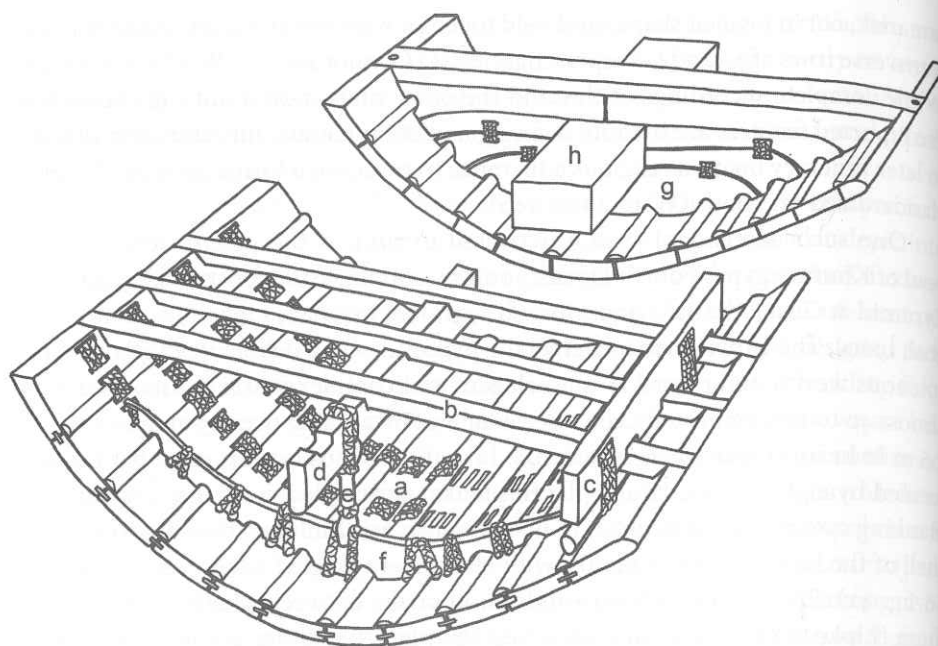


Figure 16.1 Sketch showing various features of Egyptian hull construction: (a) transverse lashings; (b) deck-level beams; (c) side stringer and hold-down; (d) central carling; (e) stanchions; (f) floor timber; (g) composite frame and beam assembly; (h) massive longitudinal timber. Drawing by the author. After Landström 1970: 29 fig. 86 and Ward 2000: 125 fig. 70.

throughout (Creasman 2005: 31 fig. 15, 47 fig. 21, 89–90 figs. 39–40; Ward 2000: 86 fig. 37). They are built up from a thick central bottom strake consisting of planks joined by superficial dovetail joints, and they have symmetrical sides, each with three strakes and a gunwale. The gunwales replace the side stringers of Khufu's boat as longitudinal stiffeners (Ward 2000: 102).

The hulls of these vessels differ from the Giza and Abydos examples mostly in their edge joinery and lack of transverse lashing. Like their predecessors, the Dashur builders used tenons between planks, but ones that are substantially longer and more tightly fitted (Creasman 2005: 60–62, 102–103; Haldane 1984: 23–24; Steffy 1994: 33; Ward 2000: 90). These are more than mere coaks; they not only would have stiffened the hull longitudinally and prevented movement along seams, but also would have contributed considerable transverse strength to the hull (Steffy 1994: 33). The Dashur builders deviated as well by employing superficial dovetail fastenings, rather than ligatures, to connect all seams, although they located them in similar positions. These joints acted in concert with compression forces to hold the planks together (Ward 2000: 101–102). To accomplish this, builders united the sides of the hulls with deck beams notched between sheer strakes and gunwales, fixed with square treenails and rope girders, and supported from below with stanchions (Creasman 2005: 53–56; Haldane 1984: 16–19; Steffy 1994: 33–35; Ward 2000: 86 fig. 37, 87).

Cheryl Ward (Haldane 1984: 98–101; Haldane and Shelmerdine 1990: 535–539; Ward 2000: 93, 94–95 figs. 42–44) believes that the builders did in fact use ligatures to tie the planks and that the dovetail mortises were originally dilapidated lashing channels that nineteenth-century reconstructors modified and fitted with dovetail tenons (Haldane 1996: 240–241). However, the mortises would seem too narrow and shallow to have been lashing channels, and examples of dovetail joints found in boat timbers from Wadi Gawasis (see below) and their longtime use in Egyptian carpentry (Creasman 2005: 11 n. 33, 122–123 fig. 37; Lucas 1962: 513; Ward 2000: 93) suggest that they may indeed be original to the boats' construction.

Aside from recovered boat burials, excavations of ramps and causeways in the vicinity of the Middle Kingdom pyramid of Senwosret I at Lisht have unearthed more than 90 timbers of local tamarisk or acacia wood from dismantled boats reused as construction material (Haldane 1988, 1992: 108–112 for timber catalog, 1996: 236–239; Ward 2000: 108–117). A majority of these timbers comes from working vessels, so they provide evidence for hull construction in more mundane craft. Most of the planks have joggled edges, though the size and shape of the joggles vary (Ward 2000: 127 fig. 71). Fastening holes for tenons and ligatures are present in the planks, penetrating only their inner surface and edges, never their exterior face. The Lisht and Khufu builders used planks of a similar and substantial thickness, and both used ligatures to reinforce their assembly at points of stress. The Lisht boats also had large tenons, like those from Dashur, which provided much of their longitudinal and transverse rigidity. Additionally, the Lisht builders paired some mortise-and-tenon joints within the thickness of planks, thus increasing the strength of the edge joinery. In short, these vessels were sturdily built and probably were designed to transport heavy freight (Ward 2000: 110–111, 114).

This is further and perhaps most strikingly demonstrated by a frame assembly found among the timbers. The preserved portion of the frame consists of a curved floor timber and a pair of futtock-like timbers attached to the floor's upper face with mortise-and-tenon joints and lashings (Ward 2000: 120–121 figs. 65–67). The outer faces of the floor and upper timbers, where they touch the hull, have notches to accommodate planking seams fitted with battens, and three drilled holes indicate that the frame was treenailed to the hull (Ward 2000: 119, 120 fig. 65; note her reservations about the treenails on 126). Ward has reconstructed the Lisht frame as a vertical composite structure built up from floor timber to deck beam with successive elements (Figure 16.1g) (Ward 2000: 125 fig. 70). The frame components enclose a massive keelson-like timber (Figure 16.1h) that would have provided much of the hull's longitudinal strength and lowered the boat's center of gravity (Ward 2000: 121–123). Composite assemblies like this would have formed a series of stout bulkheads designed to bolster and stabilize a heavily built transport vessel and support heavy cargoes carried topside.

