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Deep-water Archaeological Survey in the Black Sea: 2000 Season

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Recent archaeological survey by sidescan sonar and remotely operated vehicles (ROVs) resulted in the discovery of one of the best-preserved seagoing ships from antiquity in the anoxic waters of the Black Sea. Three shipwrecks from the 4th to 6th centuries AD, with cargoes of shipping jars from Sinop, Turkey, were found at depths of about 100 m; the fourth sits upright on the sea-bed, buried to deck level in sediment. A description of each site and identification of visible site components is followed by a discussion of directions and possible implications of future research.

Key words: maritime archaeology, shipwrecks, Black Sea, ROV, Sinop, ship construction.

Recent survey work in the Black Sea as part of a long term project developed by the Institute for Exploration (IFE) resulted in the discovery of one of the best-preserved seagoing ships from antiquity (Ballard *et al.*, 2001). This ship, found at a depth of 320 m, and three others located between 85 and 101 m date to the 4th to 6th centuries AD, and may provide information about both technological change and trade in the Black Sea during a period of political, social, and economic transition through the study of ship construction techniques.

Historical and archaeological studies indicate that the area of Sinop had developed long-distance exchange as early as 4,500 BC, and that seaborne traffic in the region was most intense during the period of late antiquity, between the 2nd and 7th centuries AD (Hiebert *et al.*, 1997; Hiebert, 2001). Remote examination of four shipwrecks from the latter period has provided the direct evidence for Black Sea maritime trade so well attested by the distribution of ceramics on land.

The application of both traditional and innovative remote sensing methods to deep-water archaeological survey supports standard archaeological approaches to site survey and allows the non-destructive evaluation of sites in a marine environment more hostile than most. The anoxic environment of the Black Sea, hostile to many biological organisms that destroy wood in oxygenated waters, provides an excellent testing site for deepwater archaeological survey. This report describes the methodology used to locate four ships in 2000, presents preliminary conclusions about those vessels, and discusses directions and possible implications of future research.

Background

In 1976 Willard Bascom suggested that the deep, anoxic waters of the Black Sea (Fig. 1) might preserve a treasure trove of ships from antiquity because typical wood-devouring organisms could not survive there (1976: 38). At depths greater than 150 m the Black Sea contains insufficient oxygen to support most familiar biological life forms; a suboxic zone in the next 20 to 50 m has both low oxygen and low sulphides, and in the anoxic layer below 200 m water chemistry studies consistently document relatively high concentrations of sulphides and low oxygen (Murray *et al.*, 1989; Codispoti *et al.*, 1991).

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Figure 1. The Black Sea, with approximate locations of ship finds and Sinop.

Originally a land-locked fresh water lake, the Black Sea was inundated with salt water from the Mediterranean Sea during the Holocene. The influx of salt water essentially smothered the fresh water below it because a lack of internal motion and mixing meant that no fresh oxygen reached the deep waters (Oğuz *et al.*, 1993). The influx probably took place about 7000 years ago. Its speed and intensity are debated (Ryan *et al.*, 1997; Uchupi and Ross, 2000; Görür *et al.*, 2001; Aksu *et al.*, 2002), but the extinction of fresh water molluscs and replacement by saline species seems to have occurred between 7460 and 6820 BP (uncorrected radiocarbon years) according to radiocarbon dates from mollusc shells near Sinop collected on a 1999 Black Sea expedition (Ballard *et al.*, 2000).

The collaborative efforts of the Institute for Exploration, the University of Pennsylvania, University of Rhode Island Graduate School of Oceanography, the Massachusetts Institute of Technology, and the Institute of Nautical Archaeology resulted in a programme of terrestrial and marine survey focused on Sinop, Turkey (Ballard *et al.*, 2001). The potential for wood preservation in the deep waters of the Black Sea (up to 2210 m deep), and the long occupation and central role Sinop played in regional trade, including extensive exchange with settlements on the Crimean peninsula made this region attractive for testing several hypotheses.

The Black Sea Trade Project, a multi-year terrestrial survey near Sinop, led by Fredrik Hiebert, Owen Doonan and Alex Gantos, identified small, relatively isolated, Neolithic sites on elevated areas that often overlooked watercourses, as well as a Bronze Age settlement on one of Sinop's high points and a number of later sites (Hiebert *et al.*, 1997). A rich record of farming groups from the time of Greek colonisation through the medieval period (Kassab Tezgör and Tatlican, 1998) adds to previous archaeological knowledge of the region, and has suggested to Hiebert (2001) that the Sinop sites exhibit specialised adaptation to the coastal maritime environment.

Underwater surveys of Sinop's anchorage, portions of the submerged coastline, and exploration of deeper waters along possible trade routes linking Sinop to the Crimean peninsula and towards Byzantium to the west took place each year from 1998 to 2000 with a fourth season in 2003. A side-scan sonar survey of waters less than 60 m deep near Sinop harbour in 1998 produced several dozen anomalies examined through images provided by camera-carrying ROVs in 1999 (Mindell *et al.*, 1998; Ward, 2000). Most of these low-relief anomalies proved to be colonies of large-shelled molluscs, but a late 18th-century AD iron anchor, a large jar, and the remains of a 19th-century steamship were also identified (Fig. 2). Work north-east of Sinop focused on a search for the ancient coastline of the Black Sea, and included sampling by dredging (Ballard *et al.*, 2000).

2000 survey season

In 2000, the archaeological survey conducted under water focused on exploration of the sea-bed about 15–30 km west of Sinop, with additional deep-water survey east and north of the promontory. The project had several goals. We sought to discover whether human habitation sites could be identified on the ancient submerged landscape, to examine the sea-bed for shipwrecks, to test the hypothesis that the anoxic waters below 200 m would protect shipwrecks from the expected biological attacks on organic components, and to seek data about an ancient trade route between Sinop and the Crimea indicated by terrestrial archaeological remains.

