Newport Medieval Ship Project
Specialist Report: RIGGING

Site number: GGAT 467
Site location: NGR: ST 31286 88169 Kingsway, Newport, South Wales, UK.

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The Newport Ship Project

Introduction

In 2002, during the construction of the Riverfront Theatre, on the banks of the River Usk in Newport, South Wales, an archaeological find of great significance was unearthed. In the summer of that year, while undertaking the excavations for the theatre's orchestra pit, the well-preserved remains of a 15th century clinker built merchant vessel were discovered.

The site, which was surrounded by a cofferdam, was being monitored by the Glamorgan Gwent Archaeological Trust at the time of discovery. The ship lay in what is locally known as a pill or small inlet, with its stern closest to the river and its bow facing into the inlet. The timbers were covered in thick alluvial mud, which created an ideal anaerobic environment for successful preservation. Seventeen strakes of planking remained on the port side and thirty-five on the starboard side of the ship. The vessel was approximately 30m in length.

A silver French coin was found purposely inserted into the keel of the vessel, dating the ship to after May 1447. Dendrochronological research has shown the hull planking to be from the Basque country and after 1449 in date.

After a much publicised 'Save Our Ship' campaign, it was decided that the ship would not be recorded and discarded but excavated with the aim to conserve. The riders, stringers, braces, mast step, frames and overlapping clinker planks and keel were dismantled one by one and lifted. Almost 2000 ship components as well as hundreds of artefacts were excavated.

This report and catalogue examines and lists the rigging assemblage excavated from the Newport Medieval Ship site.

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An Examination of 15th Century Ships' Rigging

Case Study: The Newport Medieval Ship

A dissertation submitted as part of the requirement for

MSc Maritime Archaeology

By

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Abstract

The 15th century was a transitional period in nautical technology, specifically with regards to ships' rigging. The amalgamation of ship building traditions led to the widespread utilization of two and three masts, paving the way for the addition of the spritsail and main topsail and the eventual fully rigged ships of the following centuries. In the past, the study of ships' rigging from archaeological sites was often thought to be a futile exercise (Muckelroy 1978), however attitudes in this area are changing with recent studies acknowledging the symbiotic relationship between hull and rig (Polzer 2008). Although the archaeological evidence of ship's rigging for this period is scarce, through the examination of iconographic sources, contemporary writings and information attained from replicas, much can be ascertained on this subject.

This research examines the available data for evidence of the transitional features in ships' rigging during the 15th century as the use of two and three masts spread throughout Europe. The 15th century Basque merchant ship, known as the Newport Medieval ship, is examined here as a case study. Scrutiny of the rigging assemblage excavated from within the ship, involving the three dimensional digital documentation of each piece as well as the hull itself, allows a rig type hypothesis to be created and aims to broaden our understanding of 15th century ships' rigging.

Acknowledgements

This research would not have been possible without the guidance of my supervisor, Paola Palma, Newport Medieval Ship Curator Toby Jones and Newport Museum and Heritage Service. I would also like to thank Nigel Nayling for answering the excavation queries and Pat Tanner for sharing his preliminary results. Others that provided advice and access to their data and artefacts include, Anne Leaver, Dr Colin Martin, Dave Parham, Holger Sweitzer, Connie Kelleher and Catharine Leigh Inbody Corder. Stephen O’Donnell must also be thanked for his support.

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Abbreviations

Abbreviation	Meaning	Page
2D	Two dimensional	18
3D	Three dimensional	16
AR	Aspect ratio	51
Cp	Prismatic coefficient	49
CT#	Cow Tag # (unique identifying number of Newport Medieval Ship artefacts)	14
F#	Frame station number	14
hp	Horse power	49
kts	Knots	49
m	Metre	12
mm	Millimetre	22
MSG#	Maesglas # (unique identifying number given to Newport Medieval Ship non wood artefacts)	14
PDF	Portable document format	17
sq. m	Square metre	49
Stbd	Starboard	14
STL	Stereolithography	17
t	Tonnes	49
Tiff	Tagged Image File Format	16
U/S	Unstratified	14

1. Introduction

1.1 Background

The 15th century is an important period in the evolution of the ship, specifically in the evolution of ships' rigging. This period, which was at the commencement of the 'Age of Discovery', witnessed the European expansion and the extension of trade routes into Africa and India (Schwarz 2008). Developments in nautical technology such as the decline in the Nordic, shell first shipbuilding tradition and the increase of the use of the caravel and Mediterranean frame first construction (McGrail 2001) were essential in enabling these voyages of exploration and trade. Rigging technology, being intrinsically linked with hull form, continually adapted to the changes in ship design to maximize efficiency, stability and manoeuvrability.

Up until the 1500s the 'single, loose footed square sail' was the most commonly utilised rig type (McGrail 1987) with only some large ships having a second mast at either the bow or stern (Hutchinson 1994). This type of sail is referred to as a square sail, not only because of its shape, but because the yard and cloth were hung at right angles to the length of the hull (Hutchinson 1994). It was possible to adjust the sail area of square sails through the use of reefs and bonnets. Bonnets, which were introduced in the 14th century, were used as an 'extension of a sail' (Layton 1955) and could be attached to the foot of the sail in light weather conditions to enlarge the sail area and subsequently removed if the wind increased (Hutchinson 1994).

Although this type of square sailed rig was utilised successfully for centuries in all parts of Europe, it was not flawless in its design. When sailing to windward the separation of central effort and centre of lateral resistance of the reefed or angled square sail caused the vessel to be forced away from windward therefore making it inefficient (McGrail 1987). This limitation would make certain routes, depending on wind direction, difficult and time consuming. The 15th century, which was a period with an intense focus on maritime endeavours, would see developments in rigging that would dramatically reduce the limitations in sailing to windward, namely, the widespread utilization of the second and third mast. The second and third mast would allow greater ease when tacking as well as dividing the weight of the sail to increase manageability (Hutchinson 1994) and resulting in less strain being put on the vessel and its rigging (McGrail 1987). Most importantly however, the introduction would enable the vessel to sail closer to windward, decreasing passage time along new routes.

1.2 Importance of Studying Rigging

The significance of these technological changes to ships' rigging cannot be underestimated. Acting as a reflection of the changing needs of, and developments in, medieval society, nautical technology gives us an insight into the lives of those who used the oceans' highways. In his study of ships depicted in medieval manuscripts, Flatman (2009, p12) explains 'Seaborne trade, exchange, conflict, exploration and innovation all meant that the maritime world was a central and constantly evolving preoccupation of medieval society'. The study of rigging is therefore undertaken not only to understand the working mechanics of a vessel but can be used as an aid in the interpretation of the changes in maritime civilisations that occurred during the medieval period.

To get a full understanding of ship technology, a number of interconnected systems and components must be taken into consideration, for example, cordage, standing and running rigging, and hull structure. To put less importance on one of these is to get only a partial view of the technology. Recent publications have emphasized the symbiotic relationship between hull and rig and recognise the significance of rigging in its broader context. Polzer (2008, p225) states, 'The types of sails used throughout history and their development, use and evolution are part of the story of technology and indicative of wider geographical, social, and economic concerns'.

Sanders (2009, p3) outlines many reasons why it is vitally important to record and analyse ships' rigging, suggesting that hull design was, in some ways, 'a product of rigging' and that rigging was a reflection of the function of the vessel and therefore the trade it was involved in. Both Bradley (2007) and Sanders (2009) mention the significant industry needed to support the initial fitting and rigging maintenance of these large ocean going vessels. The study of rigging can inform us on a variety of different industries, from sail and rope making to tar production, as well as the possible importation of specific hard woods for construction of sheaves and other running rigging elements. Sanders (2009) also briefly noted the importance of rigging when looking at a specific archaeological site. He explains that by forensically examining the evidence, including the condition of the rigging, one could extrapolate the situation at the time of the ship's sinking.

The extensive and thorough work carried out on the rigging of the Red Bay wreck, in ‘The Underwater Archaeology of Red Bay vol. IV’, has helped to broaden our understanding of the development of rigging technology in the 16th century. As outlined by Bradley (2007), studying the rigging also tells us about the operational duties of the crew on board.
The importance of information gained through the study of this maritime technology cannot be understated. This fact is true of all rigging assemblages, be they complete or partial, as each assemblage can be combined to create a broader understanding of the technological development of ships, associated industries and cultural change throughout our history. Early publications such as; ‘A Treatise on Rigging’, published by the Society for Nautical research in the early 1600’s mentioned by RC Anderson (1927), ‘The Elements and Practice of Rigging and Seamanship’ by David Steel (1794) and the later revision of this by George Biddlecombe (1848) called ‘The Art of Rigging’, as well as ‘The Young Sea Officer’s Sheet Anchor’ by David Lever (1819) are useful references when understanding the function of rigging components and can often be applied to earlier archaeological assemblages.

1.3 Challenges in the Study of Rigging

Although great time and effort is spent on the detailed recording, excavating and analysing of shipwreck sites, in many cases the emphasis is on hull form and artefacts, and the rigging is somewhat ignored. As discussed by Polzer (2008), many, including Muckelroy (1978) suggest this trend is due to the nature of rigging. Rigging elements are often made of soft wood and therefore do not always survive on archaeological sites. If they do endure the often harsh conditions on the sea bed, they may have been scattered far from the wreck itself and consequently lost. Muckelroy (1978) almost dismisses the importance of surviving rigging elements, stating that the few pieces which are excavated are usually not enough to tell us much about the rigging arrangement and sails, with which they were originally associated. This view on rigging has meant that, in many cases, information has been lost and gone unreported.
Sanders (2010), claims that cordage is frequently poorly recorded on site due to its fragility and tangled character. He also refers to the fact that it is complicated to record, and that the methods of recording, as well as the terms used, are not standardised. These views and physical challenges for the archaeologist have lead to a lack of documented comparable evidence for the researcher, which is the main challenge when analysing rigging elements.

The evident lack of variation in the typology of many rigging components over time is another challenge in the study of rigging and, as Polzer (2008) explains, makes them ‘less distinctive as diagnostic objects and less attractive to researchers’ (Polzer 2008, p226). When looking for direct comparisons of specific rig types or components, the researcher runs into difficulty. There is a lack of comparative 15th century archaeological material. In contrast, the well documented Mary Rose rigging assemblage has helped to build a reference of rigging components from the 16th century and has broadened our knowledge of the working of standing and running rigging. Rule (1982), when examining the rigging of the Mary Rose, recognises the scant evidence for the use of rigging components, such as dead eyes and blocks, in running and standing rigging in 16th century Northern European war ships. She states that the evidence is ‘...confined to a limited number of contemporary but often confusing references, a few paintings and one or two loosely dated blocks in museums’ collections’ (Rule 1982, p136). Bradley (2007) discusses another one of the challenges often met when analysing rigging, this is the variation in rig pattern from vessel to vessel. He accredits this phenomenon, to a number of factors, such as the time of year in which the ship was sailing, to compensating for a limitation in the specific vessel’s hull design, to name but a few. Bradley states that ‘part of the challenge in studying rigging is to determine the allowable variation from a somewhat undefined norm’ (Bradley 2007, p2). It is, however, this author’s opinion, that many of these challenges will be overcome in time through wide scale comprehensive recording and efficient information dissemination.

1.4 Aims & Objectives

The first aim of this investigation is to study the available sources for evidence of features of 15th century ships’ rigging that may illustrate the transition from one square sail to multi-masted ships. The examination of material from this period, including both iconographic and archaeological evidence, and the detection of these transitional characteristics will broaden our understanding of the intermediary period between the quintessential rig type that predominated until the early 15th century and the fully rigged ships of the following centuries.

The second aim is to thoroughly document the rigging assemblage from the case study of this research, the 15th century Newport Medieval Ship. This documentation will be achieved through the use of 3 dimensional digital recording equipment and will be subsequently archived with the Archaeological Data Service. The archive will be accessible to the public, allowing the dissemination of information for future researchers. This detailed documentation of the 15th century merchant ships' rigging assemblage, in conjunction with the hull form analysis of the vessel, will facilitate the accomplishment of the third aim of this research. This is the creation of a preliminary rig hypothesis for the Newport Medieval Ship. The rig form hypothesis will be created using the concept of 'minimum reconstruction' outlined by Pederson and McGrail (2006, p53). As research into the original hull is ongoing the conclusions made in this research, regarding rig type, are subject to change, and should be viewed as the preliminary stage in the process.

2. Contemporary Evidence

2.1 Iconographic

Iconographic evidence can give a useful insight into 15th century nautical technology. Illuminated manuscripts, town seals, paintings, models and sketches all help to build a picture of 15th century ship technology. When examining iconographic sources Castro points out that 'iconography always involves difficulties of interpretation, and care must be taken when it is used' (Castro 2008, p107). An Editor's note in the Mariner's Mirror, when discussing ships earlier than 1500, points out that 'when pictorial representations are available, we have small means of knowing how far they are conventional, and, above all, of discovering what names were given to the types of ships illustrated' (Editor 1911, p301). Casado Soto (1998) too, when discussing iconography notes that for a number of reasons, 'in the majority of cases, interpretation is neither easy nor obvious'. However, iconographic evidence can be useful when used in conjunction with archaeological evidence. Brindley (1911, p47) states, 'We have to remember how ignorant of nautical matters nearly all early artists and real engravers were; but though we can accept no one picture as showing us what a ship was like throughout, much may be learned of the details of rig and fittings from these sources.'

Figure 1. *'St Nicholas of Bari banishing the Storm'* by Bicci di Lorenzo. Ashmolean Museum (2011).

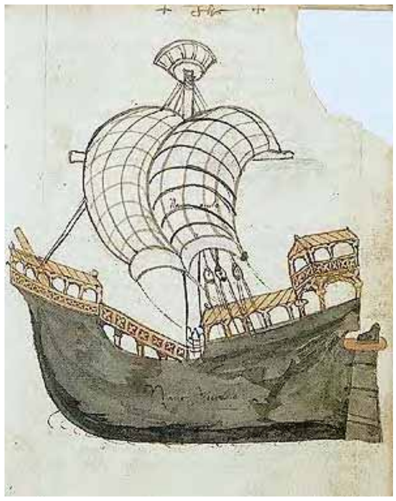


Figure 2. *'Nave Quadra'* by Michael of Rhodes. Dibner Institute (2005).

One of the earliest representations of a three masted vessel is seen on a manuscript from Catalan dated to 1409 (Mott 1994). Other contemporary iconographic examples include an altar piece by Joan. Reixach, dedicated to Saint Ursula and dated to 1468 (van Nouhuys

1931), 'A Fifteenth Century Trader' by an artist known only as W.A. (Nance 1911), the painting 'St Nicholas of Bari Banishing the Storm' by Bicci di Lorenzo (Fig. 1), and 'The Ships of Maso Finiguerra' by an unknown artist (Callender 1912), all of which are of interest when looking at the technology of the period. Callender (1912, p300) suggests that the 15th Century Florentine drawings, known as 'The Ships of *Maso Finiguerra*' illustrate the 'transitional period in the development of ships, the period when the primitive vessels with a single sail developed with such apparently startling suddenness into the glorious creations of the Henrician and Elizabethan navies'. Callender (1912, p372) also discusses, what he terms a 'bi-lobular balloon sail' which he explains is the mainsail 'divided into two hemispheres' Callender (1912, p371). He suggests that this type of sail may only have been in use during the third quarter of the 15th Century and may be seen as the missing link between earlier one masted vessels and the later galleon type rig. He sees this bi-lobular sail as quite quickly being separated over two masts. Another contemporary image, (Fig. 1) 'St Nicholas of Bari banishing the Storm', by artist Bicci di Lorenzo, also appears to depict bi-lobular balloon sails as does (Fig. 2) Michael of Rhodes' illustration of a square rigged ship. The dividing of the sail in this manner would, however, cause the sail to become less efficient when sailing to windward, which may explain the short use life of this type of sail or alternatively may prove the unreliability of artistic representations.
Another source of contemporary evidence is ship models. A 15th century ship model, called the Mataro Model, is currently on display in the Maritime Museum in Rotterdam. The model, seen in Fig. 3, originated from a small church in Mataro on the Catalonian coast in Spain (Hutchinson 1998). The model, when discovered, had three masts however Culver (1929, p216) states 'I am of the opinion that the fore and mizzen masts are both later additions and that, as originally constructed, the little vessel has only one large and tall mast centrally located.' He explains why he has come to this conclusion, noting the difference in craftsmanship and the miss alignment of the fore and mizzen masts. Unfortunately Culver describes the rigging as having 'suffered to such an extent that scarcely any of the original rigging remains in existence and of that little remnant, all is in such confusion and the lead of the ropes so illogical that it is apparent that someone wholly ignorant of the uses of the various appliances has tied the cords up 'any old way'' (Culver 1929, p216). The addition of the extra two masts is interesting to note and although it can never be stated for certain when or why this alteration occurred, it may be an indicator of what was occurring in reality during the period in which the model was constructed or altered.

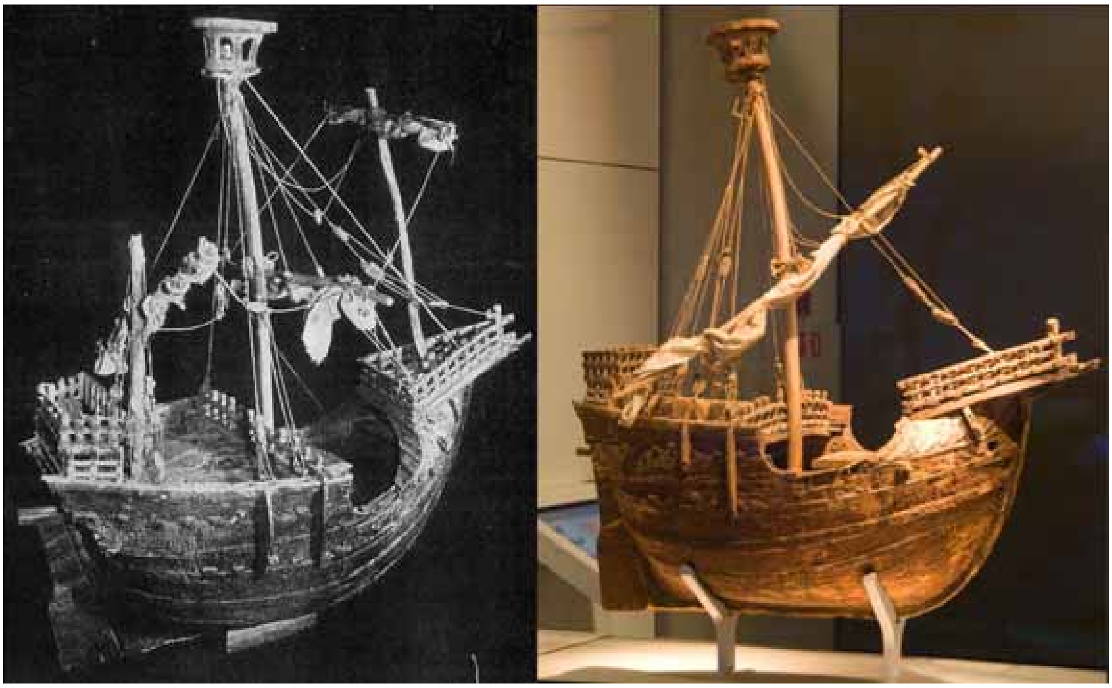


Figure 3. The Mataro Model, as discovered, displaying three masts (Left)(Culver 1929). The Mataro Model on display in the Maritime Museum in Rotterdam with one central mast (Right) (Anker 2009).

Figure 4. The Christian Fleet c1475 (Flatman 2009, p97).

Illuminated manuscripts also illustrate this transitional period in ships' rigging. Flatman (2009) examines the depictions of ships and shipping in medieval manuscripts in great detail. Flatman explains how the 'golden age of manuscript production' coincided with extensive technological developments in shipping during the medieval period, specifically from the 1100's to the 1500's. Manuscript illumination, Flatman suggests, 'consistently and accurately reflected the cycle of technological change' (Flatman 2009, p12). The illumination (fig. 4), which is 15th century in date, clearly shows the ships as having one central mast, one square sail and a fore flag pole. The presence of a flagpole is often noted on another type of contemporary ship iconography, the town seal.

Seals often depict ships which, although they may be stylized or pre-date their use, can give us an insight into ship and rig types throughout Europe. The second seal of John Holand represents what Hutchinson describes as the hulk hybrid. This is evidence of the break down of division between the keel, hulk and cog ship classifications (Hutchinson 1994), what Hutchinson describes is further evidence of the metamorphosis in ship technology that was taking place. The bow and stern flags, depicted in the seals below, may also be indicative of this transitional phase from one to two or more masts that was occurring during this century. Fig. 5 shows four examples of 15th century seals with rigging depicted.

Figure 5. 15th century Town Seals. (From left to right) the seal of Richard Plantagenet, Admiral of England 1471-1475, the second seal of Rye 1400, the Second Seal of John Holand as Admiral of England, Ireland and Aquitaine 1435-1442 and the Seal of Maxililian and Maria of Burgundy 1478 (Ewe 1972 p92, p90, p94 & p70).

From the iconographic evidence it is clear that although the earliest known depiction of a three masted vessel is dated to 1409 (Mott 1994), the single square rig was in use in conjunction with the new technological developments of the fore and mizzen masts throughout the 15th century. This fact is clearly evident in the final source of iconographic evidence that will be examined **-** graffiti.

Brady and Corlett (2004, p29) explain that as archaeological evidence of ships from the medieval period is scarce, ‘ships on plasterwork are one of the most important sources for typology and provide vital information on a variety of ship types plying Irish waters during the medieval period’. These etchings in plaster, often found in medieval ecclesiastical sites such as St Mary’s Church, New Ross (Brady and Corlett 2004), can be difficult to decipher and presumably also difficult to date. Examples of this graffiti, examined by the Norfolk graffiti Survey, are found in Wiveton and Blakeneny churches in Norfolk and also are evident in Blackfriars Barn undercroft in Winchelsea, East Sussex to name just a few. These reconstruction of 15th century etchings in Norfolk consist of single masted vessels as well as ships with two and three masts and a variety of hull forms (Champion, 2012). This multiplicity of rig type depictions, seen in Fig. 6 emphasises the huge variations in rigging that existed simultaneously.

Figure 6. Pillar depicting reconstruction of 15th century ship graffiti (Champion 2012, p28).

2.2 Archaeological Evidence

Although the archaeological evidence is not abundant for the time period in question there is some comparable evidence from a number of broadly contemporary documented wrecks. These wrecks include:

The Bremen Cog

The clinker built Hanseatic cog was built in 1380 (Hoffmann and Schnall 2003) and discovered in 1962 in the port of Bremerhaven. Experimental reconstruction of cog replicas have taught us a great deal about the sailing capabilities of this type of single masted, square sailed vessel (Hoffmann and Hoffmann 2009).

The Red Bay Wreck

The carvel built Red Bay whaling ship, the San Juan, was discovered in 1978 in Red Bay, Labrador. The wreck is from the Basque Country and dates to the 16th Century (Ringer, 2007). A large assemblage of artefacts associated with both the standing and running rigging was excavated (Bradley 2007), many items of which are directly comparable with items from the Newport Medieval Ship.

The Mary Rose

The 16th Century Mary Rose, a carrack, was recovered in 1982. Part of Henry VIII's navy, the vessel sank in the Solent in July 1545 after a use life of 33 years (Gardiner 2005). A large rigging assemblage was present on board including blocks, parrels and cordage (Rule 1982).

The Vasa

The Swedish Royal warship the Vasa was rediscovered in 1956 in Stockholm Harbour. The vessel sank on its maiden voyage on the 10th of August 1628 (Bengtsson 1975). The Vasa had a substantial amount of rigging on board; one piece in particular is of great interest when examining the Newport Medieval Ship assemblage. This will be examined in further detail below.

The Swan

The 17th Century Swan sank in 1653 off Duart Castle in the Sound of Mull, Scotland. This wreck too had rigging components remaining on board including a parrel rib and truck (pers.comm. Dr. Martin April 2011).

La Trinida Valencera

La Trinidad Valencera, a Venetian merchantman, was part of the 1588 Spanish Armada. It was discovered in 1971 having been lost in Kinnagoe Bay, Co. Donegal, Ireland. The remains of rigging included blocks, sheaves and a belaying pin (Martin 1979).

The Drogheda Boat

The Drogheda boat was discovered in 2006 in the River Boyne in Drogheda, Co. Louth, Ireland. The clinker built vessel was constructed with local timber and dates to the mid 16th Century. The vessel had two mast steps present as well as a clew garnet, supporting the hypothesis that it had two square sails (pers. comm. Holger Sweitzer 2007).

La Belle

The French barque longue called *La Belle* was discovered in 1995 in Matagorda Bay, Texas. The vessel was wrecked in a storm in 1686. Four hundred items associated with the standing and running rigging were excavated (Leigh Inbody Corder 2007).

The Pepper Wreck

The *Nossa Senhora dos Martires*, known as the Pepper Wreck, was excavated between 1997 and 2000. The Portuguese nao sank in the River Tagus, Portugal in 1606. In depth research has been undertaken by Castro to ascertain a rigging hypothesis for the vessel (Castro 2005).

Evidence from these wrecks, although not 15th century, can be compared to our case study, the Basque merchant vessel the Newport Medieval Ship. This comparison exercise will help to place the Newport Medieval Ship within the broader context of medieval shipping technology.

3. Case Study: The Newport Medieval Ship

In 2002, during the pre-construction of the Riverfront Theatre, on the banks of the River Usk in Newport, South Wales, an archaeological find of great significance was uncovered. While undertaking the excavations for the theatre's orchestra pit, the extremely well preserved remains of a 15th century clinker built merchant vessel were discovered. The site, which was surrounded by a cofferdam, was being monitored by the Glamorgan Gwent Archaeological Trust at the time of discovery. The ship lay in what was once a pill or small inlet, with its aft end closest to the main river and its bow facing up into the inlet. The timbers and associated artefacts were covered in thick alluvial mud, which created the ideal anaerobic environment for successful preservation. The vessel was approximately 25m in length with seventeen strakes remaining on the port side and a total of thirty-five on the starboard side. Some damage to the vessel took place during the construction works prior to its discovery, this included cofferdam damage to both the bow and stern as well as pile damage at various locations throughout the vessel (Trett 2010). Dendrochronological dates from one of the ship's knees gave a felling date of winter 1465/66 (pers. comm. Nayling 2010). More recent research has matched the tree ring sequence from the Newport Ship hull timbers with medieval building timbers from the Basque Country. This suggests that the ship has Basque origins (pers. comm. Nayling 10/09/12). The Newport Medieval Ship was built and sailed during an exciting transitional period which saw the oceans being used for exploration, trade and the acquisition of power. The assessment of the remains of the rigging of the Newport Medieval ship will add to our understanding of the transition from single, square sails to two and three masted rig types as well as assist in the creation of a rig type hypothesis for the 15th century merchant ship.

The rigging assemblage of the Newport Medieval ship consists of nineteen wooden artefacts and twenty fragments of cordage. The mast of the ship was not found, however the mast step and the mast partner were discovered, in situ in the midship area. Components, vital to our understanding of how the vessel was propelled, were excavated. These components include blocks and pulleys, a deadeye, bull's-eye, parrel ribs and trucks, heart blocks, sheaves and pins. Many of these pieces were found complete and, in some cases, with moving components and cordage found in situ. The function of the majority of the pieces is understood, however the purposes of a minority of the items are less clear at present.

The find location of each artefact was in most cases recorded, however it wasn't always possible to do so. In the case of the Newport Ship's rigging assemblage a site specific challenge arises. Unlike ships lost at sea, which are sunk relatively quickly, the Newport Ship may have sat at the bank of the River Usk for a long period of time before it was eventually covered over by river sediment. We understand from the archaeological evidence that the vessel was propped up on struts and that some replacement of timbers was undertaken (pers. comm. Toby Jones 7/10/2011). During this period of repair and eventual abandonment in Newport, it is possible that the ship was contaminated with intrusive material, especially small moveable artefacts such as rigging. Due to the nature of this site's formation, and the fact that the ship was partly dismantled in antiquity, the specific location for each piece is, perhaps, more complex and has a different meaning than that of a wreck lost at sea with rigging in place (pers. comm. Nigel Nayling 2010). Dr Julian Whitewright (2010) did assess the rigging components as part of the Newport Medieval Ship Post-ex Research Design, created by Oxford Archaeology and addressed this issue. He stated that; 'The assemblage as a whole has a high potential to further our understanding of the Newport Ship's use and eventual abandonment. Any further analysis will need to include a detailed understanding of each item's depositional setting in, and around the hull. This will be essential to attempt to separate items derived from the use of the ship and those potentially associated with its repair / abandonment phase in Newport' (Whitewirght 2010, p28).
Forty pieces of cordage were recovered from the site. This material underwent a preliminary assessment by Penelope Walton-Rodgers as part of the Newport Medieval Ship Post-ex Research Design. It was stated by Walton-Rodgers that the material 'can provide a wealth of information' about the use life of the ship (Walton-Rodgers 2010, p87). After a more detailed analysis of the material, Walton-Rodgers divided the cordage assemblage into two groups, grass-stem ropes and hemp cordage. The latter group is associated with the rigging (Walton-Rodgers 2012) and will be examined in greater detail below.
Tables (a) & (b) list the rigging items that have been recorded and examined in detail, compared to contemporary evidence and used to form a hypothetical rigging reconstruction for the 15th century Newport Medieval Ship (For a complete artefact catalogue and individual descriptions see Appendix (i)). Regarding the location of the artefacts, context 120 refers to the ship itself and context 130 refers to the alluvium deposit found within the ship. As can be seen in Fig. 7 there is a concentration of finds in the bow and midship areas however it is difficult to say whether or not the find locations of these pieces are indicative of their functionality during the use life of the vessel.

Table (a) Newport Medieval Ship Rigging Assemblage – Wooden Artefacts.

