Tankerton Bay

Post-excavation Assessment and Updated Project Design

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wessexarchaeology

Portway House
Old Sarum Park
Salisbury
Wiltshire
SP4 6EB

www.wessexarch.co.uk

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Document Information

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Address	Portway House Old Sarum Park Salisbury SP4 6EB
On behalf of	Historic England
Address	The Enginehouse, Firefly Avenue, Swindon.
Site location(s)	Tankerton Bay, Nr Whitstable, Kent
County	Kent
Lat Long position	Tankerton Bay Wreck (located at 51°22'0.41" N, 1° 3'2.97" E)
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WA project code	200950
Date of fieldwork	10 July - 20 July 2018
Fieldwork directed by	Paolo Croce and Toby Gane
Project management by	Toby Gane
Document compiled by	Paolo Croce, Toby Gane and Lowrie Roberts
Contributions from	Alex Brown, Alejandro Cearreta (University of the Basque Country), Alan Clapham, Liam T. Gallagher and Keith J. Gueinn (Network Stratigraphic Consulting), Inés López-Dóriga, Quita Mould, Lorraine Mepham and Rod Bale (University of Wales Trinity St David)
Graphics by	Kitty Brandon

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Summary

Wessex Archaeology was commissioned by Historic England to undertake an archaeological investigation comprising an excavation of the intra-hull fill of the Tankerton Bay Wreck. The site covers approx. 12 x 5 m centred on lat/long 51°22' 0.41" N, 1° 3' 2.97" E and is located at Tankerton Beach, Whitstable, Kent in the intertidal zone.

This work follows the preliminary evaluation of the site that was carried by Wessex Archaeology for Historic England in 2017.

The excavation of 2018 consisted of the removal of the bulk of the sediment contained within the hull of the wreck along with the retrieval of wood samples for dendrochronological analysis and bulk sampling of sediment samples for environmental analysis.

The investigation confirmed that most of the bottom of the vessel including the turn of the bilge is preserved under the fine-grained sediment characteristic of Tankerton Bay. The ship's timbers exposed showed that the remains are those of a coherent section of the lower part of what is believed to be a small-medium sized vessel and include the layer of the outer hull planking, the frames, the keelson, the ceiling which are all in their original position. The stern section is missing.

Due to the remit of the investigation, which meant that the hull could not be dismantled and to the time available on site, it was not possible to record certain specific elements such as the lower frames, keel and outer planking and fully record the timbers which were exposed.

Nonetheless, the date of the site has been refined and new important information on the service life of the vessel were obtained as result of the excavation. The artefactual evidence and the dendrochronological results indicate that the wreck dates to between the middle of the 16th century and the beginning of the 17th century. The timbers that are used on the vessel are a mixture of English, German and Scandinavian timbers, with a prevalence of German and English oak. This points towards to the Netherlands as the area where the ship was built although the possibility that the ship was built in Germany cannot be discounted. It seems that shortly after it was built the vessel may have been refitted or repaired with a number of English oak timbers, so it is plausible that the ship may have been refitted and possibly operated in English waters. However, the presence of repairs was not ascertained during the excavation and it is possible, although unlikely, that the ship was originally built with a mixture of timbers sourced from different countries.

No material that can be clearly associated with the cargo of ship has been found so far and the function of the ship at the time of loss remains unknown, although there is very limited evidence that the vessel might have been carrying grain in bulk at some point during its life. The presence of few incomplete but unused roof tiles could suggest that these were carried as cargo during its last voyage although the evidence that supports this hypothesis is limited.

The few personal items that have been found date to the last quarter of the 16th century. They may have some Dutch associations as very similar items of footwear have also been found in a shipwreck (shipwreck S01) in the Wadden Sea, off the coast of the Netherlands, that dates to around 1590.

The Tankerton Bay Wreck is a unique and complex discovery of international relevance and its study offers an unprecedented opportunity to make a significant contribution to the current debate on early ship building traditions and international trade. It is evident that its complexities in terms of construction and service life deserve to be fully explored and warrant further

investigation and recording. A prime candidate for ascertaining the presence of certain construction signatures and taking further samples for dendrochronology is the area of the floor timbers which is currently not accessible as it is under the ceiling planking. Moreover, the deposits that are at the W end of the site remain only partially excavated and has the highest potential in terms of finds as it is this area that has yielded the largest number of finds and is the location the galley area of the vessel. The potential for environmental evidence also remains extremely high in the deepest part of the deposits.

Acknowledgements

Wessex Archaeology would like to thank Historic England, for commissioning the archaeological investigation, in particular Mark Dunkley. Wessex Archaeology is also grateful for the advice of Rosie Cummings, who monitored the project for Canterbury City Council, and to Mark Harrison of Timescapes Kent and all volunteers for their cooperation and help on site.

The fieldwork was directed by Paolo Croce, with the assistance of Toby Gane. Fieldwork was conducted by Vicki Lambert, Lowri Roberts, Danielle Wilkinson and Joaquin Callejo Gomez. Fieldwork was supported by Mark Harrison of Timescapes Kent and volunteers, in particular T. Newman (Timescapes Kent), C. Leith (Timescapes Kent), S. Dunster (University of Greenwich), P. Banbury (Whitstable Museum), C. Treveil (Timescapes Kent), T. Banbury (Timescapes Kent/ aerial photography), A. Nutten (Timescapes Kent), P. Clarridge (Timescapes Kent), K. Forwood, T. Lambert, A. Leith (Timescapes Kent), R. Livingstone (Whitstable Museum), A. Reed (Timescapes Kent), A. Stone, C. Fulcher, , D. Goodburn (woodwork specialist), G. Miln (Citizan), W. Thompson, J. Preston, D. Chisholm (DC Cartoons), S. Dunster, L. Band, S. Ostrich (Citizan),

This report was written by Paolo Croce, with the assistance of Toby Gane and Lowri Roberts and was edited by Toby Gane. The project was managed by Toby Gane on behalf of Wessex Archaeology. The report was illustrated by Ken Lymer and Kitty Foster.

The bulk sediment samples were processed by Sam Rogerson, Liz Foulston and Jenny Giddins, and the flots sorted by Nicki Mulhall. The macrofossils were assessed by Inés López-Dóriga, the pollen by Alex Brown. A number of external specialists were also involved: the foraminifera were analysed by Alejandro Cearreta (University of the Basque Country), the moss by Alan Clapham, the dinoflagellates by Liam T. Gallagher and Keith J. Gueinn (Network Stratigraphic Consulting), the geochemistry by Brendan Derham and Kamal Badreshany and the animal fibre by Phil Greaves. The environmental report was compiled by Inés López-Dóriga.

Specialist reports were written by Ines Lopez-Doriga, Alex Brown, Quita Mould, Cathy Tyers (Historic England), Roderick Bale, Nigel Nayling (University of Wales Trinity St David). Lorraine Mepham and Lorraine Higbee provided advice on the faunal remains.

TANKERTON BAY WRECK EXCAVATION AND SEASALTER WRECK EVALUATION, WHITSTABLE

Post-excavation Assessment and Updated Project Design

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by Historic England to undertake an archaeological investigation comprising an excavation of the Tankerton Bay Wreck (hereafter TBW) covering and area of approx. 12 x 5 m and centred on lat/long 51°22'0.41" N, 1° 3'2.97" E, at Whitstable, Kent (**Fig. 1**).

1.1.2 The work was carried out following a licence application submitted to the Marine Management Organisation (MMO) and method statement (Wessex Archaeology 2018b) submitted to Historic England, The Crown Estate and Canterbury City Council for intrusive investigations. The investigations were generally limited to the extent of the vessel's hull.

1.1.3 The excavations were an intermediate stage in a programme of archaeological works, which had included an evaluation of TBW (Wessex Archaeology 2017) which identified significant potential for TBW to hold high quality information relating to 16th century vessels and trade. The site was considered to be at risk from coastal erosion (pers, comm. Mark Harrison).

1.1.4 The excavation was undertaken in accordance with a method statement, which detailed the aims, methodologies and standards to be employed, for both the fieldwork and the post-excavation work (Wessex Archaeology 2018b). The District Archaeologist approved the method statement, on behalf of the Local Planning Authority (LPA), prior to fieldwork commencing. The intrusive investigations were undertaken over the period 10 - 20 June 2018 and included the evaluation of a second intertidal wreck at Seasalter, known as the 'Old Brig' wreck, which will be reported on separately.

1.2 Scope of the report

1.2.1 The purpose of this report is to provide the provisional results of the excavation, and to assess the potential of the results to address the research aims outlined in the proposal. Where appropriate, to recommend a programme of further analysis work, and outline the resources needed, to achieve the aims (including the revised research aims arising from this assessment), leading to dissemination of the archaeological results via publication and the curation of the archive.

1.3 Location, topography and geology

1.3.1 The TBW site is located approx. 1800 m east of Whitstable town centre, roughly on the projected alignment of Pier Avenue, between mean high water (MHW) and mean low water (MLW) at around 100m below MHW.

1.3.2 The underlying superficial geology is mapped as beach and tidal flat deposits (undifferentiated) - clay, silt and sand. These superficial deposits formed up to 3 million years ago in the Quaternary Period. The local environment was previously dominated by shorelines. The bedrock geology is mapped as London Clay Formation - clay and silt. The sedimentary bedrock formed approximately 48 to 56 million years ago in the palaeogene

period. The local environment was previously dominated by deep seas (British Geological Survey online viewer).

2 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

2.1 Introduction

2.1.1 Whitstable has been an important maritime port for centuries. The economy of the town during the medieval period was driven by fisheries and salt production. In 1574 a royal patent was granted for fishing the oyster beds which remain a business concern today. In 1588 a copperas works was established at Tankerton, which continued in operation until the early 19th century. Copperas (iron salts) also known as 'green vitriol', were principally used as a dye fixative.

2.2 Archaeological and historical context

2.2.1 An indication of possible maritime heritage being present on Tankerton Beach comes from a ceramic vessel in Whitstable Museum, reported as recovered from a wreck on the beach at very low tide. No date is provided for the recovery. The jar is a Spanish lead glazed domestic jar from the Seville area, designed to store olive oil and is a type produced between the 16th and the 19th centuries. Whether this came from the TBW site, or another unknown site is not currently known.

2.2.2 The copperas works that lies approximately 500 m east of the site were excavated by Canterbury Archaeology Trust from 1995 onwards. The remains were dated to the late 16th and 17th century but later features including a possible wharf or similar structure were also located (Canterbury Archaeological Trust 2001). Historical sources suggest that the production of copperas was started in Whitstable around 1588 by Cornelius Stevenson (Allen 2001). Two of the copperas works were situated in the coastal flats, now foreshore, and both were lost to coastal erosion within 50 years.

2.2.3 From documentary sources it appears that since 1350 at least one beacon for navigation had been established at Tankerton, then known as Beaconfield, as part of a larger Kentish signalling system, and charts show that the later copperas houses were associated with a number of structures, presumably jetties and land staithes, which occupied the adjacent coastal flats (Wilkinson 2006; Allen 2001).

2.2.4 15km north-east of Whitstable in the Princes Channel, a navigable channel between sandbanks in the Thames Estuary, the remains of a contemporary wreck, the 'Gresham Ship', was investigated in 2003 by Wessex Archaeology. The study of the hull elements and finds from the wreck, a 16th century English armed merchantman, was published in 2014 (Auer 2014).

1927

2.2.5 In 1927, workmen 'digging for cement stone near the Copperas houses at Whitstable' came across the remains of a buried vessel. Investigations were undertaken, and the vessel was described as 'a barge without deck, about 60 feet long and 17 broad, and it is supposed to have been buried some centuries' (*The Essex Chronicle,* Friday April 15, 1927). It is possible that this discovery is the first recorded discovery of the TBW site.

1996

2.2.6 Recorded simply as an 'oval feature' in the Kent HER (ref. TR 16 NW 1019), the wreck is was first observed in 1996 by Timescapes Kent (a local historical/archaeological group).

2017

2.2.7 In 2017, the local history and archaeology group Timescapes Kent, were undertaking a field survey of Tankerton beach primarily looking for the sites demolished WW2 fortifications. During this survey, an oval feature was observed.

2.2.8 In October of the same year an intrusive evaluation of the site was carried out to ascertain the extent, state of preservation and character of the remains (Wessex Archaeology 2018a). The investigation determined that this was part of a previously unknown vessel. The involvement of Historic England lead to timbers being sampled for dendrochronological analysis and a date (after which) of 1521 was established by the analysis.

3 AIMS AND OBJECTIVES

3.1 Aims

3.1.1 The general aims of the excavation, as stated in the method statement (Wessex Archaeology 2018b) and in compliance with the CIfA's *Standard and guidance for archaeological excavation* (CIfA 2014a), were:

- To examine the archaeological resource within a given area or site within a framework of defined research objectives;
- To seek a better understanding of the resource;
- To compile a lasting record of the resource; and
- To analyse and interpret the results of the excavation and disseminate them.

3.2 Research objectives

3.2.1 Following consideration of the archaeological potential of the site and the Greater Thames Research Framework (English Heritage 2010), the research objectives of the excavation were linked to:

- 2A.SO1 - Developing an understanding of the role of maritime activity in relation to settlement and land use around the estuary.
- 2A.SO2 - Developing an understanding of the social and economic role of sea-borne trade and other maritime activity within and beyond the estuary.
- 2A.AR1 - Locating and recording the remains of vessels and associated structures within the subtidal and intertidal zone;
- 2A.AR6 - Selecting vessel remains for more detailed study and recording;
- 2A.AR8 - Undertaking research on the nature of cargoes and their movements in relation to local and more distant trade; and
- 2A.AR9 - Carrying out opportunistic recording of wreck sites.

4 METHODS

4.1 Introduction

4.1.1 All works were undertaken in accordance with the detailed methods set out within the project design (Wessex Archaeology 2018b) and in general compliance with the standards outlined in CIfA guidance (CIfA 2014a). The methods employed are summarised below.

4.1.2 Excavations were limited to the immediate hull of the vessel or where specific research questions needed answering, then limited excavation took place immediately adjacent to the outer hull. All excavation was carried out by hand.

4.2 Fieldwork methods

General

4.2.1 The site extent and excavation areas were set out using GPS, in the same position as that proposed in the method statement (**Fig.1**). For selected areas, the topsoil/overburden was removed by hand, under the constant supervision and instruction of the monitoring archaeologist. Excavation proceeded until an archaeological horizon of material or the hull of the vessel was exposed.

4.2.2 Where necessary, the surfaces of archaeological deposits were cleaned by hand to aid visual definition. This proved challenging in the marine silts present on the site and in the limited time available before the tide turned and the excavation area was flooded. A sample of archaeological features and deposits identified was hand-excavated, sufficient to address the aims of the excavation.

4.2.3 Spoil derived from hand-excavated archaeological features was visually scanned for the purposes of finds retrieval. A metal detector was also used. Where found, artefacts were collected and bagged. All artefacts from excavated contexts were retained, although those considered of modern date (19th century or later) were recorded on site and not retained.

Recording

4.2.4 All archaeological features and deposits were recorded using Wessex Archaeology's pro forma recording system. A complete digitised record of excavated features and deposits was made and tied to the Ordnance Survey (OS) National Grid. The Ordnance Datum (OD: Newlyn) heights of all principal features were calculated, and levels added to plans and section drawings.

4.2.5 A Leica GNSS connected to Leica's SmartNet service surveyed the location of archaeological features. All survey data is recorded in OS National Grid coordinates and heights above OD (Newlyn), as defined by OSGM15 and OSTN15, with a three-dimensional accuracy of at least 50 mm.

4.2.6 A full photographic record was made using digital cameras equipped with an image sensor of not less than 10 megapixels. Digital images have been subject to managed quality control and curation processes, which has embedded appropriate metadata within the image and will ensure long term accessibility of the image set.

4.3 Artefactual and environmental strategies

General

4.3.1 Appropriate strategies for the recovery, processing and assessment of artefacts and environmental samples were in line with those detailed in the method statement (Wessex

Archaeology 2018b). The treatment of artefacts and environmental remains was in general accordance with: *Guidance for the collection, documentation, conservation and research of archaeological materials* (CIfA 2014b) and *Environmental Archaeology: A Guide to the Theory and Practice of Methods, from Sampling and Recovery to Post-excavation* (English Heritage 2011).

4.3.2 Bulk environmental samples were extracted by hand and locations recorded by GPS. Samples were retained and processed at WA's environmental lab.

Macrofossils

4.3.3 The eight bulk sediment samples which were processed had a combined volume of 37.8 litres, with an average of 5 litres. The bulk sediment samples were processed by bucket flotation methods; the flot retained on a 0.25 mm mesh. The 2 samples processed for ostracods were fractionated into 0.5 mm, 0.25 mm, 0.125 mm and 0.063 mm fractions. The remainder of the sample residues were fractionated into 5.6 mm and 0.25 mm fractions. The coarse fractions (>5.6 mm) were sorted by eye and discarded. A subsample of the flots were scanned using a stereo incident light microscopy (Leica MS5 microscope) at magnifications of up to x40 for the identification of environmental remains. A Nikon eclipse E400 biological research microscope was also used in aid of identification of remains that required higher magnification (x100). The preservation and nature of the plant remains, as well as the presence of other environmental remains such as terrestrial and aquatic molluscs, animal bone and insects, was recorded. Identifications follow Preliminary identifications of dominant or important taxa are noted below, following the nomenclature of Stace (1997). Abundance of remains is qualitatively quantified (A*** = exceptional, A** = 100+, A* = 30-99, A = >10, B = 9-5, C = <5) as an estimation of the minimum number of individuals and not the number of remains per taxa.

Mosses

4.3.4 Three samples were analysed for mosses. The samples were from caulking <2001> and <2004> with one from the bilge <2002>. Modern samples of mosses are identified by a mixture of different sources of evidence, these include form (whether cushion or mat forming), the habitat (what were they growing on, soil type, rock type, vegetation type – grassland, woodland, bog, stream etc –), altitude and geographical location as well as shape, size etc of the fruiting body. If this is not enough to identify the moss to species, then microscopic features of the leaf can be used. In the field a 10x magnification hand lens is also needed to pick up those features that are barely visible to the naked eye. With archaeological material a lot of this information is missing and therefore in most cases the only reliable method of identifying the mosses is to use the microscopic features of the leaves.

4.3.5 To identify mosses microscopically a high-powered (40-1000x magnification) transmitted light compound microscope is required as well as a low-powered (10-50x magnification) stereomicroscope. Under a low-powered stereomicroscope using fine-pointed forceps pluck several (ideally four leaves) and mount them in water on a glass microscope slide and then place a glass coverslip on top.

4.3.6 Mosses can be split into two groups, the cushion forming types (acrocarpous) or mat/weft forming types (pleurocarpous) with modern specimens in the field this is an easy distinction to make but with archaeological material this is in most cases very difficult to determine with the naked eye due to compression and other post-depositional conditions. Fortunately, this major division – which is no longer considered to be a natural one but is still a useful way of categorising the mosses (Watson, 1981) - can be assessed microscopically. Acrocarpous mosses in most cases can be determined by being unbranched and pleurocarpous mosses

are freely branching and form dense mats or looser wefts (Watson 1981). This will not be possible to determine if you only have the leaves. The most reliable method of determine whether the moss is acro- or pleurocarpous is by using the range of cell structure and the presence of nerves when studied under the compound microscope (Watson, 1981). Very few acrocarpous mosses have long narrow cells throughout the leaf, they are mainly isodiametric. In the pleurocarpous mosses, the long narrow cells occur throughout the leaf whilst isodiametric cells are mainly not present. Few pleurocarpous mosses have isodiametric cells in the upper part of the leaf and elongated rectangular ones in the leaf base, which is the dominant cell arrangement in the acrocarps. Another useful feature that helps in the determination between the two groups is that nerveless leaves are very rare in the acrocarps whilst strong and excurrent (those that extend beyond the leaf tip), are rare in the pleurocarps (Watson, 1981).

4.3.7 Once this division is made it is then essential to use a key to determine which species of mosses are present using the microscopical characters of the leaf. The one used in this study is that presented in Watson (1981). Whilst Watson (1981) provides a very useful key, it is advised that other moss floras are used for the description of the species and for illustrations and habitat preferences. The ones used here are Smith (1980) and Atherton, Bosanquet and Lawley (2010).

Foraminifera

4.3.8 Three wet subsamples were selected for foraminiferal analysis: <2001>, <2002> and <2004>. Samples <2001> and <2004> were composed of a mixture of 63, 125 and 250-micron sand fractions whereas sample <2002> was made of 250-micron fraction only. The samples were initially dried at 50ºC in an oven for 24 hours. All of them contained very abundant benthic foraminiferal assemblages and therefore concentration by flotation in trichloroethylene was not necessary. Tests were picked under a binocular microscope (Nikon SMZ1500) until a representative amount of at least 300 individuals for each sample was obtained. Extracted tests were located in multicelled cardboard slides for storage.

Pollen and spores

4.3.9 Nine sub-samples of 1 ml. of volume were processed using standard pollen extraction methods (Moore *et al*. 1991). Pollen was identified and counted using a Nikon eclipse E400 biological research microscope. A total of 150 pollen grains was counted for each sub-sample in addition to aquatics and fern spores, and where 150 counts were not possible, all pollen and spores were counted from four transects. One *Lycopodium* tablet was added to enable calculation of pollen concentrations. Pollen and spores were identified to the lowest possible taxonomic level. Plant nomenclature followed Stace (1997) and Bennett *et al*. (1994). Pollen sums are based on total land pollen (TLP) excluding aquatics and fern spores which are calculated as a percentage of TLP plus the sum of the component taxa within the respective category. Identification of indeterminable grains was according to Cushing (1967). At assessment stage the results are not presented as pollen diagrams but are presented in tabular form as raw data. Plant taxa are assigned to one of the following groups (trees and shrubs, dwarf shrubs, cultivated, field weeds, ruderals, herbaceous open/ undefined, fern spores and aquatics) based on their most likely ecological affinity, although many plant taxa occur in a range of environmental niches (see Stace 1997 for specific plant taxa).