The remains of another utilitarian vessel, abandoned during Egypt's Late Period in the mid-fifth century BCE, was unearthed and damaged by workers trenching in Cairo's Mataria suburb in 1987. The hull has a rounded bottom similar to the Dashur boats, but is slightly shorter and beamier (Ward 2000: 129). Its sycamore fig planks

are irregularly shaped, and some have joggled edges. The vessel has a keel plank, which reportedly protruded 1–2 cm below the outer surface of the hull (Ward 2000: 131). But what sets this boat apart from all other known Egyptian craft is that its builders used 2 cm diameter pegs to lock the large mortise-and-tenon joints in the planking assembly (Haldane 1996: 242; Ward 2000: 131). They did not peg every joint, and preservation and recording are insufficient to confirm whether they pegged tenons on both sides of a seam. Further complicating the picture is the fact that the pegs apparently protrude through planks, rather than being trimmed flush with their surfaces, and so might have been used to fix structural elements to the hull (Ward 2000: 133–134).

Collectively, these hulls show a remarkable consistency in Egyptian boat-building, while hinting at variability in design dictated by size and function (Table 16.1). Thus, builders of the small Dashur boats forwent the transverse lashings and frames that were so essential to the long and slender Khufu boat, and offset their absence by enlarging the mortise-and-tenon joints. Similarly, Lisht builders replaced beams and stanchions, like those in the Khufu and Dashur boats, with stout bulkheads in order to support much greater loads. The prudent use of short-length locally available woods and recycling of imported timber speaks to the adaptability of Egyptian shipwrights and their methods to economic and environmental conditions. The longevity of the basic characteristics of Egyptian hull construction—thick planks not penetrated below the waterline, joggled edges and coaks, battens and transverse lashings, stringers and gunwales, a reliance on compression, and integrated beams—testifies to the extraordinary success of this boatbuilding tradition. It is worth noting that significant departure from these practices does not show in the archaeological record until a late date, when Egypt was under heavy foreign influence (Ward 2000: 133).

Seagoing Vessels

Beyond the banks of the Nile, Egyptian seafarers engaged in active trade along the Levantine coast and in the Red Sea (Wachsmann 1998: 9–38, 327). The earliest-known depictions of obvious seagoing ships date to the Fifth Dynasty and decorate the funerary temple of Sahure at Abusir and the causeway of Unas at Saqqara (Borchardt 1913: pl. 12; Hassan 1955: 139 fig. 2; Wachsmann 1995: 11). The depicted hulls have crescent shapes, hogging trusses, and lashings or lacing running longitudinally below the sheer strakes and vertically at the extremities. Seagoing merchant galleys depicted in painted relief in Hatshepsut's New Kingdom mortuary temple at Deir el Bahri have similar constructional features, as well as through-beams protruding along the side of one of the ships (Säve-Söderbergh 1946: 14 fig. 1). Ships employed in Red Sea trade were built in the Nile shipyard at Gebtu (Koptos) and then disassembled for transport across the eastern desert to the coast via the Wadi Hammamat (Wachsmann 1998: 238–239; Ward 2000: 140). Recent studies and excavations at Wadi Gawasis (Bard and Fattovich 2007; Ward and Zazzaro 2009) and Ayn

Table 16.1 Hull construction features of ancient Eastern Mediterranean vessels

Provenience	Egyptian	Egyptian	Egyptian	Egyptian	Egyptian	Egyptian	Syro-Canaanite	Greek	Greek
Environmental design	riverine	riverine	riverine	riverine	seagoing	seagoing	seagoing	seagoing	seagoing
Purpose	funerary/ceremonial boat	funerary/ceremonial boat	working vessel/freighter	working vessel/freighter	trading vessel	trading vessel	trading vessel	trading vessel	trading vessel
Construction type	transverse lashing	unpegged mortise-and-tenon joints and compression	unpegged mortise-and-tenon joints and compression	unpegged mortise-and-tenon joints and compression	unpegged mortise-and-tenon joints and compression	tenon coaks and ligatures	pegged mortise-and-tenon joints	pegged lacing	pegged mortise-and-tenon joints (transitional)
Date	Early Dynastic–Old Kingdom	Middle Kingdom	Middle Kingdom	Persian Period	Middle Kingdom	Middle Kingdom	Late Bronze Age	Archaic	Late Archaic–Early Classical Period
Examples	Abydos boats (14), Khufu (2)	Dashur boats (4)	el-Lisht timbers	Mataria shipwreck	Wadi Gawasis and Ayn Sokhna timbers	Wadi Gawasis timbers	Uluburun, Cape Gelidonya shipwrecks	Giglio, Pabuç Burnu, Bon Porté, Cala Sant Vicenç, Place Jules Verne 9, Gela 1 shipwrecks	Place Jules Verne 7, César 1, Gela 2, Grand Ribaud F, Tektaş Burnu, Alonnesos, Porticello, Ma'agan Mikhael shipwrecks

Size and Shape

Lengths (m)	20–43.6	9.25–10.2	–	11+	15	small vessel	11.5–16	9.5–25	10–25
L:B Ratio	7.8–10:1	4.3:1	–	2:1	–	–	3:1	4:1	3.3:1
Shape	long, slender with curved sheer	long, slender with curved sheer	–	–	–	–	beamy	slender; sharp carriage return raking ends	beamy; raking-straight prow, curved stern; rockered keel

(continued)

Table 16.1 (continued)

Provenience	Egyptian	Egyptian	Egyptian	Egyptian	Egyptian	Egyptian	Syro-Canaanite	Greek	Greek
Section	lateral flat carriage return with rounded angled sides	central strake(s)	rounded, carriage return beamy	rounded, beamy	rounded	-	rounded	rounded	wine-glass shaped
Bottom				central strake/ keel-plank	central strake/keel-plank	-	large, rudimentary, proto-keel	rectangular, almost square keel	rectangular keel
Planking	thick (10-15 cm), symmetrical planking	thick (7-13.5 cm), symmetrical planking	thick planks (8.5-18 cm)	thick planks (7-9 cm)	thick planks (up to 22 cm)	thin planks (2.5-4.2 cm)	thick planks (6-6.5 cm)	thin planks (2.5-4.5)	thin planks (2.5-5)
Plank Shape	joggled	narrow butt ends with wide middle	joggled	joggled and narrow butt ends with wide middle	-	straight	straight, long strakes	straight, long strakes	straight, long strakes
Plank Alignment	half-mortises in plank ends, in plank ends, ligatures	half-mortises in plank ends, in plank ends, ligatures	half-mortises in plank ends, in plank ends, ligatures	half-mortises in plank ends, in plank ends, ligatures	-	small tenons	-	dowels, temporary cleats/stays	temporary cleats/stays
Edge Joinery	transverse lashing with tenon coaks	dovetail joints with large tenons, compression forces	large tenons, large compression forces	large tenons, large compression forces	unpegged mortise-and-tenon joints, dovetail joints	tenon coaks	large, pegged mortise-and-tenon joints	longitudinal pegged lacing with edge coaks	pegged mortise-and-tenon joints
- coaks	tenons	long tenons	long tenons, some doubled	small mortise-and-tenon joints	long tenons	-	none	dowels, tenons	dowels at extremities and in repairs