Tag No.	Component	Location in Ship
CT1807	Unknown	F33 - F34
CT1853	Sheave	Context 120 F41 - 42
CT1926	Unknown	Unknown
CT2367	Parrel	Context 130
CT3006	Sheave	Context 130 F25 Brace Stbd
CT3008	Unknown	Context 130, F31, Stbd
CT3009	Pin	Context 130 found under knee 1638
CT3010	Pin	Context 130, F15 Stbd
CT3011	Parrel Rib	Context 130 - aft of midship Stbd
CT3018	Unknown	Context 130
CT3023	Parrel Truck	Context 130, F44
CT3024	Bull's Eye	Context 130, F40, Stbd
CT3030	Parrel Truck	u/s F39-40s
CT3031	Bull's Eye	Context 128, F3
CT3036	Dead Eye	Context 128, F7, Port
CT3038	Loof hook	Context 130, F7-8
CT3049	Clew Garnet	Context 130, E20.65 N100.35 L5.42
CT3051/3052	Pulley Block	Context 130
CT3053	Dead Eye	Context 130, North of F44, L4.18

Table (b) Newport Medieval Ship Rigging Assemblage – Cordage (Walton Rodgers 2012).

Tag No.	Component	Location in Ship
MSG 059 (i)	Hemp cordage	F30-40 Stbd
MSG 059(ii)	Hemp cordage	F30-40 Stbd
MSG 061	Hemp cordage	F48 Stbd
MSG 062	Hemp cordage	Stbd side of mast step
MSG 075	Hemp cordage	F45 – 50 Stbd
MSG 079	Hemp cordage	NE bow
MSG 088	Hemp cordage	Context 1004
MSG 809	Hemp cordage	Under ship - Context 1022
MSG 810	Hemp cordage	Under ship - Context 1022
MSG 811	Hemp cordage	Under ship - Context 1022
MSG 828	Hemp cordage	Context 133
MSG 833	Hemp cordage	Context 133
MSG 834	Hemp cordage	F5-F6
MSG 835	Hemp cordage	Context 133
MSG 1297	Hemp cordage	In CT3036 - Context 128, F7, Port
MSG 1301	Hemp cordage	In CT3052 – Context 130
MSG 1302	Hemp cordage	In CT3052 – Context 130
MSG 1304	Hemp cordage	S15.2 Stbd. Bow

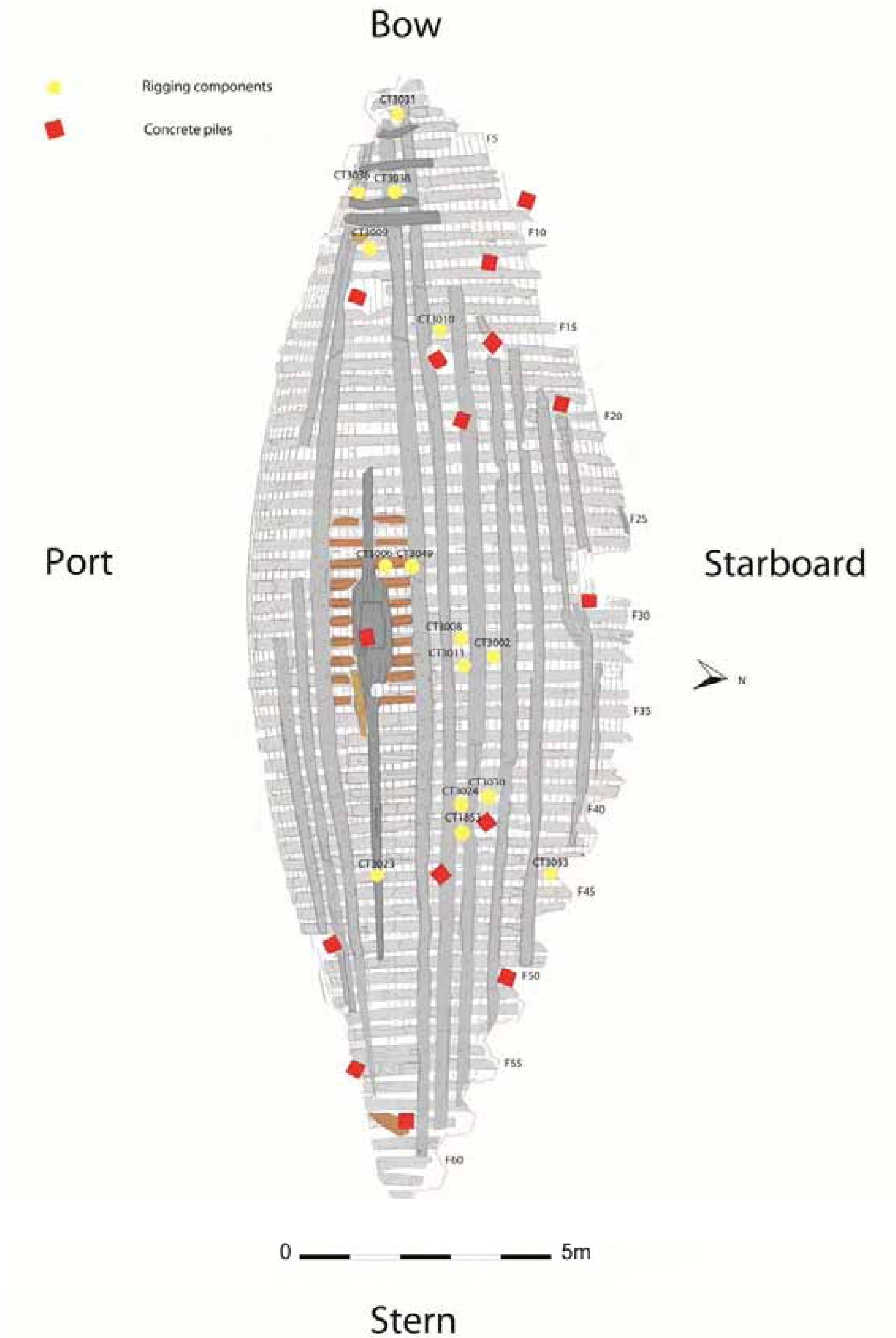


Figure 7. Distribution Map of Newport Medieval Ship Rigging Assemblage (Newport Museum and Heritage Service).

3.1 Recording Methodology

The rigging items were recorded, post excavation, using both traditional and non-traditional methods. A paper record, photograph and laser scan was completed for each item and professional archaeological illustrations were completed for a chosen few. The paper recording consisted of filling out a record sheet (see *Appendix (ii)*) with the item's individual number (which is referred to in this document as a cow tag number), a brief description, followed by a more detailed description including measurements and condition assessment, tool marks and wear marks. Details of the artefact's wood science, where possible, was also included or, indeed, filled in later bydendrochronologist Nigel Nayling. The text was then added to the project database. Immediately after the paper record was made the artefacts were photographed. The recording was carried out in this way to minimise handling of the items, as many are in a delicate condition. Each surface was photographed with a scale raised to the surface's height to ensure accuracy and reduce perspective distortion. The views were then edited individually in Adobe Photoshop and saved as tiff files. The tiff files were subsequently imported together into Adobe illustrator where they could be scaled and edited further. This was saved as one document and finished in Photoshop. The finished product was a flattened image containing all views of the artefact against a white background. It was decided to consistently turn the artefact from the left of the page to the right as is done in traditional artefact drawing. The next step in the process is the 3D laser scanning of the object.

Figure 8. Photograph of Heart Block CT3036 (Newport Museum and Heritage Service).

The rigging components were recorded with a Laser Line Probe on a Faro Fusion Arm using Geomagic version 12 software. Each object was scanned in two parts and then registered together during the editing process, using both manual and subsequently global registration. The point cloud data was then cleaned up. This procedure involved deleting outliers and disconnected components, re-computing the normals followed by curvature based sampling of the entire point cloud. The point cloud was reduced to between 500,000 and 2 million points, depending on the size and complexity of the artefact. This process allowed for manoeuvrability of the cloud without causing the software to crash. The point cloud was then wrapped, creating a surface. Spikes were removed from the surface and any holes were filled. If further editing was necessary, the mesh or wrap was returned to point form again and the normals repaired to give a smoother finish. This editing process continued until a 'water tight' mesh was achieved. Each scan was then saved as a geomagic wrap file, an STL file and finally as a 3D PDF as seen in Fig. 9.

Figure 9. A 3D Laser Scan of Heart Block CT3036 (Newport Museum and Heritage Service Click on image to view and rotate.

The illustration of the artefacts was carried out by archaeological illustrator Anne Leaver. It was an opportunity to combine traditional and non-traditional methods of recording. The process began by discussing which views should be included in the illustrations as well as deciding where and when to include cross section views. The illustrator made notes (see Fig. 10), which were then used as instructions on which views to prepare from the laser scans. The 3D PDF was rotated on screen until the desired view was achieved. An on screen measurement was taken and included in the saved view. Cross-sections of the 3D image were also captured. The desired view was saved as a 2D tiff file. This was repeated a number of times with each piece to incorporate all chosen views.

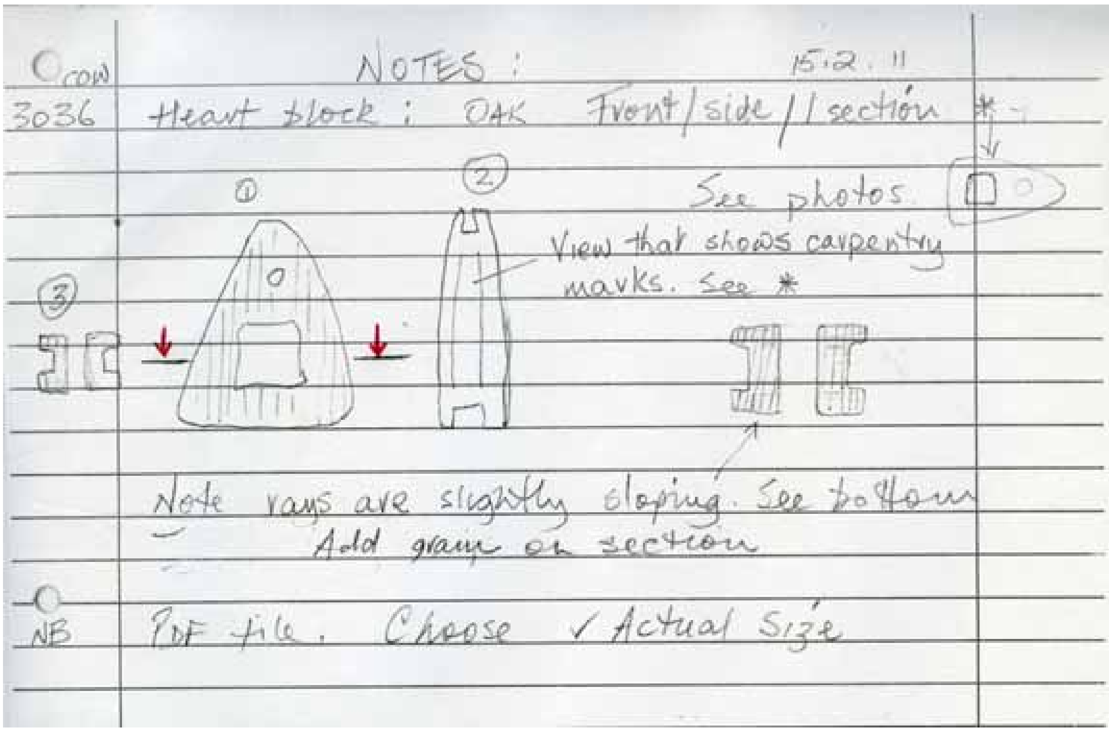


Figure 10. Illustrator's notes on Heart Block CT3036 (pers. comm. Anne Leaver March 2011).

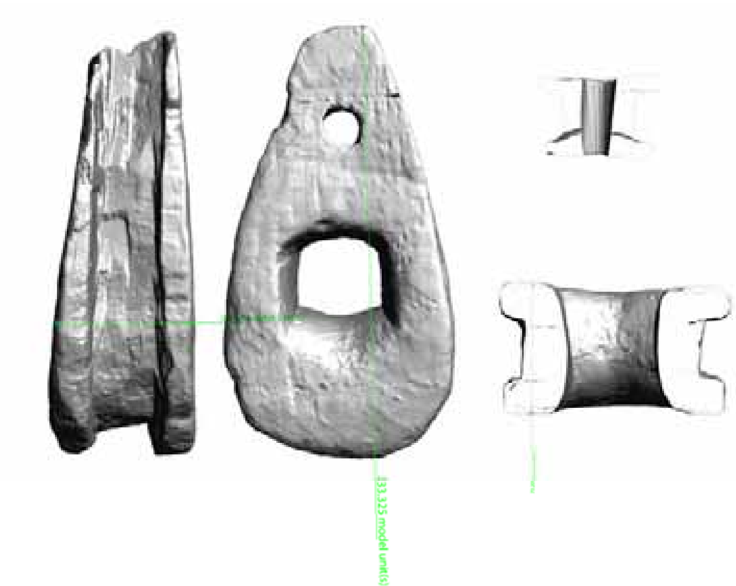


Figure 11. Selected views of Heart Block CT3036 for use by the illustrator (Newport Museum and Heritage Service).

The illustrator, using a combination of the 2D laser scan views, the photographs and the physical object, produced traditional style archaeological drawings. This was achieved by printing out the photographs and scans at 1:1 scale, taping the laser scan to a drawing board and taping drafting film over that. The photo is kept to one side. The 2 dimensional laser scan printout is then traced, checking the measurements against the actual artefact. Detail such as grain and tool marks were then added using the photographs and the object. The drawings are then scanned and opened in Adobe illustrator where they are redrawn, ensuring >Scale Lines and Effects are turned off so that all the lines are at the same weight at final publication. The illustrator found that this system, once in place, greatly sped up the process, particularly in the drawing of the cross sections of the more complex artefacts (pers. comm. Ann Leaver 14/04/2011).

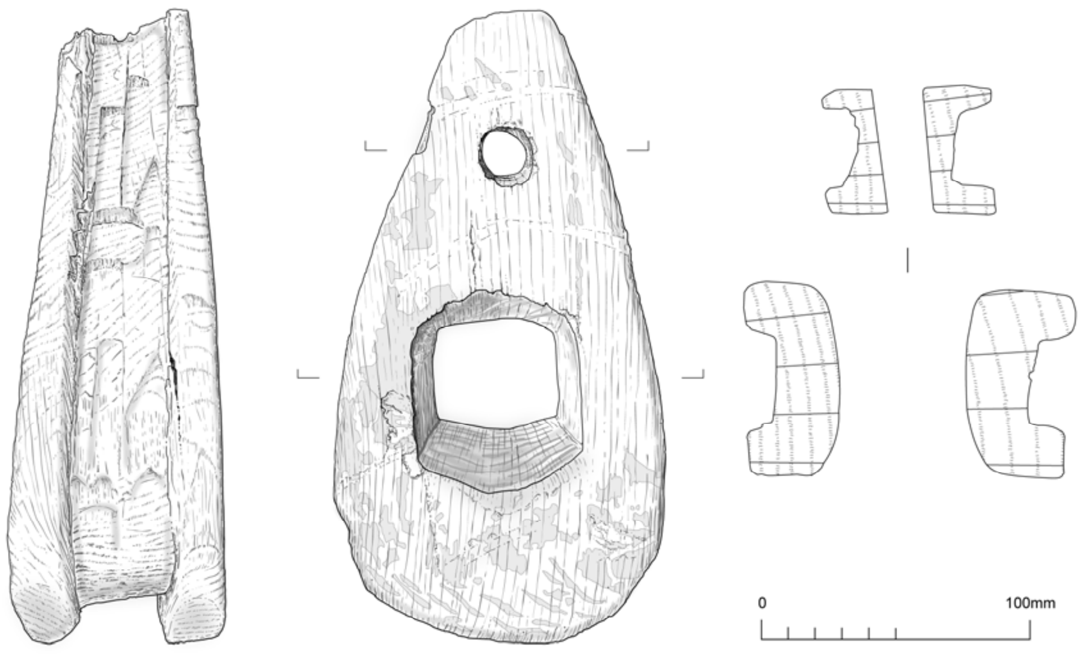


Figure 12. Illustration of Heart Block CT3036 (Newport Museum and Heritage Service).

The products of the various recording methods undertaken on the Newport Ship rigging assemblage can be used to create comparable visual representations of the same object. This is useful in the ongoing debate on how artefacts should be presented for publication, many still preferring the traditional archaeological drawings over newer methods such as 3 dimensional laser scans. It would appear that each method has its advantages and disadvantages and there is perhaps a place for each method depending on what the desired outcome of the recording exercise is. The laser scan is ideal for taking accurate measurements and vital for creating replicas through the laser sintering process. The fact that it can be saved as a PDF means it can be viewed 3 dimensionally by anyone, without the need for expensive software and is therefore extremely accessible. However some detail such as grain is not always captured and when printed on paper its 3D capabilities are, of course, lost. The photographic record is excellent for capturing grain and wear or tool marks, and is ideal for 2D publication. Due to availability of good quality cameras as well as software such as Adobe Photoshop, it is easier than ever before to take high quality photographs, however taking measurements from a photo isn't always accurate due to foreshortening affect caused by lens angle and depth of field. Archaeological illustration is useful as the illustrator can choose the important aspects to emphasise and it prints well, however it has little potential for digital manipulation in a 3 dimensional space. The recording of the Newport Medieval Ship rigging assemblage has combined the written, photographic and illustrative record as well as 3D laser scanning to produce as thorough a record as possible.

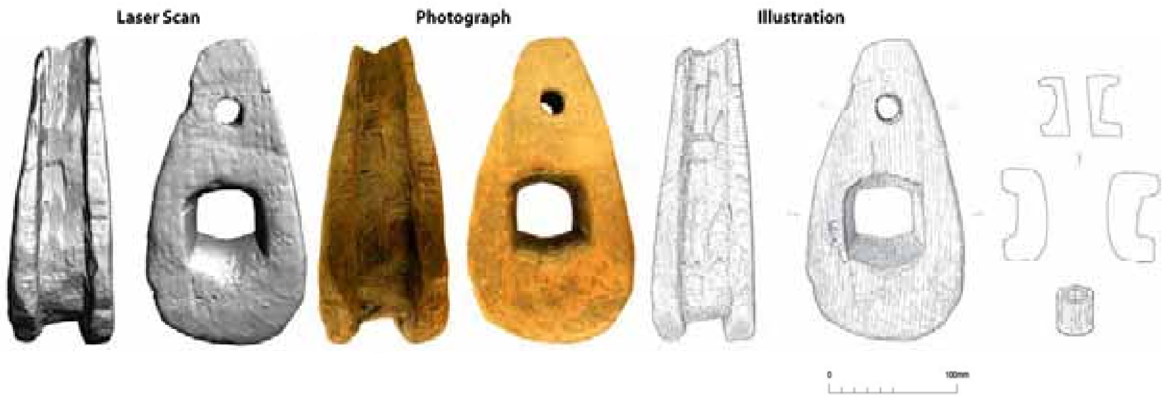


Figure 13. Comparable visual representations of Heart Block CT3036 (Newport Museum and Heritage Service).

3.2 Newport Medieval Ship Rigging Assemblage – Discussion

The rigging assemblage can be divided into two groups – the wooden artefacts and cordage. The wooden artefacts have been broken into further categories for discussion, these categories include parrel components, blocks, sheaves and miscellaneous rigging. After examining each item from the assemblage individually, the assemblage as a whole, in conjunction with the hull, must be interpreted to gain an understanding of how the vessel was rigged.

Parrel Components

A parrel, is 'a sort of collar, by which the yards are fastened at the slings to the masts, so that they may be hoisted or lowered with facility' (Biddlecomb 1990 p22). This system consists of parrel ribs, also known as a *parral* rib (Biddlecomb 1990), laths, slats, slides or sisters (McGrail 1993). The ribs would have been used as a component in a composite system along with trucks to retain the yards to the mast during raising and lowering.

The trucks, or wooden balls between the vertical ribs, allow the parrel to roll up and down the mast. A parrel truck or bead, also called a ball, roller or bullseye (McGrail 1993) acts as the moving component in the parrel system while simultaneously separating the ribs. The parrel ropes are reeved through both ribs and trucks (Lever 1998). Excavated from the Newport Medieval Ship were four components of one or more parrels. Two ribs, quite different in form from one another, and two trucks of very similar dimensions were excavated. It is a possibility that one type of parrel was in use while another form of parrel was onboard as a spare or alternatively it may have been from a second mast. In the case of the Vasa, several ribs and trucks, which are thought to possibly make up a complete spare parrel were found in a store compartment onboard, known as compartment T1 (Cederlund et al 2006). Two parrel trucks are present in the Newport rigging assemblage, however, after analysis by Dr. Julian Whiteright it was concluded that although the trucks are associated with one another, their diameters suggest they are not associated with either of the ribs found onboard (Whiteright (2010). McGrail (1993) suggests that in the 17th Century, the length of the parrel rib is an indication of the maximum diameter of the mast. He explains that the length of the rib is just slightly longer than the diameter of the mast. If this can be applied to the Newport ship, and the parrel was indeed in use onboard, it may be inferred that the mast is less than 610mm in diameter.

Parrel components have been found on many vessels, including the Mary Rose (Rule 1982) and the Vasa (Cederlund et al 2006). However, this Newport Ship parrel is curved on both edges, unlike the majority of other known examples which are flat on one edge and undulating on the parallel edge. The undulating edge facilitates the overlapping yard.

Cow Tag 2367 Parrel Rib

CT2367, seen in Fig.14, is one of two ribs found on the Newport ship. The holes running through the rib are 19mm in diameter allowing for a rope with a 60mm girth or circumference to pass through. The middle hole is slightly off centre. The second rib, CT3011, is quite different in form and according to Dr. Julian Whiteright, it is unlikely that it was from the same parrel (Whiteright 2010). A very similar example to CT2367 was found during the Wood Quay excavations in Dublin. Measuring 690mm x 100mm x 20mm, the Wood Quay example, too, is curved on both edges and dated by context to 1180-1200 (McGrail 1993).

Figure 14. 3D Laser scan of CT2367 (Newport Museum and Heritage Service)

Cow Tag 3011 Parrel Rib

CT3011 is the second parrel rib excavated from the Newport Medieval Ship. It appears to have broken in antiquity, however this cannot be determined for sure. It is quite finely made with chamfered edges. The hole is 16.4mm in diameter, allowing for a rope with a circumference of 50mm to pass through.

A very similar example to CT3011 was found on board The Swan wreck (See illustration below). This closely resembles the Newport Ship example as it has one curved edge and one straight, chamfered outer edges, chamfering around the holes and comes to a point at one end. The Swan example measures 165mm in length.

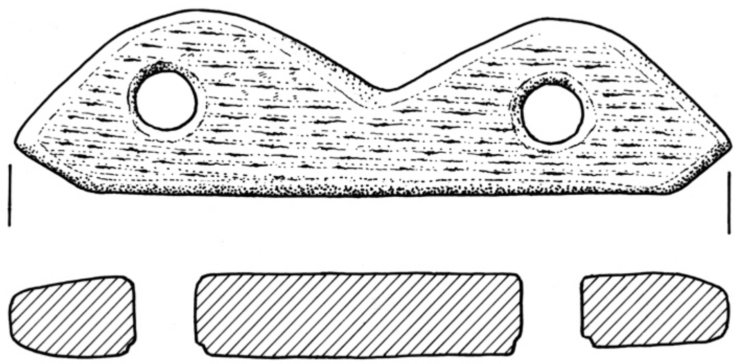


Figure 15. Parrel rib from the Swan Wreck (not to scale) (pers. comm. Dr. Martin 4/6/2011).

Figure 16. Parrel rib CT3011 from the Newport Medieval Ship (Newport Museum and Heritage Service).

Cow Tag 3023 & Cow Tag 3030 Parrel Trucks

CT3023 and CT3030 are parrel trucks. These trucks have the same dimensions (allowing slight variations due to damage and distortion), indicating that they may have been from the same parrel. CT3030 is the second and most complete truck of the assemblage. The truck, which would originally have been round, acted as a bearing to allow the movement of the parrel by 'reducing friction between the spar and the mast' (Bradley 2007, p8).

Many similar examples exist on a number of ship wrecks, their design changing little over time. The Red Bay wreck group of trucks are divided by their size, one group measuring 60mm, the other 80mm (Bradley 2007). These Red Bay examples are smaller than the two Newport Ship trucks, which measure 117mm. The Mary Rose had many examples on board; one group, comprising of 29 beads, still rigged and connected to the ribs by rope, was found in storage on board (Rule 1982). Similarly, on board the Vasa, also in storage (compartment T1), was what is thought to a complete parrel. The most interesting comparison, apart from CT3023, is the truck found on board the Swan wreck. As can be seen by examining the illustrations, (Fig. 18), both trucks have suffered distortion on one face. The flattened edge of CT3030 was most likely caused during the use of the vessel, while compressed against the mast, and would have impeded movement of the parrel system to some degree.

This distortion would hinder the movement of the parrel and as it appears to be a problem not unique to the Newport Ship, it may explain why many ships kept replacement parrels in their stores. Smaller examples, measuring 60mm and 80mm in length were recovered under the Red Bay wreck (Bradley 2007).

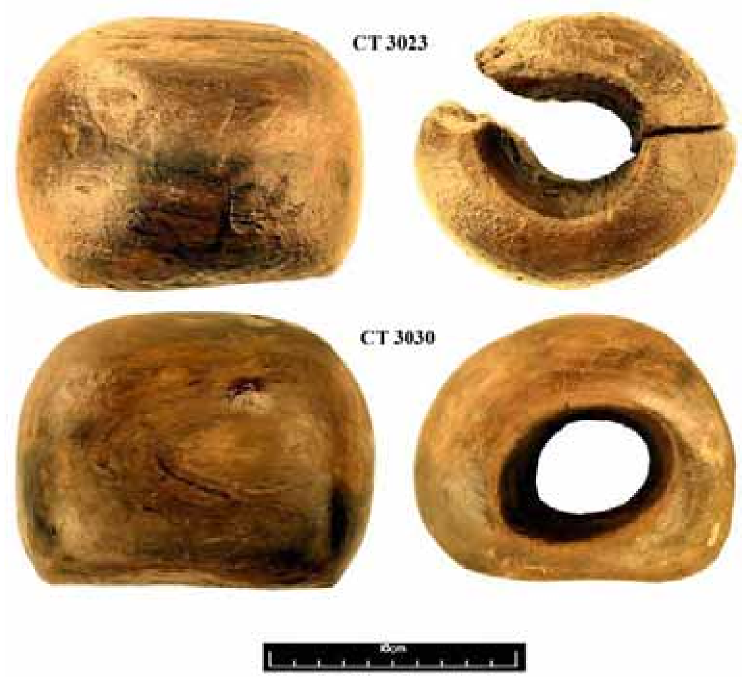


Figure 17. Two parrel trucks CT3023 & CT3030 from the Newport Medieval Ship (Newport Museum & Heritage Service).

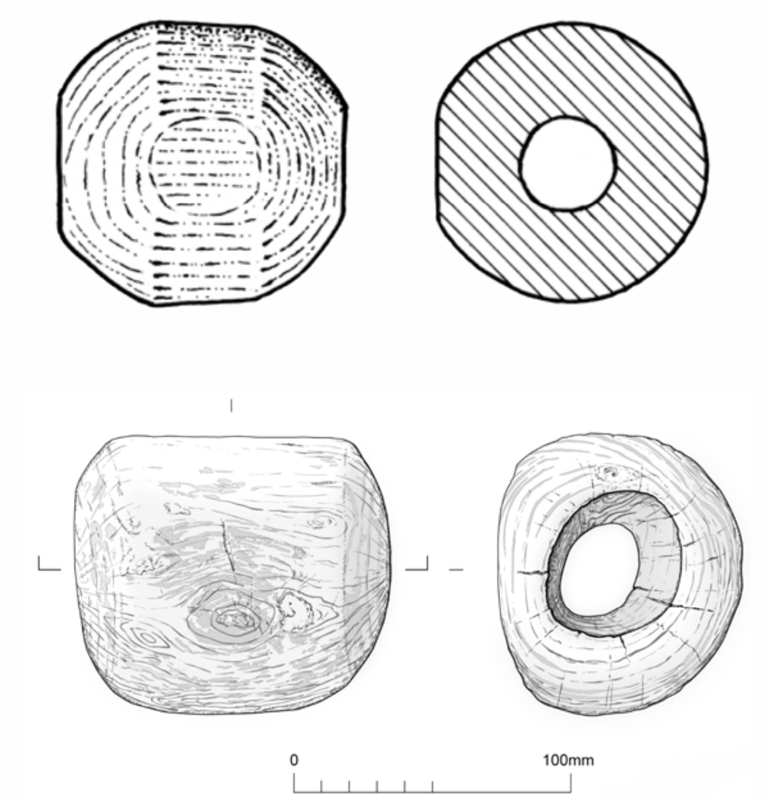


Figure 18. Truck found on the Swan, not to scale (top) (pers. comm. Colin Martin 4/06/2011). CT3030 Truck recovered from the Newport Medieval Ship (bottom) (Newport Museum and Heritage Service).

Heart Blocks

As discussed by Bradley (2007), there seems to be some degree of confusion between the terms 'dead eye', 'bull's eye' and 'heart', and possibly 'thimble'. Inter-changeability of terms seems to take place between sources, for example, what Bradley (2007) calls a 'heart block', Rule (1982) calls a 'thimble'. Lever (1998) on the other hand, when discussing bobstays, uses the terms 'Heart' and 'Dead Eye' interchangeably. For the purpose of this piece of research the names of rigging components from the Red Bay wreck will be applied to the Newport Medieval Ship Assemblage. Therefore CT3036 and CT3053 will be referred to as heart blocks. Biddlecombe (1990, p16) describes a heart as a 'peculiar sort of dead-eye, resembling a heart; it has one large hole in the middle to contain the laniard [*sic*], by which the stays or shrouds are extended.' Both these examples have a large lanyard hole and a small hole , described by Bradley (2007, p7) as a knot hole. He also suggests this heart may have been used either 'in a fore preventer stay or a fore topmast stay'.

Cow Tag 3036 & Cow Tag 3053 - Heart Blocks

Two heart blocks were excavated from the Newport Medieval Ship, CT3036 and CT3053. CT3036 has evidence of wear around the larger hole. The straight sided groove cut into the edge has clear tool marks which suggest the rope that was in place originally was stationary. Originally described as a 'dead eye' (Whiteright 2010, p26), CT3053 is more oval in shape than CT3036. Four distinct circular marks on one surface were most likely caused in antiquity, possibly by a clamp.