Dinoflagellates

4.3.10 Detailed palynological studies have been carried out on subsamples 2002, 2002A, 2002B, 2002C, 2004, 2006, 2007 & 2009 in order to establish their relative palaeoenvironmental significance (if any) with respect to the voyages of the Tankerton ship and to provide

stratigraphic position within the London Clay Formation should the samples prove *ex situ*. Approximately 60% of the total sample weight was used for analyses in order to yield sufficient palynomorphs, whilst retaining a control sample. Processed palynological residues were received from all of the samples stored in glycerine jelly. The glycerine jelly was removed from the samples and the residues sieved at 15 microns. Residue passing through the 15 micron sieve was then passed through a 10 micron sieve. All of the palynomorphs recorded were recovered from the residues caught on the 15 micron sieve.

Geochemistry

4.3.11 The samples were prepared and analysed by the Durham Archaeomaterials Research Centre (DARC). As the site has only recently been excavated, the samples are unlikely to be contaminated with post-excavation synthetic chemicals, such as surfactants and consolidants. The samples were analyzed by solid state Nuclear Magnetic Resonance (ssNMR) and pyrolysis Gas Chromatography – Mass Spectrometry (py-GC-MS) to ascertain the nature of the material.

4.3.12 ssNMR analysis: The goal of analysing the samples first with ssNMR was to identify if any organic compounds were present within the gritty fibrous samples and gain a better understanding of their nature. The sample was placed directly into a rotor and analysed on a Bruker Avance II HD solid-state NMR. The chemical shift reference was Carbon, neat tetramethylsilane. The results are presented in Figures 1 and 2.

4.3.13 Py-GC-MS analysis: The sample was analysed using Py–GC/MS with Thermally assisted Hydrolysis and Methylation (THM). The derivatizing agent used was Tetramethylammonium Hydroxide (TMAH or TMAOH) in aqueous solution at 25% w/w (Sigma-Aldrich-MI-Italy).

4.3.14 Small portions of the samples were loaded in a quartz tube closed with two small pieces of quartz wool, then 5 µL of TMAH in aqueous solution was added using a micro-syringe. Pyrolysis was performed with CDS Pyroprobe 5200 (Analytical Inc., USA) filament pyrolyzer directly connected to GC/MS system. The pyrolysis chamber was fluxed with helium and starting from 30 °C, heated to 600 °C at 50 °C/ms, then held at 600 °C for 2 min. The GC is a 7820A Network GC System (Agilent Technologies, USA) gas chromatograph with a methyl-phenyl-polysiloxane cross-linked 5% phenyl methyl silicone (30 m, 0.25 mm i.d., 0.25 µm film thickness) capillary column. The GC temperature program was: 50 °C for 2 min, then a temperature ramp to 300 °C (heating rate 10 °C/min to 130 °C, 5 °C/min to 180 °C/min then 15 °C/min to 300 °C, held for 5 min). The temperature of the injector and of the Py–GC interface was kept at 280 °C. The carrier gas was helium (1.0 mL/min), and the split ratio was 1/20 of the total flow. The mass spectrometer coupled to the GC apparatus was a 5977E Network MASS Selective Detector (Agilent Technologies, USA). Mass spectra were recorded under electron impact at 70 eV, scan range 40–600 m/z. The interface was kept at 280 °C, ion source at 230 °C, and quadrupole mass analyser at 150 °C.

4.3.15 All instruments were controlled by Agilent MassHunter Qualitative B.06.00 software. The mass spectra assignment was done with NIST2008 library and by comparison with literature data. The results are presented in Figures 3-4, Tables 1-2 and Appendix.

Radiocarbon dating

4.3.16 A staged radiocarbon dating approach was undertaken for the understanding on the chronology and depositional processes at the site. Sample selection was made by Inés López-Dóriga. In line with best-practice, pairs of dates from each sampled deposit will be obtained where possible, with each pair comprising short-lived plant remains from different species, as circumstances permit. The measurements were obtained from the 14CHRONO Centre, Queen's University, Belfast. The radiocarbon dates were calculated using the

calibration curve of Reimer *et al*. (2013) and the computer program OxCal (v4.2.3) (Bronk Ramsey and Lee 2013) and cited in the text at 95% confidence, with the end points rounded outwards to 10 years.

4.4 Monitoring

4.4.1 The Principal Archaeology and Heritage Officer, on behalf of Canterbury City Council, monitored the excavation. Any variations to the method statement, if required to better address the project aims, were agreed in advance with the Principal Archaeology and Heritage Officer.

5 EXCAVATION RESULTS

5.1 Introduction

General

5.1.1 The site is considered to be composed of a single infill context within the wooden hull of a small- medium sized timber vessel . This was a stiff, fine grained marine sediment made of a redeposited London clay (**Fig. 2**). The fill was indistinguishable from surrounding deposits of marine sediment. There were occasional cobbles and gravel inclusions overlying the fill.

Site -Summary of archaeological features and deposits

5.1.2 The 2017 evaluation of the TBW site (Wessex Archaeology 2018a) consisted of two trenches excavated within the hull of the vessel.

5.1.3 Trench 1 was excavated to a maximum depth of approximately 0.8 m and was approximately 2 m wide by 1.8 m long. The trench was dug within the perimeter of the hull in an area where the assembly of inner/outer planking and timbers were still visible and there was no particular concentration of surface material.

5.1.4 The trench revealed a section of inner lower hull at the turn of the bilge. Six strakes of inboard timbers, five ceiling planks and one possible footwale or heavy stringer were visible. They were laid flush to one another and different types of wood were used on different strakes although the construction was mostly of oak. Apart from the upper strake which was heavily eroded the remaining timbers were all in very good condition with the original surfaces preserved.

5.1.5 Trench 2 was excavated to a maximum depth of 0.4 m and only the NE half was partially excavated. It exposed a segment of the keelson assembly together with a probable mortise for the mast (mast-step).

5.1.6 The keelson ran along the approximate centreline of the remains. The SE end of the timber was sampled in July 2017 and appeared at the time damaged and worn. The other end has not yet been uncovered as the timber was buried under the clay and was only partially exposed when Trench 2 was excavated. The section of the keelson that was exposed was approximately 4 m long and it consisted of a single oak timber with chamfered upper edges and rectangular section. The lower face of the keelson was notched to receive the upper faces of the floor frames which were observed beneath.

5.1.7 On the upper face of the keelson there was a large rectangular mortise that was believed to be the mast-step. This mortise was augured at the corners and then carved out. Clear tool-marks can be seen at the foot of the mortise.

5.1.8 For the 2018 Excavation a number of assumptions were made to enable the methodology to be developed:

- It was assumed that no substantial collapsed structural elements would be encountered within the hull of the vessel. While it was known that a few disarticulated timbers were likely to be present, trench 1 had encountered no significant timber with the hull fill context and it was presumed this would be replicated elsewhere within the hull.

- The sedimentary deposit of marine clay within the hull would be sufficiently stiff to allow the entire vessel remains to be quarter sectioned, allowing a full record of the longitudinal and transverse section to be made.

5.1.9 Neither of these assumptions proved to be correct. Even before excavation had started it became apparent that more collapsed timber structure remained in the hull than had been anticipated. Erosion over the preceding months had exposed previously unseen disarticulated timbers. Superficial excavation in the starboard bow area revealed complex collapsed structure which turned out to be the remains of the ship's galley. Furthermore, the formerly stiff redeposited London clay sediment fill within the hull of the vessel had been compromised by the previous year's evaluation trenches, which resulted in the sediment fill becoming substantially more waterlogged and prone to collapse. This impeded the excavation process further.

5.1.10 Excavation took place as water levels allowed. A period of spring tides was chosen that provided one of the highest tidal ranges of the year. The associated low tides allowed access of between one and three hours per tide, depending on the stage of transition from or to neap tides. During neaps, the site was not accessible at all and remained submerged.

5.1.11 The excavation treated the hull fill as a single context. Excavation was carried out simultaneously from the SE truncated (shallower) end of the vessel as well as from the deeper NW end, provisionally interpreted as the bow end of the vessel.

5.1.12 Very quickly the SE area of the wreck encountered some significant loose timbers including outer hull planking (TNK18_44), a transverse beam (TNK18_31) and a v-form floor frame that was interpreted as coming from the stern section where the floors steepen toward the stern and deadwood of the vessel (TNK18_35).

5.1.13 In the NW part of the site superficial removal of material resulted in the realisation that a significant amount of collapsed material was present in this part of the vessel. Substantial timbers included a knee (TNK18_38/39) and other finds included considerable amounts of bricks and mortar, and undressed wood - some of which bore scorch-marks, and which have been interpreted as being related to the vessel's galley and would have been fuel for the brick hearth. Further finds from the bow area included several well-preserved leather shoes, a butchered beef bone and a cod vertebra, a plum stone, a wooden spoon and a number of concretions.

5.1.14 Due to the unexpected complexity of the archaeological deposits encountered, plus the environmental difficulties of working in a highly muddy environment between tides, it was not possible to completely remove the sediment from the vessel hull to enable full recording. However, the environmental and evidential material encountered so far has been more abundant and of a higher quality than had been anticipated.

Methods of stratigraphic assessment and quantity of data

5.1.15 All hand written and drawn records from the excavation have been collated, checked for consistency and stratigraphic relationships. Key data has been transcribed into an Access database for assessment, which can be updated during any further analysis. The excavation has been preliminarily phased using spot dating from artefacts, particularly dendrochronology.

5.1.16 **Table 1** (below) provides a quantification of the records from the excavation.

Table 1 Quantification of excavation records

Type	Quantity
Context records	1
Context registers	1
Graphics (A4 and A3)	11
Graphics (A1)	0
Graphics registers	1
Environmental sample registers	1
Object registers	1
Digital photographs	>1000 inc. photogrammetry dataset.

5.2 Deposition sequence and period

5.2.1 The wreck's surviving elements have become embedded within the superficial geology of the location in which it rests (**Fig. 2**).

5.2.2 The dendrochronological and artefactual evidence suggests that the vessel was built between the middle of the 16th century and early 17th century. It is not known when the vessel was wrecked but it is highly likely to have been during this period.

5.2.3 No evidence has been found to confirm the circumstances of the loss although from the sedimentary sequence and attitude of the vessel remains, the wrecking could be the result of a stranding. If that is correct, the vessel could have been caught in adverse weather conditions, in all likelihood a northerly gale on an ebb tide and has been blown onto what was a lee shore at the time of stranding. In doing so, the vessel could have broached (turned side on to the waves) and the rocking action of the waves may have caused the lower hull at the bow to dig itself into the seabed. At some point the E end of the site, provisionally interpreted as the vessel's stern, would have been carried away as the vessel broke up due to wave action and in time only the lower bow section, preserved in the silt, has survived. All protruding timbers would have been eroded away due to entrained sediment, wave action and tide, or suffered from bioturbation (but all these processes probably acted in-combination). It is believed that, due to its proximity to the shore, the cargo and any useable material is likely to have been salvaged by the local population, although no direct evidence of salvage has been identified in the remains. The survival of material including organic evidence has been heightened within the lower bow section that would have been below water from the point of stranding onwards.

5.2.4 The TBW site is a single period wreck event. Within the vessel structure evidence of a rough date of building, i.e. the middle of the latter half of the sixteenth century, comes from the dendrochronological results, with at least one potential phase of repair/repurposing around twenty years later (in the late-sixteenth or early seventeenth century) (see Section 8.1).

5.2.5 The date of the wrecking, subsequent abandonment and possible salvage of the site are not known at this stage of the research. However, given the absence of material that dates from the second half of the 17th century and the average lifespan of a wooden vessel it could be inferred that the vessel ceased to be in service before the start of the Anglo-Dutch Wars (1652).

5.2.6 The presence of several large and disarticulated timbers interpreted as beams and stanchions at the W end and on top of the possible galley area suggests that at some point elements supporting an upper deck collapsed and became trapped within the hull. No evidence to date this event has been found and whether it is contextual to the main wrecking event or related to an abandonment phase is unclear.

6 ARTEFACTUAL EVIDENCE

6.1 Introduction

6.1.1 The main find is the coherent but partial hull of the vessel itself which is well preserved underneath the sediment in what a appears as a single coherent section of the lower hull of a late 16th century vessel including one end, likely to be the bow (**Fig. 3**).

6.1.2 No cargo material was identified with certainty within the deposit and so far, the material identified includes items that are personal belongings of the crew such as shoes and objects that can be associated with the galley and the consumption of food. The majority of the finds come from the pocket of sediments between the frames at the W end and preserved deposits under the loose timbers in the NW area. These timbers have been interpreted as part of the collapse of the upper structure of the wreck, probably a deck, onto the layer beneath which includes a concentration of bricks and possible fire-wood that are thought to be part of the ship's hearth/galley.

6.1.3 Conversely, the E end of the hull was nearly empty of loose timbers and finds other than a small beam and the V-shaped frame which were found amidships on the S side of the hull.

6.1.4 The lack of ship's fittings and other equipment, together with the absence of any indication of cargo material seems to indicate that the vessel might have been thoroughly emptied at some point in the past, probably immediately after wrecking.

Table 2 Finds recovered by material type (number of pieces)

Material	Number of pieces
Wood	15
Metal	27
Leather	9
Pottery (inc. bricks)	14
Osteo	2

6.2 Description of the preserved part of the ship

General description and state of preservation

6.2.1 The hull is preserved as a coherent section with a total length of 11 m and 6.7 m in width (**Fig. 4 and 5**). The vessel is upright and tilted to the SW side at a deeper level (0.5 m) while the material was found to be much shallower (sometimes as shallow as 0.1 m below the surface) in the NE side. The wreck is truncated at the E end that is provisionally interpreted as the stern of the vessel. Hence no sections of the sternpost survive.

6.2.2 Under the sediment most of the bottom and turn of the bilge timbers are preserved. The ship's timbers include the layer of the outer hull planking, the frames, the keelson and the ceiling planking which are all in their original position. The level of the keel was not reached during the excavation, so its presence is not confirmed, although this is expected to survive underneath the layer of the floor frames. Timbers that are interpreted as part of the stem section are preserved at the W end and retain some strakes with their hood end still within the rabbet (rebate).

6.2.3 A concentration of bricks was encountered at the NW end of the wreck, in an area on the port side towards the possible bow of the vessel, likely indicating the presence of the remains of the ship's hearth and galley. This scatter of bricks was found to be covered by several loose timbers, including two large knees, which are thought may have protected the material underneath from being disturbed by the action of the tide and waves and potentially human interference.

6.2.4 Overall there is no indication that the wreck had been sunk deliberately, although at this point of the investigation the lack of any ship's equipment, cargo or even ballast seems to suggest that the hull content was thoroughly emptied at some point after the wrecking event. At the same time, the presence of few loose, large timbers within the hull is suggestive that at least some parts of the hull were left undisturbed.

Loose timbers

6.2.5 A few disarticulated displaced timbers have been found within the infill, on top of the ceiling planking. The dendrochronology results show that these timbers are contemporary with the hull and in the absence of contrary evidence, it is presumed that these are related to the same wreck. The timbers included knees and beams that are believed to have been supporting the deck above and then collapsed within the hull, and a V-shaped floor frame that is thought to have been dislodged from the very E (stern) end of the site (**Plate 3 and 5**).

Keel and posts

6.2.6 It was not possible to ascertain the presence of the keel during the excavation. The trench that was excavated at the eastern end of the vessel, where it is truncated, did not produce conclusive results, and no clear evidence of the keel underneath the most easterly frame *in situ* was observed. This could be indicative that at least part of the keel was broken away at some point during the deposition process and that any articulated parts may be still under the remains further W.

6.2.7 The upper part of the possible stem-post was exposed at the W end (**Plate 1**). It is made of oak and its cross section is trapezoidal with a single rabbet cut into the sides to receive the outer planking. The foremost face is 160 mm across, whilst the inner face measures 202 mm. A large treenail of 35 mm diameter is visible on the inner face. The maximum length across the section of post is 220 mm whilst the distance from the fore end to the aft end is 340 mm. The rabbet is carved 53 mm and 60 mm deep into the sides of the sternpost forming an angle of interface of approximately 110 degrees. Still within the rabbet is planking on both sides.

The planking

6.2.8 The outer planking was not inspected fully as few areas were accessible without having to remove the timbers on top. In the areas where it was possible to inspect the outer planking, such as at the ends and at a few locations along the bilge and at the W end, this was mounted edge to edge in the carvel fashion. The width of the planks varied between 320

mm to 105 mm with a thickness between 50 and 42 mm They seem to be mainly fastened with treenails. No spike plugs / spijkerpennen [1] were observed on the inner and outer surfaces of the planks although it should be noted that only limited areas were inspected due to the lack of access. No caulking material, caulking groove or battens was observed between the planks but nonetheless samples of soil material between and on top of the planks at the bow were taken as part of the bulk sampling for environmental analyses. The analyses showed the presence of hair/wool and moss in two of the samples (see below **section 7.2**).

6.2.9 In the areas where inner planking was removed for dendrochronological sampling along the side of the vessel, a possible intermediate frame/futtock between the floor and the tumblehome was observed. A raised plank/stringer ran along the longitudinal axis at the same location.

6.2.10 The arrangement of the outer planking appears to resemble a Dutch shipbuilding style where the hull planking comes up and under to the stem rather than around the sides of the vessel (Dr Damian Goodburn pers. comm.) This gives the vessel a roomy and bluff appearance in the bows. Although there is some evidence that the framing timbers were not interconnected (possibly suggestive of a contemporary Dutch favoured hull-first approach), no evidence of supporting techniques such as 'spikerpennen' was observed (Maarleveld 1996).

The frame timbers

6.2.11 The ends of the frames form the continuous oval footprint of the wreck and have eroded flush to the seabed (**Plate 3**). They consist of oak floor timbers and futtocks. The TBW appears to be closely framed with framing elements at the turn of the bilge that touch each other forming a continuous wall with the frames distributed at regular intervals and futtocks fitted snugly in between the floor timbers. However, it must be noted that any inference with regards to the framing plan remain preliminary as a full survey of the frame timbers remains to be completed especially in the areas covered by the ceiling planks.

6.2.12 From the material exposed so far, the frames seem to be regularly spaced although it is not known whether they extend the whole width of the vessel or consist of several elements. The frames do not seem to be interconnected.

6.2.13 The moulded dimensions of the frames measured at the keelson ranged from 180 to 190 mm whilst the sided dimensions varied between 245 to 285 mm. The space between the timbers measured at the keelson was quite regular although only few timbers were accessed.

6.2.14 Approximately 22 frames are believed to be below the turn of the bilge with possible futtocks alternated at and above the turn of the bilge. These elements seem to be spanning from the 2nd or the 3rd strakes outward to the side. The frames are fastened to the outer and inner planking with treenails the majority of which are 30 mm in diameter.

6.2.15 The curvature of the timbers seems to change significantly from the two ends, with the use of compass timbers at the E end that show a deep foot defining a steeper angle for accommodating the garboards, and the use of flatter timbers at the W end where the shape of the hull turns more gently into the rounded bow.

[1] These are small wooden plugs used to infill nail holes left by the use of cleats and indicative of shell first construction.

6.2.16 The presence of limber holes or the relationships between floor and keel could not be ascertained.

Ceiling

6.2.17 A total of 13 ceiling planks were found articulated as part of the remains. Eight strakes are preserved on the S side of the keelson and five on the N side. These planks are generally well preserved although the ones at the outer edges were fragmentary and showed the heaviest signs of decay.

6.2.18 The rows on the N side alternate between narrow and wide but this alternation is not symmetric on both sides of the keelson as on the S side which presents a more irregular variety of width ranging from 450 to 210 mm. The thickness of the planks is also variable with the first two planks closer to the keelson on the S side measuring 50 mm, whilst the outer planks are thicker and measure between 70 and 90 mm. It seems that the planking is connected with butt ended joints and fastened with treenails to the frames below although iron fasteners are also present, albeit rarely.

6.2.19 The limber boards are slightly different from the remaining ceiling planking, being generally shorter in length and some of the planks are not fastened to the frames so that they can be lifted. The limber boards mostly sat directly on top of the frames but at the E end some small square boards were found fastened between the frames and the limber boards. The function of these small boards in not clear but it is possible that these were inserted ad hoc to level and support the planks above (**Plate 3**).

6.2.20 The use of a mixture of softwood and hardwood is evident in the laying of the ceiling. The twisting of some planks had been evidently assisted by heat as they were substantially burnt. Regularly spaced tool-marks across the grain of the timber were visible on the inboard faces of the planking suggesting that they may have been mechanically cut by a sawmill.

6.2.21 The ceiling planking is very neatly laid with no spaces between the planks so that it creates a continuous surface.

Keelson

6.2.22 The keelson runs along the approximate centreline of the remains (**Plate 4**). The SE end of the timber which may correspond to the possible stern end of the wreck was sampled in July 2017 and appeared at the time damaged and worn. The other end has not been uncovered yet as the timber was only partially exposed during excavation. The section of the keelson that was exposed is approximately 6 m long and it consists of a single oak timber with chamfered upper edges and rectangular section. The lower face of the keelson was notched for receiving the upper faces of the floor frames which were observed underneath.

6.2.23 On the upper face of the keelson there was a large rectangular mortise that has been provisionally interpreted as a mast-step. This mortise in the keelson was augured at the corners and then carved with an adze, chisel or similar tool. Clear tool-mark can be seen at the foot of the mortise which is 140mm deep, 185mm across and 264 mm long. The mortise was located at 2/3 of the overall length of the remains, was initially seen as a potential indicator that the SE end of the wreck is the bow. However, the assumption that the SE end corresponds to the bow of the vessel is not supported by the general shape of the hull which shows a sharper angle at the E end where the floor timbers are more angled and have a more definite foot corresponding with the rise of the stern. This and the possible galley area found towards the W end of the wreck strengthen the possibility that the W end corresponds

to the bow of the vessel. If that hypothesis is correct the main mast-step could be found in the area that has not been excavated yet.

6.2.24 A second smaller mortise or slot with a square profile with sides measuring 95 by 100 mm and only 40 mm deep can be found carved onto the upper face of the keelson towards the E. The sided dimensions seem to vary little along the length of the keelson with scantlings at the NW end being 210 mm moulded and 370 mm sided. A few fasteners were observed on the upper face of the keelson that included treenails and at least three iron bolts.

6.3 Pottery

6.3.1 Very few ceramics were found during the excavation (**Plate 7**). These included the sherd of the base of a pottery vessel which was found in a small recess between floor timbers / ceiling at the bow end. The find was assessed by Lorraine Mepham, Wessex Archaeology finds specialist, and identified as a probable glazed earthenware and dated to the post medieval period, from the 16th century onwards.