- ligatures	at stress carriage return points	at stress points	at stress points	none	-	at stress points or for plank	-	for lacing at extremities and for repairs
- lashing	transverse over battens possible use of wadding	transverse over battens possible use of wadding	transverse, over battens	-	-	for frames	-	for frames
- seam stopping				-	caulking?	-	none	wadding
- lashing mortises	V- and L-shaped channels, from interior face, never penetrating through entire thickness of the plank	L-shaped channels, from interior face, never penetrating through entire thickness of the plank	L-shaped channels, from interior face, never penetrating through entire thickness of the plank	-	-	-	-	-
- lacing/ lashing material	woven straps, halfa grass, papyrus?	woven straps, halfa grass, papyrus?	woven straps, halfa grass, papyrus?	-	copper straps and rope	-	-	flax, esparto grass, monocots
- coating				-	-	waterproofing along seams	-	pine tar/pitch on interior and exterior

Transverse Structure

Primary Support	deck-level beams	deck-level beams	integrated frame/deck-level beam bulkheads	deck-level beams	frames?	rows of large, paired tenons	frames	frames
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(continued)

Table 16.1 (continued)

Provenience	Egyptian	Egyptian	Egyptian	Egyptian	Egyptian	Syro-Canaanite	Greek	Greek
Frames	small floor timbers, used to distribute stresses and weight of deck/upper works lashed	none	massive composite frames integrated with deck-beams treenailed, lashed	-	small	-	made-frames alternating with top-timbers	made-frames alternating with top-timbers
Frame Attachment								
Beams/Thwarts	transverse stiffening	transverse stiffening	transverse stiffening, integrated with frames	-	stiffening	-	lashed; top-timbers treenailed and lashed	double-clenched copper nails
Beam Attachment	notched and treenailed	dovetailed and treenailed	notched and treenailed	-	-	-	transverse stiffening	transverse stiffening
							notched and treenailed into top-timbers	beams notched and treenailed into tops of frames
Longitudinal Structure								
Primary Support	side stringers	gunwales	gunwales and massive keelson-like timber, integrated with frames	-	-	proto-keel	keel, extended carriage return	keel, extended mast step, wales
Secondary Support	central carling, used to distribute weight of deck/upper works	-	-	-	-	-	-	-

Sokhna (Mathieu 2004; Pomey in press; el-Raziq et al. 2006) testify to hull construction methods and materials, and also to a well-organized industry for repairing, dismantling, storing, and reusing ships and their hull timbers. The recycling of ship timbers either for use in other hulls, as seen in the Dashur boats, or for use as construction material, as at Wadi Gawasis and el-Lisht, demonstrates a frugality that attests to economic concerns and the value of good timber in Egypt, especially imported conifers.

Hull planks, deck beams, and other timbers and fastenings found at these sites reflect the same building tradition seen in Egyptian riverine craft, but with adaptations for open-sea conditions. All hull planks are cedar, but with thicknesses of up to 22.5 cm, they are much heavier than those on riverine vessels (Ward and Zazzaro 2009: 31–32). Builders relied on this robustness to strengthen their hulls against the greater stresses encountered at sea. They further stiffened the shells of their ships by doubling up mortise-and-tenon edge joints in the thickness of planks, much as they did in heavy Nile freighters. However, builders of seagoing vessels also had to deal with the ravages of shipworms and other marine borers, and they may have provided for this with an additional, sacrificial thickness of at least 5 cm between joints and the outboard surface of hull planks (Ward and Zazzaro 2009: 41). In typical fashion, lashings through standard L-shaped channels reinforced stress points in the planking. Here, however, builders fortified these connections by using a combination of copper straps and ligatures, which they firmly compressed and locked within the channels with wooden wedges (Ward and Zazzaro 2009: 37, figs. 6 and 13). Deck beams seem stouter as well, thicker and wider than those of the Dashur boats, but otherwise of similar make (Ward and Zazzaro 2009: 31).

Ship timbers also include additional evidence for the use of dovetail joinery in Egyptian hull construction. Part of a keel plank has two dovetail mortises cut into its inboard face, and excavators found at least eight loose dovetail-tenon fragments made from local wood, probably acacia (Ward and Zazzaro 2009: 38 fig. 14). The keel-plank mortises are located in similar positions as those on the central strakes of the Dashur boats, and the tenons had all been chiseled or sawn into pieces and forcefully pried free of their mortises, indicating that they were fitted tightly (Ward and Zazzaro 2009: 37–38).

Particularly intriguing are five thin planks (2.5–4.2 cm) with small tenon coaks (Ward and Zazzaro 2009: 30 tables 1 and 2, 33–34, fig. 8, 36–37). Paired ligature holes, perhaps in rows running across plank widths, and what appears to be a tree-nail hole between them resemble frame fastenings found on Greek laced boats (see below), while the combination of edge tenons and lashed frames evokes some comparison to the construction of two seventh-century BCE boats, possibly Phoenician, at Mazarrón (see below).

Until recently, nautical archaeologists could only speculate as to how Egyptian shipwrights built their seagoing ships. The construction of riverine vessels designed to transport heavy cargoes, including huge granite blocks, giant stone obelisks, and other loads weighing many tons, offered clues as to how shipwrights dealt with great stresses in their hulls. But static loads, no matter how heavy, and the buffering forces

of rough seas pose quite different challenges to planking joints, longitudinal stiffeners, and transverse framework. Ship timbers discovered along Egypt's Red Sea coast testify to the viability of Egyptian riverine construction, with some modification, for seagoing vessels. Several also provide tantalizing evidence for another constructional method that hints at a possible diffusion of technology between Egypt and the Aegean or Levant. We therefore turn our attention northward now, to the easternmost shores of the Mediterranean.

THE LEVANT

In comparison to the vast corpus of evidence for Egyptian boats and ships, their construction, use, and sociocultural significance, knowledge of Near Eastern ships and seafaring is miniscule. The earliest-known mention of Syro-Canaanite ships is by Kamose (Seventeenth Dynasty) in his account of the capture of numerous Hyksos vessels laden with rich cargoes of trade goods (Wachsmann 1998: 39). Numerous other texts document cities along the eastern Mediterranean seaboard that were active in sea trade and provide information about the size of their fleets, inventories of ship's equipment, and even general indications of ship sizes (Hoftijzer and van Soldt 1998; Wachsmann 1998: 39–41, and additional bibliography therein).