Many comparables exist. Forty-eight heart blocks, divided into five different types were excavated from the Red Bay wreck. The heart blocks associated with the foremast and mainmast shrouds, from the Red Bay wreck are between 169mm and 242mm which are directly comparable in size with the two Newport Ship examples which measure 235mm (CT3036) and 238mm (CT3053) in length. Red Bay's closest comparable heart block appears to be artefact 24M28P3-1, seen in Fig. 19. The Mary Rose also had examples, which Rule (1982) calls 'thimbles', and *La Trinidad Valencera* has a similar example, however without the knot hole.

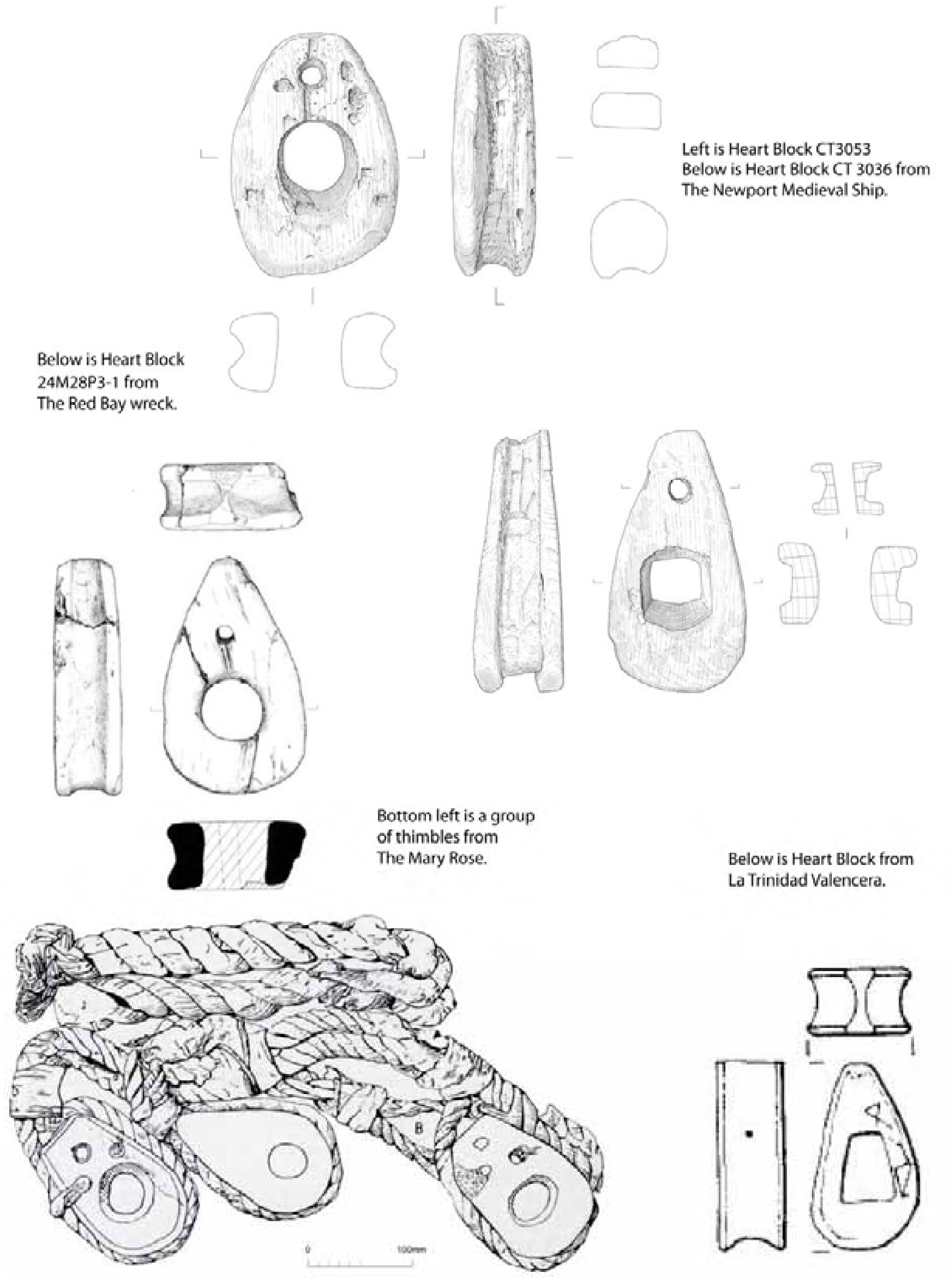


Figure 19. Heart blocks from The Newport Medieval Ship (Newport Museum and Heritage Service), The Red Bay Wreck (Grenier et. Al 2007, p7) , The Mary Rose (Rule 1983, p148) and *La Trinidad Valencera* (Martin 1979, p33).

Clew Garnet Block

A clew garnet block, sometimes called ‘clue garnet’ is present in the assemblage. Specifically associated with square rigged vessels, clew garnet block straps, as described by Biddlecomb, are passed through the clews or bottom corners of the sail. Lever explains such a block is 'strapped with two legs, which are reeved through the holes in the shoulder of the block, and the round seizing is clapped on' (Lever 1819, p52). The cross section of CT3049, seen in Fig. 20, shows the two spaces in the block’s collar where these ‘legs’ are reeved.

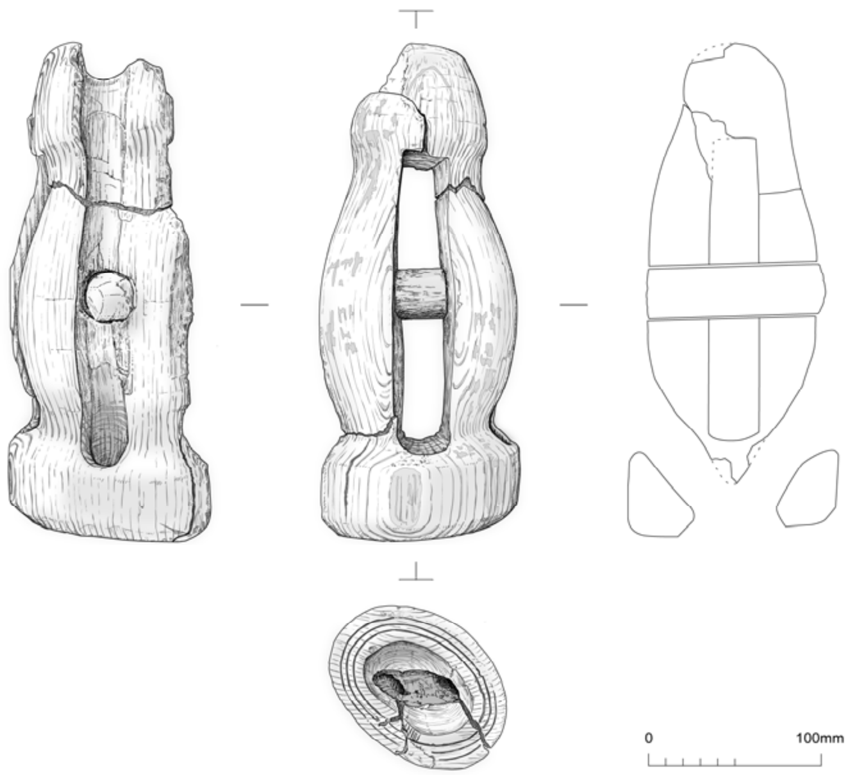


Figure 20. Illustration of CT3049 (Newport Museum and Heritage Service).

Biddlecomb (1990, p95) also states that clue garnets ‘reeve through the blocks on each side of the yard, then through the block on the clue of the sail. The standing part is carried up, and made fast round the yard by its block. The leading- part comes upon deck, and reeves through the sheave-hole in the top-sail-sheet bitts and there it belays.’ Mainwaring explains that a 'clew garnet is a rope which is made fast to the clew of the sail and from thence runs in a block which is seized to the middle of the yard [and so cometh down near the mast to the deck]; the use whereof is when we farthel our main sail or fore sail (for the name of clew garnet doth only belong to the clew lines of those two sails) then this rope doth haul up the clew of the sail close to the middle part of the yard' (Mainwaring & Perrin 1920, p127). Rule (1983) also discusses a type of single sheaved block, which she calls 'Type A3.2' whose distinguishable features include a prominent shoulder and tail. Rule (1983, p144) concludes that this type of block may have functioned 'as a clew line block to hoist the clew or lowest corner of the sail to the middle of the yard'.

Cow Tag 3049 – Clew Garnet Block

CT3049 is the example of a clew garnet discovered on the Newport Medieval Ship. An almost identical example, although smaller, was found on The Drogheda Boat wreck. The Drogheda example measures 130mm in length and 55mm in width (pers. comm. Holger Sweitzer DOEHLG 4/11/2011) compared to the Newport ship block which is 294.7mm in length and 125mm in width. Note how both The Newport Ship and The Drogheda Boat examples have suffered damage in the same areas. Both pieces have a round collar and a bulbous, grooved head.

Figure 21. Clew garnets from the Newport Medieval Ship (left) (Newport Museum and Heritage Service) and the Drogheda Boat (right) (pers. comm. Holger Sweitzer).

Dutch Lift Block/Pendant Block

Anderson (1994, p145) describes this type of block as a 'Foreign pendant-block for lower lifts'. Corder (2007) explains that this type of block was suspended by a line of rigging, with an independent line running through the sheave which is reversible. Corder shows in her diagram below how 'one side of the block would have been attached to the pendant suspended from the mast head, while the other side would have been the starting point for the line of running rigging that extended to the yard arm through a separate block and back to the sheave of the lift block, then down to a belaying point' (Corder 2007, p27).

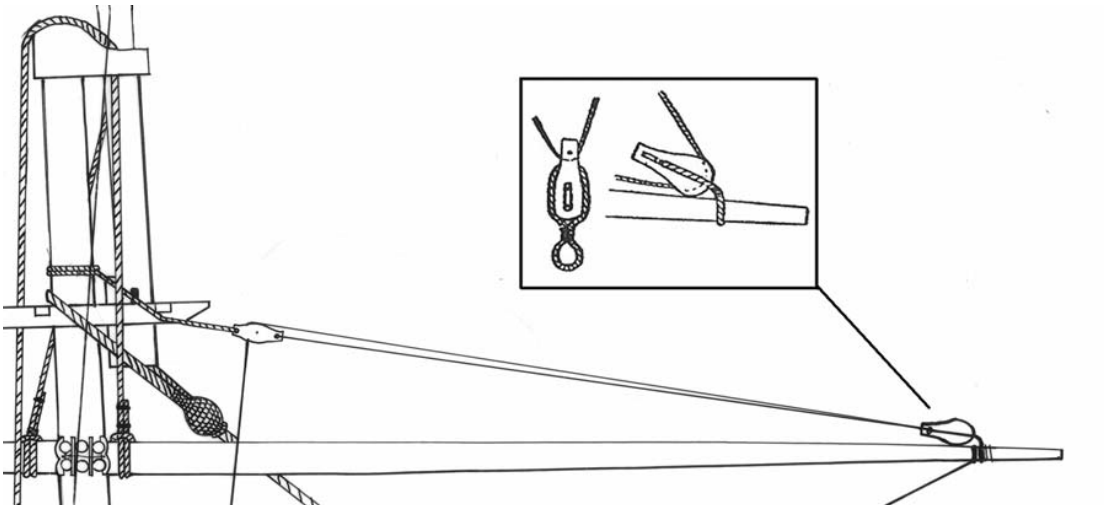


Figure 22. 17th century Dutch design of the lower lifts with topsail sheet shown in inset (Corder 2007, p28).

Cow Tag 3051 & Cow Tag 3052 – Dutch Lift Block

CT3051 and CT3052 are two parts of a single sheaved Dutch lift block. The disc sheave and pin are still in place and a small iron nail holds the pin in position. Using the digital laser scan of the two sections of the block, it was possible to successfully rejoin the two halves back together, in digital space, to their original position.

Very few comparable examples exist. Two smaller examples were found on the wreck of *La Belle*. The *La Belle* examples measure 260mm in length and 99mm in width, compared to the Newport Ship example which is 506mm in length x 146mm wide. Despite the size, both examples have a hole at each end which are at right angles to the central sheave (Corder 2007). Corder (2007, p26) however, describes the *La Belle* Blocks as being 'Dutch lift blocks' and suggests that they are 'unique to the 17th century, and are believed to have been used first by the Dutch exclusively on their lifts.' The Vasa has, what was understood to be the earliest existing examples of Dutch lifting blocks in their assemblage. If this block from the Newport Medieval Ship is from the ship's original 15th Century rigging assemblage, it predates the Vasa's blocks by over 150 years.

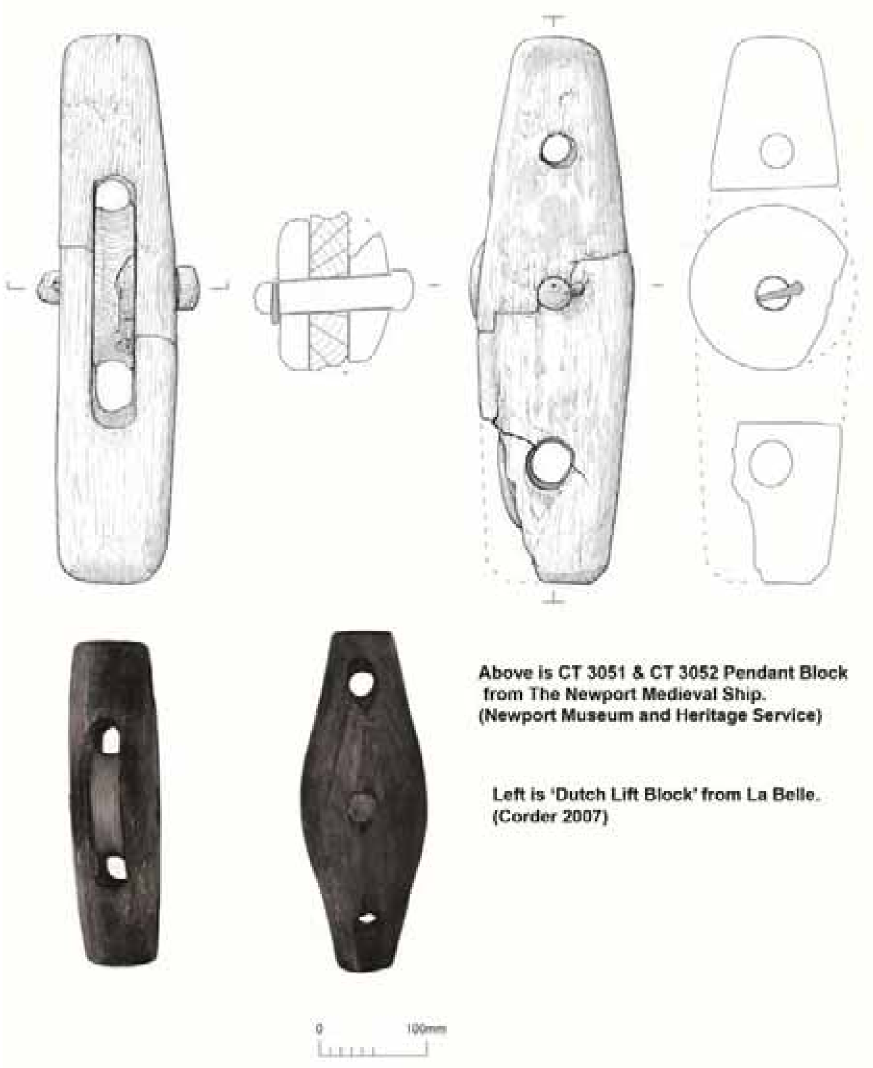


Figure 23. Pendant Blocks/Dutch Lift Blocks from the Newport Medieval Ship (top) (Newport Museum and Heritage Service) and *La Belle* (bottom) (Corder 2007, p27).

Sheave & Pin

A sheave, also referred to as a shiv, disc sheave or pulley wheel, is described by Biddlecombe as 'a solid cylindrical wheel fitted in blocks, &c., and moveable about an axis, called the pin' (Biddlecombe 1990, p27). The sheave is part of the running rigging and has a groove around its circumference to allow a rope to sit. Two disarticulated sheaves and two disarticulated pins were excavated form the Newport Medieval Ship.

Cow Tag 1853 & Cow Tag 3006 - Sheaves

Cow Tag 3009 & Cow Tag 3010 - Pins

Artefact 1853, in Fig. 24 is half a sheave. This specific piece has become separated from its original block and pin, quite likely, judging by the condition of the break, this occurred in antiquity. This groove is quite pronounced and would have had a rope with a maximum diameter of approximately 42mm running around it. This diameter was calculated by assuming that when this sheave was originally in place within a pulley, the inner surfaces of the pulley cheeks would be almost flush with the flat faces of the sheave. This would imply that the maximum diameter of the rope could therefore not be much wider than the depth or thickness of the sheave itself, or the rope running through the pulley would jam the system.

Figure 24. 3D laser scan of CT1853 (Newport Museum and Heritage Service).

CT3006 is a complete disarticulated sheave found on the Newport ship. CT3006 has a smaller diameter than CT1853, measuring 146.7mm with a pin hole diameter of 41mm but also has a groove running around the circumference to facilitate a 35mm diameter rope. CT3009 and CT3010 may be disarticulated pins which would have functioned as the axle for a pulley. CT3009 has a diameter of 30mm and 3010 has a diameter of 35mm, therefore it is possible that they are associated with the excavated sheaves.

Many comparables, of various sizes, have been found, both as composite blocks and single sheaves on the Red Bay Wreck (Bradley in Grenier et al., 2007), the Swash Channel Wreck (pers. comm. Dave Parham 15/05/2011), *La Trinidad Valencera* (Martin 1979) and The Mary Rose (Rule 1982).

Figure 25. 3D laser scan of CT3006 (Newport Museum and Heritage Service).

Bull's Eye

Biddlecombe (1990 p34) explains that a thimble is, 'fixed to the rigging for blocks to be hooked to, and for ropes to reeve through' and describes a bull’s eye as having a similar function but instead of being made of iron it is made of wood Biddlecombe (1990).

CT 3031 & Cow Tag 3024

Originally CT3031 was identified as an unfinished disc sheave with similar dimensions as CT3006 and CT1853 (Whiteright 2010). Although this is possible, it could also be interpreted as a bull's eye or wooden thimble.

Figure 16. 3D laser scan of CT3031 (Newport Museum and Heritage Service).

CT3024 suffered some damage, most likely post- depositional (Whitewright 2010). Bull's eyes often have a groove around the outer edge to facilitate a rope (Lever 1998), this piece however, does not. Whitewright (2010, p27) suggests that CT3024 may have been used as 'a hard stop at the end of a rope'.

One example from the Red Bay wreck is possibly comparable. The bull's eye found on the Red Bay wreck is quite similar in form but slightly larger than the Newport Medieval Ship examples; all are roughly worked or possibly unfinished and have one central hole. The Red Bay example, unlike the Newport Ship piece, has a shallow groove around the circumference to facilitate a rope (Bradley 2007). Bradley (2007, p19) admits that the wooden bull's eye known as 24M12P10-1, found in the starboard stern quarter is of 'uncertain function'.

Figure 27. 3D laser scan of CT3024 (Newport Museum and Heritage Service).

Miscellaneous Rigging

Rigging Bitt or Spill Toggle

Bitts are described by Biddlecombe as 'A frame composed of two upright pieces of timber, called the pins, and a cross piece, fastened horizontally near the head of them; they are used to belay cables or ropes to...'(Biddlecombe, 1990, p3). An artefact similar to the rigging bit and also associated with rigging is a spill toggle. Discussed by Polzner (2008, p240), this type of toggle is used as a type of 'quick release mechanism in knots'. This tapering piece would have been placed through a knot, keeping it from slipping. When it was necessary to release the knot in haste, the spill toggle could be pulled by a trip line attached to the hole at the wider end. Its tapering form would have prevented knots from jamming (Polzner 2008). Fig 29 shows a number of diagrammatical examples of a spill toggle in use.

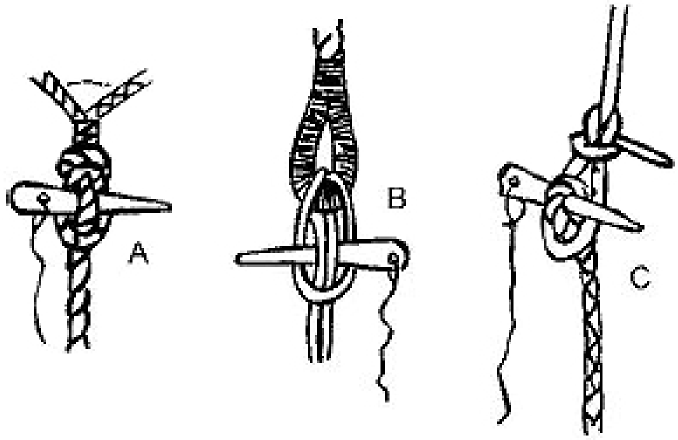


Figure 28. (A) shows a spill toggle connecting the clew of the sail to the eye of a sheet; (B) depicts a toggle being used to hoist the sail when a hasty cast off is necessary; (C) shows two eyes connected by a toggle, used for lifting a heavy object (Polzer 2008, p240).

Cow Tag 1926 – Rigging Bitt / Spill Toggle

It has been suggested that CT1926 is a rigging bitt (Whitewright 2010) and may have been used to fasten a rope to. Visible in the scan (Fig. 28) are the different areas of wear, possibly caused by the fastening of ropes to the pin. The wear on the CT1926 could also support the second interpretation, that the piece is a spill toggle. The damage is concentrated around the hole, where the trip line would have been tied as well as in the centre, which would have held the strain and endured the damage when pulled.

Dr. Julian Whitewright, having analysed this artefact, noted that 'a broadly comparable piece, identified as a belaying pin, was excavated from the remains of *La Trinidad Valencera*' (Whiteright 2010, p27). Interestingly, the example from La Trinidad, at 430mm, is almost exactly the same length as the Newport Ship artefact which is 419.7mm. Dr Martin describes the find from *La Trinidad Valencera* as a 'tapered wooden pin 17in (0.43m) long, circular cross section. Perhaps a belaying pin' (Martin 1979, p32).

Figure 29. 3D laser scan of possible spill toggle CT1926 (Newport Museum and Heritage Service).

Hook

Mainwaring (1929) makes many references to the use of hooks on board a ship for fishing and for hitching to the fluke of the anchor. These hooks however would most likely be made of iron. Loof hooks, were also found on ships and were used to alleviate stress on the tack during strong winds. These would have been made of wood (Mainwaring 1929). Hooks were part of a runner's tackle, Mainwaring (1929, p216) explains, ‘The Runner is a rope which is a part that doth belong to the garnet and the two boat tackles, that before (which comes in the aftermost shrouds of the foremast) and that tackle abaft which comes in the foremost shrouds of the mainmast. It is reeved in a single block which is seized to the end of a pendant, and hath at one end a hook to hitch into any thing, and at the other end a double block wherein is reeved the fall of the tackle, or the garnet; which doth purchase more than the tackle or the garnet would do without it, and therefore to heavy things they use this, but for light ones they use only the tackle which hath a block with a hook which is seized to the standing part of the fall. Overhaul the runner, that is, to pull down that end which hath the hook in it, to hitch it into the slings or the like’.

Cow Tag 3038 Hook

This artefact, thought to be part of the rigging assemblage, may have been a loof hook used to lessen the strain on the rig during tacking in heavy weather. It is hook like in shape and there is slight evidence of wear on the inner part of the hook.

Eight hooks, one of which was made of oak, were found on the Mary Rose (Gardiner 2005). This oak hook from the Mary Rose, (Fig.30), is very similar to CT3038 and may have had a similar function.

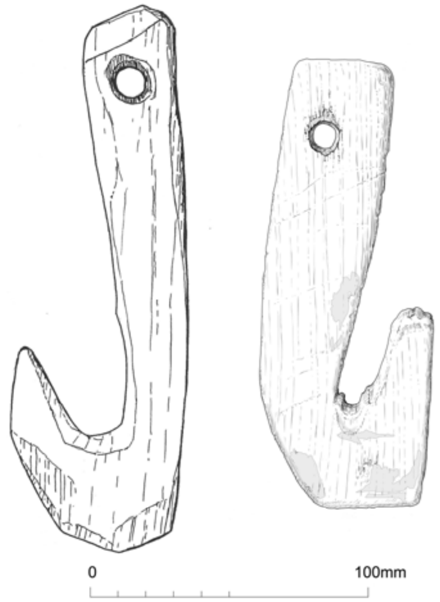


Figure 30. Oak hooks from the Mary Rose (left) (Gardiner 2005, p352) and the Newport Medieval Ship (right) (Newport Museum and Heritage Service).

Cow Tag 1807

The function of artefact CT1807 is unclear at present. It is presumed to belong to the rigging assemblage, however parallels, contemporary or otherwise have not been found by this researcher. The holes running across the width of the piece are not parallel but run at slight angles. The triangular rebate with a hole through to the longest edge has been deliberately made and without doubt had a specific function as did the hole. One small nail is present. Whitewright (2010) suggests this artefact may have been a rope guide, or possibly a component of a trestle. He concludes that the interpretation of this artefact is difficult and should not be considered part of the rigging or indeed the vessel at all.

Figure 31. 3D laser scan of CT1807 (Newport Museum and Heritage Service).

Cow Tag 3008

CT3008 is thought to be part of the Newport Ship's rigging assemblage, however little is understood about the piece. The holes are not parallel to one another but run at slight angles. It is quite roughly made with chop marks clearly visible. It is a possibility the piece was used for the purpose of belaying ropes to, or it may be a rough-out of some sort of toggle, as much of the outer round wood is un-worked. At present a comparable artefact has not been found.

Figure 32. 3D laser scan of CT3008 (Newport Museum and Heritage Service).

Cow Tag 3018

The function of this object is unclear. It may have functioned as a form of toggle, however if this is the case, one would expect the toggle to be rebated all the way around the object, rather than just one face.

At present no comparable has been identified.

Figure 33. 3D laser scan of CT3018 (Newport Museum and Heritage Service).

Cordage

The cordage excavated from the Newport Medieval Ship and analysed by Walton-Rodgers was divided into two groups, hemp cordage and grass cordage. The hemp cordage is associated with the rigging and Walton-Rodgers explains that the principal component is a Z-spun yard 1-3mm in diameter, for the most part compactly twisted (helix 50°-60°) into S-twist strands, measuring 15-18mm diameter (Walton-Rodgers 2012).

Hemp cordage from the Red Bay wreck is comparable with the Newport Ship cordage. Bradley (2007) explains that the towns of Calatayud and Calahorra, located on the Ebro River, in Spain, were the main sources of rope in the Biscayan area. It is possible that the hemp cordage from the Newport Ship may have come from one of these towns. (See *Appendix* (i) for the full catalogue).

3.3 Newport Medieval Ship Rig Hypothesis

Rig Reconstruction Theory

When seeking to ascertain original hull form and rig type the theory of minimum reconstruction is usually applied. This concept can be described as, 'one or more minimalistic ways to complete the hull and point to the most likely means of propulsion and steering for the vessel' (McGrail and Crumlin Pederson 2006, p57). This is the quintessential concept applied to the creation of a rig hypothesis for the Newport Medieval Ship. Known physical constraints can also be utilised in this process.

McGrail (1987, p221) explains, 'There are limits to the loading that sail and rigging can sustain; there is a limit beyond which a boat cannot safely be heeled...' However many factors come into play and even within the natural constraints of physics there is room for variability of rig type. This may lead to more than one possible option for the rigging method and sail plan of the Newport Medieval Ship. McGrail and Crumlin Pederson (2006, p57) discuss this room for variability, stating that 'reconstruction of the original hull form and structure of an excavated boat may not always be possible and there could be several equally-valid reconstructions of a boat find'.

Constructive Evidence

There are many challenges faced when trying to understand exactly how the Newport Medieval Ship may have been rigged. The main difficulties include the lack of comparable archaeological evidence from this time period as well as the unusual nature of the archaeological site formation. The ship did not sink at sea but sat at the bank of the river for some time being repaired and then dismantled. This is evident from the ship itself as it was cut across, from bow to stern, at strake seventeen, on the portside, in antiquity. A large 'door' was cut out of the starboard side, presumably to facilitate the removal of timbers from within (pers. comm. Nayling 2010). During this period of dismantling there is every possibility that intrusive artefacts were introduced into the ship's fill. With this in mind caution must be taken when creating a rig hypothesis based on the moveable archaeological artefacts.

The Newport Medieval Ship has evidence of running rigging in the form of parrel ribs and trucks as well as blocks. The clew garnet CT3049 is direct evidence of the use of clew controlling sheets and is associated with square sails. There was also evidence of standing rigging in the form of shroud tightening heart blocks. It is certain the Newport Medieval Ship had at least one mast which was centrally located. The mast step, located in the mid ship area and part of the keelson, is evidence of this. The mast step and keelson combined are 10m long and cover 28 floor timbers. The mast step area is 2 m long and 800mm wide and covers 6 floors. The mast step would have acted like a mortise and tenon joint – the mast slotting into the mast step rebate which measures 900mm long, 400mm wide and 250mm deep (pers. comm. Toby Jones 15/08/2012). The mast partner, which would have sat at deck level to support the mast, has a diameter of 858mm. Archaeological remains support the theory that the Newport Medieval Ship had one centrally located square sail however the evidence for more than one mast is less definite. It has been suggested that the Newport Medieval Ship was rigged like a carrack (Roberts 2004), with a square main sail, a smaller square fore sail and a lateen mizzen mast however no direct archaeological evidence supports this.

Tried and tested rules of thumb have been coined and utilised by shipwrights to best deal with the natural constraints encountered by sailors and ship builders over centuries of trial and error. Bradley (2007), when creating a hypothetical rigging scheme for the Red Bay wreck, notes the importance of ship building treatises and contemporary documents referring to rigging. Bradley discusses a treatise from 1587 by Diego Garcia de Palacio in Mexico and another document by Thome Cano (Bradley 2007). Castro, when examining the possible rigging of the Pepper wreck which was lost in 1606, refers to Fernandez's *regimento*as as well as *the Livronautico* (Castro 2005). These rules of thumb, which are outlined in table (c), are broadly contemporary with our case study and are useful when used in conjunction with modern engineering software. The rig and hull cannot be examined in isolation as both are intrinsically linked. Castro points out when discussing the rigging of the Pepper Wreck 'the sizes of masts and spars are often related to the sizes of some of the most important components of a ship, such as the keel length' (Castro 2005, p111). McGrail also highlights the relationship between hull and rig when he states, 'Hull and rig must be matched, since the structure must be capable of withstanding the loadings imposed by the sail operating at maximum efficiency' (McGrail 1987, p195).

