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The Newport Medieval Ship, Wales, United Kingdom

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The Newport Ship is the most substantial late medieval vessel excavated and recovered in Britain in recent years. It was abandoned after extensive salvage, possibly following attempts at repairs to the hull. More than 23 m of the clinker-built ship were recovered, along with significant artefact and environmental assemblages. Finds point to strong Iberian connections during the active life of the ship, which arrived in Newport in the Severn Estuary, after the spring of AD 1468. The dismantling and recovery of the ship has enabled detailed recording using innovative 3D digital techniques and approaches to hypothetical reconstruction. Publication includes a digital archive hosted by the Archaeological Data Service, a substantial report and this article.

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Key words: ship construction, scantlings, 3D modelling, laser sintering, pumps.

The Severn Estuary, on the west coast of Britain, has offered up a number of internationally important boat and ship-finds over the past two decades, particularly along that part of the Welsh coast known as the Gwent Levels, where material of Bronze Age (Nayling and Caseldine, 1997; Bell *et al.*, 2000), Roman (Nayling and McGrail, 2004), medieval (Nayling, 1998) and post-medieval date has been the subject of detailed archaeological study and publication. These finds generally came from either development of green-field rural sites or the intertidal erosion of later Holocene stratigraphy. It is perhaps surprising that there has been a relative lack of similar discoveries from urban contexts in the region.

This changed in 2002 with the discovery of substantial remains of a clinker-built ship, during the construction of an arts centre on the right bank of the River Usk in Newport (NGR ST3128388164, Fig. 1). Its excavation and the vociferous, largely locally driven campaign to save it from destruction were the subject of considerable media attention including a BBC Timewatch documentary. Publications soon after the excavation were limited to brief notes on the excavations by a number of authors, including a personal account published within this journal (Howell, 2003; Hunter, 2003; Roberts, 2004).

Following housing the ship timbers in a building with facilities to allow their passive conservation in

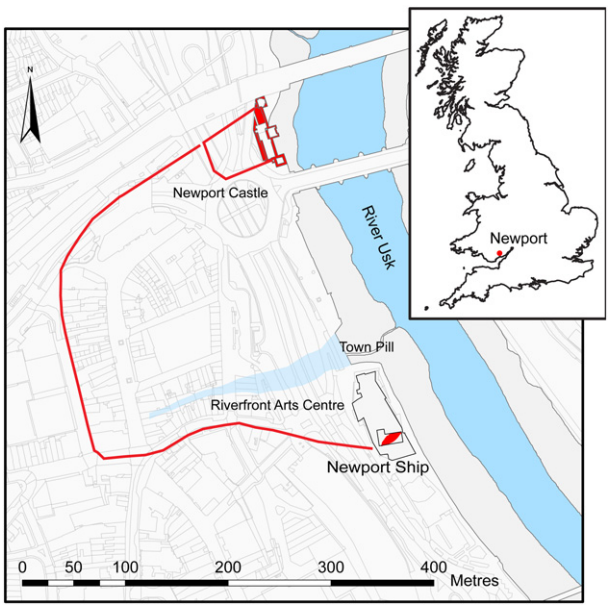

Figure 1. The location of the Newport Ship in relation to the present day city of Newport and the tidal River Usk. The remains of the medieval castle and the suspected extent of the medieval town walls and the former inlet at Town Pill are also highlighted. (Nigel Nayling, base map Crown Copyright)

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Figure 2. Medieval Newport, *c.* AD 1469. The Newport Ship is shown undergoing repairs in the centre of the image, with the River Usk, Town Bridge and Newport Castle also visible. (Anne Leaver)

large shallow water tanks, the vast task of recording them using 3D-digitisation techniques was begun. The generation of such a comprehensive digital dataset encouraged innovative approaches to the reconstruction of the ship. The construction of a scale research model using rapid prototyping technologies to reproduce scaled facsimiles of individual timbers in flexible plastic represented a first step in this process. Subsequent steps in the ship's hypothetical reconstruction have produced further innovation exploring the potential of new digital approaches.

In parallel with the documentation and analysis of the hull timbers, a range of artefact and environmental studies have been undertaken, the most significant of which are summarized here.

Cultural landscape

The discovery of a 15th-century medieval ship on the western seaboard of Britain with diverse evidence for Iberian connections needs to be considered within contexts at a range of scales from the Mediterranean, the Iberian and French Atlantic littoral, the Bristol Channel/Severn Estuary, and the urban topography of the Welsh Lordship of Newport. During the active life of the ship, *c.* AD 1450–1470, political events and economic shifts will also have impacted on the ship's mercantile life.

The recent discovery of a section of clinker-built hull at Barceloneta, Barcelona, Spain (Soberón *et al.*, 2012) provides physical evidence for the entry of ships of 'northern' design into the Mediterranean—possibly referred to in contemporary documents as *'coca tinclada'*. Such journeys would have provided one mechanism for the importation of cargoes such as sweet wines and olive oil from Andalucía to Britain (Childs, 1978; Childs, 2003). During the mid 15th century, trade between England and Iberia was regular and significant, with export from Britain of wool and cloth and the import of commodities including iron, wine and luxury food stuffs. Disruption of the wine trade between Bordeaux and England following the loss of Gascony in AD 1453 led to an increase in such activity and a growing role for Spanish merchants and ships of Biscay in this trade (Rose, 2011: 73). Iberian contacts were also fostered by the transport of pilgrims from England to the shrine of St James in Santiago de Compostela (Childs, 1999). Early sailing directions indicate that both coastal and more direct passages across the Bay of Biscay were in regular use by this time (Ward, 2004: 59). Bristol was the main port in the Severn Estuary during the medieval period, with Iberian shipping forming a significant proportion of its mercantile fleet and an identifiable resident population of Spanish merchants (Carus-Wilson, 1968: 218), although other, smaller ports were also active (Dimmock, 2003). Newport, as the administrative centre of one of the Welsh Lordships, was engaged in Atlantic trade and charged lower import taxes than Bristol. The arrival of the ship in Newport soon after AD 1468 has encouraged research within the context of the complexities of the Wars of the Roses, including the discovery of a letter from Richard Neville, so-called Warwick the Kingmaker, who had control of the Lordship between AD 1469 and AD 1471. He wrote to his reeve in Newport in November AD 1469 to make payments for a ship (Trett, 2005). The topography of the contemporary urban landscape of Newport has also been the subject of research, placing the ship's location at the southern extent of the suspected position of the town walls (Trett, 2010) (Fig. 2).

Excavation and recovery

The construction of Newport's Riverfront Arts Centre, in 2002, was subject to an archaeological watching brief

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Figure 3. First recognition of the Newport Ship. Machine damaged tops of framing timbers and outer hull planks with nail and rove fastenings on the port side. (Nigel Nayling)

carried out by the Glamorgan-Gwent Archaeological Trust. Ground-works required the driving of more than 35 reinforced concrete piles on the site, followed by machine excavation up to 5 m in depth within an area defined by sheet-piles, to allow construction of an auditorium, stage and orchestra pit. Post-medieval features including a timber-lined drain and remnants of a stone slipway were encountered in June and one of the authors (NN) was commissioned at this time to act as a timber specialist. Disarticulated boat/ship timbers encountered along one proposed wall line, and large timbers partially visible in the base of a test trench excavated in the proposed position of the orchestra pit, pointed to the potential for the discovery of earlier material of nautical interest. On the last weekend of June, timbers to the south of the timber drain, damaged by machine excavation of a foundation trench, were investigated. Preliminary cleaning of a small area of timber exposed articulated elements, tentatively interpreted as three oak framing timbers fastened to at least four overlapping strakes of oak planks attached to one another with iron nails and roves (Fig. 3).

Permission was sought and received to investigate the extent, nature and importance of the discovery over a strictly limited time period. It soon became clear that substantial ship remains occupied the majority of the area enclosed by sheet-piling with the first timbers exposed forming part of the port side which had been levelled at some time after the ship's abandonment. Further excavation identified the presence of numerous disturbed timbers within the ship, and a partially collapsed but extensively surviving starboard side (Fig. 4a). Initial exposure of the remains indicated clinker-built oak construction of the hull, although construction method at the centreline was unclear, and the increasingly pressing question of dating (and hence perceived importance) was not immediately resolved. The first secure, absolute dating evidence came two weeks after the initial identification of the vessel with dendrochronological dating of an oak timber found directly overlying the mast-step. Its tree-ring-width sequence was cross matched against medieval regional chronologies and site means from the west midlands and south-west of Britain dating to the winter of AD 1467/8. While the taphonomy of this timber was the subject of some discussion, its dating strongly pointed to a medieval date for the ship, a view which was reinforced by subsequent dating of Portuguese coinage to the mid 15th century.

As the early date of the site and the extent of the remains became clear, and more widely appreciated both within the archaeological and local communities, growing concern about the fate of the ship was reflected in increasing media coverage and the formation of local campaign group 'Save Our Ship'. Thousands visited the site on the first of a limited number of open days. Throughout these uncertain weeks, excavation continued apace on the understanding that investigations would have to be completed before the end of August. After recording, the majority of timbers and wooden artefacts found within the ship were moved to temporary, *ad hoc* storage.

Once all sediment and disarticulated timbers overlying the ship had been excavated, the site was cleaned, photographed and drawn by traditional means (Fig. 4b). Drawings were annotated with timber codes assigned to ceiling planks and stringers, and labels with these codes and unique timber numbers were attached to each ceiling plank in advance of its removal. A schematic diagram provided a useful summary of the codes assigned and the relative position of the timbers. The ceiling planks were then removed to temporary storage. Sediment within the inter-frame spaces was excavated; much of it being retained for environmental assessment and analysis. The exposure of the framing timbers represented a significant stage in the excavation (Fig. 4c).

While the campaign to save the ship escalated, and negotiations took place 'behind closed doors', work on site continued on the assumption that only selected timbers would be recovered for subsequent recording. Strategies similar to those employed in the selective recovery of sections of the ships recorded during development in Copenhagen (Lemée, 2006: 90) were under consideration when an agreement between the Welsh Assembly Government and Newport City Council to fund the ship's recovery, study, conservation and eventual display was announced on 23 August 2002.

This welcome announcement necessitated development of a strategy and logistics for lifting the ship, and the establishment of very substantial off-site storage facilities to hold the timbers. Prior to removal of any further timbers, hand drawings were completed and a photogrammetric survey was commissioned while the stringers were still in place and the framing timbers were *in situ* and largely exposed.

While a number of recovery strategies were considered, it was decided to dismantle the vessel. Factors which influenced this decision included the limited access to the structure located some 5 m below contemporary ground level, the limited space around it, the

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Figure 4. *a)* Loose timbers and hatch covers lying within the ship. View towards the port side. The keelson with mast-step, braces and pump hole is partially exposed; *b)* View towards the bow following removal of loose timbers. Stringers and ceiling tagged and running cross-section lines in place; *c)* Photogrammetric recording of the hull after removal of ceiling planks and inter-frame sedimentation. View towards the bow; *d)* Photogrammetric recording of the hull planks after removal of the majority of framing timbers. View towards the bow. (All Nigel Nayling)

numerous concrete piles which had penetrated the hull and made removal of the structure in sections problematic, and the suction of the alluvial clay in which the vessel was stratified.

Stringers, fastened with oak treenails, required some leverage to remove, and the longer timbers were cut into manageable sections prior to recovery by crane. Similarly, the mast-step timber/keelson was cut into two sections at the point where a modern concrete pile had been driven through it before being removed with a carefully rigged lifting beam. Framing timbers proved difficult to separate from the underlying hull planks due to the excellent preservation of the numerous oak treenails used to fasten them. After some experimentation, the most efficient and least damaging technique comprised driving sacrificial softwood wedges between the framing timbers and the hull planks sufficient to allow access with a handsaw to cut each treenail. Once the timber had been separated from the outer hull and any adjacent framing timbers, two (or more) slings would be attached at suitable lifting points, using small pieces of plywood as spreaders and high-density foam to prevent point loading. Final balancing of the rigging before lifting with the crane was achieved using chain hoists. Framing timbers were lifted by crane onto reusable pallets made from wood and Correx™ and placed on a flatbed lorry for transportation to temporary storage. Dismantling of the

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frames proved by far the most time-consuming aspect of the ship's recovery. In contrast, following photogrammetric recording of the inboard face of the hull planks (Fig. 4d), these were rapidly recovered. Iron nails and roves fastening the strakes together were easily broken. Occasional wooden spikes at the land needed to be cut with a handsaw, and the remains of treenails sometimes had to be forcefully removed at scarfs between hull planks on the same strake. The planks were in surprisingly good condition and could be handled with only minimal padding to protect the surface during carrying, usually by two people. Once lifted, planks were placed on large custom-built pallets which could be craned on to waiting lorries. The keel, apparently originally a single piece of beech more than 20 m long, had been damaged by a number of the modern concrete piles, and was lifted in six sections with the garboard strakes still attached as support. Towards the bow, an oak stem found scarfed to the forward end of the keel had been cut and heavily damaged by the insertion of the sheet-pile cofferdam. The recovery of these disturbed timbers completed excavation of the ship itself in November 2002, some 16 weeks after its discovery.

Excavation on the site continued in a restricted area below the vessel's starboard side where a group of large timbers, tentatively interpreted as shores on to which the ship had been heeled over, were exposed recorded and recovered. This phase of excavation allowed limited examination of the stratigraphic sequence within the inlet between the contemporary riverbank and the starboard side of the ship. The question arose of the feasibility of recovering parts of the ship which extended beyond the sheet-pile cofferdam, for example in the bow, stern and starboard side towards the stern. Mary Rose Trust Archaeological Services were commissioned by Newport City Council to assess this and discussions were held with the development contractors. A proposal to employ trench boxes to permit restricted deep excavations was considered acceptable by the constructors in the bow area, but rejected in the stern area due to health and safety concerns over the risk of collapse of the nearby riverside wall. Oxford Archaeology were commissioned to carry out the excavations during April 2003; the surviving remainder of the stem and disturbed pieces of hull planking, framing timbers, stringers and riders were recorded and recovered (Fig. 5).

Figure 5. Excavation of the bow. View of outboard face of stem and associated forward hull badly disturbed by sheet and concrete piles. (Nigel Nayling)

Documentation

On site recording

Archaeologists documented the position and context of artefacts, disarticulated timbers and hull remains with traditional scaled drawings, photogrammetry, photography and videography, with an eye towards documenting individual timbers in a high degree of detail at a later date.

Plans were hand drawn, usually at a scale of 1:10, using an arbitrary site grid set around a baseline aligned with the centreline of the ship. These were annotated with spot heights relating levels to temporary bench marks with known heights relative to Ordnance Datum (OD—the reference level for land mapping in the United Kingdom). Sections were hand drawn at the same scale, included running sections across the ship. These hand drawings were complemented by two phases of photogrammetric survey carried out when the ship was fully exposed with the ceiling planks and inter-frame sediment removed, and later, after the removal of the majority of the framing timbers, to record the inboard face of the hull planks, keel and stem. This survey, undertaken before the widespread adoption of laser scanning, used a dedicated photogrammetric camera to produce stereoscopic pairs of high-resolution photographs. The extraction of 3D line data from these stereoscopic pairs was carried out after completion of the excavations by one of the authors (NN) and the photogrammetry specialists; this ensured appropriate data capture, layering and labelling. Excavation of the bow area in 2003 was also recorded using a total station. Final site drawings of the ship were based on the results of the photogrammetric survey supplemented by information from hand-drawn plans, which were particularly useful in areas of relatively poor visibility in the vicinity of the concrete piles.

Individual timbers, whether articulated elements of the ship or other stratified wooden items, were assigned unique timber numbers during excavation and recovery. Some timbers, mostly loose deck planks, were discarded during the early stages of excavation, when the site was very much a rescue excavation, but were recorded on timber record sheets beforehand. In addition, articulated elements of the ship's hull were assigned function codes based on the relative position

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Table 1. *Function codes assigned to articulated timbers on the Newport Ship. # indicates the use of a number*

Code	Timber description
BB	Bilge board
BRP#	Brace (chock, strut) to keelson on port side
BRS#	Brace (chock, strut) to keelson on starboard side
CP#.#	Port ceiling plank
CS#.#	Starboard ceiling plank
F#.#	Framing timber Where F#.0 = Floor timber Where F#.[odd number] = framing timber port side Where F#.[even number] = framing timber starboard side
P#.#	Port side hull plank
R#	Rider
S#.#	Starboard side hull plank
Son	Keelson/mast step timber
Stem	Stem
STRP#.#	Stringer port
STRS#.#	Stringer starboard

of each timber within the excavated section of hull (Table 1). Each longitudinal timber was assigned a prefix indicating its function, followed by a decimal number indicating its position relative to the centreline and along the length of the excavated remains. Hence the third plank along the seventh starboard strake of the outer hull was assigned the code S7.3. Framing timbers, running athwart ships, were given the prefix 'F' followed by a number indicating its frame station (from F1 in the bow to F63 nearest the stern), and a decimal indicating its position within that frame group with '0' indicating a floor, an odd number indicating successive side timbers/futtocks on the port side and even numbers indicating the starboard side (after Steffy, 1994: 194). Hence F26.6 denotes the third futtock on the starboard side of the 26th frame station. Function codes are used throughout the description of the *in situ* remains. Waterproof labels marked with a unique timber number and, where appropriate, function code were stapled to each timber prior to its removal, with some timbers being cut into sections to aid lifting and handling. These numbers and codes were added to the hand drawings at the same time.

Many of the recovered timbers were heavily concreted with much of the surface detail obscured. The concretions, along with tar and animal-hair luting, were left in place and only removed later prior to detailed recording. Individual timber record sheets were started for most timbers on site but were only completed, due to time pressures, for those numbered timbers which were discarded on site. During the relocation of timbers from temporary storage to a dedicated facility for documentation, the original labels and numbers were replaced by more durable tags normally used for marking livestock. A concordance was established between this new 'unique timber number' series (preceded by CT for cow tag) and that used on site (preceded by G).

Post-excavation documentation

Between the end of the excavation in April 2003 and start of the post-excavation research in late 2004, the project managers compared various recording methodologies and chose the most efficient, accurate and suitable system for the disassembled ship timbers. A pilot study compared laser scanning, 1:1 elevated plane tracing, and contact digitising (Barker and Nayling, 2004). Laser scanning was dropped once it was realized that the resulting point cloud lacked any interpretation, and required extensive post-processing of the data. The benefits of tracing and contact digitising were compared by drawing representative ship timbers, including a floor and stringer, with digitising proving more efficient in terms of cost and time.

The project initially acquired one 12-foot Faro Advantage™ Arm contact digitiser and used Rhinoceros3D™ modelling software to capture and display the output. Introductory training and example templates were provided by the Viking Ship Museum in Roskilde, Denmark. Subsequently, Heritage Lottery funding allowed the acquisition of three more digitisers. A decision was made to capture a high level of detail during the initial recording, and to sample or decimate this data as necessary in the future. The entire hull (and disarticulated material) was recorded in two years.

During the initial training period, archaeologists were taught how to 'read' the timbers, operate the equipment (both hardware and software), and record important features such as tool marks, fasteners and edges. Different features, such as nails and wood grain, were recorded on separate layers and in specific colours. Template files were created for each hull component, with template layers specifically tailored for the characteristics commonly seen on lapstrake hull timbers, such as lands, rivet and rove impressions, and joggled floors. A step-by-step timber-recording manual helped to ensure quality and consistency in methods and interpretation among the large team (Jones, 2013).

Control points, in the form of small stainless-steel wood screws, were inserted into the edges of planks and along the inboard and outboard face of framing timbers. The points were used as reference points for the digitiser when moving or rotating a timber. They have remained in the timbers through the conservation process, and will provide a useful baseline against which distortion in the timber can be checked. After installation of control points, the archaeologist opened a read-only template file and labelled it according to the unique timber number (cow tag) and timber function code. The digitisation commenced by working

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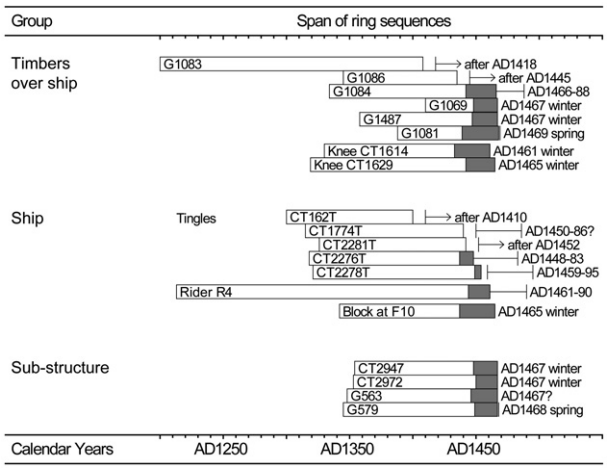

Figure 6. Bar diagram showing timbers absolutely dated against British chronologies giving felling dates or date ranges. (Nigel Nayling)

through the layering system and recording all examples of each feature, such as rove impressions or treenail holes.