The most detailed depiction of ships from this region is painted on the Theban tomb of Kenamun, an administrator under Amenhotep III of the Eighteenth Dynasty (Basch 1987: 63 figs. 111–112, 65 fig. 115; Daressy 1895; Davies and Faulkner 1947; Wachsmann 1998: 42–47). The scene includes a total of 11 ships with crescent-shaped hulls, tall vertical ends, and wickerwork and post screens running the full length of the sheer. A few strakes are delineated by seam lines, as are several possible butt joints. The only other construction features shown are a line of through-beam ends protruding from the side of the hulls below the sheer strake, and what appears to be a short run of lacing along the sheer at the bow of the ships. Typically, however, such evidence is not only limited, its interpretation is also problematic due to artistic factors. The lacing and through-beams, for example, may be Egyptianizing elements introduced by the artist, and not necessarily true features of the actual ships (Wachsmann 1998: 44; for additional examples of these features in Egyptian craft, see Glanville and Faulkner 1972: fig. 13; Landström 1970: figs. 64–72; Ward 2000: 36, 73 fig. 26).

Archaeological evidence for Levantine ships is provided by scanty hull remains from two Late Bronze Age shipwrecks excavated off the coast of Turkey. The older of these wrecks, dated to 1320 BCE $\pm$ 15 years (Pulak 1998: 214; but revised in Manning et al. 2009: 184), was discovered off Uluburun, near Kaş, on Turkey's southwestern Anatolian coast. Eleven seasons of excavation recovered a combined 11 tons of copper and tin ingots; 175 cobalt blue, turquoise, and lavender glass ingots; jars of terebinth resin; African blackwood logs; elephant and hippopotamus ivory; tortoise

shells and ostrich eggshells; Cypriot pottery; metal vessels; ritual faience drinking cups; luxurious carved ivory objects; seashell rings; beads of various designs and materials; gold and silver jewelry; a gold chalice; sets of pan-balance weights; an assortment of weapons, tools, and fishing equipment; and sundry spices and foodstuffs (Pulak 1998: 193–210). Shipboard items and its enormously rich and diverse cargo of raw materials and luxury goods indicate that the ship probably originated from one of the ports in the northern Carmel coast, possibly at Tel Abu Hawam (Pulak 2008: 299), and was almost certainly engaged in a trading venture of royal gift exchange (Pulak 1998: 220). A ship carrying such a cargo would rightly be expected to epitomize the best available methods and materials of construction for its day.

Three small sections of preserved hull include parts of the ship's keel, garboards, and fragments of three port and seven starboard strakes (Pulak 1999: 234 fig. 2). Based on these remains and distribution of cargo, the cedar-built vessel is estimated to have been about 15–16 m long and 5 m in beam, and to have displaced approximately 34 tons (Lin 2003: 220, 224; Pulak 1999: 210, 212). The vessel's builders began with a rudimentary keel, or proto-keel, which they cut wider (sided 28 cm) than high (molded 22 cm) (Figure 16.2a). It extended about 2 cm beyond the outer hull, but protruded into the interior of the hull some 10 cm (Pulak 1999: 215–216, 234 fig. 2). Unlike most Egyptian boats, which relied on a central strake or bottom flat only slightly thicker than the garboards and planking, the Uluburun proto-keel was

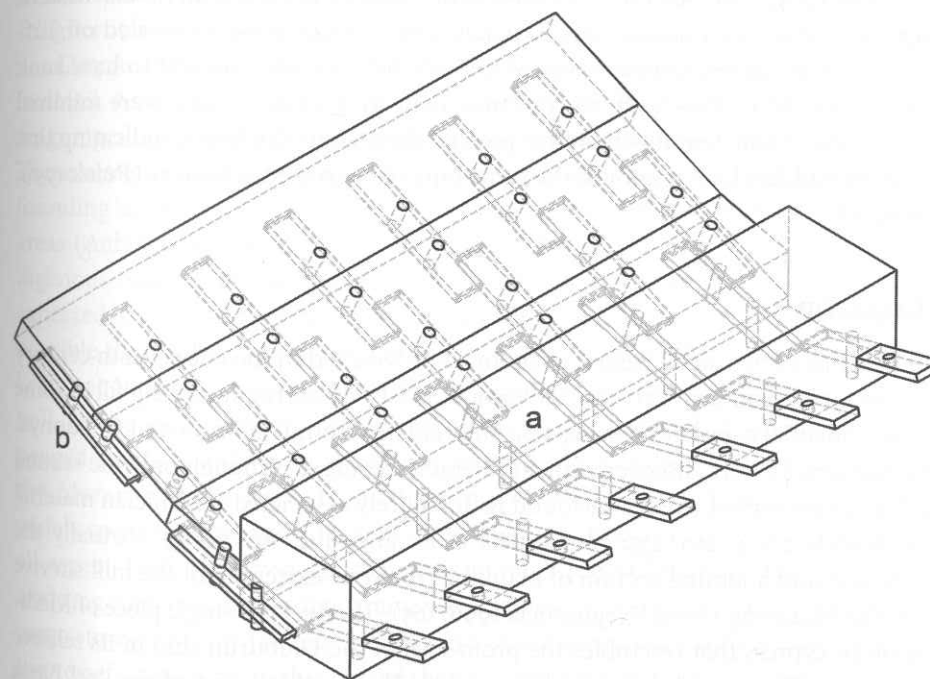


Figure 16.2 Isometric reconstruction of the Uluburun hull remains: (a) proto-keel; (b) pegged mortise-and-tenon joints. Drawing by W. van Duivenvoorde.

a more massive timber that acted as a spine and provided a good deal of longitudinal stiffening (Pulak 1999: 217). Hull planking was thick (6–6.5 cm) when compared to later Mediterranean vessels, but not nearly as massive as that of Egyptian hulls (Pulak 1999: 218). The preserved remains offer no evidence for framing, or any indication that builders used treenails, ligatures, or metal fastenings in assembling the hull. However, nothing of the vessel's extremities survived, and the preserved portions of the hull may not be long or wide enough to include frames or bulkheads or evidence for securing such structural elements to the planking (Pulak 1999: 215).

Builders joined the edges of their planks with large oak tenons (Pulak 1999: 237 fig. 5) and secured the seams by locking the tenons in their mortises with 2.2 cm diameter oak pegs driven from inside the hull through the thicknesses of planks and tenons (Figure 16.2b) (Bass 1989: 31 fig. 2; Pulak 1999: 212, 218–219, 232 table 1). They cut deep mortises that extended well across the width of planks, and positioned them immediately adjacent to the nearest mortise cut from the opposite edge (Pulak 1998: 211). In this manner the joints formed continuous lateral runs of alternating paired tenons within the hull planking. The size and positioning of the joints suggest that the builders intentionally designed them to act as internal framing, perhaps in order to compensate for the lack of proper framing (Pulak 1999: 219–220). This construction must have proven sturdy, since the ship's crew made no concessions for seams or planking scarfs—typically the weakest points in a hull—when stowing heavy cargo within the hold directly against the hull (Pulak 1999: 218, 222–223).