Side-scan survey in search of features such as relic stream beds in the submerged landscape and shipwrecks, followed by target evaluation through examining images obtained by cameras on an ROV, were the season's primary activities (Coleman *et al.*, 2000). A DSL-120 phased-array, 120 kHz side-scan sonar developed by the Woods Hole Oceanographic Institution was towed at

Figure 2. Acoustic image of the wreck of a 19th-century steamship east of Sinop harbour (Courtesy D. Mindell; copyright Marine Sonic Technologies).

about 40–50 m above the sea-bed, and provided returns over 600 m, which enabled relatively small acoustic anomalies (shipwreck-sized) to be identified.

After anomalies were evaluated, we selected targets for visual inspection and photography using a combination of two vehicles: the optical tow sled *Argus* and the remotely-operated vehicle *Little Hercules*, both developed by IFE (Coleman, 2002) and operated from *Northern Horizon*, a research vessel with direct positioning capability. *Argus* acts as a platform for lights and cameras, including a 3-chip video camera, an electronic still camera, and a 35-mm colour still camera. Shipboard operators control its cameras and thrusters, which provide it with independent movement. *Argus* easily located acoustic targets originally identified by the DSL-120 with a 675 kHz fan-beam scanning sonar mounted directly on the tow sled.

Little Hercules is tethered directly to *Argus*, reducing the effects of ship motion and cable drag on the ROV. *Little Hercules* carries cameras capable of providing extremely high quality images; it also has a variety of sensors for pressure, depth, and compass heading, and thrusters for movement both laterally and vertically. It carries the same obstacle-avoidance sonar, which functioned effectively in quickly locating desired acoustic targets. Both vehicles worked well, and provided outstanding visual images (Fig. 3). Precise measurement of archaeological materials was not a goal during the 2000 season, so all measurements provided here were estimated through use of depth sensors or comparison to objects of known size.

Shipwrecks A, B, C

More than 200 acoustic targets were identified by the DSL-120, and 52 were subsequently inspected by *Little Hercules* and *Argus*. Three shipwrecks (A-C) discovered west of Sinop during the 2000 season date to the Late Roman or early Byzantine period, probably between the 4th and late 6th centuries AD. Although Sinop served as a primary trade node in the Black Sea, the wrecks we located are west of the trade route predicted by the preponderance of Sinopian ceramics on the Crimean peninsula (Ballard *et al*., 2001: 608). On wrecks A-C, ovoid mounds of distinctive carrot-shaped shipping jars of a style associated with Sinop retain much of their original stacking pattern. The jars may have carried a variety of well-attested Black Sea products such as olive oil, honey, wine, or fish sauce, but the contents are presently unknown as no artefacts were recovered from any of these wreck sites in 2000.

Shipwreck A appeared in the video images from Argus as Little Hercules' lights illuminated a wall of shipping jars standing about 2 m above the sea-bed (Fig. 4). It is an isolated hump on the sea-bed at a depth of 101 m. The mound appears to be about 20 m long and 10 m wide. Shipping jars on this site most closely correspond to 4th to 5th century AD examples from an amphora kiln near Sinop (Kassab Tezgör and Tatlican, 1998). Because the amphoras highest on the mound have fallen over without displacing those still

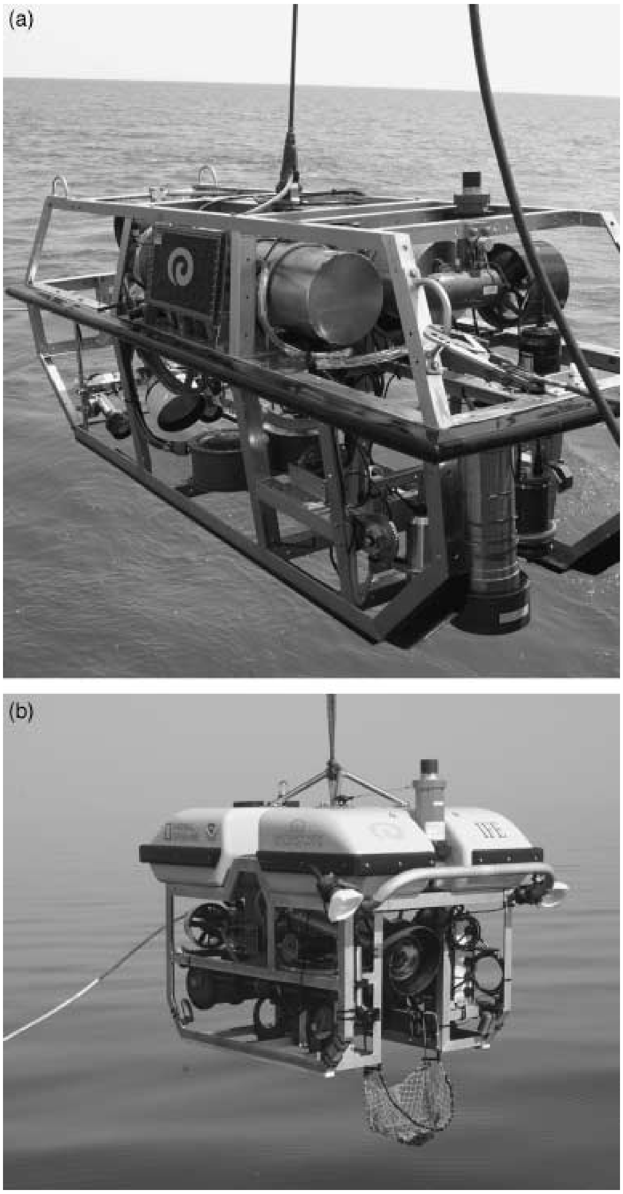

Figure 3. a) Optical tow sled *Argus*; b) imaging ROV *Little Hercules* (Photo courtesy Institute for Exploration/Institute for Archaeological Oceanography-URI/GSO).