6.3.2 Samples of the bricks were recovered from the possible galley area (**Plate 6**). The bricks are in two different fabrics, one of red colour and the other olive green. They are all similarly sized and a complete brick measures approximately 50 mm in thickness, 114 mm in width and 240 mm in length. The bricks are handmade stock bricks of good quality and consistent with a production date between the 16th – 17th century to the standard Tudor style of the "Statute bricks" that were sanctioned in 1571. Most of the samples are surface scored and retain traces of fine mortar. Smoke and fire staining is visible on most of the bricks and it is assumed that they were used onboard the vessel. Markings were traced on the sides of at least two bricks. A sample of mortar was archived for future analysis.

In addition to the bricks some fragments of red roof tiles were found (5128, 5143). The surface of the tiles are very clean with no residues of mortar. The use of tiles onboard the vessel could relate to the superstructure or a possible cover for the chimney of the hearth although the fact that they are in new condition could be an indication that they might have been transported as part of a cargo.

6.4 Leather

6.4.1 Parts of at least four shoes were recovered from the wreck and two (SF5123 and 5133/5136) were relatively well preserved (**Plate 7**). The leather from the wreck was examined by Quita Mould, specialist in archaeological leatherwork.

6.4.2 SF5123 is a slip-on shoe. It has a complete insole and the delaminated remains of the midsole (or possibly the sole as it is now too deteriorated to be certain), delaminated remains of the vamp and one-piece quarters with a row of decorative stitching running below the top edge. This general style of slip-on shoe was worn in the middle and later part of the 16th century. It was found on the Mary Rose (1545, Evans and Mould 2005) and is of Volken' s style Hull-DD which is dated to the last quarter of the 16th century (cat. no. 12.38 Volken 2014: 174, 299). It has an estimated equivalent modern shoe size of Adult size 2 (continental size 34). One-piece quarters (SF5121) from a second shoe, also with a row of decorative stitching, was also found from the Tankerton wreck.

6.4.3 The other shoe (SF5133/5136) is a latchet tying shoe. It has a complete insole and midsole (the sole is missing) with the complete welt surviving. It has remains of the front part of the vamp with a high peaked throat and two quarters joining with a back seam. The quarters had extended at the top of front seams into fastening straps (called latchets) and would have tied across the instep under the vamp tongue, but these fastening straps have not

survived. It is of Volken's Waddenzee-Vq style also dated to the last quarter of the 16th century (cat. no. 15.12 Volken 2014: 179, 308). This shoe has an estimated equivalent modern shoe size of Adult size 3 (35).

6.4.4 The shoes are of welted construction and are of styles that have also been found on a shipwreck (shipwreck S01) in the Wadden Sea, off the coast of the Netherlands, that dates to around 1590 (Goubitz 1985).

6.4.5 The sizes of the shoes are thought to have been worn by grown men. Some 300 years later in the late 19th and early years of the 20th century the most popular sizes worn by men were modern Adult size 2-7 (Grew and de Neergaard 1988: 103) so considerably smaller than modern foot sizes.

6.5 Faunal remains

6.5.1 Two cattle bones (rib and tibia shaft) and the caudal vertebra from a cod (*Gadus morhua*) were recovered from bow area (**Plate 7**). These were inspected by Lorrain Higbee, Wessex Archaeology osteoarchaeologist. The fragment of the tibia shaft presented butchery marks as it had been split lengthways and along the lateral side had nick marks that were assessed as consistent with the process of filleting meat off-the-bone.

6.5.2 Also, the fish vertebra showed apparent butchery marks as one of the transverse processes (or zygopophyses) on the cod vertebra had been cut through and this undoubtedly occurred during the initial stages of processing when the head and tail are removed prior to filleting.

6.6 Wooden finds

6.6.1 A wooden spoon was found in the bow area not far from the ship's hearth (**Plate 7**). Although part of the bowl is missing, the spoon conforms to the ficulate ('fig-shaped') bowl type which is characteristic of spoons during the period from around the 14th to mid-17th century.

6.6.2 Found in association with the concentrations of bricks and potentially part of the ship's galley is a vertical wooden post and several twig-like unworked timbers. These small timbers of apparently different wood species are believed to have been kindling for the fire.

7 ENVIRONMENTAL EVIDENCE

7.1 Introduction

7.1.1 Nine bulk sediment samples were taken from the TBW and were processed for the recovery and assessment of the environmental evidence.

7.1.2 Whilst most of the samples were processed by flotation and wet-sieving for macrofossil evidence, 2 were also processed for the retrieval of ostracods. Before processing, 2 of the samples were subsampled for chemical analysis and 9 for pollen and dinoflagellate assessment (**Table 3**). The processed macrofossil samples were also submitted for moss, foraminifera and animal fibre analyses. A sample of mortar was archived for future analysis.

Table 3. Samples and subsamples per types of evidence.

Sample no.	Provenance	Macrofossil	Moss	Foraminifera	Animal fibre	Ostracods	Pollen	Dinoflagellates	Chemical
2001	Bow Caulking	1	1	1		1	1	1	1
2002	Bilge	1	1	1			4	4	
2003	Bow	1							

2004	Bow Caulking	1	1	1		1	1	1	1
2005	Galley Mortar	-	-	-	-	-	-	-	-
2006	Keelson	1					1	1	
2007	Keelson	1					1	1	
2008	Timber	1							
2009	Bow	1					1	1	

7.2 Environmental results

Macrofossils

7.2.1 The flots from the bulk sediment samples were generally large, with a wealth of well-preserved environmental evidence (**Appendix 2**).

7.2.2 There was a general abundance of plant macrofossils preserved by waterlogging. These were generally dominated by vegetative plant remains such as seaweed, wood and stem fragments, bud scales, moss leaves and stems (including taxa such as *Sphagnum* sp.) and leaf and bark fragments. Abundant seeds and fruits from both aquatic and terrestrial (generally wetland and disturbed if wild plants) habitats were also present in the samples. The taxa include: indeterminate cereal (*Triticeae*), plum (*Prunus domestica*), hazel (*Corylus avellana*), birch (*Betula* sp.), rushes (*Juncus* spp.), sedges (Cyperaceae), thistle (*Carduus/Cirsium*), cornflower (*Centaurea cyanus*), quaking grass (*Briza* sp.) and other grasses (Poaceae), annual sea-blite (*Suaeda maritima*), raspberry (*Rubus idaeus*), kiwi (*Actinidia deliciosa*), buttercups (*Ranunculus* spp.), thrift (*Armeria maritima*), bulrush (*Typha* sp.), algae (Characeae), clubmoss (*Selaginella* sp.), the mint family (Lamiaceae), water-plantain (*Alisma* sp.), stitchwort (*Stellaria graminea/uliginosa*) and indeterminates.

7.2.3 Traces of fine wood charcoal were noted in some of the samples. Remains of aquatic molluscs (both freshwater and marine), ostracods, foraminifera and insects were also present in variable quantities in most of the samples. One of the caulking samples was rich in fibres tentatively identified as animal hair or wool. An almost complete bran of an indeterminate cereal (*Triticeae*), was found in the sample from the bilge.

Mosses

7.2.4 Eleven species of moss were identified from the 3 samples. Nine of the 11 mosses are of the weft forming types, with the remaining 2 being of the cushion forming type (Appendix 2).

7.2.5 Sample <2001>: This sample of caulking contained 5 species of moss, but one was more common than the others, that of the Cypress-leaved/Supine Plait-moss (*Hypnum cupressiforme/resupinatum*). Both these species can be found throughout the British Isles, both are found on tree trunks and base-rich siliceous rocks, with Supine Plait-moss being found on slightly more alkaline conditions than that of the Cypress-leaved form. The other less commoner mosses can be found in a wide variety of habitats and may well have been harvested along with the dominant type.

7.2.6 Sample <2002>: This sample from the bilge, contained a large amount of moss of 6 different species, the most abundant one being, Waved Silk-moss (*Plagiothecium undulatum*). This moss grows in more acidic environments than that of the more common moss in <2001>. In modern times, this moss can be found growing on acidic soils, wood, rocks and in turf, in deciduous woodland, conifer plantations, heathland, and amongst boulders in block scree as well as blanket bogs (Atherton *et al*. 2010). It is likely that it was collected from the same places as that of the Cypress-leaved /Supine Plait-moss, most likely heathland.

7.2.7 Sample <2004>: This sample was of caulking but was different from that of the other caulking sample <2001> in the fact that was mostly composed of animal hair, most likely that of pig or horse. Some mosses were identified but they were present in small quantities. Sphagnum moss (*Sphagnum* sp) is most often found on raised and blanket bogs where it can form most of the biomass. The other moss, Dentated/Curved Silk-moss (*Plagiothecium denticulatum/curvifolium*), can be found on soil, rocks, logs and tree bases, mostly in woodland. It can also be found in upland block scree and rock crevices, with the Curved Silk-moss occurring at lower altitudes.

Foraminifera

7.2.8 Complete foraminiferal results with indication of all species present, their abundances and other micropalaeontological parameters for each sample can be found in Appendix 2. Foraminiferal results of the three studied samples were very similar. Similarity between samples varied from 77.1 to 85.2% (results above 70% are indicative of a high degree of similarity). Species number was low. In all, 21 different benthic foraminiferal taxa were found, although the maximum number of species (16) was present at sample <2001> and the other two samples contained 10 species each. Assemblages were made basically of hyaline tests (average 99.7%, range 99.4-100%), with very minor porcellaneous (0.2%, 0-0.3%) and agglutinated (0.1%, 0-0.3%) wall types. The dominant species were only three hyaline forms that together represented about 90% of the assemblages (range 84-95%). Their relative abundances were: *Ammonia tepida* (average 40%, range 34-47%), *Cribroelphidium williamsoni* (36%, 27-46%) and *Haynesina germanica* (14%, 12-19%) (Figure 2). The presence, abundance and dominance of these main species, together with the general characteristics of the assemblages, are indicative of a brackish, intertidal, lagoon-estuarine environment located on the Atlantic seaboard of Europe (from Denmark to Portugal, including the British Isles). Numbers of marine tests transported into the depositional coastal area were low (average 9%, range 4.7-14.2%). General geographical distribution of the minor, marine species found in the samples is also the Atlantic seaboard of Europe. However, the forms *Procerolagena clavata* (2 samples, 2 tests), *Bolivina britannica* (1 sample, 4 test), *Asterigerinata mamilla* (1 sample, 1 test), *Favulina melo* (1 sample, 1 test), *Homalohedra williamsoni* (1 sample, 1 test), *Lenticulina orbicularis* (1 sample, 1 test) and *Rosalina williamsoni* (1 sample, 1 test) have been previously recorded in the inner shelf of the Bay of Biscay, the British Isles and the English Channel.

Pollen and spores

7.2.9 Nine samples were assessed for pollen preservation and concentration from a range of contexts including possible caulking material (2001 and 2004), bilge material (2002A-C), tar (2002-TAR) and bulk samples of organic sediment (2006, 2007 and 2009) (Appendix 2). Pollen was present in all but one sample (2002-TAR). Pollen preservation was good in the remaining eight samples, although pollen concentration was variable, with good concentrations in samples 2001, 2002A-C and 2007, moderate in 2006 and 2009 and very poor in 2004; a full assessment count was not possible for 2004. Although the samples display some broad similarities in the range of pollen taxa present, they can be coarsely divided between caulking and bilge samples (2001, 2002A-C) and bulk samples (2006, 2007 and 2009).

7.2.10 The caulking and bilge samples include large quantities of arboreal pollen (74-84%), largely comprising *Quercus* (oak) and *Corylus avellana* type (hazel) along with *Betula* (birch), *Pinus* (pine) and *Alnus glutinosa* (alder), *Salix* (willow) and very occasional grains of *Fagus* (beech) and *Tilia* (lime). More *Pinus* was recorded in 2001, with higher quantities of *Betula* recorded from 2002B. Occasional grains of dwarf shrub species were recorded, comprising *Calluna vulgaris* (common heather) and Ericaceae (heather family). Herbaceous pollen taxa account for between 16-26% of the pollen assemblages, but comprise a variety of taxa,

predominantly Poaceae (grass family) along with a small number of cereal-type pollen grains (*Cerealia* – undiff. cereals and *Avena-Triticum* – oats and wheat), *Cannabis* type (Cannabis), Chenopodiaceae (goosefoot family), *Plantago lanceolata* (ribwort plantain) and one or two grains of a range of other herbaceous taxa (Table 4). Moderate quantities of fern spores were recorded, including *Polypodium* (polypody), *Pteridium* (bracken) and Pteropsidae (undifferentiated fern spores).

7.2.11 The pollen samples derived from bulk sediment samples differ from those caulking and bilge samples in comprising less arboreal pollen (52-58%) and larger quantities of herbaceous pollen (42-48%). Arboreal pollen largely comprises *Corylus avellana*-type and *Quercus*, along with *Pinus*, *Alnus glutinosa*, *Betula* and consistent but small quantities of *Tilia* and *Ulmus* (elm). Also recorded were occasional pollen grains of *Salix*, *Fagus*, *Fraxinus* (ash) and *Acer* (maple). In addition, 2006 includes a small number of grains of *Carpinus betulus* (hornbeam) and a single grain of *Picea abies* (spruce). Occasional grains of dwarf shrub species were recorded, comprising *Calluna vulgaris* (common heather) and Ericaceae (heather family). Herbaceous pollen largely comprises Poaceae and Chenopodiaceae, along with a range of taxa including *Aster* type (daisies), Lactuceae (lettuce family) and *Rumex acetosa* (common sorrel). Fern spores are present in higher quantities in 2007, particularly Pteropsida, with occasional aquatic grains of *Potamogeton natans* type (pondweed) and *Sparganium emersum* type (unbranched bur-reed).

Dinoflagellates

7.2.12 All of the samples studied yielded relatively sparse assemblages of generally well preserved palynomorphs. The assemblages (see Appendix 2) are dominated by dinocysts and are similar in composition and are, therefore, discussed together.

7.2.13 The dinocyst assemblages include Cordosphaeridium gracile (present in all samples), *Apectodinium homomorphum* (2001). *Cerodinium depressum* (2002C and 2007), *Cerodinium speciosum/striatum* group (2001 and 2002A), Deflandrea oebisfeldensis (2002B), *Diphyes colligerum* (2002C, 2004 and 2007), *Eatonicysta ursulae/ Membranilarnacia furensis* group (2002B and 2006), *Hafniasphaera septata* (2001, 2002A, 2002B, 2002C and 2007), *Thalassiphora pelagica* (2009) and *Wetzeliella* spp. (2002A, 2002C, 2004, 2006, and 2007). All of these taxa are characteristic of Early Eocene, Ypresian aged sediments.

7.2.14 In addition to these characteristic Early Eocene dinocysts some dinocysts and miospores typical of Mesozoic and Palaeozoic sediments have been recorded. These are the dinocysts *Tubotuberella apatela* (Earliest Cretaceous) at 2002B, Cribroperidinium spp. (Early Cretaceous/Late Jurassic) at 2006 and 2007 and the miospores *Callialasporites* spp. (Jurassic - Early Cretaceous) 2002A, 2002C, 2004, 2006, 2007 and 2009, *Chasmatosporites* spp.(Early - Middle Jurassic) 2001, 2007 and 2009, *Classopollis* spp. (Late Triassic - Cenomanian) 2002A, 2002B, 2002C, 2004, 2007 and 2009, *Densosporites* spp. (Carboniferous) 2001, 2002B and 2009, *Lycospora* spp., (Carboniferous) 2002, and 2002C and *Vestispora tortuosa* (Carboniferous, Westphalian) 2002C.

Geochemistry

7.2.15 ssNMR analysis: The results of the ssNMR analysis show that sample 2001 does not give any readily detectable carbon signal (Figure 1). This sample contains only trace levels of organic matter that is insufficient to give a signal. The majority of sample 2001 is inorganic. In contrast sample 2004 does give a range of signals, albeit relatively weak (Figure 2). The spectrum shows analogues with typical spectra of wood cellulosic signals, 60-115 ppm, with lignin at 56 and 120-180 ppm. The results of the NMR analysis show wood material is present in the samples. The results cannot rule out the presence of a pine resin, but by this

method it would be difficult to definitively disentangle its signals from those originating from whatever else is present in the sample.

7.2.16 Py-GC-MS analysis: The majority of compounds in the chromatograms are associated with the anaerobic degradation of plant biomass during the pyrolysis process. A number of compounds did provide mass spectra of sufficient quality to allow their reliable identification. A number of the compounds that were identified are generic to modern plant or animal biomass. The chromatogram is searched for the mass spectra of known idiosyncratic compounds taken from a library of identified samples from archaeological contexts, as well as modern reference standards. This makes it possible to identify any stable, distinctive and characteristic compounds, termed “biomarkers”, that may be present that give greater specificity as to the identity of the material being analysed.

7.2.17 The raw data for the analysis of samples 2001 and 2004 are provided in **Appendix 3**. Compounds identified at retention times up to 6.3 (Figures 3-4, Tables 1-2) minutes are mainly products of the derivatizing reagent used in the analysis and volatiles. Modern synthetic chemicals are not present in any detectable quantities. No terpanes or steranes, the major components of bitumen, were detected (Kaye 2013).

Radiocarbon dating

7.2.18 A date of 1400-1440 cal AD (UBA-39430) was obtained for the plum (*Prunus domestica*) stone from the sample from the bilge while the kiwi (*Actinidia deliciosa*) seed from the bow proved to be intrusive.

7.3 Environmental discussion

7.3.1 The evidence retrieved so far has highlighted the high potential of the wreck to provide significant palaeoenvironmental information (beyond that provided by the timbers and other structural elements, such as the cordage) related to both the building of the ship, its use and its depositional environment (see also Gorham and Bryant 2001). Therefore, this information is of extreme interest for the understanding of this particular wreck, and for maritime archaeology in general. This is particularly so because, despite the immense popularity of underwater and maritime archaeology, there are very few other archaeobotanical studies from shipwrecks, not only in Great Britain, where only a few wrecks have been sampled (e.g. Carruthers 2014), but also in Europe (e.g. Manders and Kuijper 2015) and beyond. In addition, save a few examples (e.g. Carruthers 2014), the quality of the little existing evidence is in general relatively deficient in terms of the level sampling, the recording of the contextual background of the samples and the degree of identification of the evidence and therefore the information that can be gained from the botanical data is often underexploited (see also Deforce *et al*. 2014, Mander and Kuijper 2015).

7.3.2 Unfortunately, no clear pattern emerges from the examination of the type of evidence in relation to its provenance within the wreck. The assessment of existing samples and the high variability of the results, show that analysis of only a few samples from a single shipwreck are not representative of the construction and use of a whole ship (see also Deforce *et al*. 2014). Therefore, an extensive sampling strategy is recommended for the further stages of work at the wreck, following the example of the Newport medieval ship (Nayling and Jones 2014). At present, two possible indicators of northern European contact have been found: a spruce pollen grain and a combination of hair/wool and heathland moss in the caulking. This evidence is however too imprecise to make firm conclusions on the possible links of the vessel with continental Europe although the evidence provided by the timbers support it. Further multiproxy analysis of additional samples to be taken will

undoubtedly maximise the information to be obtained from each sample, as each type of palaeoenvironmental proxy can provide a wealth of complementary information. Equally, control samples need to be taken to correctly understand the significance of the environmental assemblages and their formation processes (see Gorham and Bryant 2001).

Macrofossils

7.3.3 The macrofossil composition of the two caulking samples is notably different (one is dominated by moss remains and the other by hair/wool), possibly indicating the application of different materials, possibly representing different application times (construction vs. reparation?) or possibly representing sampling at different locations within the caulking. Both hair/wool and moss were reportedly common in traditional ship building, although hair seems to have been preferred in Great Britain and moss in continental Europe (Deforce *et al*. 2014). However, a combination of both hair and moss has been found in Scandinavia, such as in the case of the Gedesby shipwreck in Denmark (Robinson and Aaby 1994) The *Mary Rose*, by comparison, used mainly hemp derivatives and animal hair in its caulking (Marsden 2009).

7.3.4 Abundant remains of marine microfossils (insects, molluscs, foraminifera and ostracods) were retrieved in all samples. Whilst the ones occurring in the bilge, box and keelson samples are probably naturally accumulated during the sedimentation of the wreck and are of little palaeoenvironmental significance since they may be the result of recent contamination, the ones within the caulking samples may be indicative of the type of environment and the region in which the caulking was applied or repaired.

7.3.5 Although a number of non-vegetative (i.e. reproductive) remains of wild, terrestrial and aquatic, plants were present in all the samples (excluding the ones from the caulking where no seeds or fruits were found) probably also following natural sedimentation processes, traces of a particular pattern seem to emerge when looking at the types of plants from each ship area: plants of economic interest are only present in the bilge and bow but not in the keelson samples.

7.3.6 Some of the plant macrofossils recovered in the area of the bilge and the bow, such as plum stones (*Prunus domestica*), hazelnut shells (*Corylus avellana*) and raspberry seeds (*Rubus idaeus*) represent plants of economic interest that may have been transported within the ship's cargo, or may have been consumed by the crew. However, some of these are quite resistant plant remains (e.g. nutshells, plum stones) and it is difficult to rule out whether they may have accumulated naturally, particularly as there were also wild plant remains present in the samples that probably indicate natural deposition of remains from the local vegetation. Still, these plant remains from economic taxa are not widespread and are present only in the bilge and bow areas. Further sampling will help clarify if this is a mere coincidence. Other plants of economic interest that were undoubtedly transported within the ship were the cereals, of which little but reliable evidence was obtained: an almost complete cereal bran was found in the sample from the bilge. This item is often found in waterlogged deposits with faecal material (e.g. Britton and Huntley 2011) but in a fragmentary state: it is a very fragile empty envelope without the seed endosperm and to be preserved complete could not have been water-dispersed and redeposited nor consumed or prepared, but it is not a recent intrusion either as the decomposition of the endosperm in waterlogged conditions takes centuries (Körber-Grohne 1991). Therefore, it may represent part of the ship's cargo.

7.3.7 The plants that are probably accumulated naturally are either aquatic (*Characeae*, *Selaginella* sp., *Alisma* sp.) or from terrestrial wetlands and disturbed habitats and appear randomly across ship areas, many of them being hydrochoric (water as a vector for

reproductive dispersal) or anemochoric (wind-dispersed). These include the fruits and seeds of birch, thrift, sea-blite, bulrush rush and sedge. The case of cornflower (*Centaurea cyanus*) is particularly interesting, since it is not an economic plant but rather the opposite: it used to be a particularly noxious and widespread weed from crop fields from medieval times onwards (partly because it became difficult to separate due to its large seed size similar to cereal grains) but it became almost eradicated with modern herbicides (although it is abundant again due to its use in bird seed). Since it only appears in the bow and bilge areas (where economic plants also appear), is it a further indicator of possible stored bulk grain?