Supporting evidence for this construction comes from another Near Eastern shipwreck, that of a possible Syro-Canaanite or Cypriot vessel excavated off Turkey's southern Mediterranean coast at Cape Gelidonya, and thought to have sunk around 1200 BCE (Bass 1967: 50–51; Pulak 1999: 214). Hull remains were minimal but included a half-tenon with a hole pierced through its thickness, indicating that the ship's builders had employed the same type of pegged edge joinery (Pulak 1999: 237 fig. 6).

Mazarrón

The remains of two small vessels abandoned or wrecked in the late seventh century BCE on Spain's southeastern coast at Playa de la Isla, Mazarrón, may help fill in some of the evidential gaps left by the sparse hull remains from Uluburun and Gelidonya. The two wrecks were discovered in a Phoenician context, although only the second and better-preserved wreck was found with securely associated Phoenician material (Negueruela 2004: 230, 235; Negueruela et al. 1995: 190–191, 2004). Virtually the entire keel and a joining section of planking from one extremity of the hull survive from the Mazarrón 1 boat (Negueruela 1996: 165). The keel is a single piece of Mediterranean cypress that resembles the proto-keel of the Uluburun ship in its relative dimensions (Negueruela 1996: 167, 2004: 237). The surviving end of the keel has a short tongue that originally would have fit into a corresponding groove in the end post (Negueruela 1996: 165, 167). The nine preserved hull strakes consist of pine

planks joined end-to-end with diagonal scarfs and edge-joined with olive tenons pegged in their mortises (Negueruela 1996: 165, 167; Ruiz 2008: 138). Plank edges are beveled so that they form a shallow V-shaped recess along the inboard seams of the strakes, somewhat reminiscent of the Khufu I planking (see Mark 2009: 151). Here, small ropes or twists of esparto grass lie within the recesses and are held in place with small ligatures laced over the seams in a continuous, one-pass diagonal pattern through holes predrilled along the sides of the planks (Negueruela 2004: 237; Negueruela et al. 2000: 1673). Preserved "frames" are small fig branches that have been trimmed of twigs or other protrusions, but otherwise left unshaped. They were tied lightly to the hull with ligatures presumably made from esparto as well (Negueruela 1996: 167; Negueruela et al. 2000: 1673, 2004: 467 fig. 13, 478).

Mazarrón 2 is larger and better preserved; in fact, almost the entire hull is intact. It measures 8.5 m long and 2.2 m at the beam, and has a sheer height of some 90 cm (Negueruela 2004: 235). The keel is a single timber scarfed to stem and sternpost with simple tongue-and-groove joints. From garboard to sheer the vessel's sides have nine strakes that are only 1.9–2.3 cm thick and are fastened together with small, pegged mortise-and-tenon joints (Negueruela 2004: 247). These planks, however, have no edge beveling or seam wadding. Light fig branches, 4–8 cm in diameter and running athwartship from sheer to sheer, are lashed to the hull interior every 40–50 cm (Cabrera et al. 1992: 39; Gómez-Gil Aizpurúa and Sierra Méndez 1996: 219; Negueruela 2004: 249). Also spanning the hull are seven benchlike thwarts that dovetail into the top of the seventh strake, except for two in the stern. The hull is coated inside and out with pitch (Negueruela 2004: 235–236).

Despite their importance, these two boats have yet to be recorded and studied in detail. As is clear from their small size and low freeboard, these vessels were not seagoing ships. Furthermore, questions as to their cultural designation remain. These vessels may have been small lighters associated with the mining and silver-founding activities at Punta de los Gavilanes (Mazarrón) and the surrounding areas (Aubert 2001: 339–340). In this light, the boats could be representative of indigenous watercraft, although some Phoenician influence might rightly be expected. Certainly, they have similarities with the Uluburun vessel that suggest a possible descendancy of their building method. Each of the vessels has a proto-keel, but in the Mazarrón boats, the proto-keel only projects outward from the hull, as the garboards are set flush with its inboard face. The vessels all rely on pegged mortise-and-tenon joinery to fasten strakes and secure seams. However, the Mazarrón hulls have much thinner planking and much smaller and more widely spaced joints, and adjacent joints are not paired as in the Uluburun ship. In all aspects, the Mazarrón construction is much less substantial. The use of seam wadding and the diminutive frames is curious. The latter seem more suited to cargo stowage for protecting the hull, and would have added little if any strength to the vessel's structure. In this regard they resemble the heavier branches of dunnage laid athwartship in the Uluburun hull (Pulak 1998: 197). What is certain is that builders assembled these hulls using pegged mortise-and-tenon joinery and not

lacing, which they employed simply as tie-downs. For a shipbuilding tradition in which shell planking was laced together, we move now to the Aegean.

THE AEGEAN

No direct evidence for early seacraft in the Aegean exists until the Bronze Age (Wachsmann 1998: 69). Enigmatic, mostly ceramic vessels, known by archaeologists as "frying pans" because of their unusual shape, have been found at sites throughout the Aegean and on mainland Greece and Anatolia (Coleman 1985: 191–193). The flat surfaces of at least a dozen examples from Early Cycladic II tombs on Syros are decorated with incised illustrations of ships (Basch 1987: 80–81 figs. 159–167; Casson 1995: 30–31; Coleman 1985: 191–193, 199 ill. 5). The ships have one high extremity and a lower end that is angled upward slightly and has a short, horizontal projection. Some of the vessels are shown with vertical lines or a zigzag pattern along their hull, which may suggest laced or lashed construction (Basch 1987: 47, 86; Wachsmann 1998: 14). Similar ships would seem to be depicted by an Early Minoan I–II terracotta model found at Palaikastro in Crete (Basch 1987: 83 figs. 170–171; Evans 1964: 240 fig. 137; Wachsmann 1998: 71–73, 75 fig. 5.9), and three contemporary lead models from Naxos, though the latter have no stern projection (Casson 1995: 41–42; Renfrew 1967: 5; 1972: 318, 356–357, 358 fig. 17.7 and pl. 28, 3 and 4; Wachsmann 1995: 13, 1998: 69–70). Archaeologists have long debated what sort of early Aegean vessel is depicted, what function the horizontal projection served, and even which end of the craft is the bow and which the stern (e.g., Basch 1987: 84–85; Casson 1995: 41–42; Coleman 1985: 198–199; Johnstone 1973: 6–11; Johnstone 1982; Renfrew 1967: 5; 1972: 355–358; Roberts 1987; Wachsmann 1995: 12–14, 1998: 70–71). The latter question would seem to have been answered when excavations at Akrotiri, on the island of Thera, revealed a magnificent wall fresco that contains the most detailed portrayal yet found of Bronze Age Minoan ships (Marinatos 1974: 19–31, pl. 2; Wachsmann 1998: 86–99; for varying interpretations of the Thera ship scene and the vessels depicted, see also Raban 1984; Giesecke 1983; Wachsmann 1980). All of the boats portrayed in procession are fitted with a horizontal projection at their stern.