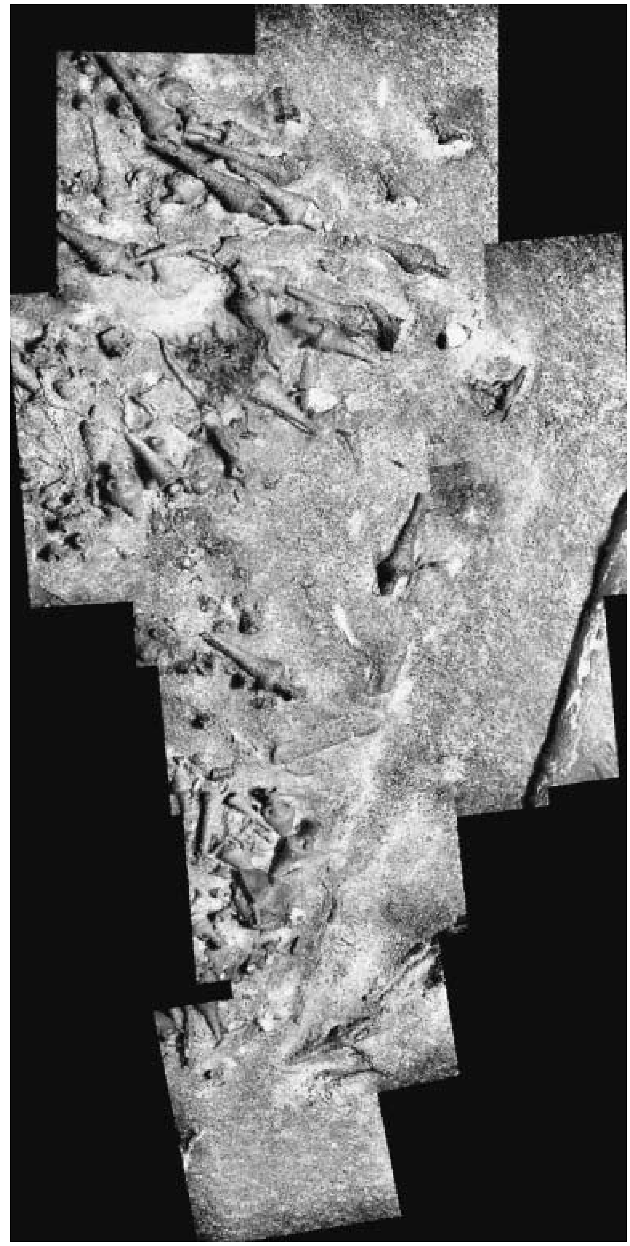

Figure 4. Partial photomosaic of Shipwreck A from electronic still camera images. (Courtesy Institute for Exploration/Institute for Archaeological Oceanography-URI/GSO).

standing in rows beneath them, it is likely that the ship settled upright on the sea-bed, gradually being both buried in and filled with sediment as exposed wood was devoured by the larva of *Teredo navalis*, the shipworm.

Shipwreck B, covering an area approximately 24 m long and 12 m wide at 85 m depth, also consisted of a large pile of shipping jars, but several types are visible, as are multiple timbers protruding from within the mound and on it (Fig. 5). In addition to the Sinop-style jars, several LR1 (hour-glass shaped) amphoras similar to examples excavated on the Yassiada Byzantine shipwreck and dating from the 5th to late 6th century AD are present (van Doorninck, 2002). The presence of exposed timbers, some of which are partially buried in the mound, is intriguing, but at this time it is unclear whether any of them belong to the original ship. No fastenings or other features are apparent.

Two discrete and mostly buried piles of carrot-shaped shipping jars at a depth of 85 m comprise shipwreck C (Fig. 6). The visit to this site was

