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Linking Land and Navy: archaeological investigations at the site of the Woolwich Royal Dockyard, south-eastern England

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This paper outlines the archaeological evidence found at the demolished Royal Naval Dockyard at Woolwich for the development and construction of dockyard structures of the 18th to early-19th centuries. This is set within the framework provided by historic, documentary, map and historic-model evidence. The results of earlier excavations at the same facility are also reviewed. The themes covered include; the interplay of 'carpentry' versus 'shipwrightry' in dockyard construction, aspects of naval timber-supply and landscape, the recycling of ships' timbers, dockyard craft specialisation and changing relative sea-levels.

Key words: carpentry, dockyard, slip, Woolwich.

In archaeology related to maritime culture most work has focused on ships, boats, trade-routes, battle-sites and cargoes, and much less effort has been directed towards the systematic investigation of ship- and boatyards and related water-margin sites. This is particularly true in Northern Europe for the post-medieval period. However, the situation is now beginning to change with some detailed investigations in England and the Netherlands being published (Saxby and Goodburn, 1998; Divers, 2002; Gawronski, 2003; Heard and Goodburn, 2003; Divers *et al.*, 2004). There is also a good review of the archaeological survival of 18th- and 19th-century merchant shipyards in the United Kingdom by Stammers (1999: 253–64). In Québec, Canada, the colonial port facilities and development have been studied (Rouleau, 2009: 229–44). In Maryland in the United States a predictive GIS model has been tested to assist in specifying the probability of locations with certain characteristics having been used for historic shipbuilding yards in the past (such as being located within 8 km of an urban centre, up a river channel wide and deep enough to launch a vessel, with a bank slope of between 3 and 11%, and within 0.7 miles of oak-supporting soils) (Ford, 2007: 125–36).

In a geographical, functional and socio-political sense, boat- and shipbuilding sites straddle both the land and the water, be it river, lake, estuary or sea. In the case of the naval dockyards developed in post-medieval Europe the yards were generally large, well-demarcated industrial complexes. They were also normally sited on substantial estuaries or sheltered sea inlets and depended on huge supply networks running into their hinterlands and the hinterlands of other regions often quite distant. These networks existed for the supply of essential materials such as wood tar, imported timber, spars, iron, sailcloth, and cordage fibres. Through the various routes on water and land the maritime naval world was linked to landscapes often at considerable distances from the maritime realm itself.

Archaeologists and historians working on ship- and boatyards and their activities can contribute to a better understanding of the sites themselves, local settlements, trade connections and infrastructures, as well as the field of reconstructing historic landscape development and use. The latter are traditional themes explored in landscape archaeology and economic, social and environmental history. The recording and study of a range of boat-, ship- and dockyard sites can

reduce the sometimes-unhelpful divide between land-based and water-based research. As naval dockyards of the last 400 years or so tend to be relatively well-documented in England, the views of them gained through historical and iconographic sources can additionally be critically tested by archaeological research.

Archaeology and the port of London

The extensive and comparatively thorough excavations by urban archaeologists along the medieval waterfronts of the London region are fairly well known by both 'land' and some 'water' focused archaeologists (for example Tatton-Brown, 1975; Milne and Milne, 1982; Milne, 1992; Proctor, 2000; Ayre and Wroe-Brown, 2003). Relatively-complete ships and boats have also been found, together with a large number of fragments of vessels, which throw light on regional and international traditions of boat- and shipbuilding from medieval times to the 19th century (for example Marsden, 1978; Goodburn and Redknap, 1988; Goodburn, 1991; Marsden, 1996; Goodburn, 1999; Goodburn, 2003). While archaeological evidence of medieval ship- and boat-breaking and repair is scattered along several areas of waterfront in the London region, only one medieval boatyard location has been found and partially investigated. This lay well upstream of London's historic core, in the freshwater reaches of the Thames by Kingston Bridge (Potter, 1991; Goodburn, 2000). Other areas, such as 'Galley Quay' in the City of London, are known from documentary evidence but development-led archaeology has not provided opportunities for detailed investigations to date (Friel, 1994: 49).

Unfortunately, during the boom in modern urban archaeology in the 1970s, relatively few comprehensive investigations were undertaken of the post-medieval waterfront and boat- and shipyard sites, apart from the pioneering work led by Courtney on the Woolwich Dockyard site itself (as this work is not well known to maritime archaeologists it is briefly summarised below). Over 20 years later, systematic funded excavations and watching briefs on London docklands redevelopment sites finally began to be carried out as a matter of course. Several ship-, boat- and barge-building, repair and breaking yards have now been fairly extensively investigated covering the later-16th to late-19th centuries (Saxby and Goodburn, 1998; Goodburn, 1999; Tyler, 2001; Divers, 2002; Pitt *et al.*, 2003; Heard and Goodburn, 2003; Divers *et al.*, 2004). The importance of these types of sites, including those dating to the earlier-20th century, has also been highlighted by representatives of English national maritime heritage bodies (for example Stammers, 1999), as well as those of the Greater Thames Estuary region (Williams and Brown, 1999: 21; Nixon *et al.*, 2002: 71, 75). Consequently considerable information is now accruing on the nature of the post-medieval port, its topographic development, the nature of ship- and boatyards and the varied craft that were built, used, repaired and broken up in the region.

Changes in both the technology and materials used to build waterfront structures including river-walls, docks, slipways, dry docks, jetties, industrial buildings, watermen's stairs and landing 'hards' are beginning to be documented. Although stone, and later brick, river- and dock-walls are known from as early as the very end of the 14th century in the historic core of the City of London, the use of masonry and brick for waterfront structures, though known (Proctor, 2000), appears to have been rare until the early to mid-19th century along the post-medieval waterfront of Greater London. This is due to there being no local hard building stone.

Due to the waterlogged conditions, timber structures and organic materials such as woodworking debris, cordage, and caulking materials are often found well preserved at waterfront sites (Goodburn, 2001; Divers *et al.*, 2004). At the Woolwich Royal Dockyard the main focus is the development of the central part of the facilities, where heavy-duty dockyard carpentry and shipwright's work were carried out. However, the site has also yielded some evidence of the work of other quite specialised maritime-related crafts such as dockyard sawyers, and even very unusual evidence for early ship glazing (below). The large Royal Dockyards and some belonging to, or working for, organisations such as the East India Companies, developed as early factories with large labour forces. These were broken down into highly specialist groups working in specially-laid-out activity areas and bespoke buildings. Tracking and documenting the nature of this specialisation and factory approach is one of the concerns of this new field of archaeology.

Some broad patterns are emerging in both the main post-medieval structural fields of woodworking—shipwrightry and waterfront carpentry. Some developments are quite distinct from those of late-medieval times, and others indicate changes leading to practices familiar in the mid-19th century (for ship-, boat- and barge-building technology see Marsden, 1996; Goodburn, 1999; Goodburn, 2003; for changes in waterfront carpentry see Goodburn, 1999; Heard and Goodburn, 2003; Divers *et al.*, 2004). This paper is principally concerned with evidence for the topographic development of the yard, waterfront carpentry as applied in the particular context of a Royal Naval Dockyard, and aspects of large carvel shipbuilding and the interplay of shipwrightry versus carpentry techniques. A brief summary of evidence for other specialist activities in the yard is also provided.

The location of the site

The former Woolwich Royal Dockyard lies towards the upper end of the strongly tidal estuary of the river Thames, about 11 miles (18 km) downstream from the medieval port of the City of London (Fig. 1). The

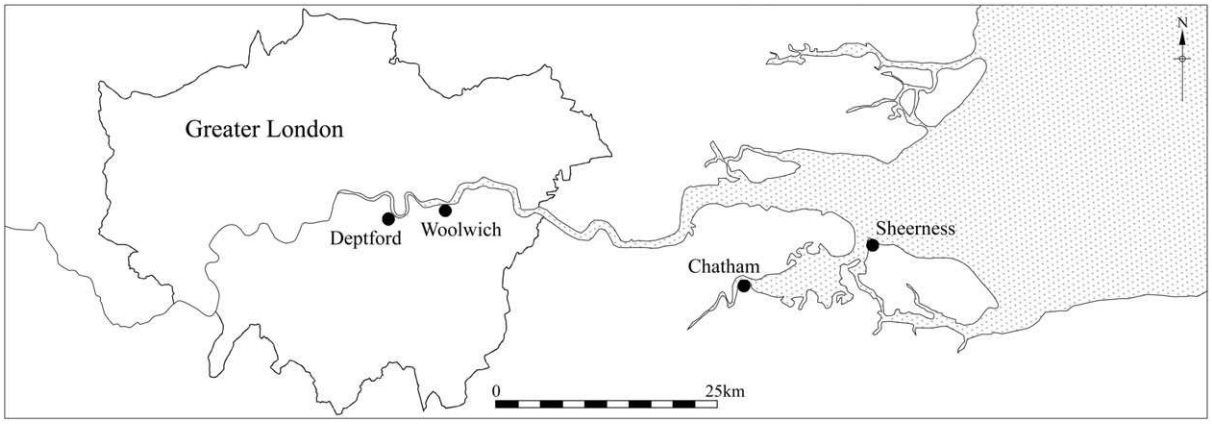

Figure 1. Location of Woolwich and the other Royal Naval Dockyards along the Thames. (PCA Ltd)

dockyard comprised a narrow stretch of foreshore in front of a low cliff on the south side of the estuary, which by the 17th century had been embanked. This confined position was a major factor in the development of the dockyard, where there was a continual need for more space for timber-storage, dry docks, slipways and large buildings. Space was gained by the acquisition of land sideways along the narrow frontage, and by constantly winning land from the river by building revetments and land-filling behind them (Fig. 2).

With a modern eye for the logistical considerations of developing such a facility it is not easy to see why this location was chosen. It was not near a navigable tidal tributary, as was the Deptford Royal Dockyard, and there were clearly going to be problems with the lack of space from the very beginning. Some of the factors involved in its siting will have concerned the presence of the pre-existing naval storage facility, as well as the draught and size of the vessels to be built and repaired. The first vessel to be constructed at Woolwich, rather than at the nearby upstream Royal Naval Dockyard at Deptford (Fig. 1), was the largest naval vessel of its day, the *Henri Grâce a Dieu*. Woolwich's proximity to land-routes linked to necessary resources in the hinterland, such as a trained labour force and the availability and cost of local land, may also have played a role in its location.