Mosses

7.3.8 Eleven species were identified from the samples which could be found in a variety of habitats. The most likely habitats from which the mosses were gathered included heathland and other acidic environments, and South-eastern woodland floors, although collection from other habitats cannot be ruled.

7.3.9 Some of the mosses were found in the bilge sample (2002) which may suggest that some of the caulking may have become detached or possibly that the mosses were used for another purpose such as packing around delicate cargo.

7.3.10 One of the caulking samples (2004) contained very few mosses and was dominated by animal hair, either pig or horse. Hair too, was commonly used as a caulking material.

7.3.11 Eleven species of moss were identified from the samples of caulking and bilge contents taken from the wreck at Tankerton Bay. Mosses can be found in a variety of habitats and in some cases have a limited distribution given their individual ecological requirements. Two habitats are represented by a greater number of taxa, these are heathland and South-eastern woodland floor and rocks with 5 taxa each. Eight habitat types (raised and blanket bogs, acid and neutral fens and flushes, acidic grassland, general epiphytes, conifer plantations floor, scree beds, and siliceous cliffs, outcrops and boulders. These eight habitat types and the heathland have one thing in common, in that they are mainly acidic environments and are usually found further north than the shipwreck site at Whitstable.

Foraminifera

7.3.12 The foraminiferal results of the three studied subsamples were very similar and were indicative of a brackish, intertidal, lagoon-estuarine environment located on the Atlantic seaboard of Europe (mainly from the Bay of Biscay to the British Isles). This evidence does not support the potential connection of the vessel with the North of continental Europe.

Pollen and spores

7.3.13 Palaeoenvironmental studies have previously been undertaken on a small number of medieval shipwrecks, including the Gedesby shipwreck, Denmark (Robinson and Aaby 1994), Newport Medieval boat, South Wales (Jones 2012, Nayling and Jones 2014), and from more recent finds of two medieval cogs from the harbour at Antwerp, Belgium (Deforce *et al*. 2014).

7.3.14 Analysis of caulking material, for example, can provide information on the region where a ship had been built, repaired or visited (e.g. Deforce *et al*. 2014). However, there are taphonomic issues to consider regarding the interpretation of the pollen from the Tankerton samples and its origin and relationship to the wreck, particularly in material contained within the bulk samples.

7.3.15 The pollen may be derived from the local environment, entrained in and/or contaminated by sediment deposited after the ship lay abandoned on the coastline. The pollen assemblages from the bulk samples (2006, 2007 and 2009) in particular include higher frequencies of pollen from halophyte plants such as Chenopodiaceae, that along with *Aster* type, and Poaceae, are typically associated with estuarine saltmarsh environments.

7.3.16 Contamination with pollen from marine and estuarine waters is also likely as part of the background pollen reservoir, potentially including pollen from across a local to regional source area, and again subsequently entrained in sediment deposited within the decaying wreck.

7.3.17 *Pinus*, for example, is typically over-represented in marine and estuarine waters owing to the buoyancy and long-distance transport of its pollen grains. *Pinus* grains are typically more poorly preserved in the Tankerton samples, despite being one of the pollen taxa more resistant to decay processes (Sangster and Dale 1961). This could suggest the *Pinus* grains were derived from an estuarine/marine reservoir where they had been subjected over time to increased degradation and mechanical damage.

7.3.18 There is a clear similarity in the broad range of taxa present in the pollen assemblages from the bulk samples (2006, 2007 and 2009) and from the caulking (2001) and bilge samples (2002A-C), but with a noticeable difference in the quantities of arboreal pollen; the caulking and bilge samples consistently contain 20-30% more arboreal pollen than the bulk samples.

7.3.19 The reasons for the higher instance of arboreal pollen in the bilge and caulking samples are not obviously apparent. This could reflect a greater component of well-dispersed and largely wind-pollinated arboreal pollen (contained in the pollen rain and marine/estuarine water) deposited during the initial stages of ship abandonment before estuarine sediment invaded and progressively sealed the decaying wreck. Wind-pollinated arboreal species are typically over-represented in pollen profiles owing to their increased pollen productivity and dispersal relative to insect and self-pollinated herbaceous plants.

7.3.20 However, the bilge samples also include consistent quantities (albeit small) of cereal-type pollen, and along with the caulking sample, small quantities of *Cannabis* type pollen. It is possible that the *Cannabis* pollen may derived from hemp products (e.g. cordage and rigging); surviving cordage and rigging recorded from the Newport medieval boat was made from hemp and possibly also grass (Nayling and Jones 2014). The cereal type pollen could derive from cereal products or waste transported or consumed within the ship.

7.3.21 Pollen analysis undertaken on the Newport Medieval ship included samples from the bilge, but it was not possible to determine any specific function from the palynological remains (Jones 2013).

7.3.22 The source area of the majority of the pollen is difficult to determine with certainty but the similarity in range of taxa across the samples could suggest a similar range of sources from a local to regional scale. Saltmarsh indicators in the bulk samples (2006, 2007 and 2009) are likely to reflect nearby saltmarsh environments on Sheppey within which the vessel was abandoned and sealed, but also similar environments within the nearby Medway and Thames Estuary area. Arboreal pollen is likely to be derived from a wide source area, reflecting a component of contemporary vegetation environments, pollen reworked and redeposited from earlier formations as well as pollen contained within the estuarine/marine reservoir. The single grain of *Picea* (2006) represents a non-native species and could have been included as a contaminant in sea-water from a continental European source (e.g. North Germany and Scandinavia; Brewer *et al* 2017), rather than suggesting some

contact/origin in northern Europe/Southern Scandinavia. However, given the assessed timber origins of North Germany and Scandanavia this seems unlikely.

Dinoflagellates

7.3.23 The palynological content has been used to identify the stratigraphic level from which each of the eight samples studied originated. The dinocyst assemblages are dominated by Early Eocene taxa, from Ypresian aged sediments and consistent with derivation from the London Clay Formation, and also including some earlier taxa, that may have been recorded as the result of direct erosion of Mesozoic and Palaeozoic sediments and transported into the Tankerton area or more likely they have been reworked into London Clay Formation sediments. No taxa have been recorded that are definitely indicative of an age younger than Early Eocene. Therefore, no specific palaeoenvironmental significance with respect to the voyages of the Tankerton ship are possible as all study material is derived from the lithology in which the wreck now lies.

Geochemistry

7.3.24 The major chemical components of sample 2001 (Table 1) are cresol. phenol and retene. The first two compounds are major constituents of creosotes (Evershed *et al*. 1985), whilst retene is a product of thermal degradation of pine/spruce resin (Derham 2000). The major chemical components of sample 2004 (Table 2) are also phenols, the major constituents of creosotes, whilst 2-methyliminoperhydro-1,3-oxazine has been shown to be a volatile component of the dried biomass of the various *Pinus* species (Robinson *et al.* 1987).

7.3.25 In both samples, the absence of any intact diterpenoids, or significant quantities of a wider range of degraded terpenes, such as abietanes and phenanthrenes, demonstrates that the sample is not of a good quality resin, pitch or “branded tar” such as Stockholm Tar (Burger *et al*. 2013).

7.3.26 The analysis indicates a heterogeneous matrix based predominantly on inorganic material that cannot produce an NMR signal, as well as plant biomass derived fibres. The organic components extracted from both samples are based on creosote. Both samples also contain indications of a pine wood origin. The presence of these more characteristic compounds indicate that the samples are caulking impregnated with a pine/spruce derived creosote.

7.3.27 More specifically, the data indicates that the sample should be considered a ‘crude’ or ‘unrefined’ creosote. The destructive pyrolysis of pine produces a sequence of crude products (Figure 5); steam and carbon dioxide, followed by turpentine (a mix of monoterpenes), pyroligneous acids (acetone, acetic acid and methanol), creosote (a crude mix of phenolic compounds such as cresol and creosol etc.) and finally tar/pitch (a mix of diterpenoids). The ability to subsequently purify, by distillation, the crude creosote into its individual components was an early 19th century development, but some more heterogenous product largely composed of creosotes or, pine phenolics, was produced before this time. It is possible, although unlikely, that the material is derived from a very low rank coal such as lignite (brown coal), rather than wood. The sample showed only limited evidence for diterpenoids, which distinguishes it from Pine Tar or Pitch. Thus, the identification of the sample using the term Cresote or ‘pine phenolics’ is preferred to tar or pitch in this instance.

7.3.28 Historically, creosote has been produced along with tar and pitch, as a product of the thermal rendering of scrap material from pine/spruce timber industry or from the anaerobic pyrolysis of coal, to produce coke and/or town gas. The thermal processing of coal however only became common from the later 18th century onwards.

Radiocarbon dating

7.3.29 The results of the radiocarbon measurements obtained confirm the existence of intrusion phenomena, which were suspected to affect parts of the deposit. Still, significant environmental evidence was also found which is probably related to the use of the vessel, and its consistency was confirmed by radiocarbon dating. The disagreement between the radiocarbon dating results and the dendrochronological information is likely to indicate a long life of use for the vessel with the addition of newly sourced timber during repairs. However, further radiocarbon dating is recommended to address this issue.

7.4 Dendrochronology

7.4.1 The dendrochronological analyses of the Tankerton Bay wreck were carried out by Roderick Bale, Nigel Nayling (UWTSD) and Cathy Tyers (Historic England). The following paragraphs are from their HE Scientific Dating Team interim statement (Historic England 2018).

7.4.2 A total of 46 timbers, or timber fragment groups, have been sampled for dendrochronological analyses between 2017 and 2018. Samples from 26 oak timbers and three conifer timbers with sufficient rings to warrant analyses were measured and resulted in the successful dating of 13 oak timbers and two conifer timbers (**Appendix 1**).

Six of the dated oak timbers are most likely of English origin, whereas the other seven dated oak timbers are most likely of German origin. The two dated conifer timbers appear most likely of Scandinavian origin. The correlation between the dated individual English timbers are relatively low, indicative of disparate source woodlands, whilst those between the dated individual timbers of German provenance are more varied and include some timbers likely to have a woodland source in the same area.

7.4.3 All dated timbers are broadly coeval and interpretation of the sapwood, using sapwood estimated appropriate for the source, on those oak timbers that have it, or the heartwood/sapwood boundary, produces felling date ranges in the latter half of the sixteenth century and early-seventeenth century. Sapwood recognition on conifers can be more problematic and thus, bearing in mind the high level of similarity between the two dated conifer timbers, it appears that these are probably both felled in the late-sixteenth or early mid seventeenth century.

7.4.4 The German oak timbers appear to have been felled slightly earlier than the English timbers and if they are associated with the initial construction of the vessel then a construction date towards the middle of the latter half of the sixteenth century is suggested with repairs or modification being undertaken in the late-sixteenth or early seventeenth century. The Scandinavian conifer timbers could be coeval or slightly later.

7.4.5 Whilst both of the dated Scandinavian timbers are ceiling planks, the dated oak timbers are of a variety of functions with no clear distinction between element type and provenance.

8 CONCLUSIONS AND DISCUSSION

8.1 Dating and origin

8.1.1 The dendrochronological analyses seem to indicate that the vessel was built towards the middle of the latter half of the sixteenth century. The provenance of the oak timbers used in what is believed was the initial phase of construction of the vessel is Germany, which could suggest a North German or Dutch initial construction of the vessel as Germany was one of the main sources of timber import for the Low Countries. The possibility that the vessel was made in continental northern Europe seems to be further validated by the fact that some of

the German timbers were sourced in the same area, whilst the English came from more disparate woodlands which would suggest that these timbers had been harvested together. Furthermore, the only knee that was dated is of German origin and usually the awkwardness of the shape and weight of timber for knees made them more difficult to transport over long distances, and more likely to be fashioned close to the timber source.

8.1.2 A second phase of the life of the vessel could be suggested by the use of English and Scandinavian timbers and dates to the late sixteenth/early seventeenth century. Whilst the Scandinavian planking could be interpreted as imported timbers, it is likely that the English timbers might have been part of a repair/modification program and it is possible that this could have taken place within England mainly using domestic wood. Furthermore, the fact that the timbers come from a wider region and not from a single area or forest could suggest the stock piling of timbers.

8.1.3 However, the possibility that some of the timbers were salvaged from vessels at the end of their service life and re-used cannot be completely discounted at this stage of the investigation and a more comprehensive and detailed study of the timbers is required to highlight the potential re-use of certain elements. Hence at this stage of the investigation the evidence does not prejudice either a North German, Dutch or English origin.

8.1.4 The habitats of the mosses found on the shipwreck seem to suggest that it is most likely these were not originally collected from the area where the ship was wrecked at Whitstable, but from further north. It is not possible to be certain from where, but it is likely to be from Yorkshire northwards, there is even a possibility that it may have been from further north, even Scandinavia.

8.1.5 The finds are consistent with a late sixteenth – first half of the seventeenth century date of use of the vessel, and the scarce evidence so far seems to suggest that it might have been operating in the southern North Sea considering the recurrence of Dutch and English elements.

8.2 General conclusions and parallel finds

8.2.1 The TBW is a small to medium sized carvel-built boat or ship with a rather large cargo capacity as a result of its beam and bluff bows. The remains of timbers within the hull have been interpreted as collapsed deck, but this decking may have only been partial. A partially open vessel could potentially be classed as a boat, whilst more extensive decking would make it a ship. However, insufficient evidence exists to determine the extent of decking at present.

8.2.2 At this stage of the investigation no defining construction features have been observed to allow the association of the wreck to a specific shipbuilding tradition although similarities have been observed that may suggest a Dutch influence (Dr Damien Goodburn pers. comm.).

8.2.3 Due to the limited data available and the lack of a frame plan, the comparison of the TBW with other carvel wreck sites is in its early stages. However, certain characteristics of the TBW such as the overall dimensions and proportions, the ceiling planking of alternating thickness are broadly consistent with site B&W4, a Dutch medium-sized coastal trader built in the same period as TBW (Lemee 2006). Nonetheless, it should be noted that currently there is a general lack of substantial similarities amongst the few English vessels of the period and the characterisation of the constructional features of a potential Dutch/German/Scandinavian tradition is hindered by the lack of studies (Auer 2014).

8.2.4 The contextual evidence does not seem to contradict the possibility of a Dutch-built vessel in this area in the early 17th century. The vessel dates to a period when the Dutch presence in this part of England was considerable both in terms of trade, Dutch trading ships often landed at ports such as Faversham, and in terms of fishing activity. The influence of the Dutch within the local area is well attested in an estate map of Minster in Sheppey, dated 1708 (CKS, U36: 15.) which has in the top left corner one of the early representations of a Dutch-influenced hoy with leeboard and round bows. Furthermore, the possibility that the vessel was carrying grain at some point of its life could also be a tentative indicator that it operated as a Dutch vessel considering the dominance of the Dutch in bulk grain transportation from the Baltic shores to the large urban centres of western Europe (Willems 1997). Conversely the acquisition of Dutch ships by the English was also known and the vessel could be part of the type of vessel that was first imported from the Netherlands and then operated, adapted or repaired locally.

8.2.5 At present, the environmental evidence provides possible indicators of northern European contact: a spruce pollen grain and a combination of hair/wool and moss in the caulking and is supported by the dendrochronological results. This is added to the artefactual evidence from the leather recovered that has parallels with similar items found in wrecks of the period that have been identified as Dutch, such as shipwrecks S01 and T24 (Maarleveld 2007). However, it is believed that, at the current stage of the investigation, the evidence is too imprecise to make firm conclusions on the possible links of the vessel with continental Europe although the evidence provided by the timbers it is compelling.

8.2.6 It is noteworthy that both moss and animal hair were found in the environmental samples and are likely to be associated with caulking. This may suggest that the ship had been repaired at some stage in its working life where the traditional material for caulking was different from that from where it was originally constructed.

8.2.7 The presence of a large amount and number of moss taxa (as well as other plant material, such as wood chips and arable weed seeds) may suggest other uses of mosses on board the vessel, such as bedding material or as packing for valuable or delicate cargo to prevent damage during transit.

8.2.8 The use of both English and German timbers appears to be very rare in the archaeological record for vessels of the 16th century, so further research aimed at understanding the building sequence of this vessel will be important not only for interpreting the history of this wreck but as a way to provide a significant contribution to our understanding of the exchanges of knowledge and shipbuilding methods/traditions between England and continental Northern Europe in the early modern period.

9 STATEMENT OF POTENTIAL

9.1 Stratigraphic potential

9.1.1 The remaining elements of the vessel's timber structure are intact enough to provide significant potential for informing on the form, construction techniques, repairs and modifications. The section that is believed to be the stern of the vessel is no longer present.

Recommendations and proposed methodologies for analysis

9.1.2 The initial analysis techniques have been completed. The site is likely to yield considerable further evidence from subsequent investigation. It is also acknowledged that the site is at risk from intermittent erosion as well as potential human threats (e.g. metal detecting). It is therefore recommended that the site be considered for further fieldwork and that it is

documented with further site photogrammetry as well as environmental and other analysis undertaken.

9.2 Finds potential

9.2.1 The finds recovered during the 2018 investigation have exceeded expectations in terms of preservation and quantity. A highly anoxic environment has meant that there is potential for well-preserved organic material surviving, evidenced by the very well-preserved footwear and wooden spoon already found. Significant further artefactual evidence can be expected.

9.2.2 Currently the recommendation is that all archaeologically recovered leather is conserved to permit safe storage and make it available for study (English Heritage: 2012). This is because of the relatively rarity of the survival of organic materials in the archaeological record and the wealth of information that can be recovered from them. In view of the excellent dating evidence that the leather provides (see the summary below) and as a significant part of the material is fragile and liable to deteriorate, specialist conservation is recommended for SF5121, 5123 and 5133/5136. The various conservation options are given in English Heritage 2012.

9.2.3 A basic record of the leather has been made (appended below). Selected leather (SF5121, 5123, 5133/5136) should be conserved to allow for its storage, further examination and professional illustration or photography if required for publication. As the leather provides such good dating evidence, the leather should be briefly re-examined following conservation, the basic record updated as necessary and a summary prepared to inform those preparing any narrative and for inclusion in any subsequent publication. This should be accompanied by either working drawings or photographs.

9.2.4 The galley area was found under a layer of disarticulated timber material that is believed to have collapsed onto the level beneath, potentially protecting it and creating the conditions for the preservation of relatively undisturbed deposits. The finds potential in this part of the wreck is considerable.

Recommendations and proposed methodologies for analysis

9.2.5 Most of the initial analysis techniques have been completed and specialist reports have been produced with regards to the leather, fish and faunal remains. Further research could be carried in terms of documenting the marks that were found on the bricks and wooden objects with RTI and a more detailed study of the wood kindling that includes species identification. It is recommended that the full catalogue of the finds is finalised to include the artefacts that are currently stored at the University of Lampeter and a selection of chosen items are recorded with photogrammetry or laser scanner.

9.2.6 The production of a full catalogue of the timbers recovered that include 3D timber drawings and textured models is highly recommended.

9.3 Environmental potential

9.3.1 The evidence retrieved so far has highlighted the high potential of the wreck to provide significant palaeoenvironmental information (beyond the one provided by the timbers and other structural elements, such as the cordage) related to both the building of the ship, its use and its depositional environment (see also Gorham and Bryant 2001). Therefore, this information is of extreme interest for the understanding of this particular wreck, and for maritime archaeology in general. This is particularly so because, despite the immense popularity of underwater and maritime archaeology, there are very little other archaeobotanical studies from shipwrecks, not only in Great Britain, where only a few

wrecks have been sampled (e.g. Carruthers 2014), but also in Europe (e.g. Manders and Kuijper 2015) and beyond. In addition, save a few examples (e.g. Carruthers 2014), the quality of the little existing evidence is in general relatively deficient in terms of the level sampling, the recording of the contextual background of the samples and the degree of identification of the evidence and therefore the information that can be gained from the botanical data is often underexploited (see also Deforce *et al*. 2014; Manders and Kuijper 2015).

9.3.2 Contained within the lower fill of the bow section area yet to be excavated, there is a very high potential for environmental evidence. Anoxic fine sediment has provided ideal conditions for the preservation of potentially high-quality environmental evidence.

Recommendations and proposed methodologies for analysis

9.3.3 Limited environmental samples were taken during the excavation phase of the TBW site. Due to the substantial amount of environmental evidence found to be present in the lower fills of the TBW site, an improved methodology for environmental sampling is also recommended. The site has the potential of understanding more about the diet and shipboard life of seafarers of the time due to the discovery of the galley hearth.

9.3.4 An extensive sampling strategy is recommended for the further stages of work at the wreck, following the example of the Newport medieval ship (Nayling and Jones 2014). Further multiproxy analysis of the existing and new samples will undoubtedly maximise the information to be obtained from each sample, as each type of palaeoenvironmental proxy can provide a wealth of complementary information. Equally, control samples need to be taken to correctly understand the significance of the environmental assemblages and their formation processes (see Gorham and Bryant 2001).

9.4 Dendrochronological dating

Recommendations and proposed methodologies for analysis

9.4.1 Further dendrochronological sampling the site is considered beneficial for understanding the vessel's construction, repair and refitting during its service life. Any future sampling should focus on extending the range of elements sampled and target timbers that retain bark edge or sapwood in order to provide a precise date of the vessel's construction and subsequent sequence of refitting or repairs.

9.4.2 A prime area for the potential survival of sapwood and bark edge is on floor timbers currently covered by ceiling planks, with the removal of selected ceiling planks or sections of planks potentially providing adequate access to determine the condition of these currently inaccessible timbers.

9.5 Documentary records

9.5.1 No documentary evidence for the vessel has yet been found. Due to the complexity of consulting and accessing the relevant 16th-17th century records no detailed archival research has been carried so far. However, it is advised that archival sources that might hold potential information relating to the vessel and the wrecking event are located when the chronology and character of the site is more fully understood.