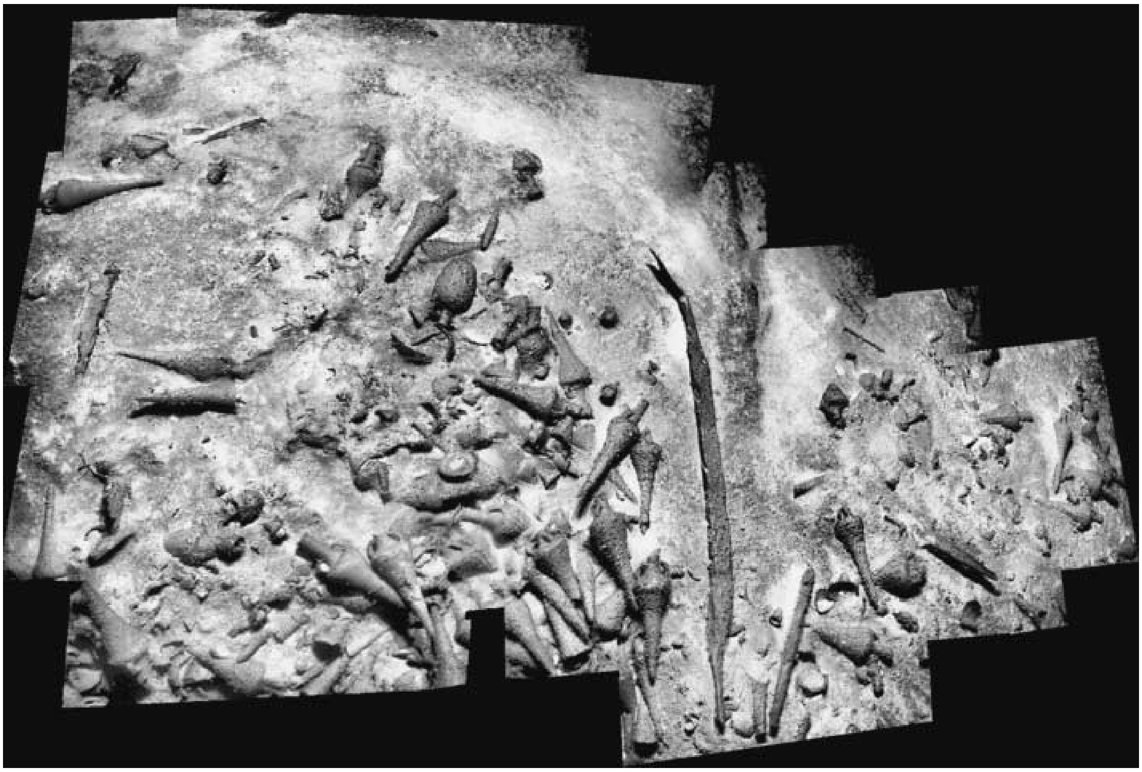

Figure 5. Photomosaic of part of Shipwreck B from electronic still camera images (Courtesy Institute for Exploration/Institute for Archaeological Oceanography-URI/GSO).

quite brief, and intended primarily to test survey methodology for deep-water procedures.

The shipwrecks serve as excellent traps for objects that fall from the surface or move with currents along the sea-bed, as there is modern rubbish—plastic bags and bottles—as well as sticks and brush, on each site's surface. Other acoustic targets (for example boulders or tree trunks) showed the same pattern of accumulation of debris. Because radiocarbon-dated wood samples from other surface deposits in the area include relatively recent wood, it is difficult directly to associate any of the timbers with the ancient ships from their position on the ancient materials. Reviewing the images provided no indisputable evidence of ancient woodworking techniques, but additional documentation is required. Full mapping of the sites is scheduled for 2003.

Shipwreck D

Unlike the other wreck sites, shipwreck D provides us with unprecedented opportunities to document hull construction during a time of transition already documented elsewhere in the ancient world. The fourth ship, Shipwreck D, was identified as a target on the ocean bottom at a depth of 320 m about 25 km north of Sinop. Its sonar signature, a long, slender upright feature on the sea-bed, transformed itself into a wooden mast, standing about 11 m above the sea-bed under the lights of the ROVs (Fig. 7). At deck level the mast disappears into thick, dark sediment topped with a soft, whitish organic substance biologists call 'marine snow', the remains of tiny organisms which live in the water column.

Elements rarely present on shallower shipwreck sites are beautifully preserved here. A 5th-century vessel at Anse des Laurons near Marseille had portions of a hatch and deck preserved (Gassend *et al*., 1984), and recent excavations at Olbia include a mast (Riccardi, 2002), but discovery of a mast in place with associated spars and deck structures from the 5th century AD is unique. A radiocarbon date of 1610 ± 40 (Beta-147532) calibrated to 410–520 AD was obtained on a sample of wood from the robust timber designated as a rudder support in the stern and identified as fir (*Abies* sp.). A second wood fragment was identified as oak (*Quercus* sp., white oak group), but its original location on the ship is not known.

Figure 6. Shipwreck C from video camera image (Courtesy Institute for Exploration/Institute for Archaeological Oceanography-URI/GSO).

A number of long ridges, possibly spars partially covered with drifted sediment, lie along the deck, some between two pairs of uprights aft of the mast. The direction of the mast's cant permitted the determination of the bow and stern. Timbers protrude above the sediment, and allow a rough tracing of the ship's shape and dimensions (Figs 8 and 9). Identifiable timbers include an endpost, a starboard rudder support, 18 timber heads, one pin, at least five spars, a beam, the mast and its bracing timber, two pairs of stanchions, and a handful of treenails. The area of the deck outlined by these timbers is between 12 and 14 m long and about 4 m wide. All measurements are approximate and subject to confirmation by further investigation.

The curved timber aligned with the mast and about 6 m aft of it on the central axis of the ship is designated as the sternpost. Protruding at least 0.5 m above the sediment, the timber curves upwards and inwards, and incorporates one half of a scarf on its outer face. The scarf implies another timber once extended the sternpost, but no timbers visible in the area correspond to its dimensions. Moving from the endpost to the starboard sheerline, we next encounter a substantial upright timber with a notch on its after face. Tentatively designated as a rudder support, this timber is firmly fixed to the hull. Its position and relative bulk are reminiscent of a similarly upright timber visible on depictions of Roman ships in the Ostia mosaics, the Torlonia relief, and on Trajan's column (Fig. 10).