Brief history of Woolwich Royal Dockyard

The Woolwich Royal Dockyard is comparatively well supplied with surviving documentary evidence. It was founded during the beginning of Henry VIII's reign in 1512 when naval storehouses were built somewhere on the site, and vessels such as the *Mary Rose* visited. Unfortunately no clear traces of the Tudor dockyard have been found archaeologically. One might guess that it lay hard against the southern boundary of the later yard, where the natural shoreline is likely to have been before extensive land-winning to the north. The Woolwich Yard was one of several royal dockyards founded in the 16th century, which replaced more *ad hoc* shipbuilding centres such as Smallhythe in Kent (Friel, 1995: 52; Milne, 2001). Mud-cut docks of some kind appear to have been added by 1514, and the growing yard was surrounded by a secure pale fence in 1607, which would have helped prevent pilfering of valuable stores. A key feature of this and some other large shipyards, a long 'double dock', was recorded as in use by 1612. In this dock two large ships could be accommodated end-to-end and the water drained out. During the 17th century the dockyard was supplied with many new buildings and the surfaces were partially paved, with areas demarcated for very specific uses such as the 'plank yard', 'galley dock' and 'mast house' listed by master-shipwright Peter Pett in a survey of 1634. Many large warships were constructed here, despite the comparatively cramped site, such as the great *Sovereign of the Seas* rated at 1600 tons, 'a monstrous vessel so called being for burthen, defence and armament the richest that ever spread cloth before the wind' (John Evelyn, *Diary*, July 1641).

The 18th century

The Royal Dockyard and the town of Woolwich both expanded greatly in the 18th century, together with the other large military installation, the Woolwich Royal Arsenal. The dockyard's formal workforce expanded from 511 men in 1712 to 1111 in 1774. The area of the yard was also enlarged and there are specific references to its extension out into the Thames, such as the northward enlargement of the single dry dock to accommodate 1st-rate ships (warships with 100 or more guns). In the 1720s the general frontage was advanced northward and a large new mast-pond dug on the eastern side of the site. Mast-ponds were used to prevent premature drying-out and splitting of softwood timbers.

Four new slips were built in the central part of the yard. Two of these were set very close together, side-by-side, and parts of them were key features of the

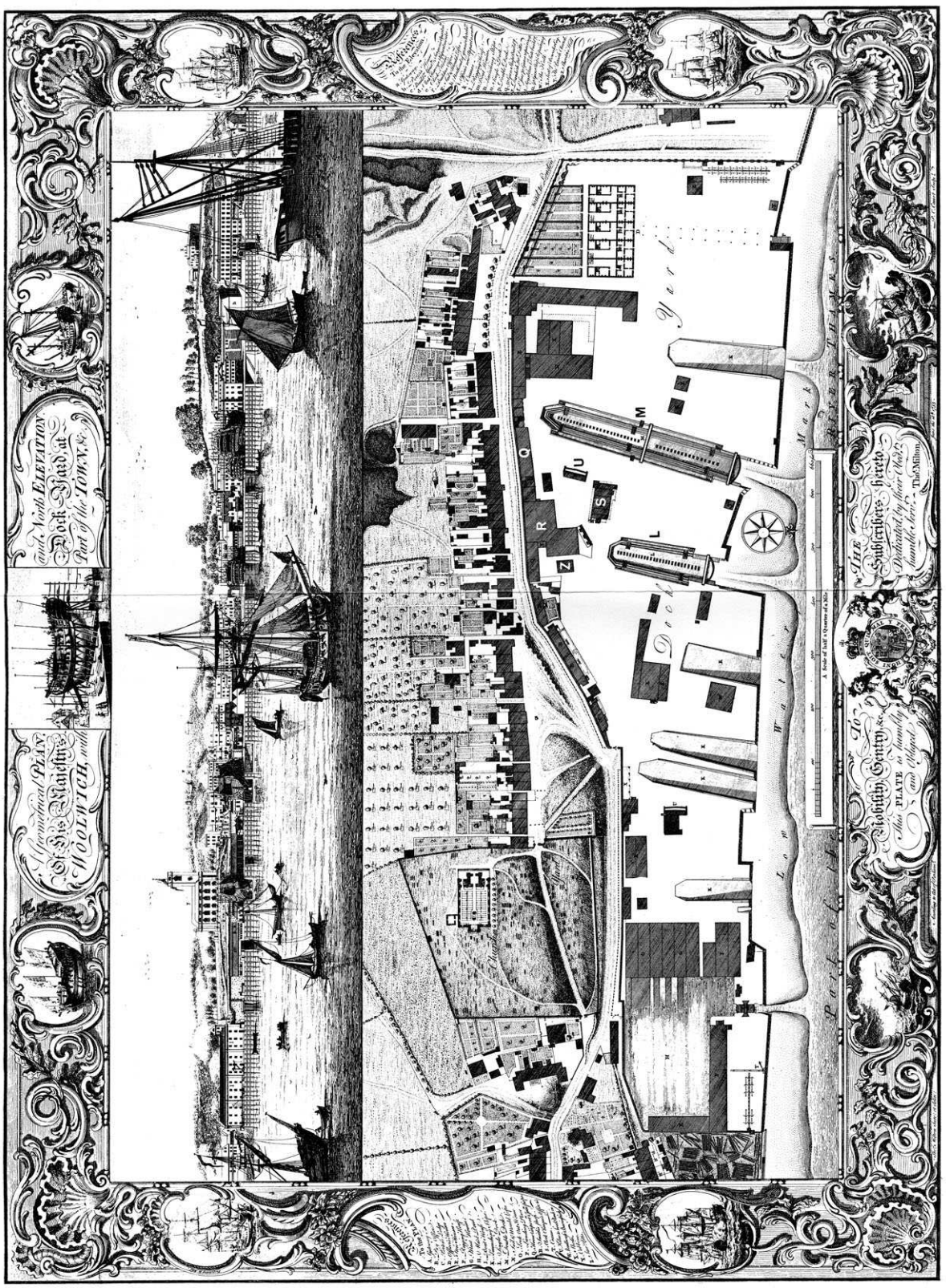

Figure 2. 1753 Milton Plan and Elevation. 'Publsih'd according to Act of Parliament Thos. Milton. June the 18th. 1753'. (reproduced with permission of the Greenwich Heritage Centre)

2004 investigations. Between 1732 and 1746 the wharf frontage running east from these slips was extended northwards again, as were the riverward ends of the paired slips (see below). By this time many of the dockyard buildings had been built or rebuilt in brick, often to very specialised designs to serve particular functions such as bending hull-planking using various forms of heat (see below). The double and single dry docks were also rebuilt in the mid-18th century.

Key historic map evidence

There are many surviving local maps which include the dockyard, and a number of more detailed dockyard-specific plans, elevations and views from the 17th to mid-19th centuries. Here we are concerned with the 18th to mid-19th century sources. Among several 18th-century representations of the yard the map and north elevation of Woolwich Royal Dockyard produced by Thomas Milton in 1753 are the most informative (Fig. 2). These are very detailed and appear to be in fair agreement with other maps as to the key features. The map shows five main building-slips, the single and double docks, mast-pond, major dockyard buildings, ships under construction and even some elements of the timber waterfronts. The north elevation appears to show five vessels under construction or repair. In the double dock a large ship lies inland behind a much smaller vessel. The larger ship would appear to be the 1st-rate *Royal George*. This conforms with the lists of vessels built at the yard at the period of the compilation of the map (Dodds and Moore, 1984: 11). The construction scenes depicted, at a distance, look plausible, as does the structure of the waterfront, but this type of source must still be critically interrogated and may represent a simplified and/or idealized image rather than historical reality.

The 1774 model

A very unusual 3-dimensional historical source for understanding the layout and functioning of the Woolwich Dockyard is the detailed model built in 1774 and presented to George III. The model gives the impression of great accuracy, and is in general accord with the map evidence from the mid-18th century (Figs 3–4). It clearly shows the relatively cramped layout of the yard, with large stacks of different types of timber, some 'sided', some minimally trimmed, jammed in between slipways and the various specialised buildings. Some structural details of the timber waterfronts are also shown in outline, but particulars of the materials used, jointing and fastening are not visible. Ships are shown in various stages of construction from keel laid, to framed-up and near-complete. The model is on display in the London Gallery at the National Maritime Museum in Greenwich, London.

Key developments

The Napoleonic wars exerted pressure for the continued development of the dockyard and town of

Figure 3. 1774 model of Woolwich Dockyard, overview. (© National Maritime Museum, Greenwich, London)

Figure 4. 1774 model of Woolwich Dockyard, detail of excavation area. (© National Maritime Museum, Greenwich, London)

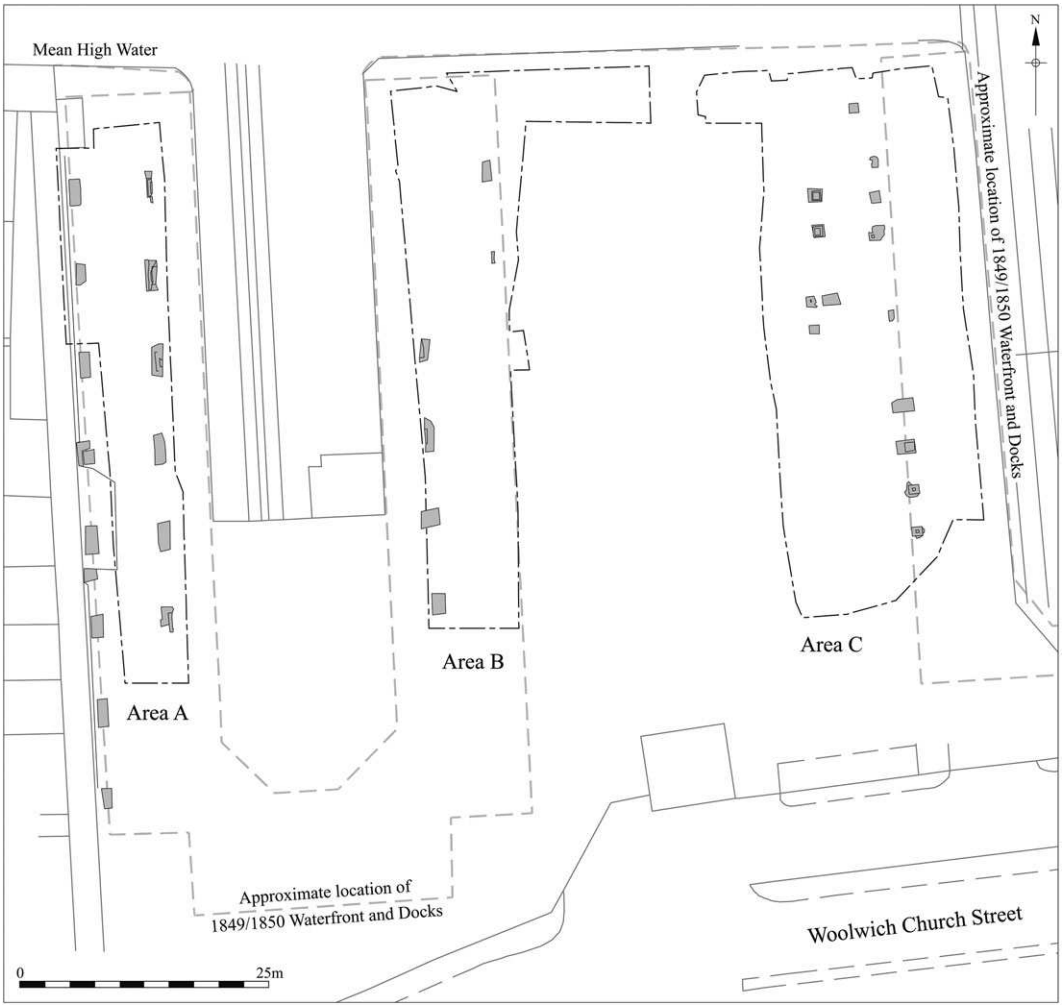

Figure 5. Early-19th-century dockyard features, outline plan of the covered slipway areas. (PCA Ltd)

Woolwich. In 1818 a steam-powered smithy was introduced, and by 1840 a steam-engine factory occupied much of the western end of the yard. The large double dry dock was filled-in in 1834. Despite serious silting problems, building and repair slips were repaired and modified including the roofing of some of them in 1825 (Fig. 5), to reduce weather damage during building and repair. In the 1840s two granite-lined docks were built, and in 1849 the paired slips were infilled and the space occupied by a larger single slip. The last naval ship to be built in the Woolwich Royal Dockyard was the 120-gun *Trafalgar* in 1841. The dockyard finally closed and was sold off in parcels in 1869, and work was transferred to more spacious yards such as those at Chatham and Portsmouth.