Each digital drawing was checked by another archaeologist while the timber was still on the recording table. If mistakes or omissions were noted, it was a straightforward process to reference the digitiser back to the original timber and make corrections. After final checks, the digital drawings were saved and archived for future analysis and modelling.

The digital documentation methods were complemented by handwritten timber sheets which included observations made during cleaning, notes on wood science, and recorded selective digital photography, laser scanning and physical casting of special features. In addition, details about each timber, including function code, description and its progress through the documentation process were tracked in a database.

Site description

This section provides a summary of the major structural groups in chronological order. The absolute dating of these groups is largely based on dendrochronological dating of oak timbers (Nayling, 2013). The results of an extensive dendrochronology study are summarized in Figure 6, where ring-width sequences dated against British chronologies are presented with their felling-date ranges based on current sapwood estimates, in line with guidance on best practice (English Heritage, 1998) (See also Nayling and Susperregi, 2013, this volume).

Context

The ship was found close to the present right bank of the highly tidal River Usk, downstream from both the medieval castle and the Town Pill—a formerly large

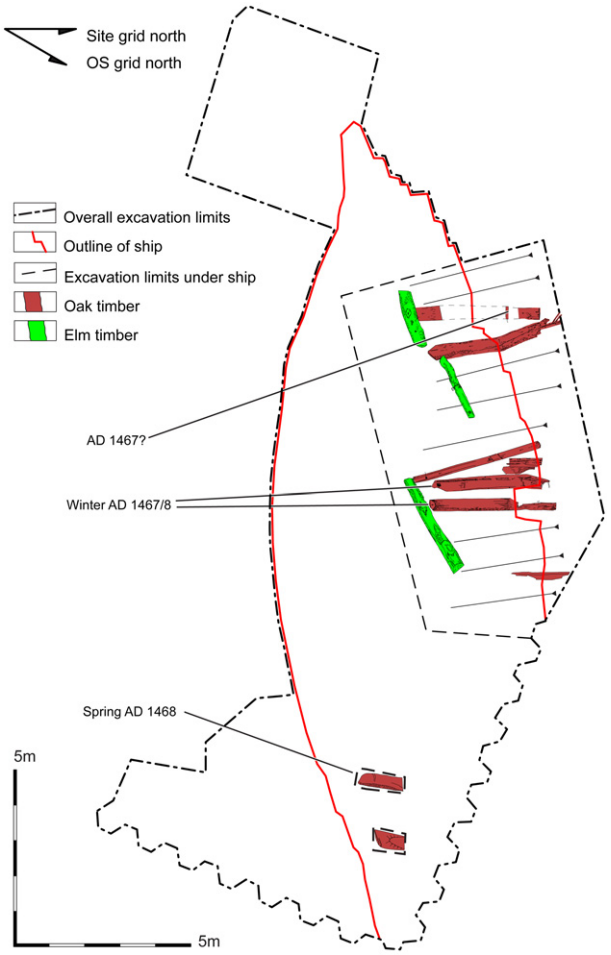

Figure 7. Plan of structures below the ship. Timbers are colour coded by species and tree-ring dates indicated. (Nigel Nayling)

inlet, still evident in the line of the present riverside wall, thought to have been the main focus for medieval shipping (Figs 1–2).

Investigation of the physical context of the ship-find was limited, but it would appear that the ship had been brought into a small inlet which was certainly active in the late prehistoric period; excavations below the starboard side of the ship revealed part of an articulated human skeleton at the base of the palaeochannel, radiocarbon-dated to the late Iron Age (Coard, 2013). It is perhaps linked to prehistoric practices of interment on wetland locales in the estuary (*see* Bell *et al.*, 2000). The bed of this inlet was defined by degraded Mercian mudstone with a marked red colour (formerly known as Keuper marl), which merged with overlying alluvium and was encountered most extensively during removal of the keel which had sunk into this interface.

Prior to the ship's arrival, a structure was built using trimmed trunks of oak and elm laid in the bed of the inlet and sloping down its northern side on to which the ship could be heeled over (Fig. 7). The side of the inlet was also consolidated through the dumping of

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deposits rich in iron slag which interleaved with greyish alluvium. Two partially excavated oak trunks were found laid approximately north-south across the bed of the channel close to where the keel near the stern came to rest. The felling date of the parent tree of one of these, determined by dendrochronology, is the spring of AD 1468, which provides a precise *terminus post quem* for the ship's deposition. Further into the inlet, three elm trunks had been laid lengthwise in the bed of the channel, and at least five oak trunks and some reused beams laid sloping down the north side of the inlet at an angle of approximately 30 degrees from horizontal. The majority of these timbers comprised tree trunks with felling cuts, hauling holes and minimal secondary working. Three of the oak shoring timbers produced felling dates, two to the winter of AD 1467/8 and one to AD 1467(?). Hawsers found directly underlying the starboard side and port side near the bow may have been used to manoeuvre the ship into position.

The ship *in situ*

The extent, disposition and form of the excavated remains of the ship were affected by a number of factors including the limits of areas available, the underlying topography of the inlet and of intentionally placed timbers (shores), collapse of the latter and associated flattening of the starboard side, salvage or clearance, and compression by up to 5 m of overlying deposits (Fig. 8).

The overall dimensions of the remains exposed within the excavations delimited by sheet-piles were 22.5 m in length by 7.65 m across, approximately amidships, with a maximum surviving depth from the inboard face of the keel to the uppermost surviving strake of 1.65 m. The ship lay with the stern towards the river and the bow to the west-south-west, such that the height of the top of the keel rose by 0.75 m over its exposed length of 19.3 m. The ship listed perceptibly to starboard by approximately 14° amidships, and the starboard side had flattened out.

The port side appeared to have been intentionally reduced down to the 16th/17th strake, with axe marks clearly defined on hull-plank edges and the heads of the frames, possibly to clear the site for subsequent use. The full surviving extent of the hull remains were exposed along the port side from F8–F 61. At F45–F51 the hull had been further truncated to P13, from F52–F53 to P10, and from F54–F59 to P7. The upper edge of the aftermost portside planking met the eastern wall of sheet-piling near the stern at P5/F61. This sheet-piling cut across the portside planking and keel to meet the return in the sheet-piling on the starboard side at S5/F63.

The forward surviving extent of the starboard side again exhibited numerous axe marks along edges of the hull planks and frames. The uppermost surviving starboard strake rose from S14 at frame station 1 (F1) to the partial survival of the 35th strake at F25. Contrary to Roberts' comment (2004: 159), there is no evidence that this uppermost surviving starboard strake (S35) was the sheer strake. Its upper edge was not encountered in the small length of plank fragment recovered.

Aft of F36 on the starboard side, excavation was limited by the north wall of sheet-piles cutting through the hull from the 34th strake at frame station F39 to S5/F63. As a result of additional excavation in the bow area in April 2003, the full surviving forward extent of the much disturbed stem and hull planking was exposed and recovered.

Post-depositional distortion of the hull was most evident during photogrammetric recording of the outer hull after removal of the majority of the framing timbers. The keel had settled (presumably on to the contemporary river-bed) leading to marked hogging of the hull; its top height rose from 4.0 m OD at the forward-most exposure of the inboard face at its scarf with the stem at F9, to 4.20 m OD at F26, then sloped down to 3.45 m OD at F59, immediately forward of a vertical swelling in the keel. Unevenness in the lines of the strakes of hull planks was most marked on the starboard side between frame stations F20 and F28 where compression over underlying timber shores distorted the hull form. A general list to starboard was evident, emphasized by puddling of water around starboard strakes S10–S14.

The surviving remains of the inner hull included an oak keelson with integral mast-step, three and seven runs of stringers respectively on the port and starboard sides, areas of ceiling planks, and four riders in the bow, along with numerous bilge boards. Runs of oak stringers alternated with runs of less-robust oak ceiling planks to form the inner hull. Partial removal of both ceiling and stringers had occurred leading to gaps in the inner hull. With the exception of a single possible repair, no ceiling planks were encountered further up the starboard side than the fourth run of stringers. *In situ* ceiling planks found below the fourth run of stringers on the starboard side, and throughout the surviving port side, were usually fastened to the underlying frames with iron spike-nails. Some bilge boards were found *in situ* sitting in rebates on the fourth starboard stringer and between the keelson braces. Four timbers were found fastened over the stringers; these were riders in the bow over F4, F6, F8 and F9. The aftermost riders were substantial, rebated over the stringers to ensure extensive faying surfaces with the upper faces of the adjacent framing timbers. Rider R4 has been dated against British chronologies, giving a felling-date range of AD 1461–90.

Sixty-three frame stations were identified. The frames were straight and closely spaced. Characteristically, each surviving frame comprised a floor-timber, with a portside futtock and one or more side timbers on the starboard side (see Fig. 8b). Scarfs between floor-timbers and portside futtocks were usually still tight with few signs of either cracking or opening up of

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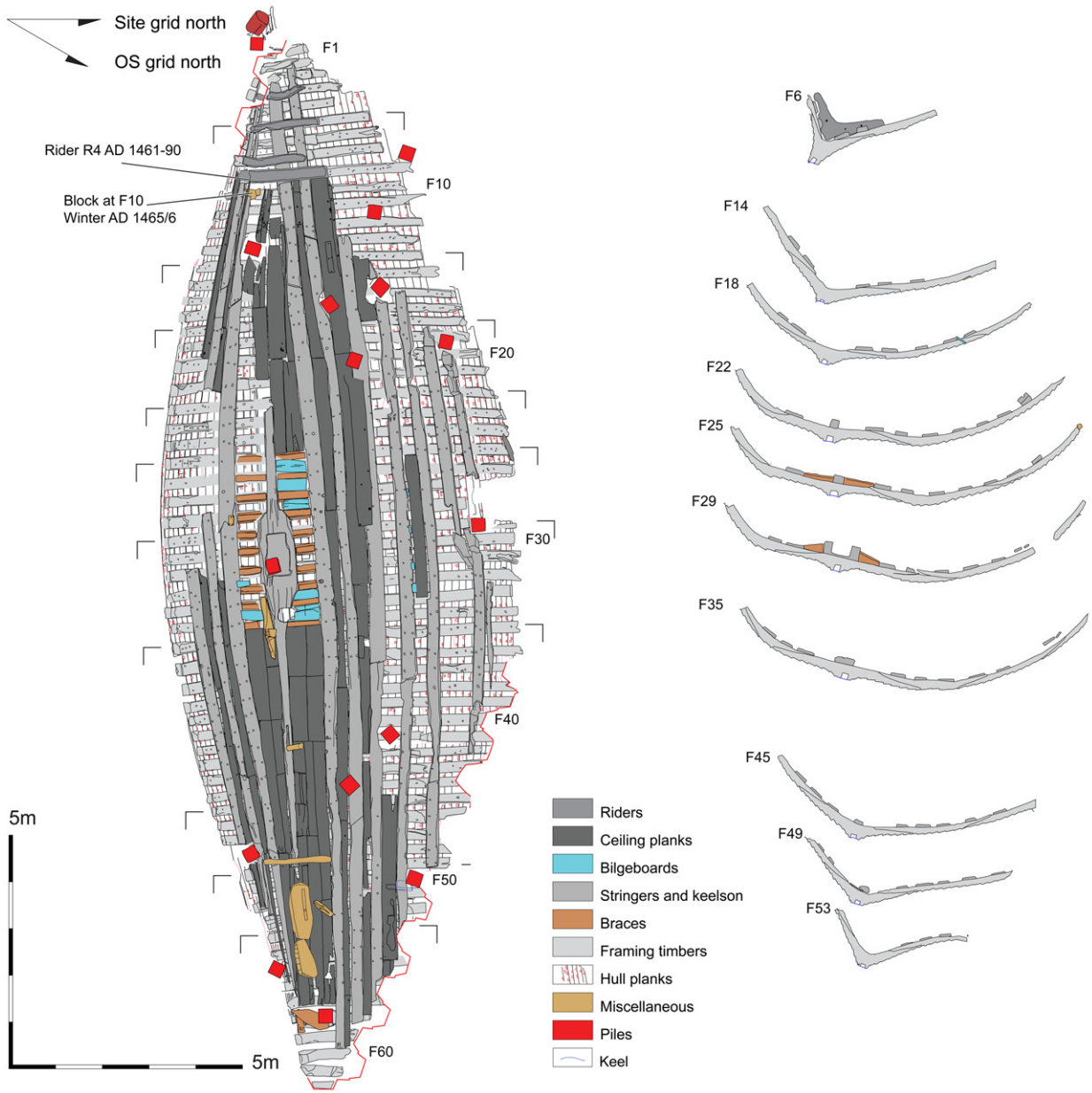

Figure 8. *a)* Plan of the ship based on photogrammetric recording supplemented by hand drawings. Timber types are colour coded and position of cross-section drawings indicated; *b)* Sections through the ship *in situ* based on photogrammetric recording supplemented by hand drawings. View towards bow. (Both Nigel Nayling)

the scarf. On the starboard side, in contrast, scarfs often gaped, and cracks across framing timbers reflected compression and collapse of the hull.

At frame station F10, a roughly hewn block of oak had been wedged directly over the keel between framing timbers which may have originally formed a single floor-timber. This inserted block has been tree-ring dated to the winter of AD 1465/6 with its tree-ring sequence very closely matching that of a large displaced knee forming part of a knee-crossbeam assembly found within the ship. Both these timbers appear to derive from timber which grew in the south-west of Britain.

Salvage

In addition to the reduction of the hull indicated by hack marks around the surviving extent of the hull, numerous features indicate removal of timbers from within the hull. Exposed forward scarfs or hacked ends on stringers STRS3 near F13, STRS4 near F15, STRS5 near F17 and STRS6 at F20, along with the presence of

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upstanding treenails on framing timbers forward of these locations, indicate the removal of timbers on the forward starboard side. STRS6 aft of F28–30 is also absent, and the swellings on STRS7 exhibited numerous hack marks where the jointed ends of cross beams had been removed. Presumably, ceiling planks had originally lined the hold up to STRS4 where rebates accommodated bilge boards, but these were absent between STRS4 and STRS3 aft of F18 and forward of F45. A ceiling plank on the starboard side between STRS4 and STRS5 was not in its original position and had presumably been moved during salvage on the vessel. On the port side, stringers and ceiling had been hacked out near midships beyond STRP1 aft of F20–21 and forward of F31 with STRP3 completely removed forward of F31. Ceiling and stringer STRP2 had also been removed aft of F51. Ceiling planks had also been removed from an area forward of the braces to the keelson on the port side, and many of the bilge boards between these braces were also absent.

Infill on the starboard side

Prior to the ship's collapse and deformation by the accumulation of overlying sedimentation, a gap between the starboard side of the vessel and the underlying structure on which it had been placed allowed material to fall into this gap and become preserved in the alluvium which built up both within and around the ship. Timbers recovered included a single knee, hacked fragments of oak side timbers and outer hull planking, a possible hatch cover and smaller items such as cask fragments and oak wedges.

Infill within the ship

Inside the ship the inter-frame spaces usually contained a highly organic, dark-brownish-black, sandy silt with visible organic content such as fish bone and caulking/luting material. This basal deposit lay in direct contact with the inboard face of the outer hull timbers and was generally no more than 50 mm thick. It is this deposit from which the majority of the palaeo-environmental evidence described in later sections was derived. Generally, this basal organic deposit was overlain by clean blue-grey clay which in-filled the inter-frame spaces, the pump hole amidships, the mast-step and also the interior of the hull. Numerous timbers and other artefacts were found lying directly on the inner hull of the ship surrounded by this and later alluvium. Given the potentially semi-fluid nature of the sediments which accumulated within and around the ship, caution is needed in interpreting the chronological relationship between such items and these deposits.

The disarticulated timbers lying within the ship (Fig. 9) generally comprised tangentially sawn planks (mostly oak but also some elm and conifer) with iron spike-nail fasteners. While some of these may be displaced ceiling planks, the majority are interpreted as

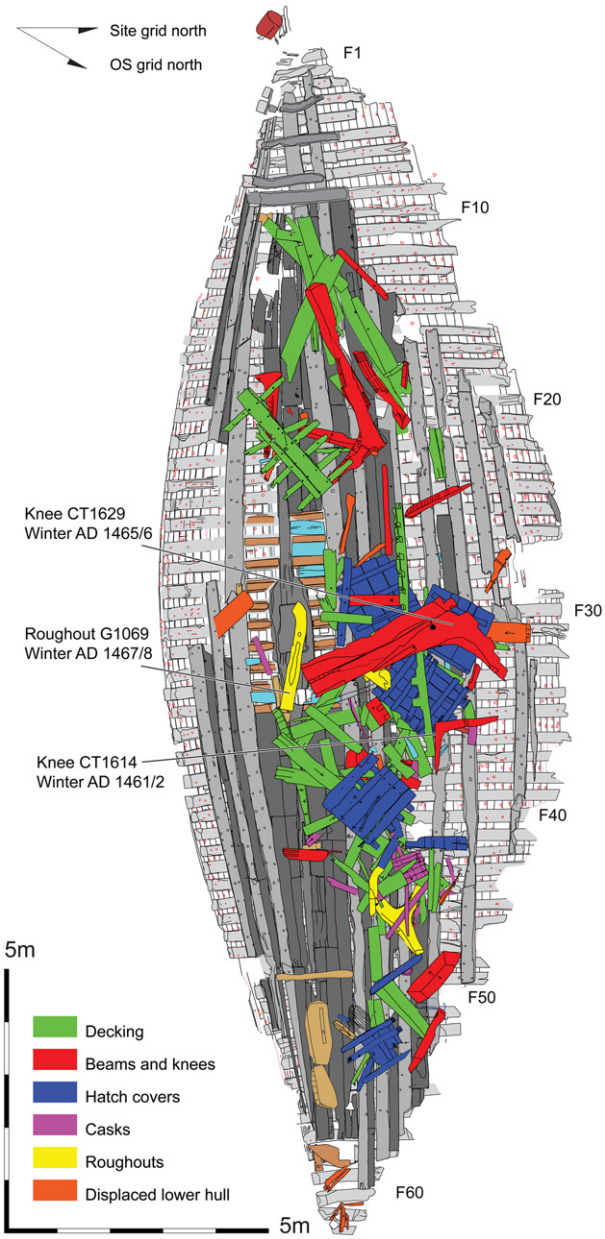

Figure 9. Timbers lying within the ship, colour coded by major categories. (Nigel Nayling)

deck planks—certainly the case for two where rebates would have accommodated the frames, and a partially articulated group comprising oak planks fastened to ledges with hacked half-dovetail joints. Numerous fragments of beams, some still fastened together and attached to knees, are interpreted as the remains of cross-beam/knee assemblies. A large timber, interpreted as a mast partner, was also recovered in the vicinity but not planned before its removal. Many of these timbers exhibited axe marks indicating intentional dismantling of interior structures of the ship. The large knee CT1629, forming part of an articulated beam-knee assembly, has been dated against British

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tree-ring chronologies to the winter of AD 1465/6. Knee CT1614 was similarly dated to the winter of AD 1461/2. Five hatch covers comprising elm or conifer sawn planks with bevelled oak beams, along with a number of completely disarticulated beams, show marked similarities to those recovered from the Red Bay ship (Grenier *et al*., 2007: 197). The articulated remains of a cask, probably cut down for reuse as a container, were also recorded along with numerous individual staves and heads.

Fragments of lower hull timbers, usually showing axe marks from dismantling/salvage, were noted both lying directly on the inner hull but also within contexts overlying the alluvium within which most of the timbers were stratified.

A 0.9-m slot had been cut through the starboard side aft of F26 and partially through framing timbers at F29 from S35–S27. A plank placed horizontally within this slot, along with reused framing-timber fragments, appears too narrow to provide useful access and may have acted as a drain after the ship's abandonment. This timber, which may have been reused, has been dated by dendrochronology giving a felling date in the winter of AD 1467/8.

Later structures

Following the accumulation of further alluvium over the ship, a simple timber drain was constructed directly over the ship running down from the west-south-west (base height 5.92 m OD) towards the river in the east (where its base height was 5.50 m OD). The use of wood waste from the sawing of oak baulks in its construction, and the presence of wood shavings within it, suggests this drain was in use when this part of the riverfront was in use as a timber yard. In the eastern extent of the site, this was superseded by a stone-built slip which also sloped down towards the river.