9.6 Summary of potential

9.6.1 Well preserved wrecks of early modern ships are rare finds and the evolution of shipbuilding during the 16th and early 17th centuries is difficult to follow, as a limited number of sites have been excavated to high archaeological standards. The study of this wreck could

potentially reveal internationally significant information on the construction of ships of this period and transfer of knowledge in different shipbuilding contexts, resulting in an important contribution to the advancement and understanding of the discipline. Conversely, the loss of data contained in the site and associated deposits would be extremely unfortunate equating to a sizable loss of a significant and valuable resource.

9.6.2 In every aspect other than documentary evidence, the potential of the site to inform us about seafaring in the late 16th century is considered **high**.

10 UPDATED PROJECT DESIGN

10.1 Summary of recommendations

10.1.1 Further excavation of the remaining deposits towards the W end of the hull is recommended. This will provide a record of the context before its potential loss due to erosion and will allow detailed recording of the hull timbers underneath and complete the excavation plan of the wreck at the level of the ceiling planking.

10.1.2 Once the sediment in the W section has been excavated it is suggested that the hull is thoroughly cleaned and the recorded with a photogrammetric survey, aerial photographs and detailed drawings by a team of archaeologists with experience in nautical archaeology.

10.1.3 The removal of selected ceiling planks to access the floor timbers underneath should also be considered. This would provide the opportunity to partially record the framing system and external planking (which is critical to the understand the ship construction methods and history) but also would benefit the programs of dendrochronological and environmental sampling concurrent to the excavation.

10.1.4 Provision for the conservation of the timbers removed should be made in the preliminary phase of the works and these should be fully documented in a timber catalogues containing 3d models and 3d drawings of each timber.

10.1.5 At the end of the excavation the site should be covered with geotextile and sandbags and part of the infill reinstated so that the remains are protected.

10.2 Updated project aims

10.2.1 The aims of the project remain the same as those stated above, with the addition of the following points:

- Establish what, if any, evidence of cargo remains on the site;
- Establish whether the vessel was operated by an English, Dutch or other crew;
- Establish where the vessel was based, provisioned and crewed;
- Increase the available artefactual and environmental evidence to assist analysis.
- Identify the shipbuilding methods that underpin the construction of the vessel.
- Gather information from the Galley area.
- Locate the forward mast step.

10.3 Proposals for publication

10.3.1 The final results of the excavation, including specialist reports, finds and timbers catalogue and plans of the site should be published in a dedicated monograph. An article that provides a resume of the findings should be published in relevant journal such as IJNA.

10.4 Programme for analysis and publication

10.4.1 This stage and cost proposal is for interim reporting, interim conservation and a final fieldwork phase to complete the excavation of the internal fill of the hull and associated sampling. A final updated PD will be produced following the next phase of excavation.

10.5 Personnel and resources

10.5.1 The following Wessex Archaeology core staff are scheduled to undertake the next phase work as outlined in the task list for excavation (**Table 3**) and for post-excavation analysis and publication (**Table 4**).

Table 3 Task list (excavation)

Task no.	Task description	Days	Staff
Management and support			
1	Project management	5	
2	Project monitor and QA	2	
3	Finds management	3	
4	Environmental management	3	
Fieldwork			
5	Project meetings	1	TG
6	Mobilisation	2	TG, PC, LR
7	Fieldwork	10	TG, PC, LR
8	Extraction of environmental samples	3	ILD
9	Survey	2	
10	Finds processing	5	VC
Analysis and specialist assessment			
Finds			
11	Pottery report	2	LM
12	Bone	1	LH
13	Leather report	2	QM
14	Illustrations: finds	5	KF
15	Conservation	5	LW
16	x-rays	1	LW
Environmental			
17	Plant remains	2	Ext
18	Insects	2	Ext
19	Foraminifera	2	Ext
20	Ostracods	2	Ext
21	Chemical Analysis	2	Ext
22	Animal Hair	2	Ext
23	Radiocarbon dating	2	Ext

Table 4 Task list (Post-Ex)

Task no.	Task description	Days	Staff
Management and support			
1	Project management	TBC	TBC
2	Project monitor and QA		
3	Finds management		
4	Environmental management		
Pre-analysis			
5	Check phasing and grouping, update site database	TBC	TBC
6	Digitisation of selected drawings		
7	Project meetings		
8	Background research		
9	Extraction of environmental materials		
Analysis and specialist reporting			
Stratigraphic			
10	Stratigraphic report	TBC	TBC
Finds			
11	Pottery report	TBC	TBC
12	Flint report		
13	Leather report		
14	Illustrations: finds		
15	Conservation		
Environmental			
16	Plant remains	TBC	TBC
17	Insects		
18	Foraminifera		
19	Ostracods		
20	Chemical Analysis		
21	Animal Hair		
22	Radiocarbon dating		
23	Wood charcoal		
Report compilation *(journal article)*			
24	Introduction and background	TBC	TBC
25	Compile and integrate report		
26	Discussion		
27	Bibliography		
28	Captions (figures, plates and tables)		
29	Brief finds and figure illustrations		
30	Illustrations		
31	Edit report		
32	Review report		
33	Check proofs		
34	Journal publication cost		
Archiving			
35	Archive preparation	TBC	TBC
36	Archive scanning		
37	Final finds archive checking		
38	Final environmental archive check-in		

39	Digital archive		
40	Archive deposition		
41	Box storage grant		

10.6 Management structure

10.6.1 Wessex Archaeology operates a project management system. The team will be headed by a Post-excavation Manager, who will assume ultimate responsibility for the implementation and execution of the project specification as outlined in the Updated Project Design, and the achievement of performance targets, be they academic, budgetary, or scheduled.

10.6.2 The Post-excavation Manager may delegate specific aspects of the project to other key staff, who will both supervise others and have a direct input into the compilation of the report. They may also undertake direct liaison with external consultants and specialists who are contributing to the publication report, and the museum named as the recipient of the project archive. The Post-Excavation Manager will have a major input into how the publication report is written. They will define and control the scope and form of the post-excavation programme.

10.6.3 The Post-excavation Manager will be assisted by the Senior Research Manager, who will help to ensure that the report meets internal quality standards as defined in Wessex Archaeology's guidelines.

11 STORAGE AND CURATION

11.1 Museum

11.1.1 The archive resulting from the excavation is currently held at the offices of Wessex Archaeology in Salisbury. Whitstable Community Museum has agreed in principle to accept the archive on completion of the project, under the accession code **canwh2019.1.1**. Deposition of any finds with the museum will only be carried out with the full written agreement of the landowner to transfer title of all finds to the museum.

11.1.2 The finds recovered are currently under passive conservation treatment to allow under the supervision of Wessex Archaeology conservator specialist to allow long term storage.

11.2 Preparation of the archive

11.2.1 The archive, which includes paper records, graphics, artefacts, ecofacts and digital data, will be prepared following the standard conditions for the acceptance of excavated archaeological material by Whitstable Museum, and in general following nationally recommended guidelines (SMA 1995; CIfA 2014c; Brown 2011; ADS 2013).

11.2.2 The archive will be finalised under the completion of fieldwork and a full index will be prepared.

11.3 Selection policy

11.3.1 Wessex Archaeology follows national guidelines on selection and retention (SMA 1993; Brown 2011, section 4). In accordance with these, and any specific guidance prepared by the museum, a process of selection and retention will be followed so that only those artefacts or ecofacts that are considered to have potential for future study will be retained. The selection policy will be agreed with the museum, and is fully documented in the project archive.

11.4 Security copy

11.4.1 In line with current best practice (e.g., Brown 2011), on completion of the project a security copy of the written records will be prepared, in the form of a digital PDF/A file. PDF/A is an ISO-standardised version of the Portable Document Format (PDF) designed for the digital preservation of electronic documents through omission of features ill-suited to long-term archiving.

11.5 OASIS

11.5.1 An OASIS online record (http://oasis.ac.uk/pages/wiki/Main) has been initiated, with key fields and a .pdf version of the final report submitted. Subject to any contractual requirements on confidentiality, copies of the OASIS record will be integrated into the relevant local and national records and published through the Archaeology Data Service ArchSearch catalogue.

12 COPYRIGHT

12.1 Archive and report copyright

12.1.1 The full copyright of the written/illustrative/digital archive relating to the project will be retained by Wessex Archaeology under the *Copyright, Designs and Patents Act* 1988 with all rights reserved. The client will be licenced to use each report for the purposes that it was produced in relation to the project as described in the specification. The museum, however, will be granted an exclusive licence for the use of the archive for educational purposes, including academic research, providing that such use conforms to the *Copyright and Related Rights Regulations* 2003. In some instances, certain regional museums may require absolute transfer of copyright, rather than a licence; this should be dealt with on a case-by-case basis.

12.1.2 Information relating to the project will be deposited with the Historic Environment Record (HER) where it can be freely copied without reference to Wessex Archaeology for the purposes of archaeological research or development control within the planning process.

12.2 Third party data copyright

12.2.1 This document and the project archive may contain material that is non-Wessex Archaeology copyright (e.g., Ordnance Survey, British Geological Survey, Crown Copyright), or the intellectual property of third parties, which Wessex Archaeology are able to provide for limited reproduction under the terms of our own copyright licences, but for which copyright itself is non-transferable by Wessex Archaeology. Users remain bound by the conditions of *the Copyright, Designs and Patents Act* 1988 with regard to multiple copying and electronic dissemination of such material

REFERENCES

A.J. Powell, H. Brinkhuis & J. P. Bujak. 1996. Upper Paleocene-Lower Eocene dinoflagellate cyst sequence biostratigraphy of southeast England. Geological Society, London, Special Publications, 101, 145-183.

ADS 2013 *Caring for Digital Data in Archaeology: a guide to good practice*. Archaeology Data Service and Digital Antiquity Guides to Good Practice

Aldiss, D.T. 2014 The stratigraphical framework for the Palaeogene successions of the London Basin, UK. Version 2, with minor revisions. Nottingham, UK, British Geological Survey, 88pp.

Atherton, I., Bosanquet, S. & Lawley, M. 2010. Mosses and Liverworts of Britain and Ireland. A Field Guide. British Bryological Society. London

Auer, J., & Maarleveld, T. J., 2014, A 16th-century Merchantman Wrecked in the Princes Channel, Thames Estuary, BAR British Series 602, NAS Monograph Series No.4, Archeopress, Oxford.

Bennett, K D, Whittington, G and Edwards, K J, 1994, Recent plant nomenclatural changes and pollen morphology in the British Isles, Quat Newsl 73, 1–6

Brewer S, Giesecke T, Davis B, Finsinger W, Wolters S, Binney H, de Beaulieu J, Fyfe R, Gil-Romera G, Kuhl N, Kune P, Leydet M, and Bradshaw R H W 2017 Late glacial and Holocene European pollen data: the maps. J Maps 13(2), 921-928

British Geological Survey online viewer http://mapapps.bgs.ac.uk/geologyofbritain/home.html (accessed 10/03/2019)

Britton, K and Huntley, J 2011 New evidence for the consumption of barley at Romano-British military and civilian sites, from the analysis of cereal bran fragments in faecal material, Veget Hist and Archaeobot 20, 41

Brown, D H 2011 *Archaeological Archives: a guide to best practice in creation, compilation, transfer and curation* (revised edition). Archaeological Archives Forum

Burger P., Gros-Balthazar M., Stacey R.J. (2013) *Newport Medieval Ship Project Specialist Report: TAR*, Newport City Council, Wales

Carruthers, W J 2014 The Waterlogged Plant Remains, in: Nayling, N and Jones, T (ed.), Newport Medieval Ship (467), Newport Museums and Heritage Service

CIfA 2014a *Standard and Guidance for Archaeological Excavation*. Reading, Chartered Institute for Archaeologists

CIfA 2014b *Standard and Guidance for the Collection, Documentation, Conservation and Research of Archaeological Materials*. Reading, Chartered Institute for Archaeologists

CIfA 2014c *Standard and Guidance for the Creation, Compilation, Transfer and Deposition of Archaeological Archives*. Reading, Chartered Institute for Archaeologists

Clapham, A.J. 2007. Plant Remains in: Hanson, W.S. (ed) Elginhaugh: A Flavian Fort and Its Annexe. Volume 2. Britannia Monograph Series, No. 23, Society for the Promotion of Roman Studies. London, pp 571-614

Cushing, E J 1967 Evidence for differential pollen preservation in late Quaternary sediments in Minnesota, Rev Palaeobot Palynol 4, 87–101

De Coninck, J. 1991. Ypresian Organic Walled Phytoplankton in the Belgian Basin and Adjacent Areas. Bulletin de la Société belge Géologie. 97-3/4.

Deforce, K, Allemeersch, L, Stieperaere, H and Haneca, K 2014 Tracking ancient ship routes through the analysis of caulking material from shipwrecks? The case study of two 14th century cogs from Doel (northern Belgium). J Archaeol Sci 43, 299-314

Derham, B. (2000) Chemical analysis of medicines from the Barber-surgeons chest from the Mary Rose, PhD Bradford University

Dickson, J.H. & Ransom, M. 1968. Report on the caulking of the Home Pierrepoint Canoe No. 2. Transactions of the Thoroton Society of Nottingham, 72, 29

Dickson, J.H., 1973. Bryophytes of the Pleistocene. Cambridge University Press.

Dickson, J.H., 2000. Bryology and the Iceman: Chorology, Ecology and Ethnobotany of the Mosses Neckera complanata Hedw. and Neckera crispa Hedw. In: Borthenschlager, S. & Oeggl, K., (eds) The Iceman and His Natural Environment. The Man in the Ice. Volume 4. Springer Verlag, Wien

Dickson, J.H., Bortenschlager, Oeggl, K., Porley, R. and McMullen, A. 1996. Mosses and the Tyrolean Iceman's Southern Provenance. Proceedings of the Royal Society of London, B. 263, 567-571

Dickson, J.H., Hofbauer, W., Porley, R., Schmidl, A., Kofler, W. and Oeggl, K., 2009. Six Mosses from the Tyrolean Iceman's Alimentary Tract and their Significance for his Ethnobotany and the Events of his Last Days. Vegetation History and Archaeobotany, 10, pp 1-10

Dickson, J.H., Maier, U., Mainberger, M & Lécrivan, G.M-J., 2013. Mosses for Caulking the Early Bronze Age Logboat from Degersee, Southern Germany. Archive for Bryology, 185, pp 1-11

Ellison, R. A., Woods, M. A., *et alia*, 2004. Geology of London. Memoir of the British Geological Survey, Sheets 256 (North London), 257 (Romford), 270 (South London) and 271 (Dartford), England and Wales.

English Heritage, 2011, *Environmental Archaeology: a guide to theory and practice of methods, from sampling and recovery to post-excavation*. Swindon, Centre for Archaeology Guidelines

English Heritage, 2012, Waterlogged Organic Artefacts Guidelines on their Recovery, Analysis and Conservation. English Heritage Publishing

English Heritage, 2010, The Greater Thames Estuary Historic Environment Research Framework, Update and Revision of the Archaeological Research Framework for the Greater Thames Estuary (1999)

Essex County Council, 1999, Greater Thames Estuary Research Framework. Essex County Council

Essex County Council, 2010, Greater Thames Estuary Research Framework Review. Web published document.

Evans, N. and Mould, Q. 2005 'Footwear'. In Gardiner, J. with Allen, M.J. (eds) Before the Mast: Life and Death Aboard the Mary Rose. Portsmouth: The Mary Rose Trust, 59-94

Evershed, R.P., Jerman, K., Eglinton, G. (1985) Pine wood origin for pitch from the Mary Rose, Nature 314, pp. 528–530.

Frei, K M, Frei, R, Mannering, U, Gleba, M, Nosch, M L and Lyngstrøm, H 2009 Provenance of Ancient Textiles—a Pilot Study Evaluating the Strontium Isotope System in Wool*, Archaeometry 51(2), 252-276

Gorham, L D and Bryant, V M J 2001 Pollen, phytoliths, and other microscopic plant remains in underwater archaeology, Int J Nautic Archaeol 30(2), 282-298

Goubitz 1985 'Modeschoenen uit een Waddenwrak'. Westerheem, Tijdschrift voor de Nederlandse archeologie 34. Archeo-Brugge 1, 223-228

Grew, F. and de Neergaard, M. 1988 Shoes and Pattens. Medieval finds from excavations in London: 2. London: Her Majesty's Stationery Office

Historic England, 2018, Scientific Dating Team, Tankerton Bay Wreck, Kent: interim statement on dendrochronological analyses, Historic England

Joby, C., 2015, The Dutch Language in Britain (1550-1702): A Social History of the Use of Dutch in Early Modern Britain

Jolley, D.W. 1992. Palynofloral association sequence stratigraphy of the Paleocene Thanet Beds. eview Palaeobotany & Palynology. 74.

Jolley, D.W., 1998. Palynostratigraphy and depositional history of the Palaeocene Ormesby/Thanet depositional sequence set in southeastern England and its correlation with continental West Europe and the Lista Formation, North Sea. Review Palaeobotany & Palynology. 99.

Jones, S 2012 Newport Medieval Ship Project, specialist report: pollen. GGAT 467 Unpublished report. http://archaeologydataservice.ac.uk/archiveDS/archiveDownload?t=arch-1563-2/dissemination/pdf/Newport_Medieval_Ship_Specialist_Report_Pollen.pdf (accessed 07-09-18)

Kaye, T.P. (2013) *Pine Tar; History and Uses*, nationalhistoricships.org.uk

King, C. 1981. The stratigraphy of the London Clay Formation and associated deposits. Tertiary Research, Special Paper 6, Backhuys, Rotterdam.

King, C. 1991. Stratigraphy of the London Clay Formation (Early Eocene) in the Hampshire Basin. CNAA Thesis (Ph.D.) unpubl. Kingston Polytechnic.

Körber-Grohne, U 1991 Identification key for subfossil Gramineae fruits, in: Probleme der Küstenforschung im südlichen Nordseegebiet, August Lax, Hildesheim 169–234

Lemée, C., 2006, Renaissance Shipwrecks from Christianshavn, Ships and Boats of the North Vol.6, Roskilde.

Maarleveld, T., 1994, Double Dutch Solutions in Flush-Planked Shipbuilding: Continuity and Adaptations at the Start of Modern History. Netherlands: Department of Underwater Archaeology.

Maarleveld, T., 2007, New Data on Early Modern Dutch-Flush Shipbuilding: Scheurrak T24 and Inschot/Zuidoostrak, in International Journal of Nautical Archaeology 23(1):13 - 25

Maarleveld, T., 2013, Early Modern Merchant Ships, Nicolaes Witsen and a Dutch-Flush Index, in International Journal of Nautical Archaeology 42(2):348-357

Manders, M and Kuijper, W 2015 Shipwrecks in Dutch Waters with Botanical Cargo or Victuals, Anal Praehist Leidensia 45

Moore, P D, Webb, J A and Collinson, M E 1991 Pollen analysis (2nd edition). Oxford, Blackwell

Munro, R., 1882. Ancient Scottish Lake-dwellings or Crannogs. David Douglas, Edinburgh

Nayling, N and Jones, T 2014 The Newport Medieval Ship, Wales, United Kingdom. International J. Naut Archaeol 43(2), 239-278

O'B. KNOX, R.W., HINE, N.M. & ALI, J.R. 1994. New information on the age and sequence stratigraphy of the type Thanetian of southeast England. Newsl. Stratigr., 12. (4).

Robinson N., Evershed R.P., Higgs J., Jerman K., Eglinton G. (1987) Proof of a pine wood origin for pitch from Tudor (Mary Rose) and Etruscan shipwrecks: application of analytical organic chemistry in Archaeology, Analyst 112, pp. 637–644.

Robinson, D and Aaby, B 1994 Pollen and plant macrofossil analyses from the Gedesby ship - a medieval shipwreck from Falster, Denmark. Veg Hist Archaeobot 3(3), 167-182

Ryder, M L 1998 Animal Hair in Medieval Ship Caulking Throws Light on Livestock Types, Environ Archaeol 2(1), 61-66

Saatkamp, A., Guyon, M., & Philippe, M. 2011. Moss caulking of boats in the Upper French Rhône and Saône (Eastern France) from the 3rd to the 20th century and the use of Neckera crispa Hedwig. Vegetation History and Archaeobotany, 20, pp293-304

Sangster, A G and Dale, H M 1961 A preliminary study of differential pollen grain 517 preservation. Can J Bot 39, 35-43

SMA 1993 *Selection, Retention and Dispersal of Archaeological Collections*. Society of Museum Archaeologists

SMA 1995 *Towards an Accessible Archaeological Archive*. Society of Museum Archaeologists

Smith, A.J.E. 1980. The Moss Flora of Britain and Ireland. Cambridge University Press, Cambridge

Stace, C 1997 New flora of the British Isles (2nd edition). Cambridge, Cambridge University Press

Volken, M. 2014 Archaeological Footwear. Development of shoe patterns and styles from Prehistory till the 1600's. Zwolle: SPA Uitgevers

von Holstein, I C C, Font, L, Peacock, E E, Collins, M J and Davies, G R 2015 An assessment of procedures to remove exogenous Sr before 87Sr/86Sr analysis of wet archaeological wool textiles J Archaeol Sci 53, 84 -– 93

Watson, E.V. 1981. British Mosses and Liverworts. Third Edition. Cambridge University Press, Cambridge

Wessex Archaeology, 2018a, Tankerton Bay Wreck, Whitstable, Kent: Undesignated Site assessment. Unpublished report ref. 108281.06.

Wessex Archaeology, 2018b, Tankerton Bay and “Old Brig” Wrecks: Proposal for an Intrusive Investigation and Rapid Assessment and Recording, unpublished report ref. 200950.1

Wessex Archaeology, 2019, Assessment of environmental evidence from Tankerton Bay Wreck, draft, internal report ref. 200950.2

Willems, W., 1997, Archaeological Heritage Management in the Netherlands: Fifty Years State Service for Archaeological Investigations

Wright, E.V., 1990. The Ferriby Boats Seacraft of the Bronze Age. Routledge, London.