Archaeological investigations

In 1972 and 1973 excavations and test-pits were dug at several locations in the dockyard (Fig. 6), the first systematic excavations in a royal dockyard in Britain. As the principal of the project noted, it was surprising that the royal dockyards had not been prioritised for archaeological investigations before, for as a group 'they were the single biggest industry of Great Britain' during the post-medieval period (Courtney, 1974: 3). They consumed vast quantities of diverse materials, not just timber and iron, and employed large labour-forces.

Access to several areas was limited by the presence of standing buildings and foundations and the considerable depth of some historic structures below recently-disturbed ground prevented full excavation, a perennial problem of dockyard investigations. The full range of the surviving historic sources was used to decide where to locate the trenches. From a modern perspective we might suggest that on occasion the existing historical record was used a little uncritically, and names and functions of some structures and areas were taken from historical sources alone rather than being tempered by excavated evidence. However, as the archaeological evidence was described in considerable detail, re-interpretation of some of the structural remains is quite possible.

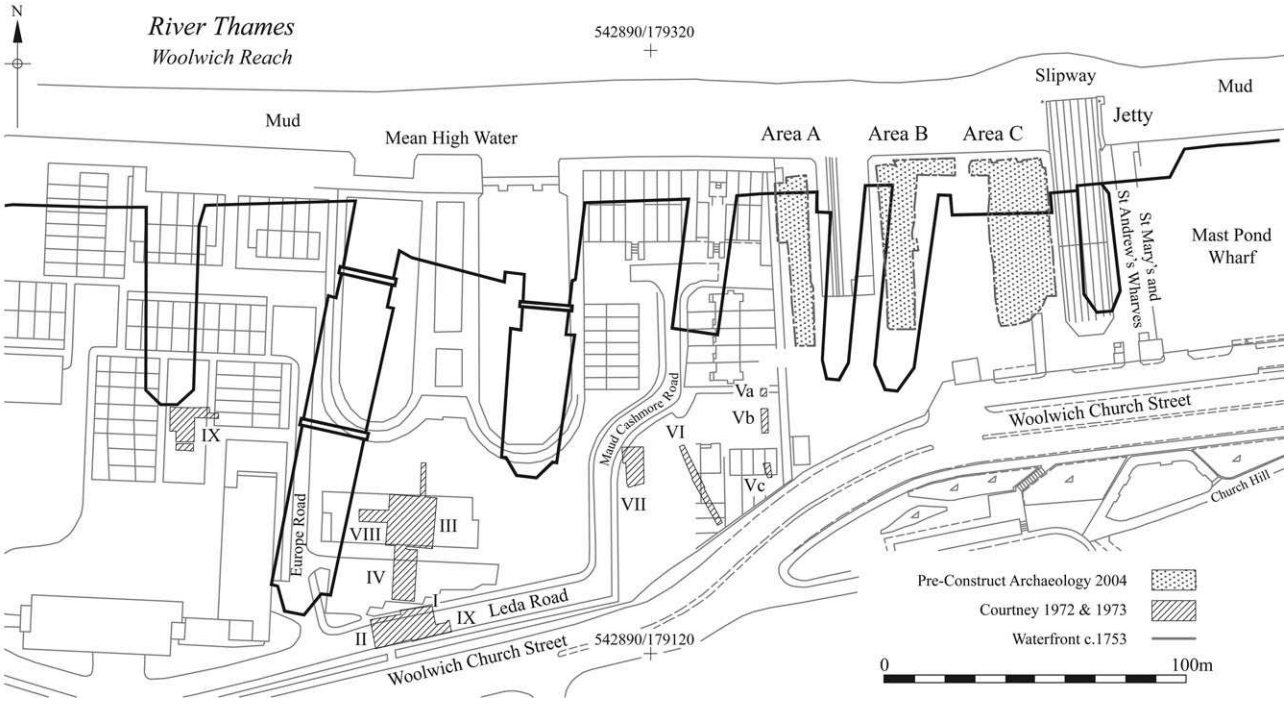

Figure 6. Location plan showing the excavations of Courtney in 1972 and 1973 and Pre-Construct Archaeology in 2004, and the 1753 waterfront. (PCA Ltd)

A particular problem is the multiple phasing of many structures and buildings which lay superimposed but which were presented on the same plan. Another problem is that levels of features encountered, such as working surfaces, were recorded in relation to the then-current ground surfaces rather than in relation to the more consistent national mapping datum level (Ordnance Datum). Many other waterfront archaeologists in the Thames Estuary region have recorded levels to this standard datum since the mid 1970s, which has enabled the close tracking of changing relative sea-levels and tidal regimes for most periods for the region (Milne and Milne, 1982: 60; Brigham, 1990: 143; Heard and Goodburn, 2003: 48; Divers 2004: 53).

The project involved a mix of professional and volunteer archaeologists and was led by T. W. Courtney who, together with some additional specialists in materials identification and conservation, very rapidly produced published reports (1974; 1975). The dating of the structural remains and stratigraphy encountered was achieved by reference to historic-plan evidence and associated tobacco pipes and pottery. The earliest features were dated to the 17th century but the bulk were of 18th to mid-19th century date.

Structural remains and finds

The present paper is primarily concerned with features directly related to shipbuilding and -repair, and the more domestic and commonplace structural remains such as drains and cess-pits for dockyard buildings excavated in the 1972 and 1973 campaigns are not further detailed here. Courtney and his team exposed and recorded a range of specialised dockyard structures, parts of a building slip and the edge of a known double dry dock, changing forms of saw-pits, pitch-heating houses, roofed plank-bending kilns, and foundations of both a mast-house and a store for large beams and other smaller structures. Evidence for the levelling and raising of the yard surfaces was also found, and even the wheel-ruts of vehicles were uncovered.

The westernmost slipway

In Cutting IX a sample section of the landward end of the westernmost shipbuilding slipway was examined and several phases of construction were found to have survived (Courtney, 1974: 20). The limited finds suggested a date-range from the mid-18th to the mid-19th centuries. As the landward end of the slipway was highest, waterlogging was not complete and the timber sides of the slip were totally decayed. However, the partially-decayed timber support-beams for the base of the slip had survived. The excavators expected to find lines of keel-blocks as depicted in typical dockyard illustrations, but these were absent. Each phase they revealed had been partially dismantled, with the basal lining-planking and any overlying keel-blocks having been removed for re-use or fuel.

The principal surviving elements were decayed east-west beams in the early phases, together with large spikes and bars of wrought iron (Fig. 7a). Some of the

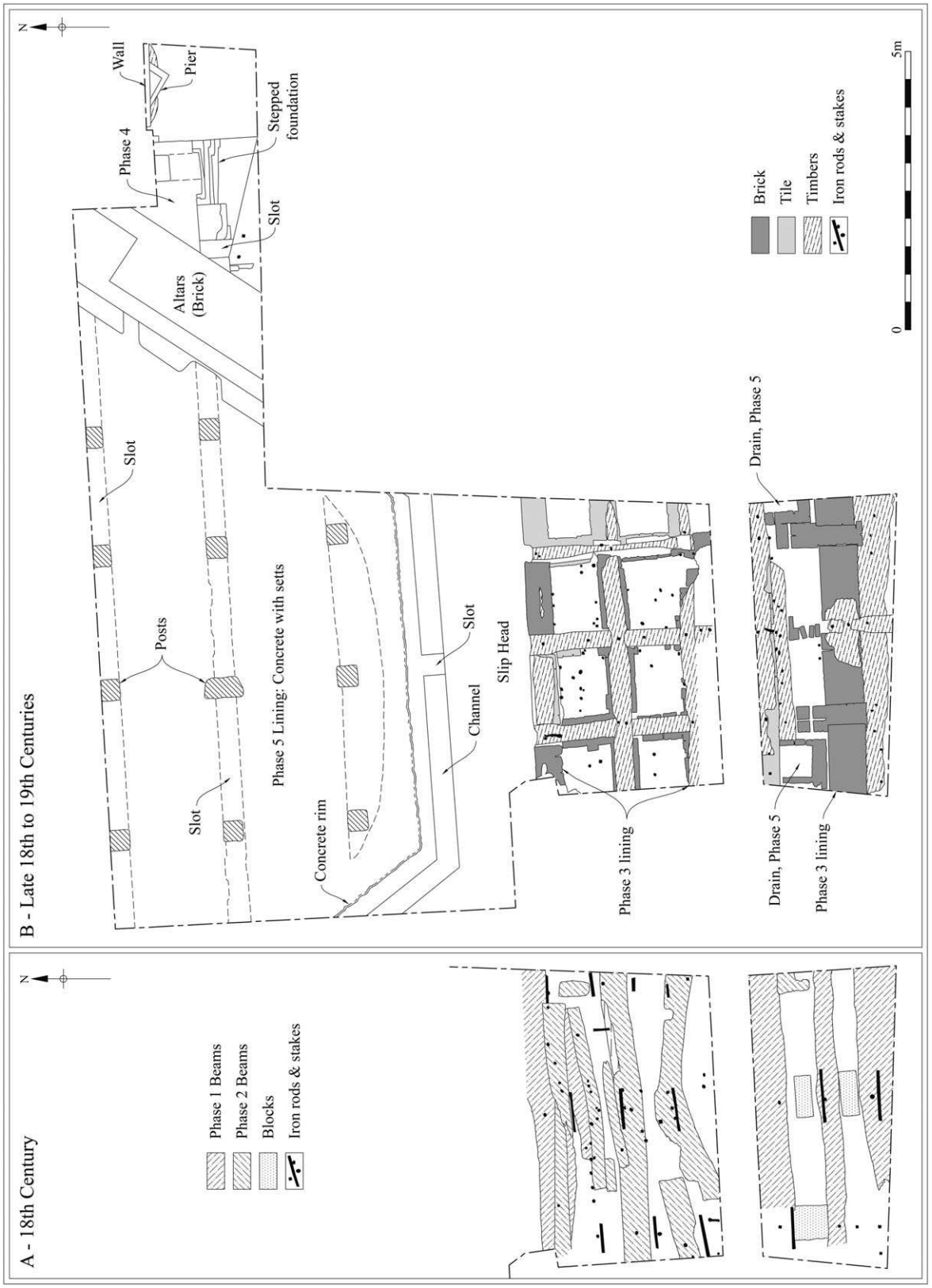

Figure 7. Features exposed by Courtney. A. Phase 1 and 2 slip linings exposed in Cutting IX. B. Phase 3 slip lining exposed in Cutting IX. (from Courtney, 1974: 4–5)