The Ship

The articulated hull consists of a keel, stem, outer hull planking, framing, stringers, braces, riders and a keelson with integral mast-step, along with ceiling, bilge boards and other non-structural timbers.

Keel

The keel is fashioned from a single beech (*Fagus sylvatica*) tree with a surviving length of 19.8 m (Fig. 10). The tree was more than 94 years old when felled with an average ring-width of 1.8 mm. The keel was hewn from the tree with its butt end towards the stern and a concentration of knots near the forward scarf indicating proximity of the crown. The branch angles of these side branches were steep suggesting the tree had grown in a closed-canopy environment.

There was considerable damage caused by the insertion of the concrete piles, with the keel being severed at F13 and F31. There are numerous compression or crush marks on the inboard face of the keel, caused by the lowermost outboard faces of the oak floors (the 'feet' on either side of the limber hole). The compression marks appear deepest in the stern area. It is likely that these compression marks are a product of the depositional environment. Distortion and damage made it difficult to determine initially if the keel was rockered. However, subsequent modelling has shown that the keel was flat.

The aft part of the keel was severed by the sheet-pile cofferdam, which cut through a vertical swelling on the keel (Fig. 11a). This vertical swelling, covering the aftmost 750 mm of the extant keel, may have formed part of the stern joint. The keel tapers in section towards the forward end, and is vertically scarfed on the port side to join the stem. The keel ranges in width (measured on the inboard face) from 180 mm to 270 mm, and in height from 170 mm to 240 mm. The keel is trapezoidal in section, with deep rebates to accommodate the garboard strakes (Fig. 11b). The garboards are attached to the keel using wrought-iron spike-nails.

During cleaning of the forward end of the keel (CT1639), a small square rebate was discovered on the inboard face, which contained a silver French coin dated to AD 1447, originally covered by the stem (Fig. 11c). The keel and stem were fastened together with numerous wrought-iron spike-nails and clench nails that ran through the keel and stem scarf as well as both garboards.

Stem

The stem was shattered into nine pieces when the cofferdam and concrete piles were inserted (Fig. 12). The stem was hewn from a single piece of curving oak (*Quercus* spp.) with a high average ring-width (2.7 mm/pa). It is rebated to accept the hood-ends of the planking, as well as being scarfed to the keel over a length of 550 mm (Fig. 13). These rebates change from individual rebates for hooked hood-ends to a continuous straight rebate at strake 12. The forward uppermost part of the stem was salvaged sometime in the past. The length of the surviving timber is estimated to be 4.26 m. The overall dimensions range from 220–520 mm moulded and 180–260 mm sided. There was a hole augered and then chiselled transversally through the stem, measuring *c.* 85 × 140 mm, located at the lower end of the foremost surviving fragment.

Planking

There are remains of 52 strakes of oak (*Quercus* spp.) hull planking; 17 on the port, and 35 on the starboard sides (see schematic plan, Nayling and Susperregi, 2013, fig 1). There are 373 distinct planks, composed of 711 fragments. The longest extant strakes contain ten planks, although no complete and intact (stem to stern) strakes were recovered.

The planks were normally radially split from straight-grained trees with minimal knotting. In some cases, trimmed side branches, encapsulated by later

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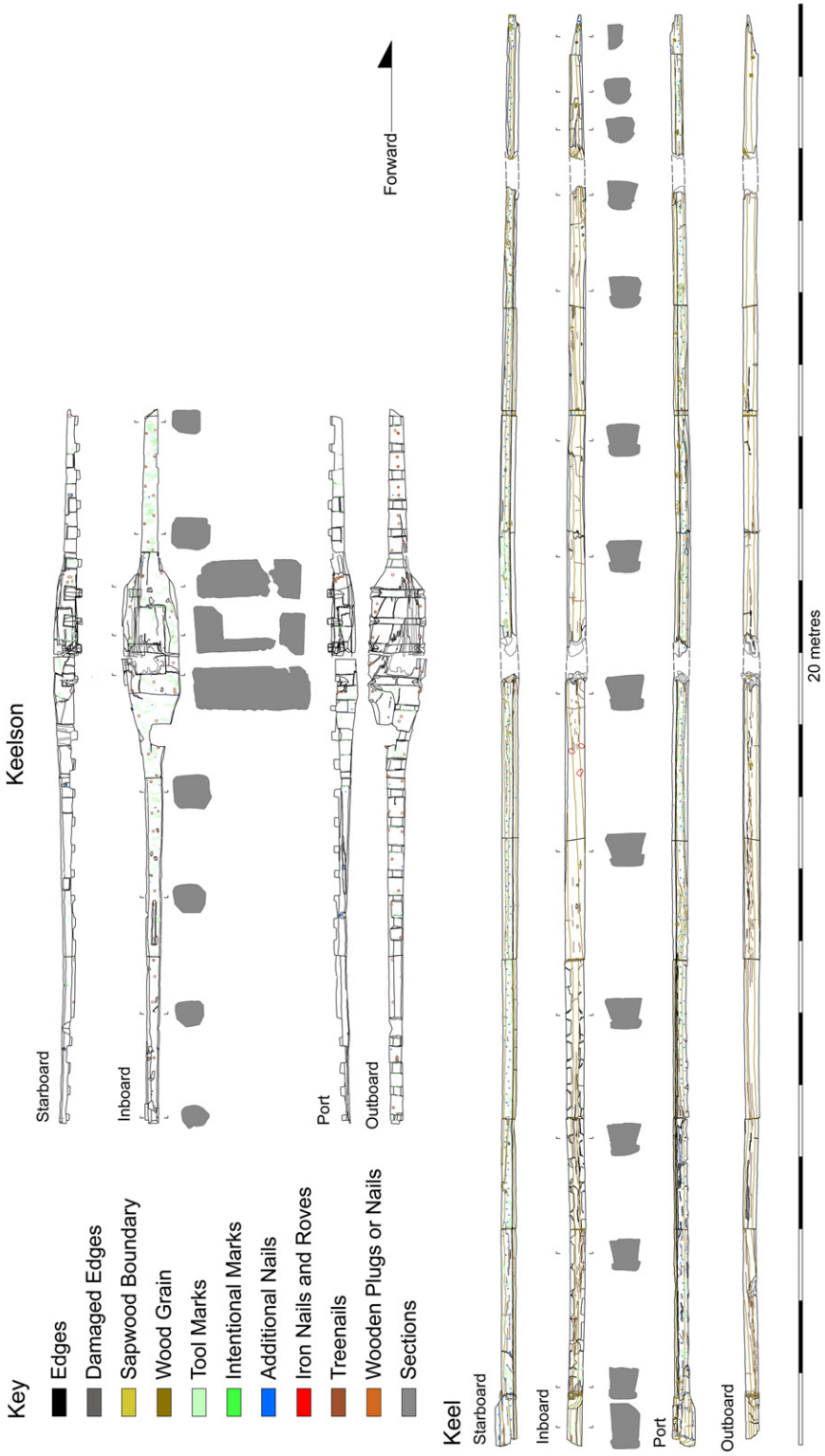

Figure 10. Keel and keelson based on 3D record. Sections shown at double scale. Colour coding of lines shown in key used throughout for timber drawings. (Toby Jones)

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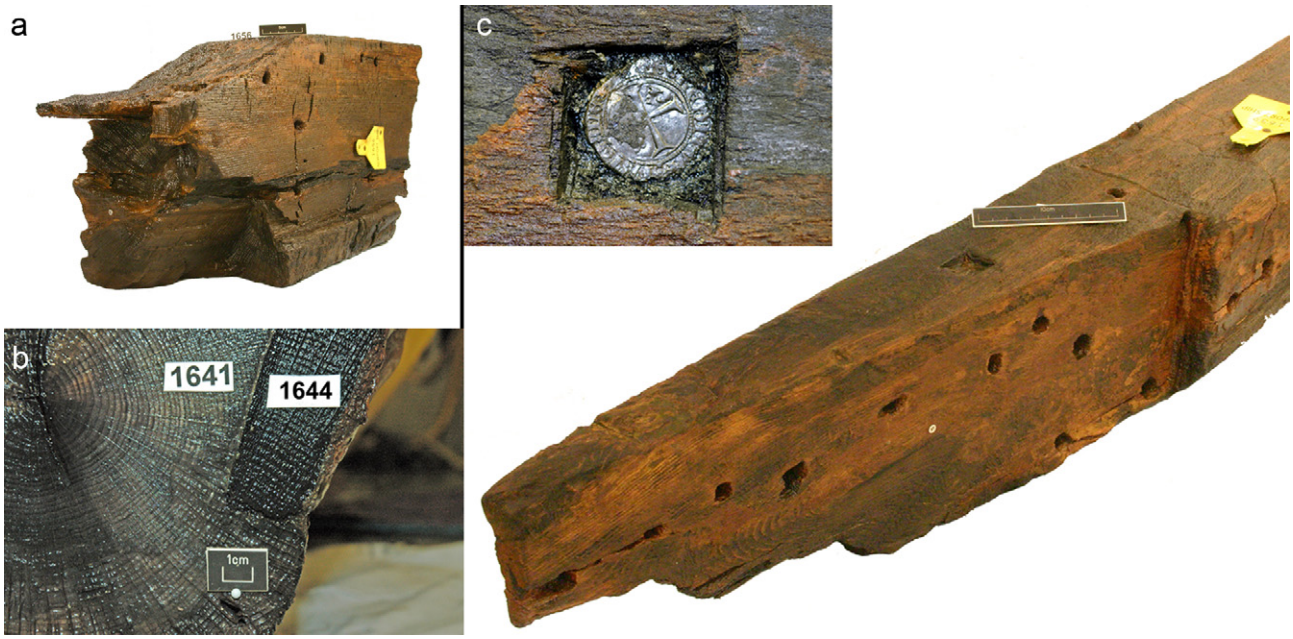

Figure 11. *a)* Aft swelling in keel (Stuart Churchley, Newport Museums and Heritage Service); *b)* Cross section through keel and adjoining starboard garboard showing rebate. (Newport Museums and Heritage Service); *c)* Keel forward scarf with rebate for coin on inboard face. Coin shown *in situ* in inset, diameter 22 mm. (Newport Museums and Heritage Service)

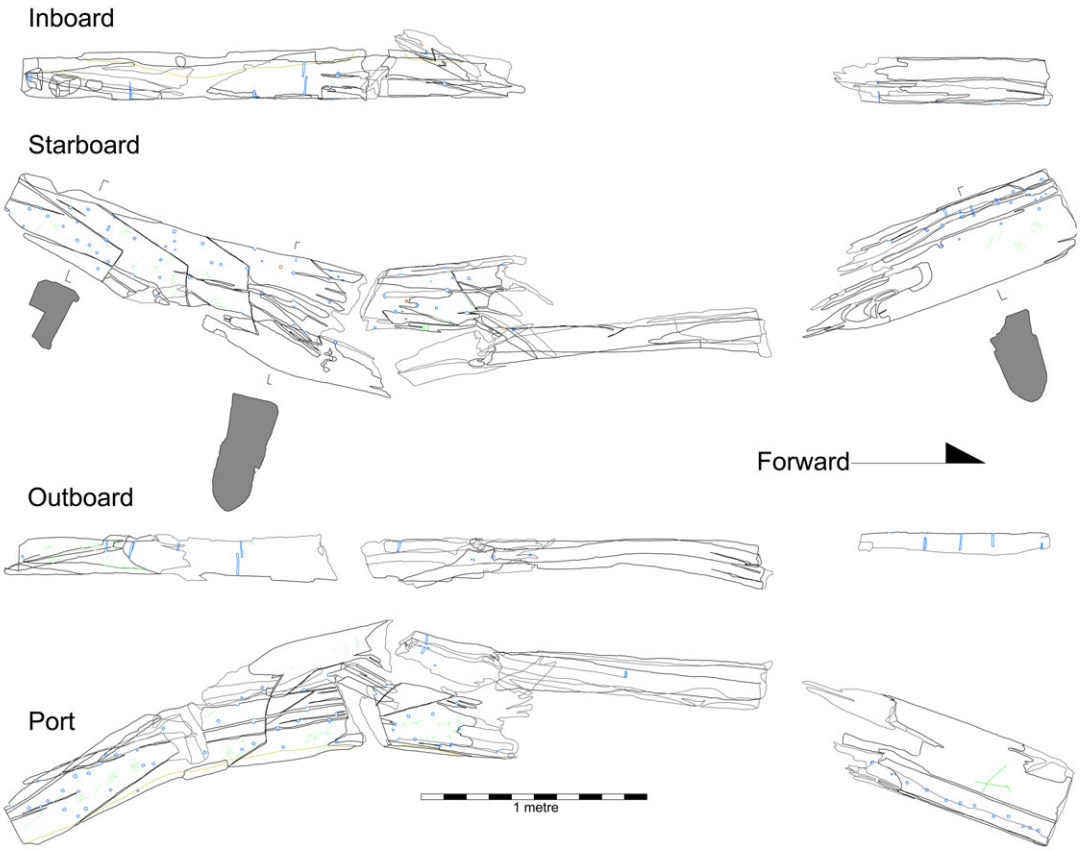

Figure 12. The stem was heavily damaged by sheet and concrete piles. This drawing shows the recorded fragments in their approximate original positions. (Toby Jones)

Figure 13. Starboard side of the stem showing scarf to keel and rebates for hull planks. (Stuart Churchley, Newport Museums and Heritage Service)

Figure 14. Trimmed sidebranch encapsulated by later tree growth on P10.7—evidence for forest management. (Newport Museums and Heritage Service)

tree growth indicate forestry management (Fig. 14). Occasional planks exhibited the normally straight grain curving away from the long axis of the plank at one end, suggesting proximity of the crown or root of the parent tree. The age of the parent trees when felled cannot be determined with total confidence due to secondary working after initial splitting of the timber, removing the feather-edge in the vicinity of the pith and the bark and some, if not all, of the sapwood from the outer edge. The majority of planks were converted from parent trees more than 100 years old, with many retaining over 140 annual rings. Marked growth trends, with a distinct transition from relatively fast growth (wide rings) to relatively slow growth (narrow rings), were common, suggesting many parent trees had begun growth in relatively open conditions before coming into competition with neighbouring trees in an increasingly closed woodland environment. The dendrochronological dating of this group of timbers is considered in a separate article (Nayling and Susperregi, 2013).

The intact planks range in length from 1.28–4.51 m, with a mean length of 2.69 m (longer and shorter planks are a distinct possibility, as many were damaged during salvage and post-depositional damage) (Fig. 15). The plank widths, measured at the midpoint of the length, range between 170 mm and 256 mm, with a mean width of 212 mm. The planks range between 11 mm and 33 mm thick, with a mean thickness of 24 mm along the upper edge and 19 mm along the lower edge. Plank widths taper fairly evenly towards the ends of the vessel, with the visible width (measured on the inboard face) ranging from an average of 176 mm at F30 to an average of 147 mm at F1 and F60.

There are lands on the lower inboard face and upper outboard face of each hull plank. The outboard lands average 49 mm in width, while the inboard lands average 50 mm. A pronounced bevel on the land was visible on the second and third strakes (Fig. 16), with little or no bevel apparent on the other strakes. The surfaces of the lands are well preserved, having been protected by a layer of animal hair and wood tar, along with the overlapping planking. Occasionally an inscribed line or carpenter's mark was visible marking out the area to be trimmed for the land.

There are stop-splayed on-edge, face-nailed scarfs present on the forward and aft ends of each plank (McGrail and Denford, 1982: 35) (Fig. 17). The scarfs have a mean length of 382 mm and a mean width of 210 mm. The forward scarfs are thicker than the aft scarfs, which can taper to a near feather-edge.

The scarf joints are generally staggered across the hull, and some patterning can be recognized (with notable exceptions). On the port side of the ship, there are areas where each successive strake tends to have a scarf slightly further aft than the one on the strake below. This is a clearly visible pattern between P2 and P10 and between F30 and F45 (Fig. 18). In some areas, the next higher strake has a scarf that begins immediately abaft of the end of the scarf on the next lower strake. In others, the scarfs are in a slightly staggered, but more-or-less clustered, vertical line, creating areas of potential weakness. Good building practice is to stagger the scarfs so that areas of potential weakness are kept to a minimum. It is unclear why certain areas of the hull have seemingly purposely staggered scarfs and other areas have clustered scarfs.

Fastenings clearly visible on the inboard face of the outer hull consisted of oak treenails, concreted roves along the inboard upper edge of the strakes and at the scarfs between planks, iron spike-nails also visible along the upper edge of each strake located at the frame stations, and oak spike-nails presumably reflecting repair of failing iron fastenings. The planks are fastened to each other with round-headed square-shanked wrought-iron nails driven from the outboard through pre-drilled holes and peened over wrought-iron roves (Fig. 19a). Two extra nails and roves were used to

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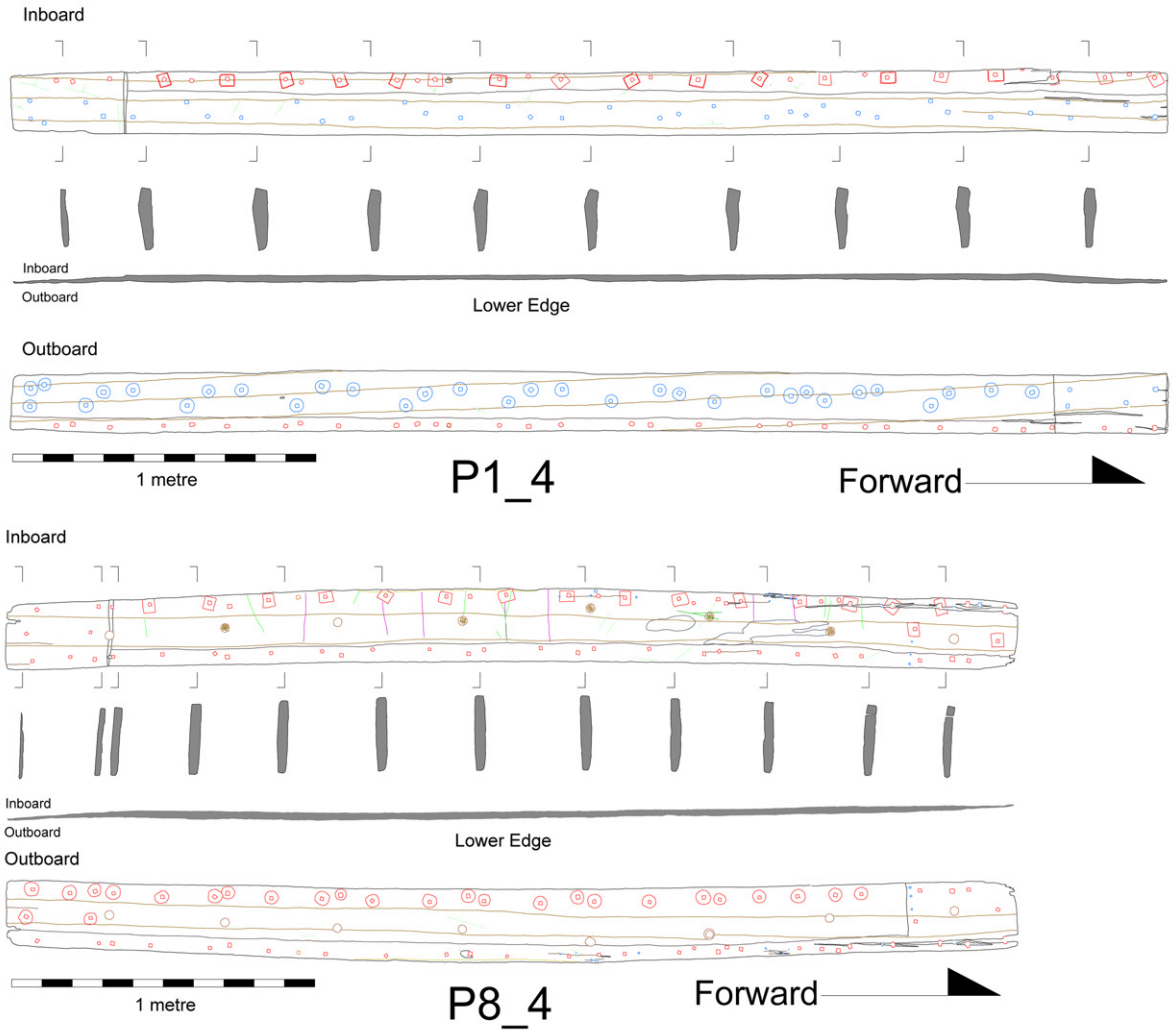

Figure 15. Typical garboard plank (P1.4) with spike-nail fasteners passing through into the keel and clench nails along the upper land; Typical hull plank (P8.4) with nailheads on lower outboard face and roves on upper inboard face. (Toby Jones)

fasten the scarf, in additional to the standard nails and roves along the lands. On a typical scarf, these nails are placed along the centreline of the plank, with one near the edge and one set back from the lip of the scarf.