13 APPENDICES

13.1 Appendix 1: TimberSamples

Timber from 2017 Evaluation

Sample Number	Timber description/location	Conversion Type	Dimensions	Wood type	Date span of measured sequence (AD)	Felling date/date range (AD)
TNK01	Central longitudinal axial timber, stempost/sternpost	halved	310x130	oak	undated	------
TNK02	Ceiling plank south of TNK01	radial	210x100	oak	undated	
TNK03	Ceiling plank from south west end of wreck.	tangential	245x55	elm	to be analysed	------
TNK04	ceiling plank	tangential	230x30	conifer	1487-1585	after 1585
TNK05	Hull plank from northwest end of wreck	tangential	290x60	elm	to be analysed	------
TNK06	Hull plank from west end of wreck, just north of TNK03	tangential	160x50	beech	to be analysed	------
TNK07	Hull plank from north east end of wreck	tangential	210x50	oak	rejected	------
TNK08	Hull plank from south east of wreck	tangential	140x50	oak	undated	------
TNK09	Hull plank from south east of wreck	tangential	330x50	beech	rejected	------
TNK10	Hull plank from south west of wreck	tangential	140x80	oak	1425-1521	after 1531
TNK11	Hull plank from north east of wreck	halved	245x80	oak	rejected	------
TNK12	Possible stringer running over frames from north east of wreck	sub-whole	250x85	oak	undated	------
TNK13	South side frame	Quartered	80x75	oak	rejected	------
TNK14	South side midships frame	Quartered	210x140	oak	rejected	------
TNK15	South side midships hull plank immediately west of TNK04	Quartered	200x125	oak	undated	------
TNK16	ceiling plank south west area of wreck	tangential	300x30	conifer	undated	------
TNK17	ceiling plank south west area of wreck	tangential	350x45	oak	undated	------

TNK18	ceiling plank, fragment south west area of wreck	radial	55x20	oak	rejected	------
TNK19	hull plank south west area of wreck	tangential	340x50	oak	1392-1479	after 1489
TNK20	hull plank, fragment above TNK19 south west area of wreck	radial	70x40	oak	rejected	------
TNK21	displaced knee, c 1m north of TNK16-TNK19	sub-whole	300x280	oak	1400-1547	1555-85
TNK22	displaced stringer fragment				to be sampled	
TNK23	Partial stringer to east of 30. Appears to have been axe cut in antiquity				to be sampled	

Timber from 2018 Excavation

Sample Number	Timber description/location	Conversion Type	Dimensions	Wood type	Date span of measured sequence (AD)	Felling date/date range (AD)
TNK24	ceiling plank south side midships	tangential	240x230	oak	1401-1521	after 1546
TNK25	ceiling plank above 24	sub-whole	240x200	conifer	1485-1562	after 1562
TNK26	frame -first futtock. Below 24 and 25	quartered	240x240	oak	undated	------
TNK27	Frame – first futtock to west of 26				to be sampled	
TNK28	hull plank. East end of wreck	tangential	------	------	to be analysed	------
TNK29	knee fragment west end of wreck	sub-whole	------	------	to be analysed	------
TNK30	Stringer below 24	tangential	320x100	oak	1417-1511	after 1519
TNK31	Beam to west of 29 – unknown function	sub-quartered	------	------	to be analysed	------
TNK32	hull plank behind 43	tangential	180x50	oak	undated	------
TNK33	Floor timber at eastern most end of vessel near 28	------	------	oak	to be sampled	------
TNK34	Stringer south of keelson	tangential	320x45	oak	1473-1557	after 1567
TNK35	displaced frame midships west of mast step	------	------	------	to be analysed	------
TNK36	Northern most stringer	tangential	370x100	oak	1501-1590	1590-1623

TNK37	displaced beam, galley area	quartered	150x100	oak	1414-1501	after 1509
TNK38	knee fragment west of 37	sub-whole	------	------	to be analysed	------
TNK39	knee fragment south of 29	sub-whole	------	------	to be analysed	------
TNK40	Frame-floor timber at extreme west end of wreck	quartered	200x150	oak	1402-1530	after 1538
TNK41	ceiling plank below 34	tangential	200x55	oak	undated	------
TNK42	hull plank below 32	radial	330x50	oak	undated	------
TNK43	Frame-futtock between 26 and 32	halved	260x160	oak	1465-1572	1572-1606
TNK44	hull plank – displaced midships	tangential	400x50	oak	1422-1569	1569-1596
TNK45	displaced futtock below 44	halved	250x140	oak	1414-1561	1561-1581
TNK46	Stringer west of 34	tangential	230x50	oak	undated	------
TNK47	Frame-futtock between 26 and 43	quartered	220x170	oak	undated	------
TNK48	fragment, galley area	radial	120x40	oak	1434-1535	after 1543
TNK49	49A-Oak fragment from below 34. 49B-Softwood fragment below 34 49C- Softwood fragment below 34	------	------	------	to be analysed	------
TNK50	2 excavated oak fragments from galley area	------	------	------	to be analysed	------
TNK51	post fragment galley area	sub-whole	------	------	to be analysed	------
TNK52	displaced plank below 45	tangential	------	------	to be analysed	------

13.2 Appendix 2: Environmental Results

Table 1. Assessment of the macrofossil evidence.

Sample	Vol (L)	Flot (ml)	Subsample	Charred Plant Remains	Charcoal > 4/2mm	Uncharred vegetative parts	Uncharred other	Invertebrates	Other
2001	0.1	55	-	-	-	A**: moss (inc. *Sphagnum* sp.) leaves, culms and wood fragments	Characeae	Foraminifera spp. A**, Ostracods spp., moll-m/f, insects + mites A*	Bitumen?
2002	9.5	5000	250ml		Trace	A***: wood, moss (inc. *Sphagnum* sp.) leaves, seaweed, bud scales, leaves	A: Triticeae (bran), *Prunus domestica*, *Corylus avellana*, *Betula* sp., *Juncus* sp., Cyperaceae, *Carduus/Cirsium*, *Centaurea cyanus, Briza* sp., *Suaeda maritima*, catkin fragment	Foraminifera spp. A**, ostracods spp. A*, moll-f, insects and pupae cases, mites	Coal
2003	9	700	25% (175ml)	-	Trace	A***: inc. wood and *Sphagnum* sp. leaves	A*: *Rubus* sp. (inc. *idaeus), Actinidia deliciosa*, *Juncus* spp., *Ranunculus* spp., *Centaurea cyanus*, *Armeria maritima*, Cyperaceae, Poaceae, *Suaeda maritima*, *Typha* sp.	Foraminifera spp. A*** , ostracods spp. A*, moll-m-f, insects (inc. pupae cases) A*	Hair/wool (A), coal, fossil fruit
2004	0.1	35	-	-	-	A	-	Foraminifera spp. A***, ostracods spp., moll-m, insects A*	Hair/wool (A***)
2006	8	1000	25%	-	-	A**: mainly seaweed, also wood, moss (inc. *Sphagnum* sp.) leaves, possible bark	A*: *Armeria maritima, Ranunculus* sp., *Suaeda maritima*, *Carduus/Cirsium*, Characeae, *Betula* sp., *Juncus* sp., indets	Foraminifera spp. A***, ostracods spp. A**, moll-m-f, insects + mites A*	Coal
2007	2	400	50%	-	-	A***: moss (inc. *Sphagnum* sp.) leaves, roots, seaweed, bud scales	A: Characeae, *Juncus* spp., *Selaginella* sp.	Foraminifera spp. A**, ostracods spp. A*, insects + mites A*	
2008	0.1	10	-	-	-	A**: inc. *Sphagnum* sp. leaves, wood	A: *Juncus* sp., Characeae, Lamiaceae, Chenopodiaceae, *Armeria maritima*	Foraminifera spp. A***, insects A*	
2009	9	800	25%	-	Trace	A**: inc. wood, moss (inc. *Sphagnum* sp.), seaweed	A*: *Corylus avellana*, *Rubus* sp. (inc. *idaeus*), *Alisma* sp., Characeae, *Ranunculus* sp., Cyperaceae, *Juncus* sp., *Suaeda maritima*, *Armeria maritima*, *Stellaria graminea/uliginosa*, indets	Foraminifera spp. A***, ostracods A**, moll-f-m (inc. mussel), insects and pupae cases A*	Coal

Key: A*** = exceptional, A** = 100+, A* = 30-99, A = 30-10, Moll-t = terrestrial molluscs, Moll-f = fresh-water molluscs, Moll-m = marine molluscs.

Table 2. Moss and other caulking agents from TBW

Context		**2001**	**2002**	**2004**
Description		caulking	bilge	caulking
Taxa	**Common name**			
Spahgnum sp	Bog-moss			occ
Dicranium scoparium	Broom Fork-moss	occ		
Dicranium majus	Greater Fork-moss		occ	
Neckera complanata	Flat Neckera	occ	occ	
Thuidium tamariscum	Common Tamarisk-moss	occ		
Isothecium myosuroides	Mouse-tail moss		occ	
Eurhynchium striatum	Lesser Striated Feather-moss		occ	
Plagiothecium undulatum	Waved Silk-moss		abun	
Plagiothecium denticulatum/curvifolium	Dentated/Curved Silk-moss			rare
Hypnum cupressiforme /resupinatum	Cypress-leaved/Supine Plait-moss	abun	occ	
cf *Hyloconium splendens*	Glittering Wood-moss	rare		
Animal hair	Pig/horse?			abun

Table 3. Habitats of the mosses identified from TBW (*After Atherton, Bosanquet and Lawley, 2010).

Habitat*	Raised & blanket bogs	Sand dunes	Coastal rocks	Heathland	Acid & neutral fens & flushes	Base-rich fens & flushes	Neutral grassland	Acidic grassland	base-rich grassland	Marshy grassland	General epiphytes	Trees by rivers	On rotting stumps & logs	South-eastern woodland floor & rocks	North-western woodland floor & rocks	Conifer plantations floor	Wet woodland floor	Scree beds (siliceous)	Cliffs, outcrops & boulders (siliceous)	Cliffs, outcrops & boulders (base-rich siliceous)	Cliffs, outcrops & boulders (chalk & limestone)
Taxa																					
Spahgnum sp	+																				
Dicranium scoparium	+			+	+		+	+	+		+	+	+	+		+		+	+		
Dicranium majus															+	+					
Neckera complanata									+		+	+		+						+	+
Thuidium tamariscum		+		+	+		+	+	+	+				+			+			+	+
Isothecium myosuroides											+	+						+	+		
Eurhynchium striatum														+						+	+
Plagiothecium undulatum	+			+											+	+		+	+		
Plagiothecium denticulatum/curvifolium					+								+				+				
Hypnum cupressiforme /resupinatum			+	+	+			+			+	+	+	+					+		
cf *Hyloconium splendens*	+			+		+		+		+					+	+		+			
No. of taxa/habitat	**4**	**1**	**1**	**5**	**4**	**1**	**2**	**4**	**3**	**2**	**4**	**4**	**3**	**5**	**3**	**4**	**2**	**4**	**4**	**3**	**3**

Table 41. Results of the foraminifera analyses on samples from TBW

200950 <2001> Caulking

Species	Cell	No.	%
Ammonia tepida	2, 10, 18	122	38.5
Cribroelphidium williamsoni	1, 9, 17	85	26.8
Haynesina germanica	3, 11	60	18.9
Haynesina depressula	4	16	5.0
Cibicidoides lobatulus	5	8	2.5
Buccella frigida	5	8	2.5
Elphidium margaritaceum	7	5	1.6
Bolivina britannica	4	4	1.3
Gavelinopsis praegri	5	2	0.6
Miliolinella subrotunda	4	1	0.3
Favulina melo	5	1	0.3
Procerolagena clavata	6	1	0.3
Elphidium oceanense	6	1	0.3
Rosalina williamsoni	6	1	0.3
Siphonina sp.	6	1	0.3
Asterigerinata mamilla	8	1	0.3
Total		317	99.8

No. of species:	16
% Marine tests:	14.2
Agglutinated:	0
Porcellaneous:	0.3
Hyaline:	99.7
Similarity <2001>/<2002>	77.1%
Similarity <2001>/<2004>	81.2%

Very abundant foraminifera

200950 <2002> Bilge (>250 microns)

Species	Cell	No.	%
Cribroelphidium williamsoni	1, 2, 9, 10	141	46.1
Ammonia tepida	4, 5, 12	105	34.3
Haynesina germanica	6	38	12.4
Elphidium margaritaceum	8	12	3.9
Haynesina depressula	3	3	1.0
Cibicidoides lobatulus	7	2	0.7
Elphidium crispum	7	2	0.7
Miliolinella subrotunda	3	1	0.3
Entzia macrescens	3	1	0.3
Buliminella elegantissima	7	1	0.3
Total		306	100

No. of species:	10
% Marine tests:	6.9
Agglutinated:	0.3
Porcellaneous:	0.3
Hyaline:	99.4
Similarity <2002>/<2001>	77.1%
Similarity <2002>/<2004>	85.2%

Very abundant foraminifera

200950 <2004> Caulking

Species	Cell	No.	%
Ammonia tepida	3, 11, 12	141	47.0
Cribroelphidium williamsoni	1, 2, 10	109	36.3
Haynesina germanica	4	36	12.0
Haynesina depressula	5	5	1.7
Elphidium margaritaceum	6	4	1.3
Homalohedra williamsoni	7	1	0.3
Procerolagena clavata	7	1	0.3
Lenticulina orbicularis	7	1	0.3
Cibicidoides lobatulus	8	1	0.3
Siphonina sp.	6	1	0.3
Total		300	99.8

No. of species: 10
% Marine tests: 4.7
Agglutinated: 0
Porcellaneous: 0
Hyaline: 100
Similarity <2004>/<2001>: 81.2%
Similarity <2004>/<2002>: 85.2%

Very abundant foraminifera

Table 5. Results of the pollen assessment.

Taxa	Samples *							
	2001	2002 A	2002 B	2002 C	2004	2006	2007	2009
Trees and Shrubs								
Betula (birch)	6	6	16	3	-	7	2	6
Pinus sylvestris (pine)	23	6	5	3	4	10	11	17
Picea (spruce)	-	-	-	-	-	1	-	-
Corylus avellana type (hazel)	19	17	35	27		33	28	20
Ulmus (elm)	-	-	-	-	-	1	1	4
Quercus (oak)	53	83	56	88	1	19	26	24
Tilia (lime)	2	-	-	-	-	1	3	1
Alnus glutinosa (alder)	11	4	5	3	1	10	6	5
Carpinus betulus (hornbeam)	-	-	-	-	-	2	-	-
Fagus sylvatica (beech)	1	-	-	1	-	1	-	1
Fraxinus excelsior (ash)	-	-	-	-	-	1	-	1
Acer (maple)	-	-	-	-	-	-	-	1
Salix (willow)	2	4	3	1	-	3	2	-
Rosa (roses)	-	-	-	1	-	-	-	-
Dwarf Shrubs								
Ericaceae (heather family)	-	1	-	-	-	1	1	3
Calluna vulgaris (common heather)	-	1	1	-	-	-	1	-
Cultivated								
Avena-Triticum type (oat-wheat)	-	2	1	1	-	-	-	1
Cerealia type (cereal undiff.)	-	4	3	2	1	1	-	-
Cannabis type (cannabis)	2	4	4	2	-	-	-	-
Herbaceous								
Poaceae (grass family)	11	13	8	10	1	30	31	31
Cyperaceae (sedge family)	1	-	-	1	-	-	2	1
Rumex acetosa (common sorrel)	-	-	1	-	-	1	4	2

Taxa	Samples *							
	2001	2002 A	2002 B	2002 C	2004	2006	2007	2009
Chenopodiaceae (goosefoot family)	8	4	2	1	-	19	21	17
Artemisia type (mugwort)	1	1	-	-	-	1	-	1
Brassicaceae (cabbage family)	1	2	-	-	-	2	-	2
Caryophyllaceae (pink family)	1	-	-	-	-	-	-	-
Silene type (campion)	-	-	-	-	-	1	-	-
Rosaceae (rose family)	1	1	1	2	-	-	1	3
Filipendula (meadowsweet)	1	1	-	-	-	2	-	-
Fabaceae (peas/beans)	-	-	-	-	-	-	1	-
Trifolium type (clover)	-	-	1	-	-	-	-	2
Apiaceae (carrot family)	-	1	-	-	-	-	-	-
Lamiaceae (mint family)	-	1	-	-	-	-	-	-
Plantago lanceolata (ribwort plantain)	3	3	4	1	-	1	4	-
Plantago maritima (sea plantain)	-	1	1	-	-	-	-	-
Armeria maritima (sea thrift)	-	1	-	-	-	-	-	-
Succisa pratensis (devil's-bit scabious)	-	-	-	-	-	-	-	2
Centaurea scabiosa (greater knapweed)	-	-	-	-	-	-	-	1
Lactuceae (lettuce family)	-	-	1	3	-	2	1	2
Aster type (daisies)	2	1	2	-	-	3	5	1
Anthemis (mugwort)	1	-	-	-	-	-	1	1
Fern Spores								
Pteropsida undiff. (undiff fern spore)	3	2	-	1	-	-	18	-
Pteridium aquilinum (bracken)	3	3	5	1	-	2	6	-
Dryopteris filix-mas (male fern)	-	-	-	-	-	-	1	-
Thelypteris palustris (marsh fern)	-	-	-	-	-	-	1	-
Polypodium vulgare (common polypody)	12	4	5	1	-	2	-	-
Aquatics								
Potamogeton natans type (pondweed)	-	-	1	-	1	2	1	-
Sparganium emersum type (unbranched bur-reed)	-	-	-	-	1	1	-	-
Sphagnum (bog moss)	2	-	-	-	-	1	2	-
Indeterminable	21	2	8	0	0	10	6	
Exotic (*Lycopodium*)	582	189	163	123	276	749	368	1025
Total Land Pollen (TLP)	**150**	**162**	**150**	**150**	**8**	**153**	**152**	**150**
Preservation	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Concentration	**2**	**2**	**2**	**2**	**5**	**3**	**2**	**3**

* Sample 2002-TAR produced no pollen and is not included in table. Sample contexts: 2001 – possible caulking, 2002a-c – bilge material, 2002 TAR – tar, 2004 – caulking at bow, 2006 – organic material overlying keelson, 2007 – bulk sample of organic clay beside 2006, 2009 – bulk sample from bow below shoe. Preservation/Concentration: 1 – Excellent, 2 – Good, 3 – Moderate, 4 – Poor, 5 – Very Poor

Table 6. Results of the dinoflagellate analysis.

Sample Label	Sample Type		Achomosphaera/Spiniferites spp	Achomosphaera alcicornu	Achomosphaera crassipellis	Apectodinium homomorphum	Apectodinium spp	Apteodinium sp	Areoligera spp	Areoligera/Glaphyrocysta spp	Cerodinium sp	Cerodinium depressum	Cerodinium speciosum/striatum	?Chiropteridium sp	Cleistosphaeridium diversispinosum grp	Cordosphaeridium gracile	Cordosphaeridium fibrospinosum	Cordosphaeridium multispinosum	Cordosphaeridium spp	Cribroperidinium sp	Cyclonephelium distinctum	Dapsilidinium simplex	Deflandrea spp	Deflandrea oebisfeldensis	Deflandrea phosphoritica	Dinocysts undifferentiated	Diphyes colligerum	Eatonicysta ursulae/furensis	Glaphyrocysta semitecta	Glaphyrocysta sp	Hystrichosphaeridium tubiferum	Hystrichostrogylon sp	Hystrichokolpoma sp	Hystrichokolpoma eisenackii	Hafniasphaera septata	Melitasphaeridium pseudorecurvatum	Operculodinium spp	Operculodinium sp. 2004	Palaeocystodinium sp	Pareodinia sp	Thalassiphora pelagica	Thalassiphora sp	Tubotuberella apatela	Wetzeliella spp	Wetzeliella ovalis	Alnipollenites spp	Callialasporites spp	Caryapollenites spp	Cerebropollenites mesozoicus	Chasmatosporites spp	Chenopodiaceae pollen	Classopollis spp	Densosporites sp	Intratriporopollenites sp	Lycospora spp	Triatriopollenites subtriangulus	Vestispora tortuosa	Microforaminiferid test linings	Tasmanites spp
2001	OC		5			1		2			1		1	1	1	4						1	2	1?		12			1?						2		2?		1?											1			1	1					
2002A	OC		3	2?	2		2?						1	1		3							1		1?	11					1				1									2	1		2	1				3				1			
2002B	OC		4						3		1				1	1					1?		2	2		14		1			2?				3		1						1	1?					1			2	1		2	4		1	
2002C	OC		1	12					1		1	1		1	7	6										9	1			1?					4	1	4	2		1				3		1	4		1		1	3			1		1	1	
2004	OC		7	5			1?	1	3							14		1					1		1?	7	1				1?	1?						2		6				1			1					1						1	2
2006	OC		3	3			2		2?	1				1	1	1			6?	1			1			15		1			1?		1									1?		2			3												
20	OC		1									1				1	1?	1	3								1							1	1			2						4			1			1		1							1

Sample Label	Sample Type		Achomosphaera/Spiniferites spp	Achomosphaera alcicornu	Achomosphaera crassipellis	Apectodinium homomorphum	Apectodinium spp	Apteodinium sp	Areoligera spp	Areoligera/Glaphyrocysta spp	Cerodinium sp	Cerodinium depressum	Cerodinium speciosum/striatum	?Chiropteridium sp	Cleistosphaeridium diversispinosum grp	Cordosphaeridium gracile	Cordosphaeridium fibrospinosum	Cordosphaeridium multispinosum	Cordosphaeridium spp	Cribroperidinium sp	Cyclonephelium distinctum	Dapsilidinium simplex	Deflandrea spp	Deflandrea oebisfeldensis	Deflandrea phosphoritica	Dinocysts undifferentiated	Diphyes colligerum	Eatonicysta ursulae/furensis	Glaphyrocysta semitecta	Glaphyrocysta sp	Hystrichosphaeridium tubiferum	Hystrichostrogylon sp	Hystrichokolpoma sp	Hystrichokolpoma eisenacki	Hafniasphaera septata	Melitasphaeridium pseudorecurvatum	Operculodinium spp	Operculodinium sp. 2004	Palaeocystodinium sp	Pareodinia sp	Thalassiphora pelagica	Thalassiphora sp	Tubotuberella anatela	Wetzeliella spp	Wetzeliella ovalis	Alnipollenites spp	Callialasporites spp	Caryapollenites spp	Cerebropollenites mesozoicus	Chasmatosporites spp	Chenopodiaceae pollen	Classopollis spp	Densosporites sp	Intratriporopollenites sp	Lycospora spp	Triatriopollenites subtriangulus	Vestispora tortuosa	Microforaminiferid test linings	Tasmanites spp
07																																																											
2009	OC		4				1?									2				1						9					2							1			1						2		3	1		4	1						

13.3 Appendix 3: Results of the geochemistry analysis

Table 1: py-GC-MS major components of sample 2001 from TBW.