large spikes pierced the underlying compacted natural sands and appear to have helped to anchor the joist-like beams. The beams varied in size, were up to *c*.0.5 m wide and had been set between 0.1 and 0.3 m apart. Other spikes were probably displaced from rotten lining-planking during demolition phases. Some of the larger wood elements were identified as oak and it is also clear from their curving, notched shape that some were re-used ship-timbers (see centre of Fig. 7a, a strongly-curved beam, f.1157, with various housings—a probable rider). The re-use of large ship-timbers and dockyard rough-outs in slipway construction is known from the excavation of other slipways. Examples of similar date were found recently in a private shipyard at Deptford (Divers *et al.*, 2004: 52) and, in the Netherlands, at a late-17th-century shipyard in the Zaandam area (Gawronski, 2003: 138).

In the latest surviving phases of the slipway-base a complex grid-work of east-west and north-south beams was found, which was in turn set on low, loosely mortared brick dwarf walls. The rough 1-m-square spaces between the support-beams were filled with sandy material. It would appear that this was an attempt to render the base of the slipway more free-draining.

Traces of the double dry-dock

A small machine trial-trench was dug to locate and examine the construction of the eastern edge of the double dock, and the edge of the cut for the dock was indeed found, but little survived of the lining. Some displaced decayed oak timbers were noted in the fill but no coherent structure was found (Courtney, 1975: 75), nor any sign of the stepped sides, or 'altars' of the dry dock. Clearly extensive decay and deliberate demolition had taken place before it was filled in.

The sawpits

Recent studies of the re-used ship-timbers and rough-outs found on several east-London sites indicate that pit-sawing timber for conversion and sometimes shaping gradually became more common from the early-16th century onwards (Goodburn, 1999; Heard and Goodburn, 2003: 45). By the 18th century in south-east England all the planks and boards, and a great many of the large beams, frame-elements and knees were largely cut to thickness ('sided') and even partially shaped by pit-sawing, although other methods were used in different parts of the world. Pit-sawing involves sawing lengthwise along a marked log or baulk with a large open saw operated by at least two people, one above the timber, one (or more) below. So the installations used for this form of manual sawing would have been essential features of any shipyard, with 22 historically known in the Woolwich Dockyard by 1772. Manual sawing of timber persisted later in Britain than in many other industrialised states, and was common into the early-20th century for some types of work with native timbers (Edlin, 1949: 16).

Courtney's team recorded the plans of several sawpits in the area of the late-17th-century Clock House/Mould Loft (Courtney, 1975: 53). The sequence appears to date from the very end of the 17th century to the mid-18th. The earlier examples were lined with planks retained by squared, earth-fast posts, a relatively intact example (F.416) was rectangular, *c*.5.5 m long and 1.8 m wide and had an estimated original depth of *c*.2 m (Fig. 7b). The lack of durability of the timber lining in the damp soil was clearly a problem, and by the later-18th century the timber-lined group had been replaced by slightly-longer brick-lined examples (F.432). Two niches survived in the walls of this pit on either side, which could have been used for holding a candle to illuminate guidelines on gloomy days, and also oils for the saw, and drink for the always-thirsty bottom sawyer.

Some other specialised structures

The truncated brick and sometimes timber foundations of a number of other specialised structures were found during the project, which are not further listed or described here. However, two categories of specialised facilities stand out as worth noting—installations for heating pitch to make it softer and more adhesive, and varied buildings used to heat heavy man-of-war planking for bending. During the 18th century the direct application of flames and water to bend ship-planking was gradually replaced in royal dockyards by steaming or boiling systems. In trench IV the foundations and cobble traces and parts of two hearths for a timber-steaming kiln were located (Courtney, 1975: 59). Although much disturbed by mid-19th century works, the overall dimensions of the structure could be estimated as *c*.14.8 m long by 5.64 m wide. This was one of several documented plank-bending houses in the yard. It was presumably necessary to have the installations spread around in the yard close to individual building areas, as the thick planks had to be quickly bent in place while still piping hot.

Towards the southern boundary of the site several phases of an 18th-century brick pitch-house were exposed, where traces of pitch, resin and caulking materials lay in rubbish deposits. Historic plans show that although adjacent workshops were of timber, the pitch-house was of brick due to the fire risk. Flues, ducting and foundations for three tall chimneys for the large pitch-vessels were found preserved well enough to see that surviving mid-18th plans for the proposed pitch-house had not been followed, or had been amended in several respects (Courtney, 1975: 66).

Key finds

A very unusual category of ship-related material uncovered during the excavations was layers of dumped mica. The type found was identified as 'Muscovy Mica' (Courtney, 1975: 49). It comprises a laminated more-or-less clear mineral material that was split and used in small panes like a form of glass. Mica

was used in the British navy for ships' lanterns and glazing until replaced with glass in the early-18th century. The Woolwich mica was found as fragments and as complete panes mainly of rhomboid shape measuring up to 20 cm long, and its deposition appears to have taken place between *c*.1680 and 1720.

Other diagnostic dockyard finds included very large wrought-iron spikes, and clenched drift-bolts from woodwork and shipbuilding debris. At least two typical shipyard tools were also found, including a large socketed triangular iron scraper for cleaning hulls prior to recoating with tar or paint finishes. A broken-eyed shell-auger measuring 25 mm (1″) in diameter and over 700 mm long was also found (Courtney, 1975: 81). This would have been used for boring long holes for treenails and bolts.

The 2004 fieldwork

New building works involving deep excavation in what had once been the central part of Woolwich dockyard clearly required archaeological monitoring. A strategy was developed by CgMs Consulting and approved by English Heritage for a targeted watching-brief. This entailed rapid recording of structural remains exposed during the building ground-works phase and the salvage of historic woodwork where possible, for later more detailed recording and sampling, with limited opportunities for finds retrieval. Often depth and safety restrictions limited the areas of the structures which could be investigated and recorded *in situ*. Late-19th and 20th-century building works and decay had also truncated many of the earlier structures.

The site work was undertaken by Pre-Construct Archaeology, led by S. Holden (Holden, Wragg and Meddens, 2005). Of the timber sampled and recorded a large representative sample was drawn and photographed following recommendations outlined in the guidelines of the Museum of London and English Heritage (Spence, 1990; Brunning, 1996). The site archive will be deposited with the Museum of London, London Archaeological Archive Research Centre (LAARC), under site code CRQ 04, where it can be consulted in due course. All the significant structures encountered appear to belong to the 18th and 19th centuries and here we are principally concerned with the evidence for these periods. The watching-brief areas were coded A, B, and C running from west to east (Figs 6 and 8).

Wood identification and dating

The vast bulk of the timber was of oak (White oak/Northern European oak, *Quercus sp*. probably *Q. robur* or *Q. petrea*) with a small amount of elm (*Ulmus sp.*) and a little softwood, probably a type of pine. In practice the key deciduous species groups cannot be botanically identified closely to species, so experienced visual identification of clean timber is adequate, backed up by tree-ring samples as a check if required.

The great majority of the oak was very fast grown, with few annual rings, as is typical of most British lowland oak since the 13th century. Only nine timbers appeared to have suitable sequences for tree–ring dating, stopping near to or including sapwood and with *c*.50 or more annual rings. All proved to derive from fast-grown oak, with some showing extreme growth-retardation phases. Several were of quite distorted trees, typical of 17th-19th-century English woodland-management systems. The limited sourcing data currently available suggests an origin north of London, possibly from the Midlands region. All of these samples were of oak and only one turned out to be datable (sample 480 of context [480]) with a sequence of 151 rings and a heartwood/sapwood boundary. This dated to AD 1576–1726; allowing for missing sapwood this produces a likely felling date of 1736–72 (Tyers, 2006). No items of tropical hardwood were salvaged, although teak and *lignum vitae* have been found on other London shipyard sites from *c*.1800 and might have been expected from the early-19th-century contexts at the Woolwich Dockyard (Goodburn, 2003: 202).

Key structural sequence, Area B

The significant structural remains uncovered in Area B were substantial sections of two phases of Georgian timber walls of the paired building slips in the centre of the yard. They included the east-west river-facing end walls and parts of the north-south slip wall of the easternmost of the paired slips (Slip No. 3 on the 1778 plan, PRO ADM140/1135). They also include some land-tie assemblies, and comprise structures [152] and [213]. These demonstrate land-winning from the Thames to the north for the extension of the paired slips (Fig. 8). The earliest recorded timber revetment structure [213] ran east-west for *c*.2.3 m and included the corner-post of the easternmost north-south slipway wall of Slip No. 3 at the east end. The revetment was battered, a feature which is known from the 17th century onwards in dock- and river-walls on the Thames (Goodburn, 2003; Divers *et al.*, 2004: 8). Earlier examples were built with vertical revetments.