The clinker fasteners have a mean spacing of 175 mm along the land. The nails have a mean shank dimension of 12 mm square with the nail heads having a mean diameter of 43 mm. The roves are sub-rectangular, with mean dimensions of 43 x 36 mm. It is interesting to note that the mean maximum width of the rove and the mean nail-head diameter are identical. The roves are generally oriented with the longer edge vertical or near-vertical on the inboard face of the hull plank, with some rove impressions extending off of the upper edge of the timber. It was not possible to determine the thickness of the nail heads or roves as they had substantially corroded; however, the other dimensions could be readily measured from the clear impressions left in the surface of the planking. Several

Figure 16. Angled inboard land on hull plank P2.4. (Newport Museums and Heritage Service)

nail-head impressions contained a clear star-shaped mark, evidence of a maker's mark standing proud on the underside of the nail-head (Fig. 19b).

The standard pattern of inserting the nails from the outboard was reversed in the extant bow area. Here nail-head impressions were visible on the inboard face, with corresponding rove impressions on the outboard face. This practice, while not universal in the bow, was certainly addressing a practical problem of having enough clearance for the hammer to peen over the nail on to the rove.

Numerous additional nail holes (spikes and other fasteners without roves) were recorded on the hull planking. Several small nail holes were often seen on the after scarf ends, serving to tack down the feather end of the outboard scarf to the outboard face of the forward scarf of the adjoining plank. It is not known if these nails were inserted during the original construction or represent a repair phase. Other small additional nails were used to close up cracks that might appear along a land. These nails were often driven in from the lower outboard edge of the planking upwards towards the underlying plank. The small additional nails had a mean head diameter of 16 mm and a mean shank of 5 mm square, with a considerable amount of internal variation. Numerous small blind (and through) additional spike-nail holes were seen on the inboard face of the planking in the bow area. Their function has not been discerned, but could relate to the construction process, as they lie near the centreline. On one occasion, four sintels or staples were used to keep a crack from spreading (Fig. 19c). Other repairs to the hull planks included the insertion of oak spike-nails driven into holes previously occupied by wrought-iron nails, as evidenced by the presence of an iron nail-head impression. Other wooden spikes appear to be driven into purpose-drilled holes, leaving no iron nail-head impressions. These minor repairs can be interpreted as regular maintenance of the hull.

Figure 17. Inboard face of aft scarf on hull plank P11.5. (Newport Museums and Heritage Service)

Oak tingles or repair planks covering areas of cracking or damage were primarily found attached to the outboard faces of the hull planking (Fig. 20). Tingles were recorded in the lower bow area as well as amidships. The tingles could be classified by the presence or absence of rebates on the inboard face. Tingles with such rebates were designed to accommodate the proud-standing extant fastener heads, while tingles without rebates were applied to areas where the original

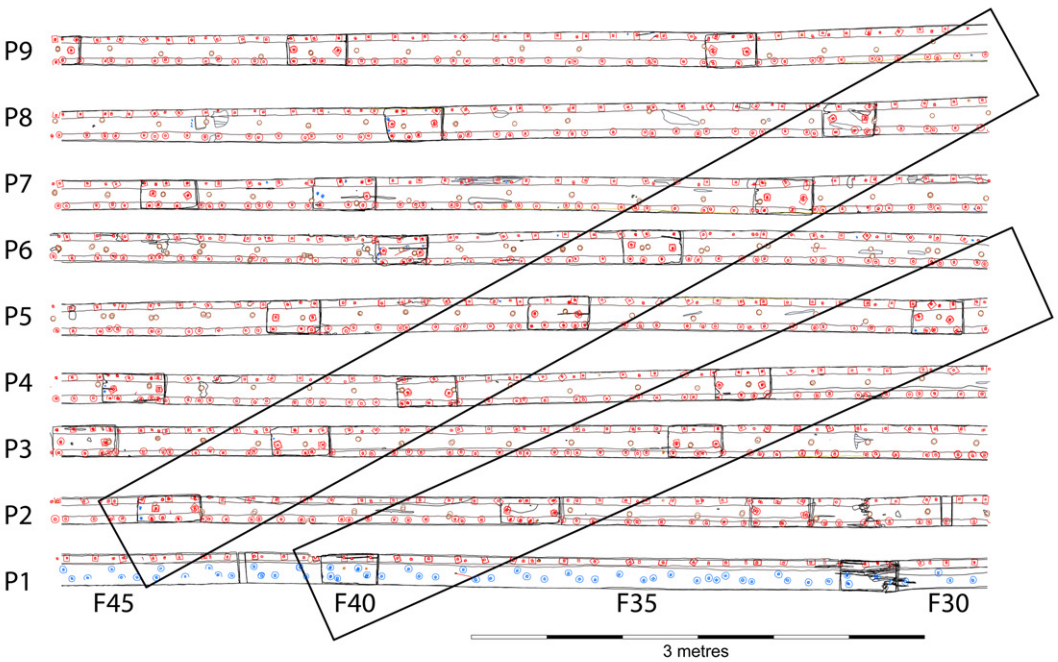

Figure 18. Scarf pattern between P1 and P10 and between F30 and F45. (Toby Jones)

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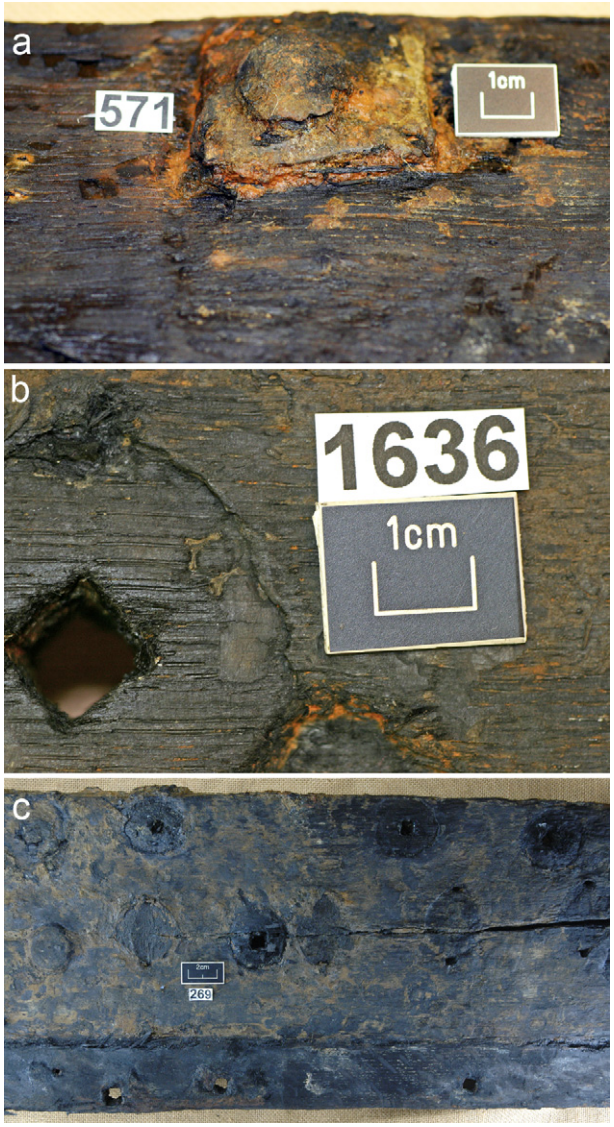

Figure 19. *a)* Rove on the inboard face of hull plank S2.5; *b)* Nail-head impression on outboard face of garboard hull plank S1.1. A star-shaped impression is interpreted as a nail-maker's mark; *c)* Outboard face of hull plank S17.4 during cleaning. Impressions of four sintels used to repair a crack. (All Newport Museums and Heritage Service)

fastener heads had been purposely removed or rotted/corroded away. Tree-ring analysis of some of these timbers led to the cross-matching of five unrebated tingles which were dated against a range of British (and one Irish) chronologies. Assuming these represent a single repair phase, the parent trees for these timbers were felled AD 1459–1483.

A peculiar feature seen on the hull of the Newport Ship was the insertion of iron spike-nails through the hull planking and into the framing. These nails are similar in size to the nails used in conjunction with roves, with a mean shank measurement of 13 mm square and a mean head diameter of 50 mm. It could

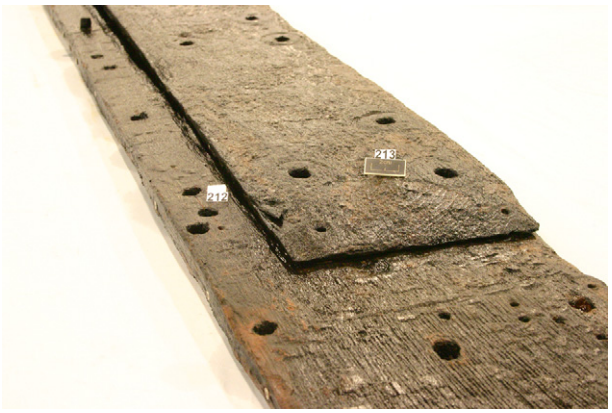

Figure 20. Tingle (repair patch) on outboard face of hull plank P11.6. (Newport Museums and Heritage Service)

be that these spike-nails, with their slightly larger heads and shanks, represent a distinct event, perhaps tightening up the hull at some point during the active life of the vessel. Alternatively, they could have been used to tack the framing in place while it was being drilled to accept the treenails. With few exceptions, these iron spike-nails were driven into every plank/frame intersection, often in close vertical proximity to the treenail.

Framing

A total of 63 frames were recorded during the excavation. Each extant frame consisted of a floor-timber and up to four surviving futtocks, with up to three preserved on the starboard side and two on the port side (Figs 21–22, schematic plan Nayling and Susperregi, 2013; fig 4). The frames were straight and continuous with adjoining framing timbers scarfed together with simple, horizontally splayed scarfs. The floor-timbers contained a centreline sub-rectangular limber hole, except at the ends of the vessel, where the limber hole was occasionally notched into the side of the base of the floor-timber. These framing timbers did not appear to be canted. Futtocks were generally, but not universally, scarfed over the next lower framing timber. The outboard faces of all the framing timbers were joggled to ensure a tight fit at the faying surfaces with the outer hull planking. These joggles often contained rebates to accommodate the roves that were present on the inboard face of the planking. The floor-timbers were flat in the midships area and V-shaped in the bow and stern (McGrail, 1993: 13) (Fig 8b). The mean centre-to-centre frame spacing was *c.*0.37 m.

Frames amidships average 3.188 m in length and 211 mm moulded by 256 mm sided. Towards the bow and stern, the transverse curvature of the floor-timbers becomes increasingly sharp. Few side timbers (futtocks) survive in these areas (Fig. 8). Framing timbers were fastened to the planking with oak treenails and, unusually, with iron spike-nails driven from outboard through the land and into the underside of the framing timbers. Filler pieces were employed on the upper faces

of framing timbers to ensure even curvature to take the keelson, ceiling and stringers.

The oak treenails, used to fasten the framing to the planking shell, were present at nearly every frame/plank intersection, with occasional intersections having two treenails. The treenails, made from split and turned oak, had a mean diameter of 30 mm and a mean spacing of 371 mm longitudinally where they passed through the outer hull planking. It was difficult to judge the length of many of the treenails as they could not be removed from the framing. Small dimples were sometimes visible on the heads of the treenails, along with striations around the shoulder, indicating that at least some, if not all, of the treenails were produced using a lathe (Fig. 23a). This interpretation is at odds with the method of manufacture of treenails proposed for the 16th-century Red Bay ship 24 M (Grenier *et al*., 2007: vol. III–22). Some treenails had pronounced heads, while others were driven in flush with the outer surface of the planking, although none of the hull planks appear to have been rebated on the outboard face. Certain treenails had a distinct faceted head with three or more cut faces (Fig. 23b). Rectangular oak wedges were visible in some treenail heads (Fig. 23c).

Keelson/mast-step

The mast-step timber/keelson, a single oak timber with an overall surviving length of 9.87 m, ran along the centreline from F21 to F49 (spanning 28 floors) with a marked swelling between F25 and F34 accommodating a rectangular mast-step (Fig. 10). The mast-step mortise is 960 mm long, 430 mm wide and 230 mm deep. For much of its length, the keelson was rebated on its outboard face to run over the floor-timbers at the centreline, with square-sectioned oak treenails inserted at opposing angles, and occasional nails fastening it to the frames. Chevron-shaped bevelling of the lower edges between these rebates, reminiscent of those seen on the Red Bay 24 M-wreck keelson, were present in the swollen area associated with the mast-step (Grenier *et al*., 2007: III-153, fig 15.1.5). Adjacent to the port side of the keelson, a 1.37-m-long timber with a near-square mortise had contained the remains of a beech stanchion. It may have formed part of a pump housing as a pump hole had been cut through the after starboard side of the swelling on the keelson and through the floors on frame stations F33 and F34. This pump hole contained the remains of a basketry lining or 'strum box' (Fig. 24). An apparently earlier pump hole, again at F33/4 but to port of the keelson, had been covered up by ceiling planks and the mortised timber associated with the active pump hole. A mortise in the upper face of the keelson, between F40 and F42, accommodated the remains of another beech stanchion.

Stringers

There are 25 distinct stringer timbers, recovered as 124 components (Fig. 25). The longest stringer measures 12.9 m and spans 35 floors. The stringers were converted from relatively fast-grown, immature oak by sawing. They vary in thickness from 48–97 mm, and, where rebated from 30–86 mm. The mean width of a stringer is 304 mm, with a range of 252–377 mm. There is considerable variation in scantlings between different stringers and even within a single stringer.

On the port side, three runs of stringers survived (STRP1–STRP3), with individual timbers within each 'strake' joined by horizontal half-lap scarfs. On the starboard side, remains of eight runs of stringers were found (STRS1–STRS8), including stringers at STRS4

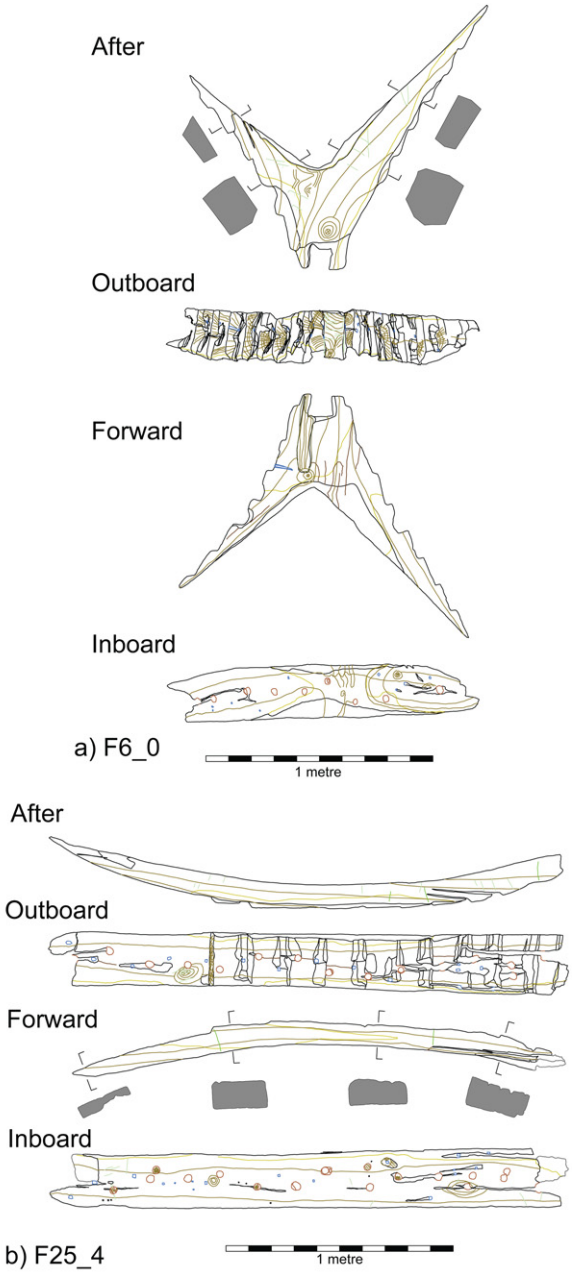

Figure 21. a) Typical V-shaped floor-timber from the bow; *b)* Typical side timber—second futtock starboard side. (Both Toby Jones)

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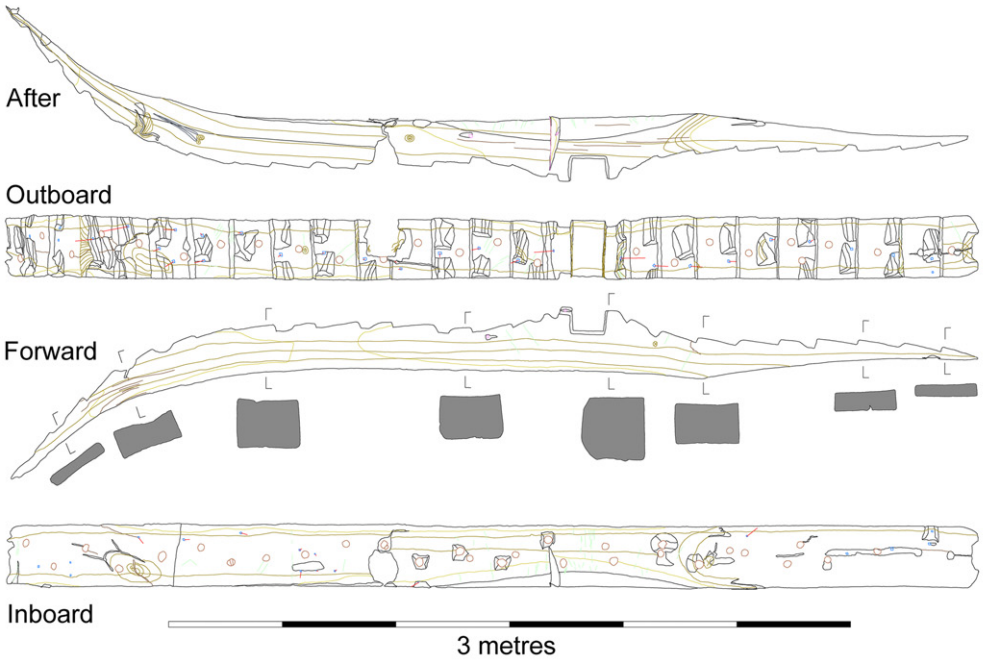
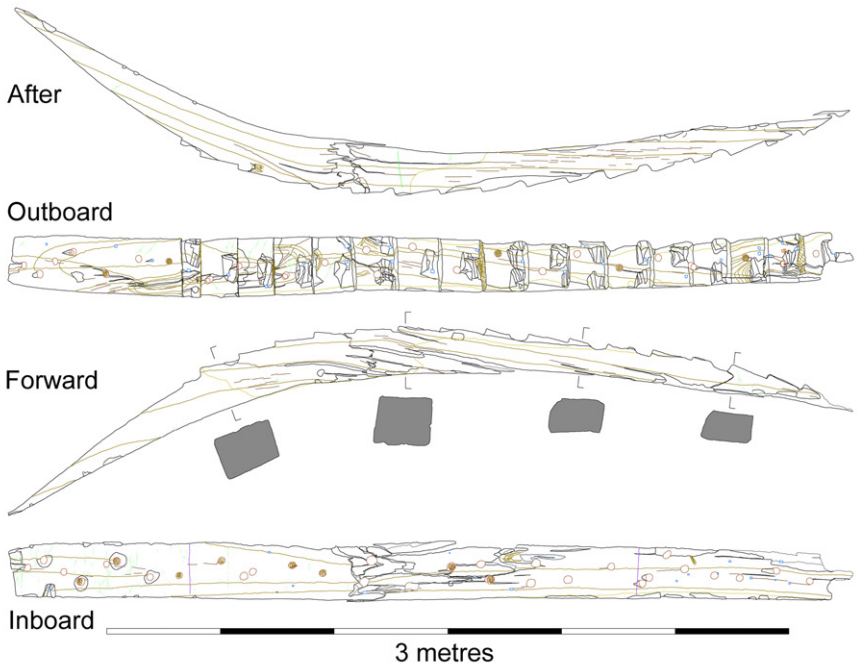


a) F28_0



b) F32_2

Figure 22. *a)* Typical floor-timber—assymetric floor from near to midships; *b)* Typical side timber—first futtock starboard side. (Both Toby Jones)

with rebates on their upper edges to take bilge boards, which presumably were intended to seal the bilges. Rebates for the framing tend to be more pronounced (that is cut deeper) when the stringer lay closer to the centreline. Some stringers had no visible rebates for the framing. Most stringers were fastened to the framing timbers with two treenails at each station, often rebated into the inboard face.