Unfortunately, no vestige of any early Aegean ship has yet surfaced in the archaeological record. To date, the earliest—in fact, only—pre-classical Aegean shipwreck to be excavated and studied by nautical archaeologists is that of a modest trading vessel, probably East Greek, that sank around 570–560 BCE at Pabuç Burnu, a small promontory on the southwestern Turkish coast just east of Bodrum (Greene 2003; Greene, Lawall, and Polzer 2008; Polzer 2004, 2009a). Six fragmentary planks are all that remain from its hull, but these preserve a surprising amount of evidence for the vessel's construction (Polzer 2009a, 2009b). Most prominently, the hull components were joined with ligatures laced along planking seams and lashed around

frames. Interpretation of the preserved features is facilitated by evidence from beyond the physical confines of the Aegean, in areas of Greek colonization and trade, where archaeologists have excavated the remains of five Archaic Greek ships that have similar joinery and construction techniques. In chronological order, these include shipwrecks at Giglio (Italy, 600–580 BCE) (Bats 1996: 577; Bound 1985, 1991a, 1991b; Bound and Vallintine 1983; Cristofani 1996: 21–48; see Mark 2005: 40–42 for discussion of the vessel's origin), Bon Porté (France, circa 540–510 BCE) (Joncheray 1976; Kahanov and Pomey 2004; Liou 1974, 1975: 595–597; Pomey 1981, 1995, 1999a, 2001, 2002a, 2002b, 2003: 14; Pomey and Long 1992: 192), Cala Sant Vicenç (Majorca, 520–510 BCE) (Nieto and Santos 2009; Nieto et al. 2002, 2004, 2005), Place Jules-Verne (wreck 9, Marseille, circa 525–510 BCE) (Pomey 1995, 1999a, 2001, 2002b, 2003), and Gela (wreck 1, Sicily, 500–480 BCE) (Panvini 2001a). The construction features preserved in the hull remains from these wrecks are remarkably consistent in make, form, materials, and application, demonstrating in their totality a clearly definable shipbuilding tradition (as per Prins 1986: 23–24)—in this case, a Greek tradition (Table 16.1).

Construction evidence from five additional Greek shipwrecks, spanning the late sixth, fifth, and fourth centuries BCE, indicates that a major technological shift occurred in Greek shipbuilding that transformed Archaic laced construction into the so-called Graeco-Roman building tradition, exemplified in the well-preserved hull of the Kyrenia ship (Cyprus, 295–285 BCE) (Steffy 1985, 1994: 42–59). The evidence comes from the hull remains of the Place Jules-Verne 7 (Marseille, circa 525–510 BCE) (Pomey 1995, 1999a, 2001, 2002b, 2003), César 1 (Place Villeneuve-Bargemon, Marseille, 510–500 BCE) (Pomey 2001: 429–430), Grand Ribaud F (France, 510–490 BCE) (Long et al. 2001; Long, Gantès, and Drap 2002; Long and Sourisseau 2002; Pomey and Rival 2002), Gela 2 (450–425 BCE) (Panvini 2001b), and Ma'agan Mikhael (Israel, 410–390 BCE) (Kahanov and Linder 2004; Linder and Kahanov 2003) wrecks. Shipwrecks at Tektaş Burnu (Turkey, 440–425 BCE) (Carlson 2003; van Duivenvoorde forthcoming), Alonnesos (Greece, 420–400 BCE) (Hadjidaki 1996; Mantzouka 2004), and Porticello (Italy, 400–385 BCE) (Eiseman and Ridgway 1987; Lawall 1998) can also be included for the sake of completeness, although they have provided very little in the way of hull remains, due to poor preservation or incomplete excavation.

Ancient Greek shipwrights began building their hulls by first laying down the ship's spine, which they formed by joining keel to stem and sternpost using keyed box-scarfs, a particular hallmark of this building tradition (Pomey 1997a: 195). Small, rectangular (almost square) keels generally proportional to a vessel's length appear to have been the norm, as did rounded hulls.

Greek shipbuilders predominantly utilized pine in their hulls, as the wood was readily available, strong, durable, resistant to rot, and easily worked (Steffy 1994: 258–259). They connected planks end-to-end with diagonal, three-planed (Z), or curved (S) scarfs to form long, continuous strakes that generally ran from stem to sternpost. Like their Egyptian counterparts, they staggered scarfs so as not to locate joints in adjacent strakes next to one another. However, they used much thinner planks than Egyptian and Near Eastern builders. This probably was not predicated

on the choice of joinery, as some have suggested (e.g., Mark 2005: 58–59, 62), but more likely was the product of how shipwrights conceived and approach the construction of their hulls. Within Greek shipbuilding itself, laced hulls could have planks as thick or thicker than mortise-and-tenon-joined planks. Hull dimensions and planking thicknesses indicate that the latter were related more to the size of a vessel than to the type of edge fastening employed (Polzer 2009b: 98–102).

The two essential elements of Greek laced joinery are ligatures and wooden coaks. Much as in Egyptian lashed joinery, coaks served the dual purpose of aligning planks during construction and, more importantly, reinforcing the seams to help prevent longitudinal slippage between strakes. Greek builders traditionally used cylindrical dowels (typically about 12 cm long and 1.0–1.5 cm in diameter) in laced hulls, which they centered within the thickness of planks and staggered across their sides (Figure 16.3a) (Bound 1985: 55; Joncheray 1976: 28; Pomey 1995: 471). However, the Pabuç Burnu (Polzer 2004: 111–113, 2009a: 31) and Cala Sant Vicenç (Nieto and Santos 2009: 27 fig. 22, 51) builders employed small hardwood tenons for coaks, while those responsible for the Gela 1 vessel inserted both dowels and tenons (Panvini 2001a: 21, 22 fig. 13, 25 fig. 20, 26 fig. 22). The Pabuç Burnu coaks represent the earliest archaeologically attested use of tenons in Greek shipbuilding.