Cpd	RT	Name	Formula	m/z	Ions	Height	Score	Polarity	Library
137	8.4	p-Cresol	C7H8O	107.1	32	2,023,926	94.38	Positive	NIST11.L
176	9.8	Phenol, 4-ethyl-	C8H10O	107.1	27	1,174,007	88.08	Positive	NIST11.L
548	25.5	Retene	C18H18	219.1	59	1,185,789	96.58	Positive	NIST11.L

Table 2: py-GC-MS major components of sample 2004 from TBW.

Cpd	RT	Name	Formula	m/z	Ions	Height	Score	Polarity	Library
74	7.2	2-Methyliminoperhydro-1,3-oxazine	C5H10N2O	114	26	1,342,448	81.52	Positive	NIST11.L
153	12.0	2-Methoxy-4-vinylphenol	C9H10O2	150.1	39	1,132,543	93.12	Positive	NIST11.L
162	12.6	Phenol, 2,6-dimethoxy-	C8H10O3	154.1	50	1,284,007	95.78	Positive	NIST11.L
184	14.3	Phenol, 2-methoxy-6-(2-propenyl)-	C10H12O2	164.1	49	1,090,555	93.6	Positive	NIST11.L
206	16.4	3',5'-Dimethoxyacetophenone	C10H12O3	180.1	53	2,170,879	87.07	Positive	NIST11.L
222	19.1	Phenol, 2,6-dimethoxy-4-(2-propenyl)-	C11H14O3	194.1	75	2,744,724	91.07	Positive	NIST11.L

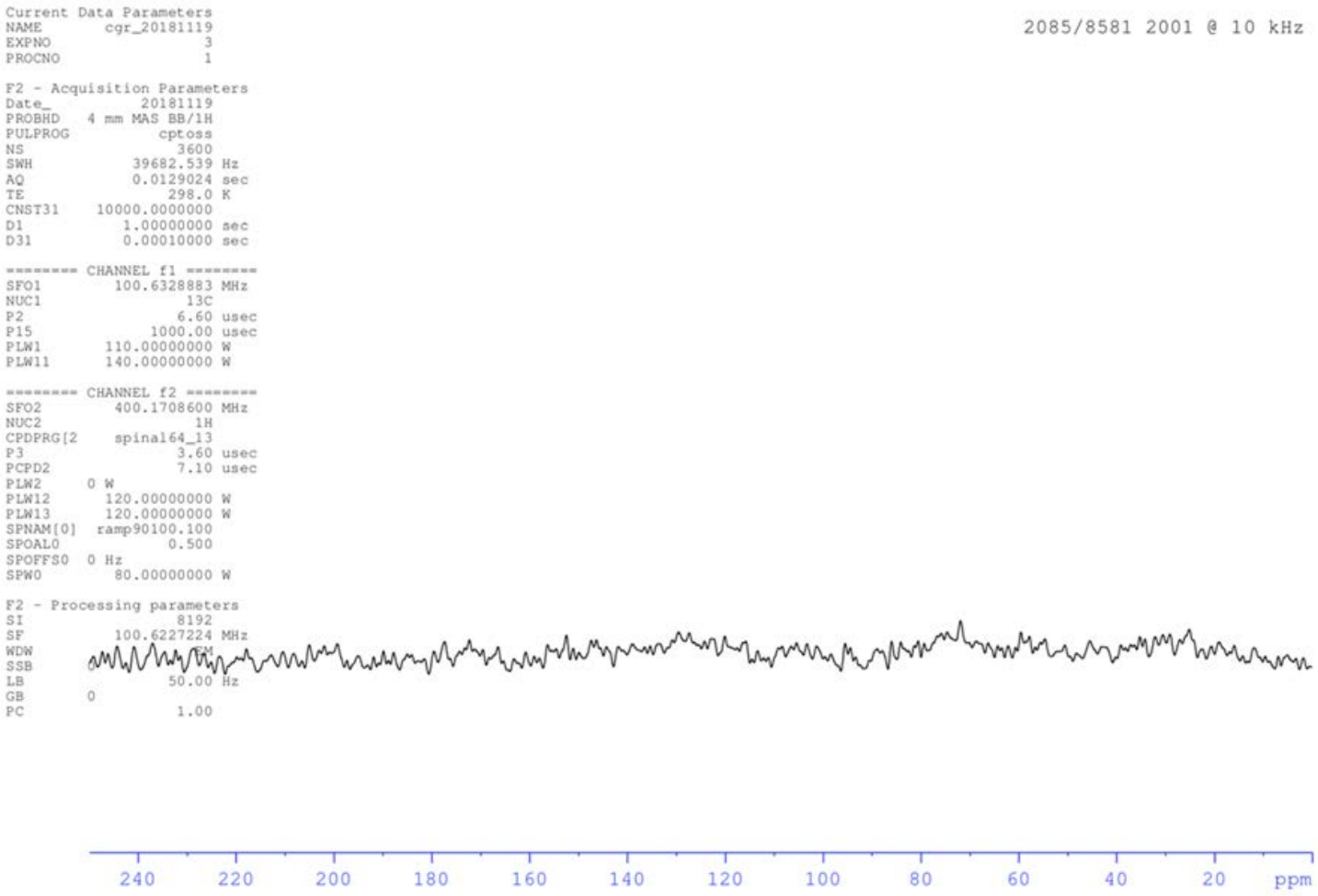


Figure 1. ssNMR analysis spectrum of sample 2001 from TBW.

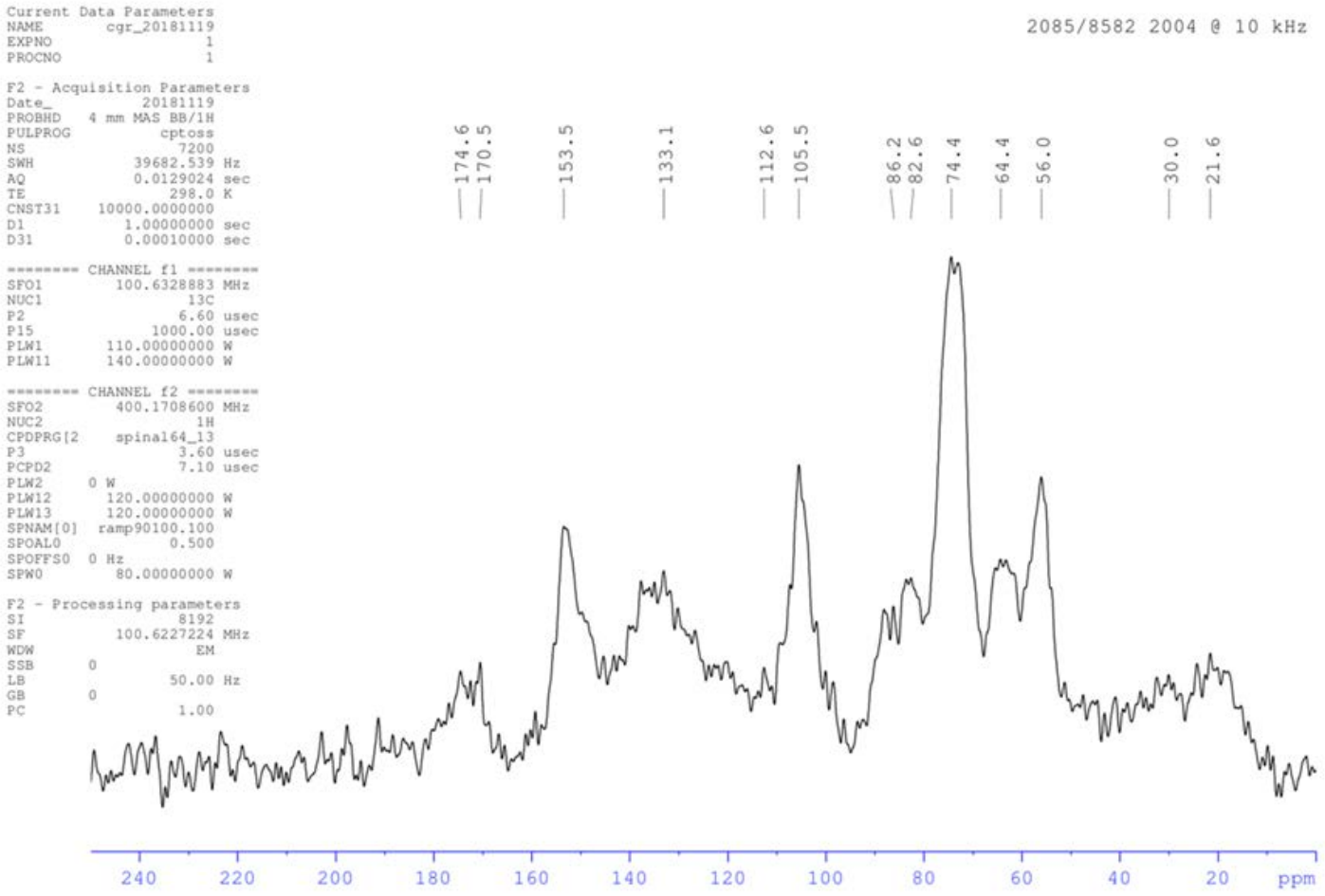


Figure 2. ssNMR analysis spectrum of sample 2004 from TBW.

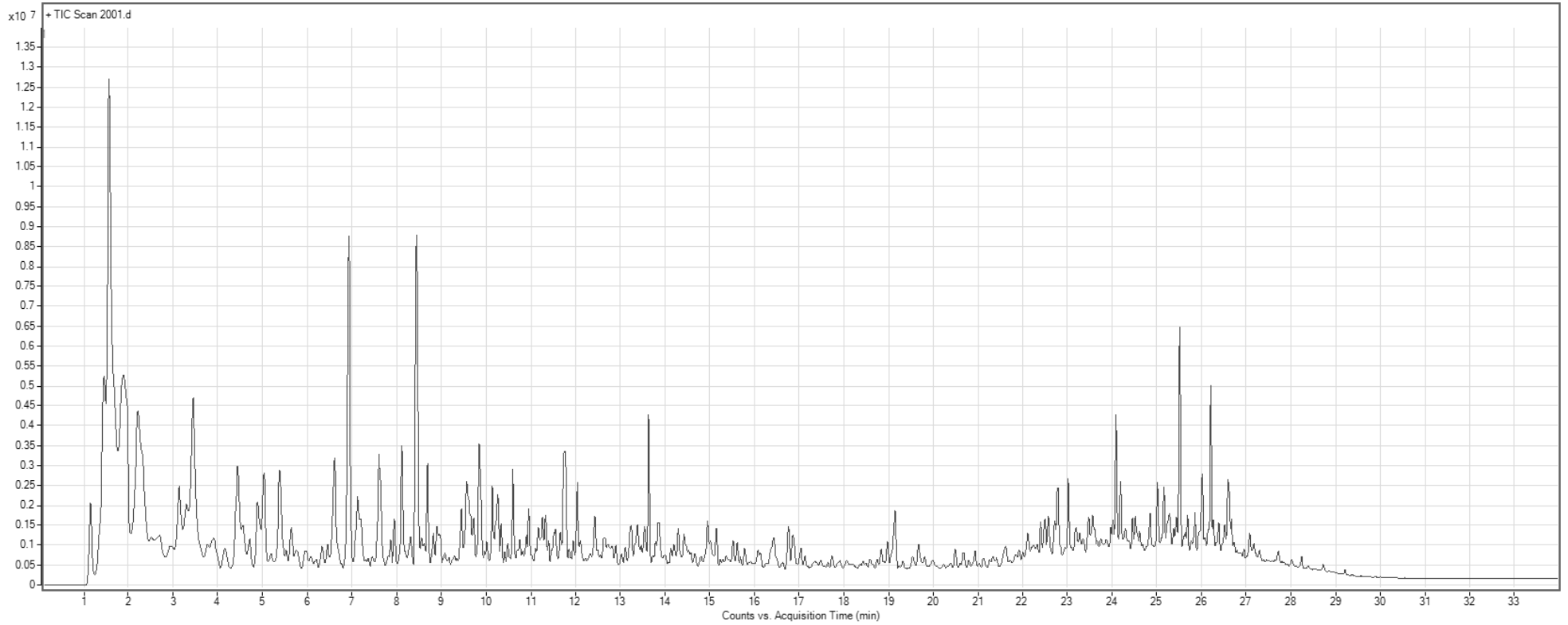


Figure 3. py-GC-MS spectrum of sample 2001 from TBW.

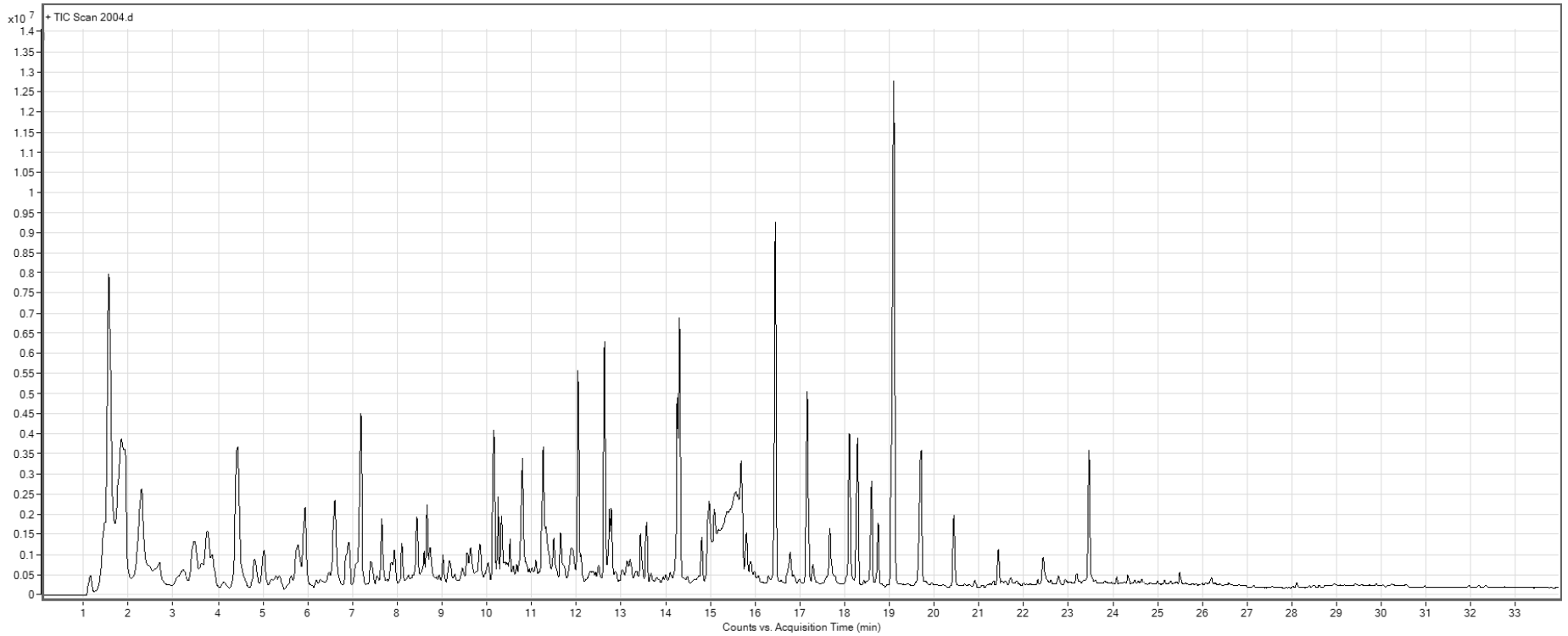


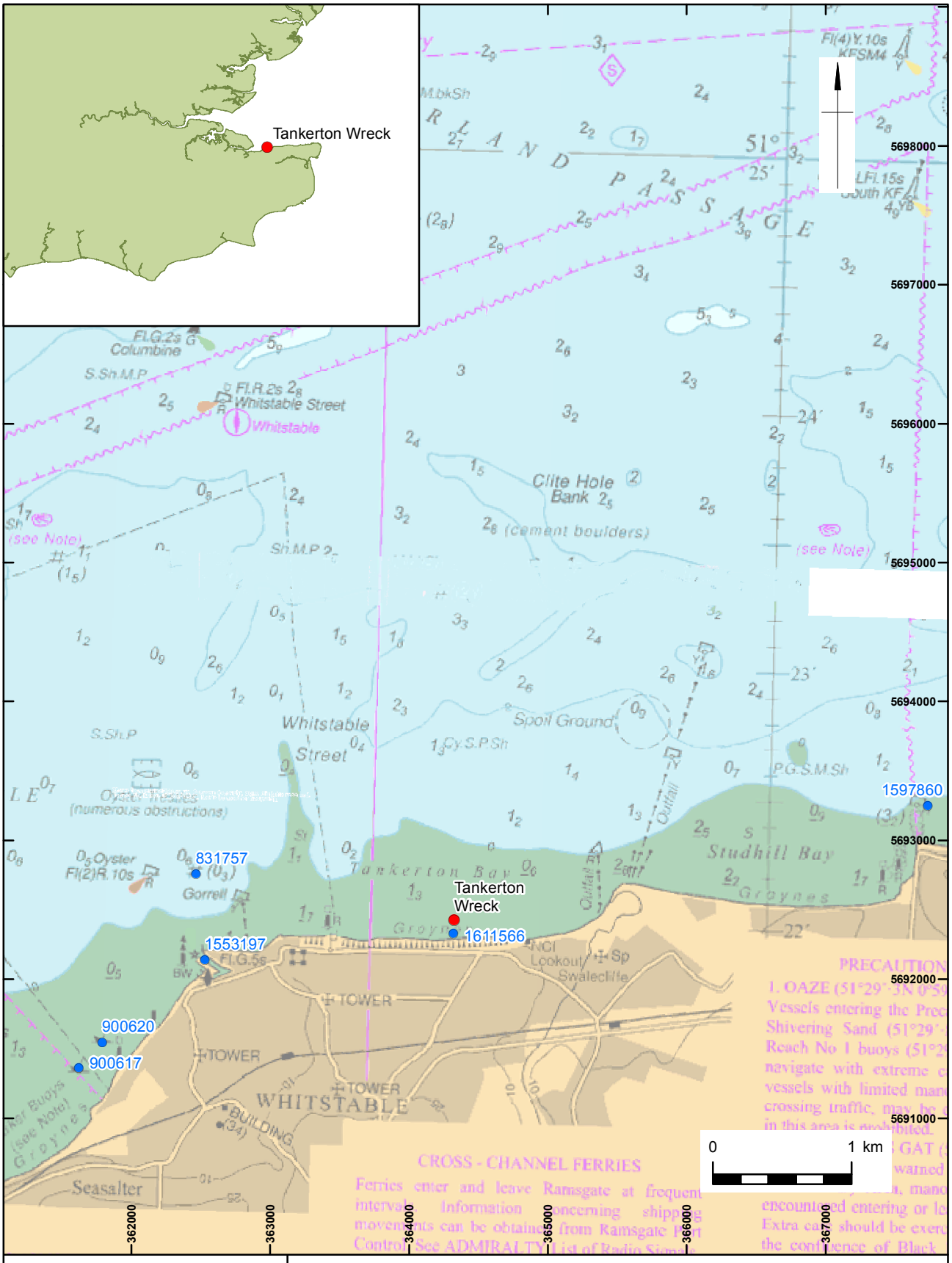
Figure 4. py-GC-MS spectrum of sample 2004 from TBW.