The seventh run of starboard stringers, although much damaged by modern disturbance, exhibited three

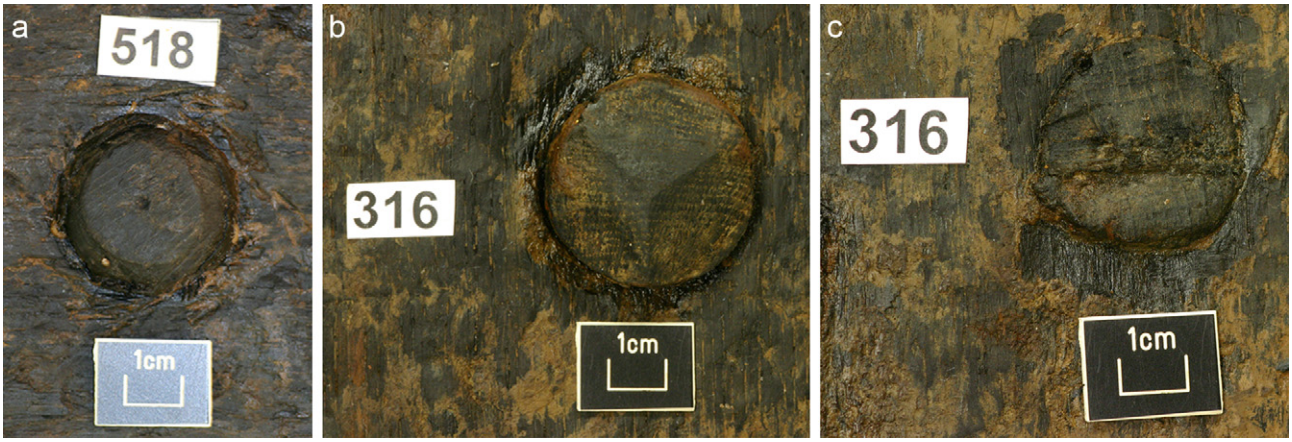


Figure 23. Treenail heads *a)* fastening framing timber to hull plank S13.7 with well-defined dimple; *b)* fastening framing timber to hull plank S19.5 with faceted head; *c)* fastening framing timber to hull plank S19.5 with wedged head. (All Newport Museums and Heritage Service)

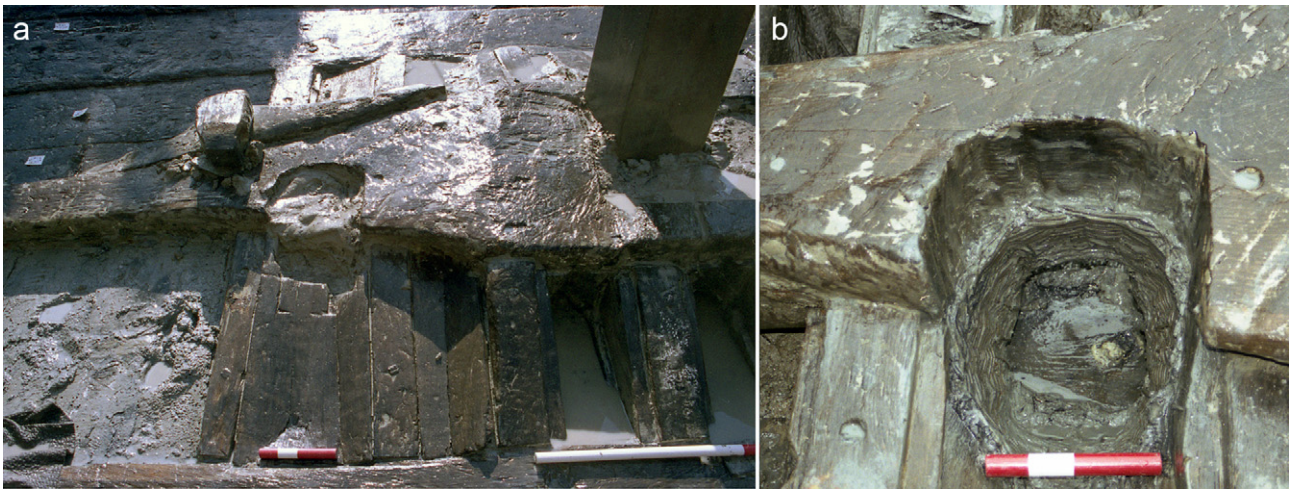


Figure 24. *a)* Keelson and surrounding timbers during excavation viewed from the starboard side. The mast-step and starboard pump hole have not been excavated. A stanchion found in a mortise in the timber adjacent to the keelson on the port side has been lifted; *b)* Starboard pump hole with strum box *in situ*. (Both Nigel Nayling)

distinct thickenings centred near frame stations F21, F30 and F40 which appear to have acted as beam shelves. Hence there is evidence for at least three cross beams rather than the two suggested by Roberts (2004: 159). No *in situ* beams were found during excavation although disarticulated sections of beams, some with end joints surviving, were encountered during excavation of the ship's interior. The most substantial of these comprised a composite assembly of three beams and a large knee held together by iron bolts (Fig. 9). If these derive from the ship, they suggest that some cross beams were fastened to the inner hull rather than having through-beam heads such as those found on the Aber Wrac'h 1 wreck (L'Hour and Veyrat, 1994: 174).

Braces

Ten braces (or chocks) on each side of the swelling of the mast-step timber, fastened to underlying frames F25–F34 with square and round oak treenails and some iron spike-nails, ran port and starboard to rebates in this first run of oak stringers (Fig. 26). Rebates along the sloping upper edges of the braces carried boards which sealed the gap between the keelson, frames and stringers. Braces range in length from 400–784 mm with an average of 583 mm. They averaged 201 mm in width and 166 mm in height (at the thick end, abutting the mast-step). As with stringers, there is considerable size variation within the braces, possibly to accommodate the irregularly shaped mast-step.

Ceiling planks and bilge boards

Oak ceiling planks and bilge boards were also recovered during the excavation. Many of the ceiling planks were attached to the underlying frames with small wrought-iron nails and had clearly visible saw marks.

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Figure 25. Stringer STRP1_2, with rebates for the mast-step braces visible along the lower edge. (Toby Jones)

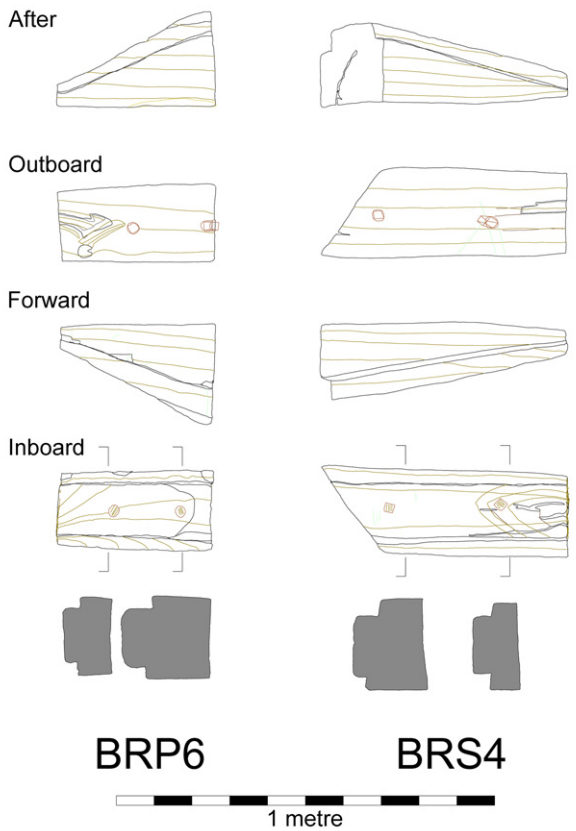

Figure 26. Typical mast-step brace. The braces were fastened to the underlying floor-timbers with square-sectioned treenails. (Toby Jones)

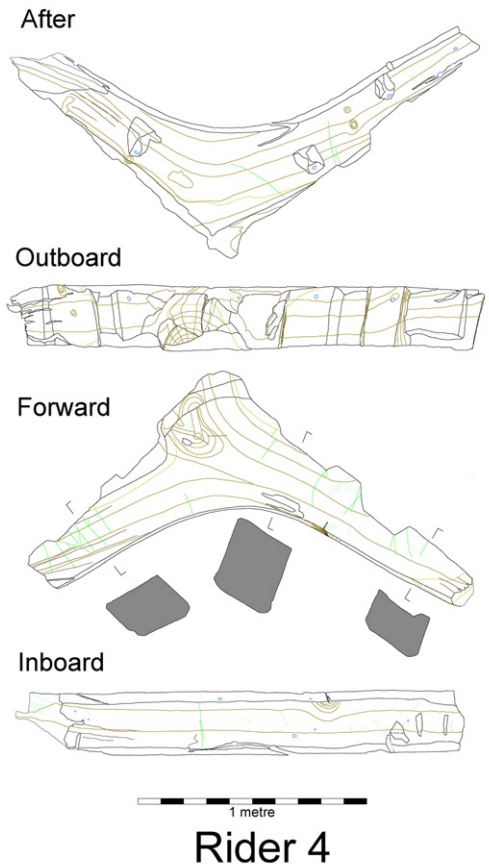

Figure 27. The largest of four riders found in the bow of the vessel. The riders were rebated on their outboard faces to fit over the stringers. (Toby Jones)

The ceiling planks were distinctly thinner than the stringers with a mean thickness of 25 mm.

Riders

The four riders (all found in the bow area) were made from compass-grown oak timbers and rebated to sit on top of the stringers (Fig. 27). They range in length from 1.04–2.01 m, in width from 100–261 mm and in height from 306– 636 mm.

Cordage and rigging

A substantial and diverse range of cordage was discovered during the excavation, both inside and underneath the vessel. The recovered cordage was made from either grass or hemp and ranged in size from 12 mm (38 mm) to 40 mm (125 mm) in diameter (circumference). The smaller ropes were used in the running and standing rigging, while the largest ropes, known as hawsers, were used for mooring and towing. Some rigging elements, including a pulley, were found to have fragments of rope still *in situ*.

Recovered rigging elements (Fig. 28) include two parrel ribs, two parrel trucks or beads, two heart blocks, a clew garnet block, and a Dutch lift/pendant block as well as several loose sheaves, pins, a rigging bitt or spill toggle, bullseye, and a lifting hook. The rigging assemblage is small in terms of quantity and size, and it seems likely that many of the larger rigging elements, and cordage, would have been salvaged for reuse (McCarthy, 2013).

Waterproofing: tar and luting

The hull of the Newport Ship was covered with tar to help make it waterproof. All of the joints and seams were filled with a mixture of animal hair and tar to prevent the ingress of water. These animal hairs and tars were sampled during the timber-cleaning process and subjected to detailed mass-spectroscopy analysis. The results show that the tars used in the original construction were made from the destructive distillation of coniferous wood products, and that, based on isotopic analysis, were probably manufactured in the Basque country. Tars used for some of the repairs differ in their isotopic composition, and match tars having a presumed Mediterranean origin (Burger, 2013).

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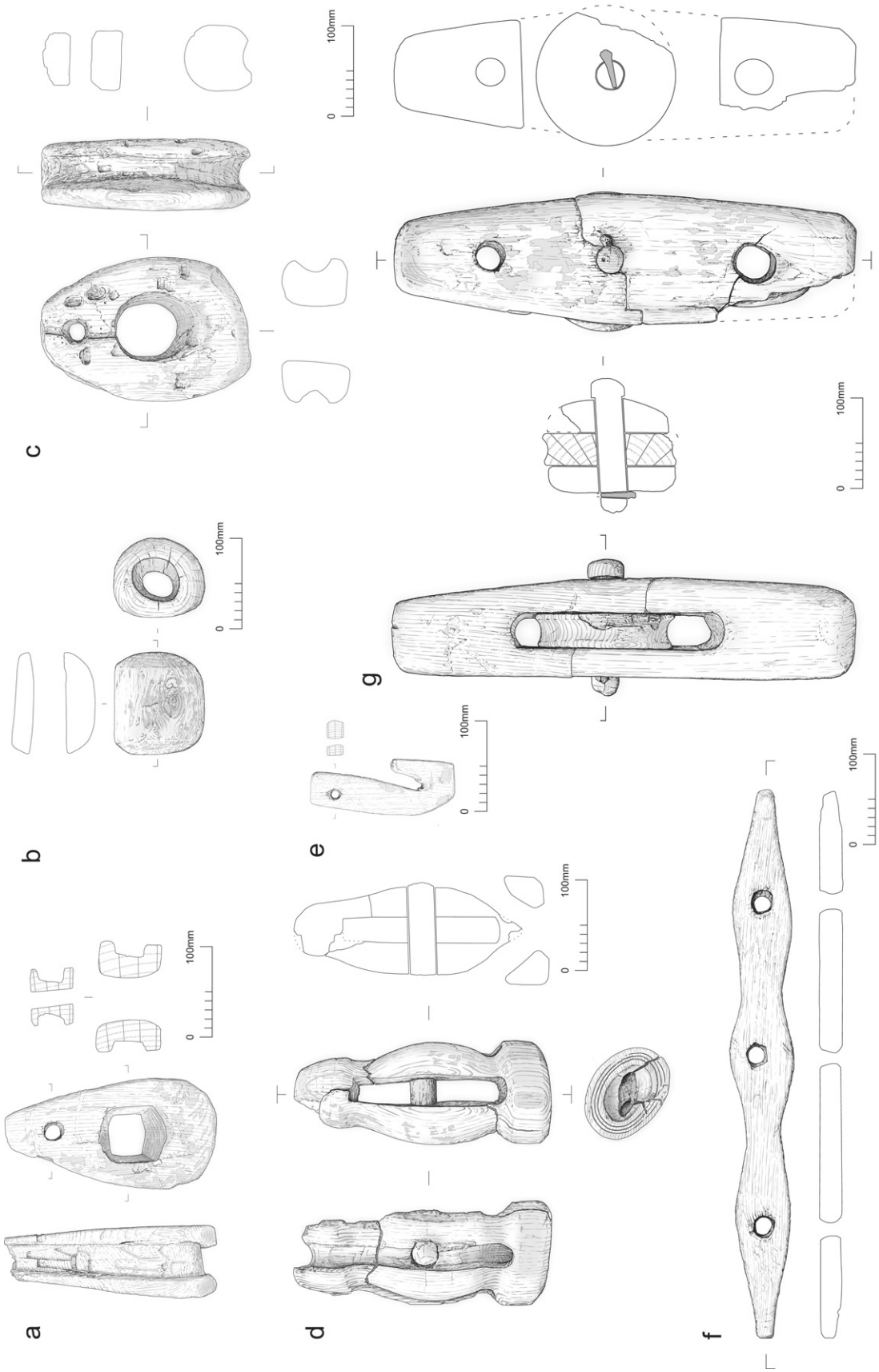

Figure 28. *a)* Heart block; *b)* Parrel truck or bead; *c)* Heart block; *d)* Dutch lift block; *e)* Lifting hook; *f)* Parrel rib; *g)* Clew garnet block. (All Anne Leaver)

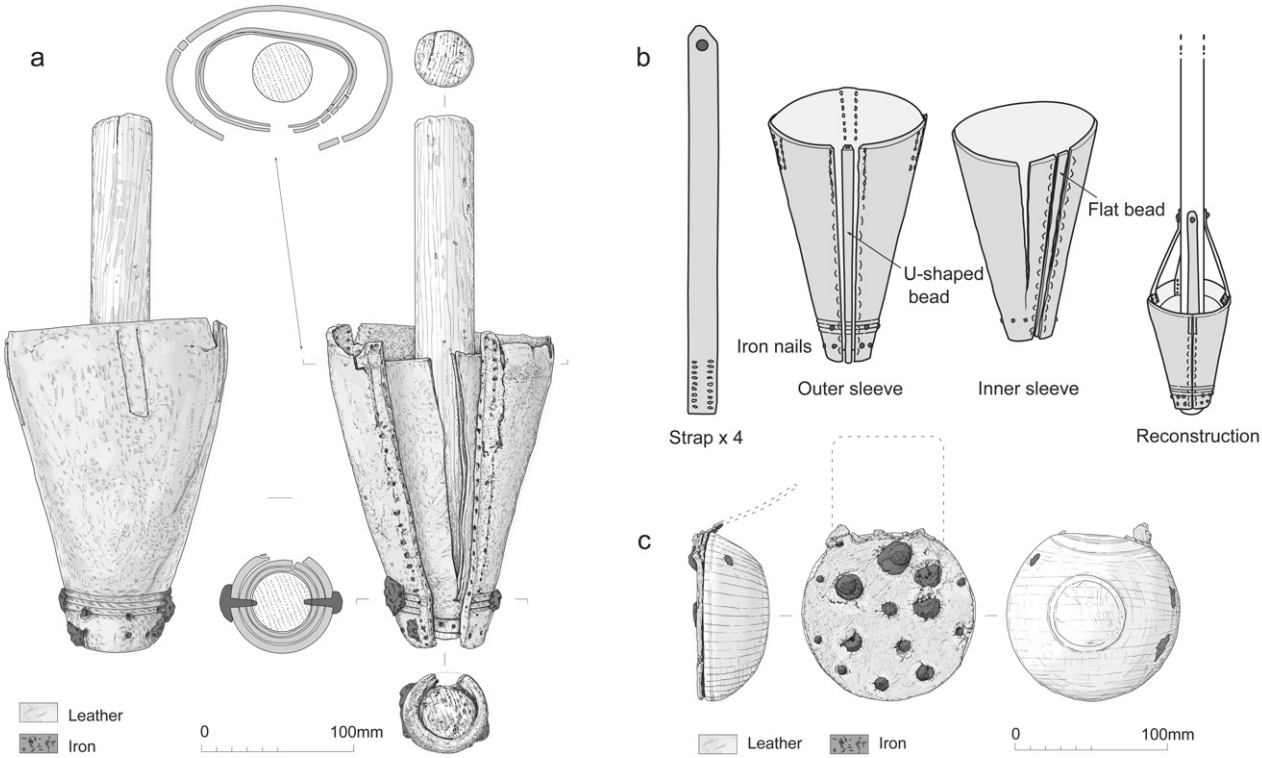

Figure 29. a) Composite pump spear or burr from a common pump, made from leather, iron and wood (Anne Leaver); *b)* Detail of pump spear showing stitching pattern and the interesting second/inner cone of leather (Quita Mould and Anne Leaver); *c)* Foot valve with remains of leather claque or hinge. Striations are visible where the hemisperhical object was turned on a lathe. (Anne Leaver)

Animal-hair luting was also analysed from all parts of the hull. Luting samples from along the lands and scarfs were compared to hair found in the keel-stem scarf as well as material from under the tingles/repair patches. The animal-hair samples were found to consist of sheep's wool (primarily hill or mountain breeds), and cattle, goat and horse hair. Some of the wool was dyed, and probably represents waste from the dyeing or spinning process. The other animal hair is likely tannery waste, which would have been cut or scraped off the hide during the tanning process and collected. The mixed nature of the animal fibre might suggest that the use of a variety of sources was necessary to acquire enough material for luting such a large vessel. Given the probable upland origin of some of the sheep's wool, Walton Rogers suggests that the luting materials 'were collected in a port with a hilly or mountainous hinterland' (2013b).

Ship's pumps

Several artefacts and objects relating to the ship's pumps were found during the excavation. These items include four pump holes, a strum box, pump tube, pump base, various foot valves, pump spear (burr valve) with handle and assorted basketry fragments (Fig. 29). Pumps of the period consisted of hollowed-out tree trunks with a cone-shaped upper (or burr) valve, and a lower foot valve. Bilge water was drawn up the tube, and prevented from leaking out the bottom by the one-way foot valve. Leather was the ideal material to make the durable hinges and cones necessary for the continuous operation of the pump. There was also a mortised block and associated stanchion that may have formed part of a trunk surrounding and protecting the midships pump tube.