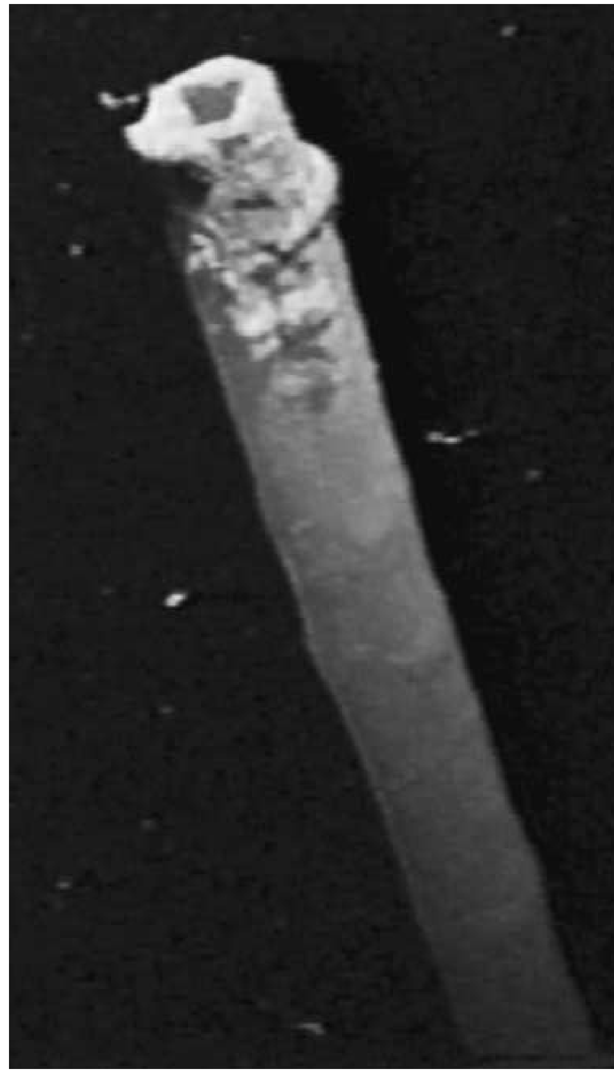

Figure 7. Acoustic image of Shipwreck D, top of mast with cordage (Courtesy Institute for Exploration/Institute for Archaeological Oceanography-URI/GSO).

Timbers that rise above the sediment surface and are rectangular in section, with the narrow dimension oriented towards the vessel's centreline, are designated as top timbers. These uppermost components of frames have a gentle inward curve on their inner face, and a slightly shaped or eroded area near the sediment level on the outer face. A hole approximately 25 mm in diameter passes through forward and aft faces of the timber heads; the holes are aligned with those in adjacent top

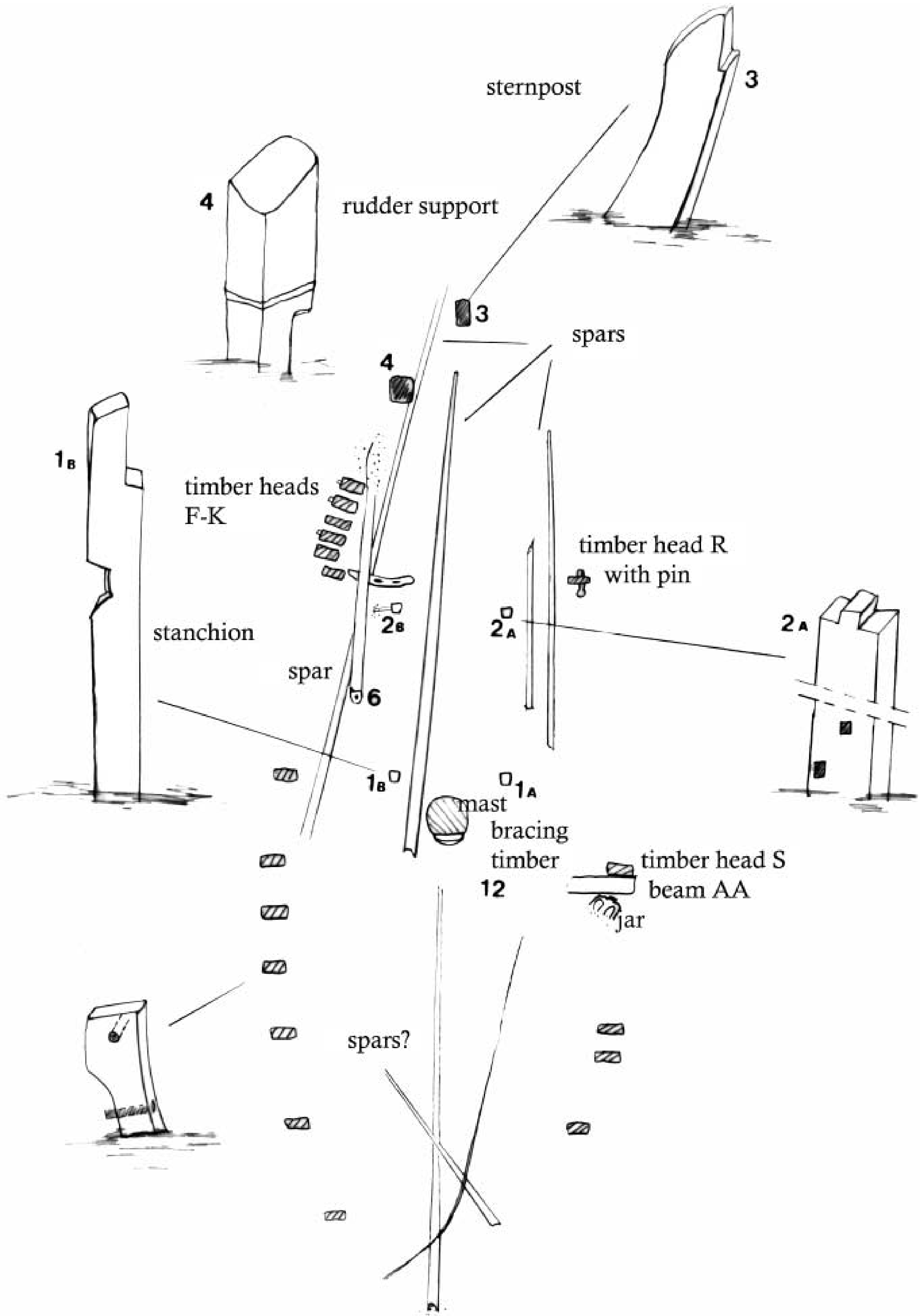

Figure 8. Plan of Shipwreck D with labelled elements, including details (C. Ward).