Table (c) Shipbuilding rules of thumb from contemporary shipbuilding treatises.

Name	Date	Ship Type	Mast height	Mast Diameter	Yard Length	Yard Diameter
Instruccion nautical para el buenuso y regimento de lasnaos Diego Garcia de Palacio (Laanela 2008)	1587		Length of the keel plus the rake of the stern.	-------------------	2 1/3 times the ship's beam.	--------------------------------
Livro nautico Castro (2005) (b)	1590	Nau	As many bracas of length as the number of rumos of the keel.	1/10 the ship's maximum beam	3 times the value of the maximum beam.	2 palmos de goa Tapering to half it maximum value at either end.
Livro nautico Castro (2005) (b)	1590	Galleon	As long in bracas as the keel is in rumos.	1/10 the ship's maximum beam at deck level, tapering to half that value below the cheeks.	40.05m	Half the diameter of the main mast, Tapering to half it maximum value at either end

Livro de Tracas de Carpintaria Fernandez Castro (2005) (b)	1616		18 bracas	4.5 palmos de goa tapering to 5/7 of that value at the top, below the cheeks.	Should be same length as the main mast.	51cm (2 palmos de goa) tapering to half the maximum diameter at each end.
Fabbrica Di Galere (Anderson 1945) (Bellabarba 1988)	1400 - 1500	2 masted square main & lateen mizzen	3.5 times the length of the maximum beam or approx the length of the hull	Diameter length ratio of 1:44	3 times the beam or 4/5 of the mast length. (in two parts)	
Giorgio Timbotta da Moda (Hoffmann & Hoffmann 2009)	1445	coche	4 times the hull's beam		4/5 of the length of the4 mast	

Rig Reconstruction Methodology

Due to the universal physical constraints associated with sailing a ship, certain limitations to rig specifications exist. Using the known and estimated dimensions of the Newport Ship we can calculate approximately what sail area would be required to power the vessel and therefore the length of the mast and yard needed to support that area of sail. Castro (2008, p188), when discussing the reconstruction of the Pepper wreck, suggests that 'The best strategy is to try to understand which ranges of values are actually plausible, when we compound the archaeological data with documentary evidence – both descriptions and representations – and then test our theoretical model again and again, humbly and patiently, against all the information we will be able to gather'.

As a large percentage of the Newport Medieval Ship hull was recovered, it was possible to create a digital minimum reconstruction of the vessel up to the 35th strake. This reconstruction, which was achieved by utilizing the 3 dimensional laser scan of the model, was undertaken by boat builder and 3D laser scanning specialist, Pat Tanner. The construction of the physical model of the Newport Medieval Ship as well as subsequent preparation of digital files for Tanner's analysis was undertaken by staff of the Newport Medieval Ship Project including the author.

Figure 34. The physical model of the Newport Medieval Ship being laser scanned (Newport Museum and Heritage Service).

The testing of the reconstructed model was carried out using Orca 3D, a software programme commonly used by naval architects for hydrostatic analysis and performance predictions. Tanner carried out two sets of tests, the first is the Holtrop analysis of an empty or lightship and then the test was repeated for a fully laden ship to determine powering requirements in both states. This speed/power analysis uses the wetted area of a half hull, to the dimensions of the scanned model scaled to full size, both unladen and with the ships estimated maximum load of circa 120 tonnes. The ship sits with approximately a meter deeper draft in the latter state. Work on this digital reconstruction has not been completed therefore the figures below may change, however the method will remain consistent (pers. comm. Pat Tanner 30/08/2012).

Test 1 Lightship Analysis

Test 1 undertaken by Tanner, which analysed the propulsion requirements of the Newport Medieval Ship in a lightship state used the following dimensions from the hydrostatic and stability report. The digital reconstruction of the vessel, created by utilizing the 3D laser scan of the model was tested to create the hydrostatic and stability report;

Length overall:	26.483m
Beam Overall:	8.576m
Length waterline:	24.271m
Navigation Draft:	1.750m
Displacement:	103.560t
Wetted Surface Area:	144.615 m²
Cp (prismatic coefficient):	0.526

Using the above specifications the investigation determined the approximate horse power requirement to achieve these various speeds;

3 kts	requires	1.9hp
4 kts	requires	4.3hp
5 kts	requires	8.0hp
6 kts	requires	13.5hp
7 kts	requires	21.7hp
8 kts	requires	35.3hp
9 kts	requires	57.3hp
10 kts	requires	91.1hp
11 kts	requires	158.6hp
12 kts	requires	298.8hp

To calculate the sail area required to achieve the necessary horse power to subsequently attain a certain hull speed, differing sail areas were entered into the 'sail area wind load calculations spreadsheet' devised by Tanner. In the lightship state Tanner ascertained that for the Newport Medieval Ship to achieve 8 kts it would necessitate 35.3 hp which would require 195.09 sq. m. of sail area in 15 kts of wind (pers. comm. Pat Tanner 30/08/2012). A hull speed of 8 kts, for this research, will be considered an acceptable hull speed. At this speed, if constant, the vessel would complete a journey from San Sebastion to Bristol in 3 - 4 days. (See *Appendix* (iii) for Light ship Condition Drawing, Lightship Holtrop Analysis Report and Lightship Hydrostatics & Stability Report).

<u>Test 2 Fully Laden Ship Analysis</u>

Test 2 undertaken by Tanner, which analysed propulsion requirements of the Newport Medieval Ship in a fully laden ship state used the following dimensions from the hydrostatic and stability report;

Length overall:	26.483m
Beam Overall:	8.576m
Length waterline:	25.218m
Navigation Draft:	2.716m
Displacement:	224.999t
Wetted Surface Area:	204.178 m^2
Cp (prismatic coefficient):	0.563

Using the above specifications the investigation determined the horse power requirement for these various speeds;

3 kts	requires	3.3hp
4 kts	requires	7.4hp
5 kts	requires	13.9hp
6 kts	requires	23.3hp
7 kts	requires	37.0hp
8 kts	requires	58.9hp
9 kts	requires	97.7hp
10 kts	requires	153.8hp
11 kts	requires	253.4hp
12 kts	requires	478.6hp

As in Test 1, to calculate the sail area required to achieve the necessary horse power to subsequently attain a certain hull speed, differing sail areas were entered into the 'sail area wind load calculations spreadsheet' devised by Tanner. In the fully laden ship state Tanner ascertained that for the Newport Medieval Ship to achieve 8 kts requires 58.9 hp which would require 325.16 sq. m. of sail area in 15 kts of wind (pers. comm. Pat Tanner 30/08/2012).
(See *Appendix* (iv) for Fully Laden Ship Condition Drawing, Fully Laden Ship Holtrop Analysis Report and Fully Laden Ship Hydrostatics & Stability Report).

Results

There is only one case where an entire mast has survived in an archaeological context. That is from a vessel, thought to be about 11m. It was excavated in Bryggen, Bergen, Norway and may date to the fourteenth century (Hutchinson 1998). This scarcity of comparable archaeological evidence necessitates the use of contemporary treatises when estimating rig dimensions for the Newport Medieval Ship.
According to contemporary ship building treatises, (see table (c)), such as the *Instruccion nautical para el buenuso y regimento de lasnaos Diego Garcia de Palacio* and the *Livro nautico*, the main yard can be from 2 1/3 (*Garcia de Palacio* 1587*)* to 3 times (*Livro nautico 1590*) the width of the ship's beam. In the case of the Newport Medieval Ship the beam is 8.5m giving a main yard length of between 20m and 25.5m. Taking the yard to be 22m, to achieve the required 325 sq. m area required for as laden vessel, a single sail would need to measure approximately 20m wide x 16.25m in height. As can be seen from the investigations above a fully laden vessel would require 130 sq. m more sail area than an empty vessel.
A sail of these dimensions would require a mast of approximately 25m in length. This mast length has been calculated by adding the distance from mast step to deck height, which is in the region of 5m, an additional 2m head height on deck, 16.25m which is the height of the sail and 2.25m at the head of the mast. From the archaeological evidence it is understood that the mast step would have facilitated a mast with a maximum diameter of 720mm at the base (pers.comm. Toby Jones 15/08/2012).
A sail of these calculated dimensions would have an aspect ratio (AR) of 1.2. McGrail (1987) explains that for a square sail to be efficient to windward and to achieve optimum camber an AR (height/Breadth) of between 1.5 and 2 is ideal. It can therefore be inferred that

the Newport Medieval Ship may have been inefficient when sailing close to the wind. It is also a possibility that the sail was squarer in shape, creating a higher AR, improving performance to windward and perhaps supplemented by a second mast. Spreading the sail area across two masts would make it easier to manage for the crew on board, therefore requiring fewer people on the ship. The presence of two different parrel ribs on the Newport Ship appears to support this two mast hypothesis. Sanders (2010, p13) explains that 'vessels often had their rig modified, even to the extent of removing and adding masts', this may also have been a possibility with the Newport Ship. The use of bonnets and reefs is also likely and would have allowed the crew to adapt the rigging to the wind conditions McGrail (1987).

4. Conclusion

The technological advances in ship construction and rigging in the 15th century have been compared in significance to the change from sail to steam in the 19th and 20th centuries and it is believed Basque shipbuilders played an imperative role in these developments (Sanders 2010). The archaeological evidence from the Newport Ship, in conjunction with that of the later Red Bay wreck, both of Basque origin, tangibly depicts the developments that were occurring in nautical technology in Medieval Europe. The most impartial source of evidence, the rigging components themselves, are rarely preserved in an archaeological context and have, in the past, been poorly documented and are therefore difficult to access. Fortunately technological advances and interdisciplinary research are augmenting recent studies in this subject. In the case of the Newport Medieval Ship Project and other projects using similar 3D methods of documentation, even if evidence of rigging itself is not found, much can still be concluded in 3 dimensional space without the need for 1:1 physical replica construction.
The substantial amount of iconographic evidence for the medieval period, although useful, is frustratingly unreliable, which is an issue not easily resolved. However there are clues that are depicted that can shed light on the nautical developments of the 15th century and for that reason this source can not be overlooked. Features such as the 'bi-lobular balloon sail' (Callender 1912, p371) and the presence of flags at the bow and stern of 15th century vessels illustrated in contemporary manuscripts, are difficult to detect in the archaeological record. These attributes that appear to be portrayed repeatedly in the iconographic record, may represent a technological vestige that was unique to the period.

4.1 Further Research

Medieval ships' rigging is a subject that will benefit from ongoing research. Future study of 15th century archaeological remains will immensely benefit those involved in the task of establishing ship reconstructions. The rig hypothesis created in this investigation for the Newport Medieval Ship is based on the concept of 'minimum reconstruction' (Crumlin-Pederson & McGrail 2006, p57). The construction of a hypothetical rig, from limited remains is an ambiguous exercise with many unanswerable questions. As research in to the original hull form of this merchant ship continues the results given here may be re-evaluated by the author as well as future researchers.

References

Anderson, R. C. *A Treatise on Rigging*, written about the year 1625. From a manuscript at Petworth House. Edited by R. C. Anderson, ff. 20. 1921.

Anderson, R. C. (1924). "Early Books on Shipbuilding and Rigging." *The Mariner's Mirror,* **10**(1): 53-64.

Anderson, R. C. (1927). *The rigging of ships in the days of the spritsail topmast : 1600-1720*. Salem, Mass., Marine Research Society.

Anderson, R. C. (1945). "Jal's 'Memoire No. 5' and the Manuscript 'Fabbrica Di Galere'." *Mariner's Mirror,* **31**(3): 160-167.

Anker, J. (2009). *Mataro Model.* Available from: http://ca.wikipedia.org/wiki/Fitxer:Mataro_Model_-_Maritime_Museum_Rotterdam_-_WLANL.jpg. [Accessed 07/07/2012]

Arenhold, L. (1911). "Ships Earlier Than 1500 A.D." *Marriner's Mirror,* **1**(no. 4): 298 - 301.

Ashley, C. W. (1947). *The Ashley book of knots*. London; Boston, Faber and Faber.

Ashmolean Museum (2011). '*St Nicholas of Bari banishing the Storm'* by Bicci di Lorenzo. *In:* Ashmolean Museum's Complete Illustrated Catalogue of Paintings. Available from: http://www.ashmolean.org/php/makepage.php?db=wapaintings&view=llisti&all=&arti=Bicci+di+Lorenzo,&titl=&mat=&prov=&sour=&acno=&park=&strt=1&what=Search&cpos=1&s1=artist&s2=mainid&s3=&dno=25. [Accessed 20/01/2011]

Bellabarba, S. (1988). "The Square-rigged Ship of the Fabrica Di Galere Manuscript Part 1." *Mariner's Mirror,* **74**(2): 113-130.

Bengtsson, S. (1975). "The Sails of the Wasa. Unfolding, identification and preservation." *The International Journal of Nautical Archaeology and Underwater Exploration,* **4**(1): 27-41.

Biddlecombe, G. (1990). *The art of rigging: containing an explanation of terms and phrases and the progressive method of rigging expressly adapted for sailing ships*. New York, Dover; London: Constable.

Bradley, C. S. (2007). Rigging and Deck Harware. *In:* Grenier, R., Bernier, M.-A. and Stevens, W., *The Underwater Archaeology of Red Bay. Basque Shipbuilding and Whaling in the 16th Century IV.* Ottawa, Publishing and Depository Services. Public works and Government Services Canada.

Brady, K. and C. Corlett (2004). "Holy Ships: Ships on Plaster at Medieval Ecclesiastical Sites in Ireland." *Archaeology Ireland,* **18**(No.2): 28 - 31.

Brindley, H. H. (1911) "Medieval Ships in Painted Glass and on Seals, I.*" The Mariner's Mirror,* **1**(1)

Callender, G. (1912). "The Ships Of Maso Finiguerra." *Mariner's Mirror,* **2**(no.4).

Callender, G. (1913). "A Mediaeval Ship in the Ashmolean." *The Mariner's Mirror,* **3**(3).

Casado Soto, J. L. (1998). The Spanish Ships of the Oceanic Expansion. Documentation, archaeology and iconography from the 15th and 16th centuries. *In:* De Catro, F.V. and Custer, K. *International Symposium on Archaeology of Medieval and modern Ships of Iberian-Atlantic Tradition*, Lisbon, Metropolitano de Lisboa.

Castro, F. (2005). "Rigging the Pepper Wreck. Part 1 - Masts and Yards." *The International Journal of Nautical Archaeology,* **34**(1): 110 - 122.

Castro, F. (2009). "Rigging the Pepper Wreck. Part 2 Sails." *The International Journal of Nautical Archaeology*, **39**(1): 105-115.
Castro, F. V. d. (2005). *The pepper wreck : a Portuguese Indiaman at the mouth of the Tagus river*. College Station, Tex., Texas A&M University Press; [London : Eurospan distributor].

Cederlund, C. O. and Hocker, F. M. (2006). *Vasa I: the archaeology of a Swedish warship of 1628.* Stockholm, Swedish State Maritime Museum; Oxford: Oxbow [distributor].

Champion, M. (2012). Unpublished Report. Blackfriars Barn Undercroft, Winchelsea, East Sussex.

Crumlin-Pedersen, O. and McGrail, S. (2006). "Some Principles for the Reconstruction of Ancient Boat Structures." *The International Journal of Nautical Archaeology,* **35**(1): 53-57.

Culver, H. B. (1929). "A Contemporary Fifteenth-Century Ship Model." *Mariner's Mirror*, **15**(no. 3).

Dibner Institute (2005). '*Nave Quadra'* by Michael of Rhodes. *In:* Michael of Rhodes: A Medielval Mariner and His Manuscript. Available from: http://brunelleschi.imss.fi.it/michaelofrhodes/. [Accessed 10/01/2011]

Editor's note. (1911*) Mariner's Mirror*, vol. no.4 p301

Ewe, H. (1972). *Schiffe Auf Siegeln*. Bielefeld, Berlin, Verlag Delius, Klasing & Co.

Flatman, J. (2009). *Ships and shipping in medieval manuscripts*. London, British Library.

Gardiner, J., M. J. Allen and M. A. Alburger (2005*). Before the mast : life and death aboard the Mary Rose.* Portsmouth, Mary Rose Trust.

Greenhill, B. (1995). *The evolution of the sailing ship, 1250-1580.* London, Conway Maritime Press.

Grenier, R., W. Stevens and M. A. Bernier (2007). *The underwater archaeology of Red Bay: Basque shipbuilding and whaling in the 16th century.* [Ottawa], Parks Canada.

Hoffmann, G. and P. Hoffmann (2009). "Sailing the Bremen Cog." *The International Journal of Nautical Archaeology,* **38.2**: 281-296.

Hoffmann, G. and U. Schnall (2003). *Die Kogge : Sternstunde der deutschen Schiffsarcha\0308ologie.* Hamburg, Convent.

Hutchinson, G. (1994). *Medieval ships and shipping.* London, Leicester University Press.

L'Hour, M. (1989). "A mid-15th century clinker boat off the north coast of France, the Aber Wrac'h I wreck: A prliminary report." *The International Journal of Nautical Archaeology and Underwater Exploration*, **18**(4): 285-298.

Laanela, E. E. (2008). *Instruccion Nautica (1587) by Diego Garcia de Palacio: An Early Nauticcal Handbook from Mexico.* Masters of Arts, Texas A&M UNiversity.

Layton, C. W. T. (1955). *Dictionary of nautical words and terms.* Glasgow, Brown, Son and Ferguson.

Leigh Inbody Corder, C. (2007). *La Belle: Rigging in the Days of the Spritsail and Topmast, a reconstruction of a Seventeenth-Century Ship's Rig.* Nautical Archaeology, Texas A&M.

Lever, D. o. P. (1819). *The Young Sea Officer's Sheet Anchor; or, a Key to the leading of Rigging and to Practical Seamanship.* (Appendix.), London.

Mainwaring, H. S., Manwaring G. E. and Perrin W. G. (1920). *Life and works of Sir Henry Mainwaring*. [S.l.], Navy Records Society.

Martin, C. J. M. (1979). "La-Trinidad-Valencera - Armada Invasion Transport Lost Off Donegal - Interim Site Report, 1971-76." *International Journal of Nautical Archaeology,* **8**(1): 13-38.

McGrail, S. (1987). *Ancient boats in NW Europe : the archaeology of water transport to AD 1500*. London, Longman.

McGrail, S. (1993). *Medieval boat and ship timbers from Dublin*. Dublin, Royal Irish Academy.

McGrail, S. (2001). *Boats of the world: from the Stone Age to Medieval times*. Oxford, Oxford University Press.

Mott, L. V. (1994). "A three-masted ship depiction from 1409." *The International Journal of Nautical Archaeology,* **23:1**: 39-40.

Muckelroy, K. (1978). *Maritime Archaeology*. Cambridge, Cambridge University Press.

Nance, M. (1911). "A fifteenth Century Trader." *Mariner's Mirror***, 1**(no.1).

Nance, R. M. (1913). "Some Old-Time Ship Pictures. A Group of Florentines." *Mariner's Mirror,* **3**(no.3).

Polzer, M. E. (2008). "Toggles and sails in the ancient world: Rigging elements recovered from the Tantura B shipwreck, Israel." *International Journal of Nautical Archaeology,* **37**(2): 225-252.

Rule, M. (1982). *The Mary Rose : the excavation and raising of Henry VIII's flagship*. London, Conway Maritime Press.

Sanders, D. (2010). "Knowing the Ropes: The Need to Record Ropes and Rigging on Wreck-Sites and Some Techniques for Doing So." *International Journal of Nautical Archaeology,* **39**(1): 2-26.

Steel, D. and J. Bourde\ De Villehuet (1794). *The elements and practice of rigging and seamanship, etc*. London.

Trett, B. (2010). *Newport medieval ship: a guide*. Newport, Friends of the Newport Ship.

Van Nouhuys, J. (1931). "The model of the Spanish Caravel of the Begining of the Fifiteenth Century." *The Mariner's Mirror,* **17**(4).

Walton Rodgers, P. (2010). *In:* Newport Medieval Ship Post Excavation Research Design. Oxford Archaeology (unpublished).

Walton Rodgers, P. (2012). *Newport Medieval Ship Cordage Report*. (unpublished).

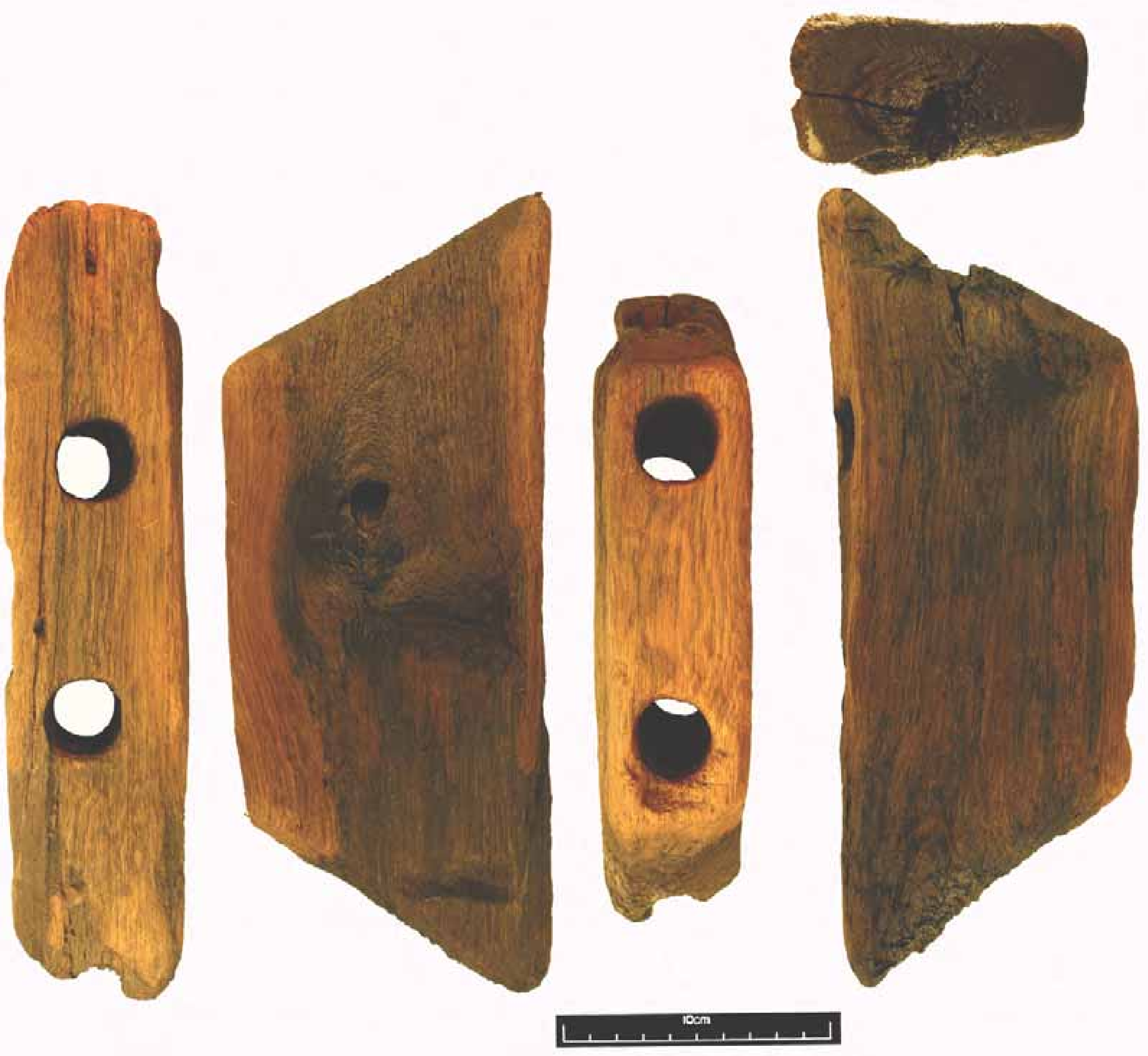
W.B.W (1913). "Notes : Bellying of XV. Century Sails." *The Mariners Mirror,* **3**(4): 347 - 348.

Whitewright, J (2010). *In:* Newport Medieval Ship Post Excavation Research Design. Oxford Archaeology (unpublished).

APPENDIX

Appendix Contents

I. Rigging Assemblage Catalogue



Context: 130 F33-34	Description: Wooden artefact, Isosceles Trapezoidal in plan with two holes running through it's width. A triangular rebate on one surface, measuring 50mm x 80mm x 80mm and 20 mm deep. One small iron nail is present. Sapwood is clearly visible.
Component: Unknown	
Rigging Type: Unknown	
Species: Quercus	
Dimensions: Max L x B x D= 289mm x 113mm x 65mm. Diameter of holes =30mm	

Context: 130 F33-34

Component: Unknown

Rigging Type: Unknown

Species: Quercus

Dimensions: Max L x B x D= 289mm x 113mm x 65mm. Diameter of holes =30mm

Description:
Wooden artefact, Isosceles Trapezoidal in plan with two holes running through it's width. A triangular rebate on one surface, measuring 50mm x 80mm x 80mm and 20 mm deep. One small iron nail is present. Sapwood is clearly visible.

Context: 120

Component: Sheave

Rigging Type: Running

Species: Ulmus

Dimensions: 164mm (sheave diameter), 34.5mm (pin hole diameter), 41.3mm in depth.

Description:
Half a sheave or pulley wheel, broken through the pin hole. A groove for a rope is present on the outer surface. No v surface detail such as wear or tool m Some damage exists. Appears to have been broken in antiquity

Cowtag: 1853

Context: 120

Component: Sheave

Rigging Type: Running

Species: Ulmus

Dimensions: 164mm (sheave diameter), 34.5mm (pin hole diameter), 41.3mm in depth.

Description:
Half a sheave or pulley wheel, broken through the pin hole. A groove for a rope is present on the outer surface. No v surface detail such as wear or tool m Some damage exists. Appears to have been broken in antiquity

Context: Unknown

Component: Rigging Bitt Pin

Rigging Type: Running

Species:Quercus

Dimensions: Max L x B x D = 419.7mm x 69.1mm x 40.6mm. Hole has 22.3mm diameter

Description:
Tapering in width from top to bottom .One hole at wide end. Some damage and pos ble wear is visible throughout. This is quite soft and in poor condition.

Cowtag: 1926

Context: Unknown

Component: Rigging Bitt Pin

Rigging Type: Running

Species: Quercus

Dimensions: Max L x B x D = 419.7mm x 69.1mm x 40.6mm. Hole has 22.3mm diameter

Description:
Tapering in width from top to bottom. One hole at wide end. Some damage and pos-
ble wear is visible throughout. This is quite soft and in poor condition.

Context: 130

Component: Parrel Rib

Rigging Type: Running

Species **Quercus**

Dimensions: Max L x B x D = 610.1mm x 71.9mm x 22.6mm

Description:
Complete parrel rib, narrow in width. good condition. Three holes present. Middle hole is off centre.

Cowtag: 2367

Context: 130

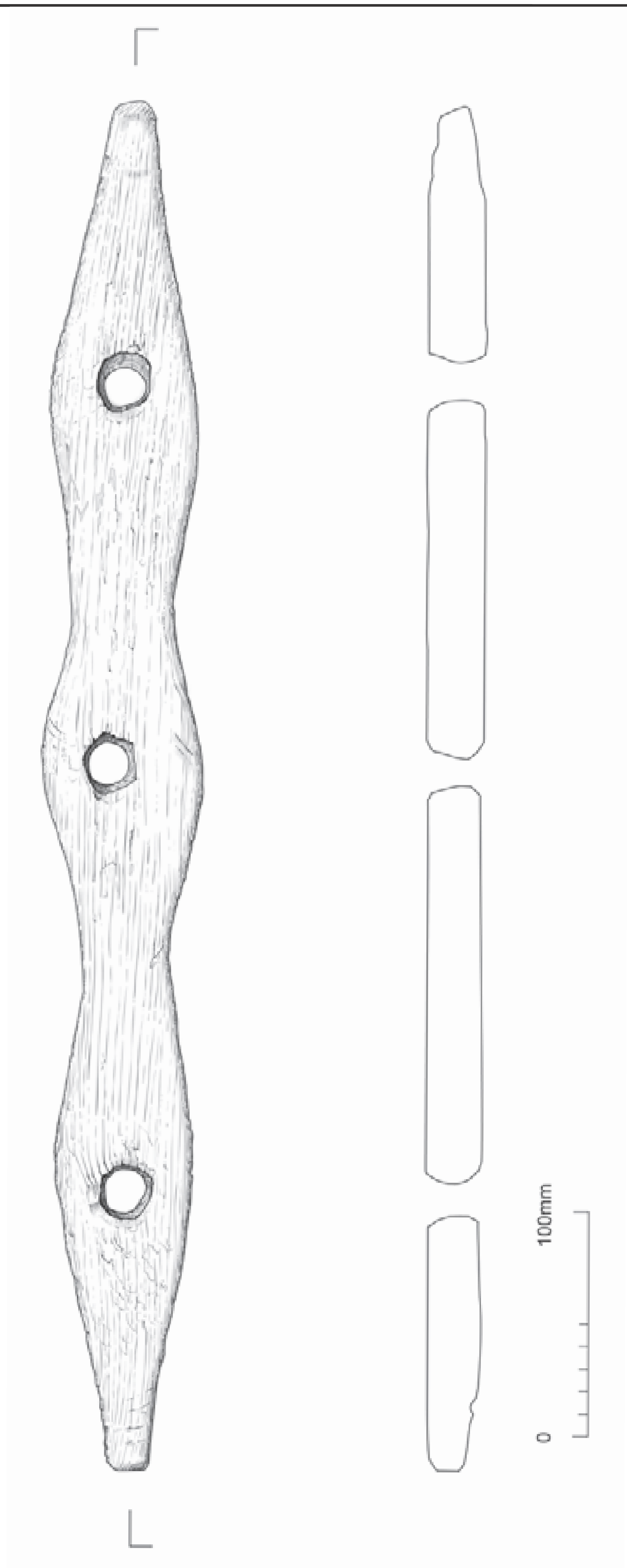
Component: Parrel Rib

Rigging Type: Running

Species: Quercus

Dimensions: Max L x B x D = 610.1mm x 71.9mm x 22.6mm

Description:
Complete parrel rib, narrow in width. good condition. Three holes present. Middle hole is off centre.