There was a pump hole crudely made by chiselling the after face of F7.0 and the forward face of F8.0 (Fig. 30). Near the stern of the vessel, at F58, the remains of a pump tube, pump base and associated wood and leather valves were found in a gap apparently created by the removal of the central part of the floor-timber at this frame station. Fragments of a probable pump basket were also found in the stern, near the remains of the pump tube. The amidships pump hole, at F33.0–F34.0, just off the centreline axis on the starboard side, contained a woven willow strum box, but no other pump-related artefacts (Fig. 24). This basket was designed to act as a filter, keeping mud and debris from entering and damaging the ship's pump. There was an additional pump hole at F33.0–F34.0, just off the centreline axis on the port side, but this area was sealed up at some point during the working life of the vessel. Other parts of pumps,

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Figure 30. Roughly cut pump hole at F7/F8. (Nigel Nayling)

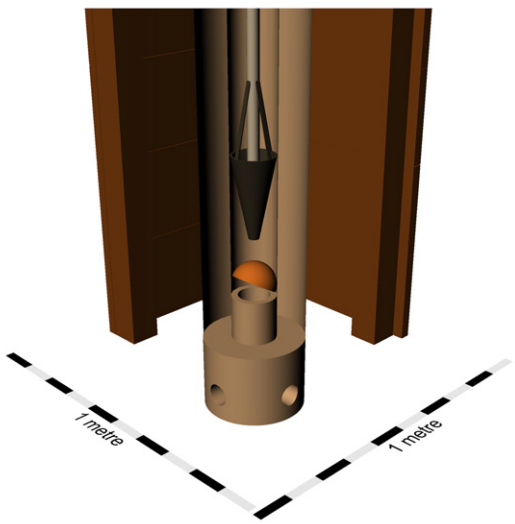

Figure 31. Schematic digital reconstruction of a ship's pump using disarticulated pump-related artefacts found during the ship excavation. (Toby Jones)

including several foot valves, were found scattered around the hull. The diverse nature of the pump-related artefacts made it possible to create a schematic reconstruction using the recovered components (Fig. 31). These pumps predate the earliest-known similar pumps, and shed light on the structure and function of medieval pumping technology and broader technological innovation in the late medieval period (Oertling, 1996: 20).

Construction sequence

The vessel was constructed in a northern European clinker-built tradition, beginning with attachment of the stem and stern to the keel. The keel was then rebated and the garboards were added, fastened with spike-nails, followed by lapstrake planking, presumably from stern to bow in successive strakes, to at least the turn of the bilge. Floor-timbers, joggled on their outboard faces, were fastened to the planking shell with treenails. It was interesting to note the pattern of framing timbers amidships, with alternating asymmetric floor-timbers (Fig. 32). Numerous rebates were cut in these joggled faces to accommodate the roves sitting proud on the inboard face of the planking. The universal presence of this feature indicates that the planking was always fastened together ahead of the insertion of the framing. Futtocks were inserted with the second futtocks occasionally being placed before, or concurrently, with the first futtocks. The keelson was fastened with treenails along the centreline on to the floor-timbers. The braces were then fastened to the underlying floor-timbers. Stringers were added, with those adjacent to the mast-step area being rebated or notched to fit the tapering end of the braces. The insertion of ceiling planking and bilge boards completed the inner hull, with riders being placed over some of the stringers. The construction sequence of the rest of the hull (disarticulated or missing parts) remains conjecture, but it seems logical that cross beams would have been fitted into the swellings in the upper stringers, followed by the construction of decking and bulwarks.

Reconstruction

Digital solid modelling of individual timbers

In 2008, the Newport Ship Project received a grant from the UK Arts and Humanities Research Council to develop 3D digital and physical models of the 3D wireframe drawings created during the documentation of the ship timbers. The aim of the project was to create an efficient and consistent methodology for the conversion of wireframe data into 3D digital solid models, and to use these to determine the original hull form.

The traditional approach to modelling hull forms from archaeological remains has begun with the critical step of accurately recording the timbers. The most common method involved tracing the actual timber and then scaling the resulting 2D drawing down to a manageable size. These paper drawings were then cut out and applied to card stock and were experimentally assembled, fastened, twisted and bent until a viable hull form was achieved (Crumlin-Pedersen, 2002: 121). The physical model could then serve to inform about the potential original hull form. This approach, while viable, was essentially modelling a 3D form using 2D data and methodology.

Given that the Newport Ship timbers were recorded in a digital 3D format, it was logical to use the 3D data directly in the modelling stages, instead of converting it into 2D information. The first major step in this process was the simplification of the existing data sets, to minimize both the file sizes and amount of time spent creating the models. In practice, this meant editing out details such as wood grain and small cracks and reducing the number of points in each file.

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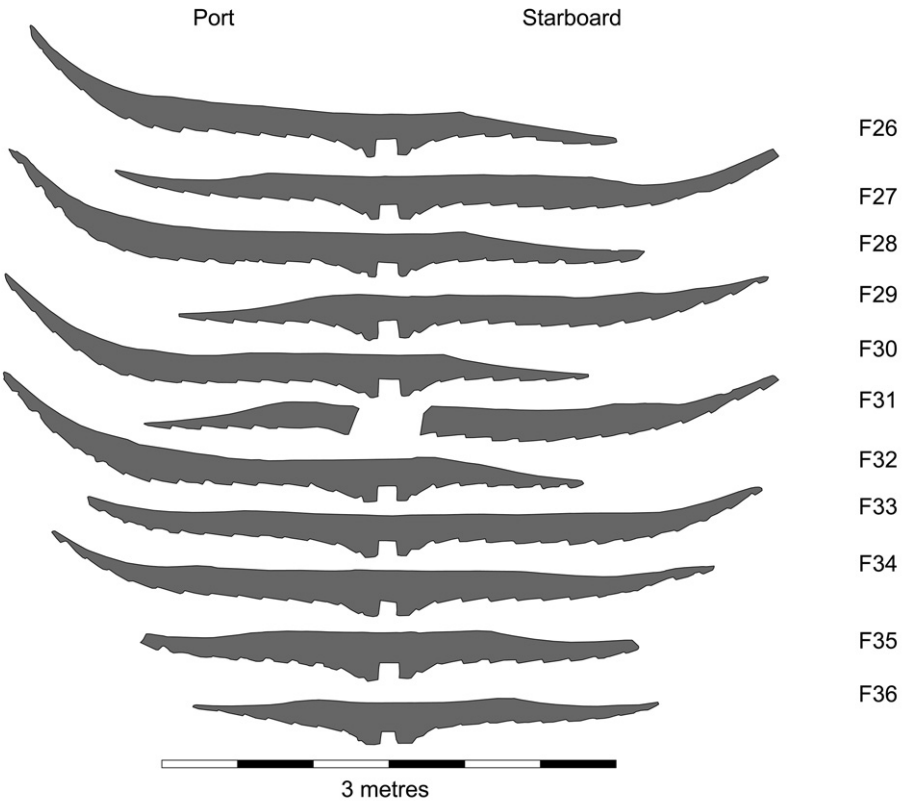

Figure 32. Alternating pattern of asymmetric floor-timbers amidships. (Nigel Nayling and Toby Jones)

The next step involved surfacing the wireframe drawing. This process resulted in the creation of a digital solid model (DSM) which accurately represented the volume and geometry of each timber using Rhinoceros3D software. The numerous fastener holes, including the rivets and treenails were then modelled. The resulting DSM was then compared against the original wireframe drawing and checked for deviation. The final DSM of each timber had the advantage of having a relatively small file size (less than 1 MB when saved in the .STL format), which allowed many files to be added together in a single master file, creating a tool for analysing patterns and construction sequence. The modelling software also allowed the user to orient the digital ship timbers to each other in 3D space, facilitating digital re-assembly. The 30-month digital-modelling work was subsequently used in the production of physical solid models. After a trial period where methods of creating the digital models were explored and refined, the process was codified and staff trained in order to produce consistent DSMs (Jones and Nayling, 2011; Nayling and Jones, 2012).

Production and assembly of a scaled physical model

The Newport Ship Project used the DSMs and a rapid prototyping technology called selective laser sintering to create scaled physical models of each of the structural ship timbers. The 1:10 scale model pieces were then experimentally assembled with micro-fasteners to build an as-found model of the remains of the Newport Ship (Fig. 33).

The ship project contracted the Manufacturing Engineering Centre at Cardiff University to create the scaled solid ship-timber models using the most suitable rapid prototyping technology available. After investigating the various methods, the clear choice was selective laser sintering, which provided an accurate, strong and slightly flexible product. Laser sintering is a process where thin layers of finely ground material (in this case, polyamide-12 nylon dust) are repeatedly laid down and selectively fused with a laser (Soe *et al.*, 2012). Each subsequent layer is fused to the layer below, with the laser being activated only where a solid form is desired. In areas where the laser is not activated, the deposited powder remains unfused, and is later removed from the part by tapping it or using compressed air. Because polyamide-12 is a thermoplastic, the manufactured pieces can be gently heated and reshaped and, when cooled, will hold their new shape, allowing for the 3D reshaping of 3D model timbers, if desired.

There were several manufacturing constraints that had to be taken into consideration, including the maximum size of part that the laser sintering machine could make, and the production tolerances. All of the modelled Newport Ship timbers happened to fit within

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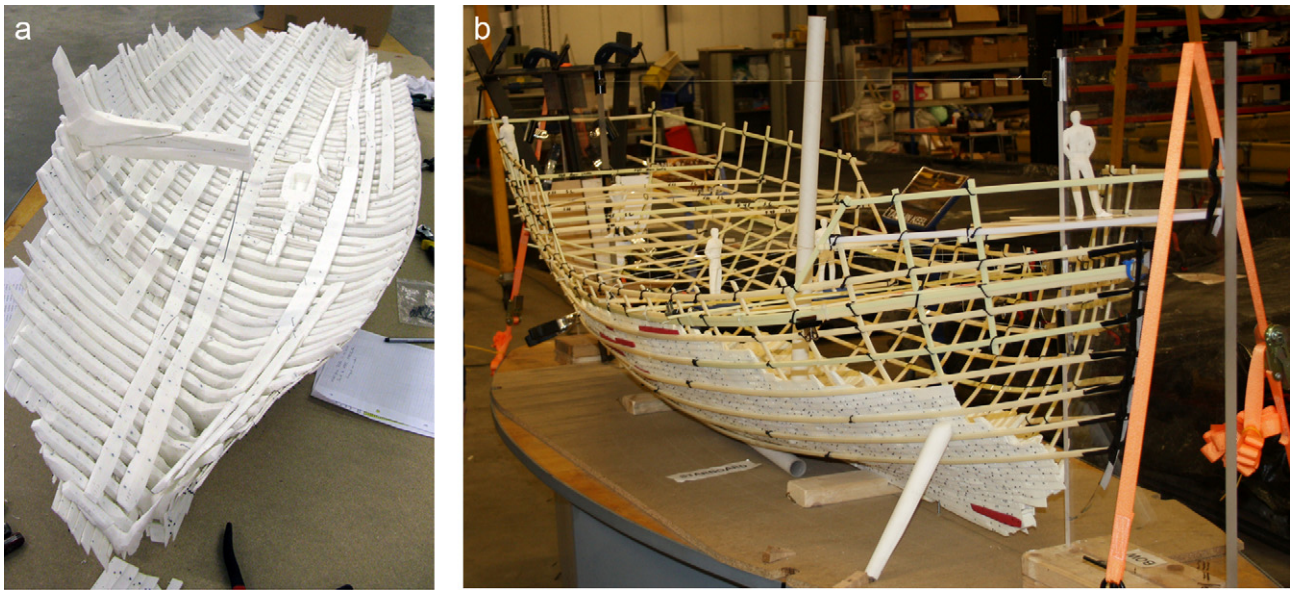

Figure 33. a) 1:10 scale model of the hull remains, with individual model pieces created by laser sintering and fastened with micro-fasteners; *b)* Physical model with ribbands added to ghost in missing areas of the hull. (Toby Jones)

the manufacturing bed because the longest timbers, such as the mast-step/keelson and stringers, had been cut into shorter lengths during the excavation.

A more problematic constraint was the inability of the laser sintering machine to create small holes. For example, the square-sided clench nail fasteners on an average lapstrake hull plank from the ship were approximately 12 mm in width. At the 1:10 scale chosen for production, these nail holes would have measured 1.2 mm. The machine was unable to produce square holes at this small size. A related consideration was the necessity of finding a method of fastening the model ship timbers together in a strong yet non-permanent way. As it would have been impractical to manufacture and install thousands of miniature rivets and roves, an alternative was required. A solution was achieved by sourcing small metal screws called micro-fasteners, which were specifically designed to thread into thermoplastics such as polyamide-12. The small screws were slightly larger than 1.2 mm, which necessitated deviating from the recorded hole size of and modelling a hole with a large enough diameter to accommodate the screws. The same consideration was necessary when modelling the treenail holes. The effect of the fastener substitution seemed to have no discernible impact on the resulting hull form.

The scale model was assembled piece by piece, starting with the keel and garboards. Subsequent strakes were added until the turn of the bilge was reached, and selected floors were inserted. More planking was added, followed by additional floors and futtocks. The mast-step/keelson and associated braces were added next, followed by stringers and riders. Numerous disarticulated timbers were also digitally and physically modelled, and attempts were made to fit this material into the reconstruction, with some success. The hatch covers, for example, were digitally and physically modelled and placed within the 1:10 scale model.

The entire assembly process was recorded using time-lapse photography and the shape of the model was recorded at various intervals using both the contact digitiser and the laser scanner. The resulting data was converted into section contours and the shape of the model was analysed as model timbers were added.

Long plastic ribbands were then attached to the model along every fourth strake and were used to ghost in missing areas of the hull and determine the likely location of the stem and stern. Transverse ribbands were installed to approximate the position of selected frame stations. The use of temporary fasteners, such as bulldog clips and cable ties, allowed for easy adjustment of the ribbands. The physical model, complete with a sheer and castles, and representing a minimum reconstruction (Fig. 33b), was documented using a contact digitiser and laser scanner. The resulting 3D digital hull form data served as the foundation of the minimum reconstruction.

Digital hypothetical minimum reconstruction

The digital hull form data was imported into Rhinoceros3D, where a preliminary set of lines was extracted and faired. This digital model of the complete physical 'minimum' hull was then used as a starting point for repairing the localized damage (humps and hollows) and twist present, in an effort to create an ideal hull form representing the ship when it was newly built. This was an iterative process that continuously referred back to and relied upon the physical model, using it as a check against creating modifications in the digital reconstruction that were impossible in the physical one

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(Tanner, forthcoming). A series of 3D models and drawings, including a torso/as-found drawing, a construction drawing, and a minimum reconstruction showing masts, rig and steering gear, were all produced using Rhinoceros3D and the associated OrcaMarine plugin (Figs 34–6).

Reconstruction results

The recreation of the original hull form within a digital environment has allowed for the use of OrcaMarine to analyse the cargo capacity, sea-keeping characteristics and performance of the vessel in a variety of situations. The hull was tested as an empty shell, ballasted, and fully laden; all states that it would have regularly experienced during its working life. The vessel was found to have a notional cargo capacity of 107–141 metric tonnes, with an additional 17 tonnes of ballast. The total displacement of the ship, when fully loaded, would have been around 207 tonnes (Fig. 37). The total hold volume on the minimum reconstruction was estimated to be 225 m^3. The inclusion of an aisle 900 mm wide running fore and aft would result in a reduced useable volume of 170 m^3 (Tanner, 2013: 101).

The main sail was estimated to be around 264 m^2. This amount of sail could propel the ship fully laden at a speed of 6–7 knots in a Force 3 wind (blowing 9–10 knots), when sailing downwind. The additional sail area of a fore and mizzen mast would have made the ship more effective when sailing to windward. Subdividing the sail plan over three masts would make it more manageable for the crew, as it was easier and safer to handle smaller sails. It is important to remember that these numbers are based on a minimum reconstruction, and represent the lower end of the ship's capacity and speed capabilities, when compared to the capacity and performance of a capital reconstruction. It should be noted that the numbers are also computer-modelled statistics, and are based on the hull being clean and smooth, an unlikely characteristic in the medieval period.

While the minimum reconstruction adheres strictly to the archaeological evidence, with any areas of conjecture supported by tangible direct or indirect evidence, the resulting model is not entirely convincing, especially in terms of sheer line and associated freeboard. Based on an analysis of contemporary iconography, it seems likely that ships the size and shape of the Newport Ship typically had three masts and two decks. While only one deck is shown on the minimum reconstruction, a capital reconstruction with two decks seems plausible, if not probable. The strong and closely spaced framing would also support a more substantial vessel than that shown in the minimum reconstruction. Research efforts are currently focused on the creation of a digital capital reconstruction, which will be created using the digital minimum reconstruction as a foundation. The hydrostatic, hydrodynamic and sailing characteristics of both models will be compared in a future article.

Both the minimum and capital reconstructions have a transom stern. There is indirect archaeological evidence that supports the reconstruction of the Newport Ship with a transom stern as opposed to a double-ended vessel as, for example, is shown in the latest reconstruction of the Aber Wrac'h 1 vessel (pers comm. Alexandra Grille). The slight flaring out of the V-shaped floor-timbers and first futtocks in the stern suggest the end of the vessel has to have a wine-glass stern, similar to the Red Bay 24 M (Grenier *et al.*, 2007: vol. III–32).

Artefactual and environmental analysis

Although the ship had been subjected to extensive salvage, hundreds of artefacts were discovered during the excavation, including items identified as crew or personal effects, rigging, weaponry, and casks. Additionally, several hundred environmental samples were taken, with analysis focusing on sediment from the inter-frame spacing in the bilges. This material was subsequently processed to recover plant macrofossils, shells, pollen, insects, fishbone and faunal remains. Together, the artefacts and environmental material provide evidence relating to the working life of the vessel, including previous cargoes and origins, shipboard diet, and living conditions on board. In this section, specialist reports on material types of objects, and palaeo-environmental analysis are summarized thematically.

Given the complex taphonomy of the site, situated along a tidal river in a busy medieval town, there is the possibility that some of the recovered artefacts may not, in fact, be associated with the original deposition of the vessel. Some material may be intrusive, while other objects were not recovered archaeologically, and, as such, their association with the working life of the medieval ship is uncertain. Having said this, the majority of material was recovered within the ship from contexts sealed by later alluvium.

Crew and personal effects

Wooden bowls, combs, a knife handle, ceramics and a wooden gaming piece were amazingly well preserved and richly illustrate the daily life of the sailors and merchants onboard. A variety of leather shoe and boot fragments were also well preserved, along with a handful of coins.