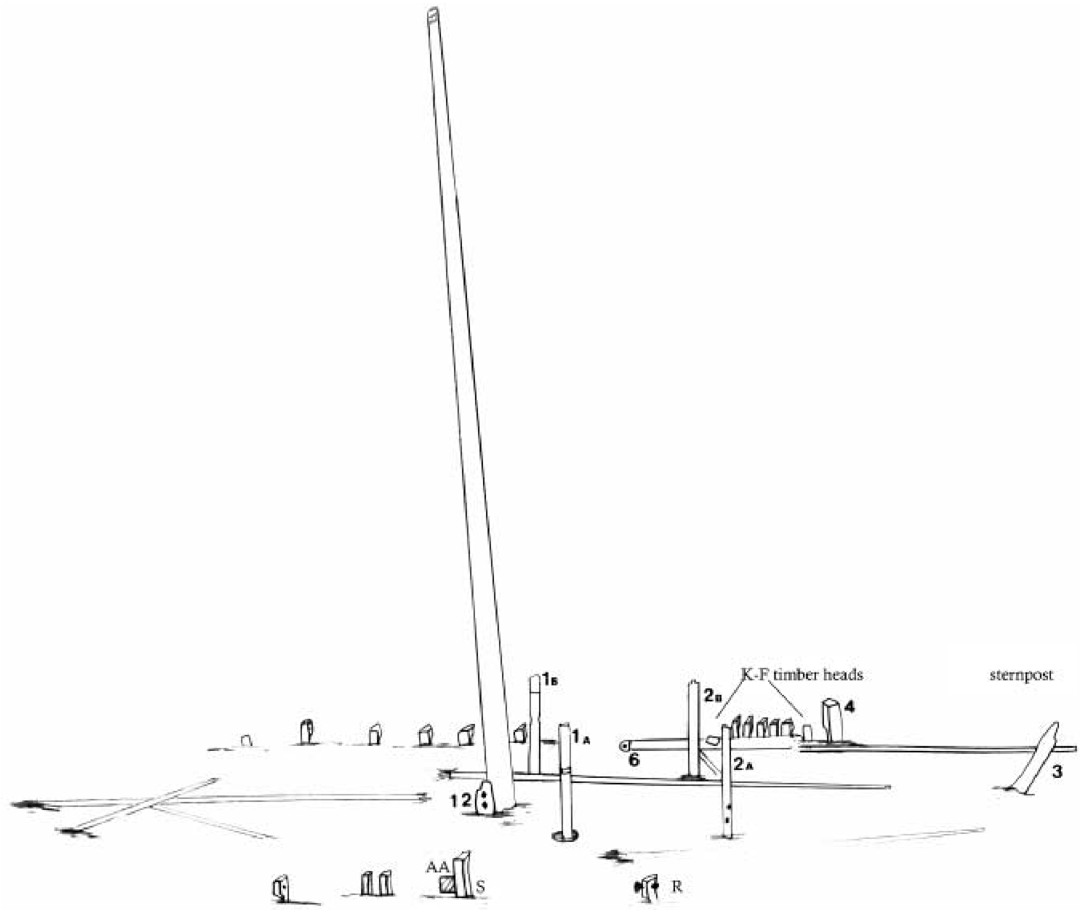

Figure 9. Sheer view of Shipwreck D with labelled elements (C. Ward).

Figure 10. Ship with rudder support and stanchions from Trajan's column, 113 AD (Photo courtesy Romisch-Germanischen Zentralmuseums, Mainz).

timbers. At least one of these holes was filled with a wooden pin (Fig. 11), probably for securing rigging lines. Lost pins, or perhaps cordage strung between frame heads to enclose the deck, may once have filled the other holes.

A group of six close-set top timbers includes one that seems to be out of alignment (F-K on Fig. 9), perhaps because the heavy spar just inboard of it may have fallen on it and broken it. There are 12, possibly 13, timber heads on the starboard side. Only five timber heads are visible on the port side, but two of these have unique features. Top timber R incorporates a *c.*20 cm pin, and S has a notch cut into its outer face.

In the region of midships, a tantalising glimpse of a single transverse beam connected to top timber S hints at the nature of the vessel's interior. Beams at deck level function in several ways. In addition to providing transverse support to the ship, beams may serve for the attachment of deck planking. Because the sole deck beam visible in the 2000 expedition photographs is directly forward of the mast, it is also possible

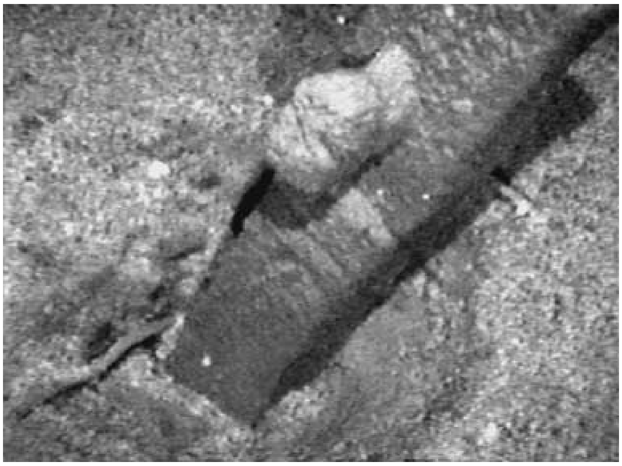

Figure 11. Pin in top timber, Shipwreck D (Courtesy Institute for Exploration/Institute for Archaeological Oceanography-URI/GSO).

that this beam functioned as a mast partner. Both the beam end and the top timber beside it have a notch cut into the surface originally adjacent to the inner planking surface (Fig. 12a). At this stage in the investigations, existence of a planked deck is uncertain. This is a small ship—only 12 to 14 m long—and it is possible that, as on many other ancient ships, decking was present only at the bow and stern, leaving the interior open for easy access to the hold.