Context: 130

Component: Parrel Rib

Rigging Type: Running

Species:Quercus

Dimensions: Max L x B x D = 610.1mm x 71.9mm x 22.6mm

Description:
Complete parrel rib, narrow in width. good condition. Three holes present. Middle hole is off centre.

Context: 130

Component: Sheave

Rigging Type: Running

Species **Fraxinus excelsior**

Dimensions: 146.7mm (outer diameter), 41mm (pin hole diameter), 34.9mm in depth.

Description:
Sheave, in good condition. Part of th
moving component of a block or puAlley
groove, where a rope would have run,
exists around the outer edge. Concent
circles are visible on both surfaces
the pin hole, these are possibly from

Context: 130

Component: Sheave

Rigging Type: Running

Species:Fraxinus excelsior

Dimensions: 146.7mm (outer diameter), 41mm (pin hole diameter), 34.9mm in depth.

Description:
Sheave, in good condition. Part of th
moving component of a block or pulley. A
groove, where a rope would have run,
exists around the outer edge. Concent
circles are visible on both surfaces
the pin hole, these are possibly from

Context: 130, F31 Stbd

Component: Unknown

Rigging Type: Unknown

Species:Fraxinus excelsior

Dimensions: Max L x B x D = 260mm x 77.6mm x 67.4mm. Hole diameters 14.1mm and12.3mm

Description:
Despite the poor condition of this pi
tool marks, including tool striations
survived very well. Sap wood is prese
and only minor damage exists

Context: 130, F31 Stbd

Component: Unknown

Rigging Type: Unknown

Species: Fraxinus excelsior

Dimensions: Max L x B x D = 260mm x 77.6mm x 67.4mm. Hole diameters = 14.1mm and 12.3mm

Description:
Despite the poor condition of this pi
tool marks, including tool striations
survived very well. Sap wood is prese
and only minor damage exists

Context: 130

Component: Pin

Rigging Type: Running

Species:

Dimensions: 103mm x 30mm diameter

Description:
Dimple present on both ends and concentric circles are visible on the head and the shaft. The head has a diameter of 32mm and a depth of 5mm. It is slightly oval in section and in very good condition.

Context: 130

Component: Pin

Rigging Type: Running

Species:

Dimensions: 103mm x 30mm diameter

Description:
Dimple present on both ends and conce-
tric circles are visible on the head
shaft. The head has a diameter of 32m
and a depth of 5mm. It is slightly ov
section and in very good condition.

Context: 130 F15 Stbd

Component: Pin

Rigging Type: Running

Species: buxus

Dimensions: 133mm in length x 35mm diameter

Description: Dimples at both end suggest it was turned on a lathe. Diameter narrows to 29mm. Concentric circles visible on the head. 34mm compression mark on the shaft. Good condition. End is cut at a slight angle.

Context: **130 F15 Stbd**

Component: **Pin**

Rigging Type: **Running**

Species: Buxus

Dimensions: 133mm in length x 35mm diameter

Description: Dimples at both end sugg
it was turned on a lathe. Diameter na
to 29mm. Concentric circles visible o
head. 34mm compression mark on the
shaft. Good condition. End is cut at
slight angle.

Context: 130

Component: Parrel rib

Rigging type: Running

Species: Fagus sylvatica

Dimensions: Max L x B x D= 164.1mm x 77.1mm x 20mm. Hole has diameter of 16.4mm

Description: vv
Broken parrel rib in otherwise good condi-
tion. Roughly semi-circular in plan.
edges are chamfered. What looks to be
wear is present, running from the cen
hole out to the curved edge. Straight
grained.

Context: 130

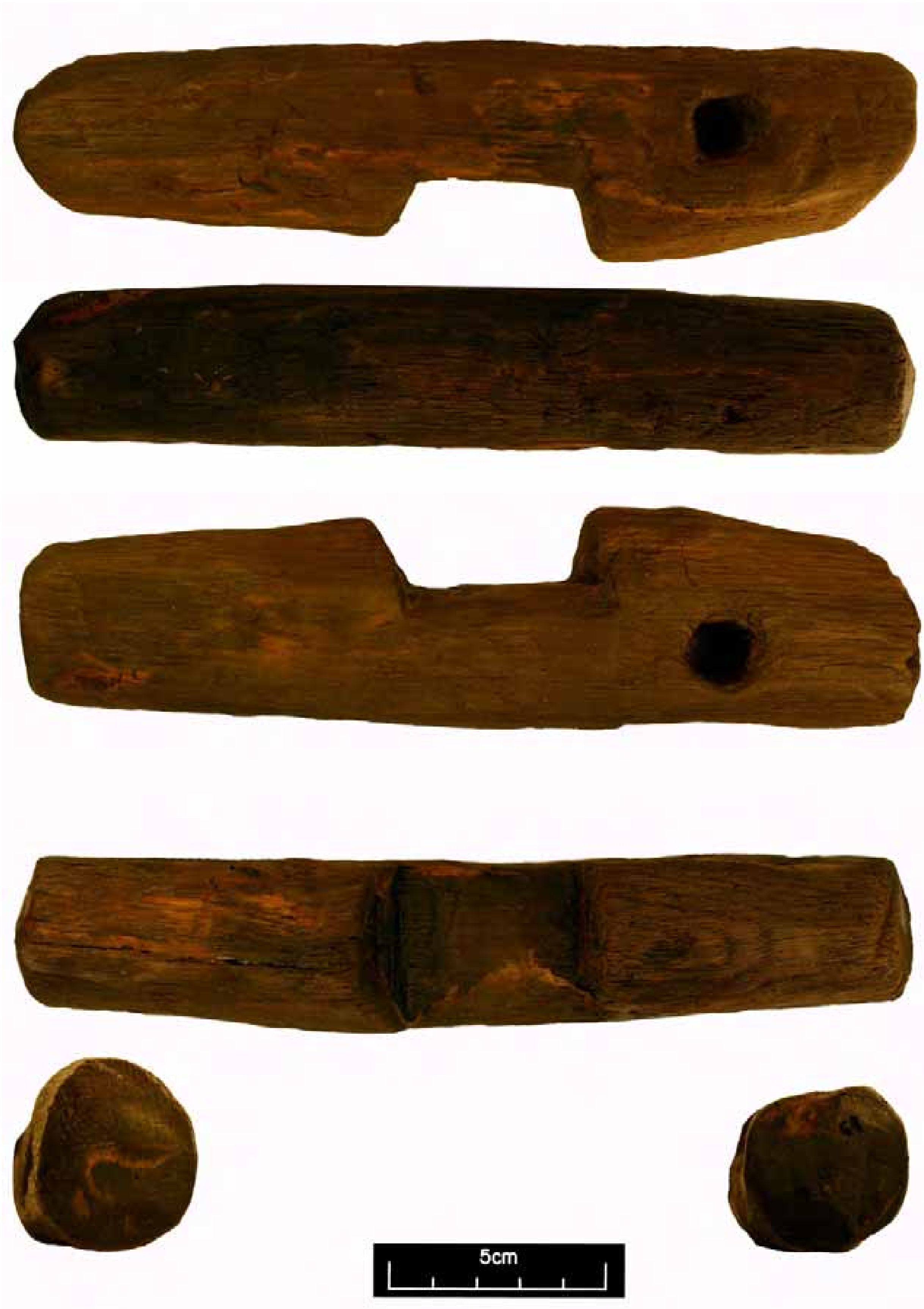
Component: Parrel rib

Rigging Type: Running

Species: Fagus sylvatica

Dimensions: Max L x B x D= 164.1mm x 77.1mm x 20mm. Hole has diameter of 16.4mm

Description: vv
Broken parrel rib in otherwise good c
tion. Roughly semi-circular in plan.
edges are chamfered. What looks to be
wear is present, running from the cen
hole out to the curved edge. Straight
grained.



Context: 130

Component: Unknown

Rigging Type: Unknown

Species:Quercus

Dimensions: Max L x B x D = 226mm x 53.2mm x 40.3mm. Hole has a diameter of 13.9mm.

Description:
Peg like in appearance with rounded edges. One square hole perforates the width of the artefact. One rebate is the obect across its width. Sapwood s vives as does clear tool marks.

Context: 130

Component: Unknown

Rigging Type: Unknown

Species: Quercus

Dimensions: Max L x B x D = 226mm x 53.2mm x 40.3mm. Hole has a diameter of 13.9mm.

Description:
Peg like in appearance with rounded edges. One square hole perforates th width of the artefact. One rebate is the obect across its width. Sapwood s vives as does clear tool marks.

Context: 130 F44v	Description: Parrel truck, now in two pieces, crac along its length. Roughly circular in tion with slight distortion through c pression A hole runs through the centre.
Component: Parrel Truck	
Rigging Type: Running	
Species: Possibly alder	
Dimensions: L=116.3mm. Max outer diam= 106.7 mm. Min outer diam=85.2mm. Max inner diameter = 48.1mm. Min inner diameter = 34.3mm.	

Context: 130 F44v

Component: Parrel Truck

Rigging Type: Running

Species: Possibly alder

Dimensions: L=116.3mm. Max outer diam= 106.7 mm.
Min outer diam=85.2mm. Max inner diameter = 48.1mm.
Min inner diameter = 34.3mm.

Description:
Parrel truck, now in two pieces, crac
along its length. Roughly circular ir
tion with slight distortion through c
pression. A hole runs through the centre.

Context: 130 F40 Stbd

Component: Bull's Eye/Thimble

Rigging Type: Running

Species: Alnus

Dimensions: 71.2mm outer diameter, 35.4mm inner diameter 17.8mm in depth.

Description:
Slightly crushed circular artefact, w
hole through the centre. Cracks are
present on both sides of the central

Context: 130 F40 Stbd

Component: Bull's Eye/Thimble

Rigging Type: Running

Species: Alnus

Dimensions: 71.2mm outer diameter, 35.4mm inner diameter 17.8mm in depth.

Description:
Slightly crushed circular artefact, w
hole through the centre. Cracks are
present on both sides of the central

Context: Unknown

Component: Parrel Truck

Rigging Type: Running

Species: Unknown

Dimensions: 117.6mm in length. 107.1mm outer diameter 35.9mm inner diameter

Description:
Parrel truck in good condition. Hole
ning through the centre. Distortion i
visible on both the outer surface and
inner hole.

Context: Unknown

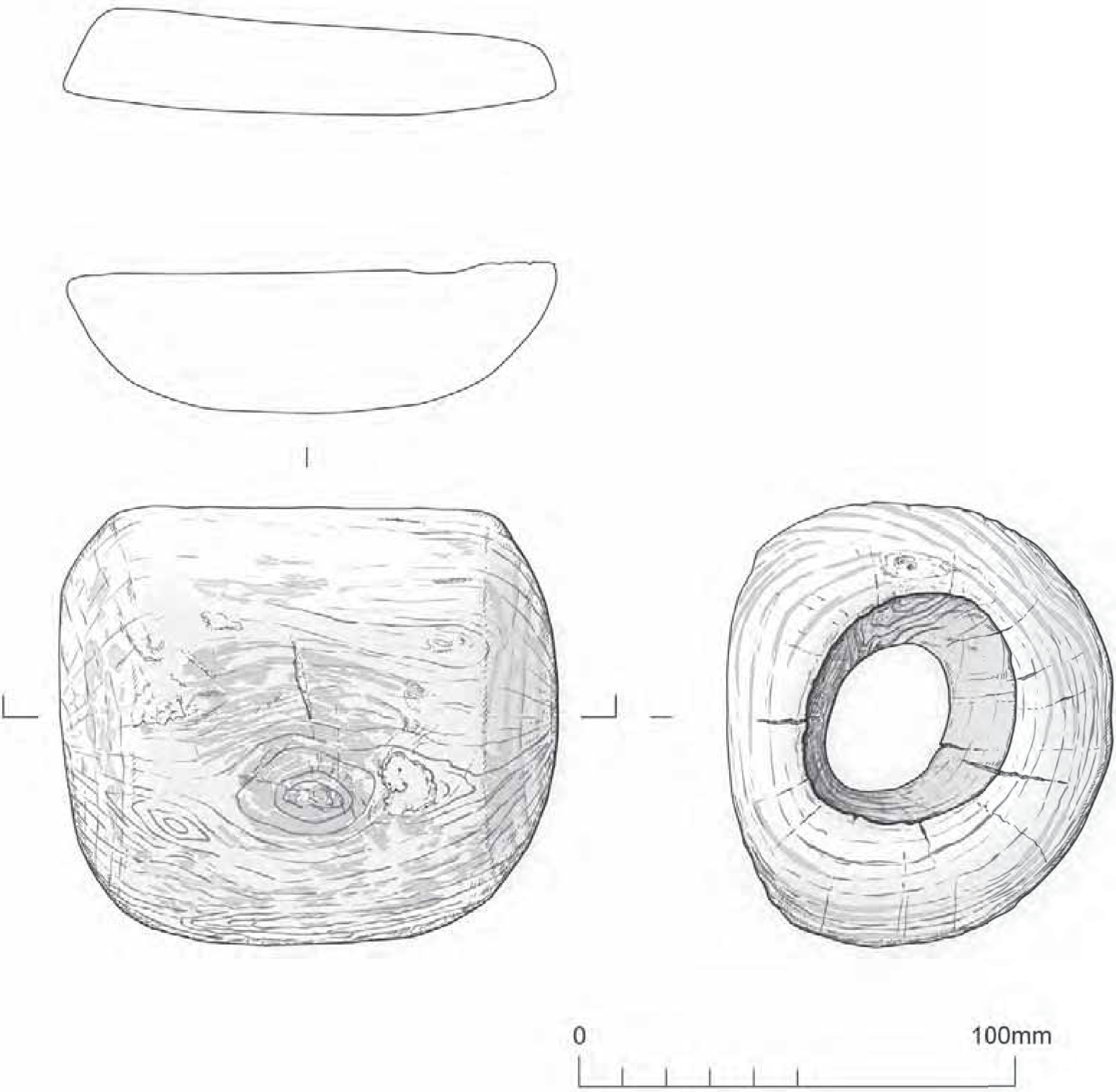
Component: Parrel Truck

Rigging Type: Running

Species: Unknown

Dimensions: 117.6mm in length. 107.1mm outer diameter. 35.9mm inner diameter.

Description:
Parrel truck in good condition. Hole ning through the centre. Distortion i visible on both the outer surface and inner hole.



Context: Unknown

Component: Parrel Truck

Rigging Type: Running

Species: Unknown

Dimensions: 117.6mm in length. 107.1mm outer diameter 35.9mm inner diameter

Description:
Parrel truck in good condition. Hole
ning through the centre. Distortion i
visible on both the outer surface and
inner hole.

Context: 128 F3

Component: Disc Sheave

Rigging Type: Running

Species: Ulmus

Dimensions: 110mm outer diameter, 35.6mm inner diameter, 35.5mm in depth.

Description:
Circular artefact with hole in the ce
Outer circumference is uneven. The wo
is quite soft, and some iron staining
exists. No visible tool marks abut wo
facets can be seen around the circumf
ence.

Context: 128 F3

Component: Disc Sheave

Rigging Type: Running

Species: Ulmus

Dimensions: 110mm outer diameter, 35.6mm inner diameter, 35.5mm in depth.

Description:
Circular artefact with hole in the ce
Outer circumference is uneven. The wo
is quite soft, and some iron staining
exists. No visible tool marks abut wo
facets can be seen around the circumf
ence.

Context: 128	Description: Teardrop shaped heart block. A small round hole is present at the narrower with a large almost square hole in the centre. A wide, straight edged groove runs around the circumference and has clea tool marks evident.
Component: Heart Block	
Rigging Type: Standing	
Species: Unknown	
Dimensions: LxBxD=235.9mmx123mmx70.2mm. Large hole has 56.8mm diam. Small hole has 20.5mm diam.	

Context: 128

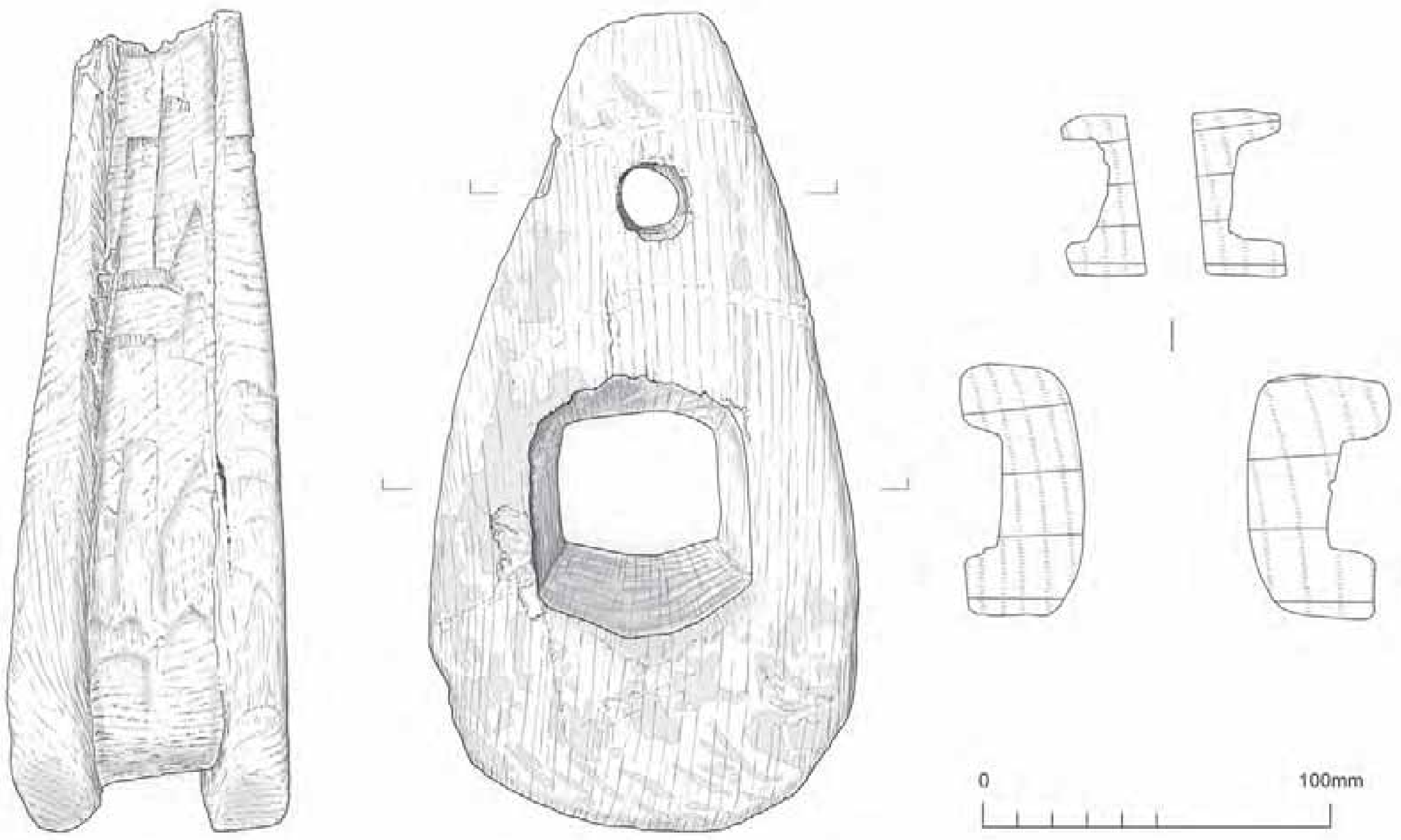
Component: Heart Block

Rigging Type: Standing

Species: Unknown

Dimensions: LxBxD=235.9mmx123mmx70.2mm. Large hole has 56.8mm diam. Small hole has 20.5mm diam.

Description:
Teardrop shaped heart block. A small round hole is present at the narrower with a larger almost square hole in the centre. A wide, straight edged groove runs around the circumference and has clea tool marks evident.



Context: 128

Component: Heart Block

Rigging Type: Standing

Species: Unknown

Dimensions: LxBxD=235.9mmx123mmx70.2mm. Large hole has 56.8mm diam. Small hole has 20.5mm diam.

Description:
Teardrop shaped heartblock. A small round hole is present at the narrower with a large almost square hole in the centre. A wide, straight edged groove runs around the circumference and has clea tool marks evident.

Context: 130 F7-8	Description: Hook shaped artefact. One end is hook with a flat bottom. The opposite end small hole that perforates through th artefact. Tool marks on the surface indi- cate that the piece was worked down- wards toward the hook.
Component: Unknown	
Rigging Type: Unkown	
Species: Quercus	
Dimensions: Max L x B x D = 161.5mm x 63.4mm x 18.6mm. Hole has a 7.1mm diameter.	

Context: 130 F7-8

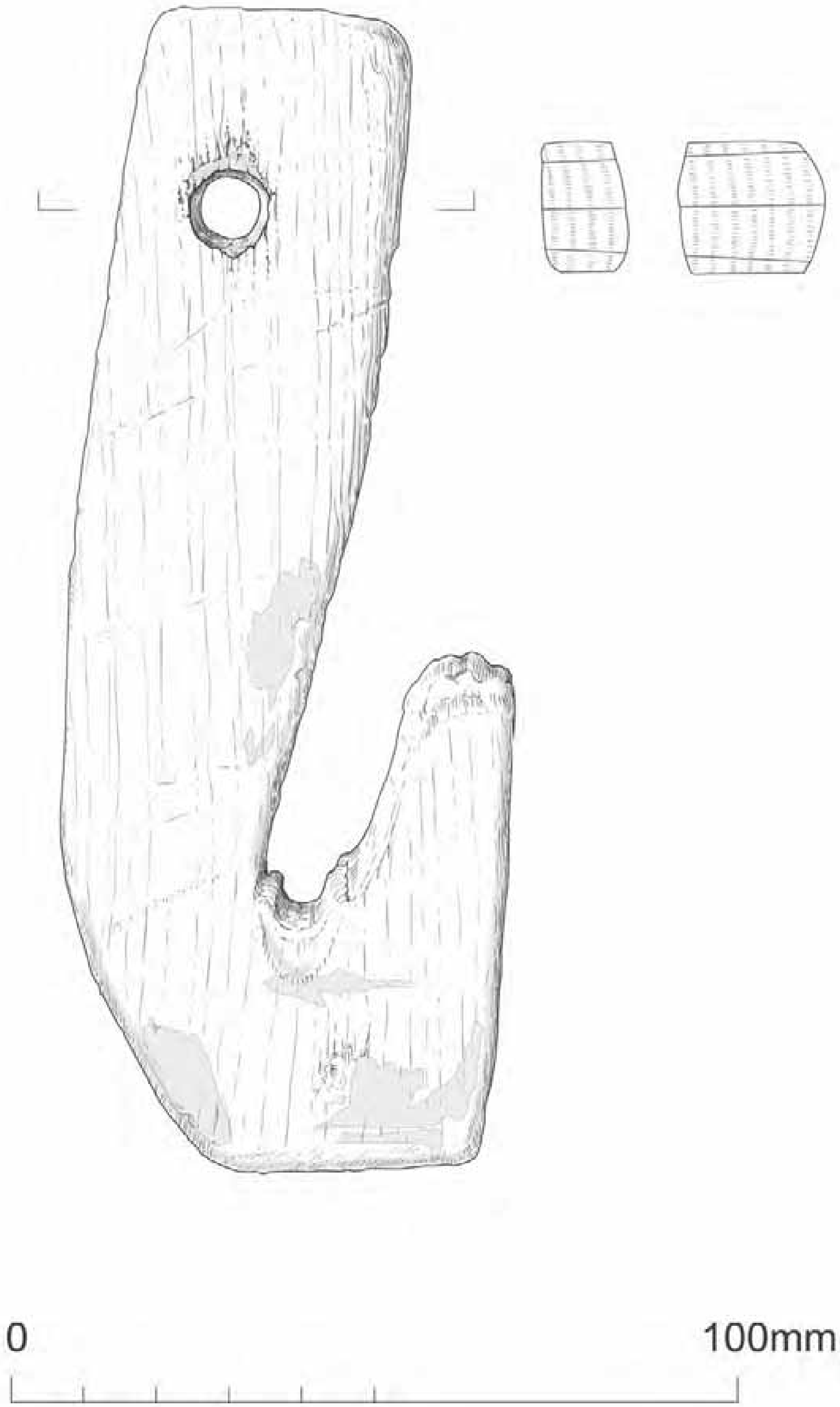
Component: Unknown

Rigging Type: Unkown

Species: Quercus

Dimensions: Max L x B x D = 161.5mm x 63.4mm x 18.6mm. Hole has a 7.1mm diameter.

Description:
Hook shaped artefact. One end is hoo
with a flat bottom. The opposite end
small hole that perforates through th
artefact. Tool marks on the surface indi-
cate that the piece was worked down-
wards toward the hook.



Context: 130 F7-8

Component: Unknown

Rigging Type: Unkown

Species: Quercus

Dimensions: Max L x B x D = 161.5mm x 63.4mm x 18.6mm. Hole has a 7.1mm diameter.

Description:
Hook shaped artefact. One end is hook with a flat bottom. The opposite end small hole that perforates through th artefact. Tool marks on the surface indi cate that the piece was worked down-wards toward the hook.

Context: 130

Component: Pulley/Clew garnet

Rigging Type: Running

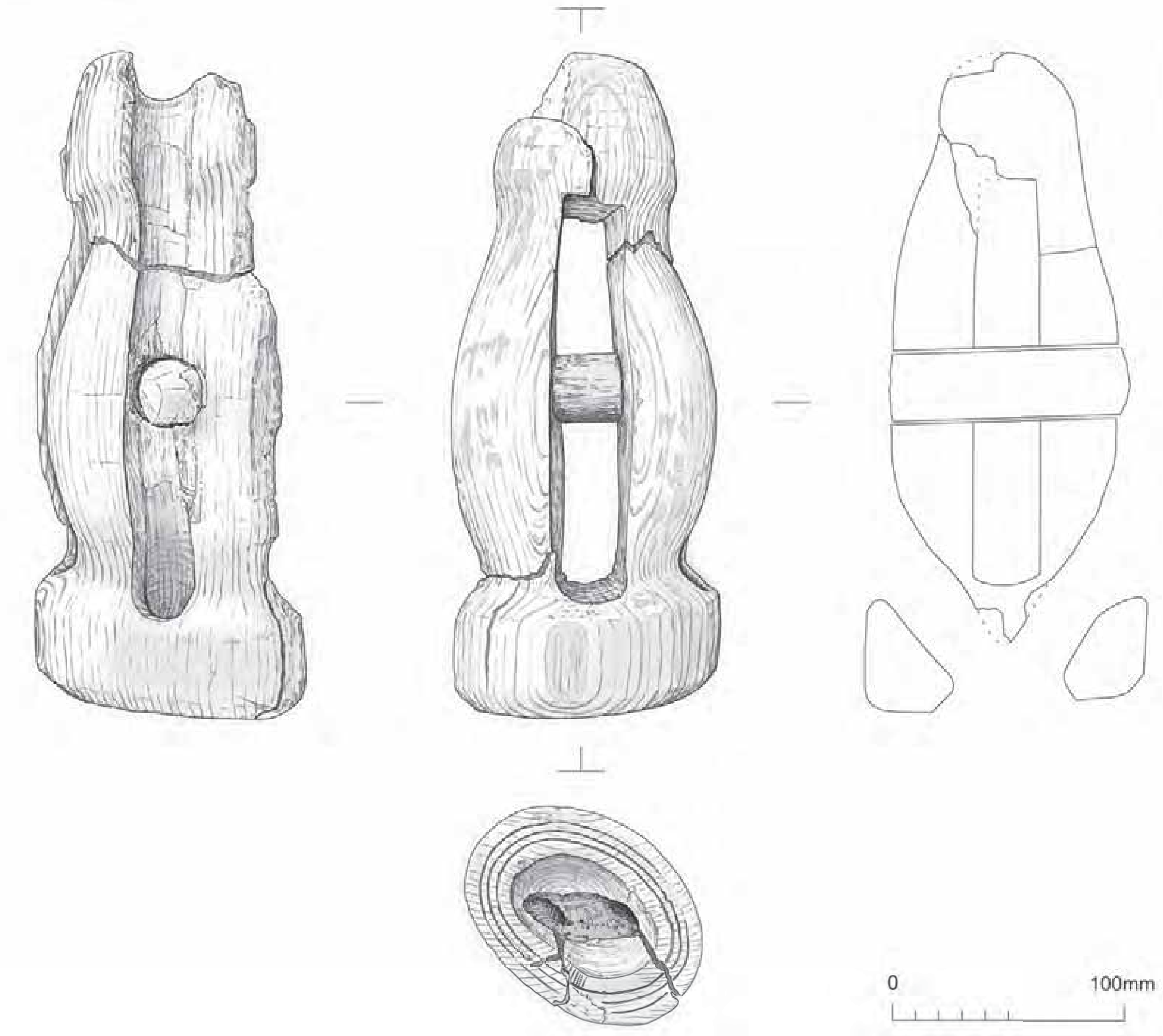
Species **Fraxinus excelsior**

Dimensions: Max L x B x D = 294.7 mm x 125.4mm x 124.7mm

Description:
Pulley in two parts, has been crushed
There are three concentric circles on
base, uniformly spaced, 4mm apart.
Sheave is no longer in situ, however the
pin is intact. A slight chamfer exists
between the base and cheeks of the
pulley

Context: 130	Description: Pulley in two parts, has been crushed. There are three concentric circles on base, uniformly spaced, 4mm apart. Sheave is no longer in situ, however the pin is intact. A slight chamfer exists between the base and cheeks of the pulley
Component: Pulley/Clew garnet	
Rigging Type: Running	
Species: Fraxinus excelsior	
Dimensions: Max L x B x D = 294.7 mm x 125.4mm x 124.7mm	

Cowtag: 3049



Context: 130

Component: Pulley/Clew garnet

Rigging Type: Running

Species: Fraxinus excelsior

Dimensions: Max L x B x D = 294.7 mm x 125.4mm x 124.7mm

Description:
Pulley in two parts, has been crushed. There are three concentric circles on base, uniformly spaced, 4mm apart. Sheave is no longer in situ, however the pin is intact. A slight chamfer exists between the base and cheeks of the pulley

Context: 130

Component: Pulley

Rigging Type: Running

Species Fraxinus excelsior

Dimensions: LxBxD=506.1mm x 146mm x 157.1 mm.
Swallow gorge=229.1mmx146mmx43.7mm.