Several turned wooden bowls made from ash (*Fraxinus excelsior*) were recovered (Fig. 38a). Two boxwood (*Buxus sempervirens)* combs were found, with one comb double sided, with coarse and fine teeth, for straightening hair and removing lice, respectively, with the other comb a single-sided example with coarse teeth (Figs 35b, c). Similar combs were found on the Cattewater shipwreck and the *Mary Rose*, as well as slightly later shipwrecks, including the *San Juan* (AD 1560) and *Trinidad Valençera* (AD 1588). A boxwood knife handle corresponds closely with other early to

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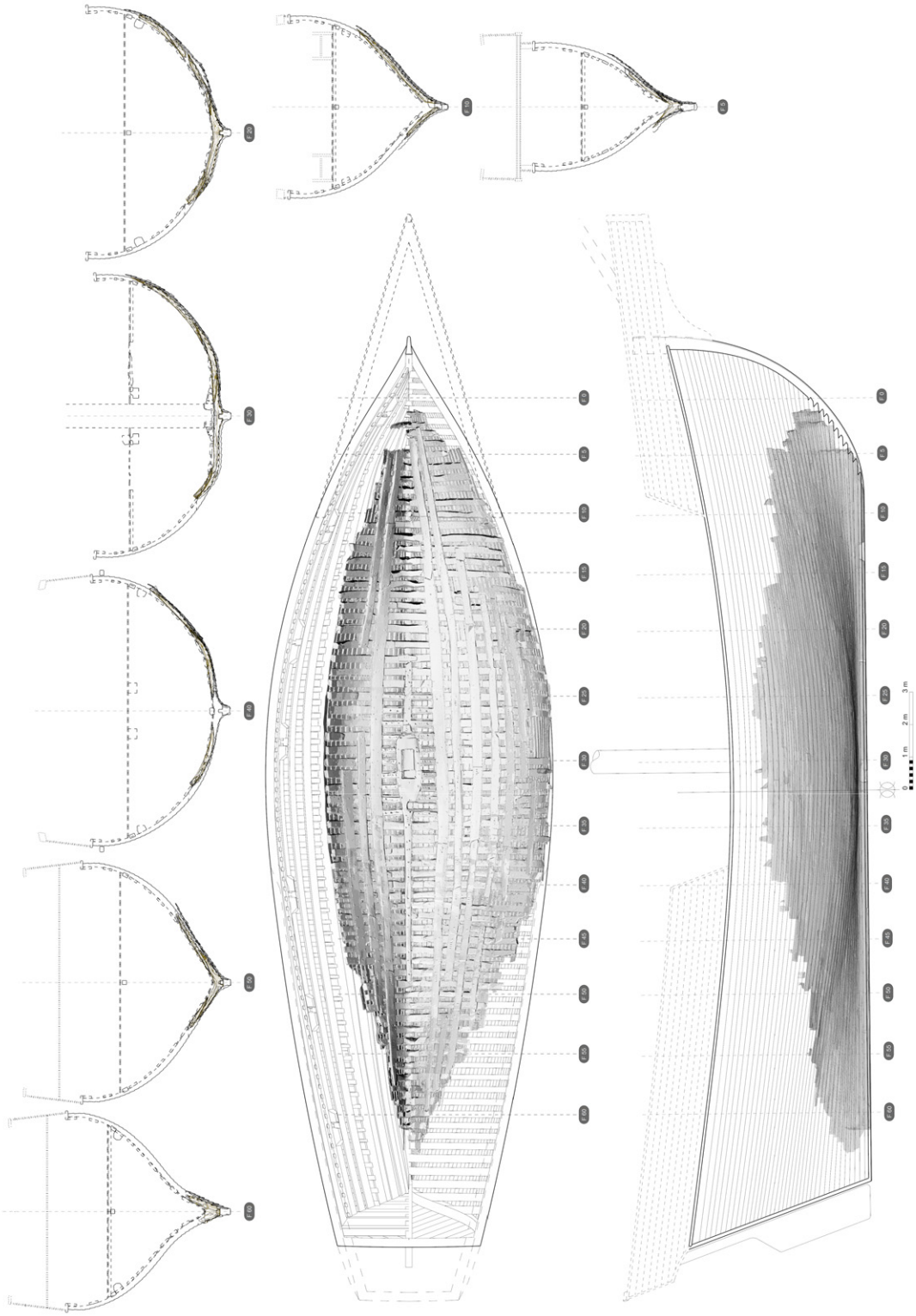

Figure 34. Torso drawing showing a laser scan of the model of the articulated hull remains superimposed on the minimum reconstruction. (Pat Tanner)

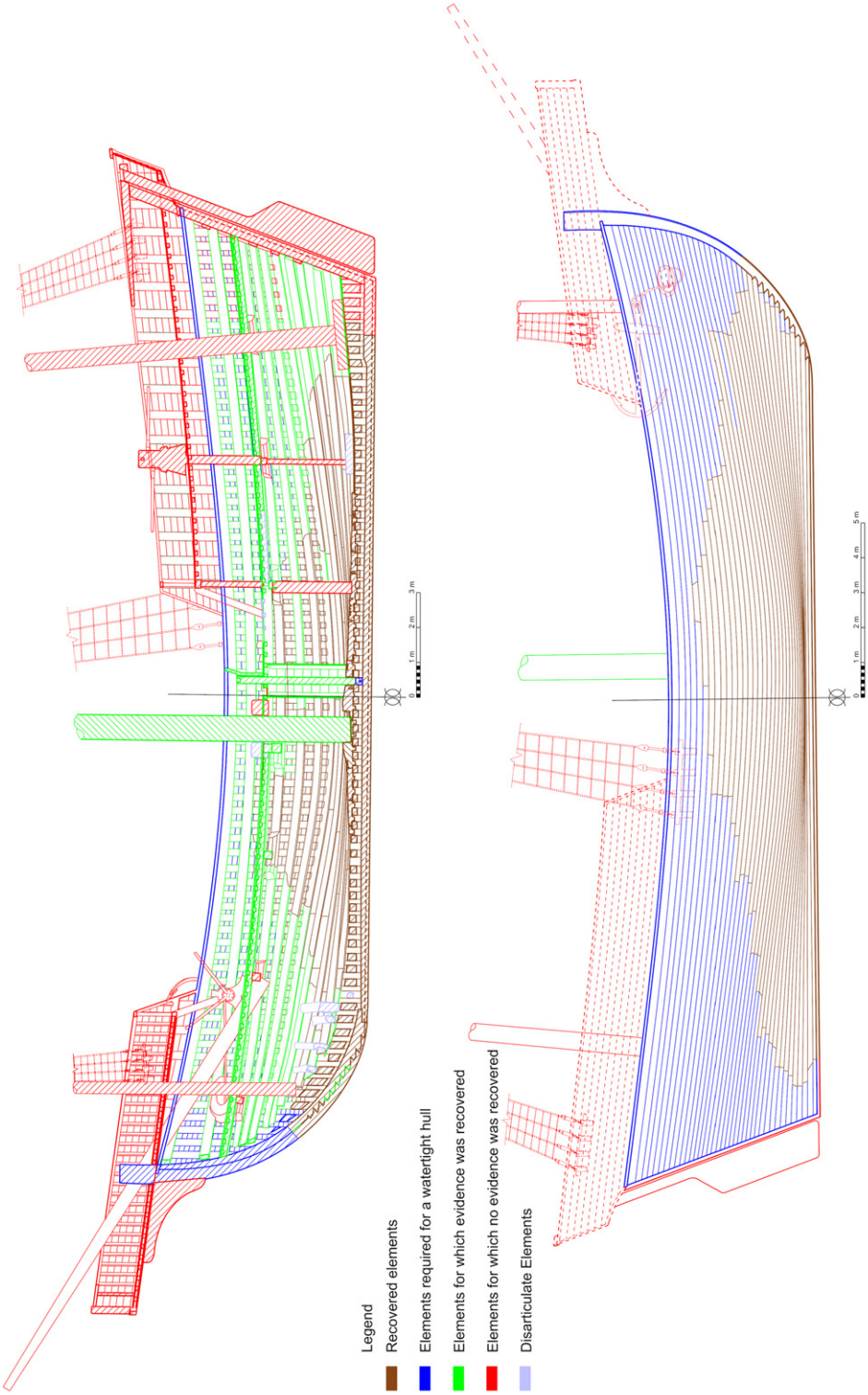

Figure 35. Drawing showing what parts of the reconstruction were based on direct archaeological evidence and what parts are conjecture. (Pat Tanner)

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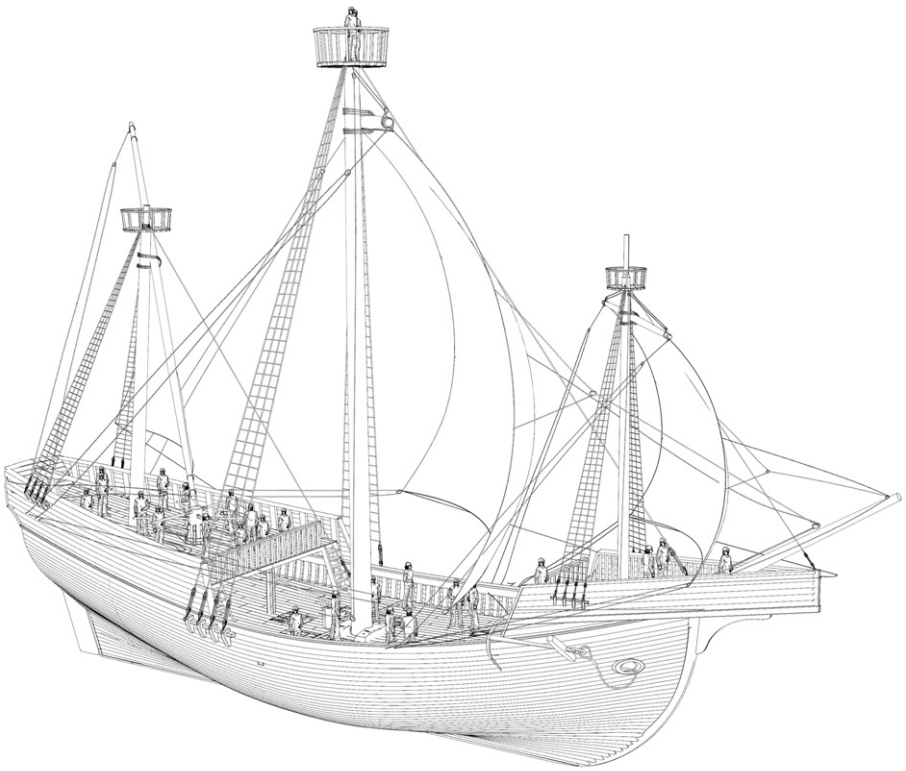

Figure 36. A perspective view of the minimum reconstruction drawing. (Pat Tanner)

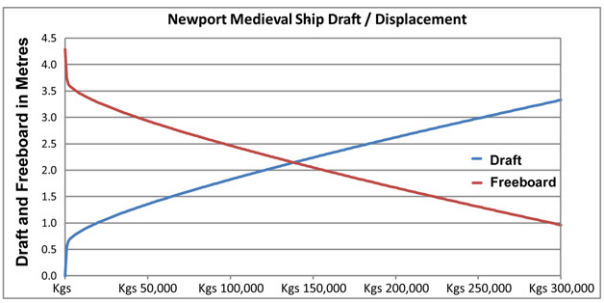

Figure 37. Graph showing the relationship between draft, freeboard and displacement. (Pat Tanner)

mid 15th-century examples found during excavations in London (Cowgill *et al*., 1987: 102–3, fig 265), as well as handles found on the Cattewater wreck and *Mary Rose* (Fig. 38f). The wooden gaming piece is a finely crafted disc of boxwood that has been turned and carved with concentric decorations (Fig. 38d). Measuring 33 mm in diameter, the gaming piece or counter could have been used for games such as backgammon, *tabula*, or merels. An awl or fid was recovered near the mast-step. It is finely made from boxwood and measures 100 mm in length (Fig. 38e).

Most of the textiles found during the ship excavation are fragments of well-spun natural-colour wool, woven into a heavy, coarse cloth, ideally suited for making the durable work clothes required by mariners. The textiles were all woven using a 2/2 twill weave or a tabby weave. Several examples have darker stripes surrounded by a lighter background. Most of the textile fragments seem to have been serving secondary purposes, such as plugging leaks, indicating that the sailors were resourceful in the reuse of worn-out clothing (Walton Rogers, 2013a).

Eight distinct leather shoes and three boots were recovered during the excavation (Fig. 39). Numerous other shoe parts were also found, drawing attention to the ubiquity of leather footwear during this period. Several of the shoes had long, pointed toes, which were stuffed with moss to hold their shape. Referred to as pikes or poulaines, these shoes were highly fashionable and subject to sumptuary laws in the medieval period. These laws were designed to enforce traditional social and economic hierarchies and limit expenditure on luxury items. The specific effect on the long-toed shoes was to limit the length of the toe to two inches. The long-toed poulaine shoe found on the Newport Ship exceeds this law by more than an inch (Mould, 2013).

Leather reuse was common during the medieval period, with boots and shoes being resoled or repaired several times. Leather from the relatively unworn upper part or leg of a boot could be cut off and reused. There is evidence that some of the shoes found on the ship were made from cut down boots. A large number of leather fragments were found during the excavation, which may represent those fragments of shoes that

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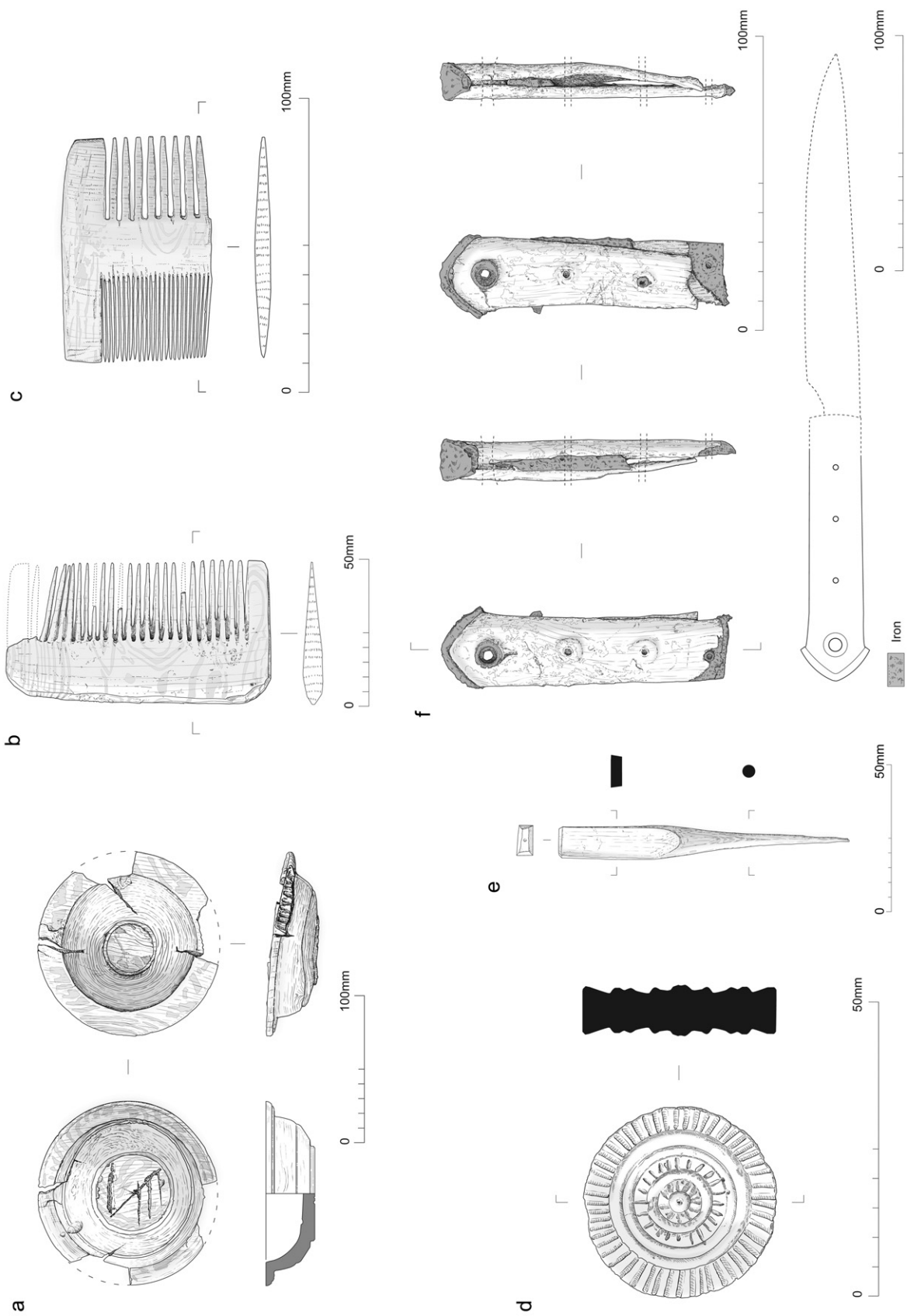

Figure 38. *a)* Turned ash bowl with possible ownership marks; *b)* Single-sided boxwood comb; *c)* Double-sided boxwood comb; *d)* Carved discoid boxwood gaming piece; *e)* Boxwood awl or fid; *f)* Boxwood knife handle with fragment of iron blade and bimetallic rivets. (Anne Leaver)

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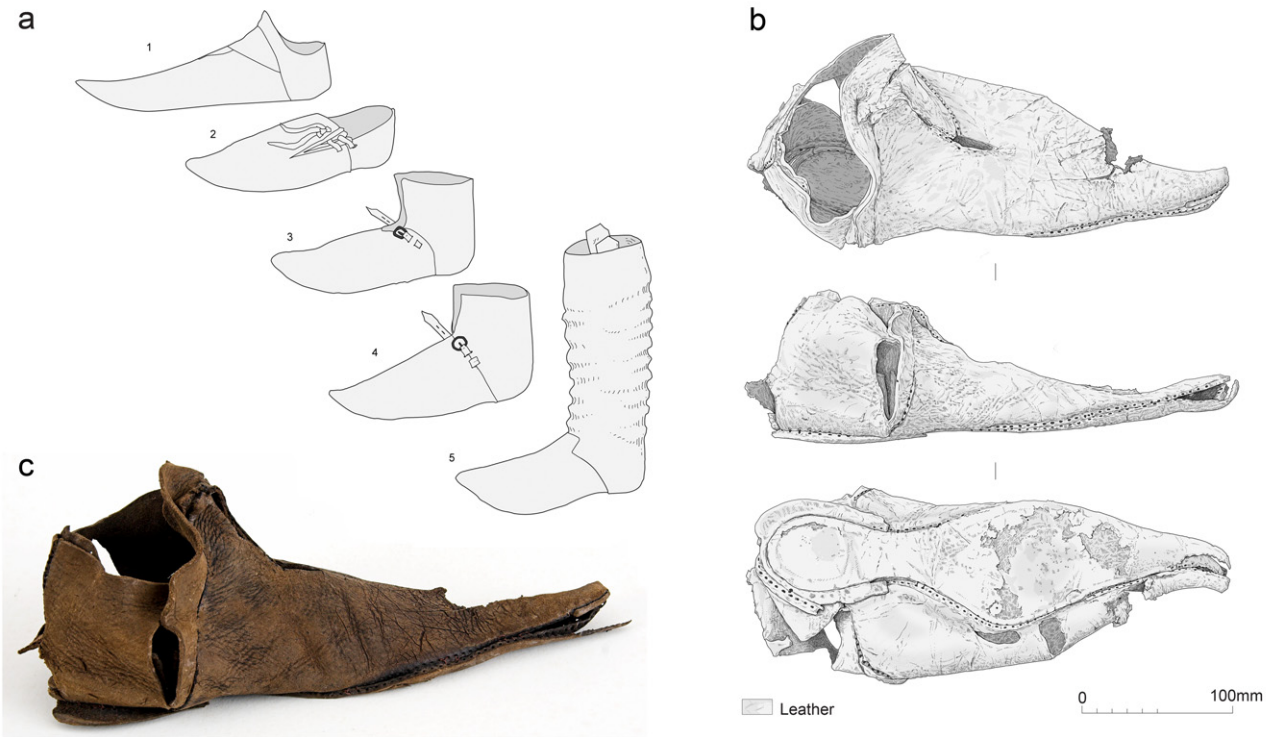

Figure 39. *a)* Types of footwear found during the excavation. (Quita Mould and Anne Leaver); *b)* Poulaine shoe with moss-filled toe. (Anne Leaver); *c)* Conserved poulaine shoe with moss-filled toe. (Rex Moreton)

could no longer be economically rebuilt. The shoes and boots found came in a range of sizes fitting adolescents and adults, with both right and left footwear being identified, but with no matching pairs. Substantial amounts of waste leather were also found in the bow of the vessel, but this may represent waste leather produced by a shoemaker or cobbler and dumped inside the vessel after it came to rest in Newport.

Large amounts of fragmented pottery were found, with the majority being sherds of Portuguese Mérida-type ware. The sherds were from a variety of objects, including pitchers, jugs and jars with lids. The items appear to be primarily for use on board the vessel, as opposed to cargo. Similar Portuguese ceramics have been found on several comparable and contemporary shipwrecks (Redknap, 2013a).

The sole item related to navigation was a fragment from the neck of a sandglass which was recovered near the mast-step (Fig. 40). Made from cloudy potash glass, it would have formed part of one half of the instrument, with the two halves being fitted into a wooden frame for protection.

Six coins (five Portuguese and one French) and one jetton (from Nuremburg, Germany) were recovered, all dating to the 14th or 15th centuries. The Portuguese coin assemblage consists of one *real preto* of Duarte I (1433–1438) and four *ceitils* of Afonso V (1438–1481) (Besly, 2013) (Fig. 41). These coins were probably used by the crew and lost during voyages, becoming trapped in the bilges. The jetton was used by merchants as a counter and is made from brass or latten, a similar type of copper alloy common in the medieval period.

The most remarkable coin, and one of the most significant artefacts recovered during the entire project, was the silver French coin of Louis II, Dauphin de Vienois (later King Louis XI of France), which was found purposely embedded in the keel of the vessel (Fig. 11c), in a small rebate cut on the inboard face near the forward end. The silver *petit blanc* was placed in the rebate and covered with tar and animal hair before the stem was attached, effectively sealing the coin in the fabric of the ship. The coin was found long after the excavation, during cleaning of the keel in 2006. The coin was in uncirculated condition and was identified as being minted at Crémieu in France between May and July 1447. This means the ship could not have been constructed before May 1447. This coin was presumably placed in the fabric of the ship as a good luck charm, with the coin having a cross and the motto 'Blessed be the Name of the Lord'. Such practices date back to at least Roman times (Carlson, 2007), and continue today.