The lacing system developed by the ancient Greeks was unique in its use of tetrahedral notches in conjunction with oblique ligature holes, seam wadding, and locking pegs (Polzer 2009a: 30; Pomey 1999b: 150). Builders first chiseled

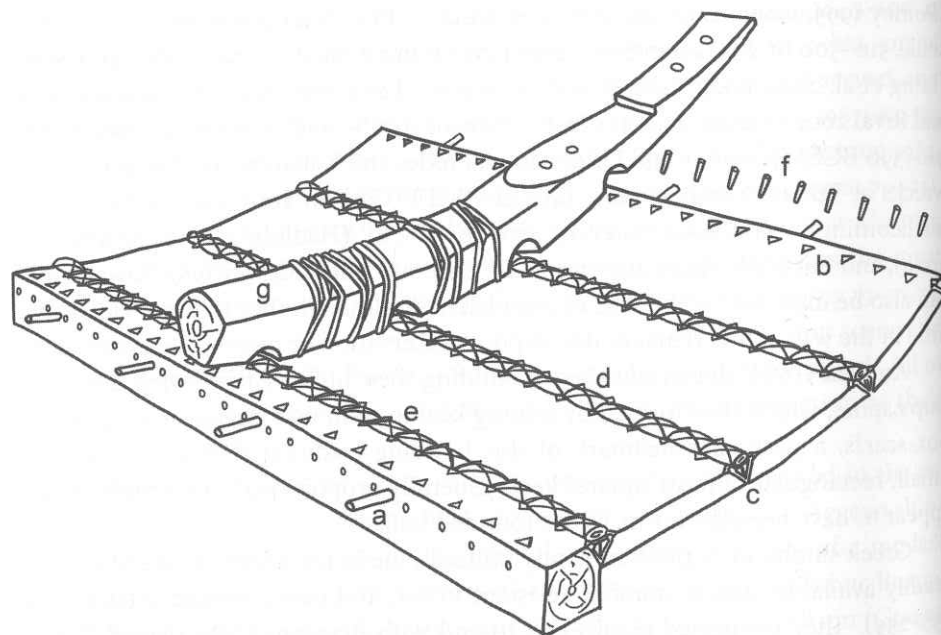


Figure 16.3 Hull construction features of typical Archaic Greek laced ships: (a) dowel coaks; (b) tetrahedral notches; (c) oblique ligature channels; (d) seam wadding; (e) double-helical lacing; (f) ligature pegs; (g) made-frame floor timber. Drawing by the author. After Pomey 1997b: 92.

small tetrahedral notches along each inboard side of a plank, close to the edge (Figure 16.3b). Using the notches as guides, they drilled a small, angled hole from the base of each notch through the thickness of the plank to the outside corner of the seam edge. The holes in one plank matched up with those in the adjacent plank to form a line of V-shaped lacing channels along the seam (Figure 16.3c). The notches also reduced the severity of the angles around which the lacing bent, which in turn reduced stress and wear on the ligatures (Polzer 2009b: 128–129). Additionally, they oriented the diagonal lacing turns across the inboard seams and kept the ligatures in proper alignment (Pomey 1995: 474, 1999b: 150), which helped distribute the resistance from the diagonal lacing evenly to the lateral and longitudinal loadings of the joint.

Shipwrights laid a strip of flax or other fibrous wadding along the inboard seam between the two lines of notches and laced a length of ligature through the holes and over the wadding, securing both wadding and seam (Figure 16.3d) (Pomey 1999b: 149, 150 n. 3; Nieto and Santos 2009: 54–55, fig. 47). Such wadding likely would have been ineffective at stopping a seam. Rather, it made it easier to maintain uniform tension on the ligatures when lacing multiple turns through a hole (Foerster Laures 1989: 266–267), and it provided a softer and more rounded surface over which to cinch the lacing taut. In this way, it acted much like a spring washer over which a nut is tightened.

Builders laced ligatures across the seams of their boats in a symmetrical double-helical pattern that produced at least one pass of the ligature between each hole and the three opposing holes in the adjacent plank (Figure 16.3e) (Nieto and Santos 2009: 27, fig. 22.6, 55–57, figs. 49 and 51). Ligature turns oriented perpendicularly to the seam joined the strakes and kept the seams from opening. The diagonal turns, on the other hand, helped to connect the strakes (as joints), but also to prevent them from moving longitudinally against one another (as stiffeners) (Polzer 2009b: 131–136).

Once builders had laced two strakes together, they drove tapered pegs into the lacing holes until they would go no farther, and then trimmed the pegs flush with the inner surface of the plank (Figure 16.3f). The primary function of the pegs was to lock the ligatures in their holes, which allowed the stretched parts of the lacing to be loaded to their breaking point (Coates 1985: 14). The pegs effectively isolated the ligature segments of each turn and created three independent “joints” between each pegged hole. This prevented the loosening of unloaded ligatures (due to flexing of the hull, wear, or breakage) from spreading to the loaded parts of the lacing and causing the lacing as a whole to slacken. In this way, the pegs enabled symmetrical helical lacing to resist shearing forces between planks, which otherwise it could not (Coates 1985: 17).

Greek builders strengthened their hulls transversely with internal framing comprised of preassembled “made-frames” (Figure 16.3g) alternating with top-timbers (Pomey 2003: 62 fig. 11.8). They fashioned the frames by connecting a single futtock to each end of the floor timbers using hook scarfs fixed with treenails. With wide, rounded inner surfaces and narrow outer surfaces notched over planking seams, the frames were ideally suited morphologically for lashing and for protecting

seam joinery (Pomey 1997a: 195, 197 fig. 5). Between the frames and higher up the sides of the hull, shipwrights installed top-timbers with more rectangular sections. They both lashed and treenailed these to the planking, since ligatures alone are not particularly well suited for holding timbers in vertical positions (Polzer 2009a: 31; Pomey 1999b: 152).

The final step in completing the lower hull was paying the interior with a coating of pine tar, a common practice that continued throughout antiquity (Casson 1995: 211–212; Polzer 2009a: 31). The main function of the tar was to protect the interior of the hull and especially the exposed joinery elements—ligatures, wadding, and pegs—from seawater, condensation, and the elements, which could cause rot and jeopardize seam integrity.

Transition

Construction features evidenced in two shipwrecks from Marseille (Jules-Verne 7 and César 1) and those at Grand Ribaud, Gela (wreck 2), and Ma'agan Mikhael attest to a major shift in Greek shipbuilding in which pegged mortise-and-tenon joints and metal nails replaced pegged ligatures in hull joinery (Polzer 2009a: 33; Pomey 1997a). The builders of these vessels joined hull planks with mortise-and-tenon joints locked on both sides of the seam with wooden pegs driven perpendicularly through plank and tenon, and they attached frames with double-clenched copper nails driven from outside the hull (Table 16.1). Some pegged lacing is still present, but builders used it only to close and reinforce the end assemblies at stem and stern and to make repairs. In testament to their conservatism, builders continued to shape frames in the traditional manner even though it served no purpose, since they no longer lashed frames to the hull (Benini 2001: 101, 153 pls. XXXVI–XXXVII; Kahanov 2003: 88–95; Kahanov and Pomey 2004: 17; Long et al. 2001: 39–40; Pomey 2001: 430).