Based on the woodwork technology alone we would suggest a 17th to early-19th century range, which is an unhelpfully long period. The modifications to the dockyard, which included the building of this river-wall, were probably those taking place in *c*.1720, which saw the construction of Slips Nos 1, 2, 3 and 4, as well as the reclaiming of a considerable section of land and the digging of the mast-pond (Courtney, 1974: 16, 21). These works are shown on a plan dated to 1732 (NMM ADM/Y/W/8). Due to depth restrictions the structure could not be fully exposed, so it is uncertain whether the uprights were driven piles or posts set in a sill-beam, although the latter seems most likely. Clearly the assembly of the prefabricated structure must have

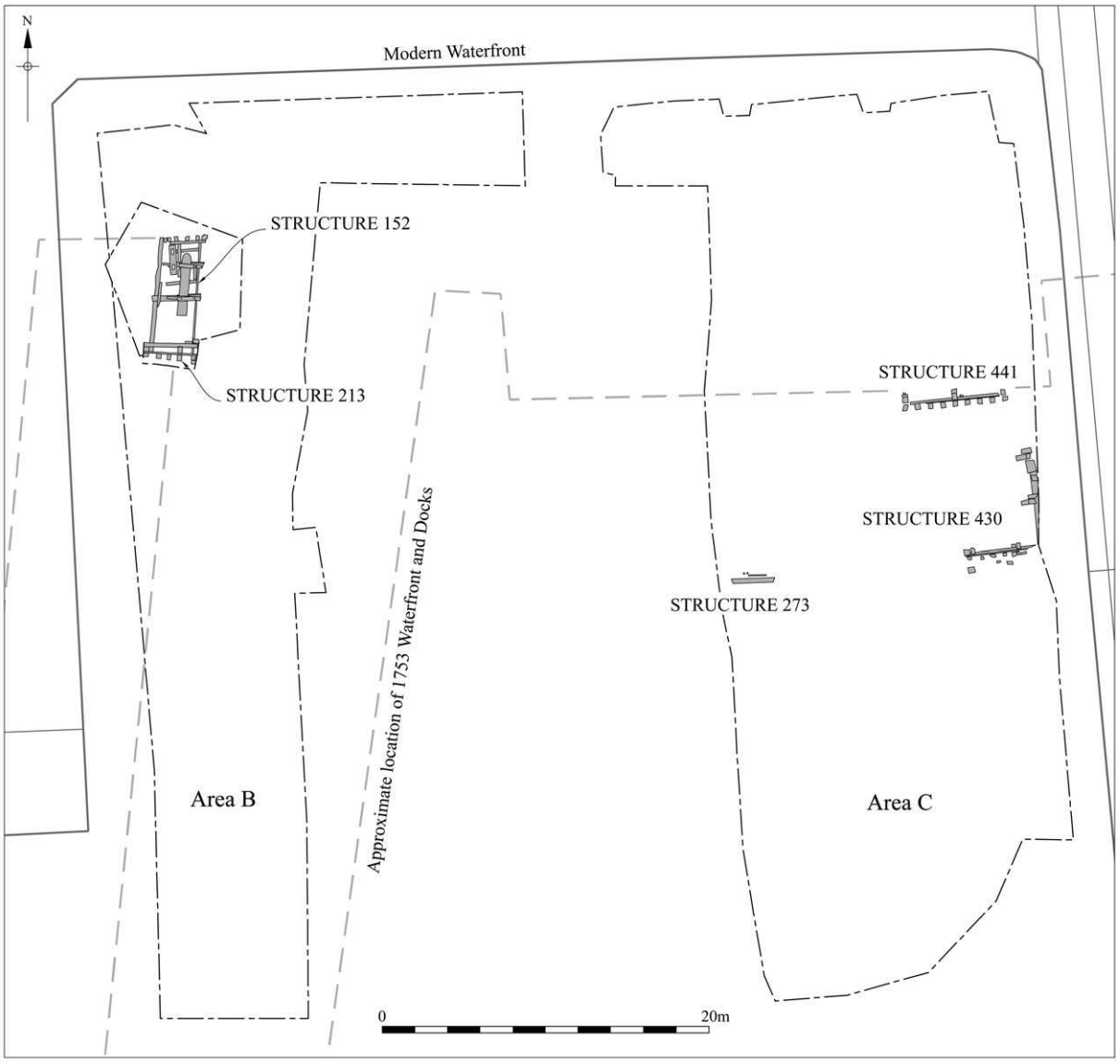

Figure 8. CRQ 2004 watching brief plans. Area plans with dockyard boundaries etc., with main structures in areas B and C, Str. [213]. (PCA Ltd)

taken place at low spring tides to maximise accessibility to the river from the slip. The total height recorded was *c*.1.7 m to the worn, rounded post-tops.

The main revetment posts varied a little in dimension and were *c*.0.25–0.3 m by 0.3–0.35 m in cross-section, and set on 0.7-m centres (Fig. 8). The plank-sheathing was set on edge and fastened to the riverward side of the posts with large square-section iron spikes with shanks up to 20 mm square. The plank-sheathing was also very substantial, 0.1 m thick and 0.45–0.5 m wide. The lifted elements demonstrated that its construction was predominantly in oak. Similar rectangular-section uprights were set at *c*.2.1 m centres in front of the plank-sheathing as rubbing-posts to strengthen the pier-like finger of land between the paired slips. It is probable these were piles rather than posts. This area must have been vulnerable when the large ships were being launched and brought in for repair. None of the timber elements showed clear signs of being recycled, as was often the case in waterfront structures.

The building of structure [152] to the north of structure [213] pushed the frontage out over the tidal foreshore a further 7 m. The construction appeared similar to that of [213] and rebated oak post [194] (Fig. 9), from the north-east corner of the structure, had a tenoned base, cut to fit a sill allowing for a slight batter in both directions. The regularity of the positioning of the rectangular-section posts also suggests that they were jointed into a sill-beam. The rebates are likely to have been cut to house the planking that may have been stripped off during a later phase of remodelling.

Figure 9. Timbers lifted from Str. [152], double rebated corner post [194]. (PCA Ltd)

The land behind the timber frontages was formed from a dense grid of re-used and off-cut beams (Fig. 8) packed with clay and chalk. The grid-work of beams was presumably required because the use of heavy scaffold posts, windlasses, capstans and shores would have applied considerable forces at times, in addition to the normal land-fill pressures.

Nineteen timbers from structure [152] could be salvaged, of which some key timbers are discussed below. Many of these were clearly re-used and this practice appears to have been particularly prevalent in the royal dockyards, fresh timber being an expensive commodity and used timber often becoming available from vessels being broken up. A letter from Sheerness Dockyard, dated 5 March 1753, describes in detail the timbers acquired from 70-gun ships for the construction of a new wharf, including gun-deck beams, upper-deck beams, forecastle beams and planks of 3 or 4 inches (Atkinson, 2007: 64).

Timber management and dating evidence

A single dendrochronology date was obtained from a timber off-cut [480], recovered from the vicinity of structure [152], indicative of a felling-date of between 1732 and 1772. A further two oak beam off-cuts were found among the timbers of [152] which bore inscribed numbers which appear to be dates. Timber [136] bore marks along its side made using a rase knife (Fig. 10 II) while timber [180] was marked on the end-grain using a die-stamp and also along its side with a rase knife

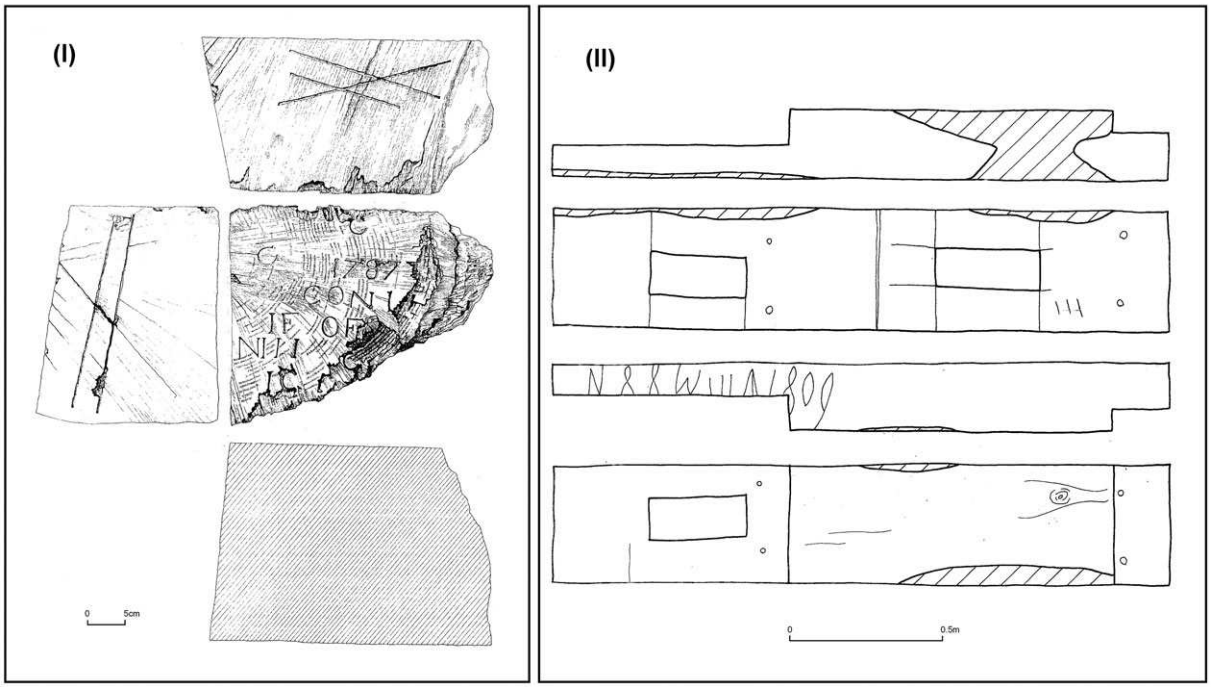

Figure 10. I. Rase markings on timber I) from [152] [180] end stamp. II. Rase markings on timber II) [136] side rase markings. (PCA Ltd)

(Fig. 10 I). In-depth study of timber-marks from the Royal Naval Dockyards is a relatively new exercise. Atkinson (2007) has produced a body of research on timber-markings from HMS *Victory* and HMS *Unicorn* (launched at Chatham in 1824) (Atkinson 2007: 213), a large group of timbers found re-used in dockyard buildings in Chatham, and in the Master Shipwright's House in Deptford and, together with documentary evidence, these have begun to unravel the evidence. This pioneering work has enabled an initial interpretation to be made for the marks found on timbers from Woolwich.

The management of timber in the dockyards was vital to ensure that there was an adequate supply available. Supply contracts were fulfilled, wastage was kept to a minimum, and loss of material through misappropriation was minimised. Various systems of control were implemented, revised and reformed from the mid-18th century onwards. Purveyors were sent to the royal and private forests to acquire timber to restock the dockyard stores. The selected timbers were assigned 'progressive' numbers in order to identify them within the report prepared and sent to the Navy Board detailing the particulars (dimensions, species) of each. The felled timbers were marked with the progressive number stamped in the end-grain or, if the tree was still standing, the number was placed on the claw of the root. By doing this, each timber could be checked against the contract on receipt at the yard. A Standing Order issued by the Navy Board (No. 408, 13 May 1751) states 'that the initial letters of each contractor's name be stamped on every piece of timber received from them and also the date of the year in which the same shall be received'.