Conflict

It would be common for medieval vessels to carry selected weapons in order to protect against attack by pirates or privateers. Stone shot, an archer's wrist

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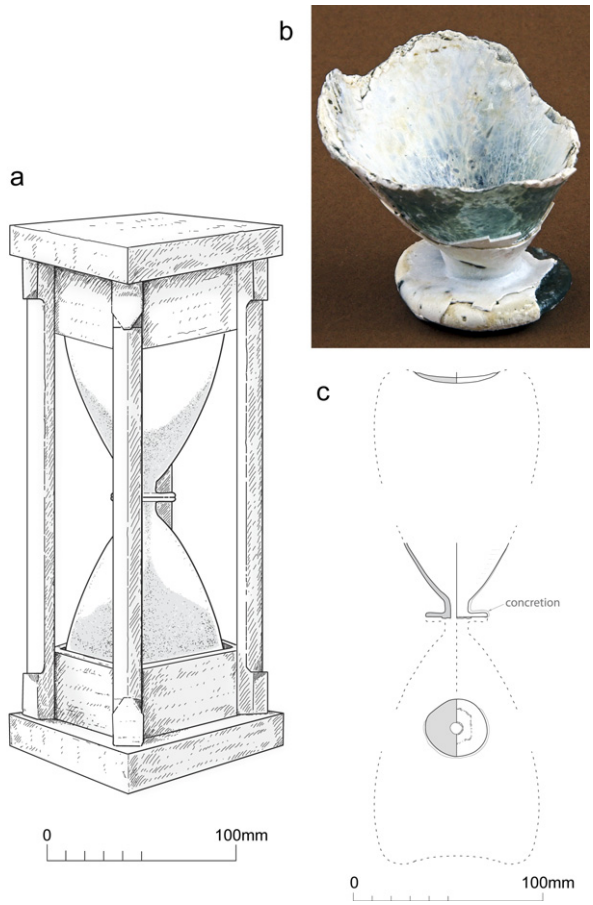

Figure 40. a) Reconstruction of a sandglass showing the probable origin of b) the recovered fragment (Anne Leaver); *c)* Fragment of a sandglass recovered near the mast-step. (Rex Moreton)

guard and decorated helmet fragments are evidence that the ship carried weaponry to protect against piracy and other unwanted visitors.

Five examples of stone shot were recovered, and can be divided into three size classes: 55 mm, 67/70 mm, and 80/82 mm. This size of shot would have likely have been used in light wrought-iron breech loading pieces, with the smallest diameter (55 mm) being similar to the bore diameter of three swivel guns found on the Cattewater wreck (Redknap 1984, fig. 47, nos 136, 137) (Fig. 42).

The archer's wrist guard, or bracer, is a fine example of medieval leatherwork, with embossed decorations and the Latin word *amilla,* which translates as bracer (Fig. 43). It shows wear marks consistent with the repeated shooting of a bow. The bracer is made from cattle hide, with a calfskin lining, and is similar to bracers recovered from *Mary Rose* (Soar, 2011).

Fragments of a decorated iron helmet were also discovered (Fig. 44). The decoration consisted of two copper-alloy strips with engraved Gothic Latin texts quoting a biblical passage. The text (recovered portion in bold) probably read: IHESUS AUTEM TRAN**SIENS** PER **MEDIUM ILLORUM** IBAT, which translates as 'But Jesus passing through the midst of them went on his way'. The passage is from Luke IV.30, and was used as a commonly quoted charm during the medieval period (Redknap, 2013b).

Cargo and diet

Evidence for cargo handling comes largely from timbers from coopered vessels, triangular wooden chocks used to stabilize casks in the hold, and plant-macrofossil evidence for dunnage. Faunal remains either recovered by hand during excavation or extracted from the processing of environmental samples, mostly from basal sediments within the bilges, provide indicators of diet (Coard, 2013; Russ, 2013).

Figure 41. Portuguese ceitels, a real preto, and a folded jetton from Nuremburg. (Rex Moreton)

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Plant-macrofossil evidence provides further indicators of diet, with a variety of seeds, nut shells and fruit stones reflecting the collection of sewage and waste in the bilges, although this can also be taken as an indicator of a range of foodstuff cargoes pilfered by the crew (Carruthers, 2013).

Numerous cask components in a variety of sizes were recovered, including staves, heads and hoops. The ship probably often carried a cargo of wooden casks, which could hold all manner of contents, wet or dry. These casks could be placed in the hold of the vessel on a layer of plant material called dunnage. This organic layer protected the casks from sharp jolts and damage during heavy weather. Hundreds of recovered wedge-shaped alder (*Alnus* spp.) chocks, some with nail holes, may have been used to secure the casks while at sea, described as 'Canting-Coines' in Smith's *Seaman's Grammar* (Smith, 1691: 33) (Fig. 45). Cork (*Quercus suber*) bungs would have been used to seal casks and other containers. Small sheets of cork oak might represent remnants of cargo. Most of the environmental samples analysed contained substantial quantities of western prickly juniper leaves of a species that grows in south-western Portugal. These samples also contained quantities of heather, which, upon close inspection, contained flowering bodies, indicating that they had been harvested in late summer (July-August). Dunnage was of low value and could probably be freely collected on the dry coastal areas near the ports on the Iberian Peninsula. It is therefore likely that the Newport Ship used locally available fresh dunnage when picking up cargoes along the Atlantic-Iberian coast.

Figure 42. Five stone shot recovered during the excavation. They range in diameter from 55–82 mm. (Newport Museums and Heritage Service)

Analysis of the food remains has revealed the wide variety of plants, fruits and vegetables that were carried on board for human and animal consumption or as cargo. Durable items such as walnuts, hazelnuts, almonds, pine nuts, pomegranates, millet, grapes (as raisins), figs and olives were ideal for sea voyages, were highly nutritious and had a low risk of spoilage. Other foodstuffs and flavourings found include mustard, coriander, and dill, as well as flax, hemp and hops. Certain foods, such as peaches and apples, were likely eaten fresh. Some food remains, such as fig seeds and grape pips, were evenly distributed throughout the ship, suggesting that they were consumed and that the resulting sewage entered the bilge before becoming dis-

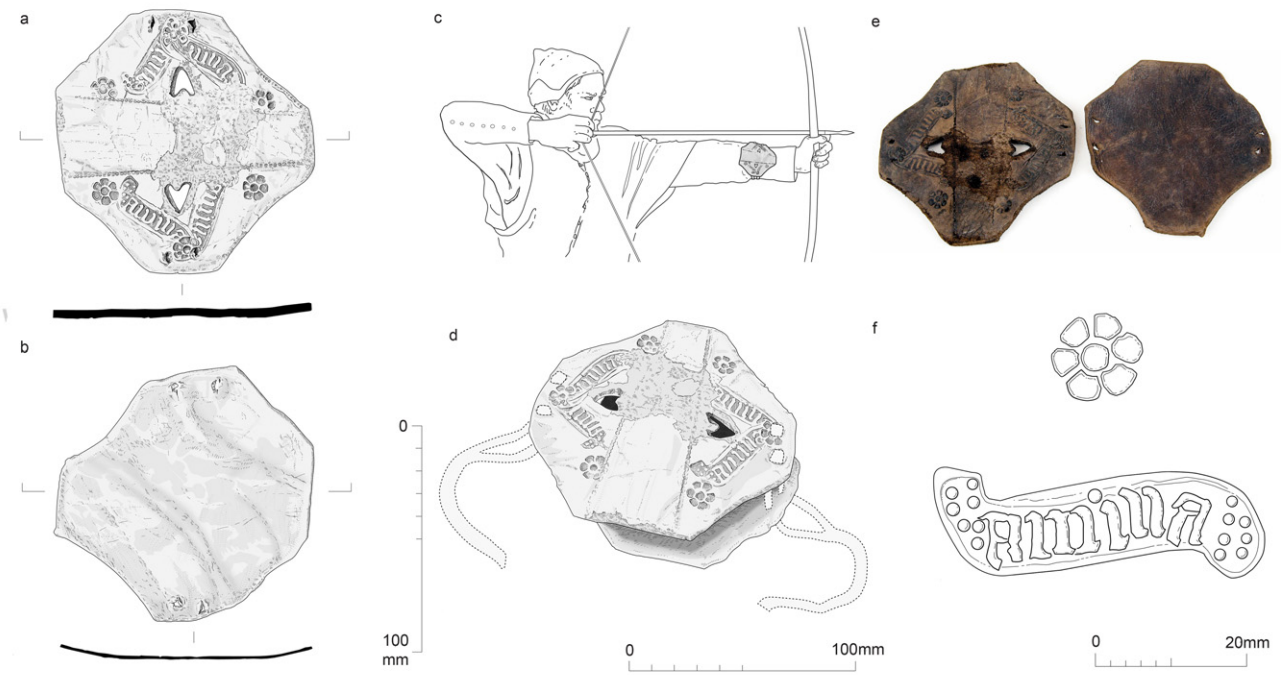

Figure 43. a–f) Bracer with stamped inscription. Note the wear caused by repeatedly being struck by bow string. (Drawingsanne Leaver, photo Rex Moreton)

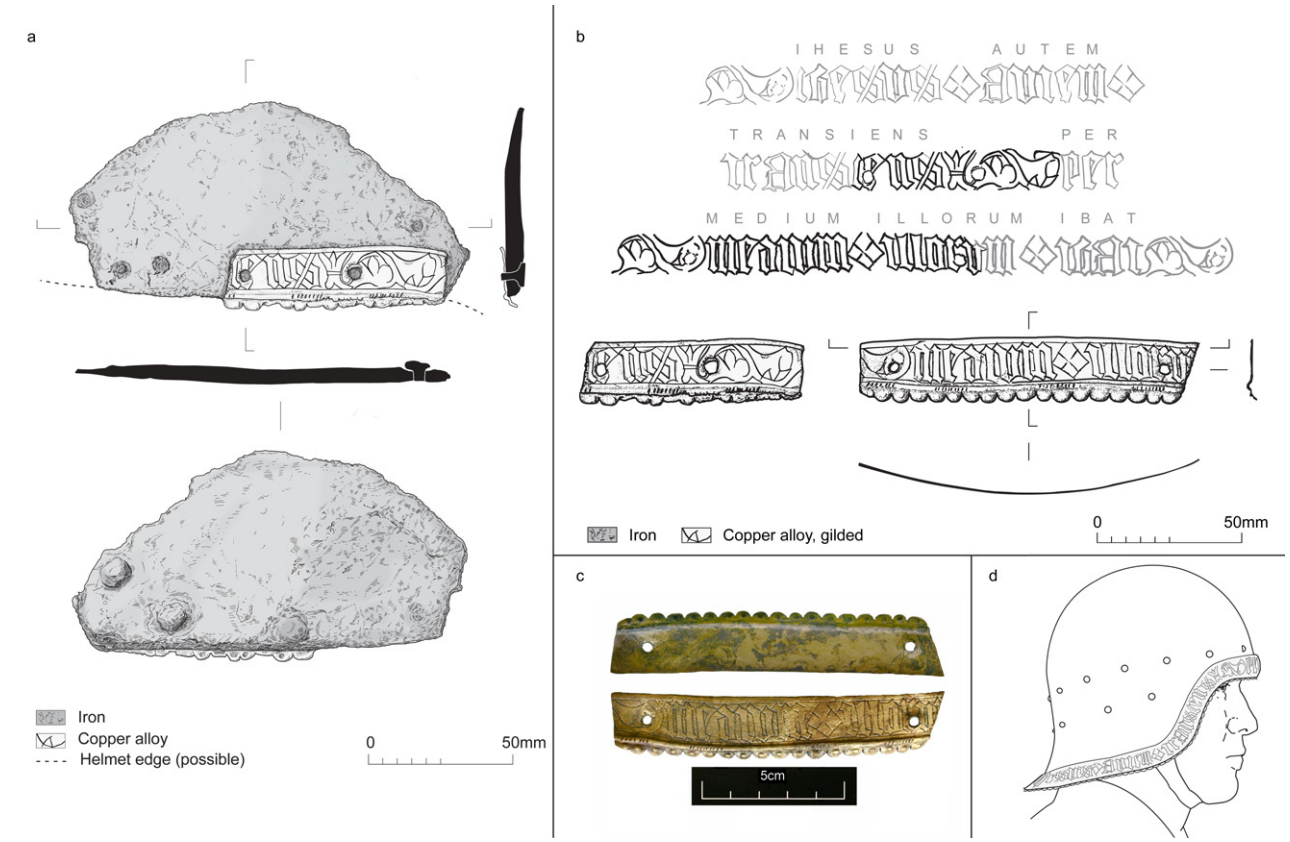

Figure 44. *a)* Fragment of an iron helmet with engraved brass decorative strips; *b)* Reconstructed engraved brass decorative strips; *c)* Engraved brass decorative strips from iron helmet; *d)* Reconstruction of iron helmet showing placement of engraved brass decorative strips. (Drawings Anne Leaver; photo Newport Museums and Heritage Service)

Figure 45. One of numerous triangular pieces of alder interpreted as chocks for stowage of casks. (Newport Museums and Heritage Service)

persed. Many of these foodstuffs are mentioned as cargoes in the Iberian trade with England, especially nuts and dried fruits which found a premium seasonal market in British ports (for example Carus-Wilson, 1968: 81; Childs, 1978: 125).

A range of insect remains was recovered from the environmental samples, with some specimens, such as the wood-boring *Sinoxylon sexdentatum,* having never been found in the United Kingdom before. Woodworm (actually a beetle—*Anobium punctatum*) was also found, and could indicate that the ship carried a cargo of infested wood, or that the upper works of the ship were infected (Smith, 2013).

Beetles and weevils that target stored grain and those that are indicative of decaying hay and straw were also discovered throughout the vessel. The grain pests indicate that the ship was likely carrying legumes and grains as provisions and trade goods, while the beetles associated with decaying grasses suggest the presence of animal bedding on board and, hence, live animals. It is also possible that some of the insects may have been present in low-quality food, such as horsebread, which may have been used as fodder for the animals onboard (and sustained the crew, in times of hardship).

A substantial number of human fleas and one dog flea were discovered preserved in the mud of the bilges, along with thousands of flies and fly larvae. Their presence indicates the conditions below deck and near the bilges were quite foul, with sewage mixing with the saline bilge waters and creating an unhealthy environment containing biting insects and disease-carrying flies.

More than a thousand animal and fish bones, and numerous shellfish, were recovered. The majority of animal bones recovered belong to domesticated cattle, pigs and sheep/goats. Many of the large mammal

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bones show signs of butchery, with selected parts of the carcass being cut into joints. Certain bones provide evidence that the larger mammal carcasses were split and quartered, with some cut marks indicating that the butcher was right-handed and quite skilled. The butchery marks on other bones suggest that live animals were sometimes kept on board and slaughtered during voyages. The mixed nature of the animal bone assemblage indicates that a varied diet of fresh and preserved (smoked, salted, and brined) meats was carried on board the vessel. Other animal remains recovered include mandibles from black rats and substantial quantities of domestic fowl bones, suggesting that the crew shared the vessel with a variety of living creatures, useful or otherwise (Coard, 2013).

The fish bone was found to be quite diverse in terms of species. Substantial amounts of Atlantic cod bones suggest the use or transportation of dried stockfish. Other species recovered include European hake, ling, tusk and Atlantic herring, skate, ray or small shark, blackspot seabream, European conger, flatfish and Atlantic salmon. Some of the cod and ling were more than a metre in length. The fish remains could represent food stuffs carried for use on a voyage or trade goods. Additionally, fish could have been caught and consumed fresh during the periods of slow sailing or anchorage. Several different types of shellfish were recovered during the ship excavation with the most common being the native oyster, with additional examples of whelks, mussels and cockles. The later specimens could have been a by-catch of raking or dredging for oysters, which served as a 'poor man's food' in centuries past, only becoming a delicacy when they became more scarce due to over fishing and habitat degradation. Shellfish would have served as a readily available food source whenever the ship was in shallow coastal waters (Russ, 2013).

It is probable that the Newport Ship was sailing between the Iberian Peninsula and southern Britain, based on the analysis of waterlogged plant remains, artefacts, and historical accounts, which describe the route as well established in the late medieval period. With its heavy framing and stout beams, the Newport Ship was able to withstand the pounding Atlantic swells while crossing the Bay of Biscay. Cargo could have been carried in casks, sacks or bales, with the most common cargoes of the period being cloth and wool being exported from Britain, with iron, wine, olive oil and fruit being imported from the Iberian Peninsula.

Archive statement

The large quantity of digital data generated by the documentation and analysis of the Newport Ship has encouraged a publication model which includes provision of a freely accessible archive comprising digitised primary excavation records, post-excavation 3D timber records in a variety of formats, digital photographs and specialist reports (including those summarized and cited here). This archive is available through the United Kingdom Archaeological Data Service and can be accessed at doi: 10.5284/1020898.

Conclusions

The Newport Ship is a rare example of a late medieval ship which has been closely dated to the mid 15th century and associated with the well-documented trade with Iberia. The comprehensive documentation and analysis of the Newport Ship has provided a wealth of new information about wooden ship building construction techniques during the late medieval period. The digital recording of the hull and associated artefacts has allowed for innovative developments in structural analysis, publication and reconstruction.

The working life of the vessel has been firmly dated to the mid 15th century. The closest parallel for the ship is perhaps the Aber Wrac'h 1 ship discovered off the Brittany coast in the 1980s (L'Hour and Veyrat, 1989). The authors recently participated in a re-excavation of the *in situ* remains of the vessel, and noted that the clinker fasteners and treenail fastenings were quite similar to those found on the Newport Ship. However, notable differences between the two vessels included the lighter and more widely spaced framing on the Aber Wrac'h 1, along with hull planking of a greater scantling than the Newport Ship. The overall hull shapes are also substantially different as presently reconstructed, with the Aber Wrac'h 1 vessel being reconstructed as a double-ended ship and Newport having a transom stern. Differing midships sections were also noticed, with Newport having a more rounded turn of the bilge. While no definitive dating or provenance as yet exists for Aber Wrac'h 1, it is hoped that recent research may shed new light on these questions. The Urbieta ship, found near Guernica, is broadly contemporary and demonstrates the use of clinker construction on smaller vessels, in this case perhaps operating in estuarine and coastal waters in an area noted for its iron industry (Rieth, 2006).

An intriguing feature of the Newport Ship is the use of radially split hull planks finished by secondary hewing with axe/adze and hewing of the keel and framing timbers, while the stringers, ceiling planks, deck planks and hatch-cover planks were converted by sawing. This apparent dichotomy in tool usage and approach to timber conversion is to some extent also noted in the possibly late 15th century Cavalaire-sur-Mer wreck for which a Basque origin has been argued (Loewen, 1998: 51; Loewen and Delhaye, 2006: 99). The use of iron spike-nails, in addition to oak treenails, to fasten the framing timbers to the clinker hull on the Newport Ship is another notable feature which could reflect construction in a region rich in iron resources. Marked similarities were observed between particular timbers and internal fittings such as pumps and hatch covers in the Newport Ship and the wreck 24 M (*San Juan*) excavated in Red Bay, Labrador (Grenier *et al.*,

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2007: III–164 and III–197). Does this imply continuity of many detailed features in ship construction amid the technological shift from clinker to carvel construction?

Contrasts between the ship-finds discussed briefly above and broadly contemporary clinker-built ships found around the North Sea and in the Baltic suggest regional shipbuilding traditions in the late medieval period are becoming more recognizable. The interplay between observations of fastening details, luting methods and indications of origin derived from dendrochronology has clearly been central to discussions of such finds from the Netherlands (van Holk, 2000; Overmeer, 2007). The Skaftö ship, found off the western Swedish coast but associated with Poland both in terms of construction and cargo (von Arbin, 2012), points to a group of vessels, including the W-5 'Copper Wreck' (Litwin, 1980), built in the Baltic and engaged in export of Baltic commodities, including timber.

Documentation and analysis of the Newport Ship has required a major research effort, not least because of the extent of the surviving remains. While this publication and the accessible digital archive represent a significant stage in the dissemination of information on the ship, research continues. A digital capital reconstruction of the ship is in progress, building on assessment and critique of the minimum reconstruction presented here. Digital reshaping of the wireframe documentation of individual timbers to match the reconstructed hull form is also planned, facilitating analysis of intentional marks found on numerous timbers. The ship's discovery has already provided the stimulus for new historical research and the recent findings from specialist studies is encouraging further examination by economic and historical scholars to place the vessel in a wider late medieval context. It is to be hoped that on completion of conservation of the hull timbers, the physical re-assembly of the ship, as part of an appropriate museum development, will offer further opportunities to test our understanding of this exceptional ship-find.

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