Description Single sheaved pulley, in two two parts. Broken at the pin on one cheek and eek an slightly lower on the second cheek. Damag. Dama also present along its length. Lathe turned he tur is held in place by a metal nail through the hrough end. Sheave has a groove around its circums circ ference. Two holes present, one at either Concentric lines on the surface of the s from use. The wood is quite soft.

Context: 130

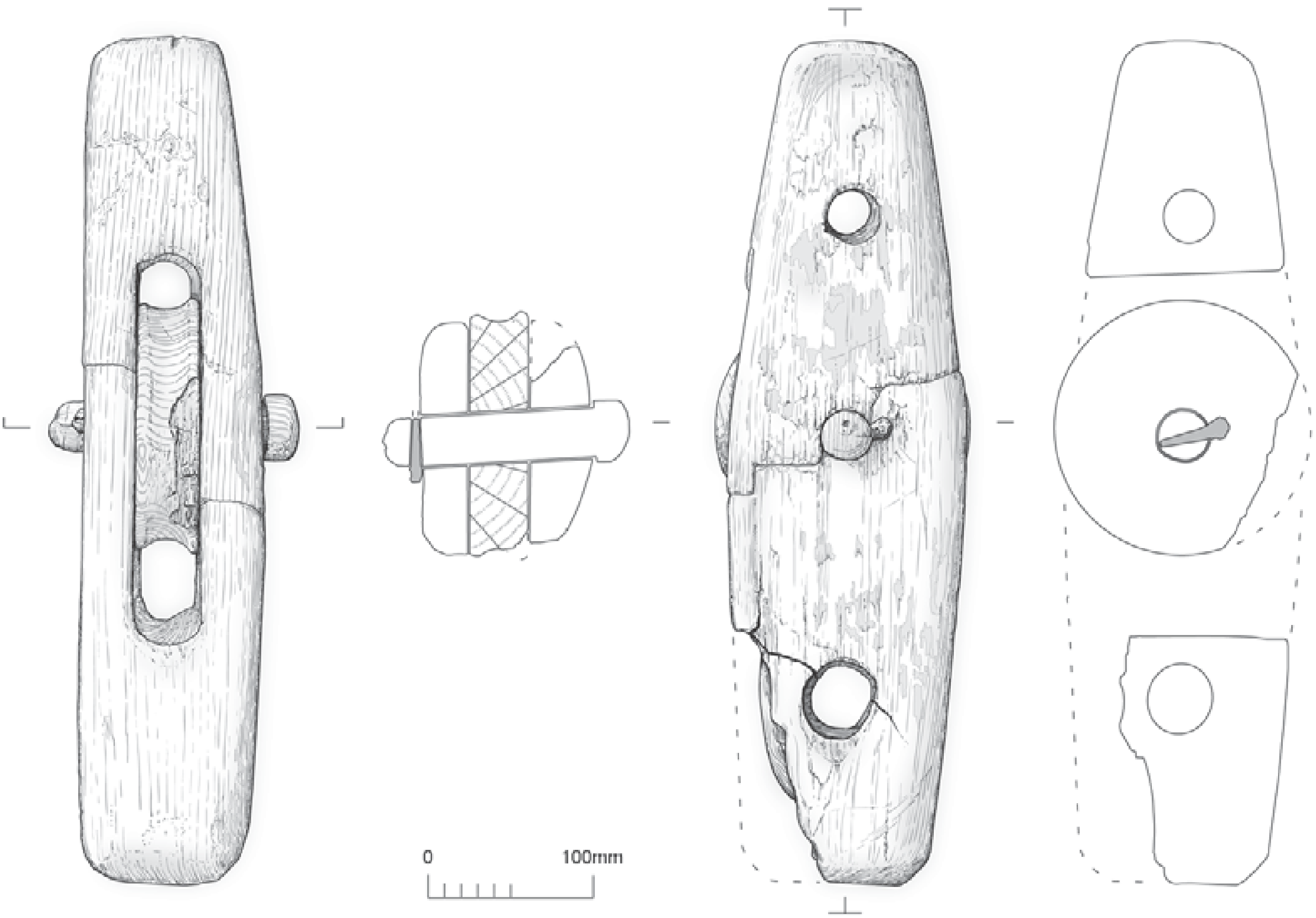
Component: Pulley

Rigging Type: Running

Species: Fraxinus excelsior

Dimensions: LxBxD=506.1mm x 146mm x 157.1 mm.
Swallow gorge=229.1mmx146mmx43.7mm.

Description: Single sheaved pulley, in two
parts. Broken at the pin on one cheek an
slightly lower on the second cheek. Dama
also present along its length. Lathe tur
is held in place by a metal nail through
end. Sheave has a groove around its circ
ference. Two holes present, one at either
Concentric lines on the surface of the s
from use. The wood is quite soft.



Context: 130

Component: Pulley

Rigging Type: Running

Species: Fraxinus excelsior

Dimensions: LxBxD=506.1mm x 146mm x 157.1 mm.
Swallow gorge=229.1mmx146mmx43.7mm.

Description: Single sheaved pulley, in two parts. Broken at the pin on one cheek an slightly lower on the second cheek. Dama also present along its length. Lathe tur is held in place by a metal nail through end. Sheave has a groove around its circ ference. Two holes present, one at either e Concentric lines on the surface of the s from use. The wood is quite soft.

Context: 130 North of F44

Component: Heart Block

Rigging Type: Standing

Species **Unknown**

Dimensions: 238.5mm x 164.4mm x 77.7mm

Description:
Almost oval in shape with groove runn
around the circumference which is sli
cracked. One small hole at the narrow
end and one large hole in the centre.
appears to be wear in the area betwee
large and small hole. One surface has
distinct marks or dimples.

Context: 130 North of F44

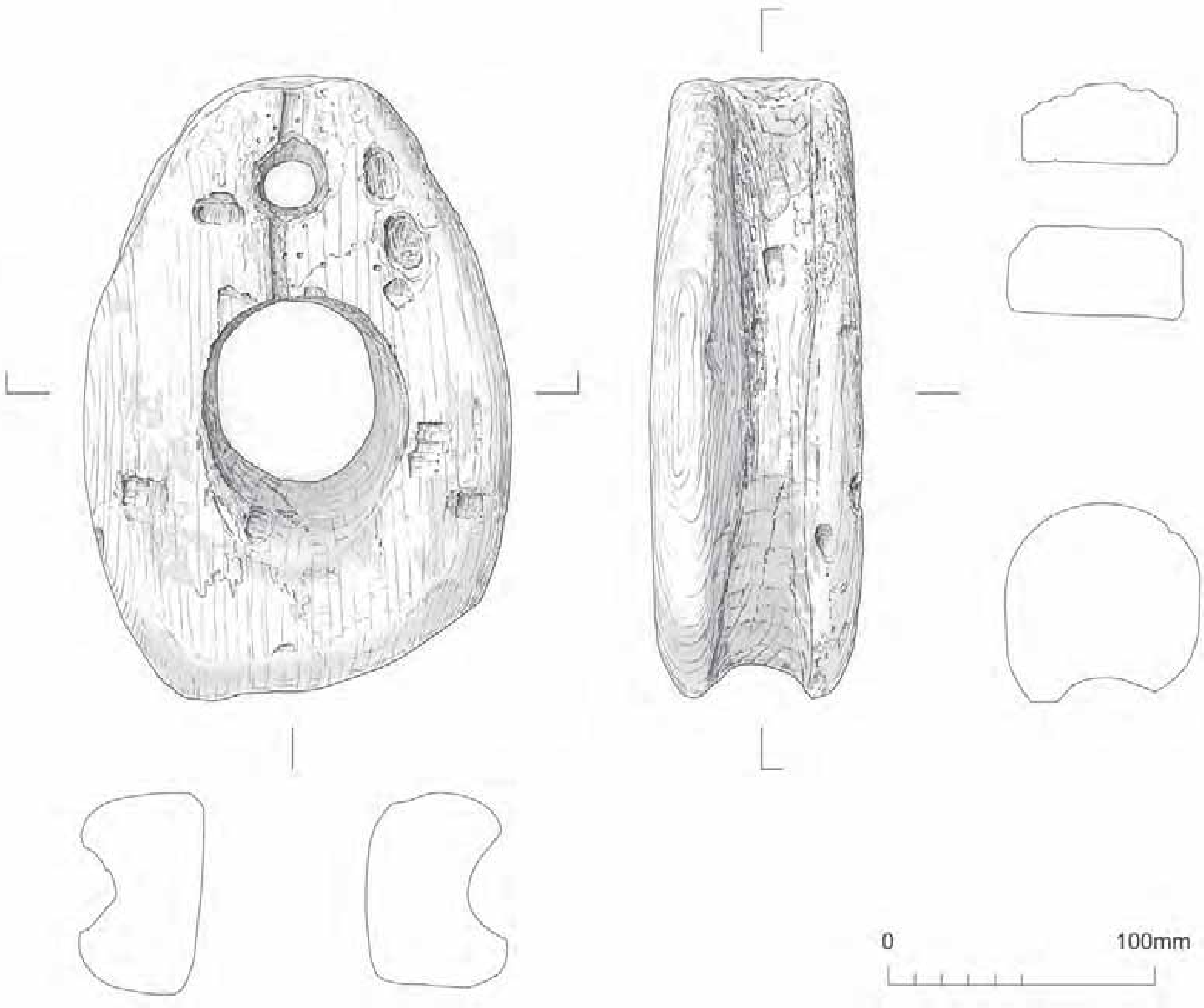
Component: Heart Block

Rigging Type: Standing

Species:Unknown

Dimensions: 238.5mm x 164.4mm x 77.7mm

Description:
Almost oval in shape with groove runn
around the circumference which is sli
cracked. One small hole at the narrow
end and one large hole in the centre.
appears to be wear in the area betwee
large and small hole. One surface has
distinct marks or dimples.



Context: 130 North of F44

Component: Heart Block

Rigging Type: Standing

Species:Unknown

Dimensions: 238.5mm x 164.4mm x 77.7mm

Description:
Almost oval in shape with groove runn
around the circumference which is sli
cracked. One small hole at the narrow
end and one large hole in the centre.
appears to be wear in the area betwee
large and small hole. One surface has
distinct marks or dimples.

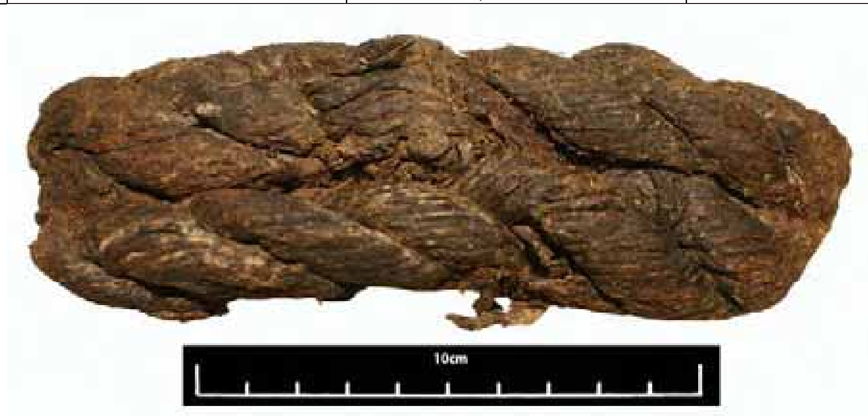
Newport Medieval Ship Hemp Cordage Catalogue

MSG Number	*Length(m)xThickness(mm)*	*Construction*	*Notes*
059 (i)	---------- x 18	Zmulti S	Two sections of matted cordage, incorporating bundles of Z-spun yarn, c.2 mm diameter, loosely S-twisted together..

MSG Number	Length(m)xThickness(mm)	Construction	Notes
059(ii)	0.18 & 0.13 39 x 21	Z28S3Z (helix S60°and final Z35°-40°)	C.F30-40 Starboard

MSG Number	Length(m)xThickness(mm)	Construction	Notes

061	0.15 & 0.15 29 x 18	ZmultiS3Z (helix S50°-60°, final Z 40°).	F48. Starboard.



MSG Number	Length(m)xThickness(mm)	Construction	Notes
079	Several, longest 0.09 28 x 12	Z multiS3Z (helix S60°, final Z40°)	NE bow.

MSG Number	*Length(m)xThickness(mm)*	*Construction*	*Notes*

088	0.06 19 x 12	?ZmultiS3Z (helix final Z 20°-30°	COW1561 (orig wood no.519)

MSG Number	Length(m)xThickness(mm)	Construction	Notes
809	0.05 x 16 x 11		Associated with timber 1132.

MSG Number	Length(m)xThickness(mm)	Construction	Notes

810	--------------------------------	Z30S (helix Z 30-40, S50)	Associated with timber 1132.

MSG Number	*Length(m)xThickness(mm)*	*Construction*	*Notes*
811	knot 2-3	Z only (helix 40°-50°)	Fragment, 40 x 30 x 8 mm: a knot of Z-spun yarns.

MSG Number	*Length(m)xThickness(mm)*	*Construction*	*Notes*

828	0.06 27 x 11	ZmultiS3Z (helix S 60°, final Z 45°)	

MSG Number	Length(m)xThickness(mm)	Construction	Notes
833	0.11	ZmultiS3Z (helix S45°, final Z 50°)	

MSG Number	Length(m)xThickness(mm)	Construction	Notes

834	0.15 20	ZmultiS3Z (helix S50°, Z35°)	F5-F6Post

MSG Number	*Length(m)xThickness(mm)*	*Construction*	*Notes*
835	0.09 28 x 16	ZmultiS3Z (helix final Z 40°)	

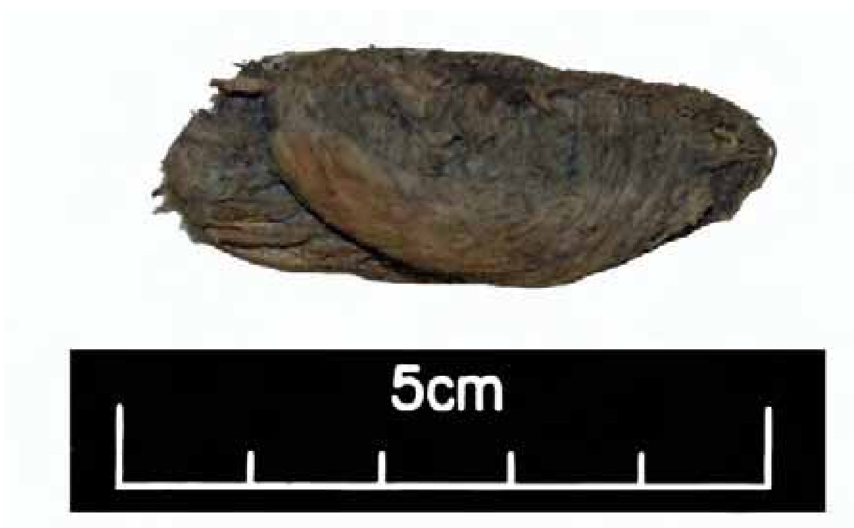
MSG Number	*Length(m)xThickness(mm)*	*Construction*	*Notes*
1297	0.08 x 26 x 15	Z15S3Z (helix final Z 40°-	Rope from wooden pulley

		50°)	block (MSG 548, Cow 3036) hemp: dressed or undressed.

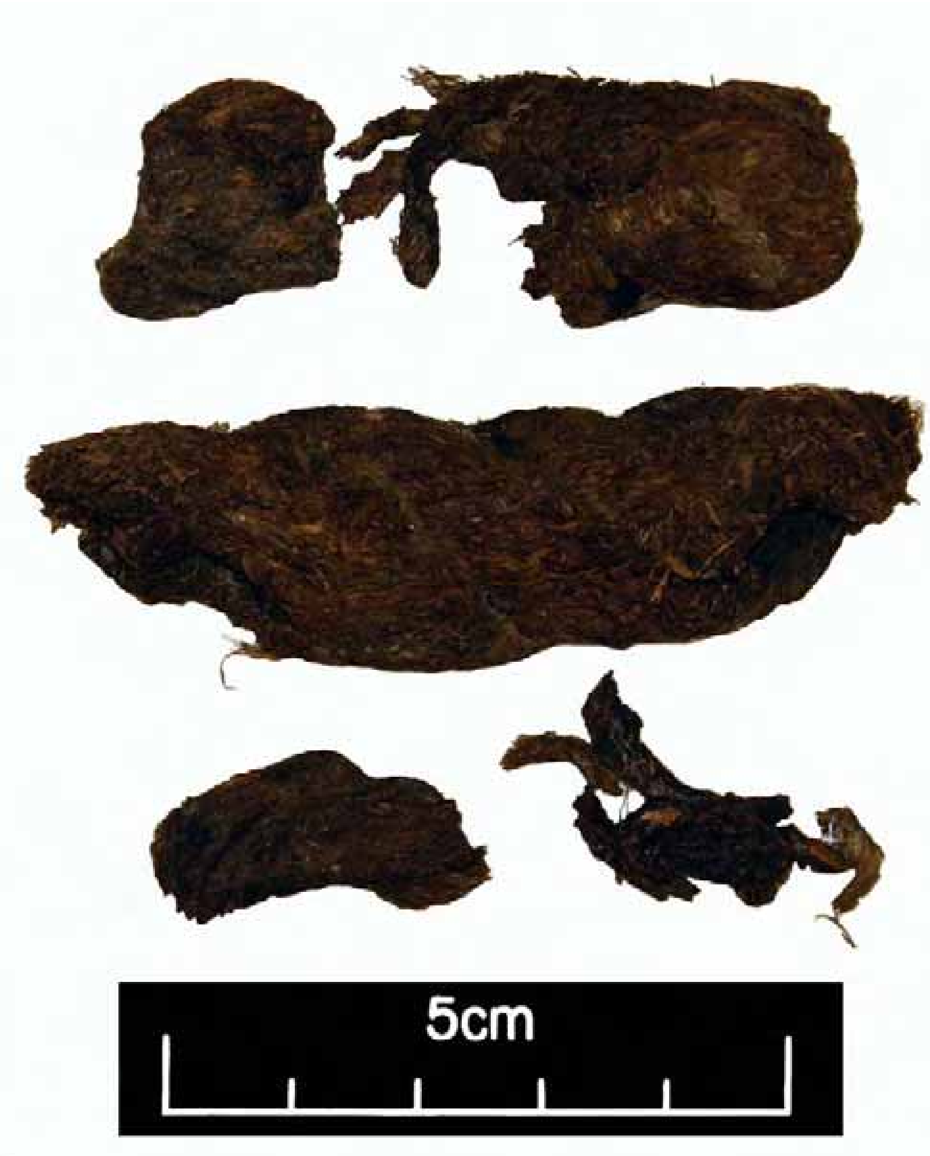
MSG Number	*Length(m)xThickness(mm)*	*Construction*	*Notes*

1301	--------------------------------	Z?S?Z	Elliptical pad, 105 x 35 x 14 mm, of compacted material , including matted cordage

MSG Number	Length(m)xThickness(mm)	Construction	Notes
1302	0.04 x 16 x 3 0.03 x 13 x 5	ZmultiS (helix S 40°).	



MSG Number	*Length(m)xThickness(mm)*	*Construction*	*Notes*
1304	0.07 x 18 x 7	ZmultiS3Z (helix S final Z 50°)	



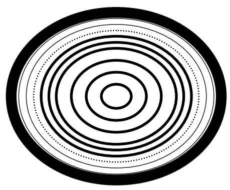
MSG Number	*Length(m)xThickness(mm)*	*Construction*	*Notes*

062	mostly imprint c.20	unclear	Starboard side of mast step. Hemp is part-processed

MSG Number	*Length(m)xThickness(mm)*	*Construction*	*Notes*
075	0.05 x 20x 3	bundle of Zs, each 1-1.5 mm diam	cF45-50, starboard side near ‘reed matting’. Possibly frayed rope. undressed hemp

MSG Number	*Length(m)xThickness(mm)*	*Construction*	*Notes*
854	0.36 20 diam.	?Z3S	<302> E17.59

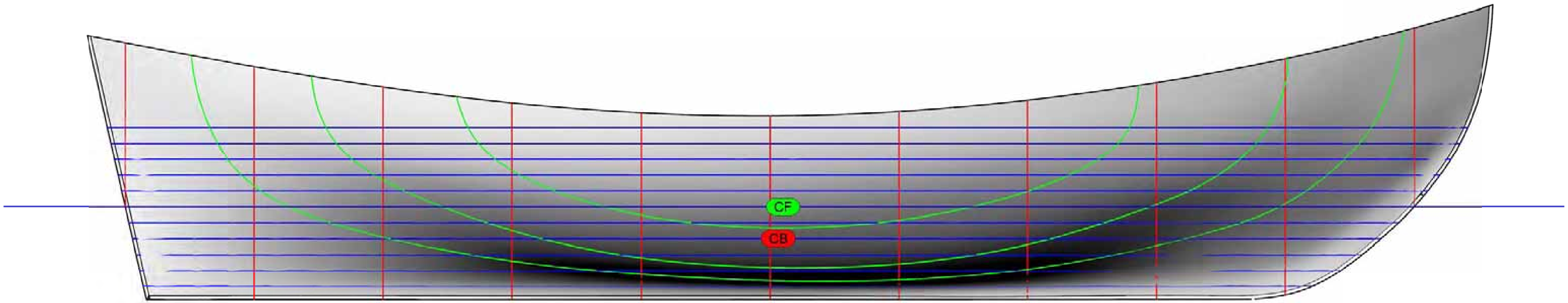
II. Artefact sheet used to record the rigging components

<table>
<tr><td colspan="4">Cow Tag</td><td colspan="4">Function Code</td></tr>
<tr><td colspan="8">Brief Description: [timber element, p/s, condition, fragments]</td></tr>
<tr><td colspan="8">Notable Features: [tool marks, scribed lines, decoration, repairs] POINTS TO LOOK OUT FOR WHEN RECORDING</td></tr>
<tr><td>T.1</td><td>T.2</td><td>T.3</td><td>T.4</td><td>T.5</td><td>T.6</td><td>T.7</td><td>T.8</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="8">Wood Science: [rings, ARW, knots, sapwood, conversion]</td></tr>
<tr><td colspan="8">Recommended action: [samples, additional photos, moulding, queries and problems]
</td></tr>
<tr><td colspan="3">Cleaned:</td><td colspan="2">Recorded:</td><td colspan="3">Photos:</td></tr>
<tr><td colspan="5">Checked: [corrections needed]</td><td colspan="3">Initials & Date:</td></tr>
<tr><td colspan="5">Corrections Done [desktop, Faro Arm?]:</td><td colspan="3">Initials & Date:</td></tr>
</table>

III. Test 1: Lightship Condition Assessment

Page

CP......0.526 AWP...... 106.228 m² WSA......144.615 m² LCB......49.3% 1089.79 kg/cm Displ.......103,560 kg



"Newport Medieval Ship"

NOTES
This plan was taken from the Scanned Model combined with alligned STL's

Lightship Condition Drawing

Traditional Boats of Ireland Project

DRAWN	P. Tanner	DATE	15/08/2012
DRAWING NUMBER	1	SHEET	18 A3
MODEL UNITS	Meters	SCALE	1 : 75

Newport Medieval Ship (Erica's Model)
Displacement Hull Resistance
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 22:44:48
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm

Prediction Parameter	Value
Method	Holtrop 1984 (mod)
SpeedCheck	OK
HullCheck	Check
DesignMarginPercent	0
DesignSpeed	6 kt
WaterType	Salt
WaterDensity	1025.9 kg/m3
WaterViscosity	1.1883E-06 m2/s
FormFactor	1.2302
CorrAllowance	0.00052402
Propulsive Efficiency	75 %

Vessel Data	Value
LengthWL	24272 mm
BeamWL	7187.9 mm
MaxMoldedDraft	1750.7 mm
DisplacementBare	1.0356E+05 kgf
WettedSurface	144.62 m^2
MaxSectionArea	7.904 m^2
WaterplaneArea	106.23 m^2
LCBFwdTransom	13023 mm
BulbAreaAtFP	0 m^2
BulbCentroidBelowWL	0 mm
TransomArea	0.38 m^2
HalfEntranceAngle	25.285 deg
SternTypeCoef	-22.982

Parameter Check	Value	Minimum	Maximum	Type
FnMax	0.20007	0	0.39844	Computed
PrismaticCoef	0.53	0.55	0.85	Computed
LwlBwlRatio	3.3768	3.9	14.9	Computed
LambdaCoef	0.66	0	0.99	Computed
BwlDraftRatio	4.11	2.1	4	Computed

Newport Medieval Ship (Erica's Model)
Displacement Hull Resistance
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 22:44:48
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm

Speed (kt)	Fn	Cf (x 1000)	Cr (x 1000)	Rbare (N)	PEtotal (hp)	Rtotal (N)
1.000	0.033	2.974	1.171	91.7	0.1	91.7
2.000	0.067	2.647	1.024	329.4	0.5	329.4
3.000	0.100	2.481	0.916	692.7	1.4	692.7
4.000	0.133	2.372	0.820	1167.1	3.2	1167.1
5.000	0.167	2.292	0.739	1744.8	6.0	1744.8
6.000	0.200	2.230	0.708	2446.5	10.1	2446.5
7.000	0.233	2.179	0.798	3367.7	16.3	3367.7
8.000	0.267	2.137	1.153	4792.1	26.4	4792.1
9.000	0.300	2.100	1.732	6927.2	43.0	6927.2
10.000	0.333	2.068	2.454	9907.6	68.4	9907.6
11.000	0.367	2.040	4.032	15670.5	118.9	15670.5
12.000	0.400	2.015	7.037	27072.1	224.1	27072.1

Newport Medieval Ship (Erica's Model)
Displacement Hull Resistance
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 22:44:48
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm

Speed (kt)	Fv	Rbare (N)	PEtotal (hp)	PPtotal (hp)	Prediction Check
1.000	0.076	91.7	0.1	0.1	OK
2.000	0.152	329.4	0.5	0.6	OK
3.000	0.228	692.7	1.4	1.9	OK
4.000	0.305	1167.1	3.2	4.3	OK
5.000	0.381	1744.8	6.0	8.0	OK
6.000	0.457	2446.5	10.1	13.5	OK
7.000	0.533	3367.7	16.3	21.7	OK
8.000	0.609	4792.1	26.4	35.3	OK
9.000	0.685	6927.2	43.0	57.3	OK
10.000	0.761	9907.6	68.4	91.1	OK
11.000	0.837	15670.5	118.9	158.6	OK
12.000	0.914	27072.1	224.1	298.8	Check=3

Sensitivity Analysis	Index	To Reduce Drag
Max section area	0.34624	Increase
Waterplane area	0.51111	Decrease
Immersed transom area	2.1791	Decrease
LCB forward of transom	0.091706	Increase

Prediction Checks

1. The Holtrop prediction method has a defined upper limit of 0.80 for the length-based Froude number (Fn). Extrapolating speed beyond this value is not recommended.

2. The Holtrop prediction method contains a calculation parameter (Lambda) that is used to estimate the humps and hollows in the drag curve. Anecdotal experience and testing by HydroComp have identified combinations of parameters that can produce significant errors with the Holtrop method. The relationship between Lambda and length-based Froude number (Fn) has proven to be one such indicator of potential errors. The prediction results may be unreliable for speeds that exceed this Lambda-Fn relationship.

3. The Holtrop prediction method is based on a variety of hull forms, including collections of transom-stern round-bilge hulls. As part of a broader evaluation of prediction methods for high-speed round-bilge hulls, HydroComp has identified a combination of parameters pertaining to the effect of stern geometry that is an indicator of potential errors. The prediction results may be unreliable for speeds that exceed this indicator.