No full and convincing explanation for why this change occurred has yet been given, but it likely involved the growing transport of bulk cargoes in amphoras, the development of the Greek trireme, and a rapid buildup of state-supported naval fleets during the sixth and fifth centuries BCE (Mark 2005: 63–69). Mortises and pegged tenons were stiffer joints that were less vulnerable to wear and damage than pegged lacing and allowed for construction of stronger and more durable hulls (Polzer 2009a: 35–36).

The three Marseille wrecks, one (Jules-Verne 9) built in the traditional laced method and two (Jules-Verne 7 and César 1) constructed with the new joinery, are particularly serendipitous. They provide a close approximation of the date when the new joinery was adopted into Greek shipbuilding, and indicate that the change was sweeping, being incorporated into fishing boats and seagoing trading vessels alike (Pomey 1997a: 198, 2001: 431). A similar scenario is presented at Gela, where two ships of comparable size and carrying similar cargoes, but separated chronologically by half a century, were built using the two different types of hull joinery. The change seems to have been comprehensive: no Greek shipwreck earlier than

Jules-Verne 7 (last quarter of the sixth century BCE) has provided evidence for pegged mortise-and-tenon joinery, and none later than Gela 1 (first decades of the fifth century BCE) has yielded full laced construction.

Faulty seam joints, cracked planking, and the inability to apply the new joint to making repairs or to closing hull extremities testify to the newness of pegged mortise-and-tenon use in Greek shipbuilding and the novice proficiency of its practitioners (Polzer 2009a: 33; Pomey 1999b: 151, 1995: 478–479). Furthermore, the retention of made-frames, with their particular laced morphology, and the reversion to traditional laced-construction techniques in problematic areas of the hull confirm that these builders were working within the same tradition (Polzer 2009a: 34–35). The use of tenon coaks instead of traditional dowels in the Pabuç Burnu and Cala Sant Vicenç hulls may represent the first, critical step in this transitional process. Due to their shape, cylindrical dowels could not easily be pegged and therefore would not likely have evolved to take the place of lacing in edge joinery. The wider, flat tenon, on the other hand, was perfectly suited for pegging. This simple modification paved the way for pegged mortise-and-tenon joinery to evolve from and replace pegged lacing in Greek shipbuilding (Wachsmann 1998: 241). The gradual transition from dowel coak to tenon coak to pegged-tenon joint, along with supporting modifications to other construction features not attested in Near Eastern or Egyptian ships, strongly suggests a natural development of pegged mortise-and-tenon construction within the Greek tradition (Polzer 2009a: 34–36, 2009b: 159–174) rather than the wholesale importation of a foreign—most likely Phoenician—technology that many scholars suppose (Bass 2006: 14; Kahanov and Pomey 2004: 24–25; Mark 2005: 35, 67–68; Pomey 1997a: 201).

As the Archaic period of Greek history came to a close, so too did an Aegean tradition of building boats with ligatures whose roots probably stretched back to methods used by Stone Age obsidian traders, and perhaps even earlier ones. Greek shipwrights incorporated pegged mortise-and-tenon joinery into their construction at the beginning of classical antiquity and would adapt, modify, and perfect their techniques to take advantage of the strengths of the new joinery. All of the basic features resulting from these changes can be seen in the Kyrenia ship, by the end of the fourth century BCE.

CONCLUSION

All shipwrights in early antiquity constructed the hulls of their boats and ships by first building up a shell of planks, fastened together with some form of edge joinery, and then stiffening and reinforcing that shell with various forms of internal structure. The planking shell formed a watertight skin that enabled the boat to displace water and float, while bearing its own weight and that of crew, passengers, and all sorts of cargoes. The watertightness of such hulls was dependent primarily upon the strength of the planking joints and on the amount of relative movement between adjacent planks (Coates 1985: 11). The bending moment and tensile forces acting on

a vessel's hull can cause hogging and open seams and are directly proportional to the hull's length and weight. The ancient seafaring cultures of the eastern Mediterranean each developed their own unique set of solutions to address these problems and create elegant, sturdy, and capable boats and ships well suited to their environments and intended purposes. Egyptian builders constructed vessels represented by Coates's (1985: 11–13) "boats with massive planks" model, wherein much of the hull's strength came from the thick, joggled planks themselves. Coaks and ligatures, transverse lashings and battens, side stringers and gunwales, and deck-level through-beams formed the compatible joinery and supporting structure necessary to ensure durability and watertightness (Coates 1985: 11). Near Eastern shipwrights built with thick planks as well, but relied more on massive internal mortise-and-tenon joints locked with wooden pegs to both close seams and fortify the hull. Their Aegean counterparts built vessels with smaller and more flexible planks joined with continuous, longitudinal lacing (Coates 1985: 15–18). Coaks, wadding, pegs, made-frames, and top-timbers all worked in concert to maintain seam integrity and strengthen the hull while still keeping it appropriately flexible. The ways in which these different builders conceived, designed, and constructed their watercraft—the materials they chose, the tools they used, and the techniques they developed—were all products of a unique coalescence of cultural, environmental, and economic circumstances. Nevertheless, it was the skill, experience, and ingenuity of the shipwrights themselves that, above all else, was the final and determining factor in the process.

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CHAPTER 17

THE SEAFARERS AND SHIPWRECKS OF ANCIENT GREECE AND ROME

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INTRODUCTION

CLASSICAL archaeology, which comprises the study of the ancient Mediterranean's two greatest cultures—the Greeks and Romans—embraces several related disciplines, including art history, history, philology, and philosophy. The result is a symbiotic but delicately balanced and at times precarious relationship between the textual, visual, and material evidence. Some examples of a maritime nature: the classical scholar can draw on no substantive archaeological evidence for either piracy or grain cargoes, two issues of enduring historical consequence for the ancients, and there are almost no textual descriptions, much less discussion, of ancient ship construction technology; this knowledge has come exclusively from archaeological remains. Ancient warships, by contrast, lie somewhere in between, with virtually no direct physical evidence that predates the first millennium, but a considerable amount of information in illustrations, inscriptions, and literary sources. The reader is cautioned, therefore, that much of the relevant data regarding Greek and Roman seafaring lies outside the realm of archaeology and thus outside the focus of the present contribution. There are, however, a wide range of excellent publications, ranging from indices (Illsley 1996; Parker 1992) and sourcebooks (Meijer and Van Nijf 1992) to histories (Bass 1972, 1975; Blackman 1973; Du Plat Taylor 1965),