Timber [180] (Fig. 9 I) was stamped with the Arabic numerals '1787' which could represent either the progressive number or, more likely, the date it was received. A further four lines of text are also present, reading 'CON I4', 'IF OF6', 'NIII' and 'IC'. The impressions measure 26 mm high by 21 wide. The 'N' characters may represent 'Z's on their sides. The letter C is stamped a further four times around the end-grain of the timber and probably indicates that the timber was received at Chatham. NIII may refer to No. 3, with the remaining groups of letters representing the initials of those receiving, checking and measuring the timber. Along the side of this timber towards the stamped end are further rase-marks for 20 in Roman numerals and three scores-crossed-through symbols which have also been recorded on the *Unicorn* (Atkinson, 2007: 219–20, 226, fig. 9.6) and in the wheelwright's shop at Chatham (Atkinson, 2007: 147).

Along the side of timber [136], a sequence of rase-marks was observed which had been partially cut away in forming a halved joint (Fig. 10 II). The truncated measurements of the marks ranged from 76 to 165 mm and, if extrapolated, could have been 80 and 220 mm in their original state. They appear to read: N 88 W III ↑ 1809 (where ↑ represents the Admiralty broad arrow or crow's foot). Given the interpretation of similar markings found on timbers at Chatham Dockyard, it is likely that these represent '[timber] N[o.] 88, received at

W[oolwich] [measuring] III (3) [cubic ft] ↑ [belonging to the Admiralty in] 1809'. The order of the information is, however, slightly different from that observed at Chatham. On one face of the timber, scores can be seen which provided guidelines for the cutting of the mortise. Adjacent to one of these is a 3 marked in Roman numerals. These markings are all related to the use of the timber as a structural element within the dockside, and are those of the House Carpenter, rather than being from potentially earlier use of the timber within a ship.

Assuming that the numbers 1787 and 1809 do represent dates, then they provide a *terminus post quem* of shortly after 1809 for this construction activity at the site, which would therefore be associated with the Napoleonic wars. Both timbers were recovered from above the level of the top of the frontage posts of [152] and are likely to have been part of superficial structures such as capstans, cranes and windlasses which would have been modified more frequently than the slip structures themselves. Cartographic evidence indicates that the majority of the frontage was extended in the period 1746–53, which is likely to be represented in the archaeological record by [152]. Although further extension occurred in the early 1770s, it appears that the pier between the slips remained unchanged. This feature is also shown in the dockyard model of 1774.

Key structures, Area C

Another two phases of substantial timber river-walls were uncovered in the eastern area comprising structures [430] and [441]. A brief window on site allowed access to east-west and north-south revetment [430], the earlier structure of the two. It was exposed to a depth of four courses of sheathing-planking, which were fastened to the riverward side of the uprights. Iron spikes were seen where the planking could be cleaned well enough. In this case both the plank-sheathing and some of the uprights showed clear signs of being recycled ships' timbers. The planking was pierced with redundant oak treenails and had some thin graving-pieces ('Dutchmen', patched repairs). The treenails were 38 mm ($1^1/_2''$) or greater in diameter, clearly implying that the planking derived from a large carvel-built vessel. Many of the uprights also had redundant treenails. Some of the main timbers were found to retain their original 'ship' curves in one plane (for example timbers [466] and [415]). Widely-spaced rubbing-posts were placed on the water side of the frontage and the heads of some form of land tie-beam lay next to them and were probably fastened to them. Several timbers from this structure were later lifted by machine and could be examined in more detail. The most diagnostic fragment was a section of mortised oak sill-beam re-cut from a carvel ship-frame timber and then finally re-used as a tenoned post (timber [466]) (Fig. 11 I).

The location of revetment [430] and its alignment with further timber elements observed on the west side of Area C comprising horizontal timbers [273] and [390] separated by vertical uprights [351], [352] and [353], suggests that they were all part of the same east-west running river-wall, which was built *c*.1720, and therefore contemporary with structure [213], the first phase of the pier-like finger between the slipways and found in Area B.

Timber frontage structure [441]

Subsequently, the later frontage structure [441] was constructed northward over the tidal foreshore, resulting in an additional area of yard space on the eastern side, amounting to *c*.835 m^2. Approximately 6.2 m of this east-west frontage was recorded in some detail (Fig. 12). The general layout was similar to that described for structure [430], with substantial plank-sheathing laid on edge and fastened to the riverward side of large posts *c*.0.3 m wide set on 0.8-m centres. In front of the sheathing were similar-sized rubbing-posts, which in some cases were pieced with large iron tie-bolts. Judging from evidence from other post-medieval waterfront sites in east London, the tie-bolts would have had a strap section beyond the post, stapled to the side of a land tie-beam (Heard and Goodburn, 2003: 35). This practice avoided cutting a complex joint between the land tie-beam and post as was typical in late-medieval practice.

Although some important details, such as the species of timber used for the different elements, could not be recorded given the conditions, the detailed elevation shows several key features of interest. The plank-sheathing was closely scribed to fit out planks of different widths and shapes, forming stepped courses a little like those of an 'anchor stock whale' used in many 18th-century naval craft. The sheathing was also secured with treenails, usually two to a post. No clear signs of previous use were noted in these timbers, in contrast to those observed in the earlier phase of timber walling in structure [430]. This structure is on the correct alignment to be of the same date as the extension to the pier-like finger between the slipways in Area B, structure [152], as visible on Barker's plan of 1749 and the plan and elevation by Thomas Milton dated 1753.

Selected mid-19th-century features

Roof structures covering the slips and docks were introduced in the 19th century to protect ship's timbers from the weather. Initially, from 1814, these were constructed in wood, such as the example covering No. 3 slip at Chatham. During the early 1840s the emphasis moved towards iron (Sutherland, 1989). The two 18th-century slips to the western side of the 2004 excavations were remodelled in the period 1838–49 and replaced with a single slip, as shown on the 1849 plan, which also suggests that the (now two) slips were

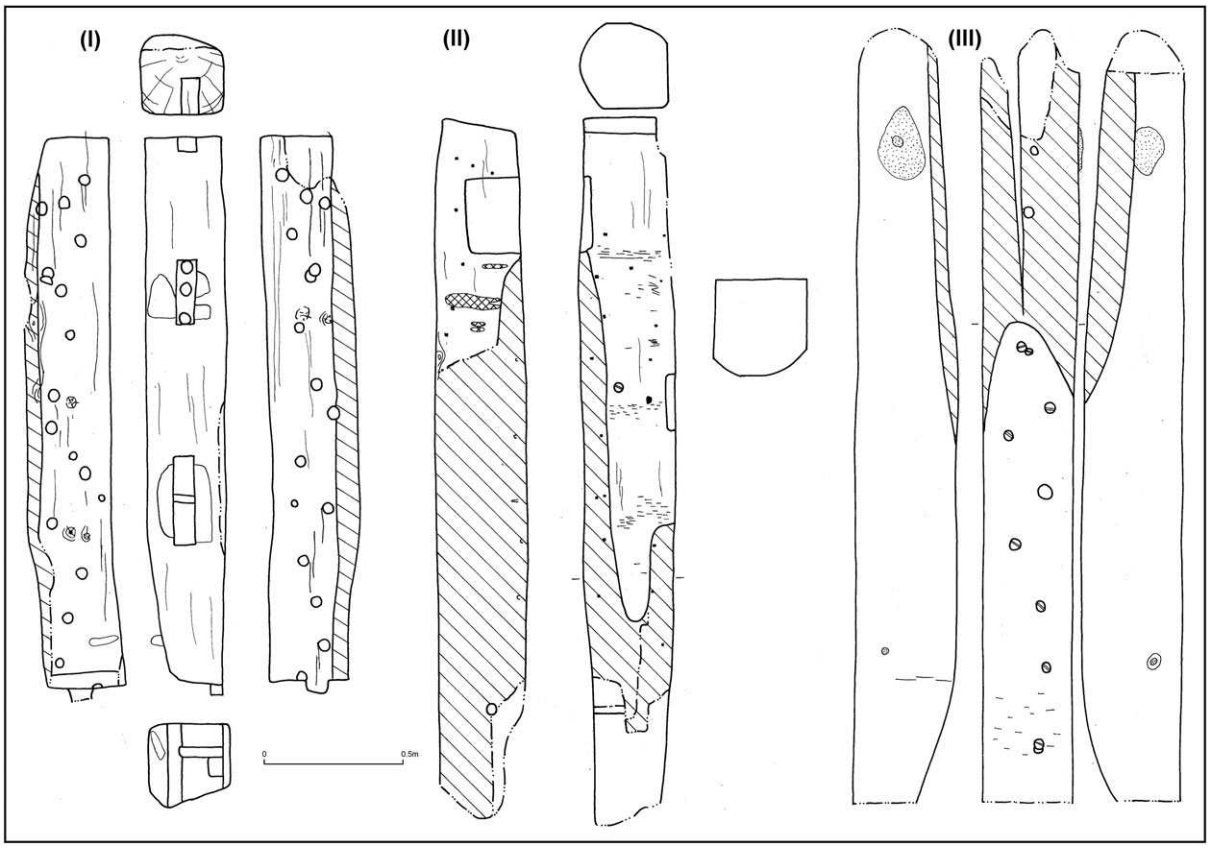

Figure 11. Selected recycled timbers from Str. [430]. I. carvel ship-frame timber re-used twice [466]; II. carvel ship-frame timber [415] re-used as a post in Str. [430]. III. a re-used ship deck-beam [468]. (PCA Ltd)

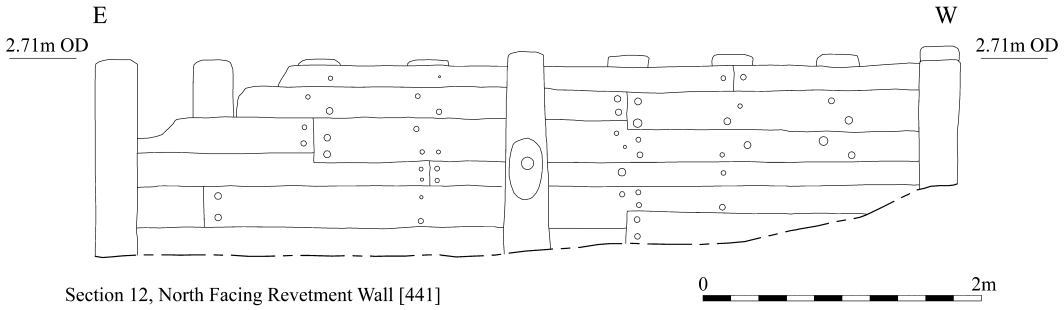

Figure 12. Elevation of timber wall Structure [441]. (PCA Ltd)

covered, a dashed line representing the footprint of the cover. Artworks held by the National Maritime Museum depicting the launch of the *Thunderer* in 1831 and the *Trafalgar* in 1841 show a pair of covered slips, although as the dates of these launches span that of the remodelling, it is likely that the slips are the pair at the western end of the dockyard. The plan of 1849 indicates the positions of the vertical stanchions which supported the enormous roofs, and these locations correspond with pier-bases exposed during the archaeological investigations. Within Area B, these piers comprised foundations of brick and concrete, which were supported by timber piles. A number of these piles were lifted and recorded. They included rebated oak posts which must have derived from earlier river or dock-walls, and what appeared to have been new oak piles with iron shoes. Pile [170] was fitted with an iron shoe and at the top had been cut to form a tenon with a part-bored hole. It was a half-log section 0.40 m by 0.22 mm by 3.55 m long, mainly cut out by pit-sawing.