The mast is completely preserved, without a trace of erosion or damage. A small cavity at its tip suggests a masthead was once attached there, probably to facilitate attaching the yard. The mast cants or perhaps has slipped towards one end of the vessel (Fig. 12a), here provisionally designated as the forward end. The mast appears

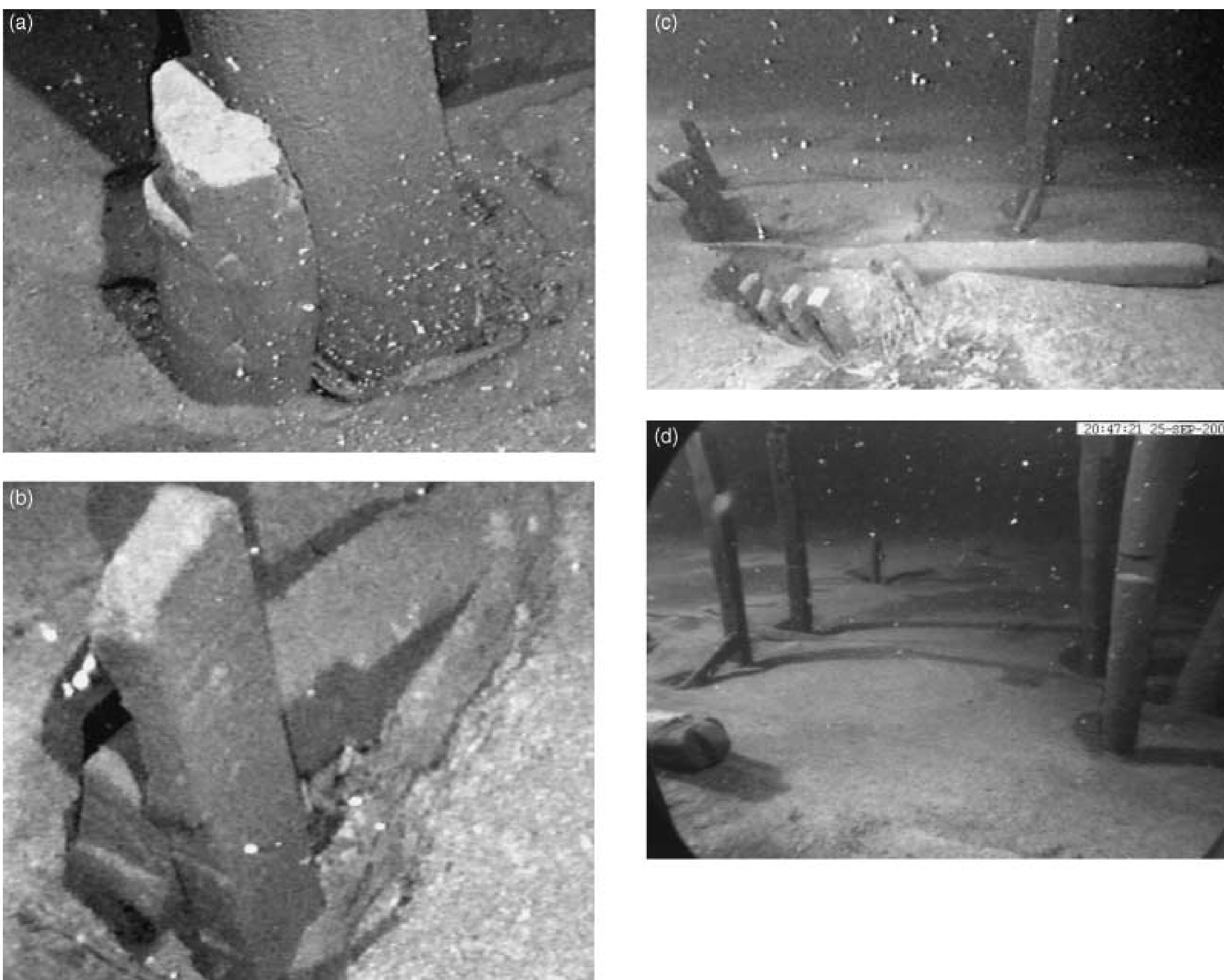

Figure 12. Shipwreck D hull components. a) Detail of bracing timber at mast; b) Beam and top timber; c) Tenon on the forward end of spar 6 (right) with timber heads F-K (left); d) Stanchions aft of the mast (Courtesy Institute for Exploration/Institute for Archaeological Oceanography-URI/GSO).

to be fitted tightly to a short, upright timber, possibly a brace fixed in the bottom of the hull. Two large treenail heads are visible on the sides of the bracing timber, suggesting that they were driven through the timber perpendicular to the mast. The bracing timber has a stepped cut, probably to facilitate lashing the mast to it.

On the starboard side of the mast is a spar running two-thirds of the length of the ship. A bit further aft is the butt end of another spar, about twice the diameter of the first, with a semi-circular tenon that has a 20 cm hole drilled through it (Fig. 12c). It is likely to be a yard. Several other spars appear to lie aft of the mast, between the stanchions, and run out on either side of the sternpost.

Two pairs of stanchions stand aft of the mast, about 1.2 m above the sediment level (Fig. 12d). The stanchions probably were connected with cross-pieces near deck level, one of which is present at stanchion 2b. The aft pair is topped by square tenons, presumably fashioned to fit into mortises on a now-missing cross-piece. A notch facing inboard on each of the forward pair may have served to secure rigging lines; the upper ends of these stanchions seem to be purposefully rounded. There are a few illustrations of similar structures on Roman ships, including a ship on Trajan's column (Fig. 10) and on 2nd- and 4th-century hulls in Tunisian mosaics (Fig. 13) (Basch, 1987: figs. 1105, 1109, 1110). The arrangement seems to have supported yards and spars both while the sail was in use and when it was lowered, and to provide a place for tying off lines.

Disappointingly for ship scholars and historians of technology, there are few indications of how the planks of this ship were held together, and not even a shadow of a stain of metal corrosion products which might provide a clue to how hull components were interlinked. There are no mortise-and-tenon fastenings, no sewing, and no metal nails visible in the images from the 2000 expedition. Treenails about 3 cm in diameter protrude about 25 mm beyond the outboard face of some frame ends, and suggest the presence of a sheer strake about that thick. Treenails also are visible on the starboard and port sides of the bracing timber.