13.4 Appendix 4: Finds Register

Object number	Description	Material	Date found	Present location	x-ray No.
5101	Short thin timber with inscription and bevel @ stern	Wood	13/07/2018	Lampeter	
5102	Brushwood wood chip (bilge)	Wood	14/07/2018	Lampeter	
5103	Loose timber, starboard of keelson (on site)	Wood	14/07/2018	On site	
5104	Animal bone in small channel between timbers at bow	Bone	14/07/2018	WA	
5105	Small object recovered from bow. Unknown identity	Wood	15/07/2018	WA	
5106	Sherd of base of pottery vessel in small channel between timbers at bow	Ceramic	15/07/2018	WA	
5107	Square shanked fastening @ port side of keelson, towards midships	Metal	15/07/2018	WA	907, 909
5108	Fragment of brick. Part of galley @ bow starboard	Brick	15/07/2018	WA	
5109	As above. Overlying 5108	Brick	15/07/2018	WA	
5110	As above. Overlying 5108	Brick	15/07/2018	WA	
5111	Whole brick. Part of galley @ bow starboard. Overlying 5108	Brick	15/07/2018	WA	
5112	Wooden spoon, part of handle missing @ galley area	Wood	15/07/2018	WA	
5113	Brick @ Loose knee, port of keelson	Brick	15/07/2018	WA	
5114	Small piece of unidentified material, possible bitumen	Unknown	15/07/2018	WA	906
5115	Square shanked spike from spoil heap	Metal	15/07/2018	WA	907, 909
5116	Concretion from spoil heap	Metal	15/07/2018	WA	894
5117	Concretion from spoil heap	Metal	15/07/2018	WA	895
5118	Concretion from spoil heap	Metal	15/07/2018	WA	896
5119	Possible futtock (loose) mid ship (on site)	Wood	15/07/2018	On site	
5120	Pieces of coal from treenail gap in timber 5119	Coal	15/07/2018	WA	
5121	Shoe sole with stitching	Leather	16/07/2018	WA	
5122	Part of fastening?	Metal	16/07/2018	WA	
5123	Leather shoe parts x 7 inlcuding an intact sole	Leather	16/07/2018	WA	

5124	Retained as possible coins this concretion was discarded once x-rays confirmed that it was not - DISCARDED, void number	Metal	16/07/2018	WA	892
5125	Small piece of leather shoe	Leather	16/07/2018	WA	
5126	Kindling x 2. Galley area	Wood	16/07/2018	Lampeter	
5127	Piece of firewood with scorch marks @ galley area	Wood	16/07/2018	Lampeter	
5128	Tile fragment	Tile	16/07/2018	WA	
5129	Nail?	Metal	16/07/2018	WA	892
5130	Hexagonal treenail next to 5123	Wood	16/07/2018	WA	
5131	Fragment of brick. Beside knee (mid-ship)	Brick	15/07/2018	WA	
5132	Y shaped firewood with scorch marks	Wood	17/07/2018	Lampeter	
5133	Leather shoe x 2 (stuck together)	Leather	17/07/2018	WA	
5134	Post from galley area	Wood	17/07/2018	Lampeter	
5135	Concretion -bolt from knee	Metal	17/07/2018	WA	
5136	Elements of leather shoe in clay	Leather	17/07/2018	WA	
5137	Needle from spoil outside vessel amidships	Metal	17/07/2018	WA	892
5138	Chain concretion	Metal	17/07/2018	WA	893
5139	Plank with saw marks	Wood	17/07/2018	Lampeter	
5140	Small Pulley	Wood	17/07/2018	Lampeter	
5141	Possible cork. In 4 pieces	Cork?	17/07/2018	Lampeter	
5142	Fragment of wood with bevelled edge	Wood	17/07/2018	Lampeter	
5143	Tile fragment	Tile	17/07/2018	WA	
5144	Kindling	Wood	17/07/2018	Lampeter	
5145	2 pieces - one is fish vertebra	Bone	17/07/2018	WA	
5146	Brown brick fragments x 3. Markings on one in the form of an X.	Brick	17/07/2018	WA	
5147	Red brick fragments x2	Brick	17/07/2018	WA	
5148	Concretion x 4 small pieces	Metal	17/07/2018	WA	906
5149	Flint stone originally thought to be a possible whetstone. Considered by finds specialists to be natural stone	Stone	17/07/2018	WA	

5150	Part of metal needle?	Metal	16/07/2018	WA	892
5151	Part of metal needle?	Metal	16/07/2018	WA	892
5152	Part of metal needle?	Metal	16/07/2018	WA	892
5153	Part of metal needle?	Metal	16/07/2018	WA	892
5154	Part of metal needle?	Metal	16/07/2018	WA	892
5155	Part of metal needle?	Metal	16/07/2018	WA	892
5156	Part of metal needle?	Metal	16/07/2018	WA	892
5157	Bolt	Metal	16/07/2018	WA	892
5158	Bolt	Metal	16/07/2018	WA	892
5159	Posible fishing weight	Metal	16/07/2018	WA	906
5160	Hook/chain link, part of	Metal	16/07/2018	WA	906
5161	Bolt	Metal	16/07/2018	WA	892
5162	Bolt	Metal	16/07/2018	WA	892
5163	Concretion (round)	Metal	16/07/2018	WA	894
5164	Concretion (shaped)	Metal	16/07/2018	WA	894
5165	Retained as possible pottery from bow this find was discarded as identified as stone, so void number	Ceramic	16/07/2018	WA	
5166	Fragment of leather shoe from enviro sample 2002	Leather	26/07/2018	WA	
5167	Fragment of leather shoe (heel with stitching) from enviro sample 2003	Leather	26/07/2018	WA	
5168	Small fragment of leather from enviro sample 2006	Leather	27/07/2018	WA	
5169	Small fragment of leather from enviro sample 2009	Leather	27/07/2018	WA	
5170	Fragment of brown brick from enviro sample 2009	Brick	24/08/2018	WA	



Tankerton wreck location

NRHE points

Coordinate system:
WGS84 UTM z31N

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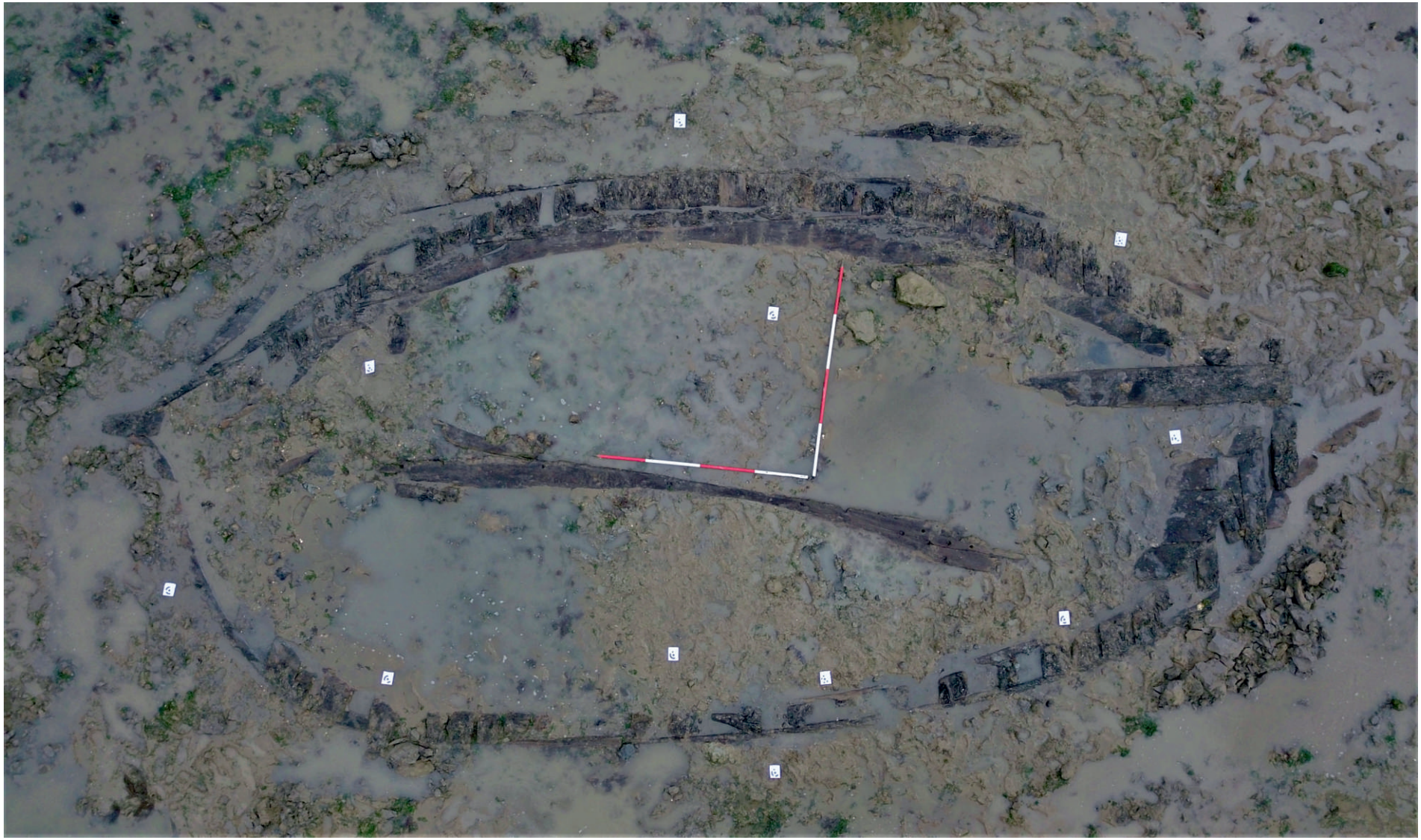
Site location

Figure 1



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Predisturbance survey aerial photo (photo credit: Tom Banbury of Timescapes, Kent)

Figure 2

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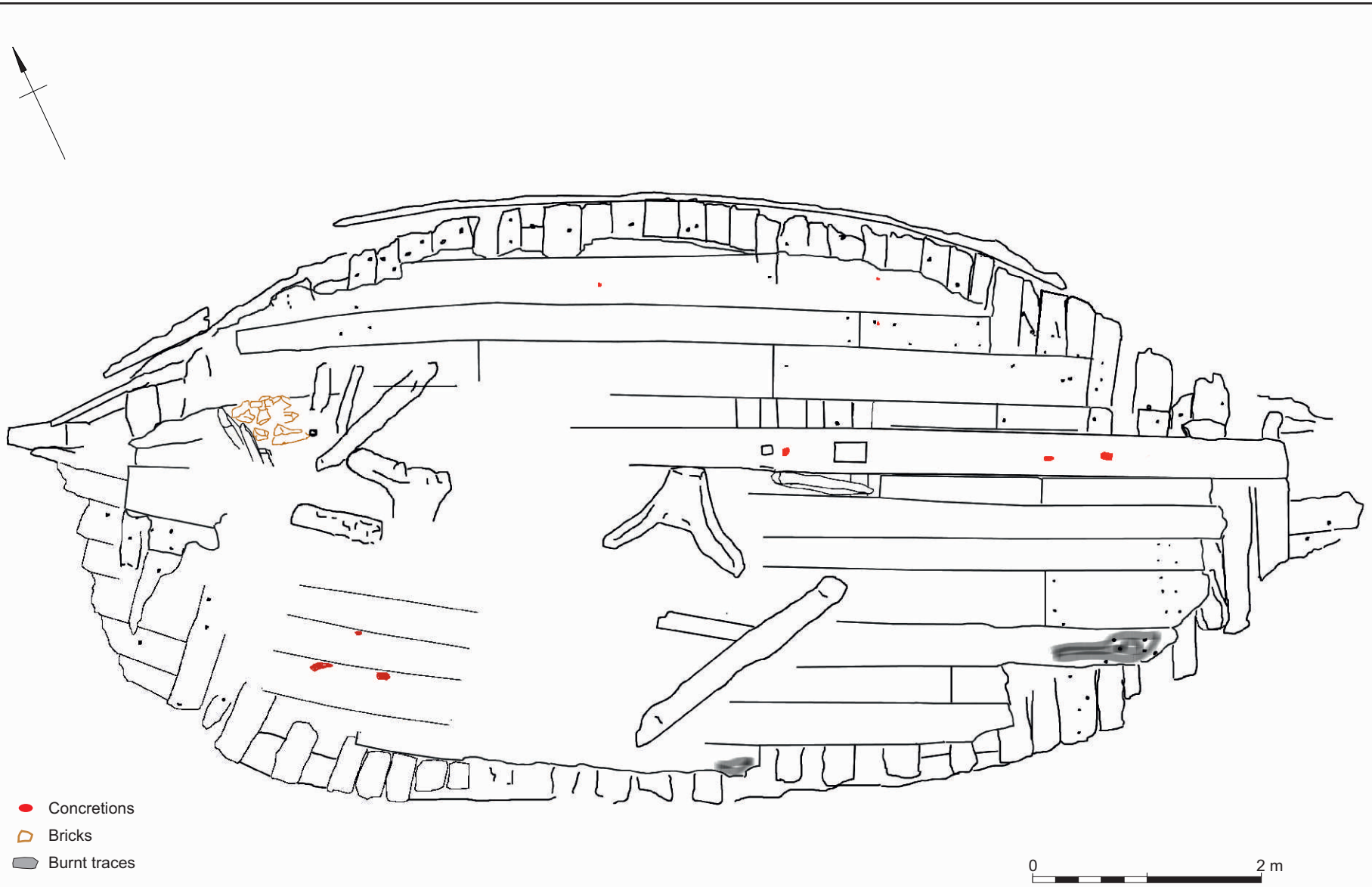
Aerial photograph of site (photo credit: Tom Banbury of Timescapes, Kent)

Figure 3



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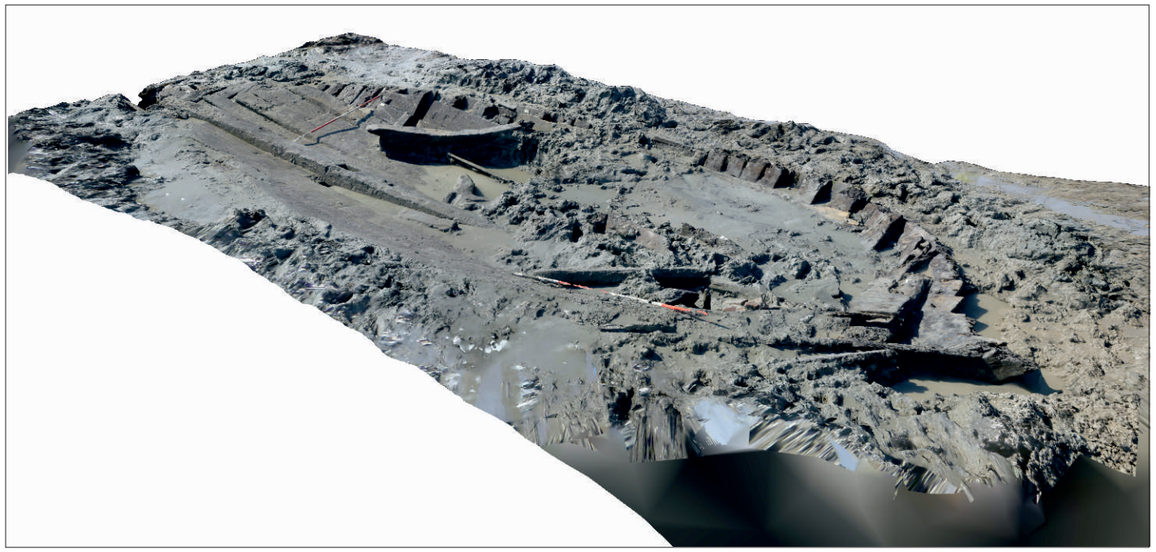
Site plan

Figure 4

A

0 4 m



B

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Hull section

Figure 5

A

B

C

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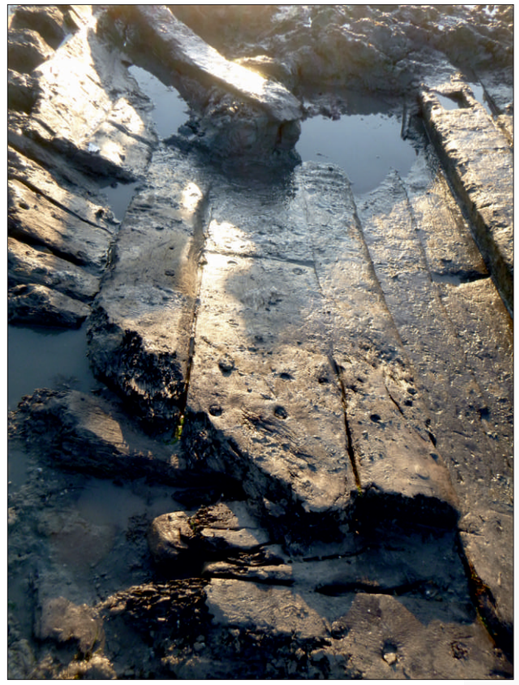
Detail of west area

A



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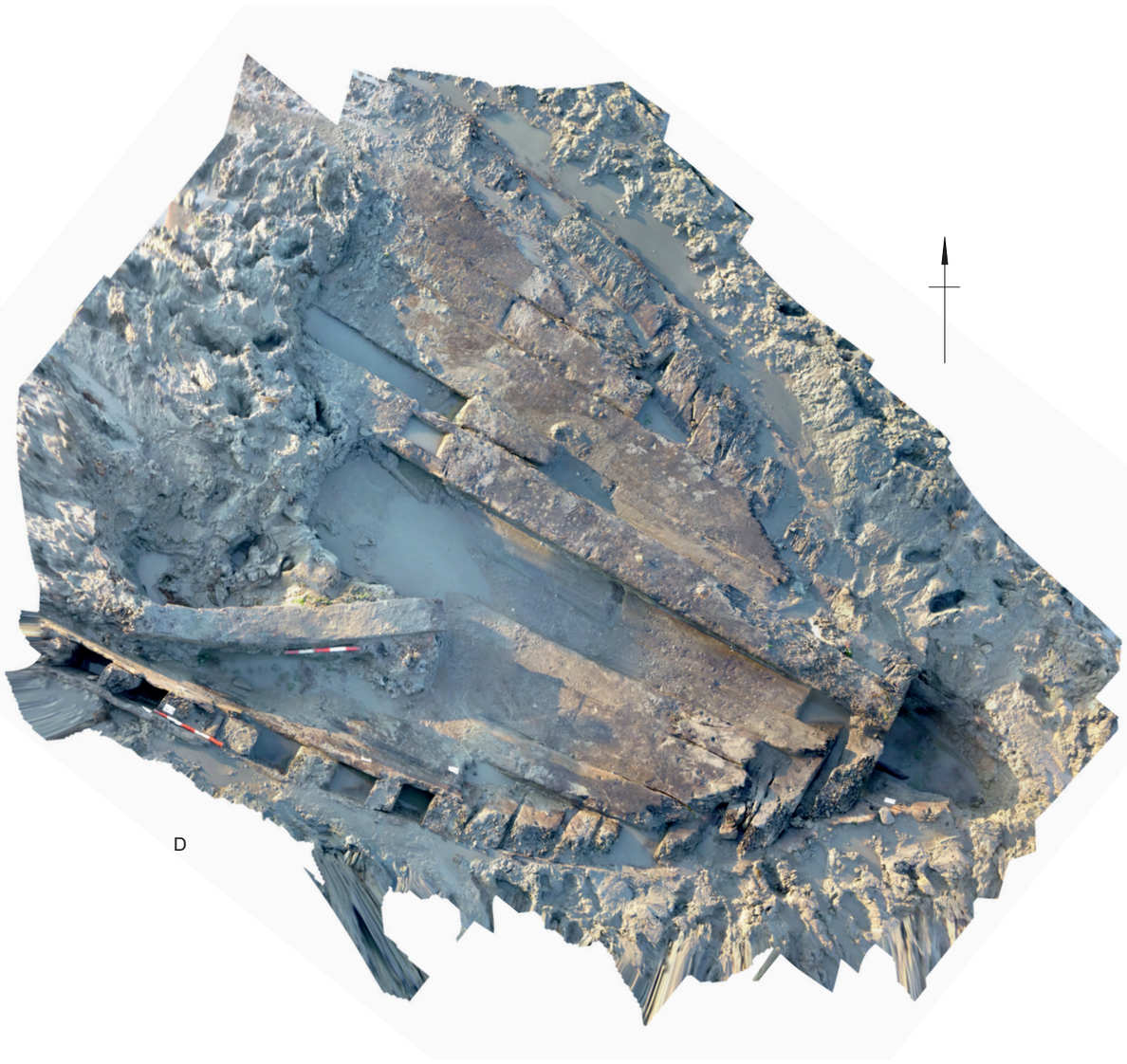
C



D

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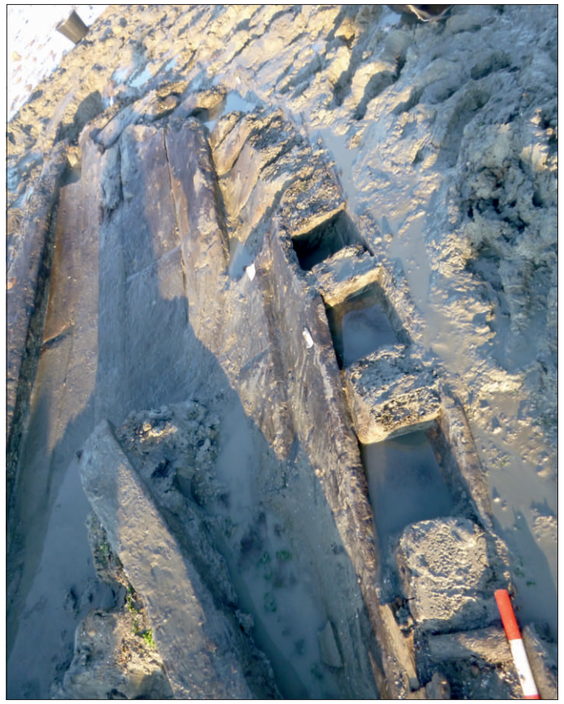
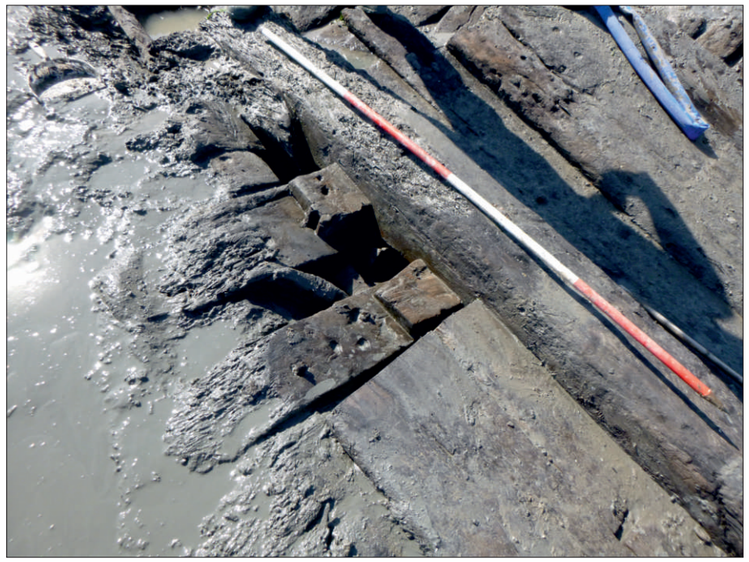
Detail of east area

A



B



C

D

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A

B

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A: TNK 18-29

B: TNK 18-37

C: TNK 18-39

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Path:	W:\Projects\200950\Graphics_Office\Rep figs\pxa\2019_02_22		

A

B

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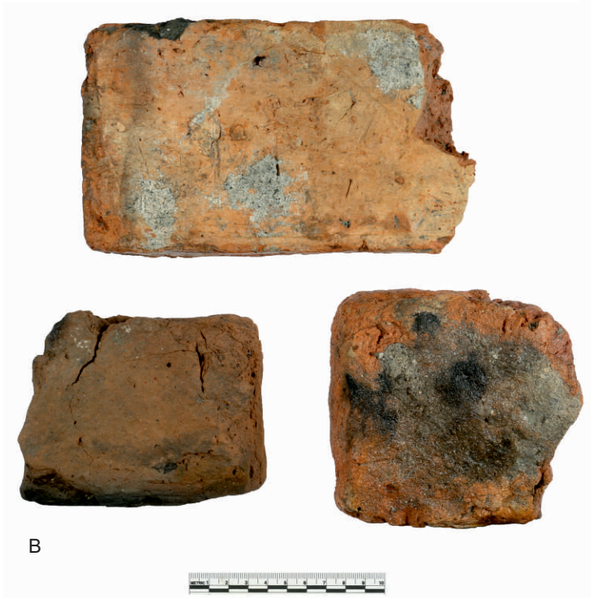
A


B


C


D


E


F


H


G


I


J

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Selection of finds

Plate 7

Wessex Archaeology Ltd registered office Portway House, Old Sarum Park, Salisbury, Wiltshire SP4 6EB
Tel: 01722 326867 Fax: 01722 337562 info@wessexarch.co.uk www.wessexarch.co.uk

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