Relating the various sources

A general point which can be made is that the while the evidence such as Milton's map and elevation of 1753 and the model of 1774 do provide an overview of the

general layout of the yard, many key details of the dock and river-walls and features internal to the buildings, are not shown. Such sources cannot indicate features such as the extensive use of second-hand materials and shipyard off-cuts in the timber walls, and features such as sawpits set under cover. We must acknowledge that much of this detail would have been difficult to indicate in any case, because of the scale of the representations. However, it is also possible that the reality of the rougher appearance of the frontages such as structure [430], made with second-hand timber, might have given a less impressive view of the royal yard than the naval patrons would have wanted to project to the king, whom they wanted to enthuse and impress by use of the dockyard model.

The approach to waterfront carpentry

It is possible to make some comparative generalisations about the quality, form and scale of the timber dock- and river-walls exposed during the 2004 work. The typical post-medieval pattern of fastening the sheathing-planking on the riverward rather than landward faces of the revetment posts was systematically followed at Woolwich. In comparison with timber river-walls and quay-frontages of the medieval period in the earlier port of the City of London, the timbers used at Woolwich Dockyard were proportionally larger, both the posts and the plank-sheathing. The land-tie assemblies and rubbing-posts were also large and often strongly secured with iron tie-bolts at key points, a feature unknown in medieval work. This use of iron strapping to replace earlier complex jointing is known archaeologically surprisingly early in the London region. The earliest use documented so far is in the 1580s just east of the City at Limehouse (Goodburn, 2001). However, the fact that these wrought-iron tie-straps were often salvaged after many years' use shows that they were costly, worth recycling, and not always so worn out that they were completely discarded.

By contrast, some attempts to save on expenditure are indicated by characteristics of the timber used in some structures. Some of the planks and beams used were rather irregular in shape or somewhat curved, being original second-hand ship-framing or shipyard off-cuts. Despite this the skilled carpenters (and/or shipwrights?) who did the work were able to lay out and scribe-fit such timbers closely. They created strong, durable and regular structures capable of resisting impacts from large ships and pressures and wear from work to shore up such massive vessels. Most other types of structures on the Thames, such as commercial wharf and dock frontages and river-walls did not have to resist quite the same range of use-pressures, as most of the craft used alongside were much smaller river-barges and coasters. This is shown in the comparatively much more lightly-built timber frontages found at sites like Adlard's Wharf, which was a boat and barge repair-yard rather than a shipyard (Divers, 2002). Similarly irregular, roughed-out, second-hand and off-cut timbers were also much in evidence at the large private shipyard investigated at the Stowage, Deptford (Divers *et al.*, 2004: 72), so such recycling cannot be isolated as a peculiarly naval practice.

In terms of the range of timber used, there are some contrasts with other broadly-contemporary and slightly-earlier shipyard sites in the region. A key surprise is that there was little evidence found for the use of large, relatively cheaper softwood timber, which was being imported in large quantities into London from northern Europe, and even North America, from the end of the 17th century. Such material was used almost exclusively in the timber dry dock of just before 1800 investigated at Pier Head on the Isle of Dogs (Pitt *et al*, 2003). On other Thames-estuary shipyard sites such as Bellamy's Wharf and Pacific Wharf in Rotherhithe, of slightly earlier date, the new softwood raw materials were mixed with native timbers such as oak and elm, and were mainly used for plank-sheathing and where long beams were needed (Saxby and Goodburn, 1998; Heard and Goodburn, 2003). This general pattern of mixed species use can also be seen in some London building carpentry from as early as the 1680s, as in the surviving Middle Temple Gatehouse of 1683.

Examples of recycled large ship-timbers

Space does not permit a full description of all the recycled timbers found, which in any case exhibit considerable repetition, but records will be available in the archive deposited with LAARC. The various categories of recycled timbers present were characterised by variations in shape and types of fastenings, such as redundant oak treenails, and jointing. Large carvel ship frame-timbers, carvel ship-planking, oak deck-beam fragments, part of a clench-bolted anchor-stock of oak and elm, shipyard off-cuts of oak, and short jointed timbers of oak and softwood, of uncertain function, were all identified. Three particularly interesting examples are discussed in more detail below.

Timber [466] was a section of carvel ship framing re-used as a sill-beam and then finally a post in a timber-framed revetment [430] (Fig. 11 I). The timber had been hewn from a whole, slightly-curved, oak log to dimensions of *c*.0.28 m sided and 0.30 m moulded, and it had a recut length of 2.03 m but had clearly been longer in its ship use. Some of the natural edge of the parent log or 'wane' had been left on, with a considerable amount of sapwood. The parent log was cut from a modest-sized oak or a large limb of a large oak. The closely-spaced treenails were of two diameters, about 38 and 25 mm ($1^1/_2$″ and 1″), which with the scantling would fit an origin in a large ship. After being extracted from a ship possibly built as early as the late-17th century, the frame-timber was mortised using chisels and shell-auger bits, and the larger mortises were supplied with a single oak peg of *c*.20 mm diameter. Thus

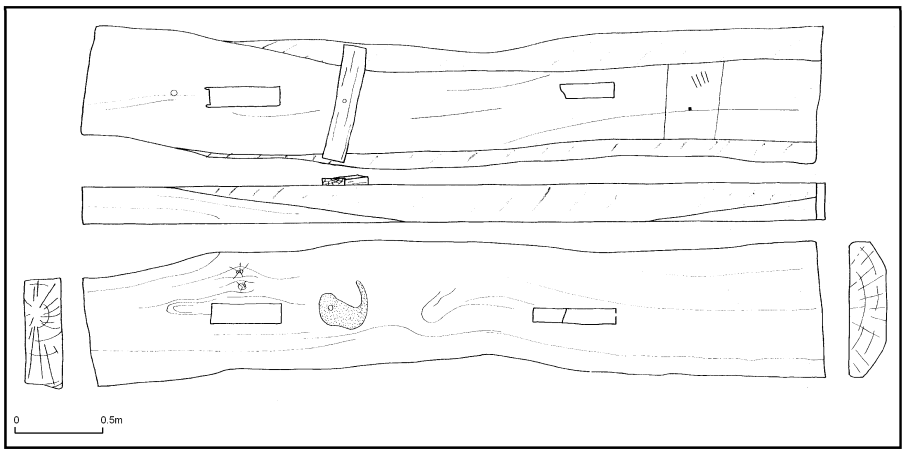

Figure 13. Timbers from Str. [152]. A large pit-sawn slab of oak [140] used as a plate for a possible simple crane. (PCA Ltd)

the ship-timber had been reworked as a carpentry-plate timber into which posts were jointed in a structure such as a building or river-wall. Finally, the timber was re-worked again and given a tenoned lower end and used as a post in timber wall [430], where iron spikes were used to secure the sheathing-planking.

Timber [415] was also a carvel ship-frame element, but it was apparently only re-used once, as a post in timber wall [430] (Fig. 11 II). It was hewn from a whole oak log with a slight curve, and a great deal of wane and sapwood was left on. It was sided up to 0.34 m and moulded *c*.0.35 m, again proportions indicating original use in a large ship. Three sizes of oak treenails from its ship use were found, from *c*.25 to 45 mm (1″ to $1^{3}/_{4}$″) diameter, and in the sides of the timber were traces of 25-mm-diameter iron bolts clenched on washers. These bolts may have functioned to bolt frame elements in the parent ship together, or possibly fastened sheathing-planking in the secondary use.

Timber [468] was an oak ship deck-beam salvaged from close to structure [430]. It was *c*.0.34 m sided and *c*.0.32 m moulded, a plausible size for a large ship's main deck-beam (Fig. 11 III). It had a housing for a carling beam and distinctive patterns of iron deck-plank spikes, occasional treenails, and bolt-holes in what would have been the sides for lodging-knees. One of the sides had four distinctive burn-marks, possibly flash marks from a canon, such as is suggested for similar marks found on re-used timbers from the *Chesapeake* (Atkinson, 2007: 166, pl. 7.6). A US naval frigate, built between 1794 and 1799, *Chesapeake* was captured and taken into service by the Royal Navy following an engagement with HMS *Shannon* off Boston Harbour in 1813, decommissioned in 1819 and broken up, with her deck-beams and planking sold in 1820 and re-used in the construction of Chesapeak flour mill on the river Meon at Wickham, Hampshire (Atkinson, 2007: 158–64).

As oak needs sustained heat to char, rather than a sudden flash, it is perhaps more likely that the mark found on timber [468] was the result of a candle or taper used for between-decks lighting in the parent ship. Though naked flames were banned below decks, they may have been used while the ship was in ordinary. Similar char-marks have been observed on timbers of the *Mary Rose,* where they have been linked with candlesticks, as well as on 18th-century ship-timbers from Ireland, and there are many examples known from building timbers, where they are quite distinctive.

Recycled slabs of shipyard waste

A large curving slab of oak timber [140] was salvaged from structure [152], measuring 4.14 m long, 0.76 m wide and 0.22 m thick (Fig. 13). Both faces bore marks of manual pit-sawing with traces of a small split section at the end of the cut, but one face was over 30% sapwood, indicating that it was a second-quality piece sawn from the outside of a large oak log. The central slabs in the log were the high-quality pieces with little sapwood, possibly used for timbers such as stems. The timber was pierced by one mortise and one chase-mortise, implying that it once acted as a plate-timber for a large braced post, possibly for something like a simple hoist or crane. Later it had two small wedges or chocks nailed cross-wise, presumable once used to support two other horizontal timbers. The parent tree was of moderate to slow growth-rate, with 180 annual rings surviving to the waney edge. Timber [140] is a waste slab of a 'great timber' (*c*.1 m chest height) or a substantial oak; whereas timber [415] and [466], for the main hull-framing, came from medium-sized mature oaks measuring *c*.0.4–0.45 m in diameter.

Maritime industrial debris

It has become clear over the last few years that post-medieval shipyard sites have many distinctive types of small finds and 'maritime industrial debris' categories (Goodburn, 2003). The waste deposits can be systematically sampled to examine aspects of shipwrightry

and specialist ancillary crafts such as block-making or caulking. Work at Woolwich in the 1970s found diagnostic waste as outlined above. The priority of the 2004 project was the recording of the structural remains exposed, rather than the stratigraphic retrieval of small finds and debris samples, but despite this a sample of fastenings was recovered totalling 62 metal items, quite a number of which post-date the Royal Dockyard. This material included large square-section iron spikes, mostly over 155 mm long, derived from ship or dock-wall building. The longest spike was 228 mm long. The bolt-like end of a wrought-iron tie-strap as used in the slipway and river-wall land-tie-to-post joints was also found. Other items of iron included a rectangular iron ballast-pig, and a wrought-iron Thames sailing barge leeboard reinforcement strip. A small number of copper rivets with square shanks and round washers (roves) probably indicate that work on smaller clinker boats also took place in the yard, but the latter material probably post-dates the naval dockyard period. Surprisingly no treenails or caulking materials were found, although three oak wedges and a single block were recovered. The wedges could have been used in a variety of ways, from anchoring timbers to splitting logs.