Examination of the site did not clarify a number of unresolved issues: although there is no visible wood erosion or damage from the teredo mollusc, a number of hull components are 'missing'. Particularly noticeable is the lack of a top rail or sheer strake although 18 timber heads stand proud of the sea-bed. Although the ship seems to be sitting evenly beneath the sediment, this is only about a third of the number expected from the distribution pattern in Figs 8 and 9.

Other than the ship itself, the only artefacts we recorded on Shipwreck D were a modern blue plastic bottle and a small ancient jug, whose neck and handles are visible below the outboard end of the beam (Fig. 14). Sediment movement and angle of approach limited our view of the jug, and thus any interpretations of its significance, but it is of primary interest as a potential chronological and cultural marker for future expeditions.

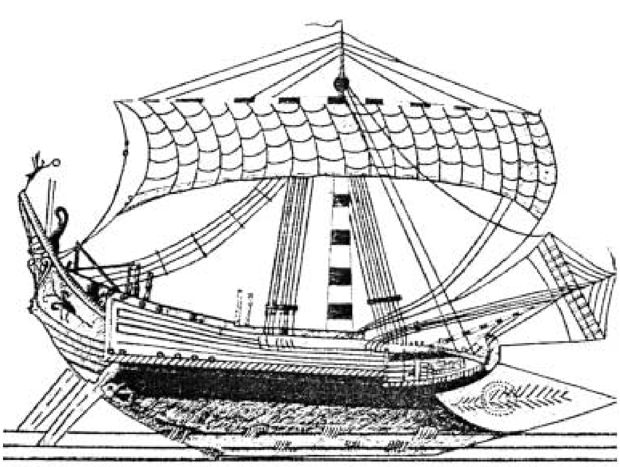

Figure 13. Mid-3rd-century AD ship with two pairs of stanchions in a mosaic from the Maison de la Procession at El Djem, Tunisia (after *Revue Archéologique* 1974, **48**: 23).

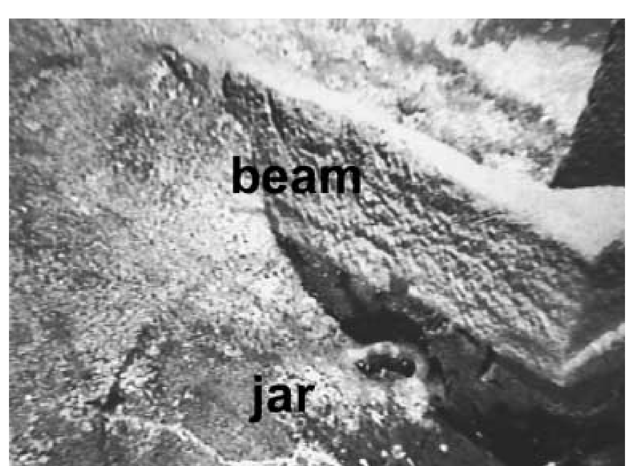

Figure 14. Two-handled ceramic jug beneath beam on Shipwreck D (Courtesy Institute for Exploration/Institute for Archaeological Oceanography-URI/GSO).

Conclusions

Shipwreck D may be one of the earliest lateen-rigged ships to be studied by archaeologists. The angle of the mast and the lack of fittings on it suggest that a lateen sail is the most likely configuration for this small vessel. Lateen sails spread into Egypt from the western Indian Ocean during the first century, and reached the Mediterranean and Aegean soon after. We know little about sailing on the Black Sea before the medieval period, although an early Byzantine sarcophagus identified by the Black Sea Trade Project land survey illustrates a much larger square-sailed vessel typical of late Roman types. A brief underwater survey in 1997 located a ship loaded with 6th-century amphoras, but nothing is known about its construction or rigging (Kassab Tezgör *et al.*, 1998). By the medieval period, lateen sails were common.

Radiocarbon dates and the shape of shipping jars suggest that all four of the shipwrecks date to the end of the Roman period and the beginning of the Byzantine period in the Black Sea. In the Aegean and Mediterranean, people built ships in the traditional plank-oriented manner, although we see signs of change in the 4th century. For millennia, most shipwrights created the planking shell first, then inserted frames and fastened them to the sides (Steffy, 1994).

Beginning in the 4th century, fastenings between plank edges became smaller and less securely fitted, and some frames were set up before the side planking in order to help control hull shape (van Doorninck, 1976). Ship timbers from Tantura Lagoon on Israel's Mediterranean coast show that by the 6th century some hulls were built completely frame first (Kahanov, 2000) although at least one other vessel at Tantura was built with closely-set mortise-and-tenon fastenings during the 7th century (Kahanov and Royal, 2001). Factors such as difficulty in obtaining the skilled labour necessary for plank-oriented construction and economic constraints that favoured the construction of smaller hulls probably influenced the change in construction methods. Van Doorninck (1976: 130) points out that timber is more efficiently used, and iron nails and bolts only partially driven into the frames do most of the work of fastening the late 4th-century AD Yassiada hull.

Learning more about how the Black Sea wrecks were built would help us compare regional economic effects and technological change between the Black Sea and the Aegean. It is possible that we might learn there are as many differences here as exist between the eastern and western Mediterranean (where a strong tradition of sewn ships is demonstrated by archaeological finds).

The Institute for Exploration Black Sea expeditions relied on remote sensing with side-scan sonar in shallow and deep water to identify potential archaeological sites to be examined by ROVs equipped with obstacle-avoidance sonar and cameras for identification and analysis. High quality images support archaeological evaluation of sites and permit decision-making about future investigations. The hypothesis that the anoxic waters of the Black Sea would allow extraordinary organic preservation is borne out by the discovery of a shipwreck 1,500 years old with excellent preservation of features above the sediment layer. A planned expedition for 2003 will use a larger, tool-equipped ROV for subsurface testing of Shipwreck D and other sites.

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