Newport Medieval Ship (Erica's Model)
Displacement Hull Resistance
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 22:44:48
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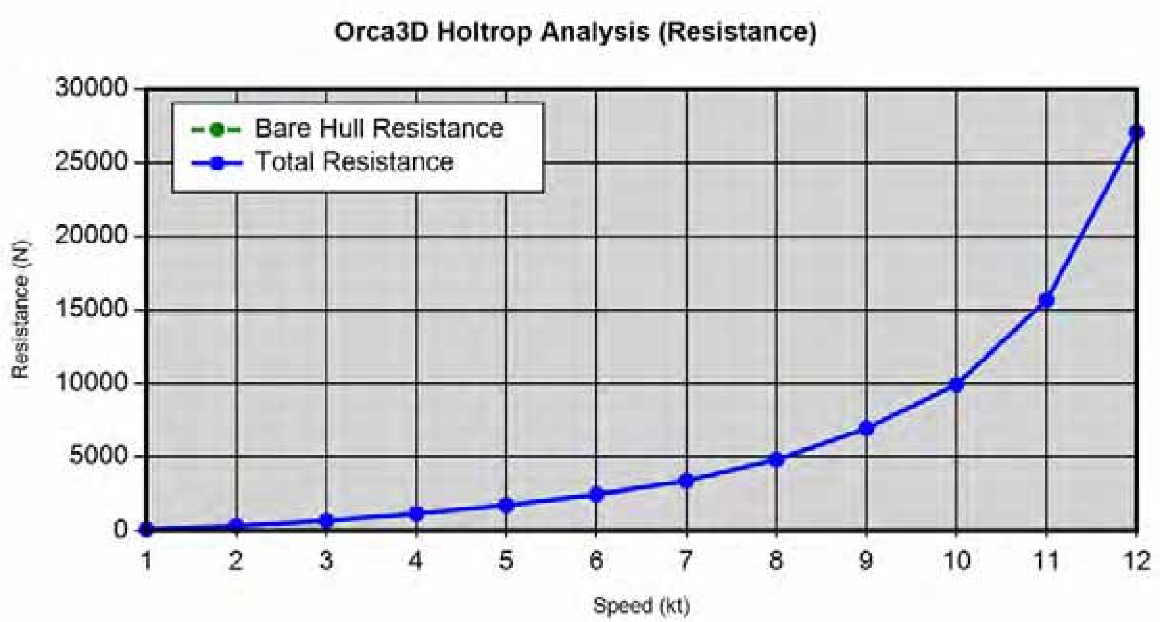
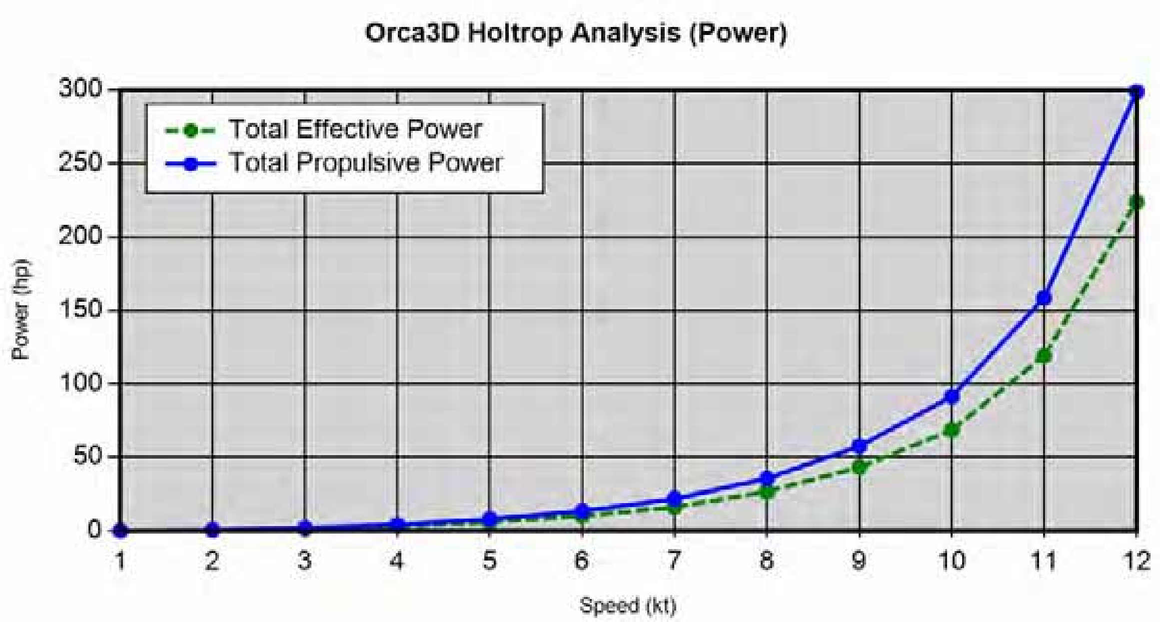
Notes

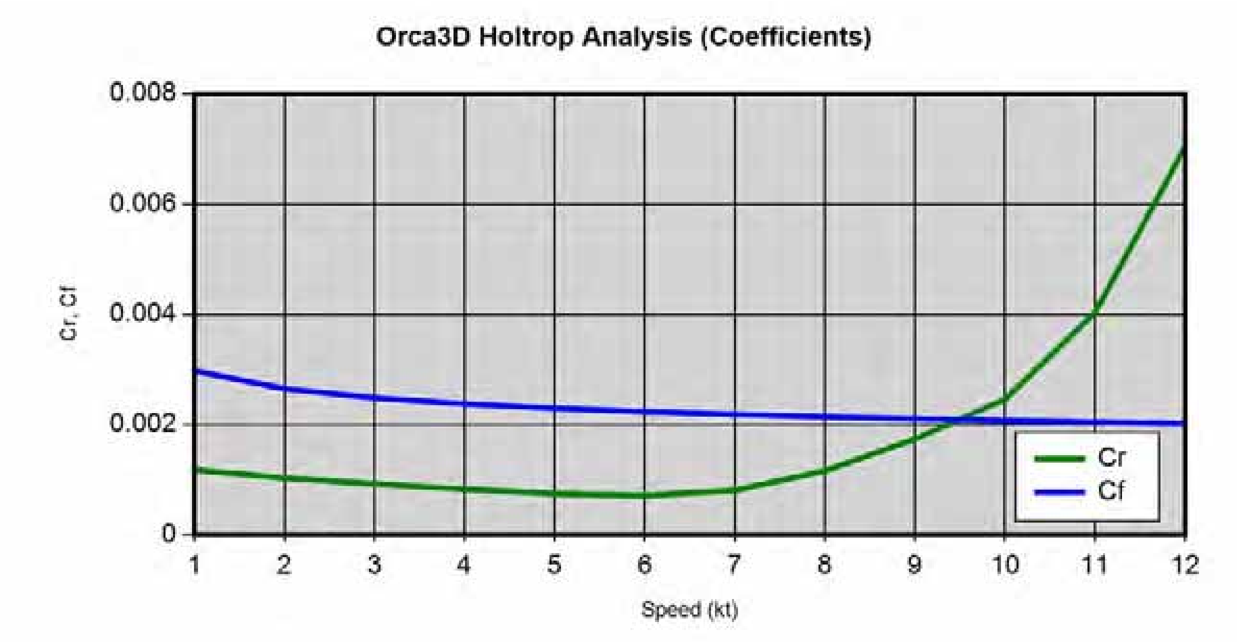
A Sensitivity index with a higher value has a greater influence on drag. Sensitivity values greater than 1.0 are considered significant.

Newport Medieval Ship (Erica's Model)
Displacement Hull Resistance
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 22:44:48
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm





Newport Medieval Ship (Erica's Model)
Displacement Hull Resistance
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 22:44:48
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm



Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 20:55:55
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm

Condition Summary

Load Condition Parameters

Condition	Weight / Sinkage	LCG / Trim	TCG / Heel	VCG (mm)
Condition 1	0.000 mm	0.000 deg	0.000 deg	None available

Resulting Model Attitude and Hydrostatic Properties

Condition	Sinkage (mm)	Trim(deg)	Heel(deg)	Ax(m^2)
Condition 1	0.000	0.000	0.000	7.90

Condition	Displacement Weight (kgf)	LCB(mm)	TCB(mm)	VCB(mm)	Wet Area (m^2)
Condition 1	103560.825	11974.853	0.000	-589.299	144.615

Condition	Awp(m^2)	LCF(mm)	TCF(mm)	VCF(mm)
Condition 1	106.228	11887.843	0.000	0.000

Condition	BMt(mm)	BMl(mm)	GMt(mm)	GMl(mm)
Condition 1	2983.049	27699.226	None available	None available

Condition	Cb	Cp	Cwp	Cx	Cws	Cvp
Condition 1	0.330	0.526	0.609	0.628	2.922	0.543

Notes

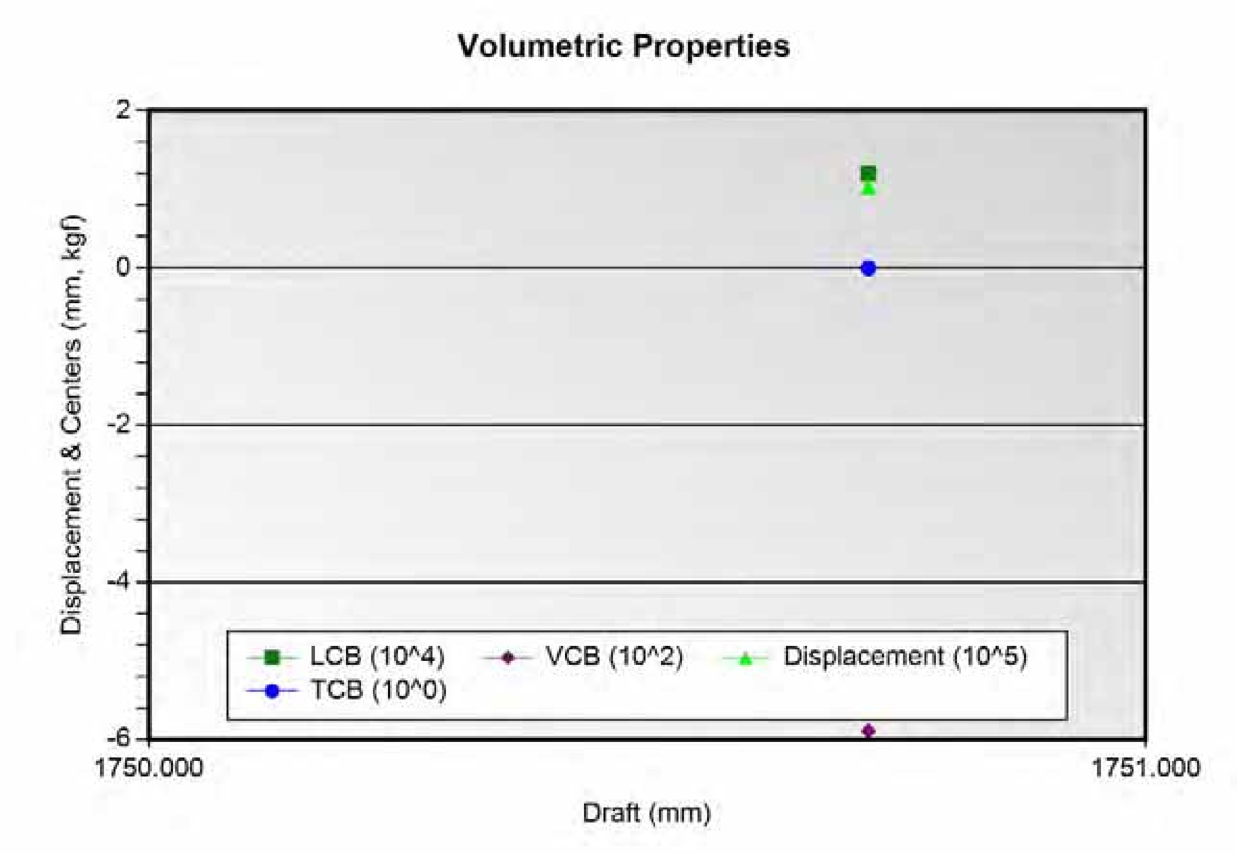
1. Locations such as the center of buoyancy and center of flotation are measured from the origin in the Rhinoceros world coordinate system.

2. The orientation of the model for an Orca3D hydrostatics solution is defined in terms of “sinkage,” “trim,” and “heel.” The sinkage value represents the depth of the body origin (i.e. the Rhino world origin) below the resultant flotation plane, and is sometimes referred to as "origin depth." Heel and trim represent angular rotations about the Rhino longitudinal and transverse axes, respectively, and are taken in that order. For a more detailed description of these terms see the Orca3D documentation.

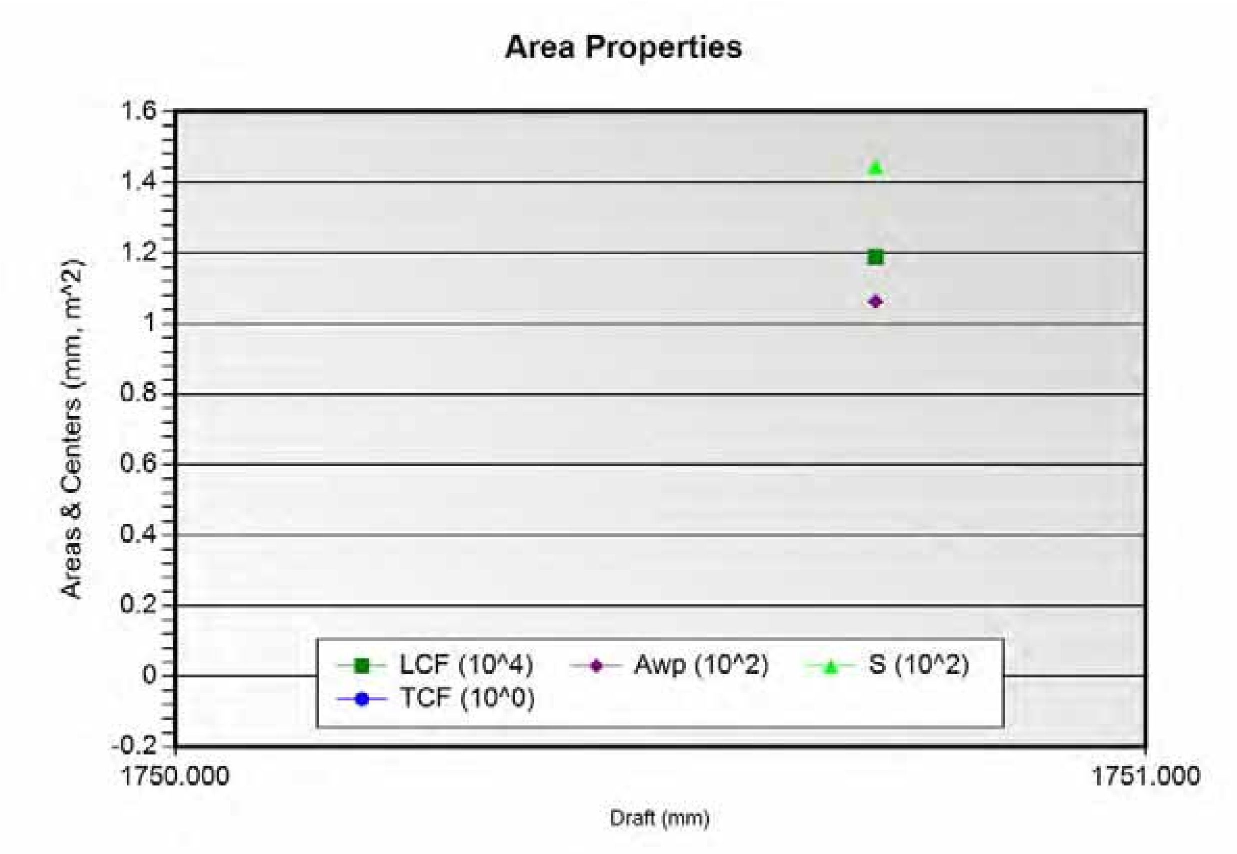
3. Hull form coefficients are non-dimensionalized by the waterline length.

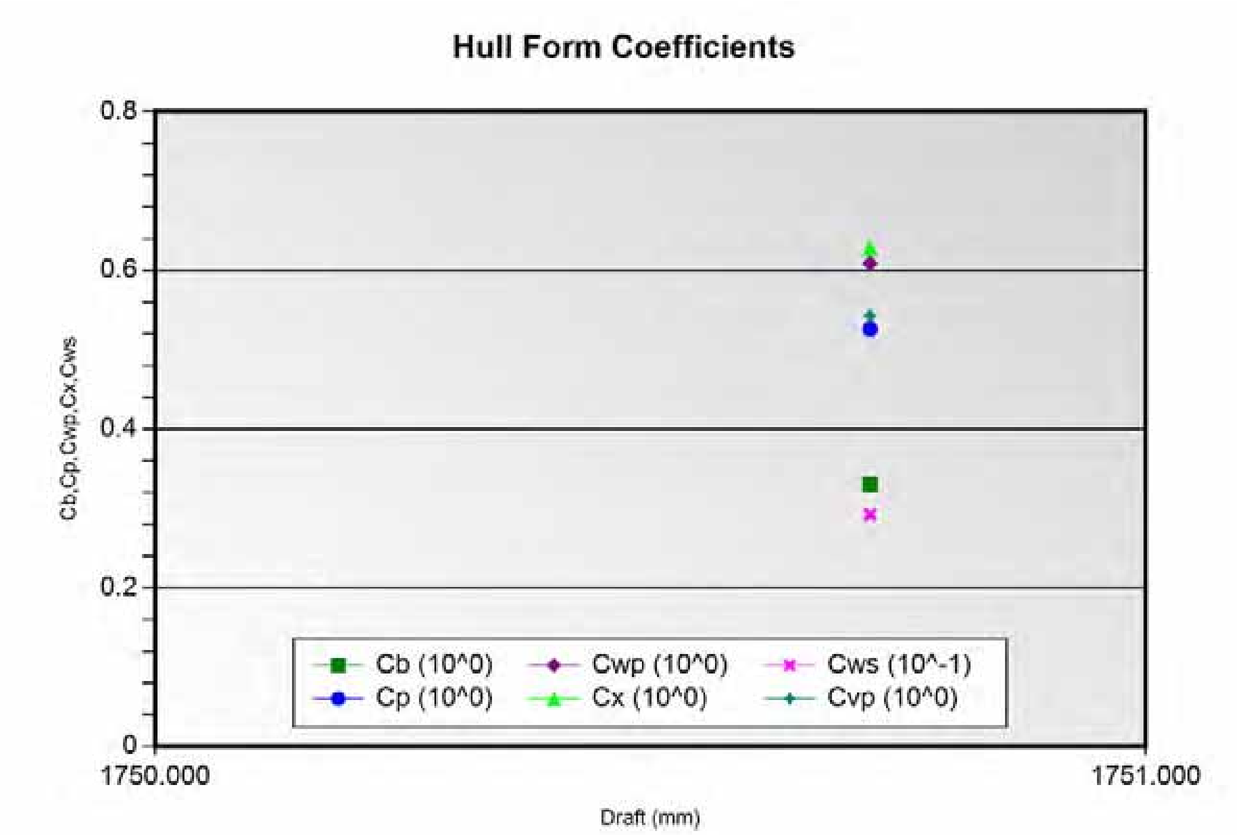
4. Calculation of Cp and Cx use Orca sections to determine Ax. If no Orca sections are defined, these values will be reported as zero.

Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 20:55:55
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm



Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 20:55:55
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm




Hull Form Coefficients
0.8
0.6
0.4
0.2
0
Cb,Cp,Cwp,Cx,Cws
Cb (10^0)
Cwp (10^0)
Cws (10^-1)
Cp (10^0)
Cx (10^0)
Cvp (10^0)
1750.000
1751.000
Draft (mm)

Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 20:55:55
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm

Object Type	Name	ID
polysurface	Newport Medieval Ship	{7c18b65e-fcfa-4a34-8a97-f9d245d7a307}

Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 20:55:55
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm

Condition Name=Condition 1,Model Sinkage=0.00,Model Trim=0.00,Model Heel=0.00

General Info

Analysis Type	FixedFlotationPlane	Up Direction = Positive_Z
		Fwd Direction = Negative_X

Surface Meshing Parameters

Density	1	Minimum edge length	0.0001 mm
Maximum angle	0	Maximum edge length	0 mm
Maximum aspect ratio	0	Max distance, edge to surf.	0 mm
Minimum initial grid quads	0	Jagged seams	False
Refine mesh	True	Simple planes	True

Load Condition Parameters

Model Sinkage	0.000	mm
Model Trim	0.000	deg
Model Heel	0.000	deg
VCG	None available	mm
Fluid Type	Seawater	
Fluid Density	1025.900	kg/m^3
Mirror Geometry	True	

Resultant Model Attitude

Heel Angle	0.000 deg	Sinkage	0.000 mm
Trim Angle	0.000 deg		

Overall Dimensions

Length Overall, LOA	26483.916 mm	Loa / Boa	3.088
Beam Overall, Boa	8576.969 mm	Boa / D	1.541
Depth Overall, D	5567.547 mm		

Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
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Waterline Dimensions

Waterline Length, Lwl	24271.799	mm	Lwl / Bwl			3.377
Waterline Beam, Bwl	7187.916	mm	Bwl / T			4.106
Navigational Draft, T	1750.722	mm	D / T			3.180

Volumetric Values

Displacement Weight	103560.825	kgf	Displ-Length Ratio			201.846
Volume	100.946	m^3				
LCB	11974.853	mm	FB/Lwl	0.493	AB/Lwl	0.507
TCB	0.000	mm	TCB / Bwl			0.000
VCB	-589.299	mm				
Wetted Surface Area	144.615	m^2				
Moment To Trim	1181.847	kgf-m/cm				

Waterplane Values

Waterplane Area, Awp	106.228	m^2				
LCF	11887.843	mm	FF/Lwl	0.490	AF/Lwl	0.510
TCF	0.000	mm	TCF / Lwl			0.000
Weight To Immerse	1089.792	kgf/cm				

Sectional Parameters

Ax	7.904	m^2		
Ax Location	11600.975	mm	Ax Location / Lwl	0.478

Hull Form Coefficients

Cb	0.330	Cx	0.628
Cp	0.526	Cwp	0.609
Cvp	0.543	Cws	2.922

Static Stability Parameters

Orca3D - Marine Design Plug-in for Rhinoceros

Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
Traditional Boats of Ireland Project
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I(transverse)	301.128	m^4	I(longitudinal)	2796.135	m^4
BMt	2983.049	mm	BMl	27699.226	mm
GMt	None available	mm	GMl	None available	mm
Mt	2393.750	mm	Ml	27109.927	mm

Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 20:55:55
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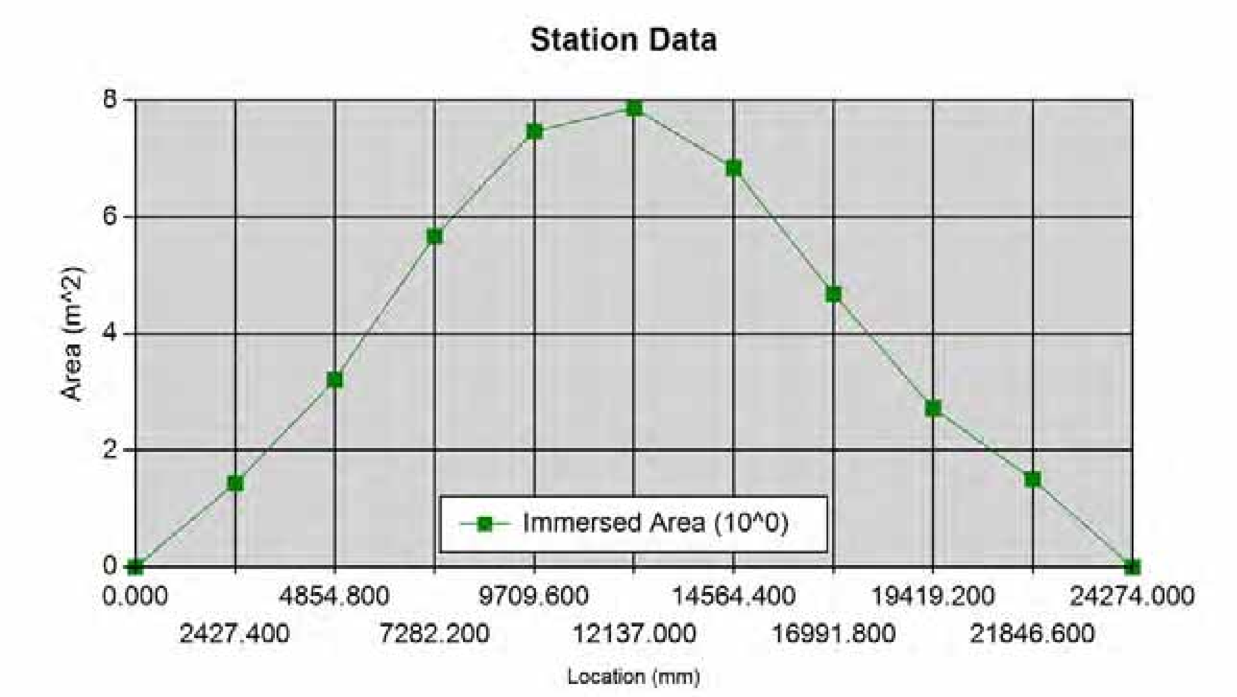
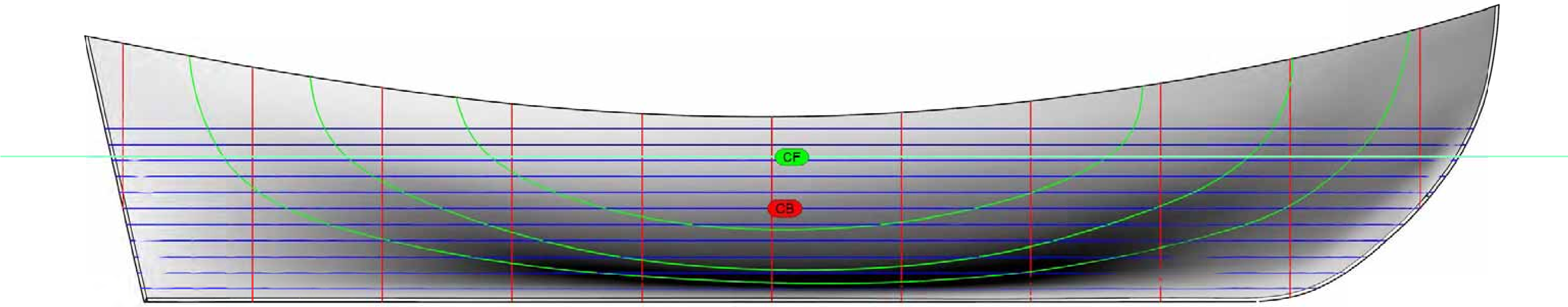


Location (mm)	Immersed Area (m^2)	Immersed Girth (mm)
0.000	0.000	0.000
2427.400	1.430	4110.635
4854.800	3.215	5635.236
7282.200	5.675	7136.424
9709.600	7.470	8086.461
12137.000	7.870	8360.695
14564.400	6.838	7866.821
16991.800	4.682	6584.006
19419.200	2.728	5004.938
21846.600	1.498	4053.566
24274.000	0.000	202.225

IV. Test 2: Fully Laden Ship Assessment

Page

CP......0.563 AWP...... 135.719 m² WSA......204.18 m² LCB......50% 1392.34 kg/cm Displ.......225,000 kg



"Newport Medieval Ship"

Fully Laden Condition Drawing

NOTES
This plan was taken from the Scanned Model combined with alligned STL's

Traditional Boats of Ireland Project

DRAWN	P. Tanner	DATE	15/08/2012
DRAWING NUMBER	1	SHEET	18 A3
MODEL UNITS	Meters	SCALE	1 : 75

Newport Medieval Ship (Erica's Model)
Displacement Hull Resistance
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 22:53:26
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm

Prediction Parameter	Value
Method	Holtrop 1984 (mod)
SpeedCheck	OK
HullCheck	Check
DesignMarginPercent	0
DesignSpeed	6 kt
WaterType	Salt
WaterDensity	1025.9 kg/m3
WaterViscosity	1.1883E-06 m2/s
FormFactor	1.4167
CorrAllowance	0.00052096
Propulsive Efficiency	75 %

Vessel Data	Value
LengthWL	25219 mm
BeamWL	8260.1 mm
MaxMoldedDraft	2716.2 mm
DisplacementBare	2.25E+05 kgf
WettedSurface	204.18 m^2
MaxSectionArea	15.439 m^2
WaterplaneArea	135.72 m^2
LCBFwdTransom	13109 mm
BulbAreaAtFP	0 m^2
BulbCentroidBelowWL	0 mm
TransomArea	1.024 m^2
HalfEntranceAngle	27.545 deg
SternTypeCoef	6.772

Parameter Check	Value	Minimum	Maximum	Type
FnMax	0.19628	0	0.40379	Computed
PrismaticCoef	0.56	0.55	0.85	Computed
LwlBwlRatio	3.0531	3.9	14.9	Computed
LambdaCoef	0.72	0	0.99	Computed
BwlDraftRatio	3.04	2.1	4	Computed

Newport Medieval Ship (Erica's Model)
Displacement Hull Resistance
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 22:53:26
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm

Speed (kt)	Fn	Cf (x 1000)	Cr (x 1000)	Rbare (N)	PEtotal (hp)	Rtotal (N)
1.000	0.033	2.955	2.201	157.3	0.1	157.3
2.000	0.065	2.631	1.973	568.2	0.8	568.2
3.000	0.098	2.466	1.815	1197.7	2.5	1197.7
4.000	0.131	2.358	1.678	2020.8	5.6	2020.8
5.000	0.164	2.279	1.558	3019.7	10.4	3019.7
6.000	0.196	2.217	1.485	4213.6	17.4	4213.6
7.000	0.229	2.167	1.538	5739.3	27.7	5739.3
8.000	0.262	2.125	1.863	7998.0	44.1	7998.0
9.000	0.294	2.089	2.647	11801.8	73.3	11801.8
10.000	0.327	2.057	3.454	16719.7	115.3	16719.7
11.000	0.360	2.029	4.917	25042.6	190.0	25042.6
12.000	0.393	2.004	8.338	43360.4	359.0	43360.4

Newport Medieval Ship (Erica's Model)
Displacement Hull Resistance
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Speed (kt)	Fv	Rbare (N)	PEtotal (hp)	PPtotal (hp)	Prediction Check
1.000	0.067	157.3	0.1	0.1	OK
2.000	0.134	568.2	0.8	1.0	OK
3.000	0.201	1197.7	2.5	3.3	OK
4.000	0.268	2020.8	5.6	7.4	OK
5.000	0.334	3019.7	10.4	13.9	OK
6.000	0.401	4213.6	17.4	23.3	OK
7.000	0.468	5739.3	27.7	37.0	OK
8.000	0.535	7998.0	44.1	58.9	OK
9.000	0.602	11801.8	73.3	97.7	OK
10.000	0.669	16719.7	115.3	153.8	OK
11.000	0.736	25042.6	190.0	253.4	OK
12.000	0.803	43360.4	359.0	478.6	OK

Sensitivity Analysis	Index	To Reduce Drag
Max section area	0.33966	Increase
Waterplane area	0.42312	Decrease
Immersed transom area	2.9289	Decrease
LCB forward of transom	0.15712	Increase

Prediction Checks

1. The Holtrop prediction method has a defined upper limit of 0.80 for the length-based Froude number (Fn). Extrapolating speed beyond this value is not recommended.