Markers of relative tidal estuary levels

It is clear that waterfront, foreshore and underwater archaeology can provide data for research into regional, and indeed global, sea-level change. The age of the revetments at the Woolwich Dockyard site, dating to the 18th century, ties in with the beginning of the period of regularly documented tides, high-water levels and tidal predictions (Hughes and Wall, 2004; Hughes, 2006). The standardisation of this record-keeping was not in place until later in the 19th century (Hughes, 2006: 451–2). This project can make a contribution to this area of study very important from both the land and seaward perspective.

The large size of the timbers used in most of the structures aided in their preservation to higher levels OD than is typical. These levels can be critically used as markers of relative sea-level in the Thames estuary around Woolwich at the threshold of the industrial revolution. A clear proviso here is that we should expect minor flooding at high spring tides to be accepted on the riverward side of the yard, as it was not used for domestic or dry-storage functions. Such minor flooding a few tides a year is a common feature of Thames-estuary boatyards at present. Having the wharfside surfaces high enough to be dry for working virtually all the time but low enough for the easy unloading of timber barges and for ship access would have been a convenient compromise.

The main useful pointers to local high spring-tide levels on this site are the tops of the posts in the slipway and river-walls. The highest levels of structure [213] on their slightly eroded tops were recorded at 2.94 m OD in Area B, and in Area C the highest levels of structure [430] at 2.83 m OD. This is a little lower than levels for the yard surface recorded at Pacific Wharf in the 1660s (Heard and Goodburn, 2003: 48). Since the construction of the revetments at the Woolwich dockyard, the spring high-tide levels have risen by approximately 0.6 m per century. Unfortunately it is not possible to relate the current Port of London tide-table data from nearby North Woolwich to the excavation results. The recorded top level of the revetments can, however, serve as an adequate indication of the spring high-tide limit during the later-18th century along this part of the waterfront.

General conclusions

Testing the map and model evidence

The 1774 model of Woolwich Royal Dockyard is clearly of considerable significance in view of the archaeological evidence from the site. Photographs and sometimes drawings of the model are frequently used in the literature on historic dockyards and shipbuilding in 18th-century England (for example Lavery, 1991: 76). It was one of six models made at the instigation of Lord Sandwich, 1st Lord of the Admiralty at the time (pers. comm. S. Stevens). All are now in the National Maritime Museum. Although it is clear that the model provides a range of informative scenes of what took place in Woolwich dockyard in general terms, with ships in various stages of construction, its small scale of 40 feet to the inch means that the fine detail of dock-construction can not be observed. Or perhaps the model-makers wished to present a tidier, more finely-finished view of the dockyard structures than was actually the case? The river frontage of the large dockyard is *c*.1.15 m long on the model, with the main area investigated during the excavations being only a few centimetres wide.

The east-west timber river-wall between the paired slips represented by structure [213] appears to be that which would be contemporary with the model, and it is in very general terms similar (see below). The battered frontage is shown with four large squared uprights visible on the riverward face for ships to rub against. The excavation revealed five such uprights, thus we must doubt the accuracy of the model in detail, if not in its general layout. At a more subtle level, we may suggest that although the model shows stacks of timber of various sizes and shapes laid out in all free spaces in the yard, demonstrating its crowded nature, it could not possibly have been as neat and tidy when actually working. This is because as curved timber was sought by shipwrights to fit their moulds (patterns), the stacks would have had to be partially spread out and dismantled in a somewhat chaotic manner. Neither was there any evidence in the model of the continual practice of the re-use of off-cuts and second-hand ships' timbers in the naval

buildings, as can easily be seen in the late-18th century dockyard buildings and below-ground structures at Woolwich, and at the much-more-intact yards at Portsmouth and Chatham. In sum, the model of 1774 is very useful for illustrating what the naval nobility thought a dockyard should look like, but it only provides a general guide to the much grimmer industrial reality experienced by the workers at the yard and those who built its structures.

All the timber structures, such as slipway walls, so far investigated at the Woolwich dockyard site are large, solidly-built and only parts of a much larger complex. They demonstrate the power of the British crown to concentrate labour and materials and instigate the building of permanent 'warship factories'. However, at a detailed level some of the structural evidence such as the use of second-hand timber and irregular off-cuts presents a qualification of that simple impression; materials and labour time in converting timber by hand were being saved on a grand scale in many phases of building work. Some timbers were even re-used twice such as timber [466]. Up close the appearance of some of the structures would not have been particularly smart.

Carpentry versus shipwrightry

One of the features highlighted by the detailed recording of dockyard timber structures found in 2004 is that techniques and materials used in shipbuilding were sometimes used alongside those of traditional English timber-frame carpentry. The dock and slip walls investigated were principally built as timber-framed structures (that is, works of carpentry), often with complex carpentry-style, draw-bored mortise-and-tenon joints. However, in some of the work, typical techniques of Napoleonic-period shipwrights were also used such as treenail fastenings and the use of individually scribed (or 'spiled') plank-sheathing. This resembled 'anchor-stock' wale planking (for example structure [441]) in a large man-of-war.

This mixing of carpentry and shipwrightry can also be seen in some of the surviving 18th-century timber buildings in other royal dockyards, as at Chatham in the mould-loft and wheelwrights'-shop complex. It was not just a matter of re-using ships' timbers, but also using shipwrights to do what was generally considered the work of carpenters. The strict division of workmanship or guild rules evidenced by work in the medieval port of London was clearly much less rigidly applied in the post-medieval port which grew up to the east. Indeed, by the mid-20th century in England waterfront carpentry work such as wharf-building was often actually called 'shipwrights work' and the work on wooden ships or large boats was generally restricted to repairs. The position of 'House Carpenters' within the dockyards may have effectively bridged the differences in techniques between shipwrights and landward carpentry, perhaps having the benefit of knowledge of both.

Timber-supply to the yard

As stated above the use of often crooked and waney off-cut timber, second-hand ship-timbers and sometimes timbers from earlier dockyard structures, clearly indicates the careful management of timber resources, particularly oak. The excavations in the 1970s and 2004 do not show the widespread use of cheaper, more regular and easily worked imported softwood timber as might have been expected. The practice of stockpiling timber from ship-breaking, repairs and leftovers was instigated by orders from the Navy Board and prevalent in all the yards, regardless of any shortage of space such as was a considerable issue at the Woolwich Royal Dockyard. This practice is unusual in comparison to Continental counterparts, and illustrates the value of oak timber, which was in short supply, and the need to maintain a large fleet at sea at all times. The limited efforts at the reconstruction of the parent oaks used for different types of shipyard work show a range of log sizes and forms were used. Shipwrights and their suppliers had to obtain large-girth fairly straight trees for straight and slightly-curved major ship-elements such as deck-beams and hull-planking but also smaller medium-sized logs, often with marked curves, for frames (and other components such as smaller deck-beam elements). It is likely that elm was also used below the waterline and for specialised items such as blocks and anchor-stocks, although little was found in the 2004 investigations. A shoring wedge of beech also suggests that this rather rot-prone timber was also used, perhaps sparingly under water. This is suggested in some ship contracts and exemplified by finds of re-used 18th-century false keels of beech at Pacific Wharf, Rotherhithe (Heard and Goodburn, 2003: 43).

Some of the oak used was likely to have been imported from northern Europe and even the north-eastern USA, and cannot be easily distinguished from local oak without extensive tree-ring studies. Interestingly all the timber subjected to tree-ring study appeared to be of local, or possibly Midlands origin (Tyers, 2006). However, some other groups of timber can easily be visually distinguished by an experienced eye to certain broad categories. The use of imported softwood was also clearly a feature of work in the yard as the presence of the 'deal yard' in the map and documentary evidence shows, despite little being found in the excavations. This material was most likely used in decks, cabin-building and for sacrificial sheathing, as has been found in other London shipyard excavations. The lack of evidence for the use of tropical hardwoods in the latest structures and of working debris of these materials may just indicate their compartmentalised use in the dockyard, rather than a complete lack of use. They would presumably have been mainly used in rigging, and fine joiner-work at this period, as known at Pier Head, Isle of Dogs, just after 1800 (Pitt and Goodburn, 2003: 202). By the mid-19th century shipbuilding in iron was beginning to take over for larger

craft on the Thames, and stone-lined docks replaced those built of timber.

Miscellaneous and exotic materials

The finds of iron fastenings of many types, and in the 1972–73 excavations caulking materials of animal hair and vegetable fibre and cordage, are also indicative of the supply networks used by the dockyard administrators. The finds of wood pitch, and mica panes for lanterns and windows also shed light on essential materials traded from the Baltic region, which also supplied rope and spars. Such finds exemplify the extended supply networks which often stretched well into the hinterlands of distant regions—a parallel with modern oil-supply networks is obvious.

Markers of relative sea-level change

A river frontage level of *c*.2.95 m OD is indicated by the slightly-eroded tops of the posts of structure [213]. This is a little lower than levels for the yard surface recorded at Pacific Wharf in the 1660s (Heard and Goodburn, 2003: 48). The riverward edge of the Woolwich yard must have flooded a little several times a year; unfortunately we do not have clear evidence for the levels further inland in the yard close to the officers' housing or saw-pits which ought to be higher. It should be noted here that the dry riverside surface levels at the head of the estuary at London Bridge before the completion of the new Thames Barrage were *c*.4.5 m OD. Thus the 'safe' tidal riverside occupation level has risen *c*.1.5 m since *c*.1660. Although levels can vary across the width of a river, with flow and obstructions having the potential for causing differences (Hughes, 2006: 449–50), this is unlikely to be significant at Woolwich. Only more accurately-plotted 18th-century marker levels can show whether the relatively low levels recorded for the river-edge Woolwich dockyard structures are markers of a pause in relative sea-level rise or were deliberately built on the low side for reasons related to the floating-off of vessels to enter the river channel, and for ease of unloading timber-supply barges.

The investigations demonstrate the progression of the 18th-century expansion of the dockyard, and show how it coped with changing tidal levels, its management of native oak timber resources and opportunistic re-use of ship-timbers from breaking and dismantling activities in the construction of waterfront structures, as well as the adaptation of a variety of carpentry technologies to its needs. The dockyard as a dynamic environment employed a large workforce and responded as necessary to the requirements of a growing colonial empire. The dockyard had a significant reach into the wider landscape accessing local as well as distant supply networks to address its needs.

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