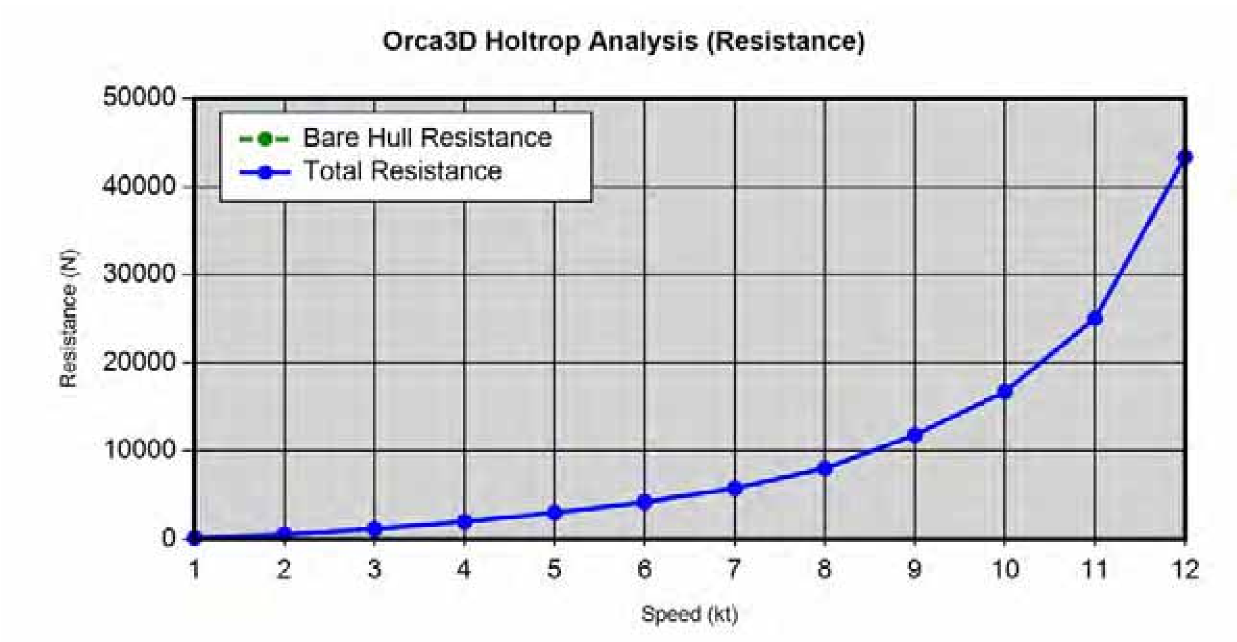
2. The Holtrop prediction method contains a calculation parameter (Lambda) that is used to estimate the humps and hollows in the drag curve. Anecdotal experience and testing by HydroComp have identified combinations of parameters that can produce significant errors with the Holtrop method. The relationship between Lambda and length-based Froude number (Fn) has proven to be one such indicator of potential errors. The prediction results may be unreliable for speeds that exceed this Lambda-Fn relationship.

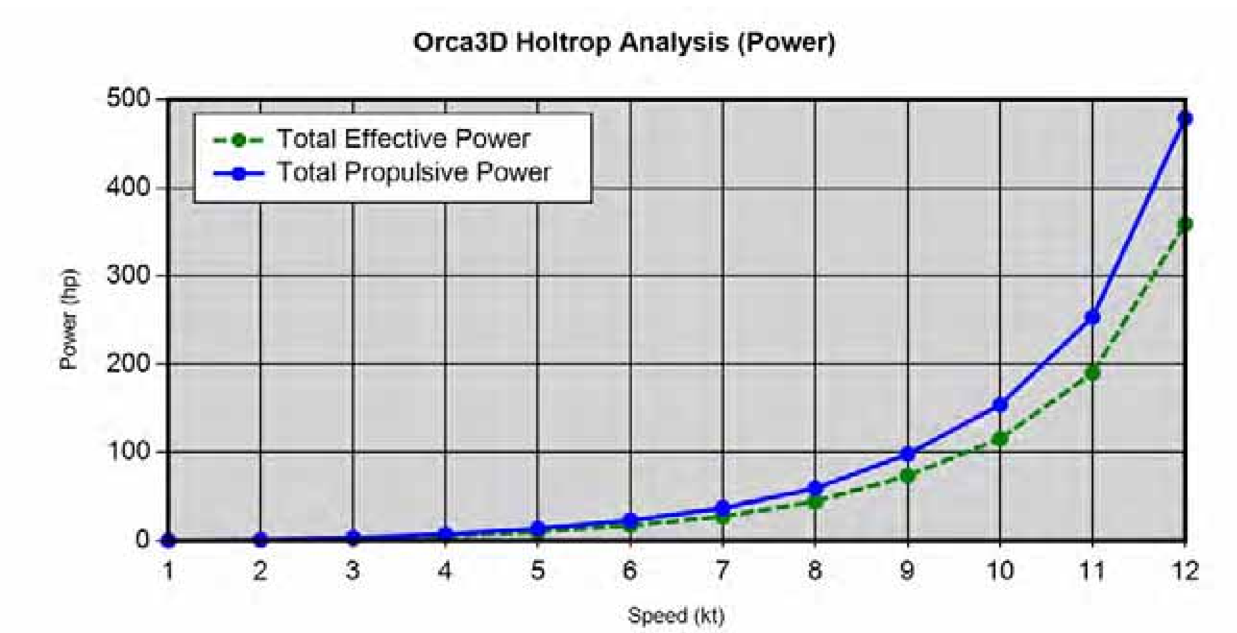
3. The Holtrop prediction method is based on a variety of hull forms, including collections of transom-stern round-bilge hulls. As part of a broader evaluation of prediction methods for high-speed round-bilge hulls, HydroComp has identified a combination of parameters pertaining to the effect of stern geometry that is an indicator of potential errors. The prediction results may be unreliable for speeds that exceed this indicator.

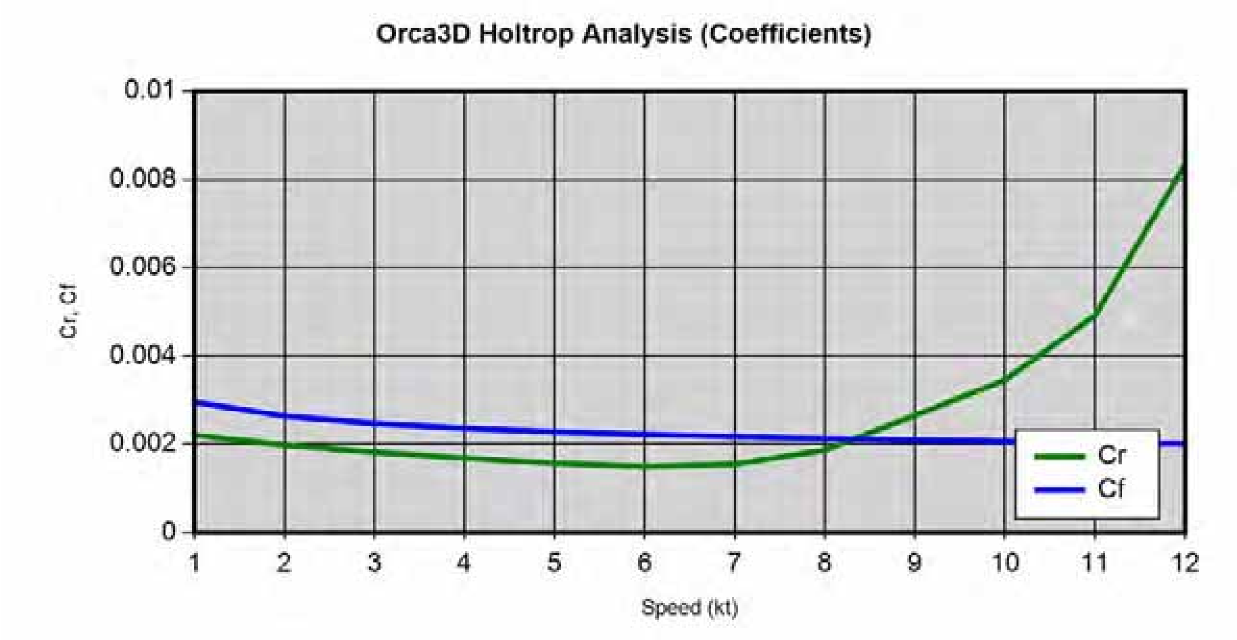
Notes

A Sensitivity index with a higher value has a greater influence on drag. Sensitivity values greater than 1.0 are considered significant.

Newport Medieval Ship (Erica's Model)
Displacement Hull Resistance
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 22:53:26
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm






Orca3D Holtrop Analysis (Coefficients)
Cr, Cf
Speed (kt)
0.01
0.008
0.006
0.004
0.002
0
1
2
3
4
5
6
7
8
9
10
11
12
Cr
Cf

Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 21:14:17
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm

Condition Summary

Load Condition Parameters

Condition	Weight / Sinkage	LCG / Trim	TCG / Heel	VCG (mm)
Condition 1	225000.000 kgf	0.000 deg	0.000 deg	0

Resulting Model Attitude and Hydrostatic Properties

Condition	Sinkage (mm)	Trim(deg)	Heel(deg)	Ax(m^2)
Condition 1	965.480	0.000	0.000	15.44

Condition	Displacement Weight (kgf)	LCB(mm)	TCB(mm)	VCB(mm)	Wet Area (m^2)
Condition 1	224999.808	11889.019	0.000	-0.228	204.178

Condition	Awp(m^2)	LCF(mm)	TCF(mm)	VCF(mm)
Condition 1	135.719	11750.827	0.000	965.480

Condition	BMt(mm)	BMl(mm)	GMt(mm)	GMl(mm)
Condition 1	2404.080	18977.093	2403.85	18976.86

Condition	Cb	Cp	Cwp	Cx	Cws	Cvp
Condition 1	0.388	0.563	0.652	0.688	2.745	0.595

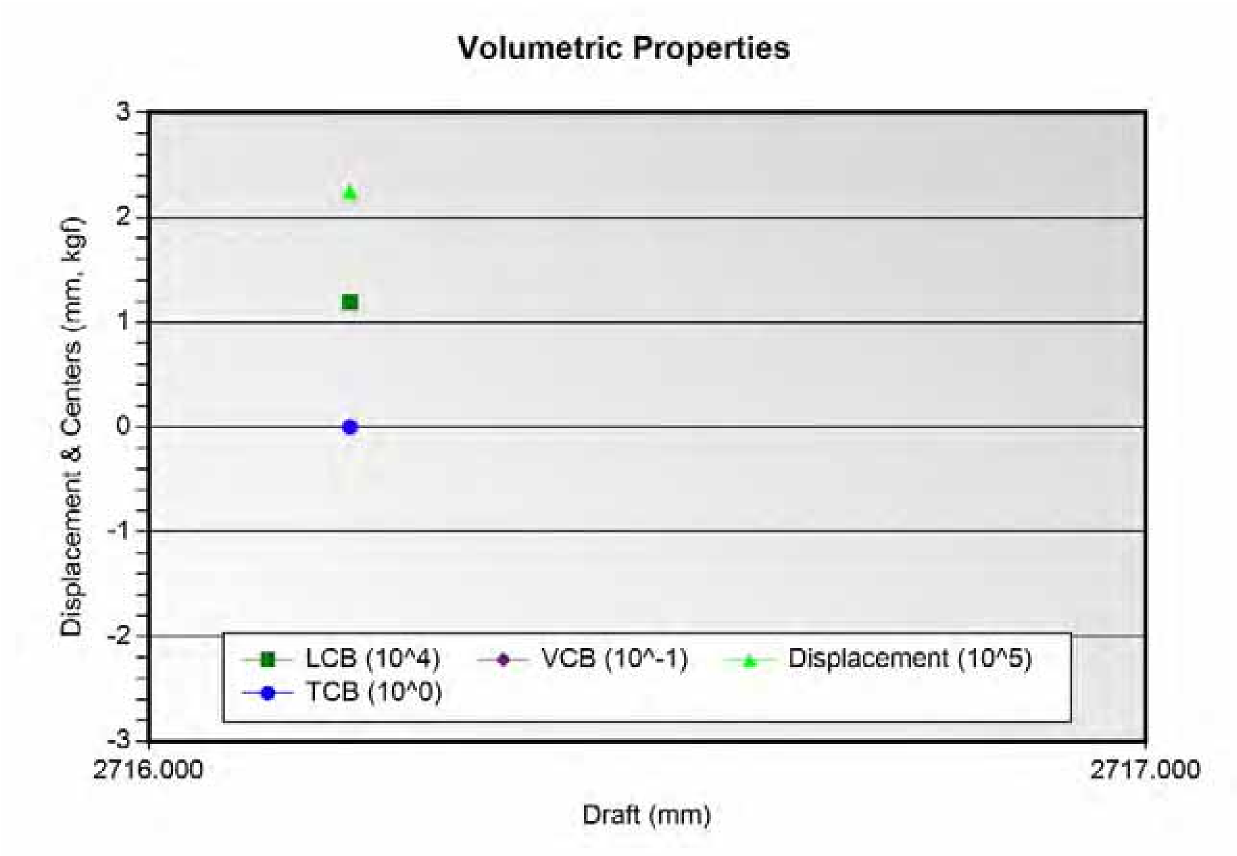
Notes

1. Locations such as the center of buoyancy and center of flotation are measured from the origin in the Rhinoceros world coordinate system.

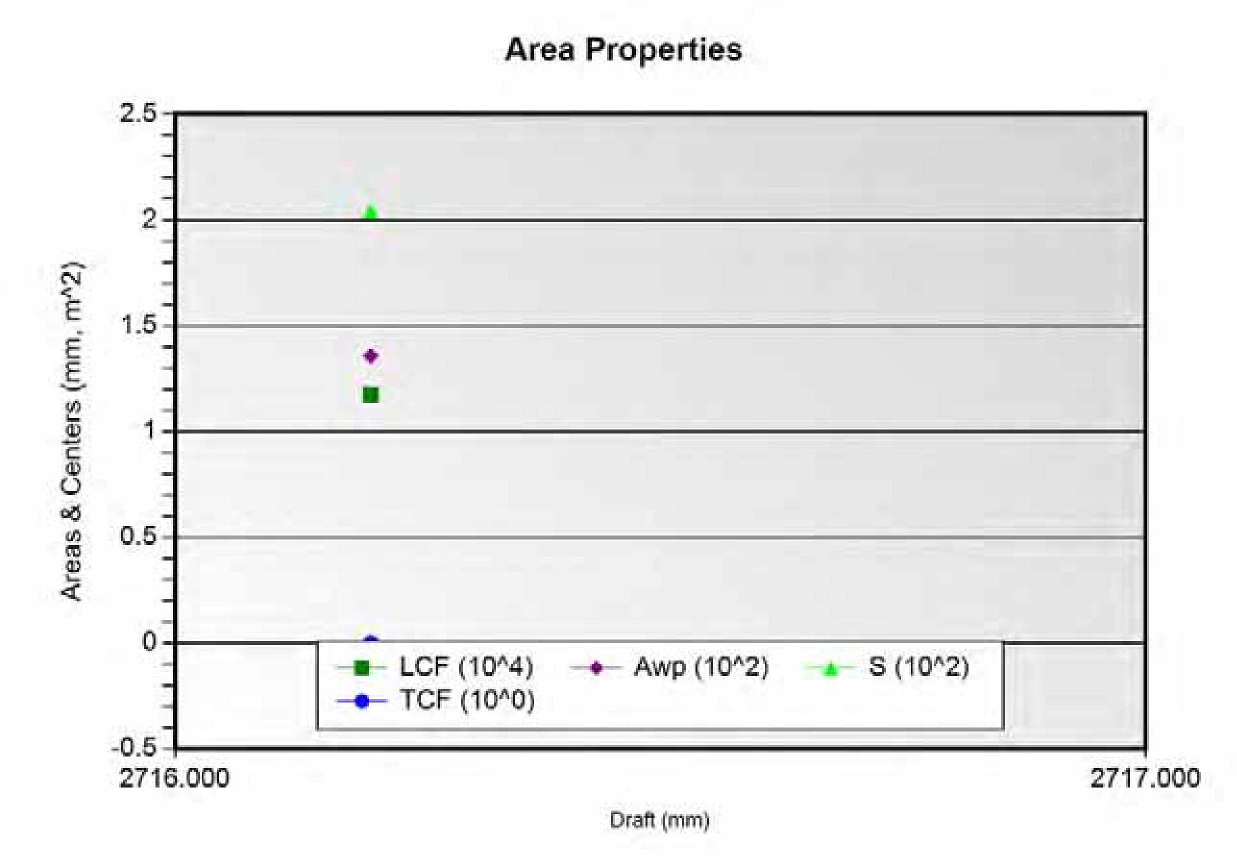
2. The orientation of the model for an Orca3D hydrostatics solution is defined in terms of “sinkage,” “trim,” and “heel.” The sinkage value represents the depth of the body origin (i.e. the Rhino world origin) below the resultant flotation plane, and is sometimes referred to as "origin depth." Heel and trim represent angular rotations about the Rhino longitudinal and transverse axes, respectively, and are taken in that order. For a more detailed description of these terms see the Orca3D documentation.

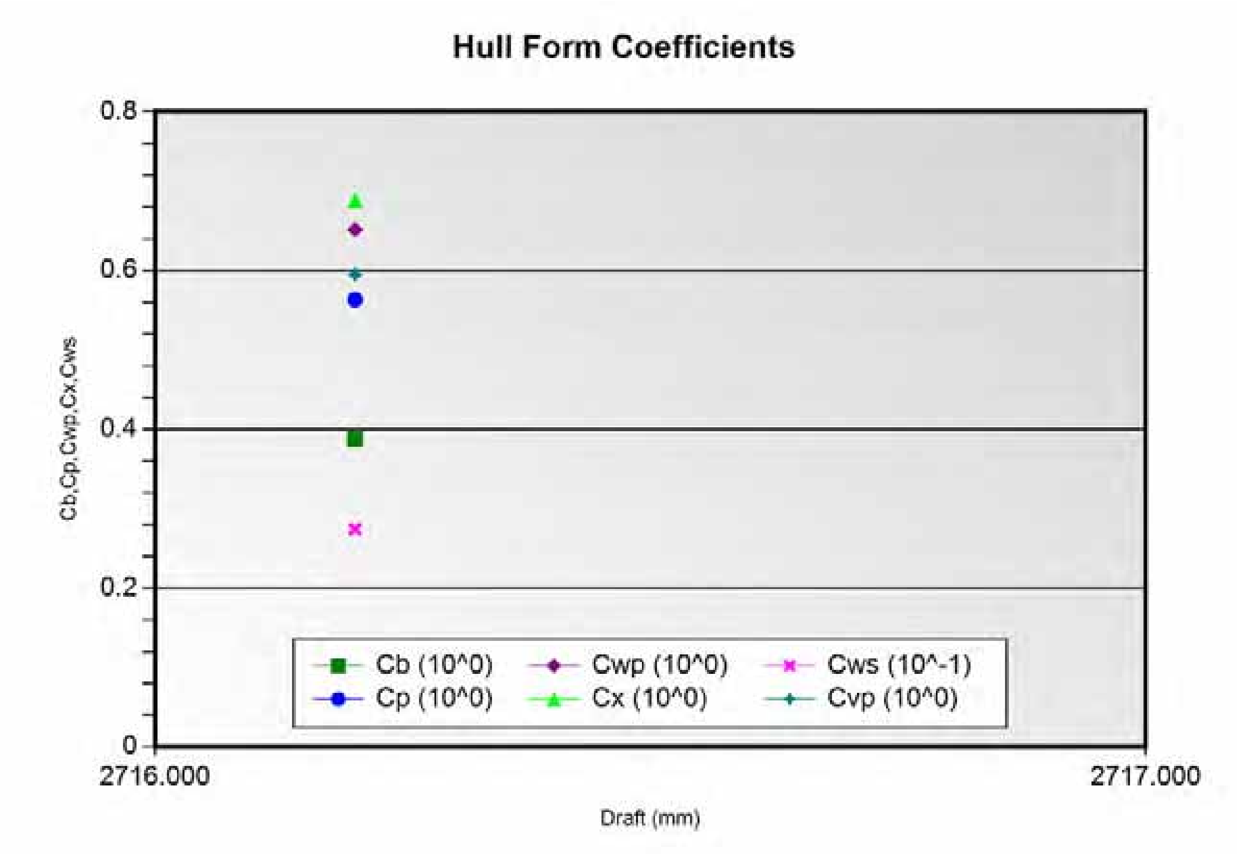
3. Hull form coefficients are non-dimensionalized by the waterline length.

4. Calculation of Cp and Cx use Orca sections to determine Ax. If no Orca sections are defined, these values will be reported as zero.


Volumetric Properties
Displacement & Centers (mm, kgf)
3
2
1
0
-1
-2
-3
LCB (10^4)
VCB (10^-1)
Displacement (10^5)
TCB (10^0)
2716.000
2717.000
Draft (mm)

Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 21:14:17
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm




Hull Form Coefficients
0.8
0.6
0.4
0.2
0
Cb,Cp,Cwp,Cx,Cws
Cb (10^0)
Cwp (10^0)
Cws (10^-1)
Cp (10^0)
Cx (10^0)
Cvp (10^0)
2716.000
2717.000
Draft (mm)

Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
Traditional Boats of Ireland Project
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Object Type	Name	ID
polysurface	Newport Medieval Ship	{7c18b65e-fcfa-4a34-8a97-f9d245d7a307}

Newport Medieval Ship (Erica's Model)
Hydrostatics & Stability Analysis
Traditional Boats of Ireland Project
Report Time: 29 August 2012, 21:14:17
Model Name: C:\Users\Pat Tanner\Documents\Newport\Erica Orca Model.3dm

Condition Name=Condition 1,Weight=225,000.00,Model Trim=0.00,Model Heel=0.00

General Info

Analysis Type	FreeFloatEquilibrium	Up Direction = Positive_Z
		Fwd Direction = Negative_X

Surface Meshing Parameters

Density	1	Minimum edge length	0.0001 mm
Maximum angle	0	Maximum edge length	0 mm
Maximum aspect ratio	0	Max distance, edge to surf.	0 mm
Minimum initial grid quads	0	Jagged seams	False
Refine mesh	True	Simple planes	True

Load Condition Parameters

Weight	225000.000 kgf
Model Trim	0.000 deg
Model Heel	0.000 deg
VCG	0 mm
Fluid Type	Seawater
Fluid Density	1025.900 kg/m^3
Mirror Geometry	True

Resultant Model Attitude

Heel Angle	0.000 deg	Sinkage	965.480 mm
Trim Angle	0.000 deg		

Overall Dimensions

Length Overall, LOA	26483.916 mm	Loa / Boa	3.088
Beam Overall, Boa	8576.969 mm	Boa / D	1.541
Depth Overall, D	5567.547 mm		

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Waterline Dimensions

Waterline Length, Lwl	25218.922	mm	Lwl / Bwl			3.053
Waterline Beam, Bwl	8260.127	mm	Bwl / T			3.041
Navigational Draft, T	2716.202	mm	D / T			2.050

Volumetric Values

Displacement Weight	224999.808	kgf	Displ-Length Ratio			390.961
Volume	219.319	m^3				
LCB	11889.019	mm	FB/Lwl	0.500	AB/Lwl	0.500
TCB	0.000	mm	TCB / Bwl			0.000
VCB	-0.228	mm				
Wetted Surface Area	204.178	m^2				
Moment To Trim	1693.090	kgf-m/cm				

Waterplane Values

Waterplane Area, Awp	135.719	m^2				
LCF	11750.827	mm	FF/Lwl	0.495	AF/Lwl	0.505
TCF	0.000	mm	TCF / Lwl			0.000
Weight To Immerse	1392.339	kgf/cm				

Sectional Parameters

Ax	15.439	m^2		
Ax Location	11633.636	mm	Ax Location / Lwl	0.490

Hull Form Coefficients

Cb	0.388	Cx	0.688
Cp	0.563	Cwp	0.652
Cvp	0.595	Cws	2.745

Static Stability Parameters

Orca3D - Marine Design Plug-in for Rhinoceros

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I(transverse)	527.261	m^4	I(longitudinal)	4162.045	m^4
BMt	2404.080	mm	BMl	18977.093	mm
GMt	2403.85	mm	GMl	18976.86	mm
Mt	1438.371	mm	Ml	18011.385	mm

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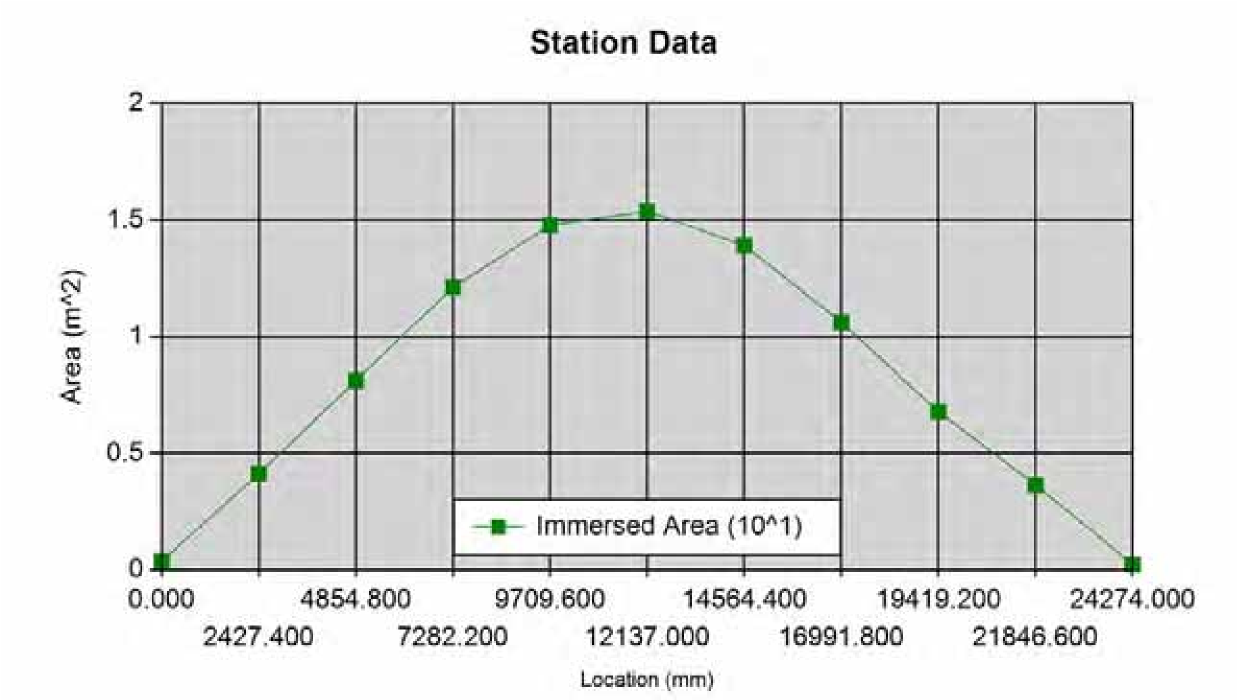

Location (mm)	Immersed Area (m^2)	Immersed Girth (mm)
0.000	0.377	2242.452
2427.400	4.126	6504.962
4854.800	8.125	8144.775
7282.200	12.118	9482.119
9709.600	14.786	10362.678
12137.000	15.394	10578.014
14564.400	13.923	10099.093
16991.800	10.609	8942.377
19419.200	6.797	7470.138
21846.600	3.643	6188.825
24274.000	0.237	2141.133

V. Wood Species Identification

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Wood species identification was undertaken by Project Consultant Nigel Nayling and Project Conservator Marie Jordan. Successful species identification was possible in all but two cases where the artefacts were too soft to take useful slides. Each species id was then included in the assemblage catalogue and was used to create a conservation treatment plan. The results of the wood species identification are as follows;

Cowtag	ID
3053	?
3049	fraxinus excelsior
2367	quercus
1807	quercus
1747	quercus
3010	buxus
3006	fraxinus excelsior
3038	quercus
3094	fraxinus excelsior
3031	ulmus
1926	fraxinus excelsior
3011	Fagus sylvatica
3018	quercus
3112	ulmus
3030	?
3054	quercus
1853	ulmus
3008	fraxinus excelsior
3023	alder?
3024	alnus
3052	fraxinus excelsior
3051	fraxinus excelsior

VI. Conservation of the rigging

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The conservation treatment of the rigging assemblage was undertaken by Project Conservator Marie Jordan. The treatment plan is divided into three stages.

Stage 1: Ammonium Citrate

During this initial treatment the rigging was soaked in a 2% solution of ammonium citrate. This was carried out in order to remove iron salts from the wood. Ammonium citrate was chosen as it is considered to be of minimal health risk and was used previously on the ship timbers and therefore keeps cost down and provides continuity throughout the project's treatment regime. The ammonium citrate solution was monitored throughout the process with samples being taken at regular intervals. By observing the change in colour of the solution over time, the effectiveness of the treatment was gauged. When the samples ceased to change colour the conservator concluded that the treatment process was complete and the iron was removed. The artefacts were then rinsed in water baths.

Stage 2: PEG Treatment

Using the PEGcon program, two poly ethylene glycol treatment regimes were established for the artefacts depending on the objects' moisture content.

Regime A: 27% PEG 400 (achieved in two steps) followed by 5% PEG 3350

Regime B: 8% PEG 400 followed by 25% PEG 3350 (achieved in two steps).

The conservator determined these treatment plans by dividing the PEGcon recommendations in to two broad groups and averaging the values in each of the two groups.

The treatment steps were broken into three-week increments. The initial treatment solution, consisting of the first step for PEG 400 for Regime A and the full PEG 400 volume for Regime B lasted for three weeks. At that point, the final percentage was reached for Regime A, and Regime B began the first step of PEG 3350 treatment. Three weeks after that, Regime A began the 3350 treatment, and Regime B was topped up to the full 3350 volume, so that both regimes are at the desired ratios of PEG to water. The rigging elements were held at this final stage for 4 weeks before moving onto the next stage.

Stage Three: Freeze Drying

The Conservator loaded the rigging pieces into the freeze dryer, sited at the Newport Medieval Ship Centre. The temperature was lowered to -30° C and the objects frozen. The vacuum was turned on and the temperature within the chamber allowed to slowly rise to encourage sublimation of water. The objects were weighed regularly and the weight monitored to determine the endpoint of treatment. When the weight loss of the object had slowed to be nearly untraceable all excess moisture was then known to have been removed and the objects were taken out of the freeze-dryer and placed into storage.

Following freeze-drying, the PEG residue visible on the surface of the objects was removed by wiping down the objects with warm water and a cloth (pers. comm. Marie Jordan 02/04/2012).